ATTACHMENT F

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION
320 West 4th Street, Suite 200, Los Angeles

FACT SHEET

WASTE DISCHARGE REQUIREMENTS FOR COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY (POMONA WATER RECLAMATION PLANT)

NPDES No. CA0053619
Public Notice No. : R4-2004-015

FACILITY ADDRESS	FACILITY MAILING ADDRESS
Pomona Water Reclamation Plant	County Sanitation Districts of Los Angeles County
295 Humane Way	1955 Workman Mill Road
Pomona, CA 91766	Whittier, CA 90601
	Contact: Victoria Conway
	Telephone: (562) 699-7411

I. Public Participation

1. The California Regional Water Quality Control Board, Los Angeles Region (Regional Board) is considering the issuance of waste discharge requirements (WDRs) that will serve as a National Pollutant Discharge Elimination System (NPDES) permit for the above-referenced facility. As an initial step in the WDR process, the Regional Board staff has developed tentative WDRs. The Regional Board encourages public participation in the WDR adoption process.

A. Public Comment Period

The staff determinations are tentative. Interested persons are invited to submit written comments on the tentative WDRs for the County Sanitation Districts of Los Angeles County (CSDLAC or Discharger), Pomona Water Reclamation Plant (Pomona WRP). Comments should be submitted either in person or by mail to:

Executive Officer
California Regional Water Quality Control Board
Los Angeles Region
320 West 4th Street, Suite 200
Los Angeles, CA 90013

To be fully responded to by staff and considered by the Regional Board, written comments regarding the revised tentative Order should be received at the Regional Board offices by 5:00 p.m. on May 26, 2004.

The discharger submitted comments to the RWQCB based on previous tentative permits mailed to them. However, previous tentative permits contained limits been based on the United States Environmental Protection Agency's (USEPA) Technical Support Document. The Regional Board staff has incorporated some of the discharger's suggestions into this tentative.

B. Public Hearing

The Regional Board will hold a public hearing on the tentative WDRs during its regular Board meeting on the following date and time and at the following location:

Date: June 10, 2004
Time: 9:00 a.m.
Location: Council Chambers
Metropolitan Water District of Southern California
Board Room
700 N. Alameda Street
Los Angeles, California

Interested persons are invited to attend. At the public hearing, the Regional Board will hear testimony, if any, pertinent to the discharge, WDRs, and permit. Oral testimony will be heard; however, for accuracy of the record, important testimony should be in writing.

Please be aware that dates and venues may change. Our web address is www.swrcb.ca.gov/rqcb4 where you can access the current agenda for changes in dates and locations.

C. Information and Copying

Copies of the tentative WDRs and NPDES permit, report of waste discharge, Fact Sheet, comments received, and other documents relative to this tentative WDRs and permit are available at the Regional Board office. Inspection and/or copying of these documents are by appointment scheduled between 8:00 a.m. and 4:50 p.m., Monday through Friday, excluding holidays. For appointment, please call the Los Angeles Regional Board at (213) 576-6600.

D. Register of Interested Persons

Any person interested in being placed on the mailing list for information regarding this NPDES permit should contact the Regional Board, reference this facility, and provide a name, address, and phone number.

E. Waste Discharge Requirements Appeals

Any aggrieved person may petition the State Water Resources Control Board to review the decision of the Regional Board regarding the final

WDRs. The petition must be submitted within 30 days of the Regional Board's action to the following address:

State Water Resources Control Board
Office of Chief Counsel
ATTN: Elizabeth Miller Jennings
P.O. Box 100
Sacramento, CA 95812

II. PURPOSE OF ORDER

CSDLAC discharges tertiary-treated wastewater, from the Pomona WRP under Order No. 95-078, adopted by this Regional Board on June 12, 1995. That Order served as the permit under the National Pollutant Discharge Elimination System (NPDES No. CA0053619). The Discharger's permit was administratively extended beyond the May 10, 2000, expiration date. CSDLAC filed a Report of Waste Discharge (ROWD) and applied to the Regional Board for renewal of its WDRs and NPDES permit on November 15, 1999. This WDR and NPDES permit will expire on May 10, 2009.

III. FACILITY AND TREATMENT PROCESS DESCRIPTION

1. The Pomona WRP is one of eleven publicly owned treatment works (POTWs) (Saugus, Valencia, Whittier Narrows, Pomona, La Cañada, Long Beach, Los Coyotes, San Jose Creek, Lancaster, Palmdale, and Joint Water Pollution Control Plant) owned and operated by CSDLAC. The Pomona WRP is a tertiary treatment facility located at 295 Humane Way, Pomona, California. The plant has a dry weather average design capacity of 15 million gallons per day (mgd), but only discharges an average of 1.89 mgd (the Year 2002) of tertiary treated municipal wastewater to San Jose Creek, at Pomona, California. The Pomona WRP is a part of CSDLAC's regional system, known as the Joint Outfall System (JOS), which includes seven treatment plants. The upstream treatment plants (Whittier Narrows, Pomona, La Cañada, Long Beach, Los Coyotes, and San Jose Creek) are connected to the Joint Water Pollution Control Plant (JWPCP) located in Carson. This system allows biosolids, solids, and excess flows from the Pomona WRP to be diverted to the JWPCP for treatment and disposal. Figure 1 shows the vicinity map for the Pomona WRP.

2. The Pomona WRP serves a population of approximately 113,100 people. Flow to the plant consists of domestic, commercial and industrial wastewater. According to CSDLAC's *Preliminary Local Limits Evaluation*, prepared on November 8, 1996, industrial wastewater represents approximately 4.7% of the total flow to the plant. Discharges to the collection system from industry include discharges from metal finishers (40 CFR Part 433), pulp, paper, and paper board manufacturers (40 CFR Parts 430 and 431), textile mills (40 CFR Parts 410), aluminum forming (40 CFR Part 467), and electroplaters (40 CFR Part 413).

3. The United States Environmental Protection Agency (USEPA) and the Regional Board have classified Pomona WRP as a major discharger. It has a Threat to Water Quality and Complexity Rating of 1-A, pursuant to Section 2200, Title 23, CCR.

4. Pursuant to 40 CFR, Part 403, the Pomona WRP developed, and has been implementing, an industrial wastewater Pretreatment Program, which has been approved by USEPA and the Regional Board.

5. Treatment at the Pomona WRP consists of primary sedimentation, nitrification/denitrification (NDN) activated sludge biological treatment, secondary sedimentation with coagulation, inert media filtration, chlorination and dechlorination. No facilities are provided for solids processing at the plant. Sewage solids separated from the wastewater are returned to the JOS trunk sewer for conveyance to JWPCP for treatment and disposal. Figure 2 depicts the schematic of the Pomona WRP wastewater flow.

   A. *Primary sedimentation*. The main objective of primary sedimentation is to remove solids from the wastewater by gravity. The heavier solids (settleable solids) precipitate out and are scraped out of the primary sedimentation basin. The lighter solids float to the top and are skimmed off. However, some solids remain in suspension.

   B. *NDN Activated sludge*. The activated sludge process is a treatment system in which the incoming wastewater is mixed with existing biological floc (microorganisms, bugs, or activated sludge) in an aeration basin. Activated sludge converts non-settleable and dissolved organic contaminants into biological floc, which can then be removed from the wastewater with further treatment. The nitrification process converts ammonia nitrogen into nitrate plus nitrite nitrogen (inorganic nitrogen). The denitrification process converts the inorganic nitrogen into gaseous nitrogen, thus removing it from the wastewater.

   C. *Secondary sedimentation with coagulation.* The main objective of secondary sedimentation is to remove biological floc from the wastewater. Chemicals, such as aluminum sulfate (alum), may be added as part of the treatment process to enhance solids removal. Alum causes the biological floc to combine into larger clumps (coagulate). This makes it easier to remove the floc.

   D. *Inert media filtration*. The filtration process is used to remove or reduce suspended or colloidal matter from a liquid stream, by passing the water through a bed of graded granular material. Filters remove the solids that the secondary sedimentation process did not remove, thus, improving the disinfection efficiency and reliability.

   E. *Chlorination*. In the past, gaseous chlorine was used as a disinfectant in the Pomona WRP. However, gaseous chlorine was replaced by liquid sodium hypochlorite. Disinfectant is added to the treated effluent prior to the filters to destroy bacteria, pathogens and viruses, and to minimize algal growth in the filters. Additional disinfectant may be dosed prior to the serpentine chlorine contact chamber.

   F. *Dechlorination*. Prior to discharge, sodium bisulfite is added to the treated

effluent to remove residual chlorine.

G. *Sludge*. No facilities are provided for solids processed at the plant. All sewage solids separated from the wastewater are returned to the trunk sewer for conveyance to CSDLAC's Joint Water Pollution Control Plant (JWPCP), where treatment and disposal occur, under Order No. 97-090 (NPDES No. CA0053813).

In order to achieve compliance with the ammonia Basin Plan objectives, CSDLAC retrofitted the activated sludge treatment units at the Pomona WRP for NDN treatment. The NDN modifications were completed on June 11, 2003.

However, recent scientific investigations have found that the disinfection of the filtered activated sludge NDN effluent and increased polymer dosing generates n-nitrosodimethylamine (NDMA) as a byproduct. To date, ultra violet (UV) oxydation is the only available technology capable of destroying NDMA in wastewater. Currently, CSDLAC is conducting a UV disinfection pilot project at the Whittier Narrows WRP in an effort to eliminate in-plant generation of NDMA. Pending the outcome of this pilot study, the disinfection process at the Pomona WRP, and other CSDLAC WRPs, may be changed from chlorination to UV. The purpose of installing and operating the UV disinfection systems, will be to restore NDMA concentrations to their pre-NDN levels, for the continued protection of local groundwater, and to prevent the formation of other chlorination disinfection byproducts, such as cyanide and trihalomethanes.

6. ***Water Recycling Facility.*** The treated effluent is also regulated under Water Recycling Requirements (WRRs) contained in Order No. 81-34, adopted by this Board on July 27, 1981. The WRRs were re-adopted on May 12, 1997, by Board Order No. 97-072. In 2002, an average of 7.14 mgd of treated effluent was recycled.

Recycled water is used for irrigation of landscapes, impoundments and agricultural crops, for fire protection, livestock watering, dust control, in cooling towers, and in paper manufacturing. The Los Angeles County Department of Public Works uses the recycled water for groundwater recharge at the San Gabriel River Spreading Grounds and the Rio Hondo Spreading Grounds. As described in subsequent findings, the recharge is regulated under a separate permit (Regional Board Order No. 91-100). CSDLAC is promoting additional reuse options for the treated effluent.

7. ***Storm Water Management.*** CSDLAC does not treat storm water runoff at the Pomona WRP, except for stormwater infiltration and inflows in the sewer and stormwater that traverses the treatment tanks. It has developed a Storm Water Pollution Prevention Plan (SWPPP) for storm water that does not enter the treatment system.

IV. DISCHARGE OUTFALL AND RECEIVING WATER DESCRIPTION

1. The Pomona WRP discharges tertiary-treated municipal and industrial wastewater to the South Fork of San Jose Creek, through Discharge Serial No. 001 (approximate coordinates: Latitude 34° 03' 18", Longitude 117° 47' 43"). The South Fork San Jose Creek is tributary to the San Jose Creek and thence to the San Gabriel River, a water of the United States, at a point near the interchange of the Pomona Freeway and the San Gabriel River, above the estuary, within San Gabriel River Watershed.

2. During dry weather (May 1 – October 31), the primary sources of water flow in the receiving waters, downstream of the discharge point, are the Pomona WRP effluent and other NPDES-permitted discharges, including urban runoff conveyed through the municipal separate storm sewer system (MS4). Storm water and urban runoff from MS4 are regulated under an NPDES permit, *Waste Discharge Requirements for Municipal Storm Water and Urban Runoff Discharges Within the County of Los Angeles* (LA Municipal Permit), NPDES Permit No. CAS004001.

3. The Los Angeles County Flood Control District channelized portions of the San Gabriel River and San Jose Creek to convey and control floodwater, and to prevent damage to homes located adjacent to the river. Although not their main purpose, the San Gabriel River and San Jose Creek convey treated wastewater along with floodwater, and urban runoff. The South Fork of San Jose Creek is concrete-lined at the point of discharge, however, further downstream before its confluence with the San Gabriel River, San Jose Creek is unlined (near receiving water station R-D). Groundwater recharge occurs both incidentally and through separate WRRs for groundwater recharge, in these unlined areas of the San Gabriel River where the underlying sediments are highly transmissive to water as well as pollutants. The Water Replenishment District of Southern California recharges the Rio Hondo and San Gabriel Spreading Grounds, located in the Montebello Forebay, with water purchased from CSDLAC's Whittier Narrows, Pomona, and San Jose Creek WRPs, under WRR Order No. 91-100, adopted by the Board on September 9, 1991.

   Notwithstanding that segments located further downstream of the discharge are concrete-lined, the watershed supports a diversity of wildlife, particularly an abundance of avian species such as the *Least Bell's Vireo, Tricolored Blackbird, and California Gnatcatcher*. Aquatic life, such as fish, invertebrates, and algae exist in the San Gabriel River Watershed.

4. As described in the State of the Watershed Report, the San Gabriel River drains a 689 square mile area of eastern Los Angeles County; its headwaters originate in National Forest lands in the San Gabriel Mountains. The San Gabriel River watershed consists of extensive areas of undisturbed riparian and woodland habitats in its upper reaches. The U.S. Congress has set aside a wilderness area in much of the West and East Forks of the San Gabriel River. Towards the middle of the watershed, large spreading grounds are used to recharge groundwater basins. The watershed is hydraulically connected to the San Gabriel River Watershed through the Whittier Narrows Reservoir. Nurseries and small stable areas are located along channelized portions of the river. The lower part of the San Gabriel River Watershed is heavily urbanized.

V. DISCHARGE QUALITY DESCRIPTION

1. From June 1995 to December 2003, the Discharger's discharge monitoring reports showed the following:

   A. treated wastewater average annual flow rate of 2.51 mgd;

   B. average annual removal rate of 97.6% and >99%, of BOD and total suspended solids, respectively; and,

   C. 7-day median and daily maximum coliform values as <1 CFU/100 ml in the treated wastewater.

2. Based on data submitted in the 2002 Annual Summary Report, Table 1 represents the characteristics of the effluent discharged. (The "<" symbol indicates that the pollutant was not detected (ND) at that concentration level.) Attachment D contains more extensive statistical analyses of the effluent priority pollutants data from July 1995 to December 2003.

Table 1
Effluent Characteristics

CTR#	Constituent	Unit	Average or Range	Maximum	Minimum
	Flow	mgd	1.89	4.49	0.2
	pH	pH units	7.3	7.5	7.3
	Temperature- (Nov. – April) (May – Oct.)	°F °F	72 winter 80 summer	75 83	71 75
	BOD_5 20°C	mg/L	4	6	<3
	Suspended solids	mg/L	1	2	<1
	Settleable solids	ml/L	<0.1	<0.1	<0.1
	Total dissolved solids	mg/L	545	573	489
	Chloride	mg/L	139	158	117
	Sulfate	mg/L	69	86	58
	Boron	mg/L	0.47	0.52	0.43
	Total Phosphate	mg/L	1.2	1.4	0.9
	Turbidity	NTU	1.4	1.7	0.9
	Oil and grease	mg/L	<4 -<5	<5	<4
	Fluoride	mg/L	0.37	0.45	0.31
	MBAS	mg/L	0.14	0.3	0.07
	Ammonia-N	mg/L	13.9	19.3	7.35
	Organic-N	mg/L	2.0	4.8	0.7
	Nitrate-N	mg/L	1.15	4.9	0.1
	Nitrite-N	mg/L	1.89	3.75	0.22
	Total Nitrogen	mg/L	19.03	22.03	15.29
	Total residual chlorine	mg/L	<0.52	0.69	<0.07
1	Antimony	µg/L	<0.5 – 1.3	1.3	<0.5
2	Arsenic	µg/L	<1 – 2.4	2.4	<1
3	Beryllium	µg/L	<0.5	<0.5	<0.5
4	Cadmium	µg/L	<0.4	<0.4	<0.4

CTR#	Constituent	Unit	Average or Range	Maximum	Minimum
5a	Chromium III				
5b	Chromium VI				
	Total Chromium	µg/L	<10	<10	<10
6	Copper	µg/L	<8 14	14	<8
	Iron	µg/L	<50	<50	<50
7	Lead	µg/L	<2 - 2	2	<2
8	Mercury	µg/L	<0.04 -<0.1	<0.04	<0.1
9	Nickel	µg/L	<20	<20	<20
10	Selenium	µg/L	<1	<1	<1
11	Silver	µg/L	<0.24 – 0.49	0.49	<0.24
12	Thallium	µg/L	<1	<1	<1
13	Zinc	µg/L	60	80	50
14	Cyanide	µg/L	<5 - <10	<10	<5
16	2,3,7,8-TCDD (Dioxin)	µg/L	<3.8 - <3.9	<3.8	<3.9
17	Acrolein	µg/L	<2 - <10	<10	<2
18	Acrylonitrile	µg/L	<2 - <5	<5	<2
19	Benzene	µg/L	<0.5	<0.5	<0.5
20	Bromoform	µg/L	<0.5 – 0.6	0.6	<0.5
21	Carbon tetrachloride	µg/L	<0.5	<0.5	<0.5
22	Chlorobenzene	µg/L	<0.5	<0.5	<0.5
23	Dibromochloromethane	µg/L	<0.5 – 0.5	0.5	<0.5
24	Chloroethane	µg/L	<0.5	<0.5	<0.5
25	2-Chloroethylvinyl ether	µg/L	<0.5	<0.5	<0.5
26	Chloroform	µg/L	5	10	2.5
27	Bromodichloromethane	µg/L	<0.5 – 1.5	1.5	<0.5
28	1,1-Dichloroethane	µg/L	<0.5	<0.5	<0.5
29	1,2-Dichloroethane	µg/L	<0.5	<0.5	<0.5
30	1,1-Dichloroethylene	µg/L	<0.5	<0.5	<0.5
31	1,2-Dichloropropane	µg/L	<0.5	<0.5	<0.5
32	1,3-Dichloropropylene	µg/L	<0.5	<0.5	<0.5
33	Ethylbenzene	µg/L	<0.5	<0.5	<0.5
34	Methyl bromide (Bromomethane)	µg/L	<0.5 - <1	<1	<0.5
35	Methyl chloride (Chloromethane)	µg/L	<0.5	<0.5	<0.5
36	Methylene chloride	µg/L	<1 - <0.5	<1	<0.5
37	1,1,2,2-Tetrachloroethane	µg/L	<0.5	<0.5	<0.5
38	Tetrachloroethylene	µg/L	<0.5	<0.5	<0.5
39	Toluene	µg/L	<0.5	<0.5	<0.5
40	1,2-Trans-dichloroethylene	µg/L	<0.5	<0.5	<0.5
41	1,1,1-Trichloroethane	µg/L	<0.5	<0.5	<0.5
42	1,1,2-Trichloroethane	µg/L	<0.5	<0.5	<0.5
43	Trichloroethylene	µg/L	<0.5	<0.5	<0.5
44	Vinyl chloride	µg/L	<0.5	<0.5	<0.5
45	2-Chlorophenol	µg/L	<1 - <5	<5	<1
46	2,4-Dichlorophenol	µg/L	<1 - <5	<5	<1
47	2,4-Dimethylphenol	µg/L	<2	<2	<2
48	2-Methyl-4,6-dinitrophenol	µg/L	<5	<5	<5
49	2,4-Dinitrophenol	µg/L	<5	<5	<5

CTR#	Constituent	Unit	Average or Range	Maximum	Minimum
50	2-Nitrophenol	µg/L	<1 - <10	<10	<1
51	4-Nitrophenol	µg/L	<1 - <10	<10	<1
52	3-Methyl-4-chlorophenol	µg/L	<1	<1	<1
53	Pentachlorophenol	µg/L	<1 - <5	<5	<1
54	Phenol	µg/L	<1	<1	<1
55	2,4,6-Trichlorophenol	µg/L	<1 - <10	<10	<1
56	Acenaphthene	µg/L	<1	<1	<1
57	Acenaphthylene	µg/L	<1 - <10	<10	<1
58	Anthracene	µg/L	<1 - <10	<10	<1
59	Benzidine	µg/L	<5	<5	<5
60	Benzo(a)anthracene	µg/L	<1 - <5	<5	<1
61	Benzo(a)pyrene	µg/L	<0.0031	<0.0031	<0.0031
62	Benzo(b)fluoranthene	µg/L	<0.0031-0.014	<0.014	<0.0031
63	Benzo(g,h,i)perylene	µg/L	<1 - <5	<5	<1
64	Benzo(k)fluoranthene	µg/L	<0.0031- 0.01	0.01	<0.0031
65	Bis(2-chloroethoxy)methane	µg/L	<1 - <5	<5	<1
66	Bis(2-chloroethyl)ether	µg/L	<1	<1	<1
67	Bis(2-chloroisopropyl)ether	µg/L	<1 - <2	<2	<1
68	Bis(2-ethylhexyl)phthalate	µg/L	<1 - <5	<5	<1
69	4-Bromophenyl phenyl ether	µg/L	<1 - <5	<5	<1
70	Butylbenzyl phthalate	µg/L	<1 - <10	<10	<1
71	2-Chloronaphthalene	µg/L	<1 - <10	<10	<1
72	4-Chlorophenyl phenyl ether	µg/L	<1 - <5	<5	<1
73	Chrysene	µg/L	<0.0031 – 0.0049	0.0049	<0.003
74	Dibenzo(a,h)anthracene	µg/L	<0.006 – 0.007	0.007	<0.006
75	1,2-Dichlorobenzene	µg/L	<1 - <2	<2	<1
76	1,3-Dichlorobenzene	µg/L	<1	<1	<1
77	1,4-Dichlorobenzene	µg/L	<1 – 1.1	1.1	<1
78	3,3'-Dichlorobenzidine	µg/L	<5	<5	<5
79	Diethyl phthalate	µg/L	<1 - <2	<2	<1
80	Dimethyl phthalate	µg/L	<1 - <2	<2	<1
81	Di-n-butyl phthalate	µg/L	<1 - <10	<10	<1
82	2,4-Dinitrotoluene	µg/L	<1 - <5	<5	<1
83	2,6-Dinitrotoluene	µg/L	<1 - <5	<5	<1
84	Di-n-octyl phthalate	µg/L	<1 - <10	<10	<1
85	1,2-Diphenylhydrazine	µg/L	<1	<1	<1
86	Fluoranthene	µg/L	<1	<1	<1
87	Fluorene	µg/L	<1 - <10	<10	<1
88	Hexachlorobenzene	µg/L	<1	<1	<1
89	Hexachlorobutadiene	µg/L	<1	<1	<1
90	Hexachlorocyclopentadiene	µg/L	<5	<5	<5
91	Hexachloroethane	µg/L	<1	<1	<1
92	Indeno(1,2,3-cd)pyrene	µg/L	0.006 – 0.014	0.014	0.006
93	Isophrone	µg/L	<1	<1	<1
94	Naphthalene	µg/L	<1	<1	<1
95	Nitrobenzene	µg/L	<1	<1	<1
96	N-Nitrosodimethylamine (NDMA)	µg/L	<1 - <5	<5	<1

CTR#	Constituent	Unit	Average or Range	Maximum	Minimum
97	N-Nitrosodi-n-propylamine	µg/L	<1 - <5	<5	<1
98	N-Nitrosodiphenylamine	µg/L	<1	<1	<1
99	Phenanthrene	µg/L	<1 - <5	<5	<1
100	Pyrene	µg/L	<1 - <10	<10	<1
101	1,2,4-Trichlorobenzene	µg/L	<1 - <5	<5	<1
102	Aldrin	µg/L	<0.01	<0.01	<0.01
103	alpha-BHC	µg/L	<0.01	<0.01	<0.01
104	beta-BHC	µg/L	<0.01	<0.01	<0.01
105	gamma-BHC (Lindane)	µg/L	<0.01 – 0.01	0.01	<0.01
106	delta-BHC	µg/L	<0.01	<0.01	<0.01
107	Chlordane	µg/L	<0.05	<0.05	<0.05
108	4,4'-DDT	µg/L	<0.01	<0.01	<0.01
109	4,4'-DDE	µg/L	<0.01	<0.01	<0.01
110	4,4- DDD	µg/L	<0.01	<0.01	<0.01
111	Dieldrin	µg/L	<0.01	<0.01	<0.01
112	alpha-Endosulfan	µg/L	<0.01	<0.01	<0.01
113	beta-Endosulfan	µg/L	<0.01	<0.01	<0.01
114	Endosulfan sulfate	µg/L	<0.1	<0.1	<0.1
115	Endrin	µg/L	<0.01	<0.01	<0.01
116	Endrin aldehyde	µg/L	<0.04	<0.04	<0.04
117	Heptachlor	µg/L	<0.01	<0.01	<0.01
118	Heptachlor epoxide	µg/L	<0.01	<0.01	<0.01
	Polychlorinated biphenyls (PCBs)				
119	Aroclor 1016	µg/L	<0.1	<0.1	<0.1
120	Aroclor 1221	µg/L	<0.1	<0.1	<0.1
121	Aroclor 1232	µg/L	<0.1	<0.1	<0.1
122	Aroclor 1242	µg/L	<0.1	<0.1	<0.1
123	Aroclor 1248	µg/L	<0.1	<0.1	<0.1
124	Aroclor 1254	µg/L	<0.05	<0.05	<0.05
125	Aroclor 1260	µg/L	<0.1	<0.1	<0.1
126	Toxaphene	µg/L	<0.5	<0.5	<0.5
	MTBE	µg/L	<0.5 – 1.5	1.5	<0.5

3. The Discharger's effluent demonstrated chronic toxicity during the last permit cycle. Based on this information, the Regional Board has determined that there is a reasonable potential that the discharge will cause toxicity in the receiving water. However, the circumstances warranting a numeric chronic toxicity effluent limitation when there is reasonable potential were reviewed by the State Water Resources Control Board (State Board) in SWRCB/OCC Files A-1496 & A-1496(a) [Los Coyotes/Long Beach Petitions]. On September 16, 2003, at a public hearing, the State Board adopted Order No. WQO 2003-0012, deferring the issue of numeric chronic toxicity effluent limitations until Phase II of the SIP is adopted. In the mean time, the State Board replaced the numeric chronic toxicity limit with a narrative effluent limitation and a 1 TUc trigger, in the Long Beach and Los Coyotes WRP NPDES permits. This permit contains a similar chronic toxicity effluent limitation. This Order also contains a reopener to allow the Regional Board to modify the permit, if necessary, consistent with any new policy, law, or regulation.

4. **N-Nitrosodimethylamine (NDMA)**

A. NDMA is a by-product found in the effluent of POTWs, which use chlorination as a primary form of disinfection. There was RPA (Tier 3) for the Pomona WRP effluent to exceed the CTR human health organisms only criteria, therefore a CTR-based effluent limitation was included in this Order. NDMA has been detected every month in the final effluent since July 2000, when DHS directed the Discharger to initiate monthly NDMA sampling. The highest detected concentration of NDMA at the Pomona WRP was 1266 ng/L (on February 11, 2002). This concentration exceed DHS' Action Level of 10 ng/L for drinking water by a factor of up to 120.

B. In addition to the recharge of effluent that occurs in unlined portions of the San Gabriel River and San Jose Creek, the Water Replenishment District recharges the Rio Hondo and San Gabriel Spreading Grounds, located in the Montebello Forebay, with effluent purchased from CSDLAC's Pomona, Whittier Narrows and San Jose Creek WRPs, under WRRs (Order No. 91-100), adopted by the Regional Board on September 9, 1991. Although there were data presented to both the Regional Board and DHS that there is significant attenuation by both soil and sunlight in the spreading basins located approximately 20 miles away from the Pomona WRP, recent data from monitoring wells located at the Rio Hondo Speading Ground have detected increasing NDMA concentrations below the AL. Monitoring wells located at the San Gabriel Spreading Grounds have detected increasing concentrations of NDMA above the AL (up to 460 ng/L, on 10/23/03).

C. There has not been any site-specific groundwater monitoring data (for those areas underlying the reaches of the San Jose Creek and San Gabriel River recharged by the Pomona WRP's effluent) submitted to the Regional Board to determine if an attenuation factor should be applied. Groundwater is thought to occur at approximately 60 feet below ground surface.

D. On April 15, 2004, CSDLAC submitted information to the Regional Board detailing the measures they have taken and plan to take to address NDMA. The following table summarizes the major efforts:

Project	Timeline
Source Control/Pollution Prevention	1980's - ongoing
Study NDMA formation process in POTWs	2000 - ongoing
Divert filter backwash water to the JWPCP Plant	June 2002 - ongoing
Optimize chlorination disinfection chemical usage	March 2004
Obtain laboratory equipment more sensitive analytical detection levels	June 2004
Optimize polymer usage	June 2004
Conduct site specific hydrologic modeling and study attenuation of NDMA in GW basins through Soil Aquifer Treatment	June 2004 – June 2007
Study destruction of NDMA by photolysis at Long Beach WRP	Fall 2004
UV Pilot Project at Whittier Narrows WRP • Preliminary Investigation	 Oct. 2003 – April 2004

Project	Timeline
• Research	Jan. 2004 – Feb. 2005
• UV Equipment procurement	June 2004 – Oct. 2005
• Design of UV facilities	April 2004 – July 2005
• Construction	July 2005 – Aug. 2006
• Full scale evaluation	June 2006 – June 2007
Collaborative Studies	
• Removal/destruction of NDMA and its precursors in WTPs	Jan. 2001 – Sept. 2004
• Low cost analytical methods for measuring NDMA	Nov. 2002 – Aug. 2004
• Fate and transport of NDMA in irrigation reuse water	April 2003 – Oct. 2005

VI. APPLICABLE LAWS, PLANS, POLICIES, AND REGULATIONS

The requirements contained in the proposed Order are based on the requirements and authorities contained in the following:

1. ***Federal Clean Water Act –*** Section 301(a) of the federal Clean Water Act (CWA) requires that point source discharges of pollutants to a water of the United States must be done in conformance with a NPDES permit. NPDES permits establish effluent limitations that incorporate various requirements of the CWA designed to protect water quality. CWA section 402 authorizes the USEPA or States with an approved NPDES program to issue NPDES permits. The State of California has an approved NPDES program.

2. ***Basin Plan –*** The Regional Board adopted a revised *Water Quality Control Plan for the Los Angeles Region: Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* (Basin Plan) on June 13, 1994, and amended by various Regional Board resolutions. This updated and consolidated plan represents the Board's master quality control planning document and regulations. The State Board and the State of California Office of Administrative Law (OAL) approved the revised Basin Plan on November 17, 1994, and February 23, 1995, respectively. On May 26, 2000, the USEPA approved the revised Basin Plan except for the implementation plan for potential municipal and domestic supply (MUN) designated water bodies, which is not applicable to this discharge.

   Ammonia Water Quality Objective (WQO). The 1994 Basin Plan contained water quality objectives for ammonia to protect aquatic life, in Tables 3-1 through Tables 3-4. However, those ammonia objectives were revised on April 25, 2002, by the Regional Board, with the adoption of Resolution No. 2002-011, Amendment to the Water Quality Control Plan for the Los Angeles Region to Update the Ammonia Objectives for Inland Surface Waters (including enclosed bays, estuaries and wetlands) with Beneficial Use designations for protection of Aquatic Life. Resolution No. 2002-011 was approved by the State Board, OAL, and USEPA on April 30, 2003, June 5, 2003, and June 19, 2003, respectively, and is now in effect. The final effluent limitations for ammonia prescribed in this Order are based on the revised ammonia criteria (see Attachment H) and apply at the end of pipe.

Chloride WQO. The 1994 Basin Plan contained water quality objectives for chloride in Table 3-8. However, the chloride objectives for some waterbodies were revised on January 27, 1997, by the Regional Board, with the adoption of Resolution No. 97-02, *Amendment to the Water Quality Control Plan for the Los Angeles Region to Incorporate a Policy for Addressing Levels of Chloride in Discharges of Wastewaters*. Resolution No. 97-02 was approved by the State Board, OAL, and USEPA on October 23, 1997, January 9, 1998, and February 5, 1998, respectively, and are now in effect. The chloride WQO was revised from 150 mg/L to 180 mg/L, for the San Gabriel River between Valley Boulevard and Firestone Boulevard (including Whittier Narrows Flood Control Basin, and San Jose Creek downstream of 71 Freeway only).

The Basin Plan (i) designates beneficial uses for surface and groundwater, (ii) sets narrative and numerical objectives that must be attained or maintained to protect the designated (existing and potential) beneficial uses and conform to the State's antidegradation policy, and (iii) includes implementation provisions, programs, and policies to protect all waters in the Region. In addition, the Basin Plan incorporates (by reference) all applicable State and Regional Board plans and policies and other pertinent water quality policies and regulations. The 1994 Basin Plan was prepared to be consistent with all State and Regional Board plans and policies adopted in 1994 and earlier. This Order implements the plans, policies, and provisions of the Board's Basin Plan.

3. ***Sources of Drinking Water Policy***. On May 19, 1988, the State Board adopted Resolution No. 88-63, *Sources of Drinking Water (SODW) Policy*, which established a policy that all surface and ground waters, with limited exemptions, are suitable or potentially suitable for municipal and domestic supply. To be consistent with State Board's SODW policy, on March 27, 1989, the Regional Board adopted Resolution No. 89-03, Incorporation of Sources of Drinking Water Policy into *the Water Quality Control Plans (Basin Plans) – Santa Clara River Basin (4A)/ Los Angeles River Basin (4B)*.

4. ***Potential Municipal and Domestic Supply (P* MUN) –*** Consistent with Regional Board Resolution No. 89-03 and State Board Resolution No. 88-63, in 1994 the Regional Board conditionally designated all inland surface waters in Table 2-1 of the 1994 Basin Plan as existing, intermittent, or potential for Municipal and Domestic Supply (P* MUN). However, the conditional designation in the 1994 Basin Plan included the following implementation provision: "no new effluent limitations will be placed in Waste Discharge Requirements as a result of these [potential MUN designations made pursuant to the SODW policy and the Regional Board's enabling resolution] until the Regional Board adopts [a special Basin Plan Amendment that incorporates a detailed review of the waters in the Region that should be exempted from the potential MUN designations arising from SODW policy and partial approval (May 26, 2000) of the 1994 Basin Plan amendments and acknowledged that the conditional designations do not currently have a legal effect, do not reflect new water quality standards subject to USEPA review, and do not support new effluent limitations based on the conditional designations stemming from the SODW Policy until a subsequent review by the Regional Board finalizes the designations for these waters. This permit is designed to be consistent with the existing Basin Plan.

5. ***State Implementation Plan (SIP) and California Toxics Rule (CTR)***. The State Board adopted the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (also known as the State Implementation Plan or SIP) on March 2, 2000. The SIP was amended by Resolution No. 2000-30, on April 26, 2000, and the Office of Administrative Law approved the SIP on April 28, 2000. The SIP applies to discharges of toxic pollutants in the inland surface waters, enclosed bays and estuaries of California which are subject to regulation under the State's Porter-Cologne Water Quality Control Act (Division 7 of the California Water Code) and the Federal Clean Water Act (CWA). This policy also establishes the following:

   A. Implementation provisions for priority pollutant criteria promulgated by USEPA through the CTR and for priority pollutant objectives established by Regional Boards in their Basin Plans;

   B. Monitoring requirements for priority pollutants with insufficient data to determine reasonable potential;

   C. Monitoring requirements for 2, 3, 7, 8 – TCDD equivalents; and,

   D. Chronic toxicity control provisions.

   The CTR became effective on May 18, 2000 (codified as 40 CFR Part 131.38). Toxic pollutant limits are prescribed in this Order to implement the CTR and Basin Plan.

   In the CTR, USEPA promulgated criteria that protects the general population at an incremental cancer risk level of one in a million (10^{-6}), for all priority toxic pollutants regulated as carcinogens. USEPA recognizes that adoption of a different risk factor is outside of the scope of the CTR. However, states have the discretion to adopt water quality criteria that result in a higher risk level, if it can demonstrate that the chosen risk level is adequately protective of the most highly exposed subpopulation, and has completed all necessary public participation. This demonstration has not happened in California. Further, the information that is available on highly exposed subpopulations in California supports the need to protect the general population at the 10^{-6} level. The Discharger may undertake a study, in accordance with the procedures set forth in Chapter 3 of USEPA's Water Quality Standards Handbook: Second Edition (EPA-823-B-005a, August 1994) to demonstrate that a different risk factor is more appropriate. Upon completion of the study, the State Board will review the results and determine if the risk factor needs to be changed. In the mean time, the State will continue using a 10^{-6} risk level, as it has done historically, to protect the population against carcinogenic pollutants.

6. ***Alaska Rule***. On March 30, 2000, USEPA revised its regulation that specifies when new and revised State and Tribal water quality standards (WQS) become effective for CWA purposes (40 CFR 131.21, 65 FR 24641, April 27, 2000). Under USEPA's new regulation (also known as the *Alaska rule*), new and revised standards submitted to USEPA after May 30, 2000, must be approved before

being used for CWA purposes. The final rule also provides that standards already in effect and submitted to USEPA by May 30, 2000, may be used for CWA purposes, whether or not approved by EPA.

7. ***Beneficial Uses***. The designated beneficial uses in the Basin Plan for the San Gabriel River, San Jose Creek and their contiguous waters are:

A. The beneficial uses of the receiving surface water are:

San Jose Creek - Hydrologic Unit 405.41	
Existing:	wildlife habitat.
Intermittent:	groundwater recharge, non-contact water recreation, warm freshwater habitat.
Potential:	water contact[1] recreation and municipal and domestic water supply (MUN[2]).
San Gabriel River - Hydrologic Unit 405.41	
Existing:	wildlife habitat.
Intermittent:	groundwater recharge, water contact recreation[1], non-contact water recreation, warm freshwater habitat.
Potential:	MUN[2].
San Gabriel River: Whittier Narrows to Firestone Boulevard - Hydrologic Unit 405.15	
Existing:	water contact[1] recreation and non-contact water recreation; wildlife habitat; and rare, threatened, or endangered species.
Intermittent:	groundwater recharge and warm freshwater habitat.
Potential:	industrial service supply; industrial process supply; and MUN[2].
San Gabriel River: Firestone Boulevard to the Estuary - Hydrologic Unit 405.15	
Existing:	water contact[1] recreation and non-contact water recreation.
Potential:	MUN[2]; warm freshwater habitat; and wildlife habitat.
San Gabriel River Estuary - Hydrologic Unit 405.15	
Existing:	industrial service supply; navigation; water contact[1] recreation and non-contact water recreation; commercial and sport fishing; estuarine habitat; marine habitat; wildlife habitat; rare, threatened, or endangered species; migration of aquatic organisms; and spawning, reproduction, and/or early development.
Potential:	shellfish harvesting.

B. The beneficial uses of the groundwater are:

[1] Although the Los Angeles County Department of Public Works posted signs prohibiting access to San Jose Creek, San Gabriel River, and its tributaries, the public has been observed fishing and wading across sections of the streams. There is public access to the San Gabriel River and its tributaries through the bike trails that run parallel to the river. Since there is public contact in the receiving water downstream of the discharge, the quality of wastewater discharged to San Jose Creek, San Gabriel River, and its tributaries must be such that no public health hazard is created.

[2] The potential MUN beneficial use for the water body is consistent with Regional Board Resolution 89-03; however the Regional Board has only conditionally designated the MUN beneficial uses and at this time cannot establish effluent limitations designed to protect the conditional designation.

San Gabriel Valley (Puente Basin) - DWR Basin No. 4-13	
Existing:	municipal and domestic supply, industrial service supply; industrial process supply; and, agricultural supply.
Los Angeles Coastal Plain (Central Basin) – DWR Basin No. 4-11	
Existing:	municipal and domestic supply, industrial service supply, industrial process supply, and agricultural supply

C. The requirements in this Order are intended to protect designated beneficial uses and enhance the water quality of the watershed. Effluent limits must protect both existing and potential beneficial uses.

D. Consistent with Regional Board Resolution No. 89-003 and State Board Resolution No. 88-63, all inland surface waters in Table 2-1 of the 1994 Basin Plan are designated existing, intermittent, or potential for MUN.

8. ***Title 22 of the California Code of Regulations -*** The California Department of Health Services established primary and secondary maximum contaminant levels (MCLs) for inorganic, organic, and radioactive contaminants in drinking water. These MCLs are codified in Title 22, California Code of Regulations (Title 22). The Basin Plan (Chapter 3) incorporates Title 22 primary MCLs by reference. This incorporation by reference is prospective including future changes to the incorporated provisions as the changes take effect. Title 22 primary MCLs have been used as bases for effluent limitations in WDRs and NPDES permits to protect the groundwater recharge beneficial use when that receiving groundwater is designated as MUN. Also, the Basin Plan specifies that "Ground waters shall not contain taste or odor-producing substances in concentrations that cause nuisance or adversely affect beneficial uses." Therefore the secondary MCL's, which are limits based on aesthetic, organoleptic standards, are also incorporated into this permit to protect groundwater quality.

Action Levels (ALs). DHS also establishes Action levels (ALs), or health-based advisory levels, for chemicals in drinking water that lack MCLs. An AL is the concentration of a chemical in drinking water that is considered not to pose a significant health risk to people ingesting that water on a daily basis. ALs may be established by DHS for non-regulated chemical contaminants when one of the following occurs:

1. A chemical is found in an actual or proposed drinking water source, or
2. A chemical is in proximity to a drinking water source, and guidance is needed, should it reach the source.

An AL is calculated using standard risk assessment methods for non-cancer and cancer endpoints, and typical exposure assumptions, including a 2-liter per day ingestion rate, a 70-kilogram adult body weight, and a 70-year lifetime. For chemicals that are considered carcinogens, the AL is considered to pose *"de minimis*" risk, i.e., a theoretical lifetime risk of up to one excess case of cancer in a population of 1,000,000 people—the 10^{-6} risk level. (In that population, approximately 250,000-300,000 cases of cancer would be anticipated to occur naturally.) On occasion, the chemical may not be detectable as low as the action

level by usual laboratory analytical methods. In this case, detectability prevails, and DHS' approach is to consider a detectable quantity as over the action level until a more sensitive method is available. ALs may be revised from time to time to reflect new risk assessment information. Chemicals for which ALs are established may eventually be regulated by MCLs, depending on the extent of contamination, the levels observed, and the risk to human health. A number of the contaminants for which action levels were originally established now have MCLs.

In April 1998, DHS established an action level of 0.002 µg/L for NDMA, based on a deminimus cancer risk level. The AL was later revised by DHS, once in November 1999 to 0.02 µg/L, and once in March 2002 to 0.01 µg/L or 10 ng/L (the current AL). The AL for NDMA is based on an evaluation conducted by CalEPA's Office of Environmental Health Hazard Assessment. NDMA is classified as a possible human carcinogen on USEPA's Integrated Risk Information System (IRIS), based on the development of tumors, at multiple sites, in both rodent and non-rodent mammals exposed to NDMA by various routes.

The primary routes of potential human exposure to NDMA are ingestion, inhalation, and dermal contact. The general population may be exposed to unknown quantities of NDMA present in foods, beverages, tobacco smoke, herbicides, pesticides, drinking water, and industrial pollution. The National Institute for Occupational Safety and Health (NIOSH) lists the following symptoms experienced depending upon the route of exposure to NDMA:

Route of Exposure	**Symptoms**
Inhalation	Nausea, vomiting, diarrhea
Skin adsorption	Abdominal cramps, headaches
Ingestion	Fever, enlarged liver
Skin and/or eye contact	Jaundice, decreased organ function of the liver, kidney, and lungs

Although DHS only uses ALs as advisory levels, the Regional Board, exercising its best professional judgement, in the review of the best available science, has in the past considered and used ALs when deemed appropriate to establish effluent limitations in WDR and NPDES permits adopted by this Board. The need for a revised limit for NDMA, for the protection of the GWR beneficial use, will be assessed three years after the effective date of this Order, following the conclusion of the studies mentioned in Section V.4 of this Fact Sheet, and in accordance with Section V.H - *Reopeners and Modifications* of the WDR.

Groundwater Recharge. Sections of San Jose Creek, located downstream of the Pomona WRP discharge point, are designated as GWR. Surface water from the San Jose Creek enters the San Gabriel Valley Basin and the Central Los Angeles Coastal Plain Groundwater Basin. Since ground water from these basins is used to provide drinking water to over one million people, Title 22-based limits are needed to protect that drinking water supply where there is reasonable potential for the contaminant to be present in the discharge. By limiting the contaminants in the Pomona WRP discharges, the amount of pollutants entering the surface waters and groundwater basins are correspondingly reduced. Once groundwater

basins are contaminated, it may take years to clean up, depending on the pollutant. Compared to surface water pollution, investigations and remediation of groundwater are often more difficult, costly, and extremely slow

9. ***Antidegradation Policy*** **-** On October 28, 1968, the State Board adopted Resolution No. 68-16*, Maintaining High Quality Water*, which established an antidegradation policy for State and Regional Boards. The State Board has, in State Board Order No. 86-17 and an October 7, 1987 guidance memorandum, interpreted Resolution No. 68-16 to be fully consistent with the federal antidegradation policy. Similarly, the CWA (section 304(d)(4)(B)) and USEPA regulations (40 CFR, Section 131.12) require that all permitting actions be consistent with the federal antidegradation policy. Together, the State and Federal policies are designed to ensure that a water body will not be degraded resulting from the permitted discharge. The provisions of this Order are consistent with the antidegradation policies.

10. ***Watershed Approach*** **-** This Regional Board has been implementing a Watershed Management Approach (WMA), to address water quality protection in the Los Angeles Region, as detailed in the Watershed Management Initiative (WMI). The WMI is designed to integrate various surface and ground water regulatory programs while promoting cooperative, collaborative efforts within a watershed. It is also designed to focus limited resources on key issues and use sound science. Information about the San Gabriel River Watershed and other watersheds in the region can be obtained from the Regional Board's web site at *http://www.swrcb.ca.gov/rwqcb4/* and clicking on the word "Watersheds".

Pursuant to this Regional Board's watershed initiative framework, the San Gabriel River Watershed Management Area was the targeted watershed for fiscal year 1999-2000. However, the NPDES permit renewals were originally re-scheduled so that provisions of the CTR and SIP could be incorporated into the permits.

VII. REGULATORY BASIS FOR EFFLUENT AND RECEIVING WATER LIMITS AND OTHER DISCHARGE REQUIREMENTS

1. ***Water Quality Objectives and Effluent Limits*** **-** *Water* Quality Objectives (WQOs) and effluent limitations in this permit are based on:

   A. Applicable State Regulations/Policies/Guidances

      a. The plans, policies and water quality standards (beneficial uses + objectives + antidegradation policy) contained in the 1994 *Water Quality Control Plan, Los Angeles Region: Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*, as amended, including chemical constituent limitations established by incorporating the California Code of Regulations, Title 22, Maximum Contaminant Levels designed to protect the existing drinking water use of the receiving groundwaters;

      b. California Toxics Rule (40 CFR 131.38);

c. The State Board's "Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California" (the State Implementation Plan or SIP); and,

d. Administrative Procedures Manual and Administrative Procedure Updates.

B. Applicable Federal Regulations/Policies/Guidances

a. Federal Clean Water Act;

b. 40 CFR, Parts 122, 131, among others;

c. Best Professional Judgment (pursuant to 40 CFR 122.44);

d. USEPA Regions 9 & 10 Guidance for Implementing Whole Effluent Toxicity Programs Final May 31, 1996;

e. USEPA Whole Effluent Toxicity (WET) Control Policy July 1994;

f. Inspectors Guide for Evaluation of Municipal Wastewater Treatment Plants, April 1979 (EPA/430/9-79-010);

g. Fate of Priority Pollutants in Publicly Owned Treatment Works Pilot Study October 1979 (EPA-440/1-79-300);

h. *Technical Support Document for Water Quality Based Toxics Control,* March 1991 (EPA-505/ 2-90-001);

i. *U.S. EPA NPDES Permit Writers' Manual,* December 1996 (EPA-833-B-96-003); and,

j. USEPA's *National Recommended Water Quality Criteria: 2002*, November 2002 (EPA-822-R-02-047).

Where numeric water quality objectives have not been established in the Basin Plan, 40 CFR Part 122.44(d) specifies that water quality based effluent limits may be set based on USEPA criteria and supplemented where necessary by other relevant information to attain and maintain narrative water quality criteria to fully protect designated beneficial uses.

2. ***Mass and Concentration Limits –*** 40 CFR section 122.45(f)(1) requires that, except under certain conditions, all permit limits, standards, or prohibitions be expressed in terms of mass units. 40 CFR section 122.45(f)(2) allows the permit writer, at their discretion, to express limits in additional units (e.g., concentration units). The regulations mandate that, where limits are expressed in more than one unit, the permittee must comply with both.

Generally, mass-based limits ensure that proper treatment, and not dilution, is employed to comply with the final effluent concentration limits. Concentration-

based effluent limits, on the other hand, discourage the reduction in treatment efficiency during low-flow periods and require proper operation of the treatment units at all times. In the absence of concentration-based effluent limits, a permittee would be able to increase its effluent concentration (i.e., reduce its level of treatment) during low-flow periods and still meet its mass-based limits. To account for this, this permit includes mass and concentration limits for some constituents, except during wet-weather, storm events that cause flows to the treatment plant to exceed the plant's design capacity.

3. ***Maximum Daily Effluent Limitations –*** Pursuant to 40 CFR section 122.45(d)(2), for POTWs continuous discharges, all permit effluent limitations, standards, and prohibitions, including those necessary to achieve water quality standards, shall, unless impracticable, be stated as average weekly and average monthly discharge limitations. It is impracticable to only include average weekly and average monthly effluent limitations in the permits, because a single daily discharge of certain pollutants, in excess amounts, can cause violations of water quality objectives. The effects of certain pollutants on aquatic organisms are often rapid. For many pollutants, an average weekly or average monthly effluent limitation alone is not sufficiently protective of beneficial uses. As a result, maximum daily effluent limitations, as referenced in 40 CFR section 122.45(d)(1), are included in the permit for certain constituents as discussed in the Fact Sheet accompanying this Order.

4. ***Pretreatment –*** Pursuant to 40 CFR section 403, the CSDLAC developed and has been implementing an approved industrial wastewater Pretreatment Program. This Order requires implementation of the approved Pretreatment Program.

5. ***Sludge Disposal -*** To implement CWA Section 405(d), on February 19, 1993, the USEPA promulgated 40 CFR, Part 503 to regulate the use and disposal of municipal sewage sludge. This regulation was amended on September 3, 1999. The regulation requires that producers of sewage sludge meet certain reporting, handling, and disposal requirements. It is the responsibility of the Discharger to comply with said regulations that are enforceable by USEPA, because California has not been delegated the authority to implement this program.

6. ***Storm Water Management –*** CWA section 402(p), as amended by the Water Quality Act of 1987, requires NPDES permits for storm water discharges. Pursuant to this requirement, in 1990, USEPA promulgated 40 CFR section 122.26 that established requirements for storm water discharges under an NPDES program. To facilitate compliance with federal regulations, on November 1991, the State Board issued a statewide general permit, *General NPDES Permit No. CAS000001 and Waste Discharge Requirements for Discharges of Storm Water Associated with Industrial Activities.* This permit was amended in September 1992 and reissued on April 17, 1997 in State Board Order No. 97-03-DWQ to regulate storm water discharges associated with industrial activity. The Pomona WRP is covered by general NPDES permit No. CAS000001.

7. ***Clean Water Act Effluent Limitations -*** Numeric and narrative effluent limitations are established pursuant to Section 301 (Effluent Limitations), Section 302 (Water Quality-Related Effluent Limitations), Section 303 (Water Quality Standards and

Implementation Plans), Section 304 (Information and Guidelines [Effluent]), Section 305 (Water Quality Inventory), Section 307 (Toxic and Pretreatment Effluent Standards), and Section 402 (NPDES) of the CWA. The CWA and amendments thereto are applicable to the discharges herein.

8. ***Antibacksliding Policies*** **-** Antibacksliding provisions are contained in Sections 303(d)(4) and 402(o) of the CWA, and in 40 CFR section 122.44(l). Those provisions require a reissued permit to be as stringent as the previous permit with some exceptions. Section 402(o) of the CWA establishes express statutory language prohibiting the backsliding of effluent limitations. It consists of the following three parts:

   A. Section 402(o)(1) prohibits (subject to exceptions in section 303(d)(4) and/or 402(o)(2)) the relaxation of effluent limitations for two situations:

      a. When a permittee seeks to revise a technology-based effluent limitation based on BPJ to reflect a subsequently promulgated effluent guideline which is less stringent, and

      b. When a permittee seeks relaxation of an effluent limitation which is based upon a changed State treatment standard or water quality standard.

   B. Section 402(o)(2) outlines specific exceptions to the general prohibition against establishment of less stringent effluent limitations. Codified in the NPDES regulations at 40 CFR 122.44(l), Section 402(o)(2) provided that the establishment of less stringent limits may be allowed where:

      a. There have been material and substantial alterations or additions to the permitted facility which justify this relaxation;

      b. New information (other than revised regulations, guidance, or test methods) is available that was not available at the time of permit issuance which would have justified a less stringent effluent limitation;

      c. Technical mistakes or mistaken interpretations of the law were made in issuing the permit under Section 402(a)(1)(b);

      d. Good cause exists due to events beyond the permittee's control (e.g., acts of God) and for which there is no reasonably available remedy;

      e. The permit has been modified under certain specified sections of the CWA; or,

      f. The permittee has installed and properly operated and maintained required treatment facilities, but still has been unable to meet the permit limitations (relaxation may only be allowed to the treatment levels actually achieved).

Although the statute identified six exceptions where effluent limitations may be relaxed, the language specifically stated that exception "c" (as listed above) does not apply to water quality-based effluent limitations. Further, exception "e" as listed above only concerns sections of the CWA governing technology-based limits. Thus, exceptions c & e would only apply to technology-based effluent limitations.

C. Section 402(o)(3) prohibits the relaxation of effluent limitations in all cases if a revised effluent limitation would result in a violation of applicable effluent limitation guidelines or water quality standards, including antidegradation requirements. Thus, even if any of the antibacksliding exceptions outlined in either the statute or regulations are applicable, Section 402(o)(3) acts as a floor and restricts the extent to which effluent limitations may be relaxed. This requirement affirms existing provisions of the CWA that require limits, standards, and conditions to ensure compliance with applicable technology-based limits and water quality standards.

9. ***Applicable Water Quality Objectives -*** 40 CFR, Section 122.44(d)(vi)(A) requires the establishment of numeric effluent limitations to attain and maintain applicable narrative water quality criteria to protect the designated beneficial use.

The Basin Plan includes narrative and numeric WQOs. The CTR promulgates numeric aquatic life criteria for 23 toxic pollutants and numeric human health criteria for 57 toxic pollutants. A compliance schedule provision in the CTR and the SIP authorizes the State to issue schedules of compliance for new or revised NPDES permit limits based on the federal CTR criteria when certain conditions are met. Where numeric water quality objectives have not been established in the Basin Plan, 40 CFR, Section 122.44(d) specifies that WQBELs may be set based on USEPA criteria and supplemented, where necessary, by other relevant information to attain and maintain narrative water quality criteria to fully protect designated beneficial uses.

10. ***Types of Pollutants –*** For CWA regulatory purposes, pollutants are grouped into three general categories under the NPDES program: conventional, toxic, and non-conventional. By definition, there are five conventional pollutants (listed in 40 CFR 401.16) – 5-day biochemical oxygen demand, total suspended solids, fecal coliform, pH, and oil and grease. Toxic or "priority" pollutants are those defined in Section 307(a)(1) of the CWA (and listed in 40 CFR 401.15 and 40 CFR 423, Appendix A) and include heavy metals and organic compounds. Non-conventional pollutants are those which do not fall under either of the two previously described categories and include such parameters as ammonia, phosphorous, chemical oxygen demand, whole effluent toxicity, etc.

11. ***Technology-Based Limits for Municipal Facilities (POTWs) –*** Technology-based effluent limits require a minimum level of treatment for industrial/municipal point sources based on currently available treatment technologies while allowing the Discharger to use any available control techniques to meet the effluent limits.

The 1972 CWA required POTWs to meet performance requirements based on available wastewater treatment technology. Section 301 of the CWA established a required performance level—referred to as "secondary treatment"—that all POTWs were required to meet by July 1, 1977. More specifically, Section 301(b)(1)(B) of the CWA required that USEPA develop secondary treatment standards for POTWs as defined in Section 304(d)(1). Based on this statutory requirement, USEPA developed national secondary treatment regulations, which are specified in 40 CFR 133. These technology-based regulations apply to all POTWs and identify the minimum level of effluent quality to be attained by secondary treatment in terms of five-day biochemical oxygen demand, total suspended solids, and pH.

12. ***Water Quality Based Effluent Limits (WQBELs) -*** Water quality-based effluent limits are designed to protect the quality of the receiving water by ensuring that State water quality standards are met by discharges from an industrial/municipal point source. If, after technology-based effluent limits are applied, a point source discharge will cause, have the reasonable potential to cause, or contribute to an exceedance of an applicable water quality criterion, then 40 CFR 122.44(d)(1) requires that the permit contain a WQBEL. Although the CWA establishes explicit technology-based requirements for POTWs, Congress did not exempt POTWs from additional regulation to protect water quality standards. As a result, POTWs are also subject to WQBELs. This was upheld by the Appellate Court in *the City of Burbank, City of Los Angeles v. State Water Resources Control Board* case. Applicable water quality standards for the San Gabriel River are contained in the Basin Plan and CTR, as described in previous findings.

13. ***Water Quality Based Effluent Limitations for Toxic Pollutants.*** Toxic substances are regulated in this permit by water quality based effluent limitations derived from the 1994 Basin Plan, the CTR, and/or best professional judgment (BPJ) pursuant to Part 122.44. If a discharge causes, has a reasonable potential to cause, or contribute to a receiving water excursion above a narrative or numeric objective within a State water quality standard, federal law and regulations, as specified in 40 CFR 122.44(d)(1)(i), and in part, the SIP, require the establishment of WQBELs that will protect water quality. As documented in the fact sheet, pollutants exhibiting reasonable potential in the discharge, authorized in this Order, are identified in the Reasonable Potential Analysis (RPA) section and have final effluent limits. Reasonable potential was not triggered for some of the 126 priority pollutants and final limits cannot be determined at this time. The Discharger is required to gather the appropriate data and the Regional Board will determine if final effluent limits are needed. If final limits are needed, the permit will be reopened and limits will be included in the permit.

14. ***Basis for Effluent Limits for 303(d) Listed Pollutants -*** For 303(d) listed pollutants, the Regional Board plans to develop and adopt Total Maximum Daily Loads (TMDLs) which will specify wasteload allocations (WLAs) for point sources and load allocations (LA) for non-point sources, as appropriate. Following the adoption of TMDLs by the Regional Board, NPDES permits will be issued, and where appropriate, reopened to include effluent limits consistent with the assumptions of the TMDL, based on applicable WLAs. In the absence of a TMDL, the permits will include water quality-based effluent limitations derived as provided

in the Basin Plan, CTR, and SIP (if applicable). These effluent limits are based on criteria applied end-of-pipe due to no mixing zone or dilution credits allowed.

15. ***303(d) Listed Pollutants -*** On July 25, 2003, USEPA approved the State's most recent list of impaired waterbodies. The list (hereinafter referred to as the 303(d) list) was prepared in accordance with Section 303(d) of the Federal Clean Water Act to identify specific impaired waterbodies where water quality standards are not expected to be met after implementation of technology-based effluent limitations on point sources.

The San Gabriel River (SGR) and its tributaries are on the 303(d) List for the following pollutants/stressors, from point and non-point sources:

San Jose Creek Reach 2 (Temple to I-10 at White Ave.) -- Hydrologic Unit 405.51:
- algae, and high coliform count;

San Jose Creek Reach 1 (SGR confluence to Temple St.)—Hydro. Unit 405.41:
- algae, and high coliform count;

San Gabriel River Reach 3 (Whittier Narrows to Ramona) – Hydro. Unit 405.41
- toxicity

San Gabriel River Reach 2 (Firestone to Whittier N. Dam) – Hydro. Unit 405.15:
- copper (dissolved), high coliform count, lead, and zinc (dissolved);

San Gabriel River Reach 1 (Estuary to Firestone) -- Hydrologic Unit 405.15
- abnormal fish histology, algae, high coliform count, and toxicity; and,

San Gabriel River Estuary -- Hydrologic unit 405.15
- abnormal fish histology.

The Regional Board revised the 303(d) list in 2002 and submitted the draft to the State Board for approval. The State Board had scheduled the draft 303(d) list, dated October 15, 2002, for approval at two of its meetings, however the item was postponed to hold additional workshops and to allow more time for the public to submit comments. The draft 303(d) list dated October 15, 2002, was revised on January 13, 2003, based on comments received. The draft 303(d) list, dated January 13, 2003, was adopted by the State Board at its February 4, 2003 meeting. The adopted 303(d) list was approved by USEPA on July 25, 2003.

16. ***Relevant Total Maximum Daily Loads (TMDLs).*** A TMDL is a determination of the amount of a pollutant, from point, nonpoint, and natural background sources, including a margin of safety, which may be discharged to a water quality-limited water body. Section 303(d) of the CWA established the TMDL process. The statutory requirements are codified at 40 CFR, Part 130.7. TMDLs must be developed for the pollutants of concern, which impact the water quality of water bodies on the 303(d) list. Under the federal consent decree, the San Gabriel River was listed for toxicity, algae, coliform, and metals. The ammonia listing was removed on the 2002 303(d) list because the POTWs were scheduled to implement nitrification/denitrification. Under the federal consent decree, USEPA

was to establish TMDLs for algae and pollutants causing toxicity by March 22, 2004. USEPA has requested a multi-year extension of the consent decree deadline for the nutrient TMDL from the litigants. The approval of the extension is currently under review, and USEPA has been given a temporary 60-day extension (until May 21, 2004) while the litigants review the request for more time. Under the federal consent decree the, the San Gabriel River metals TMDL is scheduled to be adopted by the Regional Board by March 22, 2006.

17. ***Mixing Zones and Dilution Credits -*** Mixing zones, dilution credits, and attenuation factors are not allowed in this Order. Allowance of a mixing zone is in the Regional Board's discretion under Section 1.4.2 of the SIP and under the Basin Plan (Basin Plan Chapter 4, page 30). If the Discharger subsequently conducts appropriate mixing zone and dilution credit studies, the Regional Board can evaluate the propriety of granting a mixing zone or establishing dilution credits. The Regional Board has concluded mixing zones and dilution credits would be inappropriate to grant, at this time, in light of the following factors:

    A. The Pomona WRP discharge contributes the largest flow (effluent dominated) into the South Fork San Jose Creek, within the San Gabriel River watershed, in the vicinity of the discharge point where it overwhelms the receiving water providing very limited mixing and dilution;

    B. Even in the absence of the Pomona WRP discharge, the receiving water primarily consists of nuisance flows and other effluents, limiting its assimilative capacity;

    C. Several reaches of the San Gabriel River [including those subject to this Order] are 303(d) listed (i.e., impaired) for certain constituents;

    D. Impaired waters do not have the capacity to assimilate pollutants of concern at concentrations greater than the applicable objective;

    E. For the protection of the beneficial uses listed in Section VI.7 of this Fact Sheet;

    F. Consistent with Antidegradation Policies;

    G. Because a mixing zone study has not been conducted;

    H. Because hydrologic models of the discharge and the receiving waters have not been conducted;

    I. Because there has been no Site-specific Soil Attenuation Study nor Fate and Transportation Modeling performed.

18. Specific effluent limitations for each constituent contained in this order were developed in accordance with the foregoing laws, regulations, plans, policies, and guidance. The specific methodology and example calculations are documented in the fact sheet prepared by Regional Board staff that accompanies this Order.

VIII. REASONABLE POTENTIAL ANALYSIS

1. As specified in 40 CFR, Part 122.44(d)(1)(i), permits are required to include limits for all pollutants "which the Director (defined as the Regional Administrator, State Director, or authorized representative in 40 CFR, Part 122.2) determines are or may be discharged at a level which will cause, have the reasonable potential to cause, or contribute to an excursion above any State water quality standard."

   A. Using the method described in the TSD, the Regional Board has conducted Reasonable Potential Analysis (RPA) for:

      1. Chronic Toxicity - RPA was conducted for Chronic Toxicity (Table R2 of the accompanying Fact Sheet) using the discharger's effluent data from their ROWD and annual self monitoring reports. Chronic Toxicity effluent data is summarized in Table D1 of the accompanying Fact Sheet. The RPA compares the effluent data with USEPA's 1 TUc water quality criteria. The Discharger's effluent demonstrated Chronic Toxicity during the last permit cycle. Based on this information, the Regional Board has determined that there is a reasonable potential that the discharge will cause toxicity in the receiving water and, consistent with SIP section 4, the Order contains a narrative effluent limitation for Chronic Toxicity. The circumstances warranting a numeric Chronic Toxicity effluent limitation were reviewed by the State Board in SWRCB/OCC Files A-1496 & A-1496(a) [Los Coyotes/Long Beach Petitions]. On September 16, 2003, the State Board adopted Order No. WQO 2003-0012, deferring the numeric chronic toxicity effluent limitation issue until the adoption of Phase II of the SIP, and replaced the numeric chronic toxicity effluent limitation with a narrative effluent limitation for the time being.

      2. Ammonia-N, other Nitrogen Species, and MBAS – RPA was conducted for Ammonia, Nitrate plus Nitrite as Nitrogen, Nitrite Nitrogen, and MBAS (Table **R2** of the accompanying Fact Sheet) using the Discharger's effluent data from their self monitoring reports. Ammonia, Nitrate plus Nitrite as Nitrogen, and Nitrite Nitrogen effluent data is summarized in Table A1 of the accompanying Fact Sheet. Temperature and pH effluent data is summarized in Table A1 of the accompanying Fact Sheet. The RPA compares the effluent data with the Basin Plan WQOs. The Discharger's effluent exceeded the Basin Plan WQOs for Ammonia, Nitrate plus Nitrite as Nitrogen, and Nitrite Nitrogen, during the last permit cycle. Based on this information, the Regional Board has determined that there is a reasonable potential that the discharge will cause or contribute to an exceedance of the Basin Plan WQOs and, consistent with 40 CFR 122.44(d), the Order contains numeric effluent limitations for Ammonia, Nitrate plus Nitrite as Nitrogen, and Nitrite Nitrogen.

B. Using the method described in the SIP, the Regional Board has conducted RPA for priority pollutants using the discharger's effluent data contained in Table D1. The RPA compares the effluent data with water quality objectives in the Basin Plan and CTR.

1. ***Reasonable Potential Determination -*** The RPA (per the SIP) involves identifying the observed maximum pollutant concentration in the effluent (MEC) for each constituent based on the effluent concentration data. There are three tiers to determining reasonable potential. If any of the following three tiers is triggered, then reasonable potential exists:

   a. For the first tier, the MEC is compared with the lowest applicable Water Quality Objective (WQO), which has been adjusted for pH, hardness and translator data, if appropriate. If the MEC is greater than the (adjusted) WQO, then there is reasonable potential for the constituent to cause or contribute to an excursion above the WQO and a WQBEL is required. However, if the pollutant was not detected in any of the effluent samples and all of the reported detection limits are greater than or equal to the WQO, proceed with Tier 2. The Regional Board exercised its discretion in identifying all available, valid, relevant, representative data and information in accordance with SIP Section 1.2 (page 8).

   b. For the second tier, if the MEC is less than the adjusted WQO, then the observed maximum ambient background concentration (B) for the pollutant is compared with the adjusted WQO. If B is greater than the adjusted WQO, then a WQBEL is required. If B is less than the WQO, then a limit is only required under certain circumstances to protect beneficial uses. If a constituent was not detected in any of the effluent samples and all of the detection limits are greater than or equal to the adjusted WQO, then the ambient background water quality concentration is compared with the adjusted WQO. The Regional Board exercised its discretion in identifying all available, applicable ambient background data in accordance with SIP Section 1.4.3 (page 16).

   c. For the third tier, other information is used to determine RPA, such as the current CWA 303(d) List. Section 1.3 of the SIP describes the type of information that can be considered in Tier 3.

   For all parameters that have reasonable potential to cause or contribute to an exceedance of a WQO/criteria, numeric WQBELs are required. Section 1.4, Step 5 of the SIP (Page 8) states that MDELs shall be used for POTWs in place of average weekly

limitations. WQBELs are based on CTR, USEPA water quality criteria, and Basin Plan objectives.

If the data are unavailable or insufficient to conduct the RPA for the pollutant, or if all reported detection limits of the pollutant in the effluent are greater than or equal to the WQO, the Regional Board shall establish interim requirements, in accordance with Section 2.2.2. of the SIP, that require additional monitoring for the pollutant in place of a WQBEL. The effluent monitoring data from July 1995 to December 2003 indicate that the following constituents were not detected and their lowest detection limits were greater than their corresponding CTR WQO: 2,3,7,8-TCDD, benzidine, benzo(a)anthracene, 3,3'-dichlorobenzene, 1,2-diphenylhydrazine, hexachlorobenzene, aldrin, chlordane, 44'-DDD, dieldrin, heptachlor, heptachlor epoxide, PCBs, and toxaphene.

Therefore these constituents require interim requirements. Section 2.4.5 of the SIP discusses how compliance will be determined in those cases. The Discharger should work with the laboratory to lower detection levels to meet applicable and reliable detection limits; follow procedures set forth in 40 CFR Part 136; and, report the status of their findings in the annual report. During the term of the permit, if and when monitoring with lowered detection limits shows any of the priority pollutants at levels exceeding the applicable WQOs, the Discharger will be required to initiate source identification and control for the particular pollutant. Appendix 4 of the SIP lists the minimum levels and laboratory techniques for each constituent.

Upon completion of the required monitoring, the Regional Board shall use the gathered data to conduct RPA and determine if a WQBEL is required. However, if Tier 1 or Tier 3 triggered reasonable potential for a pollutant, then the lack of receiving water data for Tier 2 evaluation would not prohibit the establishing of WQBELs in the permit.

A numerical limit has not been prescribed for a toxic constituent if it has been determined that it has no reasonable potential to cause or contribute to excursions of water quality standards. However, if the constituent had a limit in the previous permit, and if none of the Antibacksliding exceptions apply, then the limit will be retained. A narrative limit to comply with all water quality objectives is provided in *Standard Provisions* for the priority pollutants, which have no available numeric criteria.

2. ***RPA Data -*** The RPA was based on effluent monitoring data for July 1995 through November 2003, including interim monitoring results from July 2001 to December 2002. Table R1 of the fact sheet summarizes the RPA, lists the constituents, and where available, the lowest, adjusted WQO, the MEC, the "Reasonable Potential" result, and the limits from the previous permit.

a. **Metals Water Quality Objective -** For metals, the lowest applicable WQO was expressed as total recoverable, and where applicable, adjusted for hardness. A spreadsheet (Table R3) was used to calculate the total recoverable CTR criteria. Hardness values from samples collected in the receiving water upstream of the discharge point are typically averaged and used to determine the appropriate CTR WQO for those hardness-dependent metals. However, there was no receiving water data upstream of the discharge point. Therefore, the average effluent hardness values were used to determine the appropriate CTR WQO for hardness-dependent metals. Individual harness values greater than 400 mg/L were capped at 400 prior to calculating the average hardness. This is consistent with the preamble to the CTR, contained in Federal Register Section E.f. *Hardness* (p.31692), 40 CFR Part 131.

b. **Interim Monitoring Requirements -** In accordance with the SIP, the Regional Board may impose interim monitoring requirements upon the Discharger, so that the Discharger obtains adequate ambient, background water data for priority pollutants upstream of the discharge point as well as suitable effluent data. The Executive Officer directed the Discharger to begin an interim monitoring program for the duration of 18 months, beginning July 2001. The Discharger collected the eighteen required samples and reported the results quarterly to the Regional Board. After additional information is gathered, Regional Board staff will conduct RPA once again, to determine if additional numeric limitations are necessary. Section 1.3, Step 8, of the SIP authorizes the Regional Board to use the gathered data to conduct RPA, as outlined in Steps 1 through 7, and determine if a water quality-based effluent limitation is required.

A reopener provision is included in this Order that allows the permit to be reopened to allow the inclusion of new numeric limitations for any constituent that exhibits reasonable potential to cause or contribute to exceedance of applicable water quality objectives.

C. The numeric limitations contained in this Order are intended to protect and maintain existing and potential beneficial uses of the receiving waters. Environmental benefits provided by these limitations are reasonable and necessary.

D. Regional Board staff have determined that lead, mercury, cyanide, and acrylonitrile showed the potential to exceed respective CTR objectives, and, therefore, require CTR-based effluent limitations.

2. This Order is consistent with State and Federal antidegradation policies in that it does not authorize a change in the quantity of wastewater discharged by the facility, nor does it authorize a change or relaxation in the manner or level of treatment. As a result, both the quantity and quality of the discharge are expected to remain the same consistent with antidegradation policies. The accompanying monitoring and reporting program requires continued data collection and if monitoring data show a reasonable potential for a constituent to cause or contribute to an exceedance of water quality standards, the permit will be reopened to incorporate appropriate WQBELs. Such an approach ensures that the discharge will adequately protect water quality standards for potential and existing uses and conforms with antidegradation policies and antibacksliding provisions.

IX. PROPOSED EFFLUENT LIMITATIONS

1. Numeric toxic constituent limitations are based on the Basin Plan the narrative water quality objective for toxic constituents, "All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in, human, plant, animal, or aquatic life"; on the CTR; and, the interpretation of the Basin Plan narrative criteria using USEPA's 304(a) nationally recommended water quality criteria. For toxic constituents that have no reasonable potential to cause or contribute to excursions of water quality objectives, no numerical limitations are prescribed.

2. Pursuant to 40 CFR 122.45(d)(2), for a POTWs continuous discharges, all permit effluent limitations, standards, and prohibitions, including those necessary to achieve water quality standards, shall, unless impracticable, be stated as average weekly and average monthly discharge limitations for POTWs. It is impracticable to only include average weekly and average monthly effluent limitations in the permit, because a single daily discharge of a pollutant, in excess amounts, can cause violations of water quality objectives. The effects of pollutants on aquatic organisms are often rapid. For many pollutants, an average weekly or average monthly effluent limitation alone is not sufficiently protective of beneficial uses. As a result, maximum daily effluent limitations, as referenced in 40 CFR 122.45(d)(1), are included in the permit.

3. Furthermore, Section 1.4 of the SIP requires the step-by-step procedure to "adjust" or convert CTR numeric criteria into Average Monthly Effluent Limitations (AMELs) and Maximum Daily Effluent Limitations (MDELs), for toxics.

   A. Step 3 of Section 1.4 of the SIP (page 6) lists the statistical equations that adjust CTR criteria for effluent variability.

   B. Step 5 of Section 1.4 of the SIP (page 8) lists the statistical equations that adjust CTR criteria for averaging periods and exceedance frequencies of the criteria/ objectives. This section also reads, "For this method only, maximum daily effluent limitations shall be used for publicly-owned treatment works (POTWs) in place of average weekly limitations.

4. Table R is the spreadsheet that staff used to calculate the AMELs and MDELs for priority pollutants.

5. 40 CFR section 122.45(f)(1) requires that except under certain conditions, all permit limits, standards, or prohibitions be expressed in terms of mass units. 40 CFR section 122.45(f)(2) allows the permit writer, at its discretion, to express limits in additional units (e.g., concentration units). The regulations mandate that, where limits are expressed in more than one unit, the permittee must comply with both.

6. Generally, mass-based limits ensure that proper treatment, and not dilution, is employed to comply with the final effluent concentration limits. Concentration-based effluent limits, on the other hand, discourage the reduction in treatment efficiency during low-flow periods and require proper operation of the treatment units at all times. In the absence of concentration-based effluent limits, a permittee would be able to increase its effluent concentration (i.e., reduce its level of treatment) during low-flow periods and still meet its mass-based limits. To account for this, this permit includes mass and concentration limits for some constituents.

A. Effluent Limitations:

1. Limits for Conventional and non-conventional pollutants:

Constituent	Units	Discharge Limitations		
		Daily Maximum [1]	Weekly Average[2]	Monthly Average[2]
BOD_5 20°C [4]	mg/L	45	30	20
	lbs/day[3]	5,600	3,800	2,500
Suspended solids[4]	mg/L	45	40	15
	lbs/day[3]	5,600	5,000	1,900
Settleable solids [5]	ml/L	0.3	--	0.1
Oil and grease [6]	mg/L	15	--	10
	lbs/day[3]	1,900	--	1,200
Total residual chlorine [7]	mg/L	0.1[8]	--	--
Fluoride [9]	mg/L	--	--	1.6
	lbs/day[3]	--	--	200
Total dissolved solids [10]	mg/L	--	--	750
	lbs/day[3]	--	--	94,000
Chloride [10]	mg/L	--	--	180
	lbs/day[3]	--	--	23,000
Sulfate [10]	mg/L	--	--	300
	lbs/day[3]	--	--	38,000
Boron [10]	mg/L	--	--	1.0
	lbs/day[3]	--	--	130
MBAS [11]	mg/L	--	--	0.5
	lbs/day[3]	--	--	63
Total inorganic nitrogen [12]	mg/L	---	--	8
(nitrate + nitrite as nitrogen)	lbs/day[3]	---	--	1000
Nitrite-N (as N)	mg/L	--	--	1.0
	lbs/day[3]	--	--	130
Total Ammonia [13]	mg/L	[14]	--	[15]

Constituent	Units	Discharge Limitations		
		Daily Maximum [1]	Weekly Average[2]	Monthly Average[2]
	lbs/day	[3]	--	[3]

[1] The daily maximum effluent concentration limit shall apply to both flow weighted 24-hour composite samples and grab samples, as specified in the Monitoring and Reporting Program (Attachment T).

[2] Average Monthly Discharge Limitation means the highest allowable average of daily discharge over a calendar month, calculated as the sum of all daily discharges measures during that month divided by the number of days on which monitoring was performed.

Average Weekly Discharge Limitation means the highest allowable average of daily discharge over a calendar week, calculated as the sum of all daily discharges measures during that week divided by the number of days on which monitoring was performed.

[3] The mass emission rates are based on the plant design flow rate of 15.0 mgd, and are calculated as follows: Flow (MDG) x Concentration (mg/L) x 8.34 (conversion factor) = lbs/day. During wet-weather storm events in which the flow exceeds the design capacity, the mass discharge rate limitations shall not apply, and concentration limitations will provide the only applicable effluent limitations.

[4] See detailed information on the following Section IX.6.B.a.

[5] See detailed information on the following Section IX.6.B.b.

[6] See detailed information on the following Section IX.6.B.c.

[7] See detailed information on the following Section IX.6.B.d.

[8] For the determination of compliance with total residual chlorine limit, one of the following applies:

a. Total residual chlorine concentration excursions of up to 0.3 mg/L, at the point in treatment train immediately following dechlorination, shall not be considered violations of this requirement provided the total duration of such excursions do not exceed 15 minutes during any calendar day. Peaks in excess of 0.3 mg/L lasting less than one minute shall not be considered a violation of this requirement; or

b. For continuous total residual chlorine recording devices that require greater than one minute to level off after the detection of a spike: if it can be demonstrated that a stoichiometrically appropriate amount of dechlorination chemical has been added to effectively dechlorinate the effluent to 0.1 mg/L or less, then the exceedance over one minute, but not for more than five minutes, will not be considered to be a violation.

[9] See detailed information on the following Section IX.6.B.e.

[10] See detailed information on the following Section IX.6.B.f.

[11] See detailed information on the following Section IX.6.B.h.

[12] See detailed information on the following Section IX.6.B.i.

[13] See detailed information on the following Section IX.6.B.j.

[14] The Discharger must comply with the updated ammonia water quality objectives in the Basin Plan, Table 3-1 (Attachment H) which resulted from Resolution No. 2002-011 adopted by the Regional Board on April 25, 2002.

For compliance with Criteria Maximum Concentration (CMC) in the Attachment H, the pH sample collected in the receiving water downstream of the discharge and the ammonia nitrogen sample collected in the effluent, shall be taken and reported at the same time. Should there be no receiving water present, the pH of the

effluent at the end of pipe shall be determined and reported. However, the Discharger has the option of using average effluent pH and temperature, as approved by the Executive Officer.

[15] The Discharger must comply with the updated ammonia water quality objectives in the Basin Plan, Table 3-3 (Attachment H) which resulted from Resolution No. 2002-011 adopted by the Regional Board on April 25, 2002.

For compliance with Criteria Continuous Concentration (CCC) in the Attachment H, the pH and temperature samples collected in the receiving water downstream of the discharge and the ammonia nitrogen sample collected in the effluent, shall be taken and reported at the same time. Shall there be no receiving water present, the pH and temperature of the effluent at the end of pipe shall be determined and reported. However, the Discharger has the option of using average effluent pH and temperature, as approved by the Executive Officer.

B. Basis for Conventional and nonconventional pollutants:

a. *Biochemical Oxygen Demand (BOD) and Suspended solids*

Biochemical oxygen demand (BOD) is a measure of the quality of the organic matter in the water and, therefore, the water's potential for becoming depleted in dissolved oxygen. As organic degradation takes place, bacteria and other decomposers use the oxygen in the water for respiration. Unless there is a steady re-supply of oxygen to the system, the water will quickly become depleted of oxygen. Adequate dissolved oxygen levels are required to support aquatic life. Depressions of dissolved oxygen can lead to anaerobic conditions resulting in odors, or, in extreme cases, in fish kills.

40 CFR Part 133 describes the minimum level of effluent quality attainable by secondary treatment, for BOD and suspended solids, as:
- the monthly average shall not exceed 30 mg/L and
- the 7-day average shall not exceed 45 mg/L.

Pomona WRP provides tertiary treatment, as such, the limits in the permit are more stringent than secondary treatment requirements. The Plant achieves solids removal that are better than secondary-treated wastewater by adding a polymer (Alum) to enhance the precipitation of solids, and by filtering the effluent.

The monthly average, the 7-day average, and the daily maximum limits cannot be removed because none of the antibacksliding exceptions under apply. Those limits were all included in the previous permit (Order 95-078) and the Pomona WRP has been able to meet all three limits (monthly average, the 7-day average, and the daily maximum), for both BOD and suspended solids.

In addition to having mass-based and concentration-based effluent limitations for BOD and suspended solids, the Pomona WRP also has a percent removal requirement for these two constituents. In accordance with 40 CFR section 133.102(a)(3) and 133.102(b)(3), the 30-day average percent removal shall not be less than 85 percent. Percent removal is defined as a percentage expression of the removal efficiency across a treatment plant for a given pollutant parameter, as

determined from the 30-day average values of the raw wastewater influent pollutant concentrations to the facility and the 30-day average values of the effluent pollutant concentrations for a given time period.

b. *Settleable solids*

Excessive deposition of sediments can destroy spawning habitat, blanket benthic (bottom dwelling) organisms, and abrade the gills of larval fish. The limits for settleable solids are based on the Basin Plan (page 3-16) narrative, "Waters shall not contain suspended or settleable material in concentrations that cause nuisance or adversely affect beneficial uses." The numeric limits are empirically based on results obtained from the settleable solids 1-hour test, using an Imhoff cone.

It is impracticable to use a 7-day average limitation, because short-term spikes of settleable solid levels that would be permissible under a 7-day average scheme would not be adequately protective of all beneficial uses. The monthly average and the daily maximum limits cannot be removed because none of the antibacksliding exceptions apply. The monthly average and daily maximum limits were both included in the previous permit (Order 95-078) and the Pomona WRP has been able to meet both limits.

c. *Oil and grease*

Oil and grease are not readily soluble in water and form a film on the water surface. Oily films can coat birds and aquatic organisms, impacting respiration and thermal regulation, and causing death. Oil and grease can also cause nuissance conditions (odors and taste), are aesthetically unpleasant, and can restrict a wide variety of beneficial uses. The limits for oil and grease are based on the Basin Plan (page 3-11) narrative, "Waters shall not contain oils, greases, waxes, or other materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, that cause nuisance, or that otherwise adversely affect beneficial uses."

The numeric limits are empirically based on concentrations at which an oily sheen becomes visible in water. It is impracticable to use a 7-day average limitation, because spikes that occur under a 7-day average scheme could cause a visible oil sheen. A 7-day average scheme would not be sufficiently protective of beneficial uses. The monthly average and the daily maximum limits cannot be removed because none of the antibacksliding exceptions apply. Both limits were included in the previous permit (Order 95-078) and the Pomona WRP has been able to meet both limits.

d. *Residual chlorine*

Disinfection of wastewaters with chlorine produces a chlorine residual. Chlorine and its reaction products are toxic to aquatic life. The limit for residual chlorine is based on the Basin Plan (page 3-9) narrative, "Chlorine residual shall not be present in surface water discharges at

concentrations that exceed 0.1 mg/L and shall not persist in receiving waters at any concentration that causes impairment of beneficial uses."

It is impracticable to use a 7-day average or a 30-day average limitation, because it is not as protective as of beneficial uses as a daily maximum limitation is. Chlorine is very toxic to aquatic life and short term exposures of chlorine may cause fish kills.

e. *Fluoride*

The existing permit effluent limitation of 1.6 mg/l for fluoride was developed based on the Basin Plan incorporation of Title 22, *Drinking Water Standards,* by reference, for the protection of GWR. It is practicable to express the limit as a monthly average, since fluoride is not expected to cause acute effects on beneficial uses.

f. *Total Dissolved Solids, Sulfate, Chloride, and Boron*

The limits for total dissolved solids, sulfate, and boron are based on Basin Plan Table 3-8 (page 3-13), for the San Gabriel River watershed between Ramona Boulevard and Firestone Boulevard. TDS = 750 mg/L; Sulfate = 300 mg/L; and Boron = 1.0. The Chloride limit is no longer 150 mg/L, but 180 mg/L, which resulted from Regional Board Resolution No. 97-02*, Amendment to the Water Quality Control Plan to incorporate a Policy for Addressing Levels of Chloride in Discharges of Wastewaters*. Resolution 97-02 was adopted by Regional Board on January 27, 1997; approved by SWRCB (Resolution 97-94); and, approved by OAL on January 8, 1998; and served to revise the chloride water quality objective in the San Gabriel River and other surface waters. It is practicable to express these limits as monthly averages, since they are not expected to cause acute effects on beneficial uses.

g. *Iron*

The existing permit effluent limitation of 300 mg/l for iron was developed based on the USEPA document, *Quality Criteria for Water 1986* [EPA 440/5-86-001, May 1, 1986], also referred to as the *Gold Book*, for the protection of GWR beneficial use. 300 µg/L is the secondary MCL for iron, however iron is not a priority pollutant. The monthly average limit included in the previous permit (Order 95-078) was removed because one of the antibacksliding exceptions apply. New monitoring information and the TSD methodology was used to determine that there was no reasonable potential for the treated effluent to exceed the Gold Book criteria for iron.

h. *Methylene Blue Activated Substances (MBAS)*

The MBAS procedure tests for the presence of anionic surfactants (detergents) in surface and ground waters. Surfactants disturb the water surface tension, which affects insects and can affect gills in aquatic life. The MBAS can also impart an unpleasant soapy taste to water, as well

as cause scum and foaming in waters, which impact the aesthetic quality of both surface and ground waters.

Given the nature of the facility (a POTW) which accepts domestic wastewater into the sewer system and treatment plant, and the characteristics of the wastes discharged, the discharge has reasonable potential to exceed both the numeric MBAS water quality objective (WQO) and the narrative WQO for prohibition of floating material such as foams and scums. Therefore an effluent limitation is required.

In self-monitoring reports submitted to the Regional Board under MRP requirements, the Discharger has reported MBAS concentrations in the effluent in excess of 0.5 mg/L. The 0.5 mg/L concentration (which has been determined to be protective of beneficial uses and the aesthetic quality of waters), is based on the Department of Health Services' secondary drinking water standard, and on the Basin Plan WQO (p.3-11) which reads, "Waters shall not have MBAS concentrations greater than 0.5 mg/L in waters designated MUN." While the wastewater from this POTW is not directly discharged into a MUN designated surface water body, it will percolate into unlined reaches of the Santa Clara River [via ground water recharge designated beneficial use (GWR)] to ground water designated for MUN beneficial use. In addition, the Basin Plan states that "Ground water shall not contain taste or odor-producing substances in concentrations that cause nuisance or adversely affect beneficial uses." Therefore, the secondary MCL should be the MBAS limit for this discharge to protect ground water recharge and the MUN use of the underlying ground water, while also protecting surface waters from exhibiting scum or foaming.

Since the Basin Plan objective is based on a secondary drinking water standard, it is practicable to have a monthly average limitation in the permit.

i. *Total inorganic nitrogen*

Total inorganic nitrogen is the sum of Nitrate-nitrogen and Nitrite-nitrogen. Nitrogen is considered a nutrient. High nitrate levels in drinking water can cause health problems in humans. Infants are particularly sensitive and can develop methemoglobinemia (blue-baby syndrome). The nitrite-N limit of 1 mg/L is based on the Basin Plan WQO located on page 3-11.

1. **Algae**. Several reaches of the San Gabriel River are 303(d) listed for algae. Excessive growth of algae and/or other aquatic plants can degrade water quality. Algal blooms sometimes occur naturally, but they are often the result of excess nutrients (i.e., nitrogen, phosphorus) from waste discharges or nonpoint sources. These algal blooms can lead to problems with tastes, odors, color, and increased turbidity and can depress the dissolved oxygen content of the water, leading to fish kills. Floating algal scum and algal mats are also an aesthetically unpleasant nuisance.

The 303(d) listing for algae is being addressed by applying the narrative WQO for biostimulatory substances, "Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance or adversely affects beneficial uses," and other relevant information to arrive at a mass based-limit intended to be protective of the beneficial uses, pursuant to 40 CFR 122.44(d). Total nitrogen will be the indicator parameter intended to control algae, pursuant to 40 CFR 122.44(d)(1)(vi)(C).

2. **Concentration-based limit**. The effluent limit for total inorganic nitrogen (NO2-N + NO3-N) of 8 mg/L is based on Basin Plan Table 3-8 (page 3-13), for the San Gabriel River watershed (between Ramona Boulevard and Firestone Boulevard)

3. **Mass based limit.** The mass emission rates are based on the plant design flow rate of 15.0 mgd.

Watershed-wide monitoring will track concentration levels of phosphorus and all nitrogen series pollutants present in the effluent and receiving waters, pursuant to 40 CFR 122.44(d)(1)(vi)(C)(3).

j. *Ammonia-nitrogen*

1. Ammonia is a pollutant routinely found in the wastewater effluent of POTWs, in landfill-leachate, as well as in run-off from agricultural fields where commercial fertilizers and animal manure are applied. Ammonia exists in two forms – un-ionized ammonia (NH_3) and the ammonium ion (NH_4^+). They are both toxic, but the neutral, un-ionized ammonia species (NH_3) is much more toxic, because it is able to diffuse across the epithelial membranes of aquatic organisms much more readily than the charged ammonium ion. The form of ammonia is primarily a function of pH, but it is also affected by temperature and other factors. Additional impacts can also occur as the oxidation of ammonia lowers the dissolved oxygen content of the water, further stressing aquatic organisms. Oxidation of ammonia to nitrate may lead to groundwater impacts in areas of recharge. [There is groundwater recharge in these reaches]. Ammonia also combines with chlorine (often both are present in POTW treated effluent discharges) to form chloramines – persistent toxic compounds that extend the effects of ammonia and chlorine downstream.

2. Ammonia is 303(d) listed in the San Gabriel River and San Jose Creek. Since ammonia has reasonable potential to cause or contribute to an excursion of a water quality objective, a water quality-based effluent limitation for total ammonia is required in order to be protective of the water quality objective.

3. The 1994 Basin Plan contained water quality objectives for ammonia to protect aquatic life, in Tables 3-1 through Tables 3-4. However, those ammonia objectives were revised on April 25, 2002, by the Regional Board, with the adoption of Resolution No. 2002-011, *Amendment to the Water Quality Control Plan for the Los Angeles Region to Update the Ammonia Objectives for Inland Surface Waters (including enclosed bays, estuaries and wetlands) with Beneficial Use designations for protection of Aquatic Life*. Resolution No. 2002-011 was approved by the State Board, the Office of Administrative Law, and USEPA on April 30, 2003, June 5, 2003, and June 19, 2003, respectively, and is now in effect. The final effluent limitations for ammonia prescribed in this Order are based on the revised ammonia criteria (see Attachment H) and apply at the end of pipe.

k. *Coliform/Bacteria*

Total and fecal coliform bacteria are used to indicate the likelihood of pathogenic bacteria in surface waters. Given the nature of the facility, a wastewater treatment plant, pathogens are likely to be present in the effluent in cases where the disinfection process is not operating adequately. As such, the permit contains the following:

1. Effluent Limitations:

   a. The 7 day median number of coliform organisms at some point in the treatment process must not exceed 2.2 Most Probable Number (MPN) per 100 milliliters, and

   b. The number of coliform organisms must not exceed 23 MPN per 100 milliliters in more than one sample within any 30-day period.

   These disinfection-based effluent limitations for coliform are for human health protection and are consistent with requirements established by the Department of Health Services. These limits for coliform must be met at the point of the treatment train immediately following disinfection, as a measure of the effectiveness of the disinfection process.

2. Receiving Water Limitation

   a. Geometric Mean Limits

      * E.coli density shall not exceed 126/100 mL.
      * Fecal coliform density shall not exceed 200/100 mL.

   b. Single Sample Limits

      * E.coli density shall not exceed 235/100 mL.

* Fecal coliform density shall not exceed 400/100 mL.

These receiving water limitations are based on Resolution No. 01-018, Amendment to the Water Quality Control Plan for the Los Angeles Region to Update the Bacteria Objectives for Water Bodies Designated for Water Contact Recreation, adopted by the Regional Board on October 25, 2001. The Resolution was approved by State Board, OAL, and USEPA, on July 18, 2002, September 19, 2002, and September 25, 2002, respectively.

l. pH

The hydrogen ion activity of water (pH) is measured on a logarithmic scale, ranging from 0 to 14. While the pH of "pure" water at 25°C is 7.0, the pH of natural waters is usually slightly basic due to the solubility of carbon dioxide from the atmosphere. Minor changes from natural conditions can harm aquatic life. The effluent limitation for pH which reads, "the wastes discharged shall at all times be within the range of 6.5 to 8.5," is taken from the Basin Plan (page 3-15) which reads" the pH of inland surface waters shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharge.

m. Turbidity

Turbidity is an expression of the optical property that causes light to be scattered in water due to particulate matter such as clay, silt, organic matter, and microscopic organisms. Turbidity can result in a variety of water quality impairments. The effluent limitation for turbidity which reads, "For the protection of the water contact recreation beneficial use, the wastes discharged to water courses shall have received adequate treatment, so that the turbidity of the wastewater does not exceed: (a) a daily average of 2 Nephelometric turbidity units (NTUs); and (b) 5 NTUs more than 5 percent of the time (72 minutes) during any 24 hour period," is based on the Basin Plan (page 3-17).

n. Radioactivity

Radioactive substances are generally present in natural waters in extremely low concentrations. Mining or industrial activities increase the amount of radioactive substances in waters to levels that are harmful to aquatic life, wildlife, or humans. The existing effluent limitation for radioactivity which reads, "Radioactivity of the wastes discharged shall not exceed the limits specified in Title 22, Chapter 15, Article 5, Section 64443, of the California Code of Regulations, or subsequent revisions," is based on the Basin Plan incorporation of Title 22, *Drinking Water Standards,* by reference, to protect the surface water MUN beneficial use. However, the Regional Board has new information about the appropriate designated uses for the water body, and based on the current designated uses, a limit for Radioactivity is unnecessary and inappropriate unless discharge is to a reach used for groundwater recharge, where Title 22-based limits apply. Therefore, the accompanying Order will contain a limit for radioactivity to protect the GWR beneficial use.

C. *Toxicity.*

Ambient monitoring data indicates that the background concentration in the lower San Gabriel River is toxic to aquatic organisms, and therefore exceeds water quality standards. Final effluent water quality data, contained in the Discharger's monitoring reports, also shows that chronic toxicity in the effluent has exceeded 1TUc (EPA WQO) several times. Therefore, pursuant to the TSD, reasonable potential exists for toxicity. As such, the permit should contain a numeric effluent limitation for toxicity.

The following support the inclusion of toxicity numeric effluent limitations for chronic toxicity:

a. 40 CFR 122.2 (Definition of Effluent Limitation);

b. 40 CFR 122.44(d)(v) – limits on whole effluent toxicity are necessary when chemical-specific limits are not sufficient to attain and maintain applicable numeric or narrative water quality standards;

c. 40 CFR 122.44(d)(vi)(A) – where a State has not developed a water quality criterion for a specific pollutant that is present in the effluent and has reasonable potential, the permitting authority can establish effluent limits using numeric water quality criterion;

d. Basin Plan objectives and implementation provisions for toxicity;

e. Regions 9 & 10 Guidance for Implementing Whole Effluent Toxicity Programs Final May 31, 1996;

f. Whole Effluent Toxicity (WET) Control Policy July 1994; and,

g. Technical Support Document (several chapters and Appendix B).

However, the circumstances warranting a numeric chronic toxicity effluent limitation when there is reasonable potential were reviewed by the State Water Resources Control Board (State Board) in SWRCB/OCC Files A-1496 & A-1496(a) [Los Coyotes/Long Beach Petitions]. On September 17, 2003, at a public hearing, the State Board decided to defer the issue of numeric chronic toxicity effluent limitations until Phase II of the SIP is adopted. In the mean time, the State Board replaced the numeric chronic toxicity limit with a narrative effluent limitation and a 1 TUc trigger, in the Long Beach and Los Coyotes WRP NPDES permits. This permit contains a similar chronic toxicity effluent limitation. This Order also contains a reopener to allow the Regional Board to modify the permit, if necessary, consistent with any new policy, law, or regulation.

Acute Toxicity Limitation:

The Dischargers may test for Acute toxicity by using USEPA's *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*, October 2002 (EPA-821-R-02-012). Acute toxicity

provisions in the accompanying Order are derived from the Basin Plan's toxicity standards (Basin Plan 3-16 and 3-17). The provisions require the Discharger to accelerate acute toxicity monitoring and take further actions to identify the source of toxicity and to reduce acute toxicity.

Chronic Toxicity Limitation and Requirements:

Chronic toxicity provisions in the accompanying Order are derived from the Basin Plan's toxicity standards (Basin Plan 3-16 and 3-17). The provisions require the Discharger to accelerate chronic toxicity monitoring and take further actions to identify the source of toxicity and to reduce chronic toxicity. The monthly median trigger of 1.0 TU_c for chronic toxicity is based on *USEPA Regions 9 & 10 Guidance for Implementing Whole Effluent Toxicity (WET) Programs* Final May 31, 1996 (Chapter 2 – Developing WET Permitting Conditions, page 2-8). In cases where effluent receives no dilution or where mixing zones are not allowed, the 1.0 TU_c chronic criterion should be expressed as a monthly median. The "median" is defined as the middle value in a distribution, above which and below which lie an equal number of values. For example, if the results of the WET testing for a month were 1.5, 1.0, and 1.0 TU_c, the median would be 1.0 TU_c.

The *USEPA Regions 9 & 10 Guidance for Implementing Whole Effluent Toxicity (WET) Programs* Final May 31, 1996 (Chapter 2 – Developing WET Permitting Conditions, page 2-8) recommends two alternatives: using 2.0 TUc as the maximum daily limit; or using a statistical approach to develop a maximum daily effluent limitation.

D. Limits for priority pollutants for Discharge Serial No. 001:

CTR # [1]	Constituent	Units	Discharge Limitations	
			Monthly Average	Daily Maximum
4	Cadmium	µg/L	5 [c]	---
		lbs/day[3]	0.6	---
7	Lead [6]	µg/L	6.6 [2] [4]	13 [2] [4]
		lbs/day[3]	0.83	1.6
8	Mercury [6]	µg/L	0.051 [4], b	0.10[4], b
		lbs/day[3]	0.0064	0.013
14	Cyanide [6]	µg/L	4.2 [4], a	8.5 [4], a
		lbs/day[3]	0.53	1.1
18	Acrylonitrile [6]	µg/L	0.66 [4], b	1.3 [4], b
		lbs/day[3]	0.083	0.16
38	Tetrachloroethylene	µg/L	5 [c]	---
		lbs/day[3]	0.6	---
68	Bis(2-Ethylhexyl)phthalate	µg/L	4 [c, [7]	---
		lbs/day[3]	0.5 [7]	---
77	1,4-Dichlorobenzene	µg/L	5 [c]	---
	(p-dichlorobenzene)	lbs/day[3]	0.6	---
96	N-Nitrosodimethylamine	µg/L	8.1	16
	(NDMA) [5]	lbs/day[3]	1.0	2.0

[1] This number corresponds to the compound number found in Table 1 of CTR. It is simply the order in which the 126 priority pollutants were listed 40 CFR part 131.38 (b)(1).

[2] Concentration expressed as total recoverable.

[3] The mass emission rates are based on the plant design flow rate of 15 mgd, and calculated as follows: Flow (MDG) x Concentration (mg/L) x 8.34 (conversion factor) = lbs/day. During wet-weather storm events in which the flow exceeds the design capacity, the mass discharge rate limitations shall not apply, and concentration limitations will provide the only applicable effluent limitations.

[4] For priority pollutants, Section 2.4.5 of CTR *Compliance Determination*, reads, "Dischargers shall be deemed out of compliance with an effluent limitation if the concentration of the priority pollutant in the monitoring sample is greater than the effluent limitation and greater than or equal to the reported ML."

[5] There was RPA (tier 3) for the Pomona WRP effluent to exceed the CTR human health organisms only criteria, therefore, a CTR-based effluent limitation was included in the accompanying Order.

[6] this effluent limitation will not be in effect until May 10, 2009, and until that time the Discharger shall comply with the interim limits established in Section I.A.(9) of the accompanying NPDES Order No. R4-2004-0099.

[7] This effluent limitation will not be in effect until May 10, 2009, and until that time the Discharger shall comply with the interim limits established in the Time Schedule Order No. R4-2004-0100.

Additional Footnotes - Priority Pollutants:

a. Based on most stringent CTR criteria [Criterion Continuous Concentration (CCC)] for the protection of freshwater aquatic life. To arrive at this calculated limitation, the CTR CCC was adjusted, according to SIP Section 1.4.

   Federal Register Vol. 65, No. 97, page 31689, discusses the basis for the aquatic life criteria in the CTR. The Criterion Maximum Concentration (CMC), a short term concentration limit, and the Criterion Continuous Concentration (CCC), a four day concentration limit, are designed to provide protection of aquatic life and its uses from acute and chronic toxicity to animals and plants. The criteria are intended to identify average pollutant concentrations which will produce water quality generally suited to maintenance of aquatic life and designated uses while restricting the duration of excursions over the average so that total exposures will not cause unacceptable adverse effects.

   Federal Register Vol. 65, No. 97, page 31691, discusses how CCC is intended to be the highest concentration that could be maintained indefinitely in a water body without causing an unacceptable effect on aquatic community or its uses.

b. Based on most stringent CTR criteria for the protection of human health from consumption of organisms only. CTR criteria was adjusted according to SIP Section 1.4, to arrive at this calculated limitation.

c. Based on the Basin Plan chemical constituent incorporation of Title 22, *Drinking Water Standards,* by reference, for the protection of GWR beneficial use.

E. Basis for priority pollutants:

Mixing zones, dilution credits, and attenuation factors are not used in the accompanying order and would be inappropriate to grant, at this time, in light of the factors discussed in Section VII.17.A. through I of this Fact Sheet.

Allowance of a mixing zone is in the Regional Board's discretion under Section 1.4.2 of the SIP and under the Basin Plan (Basin Plan Chapter 4,

page 30). If the Discharger subsequently conducts appropriate mixing zone and dilution credit studies, the Regional Board can evaluate the propriety of granting a mixing zone or establishing dilution credits.

F. Example calculation: Cyanide

Is a limit required? What is RPA?

- From Table R, *Reasonable Potential & Limit Derivation*, we determined that Reasonable potential analysis (RPA) = Yes, therefore a limit is required.

Step 1 – Identify applicable water quality criteria.
From California Toxics Rule (CTR), we can obtain the Criterion Maximum Concentration (CMC) and the Criterion Continuous Concentration (CCC).

Freshwater Aquatic Life Criteria:
CMC = 22 µg/L (CTR page 31712, column B1) and
CCC = 5.2 µg/L (CTR page 31712, column B2); and

Human Health Criteria for Water & Organisms = 700 µg/L.

Step 2 – Calculate effluent concentration allowance (ECA)
ECA = Criteria in CTR, since no dilution is allowed.

Step 3 – Determine long-term average (LTA) discharge condition

a. Calculate CV:
CV = Standard Deviation / Mean
= 0.6 (By default because data was > 80% nondetect, SIP page 6)

b. Find the ECA Multipliers from SIP Table 1 (page 7), or by calculating them using equations on SIP page 6. When CV = 0.6, then:
ECA Multiplier acute = 0.321 and
ECA Multiplier acute = 0.527.

c. LTA acute = ECA acute x ECA Multiplier acute
= 22 µg/L x 0.321 = 7.062 µg/L

d. LTA chronic = ECA chronic x ECA Multiplier chronic
= 5.2 µg/L x 0.527 = 2.7404 µg/L

Step 4 – Select the lowest LTA.
In this case, LTA chronic < LTA acute, therefore lowest LTA = 2.74 µg/L

Step 5 – Calculate the Average Monthly Effluent Limitation (AMEL) & Maximum Daily Effluent Limitation (MDEL) for AQUATIC LIFE.

a. Find the multipliers. You need to know CV and n (frequency of sample collection per month). If effluent samples are collected 4 times a month or less, then n = 4. CV was determined to be 0.6 in a previous step.
AMEL Multiplier = 1.55
MDEL Multiplier = 3.11

b. AMEL aquatic life = lowest LTA (from Step4) x AMEL Multiplier
= 2.74 µg/L x 1.55 = 4.2476 µg/L

c. MDEL aquatic life = lowest LTA (from Step4) x AMEL Multiplier
= 2.74 µg/L x 3.11 = 8.5226 µg/L

Step 6 – Find the Average Monthly Effluent Limitation (AMEL) & Maximum Daily Effluent Limitation (MDEL) for HUMAN HEALTH.

a. Find factors. Given CV = 0.6 and n = 4.
For AMEL human health limit, there is no factor.
The MDEL/AMEL human health factor = 2.01

b. AMEL human health = ECA = 700 µg/L

c. MDEL human health = ECA x MDEL/AMEL factor
= 700 µg/L x 2.01 = 1407

Step 7 – Compare the AMELs for Aquatic life and Human health and select the lowest. Compare the MDELs for Aquatic life and Human health and select the lowest.

a. Lowest AMEL = 4.2 µg/L (Based on Aquatic life protection)

b. Lowest MDEL = 8.5 µg/L (Based on Aquatic life protection)

G. A numerical limit has not been prescribed for a toxic constituent if it has been determined that it has no reasonable potential to cause or contribute to excursions of water quality standards. A narrative limit to comply with all water quality objectives is provided in *Standard Provisions* for the priority pollutants which have no available numeric criteria.

H. The numeric limitations contained in the accompanying Order were derived using best professional judgement and are based on applicable state and federal authorities, and as they are met, will be in conformance with the goals of the aforementioned water quality control plans, and water quality criteria; and will protect and maintain existing and potential beneficial uses of the receiving waters.

X. INTERIM REQUIREMENTS

1. Pollutant Minimization Program

A. The accompanying Order provides for the use of Pollutant Minimization Program, developed in conformance with Section 2.4.5.1 of the SIP, when there is evidence (e.g., sample results reported as DNQ when the effluent limitation is less than the MDL, sample results from analytical methods more sensitive than

those methods included in the permit in accordance with sections 2.4.2 or 2.4.3 above, presence of whole effluent toxicity, health advisories for fish consumption, results of benthic or aquatic organisms tissue sampling) that a priority pollutant is present in the discharger's effluent above an effluent limitation.

B. The Discharger shall develop a Pollutant Minimization Program (PMP), in accordance with Section 2.4.5.1.,of the SIP, if all of the following conditions are true, and shall submit the PMP to the Regional Board within 120 days of determining the conditions are true:

a. when there is evidence that the priority pollutant is present in the effluent above an effluent limitation and either:

i. A sample result is reported as detected but not quantified (DNQ) and the effluent limitation is less than the reported ML; or

ii. A sample result is reported as nondetect (ND) and the effluent limitation is less than the MDL.

b. Examples of evidence that the priority pollutant is present in the effluent above an effluent limitation are:

i. sample results reported as DNQ when the effluent limitation is less than the method detection limit (MDL);

ii. sample results from analytical methods more sensitive than those methods included in the permit in accordance with Sections 2.4.2 or 2.4.3;

iii. presence of whole effluent toxicity;

iv. health advisories for fish consumption; or,

v. results of benthic or aquatic organism tissue sampling.

C. The goal of the PMP is to reduce all potential sources of a priority pollutant(s) through pollution minimization (control) strategies, including pollution prevention measures as appropriate, to maintain the effluent concentration at or below the WQBEL.

D. The Discharger shall propose a plan with a logical sequence of actions to achieve full compliance with the limits in this Order. The first phase of the plan is to investigate the sources of the high levels of contaminants in the collection system. If the sources can be identified, source reduction measures (including, when appropriate, Pollution Minimization Plans) will be instituted. At the time this Order is considered, the Discharger is unsure whether or not all sources contributing to the high contaminant levels can be identified. Therefore, a parallel effort will be made to evaluate the appropriateness of Site Specific Objectives (SSO) and, where appropriate, Use Attainability Analyses (UAA), and modifications to and/or

construction of treatment facilities. If it is determined that a SSO or UAA is necessary and appropriate, the Discharger will submit a written request for a SSO study, accompanied by a preliminary commitment to fund the study, to the Regional Board. The Discharger will then develop a workplan and submit it to the Regional Board for approval prior to the initiation of the studies.

2. Interim Limits

A. The Pomona WRP may not be able to achieve immediate compliance with the limits for lead, mercury, cyanide, acrylonitrile, and bis(2-ethylhexyl)phthalate contained in the accompanying Order Section I.A.2.b Data submitted in previous self-monitoring reports indicate that these constituents have been detected in the effluent/receiving water, at least once, at a concentration greater than the new limit proposed in the accompanying Order.

B. 40 CFR, Section 131.38(e) provides conditions under which interim effluent limits and compliance schedules may be issued. However, until recently, the Basin Plan did not allow inclusion of interim limits and compliance schedules in NPDES permits for effluent limits.

1. With the Regional Board adoption and USEPA approval of Resolution No. 2003-001, compliance schedules can be allowed in NPDES permits if:

a. the effluent limit implements new, revised, or newly interpreted water quality standards, or

b. the effluent limit implements TMDLs for new, revised or newly interpreted water quality standards.

However, the provisions under Resolution No. 2003-001 do not apply to any constituent with a final effluent limitation.

2. The SIP allows inclusion of interim limits in NPDES permits for CTR-based priority pollutants. The CTR provides for a five-year maximum compliance schedule, while the SIP allows for longer, TMDL-based compliance schedule. However, the USEPA has yet to approve the longer compliance schedules. Therefore, this Order includes interim limits and compliance schedules for CTR-based priority pollutant limits, for a maximum of five years, when the Discharger has been determined to have problems in meeting the new limits. This Order also includes a reopener to allow the Regional Board to grant TMDL-based compliance schedules if the USEPA approves the longer compliance schedule provisions of the SIP.

3. For new non-CTR-based limits (bis(2-ethylhexyl)phthalate) prescribed in this Order, for which the Discharger will not be able to meet immediately, interim limits and compliance dates are provided in an accompanying Time Schedule Order R4-2004-0100.

C. In conformance with the CTR and the relevant provisions of SIP Section 2.1, the Discharger has submitted documentation regarding the efforts they have made

to quantify pollutant levels in the discharge and the sources of the pollutants entering the POTW. In addition, the Discharger already has in place a source control and pollutant minimization approach through its existing pollutant minimization strategies and through the pretreatment program. The duration of interim requirements established in this Order was developed in coordination with Regional Board staff and the Discharger, and the proposed schedule is as short as practicable. The five-year compliance schedule is based on the maximum allowable compliance schedule. However, the Discharger anticipates it may take longer than five years to achieve some of the final limits.

ATTACHMENT F

State of California
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION
320 West 4th Street, Suite 200, Los Angeles

FACT SHEET

WASTE DISCHARGE REQUIREMENTS FOR COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY (San Jose Creek Water Reclamation Plant)

NPDES No. CA0053911
Public Notice No.: 04-008

PLANT ADDRESS
San Jose Creek Water Reclamation Plant
1965 South Workman Mill Road
Whittier, CA 90607

Contact Person: June Nguyen
Title: Senior Engineer
Phone No.: 562-699-7411, Ext. 2831

MAILING ADDRESS
County Sanitation Districts of
Los Angeles County
1965 South Workman Mill Road
Whittier, CA 90607

Contact Person: James F. Stahl
Title: Chief Engineer and General Manager
Phone No.: 562-699-7411

I. PUBLIC PARTICIPATION

1. The California Regional Water Quality Control Board, Los Angeles Region (Regional Board) is considering issuance of waste discharge requirements (WDRs) that will serve as a National Pollutant Discharge Elimination System (NPDES) permit for the above-referenced plant. As an initial step in the WDR process, the Regional Board staff has developed tentative WDRs. The Regional Board encourages public participation in the WDR adoption process.

   A. Public Comment Period

      Interested persons are invited to submit written comments on the tentative WDRs for the County Sanitation Districts of Los Angeles County (CSDLAC or Discharger), San Jose Creek Water Reclamation Plant (San Jose Creek WRP). Comments should be submitted either in person or by mail to:

      EXECUTIVE OFFICER
      California Regional Water Quality Control Board, Los Angeles Region
      320 W. 4th Street, Suite 200
      Los Angeles, CA 90013
      ATTN: Don Tsai

      To be fully responded to by staff and considered by the Regional Board, written comments regarding the revised tentative Order should be received by 5:00 p.m. on May 26, 2004.

The discharger submitted comments to the RWQCB based on previous tentative permits mailed to them. However, previous tentative permits contained limits been based on the United States Environmental Protection Agency's (USEPA) Technical Support Document. The Regional Board staff has incorporated some of the discharger's suggestions into this tentative.

In August 2002, Mr. Bill Robinson attempted to submit written comments and other documentation to the Regional Board, for inclusion in the administrative record of the CSDLAC Whittier Narrows WRP WDR and NPDES permit renewal hearing. However, his written comments were not accepted by the Board because they were submitted past the deadline for the public comment period. However, those written comments will be included in the administrative record for consideration during the San Jose Creek WRP WDR and NPDES permit renewal process.

B. Public Hearing

The Regional Board will consider the tentative WDRs and NPDES permit during a public hearing on the following date, time and place:

Date: June 10, 2004
Time: 9:00 a.m.
Location: Council Chambers
Metropolitan Water District of Southern California
700 N. Alameda Street
Los Angeles, California

Interested parties and persons are invited to attend. At the public hearing, the Regional Board will hear testimony, if any, pertinent to the waste discharge that will be regulated and the proposed WDRs and permit. Oral testimony will be heard; however, for accuracy of the record, important testimony should be in writing.

Please be aware that dates and venues may change. Our web address is www.swrcb.ca.gov/rqcb4 where you can access the current agenda for changes in dates and locations.

C. Information and Copying

Copies of the tentative WDRs and NPDES permit, report of waste discharge, Fact Sheet, comments received, and other documents relative to this tentative WDRs and permit are available at the Regional Board office. Inspection and/or copying of these documents are by appointment scheduled between 8:00 a.m. and 4:50 p.m., Monday through Friday, excluding holidays. For appointment, please call the Los Angeles Regional Board at (213) 576-6600.

D. Register of Interested Persons

Any person interested in being placed on the mailing list for information regarding this NPDES permit should contact the Regional Board, reference this facility, and provide a name, address, and phone number.

E. Waste Discharge Requirements Appeals

Any aggrieved person may petition the State Water Resources Control Board to review the decision of the Regional Board regarding the final WDRs. The petition must be submitted within 30 days of the Regional Board's action to the following address:

State Water Resources Control Board
Office of Chief Counsel
ATTN: Elizabeth Miller Jennings
P.O. Box 100
Sacramento, CA 95812

II. PURPOSE OF ORDER

CSDLAC discharges tertiary-treated municipal wastewater from the San Jose Creek WRP under waste discharge requirements contained in Order No. 95-079, adopted by this Regional Board on June 12, 1995. This Order serves as the permit under the National Pollutant Discharge Elimination System Program (NPDES No. CA0053911). The Discharger's permit was administratively extended beyond the May 10, 2000 expiration date. CSDLAC filed a Report of Waste Discharge (ROWD) and applied for renewal of its WDRs and NPDES permit on November 15, 1999. This WDRs and NPDES permit will expire on May 10, 2009.

III. DESCRIPTION OF FACILITY AND TREATMENT PROCESS

1. The San Jose Creek WRP consisting of East and West WRPs is one of eleven publicly owned treatment works (POTWs) (Saugus, Valencia, Whittier Narrows, Pomona, La Cañada, Long Beach, Los Coyotes, San Jose Creek, Lancaster, Palmdale, and Joint Water Pollution Control Plant) owned and operated by CSDLAC. The San Jose Creek WRP is a tertiary treatment facility located at 1965 South Workman Mill Road, Whittier, California 90607. The plant consists of two completely separate, independently operated units with separate raw sewage sources and outfalls. As reported in the ROWD, the San Jose Creek WRP has a combined design capacity of 100 million gallons per day (mgd), which San Jose Creek East and West WRPs individually contribute 62.5 and 37.5 mgd, respectively. In 2002, the San Jose Creek WRP only discharged an average total of 83 mgd of tertiary treated municipal wastewater to the San Gabriel River and San Jose Creek, at Whittier, California.

   The plant was constructed in three stages. Stages I and II (also identified here as the San Jose Creek East WRP) are located on the east side of the 605 Freeway. Stage III (also identified here as the San Jose Creek West WRP) is located on the west side of the 605 Freeway and was placed into full operation in January 1993. The San Jose Creek WRP is part of CSDLAC's integrated network of facilities, known as the Joint Outfall System, which includes seven treatment plants. The upstream treatment plants

(Whittier Narrows, Pomona, La Cañada, Long Beach, Los Coyotes, and San Jose Creek) are connected to the Joint Water Pollution Control Plant (JWPCP) located in Carson. This system allows for the diversion of influent flows into or around each upstream plant, if so desired. Figure 1 shows the vicinity map for the San Jose Creek WRP.

2. The San Jose Creek WRP serves approximately 914,100 people in the Cities of Arcadia, Azusa, Baldwin Park, Bradbury, Industry, Covina, Diamond Bar, Duarte, El Monte, Glendora, Irwindale, La Habra Heights, La Puente, La Verne, Monrovia, Pasadena, Pomona, Rosemead, San Dimas, San Gabriel, San Marino, Sierra Madre, Temple, and West Covina. Flow to the plant consists of domestic and industrial wastewater. During 2002, industrial wastewater represented approximately 15% of the total flow to the plant.

3. The United States Environmental Protection Agency (USEPA) and the Regional Board have classified San Jose Creek WRP as a major discharger. It has a Threat to Water Quality and Complexity Rating of 1-A pursuant to Section 2200, Title 23, CCR.

4. Pursuant to 40 CFR, Part 403, the San Jose Creek WRP developed, and has been implementing, an industrial wastewater Pretreatment Program, which has been approved by USEPA and the Regional Board.

5. Treatment at the San Jose Creek WRP currently consists of primary sedimentation, nitrification-denitrification (NDN) activated sludge biological treatment, secondary sedimentation with coagulation, inert media filtration, chlorination and dechlorination. No facilities are provided for solids processing at the plant. Sewage solids separated from the wastewater are returned to the trunk sewer for conveyance to JWPCP for treatment and disposal. Figures 2A and 2B depict schematics of the San Jose Creek East and West WRP wastewater flows.

   A. ***Primary sedimentation -*** The main objective of primary sedimentation is to remove solids from the wastewater by gravity. The heavier solids (settleable solids) precipitate out and are scraped out of the primary sedimentation basin. The lighter solids float to the top and are skimmed off. However, some solids remain in suspension.

   B. ***NDN activated sludge -*** The NDN activated sludge treatment system in which the incoming wastewater is mixed with existing biological floc (microorganisms, bugs, or activated sludge) is processed in an aeration basin. Activated sludge converts non-settleable and dissolved organic contaminants into biological floc, which can then be removed from the wastewater with further treatment. The nitrification process converts ammonia nitrogen into nitrate plus nitrite nitrogen (inorganic nitrogen). The denitrification process converts the inorganic nitrogen into gaseous nitrogen, thus removing it from the wastewater.

   C. ***Secondary sedimentation with coagulation -*** The main objective of secondary sedimentation is to remove biological floc from the wastewater. Chemicals, such as aluminum sulfate (alum), may be added as part of the treatment process to enhance solids removal. Alum causes the biological floc to combine into larger

clumps (coagulate). This makes it easier to remove the floc.

D. ***Mixed dual media filtration -*** The filtration process is used to remove or reduce suspended or colloidal matter from a liquid stream, by passing the water through a bed of graded granular material. Filters remove the solids that the secondary sedimentation process did not remove, thus, improving the disinfection efficiency and reliability.

E. ***Chlorination -*** Sodium hypochlorite is used as a disinfectant in the San Jose Creek WRP. Disinfectant is added to the treated effluent prior to the filters to destroy bacteria, pathogens and viruses, and to minimize algal growth in the filters. Additional disinfectant may be dosed prior to the chlorine contact tank.

F. ***Dechlorination -*** Sulfur dioxide is added to neutralize the chlorine prior to the treated water discharged to the San Gabriel River and San Jose Creek.

In order to achieve compliance with the ammonia Basin Plan objectives, the Districts began the conversion of San Jose Creek East WRP to NDN operating mode in August 2000. As of June 12, 2003, San Jose Creek East and West WRPs are in full NDN mode, and 100% of the effluent discharged to the San Jose Creek and/or the San Gabriel River has undergone full treatment including NDN treatment. Even though the San Jose Creek East is operating in full NDN mode, NDN-related construction, which includes expansion of the return activated sludge (RAS) stations and modifications to the aeration tanks, is still occurring. Modifications to the aeration tanks require the diversion of some influent flow from San Jose Creek East to San Jose Creek West and thus, starting on October 6, 2003, approximately 6 mgd of flow is being diverted from San Jose Creek East to San Jose Creek West. The diversion is anticipated to end when the aeration work is completed by June 2004.

However, recent scientific investigations have found that the disinfection of the filtered activated sludge NDN effluent and increased polymer dosing generates n-nitrosodimethylamine (NDMA) as a byproduct. To date, ultra violet (UV) oxidation is the only available technology capable of destroying NDMA in wastewater. Currently, CSDLAC is conducting a UV disinfection pilot project at the Whittier Narrows WRP in an effort to eliminate in-plant generation of NDMA. Pending the outcome of this pilot study, the disinfection process at the San Jose Creek WRP, and other CSDLAC WRPs, may be changed from chlorination to UV. The purpose of installing and operating the UV disinfection systems, will be to restore NDMA concentrations to their pre-NDN levels, for the continued protection of local groundwater, and to prevent the formation of other chlorination disinfection byproducts, such as cyanide and trihalomethanes.

6. ***Water Recycling Facility.*** During 2002, the Discharger recycled approximately 5% (33 million gallons of treated effluent per year) from the San Jose Creek East WRP and 11% (39 million gallons of treated effluent per year) from the San Jose Creek West WRP, and plans to continue doing so. The production, distribution, and reuse of recycled water are presently regulated under Water Reclamation Requirements (WRR) contained in Order No. 87-51, adopted by this Board on April 27, 1987. Pursuant to California Water Code section 13523, these WRRs were reviewed in

1997 and were readopted without change in Board Order No. 97-072, adopted on May 12, 1997.

Recycled water is used for landscape irrigation, in cooling towers, and for dust control. Recycled water reuse areas include parks, schools, country club, landfills, and a cemetery in the San Jose Creek WRP's distribution system. CSDLAC is promoting additional reuse options for the treated effluent.

As illustrated on the Schematic of Wastewater Flow (Attachments 2a and 2b) for the San Jose Creek WRP, the recycled water that is piped for reuse is not dechlorinated to maintain an adequate level of residual chlorine to prevent/minimize regrowth of bacteria during distribution.

7. **Storm Water Management.** CSDLAC does not treat storm water runoff at the San Jose Creek WRP, except for stormwater infiltration and inflows in the sewer and stormwater that traverses the treatment tanks. It has developed and implemented a Storm Water Pollution Control Plan for storm water that does not enter the treatment system.

IV. DISCHARGE OUTFALL AND RECEIVING WATER DESCRIPTION

1. The San Jose Creek WRP discharges tertiary-treated wastewater via two discharge points (001 and 003) to the San Gabriel River, above the estuary, within the San Gabriel River Watershed. Tertiary-treated effluent is also discharged via one discharge point (002) to San Jose Creek, a tributary of the San Gabriel River. Existing points of discharge are as follows:

   A. Discharge Serial No. 001: Discharge to San Gabriel River from both the East and West San Jose Creek WRPs (approximate coordinates: Latitude 33° 55' 50" and Longitude 118° 06' 24"). Discharge No. 001 is the primary discharge outfall and is located approximately eight miles south of the plant, near Firestone Boulevard. From this point, treated effluent flows directly to a lined, low flow channel (San Gabriel River) and travels about 9 miles prior to reaching the estuary.

   The outfall pipe is also used to deliver reclaimed water for groundwater recharge under a separate permit. A turnout (approximate coordinates: Latitude 33° 59' 39" and Longitude 118° 04' 24") located approximately midway down the pipe is used to divert reclaimed water to the San Gabriel River Spreading Grounds. CSDLAC proposes to discharge reclaimed water through this turnout into the San Gabriel River through Rubber Dam No. 2, which will not be used at all times. CSDLAC intends to increase flexibility in the Montebello Forebay Spreading Operations. Figure 3 shows the locations of the following proposed discharge points.

      a. Discharger Serial No. 001A (approximate coordinates: Latitude 33° 59' 39" and Longitude 118° 04' 24"): Treated effluent from Discharge No. 001A is allowed to recharge groundwater underneath the unlined San Gabriel River, when the headworks of the spreading grounds are unavailable due

to maintenance or other constraints. Otherwise, none of the reclaimed water can be used for recharge and all of it will flow to Discharge Serial No 001.

b. Discharger Serial No. 001B (approximate coordinates: Latitude 33°58' 14" and Longitude 118° 05' 18"): Treated effluent from Discharge Serial No. 001B increases the groundwater recharge in the vicinity through the unlined San Gabriel River. Discharge Serial No. 001B (nearby Rubber Dam No. 4) is located at the San Gabriel River bank, approximately 1475 feet upstream of Slauson Avenue.

B. Discharge Serial No. 002: Discharge to San Jose Creek from the San Jose Creek East WRP (approximate coordinates: Latitude 34° 02' 08" and Longitude 118° 01' 02"). Treated effluent from Discharge No. 002 is allowed to recharge groundwater and is conveyed via various channels and diversion structures to either the Rio Hondo Spreading Grounds or the San Gabriel River Spreading Grounds. San Jose Creek is unlined from the discharge point to the San Gabriel River.

C. Discharge Serial No. 003: Discharge to the unlined San Gabriel River from the San Jose Creek West WRP (approximate coordinates: Latitude 34° 02' 10" and Longitude 118° 01' 48"). Treated effluent from Discharge No. 003 is allowed to recharge groundwater and is conveyed via various channels and diversion structures to either the Rio Hondo Spreading Grounds or the San Gabriel River Spreading Grounds.

The depth to groundwater is approximately 40 feet below ground surface in the vicinity of the receiving water, San Jose Creek and San Gabriel River, near Discharge Serial Nos. 002 and 003, respectively. San Jose Creek and San Gabriel River are unlined at the discharge points. The unconsolidated sediments underlying the San Gabriel Valley Groundwater Basin are transmissive to water, as well as pollutants. Therefore, it is expected that there will be recharge to groundwater. In addition, groundwater recharge is a beneficial use of the receiving water bodies. Figure 3 shows the depth to groundwater near San Jose Creek WRP.

2. The Upper San Gabriel Valley Municipal Water District proposes a San Gabriel Valley Recycled Water Demonstration Project to transport treated effluent from the San Jose Creek West WRP approximately seven miles upstream, along the San Gabriel River, to recharge groundwater of the Main San Gabriel Basin. Up to 10,000 acre-feet a year of recycled water would be discharged into the San Gabriel River at five points, immediately downstream of the Santa Fe Dam, for groundwater replenishment. Figure 4 shows new points of discharge from the existing San Jose Creek West WRP are as follows:

A. Discharge Serial No. 004: Discharge to the unlined San Gabriel River (Discharge Serial No. 004 - approximate coordinates: Latitude 34° 06' 37", Longitude 117° 58' 14"). The water will discharge into a Drop Structure No. 1 located 1,900 feet north of Live Oak Avenue.

B. Discharge Serial No. 005: Discharge to the unlined San Gabriel River (Discharge Serial No. 005 - approximate coordinates: Latitude 34° 06' 27", Longitude 117° 58' 27"). The water will discharge into a Drop Structure No. 2 located 225 feet north of Live Oak Avenue.

C. Discharge Serial No. 006: Discharge to the unlined San Gabriel River (Discharge Serial No. 006 - approximate coordinates: Latitude 34° 06' 18", Longitude 117° 58' 38"). The water will discharge into a Drop Structure No. 3 located 2,770 feet south of Live Oak Avenue.

D. Discharge Serial No. 007: Discharge to the unlined San Gabriel River (Discharge Serial No. 007 - approximate coordinates: Latitude 34° 06' 09", Longitude 117° 58' 48"). The water will discharge into a Drop Structure No. 4 located 4,000 feet south of Live Oak Avenue.

E. Discharge Serial No. 008: Discharge to the unlined San Gabriel River (Discharge Serial No. 008 - approximate coordinates: Latitude 34° 06' 01", Longitude 117° 58' 58"). The water will discharge into a Drop Structure No. 5 located 5,200 feet south of Live Oak Avenue.

Discharge from these five points is contingent upon the issuance of Water Recycling Requirements (WRRs) for the San Gabriel Valley Recycled Water Demonstration Project. Depending upon where the discharge occurs, this Order may be modified. The Los Angeles County Department of Public Works (LACDPW) will operate and manage the River Channel and the pipeline used to transport suitably treated wastewater to the River Channel. The Main San Gabriel Basin Watermaster, a special state agency, will be charged with the responsibility of replenishing and monitoring the groundwater quality of the San Gabriel Groundwater Basins. In the event that this Project goes forth, depending upon the final design and the exact location of spreading, this NPDES permit may need to be revised, accordingly.

3. During dry weather (May 1 – October 31), the primary sources of water flow in San Gabriel River, downstream of the discharge points, are the San Jose Creek WRP effluent and other NPDES-permitted discharges, including urban runoff conveyed through the municipal separate storm sewer systems (MS4). Storm water and dry weather urban runoff from MS4 are regulated under an NPDES permit, *Waste Discharge Requirements for Municipal Storm Water and Urban Runoff Discharges within the County of Los Angeles* (LA Municipal Permit), NPDES Permit No. CAS004001.

4. The Los Angeles County Flood Control District channelized portions of the San Gabriel River and Rio Hondo to convey and control floodwater and to prevent damage to homes located adjacent to the river. Although not their main purpose, the San Gabriel River and Rio Hondo convey treated wastewater along with floodwater, and urban runoff. The San Gabriel River and Rio Hondo are unlined near the points of discharge. Groundwater recharge occurs both incidentally and through separate WRRs for groundwater recharge, in these unlined areas of the San Gabriel River where the underlying sediments are highly transmissive to water as well as pollutants. The Water Replenishment District of Southern California recharges the

Rio Hondo and San Gabriel Spreading Grounds, located in the Montebello Forebay, with water purchased from CSDLAC's Whittier Narrows, Pomona, and San Jose Creek WRPs, under WRRs Order No. 91-100, adopted by the Board on September 9, 1991.

Notwithstanding that segments located further downstream of the discharge are concrete-lined, the watershed supports a diversity of wildlife, particularly an abundance of avian species such as the *Least Bell's Vireo, Tricolored Blackbird, and California Gnatcatcher*. Aquatic life, such as fish, invertebrates, and algae exist in the San Gabriel River Watershed.

5. As described in the State of the Watershed Report, the San Gabriel River drains a 689 square mile area of eastern Los Angeles County; its headwaters originate in National Forest lands in the San Gabriel Mountains. The San Gabriel River watershed consists of extensive areas of undisturbed riparian and woodland habitats in its upper reaches. The U.S. Congress has set aside a wilderness area in much of the West and East Forks of the San Gabriel River. Towards the middle of the watershed, large spreading grounds are used to recharge groundwater basins. The watershed is hydraulically connected to the San Gabriel River Watershed through the Whittier Narrows Reservoir. Nurseries and small stable areas are located along channelized portions of the river. The lower part of the San Gabriel River Watershed is heavily urbanized.

V. DISCHARGE QUALITY DESCRIPTION

1. From July 1995 to November 2003, the Discharger's discharge monitoring reports showed the following:

   A. treated wastewater average annual flow rate of approximately 55 and 29 mgd for the San Jose Creek East and West WRPs, respectively;

   B. average annual removal rates of >98% and >99% of BOD and total suspended solids, respectively, in the treated wastewater of the both plants; and,

   C. 7-day median and daily maximum coliform values as <1 MPN/100 ml in the treated wastewater of the both plants.

2. The characteristics of the treated wastewater discharged, based on data submitted in the 2002 Annual summary discharge monitoring report, are as follows in Table 1. The "<" symbol indicates that the pollutant was not detected (ND) at that concentration level. It is not known if the pollutant was present at a lower concentration.

Table 1 Effluent Characteristics

CTR#	Constituent	Unit	East			West		
			Avg.	Maxi.	Mini.	Avg.	Maxi.	Mini.
	Flow	mgd	54.6	57.5	49.4	28.6	30.2	26.5
	pH	pH units	6.9	7.0	6.9	7.1	7.2	7.0

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Table 1 Effluent Characteristics

CTR#	Constituent	Unit	East			West		
			Avg.	Maxi.	Mini.	Avg.	Maxi.	Mini.
	Temperature	°F	78	84	72	78	83	73
	BOD_5 20°C	mg/L	<3	5	<2	<6	8	<4
	Suspended solids	mg/L	<1	1	<1	<1	1	<1
	Settleable solids	ml/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Total dissolved solids	mg/L	642	668	586	555	575	534
	Total residual chlorine	mg/L	4.3	4.8	3.7	1.8	2.1	1.6
	Chloride	mg/L	151	172	113	118	163	105
	Sulfate	mg/L	133	154	85.4	101	125	91
	Boron	mg/L	0.52	0.59	0.46	0.6	0.69	0.5
	Total Phosphate	mg/L	<2.2	4.7	<0.5	7.2	7.8	6.8
	Turbidity (24-Hr Composite)	NTU	1.0	1.1	0.8	1.0	1.3	0.8
	Oil and grease	mg/L	<4	<4	<4	<4	<5	<4
	Fluoride	mg/L	0.48	0.85	0.36	0.74	0.91	0.41
	MBAS	mg/L	0.3	0.6	0.2	0.3	0.7	0.1
	Ammonia-N	mg/L	7.3	12.2	5.2	10	14.5	6.1
	Organic-N	mg/L	1.4	1.7	1.2	1.7	2.2	1.4
	Nitrate-N	mg/L	3.4	5.0	2.1	2.94	5.14	1.59
	Nitrite-N	mg/L	0.5	1.1	0.2	0.83	1.42	0.13
1	Antimony	µg/L	<0.6	1.8	<0.5	<0.7	1.4	<0.5
2	Arsenic	µg/L	<1	1	<1	<1	1.8	<1
3	Beryllium	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4	Cadmium	µg/L	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
5	Total Chromium	µg/L	<10	<10	<10	<10	<10	<10
6	Copper	µg/L	<10	31	<8	<10	22	<8
	Iron	µg/L	60	90	70	<50	70	<50
7	Lead	µg/L	<2	4	<2	<2	<3	<2
8	Mercury	µg/L	<0.04	<0.1	<0.04	<0.04	<0.1	<0.04
9	Nickel	µg/L	<20	<20	<20	<20	30	<20
10	Selenium	µg/L	<1	1	<1	<1	1	<1
11	Silver	µg/L	<0.17	0.26	<0.1	0.19	0.33	0.096
12	Thallium	µg/L	<1	<1	<1	<1	<3	<1
13	Zinc	µg/L	50	70	40	70	90	40
14	Cyanide	µg/L	<27	216	<5	<11	17	<5
16	2,3,7,8-TCDD (Dioxin)	µg/L	<0.7	<1.1	<0.35	<0.9	<1.3	<0.48
17	Acrolein	µg/L	<4	<10	<2	<3	<10	<2
18	Acrylonitrile	µg/L	<3	<5	<2	<3	<5	<2
19	Benzene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
20	Bromoform	µg/L	<0.5	0.9	0.5	<0.5	<0.5	<0.5
21	Carbon tetrachloride	µg/L	<0.5	<0.5	<0.5	<0.5	0.9	<0.5
22	Chlorobenzene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
23	Dibromochloromethane	µg/L	<0.8	2.1	0.5	<0.5	0.6	<0.5
24	Chloroethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
25	2-Chloroethylvinyl ether	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
26	Chloroform	µg/L	9	11	6.4	9	11	5.6
27	Bromodichloromethane	µg/L	<2	5.5	1.5	2	2	1
28	1,1-Dichloroethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
29	1,2-Dichloroethane	µg/L	<0.5	<0.5	<0.5	<1	<1	<0.5
30	1,1-Dichloroethylene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
31	1,2-Dichloropropane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
32	1,3-Dichloropropylene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
33	Ethylbenzene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

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Table 1 Effluent Characteristics

CTR#	Constituent	Unit	East			West		
			Avg.	Maxi.	Mini.	Avg.	Maxi.	Mini.
34	Methyl bromide	µg/L	<0.9	<1	<0.5	<1	<1	<0.5
35	Methyl chloride	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
36	Methylene chloride	µg/L	<0.7	2.7	<0.5	<0.7	1.3	<0.5
37	1,1,2,2-Tetrachloroethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
38	Tetrachloroethylene	µg/L	<0.5	0.9	<0.5	<1.8	16	<0.5
39	Toluene	µg/L	<0.5	<0.7	<0.5	<0.5	<0.5	<0.5
40	1,2-Trans-dichloroethylene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
41	1,1,1-Trichloroethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
42	1,1,2-Trichloroethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
43	Trichloroethylene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
44	Vinyl chloride	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
45	2-Chlorophenol	µg/L	<2	<5	<1	<2	<5	<1
46	2,4-Dichlorophenol	µg/L	<2	<5	<1	<2	<5	<1
47	2,4-Dimethylphenol	µg/L	<2	<2	<2	<2	<2	<2
48	2-Methyl-4,6-dinitrophenol	µg/L	<5	<5	<5	<5	<5	<5
49	2,4-Dinitrophenol	µg/L	<5	<5	<5	<5	<5	<5
50	2-Nitrophenol	µg/L	<3	<10	<1	<3	<10	<1
51	4-Nitrophenol	µg/L	<3	<10	<1	<3	<10	<1
52	3-Methyl-4-chlorophenol	µg/L	<1	<1	<1	<1	<1	<1
53	Pentachlorophenol	µg/L	<2	<5	<1	<2	<5	<1
54	Phenol	µg/L	<1	<1	<1	<1	<1	<1
55	2,4,6-Trichlorophenol	µg/L	<6	<10	<1	<3	<10	<1
56	Acenaphthene	µg/L	<1	<1	<1	<1	<1	<1
57	Acenaphthylene	µg/L	<3	<10	<1	<3	<10	<1
58	Anthracene	µg/L	<3	<10	<1	<3	<10	<1
59	Benzidine	µg/L	<5	<5	<5	<5	<5	<5
60	Benzo(a)anthracene	µg/L	<2	<5	<1	<2	<5	<1
61	Benzo(a)pyrene	µg/L	<0.0031	<0.0031	<0.0031	<0.071	0.0513	<0.0031
62	Benzo(b)fluoranthene	µg/L	<0.0031	0.004	<0.0031	<0.007	0.0473	<0.0031
63	Benzo(g,h,i)perylene	µg/L	<2	<5	<1	<2	<5	<1
64	Benzo(k)fluoranthene	µg/L	<0.0031	<0.0031	<0.0031	<0.0081	0.0634	<0.0031
65	Bis(2-chloroethoxy)methane	µg/L	<2	<5	<1	<2	<5	<1
66	Bis(2-chloroethyl)ether	µg/L	<1	<1	<1	<1	<1	<1
67	Bis(2-chloroisopropyl)ether	µg/L	<1	<2	<1	<1	<2	<1
68	Bis(2-ethylhexyl)phthalate	µg/L	<2	<5	<1	<3	<5	<1
69	4-Bromophenyl phenyl ether	µg/L	<2	<5	<1	<2	<5	<1
70	Butylbenzyl phthalate	µg/L	<3	<10	<1	<3	<10	<1
71	2-Chloronaphthalene	µg/L	<3	<10	<1	<3	<10	<1
72	4-Chlorophenyl phenyl ether	µg/L	<2	<5	<1	<2	<5	<1
73	Chrysene	µg/L	<0.0031	<0.0031	<0.0031	<0.0057	0.0344	<0.0031
74	Dibenzo(a,h)anthracene	µg/L	0.006	<0.006	<0.006	<0.017	0.129	<0.006
75	1,2-Dichlorobenzene	µg/L	<0.5	0.7	<0.5	<0.5	<0.5	<0.5
76	1,3-Dichlorobenzene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
77	1,4-Dichlorobenzene	µg/L	<0.6	0.8	<0.5	<0.8	1.2	<0.5
78	3,3'-Dichlorobenzidine	µg/L	<5	<5	<5	<5	<5	<5
79	Diethyl phthalate	µg/L	<2	2.3	<1	<1	<2	<1
80	Dimethyl phthalate	µg/L	<1	<2	<1	<1	<2	<1
81	Di-n-butyl phthalate	µg/L	<3	<10	<1	<3	<10	<1
82	2,4-Dinitrotoluene	µg/L	<2	<5	<1	<2	<5	<1
83	2,6-Dinitrotoluene	µg/L	<2	<5	<1	<2	<5	<1
84	Di-n-octyl phthalate	µg/L	<3	<10	<1	<3	<10	<1

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Table 1 Effluent Characteristics

CTR#	Constituent	Unit	East			West		
			Avg.	Maxi.	Mini.	Avg.	Maxi.	Mini.
85	1,2-Diphenylhydrazine	µg/L	<1	<1	<1	<1	<1	<1
86	Fluoranthene	µg/L	<1	<1	<1	<1	<1	<1
87	Fluorene	µg/L	<3	<10	<1	<3	<10	<1
88	Hexachlorobenzene	µg/L	<1	<1	<1	<1	<1	<1
89	Hexachlorobutadiene	µg/L	<1	<1	<1	<1	<1	<1
90	Hexachlorocyclopentadiene	µg/L	<5	<5	<5	<5	<5	<5
91	Hexachloroethane	µg/L	<1	<1	<1	<1	<1	<1
92	Indeno(1,2,3-cd)pyrene	µg/L	<0.006	<0.006	<0.006	<0.018	0.121	<0.008
93	Isophrone	µg/L	<1	<1	<1	<1	<1	<1
94	Naphthalene	µg/L	<1	<1	<1	<1	<1	<1
95	Nitrobenzene	µg/L	<1	<1	<1	<1	<1	<1
96	N-Nitrosodimethylamine	µg/L	<2	<5	<1	<2	<5	<1
97	N-Nitrosodi-n-propylamine	µg/L	<2	<5	<1	<2	<5	<1
98	N-Nitrosodiphenylamine	µg/L	<1	<1	<1	<1	<1	<1
99	Phenanthrene	µg/L	<2	<5	<1	<2	<5	<1
100	Pyrene	µg/L	<3	<10	<1	<3	<10	<1
101	1,2,4-Trichlorobenzene	µg/L	<2	<5	<1	<2	<5	<1
102	Aldrin	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
103	alpha-BHC	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
104	beta-BHC	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
105	gamma-BHC (Lindane)	µg/L	<0.01	0.01	<0.01	<0.01	0.01	<0.01
106	delta-BHC	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
107	Chlordane	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
108	4,4'-DDT	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
109	4,4'-DDE	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
110	4,4- DDD	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
111	Dieldrin	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
112	alpha-Endosulfan	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
113	beta-Endosulfan	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
114	Endosulfan sulfate	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
115	Endrin	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
116	Endrin aldehyde	µg/L	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
117	Heptachlor	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
118	Heptachlor epoxide	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Polychlorinated biphenyls (PCBs)							
119	Aroclor 1016	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
120	Aroclor 1221	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
121	Aroclor 1232	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
122	Aroclor 1242	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
123	Aroclor 1248	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
124	Aroclor 1254	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
125	Aroclor 1260	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
126	Toxaphene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

3. The Discharger's effluent demonstrated chronic toxicity during the last permit cycle. Based on this information, the Regional Board has determined that there is a reasonable potential that the discharge will cause toxicity in the receiving water. However, the circumstances warranting a numeric chronic toxicity effluent limitation when there is reasonable potential were reviewed by the State Water Resources Control Board (State Board) in SWRCB/OCC Files A-1496 & A-1496(a) [Los

Coyotes/Long Beach Petitions]. On September 16, 2003, at a public hearing, the State Board adopted Order No. 2003-0012, deferring the issue of numeric chronic toxicity effluent limitations until Phase II of the SIP is adopted. In the mean time, the State Board replaced the numeric chronic toxicity limit with a narrative effluent limitation and a 1 TUc trigger, in the Long Beach and Los Coyotes WRP NPDES permits. This permit contains a similar chronic toxicity effluent limitation. This Order also contains a reopener to allow the Regional Board to modify the permit, if necessary, consistent with any new policy, law, or regulation.

4. **N-Nitrosodimethylamine (NDMA)**

A. NDMA is a by-product found in the effluent of POTWs, which use chlorination as a primary form of disinfection. There was RPA to exceed a CTR-based WQBEL at the San Jose Creek East WRP. NDMA has been detected every month in the final effluent, at both the San Jose Creek East and West WRPs, since July 2000, when DHS directed the Discharger to initiate monthly NDMA sampling. The highest detected concentration of NDMA at the San Jose Creek East and West WRPs was 4000 ng/L (on August 4, 2003) and 1,510 ng/L (on September 10, 2003), respectively. These concentrations exceed DHS' Action Level of 10 ng/L for drinking water by a factor of up to 400.

B. In addition to the recharge of effluent that occurs in unlined portions of San Gabriel River and San Jose Creek, the Water Replenishment District recharges the Rio Hondo and San Gabriel Spreading Grounds, located in the Montebello Forebay, with effluent purchased from CSDLAC's Pomona, Whittier Narrows and San Jose Creek WRPs, under WRRs (Order No. 91-100), adopted by the Regional Board on September 9, 1991. Although there were data presented to both the Regional Board and DHS that there is significant attenuation by both soil and sunlight in the spreading basins located approximately 5 miles away from the San Jose Creek WRP, recent data from monitoring wells located at the Rio Hondo Speading Ground have detected increasing NDMA concentrations below the AL. Monitoring wells located at the San Gabriel Spreading Grounds have detected increasing concentrations of NDMA above the AL (up to 460ng/L, on 10/23/03).

C. There has not been any site-specific groundwater monitoring data (for those areas underlying the reaches of the San Jose Creek and San Gabriel River recharged by the San Jose Creek WRP's effluent) submitted to the Regional Board to determine if an attenuation factor should be applied. Groundwater is thought to occur at approximately 60 feet below ground surface.

D. On April 15, 2004, CSDLAC submitted information to the Regional Board detailing the measures they have taken and plan to take to address NDMA. The following table summarizes the major efforts:

Project	Timeline
Source Control/Pollution Prevention	1980's - ongoing
Study NDMA formation process in POTWs	2000 - ongoing
Divert filter backwash water to the JWPCP Plant	06/2002 - ongoing
Optimize chlorination disinfection chemical usage	03/2004
Obtain laboratory equipment more sensitive analytical detection levels	06/2004
Optimize polymer usage	06/2004
Conduct site specific hydrologic modeling and study attenuation of NDMA in GW basins through Soil Aquifer Treatment	06/2004 – 06/2007
Study destruction of NDMA by photolysis at Long Beach WRP	Fall 2004
UV Pilot Project at Whittier Narrows WRP	
• Preliminary Investigation	10/2003 – 04/2004
• Research	01/2004 – 02/2005
• UV Equipment procurement	06/2004 – 10/2005
• Design of UV facilities	04/2004 – 07/2005
• Construction	07/2005 – 08/2006
• Full scale evaluation	06/2006 – 06/2007
Collaborative Studies	
• Removal/destruction of NDMA and its precursors in WTPs	01/2001 – 09/2004
• Low cost analytical methods for measuring NDMA	11/2002 – 08/2004
• Fate and transport of NDMA in irrigation reuse water	04/2003 – 10/2005

VI. APPLICABLE LAWS, PLANS, POLICIES, AND REGULATIONS

The requirements contained in the proposed Order are based on the requirements and authorities contained in the following:

1. ***Federal Clean Water Act –*** Section 301(a) of the federal Clean Water Act (CWA) requires that point source discharges of pollutants to a water of the United States must be done in conformance with a NPDES permit. NPDES permits establish effluent limitations that incorporate various requirements of the CWA designed to protect water quality. CWA section 402 authorizes the USEPA or States with an approved NPDES program to issue NPDES permits. The State of California has an approved NPDES program.

2. ***Basin Plan –*** The Regional Board adopted a revised *Water Quality Control Plan for the Los Angeles Region: Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* (Basin Plan) on June 13, 1994, and amended by various Regional Board resolutions. This updated and consolidated plan represents the Board's master quality control planning document and regulations. The State Board and the State of California Office of Administrative Law (OAL) approved the revised Basin Plan on November 17, 1994, and February 23, 1995, respectively. On May 26, 2000, the USEPA approved the revised Basin Plan except for the implementation plan for potential municipal and domestic supply (MUN) designated water bodies, which is not applicable to this discharge.

Ammonia Water Quality Objective (WQO). The 1994 Basin Plan contained water quality objectives for ammonia to protect aquatic life, in Tables 3-1 through Tables 3-4. However, those ammonia objectives were revised on April 25, 2002, by the Regional Board, with the adoption of Resolution No. 2002-011, Amendment to the Water Quality Control Plan for the Los Angeles Region to Update the Ammonia Objectives for Inland Surface Waters (including enclosed bays, estuaries and wetlands) with Beneficial Use designations for protection of Aquatic Life. Resolution No. 2002-011 was approved by the State Board, OAL, and USEPA on April 30, 2003, June 5, 2003, and June 19, 2003, respectively, and is now in effect. The final effluent limitations for ammonia prescribed in this Order are based on the revised ammonia criteria (see Attachment H) and apply at the end of pipe.

Chloride WQO. The 1994 Basin Plan contained water quality objectives for chloride in Table 3-8. However, the chloride objectives for some waterbodies were revised on January 27, 1997, by the Regional Board, with the adoption of Resolution No. 97-02, *Amendment to the Water Quality Control Plan for the Los Angeles Region to Incorporate a Policy for Addressing Levels of Chloride in Discharges of Wastewaters*. Resolution No. 97-02 was approved by the State Board, OAL, and USEPA on October 23, 1997, January 9, 1998, and February 5, 1998, respectively, and are now in effect. The chloride WQO was revised from 150 mg/L to 180 mg/L, for the San Gabriel River between Valley Boulevard and Firestone Boulevard (including Whittier Narrows Flood Control Basin, and San Jose Creek downstream of 71 Freeway only).

The Basin Plan (i) designates beneficial uses for surface and groundwater, (ii) sets narrative and numerical objectives that must be attained or maintained to protect the designated (existing and potential) beneficial uses and conform to the State's antidegradation policy, and (iii) includes implementation provisions, programs, and policies to protect all waters in the Region. In addition, the Basin Plan incorporates (by reference) all applicable State and Regional Board plans and policies and other pertinent water quality policies and regulations. The 1994 Basin Plan was prepared to be consistent with all State and Regional Board plans and policies adopted in 1994 and earlier. This Order implements the plans, policies, and provisions of the Board's Basin Plan.

3. ***Sources of Drinking Water Policy***. On May 19, 1988, the State Board adopted Resolution No. 88-63, *Sources of Drinking Water (SODW) Policy*, which established a policy that all surface and ground waters, with limited exemptions, are suitable or potentially suitable for municipal and domestic supply. To be consistent with State Board's SODW policy, on March 27, 1989, the Regional Board adopted Resolution No. 89-03, Incorporation of Sources of Drinking Water Policy into *the Water Quality Control Plans (Basin Plans) – Santa Clara River Basin (4A)/ Los Angeles River Basin (4B)*.

4. ***Potential Municipal and Domestic Supply (P* MUN) –*** Consistent with Regional Board Resolution No. 89-03 and State Board Resolution No. 88-63, in 1994 the Regional Board conditionally designated all inland surface waters in Table 2-1 of the 1994 Basin Plan as existing, intermittent, or potential for Municipal and Domestic Supply (P* MUN). However, the conditional designation in the 1994 Basin Plan included the following implementation provision: "no new effluent limitations will be placed in Waste Discharge Requirements as a result of these [potential MUN

designations made pursuant to the SODW policy and the Regional Board's enabling resolution] until the Regional Board adopts [a special Basin Plan Amendment that incorporates a detailed review of the waters in the Region that should be exempted from the potential MUN designations arising from SODW policy and partial approval (May 26, 2000) of the 1994 Basin Plan amendments and acknowledged that the conditional designations do not currently have a legal effect, do not reflect new water quality standards subject to USEPA review, and do not support new effluent limitations based on the conditional designations stemming from the SODW Policy until a subsequent review by the Regional Board finalizes the designations for these waters. This permit is designed to be consistent with the existing Basin Plan.

5. ***State Implementation Plan (SIP) and California Toxics Rule (CTR)***. The State Board adopted the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (also known as the State Implementation Plan or SIP) on March 2, 2000. The SIP was amended by Resolution No. 2000-30, on April 26, 2000, and the Office of Administrative Law approved the SIP on April 28, 2000. The SIP applies to discharges of toxic pollutants in the inland surface waters, enclosed bays and estuaries of California which are subject to regulation under the State's Porter-Cologne Water Quality Control Act (Division 7 of the California Water Code) and the Federal Clean Water Act (CWA). This policy also establishes the following:

   A. Implementation provisions for priority pollutant criteria promulgated by USEPA through the CTR and for priority pollutant objectives established by Regional Boards in their Basin Plans;

   B. Monitoring requirements for priority pollutants with insufficient data to determine reasonable potential;

   C. Monitoring requirements for 2, 3, 7, 8 – TCDD equivalents; and,

   D. Chronic toxicity control provisions.

   The CTR became effective on May 18, 2000 (codified as 40 CFR Part 131.38). Toxic pollutant limits are prescribed in this Order to implement the CTR and Basin Plan.

   In the CTR, USEPA promulgated criteria that protects the general population at an incremental cancer risk level of one in a million (10^{-6}), for all priority toxic pollutants regulated as carcinogens. USEPA recognizes that adoption of a different risk factor is outside of the scope of the CTR. However, states have the discretion to adopt water quality criteria that result in a higher risk level, if it can demonstrate that the chosen risk level is adequately protective of the most highly exposed subpopulation, and has completed all necessary public participation. This demonstration has not happened in California. Further, the information that is available on highly exposed subpopulations in California supports the need to protect the general population at the 10^{-6} level. The Discharger may undertake a study, in accordance with the procedures set forth in Chapter 3 of USEPA's Water Quality Standards Handbook: Second Edition (EPA-823-B-005a, August 1994) to demonstrate that a different risk

factor is more appropriate. Upon completion of the study, the State Board will review the results and determine if the risk factor needs to be changed. In the mean time, the State will continue using a 10^{-6} risk level, as it has done historically, to protect the population against carcinogenic pollutants.

6. ***Alaska Rule***. On March 30, 2000, USEPA revised its regulation that specifies when new and revised State and Tribal water quality standards (WQS) become effective for CWA purposes (40 CFR 131.21, 65 FR 24641, April 27, 2000). Under USEPA's new regulation (also known as the *Alaska rule*), new and revised standards submitted to USEPA after May 30, 2000, must be approved before being used for CWA purposes. The final rule also provides that standards already in effect and submitted to USEPA by May 30, 2000, may be used for CWA purposes, whether or not approved by EPA.

7. ***Beneficial Uses***. The designated beneficial uses in the Basin Plan for the San Gabriel River, San Jose Creek and their contiguous waters are:

   A. The beneficial uses of the receiving surface water are:

San Jose Creek - Hydrologic Unit 405.41	
Existing:	wildlife habitat;
Intermittent:	groundwater recharge; non-contact water recreation; and warm freshwater habitat.
Potential:	municipal and domestic supply (MUN)[1] ; and water contact recreation[2];
San Gabriel River - Hydrologic Unit 405.41	
Existing:	wildlife habitat;
Intermittent:	groundwater recharge[3]; contact and non-contact water recreation; and warm freshwater habitat.
Potential:	municipal and domestic supply[1];
Whittier Narrows Flood Control Basin – Hydrologic Unit 405.41	
Existing:	groundwater recharge; contact and non-contact water recreation; warm freshwater habitat; and wildlife habitat.
Potential:	MUN[1]; and rare, threatened, or endangered species
San Gabriel River: Whittier Narrows-Firestone Boulevard - Hydrologic Unit 405.15	
Existing:	water contact recreation[2] and non-contact water recreation; wildlife habitat; and rare, threatened, or endangered species;
Intermittent:	groundwater recharge; and warm freshwater habitat.
Potential:	MUN[1]; industrial service supply; and industrial process supply;
San Gabriel River: Firestone Boulevard-Estuary - Hydrologic Unit 405.15	
Existing:	water contact recreation[2] and non-contact water recreation;
Potential:	MUN[1]; warm freshwater habitat; and wildlife habitat.
San Gabriel River Estuary - Hydrologic Unit 405.15	
Existing:	industrial service supply; navigation; contact and non-contact water

	recreation; commercial and sport fishing; estuarine habitat; marine habitat; wildlife habitat; rare, threatened, or endangered species[4]; migration of aquatic organism[5]; and spawning, reproduction, and/or early development[5].
Potential:	shellfish harvesting.

Footnote:

[1]. The potential municipal and domestic supply beneficial uses for the water body is consistent with the State Water Resources Control Board Order No. 88-63 and Regional Board Resolution No. 89-003; however, the Regional Board has only conditionally designated the MUN beneficial use and at this time cannot establish effluent limitations designed to protect the conditional designation.

[2] Although the Los Angeles County Department of Public Works post signs prohibiting access to the San Gabriel River, its tributaries and estuary, the public has been observed fishing and wading across the river. There is public access to the San Gabriel River, its tributaries, and estuary through the bike trails that run parallel to the river. Since there is public contact in the receiving water downstream of the discharge, the quality of wastewater discharged to the San Gabriel River must be such that no public health hazard is created.

[3]. This automatically becomes applicable, when the WRRs of the San Gabriel Valley Recycled Water Demonstration Project are issued by the Regional Board. Depending upon the actual area where spreading occurs, this Order may be modified, accordingly.

[4]. One or more rare species utilize all ocean, bays, estuaries, and coastal wetlands for foraging and/or nesting.

[5]. Aquatic organisms utilize all bays, estuaries, lagoons and coastal wetlands, to a certain extent, for spawning and early development. This may include migration into areas are heavily influence by freshwater inputs.

B. The beneficial uses of the receiving groundwater are:

Los Angeles Coastal Plain (Central Basin) – DWR Basin No. 4-11	
Existing:	municipal and domestic supply, industrial service supply; industrial process supply; and, agricultural supply.
San Gabriel Valley (Main San Gabriel Basin) - DWR Basin No. 4-13	
Existing:	municipal and domestic supply, industrial service supply; industrial process supply; and, agricultural supply.
San Gabriel Valley (Puente Basin) - DWR Basin No. 4-13	
Existing:	municipal and domestic supply, industrial service supply; industrial process supply; and, agricultural supply.

C. The requirements in this Order are intended to protect designated beneficial uses and enhance the water quality of the watershed. Effluent limits must protect both existing and potential beneficial uses.

D. Consistent with Regional Board Resolution No. 89-003 and State Board Resolution No. 88-63, all inland surface waters in Table 2-1 of the 1994 Basin Plan are designated existing, intermittent, or potential for MUN.

8. ***Title 22 of the California Code of Regulations -*** The California Department of Health Services established primary and secondary maximum contaminant levels (MCLs) for inorganic, organic, and radioactive contaminants in drinking water. These MCLs are codified in Title 22, California Code of Regulations (Title 22). The Basin Plan (Chapter 3) incorporates Title 22 primary MCLs by reference. This incorporation by reference is prospective including future changes to the incorporated provisions as the changes take effect. Title 22 primary MCLs have been used as bases for effluent limitations in WDRs and NPDES permits to protect the groundwater recharge beneficial use when that receiving groundwater is designated as MUN. Also, the Basin Plan specifies that "Ground waters shall not contain taste or odor-producing substances in concentrations that cause nuisance or adversely affect beneficial uses." Therefore the secondary MCL's, which are limits based on aesthetic, organoleptic standards, are also incorporated into this permit to protect groundwater quality.

Action Levels (ALs). DHS also establishes Action levels (ALs), or health-based advisory levels, for chemicals in drinking water that lack MCLs. An AL is the concentration of a chemical in drinking water that is considered not to pose a significant health risk to people ingesting that water on a daily basis. ALs may be established by DHS for non-regulated chemical contaminants when one of the following occurs:

A. A chemical is found in an actual or proposed drinking water source, or

B. A chemical is in proximity to a drinking water source, and guidance is needed, should it reach the source.

An AL is calculated using standard risk assessment methods for non-cancer and cancer endpoints, and typical exposure assumptions, including a 2-liter per day ingestion rate, a 70-kilogram adult body weight, and a 70-year lifetime. For chemicals that are considered carcinogens, the AL is considered to pose *"de minimis*" risk, i.e., a theoretical lifetime risk of up to one excess case of cancer in a population of 1,000,000 people—the 10^{-6} risk level. (In that population, approximately 250,000-300,000 cases of cancer would be anticipated to occur naturally.) On occasion, the chemical may not be detectable as low as the action level by usual laboratory analytical methods. In this case, detectability prevails, and DHS' approach is to consider a detectable quantity as over the action level until a more sensitive method is available. ALs may be revised from time to time to reflect new risk assessment information. Chemicals for which ALs are established may eventually be regulated by MCLs, depending on the extent of contamination, the levels observed, and the risk to human health. A number of the contaminants for which action levels were originally established now have MCLs.

In April 1998, DHS established an action level of 0.002 µg/L for NDMA, based on a deminimus cancer risk level. The AL was later revised by DHS, once in November 1999 to 0.02 µg/L, and once in March 2002 to 0.01 µg/L or 10 ng/L (the current AL). The AL for NDMA is based on an evaluation conducted by CalEPA's Office of Environmental Health Hazard Assessment. NDMA is classified as a possible human carcinogen on USEPA's Integrated Risk Information System (IRIS), based on the development of tumors, at multiple sites, in both rodent and non-rodent mammals exposed to NDMA by various routes.

The primary routes of potential human exposure to NDMA are ingestion, inhalation, and dermal contact. The general population may be exposed to unknown quantities of NDMA present in foods, beverages, tobacco smoke, herbicides, pesticides, drinking water, and industrial pollution. The National Institute for Occupational Safety and Health (NIOSH) lists the following symptoms experienced depending upon the route of exposure to NDMA:

Route of Exposure	Symptoms
Inhalation	Nausea, vomiting, diarrhea
Skin adsorption	Abdominal cramps, headaches
Ingestion	Fever, enlarged liver
Skin and/or eye contact	Jaundice, decreased organ function of the liver, kidney, and lungs

Although DHS only uses ALs as advisory levels, the Regional Board, exercising its best professional judgement, in the review of the best available science, has in the past considered and used ALs when deemed appropriate to establish effluent limitations in WDR and NPDES permits adopted by this Board. The need for a revised limit for NDMA, for the protection of the GWR beneficial use, will be assessed three years after the effective date of this Order, following the conclusion of the studies mentioned in Finding 48, and in accordance with Section V.8 - *Reopeners and Modifications*.

Groundwater Recharge. Sections of the San Gabriel River and San Jose Creek, near the San Jose Creek WRP discharge points, are designated as GWR. Surface water from the San Gabriel River and San Jose Creek enters the Main San Gabriel Valley, the Central Los Angeles Coastal Plain, and the San Gabriel Valley Puente Groundwater Basins. Since ground water from these basins is used to provide drinking water to over one million people, Title 22-based limits are needed to protect that drinking water supply where there is reasonable potential for the contaminant to be present in the discharge. By limiting the contaminants in the San Jose Creek WRP discharges, the amount of pollutants entering the surface waters and groundwater basins are correspondingly reduced. Once groundwater basins are contaminated, it may take years to clean up, depending on the pollutant. Compared to surface water pollution, investigations and remediation of groundwater are often more difficult, costly, and extremely slow.

9. ***Antidegradation Policy -*** On October 28, 1968, the State Board adopted Resolution No. 68-16*, Maintaining High Quality Water*, which established an antidegradation

policy for State and Regional Boards. The State Board has, in State Board Order No. 86-17 and an October 7, 1987 guidance memorandum, interpreted Resolution No. 68-16 to be fully consistent with the federal antidegradation policy. Similarly, the CWA (section 304(d)(4)(B)) and USEPA regulations (40 CFR, Section 131.12) require that all permitting actions be consistent with the federal antidegradation policy. Together, the State and Federal policies are designed to ensure that a water body will not be degraded resulting from the permitted discharge. The provisions of this Order are consistent with the antidegradation policies.

10. ***Watershed Approach -*** This Regional Board has been implementing a Watershed Management Approach (WMA), to address water quality protection in the Los Angeles Region, as detailed in the Watershed Management Initiative (WMI). The WMI is designed to integrate various surface and ground water regulatory programs while promoting cooperative, collaborative efforts within a watershed. It is also designed to focus limited resources on key issues and use sound science. Information about the San Gabriel River Watershed and other watersheds in the region can be obtained from the Regional Board's web site at *http://www.swrcb.ca.gov/rwqcb4/* and clicking on the word "Watersheds".

    Pursuant to this Regional Board's watershed initiative framework, the San Gabriel River Watershed Management Area was the targeted watershed for fiscal year 1999-2000. However, the NPDES permit renewals were originally re-scheduled so that provisions of the CTR and SIP could be incorporated into the permits.

VII. REGULATORY BASIS FOR EFFLUENT AND RECEIVING WATER LIMITS AND OTHER DISCHARGE REQUIREMENTS

1. ***Water Quality Objectives and Effluent Limits -*** *Water* Quality Objectives (WQOs) and effluent limitations in this permit are based on:

    A. Applicable State Regulations/Policies/Guidances

        a. The plans, policies and water quality standards (beneficial uses + objectives + antidegradation policy) contained in the 1994 *Water Quality Control Plan, Los Angeles Region: Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*, as amended, including chemical constituent limitations established by incorporating the California Code of Regulations, Title 22, Maximum Contaminant Levels designed to protect the existing drinking water use of the receiving groundwaters;

        b. California Toxics Rule (40 CFR 131.38);

        c. The State Board's "Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California" (the State Implementation Plan or SIP); and,

        d. Administrative Procedures Manual and Administrative Procedure Updates.

B. Applicable Federal Regulations/Policies/Guidances

a. Federal Clean Water Act;

b. 40 CFR, Parts 122, 131, among others;

c. Best Professional Judgment (pursuant to 40 CFR 122.44);

d. USEPA Regions 9 & 10 Guidance for Implementing Whole Effluent Toxicity Programs Final May 31, 1996;

e. USEPA Whole Effluent Toxicity (WET) Control Policy July 1994;

f. Inspectors Guide for Evaluation of Municipal Wastewater Treatment Plants, April 1979 (EPA/430/9-79-010);

g. Fate of Priority Pollutants in Publicly Owned Treatment Works Pilot Study October 1979 (EPA-440/1-79-300);

h. *Technical Support Document for Water Quality Based Toxics Control,* March 1991 (EPA-505/ 2-90-001); and,

i. *U.S. EPA NPDES Permit Writers' Manual,* December 1996 (EPA-833-B-96-003).

Where numeric water quality objectives have not been established in the Basin Plan, 40 CFR Part 122.44(d) specifies that water quality based effluent limits may be set based on USEPA criteria and supplemented where necessary by other relevant information to attain and maintain narrative water quality criteria to fully protect designated beneficial uses.

2. ***Mass and Concentration Limits –*** 40 CFR section 122.45(f)(1) requires that, except under certain conditions, all permit limits, standards, or prohibitions be expressed in terms of mass units. 40 CFR section 122.45(f)(2) allows the permit writer, at their discretion, to express limits in additional units (e.g., concentration units). The regulations mandate that, where limits are expressed in more than one unit, the permittee must comply with both.

Generally, mass-based limits ensure that proper treatment, and not dilution, is employed to comply with the final effluent concentration limits. Concentration-based effluent limits, on the other hand, discourage the reduction in treatment efficiency during low-flow periods and require proper operation of the treatment units at all times. In the absence of concentration-based effluent limits, a permittee would be able to increase its effluent concentration (i.e., reduce its level of treatment) during low-flow periods and still meet its mass-based limits. To account for this, this permit includes mass and concentration limits for some constituents, except during wet-weather, storm events that cause flows to the treatment plant to exceed the plant's design capacity.

3. ***Maximum Daily Effluent Limitations –*** Pursuant to 40 CFR section 122.45(d)(2), for POTWs continuous discharges, all permit effluent limitations, standards, and prohibitions, including those necessary to achieve water quality standards, shall, unless impracticable, be stated as average weekly and average monthly discharge limitations. It is impracticable to only include average weekly and average monthly effluent limitations in the permits, because a single daily discharge of certain pollutants, in excess amounts, can cause violations of water quality objectives. The effects of certain pollutants on aquatic organisms are often rapid. For many pollutants, an average weekly or average monthly effluent limitation alone is not sufficiently protective of beneficial uses. As a result, maximum daily effluent limitations, as referenced in 40 CFR section 122.45(d)(1), are included in the permit for certain constituents as discussed in the Fact Sheet accompanying this Order.

4. ***Pretreatment –*** Pursuant to 40 CFR section 403, the CSDLAC developed and has been implementing an approved industrial wastewater Pretreatment Program. This Order requires implementation of the approved Pretreatment Program.

5. ***Sludge Disposal -*** To implement CWA Section 405(d), on February 19, 1993, the USEPA promulgated 40 CFR, Part 503 to regulate the use and disposal of municipal sewage sludge. This regulation was amended on September 3, 1999. The regulation requires that producers of sewage sludge meet certain reporting, handling, and disposal requirements. It is the responsibility of the Discharger to comply with said regulations that are enforceable by USEPA, because California has not been delegated the authority to implement this program.

6. ***Storm Water Management –*** CWA section 402(p), as amended by the Water Quality Act of 1987, requires NPDES permits for storm water discharges. Pursuant to this requirement, in 1990, USEPA promulgated 40 CFR section 122.26 that established requirements for storm water discharges under an NPDES program. To facilitate compliance with federal regulations, on November 1991, the State Board issued a statewide general permit, *General NPDES Permit No. CAS000001 and Waste Discharge Requirements for Discharges of Storm Water Associated with Industrial Activities.* This permit was amended in September 1992 and reissued on April 17, 1997 in State Board Order No. 97-03-DWQ to regulate storm water discharges associated with industrial activity. The San Jose Creek WRP is covered by general NPDES permit No. CAS000001.

7. ***Clean Water Act Effluent Limitations -*** Numeric and narrative effluent limitations are established pursuant to Section 301 (Effluent Limitations), Section 302 (Water Quality-Related Effluent Limitations), Section 303 (Water Quality Standards and Implementation Plans), Section 304 (Information and Guidelines [Effluent]), Section 305 (Water Quality Inventory), Section 307 (Toxic and Pretreatment Effluent Standards), and Section 402 (NPDES) of the CWA. The CWA and amendments thereto are applicable to the discharges herein.

8. ***Antibacksliding Policies -*** Antibacksliding provisions are contained in Sections 303(d)(4) and 402(o) of the CWA and in 40 CFR, Section 122.44(l). Those provisions require a reissued permit to be as stringent as the previous permit with some exceptions. Section 402(o)(2) outlines six exceptions where effluent limitations

may be relaxed.

A. Section 402(o)(1) prohibits (subject to exceptions in section 303(d)(4) and/or 402(o)(2)) the relaxation of effluent limitations for two situations:

   a. When a permittee seeks to revise a technology-based effluent limitation based on BPJ to reflect a subsequently promulgated effluent guideline which is less stringent, and

   b. When a permittee seeks relaxation of an effluent limitation which is based upon a changed State treatment standard or water quality standard.

B. Section 402(o)(2) outlines specific exceptions to the general prohibition against establishment of less stringent effluent limitations. Codified in the NPDES regulations at 40 CFR 122.44(l), Section 402(o)(2) provided that the establishment of less stringent limits may be allowed where:

   a. There have been material and substantial alterations or additions to the permitted facility which justify this relaxation;

   b. New information (other than revised regulations, guidance, or test methods) is available that was not available at the time of permit issuance which would have justified a less stringent effluent limitation;

   c. Technical mistakes or mistaken interpretations of the law were made in issuing the permit under Section 402(a)(1)(b);

   d. Good cause exists due to events beyond the permittee's control (e.g., acts of God) and for which there is no reasonably available remedy;

   e. The permit has been modified under certain specified sections of the CWA; or,

   f. The permittee has installed and properly operated and maintained required treatment facilities, but still has been unable to meet the permit limitations (relaxation may only be allowed to the treatment levels actually achieved).

   Although the statute identified six exceptions where effluent limitations may be relaxed, the language specifically stated that exception "c" (as listed above) does not apply to water quality-based effluent limitations. Further, exception "e" as listed above only concerns sections of the CWA governing technology-based limits. Thus, exceptions c & e would only apply to technology-based effluent limitations.

C. Section 402(o)(3) prohibits the relaxation of effluent limitations in all cases if a revised effluent limitation would result in a violation of applicable effluent limitation guidelines or water quality standards, including antidegradation requirements. Thus, even if any of the antibacksliding exceptions outlined in

either the statute or regulations are applicable and met, Section 402(o)(3) acts as a floor and restricts the extent to which effluent limitations may be relaxed. This requirement affirms existing provisions of the CWA that require limits, standards, and conditions to ensure compliance with applicable technology-based limits and water quality standards.

9. ***Applicable Water Quality Objectives -*** 40 CFR, Section 122.44(d)(vi)(A) requires the establishment of numeric effluent limitations to attain and maintain applicable narrative water quality criteria to protect the designated beneficial use.

   The Basin Plan includes narrative and numeric WQOs. The CTR promulgates numeric aquatic life criteria for 23 toxic pollutants and numeric human health criteria for 57 toxic pollutants. A compliance schedule provision in the CTR and the SIP authorizes the State to issue schedules of compliance for new or revised NPDES permit limits based on the federal CTR criteria when certain conditions are met. Where numeric water quality objectives have not been established in the Basin Plan, 40 CFR, Section 122.44(d) specifies that WQBELs may be set based on USEPA criteria and supplemented, where necessary, by other relevant information to attain and maintain narrative water quality criteria to fully protect designated beneficial uses.

10. ***Types of Pollutants –*** For CWA regulatory purposes, pollutants are grouped into three general categories under the NPDES program: conventional, toxic, and non-conventional. By definition, there are five conventional pollutants (listed in 40 CFR 401.16) – 5-day biochemical oxygen demand, total suspended solids, fecal coliform, pH, and oil and grease. Toxic or "priority" pollutants are those defined in Section 307(a)(1) of the CWA (and listed in 40 CFR 401.15 and 40 CFR 423, Appendix A) and include heavy metals and organic compounds. Non-conventional pollutants are those which do not fall under either of the two previously described categories and include such parameters as ammonia, phosphorous, chemical oxygen demand, whole effluent toxicity, etc.

11. ***Technology-Based Limits for Municipal Facilities (POTWs) –*** Technology-based effluent limits require a minimum level of treatment for industrial/municipal point sources based on currently available treatment technologies while allowing the Discharger to use any available control techniques to meet the effluent limits. The 1972 CWA required POTWs to meet performance requirements based on available wastewater treatment technology. Section 301 of the CWA established a required performance level—referred to as "secondary treatment"—that all POTWs were required to meet by July 1, 1977. More specifically, Section 301(b)(1)(B) of the CWA required that USEPA develop secondary treatment standards for POTWs as defined in Section 304(d)(1). Based on this statutory requirement, USEPA developed national secondary treatment regulations, which are specified in 40 CFR 133. These technology-based regulations apply to all POTWs and identify the minimum level of effluent quality to be attained by secondary treatment in terms of five-day biochemical oxygen demand, total suspended solids, and pH.

12. ***Water Quality Based Effluent Limits (WQBELs) -*** Water quality-based effluent limits are designed to protect the quality of the receiving water by ensuring that State

water quality standards are met by discharges from an industrial/municipal point source. If, after technology-based effluent limits are applied, a point source discharge will cause, have the reasonable potential to cause, or contribute to an exceedance of an applicable water quality criterion, then 40 CFR 122.44(d)(1) requires that the permit contain a WQBEL. Although the CWA establishes explicit technology-based requirements for POTWs, Congress did not exempt POTWs from additional regulation to protect water quality standards. As a result, POTWs are also subject to WQBELs. This was upheld by the Appellate Court in *the City of Burbank, City of Los Angeles v. State Water Resources Control Board* case. Applicable water quality standards for the San Gabriel River are contained in the Basin Plan and CTR, as described in previous findings.

13. ***Water Quality Based Effluent Limitations for Toxic Pollutants.*** Toxic substances are regulated in this permit by water quality based effluent limitations derived from the 1994 Basin Plan, the CTR, and/or best professional judgment (BPJ) pursuant to Part 122.44. If a discharge causes, has a reasonable potential to cause, or contribute to a receiving water excursion above a narrative or numeric objective within a State water quality standard, federal law and regulations, as specified in 40 CFR 122.44(d)(1)(i), and in part, the SIP, require the establishment of WQBELs that will protect water quality. As documented in the fact sheet, pollutants exhibiting reasonable potential in the discharge, authorized in this Order, are identified in the Reasonable Potential Analysis (RPA) section and have final effluent limits. Reasonable potential was not triggered for some of the 126 priority pollutants and final limits cannot be determined at this time. The Discharger is required to gather the appropriate data and the Regional Board will determine if final effluent limits are needed. If final limits are needed, the permit will be reopened and limits will be included in the permit.

14. ***Basis for Effluent Limits for 303(d) Listed Pollutants -*** For 303(d) listed pollutants, the Regional Board plans to develop and adopt Total Maximum Daily Loads (TMDLs) which will specify wasteload allocations (WLAs) for point sources and load allocations (LA) for non-point sources, as appropriate. Following the adoption of TMDLs by the Regional Board, NPDES permits will be issued, and where appropriate, reopened to include effluent limits consistent with the assumptions of the TMDL, based on applicable WLAs. In the absence of a TMDL, the permits will include water quality-based effluent limitations derived as provided in the Basin Plan, CTR, and SIP (if applicable). These effluent limits are based on criteria applied end-of-pipe due to no mixing zone or dilution credits allowed.

15. ***303(d) Listed Pollutants***. On July 25, 2003, USEPA approved the State's most recent list of impaired waterbodies. The list (hereinafter referred to as the 303(d) list) was prepared in accordance with Section 303(d) of the Federal Clean Water Act to identify specific impaired waterbodies where water quality standards are not expected to be met after implementation of technology-based effluent limitations on point sources.

    The San Jose Creek, San Gabriel River, and their tributaries are on the 303(d) list for the following pollutants/ stressors, from point and non-point sources:

A. San Jose Creek Reach 1 (San Gabriel River confluence to Temple Street) -- Hydrologic Unit 405.41: Algae, Coliform,

B. San Gabriel River Reach 3 (Whittier Narrows to Ramona) -- Hydrologic Unit 405.41: Toxicity

C. San Gabriel River Reach 2 (Firestone to Whittier N. Dam) -- Hydrologic Unit 405.15: Coliform, Lead

D. San Gabriel River Reach 1(Estuary to Firestone) -- Hydrologic Unit 405.15: Abnormal fish histology, Algae, Coliform, Toxicity;

E. San Gabriel River Estuary -- Hydrologic unit 405.15: Abnormal fish histology.

The Regional Board revised the 303(d) list in 2002 and submitted the draft to the State Board for approval. The State Board had scheduled the draft 303(d) list, dated October 15, 2002, for approval at two of its meetings, however the item was postponed to hold additional workshops and to allow more time for the public to submit comments. The draft 303(d) list dated October 15, 2002, was revised on January 13, 2003, based on comments received. The draft 303(d) list, dated January 13, 2003, was adopted by the State Board at its February 4, 2003 meeting. The adopted 303(d) list was approved by USEPA on July 25, 2003.

16. ***Relevant Total Maximum Daily Loads -*** A TMDL is a determination of the amount of a pollutant, from point, nonpoint, and natural background sources, including a margin of safety, which may be discharged to a water quality-limited water body. Section 303(d) of the CWA established the TMDL process. The statutory requirements are codified at 40 CFR, Part 130.7. TMDLs must be developed for the pollutants of concern, which impact the water quality of water bodies on the 303(d) list. Under the federal consent decree, the San Gabriel River was listed for toxicity, algae, and metals. The ammonia listing was removed on the 2002 303(d) list because the POTWs were scheduled to implement nitrification/denitrification. Under the federal consent decree, USEPA was to establish TMDLs for algae and pollutants causing toxicity by March 22, 2004. USEPA has requested a multi-year extension of the consent decree deadline for the nutrient TMDL from the litigants. The approval of the extension is currently under review, and USEPA has been given a temporary 60-day extension (until May 21, 2004) while the litigants review the request for more time. Under the federal consent decree the, the San Gabriel River metals TMDL is scheduled to be adopted by the Regional Board by March 22, 2006.

17. ***Mixing Zones and Dilution Credits.*** Mixing zones, dilution credits, and attenuation factors are not allowed in this Order. Allowance of a mixing zone is in the Regional Board's discretion under Section 1.4.2 of the SIP and under the Basin Plan (Basin Plan Chapter 4, page 30). If the Discharger subsequently conducts appropriate mixing zone and dilution credit studies, the Regional Board can evaluate the propriety of granting a mixing zone or establishing dilution credits. The Regional Board has concluded mixing zones and dilution credits would be inappropriate to grant, at this time, in light of the following factors:

A. The San Jose Creek WRP discharge contributes the largest flow into the San Gabriel watershed in the vicinity of the discharge point it overwhelms the receiving water providing limited mixing and dilution;

B. Even in the absence of the San Jose Creek WRP discharge, the receiving water primarily consists of nuisance flows and other effluents, limiting its ability to assimilate additional waste;

C. Several reaches of the San Gabriel River [including those subject to this Order] are 303(d) listed (i.e., impaired) for certain constituents;

D. Impaired waters do not have the capacity to assimilate pollutants of concern at concentrations greater than the applicable objective;

E. For the protection of the beneficial uses is listed on VI.7.

F. Consistent with Antidegradation Policies;

G. Because a mixing zone study has not been fully conducted;

H. Because a hydrologic model of the discharge and the receiving water have not been conducted; and,

I. Because there has been no Site-specific Soil Attenuation Study nor Fate and Transportation Modeling performed.

18. Specific effluent limitations for each constituent contained in this Order were developed in accordance with the foregoing laws, regulations, plans, policies, and guidance. The specific methodology and example calculations are documented in the Fact Sheet prepared by Regional Board staff that accompanies this Order.

VIII. REASONABLE POTENTIAL ANALYSIS

1. As specified in 40 CFR Part 122.44(d)(1)(i), permits are required to include limits for all pollutants "which the Director (defined as the Regional Administrator, State Director, or authorized representative in 40 CFR Part 122.2) determines are or may be discharged at a level which will cause, have the reasonable potential to cause, or contribute to an excursion above any State water quality standard."

   A. Using the method described in the TSD, the Regional Board has conducted Reasonable Potential Analysis (RPA) for:

      a. Chronic Toxicity - RPA was conducted for Chronic Toxicity (Tables 1A and 1B of the accompanying Fact Sheet) using the discharger's effluent data. Chronic Toxicity effluent data is summarized in Tables 2A and 2B of the accompanying Fact Sheet. The RPA compares the effluent data with USEPA's 1 TUc water quality criteria. The Discharger's effluent demonstrated Chronic Toxicity during the last permit cycle. Based on this information, the Regional Board has determined that there is a

reasonable potential that the discharge will cause toxicity in the receiving water and, consistent with SIP section 4, the Order contains a narrative effluent limitation for Chronic Toxicity. The circumstances warranting a numeric Chronic Toxicity effluent limitation were reviewed by the State Board in SWRCB/OCC Files A-1496 & A-1496(a) [Los Coyotes/Long Beach Petitions]. On September 16, 2003, the State Board adopted Order No. WQO 2003-0012, deferring the numeric chronic toxicity effluent limitation issue until the adoption of Phase II of the SIP, and replaced the numeric chronic toxicity effluent limitation with a narrative effluent limitation for the time being.

b. Ammonia and other Nitrogen Species – RPA was conducted for Ammonia, Nitrate plus Nitrite as Nitrogen, and Nitrite Nitrogen (Tables 1A and 1B of the accompanying Fact Sheet) using the Discharger's effluent data. Ammonia Nitrogen, Nitrate plus Nitrite as Nitrogen, and Nitrite Nitrogen effluent data are summarized in Tables 2A and 2B of the accompanying Fact Sheet. Temperature and pH effluent data are summarized in Tables 3A and 3B of the accompanying Fact Sheet. The RPA compares the effluent data with the Basin Plan WQOs. The Discharger's projected effluent from San Jose Creek West Plant exceeded the Basin Plan WQOs for Ammonia during the last permit cycle. Based on this information, the Regional Board has determined that there is a reasonable potential that the discharge will cause or contribute to an exceedance of the Basin Plan WQOs and, consistent with 40 CFR 122.44(d), the Order contains numeric effluent limitations for Ammonia, based on the corresponding Basin Plan WQOs.

c. MBAS – RPA was conducted for MBAS (Tables 1A and 1B of the accompanying Fact Sheet) using the Discharger's effluent data from their self-monitoring reports. MBAS is summarized in Tables 2A and 2B of the accompanying Fact Sheet. The RPA compares the effluent data with the Basin Plan water quality objective (WQOs). The Discharger's projected effluent exceeded the Basin Plan WQOs for MBAS during the last permit cycle. Based on this information, the Regional Board has determined that there is a reasonable potential that the discharge will cause or contribute to an exceedance of the Basin Plan WQOs and, consistent with 40 CFR 122.44(d), the Order contains a numeric effluent limitation for MBAS.

B. Using the method described in the SIP, the Regional Board has conducted RPA using the discharger's effluent data contained in Table 4. The RPA compares the effluent data with water quality objectives in the Basin Plan and CTR.

a. ***Reasonable Potential Determination.*** The RPA (per the SIP) involves identifying the observed maximum pollutant concentration in the effluent (MEC) for each constituent based on the effluent concentration data. There are three tiers to determining reasonable potential. If any of the following three tiers is triggered, then reasonable potential exists:

i. For the first tier, the MEC is compared with the lowest applicable Water Quality Objective (WQO), which has been adjusted for pH, hardness and translator data, if appropriate. If the MEC is greater than the (adjusted) WQO, then there is reasonable potential for the constituent to cause or contribute to an excursion above the WQO and a WQBEL is required. However, if the pollutant was not detected in any of the effluent samples and all of the reported detection limits are greater than or equal to the WQO, proceed with Tier 2. The Regional Board exercised its discretion in identifying all available, valid, relevant, representative data and information in accordance with SIP Section 1.2 (Page 8).

ii. For the second tier, if the MEC is less than the adjusted WQO, then the observed maximum ambient background concentration (B) for the pollutant is compared with the adjusted WQO. If B is greater than the adjusted WQO, then a WQBEL is required. If B is less than the WQO, then a limit is only required under certain circumstances to protect beneficial uses. If a constituent was not detected in any of the effluent samples and all of the detection limits are greater than or equal to the adjusted WQO, then the ambient background water quality concentration is compared with the adjusted WQO. The Regional Board exercised its discretion in identifying all available, applicable ambient background data in accordance with SIP Section 1.4.3 (Page 16).

iii. For the third tier, other information is used to determine RPA, such as the current CWA 303(d) List. Section 1.3 of the SIP describes the type of information that can be considered in Tier 3.

For all parameters that have reasonable potential to cause or contribute to an exceedance of a WQO/criteria, numeric WQBELs are required. Section 1.4, Step 5 of the SIP (Page 8) states that MDELs shall be used for POTWs in place of average weekly limitations. WQBELs are based on CTR, USEPA water quality criteria, and Basin Plan objectives.

If the data are unavailable or insufficient to conduct the RPA for the pollutant, or if all reported detection limits of the pollutant in the effluent are greater than or equal to the WQO, the Regional Board shall establish interim requirements, in accordance with Section 2.2.2. of the SIP, that require additional monitoring for the pollutant in place of a WQBEL. The effluent monitoring data from July 1995 to November 2003 indicate that the following constituents were not detected and their lowest detection limits were greater than their WQO.

i. For San Jose Creek East WRP: 2,3,7,8-TCDD, acrylonitrile, benzidine, benzo(a)anthracene, 3,3'-dichlorobenzidine, 1,2-diphenylhydrazine, hexachlorobenzene, aldrin, chlordane, 44'-DDD, dieldrin, heptachlor, heptachlor epoxide, PCBs, and toxaphene.

ii. For San Jose Creek West WRP: 2,3,7,8-TCDD, acrylonitrile, benzidine, benzo(a)anthracene, 3,3'-dichlorobenzidine, 1,2-diphenylhydrazine, hexachlorobenzene, aldrin, chlordane, 44'-DDT, 44'-DDE, 44'-DDD, dieldrin, heptachlor, heptachlor epoxide, PCBs, and toxaphene.

Therefore these constituents require interim requirements. Section 2.4.5 of the SIP discusses how compliance will be determined in those cases. The Discharger should work with the laboratory to lower detection levels to meet applicable and reliable detection limits; follow procedures set forth in 40 CFR Part 136; and, report the status of their findings in the annual report. During the term of the permit, if and when monitoring with lowered detection limits shows any of the priority pollutants at levels exceeding the applicable WQOs, the Discharger will be required to initiate source identification and control for the particular pollutant. Appendix 4 of the SIP lists the minimum levels and laboratory techniques for each constituent.

Upon completion of the required monitoring, the Regional Board shall use the gathered data to conduct RPA and determine if a WQBEL is required. However, if Tier 1 or Tier 3 triggered reasonable potential for a pollutant, then the lack of receiving water data for Tier 2 evaluation would not prohibit the establishing of WQBELs in the permit.

A numerical limit has not been prescribed for a toxic constituent if it has been determined that it has no reasonable potential to cause or contribute to excursions of water quality standards. However, if the constituent had a limit in the previous permit, and if none of the Antibacksliding exceptions apply, then the limit will be retained. A narrative limit to comply with all water quality objectives is provided in *Standard Provisions* for the priority pollutants, which have no available numeric criteria.

b. ***RPA Data.*** The RPA was based on effluent monitoring data for July 1995 through November 2003. Tables 5A and 5B of the Fact Sheet summarizes the RPA, lists the constituents, and where available, the lowest, adjusted WQO, the MEC, the "Reasonable Potential" result, and the limits from the previous permit.

i. **Metals Water Quality Objective**. For metals, the lowest applicable WQO was expressed as total recoverable, and where applicable, adjusted for hardness. Regional Board Staff used a hardness value of 400 mg/L, which is the highest value allowed to convert the dissolved metal CTR criteria into the total recoverable metal form, although the San Jose Creek WRP's 18-month interim monitoring upstream receiving water data collected from July 2001 to December 2002 showed that the median value is 442.5 mg/L.

ii. **Interim Monitoring Requirements**. In accordance with the SIP, the Regional Board may impose interim monitoring requirements upon

the Discharger, so that the Discharger obtains adequate ambient, background water data for priority pollutants upstream of the discharge point as well as suitable effluent data. The Executive Officer directed the Discharger to begin an interim monitoring program for the duration of 18 months, beginning July 2001. The Discharger collected samples on a monthly basis for all priority pollutants, with the exception of asbestos and 2,3,7,8-TCDD that were sampled semiannually, and reporting the results quarterly to the Regional Board. Section 1.3, Step 8, of the SIP authorizes the Regional Board to use the gathered data to conduct RPA, as outlined in Steps 1 through 7, and determine if a water quality-based effluent limitation is required.

A reopener provision is included in this Order that allows the permit to be reopened to allow the inclusion of new numeric limitations for any constituent that exhibits reasonable potential to cause or contribute to exceedance of applicable water quality objectives.

C. The numeric limitations contained in this Order are intended to protect and maintain existing and potential beneficial uses of the receiving waters. Environmental benefits provided by these limitations are reasonable and necessary.

D. Regional Board Staff have determined the following constituents showing the potential to exceed their respective CTR criteria and Basin Plan WQC Title 22 GWR, and, therefore, require effluent limitations.

a. Copper, lead, mercury, selenium, cyanide, n-nitrosodimethylamine, 44-DDT, and 44-DDE – detected from San Jose Creek East WRP;

The concentration of selenium in the receiving water of the San Jose Creek is higher than that in the effluent. Therefore, selenium also requires CTR-based effluent limitations.

b. Mercury, selenium, cyanide, tetrachloroethylene, benzo(a)pyrene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene – detected from San Jose Creek West WRP.

The concentration of tetrachloroethylene in the effluent is higher than that in the Basin Plan WQC Title 22 GWR. Therefore, tetrachloroethylene also requires effluent limitations.

2. This Order is consistent with State and Federal antidegradation policies in that it does not authorize a change in the quantity of wastewater discharged by the facility, nor does it authorize a change or relaxation in the manner or level of treatment. As a result, both the quantity and quality of the discharge are expected to remain the same consistent with antidegradation policies. The accompanying monitoring and reporting program requires continued data collection and if monitoring data show a reasonable potential for a constituent to cause or contribute to an exceedance of

water quality standards, the permit will be reopened to incorporate appropriate WQBELs. Such an approach ensures that the discharge will adequately protect water quality standards for potential and existing uses and conforms with antidegradation policies and antibacksliding provisions.

IX. PROPOSED EFFLUENT LIMITATIONS

1. Numeric toxic constituent limitations are based on the Basin Plan the narrative water quality objective for toxic constituents, "All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in, human, plant, animal, or aquatic life"; on the CTR; and, the interpretation of the Basin Plan narrative criteria using USEPA's 304(a) nationally recommended water quality criteria. For toxic constituents that have no reasonable potential to cause or contribute to excursions of water quality objectives, no numerical limitations are prescribed.

2. Pursuant to 40 CFR 122.45(d)(2), for a POTWs continuous discharges, all permit effluent limitations, standards, and prohibitions, including those necessary to achieve water quality standards, shall, unless impracticable, be stated as average weekly and average monthly discharge limitations for POTWs. It is impracticable to only include average weekly and average monthly effluent limitations in the permit, because a single daily discharge of a pollutant, in excess amounts, can cause violations of water quality objectives. The effects of pollutants on aquatic organisms are often rapid. For many pollutants, an average weekly or average monthly effluent limitation alone is not sufficiently protective of beneficial uses. As a result, maximum daily effluent limitations, as referenced in 40 CFR 122.45(d)(1), are included in the permit.

3. Furthermore, Section 1.4 of the SIP requires the step-by-step procedure to "adjust" or convert CTR numeric criteria into Average Monthly Effluent Limitations (AMELs) and Maximum Daily Effluent Limitations (MDELs), for toxics.

   A. Step 3 of Section 1.4 of the SIP (page 6) lists the statistical equations that adjust CTR criteria for effluent variability.

   B. Step 5 of Section 1.4 of the SIP (page 8) lists the statistical equations that adjust CTR criteria for averaging periods and exceedance frequencies of the criteria/objectives. This section also reads, "For this method only, maximum daily effluent limitations shall be used for publicly-owned treatment works (POTWs) in place of average weekly limitations.

4. Table R is the spreadsheet that staff used to calculate the AMELs and MDELs for priority pollutants.

5. 40 CFR, Section 122.45(f)(1) requires that except under certain conditions, all permit limits, standards, or prohibitions be expressed in terms of mass units. 40 CFR, Section 122.45(f)(2) allows the permit writer, as its discretion, to express limits in additional units (e.g., concentration units). The regulations mandate that, where limits are expressed in more than one unit, the permittee must comply with both.

6. Generally, mass-based limits ensure that proper treatment, and not dilution, is employed to comply with the final effluent concentration limits. Concentration-based effluent limits, on the other hand, discourage the reduction in treatment efficiency during low-flow periods and require proper operation of the treatment units at all times. In the absence of concentration-based effluent limits, a permittee would be able to increase its effluent concentration (i.e., reduce its level of treatment) during low-flow periods and still meets its mass-based limits. To account for this, this permit includes mass and concentration limits for some constituents, except during wet-weather, storm events that cause flows to the treatment plant to exceed the plant's design capacity.

   A. Effluent Limitations

      a. Conventional and nonconventional pollutants

Constituent	Unit	Discharge Limitations		
		Monthly Average[1]	Weekly Average[1]	Daily Maximum[2]
Settleable solids[3]	ml/L	0.1	--	0.3
$BOD_{5@20°C}$[4]	mg/L	20	30	45
	lbs/day[5]	16,730	25,100	37,650
	lbs/day[6]	10,460	15,690	23,530
	lbs/day[7]	6,270	9,410	14,120
Suspended solids[4]	mg/L	15	40	45
	lbs/day[5]	12,550	33,460	37,640
	lbs/day[6]	7,840	20,910	23,530
	lbs/day[7]	4,710	12,550	14,120
Oil and Grease[8]	mg/L	10	--	15
	lbs/day[5]	8,370	--	12,550
	lbs/day[6]	5,230	--	7,840
	lbs/day[7]	3,140	--	4,710
Total residual chlorine[9]	mg/L	--	--	0.1
Total dissolved solids[10]	mg/L	750	--	--
	lbs/day[5]	627,410	--	--
	lbs/day[6]	392,130	--	--
	lbs/day[7]	235,280	--	--
Sulfate[10]	mg/L	300	--	--
	lbs/day[5]	250,960	--	--
	lbs/day[6]	156,850	--	--
	lbs/day[7]	94,110	--	--
Chloride[10]	mg/L	180[7]	--	--
	lbs/day[5]	150,580	--	--
	lbs/day[6]	94,110	--	--
	lbs/day[7]	56,470	--	--
Boron[10]	mg/L	1.0	--	--
	lbs/day[5]	830	--	--

Constituent	Unit	Discharge Limitations		
		Monthly Average[1]	Weekly Average[1]	Daily Maximum[2]
	lbs/day[6]	520	--	--
	lbs/day[7]	310	--	--
Fluoride[11]	mg/L	1.6	--	--
	lbs/day[5]	1,340	--	--
	lbs/day[6]	840	--	--
	lbs/day[7]	500	--	--
MBAS[12]	mg/L	0.5	--	--
	lbs/day[5]	420	--	--
	lbs/day[6]	260	--	--
	lbs/day[7]	160	--	--
Total ammonia [13]	mg/L	[14]	--	[15]
	lbs/day	[5, 6, 7]	--	[5, 6, 7]

Footnotes:

[1]. Average Monthly Discharge Limitation means the highest allowable average of daily discharge over a calendar month, calculated as the sum of all daily discharges measures during that month divided by the number of days on which monitoring was performed.

Average Weekly Discharge Limitation means the highest allowable average of daily discharge over a calendar week, calculated as the sum of all daily discharges measures during that week divided by the number of days on which monitoring was performed.

[2]. The daily maximum effluent concentration limit shall apply to both flow weighted 24-hour composite samples and grab samples, as specified in the Monitoring and Reporting Program (Attachment T).

[3]. See detailed information on the following Section IX.6.B.a.

[4]. See detailed information on the following Section IX.6.B.b.

[5]. The mass emission rates are based on the combined plant design flow rate of 100 mgd. During wet-weather storm events in which the flow exceeds the design capacity, the mass discharge rate limitations shall not apply, and concentration limitations will provide the only applicable effluent limitations.

[6]. For the San Jose Creek East WRP, the mass emission rates are based the plant design flow rate of 62.5 mgd. During wet-weather storm events in which the flow exceeds the design capacity, the mass discharge rate limitations shall not apply, and concentration limitations will provide the only applicable effluent limitations.

[7]. For the San Jose Creek West WRP, the mass emission rates are based the plant design flow rate of 37.5 mgd. During wet-weather storm events in which the flow exceeds the design capacity, the mass discharge rate limitations shall not apply, and concentration limitations will provide the only applicable effluent limitations.

[8]. See detailed information on the following Section IX.6.B.c.

[9]. For the determination of compliance with total residual chlorine limit, one of the following applies:

- Total residual chlorine concentration excursions of up to 0.3 mg/L, at the point in treatment train immediately following dechlorination, shall not be considered violations of this requirement provided the total duration of such excursions do not exceed 15 minutes during any calendar day. Peaks in excess of 0.3 mg/L lasting less than one minute shall not be considered a violation of this requirement; or

- For continuous total residual chlorine recording devices that require greater than one minute to level off after the detection of a spike: if it can be demonstrated that a stoichiometrically appropriate amount of dechlorination chemical has been added to effectively dechlorinate the effluent to 0.1 mg/L or less, then the exceedance over one minute, but not for more than five minutes, will not be considered to be a violation.

See more information on the following Section IX.6.B.d.

[10]. See detailed information on the following Section IX.6.B.e.

[11]. See detailed information on the following Section IX.6.B.f.

[12]. See detailed information on the following Section IX.6.B.g.

[13]. See detailed information on the following Section IX.6.B.h.

[14]. The Discharger must comply with the updated ammonia water quality objectives in the Basin Plan, Table 3-3 (Attachment H) which resulted from Resolution No. 2002-011 adopted by the Regional Board on April 25, 2002.

For compliance with Criteria Continuous Concentration (CCC) in the Attachment H, the pH and temperature samples collected in the receiving water downstream of the discharge and the ammonia nitrogen sample collected in the effluent, shall be taken and reported at the same time. Shall there be no receiving water present, the pH and temperature of the effluent at the end of pipe shall be determined and reported.

[15]. The Discharger must comply with the updated ammonia water quality objectives in the Basin Plan, Table 3-1 (Attachment H) which resulted from Resolution No. 2002-011 adopted by the Regional Board on April 25, 2002.
For compliance with Criteria Maximum Concentration (CMC) in the Attachment H, the pH sample collected in the receiving water downstream of the discharge and the ammonia nitrogen sample collected in the effluent, shall be taken and reported at the same time. Should there be no receiving water present, the pH of the effluent at the end of pipe shall be determined and reported.

B. Basis for conventional and nonconventional pollutants

a. *Settleable solids*

Excessive deposition of sediments can destroy spawning habitat, blanket benthic (bottom dwelling) organisms, and abrade the gills of larval fish. The limits for settleable solids are based on the Basin Plan (page 3-16) narrative, "Waters shall not contain suspended or settleable material in concentrations that cause nuisance or adversely affect beneficial uses." The numeric limits are empirically based on results obtained from the settleable solids 1-hour test, using an Imhoff cone.

It is impracticable to use a weekly average limitation, because short term spikes of settleable solid levels that would be permissible under a weekly average scheme would not be adequately protective of all beneficial uses. The monthly average and the daily maximum limits cannot be removed because none of the antibacksliding exceptions apply. The monthly average and daily maximum limits were both included in the previous permit (Order 95-076) and the San Jose Creek WRP has been able to meet both limits.

b. *Biochemical Oxygen Demand (BOD) and Suspended solids*

Biochemical oxygen demand (BOD) is a measure of the quantity of the organic matter in the water and, therefore, the water's potential for becoming depleted in dissolved oxygen. As organic degradation takes place, bacteria and other decomposers use the oxygen in the water for respiration. Unless there is a steady resupply of oxygen to the system, the water will quickly become depleted of oxygen. Adequate dissolved oxygen levels are required to support aquatic life. Depressions of dissolved oxygen can lead to anaerobic conditions resulting in odors, or, in extreme cases, in fish kills.

40 CFR, Part 133 describes the minimum level of effluent quality attainable by secondary treatment, for BOD and suspended solids, as:

i. the monthly average shall not exceed 30 mg/L; and,

ii. the weekly average shall not exceed 45 mg/L.

San Jose Creek WRP provides tertiary treatment, as such, the limits in the permit are more stringent than secondary treatment requirements. The Plant achieves solids removal that are better than secondary-treated wastewater by adding a polymer (Alum) to enhance the precipitation of solids, and by filtering the effluent.

The monthly average, the weekly average, and the daily maximum limits cannot be removed because none of the antibacksliding exceptions apply. Those limits were all included in the previous permit (Order 95-079) and the

San Jose Creek WRP has been able to meet all three limits (monthly average, the weekly average, and the daily maximum), for both BOD and suspended solids.

In addition to having mass-based and concentration-based effluent limitations for BOD and suspended solids, the San Jose Creek WRP also has a percent removal requirement for these two constituents. In accordance with 40 CFR, Sections 133.102(a)(3) and 133.102(b)(3), the 30-day average percent removal shall not be less than 85 percent. Percent removal is defined as a percentage expression of the removal efficiency across a treatment plant for a given pollutant parameter, as determined from the monthly average values of the raw wastewater influent pollutant concentrations to the facility and the monthly average values of the effluent pollutant concentrations for a given time period.

c. *Oil and grease*

Oil and grease are not readily soluble in water and form a film on the water surface. Oily films can coat birds and aquatic organisms, impacting respiration and thermal regulation, and causing death. Oil and grease can also cause nuisance conditions (odors and taste), are aesthetically unpleasant, and can restrict a wide variety of beneficial uses. The limits for oil and grease are based on the Basin Plan (page 3-11) narrative, "Waters shall not contain oils, greases, waxes, or other materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, that cause nuisance, or that otherwise adversely affect beneficial uses."

The numeric limits are empirically based on concentrations at which an oily sheen becomes visible in water. It is impracticable to use a weekly average limitation, because spikes that occur under a weekly average scheme could cause visible oil sheen. A weekly average scheme would not be sufficiently protective of beneficial uses. The monthly average and the daily maximum limits cannot be removed because none of the antibacksliding exceptions apply. Both limits were included in the previous permit (Order 95-076) and the San Jose Creek WRP has been able to meet both limits.

d. *Residual chlorine*

Disinfection of wastewaters with chlorine produces chlorine residual. Chlorine and its reaction products are toxic to aquatic life. The limit for residual chlorine is based on the Basin Plan (page 3-9) narrative, "Chlorine residual shall not be present in surface water discharges at concentrations that exceed 0.1 mg/L and shall not persist in receiving waters at any concentration that causes impairment of beneficial uses."

It is impracticable to use a weekly average or a monthly average limitation, because it is not as protective as of beneficial uses as a daily maximum

limitation is. Chlorine is very toxic to aquatic life and short-term exposures of chlorine may cause fish kills.

e. *Total Dissolved Solids, Chloride, Sulfate, and Boron*

The limits for total dissolved solids (950 mg/L), sulfate (300 mg/L), and boron (1.0 mg/L) are based on Basin Plan Table 3-8 (page 3-13), for the San Gabriel River watershed (between Ramona Blvd. and Firestone Blvd.). The limits for Chloride (180 mg/L) is based on the Resolution No.97-072. It is practicable to express these limits as monthly averages, since they are not expected to cause acute effects on beneficial uses.

f. *Fluoride*

The 1.6 mg/L limit for fluoride is based on Basin Plan Table 3-6, *Air Temperature and Fluoride Water Quality Objectives* at the corresponding average air temperature of 79.2°F. The average temperature was calculated by taking the arithmetic mean of the maximum daily temperature readings over the past 30 years in the City of Whittier. However, if the CSDLAC provides data showing that the average air temperature differs from 79.2°F, then the permit may be reopened to revise the fluoride limit, if necessary.

g. *Methylene Blue Activated Substances (MBAS)*

The MBAS procedure tests for the presence of anionic surfactants (detergents) in surface and ground waters. Surfactants disturb the water surface tension, which affects insects and can affect gills in aquatic life. The MBAS can also impart an unpleasant soapy taste to water, as well as cause scum and foaming in waters, which impact the aesthetic quality of both surface and ground waters.

Given the nature of the facility (a POTW) which accepts domestic wastewater into the sewer system and treatment plant, and the characteristics of the wastes discharged, the discharge has reasonable potential to exceed both the numeric MBAS water quality objective (WQO) and the narrative WQO for prohibition of floating material such as foams and scums. Therefore an effluent limitation is required.

In self-monitoring reports submitted to the Regional Board under MRP requirements, the Discharger has reported MBAS concentrations in the effluent in excess of 0.5 mg/L. The 0.5 mg/L concentration (which has been determined to be protective of beneficial uses and the aesthetic quality of waters), is based on the Department of Health Services' secondary drinking water standard, and on the Basin Plan WQO (p.3-11) which reads, "Waters shall not have MBAS concentrations greater than 0.5 mg/L in waters designated MUN." While the wastewater from this POTW is not directly discharged into a MUN designated surface water body, it will percolate into unlined reaches of the Santa Clara River [via ground water recharge

designated beneficial use (GWR)] to ground water designated for MUN beneficial use. In addition, the Basin Plan states that "Ground water shall not contain taste or odor-producing substances in concentrations that cause nuisance or adversely affect beneficial uses." Therefore, the secondary MCL should be the MBAS limit for this discharge to protect ground water recharge and the MUN use of the underlying ground water, while also protecting surface waters from exhibiting scum or foaming.

Since the Basin Plan objective is based on a secondary drinking water standard, it is practicable to have a monthly average limitation in the permit.

h. *Ammonia as N*

i. Ammonia is a pollutant routinely found in the wastewater effluent of POTWs, in landfill-leachate, as well as in run-off from agricultural fields where commercial fertilizers and animal manure are applied. Ammonia exists in two forms – un-ionized ammonia (NH_3) and the ammonium ion (NH_4^+). They are both toxic, but the neutral, un-ionized ammonia species (NH_3) is much more toxic, because it is able to diffuse across the epithelial membranes of aquatic organisms much more readily than the charged ammonium ion. The form of ammonia is primarily a function of pH, but it is also affected by temperature and other factors. Additional impacts can also occur as the oxidation of ammonia lowers the dissolved oxygen content of the water, further stressing aquatic organisms. Oxidation of ammonia to nitrate may lead to groundwater impacts in areas of recharge. [There is groundwater recharge in these reaches]. Ammonia also combines with chlorine (often both are present in POTW treated effluent discharges) to form chloramines – persistent toxic compounds that extend the effects of ammonia and chlorine downstream.

ii. Ammonia is 303(d) listed in the San Gabriel River and San Jose Creek. Since ammonia has reasonable potential to cause or contribute to an excursion of a water quality objective, a water quality-based effluent limitation for total ammonia is required in order to be protective of the water quality objective.

iii. The 1994 Basin Plan contained water quality objectives for ammonia to protect aquatic life, in Tables 3-1 through Tables 3-4. However, those ammonia objectives were revised on April 25, 2002, by the Regional Board, with the adoption of Resolution No. 2002-011, *Amendment to the Water Quality Control Plan for the Los Angeles Region to Update the Ammonia Objectives for Inland Surface Waters (including enclosed bays, estuaries and wetlands) with Beneficial Use designations for protection of Aquatic Life*. Resolution No. 2002-011 was approved by the State Board, the Office of Administrative Law, and USEPA on April 30, 2003, June 5, 2003, and June 19, 2003, respectively, and is now in effect. The

final effluent limitations for ammonia prescribed in this Order are based on the revised ammonia criteria (see Attachment H) and apply at the end of pipe.

i. *Coliform/Bacteria*

Total and fecal coliform bacteria are used to indicate the likelihood of pathogenic bacteria in surface waters. Given the nature of the facility, a wastewater treatment plant, pathogens are likely to be present in the effluent in cases where the disinfection process is not operating adequately. As such, the permit contains the following:

i. Effluent Limitations:

- The 7 day median number of coliform organisms at some point in the treatment process must not exceed 2.2 Most Probable Number (MPN) per 100 milliliters, and

- The number of coliform organisms must not exceed 23 MPN per 100 milliliters in more than one sample within any 30-day period.

These disinfection-based effluent limitations for coliform are for human health protection and are consistent with requirements established by the Department of Health Services. These limits for coliform must be met at the point of the treatment train immediately following disinfection, as a measure of the effectiveness of the disinfection process.

ii. Receiving Water Limitation

- Geometric Mean Limits

  * E.coli density shall not exceed 126/100 mL.

  * Fecal coliform density shall not exceed 200/100 mL.

- Single Sample Limits

  * E.coli density shall not exceed 235/100 mL.

  * Fecal coliform density shall not exceed 400/100 mL.

These receiving water limitations are based on Resolution No. 01-018, Amendment to the Water Quality Control Plan for the Los Angeles Region to Update the Bacteria Objectives for Water Bodies Designated for Water Contact Recreation, adopted by the Regional Board on October 25, 2001. The Resolution was approved by State

Board, OAL, and USEPA, on July 18, 2002, September 19, 2002, and September 25, 2002, respectively.

j. *pH*

The hydrogen ion activity of water (pH) is measured on a logarithmic scale, ranging from 0 to 14. While the pH of "pure" water at 25°C is 7.0, the pH of natural waters is usually slightly basic due to the solubility of carbon dioxide from the atmosphere. Minor changes from natural conditions can harm aquatic life. The effluent limitation for pH which reads, "the wastes discharged shall at all times be within the range of 6.5 to 8.5," is taken from the Basin Plan (page 3-15) which reads" the pH of inland surface waters shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharge.

k. *Turbidity*

Turbidity is an expression of the optical property that causes light to be scattered in water due to particulate matter such as clay, silt, organic matter, and microscopic organisms. Turbidity can result in a variety of water quality impairments. The effluent limitation for turbidity which reads, "For the protection of the water contact recreation beneficial use, the wastes discharged to water courses shall have received adequate treatment, so that the turbidity of the wastewater does not exceed: (a) a daily average of 2 Nephelometric turbidity units (NTUs); and (b) 5 NTUs more than 5 percent of the time (72 minutes) during any 24 hour period," is based on the Basin Plan (page 3-17).

l. *Radioactivity*

Radioactive substances are generally present in natural waters in extremely low concentrations. Mining or industrial activities increase the amount of radioactive substances in waters to levels that are harmful to aquatic life, wildlife, or humans. The existing effluent limitation for radioactivity which reads, "Radioactivity of the wastes discharged shall not exceed the limits specified in Title 22, Chapter 15, Article 5, Section 64443, of the California Code of Regulations, or subsequent revisions," is based on the Basin Plan incorporation of Title 22, *Drinking Water Standards,* by reference, to protect the surface water MUN beneficial use. However, the Regional Board has new information about the appropriate designated uses for the water body, and based on the current designated uses, a limit for Radioactivity is unnecessary and inappropriate unless discharge is to a reach used for groundwater recharge, where Title 22-based limits apply. Therefore, the accompanying Order will contain a limit for radioactivity to protect the GWR beneficial use.

C. Toxicity

Ambient monitoring data indicates that the background concentration in the lower San Gabriel River is toxic to aquatic organisms, and therefore exceeds water quality standards. Final effluent water quality data, contained in the Discharger's monitoring reports, also shows that chronic toxicity in the effluent has exceeded 1TUc (EPA WQO) several times. Therefore, pursuant to the TSD, reasonable potential exists for toxicity. As such, the permit should contain a numeric effluent limitation for toxicity.

The following support the inclusion of toxicity numeric effluent limitations for chronic toxicity:

a. 40 CFR 122.2 (Definition of Effluent Limitation);

b. 40 CFR 122.44(d)(v) – limits on whole effluent toxicity are necessary when chemical-specific limits are not sufficient to attain and maintain applicable numeric or narrative water quality standards;

c. 40 CFR 122.44(d)(vi)(A) – where a State has not developed a water quality criterion for a specific pollutant that is present in the effluent and has reasonable potential, the permitting authority can establish effluent limits using numeric water quality criterion;

d. Basin Plan objectives and implementation provisions for toxicity;

e. Regions 9 & 10 Guidance for Implementing Whole Effluent Toxicity Programs Final May 31, 1996;

f. Whole Effluent Toxicity (WET) Control Policy July 1994; and,

g. Technical Support Document (several chapters and Appendix B).

However, the circumstances warranting a numeric chronic toxicity effluent limitation when there is reasonable potential were under review by the State Water Resources Control Board (State Board) in SWRCB/OCC Files A-1496 & A-1496(a) [Los Coyotes/Long Beach Petitions]. On September 17, 2003, at a public hearing, the State Board decided to defer the issue of numeric chronic toxicity effluent limitations until Phase II of the SIP is adopted. In the mean time, the State Board replaced the numeric chronic toxicity limit with a narrative effluent limitation and a 1 TUc trigger, in the Long Beach and Los Coyotes WRP NPDES permits. This permit contains a similar chronic toxicity effluent limitation. This Order also contains a reopener to allow the Regional Board to modify the permit, if necessary, consistent with any new policy, law, or regulation.

Acute Toxicity Limitation:

The Dischargers may test for Acute toxicity by using USEPA's *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*, October 2002 (EPA-821-R-02-012). Acute toxicity provisions in the accompanying Order are derived from the Basin Plan's toxicity standards (Basin Plan 3-16 and 3-17). The provisions require the Discharger to accelerate acute toxicity monitoring and take further actions to identify the source of toxicity and to reduce acute toxicity.

Chronic Toxicity Limitation and Requirements:

Chronic toxicity provisions in the accompanying Order are derived from the Basin Plan's toxicity standards (Basin Plan 3-16 and 3-17). The provisions require the Discharger to accelerate chronic toxicity monitoring and take further actions to identify the source of toxicity and to reduce chronic toxicity. The monthly median trigger of 1.0 TU_c for chronic toxicity is based on *USEPA Regions 9 & 10 Guidance for Implementing Whole Effluent Toxicity (WET) Programs* Final May 31, 1996 (Chapter 2 – Developing WET Permitting Conditions, page 2-8). In cases where effluent receives no dilution or where mixing zones are not allowed, the 1.0 TU_c chronic criterion should be expressed as a monthly median. The "median" is defined as the middle value in a distribution, above which and below which lie an equal number of values. For example, if the results of the WET testing for a month were 1.5, 1.0, and 1.0 TU_c, the median would be 1.0 TU_c trigger.

The *USEPA Regions 9 & 10 Guidance for Implementing Whole Effluent Toxicity (WET) Programs* Final May 31, 1996 (Chapter 2 – Developing WET Permitting Conditions, page 2-8) recommends two alternatives: using 2.0 TUc as the maximum daily limit; or using a statistical approach to develop a maximum daily effluent limitation.

D. Limits for priority pollutants on Discharge Serial No. 001, 001A, and 001B (from East and West plants):

CTR #[1]	Constituent	Units	Discharge Limitations	
			Monthly Average[2]	Daily Maximum
6	Copper[3, 4, 5]	µg/L	24[7,8]	52[7,8]
		lbs/day[6]	20[8]	43[8]
7	Lead[3, 4, 5]	µg/L	13[7,8]	34[7,8]
		lbs/day[6]	11[8]	28[8]
8	Mercury[3, 5]	µg/L	0.051[7,8]	0.10[7,8]
		lbs/day[6]	0.043[8]	0. 084[8]
10	Selenium[3, 5]	µg/L	3.3-4.3[7,8,9]	7.7-9.2[7,8,10]
		lbs/day[6]	3.3[8,11]	6.9[8,12]
14	Cyanide[5]	µg/L	4.3[7,8]	8.5[7,8]
		lbs/day[6]	3.6[8]	7.1[8]

CTR #[1]	Constituent	Units	Discharge Limitations	
			Monthly Average[2]	Daily Maximum
38	Tetrachloroethylene[5]	µg/L	5[13]	--
		lbs/day[6]	4.2[13]	--
61	Benzo(a)pyrene[5]	µg/L	0.049[7,8]	0.098[7,8]
		lbs/day[6]	0. 041[8]	0. 082[8]
64	Benzo(k)fluoranthene[5]	µg/L	0.049[7,8]	0.14[7,8]
		lbs/day[6]	0. 041[8]	0.12[8]
74	Dibenzo(a,h)anthracene[5]	µg/L	0.049[7,8]	0.13[7,8]
		lbs/day[6]	0. 041[8]	0.11[8]
92	Indeno(1,2,3-cd)pyrene[5]	µg/L	0.049[7,8]	0.098[7,8]
		lbs/day[6]	0. 041[8]	0. 082[8]
96	N-Nitrosodimethylamine[5] (NDMA)	µg/L	8.1[7,8]	16[7,8]
		lbs/day[6]	6.8[8]	13[8]
108	4,4-DDT[5]	µg/L	0.00059[7,8]	0.0012[7,8]
		lbs/day[6]	0.00049[8]	0.0010[8]
109	4,4-DDE[5]	µg/L	0.00059[7,8]	0.0012[7,8]
		lbs/day[6]	0.00049[8]	0.0010[8]

E. Limits for priority pollutants on Discharge Serial No. 002 (from East plant):

CTR # [1]	Constituent	Units	Discharge Limitations	
			Monthly Average[2]	Daily Maximum
6	Copper[3, 4, 5]	µg/L	24[7,8]	52[7,8]
		lbs/day[6]	13[8]	27[8]
7	Lead[3, 4, 5]	µg/L	13[7,8]	34[7,8]
		lbs/day[6]	6.8[8]	18[8]
8	Mercury[3, 5]	µg/L	0.051[7,8]	0.10[7,8]
		lbs/day[6]	0.027[8]	0.052[8]
10	Selenium[3, 5]	µg/L	4.3[7,8]	7.7[7,8]
		lbs/day[6]	2.2[8]	4.0[8]
14	Cyanide[5]	µg/L	4.3[7,8]	8.5[7,8]
		lbs/day[6]	2.2[8]	4.4[8]
96	N-Nitrosodimethylamine[5] (NDMA)	µg/L	8.1[7,8]	16[7,8]
		lbs/day[6]	4.2[8]	8.4[8]
108	4,4'-DDT[5]	µg/L	0.00059[7,8]	0.0012[7,8]
		lbs/day[6]	0.00031[8]	0.00063[8]
109	4,4'-DDE[5]	µg/L	0.00059[7,8]	0.0012[7,8]
		lbs/day[6]	0.00031[8]	0.00063[8]

F. Limits for priority pollutants on Discharge Serial No. 003 (from West plant):

CTR # [1]	Constituent	Units	Discharge Limitations	
			Monthly Average[2]	Daily Maximum
8	Mercury[3, 5]	µg/L	0.051[7,8]	0.10[7,8]
		lbs/day[6]	0.016[8]	0.031[8]
10	Selenium[3, 5]	µg/L	3.3[7,8]	9.2[7,8]
		lbs/day[6]	1.0[8]	2.9[8]
14	Cyanide[5]	µg/L	4.3[7,8]	8.5[7,8]
		lbs/day[6]	1.3[8]	2.7[8]
38	Tetrachloroethylene[5]	µg/L	5[13]	--
		lbs/day[6]	1.6[13]	--
61	Benzo(a)pyrene[5]	µg/L	0.049[7,8]	0.098[7,8]
		lbs/day[6]	0.015[8]	0.031[8]
64	Benzo(k)fluoranthene[5]	µg/L	0.049[7,8]	0.14[7,8]
		lbs/day[6]	0.015[8]	0.044[8]
74	Dibenzo(a,h)anthracene[5]	µg/L	0.049[7,8]	0.13[7,8]
		lbs/day[6]	0.015[8]	0.041[8]
92	Indeno(1,2,3-cd)pyrene[5]	µg/L	0.049[7,8]	0.098[7,8]
		lbs/day[6]	0.015[8]	0.031[8]

Footnote:

[1]. This number corresponds to the compound number found in Table 1 of CTR. It is simply the order in which the 126 priority pollutants were listed in 40 CFR section 131.38 (b)(1).

[2]. Use the requirements in WDR Section IV.5. - Compliance Determination.

[3]. Concentration expressed as total recoverable.

[4]. Receiving water samples collected at sampling station C-1 (located upstream of the plant, along San Jose Creek), as part of the 18-month interim monitoring, revealed that the median hardness was 442.5 mg/L. However, a hardness value of 400 mg/L was used to convert the dissolved metal CTR criteria into the total recoverable metal form, because the CTR does not allow using a hardness value in excess of 400 mg/L.

[5]. This constituent shows reasonable potential.

[6]. The mass emission rates are based on the combined plant design flow rate of 100 mgd. For the San Jose Creek East WRP, the mass emission rates are based the plant design flow rate of 62.5 mgd. For the San Jose Creek West WRP, the mass emission rates are based the plant design flow rate of 37.5 mgd. During wet-weather storm events in which the flow exceeds the design capacity, the mass discharge rate limitations shall not apply, and concentration limitations will provide the only applicable effluent limitations.

[7]. For priority pollutants, Section 2.4.5 of CTR *Compliance Determination*, reads, "Dischargers shall be deemed out of compliance with an effluent limitation if the concentration of the priority pollutant in the monitoring sample is greater than the effluent limitation and greater than or equal to the reported ML."

[8]. This effluent limitation will not be in effect until May 10, 2009, and until that time the Discharger shall comply with the interim limits established in I.1.I.a. of WDR.

[9]. $$\text{Monthly Average (Concentration)} = \frac{4.3 \times \text{East Flow} + 3.3 \times \text{West Flow}}{\text{East Flow} + \text{West Flow}}$$

If the entire flow of wastewater is from either the East or West plant, then the final effluent concentrations cannot be greater than either 4.3 or 3.3 µg/L, respectively.

If there is a mixed contribution of flow of wastewater from the East and West plants, then the final effluent concentrations are calculated using the above flow-weighted formula.

[10]. $$\text{Daily Maximum (Concentration)} = \frac{7.7 \times \text{East Flow} + 9.2 \times \text{West Flow}}{\text{East Flow} + \text{West Flow}}$$

If the entire flow of wastewater is from either East or West plant, then the final effluent concentrations cannot be greater than either 7.7 or 9.2 µg/L, respectively.

If there is a mixed contribution of flow of wastewater from the East and West plants, then the final effluent concentrations are calculated using the above flow-weighted formula.

[11]. $$\text{Monthly Average (Mass)} = (4.3\mu g/L \times 62.5MGD + 3.3\mu g/L \times 37.5MGD) \times 0.00834$$

[12]. $$\text{Daily Maximum(Mass)} = (7.7\mu g/L \times 62.5MGD + 9.2\mu g/L \times 37.5MGD) \times 0.00834$$

[13]. This effluent limitation will not be in effect until May 10, 2009, and until that time the Discharger shall comply with the interim limits established in the accompanying Time Schedule Order No. R4-2004-0098.

E. Basis for priority pollutants:

Mixing zones, dilution credits, and attenuation factors are not used in the accompanying order and would be inappropriate to grant, at this time, in light of the factors discussed in Section VII.17.A. through I of this Fact Sheet.

Allowance of a mixing zone is in the Regional Board's discretion under Section 1.4.2 of the SIP and under the Basin Plan (Basin Plan Chapter 4, page 30). If the Discharger subsequently conducts appropriate mixing zone and dilution credit studies, the Regional Board can evaluate the propriety of granting a mixing zone or establishing dilution credits.

F. Example calculation: Mercury

Is a limit required? What is RPA?

a. From Attachment A, *Reasonable Potential & Limit Derivation*, we determined that Reasonable potential analysis (RPA) = Yes, therefore a limit is required.

Step 1: Identify applicable water quality criteria.

From California Toxics Rule (CTR), we can obtain the Criterion Maximum Concentration (CMC) and the Criterion Continuous Concentration (CCC).

Freshwater Aquatic Life Criteria:
CMC = NA µg/L (CTR page 31712, column B1) and
CCC = NA µg/L (CTR page 31712, column B1); and
Human Health Criteria for Water & Organisms = 0.051µg/L (CTR page 31712, column D2).

Step 2: Calculate effluent concentration allowance (ECA)

ECA = Criteria in CTR, since no dilution is allowed.

Step 3: Determine long-term average (LTA) discharge condition

i. Calculate CV:

CV = Standard Deviation / Mean
= 0.6 (By default because data was > 80% nondetect, SIP page 6)

ii. Find the ECA Multipliers from SIP Table 1 (page 7), or by calculating them using equations on SIP page 6. When CV = 0.6, then:

ECA Multiplier acute = 0.321 and
ECA Multiplier acute = 0.527.

iii. LTA acute = ECA acute x ECA Multiplier acute
= NA µg/L x 0.321 = NA µg/L

iv. LTA chronic = ECA chronic x ECA Multiplier chronic
= NA µg/L x 0.527 = NA µg/L

Step 4: Select the lowest LTA

In this case, the lowest LTA is not applicable.

Step 5: Calculate the Average Monthly Effluent Limitation (AMEL) & Maximum Daily Effluent Limitation (MDEL) for AQUATIC LIFE

i. Find the multipliers. You need to know CV and n (frequency of sample collection per month). If effluent samples are collected 4 times a month or less, then n = 4. CV was determined to be 0.6 in a previous step.

AMEL Multiplier = 1.552
MDEL Multiplier = 3.114

ii. AMEL aquatic life = lowest LTA (from Step4) x AMEL Multiplier
= NA µg/L x 1.552 = NA µg/L

iii. MDEL aquatic life = lowest LTA (from Step4) x AMEL Multiplier
= NA µg/L x 3.114 = NA µg/L

Step 6: Find the Average Monthly Effluent Limitation (AMEL) & Maximum Daily Effluent Limitation (MDEL) for HUMAN HEALTH

i. Find factors. Given CV = 0.6 and n = 4.

For AMEL human health limit, there is no factor.
The MDEL/AMEL human health factor = 2.01

ii. AMEL human health = ECA = 0.051 µg/L

iii. MDEL human health = ECA x MDEL/AMEL factor
= 0.051 µg/L x 2.01 = 0.103 µg/L

Step 7: Compare the AMELs for Aquatic life and Human health and select the lowest. Compare the MDELs for Aquatic life and Human health and select the lowest

i. Lowest AMEL = 0.051 µg/L (Based on Human Health protection)

ii. Lowest MDEL = 0.103 µg/L (Based on Human Health protection)

G. A numerical limit has not been prescribed for a toxic constituent if it has been determined that it has no reasonable potential to cause or contribute to excursions of water quality standards. A narrative limit to comply with all water quality objectives is provided in *Standard Provisions* for the priority pollutants, which have no available numeric criteria.

H. The numeric limitations contained in the accompanying Order were derived using best professional judgement and are based on applicable state and federal authorities, and as they are met, will be in conformance with the goals of the aforementioned water quality control plans, and water quality criteria; and will protect and maintain existing and potential beneficial uses of the receiving waters.

X. INTERIM REQUIREMENTS

1. Pollutant Minimization Program

A. The accompanying Order provides for the use of Pollutant Minimization Program, developed in conformance with Section 2.4.5.1 of the SIP, when there is evidence (e.g., sample results reported as DNQ when the effluent limitation is less than the MDL, sample results from analytical methods more sensitive than those methods included in the permit in accordance with sections 2.4.2 or 2.4.3 above, presence of whole effluent toxicity, health advisories for fish consumption, results of benthic or aquatic organisms tissue sampling) that a priority pollutant is present in the discharger's effluent above an effluent limitation.

B. The Discharger shall develop a Pollutant Minimization Program (PMP), in accordance with Section 2.4.5.1.,of the SIP, if all of the following conditions are true, and shall submit the PMP to the Regional Board within 120 days of determining the conditions are true:

a. when there is evidence that the priority pollutant is present in the effluent above an effluent limitation and either:

i. A sample result is reported as detected but not quantified (DNQ) and the effluent limitation is less than the reported ML; or

ii. A sample result is reported as nondetect (ND) and the effluent limitation is less than the MDL.

b. Examples of evidence that the priority pollutant is present in the effluent above an effluent limitation are:

i. sample results reported as DNQ when the effluent limitation is less than the method detection limit (MDL);

ii. sample results from analytical methods more sensitive than those methods included in the permit in accordance with Sections 2.4.2 or 2.4.3;

iii. presence of whole effluent toxicity;

iv. health advisories for fish consumption; or,

v. results of benthic or aquatic organism tissue sampling.

C. The goal of the PMP is to reduce all potential sources of a priority pollutant(s) through pollution minimization (control) strategies, including pollution prevention measures as appropriate, to maintain the effluent concentration at or below the WQBEL.

D. The Discharger shall propose a plan with a logical sequence of actions to achieve full compliance with the limits in this Order. The first phase of the plan is to investigate the sources of the high levels of contaminants in the collection system. If the sources can be identified, source reduction measures (including, when appropriate, Pollution Minimization Plans) will be instituted. At the time this Order is considered, the Discharger is unsure whether or not all sources contributing to the high contaminant levels can be identified. Therefore, a parallel effort will be made to evaluate the appropriateness of Site Specific Objectives (SSO) and, where appropriate, Use Attainability Analyses (UAA), and modifications to and/or construction of treatment facilities. If it is determined that a SSO or UAA is necessary and appropriate, the Discharger will submit a written request for a SSO study, accompanied by a preliminary commitment to fund the study, to the Regional Board. The Discharger will then develop a workplan and submit it to the Regional Board for approval prior to the initiation of the studies.

2. Interim Limits

A. The San Jose Creek WRP may not be able to achieve immediate compliance with the limits for copper, lead, mercury, selenium, cyanide, benzo(a)pyrene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, n-nitrosodimethylamine, 4,4-DDT, and 4,4-DDE contained in the accompanying Order Section I.1B.b. Data submitted in previous self-monitoring reports indicate that these constituents have been detected in the effluent/receiving water, at least once, at a concentration greater than the new limit proposed in the accompanying Order.

B. 40 CFR, Section 131.38(e) provides conditions under which interim effluent limits and compliance schedules may be issued. However, until recently, the Basin Plan did not allow inclusion of interim limits and compliance schedules in NPDES permits for effluent limits. With the Regional Board adoption and USEPA approval of Resolution No. 2003-001, compliance schedules can be allowed in NPDES permits if:

a. the effluent limit implements new, revised, or newly interpreted water quality standards, or

b. the effluent limit implements TMDLs for new, revised or newly interpreted water quality standards.

The SIP allows inclusion of interim limits in NPDES permits for CTR-based priority pollutants. The CTR provides for a five-year maximum compliance schedule, while the SIP allows for longer, TMDL-based compliance schedule. However, the USEPA has yet to approve the longer compliance schedules. Therefore, this Order includes interim limits and compliance schedules based on the CTR for CTR-based priority pollutants limits when the Discharger has been determined to have problems in meeting the new limits. This Order also includes a reopener to allow the Regional Board to grant TMDL-based compliance schedules if the USEPA approves the longer compliance schedule provisions of the SIP. For new non-CTR-based limits prescribed in this Order for which the Discharger will not be

able to meet immediately, interim limits and compliance dates are provided in an accompanying Time Schedule Order R4-2004-0098.

C. In conformance with the CTR and the relevant provisions of SIP Section 2.1, the Discharger has submitted documentation the efforts they have made to quantify pollutant levels in the discharge and the sources of the pollutants entering the POTW. In addition, the Discharger already has in place a source control and pollutant minimization approach through its existing pollutant minimization strategies and through the pretreatment program. The duration of interim requirements established in this order was developed in coordination with Regional Board staff and the Discharger, and the proposed schedule is as short as practicable. The five-year compliance schedule is based on the maximum duration compliance schedule. However, the Discharger anticipates it will take longer than five years to achieve the final limits.

WATER RECLAMATION
SOLID WASTE MANAGEMENT

COUNTY SANITATION DISTRICTS
OF LOS ANGELES COUNTY

1955 Workman Mill Road, Whittier, CA 90601-1400
Mailing Address: P.O. Box 4998, Whittier, CA 90607-4998
Telephone: (562) 699-7411, FAX: (562) 699-5422
www.lacsd.org

JAMES F. STAHL
Chief Engineer and General Manager

April 15, 2004
File No. 31-370.40.4A

Ms. Blythe Ponek-Bacharowski
California Regional Water Quality Control Board
Los Angeles Region
320 West 4th Street, Suite 200
Los Angeles, CA 90013

Dear Ms. Ponek-Bacharowski:

Summary of Districts' Efforts Investigating and Reducing N-Nitrosodimethylamine (NDMA) Concentrations in Water Reclamation Plant Effluents

As follow up to our meeting on April 6, 2004 to discuss the tentative NPDES permits issued for the County Sanitation Districts of Los Angeles County (Districts) San Jose Creek and Pomona Water Reclamation Plants (WRPs), the enclosed information provides a summary of Districts' efforts to investigate and reduce N-Nitrosodimethylamine (NDMA) concentrations in effluents from the Districts' three WRPs that provide reclaimed water to the Montebello Forebay Groundwater Recharge Project. The enclosed information includes discussions on influent and effluent NDMA characteristics, sources of NDMA, measures taken to reduce NDMA concentrations in final effluent, past, present and future research activities. We greatly appreciate the California Regional Water Quality Control Board (Regional Board) continuing the adoption of the subject tentative NPDES permits from the May 6, 2004 hearing to the June 10, 2004 hearing, in order to consider this new information.

Based on a thorough review of the existing NDMA data, in general it is apparent that as a result of the modifications of the WRPs to operate in a nitrification/denitrification (NDN) mode, in order to comply with newly applicable ammonia criteria, NDMA concentrations in several of the Districts' WRPs effluents have increased. Prior to NDN modifications, the WRPs typically discharged NDMA at levels below 1000 ng/L. As explained in the enclosed information, NDMA is a chlorine disinfection byproduct. Furthermore, the addition of polymer, which is used to enhance settling properties in secondary clarifiers, appears to increase NDMA forming potential within the disinfection treatment process.

Prior to the NDN modification, when NDMA levels were typically less than 1000 ng/L, detections of NDMA in shallow groundwater wells and production wells monitored as part of the Montebello Forebay Groundwater Recharge Project, were rare and none exceeded 10 ng/L (the current California Department of Health Services Action Level for NDMA) in the production wells. These historical monitoring data indicate that pre-NDN NDMA levels in the three groundwater recharge WRP effluents have been protective of local groundwater. However, reviewing recent NDMA data collected from shallow groundwater monitoring wells in the vicinity of the San Gabriel River Spreading Grounds show that reclaimed water has contributed to more frequent detections of NDMA in the shallow groundwater where there is minimal to no blending. The Districts have already begun researching sources of NDMA and have already implemented NDMA source reduction efforts as described in the enclosed information. Based on research work done to date, even after controlling industrial and

commercial sources of NDMA it appears that the residential sector is a continued source of NDMA making the predicted effectiveness of future source reduction efforts uncertain.

To date, the Districts are only aware of one technology that has been implemented to destroy NDMA in wastewater. This technology is ultraviolet (UV) oxidation and to Districts knowledge it has only been installed at the end of reverse osmosis treatment systems. Thus, the effectiveness of this NDMA destruction technology used on the end of conventional tertiary treated wastewater is unproven and uncertain. In addition, preliminary research studies conducted by the Water Environment Foundation have indicated that a higher UV dosing (oxidation levels), other disinfection byproducts (such as cyanide) may be generated thus creating potential compliance concerns. These factors in conjunction with the fact that pre-NDN NDMA concentrations in the effluents from the three groundwater recharge WRPs (San Jose Creek, Whittier Narrows, and Pomona WRPs) have historically proven to be protective of the local groundwater, lead the Districts to the decision to immediately test pilot and full scale UV disinfection systems at its Whittier Narrows WRP. The intent of pursuing the installation and operation of a UV disinfection systems, is to restore NDMA concentrations to their pre-NDN levels (typically less than a 1000 ng/L) for the continued protection of local groundwater and to ensure compliance with all other NPDES discharge requirements, including eliminating/minimizing the in-plant generation of other disinfection byproducts such as cyanide and trihalomenthanes. This effort at the Whittier Narrows WRP, including all research and UV construction, is estimated to cost approximately 6 million dollars. At the end of the full scale UV performance research test at the Whittier Narrows WRP (see enclosed schedule for more detail), assuming that compliance with all NPDES permits requirements is achieved and that supporting studies show continued protection of local groundwater supplies, the Districts will apply the research findings to other WRPs as needed to ensure future protection of groundwater. The Districts plan to submit quarterly reports to keep the Regional Board appraised of progress on the research project.

We look forward to discussing the proposed schedule with you and your staff during our upcoming meeting on April 19, 2004. If you have any questions or need additional information, please contact the undersigned at the above listed telephone number, extension 2801 or Ms. Martha Rincon at extension 2830.

Very truly yours,

James F. Stahl

Martha Rincon for

Victoria O. Conway
Head, Monitoring Section
Technical Services Department

VOC:MR:drs
Enclosures

The N-Nitrosodimethylamine Summary

Background

N-nitrosodimethylamine (NDMA) can be found in foods, beverages, prescription drugs and tobacco smoke. NDMA is also used in the production of liquid rocket fuel and in a variety of other industrial processes. Although considerable environmental attention was given the nitrosamine family in the 1970s, NDMA detection was not widespread and interest waned for many years. However, recently in 1998, NDMA was detected at approximately 0.15 ug/L in a drinking water supply well in Eastern Sacramento County and consequently this particular well was removed from service. Coincidently, in the same year, three drinking water supply wells located in the San Gabriel Basin also detected elevated levels of NDMA (due to aerospace industrial contamination) and were either removed from service or remained out of service until mitigation measures were completed. These incidents resulted in an increased interest in NDMA, which led the California Department of Health Services (DHS) to establish an Action Level (AL) of 2 ng/L for NDMA. Action Levels are non-regulatory health-based advisory levels established on an as-needed basis for constituents that pose a threat to water supplies and lack Title 22 maximum contaminant levels (MCL).

As a result of attention being re-focused on NDMA, the California water treatment community initiated numerous studies to determine NDMA concentrations in treated water utilizing low-level NDMA detection methods. At this time it was already known that NDMA was a chlorine disinfection by-product. Based on this new monitoring data from the water treatment community the AL for NDMA was revised by California DHS in 1999 from 2 ng/L to 20 ng/L. This action level was again revised from 20 ng/L to 10 ng/L in 2002 based on additional information from the water treatment community.

In July 2000, the Los Angeles County Sanitation Districts (Districts) initiated monthly low level NDMA monitoring at the Water Reclamation Plants (WRPs) that provide reclaimed water to the Montebello Forebay Groundwater Recharge Project at the request of the DHS. These WRPs include: Pomona, Whittier Narrows and San Jose Creek (East and West) WRPs. In addition, low-level NDMA monitoring of the shallow groundwater monitoring wells and production wells within the Montebello Forebay Groundwater Recharge Project was also initiated by the Water Replenishment District (WRD). Sampling of the shallow groundwater monitoring wells is conducted on a bimonthly basis and the production wells are sampled semi-annually. All of the low-level NDMA monitoring results for the three groundwater recharge WRPs and groundwater wells (both monitoring and production) are reported to DHS on a quarterly basis. The low level NDMA test method implemented by the Districts provides results down to a 2 to 5 ng/L reporting level, which is significantly lower than the reporting level of 1 or 5 ug/L achievable with the USEPA approved method (EPA Method 8270). The low level NDMA results measured in samples obtained from the three WRPs' final effluents have consistently been above the DHS AL of 10 ng/L since the low-level detection monitoring program began in July 2000. The shallow groundwater monitoring wells have shown occasional excursions above the AL and none of the production wells have had NDMA detections above the AL. The following summarizes the Districts' NDMA efforts to date related to research, source control, monitoring, and operations as well as proposed efforts.

I.A. WRP NDMA

Influent, secondary and final effluent low level NDMA monitoring has been conducted to assess the fate of NDMA during the wastewater treatment process. Prior to July 2000, the only NDMA

WRP data available was analyzed using EPA Method 8270, which provides results with a reporting limit of 1 or 5 ug/L. Low level NDMA data are only available for the Long Beach, Pomona, San Jose Creek (East and West) and the Whittier Narrows WRPs and no low-level NDMA data are available for effluents from the Los Coyotes, Saugus and Valencia WRPs and therefore information regarding these WRPs is not included in this summary. Influent and effluent detections based on EPA Method 8270 are rare. Since June 1995, NDMA has not been detected in the influent using EPA Method 8270 at the Pomona, San Jose Creek (East and West) and Whittier Narrows WRPs. Based on the low level NDMA data recently collected, influent concentrations are typically low but spikes are observed occasionally. The Whittier Narrows WRP influent (composite) NDMA data collected in January 2004 ranged from 21.4 ng/L to 690 ng/L with an average of 148 ng/L and median of 43 ng/L. Influent hourly grab sample results for samples collected at the Long Beach WRP in June and August 2003 were low and consistently under 100 ng/L. The secondary effluent data prior to dechlorination available reflect the high biodegradability of NDMA with concentrations typically under 100 ng/L. Secondary effluent data collected prior to chlorination ranges from 5.4 to 520 ng/L with an average of 54 ng/L. Based on this monitoring, the generation of NDMA during the chlorination process was evident.

During this same time period (June 1995 through present), final effluent NDMA detections using EPA Method 8270 have been rare with only one or two detections per plant observed over the entire time period at the Pomona, San Jose Creek East and Whittier Narrows WRPs. The maximum concentration observed at the San Jose Creek East WRP was 20 ug/L, at the Pomona WRP the maximum observed was 1 ug/L, and the maximum concentration at the Whittier Narrows WRP was 7 ug/L. NDMA using EPA Method 8270 was not detected at the San Jose Creek West WRP. NDMA is consistently detected in the final effluent for the WRPs that supply reclaimed water to the Montebello Forebay Groundwater Recharge project based on the low level NDMA method. Final effluent data are highly variable on a hour to hour, day to day, and month to month basis and no trend or seasonal pattern has been observed to date. Typically, final effluent NDMA levels (24-hour composites) at the plants are well under 1000 ng/L but since July 2003, the levels at the San Jose Creek East and West WRPs have been typically greater than 1000 ng/L.

The high NDMA levels at the San Jose Creek East and West WRPs coincide with the conversion to the NDN treatment process, which was necessary in order to comply with the ammonia Basin Plan objectives. In addition, as noted in Section I.E.2 and Section I.F of this summary as a result of the NDN conversion and on going construction, polymer usage has significantly increased during this time (at some WRPs the polymer addition has more than doubled). Final effluent NDMA concentrations for the San Jose Creek East ranged from 37 to 932 ng/L with an average of 333 ng/L and at the San Jose Creek West ranged from 37.6 to 765 ng/L with an average of 173 ng/L prior to the implementation of full NDN based on data from July 2000 through June 2003. Since full NDN, the levels at the San Jose Creek East have ranged from 1000 to 4000 ng/L (average 2370 ng/L) and at the San Jose Creek West have ranged from 590 to 1700 ng/L (average 1065 ng/L) based on data from July 2003 through February 2004. At the Whittier Narrows WRP, where NDN pilot testing was completed in January 2001, the final effluent NDMA concentrations have ranged from 41 to 3170 ng/L since that time with an average value of 351 mg/L. At the Pomona WRP, there appears to be no trend in NDMA effluent concentrations or increase from prior to the conversion to full NDN as compared to previous data. This observation may be due to the fact that polymer dosing has remained the same and/or the difference in the performance of the MLE NDN process (utilized at the Pomona, and Whittier Narrows WRPs) versus the step feed process (utilized at the Long Beach, Los Coyotes, and San Jose Creek WRPs). The pre-NDN NDMA concentration average for the Pomona WRP is 474 ng/L while the post-NDN average is

318 ng/L (based on data through February 2004). It should be mentioned that collection and analysis of additional post-NDN NDMA effluent data might result in a different conclusion.

I.B. Groundwater NDMA

Montebello Forebay Groundwater Recharge Project Review
Groundwater recharge within the Montebello Forebay Groundwater Recharge Project occurs within the unlined Rio Hondo and San Gabriel Rivers, and at the Rio Hondo and San Gabriel Spreading Grounds. As previously mentioned, low level NDMA monitoring was initiated by the WRD in July 2000 at the 6 shallow groundwater wells and at the 19 intensively monitored production wells that are part of the groundwater recharge permit (Order 91-100). NDMA has been occasionally detected at the shallow monitoring wells with approximately 11 samples out of a total of approximately 130 samples from the six shallow wells, showing analytical results above the AL of 10 ng/L. Four of the samples were collected from wells 1612T and the remaining 7 samples were collected at well 1620RR both of which are located in the San Gabriel Spreading Grounds. The detections above the AL at 1612T have ranged between 11 to 170 ng/L and at well 1620RR from 20 to 460 ng/L.

The maximum concentrations observed at these two wells occurred in October 2003 and coincided with the spreading of San Jose Creek East and West WRP final effluent from the San Gabriel River Outfall at the San Gabriel Spreading Grounds. Spreading from the pipeline occurred continuously from October 2, 2003 through November 23, 2003 and again from December 8 through December 22, 2003. Since October 2003, the NDMA levels at these wells have decreased and based on the last sampling event conducted in February 2004, NDMA was measured at 12.7 ng/L at well 1612T and at 60 ng/L at 1620RR. (It should be noted that the monitoring wells are screened from approximately 60 feet to 80 feet below ground surface. Samples obtained at this depth are purely reclaimed water that has percolated. In other words, there is no dilution from groundwater at the shallow groundwater depths in the San Gabriel Spreading Grounds.)

During the months of October, November and December 2003, NDMA final effluent levels at the San Jose Creek East were measured at 2550, 2400 and >1000 ng/L, respectively and at the San Jose Creek West at 1290, 1700 and 830 ng/L, respectively. It should be noted that reclaimed water diverted from the San Gabriel River Outfall is coming directly from the San Jose Creek East and West WRPs via a pipeline where there is no dilution or the opportunity of NDMA photolysis, which are expected to occur in the surface water in the river. When reviewing the San Jose Creek WRP effluent and monitoring well data, it appears that the October 2003 groundwater spike was temporary, and more importantly that there is significant attenuation of NDMA as a result of Soil Aquifer Treatment (SAT) and that groundwater levels are continuing to decrease. If flow-weighted NDMA results obtained in October 2003 for the San Jose Creek East and West final effluents and that measured in the shallow groundwater at well 1620RR were used to determine attenuation of NDMA after infiltration, an approximate 72% reduction would be calculated. (Using an effluent flow-weighted NDMA concentration for October of 1637 ng/L and the NDMA concentration measured at well 1620RR, which is the closest well in the vicinity where the reclaimed water is discharged from the pipeline to the spreading grounds.) As a result of these NDMA detections in the San Gabriel River Spreading Grounds monitoring wells, beginning January 15, 2004, reclaimed water has not been diverted from the pipeline for spreading to the San Gabriel Spreading Grounds. The Districts will investigate other groundwater spreading strategies to ensure protection of groundwater as discussed below.

Although NDMA has been occasionally detected in the shallow groundwater, it has not been detected above the AL at any of the production wells. There have been rare detections of NDMA at the production wells in the past (maximum observed at 3.6 ng/L at well 2909V, which is located in the vicinity of the Rio Hondo Spreading Grounds). During the last semiannual monitoring, which was conducted in December 2003, NDMA was not detected in any of the production wells monitored.

The attenuation of NDMA in the groundwater system has also been observed in monitoring conducted within the Whittier Narrows Operable Unit[1] remedy (WNOU) which is operated by USEPA Region 9. The WNOU is a groundwater extraction barrier located approximately ¼ mile north of the Whittier Narrows Dam. The WNOU was installed to halt the flow of volatile organic contaminants traveling in groundwater from the San Gabriel Valley Groundwater Basin through the Whittier Narrows towards the Central Groundwater Basin. The WNOU is also located in the vicinity of the Whittier Narrows WRP. The WNOU consists of 7 extraction wells, an extensive monitoring well network and a treatment plant (completed in May 2002) to remove volatile organics from the extracted groundwater. Extraction wells (EW) 4-3, EW 4-4, EW 4-8 and EW 4-9 are identified by USEPA as shallow wells and EW 4-5, EW 4-6 and EW 4-7 are identified by USEPA as intermediate wells. Based on the Districts' preliminary review of the data available for the WNOU extraction wells and monitoring wells, and the surface water and effluent samples collected, it appears that shallow wells EW 4-3 and EW 4-8 are impacted by Rio Hondo surface water as observed through changes in stiff diagrams created from mineral data collected from March 2002 through September 2003. These two shallow extraction wells are located east of the Rio Hondo, downgradient from the Whittier Narrows WRP Rio Hondo discharge location. In December 2002 as part of monitoring conducted by USEPA, NDMA was detected at EW 4-3 at a concentration of 97 ng/L and at EW 4-8 at a concentration of 26 ng/L in June 2003, which are above the DHS AL of 10 ng/L. NDMA concentrations have significantly decreased in EW 4-3 since December 2002 and measured 47 ng/L in February 2003, 30 ng/L in April 2003 and in the most recent sampling conducted on February 11, 2004, NDMA was measured at 11 ng/L. The NDMA concentrations at EW 4-8 have also decreased with 7.7 ng/L measured in August 2003 and 12.8 ng/L measured in September 2003. The decrease in NDMA levels at these two shallow extraction wells is likely associated with the diversion of effluent from the Whittier Narrows WRP to either the Zone 1 Ditch or the San Gabriel River.

Modification of Montebello Forebay Spreading Operation

The Los Angeles Department of Public Works (LADPW) manages reclaimed water discharged to the Rio Hondo and San Gabriel Rivers as well as imported water and storm flows within the Montebello Forebay Groundwater Recharge Project. In order to reduce the possibility of NDMA in the final effluent from the Pomona, San Jose Creek and Whittier Narrows WRPs from impacting the Montebello Forebay Groundwater Recharge Project and the WNOU extraction wells, the following procedures have been implemented by the Districts, LADPW and the WRD:

- Reclaimed water from the San Jose Creek WRP (East and West) discharged via the San Gabriel River Outfall (i.e., pipeline), will not be diverted to the San Gabriel River Spreading Grounds (SGSG). The reclaimed water in the outfall will either be discharged to the lined San Gabriel River via Discharge 001 located near Firestone Blvd and/or directed to the Century/Rio Hondo reclaimed water distribution system for reuse (e.g., landscape irrigation, process water, etc,.).

[1] The Whittier Narrows Operable Unit is part of the San Gabriel Valley Superfund Sites in eastern Los Angeles County, California.

- The discharge of reclaimed water from the San Jose Creek WRP (East and West) to the unlined San Jose Creek and unlined San Gabriel River via Discharge points 002 and 003, respectively, will be minimized.
- Reclaimed water discharge from the Whittier Narrows WRP will be rotated between the Rio Hondo and San Gabriel River discharge locations with periods of continual discharge not to exceed 7 days to enhance SAT performance.
- All attempts will be made to prevent undiluted reclaimed water flows from being diverted to the Zone 1 Ditch. If the use of Zone 1 Ditch is necessary to convey reclaimed water, every reasonable attempt will be made to have the action coincide with the conveyance of sufficient blending water from storm flows and/or imported water deliveries. If possible, the Zone 1 Ditch will not be used for more than 7 consecutive days to convey reclaimed water.

I.C. River Attenuation Studies

Available receiving water data collected using EPA Method 8270 are limited with no NDMA detected at the receiving water stations monitored downstream of the Pomona, San Jose Creek East and West and Whittier Narrows WRPs. Limited low level NDMA data collected downstream (approximately 15 miles) of the Pomona WRP at the point where the San Jose Creek is unlined (i.e., where groundwater recharge could take place), the NDMA concentration has been measured at 7 and 13 ng/L (data for station C-1). These measured levels represent approximately 5% of the average effluent post-NDN NDMA concentration from the Pomona WRP demonstrating that significant attenuation from natural sunlight exposure and effects from dilution water help to keep surface water NDMA levels low. Travel times for WRP effluent flows to reach spreading and/or unlined river segments are discussed below. Recently collected NDMA data in the San Jose Creek and unlined San Gabriel River including the Zone 1 Ditch also reflect significant attenuation of NDMA downgradient of the San Jose Creek East and West WRPs.

Estimated Travel Times From WRPs to the Spreading Grounds
The following table presents distances between WRP discharge points and the unlined rivers and spreading grounds where groundwater recharge occurs.

WRP Distance to Groundwater Recharge Sites

WRP	Miles to Unlined River	Miles to Rio Hondo Spreading Grounds	Miles to San Gabriel Spreading Grounds
Pomona	14.6	21.5	20.2
Whittier Narrows	0 (immediate discharge)	2.9	2.2
San Jose Creek East	0 (immediate discharge)	5.9	4.6
San Jose Creek West	0 (immediate discharge)	5.2	3.9

Based on preliminary travel time estimates, flow discharged from the Whittier Narrows and San Jose Creek WRPs to the surface water is expected to reach the Rio Hondo and San Gabriel Spreading Grounds within approximately 20 to 30 hours and from the Pomona WRP, within 29 to 39 hours. However, it should be noted that due to the significant distances and losses due to evaporation and infiltration, flow from the Pomona WRP is not expected to reach the spreading grounds. Since the shallow monitoring wells are expected to reflect recharge water within a couple of days based on tracer experiments conducted in the past, the reductions observed from recharge water concentrations to the shallow groundwater are expected to occur rapidly.

I.D. Source Control/Pollution Prevention

Sources of NDMA

Although NDMA has rarely been detected in the influent of the Districts' WRPs using USEPA Method 8270 (with reporting limits ranging from 1 to 50 ug/L), it was expected to be present in influent wastewater at low concentrations. In January 2004, the Districts conducted a four-week influent sampling at the Whittier Narrows WRP. Twenty-seven consecutive 24-hour composite samples were taken and analyzed for NDMA using the low level test method not yet approved by the USEPA that provides NDMA results down to a 2 ng/L reporting level. The sample results, with the lower detection limits, ranged between 14 and 1,000 ng/L.

Potential sources of NDMA to sewers include residential, commercial and industrial users. Based on available information, NDMA can be formed as a result of biological, chemical or photochemical processes. NDMA precursors, including dimethylamides and trimethylamine, are ubiquitous in the environment, occurring in plants, fish, algae, urine and feces (Ayanaba and Alexander, 1974). NDMA is the most common volatile amine found in food. Nitrosamines are formed in foods by the reaction of secondary and tertiary amines with a nitrosating agent, usually nitrous anhydride, which forms from nitrite in acidic, aqueous solution. Most malt beverages, smoked meats and tobacco products contain NDMA. NDMA can also be formed in the stomach during digestion of alkylamine-containing foods. Furthermore, NDMA has been found to occur in a variety of toiletry and cosmetic products, including shampoos, hair conditioners, color toners, shower gels, bath crèmes and oils, health care products, cleaners and masks. The Orange County Sanitation Districts (OCSD) conducted domestic background sampling in 2000 and 2001. The sample results ranged from non-detect (detection limit was between 20 and 30 ng/l) to 604 ng/l. The average concentration of all samples was 103 ng/l.

NDMA is primarily used in research, and is not an industrially or commercially important chemical. However, it can be released from a wide variety of manmade sources. The inadvertent formation of NDMA in industrial situations happens when alkylamines, mainly dimethylamine and trimethylamine, come in contact and react with nitrogen oxides, nitrous acid, or nitrite salts, or when trans-nitrosation via nitro or nitroso compounds occurs. Thus, NDMA might exist in discharges from tanneries, pesticide manufacturing plants, rubber and tire manufacturers, alkylamine manufacture/use sites, fish processing industries, foundries and dye manufacturers.

The Districts have collected a large number of samples from various industrial users and analyzed them for NDMA. The samples showed the effluent from metal finishing operations that use dithiocarbamate (DTC) for metal removal often contained NDMA. DTC can be contaminated with NDMA. Textile facilities were also sampled in mid-2003 as it was thought that the dyes utilized might be a source of NDMA. However, sample results indicate that textile facilities are not a significant source of NDMA. A 2000-2001 study conducted by OCSD also found that DTC containing products, including foaming fumigants for root control in sewers, often are contaminated with NDMA. However, no industrial user tributary to the WRPs has been identified as a significant source of NDMA.

NDMA in Waste Antifreeze

The Districts have also identified waste antifreeze to be a potential source of NDMA to the influent of the Districts' WRPs. A recent study conducted by staff showed significant levels of NDMA in used radiator coolant, but only trace amounts in fresh coolant. The highest NDMA concentration measured in an antifreeze sample to date is 740,000 ng/l. Since spent radiator fluid is batched dumped and parts of the collection system provide little mixing resulting in plug flow, the volume of coolant used in just one radiator, if discharged to the sewer, has the potential to

pass-through any water reclamation plant and result in an exceedance of the DHS action level of 10 ng/L. Therefore, the Districts have already significantly stepped up efforts to reduce any radiator coolant discharges as described below.

All coolants are prohibited from being discharged to the sanitary sewer system on the basis of California Hazardous Waste regulations, specifically the toxicity characteristic. The Districts have also banned the discharge of spent antifreeze due to the potential contamination of reclaimed water. However, illegal discharge may still occur from diverse sources such as automotive garages and residences where radiators are drained. All permitted radiator repair shops and permitted automobile and truck repair facilities were notified in writing by the Districts on September 26, 2003 of the radiator coolant discharge prohibition. The Districts mailed over 200 letters to these commercial businesses and industries. The Districts also identified a drum reconditioning operation that disposed of spent radiator fluid increasing the NDMA load influent to the Whittier Narrows WRP in December 2003. This facility and the only other drum reconditioner tributary to the Districts' upstream WRPs were also given notice of the Districts' prohibition on December 31, 2003.

It should be noted that the waste radiator coolant introduced into the sewer system by residential users may be difficult to eliminate. NDMA spikes were found during the Districts' 2004 influent composite sampling at the Whittier Narrows WRP. Twenty-three out of the 27 samples were below 250 ng/l (14 of were below 100 ng/l). The remaining four samples had significantly higher concentrations of 320, 690, 720 and 1000 ng/l. The fact that spikes existed indicates that some kind of source control measures might be implemented to reduce influent NDMA loadings. Similar to the OCSD samples, high NDMA concentrations were often found during weekends. Since most industrial users are not in operation during weekends, residential discharge appears to be the most likely source of these loadings.

The Districts are in the process of utilizing electronic search engines to identify those repair facilities that may drain radiators yet do not require an industrial wastewater discharge permit since all liquid wastes are hauled. These facilities will also receive written notification of the discharge prohibition that was issued to permitted radiator repair shops and permitted automobile and truck repair facilities in September 26, 2003. In addition, all permitted radiator shops have been inspected and surveyed as to how they dispose of their waste coolant. Manifests have been reviewed in the field and temporary waste storage containers were checked. Although spent coolant is hauled, the radiators are flushed with water that is eventually discharged to the sewerage system. Currently, a sampling study is underway to determine the actual concentrations of NDMA in the wastewater discharge at these facilities. Should the results raise the level of concern regarding these facilities, further action will focus on these sources. Possible actions include working with the industry to develop Best Management Practices or effluent limitations with treatment systems to prevent residual contributions to the sewer discharge or a zero discharge program prohibiting any nondomestic wastewater discharge from a radiator repair or maintenance facility.

The Districts' Industrial Waste Section will continue to investigate NDMA sources to the WRPs. When NMDA pre-cursors are identified by Districts' research efforts, additional measures will be identified, investigated and implemented by the Districts Industrial Waste Section where appropriate. Efforts to prevent the discharge of used coolant will continue. Waste coolant will continue to be accepted from residences at the hazardous waste roundups. The Districts have actively advertised the acceptance of this material since February 1993 and have collected approximately 94,808 gallons to date. An outreach program to address the introduction of waste radiator coolant into the sewer system by residential uses will be evaluated.

I.E. Research

I.E.1. Analytical

To improve the sensitivity of NDMA analysis the Districts acquired a Finnigan TSQ mass spectrometer in 2000/2001. Utilizing this triple quadrapole instrument enabled the laboratory to push the NDMA detection limit below ~2.0 ng/L. Identifying and quantifying NDMA using GC/MS/MS in conjunction with chemical ionization minimized matrix interferences and allowed the Districts' laboratory to greatly improve the sensitivity and reliability of the analytical method. A second chemical ionization capable MS unit was recently purchased to handle the increasing demand for low level NDMA analyses. This unit should be installed sometime in June of 2004.

I.E.2. NDMA Formation Studies

The Districts' laboratory performed studies on the impact of polymers and other plant chemicals and their possible contribution to NDMA formation. These studies, which began in 2000 and are still ongoing, revealed unequivocal links between polymer use and NDMA concentration in the effluent streams. The investigations further suggested that a large fraction of the NDMA precursors were solids associated. As a consequence of these findings, the Districts discontinued backwash recycling despite the high cost associated with diverting the filter backwash to a downstream sewer for subsequent treatment at the Districts Joint Water Pollution Control Plant located in Carson. This discovery also prompted the Districts to begin a search for suitable replacements for the cationic polymer currently in use at the WRPs. Finding a substitute polymer, which lacks the precursor alkylamino functionalities or possess greatly reduced NDMA formation potential while conserving solids settling and foam mitigating properties, is the ultimate goal of this effort. To date, several commercially available formulations have been evaluated in the laboratory and compared to the Mannich polymer that is currently in use at the Districts' WRPs. Some commercial formulations which showed promise in the initial bench trials have been field tested at Districts' facilities (Long Beach and Whittier Narrows WRP), however, initial assessments revealed no discernible reduction in NDMA effluent concentrations. In addition to these efforts, the Districts are also looking into the possibility of exploring more aggressive wastewater treatment alternatives including processes that might reduce or eliminate the need for chemical agents in solids management. Additional information pertaining to this effort is documented in a paper entitled "Can N-Nitrosodimethylamine Formation be Affected by Polymer Use During Advanced Wastewater Treatment?"contained in WateReuse Association's 2003 Symposium publication, see Attachment A.

In addition, laboratory bench scale studies have already been conducted to determine the NDMA formation potentials between polymer and three chlorination modes (free chlorine, pre-formed chloramines, and ammonia addition followed by chlorine addition). Some preliminary findings from this research include:

- High polymer concentrations generate higher NDMA concentrations.
- Higher chlorine doses produce higher NDMA concentrations.
- Longer contact times yield higher NDMA concentrations.
- Among the three chlorination modes, free chlorine seems to produce the lowest NDMA concentrations (however, effluent trihalomethane concentrations increase); while the differences in NDMA formation from chloramination and pre-formed chloramines are insignificant.

I.E.3. Investigation of NDMA Reduction Options (e.g. free chlorine, preformed chloramines, etc...)

After discovering the likely role chloramination had in NDMA formation, the Districts initiated studies to assess alternate disinfection processes to the currently used chloramination disinfection process. In Fall 2003, the Districts started to investigate the feasibility of conducting pilot and full-scale tests to evaluate the performance of ultraviolet (UV) disinfection systems in the hopes of reducing current NDMA levels in WRP effluents. Laboratory and field studies are currently underway to evaluate UV disinfection treatment as a possible substitute to chlorination. This project, a portion of which is already underway, will employ both laboratory and pilot plant testing to assess the effect of UV disinfection on nitrosamine levels in the effluent. Section II.A of this summary describes the full scale efforts planned at the Whittier Narrows WRP in detail.

Some preliminary laboratory experiments using UV have already been conducted including, using a collimated-beam apparatus with a medium-pressure UV lamp, to study the NDMA destruction by UV irradiation. A secondary effluent sample from the Whittier Narrows WRP was spiked with 100 ng/L of NDMA for the test and was then irradiated. A dose of approximately 100 mJ/cm^2 resulted in approximately 28% NDMA destruction and approximately 4.8 logs reduction of coliform. It should be noted the extent of NDMA destruction might be higher than a typical UV disinfection system would provide, because the NDMA was spiked into the water, the wider wavelength spectrum of the medium pressure lamp provided additional oxidation power, and the UV doses used were higher than those for disinfection. Additional experiments, using a recently acquired collimated beam apparatus with low pressure UV lamps, have been scheduled.

Other disinfectants besides UV treatment are also being investigated, these include: peracetic acids, free chlorine and pre-formed chloramines.

I.E.4. NDMA Attenuation

The Districts laboratory has also conducted studies of natural NDMA attenuation processes in recharge basin soils. This research was performed as a collaborative effort with the *U.S. Geological Survey*. The results of this study support the existence of both aerobic and anaerobic natural bio-degradative pathways in soils for the removal of NDMA. P.M. Bradley, SA Carr, RB Baird, and FH Chapelle; *Mineralization of N-Nitrosodimethylamine in Soil From a Groundwater Recharge Facility and in Pure Cultures of Pseudomonas sp.* (in press) These results suggest that biologically mediated processes in underlying groundwater recharge basins (SAT) may play a substantial role in the natural attenuation of NDMA.

The possible influence of sunlight on NDMA destruction will also be assessed using a small scale field study at the Long Beach WRP. This will serve as a follow-up to preliminary tests that showed substantial removal of NDMA in standards that were exposed to sunlight for relatively short durations. The Districts will conduct a series of field experiments to determine the impact of natural sunlight exposure on NDMA in final effluent.

I.E.5. Collaborative Efforts with other Parties

The Districts is currently involved in a series of joint research efforts involving other utilities, academic institutions and laboratories to address issues related to NDMA.

Removal and/or Destruction of NDMA and NDMA Precursors in Wastewater Treatment Processes. WRF RFP-2.(January 2001 – September 2004)

This project will take a comprehensive look at processes, which contribute to NDMA formation in wastewater treatment plants. The study will survey precursors and their probable origin, and assess the reactions and mechanisms involved in NDMA formation. Finally, the project will determine if it is possible to prevent the *in situ* synthesis of NDMA at wastewater plants, and examine removal schemes.

Low Cost Analytical Methods for Measuring NDMA Concentrations (WateReuse Foundation RFP#3) WRF-01-001 (November 1, 2002 – August 2004)

The objective of this project is to provide water utilities with sensitive, accurate and low cost, analytical methods for measuring NDMA. The Districts have diligently explored the development of more efficient methods to extract, concentrate and quantify NDMA in effluent waters these efforts have been made both independently and jointly as a participant on this project. The Districts laboratory has taken a lead role in assessing the influence of common preservation modes and holding times on NDMA analysis. In keeping with the demands for the low level quantification, the Districts, as mentioned earlier, acquired a triple quadrupole Thermo Finnigan TSQ mass spectrometer and has recently purchased a second DSQ GC/MS unit which will also be dedicated to the analysis of nitrosamines.

Investigation of N-Nitrosodimethylamine (NDMA) Fate and Transport (WRF-02-002) (April 2003 – October, 2005)

This project was launched in April 2003 and seeks to understand the fate and transport of NDMA in soil and groundwater when recycled water is used for spray irrigation. By utilizing both field and laboratory experiments, this study hopes to provide information on the ultimate fate of nitrosamines in the environment. The Districts' laboratory has provided technical assistance related to sources and purity of ^{14}C labeled NDMA, effluent matrix DOC composition and sample preservation techniques for this project. A major portion of the study, to be conducted at the *University of California Riverside,* will be focused on NDMA uptake and transformation in sod grasses.

I.F. WRP Operations

Polymer Usage

Although the WRPs have implemented the NDN treatment process modification and are complying with ammonia requirements, NDN-related construction is ongoing at the San Jose Creek East, Long Beach and Los Coyotes WRPs. It should be noted that a portion of the San Jose Creek East influent flow is being diverted to San Jose Creek West for treatment. Since the construction at these WRPs involves taking aeration units out of service, the remaining units must operate under higher loads. As a result, polymer addition has been substantially increased at these WRPs, including the San Jose Creek West, to enhance settleability in the clarifiers. Polymer addition at the Whittier Narrows and Pomona WRPs has remained relatively the same as pre-NDN polymer dosing rates. Based on the low level NDMA data it appears as though the post-NDN NDMA levels measured in the Whittier Narrows and Pomona WRPs effluents are distinguishably lower than NDMA levels in effluents from San Jose Creek East, San Jose Creek West and Long Beach WRPs. Unfortunately, a thorough review and analysis of polymer dosing and NDMA effluent data show no clear correlation.

As mentioned in Section I.E.2 of this summary, the use of other polymers has also been investigated on a full-scale basis in an attempt to find a polymer that will not contribute to the

NDMA forming potential within the wastewater treatment process. At the Long Beach WRP, a polymer with lower NDMA formation potential (determined based on bench scale testing) was evaluated but no reduction trend in NDMA final effluent concentrations was observed when using the tested polymer. An acidified Mannich polymer, which was also identified as having lower NDMA formation potential, was also evaluated at the Whittier Narrows WRP. During its use, there was no observable reduction in NDMA effluent concentrations.

All NDN-related construction activities at the San Jose Creek WRP are expected to be completed by June 2004, at which time polymer dosing at the San Jose Creek East and West WRPs should be reduced to minimize NDMA forming potential within the chlorine disinfection process. In the mean time, the Districts' Operations Section has implemented some measures at San Jose Creek East to optimize the current polymer dosing system in an effort to lower NDMA effluent concentrations. The polymer dosage rates during the day are adjusted as needed by the sludge blanket depths in the clarifiers to prevent polymer overdosing. The Districts will continue to seek measures to optimize polymer dosing at all WRPs in an effort to maximize NDMA reductions in WRP effluents.

Filter Backwash
As briefly discussed in Section I.E.2 of this summary, the practice of diverting all filter backwash water to the sewer rather than reintroducing it back into the plants began in June 2002 at all 5 of the upstream WRPs (San Jose Creek, Whittier Narrows, Pomona, Long Beach, and Los Coyotes WRPs). Analytical results from filter backwash water samples showed NDMA concentrations in excess of 10,000 ng/L. Although, initially there appeared to be some benefit from the diversion of these minor flows, after a few months due to the variability of the NDMA concentrations, it is difficult to quantify the actual reductions in effluent NDMA concentrations at the individual WRPs. However, this practice to sewer the filter backwash will continue to ensure maximum NDMA reductions at the WRPs are being achieved.

Chlorination
Since NDMA is formed during the chloramination treatment process, the Districts' Operations Section have implemented measures to dampen out chlorine dosing in an effort to eliminate chlorine dosing spikes and thus reduce the formation potential for NDMA. Optimizing chlorine dosing was achieved by moving the set point sensor for the chlorine feedback system from the end of the chlorine contact tanks to the end of the filters. By making this change the response time for chlorine dosing is shortened thereby reducing peaks and dips in the chlorine dosing profile during the day that would prevent the need to overdose. Furthermore, chlorine dosing levels have dropped slightly since the implementation of NDN as a result of an improved secondary effluent quality (lower suspended solids and lower organic concentrations) which may also reduce the formation potential for NDMA.

II. Proposed Long-Term Efforts

II.A. Whittier Narrows WRP UV Disinfection Treatment Testing

In the Fall of 2003 the Districts began investigating disinfection alternatives, including UV disinfection, in an effort to address a number of regulatory concerns including reducing chlorination disinfection byproducts (namely cyanide and trihalomethanes). Advantages associated with use of UV treatment include reduction in effluent concentrations NDMA, also a disinfection byproduct, elimination of the need to add ammonia back to the NDN filtered effluent to facilitate chloramination disinfection, elimination of the use of chlorine (except for filter

maintenance and disinfection of a portion of wet weather flows). UV treatment, as approved by DHS, is also an acceptable alternative to achieving Title 22's Water Recycling 450 CT criteria.

In March 2004, the Districts completed the preliminary portion of the preliminary investigation identifying UV disinfection as the most feasible alternative to the current chloramination disinfection to meet NPDES permit and Title 22 Water Recycling Criteria at the Districts' three groundwater recharge WRPs (Whittier Narrows, Pomona and San Jose Creek WRPs). Two UV systems, Trojan and Wedeco, emerged as candidates for validation testing at the Whittier Narrows WRP in Summer 2004. An approved validation test for a UV system is required by DHS prior to installation of the system at a WRP. Prior to the startup of the validation test, a test protocol must be generated and reviewed by the equipment manufacturer and the Regional Board/ DHS. The development of the test protocol is currently underway by the Districts and will soon be submitted to DHS for approval. The only UV system available for validation testing by the Districts under the schedule constraints is the Trojan system. The large scale pilot plant is expected to be delivered to the Whittier Narrows WRP by the end of April 2004. Setup of the unit is expected to be completed in April 2004, with startup immediately thereafter. The actual validation testing (in addition to collecting data to facilitate design) is estimated to take 4 months. Generation of the validation report and equipment manufacturer and DHS approvals are anticipated by end of January 2005. Although a Wedeco UV pilot unit does not appear to be currently available for testing by the Districts, a recently conducted validation test on a Wedeco UV system may be applied to the Districts' proposed UV full size system design.

In order to expedite this effort, the Districts will conduct efforts in parallel. As such, preparation of procurement documents for a full-scale UV disinfection system for the Whittier Narrows WRP will begin in June 2004. The Whittier Narrows WRP was selected for the full-scale evaluation since this WRP is the primary research facility for the Districts and 100% of the treated effluent can be temporarily redirected to the sewer for subsequent treatment at the Districts' Joint Water Pollution Control Plant in cases where the WRP effluent quality is of concern. The Districts will seek competitive bids and anticipate that the contract award will take place by January 2005. Once the contract is awarded and submittal approved, fabrication of the UV disinfection system can begin. Delivery of a UV system is expected to occur by the end of September 2005.

The Districts have already initiated preliminary design efforts for the installation of a full scale UV system at the Whittier Narrows WRP. The installation of a UV disinfection system, will require retrofitting of existing plant facilities, along with construction of new plant facilities. In addition, the proposed UV system operating scenarios are required to be documented in an Engineering Report. This report will be generated by the Districts and submitted to DHS for subsequent approval. The data collected from the research/validation tests will be utilized in the preparation of this report. A DHS approved Engineering Report is required prior to start-up of the UV system. The entire design process is expected to be completed by the end of June 2005.

Once the Engineering Report has been approved, and the UV system design and the UV equipment fabrication are completed, construction of the UV system and plant modifications/retrofits can begin. This construction effort, including field commissioning of the UV equipment, is expected to be completed by the end of July 2006. The preliminary estimated cost including equipment, construction, design and construction management to install UV disinfection treatment at the Whittier Narrows WRP is approximately $6 million. This cost estimate will be refined as additional information is collected and Operations and Maintenance costs will also be developed.

Because there are few UV disinfection systems in operation at Water Reclamation Plants which have to meet both NPDES permit and Water Recycling Requirements using conventional NDN activated sludge and granular carbon media filter treatment process, the Districts believe 12 months of operation evaluation and optimization are necessary to ensure compliance with all applicable regulatory requirements. The 12-month performance evaluation period will also allow adequate time for system debugging, performance enhancement and optimization efforts to be completed. Furthermore, a comprehensive groundwater model is planned to be developed by the Districts in parallel with the efforts to install and operate the UV system. As previously mentioned, additional groundwater model calibration work, after the UV system is in full operation at the Whittier Narrows WRP is critical to ensure protection of local groundwater conditions. This evaluation period is expected to be completed by June 2006, at which time groundwater attenuation factors are expected to be developed. Assuming satisfactory performance of the UV system at the Whittier Narrows WRP and acceptable groundwater attenuation factors, system selection and design efforts can begin for the San Jose Creek and Pomona WRPs.

A schedule including project components and approximate timelines is included as Attachment B.

III.B. Groundwater Dilution/Attenuation Studies

NDMA fate and transport within the Montebello Forebay Groundwater Recharge project will be further evaluated. The Districts intend to submit a draft workplan within 3 months from the adoption of the San Jose Creek and Pomona WRP permits. Based on a preliminary schedule that reflects the required sequence of the work that may be necessary to conduct, it is expected that this work would take up to three years and will likely involve tracer studies and comprehensive groundwater modeling as described below.

The workplan would include, but not be limited, to the following:

Literature Review: A literature review of NDMA fate and transport data and research and compiling all available final effluent, surface water and groundwater data and assessing data gaps as well as hydrogeologic characteristics of the Montebello Forebay area.

Groundwater Monitoring: Continued monitoring of Montebello Forebay shallow and production wells at a minimum frequency of at least quarterly for a minimum of 1 year. Evaluation of the need to install additional shallow monitoring wells downstream of the WRP discharge points within the unlined Rio Hondo, San Jose Creek and San Gabriel River. The need to identify existing shallow and/or production wells in the vicinity of the unlined conveyance channels to be included in the monitoring program will be assessed.

Surface Water Sampling: Surface water sampling would continue at existing receiving water stations and new stations upgradient of the WRPs and downstream between the WRP discharges and the spreading grounds. Surface water stations monitoring would be conducted concurrent to groundwater monitoring. Stormwater and imported water samples would also be collected and analyzed.

Tracer Studies: The possibility of conducting tracer studies between the WRP discharge and new shallow and production well monitoring along the unlined portions of the rivers will be evaluated. If tracer experiments are conducted, these may require a time period of approximately 2 ½ years.

Data Analysis and Reporting: Existing data along with data collected during the implementation of the workplan would be evaluated and used to develop a model to predict what concentration level of NDMA in the effluent is protective of groundwater quality. A report would be prepared with specific recommendations on attenuation and dilution factors. Data analysis, modeling and report preparation would be done within a 1½ year period. Calibration of the model based on post UV disinfection NDMA performance levels at the Whittier Narrows WRP will require additional time, possibly up to one year to determine localized impacts on groundwater.

III.C. Spreading Grounds Management Plan

The Districts, in conjunction with the Los Angeles County Department of Public Works and the Water Replenishment District, will develop a long term spreading grounds management plan that addresses spreading grounds operation and monitoring of recharge water and groundwater to assess potential impacts on groundwater quality as a result of spreading operations. A draft workplan would be submitted 6 months after the adoption of the San Jose Creek and Pomona WRP permits.

ATTACHMENT A

CAN N-NITROSODIMETHYLAMINE FORMATION BE AFFECTED BY POLYMER USE DURING ADVANCED WASTEWATER TREATMENT?

Larry Neisess, LACSD SJCWQL, Whittier, CA
Rodger Baird, LACSD SJCWQL, Whittier, CA
Steve Carr, LACSD SJCWQL, Whittier, CA
John Gute, LACSD SJCWQL, Whittier, CA
John Strand, LACSD SJCWQL, Whittier, CA
Connie Young LACSD SJCWQL, Whittier, CA

Introduction

N-nitrosodimethylamine (NDMA) is a potent carcinogen in several animal species when administered by different exposure routes (Magee, *et al*, 1976) and is listed as a probable human carcinogen (U.S. EPA, 2002). As a family, the nitrosamines were the subject of considerable environmental attention in the 1970s, but outside of a number of processed and preserved foods and beverages, NDMA detection was not widespread and interest waned for many years. Attention was re-focused on NDMA in particular with the finding of ng/L levels of the compound in some Canadian drinking water supplies. Eventually, NDMA presence was attributed to both industrial and chlorine disinfection byproducts, although the precursors and mechanisms of the latter were not clearly delineated (Child, *et al* 1999; Ash, 1995). More sensitive analytical methods were developed (Taguchi, *et al, 1994*) in order to extend analytical capabilities from the ug/L to low ng/L range, and a number of possible wastewater precursors were implicated (Graham, *et al,* 1996; Child, *et al*, 1999; Najm and Trussel, 2000).

Subsequently, in California, the finding of NDMA contaminated groundwater from aerospace industrial contamination led to various State advisory levels ranging from 2-20 ng/L. Drinking water and reclaimed water producing agencies, including the Los Angeles County Sanitation Districts (LACSD), initiated NDMA surveys of treatment plants, distributed water, and groundwater supplies. For LACSD, the initial findings were satisfactory in that the recycled water operations yielded non-detects (<5 ng/L) in supplied waters. Treated effluents typically ranged from non-detects to less than 40 ng/L during the first year of the survey. Subsequently, the monitoring efforts were formalized to include more facilities on a monthly basis. At first sporadically, then consistently, several of the treatment plants began to show NDMA detection in the hundreds of ng/L. One facility on occasion showed concentrations over 1000 ng/L. These observations spurred a number of internal studies to characterize the unit processes involved, work that coincided with several published findings. Mitch and Sedlack (2002) identified a primary reaction mechanism in aqueous systems between monochloramine and dimethylamine and other amines. Child, *et al* (1996) had already suggested that quaternary amine-based polymers used in drinking water treatment could provide precursors for disinfection-induced NDMA formation, and Najm and Trussell (2001) provided additional data and literature review to support this suggestion.

Our internal studies and review of plant operations during this time showed that much of the elevated NDMA data was coincident with a phase-in of partial or complete nitrification/de-nitrification (NDN). Furthermore, it was determined that incorporation of NDN processes was accompanied by an increased use of a cationic polymer to control foaming and aid in settling and filtration, and a consistent mode of recycling filter backwash water within the plants. In short, treatment conditions and modes of

operations seemed optimal for NDMA formation, and we report here the findings of our investigations into the occurrence and formation of NDMA in several water reclamation plants.

Water Reclamation Plants

The five activated sludge (AS) water reclamation plants (WRP) described in this study represent different variations on the oxidation processes. One plant, La Canada (LAC) WRP is a 0.2 million gallons per day (MGD) conventional activated sludge secondary treatment plant that handles only domestic wastewater. The Whittier Narrows [WN] WRP (15 MGD) operates in the Modified Ludzak-Ettinger (MLE) nitrification-denitrification (NDN) mode. The San Jose Creek East (SJE) WRP (62.5 MGD) and Long Beach (LB) WRP (25 MGD) have independent units operating in step-feed NDN parallel to conventional AS. The San Jose Creek West (SJW) WRP (37.5 MGD) operates in conventional AS mode prior to filtration. In the latter four WRP, secondary effluent is treated with alum and chlorine just prior to filtration through dual media (DM), sand/anthracite filters. Secondary effluent is routinely chlorinated prior to filtration for disinfection and to control growth on the DM filters. Filtered (tertiary) effluent is maintained in chlorine-contact basins to effect contact times necessary for disinfection.

The three WRP with NDN processes used a polyacrylamide/dimethylamine (DMA) cationic polymer for foam control and/or improved settling on a continuous basis during the study. In routine operation, filter backwash water was recovered and returned to the treatment process at all four tertiary plants, although these practices varied by plant. The WN DM filters (4) were backwashed sequentially approximately every 36 hours. The SJE DM filters (20) were sequentially backwashed approximately every 24 hours, with backwash recovery water (approximately 150,000 gal/filter) pumped back into the plant via mixing with primary effluent. The LB DM filters (8) were backwashed sequentially on approximately 24-hour schedules. The SJW DM filters (14) were sequentially cycled on a 24-hour backwash schedule, and backwash recovery water was recycled via mixing with primary effluent.

Polymers

The cationic polymer used at all four tertiary plants comes from a single supplier. Based on proprietary information from the vendor, this is a Mannich-type polymer having a polyacrylamide/methyl amine formulation with DMA and formaldehyde added to activate the nucleophilic or "Mannich" condensation reaction to increase chain length. This is sold as a liquid flocculent designed for single step dilution prior to use, and is aimed at avoiding problems with on-site use of dry polymer formulations. Diluted (with chlorinated tertiary effluent) polymer is dosed via a dedicated metering pump to achieve desired dose rates in the plant (typically 0.5 – 1.5 mg/L) for de-foaming and settling.

Sample Collection

Samples were collected from individual tanks or basins using a 1L wide mouth HDPE bottle in an aluminum holder affixed to a rope. A series of sequential grabs were collected within a 2-3 minute time span and composited in 4L amber glass jugs at each location. The composite samples were transported immediately to the lab for processing. The composites were split into aliquots in 1L wide mouth jars and dechlorinated (if necessary) with sodium thiosulfate for NDMA analysis. Unprocessed sample portions were stored at 4°C in a walk-in refrigerator.

To profile filter backwash in terms of NDMA occurrence and formation potential (FP), seven samples were collected during the backwash cycle for each tertiary WRP. The first sample (A on Tables 1-8) was chlorinated secondary effluent entering the filter immediately prior to start of backwash cycle. Sample B was taken from filter residual following air scouring. Sample C was taken one minute after

backwash water began to enter the filter. Sample D was taken just as backwash water began to overflow into the launderers. Sample E was at the end of backwash, approximately 10 minutes after the backwash water began to enter the filter. Sample F was chlorinated secondary effluent filling the backwashed filter, and sample G was chlorinated filter effluent immediately downstream of filter discharge.

Samples from the LAC WRP were collected from raw influent, mixed liquor tanks, secondary effluent tanks, and chlorinated final effluent.

In the last phase of work, samples of conventional AS and NDN secondary effluent were collected from parallel AS units at SJE. Mixed secondary was sampled immediately after chlorination just prior to passing through the DM filters, and after filtration and 90 min of chlorine contact. These were grab samples as described above, and collection was based on estimates of plug-flow times through the process. These samples were analyzed for NDMA and NDMA FP to compare the effects of NDN and polymer with conventional AS.

Filter Operation

The dual-media filters vary somewhat between plants, but are deep bed anthracite/sand-filled chambers with surface area of 400-600 sf, 3.4-4 gpm/sf/d flow rates, and a backwash rate of 20-24 gpm/sf. Backwash flow lasts approximately 10 minutes, following several minutes of air scouring at approximately 2.5 - 5.25 cfm/sf. All liquid flows are chlorinated effluent. The complete backwash cycle for a single filter lasts approximately 45 minutes.

Materials and Methods

All reagents used in this study were reagent grade or better. Ammonium sulfate (>99%), sodium thiosulfate, sodium phosphate and sodium hydroxide were purchased from *Mallinckrodt*. 10% sodium hypochlorite was purchased from *Chem Lab Products*. NDMA standards were purchased from *Ultra Scientific*; d_6-NDMA standard was purchased from *Cambridge Isotope Labs,* and working standards were prepared by volumetric dilution in methanol (EM Science, OmniSolv grade).

Monochloramine standards were prepared daily by mixing 8.4 g of $(NH_4)_2SO_4$ and 90 ml reagent water in a 250 ml §24/40 ground joint Erlenmeyer flask; the mixture was stirred at room temperature until completely dissolved. The flask was placed in an ice bath and the ammonium sulfate solution spiked with 5 ml of pH 7.5 phosphate buffer. While stirring, 20 ml of a 10% NaOCl solution was added drop-wise to the cooled buffered $(NH_4)_2SO_4$ mixture using a pressure equalizing addition funnel. After addition of the hypochlorite solution was completed, the funnel was rinsed with an additional 10 ml of DI water and the rinsing was added to the cool stirred flask.

The chloramine solution was standardized iodometrically (Eaton, *et al*, 1998). 7.0 ml of a pH 7.5 phosphate buffer and a 2.68 ml aliquot of the above preparation were added (Rainen Autopipet with 10 mL chip) into 500 ml of reagent water (theoretical concentration 40 mg/L).

Sample filtration for comparisons of NDMA FP in soluble and suspended fractions was done by vacuum filtration with 0.45 μM (nominal) glass fiber filters (Whatman GFC).

3-hour NDMA Formation Potential Test

Sample aliquots of 500 ml were placed in narrow mouth, amber containers. Samples were brought to room temperature then spiked with 7.0 ml of pH 7.5 phosphate buffer and shaken. The buffered

solutions were spiked with pre-formed monochloramine standard to 40 mg/L, capped and stirred at 20 ± 2°C for three hours. Samples were then dechlorinated using 0.5 gram of sodium thiosulfate. The dechlorinated samples were checked with starch-iodide test strips to ensure chlorine removal.

NDMA Extraction

One-liter aliquots of dechlorinated samples or 250 mL aliquots, diluted to 1 liter, of dechlorinated formation potential samples were extracted by continuous liquid-liquid extraction. The sample was adjusted to pH> 10 with 12 N NaOH, then spiked with 10µL of a 5 mg/L d_6-NDMA standard in MeOH, and extracted overnight into dichloromethane using 1-L continuous liquid-liquid extractors. The extracts were concentrated on an 80° water bath using a Kuderna Danish (K-D) apparatus, and reduced to a 1-ml final volume on an N-EVAP (Organomation, Inc.) with a N_2 stream at 35°C.

GC/MS Analysis

Chromatographic analyses were performed on a ThermoFinnigan (San Jose, CA) Trace GC coupled to a ThermoFinnigan triple quadrupole mass spectrometer (TSQ) operated in chemical ionization mode with ammonia as the ionizing gas (CI/MS). The GC system used an Rtx®-5 amine (Restek, Bellefonte, PA.), 30-m × 0.25-mm I.D. fused-silica capillary column. Helium carrier gas flow rate was 1.2 mL/min. Splitless injections of 2 µL (with 25 psi surge for 0.3 min) were used with an injection port temperature of 210° C. The initial column temperature was 32° C for 5 min, programmed at 15° C/min to 80° C, then ramped to 290° C at 85° C/min, and held at 290° C for 2 min. The transfer line to the mass spectrometer was maintained at 250° C. The filament emission current was set at 600 µA, multiplier offset voltage at 300 V (total multiplier voltage at 1900 V), electron energy at –200 eV, and ion source temperature at 175° C. NDMA was analyzed by selected ion monitoring (SIM) of ions at 74.7 m/z and 91.7 m/z; d_6-NDMA was similarly analyzed using 80.7 m/z and 97.8 m/z. NDMA was quantified by isotope dilution method with d_6-NDMA using masses of 91.7 and 97.8, respectively. The instrument was checked daily using a mid-point NDMA calibration standard (50 µg/L NDMA and d_6-NDMA). Area count deviation greater than 20% required re-injection of the standard. If the deviation was still large, the instrument was recalibrated. In addition, quality of peak shapes, resolution, and retention times were carefully monitored to ensure the chromatography was acceptable.

Results and Discussion

The filter backwash cycle at each of the tertiary treatment plants was evaluated from two to nine times, following the sampling scheme outlined above. Chlorine residual was quenched immediately upon sample collection with sodium thiosulfate, and background NDMA was determined by extraction and GC/CI/MS. Isotope dilution GC/MS quantification using deuterium labeled internal standards (in this case, d_6-NDMA) is recognized as the best way to correct for analytical variables. Use of ammonia-CI/MS techniques provides specific and sensitive identification of NDMA and d_6-NDMA by excluding molecular fragments of potentially interfering compounds. Tables 1-4 present the individual NDMA results for the filter cycle experiments, and Figure 1 compares the mean NDMA background for the four WRP for each sample type.

The three-hour NDMA FP for each sample was determined by exposure to 40-mg/L monochloramine at pH 7.5. The 3-hour time period corresponds to approximately twice the normal chlorine contact time, and the nominal chlorine dosage is about four times the normal application rate in the plants. The pH was previously shown to be optimal for NDMA formation in our treated wastewater, and corresponds to published data for the reaction between monochloramine and DMA to produce NDMA (Mitch and

Sedlack, 2000). The FP results for the filter cycle experiments are shown in Tables 5-8, and mean WRP FPs are compared in Figure 2.

Table 9 contains the NDMA and FP results for the LAC plant samples (no DM filtration, no polymer).

	SJE 4 3/26/02	SJE 14 4/1/02	SJE 5 4/1/02	SJE 2 4/2/02	SJE 19 4/5/02	SJE 3 4/9/02	SJE 3 4/11/02	SJE 5 4/18/02	SJE 3 4/30/02	average
Sample A	82	n/a	748	670	187	128	1390	788	1010	625
Sample B	200	447	1790	1920	592	350	1770	1420	2400	1210
Sample C	328	524	2110	1920	644	394	1720	1380	2910	1330
Sample D	141	447	1650	1440	587	171	1100	1370	2440	1040
Sample E	128	139	706	602	306	166	n/a	882	1860	598
Sample F	82	1120	257	223	188	140	174	293	761	360
Sample G	124	130	n/a	419	132	167	188	564	625	293

Table 2. Background NDMA (ng/L) in SJW Filter B/W Cycle

	SJW 11 4/2/02	SJW 12 4/4/02	SJW 1 4/24/02	SJW 2 5/1/02	average
Sample A	13.7	11.1	7.11	11	10.7
Sample B	19.3	13.1	9.52	17.2	14.8
Sample C	20.2	16.6	13.6	31.8	20.6
Sample D	21.3	17.8	9.64	27.1	19
Sample E	18.1	15.1	14	23.7	17.7
Sample F	15.8	10.1	8.57	13.6	12
Sample G	28.2	13.7	9.68	19.9	17.9

Table 3. Background NDMA (ng/L) in WN Filter B/W

	WN 6 4/23/02	WN 3 4/25/02	Average
Sample A	303	266	339
Sample B	442	338	348
Sample C	653	370	340
Sample D	665	350	397
Sample E	271	233	226
Sample F	158	166	213
Sample G	334	195	265

Table 4. Background NDMA (ng/L) in LB Filter B/W Cycle

	LB 10 4/15/02	LB 7 4/22/02	LB 4 4/29/02	Average
Sample A	1530	134	n/a	832
Sample B	5040	552	627	2070
Sample C	6560	1010	1070	2880
Sample D	7690	1010	1060	3250
Sample E	3530	292	814	1550
Sample F	1640	93.2	138	623
Sample G	3060	220	335	1210

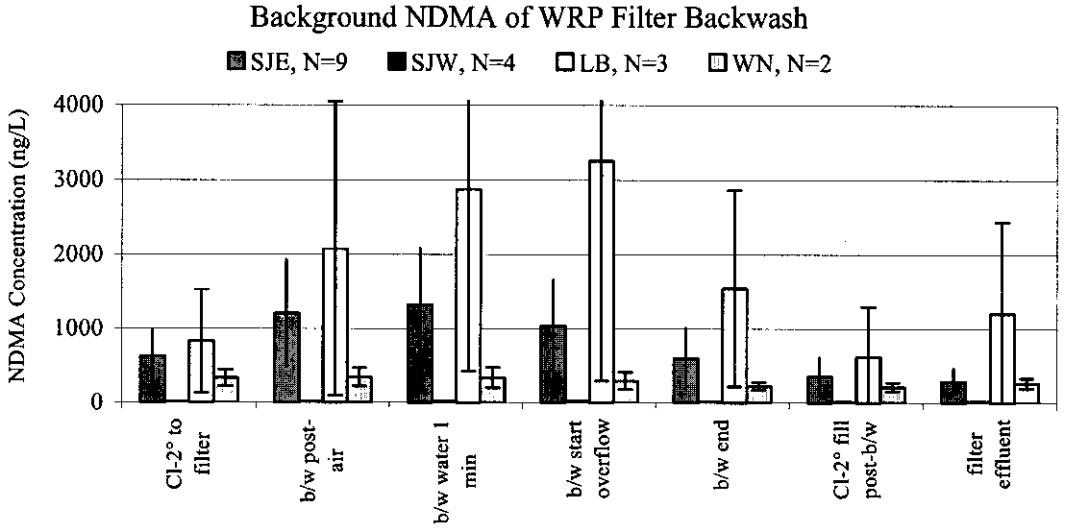

Figure 1.

Table 5. NDMA FP (ng/L) in SJE Filter B/W Cycle

	SJE 4 3/26/02	SJE 14 4/1/02	SJE 5 4/1/02	SJE 2 4/2/02	SJE 19 4/5/02	SJE 3 4/9/02	SJE 3 4/11/02	SJE 5 4/18/02	SJE 3 4/30/02	Average
Sample A	964	n/a	n/a	2120	3070	1940	3740	6180	2340	2910
Sample B	19100	5860	19300	5710	1200	14300	29400	64000	130000	32100
Sample C	14500	3900	15100	4080	832	15600	36200	47400	90000	25300
Sample D	n/a	3780	5390	2880	1000	1900	15400	43300	62700	17000
Sample E	3500	1100	404	588	3050	1480	n/a	7000	740	2230
Sample F	2980	560	1210	n/a	7030	1780	1190	n/a	3420	2600
Sample G	1400	2080	n/a	854	1400	1980	892	4250	2660	1940

Table 6. NDMA FP (ng/L) in SJW Filter B/W Cycle

	SJW 11 4/2/02	SJW 12 4/4/02	SJW 1 4/24/02	SJW 2 5/1/02	Average
Sample A	259	238	343	364	301
Sample B	169	238	3690	734	1210
Sample C	156	223	4090	660	1280
Sample D	33	52	4140	694	1230
Sample E	104	90	556	441	298
Sample F	456	392	591	381	455
Sample G	144	141	346	293	231

Table7. NDMA FP (ng/L) in WN Filter B/W

	WN 6 4/23/02	WN 3 4/25/02	Average
Sample A	1100	612	856
Sample B	33600	15300	24500
Sample C	39600	14300	27000
Sample D	32000	4410	18200
Sample E	294	282	288
Sample F	780	684	732
Sample G	n/a	194	194

Table 8. NDMA FP (ng/L) in LB Filter B/W Cycle

	LB 10 4/15/02	LB 7 4/22/02	LB 4 4/29/02	Average
Sample A	45800	3560	n/a	24700
Sample B	397000	93500	n/a	245000
Sample C	373000	79100	47800	167000
Sample D	376000	83000	44300	168000
Sample E	37200	3550	28500	23100
Sample F	51400	3010	2900	19100
Sample G	37800	2310	2790	14300

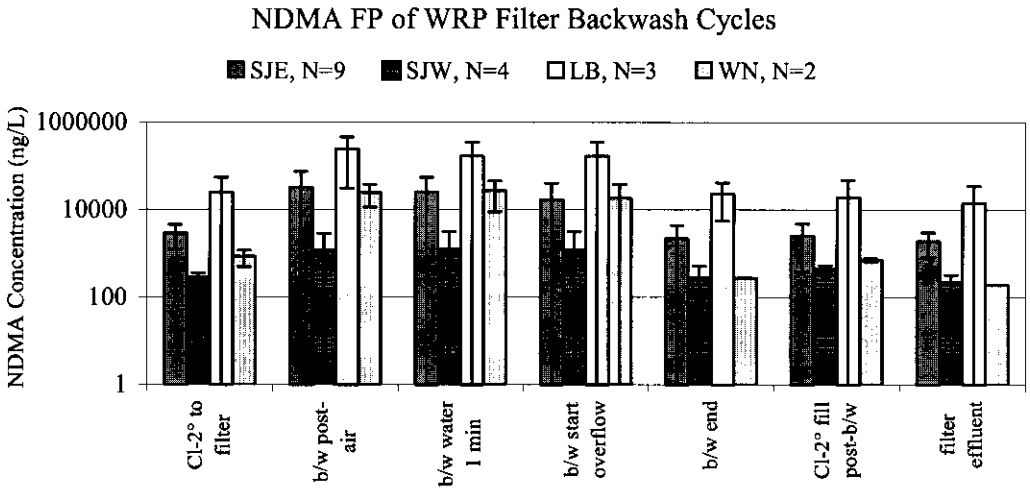

Figure 2.

Table 9. LAC NDMA and 3-Hour FP Results

Sample Description	NDMA (ng/L)	3-hr FP (ng/L)
Raw Influent	13.2	25.4
Secondary Tank 1	< 2	15.5
Secondary Tank 2	< 2	27.4
Mix Tank 1	2.8	32.9
Mix Tank 2	< 2	62.4
Chlorinated Final	25.6	n/a

Immediately apparent in these data sets is the difference between background NDMA in the three plant effluents that use cationic polymer on a regular basis, the SJW plant that does not normally use the polymer, and the domestic LAC plant that uses neither polymer nor filtration. For example, minutes after chlorination, the secondary effluent at the SJW plant averaged 11 ng/L NDMA. LAC had non-detected values (< 2 ng/L) prior to chlorination and 25 ng/L after full chlorine contact time. In contrast, the other plants' chlorinated secondary effluents averaged 630 ng/L (SJE), 340 ng/L (WN), and 830 ng/L (LB). NDMA levels in effluent just downstream of the filters (10-15 minutes after chlorination) for the four facilities averaged 18, 290, 270, and 1200 ng/L, for SJW, SJE, WN, and LB respectively. These ranges are commensurate with the patterns from the previous 12 months of routine NDMA monitoring conducted on 24 hr composite samples (data not shown) which led to the current study. The effluent data are also consistent with the initial premise that polymer usage and filter backwash recovery water recycling in the plant may be contributing to recent NDMA trends.

This premise was supported when material recovered from the initial stages of the backwash cycle at each plant was examined. The air scouring step resulted in the re-suspension of large amounts of solid material from the filter media. At the SJW plant, with no polymer usage, the air-scour liquor averaged 15 ng/L NDMA, which is very similar to the secondary and tertiary effluent NDMA concentrations.

The other plants showed average NDMA air-scour concentrations of 1200, 400, and 2100 ng/L for SJE, WN, and LB, respectively. Although these averages for the plants that apply polymer appear somewhat higher than the corresponding effluent averages, the NDMA concentrations only show a slight drop after chlorinated final effluent is used to backwash the filter media.

The 3-hr NDMA (FP) results, however, more dramatically demonstrate the location of residual precursors associated with polymer usage. The air-scour liquor FP averaged 33,000 ng/L at SJE, 25,000 ng/L at WN, and 248,000 ng/L at LB. In contrast, SJW, which does not routinely apply cationic polymer, had an average FP of 1200 ng/L, ranging below 200 ng/L on some filters. The FP in the filtered effluents from the four plants averaged 250, 2200, 300, and 15,000 ng/L for SJW, SJE, WN, and LB, respectively.

It is useful to examine these differences within the context of available precursors. Polymer residues are not the only source of NDMA precursors in wastewater, although in the treatment plants evaluated in this study, they may represent the most readily available source of reactants with monochloramine. When tested at a concentration of 1.5 mg/L, the cationic polymer mixture used in the plants yielded a background NDMA concentration of 150 ng/L. The 3-hour NDMA FP of this dilute polymer solution, however, was 39,000 ng/L. Therefore, at applied doses of 0.5-1.5 mg/L, significant NDMA and NDMA-FP are being added into the system, although a significant portion of this material added to the aeration system would be expected to settle out or otherwise be removed before being chlorinated and filtered. There are two likely contributing factors to the occurrence of elevated NDMA in these polymer-using plants. The first is the filter backwash recycling practices that allow polymer buildup and keep polymer residues under continuous oxidation conditions and long term contact with monochloramine. The second is the formulation of the polymer itself. The polymer used at the wastewater treatment plants in this study is a Mannich type polymer but the formulation supplied has added DMA (estimated to be >2%) and formaldehyde to aid condensation and increase polymeric chain length. Excess DMA is soluble enough to persist through AS treatment, particularly when added to the clarifiers after aeration (SJE, LB), and DMA can readily react with monochloramine (Mitch and Sedlack, 2002) in secondary effluent.

Based on the 3-hour NDMA-FP data, the practice of recycling filter backwash residue apparently causes a buildup of precursor within the system, much of which is readily available to react with monochloramine within the time frame of residence in the filters and chlorine contact tanks. Comparison of the FP results for several filtered (0.45 μM glass fiber) and unfiltered backwash (post-air scour cycle) samples showed that an average of 66% of the FP was associated with the filterable residue.

We were able to directly examine the consequences of removing the filter backwash recovery water from the system at SJE, WN, and LB by having Operations personnel discharge this material to the downstream sewer systems rather than recycling through the plants. The SJW plant, which routinely uses no polymer, showed similar NDMA results before and after the change. However, SJE and WN showed an average 73% reduction in NDMA following the cessation of backwash recycling in the first month. LB seemed slow to respond the first month, but showed a reduction of 75% by the second month. Overall, the three plants showed an average 55% reduction during the two months after backwash recycling ceased.

Once the filter backwash recycling was stopped, we were able to take advantage of the parallel operation of conventional AS and NDN processes at SJE, and compare the NDMA and FP of these two modes of treatment on the same primary influent. Table 10 contains results for the AS and NDN secondary

effluents, chlorinated mixed secondary just prior to filtration, and the filtered effluent 90 minutes after chlorination. The effects of adding polymer to the NDN process are readily apparent in the 30-fold increase in NDMA and FP.

Table 10. Comparison of Average NDMA and 3-hour FP in Conventional AS and NDN Effluents From SJE Reclamation Plant

	NDMA (ng/L)	3-hr FP (ng/L)
AS secondary effluent[a]	8	140
NDN secondary Effluent[a]	225	4400
Chlorinated mixed secondary[b,c]	125	3430
Chlorinated filtered effluent[d]	540	2320

a. Prior to mixing and chlorination
b. Approximately 5 minutes after chlorination
c. Approximate 50:50 mix of AS and NDN
d. 90min contact time, ca 3mg/L residual

Conclusions

Mannich type copolymers should be avoided in applications where chlorine disinfection will be practiced if NDMA formation is of concern.

Recycling of recovered filter backwash water and residue will likely lead to increased NDMA FP if cationic polymers are used, and should be avoided.

Use of any polymer that demonstrates NDMA FP should be minimized as much as possible in applications that include chlorine.

Polymer solutions should not be prepared with chlorinated plant effluent or other water that contains chlorine or chloramine residual.

There are likely NDMA precursors in domestic and industrial wastewaters that do not include polymer-based dimethylamine, which need to be characterized.

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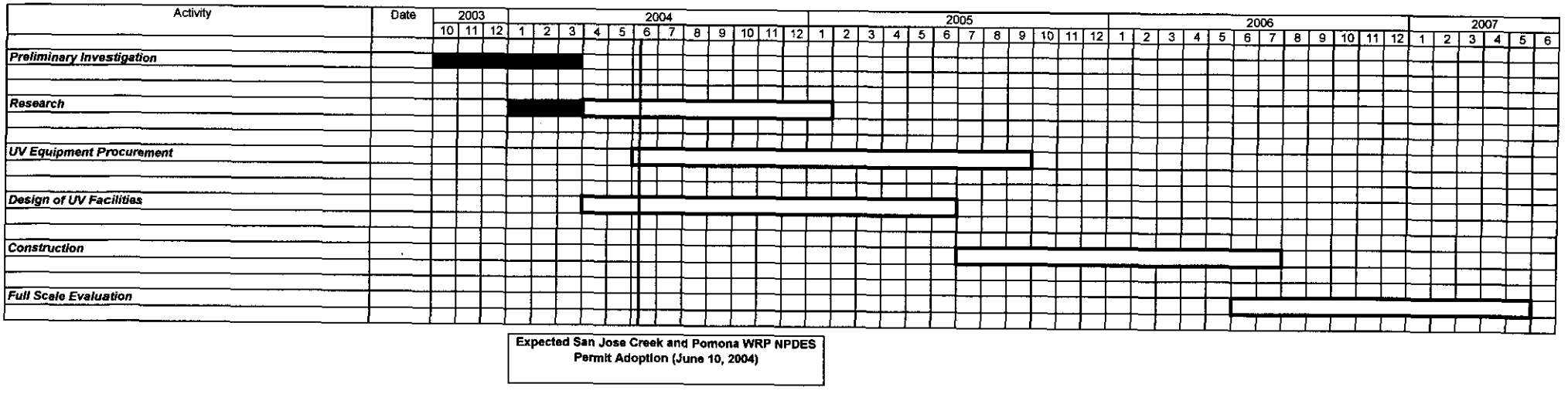
ATTACHMENT B

Whittier Narrows WRP UV Disinfection Facilities Project Schedule



CAN N-NITROSODIMETHYLAMINE FORMATION BE AFFECTED BY POLYMER USE DURING ADVANCED WASTEWATER TREATMENT?

Larry Neisess, LACSD SJCWQL, Whittier, CA
Rodger Baird, LACSD SJCWQL, Whittier, CA
Steve Carr, LACSD SJCWQL, Whittier, CA
John Gute, LACSD SJCWQL, Whittier, CA
John Strand, LACSD SJCWQL, Whittier, CA
Connie Young LACSD SJCWQL, Whittier, CA

Introduction

N-nitrosodimethylamine (NDMA) is a potent carcinogen in several animal species when administered by different exposure routes (Magee, *et al*, 1976) and is listed as a probable human carcinogen (U.S. EPA, 2002). As a family, the nitrosamines were the subject of considerable environmental attention in the 1970s, but outside of a number of processed and preserved foods and beverages, NDMA detection was not widespread and interest waned for many years. Attention was re-focused on NDMA in particular with the finding of ng/L levels of the compound in some Canadian drinking water supplies. Eventually, NDMA presence was attributed to both industrial and chlorine disinfection byproducts, although the precursors and mechanisms of the latter were not clearly delineated (Child, *et al* 1999; Ash, 1995). More sensitive analytical methods were developed (Taguchi, *et al, 1994*) in order to extend analytical capabilities from the ug/L to low ng/L range, and a number of possible wastewater precursors were implicated (Graham, *et al,* 1996; Child, *et al*, 1999; Najm and Trussel, 2000).

Subsequently, in California, the finding of NDMA contaminated groundwater from aerospace industrial contamination led to various State advisory levels ranging from 2-20 ng/L. Drinking water and reclaimed water producing agencies, including the Los Angeles County Sanitation Districts (LACSD), initiated NDMA surveys of treatment plants, distributed water, and groundwater supplies. For LACSD, the initial findings were satisfactory in that the recycled water operations yielded non-detects (<5 ng/L) in supplied waters. Treated effluents typically ranged from non-detects to less than 40 ng/L during the first year of the survey. Subsequently, the monitoring efforts were formalized to include more facilities on a monthly basis. At first sporadically, then consistently, several of the treatment plants began to show NDMA detection in the hundreds of ng/L. One facility on occasion showed concentrations over 1000 ng/L. These observations spurred a number of internal studies to characterize the unit processes involved, work that coincided with several published findings. Mitch and Sedlack (2002) identified a primary reaction mechanism in aqueous systems between monochloramine and dimethylamine and other amines. Child, *et al* (1996) had already suggested that quaternary amine-based polymers used in drinking water treatment could provide precursors for disinfection-induced NDMA formation, and Najm and Trussell (2001) provided additional data and literature review to support this suggestion.

Our internal studies and review of plant operations during this time showed that much of the elevated NDMA data was coincident with a phase-in of partial or complete nitrification/de-nitrification (NDN). Furthermore, it was determined that incorporation of NDN processes was accompanied by an increased use of a cationic polymer to control foaming and aid in settling and filtration, and a consistent mode of recycling filter backwash water within the plants. In short, treatment conditions and modes of

operations seemed optimal for NDMA formation, and we report here the findings of our investigations into the occurrence and formation of NDMA in several water reclamation plants.

Water Reclamation Plants

The five activated sludge (AS) water reclamation plants (WRP) described in this study represent different variations on the oxidation processes. One plant, La Canada (LAC) WRP is a 0.2 million gallons per day (MGD) conventional activated sludge secondary treatment plant that handles only domestic wastewater. The Whittier Narrows [WN] WRP (15 MGD) operates in the Modified Ludzak-Ettinger (MLE) nitrification-denitrification (NDN) mode. The San Jose Creek East (SJE) WRP (62.5 MGD) and Long Beach (LB) WRP (25 MGD) have independent units operating in step-feed NDN parallel to conventional AS. The San Jose Creek West (SJW) WRP (37.5 MGD) operates in conventional AS mode prior to filtration. In the latter four WRP, secondary effluent is treated with alum and chlorine just prior to filtration through dual media (DM), sand/anthracite filters. Secondary effluent is routinely chlorinated prior to filtration for disinfection and to control growth on the DM filters. Filtered (tertiary) effluent is maintained in chlorine-contact basins to effect contact times necessary for disinfection.

The three WRP with NDN processes used a polyacrylamide/dimethylamine (DMA) cationic polymer for foam control and/or improved settling on a continuous basis during the study. In routine operation, filter backwash water was recovered and returned to the treatment process at all four tertiary plants, although these practices varied by plant. The WN DM filters (4) were backwashed sequentially approximately every 36 hours. The SJE DM filters (20) were sequentially backwashed approximately every 24 hours, with backwash recovery water (approximately 150,000 gal/filter) pumped back into the plant via mixing with primary effluent. The LB DM filters (8) were backwashed sequentially on approximately 24-hour schedules. The SJW DM filters (14) were sequentially cycled on a 24-hour backwash schedule, and backwash recovery water was recycled via mixing with primary effluent.

Polymers

The cationic polymer used at all four tertiary plants comes from a single supplier. Based on proprietary information from the vendor, this is a Mannich-type polymer having a polyacrylamide/methyl amine formulation with DMA and formaldehyde added to activate the nucleophilic or "Mannich" condensation reaction to increase chain length. This is sold as a liquid flocculent designed for single step dilution prior to use, and is aimed at avoiding problems with on-site use of dry polymer formulations. Diluted (with chlorinated tertiary effluent) polymer is dosed via a dedicated metering pump to achieve desired dose rates in the plant (typically 0.5 – 1.5 mg/L) for de-foaming and settling.

Sample Collection

Samples were collected from individual tanks or basins using a 1L wide mouth HDPE bottle in an aluminum holder affixed to a rope. A series of sequential grabs were collected within a 2-3 minute time span and composited in 4L amber glass jugs at each location. The composite samples were transported immediately to the lab for processing. The composites were split into aliquots in 1L wide mouth jars and dechlorinated (if necessary) with sodium thiosulfate for NDMA analysis. Unprocessed sample portions were stored at 4°C in a walk-in refrigerator.

To profile filter backwash in terms of NDMA occurrence and formation potential (FP), seven samples were collected during the backwash cycle for each tertiary WRP. The first sample (A on Tables 1-8) was chlorinated secondary effluent entering the filter immediately prior to start of backwash cycle. Sample B was taken from filter residual following air scouring. Sample C was taken one minute after

backwash water began to enter the filter. Sample D was taken just as backwash water began to overflow into the launderers. Sample E was at the end of backwash, approximately 10 minutes after the backwash water began to enter the filter. Sample F was chlorinated secondary effluent filling the backwashed filter, and sample G was chlorinated filter effluent immediately downstream of filter discharge.

Samples from the LAC WRP were collected from raw influent, mixed liquor tanks, secondary effluent tanks, and chlorinated final effluent.

In the last phase of work, samples of conventional AS and NDN secondary effluent were collected from parallel AS units at SJE. Mixed secondary was sampled immediately after chlorination just prior to passing through the DM filters, and after filtration and 90 min of chlorine contact. These were grab samples as described above, and collection was based on estimates of plug-flow times through the process. These samples were analyzed for NDMA and NDMA FP to compare the effects of NDN and polymer with conventional AS.

Filter Operation

The dual-media filters vary somewhat between plants, but are deep bed anthracite/sand-filled chambers with surface area of 400-600 sf, 3.4-4 gpm/sf/d flow rates, and a backwash rate of 20-24 gpm/sf. Backwash flow lasts approximately 10 minutes, following several minutes of air scouring at approximately 2.5 - 5.25 cfm/sf. All liquid flows are chlorinated effluent. The complete backwash cycle for a single filter lasts approximately 45 minutes.

Materials and Methods

All reagents used in this study were reagent grade or better. Ammonium sulfate (>99%), sodium thiosulfate, sodium phosphate and sodium hydroxide were purchased from *Mallinckrodt.* 10% sodium hypochlorite was purchased from *Chem Lab Products.* NDMA standards were purchased from *Ultra Scientific*; d_6-NDMA standard was purchased from *Cambridge Isotope Labs,* and working standards were prepared by volumetric dilution in methanol (EM Science, OmniSolv grade).

Monochloramine standards were prepared daily by mixing 8.4 g of $(NH_4)_2SO_4$ and 90 ml reagent water in a 250 ml §24/40 ground joint Erlenmeyer flask; the mixture was stirred at room temperature until completely dissolved. The flask was placed in an ice bath and the ammonium sulfate solution spiked with 5 ml of pH 7.5 phosphate buffer. While stirring, 20 ml of a 10% NaOCl solution was added drop-wise to the cooled buffered $(NH_4)_2SO_4$ mixture using a pressure equalizing addition funnel. After addition of the hypochlorite solution was completed, the funnel was rinsed with an additional 10 ml of DI water and the rinsing was added to the cool stirred flask.

The chloramine solution was standardized iodometrically (Eaton, *et al*, 1998). 7.0 ml of a pH 7.5 phosphate buffer and a 2.68 ml aliquot of the above preparation were added (Rainen Autopipet with 10 mL chip) into 500 ml of reagent water (theoretical concentration 40 mg/L).

Sample filtration for comparisons of NDMA FP in soluble and suspended fractions was done by vacuum filtration with 0.45 μM (nominal) glass fiber filters (Whatman GFC).

3-hour NDMA Formation Potential Test

Sample aliquots of 500 ml were placed in narrow mouth, amber containers. Samples were brought to room temperature then spiked with 7.0 ml of pH 7.5 phosphate buffer and shaken. The buffered

solutions were spiked with pre-formed monochloramine standard to 40 mg/L, capped and stirred at 20 ± 2°C for three hours. Samples were then dechlorinated using 0.5 gram of sodium thiosulfate. The dechlorinated samples were checked with starch-iodide test strips to ensure chlorine removal.

NDMA Extraction

One-liter aliquots of dechlorinated samples or 250 mL aliquots, diluted to 1 liter, of dechlorinated formation potential samples were extracted by continuous liquid-liquid extraction. The sample was adjusted to pH> 10 with 12 N NaOH, then spiked with 10µL of a 5 mg/L d_6-NDMA standard in MeOH, and extracted overnight into dichloromethane using 1-L continuous liquid-liquid extractors. The extracts were concentrated on an 80° water bath using a Kuderna Danish (K-D) apparatus, and reduced to a 1-ml final volume on an N-EVAP (Organomation, Inc.) with a N_2 stream at 35°C.

GC/MS Analysis

Chromatographic analyses were performed on a ThermoFinnigan (San Jose, CA) Trace GC coupled to a ThermoFinnigan triple quadrupole mass spectrometer (TSQ) operated in chemical ionization mode with ammonia as the ionizing gas (CI/MS). The GC system used an Rtx®-5 amine (Restek, Bellefonte, PA.), 30-m × 0.25-mm I.D. fused-silica capillary column. Helium carrier gas flow rate was 1.2 mL/min. Splitless injections of 2 µL (with 25 psi surge for 0.3 min) were used with an injection port temperature of 210° C. The initial column temperature was 32° C for 5 min, programmed at 15° C/min to 80° C, then ramped to 290° C at 85° C/min, and held at 290° C for 2 min. The transfer line to the mass spectrometer was maintained at 250° C. The filament emission current was set at 600 µA, multiplier offset voltage at 300 V (total multiplier voltage at 1900 V), electron energy at –200 eV, and ion source temperature at 175° C. NDMA was analyzed by selected ion monitoring (SIM) of ions at 74.7 m/z and 91.7 m/z; d_6-NDMA was similarly analyzed using 80.7 m/z and 97.8 m/z. NDMA was quantified by isotope dilution method with d_6-NDMA using masses of 91.7 and 97.8, respectively. The instrument was checked daily using a mid-point NDMA calibration standard (50 µg/L NDMA and d_6-NDMA). Area count deviation greater than 20% required re-injection of the standard. If the deviation was still large, the instrument was recalibrated. In addition, quality of peak shapes, resolution, and retention times were carefully monitored to ensure the chromatography was acceptable.

Results and Discussion

The filter backwash cycle at each of the tertiary treatment plants was evaluated from two to nine times, following the sampling scheme outlined above. Chlorine residual was quenched immediately upon sample collection with sodium thiosulfate, and background NDMA was determined by extraction and GC/CI/MS. Isotope dilution GC/MS quantification using deuterium labeled internal standards (in this case, d_6-NDMA) is recognized as the best way to correct for analytical variables. Use of ammonia-CI/MS techniques provides specific and sensitive identification of NDMA and d_6-NDMA by excluding molecular fragments of potentially interfering compounds. Tables 1-4 present the individual NDMA results for the filter cycle experiments, and Figure 1 compares the mean NDMA background for the four WRP for each sample type.

The three-hour NDMA FP for each sample was determined by exposure to 40-mg/L monochloramine at pH 7.5. The 3-hour time period corresponds to approximately twice the normal chlorine contact time, and the nominal chlorine dosage is about four times the normal application rate in the plants. The pH was previously shown to be optimal for NDMA formation in our treated wastewater, and corresponds to published data for the reaction between monochloramine and DMA to produce NDMA (Mitch and

Sedlack, 2000). The FP results for the filter cycle experiments are shown in Tables 5-8, and mean WRP FPs are compared in Figure 2.

Table 9 contains the NDMA and FP results for the LAC plant samples (no DM filtration, no polymer).

	SJE 4 3/26/02	SJE 14 4/1/02	SJE 5 4/1/02	SJE 2 4/2/02	SJE 19 4/5/02	SJE 3 4/9/02	SJE 3 4/11/02	SJE 5 4/18/02	SJE 3 4/30/02	average
Sample A	82	n/a	748	670	187	128	1390	788	1010	625
Sample B	200	447	1790	1920	592	350	1770	1420	2400	1210
Sample C	328	524	2110	1920	644	394	1720	1380	2910	1330
Sample D	141	447	1650	1440	587	171	1100	1370	2440	1040
Sample E	128	139	706	602	306	166	n/a	882	1860	598
Sample F	82	1120	257	223	188	140	174	293	761	360
Sample G	124	130	n/a	419	132	167	188	564	625	293

Table 2. Background NDMA (ng/L) in SJW Filter B/W Cycle

	SJW 11 4/2/02	SJW 12 4/4/02	SJW 1 4/24/02	SJW 2 5/1/02	average
Sample A	13.7	11.1	7.11	11	10.7
Sample B	19.3	13.1	9.52	17.2	14.8
Sample C	20.2	16.6	13.6	31.8	20.6
Sample D	21.3	17.8	9.64	27.1	19
Sample E	18.1	15.1	14	23.7	17.7
Sample F	15.8	10.1	8.57	13.6	12
Sample G	28.2	13.7	9.68	19.9	17.9

Table 3. Background NDMA (ng/L) in WN Filter B/W

	WN 6 4/23/02	WN 3 4/25/02	Average
Sample A	303	266	339
Sample B	442	338	348
Sample C	653	370	340
Sample D	665	350	397
Sample E	271	233	226
Sample F	158	166	213
Sample G	334	195	265

Table 4. Background NDMA (ng/L) in LB Filter B/W Cycle

	LB 10 4/15/02	LB 7 4/22/02	LB 4 4/29/02	Average
Sample A	1530	134	n/a	832
Sample B	5040	552	627	2070
Sample C	6560	1010	1070	2880
Sample D	7690	1010	1060	3250
Sample E	3530	292	814	1550
Sample F	1640	93.2	138	623
Sample G	3060	220	335	1210

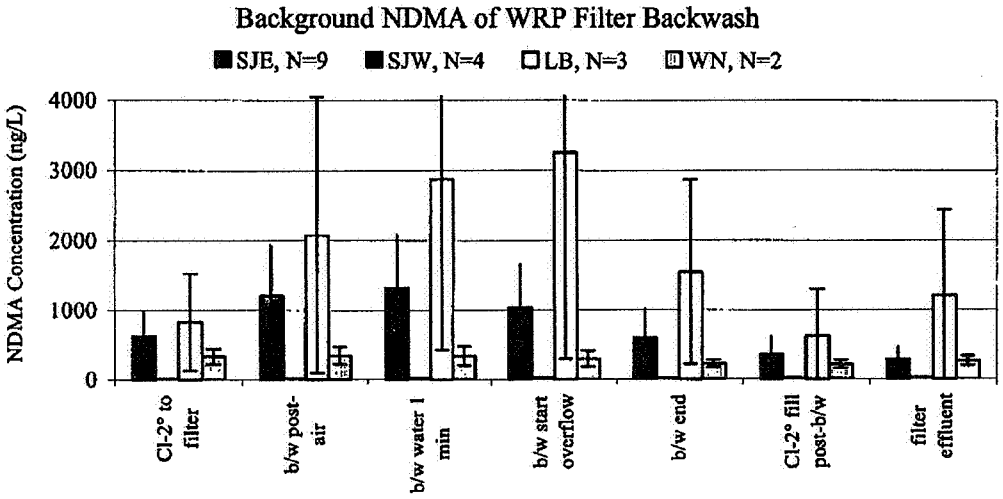


Figure 1.

Table 5. NDMA FP (ng/L) in SJE Filter B/W Cycle

	SJE 4 3/26/02	SJE 14 4/1/02	SJE 5 4/1/02	SJE 2 4/2/02	SJE 19 4/5/02	SJE 3 4/9/02	SJE 3 4/11/02	SJE 5 4/18/02	SJE 3 4/30/02	Average
Sample A	964	n/a	n/a	2120	3070	1940	3740	6180	2340	2910
Sample B	19100	5860	19300	5710	1200	14300	29400	64000	130000	32100
Sample C	14500	3900	15100	4080	832	15600	36200	47400	90000	25300
Sample D	n/a	3780	5390	2880	1000	1900	15400	43300	62700	17000
Sample E	3500	1100	404	588	3050	1480	n/a	7000	740	2230
Sample F	2980	560	1210	n/a	7030	1780	1190	n/a	3420	2600
Sample G	1400	2080	n/a	854	1400	1980	892	4250	2660	1940

The other plants showed average NDMA air-scour concentrations of 1200, 400, and 2100 ng/L for SJE, WN, and LB, respectively. Although these averages for the plants that apply polymer appear somewhat higher than the corresponding effluent averages, the NDMA concentrations only show a slight drop after chlorinated final effluent is used to backwash the filter media.

The 3-hr NDMA (FP) results, however, more dramatically demonstrate the location of residual precursors associated with polymer usage. The air-scour liquor FP averaged 33,000 ng/L at SJE, 25,000 ng/L at WN, and 248,000 ng/L at LB. In contrast, SJW, which does not routinely apply cationic polymer, had an average FP of 1200 ng/L, ranging below 200 ng/L on some filters. The FP in the filtered effluents from the four plants averaged 250, 2200, 300, and 15,000 ng/L for SJW, SJE, WN, and LB, respectively.

It is useful to examine these differences within the context of available precursors. Polymer residues are not the only source of NDMA precursors in wastewater, although in the treatment plants evaluated in this study, they may represent the most readily available source of reactants with monochloramine. When tested at a concentration of 1.5 mg/L, the cationic polymer mixture used in the plants yielded a background NDMA concentration of 150 ng/L. The 3-hour NDMA FP of this dilute polymer solution, however, was 39,000 ng/L. Therefore, at applied doses of 0.5-1.5 mg/L, significant NDMA and NDMA-FP are being added into the system, although a significant portion of this material added to the aeration system would be expected to settle out or otherwise be removed before being chlorinated and filtered. There are two likely contributing factors to the occurrence of elevated NDMA in these polymer-using plants. The first is the filter backwash recycling practices that allow polymer buildup and keep polymer residues under continuous oxidation conditions and long term contact with monochloramine. The second is the formulation of the polymer itself. The polymer used at the wastewater treatment plants in this study is a Mannich type polymer but the formulation supplied has added DMA (estimated to be >2%) and formaldehyde to aid condensation and increase polymeric chain length. Excess DMA is soluble enough to persist through AS treatment, particularly when added to the clarifiers after aeration (SJE, LB), and DMA can readily react with monochloramine (Mitch and Sedlack, 2002) in secondary effluent.

Based on the 3-hour NDMA-FP data, the practice of recycling filter backwash residue apparently causes a buildup of precursor within the system, much of which is readily available to react with monochloramine within the time frame of residence in the filters and chlorine contact tanks. Comparison of the FP results for several filtered (0.45 μM glass fiber) and unfiltered backwash (post-air scour cycle) samples showed that an average of 66% of the FP was associated with the filterable residue.

We were able to directly examine the consequences of removing the filter backwash recovery water from the system at SJE, WN, and LB by having Operations personnel discharge this material to the downstream sewer systems rather than recycling through the plants. The SJW plant, which routinely uses no polymer, showed similar NDMA results before and after the change. However, SJE and WN showed an average 73% reduction in NDMA following the cessation of backwash recycling in the first month. LB seemed slow to respond the first month, but showed a reduction of 75% by the second month. Overall, the three plants showed an average 55% reduction during the two months after backwash recycling ceased.

Once the filter backwash recycling was stopped, we were able to take advantage of the parallel operation of conventional AS and NDN processes at SJE, and compare the NDMA and FP of these two modes of treatment on the same primary influent. Table 10 contains results for the AS and NDN secondary

effluents, chlorinated mixed secondary just prior to filtration, and the filtered effluent 90 minutes after chlorination. The effects of adding polymer to the NDN process are readily apparent in the 30-fold increase in NDMA and FP.

Table 10. Comparison of Average NDMA and 3-hour FP in Conventional AS and NDN Effluents From SJE Reclamation Plant

	NDMA (ng/L)	3-hr FP (ng/L)
AS secondary effluent[a]	8	140
NDN secondary Effluent[a]	225	4400
Chlorinated mixed secondary[b,c]	125	3430
Chlorinated filtered effluent[d]	540	2320

a. Prior to mixing and chlorination
b. Approximately 5 minutes after chlorination
c. Approximate 50:50 mix of AS and NDN
d. 90min contact time, ca 3mg/L residual

Conclusions

Mannich type copolymers should be avoided in applications where chlorine disinfection will be practiced if NDMA formation is of concern.

Recycling of recovered filter backwash water and residue will likely lead to increased NDMA FP if cationic polymers are used, and should be avoided.

Use of any polymer that demonstrates NDMA FP should be minimized as much as possible in applications that include chlorine.

Polymer solutions should not be prepared with chlorinated plant effluent or other water that contains chlorine or chloramine residual.

There are likely NDMA precursors in domestic and industrial wastewaters that do not include polymer-based dimethylamine, which need to be characterized.

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Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse

Second Edition

May 2003

Published by the
National Water Research Institute
in collaboration with
American Water Works Association Research Foundation

Foreword

These guidelines are a revision of the 2000 *Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse.* They are intended to provide guidance to state and federal regulatory agencies who review applications for the use of ultraviolet (UV) disinfection systems in potable (drinkable) water and water reuse, and to water utilities who are interested in using UV for disinfection purposes. The National Water Research Institute (NWRI) would like to note that these guidelines have no binding regulatory effect unless promulgated by a federal, state, county, or local authority as official regulations. Although NWRI funded the development of this edition, it assumes no responsibility for the content of the work reported or for the opinions or statements of fact expressed herein.

More specifically, the following qualifications apply to these guidelines:

- The present guidelines are based on the minimum acceptable performance levels for the protection of public health. These guidelines are intended to encourage research (including new methods of analysis), improved operational procedures, and new technological developments. These guidelines are intended to be dynamic and will be revised as new information becomes available.
- In the present guidelines, scale-up is limited because of limitations in the state-of-the-art understanding of the appropriate relationships that should be used for scale-up. It is anticipated that scale-up will be addressed in more detail in a subsequent revision of these guidelines as more scientific and engineering findings become available.
- The present guidelines are based on the application of biodosimetry for reactor characterization using MS-2 bacteriophage as the default organism. It is recognized that a number of alternative approaches have been proposed, including multi-organism bioassay techniques and the ability to design UV disinfection systems for the target pathogen or indicator rather than MS-2 (the default organism). It is anticipated that such approaches will be incorporated in subsequent revisions of these guidelines as additional scientific evidence is gathered.
- The target pathogens and their corresponding inactivation requirements for drinking water have not been identified in the present guidelines. The design UV dose will depend on the target microorganism and the type of treatment processes employed prior to UV disinfection. The target microorganisms and the required inactivation levels must be established by the regulatory agency.
- In the present guidelines, the focus is on testing the UV disinfection systems directly. Although the importance of computational fluid dynamics in the analysis and design of UV systems is acknowledged, performance predictions based on computational fluid dynamics are not allowed in these guidelines. As the techniques of computational fluid dynamics become more standardized, the use of such computations may be incorporated in future revisions of these guidelines.
- Finally, it is important to note that these guidelines are not meant to serve as a design manual for the planning and installation of UV disinfection systems. The final design of a UV disinfection system remains the responsibility of the design engineer and the UV manufacturer.

Preface

This document had its origin in 1993 when the National Water Research Institute (NWRI) collaborated with the California Department of Health Services (DHS) to convene a group of experts and, through diligent effort, create the *Ultraviolet Disinfection Guidelines for Wastewater Reclamation in California and UV Disinfection Research Needs Identification* (1993). Over 5,000 copies of the 1993 guidelines were distributed throughout the United States and overseas. Eventually, a number of regulatory agencies within the United States adopted the ultraviolet (UV) disinfection guidelines when reviewing applications for the use of UV systems in water reuse projects.

In January 2000, NWRI and the NWRI Corporate Associates convened *UV 2000: A Technical Symposium* to address the technological advancements and regulatory changes that had occurred since the publication of the 1993 guidelines. The product of the symposium was the *UV 2000 Abstracts*, which had topics ranging from "The Status of UV Technology in Europe" to "Standardizing UV Equipment Performance Validation." More importantly, *UV 2000* focused on the need to revise and expand the 1993 guidelines. This revision would include applying UV disinfection to both water reuse and drinking water purification processes.

Following the symposium, the American Water Works Association Research Foundation (AwwaRF) approached NWRI to help assist in revising the 1993 guidelines. Over the next 10 months, NWRI and AwwaRF organized several workshops that brought together international experts to rethink and rewrite the guidelines. The resulting document was the *Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse*, which was published in December 2000.

By mid-2002, however, it became evident that actual experience gained from the application of the 2000 guidelines in a variety of situations warranted a revision; therefore, a subcommittee of the original authors was organized to prepare the second edition of the 2000 guidelines. This edition was revised to: (1) reflect needed changes resulting from the experience gained in the application of the 2000 guidelines, (2) clarify application issues, and (3) incorporate additional guidance on UV lamp storage. The subcommittee gathered together comments and prepared the revisions, which were then distributed to members of a review panel. The panel's comments were subsequently incorporated into this edition of the guidelines.

This document — *Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse, second edition* — is the result of the efforts of the following individuals:

Second Edition Revision Subcommittee:

Richard H. Sakaji, Ph.D., P.E., *California Department of Health Services*
Fred Soroushian, P.E., *CH2M Hill*
George Tchobanoglous, Ph.D., P.E., *University of California, Davis*

Review Panel:

Ernest R. Blatchley III, Ph.D., P.E., *Purdue University*
Robert W. Emerick, Ph.D., P.E., *ECO:LOGIC Engineering*
Thomas Hargy, *Clancy Environmental Consultants*
Oluf Hoyer, Ph.D., *DVGW Test Laboratory for UV-Systems (Germany)*
Robert H. Hultquist, P.E., *California Department of Health Services*
Albert Ilges, *American Water Works Association Research Foundation*
Ronald B. Linsky, *National Water Research Institute*
O. Karl Scheible, *HydroQual, Inc.*
Daniel C. Schmelling, Ph.D., *United States Environmental Protection Agency*

Editor:

Gina Melin, *National Water Research Institute*

Graphic Design:

Tim Hogan, *Tim Hogan Graphics*

Corporate Associates:

Boyle Engineering

Camp, Dresser & McKee, Inc.

Carollo Engineers

CH2M Hill

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Montgomery Watson Harza

Parsons Engineering Science, Inc.

Robert Bein, William Frost & Associates

The Irvine Company

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Acronyms

ATCC	American Type Culture Collection
DHS	(California) Department of Health Services
EPA	United States Environmental Protection Agency
GFI	Ground fault interruption
MF	Microfiltration
MPN	Most probable number
NF	Nanofiltration
ntu	Nephelometric turbidity unit
QA/QC	Quality Assurance/Quality Control
RO	Reverse osmosis
TSB	Tryptic soy broth
TSS	Total suspended solids
UF	Ultrafiltration
UPS	Uninteruptable power supply
UV	Ultraviolet
WRC	Water Recycling Criteria

Abbreviations

a.u./cm	Absorbance units per centimeter
cm	Centimeter
G	Gravity
g	Gram
g/L	Grams per liter
gpm	Gallons per minute
kW	Kilowatt
L	Liter
m	Meter
mg/L	Milligram per liter
mJ/cm^2	Millijoules per square centimeter
mL	Milliliter
mm	Millimeter
mW/cm^2	Milliwatts per square centimeter
$mW{\cdot}s/cm^2$	Milliwatt second per square centimeter (equivalent to mJ/cm^2)
nm	Nanometer
pfu/mL	Plaque forming unit per milliliter
pfu/plate	Plaque forming unit per plate
rpm	Revolutions per minute
µm	Micrometer

Chapter Two: Water Reuse

Robert W. Emerick

Richard H. Sakaji

Fred Soroushian

George Tchobanoglous

1. Introduction

Unless otherwise indicated, these UV guidelines apply to the disinfection of wastewater meeting the definition of "filtered wastewater" in California's Water Recycling Criteria (WRC), Title 22, Division 4, Chapter 3, of the California Code of Regulations. After disinfection, the filtered wastewater is defined herein as "disinfected filtered reclaimed water" and is essentially pathogen-free (i.e., 5-$\log_{10}$ poliovirus inactivation and a 7-day median total coliform of 2.2 most probable number [MPN]/100 milliliters [mL]). Disinfected filtered reclaimed water in California is suitable for the irrigation of food crops (including all edible root crops), parks, playgrounds, school yards, residential landscaping, unrestricted access golf courses, non-restricted recreational impoundments, cooling towers, flushing toilets and urinals, industrial process water, structural firefighting, decorative fountains, commercial laundries, and commercial car washes as well as for the production of artificial snow, priming of drain traps, and consolidation of backfill around potable (drinkable) water pipelines.

The U.S. Environmental Protection Agency (EPA) published *Guidelines for Water Reuse* in 1992. The EPA's guidelines feature a level of treatment and disinfection that is similar to California's requirements. This includes recommendations for the filtration and disinfection of secondary effluent to achieve turbidity less than 2 nephelometric turbidity units (ntu) (24-hour average, with a maximum of 5 ntu) and a median fecal coliform concentration of less than detection. The EPA recommends that, if total suspended solids (TSS) are used by a state in lieu of turbidity, the average TSS should not exceed 5 milligrams per liter (mg/L). These guidelines are applicable to urban reuse systems, the use of reclaimed water for the irrigation of edible crops, and the use of reclaimed water in recreational impoundments. The UV disinfection criteria contained in these guidelines are applicable to this level of treatment and disinfection recommended by the EPA.

Other states have established water reuse regulations similar to the EPA's *Guidelines for Water Reuse.* For example, Florida requires that reclaimed water used to irrigate public access areas (golf course, parks, others), residential properties, and edible crops must receive secondary treatment, filtration, and high-level disinfection. Florida requires that no TSS sample exceeds 5.0 mg/L and that at least 75 percent of all observations of fecal coliforms be less than detection (Florida Administrative Code, 1999). The UV disinfection criteria contained in these guidelines are also applicable to Florida's high-level disinfection criteria and to other states' reuse criterias, where the states' criterias are consistent with the EPA's *Guidelines for Water Reuse.*

UV disinfection may be applicable to water reuse activities that require less stringent microbiological water-quality criteria; however, the performance-based testing criteria contained herein are based on experience using water-quality conditions that are defined by the term, "filtered wastewater." While it may be appropriate to use UV disinfection on secondary effluents used for water reuse, performance-based studies need to be conducted and presented to the appropriate regulatory authorities before such applications are accepted. These guidelines will facilitate the design and commissioning of UV disinfection systems subject to the limitations set forth in the Foreword.

Performance Testing of UV Disinfection Systems

These guidelines are meant to provide a common basis for the evaluation and implementation of UV disinfection technologies. As a minimum, manufacturers are required to demonstrate the

efficacy of their equipment[2] as outlined in Chapter Three. When testing is complete, the results shall be summarized in a report. This performance-based testing approach is directed toward quantifying the inactivation of target microorganisms (i.e., MS-2 bacteriophage) by UV equipment.

Organization of the Water Reuse Guidelines

The water reuse guidelines are organized into the following sections:

1. Introduction
2. UV Dose
3. Reactor Design
4. Reliability Design
5. Monitoring and Alarm Design
6. Field Commissioning Test
7. Performance Monitoring
8. Engineering Report

The topics in Sections 2 to 7 deal specifically with the key elements involved in the design, operation, and monitoring of a UV disinfection system. These topics must be addressed in the required Engineering Report (Section 8).

2. UV Dose

The UV dose is expressed, for practical purposes, as the product of UV intensity, expressed in milliwatts per square centimeter (mW/cm^2), and the exposure time of the fluid or particle to be treated, expressed in seconds (s). The units of UV dose are expressed as millijoules per square centimeter (mJ/cm^2), which is equivalent to milliwatt seconds per square centimeter ($mW{\cdot}s/cm^2$). Currently, it is only possible to accurately characterize the UV dose when using a collimated-beam apparatus because both the intensity reaching the fluid elements and the exposure time can be accurately quantified. Non-ideal hydraulics and non-uniform intensity profiles result in a distribution of doses being applied in continuous-flow reactors.

For continuous-flow reactors, the terms "delivered UV dose," "design UV dose," and "operational UV dose" will be used hereafter and defined as follows:

- *Delivered UV dose.* The dose that is assigned to the UV test reactor based on reactor validation testing. The delivered UV dose is equivalent to that measured with the collimated-beam apparatus for the same degree of inactivation of the target microorganism.
- *Design UV dose.* The delivered UV dose required for a specific log inactivation of the target microorganism. The design UV dose is used for sizing UV disinfection systems.
- *Operational UV dose:* The UV dose that is established based on the results of the equipment validation testing. The operational UV dose, a useful index of reactor behavior, can be used to make most efficient use of the UV disinfection system (e.g., reduce power demand, reduce number of reactors or reactor trains on-line) while maintaining the design UV dose.

2. The performance-based testing outlined in these guidelines is not intended to cover the use of UV for photochemical or advanced oxidation processes.

The design of a UV disinfection system for the water reuse applications discussed in Section 1 depends on the type of filtration technologies preceding it. The following minimum criteria shall be used for these three types of filtration: media filtration, membrane filtration, and reverse osmosis (RO).

Media Filtration

When using non-membrane filtration (e.g., granular, cloth, or other synthetic media) as part of the treatment process train upstream of UV disinfection, the following performance criteria shall apply:

- The design UV dose shall be at least 100 mJ/cm^2 under maximum day flow.
- The filtered effluent UV transmittance shall be 55 percent or greater at 254 nm.
- The effluent quality as defined by turbidity or TSS should be similar to the standards applicable in California or Florida. In California, the 24-hour average effluent turbidity shall be no greater than 2 ntu, not to exceed 5 ntu more than 5 percent of the time, and never to exceed 10 ntu (California WRC, 2000). In Florida, the TSS limit is 5 mg/L as a single sample maximum (Florida Administrative Code, 1999). Although an average value is not specified, most Florida facilities will reject filtrate as being unacceptable if the turbidity exceeds a set point generally in the range of 2 to 3 ntu.

Collimated-beam apparatus testing on site-specific filtered wastewater, in accordance with the equipment validation protocol (see Chapter Three), shall be conducted to confirm compliance with the indigenous indicator microorganism (e.g., total or fecal coliform bacteria). The minimum design UV dose under the maximum day flow condition shall be either 100 mJ/cm^2 or a delivered dose corresponding to the collimated-beam apparatus dose required for achieving indigenous indicator microorganism inactivation, whichever is greater.

Membrane Filtration

When using membrane filtration (e.g., MF and UF) as part of the treatment process train upstream of UV disinfection, the following performance criteria shall apply:

- The design UV dose shall be at least 80 mJ/cm^2 under maximum day flow.
- The effluent turbidity shall be equal to or less than 0.2 ntu 95 percent of the time, not to exceed 0.5 ntu.
- The filtered effluent UV transmittance shall be 65 percent or greater at 254 nm.

Reverse Osmosis (RO)

When using RO as part of the treatment process train upstream of UV disinfection, the following performance criteria shall apply:

- The design UV dose shall be at least 50 mJ/cm^2 under maximum day flow.
- The effluent turbidity shall be equal to or less than 0.2 ntu 95 percent of the time, not to exceed 0.5 ntu.
- The permeate UV transmittance shall be 90 percent or greater at 254 nm.

Rationale

Reactor performance, in terms of the inactivation of any particular microorganism, is governed by the UV dose distribution and the intrinsic kinetics of microbial inactivation (i.e., dose-response behavior). While dose-response behavior can be measured using a collimated-beam system and appropriate microbial assays, methods available for characterizing and quantifying UV dose distributions are not well-defined. Although numerical methods are available for predicting UV dose distribution, these methods are neither standardized nor widely adopted for practical applications. As a result, these guidelines are based on biodosimetry methods for testing and validating UV reactors.

Establishing the UV dose involves determining the UV inactivation of a selected microorganism under controlled batch conditions. For equipment performance validation, MS-2 is recommended. The benefits of MS-2 include high resistance to UV, nearly first order inactivation kinetics over the range of UV doses typically used for disinfection, ease of seeding and enumeration, consistent and reproducible assay results, non-pathogenicity to humans, and the inability to photoreactivate. For the purpose of standardization, the delivered UV dose is defined as achieving the same degree of MS-2 inactivation in a continuous flow reactor as is achieved in a collimated-beam apparatus reactor equipped with a low-pressure, non-ozone producing mercury lamp. Details are provided in Chapter Three.

Based on experience, when UV disinfection systems are used with granular medium filtration, it has been found that coliform bacteria inactivation often governs the design requirements. Particulate matter shields bacteria from UV light to various degrees. While the delivered dose of 100 mJ/cm^2 is typically adequate to inactivate total coliform to less than 2.2 MPN/100 mL, in light of variability that has been observed in reuse systems, collimated-beam testing with actual filtered effluent is required to confirm the impact of particle-associated coliform on UV disinfection effectiveness. Identifying and establishing target pathogens and log inactivation requirements are beyond the intent and scope of this manual; however, based on available laboratory studies, a 5-log$_{10}$ inactivation of poliovirus can be achieved with a UV dose of 50 mJ/cm^2; therefore, the design UV dose of 100 mJ/cm^2 is suggested to account for variability in the effluent quality.

When using MF or UF, the impact of particles is eliminated and viruses are the pathogen of concern. Five-log$_{10}$ inactivation of poliovirus can be achieved with a UV dose of 50 mJ/cm^2; therefore, the design UV dose of 80 mJ/cm^2 is suggested to account for variability in the effluent quality.

When using RO for filtration, at least 2 log$_{10}$ of viruses will be removed through the RO process. Three-log$_{10}$ inactivation of poliovirus can be achieved with a UV dose of about 30 mJ/cm^2; therefore, the design UV dose of 50 mJ/cm^2 is suggested to account for variability in the effluent quality.

The UV transmittance and turbidity requirements represent experience from a number of operating facilities. This does not preclude the use of UV in systems with water-quality characteristics outside these limits. To use UV in these instances, the performance of the UV reactor must be validated under poor water-quality conditions.

Design Conditions

The design UV dose must be based on the following design conditions:

1. The UV lamp output at 50 percent of nominal (new) UV lamp output (after an appropriate burn-in period), unless the manufacturer establishes the lamp age factor for the time period

that corresponds to the lamp change-out time intervals specified in the Engineering Report. The lamp age factor shall be verified in accordance with the protocols in Chapter 3.

2. Eighty percent transmittance through the quartz sleeve for manually cleaned systems, excluding the transmittance characteristics of the quartz sleeve.
3. Eighty percent transmittance through the quartz sleeve for automatic mechanical or chemical cleaning systems, excluding the transmittance characteristics of the quartz sleeve, unless test data are provided to substantiate a higher value in accordance with the protocols in Chapter 3. The cleaning frequency will be based on the manufacturer's recommendation.
4. If transmittance data (a minimum of three samples per day spaced equally over the operating period) have been collected for a minimum period of 6 months, including wet weather periods, the 10-percentile UV transmittance value can be used. The UV transmittance measurements shall be at 254 nm wavelength.
5. Shelf life of the lamps should be considered for stocking the replacement lamps. Storage shelf life should be in accordance with the manufacturer's recommendations.

Rationale

Based on lamp testing data, it appears that the operating conditions for water reuse UV disinfection systems result in an accelerated decrease in UV lamp intensity when compared to those tested in air. The lamp age factor of 0.5 is representative of conventional low-pressure lamps after 1 year of service. Further, reduced lamp output has been observed for replacement lamps stored for extended time periods. This age value is recommended for all lamp systems unless data are collected in accordance with the protocols in Chapter 3 to substantiate a different design value. For polychromatic lamps, the impact of lamp age and fouling on lamp output characteristics and individual wavelengths emitted are not known; therefore, the same factors are assumed for polychromatic lamps until additional data are available.

3. Reactor Design

Because of the numerous system configurations that are available (e.g., open channels, closed conduits, various lamp orientations, etc.), UV facilities will have different scale-up, layout, and mechanical redundancy requirements. The following terms are used consistently throughout this document:

- *Module.* The basic building block of a UV disinfection system. It is comprised of one or more UV lamps with a common electrical feed.
- *Bank.* One or more UV modules that the entire flow for a given reactor train must pass through.
- *Reactor.* An independent combination of single or multiple bank(s) in series with a common mode of failure (e.g., electrical, cooling, cleaning system, etc.).
- *Reactor train.* A combination of reactors in series, including inlet, outlet, and level controlling arrangements (if applicable).
- *UV disinfection system.* The combination of reactor trains with associated controls and instrumentation.

Reactor trains should be designed with approach, inlet, and outlet conditions that promote plug flow (i.e., minimal longitudinal mixing, effective lateral mixing) within the irradiated zone. There must be reliable flow distribution among multiple reactor trains proportional to reactor train flow capability. Inlet approach conditions should allow sufficient distance to establish a uniform velocity field upstream of the first reactor in a reactor train, unless an alternate velocity field can be measured and demonstrated to provide satisfactory performance in accordance with the protocols in Chapter Three. The outlet condition should ensure that hydraulic behavior within the last reactor is not adversely affected by any outlet fluid-level control device or pipefittings. Regardless of the equipment utilized, the standby equipment and reliability features that are described in Section 4 must be integrated in the design of the UV disinfection system.

Hydraulic Constraints

The design of the reactor train(s) inlet and outlet are the responsibility of the UV manufacturer and should be characterized using velocity profiles. Hydraulic testing, including the measurement of velocity distribution profiles, must be performed as part of the UV validation testing (see Chapter Three). The inlet and outlet velocity profiles must be maintained between the validated UV equipment and full-scale installation. If inlet and outlet conditions are identical to those in the validated system, a velocity profile will not be required. The maintenance of velocity profiles may require the use of facilities for modifying the flow pattern, such as perforated plate diffusers or other devices (similar or in addition to those used during validation testing), as part of the full-scale reactor train. In all cases, the reactor train shall be designed to operate with the same approach velocity range used for equipment validation (see Chapter Three).

For full-scale reactors that use more lamps than the reactors used for validation testing, velocity profiles shall be established in accordance with the Chapter 3 protocols. For these reactors, it must be demonstrated that the mean measured velocity at any measured cross-sectional point (excluding momentum boundaries [i.e., stationary surfaces such as reactor walls]) does not vary by more than plus or minus 20 percent from the theoretical average velocity (i.e., flow divided by the cross-sectional area), unless an alternate velocity field can be measured and demonstrated for both pilot- and full-scale reactors to provide satisfactory performance.

For water reuse applications, scale-up of pilot data for full-scale design is allowable only for those systems where velocity profiles can be adequately quantified for both the equipment used for validation testing and for the full-scale reactor. It is not permitted to scale-up the pilot reactor if velocity profiles cannot be quantified adequately. In such instances, only modular arrangements of the validated reactor can be implemented in full-scale operation.

In the layout of the UV disinfection system, the following hydraulic factors (based on the equipment validation test results) must be addressed:

1. The required approach length and conditions prior to the first reactor.
2. The downstream length following the last reactor before the fluid-leveling device (if applicable) or other piping elements (e.g., valves, bends).
3. The spacing between multiple UV reactors. The spacing must allow for maintenance and access in addition to adequate hydraulic performance.
4. Any device, reactor component, or other feature that is used to accomplish or enhance effective uniform velocities.
5. The presence and operation of any cleaning device/mechanism.

Rationale

Based on currently available information, excessive longitudinal mixing in the irradiated zone promotes the broadening of dose distribution. Similarly, inadequate lateral mixing can promote a wide dose distribution where some fluid elements may receive an inadequate UV dose. A properly designed inlet structure and approach will help ensure that uniform flow conditions are imposed on the first reactor in a UV reactor train. Concurrently, a properly designed outlet structure or piping will ensure that outlet conditions do not adversely affect fluid behavior within the last reactor. Uniform flow distribution is typically desirable, but does not guarantee adequate hydrodynamic behavior in the irradiated zone. When inlet and outlet conditions are not identical with respect to geometry, placement of diffusers, and/or flow conditioning devices, velocity measurements will be required.

Reactor Train Layout Constraints

The number of reactor trains included must consider the hydraulic limitations and turndown ratios for the given UV disinfection system. Multiple reactor trains may be required to accommodate large variations from low-flow to peak-flow conditions. The sizing and layout of reactor trains must ensure that the reactor train velocities are within the velocity range that the equipment was validated for. Critical design elements include:

1. Reactor walls shall be consistent with the manufacturer's recommendations.
2. It must be possible to isolate each reactor train during maintenance.
3. Concrete channels shall be adequately lined or coated to ensure that organisms do not become embedded within crevices. All material exposed to UV radiation shall be UV resistant.
4. The upstream and downstream portions of the UV reactor and the sections between reactors must be water and light tight (e.g., covered) and must prevent external runoff or other materials from entering the UV reactor train.

Rationale

Extreme flow conditions (i.e., low and peak flow), which may exceed the velocity ranges acceptable for a given reactor design, can be mitigated by the use of multiple reactor trains. Because lamps may break during maintenance, the ability to isolate a reactor during maintenance would aid in containing contaminated water. Variations in reactor walls can result in regions of low UV intensity that would aid in passing inadequately disinfected fluid elements. Lining of concrete channels would aid in preventing microorganisms from growing within crevices of the channel, which could adversely affect disinfection performance. Reactor train(s) must be sealed or covered to avoid the growth of algae containing biofilms and to protect the health of personnel.

Cleaning System Constraints

As part of the UV disinfection system, the cleaning system must deal effectively with site-specific water-quality effects (e.g., precipitation and fouling due to iron, calcium, aluminum, manganese, and other inorganic and organic constituents). Site-specific testing is recommended when iron, calcium, aluminum, manganese, and magnesium concentrations are present at high concentrations relative to saturation limits. The fouling test can be done on a scale sufficient to include the smallest modular size of the commercial cleaning device.

Rationale

The effectiveness of a UV disinfection system is, in part, maintained by the performance of the cleaning system. Iron, calcium, aluminum, manganese, and magnesium have been observed to impact the effectiveness and frequency of cleaning requirements. Site-specific testing is recommended when any of these constituents are present at concentrations that can result in the fouling of quartz sleeves.

4. Reliability Design

Because regulatory standards associated with unrestricted water reuse are stringent, special attention must be devoted to the reliability of any proposed UV disinfection system, including: standby equipment, water-quality reliability, operation and maintenance, power-supply reliability, electrical safety, and design for seismic loads.

Standby Equipment

The UV disinfection system should be designed to convey the design UV dose (see Section 2) under worst-case operating conditions (e.g., flowrate, water quality) to the pathogen passing through the reactor train. At a minimum, two reactors must be simultaneously operated in any on-line reactor train. Standby UV equipment must be provided by one of the following options:

- A standby reactor per reactor train.
- A standby reactor train.

As an alternative to standby equipment, adequate storage[3] or other contingency arrangements can be provided to deal with the flow during UV disinfection system failure and must be described in the required Engineering Report.

The UV disinfection system must be capable of applying the required design UV dose with any failed or out-of-service reactor. Failure can be due to any number of conditions including, but not limited to, failure of the power supply, cleaning mechanism, and cooling system for electrical components.

Rationale

System component failure can be expected with any treatment process. The UV disinfection system must be capable of producing disinfected reclaimed water during any component failure prior to distribution. A minimum of two operating reactors per train ensures that some disinfection occurs until the standby reactor is brought on-line in the event that one of the on-line reactors fails.

Feed Water Quality Reliability

In the event that the upstream treatment process produces water unsuitable for UV disinfection (e.g., excessive turbidity, low transmittance), the contingency plan addressed in the Engineering Report shall be implemented.

3. California regulations require one of the following: (1) 24-hour storage if standby equipment replacement is available on-site, (2) appropriate long-term alternate storage (e.g., 20 days) or disposal provisions, or (3) other reliability mechanisms, if approved by the appropriate regulatory agencies.

Rationale

UV influent of poor quality may not be properly disinfected.

Operation and Maintenance

The operation and maintenance procedures for the UV disinfection system shall be included in the Engineering Report. Operators should receive specific training on the operation of UV disinfection systems.

Lamp breakage and the resulting release of mercury into the water stream is a concern with UV disinfection systems using mercury vapor lamps. A reactor train shall be isolated from the flow stream during maintenance and repair. A contingency plan must be developed as a part of the Engineering Report to address the lamp breakage issues and must be implemented upon lamp breakage.

Rationale

Reliable operation requires proper training and the timely maintenance, replacement, and calibration of system components. The presence of mercury is of concern because it can be detrimental to public health and aquatic life.

Power Supply Reliability

To ensure a continuous supply of power, the UV disinfection system must be provided with standby power and a looped power-distribution system (should one of the power supply lines fail). The disinfection system components of the same type (i.e., banks) must be divided among two or more power-distribution panel boards or switchboards to prevent a common mode of failure. Storage or alternate disposal methods of improperly treated or disinfected water must be available if a continuous power supply, including standby power, is not provided.

The UV disinfection system design must account for the technology being used. Special consideration must be provided for:

1. *Short-term power interruptions.* If the UV disinfection system cannot be immediately restarted upon a short-term power interruption, a UPS must be considered with the design. If UPS facilities are not provided, a contingency plan (i.e., storage) must be provided.
2. *Ambient temperature.* The facility design must provide for the effect of ambient temperature on ballast cooling and other electrical components.
3. *System harmonics.* The facility must address the impact of electrical harmonics generated by the UV disinfection on the plant power supply and other electrical systems.

Rationale

Because the UV disinfection system cannot operate without electrical power, reliable power supply and backup power are essential to ensure continuous disinfection (unless the reclamation plant has alternative reliability provisions or disinfection capabilities). Using multiple panel boards or switchboards would allow part of the system to remain on-line, even if one of the power-distribution panel boards or switchboards should fail.

Electrical Safety Design

All UV disinfection systems shall be provided with GFI circuitry.

Rationale

GFI circuitry is required to minimize hazard to personnel in the event of lamp breakage or any other circumstance that could create direct electrical contact with water.

Seismic Design

The UV disinfection facilities (e.g., building, structures, piping) should be designed in accordance with the seismic design requirements applicable for the seismic loads characteristic of the region in which the system is used. These same seismic design standards shall apply to structures where UV replacement equipment is stored on-site.

Rationale

Seismic design considerations are particularly important for UV disinfection systems because of the fragile components (especially lamps and quartz sleeves) used in the systems. The seismic safety design of the UV disinfection system should be at least equivalent to the design of the reclamation facilities prior to disinfection. This provision will ensure that whenever the plant is capable of producing effluent, the UV disinfection system will provide adequate disinfection.

5. Monitoring and Alarm Design

The ability to monitor operating parameters continuously is important in the operation of a UV disinfection system to ensure that adequate disinfection is provided. The continuous monitoring of parameters used to adjust the operational UV dose, UV disinfection system components, and proper calibration of on-line monitoring equipment are critical to maintaining the effectiveness of UV disinfection systems.

Continuous Monitoring

The following parameters must be monitored continuously:

1. Flowrate.
2. UV intensity.
3. UV transmittance.
4. Turbidity.
5. Operational UV dose.

UV Disinfection System

Monitoring of the following UV disinfection system components shall be provided:

1. Status of each UV reactor, on/off.
2. Status of each UV lamp, on/off.
3. UV intensity measured by at least one probe per reactor.
4. Lamp age in hours.

5. Cumulative number of reactor on/off cycles.
6. Cumulative UV disinfection system power consumption.
7. Reactor power set point (for systems with variable power input to lamps).
8. Liquid level in the UV disinfection reactor trains (for all UV disinfection systems with free water surfaces and for installations where UV lamps can be exposed to air).
9. GFI.

Verification and Calibration of Monitoring Equipment

UV intensity probe readings shall be verified (and calibrated, as necessary) at least monthly, using a reference UV intensity probe (see Chapter Three). The location of the on-line intensity probe(s) and the reference probe must be identical to those in the UV reactor used for performance validation. The calibration of turbidity and UV transmittance monitoring equipment shall be in accordance with manufacturers' recommendations. In addition, laboratory measurements of the UV transmittance of grab samples shall be used to verify the accuracy of on-line transmittance monitoring equipment on a weekly basis.

Rationale

Flowrate, UV transmittance, and UV intensity measurements are needed to establish the operational UV dose. Continuous determination of the operational UV dose is technologically feasible and is consistent with the current requirement for continuous chlorine residual monitoring. The procedure for establishing the operational UV dose shall be included in the Engineering Report (Section 8). Turbidity and UV transmittance monitoring data can be used to initiate responses to deteriorating UV influent quality. The depth of water in the reactor train must be controlled carefully to prevent the depth of water above the top UV lamps from exceeding a predetermined design maximum value (for UV disinfection systems with free water surface), which could result in inadequate disinfection, and to prevent lamps from being out of the flow and losing the effect of their UV radiation due to low water levels. The status of each UV reactor and UV lamp is needed to provide on-line monitoring of the operation of the UV disinfection system. UV intensity and lamp age are used to determine the need for cleaning and/or change-out of the lamps. GFI can be caused by a number of factors, including lamp breakage.

Alarms

To protect public health, both high-priority and low-priority alarms are required for the operation of a UV disinfection system. If left unattended, high-priority alarm conditions will compromise the performance of the UV disinfection system. Although low-priority alarm conditions will not compromise the performance of the UV disinfection system, corrective measures must be instituted before high-priority conditions occur. The set point for these alarms will vary as a function of specific site conditions. The set point should allow for adequate response time based on the importance of the alarm and subsequent consequences. The settings for the alarms shall be specified in the Engineering Report. As a minimum, the following high-priority and low-priority alarms are required:

High-Priority Alarms

- Adjacent lamp failure – when two or more adjacent lamps fail.
- Multiple lamp failure – when more than 5 percent of the lamps in a reactor fail.
- Low-low UV intensity – when the intensity probe reading drops below a predetermined set point.
- Low-low UV transmittance – when the influent water reuse UV transmittance drops below a predetermined set point.
- High-high turbidity – when the influent turbidity to the disinfection unit exceeds a predetermined set point.
- Low-low operational UV dose – when the operational UV dose drops below the predetermined set point.
- High water level – when the water level in the UV reactor train exceeds a predetermined water level (for UV disinfection systems with free water surface).
- Low water level – when the water level in the reactor or reactor train falls below a predetermined water level.
- GFI.

Rationale

The low-low operational UV dose, low-low UV intensity, and high-high turbidity shall activate the contingency plan response, regardless of the cause. For other high priority alarms, the operational UV dose should be increased by activating a standby reactor(s) or reactor train(s) (i.e., when the UV disinfection performance is being compromised).

Low-Priority Alarms

- Individual lamp failure (if a single lamp is less than 5 percent of the total lamps in a reactor) – the location of the lamp is to be indicated by reactor and lamp sequence.
- Low UV intensity – when the intensity probe reading drops below a predetermined set point.
- Low UV transmittance – when the influent UV transmittance drops below a predetermined set point.
- High turbidity – when the influent turbidity exceeds a predetermined set point.
- Low operational UV dose – when the operational UV dose drops below the predetermined set point.

Rationale

For the low operational UV dose and low UV intensity alarms, the UV dose should be increased by automatically activating a standby reactor(s) or reactor train(s). The operator then needs to investigate and address the cause for the alarm. Other low-priority alarms indicate that maintenance is required. For example, a low UV transmittance alarm causes a low-priority alarm, requiring the operator to investigate the problem. The operator may activate a standby reactor(s) or reactor train(s) during investigation or repair, as appropriate.

UV Alarm Records

All high- and low-priority alarm conditions shall be automatically recorded.

6. Field Commissioning Test

The following items shall be tested and verified before initiating the production of reclaimed water:

1. Electrical components.
2. Inlet/outlet velocity distribution (if full-scale reactors use more lamps than the reactors used for validation testing).
3. Water level.
4. Flow split between reactor trains.
5. Controls and alarms.
6. Instrument calibration.

A report documenting and detailing the field-commissioning test results shall be submitted for review to the appropriate water-utility personnel and regulatory authority.

Rationale

The commissioning test is critical to ensure the proper operation of the UV disinfection system and its conformance with design.

7. Performance Monitoring

Performance monitoring for UV disinfection systems will include microorganism sampling and the continuous on-line measurements delineated in Section 5.

Microorganism Sampling

Routine monitoring based on representative samples should include the following:

- Coliform bacteria and/or
- Other microorganisms, as required.

The representative samples for coliform bacteria and other microorganisms shall be collected downstream of the UV disinfection system at a time when water reuse characteristics are most demanding on the treatment and disinfection facilities. The sampling frequency shall be consistent with permit requirements.

Rationale

The required sampling program for performance compliance shall be consistent with the sampling requirements specified by the regulatory agency.

Monitoring of Operational UV Dose

The operational UV dose delivered by the UV disinfection system is to be determined and monitored continuously as described in Section 5.

Rationale

Continuous determination of the operational UV dose, in conjunction with the other continuous monitoring data, is comparable to monitoring chlorine residual in chlorine disinfection systems. The operational UV dose can be used to make most efficient use of the UV disinfection system while maintaining the design UV dose. As with residual chlorine monitoring, it should be noted that operational UV dose is not a deterministic parameter for reactor-performance characterization.

8. Engineering Report

For water reuse facilities that have not submitted an Engineering Report, a complete Engineering Report shall be prepared by a registered engineer and submitted to the appropriate regulatory agency prior to the implementation of a UV disinfection system.

For existing water reuse facilities for which an Engineering Report acceptable to the regulatory agencies has been submitted and for which UV is proposed for disinfection, the following types of reports may be required:

1. A complete, updated Engineering Report may be required if, since submission of the last Engineering Report, changes or modifications have occurred in the production of reclaimed water (e.g., treatment processes, plant reliability features, monitoring, or operation and maintenance procedures), reclaimed water transmission and distribution system, or reclaimed water use area (e.g., type of reuse, use area controls, or use area design). The necessity to submit a complete, updated Engineering Report in lieu of an abbreviated report that only addresses the UV disinfection system will be at the discretion of the regulatory agencies.
2. An abbreviated Engineering Report in which only the UV disinfection system and related treatment and reliability features is addressed is acceptable only if the proposed modifications solely involve disinfection processes (e.g., replacing or enhancing existing disinfection facilities with UV disinfection facilities); however, the Engineering Report should provide an evaluation of how well the UV disinfection system will integrate in the treatment process train.

Elements of an Engineering Report

Topics addressed in an Engineering Report should include, but not be limited to, the following:

Producer

The producer is the public or private entity that will treat the wastewater used in the project. Where more than one agency is involved in the treatment, the responsibilities of each agency must be described.

Purveyor

The person, party, or agency responsible for the water reuse distribution system.

Raw Wastewater

State the physical, chemical, and biological characteristics of the wastewater and identify any unusual characteristics that may affect the UV disinfection system (e.g., variable transmittance). State the proportion and type of industrial waste.

Reclaimed Water

Identify the reclaimed water uses and the corresponding water-quality and treatment requirements.

Treatment Processes

Provide a schematic diagram of the complete water reuse treatment facilities (including monitoring locations). State the existing or expected quality of the treated wastewater that will be subject to UV disinfection.

UV Disinfection System Design Basis

Provide a schematic and detailed description of the UV disinfection system. Provide sufficient detail to clearly show that the design and operational requirements conform with validation protocol and scale-up requirements, when applicable. As a minimum, the following information should be provided:

1. Reactor and reactor train layout and dimensions, inlet and outlet configuration, reactor train velocity range, and any devices used to modify the flow within the pipes or channels.
2. Description of the UV reactor; number, manufacturer, and type of UV lamps (including arc length); ballast; modules; banks; and electrical facilities.
3. Sleeve configuration and characteristics (e.g., sleeve material, sleeve diameter, sleeve thickness, and spacing).
4. Monitoring and controls, including the number, location, and function of monitoring equipment.
5. The water level relative to the UV lamps and level control device.
6. The anticipated number of reactor trains under low- and peak-flow conditions and the corresponding inlet and outlet velocity ranges.
7. Details of the bioassay experiments and the procedure used to derive the operational UV dose.
8. Applicable seismic design codes.

The equipment validation report shall be appended along with a description of how the information contained within the validation report was used used in the layout, scale-up, and design of the the UV disinfection system. A certificate shall be provided by the manufacturer to verify that the equipment supplied with respect to lamp spacing, type of lamp, quartz sleeve characteristics, and ballasts (as required above) is identical to the technology used in the validation testing.

Monitoring

The Engineering Report must describe a monitoring program. Where continuous analyses and recording equipment are used, the method and frequency of calibration must be stated. Items to be described in the monitoring section include:

1. The monitoring system used to determine and record the operational UV dose, including equipment and procedures used to monitor and record flow, UV intensity, and UV transmittance.
2. The method of monitoring the water level for open channel systems.
3. The method of monitoring lamp outages.
4. The sampling location and frequency for collecting microbial samples.

Reliability

The proposed UV disinfection system reliability features must be described in detail. When alarms are used to indicate system failure, the report must state where the alarm will be received, how the location is staffed, and who will be notified. The Engineering Report must also state the hours that the plant will be staffed and operated.

Contingency Plan

The Engineering Report must contain a contingency plan that delineates the actions to be taken for the following conditions:

1. Lamp breakage (mercury release).
2. Low-low operational UV dose, low-low UV intensity, or high-high turbidity alarms.
3. Failure of the upstream treatment processes or the UV disinfection system.
4. Power supply interruptions.
5. Activation of standby equipment, including system and lamp start-up times.

The person or persons responsible for implementing the contingency plan must be identified along with the methods used to notify them. A plan for notifying the reclaimed water users, the responsible regulatory agencies, and other agencies, as appropriate, of any treatment failures that could result in the delivery of inadequately treated wastewater to the use area should be included as part of the contingency plan.

Operator Certification and Training

The operation certification required for the operation of UV disinfection systems will depend on the requirements of the individual states. A description of the program to be implemented for training treatment plant personnel in the operation and maintenance of the UV disinfection system must be defined.

Operation and Maintenance

The Engineering Report must include an operations plan for system operation and maintenance. This plan should include a description of the control system, alarm functions, records, and reports. The plan should outline procedures and the frequency for sleeve cleaning, lamp replacement, maintenance of system components, and the frequency for calibrating the monitoring equipment. The location, access, and quantity of a backup supply of lamps and other critical components should be identified.

9. References

State of California (2000). "Water Recycling Criteria." California Code of Regulations, Title 22, Division 4, Chapter 3, Section 60301 et seq.

Florida Department of Environmental Protection (1999). *Reuse of Reclaimed Water and Land Application.* Florida Administrative Code, Chapter 62-610.

United States Environmental Protection Agency (EPA) and United States Agency for International Development (USAID) (1992). *Guidelines for Water Reuse,* EPA-625-R-92-004. United States Environmental Protection Agency, Washington, D.C.

Glossary

Ambient Temperature: The outside air temperature or the temperature of a given piece of equipment that is operated on a continuous basis.

Ballast: An electromagnetic or electronic device used to provide power to the UV lamps.

Bank: One or more UV modules that the entire flow for a given reactor train must pass through (same as Ultraviolet Lamp Bank).

Bioassay: A biological test used to assess the effectiveness of UV disinfection for the inactivation of microorganisms.

Collimated-Beam Apparatus: A device used to collimate (make parallel) a source of light.

Contingency Plan: An alternative plan that is implemented when an existing plan is not operative.

Delivered Ultraviolet Dose: The dose that is assigned to the UV test reactor based on reactor validation testing. The delivered UV dose is equivalent to that measured with the collimated-beam apparatus for the same degree of inactivation of the target microorganism.

Design Ultraviolet Dose: The delivered UV dose required for a specific log inactivation of the target microorganism. The design UV dose is used for sizing UV disinfection systems.

Disinfection: The selective destruction and/or inactivation of disease-causing (pathogenic) organisms.

Disinfection Byproducts: Compounds formed as a result of a series of complex reactions between disinfectant and organic compounds.

Disinfection Channel: A channel in which either horizontal or vertical arrays of UV lamps are placed for the disinfection of water.

Filtered Surface Water: Water from surface sources, such as rivers and lakes or groundwater under the direct influence of surface water, which has been treated by filtration, in conformance with the requirements of the Surface Water Treatment Rule.

Flowrate: The quantity of liquid that is discharged per unit time relative to a fixed reference point.

Fouling Factor: The reduction in available UV output due to changes in transmittance of the enclosure (i.e., quartz sleeve) separating the UV lamp from the liquid. The reduction in available UV output is determined by comparison to a new enclosure.

Germicidal Wavelength: The germicidal range of the electromagnetic spectrum (i.e., wavelengths between 200 and 300 nm).

Grab Samples: A discrete sample taken under specific circumstances at a given time and location.

Ground Fault Interrupter: A device that measures and trips at low leakage electrical current to ground.

Hardness: A measure of the concentration of the multivalent ions (e.g., aluminum, calcium, and magnesium) in a solution.

Headloss: Loss of energy caused by friction or turbulence induced by appurtenances in pipes and open channels.

Lamp Age Factor: The reduction in available UV output at the end of UV lamp life as compared to a new UV lamp, after the appropriate burn-in period.

Langelier Saturation Index: A measure of the potential for a water to be scale forming. The index only applies to the presence or absence of a calcium carbonate scale.

Level Control Device: Any device, such as weir or counter-balanced level controller, used to maintain the liquid level in the disinfection channel between a minimum and maximum level throughout the complete flow range.

Maximum Week Flow: The maximum 7-day flow based on a running 7-day average. The maximum week flow should be based on a minimum of 1 year's worth of flow data.

Media Filtration: Filtration process using granular, synthetic, or cloth media to remove residual suspended solids.

Microfiltration: A pressure-driven membrane process that separates micrometer-diameter and submicrometer-diameter particles (down to approximately 0.1 micrometer-diameter size) from a feed stream by using a sieving mechanism. The smallest particle size removed is dependent on the pore size rating of the membrane.

Module: The basic building block of a UV disinfection system. It is comprised of one or more UV lamps with a common electrical feed.

Most Probable Number: The results obtained using the multiple-tube fermentation technique for the analysis of bacteria are expressed in terms of MPN/100 mL. The MPN is based on the application of the Poisson distribution for extreme values to the analysis of the number of positive and negative results obtained when testing multiple portions of equal volume and in portions constituting a geometric series.

Nephelometric Turbidity Unit: The unit of measurement used to define the turbidity of a solution.

Operational Ultraviolet Dose: The UV dose that is established based on the results of the equipment validation testing. The operational UV dose can be used to make most efficient use of the UV disinfection system (e.g., reduce power demand, reduce number of the reactors or reactor trains on-line) while maintaining the design UV dose.

Pathogen: Any agent, especially a microorganism, capable of causing disease.

Peak Flow: A flowrate of a given magnitude that is sustained for a specified period of time. Because it is difficult to compare numerical peak flowrate values from different treatment plants, peak flowrate values are normalized by dividing by the long-term average flowrate. The resultant ratio is known as a peaking factor.

Performance Validation Protocol: A procedure whereby the performance of UV equipment is validated.

Quartz Sleeve: An outer jacket of quartz glass used to protect the UV lamp.

Quartz Sleeve Fouling: The formation of material on the quartz sleeve, which causes a reduction in the UV intensity emitted from the quartz sleeve.

Quartz Sleeve Scaling: The formation of a scale on the quartz sleeve that causes a reduction in the UV intensity emitted from the quartz sleeve. Scaling is typically caused by the multivalent metallic ions in solution.

Reactor: An independent combination of single or multiple bank(s) in series with a common mode of failure (e.g., electrical, cooling, cleaning system, etc.).

Reactor Train: A combination of reactors in series, including inlet, outlet, and level controlling arrangements (if applicable).

Reactor Train Inlet: The inlet arrangement used to direct the flow to a UV reactor train.

Reactor Train Outlet: The outlet arrangement used to direct the flow out of a UV reactor train.

Registered Engineer: A person who is qualified to practice engineering based on passing the national examination for civil and/or environmental engineers.

Reverse Osmosis: The separation (removal) of particulate, colloidal matter, and dissolved solids from a liquid using a thin membrane. The membrane acts as a barrier that will selectively retain certain constituents found in the liquid.

Seismic Loads: Additional loadings on UV disinfection facilities and buildings caused by earthquakes.

Standby Bank: A bank of UV lamps that is used as a standby (substitute) for the operating banks.

Supernatant: The liquid remaining after separating solids from a liquid-solid mixture.

Surface Water Treatment Rule: A rule established by the EPA for the treatment of surface waters before distribution to the public.

Target Pathogen: The microorganism that is of concern with respect to the protection of public health.

Theoretical Average Velocity: The value of the velocity obtained by dividing the flowrate by the cross-sectional area when expressed in consistent units.

Title 22: See Water Recycling Criteria.

Treatment Process Train: The assemblage or grouping of treatment units together to achieve a specified treatment objective.

Turbidity: A measure of the ability of a solution to scatter light. Light scattering is usually caused by the presence of small particles.

Ultraviolet Disinfection: The inactivation of microorganisms by exposure to UV radiation.

Ultraviolet Disinfection System: The combination of reactor trains with associated controls and instrumentation.

Ultraviolet Intensity: The intensity of UV radiation over a wavelength range of 200 to 300 nm.

Ultraviolet Intensity Probe: A device used to measure the intensity of UV radiation striking a UV sensor within a UV reactor.

Ultraviolet Lamp: A germicidal lamp used to produce UV irradiation in the range of 200 to 300 nm.

Ultraviolet Lamp Bank: One or more UV modules that the entire flow for a given reactor train must pass through (same as Bank).

Ultraviolet Radiation: A band of nonionizing electromagnetic radiation having wavelengths from 5 to 400 nm (Wavelengths that are effective for microorganism inactivation are in the range from 200 to 300 nm. The most effective range is between 250 and 275, with the optimum being between 260 and 265 nm).

Ultraviolet Transmittance of Fluid: The ability of a fluid to transmit ultraviolet radiation. Factors known to affect ultraviolet transmittance of a fluid include dissolved organics, dissolved iron, color (i.e., textile dyes), and turbidity. Ultraviolet transmittance is quantified by spetrophometric measurement at a wavelength of 253.7 nm using a 1-cm pathlength.

Ultraviolet 254 Absorbance: The absorbance of electromagnetic radiation at a wavelength 254 nm by a liquid through a 1-cm pathlength.

Unfiltered Surface Water: Water from surface sources, such as rivers and lakes or groundwater under the direct influence of surface water, that has not been treated by filtration prior to disinfection and distribution.

Uninterruptible Power Supply : The means or methods used to provide a continuous power supply to a treatment process.

Velocity Profiles: The velocity profile is a measure of the variability of the flow velocity across a cross-section perpendicular to the flow.

Water Recycling Criteria (Title 22): The section of the California Code of Regulations regarding water reuse. The reuse criteria are set forth in Title 22, Division 4, Chapter 3 of the California Code of Regulations.

Water Reuse: The treatment of wastewater to a quality that makes it suitable for one or more beneficial uses and the subsequent use of the treated water.

APPLICATION OF ULTRAVIOLET LIGHT FOR INACTIVATION OF ADENOVIRUS

C. Durance, R. Hofmann, R.C. Andrews, and M. Brown

Department of Civil Engineering, University of Toronto
35 St. George Street, Toronto, ON, Canada M5S 1A4

ABSTRACT

In the United States, the Safe Drinking Water Act requires that surface waters and ground waters under the direct influence of surface water (GUDI waters) be treated to achieve a minimum 4-log reduction of viruses. Upcoming U.S. Environmental Protection Agency (EPA) guidelines for the application of ultraviolet light (UV) are expected to set the dose requirement for 4-log inactivation of viruses based on the most resistant waterborne virus known: adenovirus (US EPA, 2003). This will mean that utilities planning to use UV alone, without additional physical or chemical treatment, would have to install systems capable of applying a dose in excess of 200 mJ/cm^2, compared to a more traditional dose of 40 mJ/cm^2. One practical solution would be to apply another disinfectant in concert with UV, to which adenovirus is more susceptible.

Previous studies have shown that adenovirus, although extremely resistant to inactivation by UV light, is quite susceptible to chlorination (Shin et al., 2002 and Thurston-Enriquez et al., 2003). Therefore, a drinking water utility wishing to install UV for primary disinfection could subsequently apply chlorine to easily achieve the required 4-log reduction of adenovirus. However, this strategy may not be practical for a GUDI source water where physical space constraints may prevent the installation of a tank for chlorine contact time. For example, a common scenario could be a GUDI well located in an urban area. As the time between disinfectant application and the first consumer may be mere seconds, it is important to determine if this would be sufficient to control adenovirus.

This paper outlines the results of a study conducted to determine if UV, applied in concert with chlorine or monochloramine at a very low CT (product of disinfectant concentration and contact time), can provide the required 4-log inactivation of adenovirus in a GUDI water. Experiments were conducted in triplicate to determine the inactivation kinetics of adenovirus types 5 and 41 in the presence of UV, chlorine, and monochloramine. In order to simulate "worst case" conditions under which the chemical disinfectants are least effective, the experiments were conducted at 5°C and pH 8.5.

Confirming earlier work by other researchers (Gerba et al., 2002; Jacangelo et al., 2002; Meng and Gerba, 1996), it was found that a traditional UV dose of 40 mJ/cm^2 will provide only 1-log inactivation of both types of adenovirus. However, even at low temperature and high pH, chlorine was found to be very effective against both adenovirus type 5 and 41, with a CT of 0.22 mg·min/L sufficient to achieve 4-log inactivation. Monochloramine was, not

unexpectedly, much less effective, with a CT of 350 mg·min/L providing at most 2.5-log inactivation of both types of adenovirus.

Further experiments were also conducted using adenovirus type 2 to determine if UV and monochloramine behave synergistically when applied sequentially, as reported by Ballester *et al.* (2004). Samples of the virus suspended in water buffered at pH 7 were exposed to UV light, followed by application of monochloramine at doses of 2.1-2.4 mg/L. Parallel virus suspensions were disinfected using monochloramine and UV individually. No evidence of synergy was observed between the UV and monochloramine under the conditions tested.

The results of this study provide confirmation that 4-log inactivation of adenovirus may be achieved with a conventional UV dose of 40 mJ/cm^2, followed by the application of a low chlorine residual for a short contact (CT of about 0.15 mg·min/L). Therefore, UV in combination with a low dose of chlorine is a feasible treatment option for a GUDI water with minimal chlorine contact time available, even under low temperature and high pH conditions.

KEYWORDS

Adenovirus, disinfection, ultraviolet light, chlorine, monochloramine, ground water, synergy

INTRODUCTION

In terms of effectiveness and efficiency, chlorination has been the drinking water disinfectant of choice for many years. However, the discovery that *Cryptosporidium* and *Giardia*, two important chlorine-resistant pathogens, are very susceptible to inactivation by UV (Bolton et al., 1998) has made the technology an attractive choice for drinking water treatment. Another important benefit is that, unlike chlorine, UV does not produce halogenated disinfectant by-products (DBPs).

A typical UV dose of 40 mJ/cm^2 (NWRI-AWWARF, 2000) has been shown to be effective for the inactivation of many waterborne viral pathogens such as echovirus, coxsackie virus, calicivirus, and poliovirus (Thurston-Enriquez et al., 2003; Gerba et al., 2002; Shin et al., 2001; Meng and Gerba, 1996). However, the same authors have found that adenovirus, another human pathogen, is more than four times more resistant to UV than these other viruses. The Environmental Protection Agency (EPA) has published a draft "UV Disinfection Guidance Manual", recommending that the UV requirement for 4-log inactivation of viruses be based on the resistance of adenovirus, which corresponds to a dose of 186 mJ/cm^2 (US EPA, 2003). This is almost 5 times the dose that most UV disinfection systems are currently designed to provide. In most situations where virus control is required, it will therefore be necessary to apply a second disinfectant to supplement UV.

There are 51 types of human adenoviruses, of which types 40 and 41 are etiologic agents of gastroenteritis, primarily in children. Types 2 and 5 are also pathogenic to humans and can cause respiratory illness and conjunctivitis. The various types of adenoviruses are characterised by differences in the antennae-like fibres that protrude from the viral capsid (protein "coat"), which are instrumental in the viral infection process (Favier et al., 2002).

These viruses are unique in that they are the only human enteric virus with double-stranded deoxyribonucleic acid (DNA) genetic material, the same type as that in human cells. Although there is limited data implicating enteric adenoviruses in waterborne outbreaks of gastroenteritis (Kukkula et al., 1997), types 3 and 4 (which belong to the same species as types 2 and 5) have been identified as the causative agents of recreational waterborne outbreaks of conjunctivitis and pharyngoconjunctival fever (McMillan et al., 1992; Martone et al., 1980; D'Angelo et al., 1979). Infectious adenoviruses have been detected in raw surface waters, treated tap water, and UV treated wastewater (Van Heerden et al., 2003; Thompson et al., 2003; Lee and Kim, 2002; Chapron et al., 2000). The range of environments in which adenoviruses have been detected is not surprising given their ability to persist and remain infectious in water. One study reported that the viability of adenovirus types 40 and 41 in tap water at 4°C is reduced by only 2-log after 92 and 304 days, respectively (Enriquez et al., 1995).

The Safe Drinking Water Act stipulates that treatment of surface waters or ground waters under the direct influence of surface water (GUDI waters) must achieve a minimum of 4-log (99.99%) removal of viruses. Although this level of removal of adenovirus is difficult to achieve using UV alone, studies have found that they, like most enteric viruses, are quite susceptible to inactivation by chlorine (Thurston-Enriquez et al., 2003; Shin et al., 2002). It is therefore practical, in a treatment train employing UV as a primary disinfectant, to utilise chlorine as a secondary disinfectant in order to achieve the required 4-log reduction of adenoviruses. This strategy may be practical in a conventional water treatment plant where physical treatment (ie. filtration) is applied and in which disinfectant contact time is achieved in a clearwell. There are however, many GUDI well locations where UV may be applied for primary disinfection in the absence of physical treatment or facilities to provide a chemical disinfectant contact time. In this situation, any post-UV disinfectant must be applied immediately prior to entry into the distribution system, often with a contact time of only a few seconds prior to reaching the first consumer. Therefore, a study was conducted to determine if sequential application of UV and a chemical disinfectant, at a low concentration with a short contact time, can provide the regulated requirement of 4-log inactivation of adenovirus.

METHODOLOGY

Propagation and Enumeration of Adenovirus

Ad 5, Ad 2 and Ad 41 (P2 Tak) were propagated and assayed in Graham 293 cells and additional Ad 41 was also propagated in PLC/PRF/5 cells. The cells were maintained in minimal essential medium (MEM) supplemented with 10% fetal bovine serum (FBS) (Invitrogen, Carlsbad, California).

Cells were harvested when cytopathic effect was complete, centrifuged at 300 *g* for 10 minutes, and then subjected to 5 freeze-thaw cycles to release intracellular virus. This cell lysate was centrifuged to separate cell debris, producing a supernatant termed clarified cell lysate. The pellet from centrifugation was further treated with Vertrel XF (Dupont Chemicals, Wilmington, Delaware) to extract lipid associated viruses. The Vertrel extract

was then pooled with cell lysate for further virus purification and concentration by cesium chloride (CsCl) density gradients. To remove CsCl, the purified virus was dialyzed against buffer. The pure viral stock was stored in glycerol at -80°C until use in experiments. Immediately prior to all experiments, an appropriate volume of thawed virus stock was dialysed into buffered water at pH 8.5.

Ad 5, Ad 2 and Ad 41 were enumerated using Graham 293 cells, by $TCID_{50}$ end point dilution assay, in microtest plates with 9 wells used for each dilution. Plates were incubated at 37°C and the cells observed for cytopathic effect (CPE) for up to 12 days. As CPE is difficult to observe in cells infected by Ad 41, this virus was also enumerated using a technique that incorporates immunofluorescent labelling. After scoring plates by CPE, cells were fixed in paraformaldehyde and incubated with the primary antibody, 2HX-2, which binds to hexon trimers. The cells were then incubated with the secondary FITC-conjugated anti-mouse antibody (Sigma, Milwaukee, USA) and viewed using a fluorescence microscope. As progeny hexon trimers are formed only in adenovirus-infected cells, cells that emit fluorescence are deemed to be infected and can be scored as such.

Chlorine and Monochloramine Preparation and Measurement

A 100 mg/L working chlorine stock solution was prepared by diluting a 4% sodium hypochlorite solution (Aldrich, Milwaukee, USA) in the same demand free buffer used to suspend virus stocks for all experiments. Monochloramine was prepared by combining equal volumes of 400 mg/L chlorine and 500 mg/L ammonium chloride stock solutions, which were both prepared in pH 9.4 carbonate buffer.

Chlorine and monochloramine residuals were measured colorimetrically according to the DPD Method (APHA, 1998) using an HP 8452A diode array spectrophotometer (Hewlett Packard, Mississauga, Ontario).

Chlorine and Monochloramine Experiments

All glass used in experiments was made chlorine demand free by soaking overnight in a chlorine solution. Experiments with Ad 5 and Ad 41 were conducted at 5°C and pH 8.5, and Ad 2 experiments at 25°C and pH 8.0, in sterile, demand free Teflon® flasks with Teflon® stir bars. Microbial samples were collected in tubes containing 10% sodium thiosulphate to quench residual disinfectant, and stored at 4°C until enumeration later the same day. Disinfectant residual samples were collected in chlorine demand free vials containing buffer and DPD reagent and analyzed immediately.

UV Experiments

A collimated beam apparatus containing low pressure UV lamps (Suntec environmental, Concord, ON) was used to expose the viruses to UV light. The intensity of the light was measured at 254 nm using an IL1700 radiometer (International Light, Inc., Newburyport, MA) and, along with the solution depth and absorbance, used to calculate the exposure times required to apply various doses, expressed in mJ/cm^2 (Bolton and Linden, 2003). A

suspension of virus was prepared and dispensed into sterile Petri dishes, each containing a Teflon® coated micro stir bar. The dishes were placed on a support plate in the path of the collimated beam of UV light and exposed, with stirring, for the appropriate time to achieve the desired dose. Exposed virus was stored at 4°C until enumeration later the same day.

RESULTS

UV

As shown in Figure 1, Ad 5 and Ad 2 demonstrate very similar levels of inactivation, which is to be expected considering the structural and epidemiological similarities of these two types of adenovirus. The inactivation kinetics of Ad 41 observed in this study were similar to those reported in previous studies with the other type of fastidious enteric adenovirus, Ad 40 (Thurston-Enriquez et al., 2003; Jacangelo et al., 2002). At lower UV doses (< 70 mJ/cm^2) the kinetics of Ad 5, Ad 2 and Ad 41 were found to be very similar, however at higher doses greater inactivation of Ad 5 and Ad 2 was observed. A UV dose of 40 mJ/cm^2 was found to inactivate approximately 90% (1-log) of Ad5 and Ad 2 and slightly less than 90% of Ad41.

Chlorine

As a result of the high pH (8.5) of the water to which chlorine was applied in these experiments, it was expected that the level of disinfection under these conditions would be compromised. The low temperature at which these experiments were conducted was also expected to be detrimental to the effectiveness of chlorine, as the reactivity of the disinfectant is decreased at low temperatures. Nonetheless, a chlorine CT value of 0.22mg·min/L was found to inactivate 99.99% (4-logs), of both Ad 5 and Ad 41, as shown in Figure 2.

Monochloramine

Monochloramine was, as expected, relatively ineffective at inactivating both types of adenovirus under the experimental conditions examined. Even at a CT of 300mg·min/L, 2.5-log inactivation was the maximum that could be achieved (Figure 3). Therefore, monochloramine may best serve as an effective secondary disinfectant if a long contact time is provided.

UV and Monochloramine

Experiments were conducted with Ad 2 to determine if prior exposure to UV would result in greater susceptibility of the virus to monochloramine. As for Ad 5 and Ad 41, a UV dose-response curve was first constructed for Ad 2 (Figure 1). Monochloramine experiments were then conducted at 25°C and pH 8.0. As illustrated in Figure 4, a CT of 150 mg·min/L provided 5-log reduction of Ad 2 (curve labelled "NH_2Cl only"). The experiments were then repeated under the same conditions, at the same CTs, with Ad 2 that had been exposed to 45 mJ/cm^2 of UV. Significantly greater inactivation of the UV-exposed virus was not observed (curve labelled "UV+NH_2Cl"), indicating that there is no synergistic virucidal effect when UV is applied prior to monochloramine.

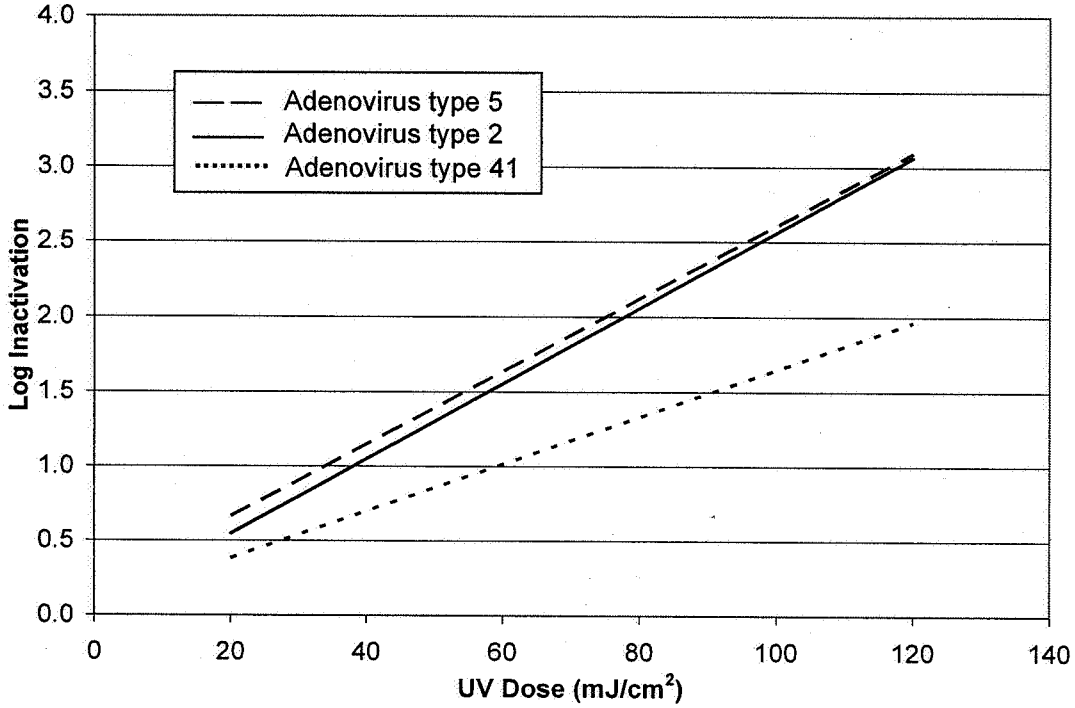

Figure 1: UV inactivation of Ad 5, Ad 2 and Ad 41

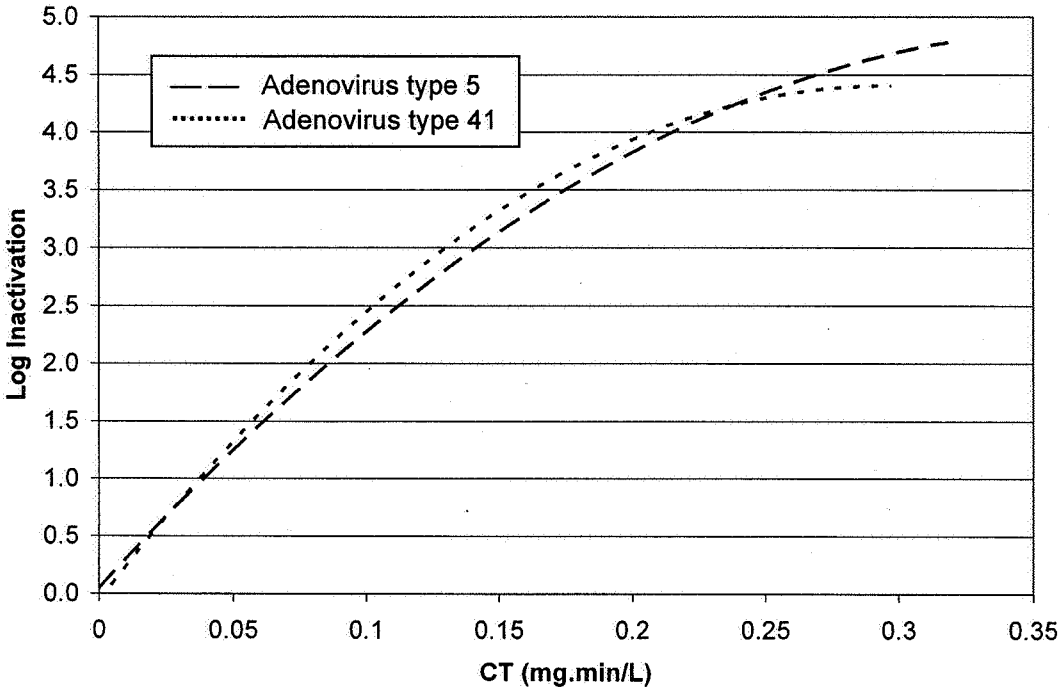

Figure 2: Chlorine inactivation of Ad 5 and Ad 41

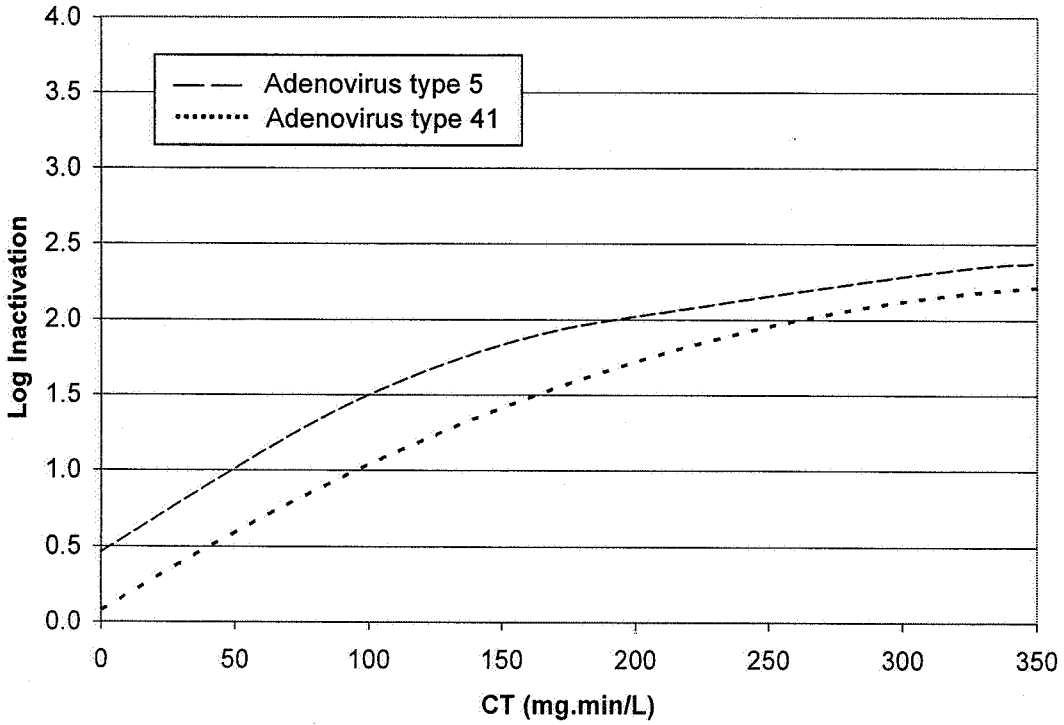

Figure 3: Monochloramine inactivation of Ad 5 and Ad 41

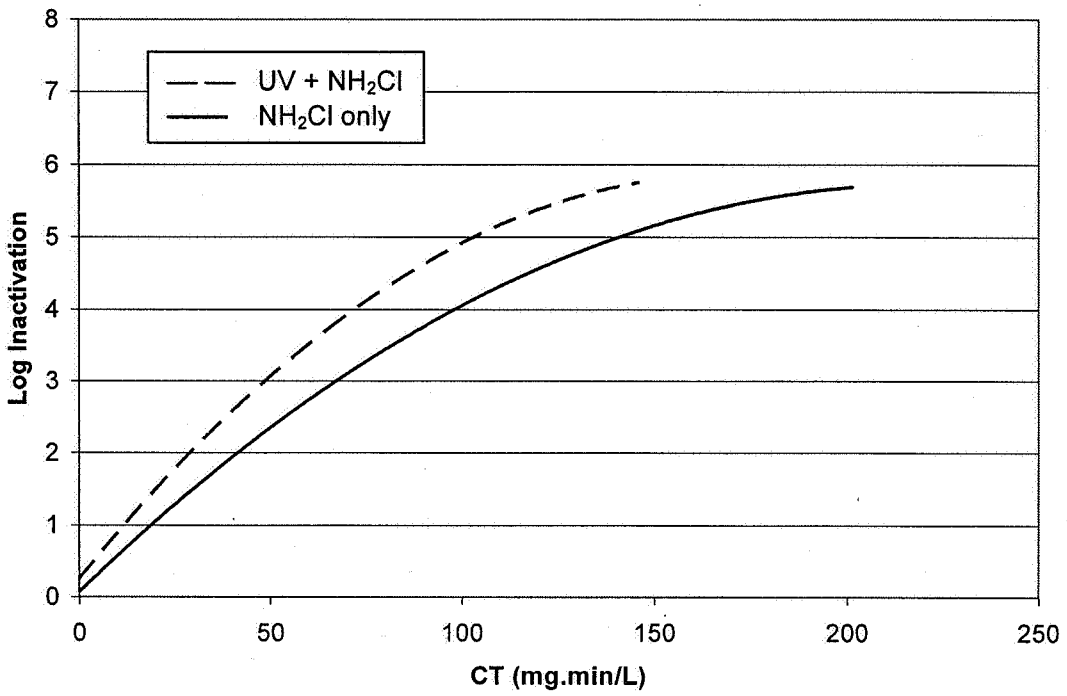

Figure 4: Monochloramine inactivation of Ad 2 with (– –) and without (—) prior UV Exposure

DISCUSSION

Similar to previously published studies, it was determined that a UV dose of 40 mJ/cm^2 will provide only 1-log inactivation of adenovirus. These studies (including this one) have used dispersed virus suspended in pure laboratory-grade waters or ground water with very low turbidity (Thurston-Enriquez et al., 2003; Jacangelo et al., 2002; Gerba et al., 2002; Meng and Gerba, 1996). However, it is likely that viruses will exist in an aggregated or particle-associated state in surface or ground waters (Young and Sharp, 1977, Hejkal et al., 1979) and viral aggregates are expected to be more resistant to disinfection than dispersed viruses because of the protective effect afforded inner viral particles by those that surround them (Grant, 1995; Thurman and Gerba, 1988). In a conventional drinking water treatment system, an effective filtration process should remove the majority of viruses, however ground waters are often only disinfected and then distributed, without prior filtration.

Although similar inactivation of Ad 5, Ad 2 and Ad 41 can be achieved with a UV dose of 40 mJ/cm^2, at higher doses Ad 41 is observed to be more resistant. While 120 mJ/cm^2 will provide 3-log inactivation of Ad 5 and Ad 2, Ad 41 is inactivated by only 2-logs at this dose. One possible explanation for this may be the structural differences between the three types of adenovirus. Ad 41 has 2 types of fibres that project from the surface of the virus, one long and one short (Pieniazek et al., 1990). In contrast, Ad 5 and Ad 2 have fibres that are all of the same length. It has been suggested that this difference in structure could account for the

difference in UV susceptibility, possibly as a result of potential shadowing by the fibres (Gerba et al., 2002).

The resistance demonstrated by all adenoviruses to UV disinfection when compared to other enteric viruses may be due to one particular distinguishing characteristic: a double-stranded DNA genome, the same type of genetic material contained in human cells. When a virus infects a cell, it seizes control of the functions of that cell, including the ability to replicate genetic material and, in the case of DNA, repair any damage. It has been shown that UV damage to adenovirus DNA may be repaired by an infected host cell's enzymes (Day et al., 1999; Arnold and Rainbow, 1996). It is yet to be determined, however if the cells used to enumerate adenoviruses *in vitro*, or the cells of the gut that adenoviruses actually infect *in vivo*, possess these repair enzymes.

CONCLUSIONS

Based on this study and prior research, it is concluded that UV cannot be practically applied as the sole disinfectant for waters at risk of harbouring adenovirus, but may be used in conjunction with a low chlorine CT for effective virus control. The low temperature and high pH used in this study represent worst-case conditions that are likely to exist in a GUDI source water. Under these conditions, subsequent to application of a UV dose of 40 mJ/cm^2, a chlorine residual of 0.5mg/L applied for less than 30 seconds will achieve the regulatory requirement for a total of 4-log reduction.

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BY NICOLA A. BALLESTER
AND JAMES P. MALLEY JR.

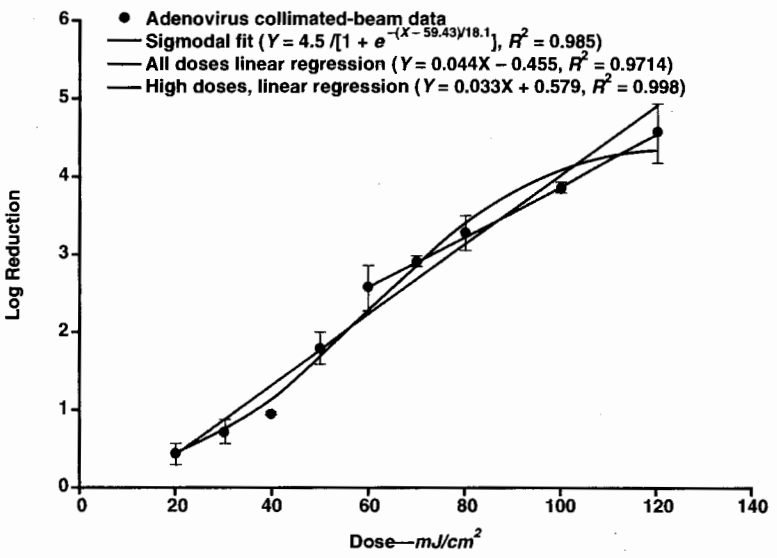
Bench-scale experiments determined the inactivation rates of adenovirus serotype 2 with low-pressure, high-output ultraviolet (UV) light, chlorine (Cl_2), and preformed chloramines. Studies with sequential chloramines were also done to mimic water treatment practices. Sequential experiments with adenovirus serotype 2 suspended in laboratory-grade water and natural waters containing ammonia were exposed to either UV light followed by Cl_2/chloramines or the reverse sequence. Adenovirus log reductions were quantified through cell culture techniques. A free Cl_2 $C \times T$ (concentration × time) of 1.22 mg-min/L resulted in a 3.72-log reduction, a preformed chloramine $C \times T$ of 264.5 mg-min/L resulted in a 1.2-log reduction, a sequential chloramine $C \times T$ of 40.5 mg-min/L resulted in a 1-log reduction, and a UV dose of 40 mJ/cm^2 resulted in a 1-log reduction. Up to 4-log reductions were achieved with a UV dose of 40 mJ/cm^2 followed by a sequential chloramine $C \times T$ of 27.2 mg-min/L. This suggests that sequential disinfection may be the best option for dealing with UV-resistant organisms such as adenoviruses.

Sequential Disinfection of adenovirus type 2 with UV–Chlorine–Chloramine

Adenoviruses have been found throughout the world in polluted water, source water, groundwater, and even treated drinking water (Gerba et al, 2002; Crabtree et al, 1997; Murphy et al, 1982). Typically they are detected at higher levels than enteroviruses in polluted waters (Gerba et al, 2002; Crabtree et al, 1997). Previous studies of enteroviruses' survival in the environment have shown that adenoviruses have a higher resistance to temperature and humidity fluctuations (Mahl et al, 1975), and survive longer than polioviruses in tap water and seawater (Enriquez et al, 1995). Adenoviruses can retain infectivity for several weeks at 4°C (39°F) and for months at –25°C (–13°F) (Liu, 1991).

There are 51 serotypes of adenovirus, 17 of which are pathogenic to humans (Hilborn et al, 2002). Adenovirus serotypes 1, 2, and 5 are endemic in North America and Europe (LeBaron et al, 1990). By the age of two and a half, 50–70% of children show immunologic evidence of infection with serotype 1 and 2 (Bell

FIGURE 1 Different fits of adenovirus type 2 low-pressure, high-output collimated-beam tests



et al, 1962). These same serotypes are also found in 50–90% of all tonsils removed, and roughly 2–7% of all lower respiratory tract illnesses in children in the United States and Great Britain may be attributed to these endemic types (Brandt et al, 1969; Bell et al, 1962). It is estimated that infections in the United States alone cause more than 200,000 children to be hospitalized (LeBaron et al, 1990).

Adenoviruses are transmitted via the fecal–oral route and through the inhalation of aerosols. Research has shown adenovirus serotype 2 can be secreted for up to 906 days after infection (Fox et al, 1977). Symptoms, including fever (80% of cases), pharyngitis (69% of cases), and tonsillitis and cough (63% of cases), usually occur five to ten days after infection (Liu, 1991). Outbreaks in military recruits (Colon, 1991; Meiklejohn, 1983), hospitals (Colon, 1991; Brummett et al, 1988), and child-care centers (Van et al, 1991; Bartlett et al, 1985; Payne et al, 1984) have been documented. In these outbreaks, acute respiratory disease and conjunctivitis were the most common illnesses. Infections are usually acute and self-limiting in nonimmunocompromised individuals (Meng et al, 1996); however, they can often be an opportunistic pathogen in immunocompromised patients (Wadell, 1984).

The etiologic agent is never identified in more than half of the reported waterborne disease outbreaks, but many are thought to be caused by viruses (Thurston-Enriquez et al, 2003). Outbreaks are believed to be underreported because of the lack of sensitive detection methods and the nature of the associated illnesses. Adenoviruses may cause latent or inapparent infections, and symptoms are similar to many other common illnesses. Therefore, any infectious human viruses detected in water supplies may pose a risk.

BACKGROUND

Why use sequential disinfection? The US Environmental Protection Agency (USEPA) is promulgating the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) (USEPA, 2003a) and the Stage 2 Disinfectants/Disinfection Byproducts Rule (S2D/DBPR) (USEPA, 2003b). The LT2ESWTR details drinking water regulations intended to provide the public adequate protection against microbial pathogens, specifically *Cryptosporidium,* and the S2D/DBPR is intended to aid in the reduction of disinfection by-products (DBPs), by further limiting the allowable levels of trihalomethanes (THMs) and haloacetic acids (HAAs). These rules, expected to be finalized in 2005, will force drinking water utilities to find a balance between the risks of pathogenic microorganisms and DBPs.

Because of public health concerns about DBPs and upcoming regulations, chloramines have been proposed as a possible secondary disinfection alternative. Benefits of using chloramines are that they form insignificant amounts of THMs and HAAs and also provide a maintainable disinfectant residual in even the longest distribution systems. The major drawback with chloramines, as shown by previous research, is they are considerably less microbiocidal and virucidal than free chlorine (Cl_2) (Sobsey, 1989).

Ultraviolet (UV) light is also becoming a popular additional disinfection method for surface water and groundwater systems in the United States. Research has shown UV light to be the most effective technology against *Cryptosporidium* infectivity (Clancy et al, 2000), with the added benefits of not producing DBPs or taste and odor problems.

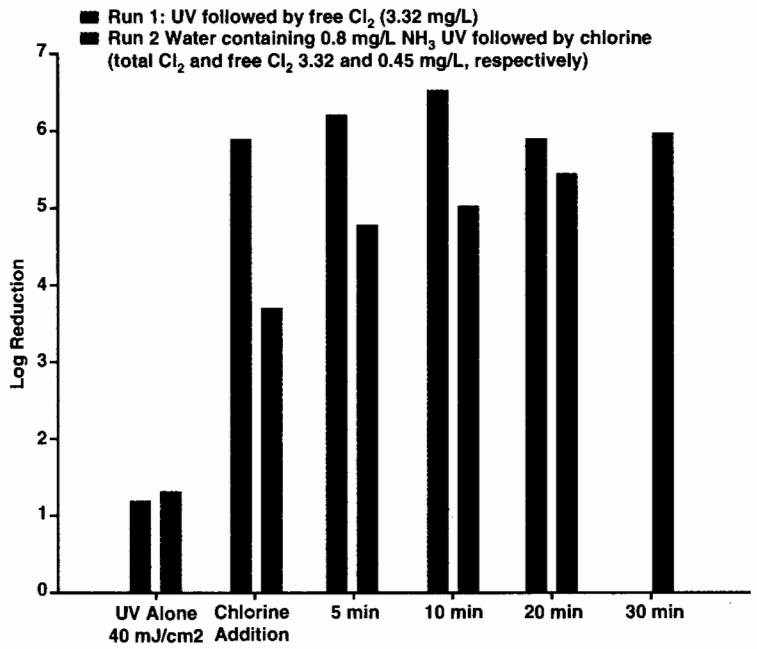
Drinking water systems in the United States that have difficulty using free Cl_2 because of resistant microorganisms (i.e., *Cryptosporidium*), taste and odor, public opposition, or the presence of high ammonia (NH_3) levels in the raw water may have difficulties meeting the USEPA's microbial inactivation requirements. UV light in combination with low levels of Cl_2 or chloramines can help meet the inactivation requirements of microorganisms, while keeping the formation of DBPs to a minimum.

Previous research on adenoviruses. Previous research on inactivation of adenoviruses with UV light has shown them to be more resistant than other enteric viruses. A UV dose of 203–226 mJ/cm^2 is needed to achieve a 4-log inactivation of serotypes 40 and 41 (Ko et al, 2003; Thurston-Enriquez et al, 2003), and a UV dose of >90 mJ/cm^2 is needed to achieve a 3- to 4-log inactivation of serotype 2 (Gerba et al, 2002; Linden et al, 2002a). These

UV doses are much higher than those needed to achieve 4-log inactivation for other human pathogens of concern. Poliovirus and rotavirus require 20–50 mJ/cm^2 (Gerba et al, 2002; Wilson et al, 1992; Chang et al, 1985), Hepatitis A virus requires 15–20 mJ/cm^2 (Battigelli et al, 1993), *Cryptosporidium* requires 2–20 mJ/cm^2 (Shin et al, 2001; Clancy et al, 2000), *Giardia* requires 2–10 mJ/cm^2 (Linden et al, 2002b; Craik et al, 2000), and *Microsporidia* requires 10 mJ/cm^2 (Huffman et al, 2002).

Adenovirus is of particular interest because of its presence on the Drinking Water Contaminant Candidate List (CCL) (USEPA, 1998). Additionally, because it is a double-stranded DNA virus, the damage from UV light may be repaired by a host cell after infection. Sensitivity to UV light has been shown to be species- and strain-dependent (Chang et al, 1985). This can be the result of complex molecular structures, tightly bound proteins in the outer shell of the virus coat, and high guanine–cytosine (GC) content in the molecular structure (Rainbow et al, 1973). Adenoviruses have both a complex molecular structure (double-stranded DNA) and a relatively high GC content (type 40 and 41–52%, type 2 and 5—58%), which may account for some of their resistance to UV light (Liu, 1991).

FIGURE 2 Sequential runs: UV–Cl_2



Cl_2—chlorine, NH_3—ammonia, UV—ultraviolet

Study objective. The objective of this study was to determine the conditions under which a 4-log reduction of adenovirus serotype 2 could be achieved using sequential disinfection with low-pressure UV light and sequential chloramines.

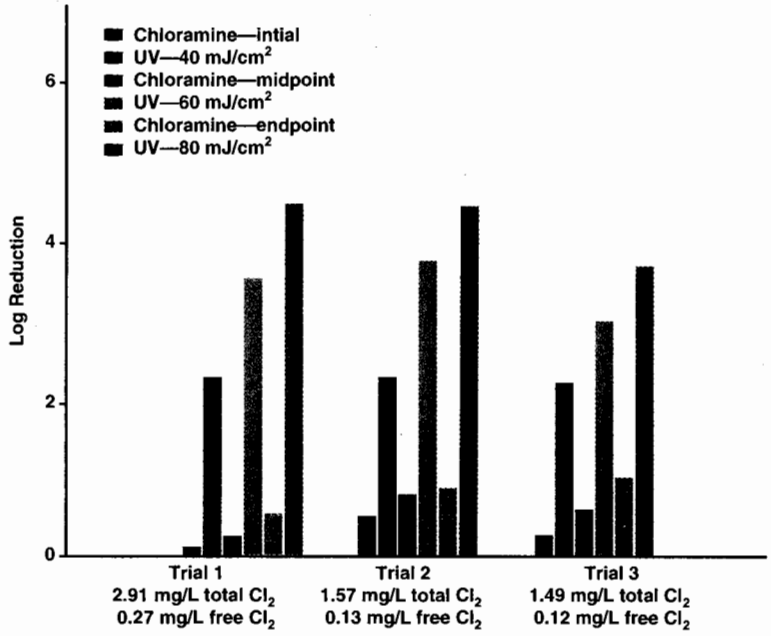
METHODS AND MATERIALS

Sequence of experiments. The sequences of experiments done with water containing adenovirus were as follows: low-pressure UV light, free Cl_2, preformed chloramines, sequential chloramines, sequential chloramines followed by UV light, and UV light followed by sequential chloramines. Sequential addition of NH_3 followed by Cl_2 will hereafter be referred to as sequential chloramines.

Adenovirus 2 propagation and quantification. Adenovirus type 2, strain adenoid 6[1] was propagated in cells[2] from a continuous human lung cell line. Cells were grown using a nutrient mixture[3] supplemented with 8.6 mg/L phenol red,[4] 8% fetal bovine serum (FBS), 0.15% sodium bicarbonate,[5] 200 µg/mL of streptomycin and 200 units/mL of penicillin. Cell monolayers were washed with a balanced salt solution[6] and inoculated with adenovirus. After adsorption for 1.5 h at 37°C, the nutrient mixture,[3] supplemented with 2% FBS, sodium bicarbonate, and antibiotics, was added. Phenol red was not added to the maintenance media to prevent additional UV absorbance of the virus stock. Cultures were incubated for 24–36 h at 37°C until 90% cytopathic effects were observed. The cultures were frozen at –80°C followed by freezing–thawing three times. Lysates were centrifuged, and the supernatant was filtered (0.2 µm) to remove any cellular debris. Adenovirus was quantified by the 50% tissue culture infectious dose ($TCID_{50}$) method (Meng et al, 1996). Host cells[2] were grown in 96 well plates[7] at 37°C with 5% carbon dioxide until 90% confluency was achieved. Samples to be analyzed were serially diluted in buffered saline and inoculated onto cells. Cells were observed for cytopathic effects daily for 10 days. Cytopathic effects consisted of cell rounding, vacuolation, sloughing, and formation of grapelike clusters. Half (50%) of the samples were passed through a second time to ensure accurate reporting of cytopathic effects.

Bench-scale, low-pressure UV lamp. Collimated-beam studies were run using a low-pressure high-output (LPHO) collimated-beam unit.[8] The delivered dose was calculated using the lamp irradiance read by a recently calibrated radiometer,[9] a spreadsheet,[10] and the UV absorbance of the seeded water matrix at 254 nm. The mathematical model[10] corrected for the spectrum of light passing through the 254-nm filter, the radiometer sensitivity, Petri factor, and the absorbance and depth of the sample. One litre of sample water was spiked with enough organisms to ensure an initial concentration of at least 10^8/mL

FIGURE 3 Adenovirus type 2 sequential runs: chloramines followed by UV doses of 40, 60, and 80 mJ/cm²



Cl_2—chlorine, UV—ultraviolet

$TCID_{50}$. High concentrations of adenovirus were needed to enable detection of 4-log reductions using the $TCID_{50}$ method. The UV_{254} absorbance of adenovirus-seeded waters ranged from 0.031 to 0.038/cm. Fifteen millilitres of spiked water was continuously stirred during irradiation at the times specified by the spreadsheet[10] to achieve the desired UV doses. Controls were run with the light shutter closed.

Chemical disinfection methods. All glassware and waters were prepared Cl_2 demand-free (*Standard Methods,* 1998). Cl_2 stock solutions[11] (5 mg/L) and ammonium chloride[12] (5%) were prepared separately (*Standard Methods,* 1998). Free Cl_2 experiments were performed by adding Cl_2 to adenovirus-seeded waters. Preformed chloramine stocks were prepared by adding Cl_2 to the NH_3 solution to achieve a 3:1 ratio of Cl_2 to nitrogen. The mixture was adjusted to pH 8 and mixed for 30–50 min to ensure chloramine formation. Sequential chloramine experiments were performed by adding Cl_2 to adenovirus-seeded waters containing NH_3. NH_3 levels were measured by the Nessler method[13] (*Standard Methods,* 1998), and total Cl_2 and free Cl_2 were measured by the DPD method[14] (*Standard Methods,* 1998) at initial, midpoint, and endpoint time periods. All experiments were performed at 22–23°C, and each experiment was repeated three times.

Sequential trials. Sequential trials were initially done in adenovirus-seeded laboratory-grade water containing chloramines, followed by varied doses of UV light (40, 60, 80 mJ/cm²). Next, seeded lab water—with or without added NH_3—was exposed to UV light (40 mJ/cm²), followed by either free Cl_2 or sequential chloramine addition. Finally, sequential trials were done in natural waters containing high levels of NH_3. Raw waters with an average NH_3 content of 0.5 mg/L were obtained from Cedar Rapids, Iowa. One-litre samples of raw water seeded with adenovirus were subjected to UV light (40 mJ/cm²), followed by Cl_2 addition to achieve a total Cl_2 residual similar to the finished water from Cedar Rapids. During the time of this study Cedar Rapids' finished water had total Cl_2 levels of 2.2–3.5 mg/L, and free Cl_2 levels of 0.32–0.69 mg/L with a Cl_2 demand of 0.85 mg/L. All experiments were performed at 22–23°C, and each experiment was repeated at least three times. Samples were added to tubes containing 1 mL of sodium thiosulfate (20 g/L) because they were removed for analysis using the $TCID_{50}$ method. Controls were run with the addition of sterile water instead of Cl_2 or chloramines.

RESULTS AND DISCUSSION

Adenovirus 2 LPHO dose–response. The linear dose–response curve for UV irradiation with an LPHO collimated-beam device on adenovirus serotype 2 (Figure 1) needed a dose of approximately 103 mJ/cm² for a 4-log reduction. Previous research on adenovirus serotype 2 showed doses of 90–119 mJ/cm² were needed to achieve a 3-log reduction with LP UV (Gerba et al, 2002; Linden et al, 2002a). Variations in adenovirus inactivation results among laboratories are mainly the result of the subjective nature of the $TCID_{50}$ assay, the use of different cell lines, and different adenovirus culture methods. In previous studies adenovirus has been used to assess the repair capabilities of different cell lines (Day et al, 1975). Therefore, results for inactivation could be highly varied among different cell lines.

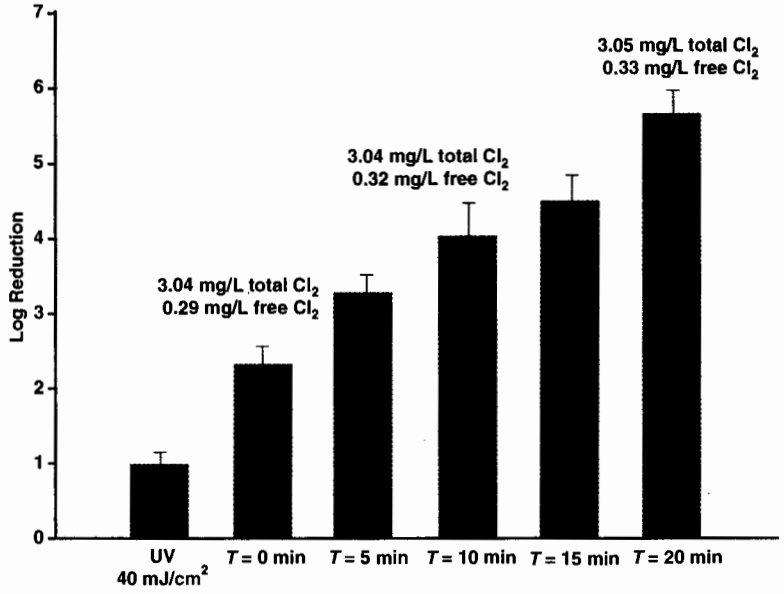
The shouldering effect is shown in Figure 1 at <50 mJ/cm² followed by a linear inactivation response at doses >50 mJ/cm². Studies on adenoviruses 40 and 41 have also exhibited this shoulder, and it is thought to be associated with a lethal lag phase because of multitarget kinetics (Gerba et al, 2003; Thruston-Enriquez et al, 2003; Gerba et al, 2002). Through excision repair, damage to adenoviruses' DNA can be reversed once inside a host cell. The authors hypothesize that at doses >50 mJ/cm² there may be enough photo lesions produced to cause lethal damage to the adenovirus virion, thus resulting in the linear inactivation response at higher doses. The mul-

tiple targets that may contribute to adenoviruses' resistance could be capsid-associated. Several possible models for the data were explored to find the best fit. Using a sigmoidal fit of the LPHO collimated-beam data rather than a linear fit (Figure 1) results in a dose of 97 mJ/cm^2 needed to achieve a 4-log reduction. If the UV doses of 60 mJ/cm^2 and higher are graphed separately using a linear regression (Figure 1), the result, like the linear regression of all the points, is a dose of 103 mJ/cm^2 needed to achieve a 4-log reduction. The main differences between the linear fits in Figure 1 are the R^2 values, 0.971 and 0.998, respectively. Plots of the residuals of the three models showed that the best fit was the linear fit of the doses of 60 mJ/cm^2 and higher.

Chemical disinfection of adenovirus 2. The results of chemical disinfection of adenovirus type 2 when done under ideal conditions with laboratory-grade water showed that a mean free Cl_2 $C \times T$ of 1.22 mg-min/L (±0.242) could achieve a 3.72-log reduction of adenovirus type 2. Preformed chloramines achieved a 1.2-log reduction with a mean $C \times T$ of 264.5 mg-min/L ±5.32. Additional studies were done on seeded waters with added NH_3 followed by Cl_2 addition. These were done to mimic water treatment processes. The result was that a mean $C \times T$ of 40.5 mg-min/L, ±5.21, could achieve a 1.07-log reduction of adenovirus. Inactivation of adenovirus type 2 was more rapid with free Cl_2 than with chloramines. Preparation methods of chloramines had a significant effect on the inactivation of adenovirus. The method of adding Cl_2 to water containing NH_3 appears to be a more effective way of inactivating adenovirus if maintaining free Cl_2 residual is a problem. When Cl_2 was added to waters already containing NH_3 in this study, the initial free Cl_2 contact had a great effect on lowering the $C \times T$ required to achieve 1-log inactivation (40.5 mg-min/L), as compared with the 1-log inactivation with preformed chloramines (264.5 mg-min/L).

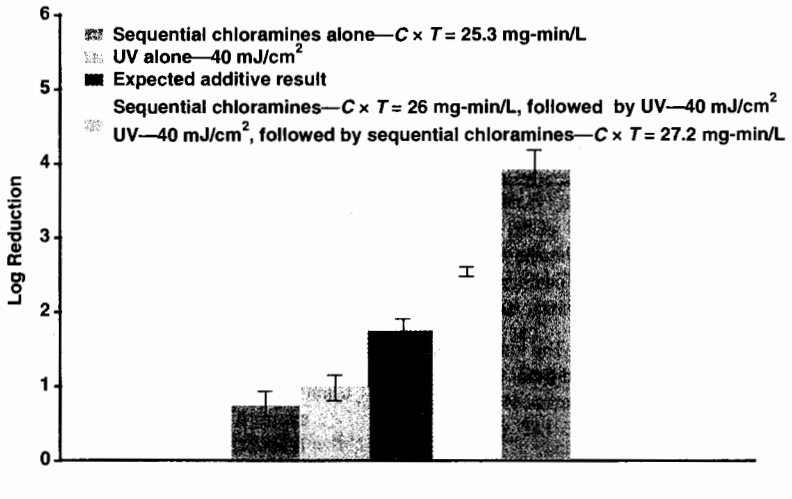
Sequential trials, UV followed by chemical disinfection. Sequential trials with adenovirus serotype 2 exposed to a UV dose of 40 mJ/cm^2 followed by chemical disinfection were performed with Cl_2 demand free laboratory water and laboratory water with NH_3 added (0.8 mg/L NH_3 as N). After a UV dose of 40 mJ/cm^2 an average 1.2-log reduction was observed in both laboratory waters (Figure 2). This result agrees with previous studies (Gerba et al, 2002). In the laboratory water without NH_3 >5-log inactivation was observed when free Cl_2 was added (residual 0.29 mg/L) and continued to increase over time until the measurable virus remaining was below the detection limit of the $TCID_{50}$ assay (Figure 2). In the laboratory water containing 0.8 mg/L NH_3 a 3.7-log reduction was observed when Cl_2 was added, to reach a total Cl_2 resid-

FIGURE 4 Sequential runs with Cedar Rapids, Iowa, raw water—0.77 mg/L NH_3, UV dose of 40 mJ/cm^2, followed by Cl_2



Cl_2—chlorine, NH_3—ammonia, T—time, UV—ultraviolet

FIGURE 5 Comparison of disinfection methods



UV—ultraviolet

ual of 3 mg/L (Figure 2). Residual chloramine levels during these trials were approximately 2.8 mg/L.

Sequential trials, chloramines followed by UV. Sequential runs with sequential chloramine pretreatment followed by varied UV doses were performed to see if the order of disinfectants played a role in the inactivation of adenovirus type 2 (Figure 3). The first, second, and third trials had sequential chloramine additions resulting in a combined Cl_2 residual of 2.64, 1.44, and 1.37 mg/L, respectively. After the addition of adenovirus serotype 2 and Cl_2 to waters containing NH_3, samples were taken out over time to irradiate with different UV doses. At the conclusion of each dosing time, an additional sample was taken from the nonirradiated water containing chloramines for analysis. For each trial the time elapsed from start to finish was approximately 30 min. The log inactivation for sequential chloramines alone, prior to a UV dose of 40 mJ/cm^2, was <0.5 logs at a mean $C \times T$ of 19.6 mg-min/L. Results showed that regardless of pretreatment sequential chloramine levels, a roughly 2-log reduction was observed after a UV dose of 40 mJ/cm^2 in all three trials (Figure 3). A dose of 60 mJ/cm^2 showed an average 3.4-log reduction, and a dose of 80 mJ/cm^2 showed an average 4.2-log reduction for all three trials (Figure 3). These trials had lower average log reductions than the previous trials with the opposite sequence of disinfection. Therefore, it appears from laboratory water trials that the sequence of UV irradiation followed by sequential chloramine disinfection achieves higher log reductions than sequential chloramine disinfection followed by UV irradiation.

Sequential trials on natural waters. The raw water from Cedar Rapids contains high NH_3 concentrations year round because of agricultural use of the surrounding land. Because of the expense of breakpoint chlorination and the upcoming DBP regulations, Cedar Rapids is a perfect candidate for sequential disinfection. During sequential disinfection trials, natural source waters containing NH_3 (0.5 mg/L) were subjected to a UV dose of 40 mJ/cm^2 followed by Cl_2 addition to achieve a residual total Cl_2 concentration similar to Cedar Rapids' finished water (3 mg/L). A UV dose of 40 mJ/cm^2 resulted in an average 1.02-log reduction of adenovirus type 2 in all the trials (Figure 4). Addition of Cl_2 (residual total Cl_2 level of 3.04 mg/L) resulted in a 4-log reduction of adenovirus at approximately 12 min; the calculated $C \times T$ was 27.2 mg-min/L (Figure 4). Therefore, this method was effective on adenovirus serotype 2, achieving a 4-log reduction within a detention time that can be cost-effectively achieved in practice.

CONCLUSION

This study has shown that sequential disinfection is a feasible and cost-effective way of dealing with resistant microorganisms and DBP formation. A comparison of the disinfection methods studied (Figure 5) shows that UV followed by sequential chloramine formation is the most effective way to inactivate adenovirus type 2 in waters containing NH_3. A UV dose of 40 mJ/cm^2 followed by a total Cl_2 level of 3 mg/L in water sources with high NH_3 content was shown to be adequate treatment for adenovirus serotype 2. Additionally, water

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sources without appreciable NH_3 levels can easily use UV followed by a shorter free Cl_2 $C \times T$ and then switch to chloramines. This combination will still achieve the desired reductions in viruses and protozoans and in theory should lower their DBP production.

Treatment facilities typically use UV doses between 40 and 60 mJ/cm^2. In this study a dose of 40 mJ/cm^2 resulted in roughly a 1-log reduction regardless of the water matrix. All the test waters had similar absorbance at 254 nm. When test waters were sequentially disinfected, up to a 4-log reduction of adenovirus serotype 2 could be achieved.

ACKNOWLEDGMENT

The authors thank the city of Cedar Rapids (Iowa) Water Department staff members who were involved with this project, including John North, Shelli Grapp, and Barbara Wagner. Thanks also to Tony Meyers from CH2M Hill Inc., Milwaukee, Wis., and Mark Duben from H.R. Green Inc. of Cedar Rapids.

ABOUT THE AUTHORS:

Nicola A. Ballester[15] is a senior engineer for Metcalf and Eddy, 14504 Greenview Dr., Suite 400, Laurel, MD 20708; e-mail nicolaballester@hotmail.com. A member of AWWA, NEWWA, the International Ultraviolet Association (IUVA), and the International Water Association, Ballester's work has been published in the Journal of Applied Microbiology, Applied and Environmental Microbiology, *and the* Journal of Water and Health. *She has seven years of experience working in*

the virology lab at the University of New Hampshire (UNH) in Durham, and three years' experience in ultraviolet disinfection at UNH. Ballester earned a master's degree in civil and environmental engineering and a bachelor's degree in microbiology from UNH. She was also awarded first place for best student oral presentation at the IUVA conference in Vienna, Austria. James P. Malley Jr. is professor of civil and environmental engineering at UNH in Durham.

FOOTNOTES

[1]ATCC VR-846, American Type Culture Collection, Rockville, Md.
[2]A549, ATCC CCL-185, American Type Culture Collection, Rockville, Md.
[3]Ham's F12, D2906, Sigma Aldrich, St. Louis, Mo.
[4]LC18240-7 Lab Chem Inc., Pittsburgh, Pa.
[5]S-5761, Sigma Aldrich, St. Louis, Mo.
[6]Hank's balanced salts, H1387, Sigma Aldrich, St. Louis, Mo.
[7]3595, Corning Inc., Corning, N.Y.
[8] LPHO collimated-beam unit, Infilco Degremont, Richmond, Va.
[9]IL7000, International Light Inc., Newburyport, Mass.
[10]Bolton Photo Sciences Inc., Edmonton, Alta., Canada
[11]Clorox Co., Oakland, Calif.
[12]A649, Fisher Scientific, Fairlawn, N.J.
[13]Hach, Nessler Method 8038, Loveland, Colo.
[14]Hach, Free Cl_2 Method 10102, Total Cl_2 Method 10101, Loveland, Colo.
[15]To whom correspondence should be addressed

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ENVIRONMENTAL ENGINEERING SCIENCE
Volume 20, Number 5, 2003

N-Nitrosodimethylamine (NDMA) as a Drinking Water Contaminant: A Review

William A. Mitch,[1] Jonathan O. Sharp,[2] R. Rhodes Trussell,[3] Richard L. Valentine,[4] Lisa Alvarez-Cohen,[2] and David L. Sedlak[2,*]

[1]Department of Chemical Engineering
Environmental Engineering Program
Yale University
New Haven, CT 06520
[2]Department of Civil and Environmental Engineering
University of California, Berkeley
Berkeley, CA 94720
[3]Montgomery Watson Harza, Inc.
Pasadena, CA 91101
[4]Department of Civil and Environmental Engineering
University of Iowa
Iowa City, IA 52242

ABSTRACT

N-Nitrosodimethylamine (NDMA) is a member of a family of extremely potent carcinogens, the *N*-nitrosamines. Until recently, concerns about NDMA mainly focused on the presence of NDMA in food, consumer products, and polluted air. However, current concern focuses on NDMA as a drinking water contaminant resulting from reactions occurring during chlorination or via direct industrial contamination. Because of the relatively high concentrations of NDMA formed during wastewater chlorination, the intentional and unintentional reuse of municipal wastewater is a particularly important area of concern. Although ultraviolet (UV) treatment can effectively remove NDMA, there is considerable interest in the development of less expensive alternative treatment technologies. These alternative technologies include approaches for removing organic nitrogen-containing NDMA precursors prior to chlorination and the use of sunlight photolysis, and *in situ* bioremediation to remove NDMA and its precursors.

Key words: *N*-nitrosodimethylamine (NDMA); nitrosation; unsymmetrical dimethylhydrazine (UDMH); chlorination; photolysis; bioremediation

INTRODUCTION

N-NITROSODIMETHYLAMINE (NDMA) IS A MEMBER of a family of extremely potent carcinogens, the *N*-nitrosamines (U.S. EPA, 2002). Their cancer potencies are much higher than those of the trihalomethanes. Much of the recent focus on NDMA as a drinking water contaminant can be traced to the detection of NDMA in drinking water wells near a rocket engine testing facility in Sacramento County, CA, that used unsymmetrical dimethylhy-

*Corresponding author: Department of Civil and Environmental Engineering, University of California, Berkeley, Berkeley, CA 94720. *Phone:* 510-643-0256; *Fax:* 510-642-7483; *E-mail:* sedlak@ce.berkeley.edu

drazine (UDMH)-based rocket fuel. With groundwater NDMA concentrations as high as 400,000 ng/L on site and 20,000 ng/L off site, it became necessary to close downgradient drinking water wells (DHS, 2002; MacDonald, 2002). The U.S. EPA established a cleanup level of 0.7 ng/L for NDMA in groundwater (U.S. EPA, 2001), based on a risk assessment target of an increased lifetime cancer risk of 10^{-6} in drinking water (U.S. EPA, 2002). The subsequent discovery of NDMA at concentrations up to 3,000 ng/L downgradient of another rocket engine testing facility in the San Gabriel Valley (CA) spurred the California Department of Health Services to sponsor a survey of NDMA in California drinking waters (DHS, 2002).

The results of this survey demonstrated that NDMA occurrence was not limited to regions proximal to facilities that used UDMH-based fuels. Rather, NMDA detected at other sites also appeared to be associated with chlorine disinfection of water and wastewater. Especially in locations where chlorinated wastewater effluent was used for aquifer recharge, NDMA was present at elevated concentrations. For example, two drinking water production wells, under the influence of recharge water from the advanced wastewater treatment system of the Orange County Water District's Water Factory 21, suspended operations due to the presence of NDMA in 2000 (OCWD, 2000a). Groundwater injection of treated wastewater from Water Factory 21 was reduced from 7 to 1 million gallons per day pending the installation of an expensive ultraviolet treatment system to remove the NDMA prior to injection (OCWD, 2000b). Even more recently, NDMA was detected in treated drinking water from sources that were not impacted by wastewater effluent or industrial sources, especially when monochloramine was used to maintain a chlorine residual (DHS, 2002).

Although NDMA is listed as a priority pollutant (CFR, 2001), a federal maximum contaminant level (MCL) has not been established for drinking water. Moreover, NDMA is not even on the Candidate Contaminant List, which sets the priorities for future regulation of drinking water (U.S. EPA, 1998). However, other regulatory agencies have established NDMA guidelines. The Ontario Ministry of the Environment and Energy established an Interim Maximum Acceptable Concentration of 9 ng/L for NDMA (MOE, 2000). After discovering the widespread presence of NDMA, the California Department of Health Services set an interim action level of 20 ng/L, which was later reduced to 10 ng/L (DHS, 2002).

Despite heightened recent concern, NDMA is not really an emerging contaminant. Since the 1960s, toxicologists have studied the health effects of nitrosamines. The concern focused on their widespread occurrence in food and consumer products, particularly beer, meats cured with nitrite, tobacco smoke, and rubber products including baby bottle nipples (IARC, 1978). Concerns about human exposure to NDMA from industrial sources also were voiced previously. During the 1970s, NDMA was detected in the air and water adjacent to a factory near Baltimore (MD) that produced UDMH from NDMA (Shapley, 1976; Fine *et al.*, 1977; Fine, 1978). More alarming was the detection of NDMA in the air upwind of the plant in downtown Baltimore (0.1 $\mu g/m^3$), and at other sites in Belle, WV (0.1 $\mu g/m^3$), and New York City (0.8 $\mu g/m^3$), areas with no known industrial sources of NDMA. On the basis of those observations, some researchers suggested that NDMA formed in the polluted atmosphere could be responsible for elevated urban cancer rates (Shapley, 1976). However, it was subsequently determined that a factory using dimethylamine was located near Belle, WV, and that air concentrations of NDMA in areas not impacted by industrial processes were orders of magnitude lower than the initial reports (Hanst *et al.*, 1977; Cohen and Bachman, 1978; Fine, 1978).

Prior review articles (IARC, 1978; ASTDR, 1989) have focused on the occurrence and toxicology of NDMA in food and consumer products. In addition to research occurring after 1989, this review covers material from prior review articles that is relevant to water treatment.

ANALYSIS

Prior to the recent interest in low-level NDMA occurrence, analysis of the compound usually was performed by liquid–liquid extraction and gas chromatography/mass spectrometry (GC/MS) or gas chromatography with a thermionic detector. The detection limit of the method was approximately 1,000 ng/L. The most common technique currently used for analysis of low concentrations of NDMA involves extraction, preconcentration, and analysis by gas chromatography with tandem mass spectrometry in the chemical ionization mode (GC/CI/MS/MS) or gas chromatography with high resolution mass spectrometry (GC/HRMS). These methods typically have detection limits around 1 ng/L. Although a standard method for low-level quantification of NDMA has not been published, several methods have been shown to yield accurate and reproducible results. In the first step, residual chlorine in the sample is quenched with ascorbic acid or sodium thiosulfate to prevent an artifact due to reaction of chlorine with methylene chloride to form NDMA (Cohen and Bachman, 1978). Deuterated NDMA is added for use in isotope dilution to reduce the uncertainty associated with extraction efficiency. In some methods, the sample is extracted in methylene chloride by the separatory funnel method according to U.S. EPA Method 3510C (U.S. EPA, 1996). Unfortunately, this

method yields low recoveries, and may generate difficult-to-handle emulsions when used for wastewater effluent samples. Extraction efficiencies can be improved to approximately 50% by the addition of up to 100 g/L of sodium chloride (Yoo *et al.*, 2000). Other methods employ continuous liquid–liquid extraction via U.S. EPA Method 3520C (U.S. EPA, 1998), which involves extraction of the sample with 100–300 mL methylene chloride for approximately 6–18 h. Continuous liquid–liquid extraction avoids problems associated with emulsions in wastewater samples, and can yield extraction efficiencies of up to 60% (Mitch *et al.*, 2003). The methylene chloride extracts are then concentrated to 1 mL or less using rotary evaporators or nitrogen blowdown.

There have been several attempts to use solid-phase extraction to improve extraction efficiency and to reduce the volume of methylene chloride required for extractions. Jenkins *et al.* (1995) reported a NDMA solid-phase extraction method involving the use of carbonaceous Ambersorb 572 resin that reduces the volume of methylene chloride required to 400 μL. Recoveries were approximately 30%. This method suffers from difficulties arising from fragmentation of the resin and subsequent recovery for extraction (Tomkins and Griest, 1996). Tomkins and Griest (1996) described solid phase extraction using a carbon-based Empore disk that resulted in 60% recovery. Unfortunately, the carbon-based Empore extraction disks are no longer available.

Following extraction, NDMA is separated by capillary gas chromatography (most often with DB-5 or DB-1701 columns) followed by detection by one of several methods: thermal energy analyzers (Fine *et al.*, 1977; Kimoto *et al.*, 1981), chemiluminescent nitrogen detectors (Tomkins *et al.*, 1995), and high-resolution mass spectrometers (Taguchi *et al.*, 1994). Although these methods are still used, the most common method used for determination of low concentrations of NDMA involves the use of chemical ionization followed by tandem mass spectroscopy.

Analytical methods also have been described for NDMA precursors. Mitch *et al.* (2003) describe methods for analyzing total concentrations of the organic nitrogen precursors for NDMA formation during chlorination of water and wastewater. Although several methods for the detection of dimethylamine (and other primary and secondary amines) have been previously described (Scully *et al.*, 1988; Hwang *et al.*, 1994, 1995; Lopez *et al.*, 1996; Sacher *et al.*, 1997; Abalos *et al.*, 1999; Liu *et al.*, 2001), a method recently was developed specifically for use in water or wastewater (Mitch *et al.*, 2003).

Obtaining blanks that are free from NDMA and NDMA precursors can be problematic. Deionized or distilled water can be contaminated with several ng/L of NDMA (Kimoto *et al.*, 1981) as well as NDMA precursors (Gerecke and Sedlak, 2003). A UV lamp can be used to destroy NDMA in deionized water prior to use or NDMA-free water can be obtained by purchase of HPLC grade water.

SOURCES AND OCCURRENCE

NDMA can be released directly from industrial sources as a contaminant of products such as liquid rocket fuel, or it can be formed in solution from chemical reactions. Available data suggest that there are two major pathways for NDMA formation: (1) nitrosation, and (2) formation by oxidation of UDMH. Although the two pathways differ in their mechanisms of formation, the organic nitrogen precursors involved in both reactions may be identical.

Nitrosation: NDMA formation via nitrite

Nitrosation involves the formation of nitrosyl cation or similar nitrogen-containing species, such as dinitrogen trioxide (N_2O_3), during acidification of nitrite (reactions 1 and 2; Mirvish, 1975). The nitrosyl cation then reacts with an amine, such as dimethylamine, to form NDMA. This reaction occurs most rapidly at pH 3.4, reflecting a balance between the protonation of nitrite (pK_a of HNO_2 = 3.35) and the increased fraction of dimethylamine in the reactive, deprotonated from with increasing pH (pK_a of $H_2N(CH_3)_2^+$ = 10.7).

$$HNO_2 + H^+ \leftrightarrow H_2O + NO^+ \quad (1)$$

$$NO^+ + (CH_3)_2NH \rightarrow (CH_3)_2N{-}N = O + H^+ \quad (2)$$

This nitrosation mechanism is believed to be responsible for the observed formation of NDMA in vegetables, fish, and especially meat products cured with nitrite to prevent the growth of *Clostridium botulinum*, the bacterium that generates botulism toxin (IARC, 1978). Nitrate also can contribute to nitrosation because it can be reduced to nitrite by bacteria in the mouth (Preussmann, 1984). *In vivo* nitrosation occurs when nitrite enters the acidic environment of the stomach (Shapley, 1976). Nucleophilic anions, particularly thiocyanate (a constituent of saliva), enhance the rate of nitrosation through catalytic NDMA formation from nitrite (Fan and Tannenbaum, 1973). Although the U.S. Food and Drug Administration reduced the concentrations of nitrite allowed for curing meat to a maximum of 120 ppm, several meat processors add reducing agents such as ascorbic acid to quench nitrosating agents and minimize *in vivo* NDMA formation (Preussmann, 1984).

Although the rate of nitrosation is slow at neutral and

basic pH, several studies indicate that photochemical reactions (Ohta *et al.*, 1982), formaldehyde (Keefer and Roller, 1973) and fulvic acid (Weerasooriya and Dissanayake, 1989) can catalyze nitrosation at circumneutral pH. For example, Ayanaba and Alexander (1976) observed that the addition of high concentrations of nitrite to lake water containing dimethylamine resulted in the formation of NDMA. Although the concentration of NDMA increased as pH decreased, NDMA formation was observed even at pH 6.2. Denitrifying bacteria that colonize the organs of sick patients also are known to catalyze the nitrosation reaction at circumneutral pH values (Leach *et al.*, 1987). Furthermore, catalysis of nitrosation by the yeast *Candida albicans* in the mouth is thought to be potentially responsible for some oral cancers (Krogh *et al.*, 1987).

Reactions similar to nitrosation also can occur in the atmosphere. Combustion often results in the formation of nitrogen-containing species (i.e., NO_x or nitroso radicals) that react with species such as dimethylamine to produce nitrosamines. Relatively slow NDMA formation may occur in the atmosphere due to reaction of NO_x (principally atmospheric nitrous acid) with dimethylamine released by industrial sources (Hanst *et al.*, 1977; Cohen and Bachman, 1978). However, atmospheric NDMA may accumulate only at night because it degrades quickly by sunlight photolysis (Hanst *et al.*, 1977; Tuazon *et al.*, 1984).

Gas-phase nitrosation may explain the occurrence of NDMA in cigarette smoke, malt beverages, dried foods, and rubber products (Preussmann, 1984; ATSDR, 1989). NDMA can be formed during food drying or during the barley malting process as a result of NO_x in the exhaust of air heaters (Preussmann, 1984; ATSDR, 1989; Sen *et al.*, 1996). For example, concentrations of NDMA detected in beer dropped by nearly an order of magnitude when malting houses switched to the use of indirect heaters to prevent contact of the barley with heater exhaust or when they applied sulfur dioxide to the flue gas as a quenching agent. Prior to these modifications, beer was estimated to be the major dietary contributor to daily NDMA ingestion. Occupational exposures to NDMA are high in the tire and rubber industries where nitroso radicals in engine exhaust react with amine-containing accelerators used for vulcanization (Preussmann, 1984). NDMA also was observed in the wastewater effluents of a variety of industrial plants manufacturing amines, herbicides, pesticides, pharmaceuticals (Cohen and Bachman, 1978) and rubber. For example, NDMA has been detected at concentrations up to 2 mg/L in the wastewater effluent of a tire factory in Ontario (Ash, 1995).

Nitrosation reactions in food and consumer products may represent a significant exposure source. The estimated daily intake of NDMA for an average German diet was 0.2 μg/day (Tricker *et al.*, 1994). The most important dietary source of NDMA may be preserved meat and fish products, beer, and tobacco (Fine, 1978; ATSDR, 1989). NDMA is occasionally detected in cheese and bakery products (Uibu *et al.*, 1978) as the result of the drying process for cheeses or catalysis of nitrosation reactions by yeast. The formation of NDMA in amine-containing toiletry and cosmetic products, such as shampoo, has been attributed to the use of nitrite (Spiegelhalder and Preussmann, 1984). NDMA volatilizing from upholstery also is detectable in the interior air of automobiles (ATSDR, 1989).

Unsymmetrical dimethylhydrazine (UDMH) oxidation: NDMA formation from chlorine and other oxidants

During the 1980s, the formation of NDMA was reported when hypochlorite was used to treat waste UDMH-containing rocket fuel (Brubaker *et al.*, 1985, 1987). NDMA also has been observed as a byproduct of UDMH oxidation by cupric ion (Banerjee *et al.*, 1984), potassium permanganate, iodate (Castegnaro *et al.*, 1986), hydrogen peroxide, and oxygen (Lunn *et al.*, 1991; Lunn and Sansone, 1994). The formation of NDMA from oxidation of UDMH is maximized at neutral and high pH (Lunn *et al.*, 1991).

The formation of NDMA during water chlorination was reported in laboratory experiments in 1980 (Kimoto *et al.*, 1980, 1981). The formation of NDMA was later documented after chlorination at full-scale drinking water treatment plants and at wastewater treatment plants (Jobb *et al.*, 1994; Ash, 1995; Child *et al.*, 1996). Because NDMA is formed when UDMH is oxidized, any chlorination reactions that produce UDMH also should produce NDMA. The reaction between monochloramine and dimethylamine to form UDMH (Yagil and Anbar, 1962) and the reaction of monochloramine with trimethylamine to form a 1,1,1-trimethyl hydrazinium salt (Omietanski and Sisler, 1956) have been known for some time. Delalu *et al.* (1981; Delalu and Marchand, 1987, 1989a, 1989b) described the kinetics of the formation of UDMH from the reaction of monochloramine and dimethylamine and the subsequent oxidation of UDMH at high concentrations of reactants. However, they did not attempt to measure the formation of NDMA.

Until recently, NDMA formation during chlorination was assumed to occur via the nitrosation pathway (Kimoto *et al.*, 1981; Jobb *et al.*, 1994; OCWD, 2000b). However, Mitch and Sedlak (2002a) and Choi and Valentine (2002a, 2002b) demonstrated that NDMA formation during chlorination could occur through UDMH as an in-

termediate (Fig. 1). The rate of UDMH formation via this process increases with pH (Yagil and Anbar, 1962). Although stable at high pH, the UDMH intermediate is oxidized nearly instantaneously at circumneutral pH to form NDMA at low yields (<1%) (Mitch and Sedlak, 2002a). The maximum rate of formation occurs at circumneutral pH. Due to the preliminary slow step, the overall rate of formation is extremely slow, resulting in formation of NDMA over a period of days. Mitch and Sedlak (2002b) demonstrated that chloramination of amines via this pathway was a plausible explanation to account for the formation of NDMA during wastewater chlorination. However, it was unclear whether dimethylamine concentrations in secondary effluent are sufficient to account for NDMA formation or whether other organic nitrogen compounds are more important precursors.

Bromide ion is frequently a trace component of drinking water and wastewater. It is readily oxidized by free chlorine and monochloramine although the rate of reaction with monochloramine is several orders of magnitude slower (Trofe *et al.*, 1980). In the presence of excess ammonia, bromamines are readily produced when hypochlorite is added to water. Given the similarity of bromamine to chloramine chemistry and the generally increased reactivity of bromamines compared to chloramines, it is not surprising that Choi and Valentine (2002b, 2002c) observed a catalytic effect of bromide on NDMA formation.

The two-step mechanism elucidated by Mitch and Sedlak (2002a) and Choi and Valentine (2002a, 2002b) is consistent with observations (Najm and Trussell, 2001; Berger *et al.*, 2002; Najm and Ma, 2002; Wilczek *et al.*, 2002) that the use of monochloramine in water treatment greatly increases NDMA formation. Because NDMA formation is slow (Mitch and Sedlak, 2002a; Mitch *et al.*, 2003), the use of monochloramine to maintain a chlorine residual can result in increasing concentrations of NDMA within the distribution system. However, the problem is not restricted to chloramines. In the absence of ammonia, hypochlorite also can produce NDMA through reaction with secondary amines, but the rate of formation is approximately an order of magnitude lower than that observed with monochloramine (Mitch and Sedlak, 2002a).

Several studies have documented NDMA formation in waters treated with ion-exchange resins having quaternary amine functional groups that could serve as NDMA precursors (Fiddler *et al.*, 1977; Gough *et al.*, 1977; Kimoto *et al.*, 1980). In many of these studies, a chlorine or monochloramine residual in the water probably reacted with resin functional groups. However, Najm and Trussell (2001) found that even distilled water leached significant concentrations of NDMA (up to approximately 60 ng/L after 4 h of contact) from anion exchange resins. These concentrations doubled in the presence of 1 mg/L nitrite, suggesting a mechanism other than UDMH oxidation was involved. Although NDMA may form from the reaction of hypochlorite with amine-containing polymers used in water treatment, two studies indicated that the concentrations formed are not likely to be significant under normal drinking water conditions (Child *et al.*, 1996; Najm and Trussell, 2001).

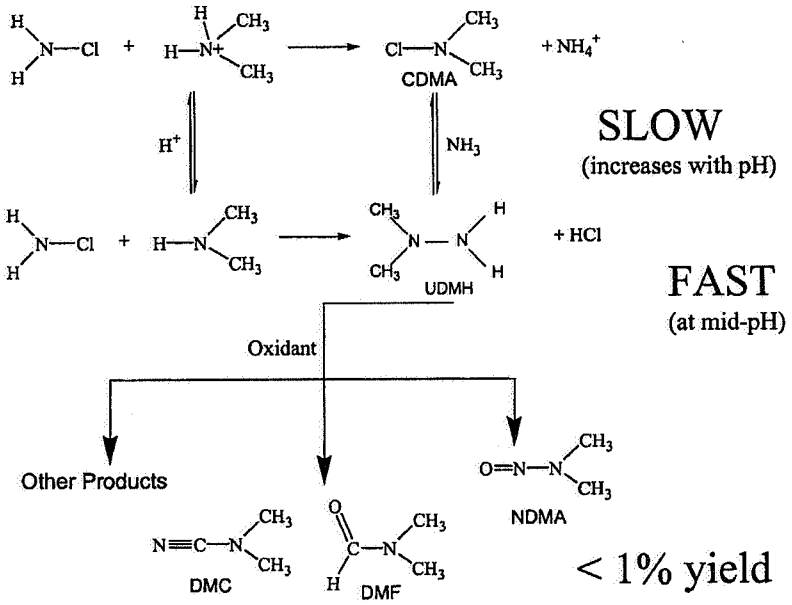


Figure 1. Pathway for NDMA formation during chloramination of dimethylamine via a UDMH intermediate (Mitch and Sedlak, 2002a).

NDMA OCCURRENCE IN DRINKING WATERS, WASTEWATERS, AND RECYCLED WATERS

The discovery of elevated concentrations of NDMA in treated drinking water in Ohsweken, Ontario, in 1989 prompted a survey of 145 Ontario drinking water plants (Jobb *et al.*, 1994; MOE, 1998). This survey indicated that the NDMA concentration in the treated water from most plants was less than 5 ng/L, although some samples exceeded 9 ng/L. Similar results were obtained by the California Department of Health Services during a survey of NDMA concentrations in drinking water systems conducted in 2001 (DHS, 2002). The results showed that 3 of the 20 chloraminated supplies surveyed contained NDMA concentrations greater than 10 ng/L, while none of the eight water supplies that used only free chlorine disinfection exhibited NDMA levels above 5 ng/L. One of the four drinking water supplies surveyed that employ anion exchange treatment also showed NDMA concentrations in excess of 10 ng/L. Other sampling programs confirmed that the majority of treated drinking water samples contain less than 10 ng/L of NDMA (Tomkins *et al.*, 1995; Tomkins and Griest, 1996). No sampling was conducted within water distribution systems, although the concentrations are anticipated to gradually increase in the presence of chlorine or chloramine residuals.

In contrast to results from drinking water treatment plants, effluents from conventional and advanced wastewater treatment plants contain relatively high concentrations of NDMA. NDMA is often present in raw sewage prior to chlorination. For example, NDMA concentrations as high as 105,000 ng/L have been reported in effluents from printed circuit board manufacturers using NDMA-contaminated dimethyldithiocarbamate to remove metals (OCSD, 2002). These industrial inputs resulted in concentrations of NDMA of approximately 1,500 ng/L in raw sewage. As a result of removal processes that occur during secondary treatment, NDMA concentrations in unchlorinated secondary effluent often are less than 20 ng/L, although industrial inputs can lead to large spikes in NDMA influent and effluent concentrations.

Chlorination of secondary wastewater effluent typically results in the formation of between 20 and 100 ng/L NDMA (Mitch and Sedlak, 2002b). Consistent with the UDMH-intermediate mechanism, nitrification of wastewater to completely remove ammonia prior to hypochlorite addition reduces NDMA formation by approximately an order of magnitude (Mitch and Sedlak, 2002e). In wastewater recycling plants receiving secondary wastewater effluent, NDMA concentrations in microfiltration effluent may increase by approximately 30–50 ng/L as a result of chlorination before the membrane to prevent biological growth (L. McGovern, personal communication). NDMA also has been detected in dried municipal sewage sludge used for agricultural fertilizer, but in this case the formation pathway may be biologically mediated nitrosation during anaerobic digestion (Brewer *et al.*, 1980; ATSDR, 1989).

ORGANIC NITROGEN PRECURSORS: SOURCES AND OCCURRENCE

Both of the NDMA formation mechanisms involve reactions between an inorganic, nitrogen-containing species (e.g., N_2O_3, NH_2Cl) and an organic nitrogen species. Not surprisingly, dimethylamine has been demonstrated to be the most effective organic nitrogen precursor of NDMA formation by both the nitrosation pathway (Fiddler *et al.*, 1972) and the UDMH pathway (Mitch and Sedlak, 2002b). Both pathways also can produce NDMA from tertiary amines containing dimethylamine functional groups (e.g., trimethylamine and dimethylethanolamine) but at lower yields. Nitrosation of trimethylamine-*N*-oxide, a common constituent of urine (Zuppi *et al.*, 1997), resulted in some NDMA formation, but much less than did trimethylamine (Fiddler *et al.*, 1972). Many other organic nitrogen-containing molecules, including the primary amine monomethylamine, the quaternary amine tetramethylamine, and amino acids or proteins, did not form significant concentrations of NDMA after chloramination (Mitch and Sedlak, 2002b). Fiddler *et al.* (1972) found that nitrosation of quaternary amines that contained trimethylamine functional groups resulted in four orders of magnitude lower NDMA concentrations than did trimethylamine. Significant organic nitrogen precursors for NDMA formation therefore appear to be limited to dimethylamine and tertiary amines with dimethylamine functional groups.

The lower yields of NDMA from species other than dimethylamine are not unexpected given the need to break a C—N bond prior to NDMA formation. In the case of the nitrosation pathway, Ohshima and Kawabata (1978) described a complex reaction scheme for NDMA formation from trimethylamine-*N*-oxide and trimethylamine that accounts for the dealkylation required to form the dimethylamine portion of NDMA using the proposed pathways of earlier researchers such as Smith and Loeppky (1967) and Lijinsky and Singer (1975). A dealkylation scheme for NDMA formation during chloramination of tertiary amines containing dimethylamine functional groups may involve chlorine transfer to the nitrogen atom followed by elimination of HCl to form an iminium ion (Ellis and Soper, 1954). Hydrolysis of the

iminium ion results in formation of the secondary amine. Finally, Mitch and Sedlak (2002b) demonstrated that chloramination of other secondary amines or tertiary amines containing functional groups other than dimethylamine resulted in the formation of their respective nitrosamines in quantities similar to those associated with NDMA formation from dimethylamine and trimethylamine.

Dimethylamine is present in food, and can be liberated from food during digestion (Tricker *et al.*, 1994). Nitrogen-containing organic molecules, such as the cell membrane structural lipid phosphatidyl choline (lecithin) and amino acids, are broken down by bacterial flora in the gastrointestinal tract to trimethylamine (Simenhoff *et al.*, 1976; Tricker *et al.*, 1994). After absorption into the bloodstream, a portion of the trimethylamine is demethylated to dimethylamine and excreted via the urine, gastric juice, or bile. The remainder is oxidized to trimethylamine-*N*-oxide, which is excreted in the urine in concentrations usually twice as high as those of dimethylamine (Zuppi *et al.*, 1997). Tricker *et al.* (1994) found that dimethylamine is present in human urine (average concentration is approximately 40 mg/L) and feces (average concentration is 0.41 μg/mL). Dimethylamine also has been detected in the feces of dairy cattle (van Rheenan, 1962).

Amines also are produced outside of the body by microbes via the vitamin B_6-mediated degradation of amino acids (Metzler, 1977). Ayanaba and Alexander (1974) demonstrated that addition of relatively high concentrations of trimethylamine or tetramethylthiuram disulfide (thiram) to lake water or municipal sewage resulted in the microbiological production and eventual consumption of dimethylamine. Trimethylamine-*N*-oxide is present in seafood, and may be broken down to trimethylamine by bacteria (Ohshima and Kawabata, 1978).

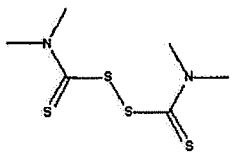
As a result of excretion and industrial activities, dimethylamine concentrations in primary wastewater effluent typically range from 20 to 80 μg/L (Mitch and Sedlak, 2002c). Dimethylamine is readily degraded by bacteria. As a result, concentrations in secondary wastewater effluents are generally low (i.e., average = 4 μg/L; Mitch and Sedlak, 2002c). Mitch and Sedlak (2002c) concluded that dimethylamine could only account for approximately 10% of the NDMA formed when secondary wastewater effluent was chloraminated. However, other authors, using a less sensitive HPLC method, have found no significant loss of dimethylamine upon secondary biological treatment (Hwang *et al.*, 1995; Abalos *et al.*, 1999).

In unpolluted waters, dimethylamine concentrations are generally less than 0.1 μg/L (Gerecke and Sedlak, 2003). These concentrations can not account for NDMA formation during chlorination (Mitch *et al.*, 2003). However, dimethylamine, methylamine and morpholine were detected at concentrations up to 3 μg/L in the Rhine and Elbe Rivers in Germany (Sacher *et al.*, 1997) where the input of wastewater effluents may be significant. Under these conditions, dimethylamine from unintentional reuse of municipal wastewater effluent could be an important NDMA precursor.

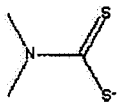
Resins used in water and wastewater treatment also may be sources of dimethylamine and other organic nitrogen-containing NDMA precursors. NDMA itself may be a contaminant of carbonaceous resins and activated carbon at levels up to approximately 10 μg/kg (Kimoto *et al.*, 1981). Najm and Trussell (2001) found that extraction of strong-base anion-exchange resins containing dimethyl-ethanol or trimethyl quaternary functional groups with distilled water in the absence of chlorine resulted in concentrations of NDMA up to approximately 50 ng/L. Moreover, while NDMA was not detected in effluent from resins containing triethyl or tripropyl functional groups, *N*-nitrosodiethylamine and *N*-nitrosodi-*n*-propylamine were detected, respectively (Najm and Trussell, 2001). NDMA precursors can leach from functional groups on quaternary amine-containing exchange resins (Cohen and Bachman, 1978; Kimoto *et al.*, 1980; Najm and Trussell, 2001). At elevated temperatures (i.e., 78°C), some of the quaternary amine functional groups on resins demethylate to form trimethylamine (Fiddler *et al.*, 1972).

Resins and granular activated carbon may promote NDMA formation by surface-catalyzed reactions. Angeles *et al.* (1978) suggested that mixed bed resins promote nitrosation of precursors because proton displacement on cationic resins creates acidity, which promotes nitrosation reactions on adjacent anionic resins (usually containing amine precursors) to which nitrite may adsorb. An enhancement of nitrosation reactions was observed when a nitrifying biofilm was active on granular activated carbon (DiGiano *et al.*, 1986), possibly as a result of biological catalysis. However, NDMA formation by this pathway is unlikely to be significant under typical drinking water treatment conditions.

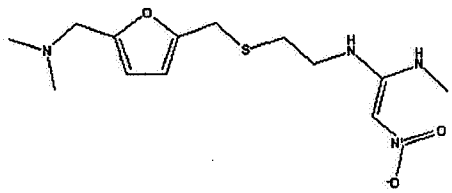
Other industrial products containing dimethylamine functional groups that could serve as precursors include fungicides such as thiram (tetramethylthiuram disulfide) (IARC, 1978) Graham *et al.*, 1995), pesticides, and herbicides such as 2,4-D, which are formulated as a dimethylamine salts (Fine, 1978; Child *et al.*, 1996), drugs such as ranitidine (IARC, 1978), and amine-containing accelerators for vulcanization of tires (Fig. 2). The dithiocarbamates, which are a family of compounds used as fungicides, herbicides, and as chelating agents to remove cationic metals from industrial wastewater, contain



tetramethylthiuram disulfide



dimethyldithiocarbamate



ranitidine (Zantac)

Figure 2. Industrial products that could be precursors for NDMA formation: the pesticide tetramethylthiuram disulfide (thiuram), the fungicide, herbicide, and metal chelator dimethyldithiocarbamate (DTC), and the H-2 receptor antihistamine pharmaceutical ranitidine (Zantac).

readily hydrolyzable dimethylamine functional groups (Weissmahr and Sedlak, 2000).

Amine-based polymers (Child *et al.*, 1996; MOE, 1998; Najm and Trussell, 2001) and unknown contaminants of alum (Jobb *et al.*, 1994) also have been identified as sources of NDMA precursors. In the case of wastewater treatment, treatment polymers containing dimethylamine groups become associated with particles, and can form a significant fraction of the total organic nitrogen precursors during wastewater treatment (S. Carr, personal communication).

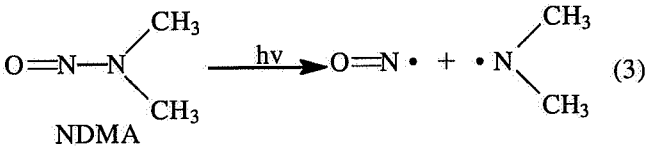
TREATMENT

Removal of NDMA

The vapor pressure of NDMA is estimated to be relatively high at 360 Pa at 20°C (Klein, 1982). Due to the high water solubility of NDMA, the estimated Henry's Law constant for NDMA is low at 2.6×10^{-4} atm M^{-1} 20°C (ATSDR, 1989; Mirvish *et al.*, 1976). Therefore, volatilization from natural waters and air stripping are unlikely to result in significant removal of NDMA from solution. As a small, uncharged molecule, NDMA is poorly removed via reverse osmosis membranes. Within wastewater recycling plants, NDMA was removed with approximately 50% efficiency by thin-film composite reverse osmosis membranes (L. McGovern, personal communication).

Due to the presence of polar functional groups, NDMA is hydrophilic, with a log K_{ow} value of −0.57 (ATSDR, 1989). As a result, NDMA sorbs poorly to soil, activated carbon, and other sorbents. Bituminous coal granular-activated carbon was used in interceptor trenches to remove NDMA arising from groundwater contamination at the Rocky Mountain Arsenal (Fleming *et al.*, 1996). Fleming *et al.* (1996) found that sorption onto hydrophilic sorbents such as silica, acrylic resins, and zeolite were insignificant. Ambersorb 572 carbonaceous resin was found to be the most effective sorbent, followed by coconut shell carbon. However, the Freundlich isotherm K and $1/n$ constants for Ambersorb 572 (9.65×10^{-3} mg/g and 1.17, respectively) were low, which resulted in prohibitive treatment costs. Consistent with these observations, the transport of NDMA was not retarded through soil columns (Dean-Raymond and Alexander, 1976).

Currently, the most commonly applied aqueous NDMA treatment method is photolysis by ultraviolet (UV) radiation. NDMA absorbs light strongly between 225 and 250 nm (Fig. 3; λ_{max} = 228 nm where ε = 7380 M^{-1} cm^{-1}). This wavelength is at the lower end of the transparency of water to UV. The absorption results in a π to π^* transition (Polo and Chow, 1976; Stefan and Bolton, 2002) followed by cleavage of the N—N bond, most likely via hydrolysis to dimethylamine and nitrous acid, or by forming nitroso and dimethylamine radicals (reaction 3).



NDMA (3)

The major products of the reaction are dimethylamine and nitrite, while minor products include nitrate, for-

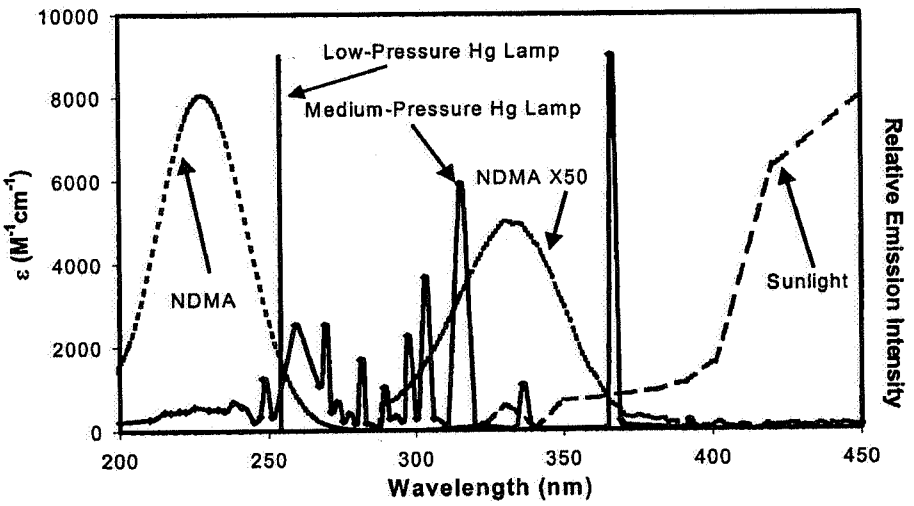


Figure 3. Emission spectra for low- and medium-pressure mercury lamps, sunlight spectrum at the surface of the Earth and absorption spectrum of 1 μM NDMA.

maldehyde, formate, and perhaps methylamine (Stefan and Bolton, 2002). The quantum yield at pH 7 is 0.13 (Stefan and Bolton, 2002). Dimethylamine is resistant to further photolytic reactions, while nitrite is readily oxidized to nitrate. NDMA also has a secondary absorption peak between 300 and 350 nm (λ_{max} = 332 nm, where ε = 109 M^{-1} cm^{-1}) within which excitation occurs via an n-to-π^* transition (Stefan and Bolton, 2002). This secondary peak overlaps well with the intensity of UV produced by medium-pressure mercury lamps (Stefan and Bolton, 2002). However, whether low- or medium-pressure lamp systems are more efficient for NDMA destruction is still unclear. Under conditions typically encountered in drinking water treatment systems, the UV dosage required for a one order of magnitude decrease in NDMA concentration is approximately 1,000 mJ/cm^2, which is approximately 10 times higher than that required for equivalent virus removal. Therefore, UV treatment for NDMA will be feasible but more expensive than UV treatment for disinfection.

UV treatment has been used to remove NDMA at a drinking water plant in Ohsweken, Ontario (Jobb *et al.*, 1994), in effluent from a tire factory upgradient of the Ohsweken plant (Ash, 1995), and at Water Factory 21 in Orange County, CA (OCWD, 2000a). Three technologies have been used for UV treatment of NDMA: low-pressure UV lamps emitting mainly monochromatic light at 254 nm, medium-pressure lamps emitting polychromatic light, and pulsed UV systems. Pulsed UV systems have the advantage of an emission spectrum that more closely matches the adsorption spectrum of NDMA (Liang, 2002). However, the technology is less proven than low- and medium-pressure UV lamps.

Because UV photolysis may not destroy NDMA precursors, some have suggested that reformation of NDMA may occur within drinking water distribution systems if chlorination is performed after the UV treatment (Jobb *et al.*, 1994). However, the concentration of dimethylamine liberated when low concentrations of NDMA are photolyzed usually will be small. If significant concentrations of NDMA are formed upon chlorination following UV treatment, the formation likely results from other NDMA precursors. Addition of hydrogen peroxide to generate hydroxyl radical for NDMA oxidation does not significantly increase NDMA destruction efficiency (Jobb *et al.*, 1994; Liang, 2002).

Photolysis of NDMA also occurs in sunlight as a result of NDMA's secondary absorption band between 300 and 350 nm. Sunlight photolysis was used by the OCWD as part of their initial attempt to reduce concentrations of the compound at Water Factory 21; placing treated water in shallow sunlit basins with residence times of approximately 1 day resulted in removal of approximately half of the NDMA (M. Wehner, personal communication). Sunlight photolysis also may be an important loss mechanism for NDMA applied in irrigation water (ATSDR, 1989).

Atmospheric photolysis of NDMA removes NDMA from the sunlit atmosphere within a few hours (Shapley, 1976; Hanst *et al.*, 1977; Cohen and Bachman, 1978; Tuazon *et al.*, 1984). NDMA is believed to decay via equation (1) with a quantum yield of 1 for $\lambda \geq 290$ nm (Tuazon *et al.*, 1984). The major product is dimethylnitramine via the reaction of NO_2 with the dimethylamino radical. Lesser products include formaldehyde and methylnitramine. The half-life for the atmospheric reac-

tion of NDMA with hydroxyl radical was estimated to be approximately 3 days compared with only 5 min for direct photolysis (Tuazon *et al.*, 1984).

Ozone does not appear to react with NDMA by a direct mechanism either in the atmosphere (Tuazon *et al.*, 1984) or in water (Liang, 2002). Hydroxyl radicals produced from ozone and hydrogen peroxide can be used to treat NDMA (Liang, 2002). However, the efficiency of ozonation and other advanced oxidation processes (AOPs) will be limited by the presence of hydroxyl radical scavengers.

Zero-valent iron catalyzes NDMA transformation by hydrogenation (Gui *et al.*, 2000; Odziemkowski *et al.*, 2000). This reduction reaction leads to the formation of dimethylamine and ammonia as final products. Although a field feasibility study conducted with canisters demonstrated NDMA reduction, the relatively slow kinetics of the reaction suggested that it would not be a cost effective treatment option (Cox, 2002). The addition of 0.25% nickel to the iron increased the reduction rate by nearly a factor of 340. However, the reaction rate for the nickel–iron mixture decreased within 100 pore volumes.

The potential for phytoremediation of NDMA is currently unknown. However, the high aqueous solubility of the compound is well-suited for the treatment. Lettuce and spinach readily took up ^{14}C-labeled NDMA from irrigation water (Dean-Raymond and Alexander, 1976). ^{14}C activity in the plants decreased with time, suggesting that the NDMA was converted to $^{14}CO_2$ in the plants.

Bioremediation could hold significant potential for the *in situ* treatment of NDMA contaminated water. Bacterial monooxygenase enzymes may be similar to the cytochrome P-450 enzymes that catalyze the NADPH-dependent oxidation of NDMA in both plants and animals (Tu and Yang, 1985; Yamazaki *et al.*, 1992; Stiborova *et al.*, 2000). Mineralization (conversion to CO_2) of NDMA by undefined consortia has been observed in two studies (Kaplan and Kaplan, 1985; Gunnison *et al.*, 2000). Biodegradation also has been reported in anaerobic and aerobic incubations of native microbial soil consortia, with half-lives ranging from 12 to 55 days (Tate and Alexander, 1975; Oliver *et al.*, 1979; Gunnison *et al.*, 2000). Biodegradation proceeded slightly faster under aerobic conditions than under anaerobic conditions (Mallik and Tesfai, 1981). In two cases, the NDMA biodegradation rate may have slowed after the first few weeks of NDMA application (Tate and Alexander, 1975; Mallik and Tesfai, 1981); however, these studies suffered from poor quantification of the effect of confounding factors such as volatilization (ATSDR, 1989). Although these studies documented degradation intermediates, including methylamine and formaldehyde, none of these studies was able to identify the responsible micro-organisms nor elucidate degradation pathways.

Despite the existence of NDMA-degrading bacteria in soil, there is limited evidence for the biodegradation of NDMA under field conditions. For example, at the Rocky Mountain Arsenal, no significant loss of NDMA was observed during passage through the aquifer (Gunnison *et al.*, 2000). However, after groundwater was passed through an *ex situ* granular activated carbon (GAC) treatment system and reinjected into the subsurface, NDMA removal was observed. Because NDMA adsorption to GAC is negligible, the GAC at the Rocky Mountain Arsenal site may have removed competitive substrates from solution, allowing NDMA biodegradation to proceed. In another study, the addition of glucose or nutrient broth to microcosms hindered NDMA mineralization, indicating that substrate competition may occur (Kaplan and Kaplan, 1985). It is likely that a complex interaction exists between dissolved organic nutrients necessary for the growth of bacteria capable of degrading NDMA and a tendency of these micro-organisms to consume these nutrients in preference to NDMA. In addition to the lack of clear evidence for bioremediation of NDMA in groundwater, there is no information regarding the potential for biological removal of NDMA within drinking water treatment systems such as biofiltration units.

Removal of NDMA precursors

Unlike NDMA, many nitrogen-containing NDMA precursors, including dimethylamine and trimethylamine, are charged at circumneutral pH. Precursors may therefore have significantly different properties than NDMA. As a result of their protonation, precursors should be even less susceptible to treatment by air stripping or adsorption compared to NDMA. Hwang *et al.* (1994) found that dimethylamine and other aliphatic amines were removed poorly by sorption to granular activated carbon (Freundlich isotherm constants for dimethylamine onto Calgon F-400 GAC were $K = 7.73$ mg/g and $1/n = 0.26$).

Although direct photolysis of NDMA is an effective treatment technique, the lack of the nitroso functional group on the nitrogen-containing precursors may make precursors unreactive. Hwang *et al.* (1994) found that the reaction of dimethylamine with ozone was slow. However, there are preliminary indications that hydroxyl radicals formed in UV–hydrogen peroxide or ozone–hydrogen peroxide systems can remove NDMA precursors (Liang, 2002).

NDMA precursors are readily removed by biological treatment. Secondary biological treatment of municipal

wastewater was found to reduce NDMA precursors in wastewater by an average of 60%, and to reduce dimethylamine concentrations by at least an order of magnitude (Mitch and Sedlak, 2002c). Although biological nitrification and denitrification reduced NDMA formation during application of hypochlorite by precluding monochloramine formation, these extended biological treatments were not found to significantly reduce organic NDMA precursor concentrations (Mitch and Sedlak, 2002c). Typical secondary treatment systems appear capable of removing the majority of biodegradable precursors.

NDMA precursors also are removed in advanced treatment systems. Microfiltration reduces the concentration of particle-associated NDMA precursors in activated sludge wastewater effluent (Mitch and Sedlak, 2002c). Reverse osmosis treatment reduces NDMA precursor concentrations by at least an order of magnitude, removing not only colloidal NDMA precursors, but also charged, dissolved precursors such as protonated dimethylamine.

AREAS OF FUTURE RESEARCH

As indicated by this review, a substantial amount of research has been performed on the source, behavior, and treatment of NDMA. However, additional research needs to be performed to develop more cost-effective means of minimizing NDMA exposure. Several research needs are listed below:

- Characterization of other *N*-nitroso compounds and other products formed from the reaction of organic nitrogen and monochloramine should be performed.
- Characterization of the precursors responsible for NDMA formation during chlorination of drinking water should be elucidated better. In particular, additional research is needed to determine the relative importance of NDMA formation during passage of water through ion exchange units or during post-treatment chlorination of precursors leached from ion exchange units relative to precursors from other sources.
- Characterization of organic nitrogen-containing NDMA precursors during wastewater treatment is needed. Only about 10% of the formation of NDMA from organic nitrogen precursors in the low molecular weight fraction of secondary wastewater effluent can be accounted for by dimethylamine. Other dissolved precursors in wastewater must be identified. In addition, the role of treatment polymers as potential NDMA precursors should be explored.
- Methods are needed to improve the removal of organic nitrogen-containing NDMA precursors prior to chlorination.
- NDMA formation did not occur during ozone disinfection (Najm and Trussell, 2001). However, an investigation regarding the effect of ozonation on NDMA precursors should be undertaken because monochloramine may be applied to maintain a disinfection residual following ozonation. Furthermore, the ability of alternative disinfectants such as chlorine dioxide to form NDMA should be investigated.
- Measurement of the quantum yield for aqueous NDMA photolysis by sunlight is needed to predict the rate of removal of NDMA upon sunlight exposure in infiltration basins, during irrigation or in surface waters.
- The uptake of NDMA by plants and its subsequent fate should be further evaluated to determine the potential for phytoremediation.
- The pathway for microbial degradation of NDMA and the associated kinetics should be evaluated to identify conditions conducive to *in situ* bioremediation. The potential for NDMA removal in biofiltration treatment units should be evaluated as a treatment strategy in drinking water treatment plants.

ACKNOWLEDGMENTS

We thank Mr. Timothy Durbin for help with this manuscript. Support for Mr. Bill Mitch was provided by the WateReuse Association and the National Water Research Institute. Support for Mr. Jonathan Sharp was provided by funding from the University of California Toxics Substances Research and Teaching Program and by NIEHS Grant ES04705.

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A LARGE-SCALE UV PILOT-PLANT STUDY: TERTIARY EFFLUENT DISINFECTION AND EFFECT ON NDMA AND CYANIDE

Yusef Jalali, Shiaw-Jy Huitric, Jeff Kuo, Chi-Chung Tang,
April Garcia, Shawn Thompson, Robert W. Horvath, James F. Stahl
Sanitation Districts of Los Angeles County
1955 Workman Mill Road, Whittier, CA 90601

ABSTRACT

The Sanitation Districts of Los Angeles County (Sanitation Districts) are currently facing new regulatory issues related to NDMA and cyanide. To prevent NDMA formation from chloramination, the Sanitation Districts are considering the use of ultraviolet (UV) disinfection to replace chloramination. UV disinfection may also result in incidental removal of NDMA. However, a recent study indicated that low levels of cyanide might be formed as a result of UV irradiation. To fully evaluate the effect of UV on tertiary effluent disinfection, NDMA removal, and potential cyanide generation, the Sanitation Districts recently conducted a large-scale pilot-plant UV testing. The testing was conducted following the procedures outlined in *Ultraviolet Disinfection Guidelines for Drinking Water and Wastewater Reclamation* (NWRI Guidelines). A UV transmittance (UVT) range of 63% to 79% was tested. Flow rates ranged from 1.5 to 3.5 million gallons per day (MGD). The pilot plant was run with varying number of UV banks and lamp power setting. Influent and effluent NDMA, total cyanide, total coliform, and MS-2 coliphage concentrations were measured. This paper presents the results of this study and discusses several technical issues related to UV testing and full-scale design.

The study indicated that inert media filtration had little effect on the fate of NDMA, while chloramination significantly increased the NDMA concentration. Both collimated beam and pilot testing results showed a linear relationship existed between log-reduction of NDMA and UV dose. At a UV disinfection dose of 100 mJ/cm^2, the removal of NDMA in the filtered effluent by the pilot-plant was approximately 40%. UV irradiation of filtered secondary effluent did not result in cyanide formation for doses up to 500 mJ/cm^2 in collimated beam testing, and for delivered UV doses up to approximately 140 mJ/cm^2 in pilot testing. At a delivered UV dose of 100 mJ/cm^2 derived from MS-2 testing, the total coliform concentration in the UV disinfected effluent meets the California Title 22 Water Recycling Criteria for unrestricted reuse. Several technical issues relevant to UV testing and design, such as single-bank vs. multiple-bank testing and adequacy of using collimated beam testing to derive delivered dose, were identified and discussed.

KEY WORDS

UV disinfection, NDMA, cyanide, total coliform, validation test, UV transmittance, UV dose

INTRODUCTION

The Sanitation Districts of Los Angeles County (Sanitation Districts) own and operate eleven wastewater treatment plants with a total design capacity of 650 million gallons per day (MGD). Seven of these plants are tertiary water reclamation plants with a combined treatment capacity of 210 MGD. Of these seven WRPs, the Whittier Narrows Water Reclamation Plant (WNWRP) is designed to treat an average flow of 15 MGD. Effluent discharge from the WNWRP is governed by three permits issued by the Los Angeles Regional Water Quality Control Board: (1) a National Pollutant Discharge Elimination System (NPDES) permit for discharges to surface water; (2) California Title 22 Water Recycling Requirements for irrigation and other non-potable uses; and (3) California Title 22 Water Recycling Requirements for groundwater recharge. The bulk of the reclaimed water from the WNWRP is used for groundwater replenishment.

The Sanitation Districts are currently facing new regulatory issues related to n-nitrosodimethylamine (NDMA) and cyanide. Monochloramine, the intended disinfectant at the WNWRP, and dimethylamine, present in wastewater and also a constituent in cationic polymers commonly used to enhance floc settling and to control foaming, were identified as the major precursors for NDMA formation.[1,2,3] The California Department of Health Services (DHS) has established a Notification Level of 10 nanograms per liter (ng/L) of NDMA for groundwater supplies. Incidentally, the cyanide discharge limit in the NPDES permit for the WNWRP is very low, at 5.2 micrograms per liter (ug/L).

To prevent NDMA formation from chloramination, the Sanitation Districts decided to evaluate ultraviolet (UV) disinfection as an alternative to chloramination at the WNWRP. UV disinfection may also result in incidental removal of NDMA. However, a recent Water Environment Research Foundation study indicated that low levels of cyanide might be formed as a result of UV irradiation.[4] To fully evaluate the effect of UV on tertiary effluent disinfection, NDMA removal, and potential cyanide generation, the Sanitation Districts decided to conduct a pilot-scale UV testing at the WNWRP. The study was also to generate site-specific data for design of a full-scale UV disinfection system at the plant.

The pilot-plant testing at the WNWRP started in June 2004. The study had two main objectives. The first was to conduct a UV equipment validation test that is required by DHS for new UV equipment or configurations. This part of the study was conducted by the equipment vendor and a third-party consultant hired by the vendor. The second part of the study was conducted by the Sanitation Districts to generate information beyond the typical UV disinfection validation testing. The specific objectives of the Sanitation Districts' study included:

- Determining if the validated UV disinfection system, which is based on MS-2 inactivation, also achieves compliance with California water reuse permit requirements, a 7-day median total coliform concentration less than 2.2 MPN/100 mL for unrestricted reuse;
- Investigating the effect of UV disinfection on the two compounds of concern, NDMA and cyanide; and
- Conducting a critical review on important technical issues related to validation testing procedures and design and operation of full-scale UV facilities.

The Sanitation Districts' pilot-plant testing was conducted following the procedures outlined in *Ultraviolet Disinfection Guidelines for Drinking Water and Wastewater Reclamation* (NWRI Guidelines).[5] A UV transmittance (UVT) range of 63% to 79% was tested. Flow rates ranged from about 1,000 to 2,500 gallon per minute (gpm), or approximately 1.5 to 3.5 million gallons per day (MGD). The pilot plant was run with varying number of banks (from one to three) in operation, while the UV lamp power setting varied from 60 to 100%. Pilot plant influent and effluent concentrations of NDMA, total cyanide, total coliform, and MS-2 coliphage were measured during the pilot testing. This paper presents the results of this study and discusses several technical issues related to UV testing and full-scale design and operations.

BACKGROUND

Treatment Processes at the WNWRP

The WNWRP utilizes the following unit processes: primary sedimentation, biological nitrogen removal using the modified Ludzack-Ettinger (MLE) process, secondary sedimentation, dual-media filtration using sand and anthracite, disinfection with chloramination, and dechlorination with sodium bisulfite. Reclaimed water used for groundwater replenishment or discharged to unlined channels is dechlorinated. Sludge generated at the WNWRP is conveyed through a sewer system to the Sanitation Districts' Joint Water Pollution Control Plant (JWPCP) in Carson for treatment and disposal.

NWRI Guidelines

In California, design of a full-scale UV disinfection system for water reuse applications requires the approval of the DHS. The design and sizing of UV equipment are required to be based on validation test results that have been conducted for specific UV systems, and have been approved by the DHS. The validation tests are typically pilot-plant studies, conducted according to the requirements of the NWRI Guidelines. The NWRI Guidelines call for a minimum UV delivered or bioassay dose of 100 milliJoules per square centimeters (mJ/cm^2) for disinfection of tertiary effluent produced by media filters. The delivered (bioassay) dose is determined by comparing removal of a surrogate microorganism (usually MS-2 coliphage) in UV pilot-plant testing and removal of the same microorganism in laboratory collimated beam testing which establishes the UV dose vs. removal relationship (commonly referred to as the dose-response curve). The NWRI Guidelines requires that the design of the full-scale facility include de-rating coefficients to account for lamp aging and for fouling of the UV quartz sleeve.

To facilitate design and operation of full-scale UV systems, the equipment vendors often develop a regression equation based on pilot-plant validation test results. The equation allows the calculation of delivered UV dose as a function of hydraulic loading (flow rate per UV lamp), UV transmittance (UVT) of the water, power setting of the UV lamps, and de-rating coefficients.

Selection of UV Pilot Test Equipment

After an evaluation of available UV disinfection equipment, the Sanitation Districts decided to test the low-pressure high-output (LPHO) UV lamps in open-channel reactor configuration, with the lamps in horizontal position parallel to the flow direction. Two LPHO UV systems, the Trojan Technologies UV-3000Plus (Trojan Technologies, Ontario, Canada) and the Wedeco Ultraviolet Technologies TAK55 (Wedeco, Charlotte, NC) were selected for pilot testing. Both UV systems were previously tested according to the NWRI Guidelines, and the validation reports had been approved by the DHS.

Although the Sanitation Districts' intent was to test both pilot-scale systems, only Trojan was able to supply a pilot plant for testing. The pilot plant is based on the Trojan UV-3000Plus system and consists of three UV banks. Hydraulically, the pilot plant can handle up to approximately four MGD of flow. The system that was validated and approved by the DHS was equipped with UV lamps at a 3.5-inch center-to-center spacing. This lamp spacing was adequate for water with relatively low UVT (e.g., 55% - 65%). The UVT of the WNWRP filtered effluent was higher (discussed later). To avoid overdosing and to reduce headloss across the UV reactors, the Sanitation Districts decided that a UV system with a lamp spacing larger than 3.5-inch should be used for disinfection at WNWRP. This change in system configuration necessitated a separate validation before a full-scale system could be designed and approved by the DHS. Following discussion with Trojan, it was decided that the pilot plant would be reconfigured such that the UV lamps were at 4-inch intervals. The validation testing of this new set-up was conducted by Trojan and a third-party consultant hired by Trojan. Results from the validation were summarized by Trojan and its consultant, and were submitted to the DHS for review and approval. That work is beyond the scope of this paper, and is therefore not discussed herein.

MATERIALS AND METHODS

Analytical Methods

UVT Determination and Adjustment. The UVT, at 254 nanometer (nm) wavelength, of the WNWRP tertiary filter effluent has been monitored since March 2004 using a Wedeco HIPPO continuous UVT monitor. During the pilot testing, the UVT of the influent to the UV reactors was measured using a portable Trojan P254C Photometer. The results were periodically checked by the plant operation laboratory using a Shimadzu mini-UV 1240 spectrophotometer (Shimadzu, Columbia, MD).

NDMA and Cyanide Analysis. The Sanitation Districts' San Jose Creek Water Quality Laboratory, a California State-certified laboratory, conducted the NDMA and cyanide analyses. Modified EPA Method 1625 - Isotope Dilution GC/MS with ammonia positive chemical ionization (PCI) mode and Standard Method 4500-CN-C were used for NDMA and cyanide analysis, respectively. Ammonia PCI was selected for NDMA analysis because of its excellent sensitivity and selectivity for NDMA. Sample handling, preservation, and quality assurance/ quality control (QA/QC) followed procedures specified by the methods.

The method detection limit developed by the San Jose Creek Water Quality Laboratory for cyanide was 1 microgram/L (μg/L), while the reporting limit for cyanide was 5 μg/L. Any cyanide level between the method detection limit and reporting limit was considered detected, but not quantifiable; and the level was considered an "estimated value." Both the detection limit and the reporting limit for NDMA were 2 ng/L.

Biological Assays. Total coliform bacteria were enumerated by the microbiology staff at the San Jose Creek Water Quality Laboratory using the Standard Total Coliform Membrane Filtration Procedure (9222B) described in the 20th edition of the Standard Methods. Appropriate QA/QC procedures were followed as specified in the Standard Methods.

MS-2 coliphages were enumerated using a Double Agar Layer (DAL) Assay as described in chapter 16 of the USEPA Manual of Methods for Virology (EPA 600/4-84/013, June 2001). MS-2 coliphage (ATCC #15597B1) stocks used in seeding were purchased from BioVir Laboratories (Benicia, CA) or from GAP EnviroMicrobial Services (London, Ontario, Canada). MS-2 coliphages were enumerated on the bacterial host Escherichia coli FAMP (ATCC #700891). Appropriate QA/QC procedures were followed as specified in the EPA Manual of Methods for Virology and in the NWRI Guidelines.

Collimated Beam Testing

Collimated Beam Apparatus. A collimated beam apparatus manufactured by Wedeco was used for the laboratory study. The unit includes a sample tray that can be adjusted to obtain different UV intensities, an electrical fixture with mirror-reflectors that incorporates four parallel LPHO UV lamps, and a 20-centimeter (cm) diameter collimating tube. A timer controls a pneumatically operated shutter for UV exposure time down to one tenth of a second. The UV lamps produce primarily monochromatic output at 254 nm.

Determination of Collimated Beam UV Dose. For the testing, the UV intensity at air-water interface at the center of Petri dish was measured using a radiometer at 254 nm and recorded before and after each sample exposure. Disposable 15-cm diameter Petri dishes were used to provide individual sample volumes of 250 milliliters (mL) with water depths of about 1.3 cm. A small stirrer bar with a constant rotation speed was used to provide continuous and complete mixing without creating vortices. Magnetic stirrers of same size and same rotation speed setting were used throughout the testing.

The UV dose for the collimated beam, D, in mJ/cm^2, was calculated based on a refined method:[6]

$$D = 97.5\% \times I_o \times PF \times t \times (1\text{-}10^{-kd}) \div (kd) \qquad [1]$$

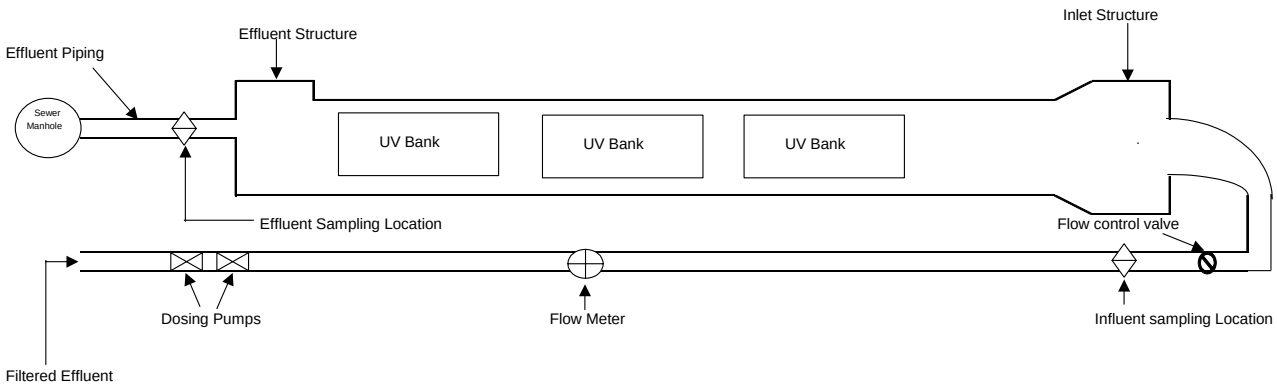
Petri factor (PF) is determined by measuring the UV intensity distribution on a grid of ½ centimeter spacing within the collimated beam field. The average radiation intensity over the entire air-water interface is the radiation intensity measured at the center (I_o, in W/cm^2) times PF and discounted by 2.5% for radiation reflection from the air-water interface. The other parameters are the exposure time (t, in seconds), absorbance at 254 nm (k, in absorbance unit/cm), and the depth of sample (d, in cm). Absorbance (in a.u./cm) is related to UVT by the following relationship:

$$UVT\ (\%) = [10^{-(a.u./cm)}] \times (100) \qquad [2]$$

UV Pilot-Scale System

UV Pilot-Scale Equipment. The Trojan UV-3000Plus pilot plant was an open channel system equipped with three banks of LPHO UV lamps. Figure 1 is a schematic diagram of the pilot plant used for the testing. The pilot plant consisted of one stainless steel open channel reactor that housed three UV banks in series. The pilot plant included inlet and outlet hydraulic transition structures and an 8-foot straight section before the first UV bank. A 10-inch diameter pipe carried the unchlorinated filtered effluent to the pilot plant. The flow rate to the pilot plant was measured by a magnetic flow meter. Two chemical feed pumps were located approximately 50 feet upstream of the influent sampling port. These pumps were used for UVT adjustment and MS-2 seeding, respectively. Effluent from the pilot plant was discharged to a sewer manhole and conveyed to the JWPCP for treatment.

Figure 1 - UV Pilot Plant Schematic Diagram (Not to Scale)



Sample Collection. Preliminary tests were conducted to determine the appropriate locations for sample collection. Sampling ports were located outside of the UV reactor channel. The influent sampling port was a 1-inch tap located just upstream of the inlet flow control valve. The effluent sampling ports were located on the discharge lines as indicated in Figure 1. The effluent samples for coliform analysis were collected directly at the effluent structure to minimize the impact from potential biofilm growth in effluent piping and sampling ports. Multiple samples at the inlet and outlet sampling ports were collected and analyzed to characterize data variability. Velocities at various points in the pilot plant were measured, according to the NWRI Guidelines, to determine the uniformity of the velocity profiles. To ensure adequate mixing of seeded MS-2 coliphage

and instant coffee (for UVT adjustment), samples were collected, before the pilot testing, at the inlet to the pilot plant at different time intervals following coffee injection and measured for UVT. A relatively constant UVT was observed indicating that mixing of coffee or seeded MS-2 was adequate.

Only grab samples were collected during the UV pilot study. On the day of pilot testing, the flow rate and the water level above the UV lamps were first stabilized. Sufficient time was allowed for lamp warm-up according to equipment manufacturer's specifications. Afterwards, MS-2 (and instant coffee in selected runs) solution was injected to obtain the targeted testing conditions. The solution was prepared using unchlorinated filtered effluent and virus stock solution with an initial MS-2 titer concentrations in the 10^{11} to 10^{12} plaque-forming units (pfu) per milliliter range. UV influent and effluent samples were collected simultaneously from the sampling ports after a minimum of four hydraulic residence times had passed. For quality assurance purposes, a number of duplicate samples were collected and analyzed.

Determination of Delivered UV Doses. For each run, the pilot plant influent was also collected and tested by the collimated beam apparatus to develop the dose-response curve for MS-2 inactivation. The delivered UV dose by the pilot plant was determined by matching the log inactivation of MS-2 from the pilot testing to the removal from the laboratory collimated beam testing.

RESULTS AND DISCUSSION

UVT of Filtered Effluent

The median UVT value for the WNWRP tertiary effluent was approximately 75%, at 254 nm, under normal operating conditions.

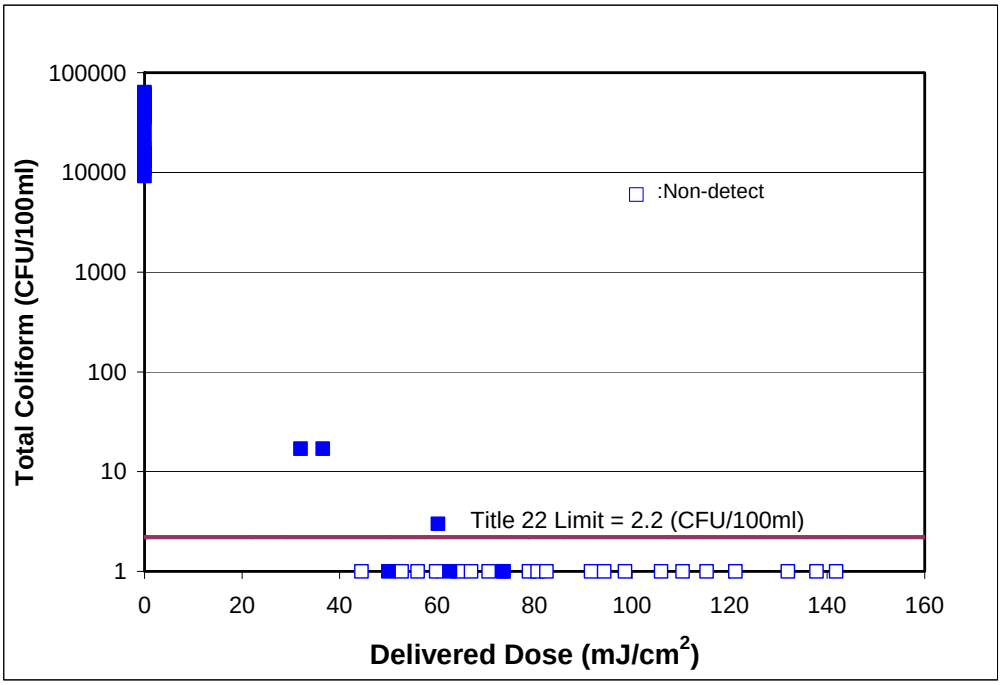
Inactivation of MS-2 and Coliforms

Collimated Beam Testing on MS-2. For each pilot-test run, laboratory collimated beam testing was conducted to establish the UV dose and MS-2 inactivation relationship. Only pfu counts within the range of 20 to 200 per plate were used for the development of the dose response curves. The developed curves (over 80% of the points) usually fell within the QA/QC control boundaries specified in the NWRI Guidelines.

Pilot Plant Testing on MS-2. The pilot testing was conducted for a range of operating conditions. Flow rates were varied from 1,000 to 2,500 gallons per minute (gpm). The highest UVT value observed during the pilot testing was 79%. The lowest UVT value tested was 63%. As mentioned earlier, instant coffee was added in some of the tests to simulate low UVT operations. The pilot plant was tested for both single bank and multiple banks operations. Power setting on the UV lamps was varied from 60 to 100%. These different testing conditions resulted in a range of delivered UV doses; the highest dose was approximately 140 mJ/cm^2.

Pilot Plant Testing on Coliform. MS-2 coliphage is widely used as the surrogate microorganism in UV pilot-plant testing; the delivered doses and design equations are typically based on the inactivation of MS-2. Total coliform inactivation by UV pilot systems was seldom reported in previous validation studies. As mentioned earlier, the compliance limit for the WNWRP effluent is based on the 7-day median total coliform concentration. The ultimate objective of the full-scale UV system is to deliver pathogen-free effluent, as indicated by meeting the the total coliform limit of <2.2 MPN/100mL. In this study, inactivation of total coliform was studied and was compared to that of MS-2 inactivation. Figure 2 shows the effluent total coliform concentrations versus delivered UV dose. The results indicate that a UV system designed to deliver a MS-2 bioassay dose of 100 mJ/cm^2 was effective for total coliform inactivation.

Figure 2 – Residual Total Coliform Concentration vs. Delivered UV Dose



Effect of UV Disinfection on NDMA

NDMA Concentrations in Secondary Effluent and Filtered Secondary Effluent. The Sanitation Districts initiated an intensive sample collection and analysis program in October 2003 to characterize NDMA concentrations in WNWRP secondary effluent and unchlorinated filtered effluent. The first part of the program was to determine whether filtration affects NDMA removal. Synchronized grab samples of secondary effluent and unchlorinated filtered effluent were collected and analyzed for NDMA. At the WNWRP, chlorination usually takes place prior to filtration (pre-chlorination). In order to collect unchlorinated filtered effluent samples, chlorination had to be changed to a location after filtration (post-chlorination). The second part of the program was to evaluate the effect of chloramination on NDMA concentrations. In this program, secondary effluent and chlorinated filtered effluent samples were collected and

analyzed for NDMA. The results were then compared to determine the effect of chloramination on NDMA formation.

Results obtained from this NDMA sampling and analysis program are summarized in Table 1. As shown, 44 sets of synchronized secondary effluent and unchlorinated filtered secondary effluent samples were collected. The NDMA concentrations in the secondary effluent ranged from 2.4 to 400 ng/L, with a median value of 31 ng/L. The NDMA concentrations of the unchlorinated filtered secondary effluent ranged from 5.2 to 360 ng/L, with a median value of 30 ng/L. The ranges and the median values of NDMA concentrations in the secondary and unchlorinated filtered effluents are not statistically different indicating that tertiary media filtration has an insignificant impact on NDMA concentrations.

A total of 19 sets of synchronized secondary effluent and chlorinated filtered effluent samples were collected and analyzed for NDMA. The range and the median value (33 ng/L) of NDMA concentrations in secondary effluent during this sampling period were similar to those from the first sampling period. The NDMA concentrations of the chlorinated samples ranged from 88 to 1,080 ng/L, with a median value of 490 ng/L. These results indicate that NDMA concentrations increase significantly due to chloramination, and the data support the decision of evaluating disinfection alternatives such as UV irradiation.

Table 1 - NDMA Concentrations (ng/L) in Secondary Effluent, Chlorinated and Unchlorinated Filtered Effluent Samples

	10/21/03 - 1/12/04		12/18/03 - 3/11/04	
	Secondary Effluent	Unchlorinated Filtered Effluent	Secondary Effluent	Chlorinated Filtered Effluent
Minimum	24	52	24	88
Maximum	400	360	520	1080
Median	31	30	22	490
No. of Sample Sets	44		19	

Collimated Beam Testing on NDMA. The purpose of the laboratory collimated beam testing is to determine the general trend of UV irradiation on NDMA in a controlled environment. Both chlorinated and unchlorinated filtered secondary effluent samples were collected from the WNWRP and irradiated with UV doses up to 500 mJ/cm^2 to determine the dose-response curve for NDMA destruction. Figure 3 presents the log reduction of NDMA versus UV dose. A linear correlation existed between the log NDMA removal and UV dose for the range of doses tested. At a typical UV disinfection dose of 100 mJ/cm^2, the log-reduction of NDMA was approximately 0.15, or approximately 30% removal.

UV Pilot Plant Testing on NDMA. Figure 4 shows the relationship between NDMA removal and delivered UV dose determined from MS-2 coliphage bioassay. For delivered UV disinfection doses up to approximately 140 mJ/cm^2, the log-reduction of NDMA and UV dose were linearly related. At 100 mJ/cm^2, the log reduction of NDMA was 0.22 and corresponded to approximately 40% removal. This observed log reduction of NDMA was in agreement with

reductions reported in previous studies; namely, that one log NDMA reduction required a UV dose of approximately 500 mJ/cm^2.[7]

The log reduction of NDMA by the UV pilot system appears to be higher than that of the collimated beam study as indicated by the greater slope in Figure 4 than in Figure 3. One plausible explanation is that the UV dose shown in Figure 4 represents the delivered UV dose derived from bioassay results. This dose is not exactly the same as the dose for laboratory collimated beam testing, as calculated using Eq. [1]. In addition, sunlight photolysis of NDMA might have played a role for NDMA reduction in the pilot-study.

Effect of UV Disinfection on Cyanide

Background Cyanide Concentrations. Historically, cyanide was sporadically detected in WNWRP's final effluent. Secondary effluent and filtered secondary effluent usually do not have detectable levels of cyanide (reporting limit is 5 μg/L)

Figure 3 – Collimated Beam Testing Results for NDMA Destruction

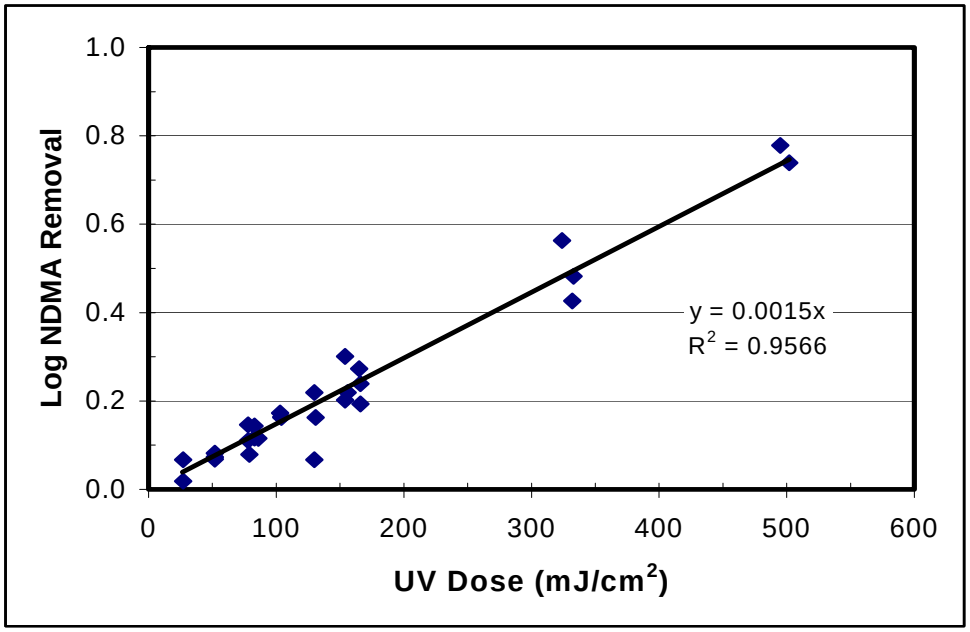
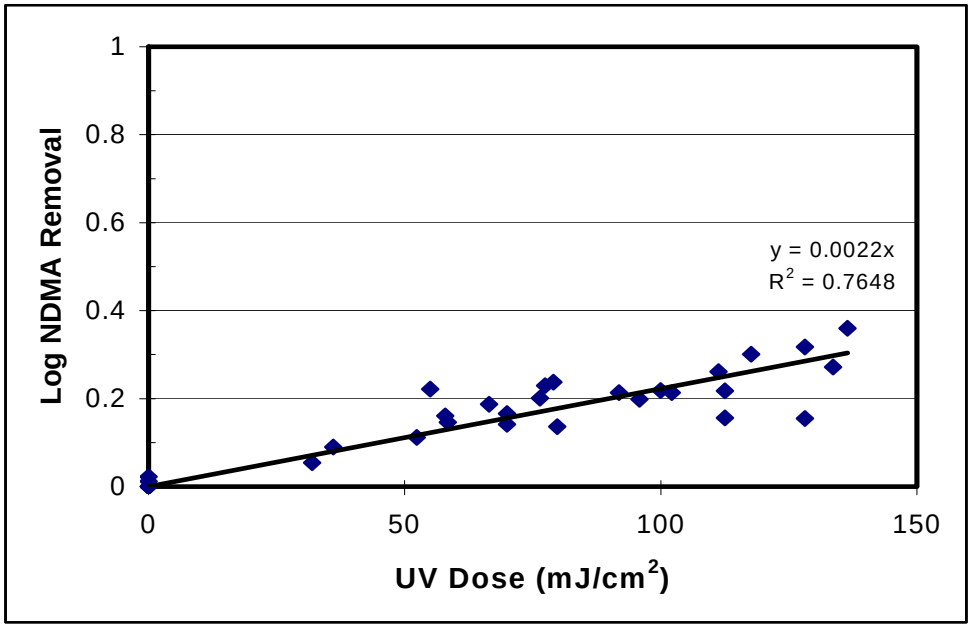
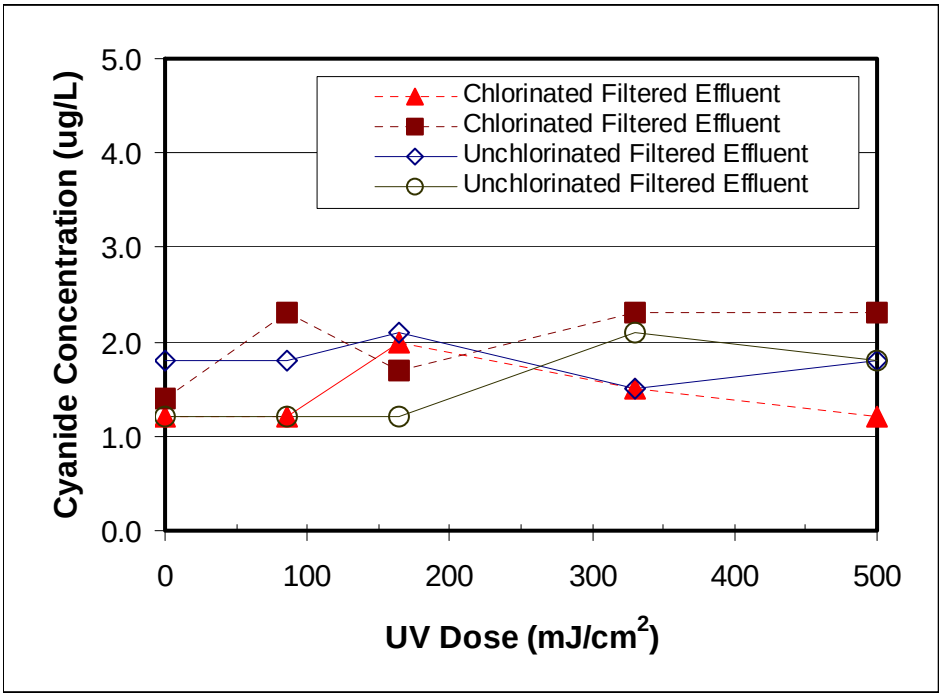


Figure 4 – Pilot Study Results for Incidental NDMA Destruction



Collimated Beam Testing on Cyanides. The collimated beam testing was to evaluate the impact of UV irradiation on cyanide in a controlled environment. Filtered secondary effluent samples were collected from the WNWRP and were irradiated by UV collimated beam apparatus. The results are presented in Figure 5. As mentioned earlier, any cyanide level between the method detection limit (1 µg/L) and reporting limit (5 µg/L) was considered as an "estimated value." UV doses up to 500 mJ/cm^2 were applied to the samples. All cyanide concentrations in the samples before and after UV irradiation were estimated values. These results indicate that UV irradiation at doses up to 500 mJ/cm^2, or five times the typical disinfection dose, do not result in cyanide formation in the WNWRP effluent.

Figure 5 – Collimated Beams Results for Cyanide Formation/Destruction



To evaluate the effect of UV irradiation on higher cyanide concentrations, 100 μg/L of cyanide was spiked into the filtered effluent samples. As shown in Figure 6, a slight decrease in spiked cyanide concentrations was detected for UV doses up to 170 mJ/cm^2. However, it should be noted that the recovery of spiked concentrations was only about 70% and other mechanisms such as volatilization during UV irradiation may have accounted for the apparent decrease in the cyanide concentrations.

UV Pilot-testing on Cyanides. Influent and effluent samples from the UV pilot plant were collected and analyzed for cyanide concentrations. These results would be more representative of full-scale operations than those from the collimated beam testing. Figure 7 compares the cyanide concentrations in the pilot plant influent (unchlorinated filter effluent) and effluent for UV doses ranging from 52 to 136 mJ/cm^2. The data show that UV irradiation had insignificant, if any, impacts on cyanide concentrations. It should be noted that all the cyanide concentrations before and after UV irradiation were estimated values.

Figure 6 – Collimated Beams Results for Cyanide Formation/Destruction (100 μg/L CN^- Spiked into Filtered Secondary Effluent Samples)

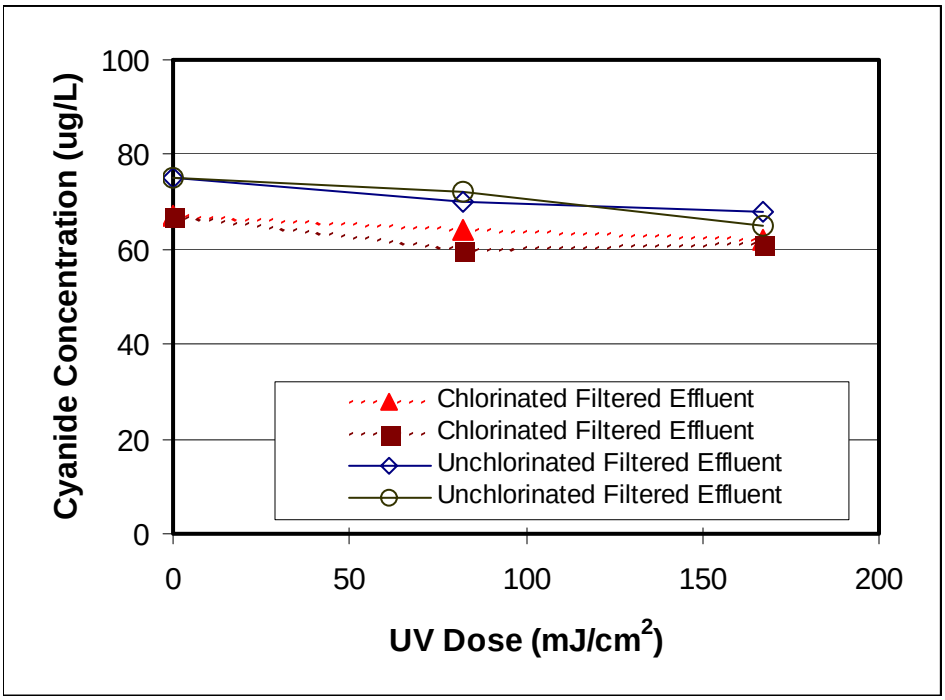
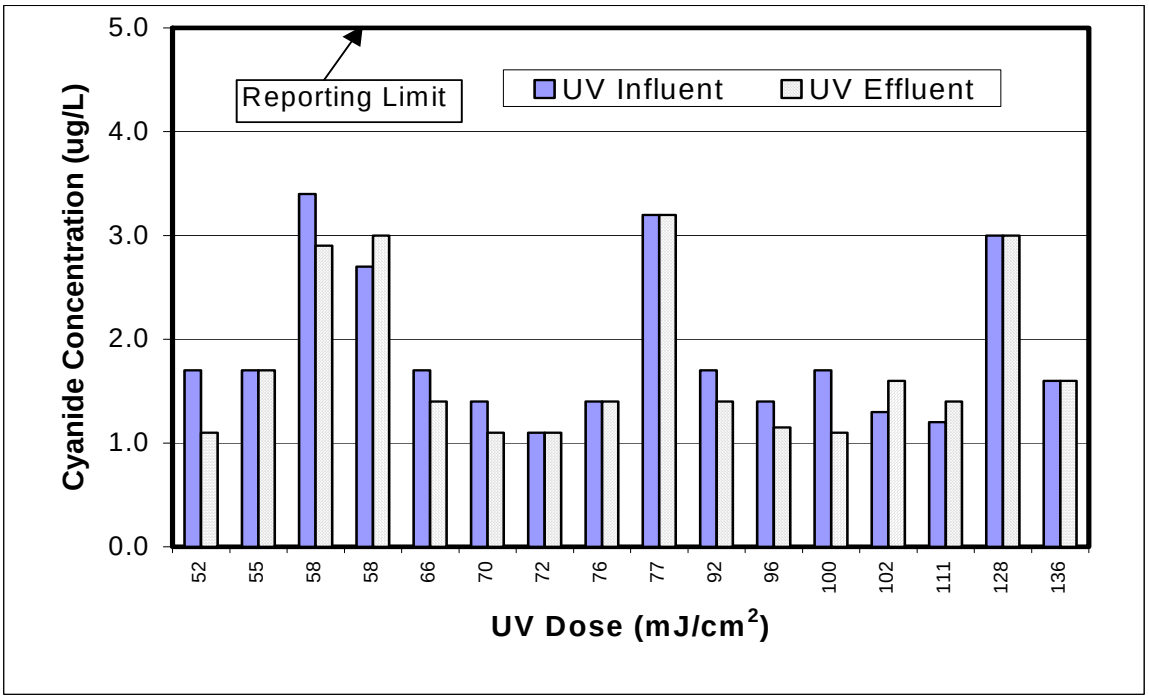


Figure 7 – Pilot-Plant Testing Results for Cyanide Formation/Destruction



Technical Issues Relevant to UV System Testing and Design

The current version of the NWRI Guidelines is a collection of knowledge and experience from many leading experts in the field of UV disinfection. Throughout this project, the Sanitation Districts followed the procedures outlined in the NWRI Guidelines. The Sanitation Districts also observed the procedures used by Trojan and its consultant for UV equipment validation, which also closely followed the NWRI Guidelines. During this process, the Sanitation Districts identified several technical issues relevant to UV testing and system design and operation that have not been fully addressed by the NWRI Guidelines. Some of the issues are briefly discussed below.

Collimated Beam Testing. The NWRI Guidelines require determination of delivered UV dose using collimated beam testing. Although the protocol of collimated beam testing is specified in the NWRI Guidelines, the testing procedures have not been standardized. Several issues related to collimated beam testing have been raised in the literature.[6,8,9] Without a standardized protocol, the delivered UV dose determined based on different procedures may be different. For example, the water depth in the Petri dish affects the calculated dose. If two samples of equal volume are subjected to the same UV irradiation (i.e., same UV intensity and exposure time) under fully mixed condition, the log inactivation should essentially be the same because both samples would receive the same amount of UV energy input. However, the calculated doses, using Eq. [1], would be different because of the difference in water depths as a result of different combinations of air-water interface area and water depth for the same total water volume.

Single-Bank vs. Multiple-Bank Testing. The majority of the data generated from UV equipment validation testing were obtained by running one bank (reactor) of UV lamps. However, in reality, full-scale UV disinfection systems usually consist of multiple UV banks in series. One main reason for using a single bank in validation testing is to minimize the costs associated with the seeded surrogate microorganism. If testing was conducted with multiple UV banks, the required influent surrogate microorganism concentrations need to be several orders of magnitude higher than those in single-bank testing. To design full-scale UV disinfection system with multiple banks based on data developed from single-bank testing, one has to assume that the delivered UV dose is additive across the banks.

In this study, the Sanitation Districts tested the pilot plant in both single-bank and multiple-bank configurations. Table 2 summarizes these testing results which show that the assumption of dose being additive is not always satisfied. This is probably partly due to the fact that the delivered dose is derived based on the dose response curve from the collimated beam testing and the log activation results from the pilot testing. The slope and intercept of the dose response curve have a significant impact on the values of the delivered dose. In addition, the log inactivation across the banks is not additive, as shown in Table 2. As the number of viable targets decreases from bank to bank, the probability of inactivating the remaining viable targets is reduced.

Table 2 - Dose and Log Inactivation Results from Single- and Multiple-Bank Testing

Test No.	Flow (gpm)	No. of Banks	Dose (mJ/cm^2)	Log Inactivation	Dose per Bank (mJ/cm^2)	Log Inactivation Per Bank
1-A	1000	3	164	6.63	55	2.21
1-B	1000	1	57	2.78	57	2.78
2-A	1000	3	147	6.05	49	2.02
2-B	1000	1	44	2.34	44	2.34
3-A	1000	3	>180	>7.53	>60	>2.51
3-B	1000	2	135	5.60	68	2.80
3-C	1000	1	96	4.19	96	4.19
4-A	1000	3	>173	>7.25	>58	>2.42
4-B	1000	1	77	3.53	77	3.53
5-A	1500	3	96	4.04	32	1.35
5-B	1500	2	67	3.04	33	1.52
5-C	1500	1	28	1.72	28	1.72
6-A	1500	2	84	3.77	42	1.88
6-B	1500	1	80	3.57	80	3.57
7-A	2000	3	45	2.28	15	0.76
7-B	2000	1	5	0.71	5	0.71
8-A	2000	3	66	3.12	22	1.04
8-B	2000	1	17	1.18	17	1.18
9-A	2000	3	76	3.51	25	1.17
9-B	2000	1	20	1.29	20	1.29
10-A	2000	3	85	3.81	28	1.27
10-B	2000	1	13	1.27	13	1.27
11-A	2000	3	123	5.32	41	1.77
11-B	2000	3	118	4.99	39	1.66
11-C	2000	2	85	3.91	42	1.95
11-D	2000	1	38	2.18	38	2.18
11-E	2000	1	28	1.80	28	1.80
12-A	2000	3	141	5.79	47	1.93
12-B	2000	1	36	2.06	36	2.06
13-A	2500	3	118	4.98	39	1.66
13-B	2500	1	31	1.83	31	1.83
14-A	2500	3	126	5.25	42	1.75
14-B	2500	1	46	2.40	46	2.40
15-A	2500	3	114	4.82	38	1.61
15-B	2500	2	86	3.86	43	1.93
15-C	2500	1	28	1.73	28	1.73
16-A	2500	3	122	5.12	41	1.71
16-B	2500	2	104	4.50	52	2.25
16-C	2500	1	38	2.09	38	2.09

Incorporation of UV Lamp Fouling and Aging Factors in Design and Operations. The NWRI Guidelines specify that the UV lamp manufacturers supply all necessary facilities to allow validation testing at reduced UV output to simulate aged and fouled lamp conditions. Different approaches have been used to achieve a conservative design of the full-scale UV system that accounts for lamp aging and fouling. These approaches include: (1) using old UV lamps during validation testing; (2) controlling power input to the UV lamps to simulate lamp aging and fouling; and (3) applying DHS approved aging and fouling factors by assuming that UV dose is directly proportional to fouling and aging. Each approach has its merits and drawbacks. However, the biggest issue is the lack of standard procedures to compare design obtained using these different approaches.

Use of Regression Model for Full-scale UV System Operation. The most commonly used approach for UV system operation is to use the regression model developed from validation testing. The model typically takes the following form:

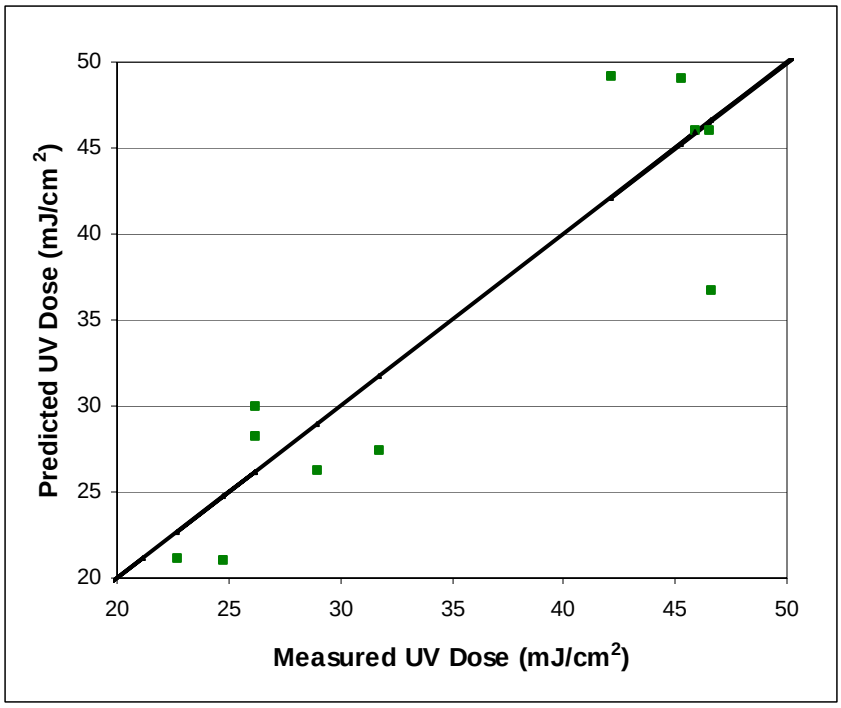
$$\text{Dose} = a \times (\text{Flow per Lamp})^b \times (\text{UVT})^c \times (\text{Power Setting})^d \qquad [3]$$

Where a, b, c, and d are constants developed from regression analysis. Depending on the UVT of the water and flow rate into the UV reactor train, the power setting may be adjusted such that a UV dose of 100 mJ/cm^2 is delivered for disinfection. Typically, the developed regression equation has a very high correlation coefficient (i.e., very close to 1) indicating excellent fit of the data. However, as is the nature of regression analysis, the calculated UV dose may over- or under-estimate the actual delivered dose for a specific set of operating conditions. This is illustrated by the following example. Figure 8 shows the measured UV doses versus doses calculated using a regression model determined from pilot testing. The regression model has a R-square value over 0.96. However, in the dose range of 20 to 50 mJ/cm^2 per bank, which the UV system is most likely be operated, the calculated dose either over- or under-estimates the actually measured delivered dose. This brings up the question of whether the system should be operated using such an approach. While the power can be turned down during low flow, high UVT, or new lamps to save energy cost, there is a potential risk of under-dosing the water to be disinfected. The cost savings may not be justified for higher potential of noncompliance with the DHS requirement and/or greater risks to public health.

Alternative Testing and Design Approach. The NWRI Guidelines specify UV design requirements based on dose that has to be determined from bioassay and collimated beam testing. Given the issues of collimated beam testing and dose determination discussed above, it appears that a more straightforward approach may be warranted. A proposed approach is to use log inactivation determined from pilot testing, instead of dose, for evaluation of UV system performance and for design of full-scale UV disinfection system. For such an approach, collimated beam testing would not be necessary. The pilot testing would be conducted under various combinations of UVT, power setting, flow rate, and number of operating UV banks. The pilot plant testing results would be directly used to design a full-scale UV system capable of delivering a specified log inactivation criterion. This is consistent with the regulatory requirements as California Code of Regulations (Title 22, Water Recycling Criteria) specifies a required log inactivation rate for virus, instead of a UV dose, for reclaimed water to be classified as disinfected tertiary effluent for unrestricted reuse. This approach should be considered and it

would minimize the potential errors associated with the current approach for dose determination in validation testing and in design of a full-scale system.

Figure 8 – Comparison of Measured vs. Predicted UV Doses



CONCLUSIONS

The findings from this study include the following:

- The median NDMA concentrations in the secondary effluent and unchlorinated filtered effluent at the WNWRP are both approximately 30 ng/L. These results show that inert media filtration has an insignificant effect on NDMA. Chloramination increases the median NDMA concentration from approximately 30 ng/L to approximately 500 ng/L.
- Collimated beam testing results show that log reduction of NDMA is linearly related to UV dose with a slope of 0.0015. At a UV dose of 100 mJ/cm^2, the log reduction of NDMA in the unchlorinated filtered effluent is expected to be 0.15, which is equivalent to approximately 30% removal.
- Pilot testing results show that log reduction of NDMA is linearly related to the UV disinfection dose with a slope of 0.0022. At a UV disinfection dose of 100 mJ/cm^2, the log reduction of NDMA in the unchlorinated filtered effluent is expected to be 0.22, which is equivalent to approximately 40% removal.

- Cyanide is usually not detected in the WNWRP secondary or filtered effluent. Collimated beam testing results indicate that UV irradiation of unchlorinated filtered effluent does not result in cyanide formation for doses up to 500 mJ/cm^2, or approximately five times the dose required for adequate disinfection of tertiary effluent.
- Pilot testing results confirm that UV irradiation does not result in cyanide generation for delivered UV doses up to approximately 140 mJ/cm^2.
- The Trojan UV-3000Plus pilot plant, validated according to the NWRI Guidelines, is effective for total coliform inactivation. At a delivered UV dose of 100 mJ/cm^2 derived from MS-2 testing, the total coliform concentration in the UV disinfected effluent meets the California Title 22 Water Recycling Criteria requirements for unrestricted reuse.
- In following the NWRI Guidelines for pilot testing, the Sanitation Districts observed several technical issues that have not been fully addressed by the existing guidelines. These issues include: collimated beam testing protocol is not standardized; the assumption of dose being additive may not be valid; there is no standard procedure to account for the lamp aging and fouling factors for UV system design; and the use of regression equation for full scale UV systems operations may result in occasional under-dosing. Additional research is suggested in these areas to advance the state of the art in UV system testing, design, and operation.

ACKNOWLEDGEMENTS

Special thanks go to Fred Yunt and Mark Pettit for their technical input and discussion during the course of this project; to Dwayne Fischer and Maria Pang for supporting the laboratory analyses conducted in this study; and to Michael Creel and Paul Prestia for setting up the UV pilot plant at the WNWRP.

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Fate of NDMA in Tertiary Water Reclamation Plants

Shiaw-Jy Huitric, Jeff Kuo, Chi-Chung Tang, Michael Creel, Robert Horvath, James Stahl
Sanitation Districts of Los Angeles County

ABSTRACT

N-nitrosodimethylamine (NDMA) is an emerging contaminant that can be formed from wastewater disinfection using chlorine. The California Department Health Services has set a notification level of 10 ng/L for NDMA due to its carcinogenic potency and mobility in groundwater. This paper summarizes the efforts of the Sanitation Districts of Los Angeles County (Sanitation Districts) on the evaluation of the occurrence and fate of NDMA at Sanitation Districts' water reclamation plants. These plants typically include primary sedimentation, activated sludge process with biological nitrogen removal, secondary sedimentation, media filtration, disinfection using chloramines, and dechlorination before discharge.

Bench-, pilot-, and full-scale studies were conducted at two water reclamation plants operated by the Sanitation Districts to evaluate NDMA formation and destruction. Results from these studies indicated: (1) influent NDMA concentrations fluctuate over a wide range; (2) the biological treatment process is capable of removing some influent NDMA; (3) use of chlorinated effluent to prepare cationic polymer solution for application in settling enhancement and foam control results in formation of high levels of NDMA; (4) chloramination increases NDMA concentrations significantly, but chlorination using free chlorine does not; and (5) ultraviolet (UV) disinfection of media filtered secondary effluent can result in 30 to 40% of incidental NDMA destruction.

KEYWORDS

NDMA, chloramination, breakpoint chlorination, UV disinfection

INTRODUCTION

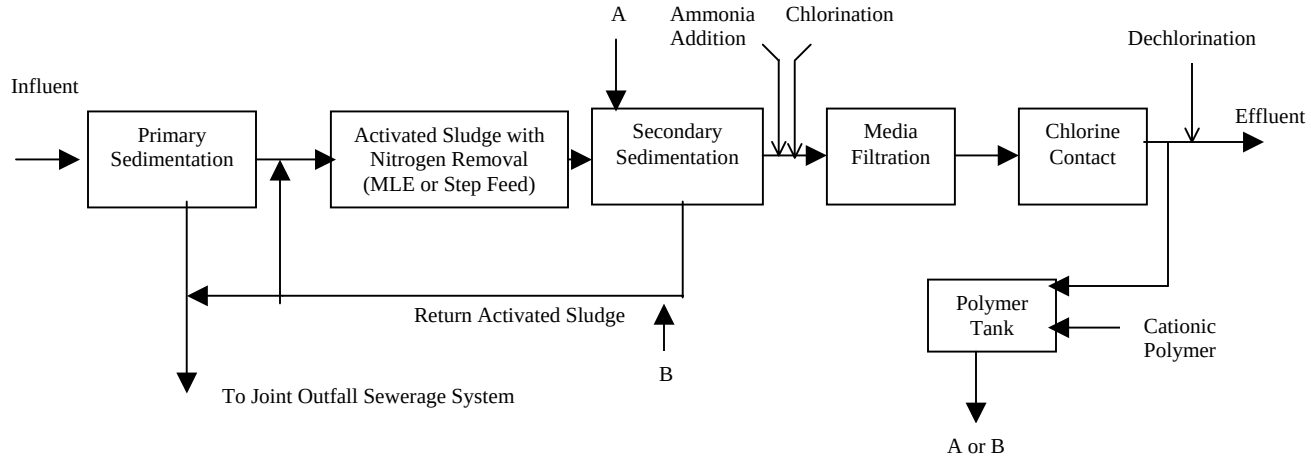
The Sanitation Districts of Los Angeles County (Sanitation Districts) are a confederation of independent special districts that provide regional wastewater treatment and municipal solid waste management services to more than five million residents in Los Angeles County. The Sanitation Districts' sewerage system includes 1,400 miles of main trunk sewers and 11 wastewater treatment plants with a total design capacity of 510 million gallons per day (MGD). Among the 11 wastewater treatment plants, seven are tertiary water reclamation plants designed to produce up to 210 MGD of effluent that is available for reuse.

Typical tertiary water reclamation plants operated by the Sanitation Districts include the following unit processes: primary sedimentation, activated sludge process with biological nitrogen removal, secondary sedimentation, media filtration, disinfection with chloramines, and dechlorination before discharge. Primary sludge and waste activated sludge produced from five

of the water reclamation plants are transported to a downstream ocean discharge plant for centralized treatment and disposal. Figure 1 is the typical process schematic diagram of the tertiary water reclamation plants operated by the Sanitation Districts. Biological nitrogen removal at these plants is accomplished using either the step feed process or the Modified Ludzack-Ettinger (MLE) process. Chloramination is employed for effluent disinfection at all water reclamation plants to minimize the formation of trihalomethanes (THMs) (Kuo et. al., 2003). THMs are carcinogenic disinfection byproducts; the USEPA and California Department of Health Services have set a drinking water standard for total THMs of 80 micrograms per liter (µg/L). Because ammonia is fully nitrified at all the tertiary water reclamation plants, it has to be added back to the secondary effluent to produce chloramines. Typical ammonia dose is between 0.5 and 1.5 milligrams per liter (mg N/L).

A cationic polymer (Clarifloc marketed by Polydyne, Inc.) is usually added to the secondary process to control potential foaming and to enhance mixed liquor settling. The cationic polymer is a Mannich type polymer and has a polyacrylamide/methyl amine formulation. The polymer is delivered as a liquid flocculent and is diluted with chlorinated final effluent (not dechlorinated) before use. The polymer solution is either added to the secondary clarifier influent channel or to the return activated sludge, as indicated in Figure 1, at doses up to 2 mg/L.

Figure 1 – Process Schematic Diagram of Typical Tertiary Water Reclamation Plants Operated by the Sanitation Districts



The compound n-nitrosodimethylamine (NDMA) is an emerging contaminant that received intense scrutiny in recent years due to its carcinogenic potency and discovery in water supplies. Although no drinking water standard has been established for NDMA, the California DHS has set a notification level of 10 nanograms per liter (ng/L) for this compound. The presence of NDMA in raw sewage has been attributed to both industrial and domestic origins (Sedlak et al., 2005). Recent studies have shown that NDMA is also a disinfection byproduct when chlorine is used. Monochloramine and dimethylamine (DMA) have been identified as the major precursors to NDMA formation in the disinfection process (Mitch and Sedlak, 2002; Choi and Valentine, 2002).

NDMA is highly soluble in water and has a low vapor pressure and a low octanol-water partition coefficient. Due to these chemical properties, it is generally believed that NDMA is not likely to adsorb to particulates or volatilize to any significant extent. Sedlak et al. (2005) reviewed influent and secondary effluent NDMA concentrations from seven activated sludge plants. They concluded that both the influent NDMA concentrations and the removal of NDMA during secondary biological treatment exhibit considerable variability. The median NDMA concentration in the secondary effluent of these plants was 46 ng/L. Overall NDMA removal from the secondary biological treatment process ranged from 0 to 75%. One explanation why the overall NDMA removal varied over such a wide range is that Sedlak et al. did not consider variations of process operations that might have affected NDMA concentrations in the secondary effluent. For example, if cationic polymer was added to the mixed liquor for foam control and to enhance secondary settling, and the polymer solution was prepared by chlorinated final effluent, residual chlorine in the final effluent could react with DMA in the cationic polymer to form NDMA. If the polymer solution was added to the influent to the secondary clarifiers, the NDMA concentration in the secondary effluent would increase. As a result, the observed NDMA removal by the activated sludge process, which was calculated by comparing primary effluent and secondary effluent NDMA concentrations, would then be underestimated.

OBJECTIVES

The overall objective of the study was to understand the fate of NDMA at the Sanitation Districts' typical tertiary water reclamation plants employing the processes depicted in Figure 1. Specifically, the Sanitation Districts' goals were:

- To characterize NDMA concentrations in raw sewage entering the water reclamation plants and in the primary effluent;
- To compare primary effluent and secondary effluent NDMA concentrations to determine the effect of biological treatment process on NDMA and the possible mechanisms responsible for NDMA removal;
- To quantify the potential effect of adding cationic polymer to the secondary treatment process on NDMA concentration in the secondary effluent;
- To determine the role of media filters on NDMA;
- To compare the use of chloramines and free chlorine on NDMA formation; and
- To assess the potential removal of NDMA resulting from ultraviolet (UV) disinfection.

METHODOLOGIES

The Sanitation Districts conducted plant sampling, bench scale testing, pilot plant operation, and full scale plant monitoring in several studies designed to address the above listed issues. The studies were conducted mainly at two of the tertiary water reclamation plants operated by the Sanitation Districts, but it is expected that the results apply to other plants with similar processes, operations, and influent water quality. The two plants where the studies were conducted are the Whittier Narrows Water Reclamation Plant (WNWRP) and the San Jose Creek West Water Reclamation Plant (SJCWWRP). The WNWRP treats an average flow of 8 MGD using the

MLE process for nitrogen removal, while the SJCWWRP treats an average flow of 30 MGD and uses the step feed process for nitrogen removal. Both plants use cationic polymer for foam control and to enhance settling of mixed liquor. Polymer is added to the return activated sludge at WNWRP, and to the mixed liquor effluent channel (or influent to secondary clarifiers) at SJCWWRP.

Sampling

To establish NDMA concentration profile at various points within the plants, several sampling programs were implemented at the WNWRP where influent wastewater, primary effluent, secondary effluent, filtered secondary effluent (chloraminated and non-chloriaminated), and chlorinaminated final effluent were sampled and analyzed for NDMA. The results from these sampling programs provided information about the influent NDMA characteristics and the effect of each unit process on the fate of NDMA. In addition, polymer solutions prepared using chloraminated final effluent as well as breakpoint chlorinated final effluent were sampled at SJCWWRP to determine NDMA formation from the use of cationic polymer.

Bench Scale Study

Bench scale experiments were conducted to evaluate the effect of chloramines and free chlorine on NDMA formation. Bench scale experiments also included the use of a collimated beam apparatus to evaluate the effect of UV irradiation on NDMA destruction and to determine the delivered UV dose for MS-2 coliphage inactivation from pilot scale UV testing (described below). The collimated beam apparatus is manufactured by Wedeco Ideal Horizons. It is equipped with four low-pressure high-output UV lamps. An intensity sensor measured UV intensity at various distances between the light source and the sample tray. UV doses were calculated by the UV intensities and exposure times.

Pilot Scale Testing

Pilot scale study included the testing of a Trojan UV pilot plant to determine NDMA destruction as a function of delivered UV dose, as determined by MS-2 coliphage inactivation. The UV pilot plant included three banks of Trojan 3000Plus low pressure high output lamps. Testing of the pilot plant followed *Ultraviolet Disinfection guidelines for Drinking Water and Water Reuse* (National Water Research Institute and American Water Works Association, 2003). To assess the effect of UV irradiation on NDMA destruction, unchlorinated filtered secondary effluent was fed to the UV reactor. Influent and effluent samples from the UV reactor were collected for NDMA analysis. Flow rate, number of operating banks, UV transmittance, and lamp power setting were adjusted to obtain a range of delivered UV doses. Details about the pilot plant and pilot testing program have been described in Jalali et al. (2005).

Full Scale Study

A full scale study was conducted at the SJCWWRP to evaluate NDMA formation from chloramination and breakpoint chlorination in April and May 2005. During this four-week study, the plant switched to breakpoint chlorination each Monday morning, from its normal

disinfection practice of chloramination, and stayed in breakpoint chlorination until around noon on each Friday.

Sampling and Analysis

Grab samples were collected in glass amber jugs. Composite samples were first collected using automatic samplers. From the automatic samplers, the aliquots were decanted into glass amber jugs. Samples were stored on ice during transportation to the laboratory, and were dechlorinated upon arrival at the laboratory. Both WNWRP and SJCWWRP are located within 15 minutes of driving distance to the Sanitation Districts' San Jose Creek Water Quality Laboratory (SJCWQL) where all NDMA analyses were performed. Following dechlorination, samples were kept in a refrigerator until analysis.

Currently, there is no state or federal approved NDMA analytical method for concentrations at parts per trillion, or ng/L, levels. The Sanitation Districts have implemented routine monitoring program for NDMA for several years and have met performance based guidelines established by the California Department of Health Services. The SJCWQL analyzed NDMA using liquid-liquid extraction followed by chemical ionization isotope dilution gas chromatography/mass spectrometry. Typically, the NDMA reporting limit for samples after secondary treatment is 2 ng/L. Higher reporting limits, from 2 to 10 ng/L, were used for influent wastewater samples due to the complexity of the matrix.

RESULTS AND DISCUSSIONS

The fate of NDMA, process by process, is discussed below.

Influent

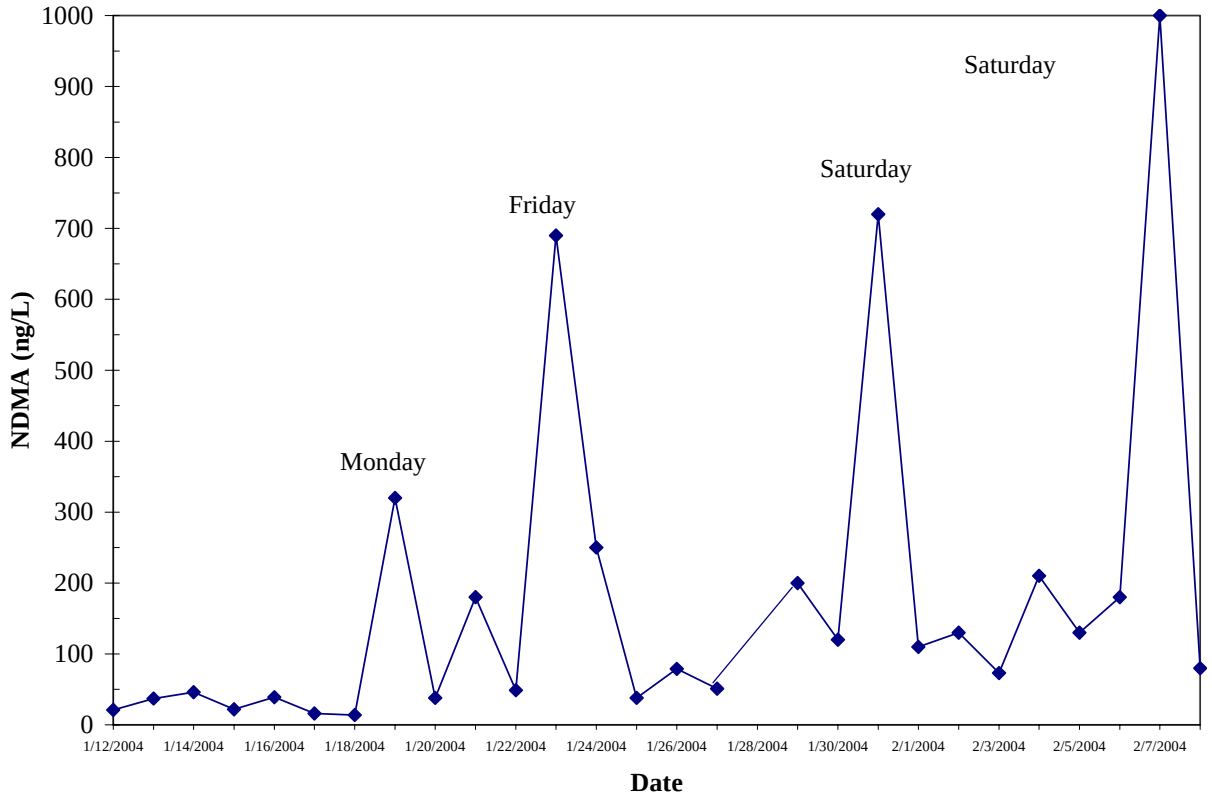
Raw sewage at the WNWRP was sampled during January and February 2004 for NDMA analysis. The samples were daily 24-hour composite. This sampling program was conducted over a 4-week period including weekends. Figure 2 shows that the NDMA concentrations in raw sewage varied over a wide range, from a low of approximately 10 ng/L to as high as 1,000 ng/L. The median value was 80 ng/L. The fluctuations in influent NDMA concentrations at this particular water reclamation plant suggest that industrial discharges may be the source of NDMA concentration spikes. It is also interesting to note that these concentration spikes typically occurred during or near weekends.

Primary Sedimentation

NDMA is soluble and has a low affinity to particles present in wastewater (Mitch and Sedlack, 2004). Therefore physical processes such as sedimentation are not expected to have a significant effect on NDMA removal. Synchronized sampling of raw sewage and primary effluent was conducted on two occasions, October 22, 2003 and January 14, 2004. The NDMA concentrations in the raw sewage and primary effluent samples collected on October 22, 2003 were 17 and 13 ng/L, respectively. For the samples collected on January 14, 2004, NDMA

concentrations in raw sewage and primary effluent were 46 and 49 ng/L, respectively. These results confirmed that primary sedimentation has negligible effect on NDMA concentrations.

Figure 2 – Concentrations of NDMA in Raw Sewage



Biological Treatment Process

From December 2003 to March 2004, the Sanitation Districts collected approximately 140 grab secondary effluent samples at the WNWRP to characterize NDMA concentration. Table 1 summarizes results collected from this sampling effort. Approximately 100 samples were collected during a two-month period when polymer was not added. The NDMA concentrations varied from approximately 4 to 400 ng/L, with a median of 26 ng/L. Some 40 samples were collected when polymer was added to the return activated sludge. The range of NDMA concentrations for these samples was from 5 to 759 ng/L, with a median of 32 ng/L. Note that when polymer addition was practiced, the median NDMA concentration in the secondary effluent was approximately 20% higher.

In April and May of 2005, grab samples of the secondary effluent were collected from the SJCWWRP and measured for NDMA. Of the 40 samples analyzed, NDMA concentrations ranged from 14 to 470 ng/L, with a median of 45 ng/L. At this plant, polymer is added to the mixed liquor effluent channel. It is estimated that the added polymer solution, prepared with chloraminated final effluent, may contribute between 50 to 75% of the NDMA concentration in

the secondary effluent based on testing of the polymer solution (see discussion under **Secondary Sedimentation**).

Table 1 - Effect of Polymer Addition, Filtration, and Chloramination on NDMA Concentrations (WNWRP)

	Secondary Effluent	Unchlorinated Filtered Secondary Effluent	Chloraminated Final Effluent
No Polymer Addition	26 (4 - 400)	22 (7 - 360)	370 (88 - 1080)
With Polymer Addition	32 (5 - 759)	43 (5 - 148)	655 (640 - 750)

Note: Data in each cell represent the median NDMA concentration followed by the range (all in ng/L).

By comparing the median NDMA concentration in the WNWRP influent (80 ng/L) and secondary effluent (26 ng/L, without polymer addition), it appears that the secondary treatment process on average removed approximately 70% of the NDMA in the influent wastewater. Among the various possible removal mechanisms for NDMA in the activated sludge process, biodegradation is considered to be the most important one. Since NDMA is hydrophilic, the extent of adsorption onto solids is often assumed to be relatively limited. In a separate study conducted by the Sanitation Districts, adsorption of NDMA to the mixed liquor was examined to determine its relative importance. The study was conducted using a pilot scale membrane bioreactor that was being tested at the WNWRP (Mansell et al., 2005). A series of grab samples were taken from the membrane tank in December of 2004. A portion of the collected samples was centrifuged (2800 × g for 25 minutes) to remove the mixed liquor suspended solids (MLSS). NDMA analyses were conducted on the mixed liquor samples and the centrate samples. The difference between the NDMA concentrations of the mixed liquor and centrate was used to calculate the amount of NDMA adsorbed onto the MLSS. Results of the analyses are summarized in Table 2. The last column in Table 2 shows the percent of total NDMA mass in the mixed liquor sample that was present in the adsorbed phase. In general, the absorbed NDMA fraction decreases with increasing centrate NDMA concentrations.

Table 2 - Results of NDMA Adsorption Analyses

	Mixed Liquor NDMA (ng/L)	Centrate NDMA (ng/L)	MLSS (mg/L)	Adsorbed NDMA (ng/g)	% Total NDMA Mass Adsorbed (%)
12/17/04	14	5	8504	1.06	64
12/10/04	54	29	8476	2.95	46
12/16/04	112	110	8924	0.22	2
12/13/04	500	440	8116	7.39	12
12/9/04	960	810	8244	18.20	16

A plot of adsorbed NDMA against the corresponding centrate NDMA concentrations results in a linear relationship ($R^2 = 0.93$). The slope of the line, 0.021 L/g, is the experimental partition

coefficient (K_p) value. The K_p value can be used to estimate the mass of NDMA removed from wasting of activated sludge using the following equation:

$$\text{NDMA Removal (mg/day)} = 10^{-3} K_p C X V / SRT$$

Where C = NDMA concentration in the mixed liquor, ng/L;
X = MLSS concentration, g/L;
V = volume of bioreactor, m^3; and
SRT = solids retention time, days.

The findings from this adsorption study and data analysis indicate that although partition of NDMA onto mixed liquor suspended solids can be significant, NDMA removal from sludge wasting accounts for an insignificant portion of the overall NDMA reduction in the biological treatment process (less than 0.1% of the NDMA mass in the influent).

Secondary Sedimentation

As discussed earlier, sedimentation process has negligible effect on NDMA. However, polymer added to the secondary clarifiers may affect NDMA concentration in the secondary effluent. Polymer is delivered as a liquid flocculent and is diluted using chlorinated final effluent before use. Because chlorinated final effluent generally contains several parts per million (mg/L) of combined chlorine residual (in the form of chloramines), and the cationic polymer contains the NDMA formation precursor dimethylamine, NDMA can be formed when chlorinated final effluent is used to prepare the polymer feed solution. Several samples representing the polymer feed solution were collected at the SJCWWRP and analyzed for NDMA. Levels of 50,000 and 67,000 ng/L were found in two samples prepared with chloraminated final effluent. The NDMA concentrations were lower, 15,200 and 17,500 ng/L, in two samples prepared with breakpoint chlorinated final effluent.

The effect of polymer on NDMA concentration in the secondary effluent depends on where polymer is added and the polymer dose. If polymer was added to the mixed liquor effluent channel, the effect is expected to be greater because the formed NDMA would only be diluted, but would not undergo significant biodegradation. On the other hand, if polymer was added to the return activated sludge, then the formed NDMA concentration would not only be diluted, but also be biodegraded in the biological process. For example, if the NDMA concentration in the polymer feed solution is 50,000 ng/L, and the polymer solution is added, at 10 gallons per minute, to 8 MGD of return activated sludge (representing a 100% recycle ratio), approximately 45 ng/L of NDMA would be expected to be added to the influent to the activated sludge process. This concentration would be further diluted by the internal mixed liquor recycle if the plant uses the MLE configuration for biological nitrogen removal. With an assumed internal recycle ratio of 300%, and an average 70% removal by the activated sludge process, the end result of polymer addition on NDMA concentration in the secondary effluent would be less than 4 ng/L. However, if the same polymer is added to the mixed liquor effluent channel, the polymer would add 45 ng/L to the secondary effluent NDMA concentration. From the standpoint of NDMA control, adding polymer to the return activated sludge is clearly the preferred approach to adding polymer to mixed liquor effluent channel. Research is currently underway to investigate alternative

polymers that do not contain NDMA formation precursor and the use of dechlorinated final effluent to prepare polymer feed solution.

Media Filtration

Media filtration, a physical separation process, is expected to have an insignificant effect on NDMA concentration. In order to collect unchlorinated filtered effluent samples, chlorination was changed to the filter effluent (post-chlorination) from the typical practice of filter influent (pre-chlorination). Results are summarized in Table 1. Median and ranges of NDMA concentrations of the unchlorinated filtered effluent and secondary effluent were not statistically different, with or without polymer addition.

Disinfection

Table 1 indicates that the NDMA concentrations significantly increased as a result of chlorinamination during the study period. To determine how NDMA formation may be affected by different chlorination schemes, the Sanitation Districts conducted both bench scale and full scale studies. In the bench scale study, fully nitrified secondary effluent samples from the WNWRP were collected. Polymer was not used at the plant during the time of this study. Chlorine, ammonia and chlorine, and preformed chloramines at various concentrations were added to the samples. This experiment was repeated five times. Results are summarized in Table 3.

The results showed that free chlorine, up to 20 mg/L, had negligible effect on NDMA concentration. The first experiment with chloramines (ammonia plus chlorine) showed an increase of NDMA concentration from 8.2 to 76 ng/L, consistent with field observations at the WNWRP (Table 1). However, this was not observed in the other four runs. The tests with preformed chloramines showed that generally NDMA concentrations increased with higher chloramines concentrations.

Table 3 – Effect of Chlorination on NDMA Formation – WNWRP Bench Study

	NDMA Concentration (ng/L) Test No.				
Testing Conditions	**1**	**2**	**3**	**4**	**5**
Secondary Effluent	8.2	16	190	20	30
Secondary Effluent + Chlorine					
5 mg/L Chlorine	-	-	160	15	19
10 mg/L Chlorine	8.5	20	-	-	-
20 mg/L Chlorine	11	16	-	-	-
Secondary Effluent + NH_3 + Chlorine					
2 mg/L NH_3 + 5 mg/L Chlorine	-	-	150	15	21
2 mg/L NH_3 + 10 mg/L Chlorine	76	18	-	-	-
Secondary Effluent + Preformed Chloramines					
5 mg/L Pre-formed Chloramines	-	-	260	56	36
10 mg/L Pre-formed Chloramines	8.6	95	380	120	77

The effect of breakpoint chlorination on NDMA was further studied in a full scale test conducted at the SJCWWRP in April and May 2005. Chloramination is practiced at this plant, and effluent NDMA concentrations are typically in the hundreds to thousands ng/L range. During the four-week study, ammonia addition to the secondary effluent was stopped in the morning hours each Monday. Free chlorine was used for disinfection until around noon on Friday when ammonia addition resumed. On each weekday, at least two secondary effluent samples and two chlorinated final effluent samples were collected and analyzed for NDMA. These results are depicted in Figure 3.

The results showed that during the weekdays when free chlorine was used for disinfection, the NDMA concentrations in the secondary effluent and chlorinated final effluent were approximately the same indicating little or no NDMA formation from breakpoint chlorination. The chlorinated final effluent samples collected early Monday or late Friday usually had very high NDMA concentrations because these samples represented effluent that had been chloraminated (depending on the sample collection time and the time ammonia addition was stopped or initiated).

Figure 3 – NDMA Concentrations – Breakpoint Chlorination vs. Chloramination at SJCWWRP

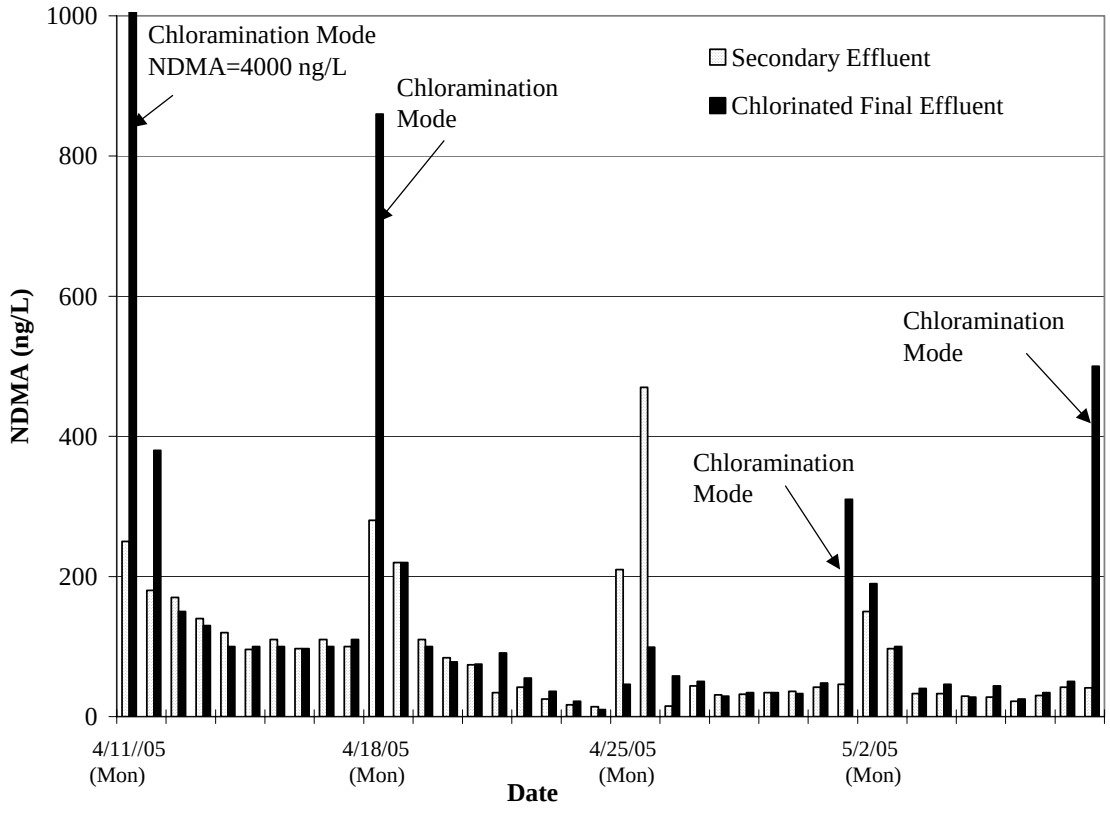
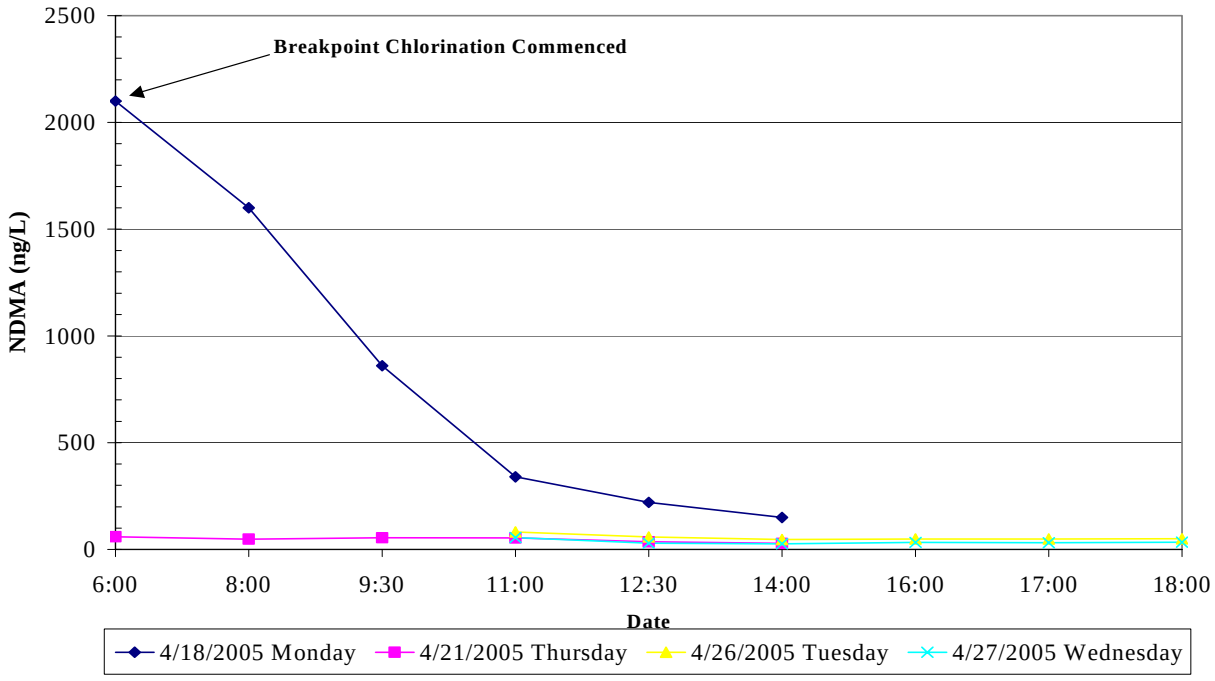


Figure 4 further illustrates the effect of chloramination and breakpoint chlorination on NDMA formation. On four different days during the full scale breakpoint chlorination testing, hourly

chlorinated final effluent samples were collected and analyzed. The NDMA concentrations of samples collected during the middle of the week, Tuesday to Thursday, were all similar to the levels of the secondary effluent (in the neighborhood of 30 ng/L on these three days) indicating no significant NDMA formation from breakpoint chlorination. On April 18, 2005, a Monday, a clear decreasing trend in NDMA concentrations was observed throughout the day. As mentioned earlier, the plant switched to breakpoint chlorination in the early morning hours each Monday. The final effluent samples collected before the change actually represented samples that had been chloraminated. As breakpoint chlorination took place, the NDMA concentration gradually decreased from >2,000 ng/L to less than 10% of the initial level.

Figure 4 – Chlorinated Final Effluent NDMA Concentration Profile - SJCWWRP



Effect of UV Disinfection on NDMA

Recognizing that the existing practice of chloramination results in NDMA formation, the Sanitation Districts are currently considering UV disinfection as an alternative to chloramination. To determine the effect of UV irradiation on NDMA in tertiary effluent, the Sanitation Districts conducted both laboratory collimated beam testing and pilot scale testing at the WNWRP. For collimated beam testing, both chlorinated and unchlorinated filtered secondary effluent samples were irradiated with UV doses up to 500 mJ/cm^2. The operating conditions during the pilot plant testing (flow rate ranging from 1,000 to 2,500 gpm, and UV transmittance ranging from 63 to 79%) resulted in UV delivered doses up to approximately 140 mJ/cm^2. Details of these studies are described in Jalali et al. (2005).

Results from these studies showed that, for both collimated beam and pilot testing, a linear relationship exists between the log NDMA removal and UV dose. The regression equations are listed below:

Laboratory Collimated Beam:	$Log_{10} (C_o/C_e) = 0.0015 * D_{CB}$	$R^2 = 0.96$
Pilot Testing:	$Log_{10} (C_o/C_e) = 0.0022 * D_d$	$R^2 = 0.76$

Where C_o is the NDMA concentration before UV irradiation, ng/L;
C_e is the NDMA concentration after UV irradiation, ng/L;
D_{CB} is the UV dose applied in collimated beam testing, mJ/cm^2; and
D_d is the delivered UV dose based on MS-2 coliphage inactivation (bioassay), mJ/cm^2.

These results imply that, for a tertiary treatment plant with media filtration and UV disinfection, an incidental NDMA reduction of 30 to 40% from the levels in the secondary effluent can be expected. As an example, if the median NDMA concentration in the influent is 80 ng/L, and the secondary process on average removes 70% of NDMA, then the median NDMA concentration in UV disinfected filtered effluent is expected to be in the 14 to 17 ng/L range.

CONCLUSIONS

The following conclusions are drawn from this research:

- Domestic and industrial sources contribute to NDMA in influent wastewater. The level of NDMA in influent wastewater fluctuates over a wide range. At the WNWRP, median NDMA concentration in the plant influent was 80 ng/L.
- Due to the high solubility of NDMA in water, physical separation processes such as sedimentation and media filtration have insignificant effects on NDMA concentrations.
- NDMA concentrations in the WNWRP secondary effluent varied over a wide range. Without polymer addition, the median concentration was 26 ng/L. With polymer, the median concentration was slightly higher at 32 ng/L.
- Biological treatment process on average removed approximately 70% of NDMA in influent wastewater. NDMA removal was mainly attributed to biodegradation. Although partition of NDMA onto mixed liquor suspended solids can be significant, NDMA removal by sludge wasting was insignificant to the overall NDMA reduction in the biological treatment process.
- The cationic polymer used at the Sanitation Districts' water reclamation plants includes NDMA precursor dimethylamine. Using chlorinated final effluent to prepare polymer feed solution resulted in the formation of elevated levels of NDMA. For NDMA control, the preferred approach is to add polymer solution to the return activated sludge instead of the mixed liquor effluent channel. Research is underway to investigate alternative polymers that do not contain NDMA formation precursor and the use of dechlorinated final effluent to prepare polymer feed solution.
- Chloramination significantly increased the NDMA levels in the secondary effluent, with or without the use of polymer. Not all chlorinating agents have the same effect on NDMA formation; free chlorine had much less effect on NDMA formation than

chloramines, as demonstrated by the full scale breakpoint chlorination study conducted at the SJCWWRP.

- NDMA removal increases with UV irradiation doses. UV disinfection of media-filtered secondary effluent is expected to achieve approximately 30 to 40% incidental NDMA reduction.

ACKNOWLEDGEMENT

The authors would like to acknowledge Dwayne Fischer, Manager, and Maria Pang, Assistant Manager, of the Laboratories Section of the Sanitation Districts of Los Angeles County for the strong analytical support they provided for the various studies reported in this paper.

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County Sanitation District No. 2
Los Angeles County
California

PRELIMINARY DESIGN REPORT
FOR
WHITTIER NARROWS WATER RECLAMATION PLANT
U.V. DISINFECTION FACILITIES

SANITATION DISTRICTS OF LOS ANGELES COUNTY

James F. Stahl
Chief Engineer and General Manager

1955 Workman Mill Road
Whittier, CA 90601

November 2005

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PRELIMINARY DESIGN REPORT
FOR
WHITTIER NARROWS WATER RECLAMATION PLANT
U.V. DISINFECTION FACILITIES

November 2005

1. INTRODUCTION

This report presents the preliminary engineering for the design of the Whittier Narrows Water Reclamation Plant - U.V. Disinfection Facilities. After review and approval of the proposed concepts and facilities by Districts' staff, the report will serve as the basis for the detailed engineering and design of the project.

This project will modify the existing treatment facilities to provide an ultraviolet light disinfection process, largely replacing the current disinfection process that uses sodium hypochlorite for chlorination and sodium bisulfite for dechlorination. The UV treatment scheme will allow the plant to meet existing regulatory disinfection levels and reduce levels of disinfection byproducts, most notably nitrosodimethylamine (NDMA). Based on evaluations conducted to date and meeting with Districts' staff, a decision has been made to utilize an open channel system, incorporating low pressure, high output (LP/HO) UV lamps targeting disinfection, rather than NDMA destruction. The project will include the installation of open channel UV reactor trains and appurtenant electrical systems, modifications to the plant filter effluent/backwash hydraulics, modifications for effluent filter cleaning and modifications to the existing plant control system.

It should be noted that some hypochlorite addition would still be required with UV disinfection. In this multi-barrier scheme, UV irradiation will be the primary means of disinfection in achieving Title 22 compliance. A low dosage of hypochlorite (with a short contact time) will act as a secondary barrier that will keep virus titers to essentially a non-detect level. Without hypochlorite, adenovirus, a viral pathogen, is still detected in the effluent at UV disinfection dosages.

A project is currently under construction at the WNWRP that provides a Recycled Water Pump Station for irrigation reuse. This pump station will be connected to the chlorine contact tanks. After UV disinfection is implemented, the CCTs will be used for effluent storage and the CCT water levels will vary diurnally.

2. WHITTIER NARROW WATER RECLAMATION PLANT (WNWRP)

The WNWRP is a part of the Los Angeles County Sanitation Districts' (LACSD) Joint Outfall System (JOS). The WNWRP provides hydraulic relief of the downstream sewers leading to the JWPCP while also providing reclaimed water to the Central Basin.

Existing treatment at the WNWRP consists of primary sedimentation, NDN activated sludge biological treatment, secondary sedimentation, coagulation, inert dual media effluent filtration, followed by chlorination and dechlorination. Tertiary effluent is normally discharged to the Rio Hondo or San Gabriel River systems for reclamation and a small amount is reused at Norman's Nursery. Primary and waste activated solids are discharged back to the JO "B" Trunk Sewer for conveyance and eventual treatment at the JWPCP.

2.1 Facility Location.

The WNWRP is located at 301 N. Rosemead Blvd. in the city of South El Monte and east of the Los Angeles metropolitan area. It is near the intersection of the Pomona Freeway (60) and Rosemead Blvd. The WNWRP site is in an unincorporated area of Los Angeles County, southeast of the Whittier Narrows Dam Recreation Area and north of San Gabriel Boulevard, between the Rio Hondo channel on the west and Rosemead Boulevard on the east. The Whittier Narrows Dam Recreation Area is operated by the City of Los Angeles Department of Parks and Recreation. The WNWRP and the recreation area are located within the Whittier Narrow Flood Control Basin, which is owned by the U. S. Government and operated by the Army Corps of Engineers (Corps). The WNWRP site is leased to the Districts until 2020, at which time an extension of the lease is expected. This is primarily because the utilization of the land as a flood control basin effectively limits any new development that may compete for land use.

The site on which the WNWRP is located is designated as an "Open Space" land use in the Los Angeles County General Plan. The site and surrounding properties are zoned for Open Space or Agricultural. Of the total 27.15 acres dedicated to the WNWRP site, approximately 16 acres is currently leased from the Corps by Norman's Nursery. The lease to Norman's Nursery may be cancelled if the Districts require use of the land. Norman's Nursery was relocated to its present location when it was displaced by the construction of San Jose Creek WRP Stage III.

2.2 Permitted Capacity and Future Expansion.

The existing facility is a tertiary wastewater treatment facility with a current NPDES permitted design capacity of 15 MGD. Therefore, the 30-day average and daily maximum mass emission limits for the WNWRP are based on daily concentrations with an effluent flow of 15 mgd. The WNWRP was originally designed for 12 MGD, but the permit was later increased to 18 MGD and then subsequently lowered to 15 MGD. Upgrades to the plant over the last 10 years for the removal of ammonia using a nitrification/denitrification (NDN) process have limited the treatment capacity of the existing tankage to approximately 13 MGD. Due to limitations of the existing return sludge pumps and process air compressors, the WNWRP has been treating approximately 8 MGD over the past few years. Another project is in the preliminary design phase to address these limitations. However, because the plant is located in a floodplain, the Districts' management has decided that no more tankage is to be provided at the WNWRP site in the foreseeable future. Therefore, the NDN capacity of the plant will likely remain limited to 13 MGD. The ultimate treatment capacity of the site identified in the 1977 Facilities Plan and the 2010 JOS Master Facilities Plan is 80 mgd.

2.3 Water Reuse at the WNWRP.

The WNWRP was the first water reclamation plant built by the Districts and was completed in 1962. Currently, most of the reclaimed water produced at the WNWRP is used by the Water Replenishment District to recharge the Central Basin. This basin is recharged through the Rio Hondo and San Gabriel Coastal Spreading Grounds (Montebello Forebay) with reclaimed water from the SJCWRP, WNWRP and Pomona WRP. Both of these spreading grounds are operated by the Los Angeles County Department of Public Works. Existing conditions are such that virtually all the reclaimed water produced at the WNWRP is reused for groundwater recharge. Reclaimed water from the WNWRP is normally discharged to the Rio Hondo, which flows to the Rio Hondo Spreading Grounds for recharge. Occasionally, during rainstorm events, the reclaimed water for the WNWRP reaches the lined portion of the Rio Hondo, which flows to the lined portion of the Los Angeles River and eventually discharges to the ocean. The reclaimed water produced at the WNWRP can also be diverted to the San Gabriel River. Just south of the Whittier Narrows Dam, reclaimed water is diverted to spreading grounds via unlined reaches of the San Gabriel River. Another project, currently under construction, will enable the Title 22 effluent produced by the WNWRP to be pumped for reuse to the Whittier Narrows Dam Recreation Area, which is situated in the Main San Gabriel Basin. Because of NDMA issues, and those related to potable water well closures in the San Gabriel Valley due to groundwater contamination, reuse by irrigation in the San Gabriel Valley Basin is emerging as a preferred alternative over groundwater recharge of the Central Basin.

Currently, the Main San Gabriel Basin contains pockets of groundwater that have organic contaminant levels that exceed current drinking water standards. Efforts by other agencies have been undertaken to develop management and treatment schemes to reclaim these impacted water supplies in order to maintain their availability in the future. It has recently been discovered that the effluent from the WNWRP that is discharged to the Rio Hondo may be affecting the groundwater quality in the short reach of the Rio Hondo that is unlined and downstream of the plant. NDMA has been discovered in EPA monitoring wells that have been strategically placed to capture and treat the plumes of organic contamination migrating downgradient in the San Gabriel Basin.

The EPA has constructed several "Operable Units" to treat this organic contamination. The Whittier Narrows Operable Unit (WNOU) that is located near the WNWRP treats the groundwater in the area downgradient of the plant. However, NDMA would not be removed by the treatment provided by the WNOU, rendering that facility obsolete and the water unusable. The WNWRP UV Disinfection Facilities Project is expected to improve the water quality of the WNWRP effluent so that it does not adversely affect the groundwater in the vicinity of the wells that pump to the EPA's WNOU. The UV disinfection project is expected to reduce NDMA to levels that were typical before the nitrification/denitrification treatment process was implemented at the WNWRP. These levels have not adversely impacted groundwater quality in the past.

In the meantime, several steps have been taken to reduce effluent NDMA levels at the WRPs. For instance, the Operations group continues to optimize chemical usage. Use of polymers with minimal amine concentrations are being evaluated and may significantly reduce current NDMA

levels. Also, for the JOS tertiary WRPs, the filter backwash, which contains high levels of NDMA, is captured and diverted back to the sewer for subsequent treatment at JWPCP. Even with these in-plant changes, levels of NDMA continue to be 1 to 2 orders of magnitude above the current DHS Notification Level (NL) of 10 ng/L. Operations has also implemented a discharge rotation program at the Whittier Narrows WRP in an effort to minimize impacts on EPA's extraction wells. In addition, the EPA is intermittently operating the extraction wells through a rotation program and is discharging the VOC-treated water to Legg Lakes under an agreement with the local Watermaster.

The WNWRP also currently provides water for direct reuse to Norman's Nursery. Additionally, the WNWRP is slated to provide water to the Upper San Gabriel Municipal Water District in the near future for direct reuse and irrigation at the Whittier Narrows Dam Recreation Area with the construction of a new recycled water pump station at the plant. **Refer to Part 4.1 of this report.**

2.4 Existing Permits and Regulations.

a. NPDES, Reuse and Groundwater Recharge

The treatment of wastewater is subject to various federal, state, and regional laws, rules, and regulations. The WNWRP operates within waste discharge requirements of NPDES Permit No. CA0053716 (Order No. R4-2002-0142). The permit is issued by the Los Angeles Regional Water Quality Control Board (RWQCB), and is scheduled for renewal every five years. The current NPDES permit will expire on July 10, 2007. The permit also requires the plant to meet various water quality objectives of the Water Quality Control Plan for the Los Angeles River Basin (Basin Plan). In addition, the plant is subject to the water reclamation (reuse) requirements of the Montebello Forebay Groundwater Recharge Permit, issued by the RWQCB. This groundwater permit pertains to the Rio Hondo and San Gabriel Coastal Spreading Grounds. According to the reuse permits, reclaimed water shall not contain trace constituents or other substances in concentrations that exceed the limits of the current California Department of Health Services Drinking Water Standards. Reclaimed water that is used to recharge groundwater, or that is discharged to a surface water body designated as a drinking water supply, must meet California drinking water standards for trace constituents, which are typically the same as the federal standards required by the Safe Drinking Water Act. The permitted disinfection requirement for reclaimed water produced at all of the Districts' WRPs, including the WNWRP, is such that the 7-day median number of total coliform cannot exceed 2.2/100 ml, and the total coliform count cannot exceed 23/100 ml in more than one sample in any 30-day period.

The permit requirements associated with chlorine residual deserve special mention. For the WNWRP, the total residual chlorine is limited to an instantaneous daily maximum of 0.1 mg/L, subject to the exclusions below. Excursions of up to 0.3 mg/L are allowable immediately following dechlorination provided that the total duration of such excursions do not exceed 15 minutes in any 24-hour period and the excursions are associated with changing of the chlorine tanks. Since chlorine tanks are not used at the WNWRP, it is not clear if any relief can be gained above the 0.1 mg/L residual [It is recommended that the reference to changing of chlorine tanks

be dropped in future permits, consistent with the language in other WRP permits of the Districts]. Also, peaks in excess of 0.3 mg/L lasting less than one minute are not considered to be a violation of the chlorine residual requirement.

Note that the residual chlorine objective may be revised in the future. The SWRCB has released a draft document in April 2004 that included freshwater limits of 0.019 mg/L as a one-hour average and 0.011 mg/L as a 4-day average. Although this is a receiving water quality objective, the precedent is to apply these limits as "end of pipe" objectives.

Operators normally add an excess of bisulfite in order to meet the chlorine residual requirements. Bisulfite residual is not regulated, but reportedly can increase toxicity and theoretically consume dissolved oxygen and lower the pH.

b. NDMA Regulatory Issues

N-nitrosodimethylamine (NDMA) is a nitrosamine formed in many industrial and natural processes. It occurs in various foods and alcoholic beverages, is created from nitrates and nitrites in the human gut, and is also detected in cigarette smoke. The nitrosamines are considered as classic carcinogens. Given the low volatility and skin permeability of NDMA, neither inhalation nor dermal exposure routes are expected to contribute significant amounts of exposure relative to the oral route. However, NDMA contributions from food sources are probably a relevant fraction of total exposure.

NDMA has become more important in California because of its increasing detection in drinking water. It has been associated with the chloramine disinfection process. California DHS requested that OEHHA develop a PHG for NDMA, to support the development of a California MCL. There is no federal Maximum Contaminant Level (MCL) for NDMA, but there is a California Notification Level (formerly known as the Action Level) of 10 ng/L. This level has fluctuated over the years as more was discovered about NDMA as an emerging contaminant.

From the discussion above, it is clear that NDMA regulatory issues with regards to the WNWRP plant effluent really originate from drinking water regulations. Because of it being an emerging contaminant, it regulatory levels have change over time and there is some uncertainty about where they will end up or how vigorous they will be enforced. The current NDMA levels in effluent discharged by all seven of the tertiary WRPs are well below the California Toxics Rule criteria for the protection of the recreational beneficial use. It is doubtful that NDMA levels in reclaimed water pose a threat to underlying groundwater when used properly for irrigation purposes (e.g., not exceeding agronomic demand). However, when a Drinking Water Standard (DWS) for NDMA is established, it will be applicable to the tertiary WRPs via the Title 22 DWS narrative requirement currently contained in the reuse permits.

In the near future, it is expected that the current DHS Notification Level for NDMA of 10 ng/L will be adopted as a Maximum Contaminant Level (MCL) for the Drinking Water Standard (DWS). This future change to the DWS will certainly impact all seven of the tertiary WRPs that discharge to unlined river reaches where underlying groundwater could be impacted. It may also

impact treated effluent used for water reuse activities since current reuse permits require compliance with DWS. Typically NDMA is detected in the WRP secondary effluent at less than 100 ng/L. This is above the current DHS Notification Level but well below the Response Level.

Notification levels are advisory levels and not enforceable standards. They are health-based advisory levels established by DHS for chemicals in drinking water that lack maximum contaminant levels (MCLs). Notification levels are established as precautionary measures for contaminants that may be considered candidates for establishment of a MCL, but have not yet undergone or completed the regulatory standard setting process.

The Response Level is set at chemical concentrations 10 to 100 times the Notification Level, depending on the toxicological endpoint (*i.e.*, non-cancer effects or cancer risk) of the chemical. The Response Level designates the point where DHS recommends that a drinking water system take the source out of service. For NDMA, the Response Level is 20 times the Notification Level, or 200 ng/L.

c. Other Permits and Environmental Documentation

1. Floodplain Management

Executive Order 11988, a federal requirement prepared in 1979, relates to floodplain management. It was promulgated to avoid long-term and short-term adverse impacts associated with occupation and modification of floodplains. Projects must be designed or actions performed to minimize the potential harm to the floodplain. Documentation is prepared and a notice is circulated explaining why the action is proposed to be located in the floodplain.

2. Storm Water

The WNWRP is also regulated by the General Permit Conditions for Industrial Activities for storm water discharges. A Storm Water Pollution Prevention Plan has been developed and is maintained for the site.

3. Storm Water Discharge for Construction Activities

The construction at the WNWRP will be subject to General Permit Conditions for Construction Activities for storm water discharges. A Storm Water Pollution Prevention Plan will be developed specifically for construction of the project.

4. National Fire Protection Act (NFPA)

The WNWRP UV Disinfection Facilities design will be in accordance with NFPA 820 guidelines and all applicable County of Los Angeles ordinances. Construction plans will require approval of the County of Los Angeles Fire Department. Because of its remote location, and the fact that it is not near a potable water or firewater supply, the WNWRP fits the NFPA description of a "Rural/Non-urban" area in which a fire prevention system does not require a pressurized hydrant system.

5. South Coast Air Quality Management District (SCAQMD)

The WNWRP UV Disinfection Facilities design will comply with all applicable rules and regulations of the South Coast Air Quality Management District (SCAQMD). A Permit to Construct and operate will be required from the SCAQMD for all equipment.

6. Additional Permit Requirements

Additional information on existing laws, rules, and regulations may be found in the Final Joint Outfall System 2010 Master Facilities Plan and EIR dated June 1995.

7. Environmental Documentation

There are no apparent negative environmental impacts that have been identified for the UV Disinfection Facilities project and therefore no mitigation measures are necessary.

3. NEED FOR UV DISINFECTION

3.1 NDN Operation.

Since 1996, the operation at the WNWRP has been a nitrification/denitrification (NDN) activated sludge process in which essentially all of the ammonia nitrogen (approx. 23 mg/L as N) and organic nitrogen (approx. 8 mg/L as N) in the bulk liquid flow is biologically removed. A change from the standard removal of carbonaceous BOD with limited nitrification was necessary to meet new effluent nitrogen standards, effective June 2003. More specifically, it was necessary to meet an effluent ammonia-nitrogen limit ranging from 1 to 2 mg/L, depending on temperature and pH, and also meet a combined nitrite/nitrate-nitrogen limit of 8 mg/L (as N) on a monthly average. In the NDN mode, organic nitrogen is converted to ammonia nitrogen and the process of nitrification converts ammonia-nitrogen to nitrite and then nitrate. The process of denitrification then converts nitrate to nitrogen gas, and the nitrogen is then removed from the aqueous system. Because the existing disinfection scheme at the WNWRP requires chloramine, a small amount of industrial aqueous ammonia (approx. 1-2 mg/L as nitrogen) is added to the secondary effluent prior to the addition of sodium hypochlorite. After injection and mixing of the sodium hypochlorite before the filters and following suitable chlorine contact time, dechlorination is accomplished by the addition of sodium bisulfite.

3.2 NDMA.

Recent data have shown that the upgrade to the NDN activated sludge process has led to increased levels of n-Nitrosodimethylamine (NDMA) in the effluent of the WNWRP and other CSDLAC facilities. Identification of NDMA or its precursors in the sewer, and the generation of NDMA in wastewater treatment processes, is complicated because of multiple formation and degradation pathways. However, it appears that disinfection by chloramination with monochloramine in the presence of NDMA precursors is the main reason for the increased NDMA levels in the NDN operation. The NDMA precursors are due in large part to the use of polymers at the plant to control foam and to improve secondary settling characteristics.

Chloramination, rather than free chlorination, has been typically used by the Districts because of the lower trihalomethane (THM) concentrations that result.

Since the NDMA issue affects a number of Districts' facilities that have switched to the NDN treatment mode, this has led to an agreement with the RWQCB to proceed with UV disinfection at the WNWRP. The San Jose Creek and Pomona WRPs also discharge to unlined reaches of the San Gabriel River and Rio Hondo and are similarly used in the Montebello Forebay for groundwater recharge. The installation of a UV system at the WNWRP has been mentioned in the recently approved Pomona WRP NPDES permit. The WNWRP will be used as a test plant to gather operational data before other plants are ever retrofitted with UV systems.

3.3 Other Factors.

Besides NDMA, a number of other regulatory concerns that are favorably impacted by the installation of a UV system at the WNWRP are listed below:

- Residual Chlorine. Exceedances should be reduced since normally chlorine will not be the primary disinfectant and can be added more cautiously. The full complement of chlorine residual will only be required occasionally when operating in standby hypochlorite mode.

- Ammonia. Exceedances will be reduced since ammonia will not be added back for chloramination purposes in the effluent going to the receiving water.

- Cyanide. Exceedances may be reduced by limiting the chlorination of the effluent. New cyanide limits are scheduled to go into effect in the years 2007-2009 at various plants (WNWRP - May 7, 2007).

- Mandatory Monetary Penalties (MMPs). Penalties associated with the above items will be reduced if the overall numbers of exceedances are minimized.

- 450 CT Requirement. Currently, the reclamation permit requires total virus inactivation in lieu of meeting the 450 CT requirement. It is expected that the 450 CT requirement may be enforced in the future. With UV disinfection, the 450 CT requirement will not be a concern.

- Sodium, Chloride and Sulfate. Effluent concentrations of these constituents will be lower, when lower amounts of sodium hypochlorite and sodium bisulfite are added.

Although the above concerns have been evident with the use of chlorine, and will be reduced by the use of UV, it should be noted that disinfection by chlorination has provided near perfect compliance in meeting coliform requirements and virus inactivation.

The use of free (and/or breakpoint) chlorination has also been explored by the Districts as both a temporary and long-term solution to disinfection problems. While considered to be an acceptable temporary alternative to chloramination in terms of NDMA, free chlorination may not be a good long-term alternative, since it raises the levels of THMs. It also does not address the 450 CT

issue and also suffers from the fact that there is some bleed-through of ammonia at high flow rates. In this case, the free chlorination process would become a chloramination process unless additional chlorine is added to achieve breakpoint chlorination. Needless to say, this would be a more difficult process to control.

The Districts have recently conducted a UV disinfection pilot project at the WNWRP to test the disinfection efficacy of UV and the extent of NDMA destruction and disinfection byproduct formation. It was determined that irradiation of the effluent by ultraviolet (UV) light was a feasible and cost effective technology capable of achieving disinfection of wastewater, without additional generation of NDMA and other chlorination byproducts. The process also achieves measurable destruction of NDMA at disinfection dosages. The use of a UV Disinfection System at the WNWRP will restore NDMA concentrations to pre-NDN levels. This will protect the quality of local groundwater and will prevent the formation of other chlorinated disinfection byproducts, such as THMs.

The pilot testing at Whittier Narrows has shown that the DHS required UV dosage (100 mJ/cm2) is inadequate to inactivate adenovirus. Therefore, as mentioned previously, a small free chlorine dose with a short contact time will be required prior to effluent discharge. This practice is not expected to increase THMs or other DBPs significantly, although some residual exceedance problems may be experienced due to faulty analyzer operation.

4. RELATED PROJECTS

The following is a list of projects related to the WNWRP UV Disinfection Facilities, along with a brief description of each project.

4.1 San Gabriel Valley Direct Reuse Project – Phase IIB Recycled Water Pump Station.

a. Project Overview

This project involves the construction of a pump station and wetwell directly south of, and connected to, the existing chlorine contact tanks (CCTs) by two 30-inch pipelines. A 24-inch diameter discharge force main will be constructed on plant property to connect with the main portion of the reuse line that proceeds north from the plant. Most of the plant effluent at the WNWRP, which is currently directed to the Central Basin for groundwater recharge, will be pumped to the San Gabriel Basin as irrigation water supplying the Whittier Narrows Dam Recreation Area and golf course. Variable speed pumps are being provided at the pump station, along with a separate SCE power feed and appurtenant transformers and switchgear.

With the UV process, the WNWRP's CCTs will no longer be required to provide the contact time for disinfection, except in a standby disinfection mode, and will thus be available for diurnal storage of reuse water for San Gabriel Valley. By using the CCTs (hereinafter referred to as Effluent Storage/Chlorine Contact Tanks, ES/CCTs) for reuse storage, USGMWD avoids the construction of a large reservoir on Districts' property. The initial proposed reservoir volume

was 2 MG and would have interfered with the future expansion of secondary clarifiers to the west.

After both contracts (UV Disinfection Facilities and Recycled Water Pump Station) are completed, the two ES/CCTs will be used for a combined reuse storage volume of approximately one million gallons, with the water level in both tanks varying diurnally. For the present condition of operating two aeration tanks, and assuming the plant will be operated to produce a relatively constant 9.4 MGD, the ES/CCT storage will provide the required steady reuse flow of 11.55 mgd during the nine hour scheduled reuse irrigation time (10 p.m. to 7 a.m.). Minor reuse demand may be expected during the day, after 7 a.m. Filter backwash will occur during the day when the water levels in the ES/CCTs have recovered to such a level that there is adequate storage volume for backwashing.

Future improvements to the WNWRP's return sludge pumping and process air compressors will allow more flow to be treated at the plant. This will allow the reuse goal to be more easily met and will reduce storage demands on the ES/CCTs. In addition, future facilities are to be added to the reuse system, which will reduce the demands on the ES/CCTs. A reuse pipeline for the SJCWRP will be tied into the reuse pipeline for the WNWRP. In addition, another 1 MG storage reservoir will be provided at the end of the system (in Arcadia). This second reservoir will likely be filled during the day by the SJCWRP and/or by the WNWRP after daily backwash requirements are satisfied.

The Districts will provide a chlorine residual for the reuse pipeline, with the chemical cost reimbursed by USGVMWD. This scheme may or may not include ammonia addition.

b. Plant Modifications

The following plant modifications are currently being made as part of the Recycled Water Pump Station Project:

1. Recycled Water Wetwell and Pumps

- Construction of a wetwell for the Recycled Water Pump Station, connected to the existing CCTs through two parallel 30-inch pipelines and butterfly isolation valves
- Installation of four reuse pumps, one surge tank and a 24-inch diameter reuse pipeline proceeding across the north boundary of the plant.

2. Process Water Systems

- Provision of weir in wetwell to prevent over-pumping and assure retention of firewater and washwater supply
- Change of the existing 16-inch foam spray/washwater/chemical dilution water suction line from the Dechlorination Channel to the reuse wetwell (for an uninterrupted supply of chlorinated, in-plant process water).

- Addition of an upstream leg and isolation valve in the above-mentioned 16-inch foam spray/washwater/chemical dilution water suction line to receive UV disinfected water (this line will be extended during the WNWRP UV Disinfection Facilities project)

- Provision of a 4-inch line and isolation valve to supply UV disinfected water to a proposed chemical dilution water pump (this line will be extended during the WNWRP UV Disinfection Facilities project)

- Extension of the draft hydrant piping to a lower level in the existing CCT (the water level in the ES/CCTs will rise and fall, but a minimum amount of water will be reserved for fire protection at all times)

- Extension of Norman's Nursery pump suction lines into the existing CCT's sump area and provision of a foot valve on each suction line to keep the pump primed (the water level in the ES/CCTs will rise and fall).

- Addition of a washwater connection to Norman's Nursery pump suction (to prime the pump, if necessary, since the water level in the ES/CCTs will rise and fall)

- Connection of the reuse discharge line to Norman's Nursery pump discharge line (allows the Norman's Nursery pump to be retired in the future, if desired)

- Provision of an emergency firewater connection on the discharge of the reuse pipeline (standby for the draft hydrant)

3. Electrical and Instrumentation

- Installation of separate electrical power feed, transformer, switchgear and power meter

- Installation of a PLC for stand alone control of the pump station

- Installation of conduit for communication between the PLC and plant DCS

- Installation of a transducer for the wetwell level indication

4.2 WNWRP Miscellaneous Plant Modifications.

This project involves the demolition of the existing airlift return sludge pumps and the construction of a proposed Return Sludge Pump Station for greater return capacity. It also involves the replacement of the existing process air compressors with larger and more efficient compressors. With the upgrade of the process air and return systems, the WNWRP plant is expected to once again operate with three aeration tanks instead of two, and at higher plant flows. This will put greater stress on the existing clarifiers and effluent filters, which in turn, may have a slight effect on the effluent UVT. The design UVT value assumed ultimately affects the number of UV lamps provided on the project.

4.3 Replacement of Existing Filter Effluent Pump Variable Speed Controls.

Although this is not a formal project, Operations is considering the replacement of the existing variable speed controls for the filter effluent pumps. The operation of these pumps has been suspect for the last year and the existing speed controls are a very old technology and obsolete, which means parts are very hard to obtain. Replacement with more modern VFCs and motors should increase the reliability of the entire facility and may possibly result in more even flows to the UV system, which would produce better disinfection and increase UV efficiency.

4.4 Replacement of Existing Power Feed and Transformer by SCE.

This project commenced in March 2005 and was required for maintenance reasons, as well as the increased capacity needed by the UV facilities. The electrical conductors, which were made of lead material, were replaced from the power pole to the transformer. The roof top transformer was also replaced. The automatic transfer switch was be updated for smoother transitions during power interruptions.

5. PLANT MODIFICATIONS

5.1 Project Overview.

a. Proposed Process Changes

- The normal disinfection practice of chloramination, now achieved by adding aqueous ammonia and sodium hypochlorite before the effluent filters (pre-chlorination), will be discontinued as the normal mode of disinfection and retained as a standby mode of operation.

- The effluent flow from the Filter Effluent Pumps will be metered and will receive a 0.5-1.5 mg/L dose of hypochlorite, at a point downstream of the effluent filters and upstream of the UV reactors, for adenovirus control.

- The effluent flow will be equally split among operating UV reactor trains and will receive a UV dose of 100-mJ/cm^2. After passing through the UV reactors, the treatment process will be considered complete and will be designated as "end of pipe". At this point, the plant effluent will be automatically sampled and grab samples will be taken for coliform.

- The UV effluent will be preferentially directed to the ES/CCTs for reuse storage and subsequently pumped by the Recycled Water Pump Station. Since free chlorination and storage of this effluent may lead to THMs, the provision for reuse water chloramination will be provided by having ammonia injection capability in the channels leading to the ES/CCTs. Hypochlorite will be added to the reuse flow as it enters the CCTs. Note that NDMA and THM formation in the irrigation reuse water will not be monitored since it is not regulated after "end of pipe".

- After the CCTs are filled, the plant effluent will automatically flow to the receiving water. Prior to leaving the plant, the flow will be monitored for chlorine residual and dechlorinated with sodium bisulfite if necessary.

- The effluent filters will be shock dosed with hypochlorite as necessary during the backwash operation to prevent filter growths.

- Backwashing will be provided by a dedicated backwash pump taking suction from ES/CCT No. 2 (west tank). The existing backwash system will be retained for standby backwashing capability.

b. General Discussion

A UV Disinfection System will be constructed and operated to act as the main mode in a multi-barrier disinfection scheme. For UV disinfection, the filter effluent flow will be equally split through parallel UV treatment trains fitted with multiple banks of lamps in series. The on/off operation of the UV trains and individual banks, including the variable power to the lamps, will be automatically controlled to achieve the appropriate UV dosage at DHS validated flowrates and transmissivity. Adenovirus will be inactivated by adding a low dose of sodium hypochlorite (0.5 –1.5 mg/L as chlorine) after effluent filtration and before the UV reactors. This low chlorine dose may or may not typically need dechlorination, depending on the dosage, the chlorine demand and the chemical addition point. The existing bisulfite system will remain operational in any case. The existing pre-chlorination and post-chlorination facilities using sodium hypochlorite will be retained as a standby system during peak storm flows and at other times when the UV reactors are either inadequate or unavailable for service.

The WNWRP effluent will be preferentially reused for irrigation via the Recycled Water Pump Station currently under construction, or discharged to the receiving water for reclamation purposes. The UV disinfected effluent that is not needed for irrigation reuse will be discharged via the effluent outfall piping to the Rio Hondo or San Gabriel River, where the reclaimed water is normally used for groundwater recharge and ultimately for indirect potable reuse. At the water purveyor's request, the irrigation reuse water will be chlorinated after UV disinfection to prevent growths in the distribution system. It will be stored in the ES/CCTs for subsequent pumping during nighttime hours.

A proposed backwash pump will use UV treated water for backwashing purposes and will take suction from an ES/CCT. Since the backwash water is taken downstream of the UV reactors, the UV system will not experience the large flow fluctuations associated with backwashing, as with the current operation. Although intuitively the use of UV disinfected water may seem inefficient, each backwash is only 0.1 million gallons. The waste of a small amount of UV treated water is acceptable in order to achieve a more stable disinfection process. This also prevents excessive startup and shutdown of the UV lamps, which can lead to premature aging and failure of the lamps.

Because the effluent filters will no longer be pre-chlorinated, all necessary piping and controls will be added so that a shock dose of hypochlorite can be added to the filters individually during the backwash cycle. Shock dosing will prevent biological growths from causing excessive headloss and filter blinding.

Since there is concern about NDMA formation from chloramination of precursors trapped in the filters, the filter waste backwash water will not be returned to the treatment process. This operational scheme is consistent with the current practice at all upstream WRPs to divert waste backwash flows to the sewer, per an agreement with the Los Angeles RWQCB. If a free chlorine residual were to be used for post-chlorination of the reuse water, the waste backwash could conceivably be recycled to the plant, since NDMA formation would be limited. However, since waste backwash recycling necessitates the use of a dedicated secondary clarifier, and the plant is clarifier limited, it is most likely that waste backwash will continue to be diverted to the sewer in order to free up the clarifier for secondary clarification and thereby increase the overall production of effluent.

Processes and facilities that will be modified and/or expanded include: chlorine contact tanks, filter backwash pumping and cleaning, chlorination, dechlorination and support facilities, such as in-plant process water systems and sampling systems.

c. System Operating Scheme

Figure No. 1 depicts an overall schematic of the proposed UV facilities and should be referenced for the discussion that follows. Refer also to **Part 5.3** of this report.

System operation will be as follows:

- Four(4) UV reactor trains will be fed from the existing CCT inlet channel (to be redesignated as the UV/CCT Inlet Channel. The channel sidewalls will be extended vertically to achieve the additional head requirement for UV treatment, while maximizing the capacity of the ES/CCTs for reuse storage.

- The UV reactor trains will be located in, and parallel to, the 2nd and 3rd passes of each existing CCT (relative to the exterior pass of each CCT as the 1st pass). The reactor trains will discharge to the UV Outlet Channel, a common channel perpendicular to the reactor trains. At low ES/CCT water levels, the channel will supply flow to individual Effluent Storage Channels, one for each ES/CCT. The flow in each channel will fill the corresponding ES/CCT from a position immediately downstream of the existing CCT inlet slide gate. The flow will be chlorinated before entering each ES/CCT. When the ES/CCTs are full, the water in the Effluent Storage and UV Outlet Channels will rise to an elevation where it overflows a weir leading to the Receiving Water Channels. The Receiving Water Channels will transfer flow into the existing Dechlorination Channel. The flow will then proceed over the existing final effluent weir and then to the Effluent Diversion Structure. Note that during the time that flow proceeds to the receiving water,

gates in the Effluent Storage Channels will close to prevent diffusion of chlorine into the receiving water effluent.

- The UV reactor trains will each be provided with an inlet sluice gate that will either be fully open or closed, depending on whether the reactor train is on-line or off-line, respectively. Each reactor train will have three to five banks of lamps in series (to be determined from the system supplier proposals). The trains will be operated in parallel with equal flows. A differential pressure cell on each train will verify that an equal flow split is achieved. An automatic weir gate located on the effluent end will control the water level in the reactor trains. This control is essential to keep the water surface on the first bank from being too high and the water surface on the last bank from being too low. This control also ensures that all lamps are submerged if there is no flow to the reactor.

- The UV reactor trains will be supplied with an automatic drain valve into a header system that will allow partially disinfected water to be dumped to the plant sewer so that the UV reactor train can be serviced. This "off-spec" (inadequately disinfected) water will not be discharged as plant effluent. The piping arrangement will also allow an out of service reactor train to be filled from an operating reactor train prior to startup.

- The operational UV dosage will be controlled by the UV manufacturer's PLC and reported to the plant distributed control system. The operational does will be based on bioassayed validation studies of delivered UV dose. Operational dose is a function of flow/lamp, UVT, lamp power, as well as lamp aging and fouling. The individual banks in each train will be capable of being turned off, or turned down to approximately 50-60% power to lower the operational dose. Unnecessary starting and stopping of lamps or banks will be minimized as it shortens lamp life.

- The lamps will be provided with mechanical, and possibly chemical/mechanical, cleaning mechanisms to keep lamp sleeve fouling to a minimum. The sleeve cleaning cycle will be experimentally determined as it is site specific and depends on the chemical constituents of the water. Periodic manual cleaning, done by bank removal and soaking in an acid bath, will be necessary if a mechanical cleaning-only system is provided (Wedeco).

- In standby hypochlorite mode, the water level will rise in the ES/CCTs to the point that flow enters the Receiving Water Channels through an extended weir at the end of these channels. This flow must then be dechlorinated as it passes through the Dechlorination Channel before it flows to the receiving water.

5.2 UV Disinfection System.

1. General

Based on evaluations conducted to date and meetings with Districts' staff, a decision has been made to utilize an open channel system utilizing low pressure/high output (LP/HO) lamps.

Open channel systems are preferable to pressure vessel systems for wastewater applications because they facilitate inspection, cleaning and maintenance. Plans are to utilize four parallel UV reactor trains with inlet sluice gates and modulating outlet weirs. The trains would be built near deck level at the front end of four passes in the existing CCTs (Refer to Figure No. 1).

LP/HO lamps are the most efficient lamp technology for the production of a monochromatic output at a wavelength of 254 nm, which is close to the peak disinfection wavelength of 260 nm. Although a fewer number of medium pressure lamps could be used, these lamps produce polychromatic light over a broad band of wavelengths. This is less efficient on a power basis and leads to biological growths because of wavelengths in the visible spectrum. Medium pressure lamps also operate at higher temperatures, which promote greater lamp fouling. Low pressure/low output (LP/LO) lamps could also be used, but because their output is so low, approximately 4 times the number of LP/HO lamps would be necessary. Recently, there have been a number of UV facilities that have retrofitted their medium pressure or LP/LO systems to LP/HO systems. Some have abandoned their UV systems altogether. In lieu of California's past energy supply problems, the most reasonable and cost effective alternative is to use LP/HO lamps.

2. Comparison of Trojan and Wedeco UV Systems

Currently there are two leading manufacturers with multiple LPHO systems operating in North America. They are Trojan Technologies (Ontario, Canada) and Wedeco ITT (Charlotte, North Carolina). Both Trojan and Wedeco UV systems are open channel systems using horizontally mounted LPHO lamps. Both systems' lamp power can be automatically adjusted for variable flow and UVT conditions.

Wedeco has a slight power turndown advantage over Trojan, 50% vs. 60% respectively, and its turndown is linear whereas Trojan's is in stepped increments. Cool down is necessary to restart the lamps upon failure of each system. Guaranteed lamp life is approximately the same. Ballasts supply two lamps in each system. Wedeco's system can be configured to have module sizes of 2-20 lamps, in increments of two lamps, and the lamps of each module are aligned in two vertical columns. Trojan's modules can be configured with either 4, 6 or 8 lamps, with the 8-lamp module being preferable in larger facilities. The lamps of Trojan's modules are aligned in one vertical column.

One of the biggest differences is that Trojan's ballasts are mounted in the UV channel headspace for cooling purposes. These are typically NEMA 6P anodized aluminum enclosures that can withstand limited submergence. Wedeco's ballasts are located outside the channel in NEMA 4X 316 SS air-conditioned panels and or NEMA 12 panels located inside an air-conditioned building.

Another major difference is the automatic cleaning mechanisms. Wedeco has a mechanical-only wiper system and uses the NWRI default cleaning factor for sizing calculations. An acid bath chemical cleaning tank will be required for out of channel cleaning of Wedeco's UV lamp

modules and banks. Trojan uses a combination chemical/mechanical wiper system, which results in an excellent fouling factor.

The following table compares some of the principal differences between the competitive systems:

Table 1.

General Comparison of Trojan and Wedeco UV Systems	Trojan UV 3000 Plus	Wedeco TAK55
Proposed Lamp Spacing	4-inch	4.7-inch
Lamp cleaning system	Chem/Mech	Mechanical
Power range	60-100%	50-100%
Power adjustment increments	3% steps	linear
Guaranteed lamp life at EOLL factor	9,000	8,760
Lamp input at full power	~ 250 watts	~310 watts
Fouling factor (FF)	0.95	0.80
End of lamp life factor (EOLL)	0.82	0.85
Combined lamp factor (FF x EOLL)	0.779	0.68
Lamp factor comparison (based on Wedeco lamp)	14.6 %	---

3. Reactor Validation Studies

All UV systems proposed for disinfection of water and wastewater in the State of California are to have a validation on file with DHS. Pertinent validations currently on file for Title 22 unrestricted reuse are as follows:

Table 2.

UV System	Lamp Spacing	Plant and Date	Location or Agency
Wedeco TAK55	120-mm (4.7-inch)	Dry Creek WRP, 2003	Roseville, CA
Trojan UV 3000 Plus	3.5-inch	Wild Horse Pass WRF, 2002	Wild Horse Pass, AZ
Trojan UV 3000 Plus	4.0-inch*	Whittier Narrows WRP, 2005	LACSD

*Note: the 4-inch validation has recently been accepted by the DHS (October 2005).

In the early stages of the Whittier Narrows project in late 2003/early 2004, plans were to have Districts' Research staff test both the Trojan and Wedeco UV systems on a pilot scale. A particular objective of the research was to determine the effectiveness of the systems in the

inactivation of coliform at UV dosages of 100 mJ/cm^2 (the target dosage recommended by NWRI and DHS). Unfortunately, Wedeco did not have a UV pilot plant available for testing and so the research had to be limited to the Trojan system only. Fortunately, it was felt that the existing Wedeco validation could be utilized for the purposes of design, equipment procurement and operation.

At the time, the production version of the UV 3000 Plus System was only offered with LSI lamps at a 3.5-inch lamp spacing. After reviewing the associated validation report, the Districts discovered that the 3.5-inch lamp spacing did not optimize the system for the high transmittance water (72-80% UVT) typically produced at the Whittier Narrows plant. Specifically, the lamps were so close together that the system would dose considerably above the target of 100 mJ/cm^2 most of the time. Attempting to reduce dosage by increasing the flow/lamp was not possible because of headloss limitations associated with the close lamp spacing.

The pilot plant furnished by Trojan was capable of being configured with three different lamp spacings; 3-inch, 3.5-inch and 4-inch. After discussions with Trojan, a decision was made to validate the UV 3000 Plus pilot plant using LSI lamps at a 4-inch lamp spacing. Trojan agreed that this lamp spacing would allow the Districts to optimize performance and avoid overdosing and headloss problems.

Because the 4-inch UV 300 Plus system had not been validated previously, Trojan agreed to validate the system at their expense. To this end, they hired Carollo Engineers to conduct the validation tests at the Whittier Narrows plant, under the direction of Andy Salveson. The Districts had previously hired Carollo and Mr. Salveson as a consultant for the project. Although considerable time had been spent by Research and Design on the development of a test protocol that was to be the basis of the validation work, Trojan's decision to validate the system at their expense meant that Trojan and Carollo had the responsibility for the development and approval of the test protocol and validation.

The validation tests on the Trojan pilot plant were conducted during the summer of 2004 and were completed by the end of August. The Districts' Research Section conducted additional tests for coliform inactivation, cyanide and duplicate virus testing after the validation testing was completed. The validation data analysis, report writing and internal discussions at Trojan took many months after the validation tests were completed. The report was finally submitted to DHS in March of 2005. DHS provided comments to Trojan and Carollo in April 2005. Trojan and Carollo responded with a revised report in June 2005. That report was accepted by DHS in October, 2005.

Although DHS has recently accepted Trojan's system with 4-inch lamp spacing, is should be noted that the Districts took exception to Trojan's use of a linear regression to analyze the collimated beam bioassay data obtained during the research. A second analysis performed by the Districts used a non-linear regression (2nd order polynomial) to provide a better curve fit. Refer to Appendix D for a comparison of these methods. The Districts' method is more conservative at the UV dosages under consideration and will effectively be used to determine the minimum number of Trojan lamps required for this project.

It should also be noted that Trojan has recently completed testing at the WNWRP for the UV 3000 Plus System with a new lamp manufactured by Heraeus that is predicted to be 25-30% more efficient. It is the Districts' understanding that this test data will be submitted to DHS for approval in the near future. The new lamp will also need to have the factors for lamp life and fouling approved as well. Upon approval, the new lamps would be available for later use at the Whittier Narrows WRP. The new lamps, which currently are slightly shorter, will be able to replace the currently validated lamps either by the insertion of pin connectors or else be manufactured to the same dimensions of the currently validated LSI lamps.

4. UV System Supplier Selection Process

The UV equipment to be used on this project will be pre-selected based on an evaluation of proposals received from Trojan and Wedeco, the two manufacturers that have the experience and qualifications for this application. The proposals will be solicited by an RFP from the Districts. The proposals will be ranked on the basis of a 20-year life cycle cost, including both capital and maintenance expenses. The purchase agreement in the selected proposal will be offered by the System Supplier to the general contractor for the installation contract. Pre-selection of the UV System Supplier is necessary in order to finalize the design with regards to number of lamps, number of banks, channel dimensions, electrical requirements, appurtenant buildings and cleaning equipment, as these requirements can change from manufacturer to manufacturer. Pre-selection will expedite the overall procurement and construction process while also allowing the Districts to maintain tighter control over the procurement process.

5. Design Criteria

a) General

The UV Disinfection System Design Criteria is summarized in the following table:

Table 3.

Total Number of UV Reactor Trains	4
Peak Dry Weather UV Flow	21.0 MGD[1]
Peak Wet Weather UV Flow	24.2 MGD[2]
Typical Daily Low UVT	71%
Lowest Expected UVT	69%
Minimum UV Dosage Under Each of the Following Conditions: 21.0 MGD and 71% UVT with Standby[3] 24.2 MGD and 69% UVT without Standby[4]	100 mJ/cm^2

1. Corresponds to a peak sanitary effluent flow of 19.5 MGD with sidestreams.
2. Corresponds to a peak storm flow of 23.0 MGD with sidestreams.
3. With one UV train out of service
4. With all UV trains in service.

A discussion of applicable plant flows and UVT's follows.

b) Plant Flows

The WNWRP was the first water reclamation plant built by the Districts and was completed in 1962. It was originally designed for conventional activated sludge treatment (and nitrification) with an average plant capacity of 12 MGD (on an effluent basis), but was later re-rated for an average plant capacity of 15 MGD (with partial nitrification). Due to its relatively small size compared to other plants, and the flexibility of being able to bypass flow without problems, the WNWRP has been used extensively for full-scale research purposes.

During research and subsequent operation in an NDN mode with an MLE configuration (since 1996), it was apparent that the plant was no longer capable of treating an average plant flow of 15 MGD at the higher level of treatment required (incorporating both anoxic and aerobic zones within the same tank volume). Because an NDN system operates at higher MCRTs, oxygen demands and D.O. levels, the existing process air compressors and RAS pumps are undersized. Currently, the plant is being operated with only two of three aeration tanks on line and is treating an average plant flow of approximately 9 MGD.

After the RAS and air systems are upgraded, it is expected that the plant will be capable of treating an average plant flow of 13 MGD. In order to achieve an average plant capacity of 15 MGD, additional secondary clarifiers would be required. There are no plans to do this, since for the time being, Districts' management has decided not to build any more tankage in the Whittier Narrows floodplain. The UV system is being designed based on peak flows (which include any additional flows above the peak effluent flows), and will be capable of disinfecting the peak flows associated with operation at average plant flows of 15 MGD.

The following design flows are proposed for this project:

Table 4.

Plant Effluent Flows	Plant Effluent Design Flow (MGD)	UV System Design Flow (MGD)	UV System Design Flow (Ratio to Average UV System Flow)
Average Flow	13.0	13.5	1.00
Minimum Flow	6.0	6.0	0.44
Peak Sanitary Flow	19.5	21.0	1.56
Peak Storm Flow	23.0	24.2	1.79

Refer to Appendix A for histogram and probability plots of effluent flow data. The more current data shown for the period October 1, 1994 to September 30, 2005 is felt to be more applicable. It can be seen that during dry weather, the peak sanitary flow is less than 19.5 MGD over 99% of the time. Furthermore, during wet weather, the peak storm flow is less than 23 MGD approximately 99% of the time. These flows are the peak plant effluent flows shown in Table 4

above. Note that with all reactors in service at typical UVTs, the UV system will be capable of disinfecting the highest recorded storm flow of the past 20 years (25.8 MGD). Note that this historical peak storm flow is unlikely to be seen in the near future, since much of the JOB sewer flow has been diverted to SJC WRP Stages Two and Three via the construction of the SJC Interceptor.

The WNWRP is technically a scalping plant without solids handling, and as such, sludge and backwash recovery flows are returned to the sewer (ahead of the proposed UV system) for further processing at the JWPCP. Other flows that will not contribute to the plant effluent flow will have to be treated by the UV system. As a result, total amount of flow that will be treated by the UV system is greater than the plant effluent flow. A summary of the internal plant (sidestream) flows, prorated for an average plant effluent flow of 15 MGD, is shown in the following table:

Table 5.

Miscellaneous Plant Flows	Instantaneous Flow (gpm)	Flow Duration	Flow Destination	Instantaneous Flow Contribution to UV at Peak Sanitary Flow (gpm)
Primary Sludge	35	24 hrs/day	To sewer, before UV	0
Waste Act. Sludge	139	24 hrs/day	To sewer, before UV	0
Skimmings	278	24 hrs/day	To sewer, before UV	0
Washwater & CDW[1]	208	24 hrs/day	To UV	144
Norman's Nursery	236	12 hrs/day	To UV	236
Waste Backwash	6700	15 min/bw	To sewer, before UV	0
Filter Draindown[2]	694	30 min//bw	To UV	694
Total Additional Flow to UV[3]				1,074 Approx. 1.5 MGD

Notes:
1. Washwater and CDW (chemical dilution water) are assumed to be recycled at 60%.
2. Current filter draindown of 3 MGD over 10 minutes will be limited to 1.0 MGD over 30 minutes following implementation of UV disinfection.
3. In addition to the plant effluent flow.

The above flows have been added as appropriate to the plant effluent design flows to obtain the UV system design flows in Table 4. Note that it has been assumed that water for Norman's Nursery will not be required during a storm.

c) Plant UV Transmittance (UVT)

Based on an analysis of UVT data collected over the past year and presented in Appendix B of this report, the effluent from the WNWRP typically varies between 72% and 78% UVT on a diurnal basis. This inference can be made from data collected when there was confidence in the on-line UVT analyzer, i.e., when the analyzer results closely matched grab samples analyzed with spectroscopy. Occasionally the on-line UVT data dipped to 70%. Although rare, even lower UVTs were encountered at times, and may have been due to calibration issues with the on-line analyzer. Over the course of the year with the plant in operation, no grab samples were ever analyzed with UVTs lower than 69.0%. A reading of 68.0% was obtained on a UVT grab sample when the plant was off-line for a short time.

Since UV systems need to be designed conservatively, the proposed design UVT at peak sanitary flow will be 71%. A 69% design UVT will be used under peak storm flow conditions. The design UVTs selected should provide for conservatism in the event of:

- an occasional errant industrial discharge or temporary plant upset
- plant operational stress as higher average flows are treated at the plant
- on-line analyzer drift

It should be noted that UV systems do not have a lot of flexibility to ramp down. As a result, care should be taken not to make the design UVT too conservative, which can result in an overdose at lower flows and higher UVTs, as well as increased maintenance and capital costs.

6. UV Equipment Sizing

a) Number of Reactor Trains

As noted previously, four new UV reactor trains will be provided, each capable of treating 7.0 MGD of flow at 71% UVT. This will allow UV system flows of 21 MGD (peak sanitary flows of 19.5 MGD plus sidestreams) to be met with one reactor train out of service. Higher flows per train will be possible when the UVT is greater than 71%, although limited by the allowable reactor train headloss (essentially equal to half the lamp spacing with the lamps of the last bank half submerged). With the standby train in operation at typical UVTs, the UV system will be capable of disinfecting the highest recorded peak storm event. During normal operation, two UV reactors trains should be enough to treat an average plant effluent flow of 13 MGD, with typical UVT's above 70 %.

b) Number of Banks/Modules/Lamps

Each reactor train will be fitted with multiple banks of lamps, with each bank contributing to a measurable amount of headloss. A minimum of two banks is required per NWRI Guidelines. Anywhere from three to five banks will be provided per train, depending on the manufacturers system limitations. Note that system headloss is a particular concern.

From preliminary calculations based on the design conditions discussed previously, assuming four reactor trains, and after assessing headloss constraints, it appears that a four-bank system would be the best configuration for both manufacturers. The Trojan system would have 8 lamps per module and each bank would contain an 8 deep × 7 wide array of 56 lamps for a total of 896 lamps. Wedeco would have 18 lamps per module and each bank would contain a 9 deep × 8 wide array of 72 lamps for a total of 1152 lamps. Refer to Appendix C for preliminary UV equipment sizing determinations.

A summary of these results follows.

Table 6.

Sizing of Trojan and Wedeco UV Systems	Trojan UV 3000 Plus 4-inch	Wedeco TAK55 4.7-inch
Number of Banks	4	4
Bank Lamp Array	8 deep 7 wide	9 deep 8 wide
Total No. of Lamps at Plant Design Condition	896	1152
Required gpm/lamp/bank at Design Condition	86.8	67.5
Headloss for 4 banks at Design Flow	1.73 in	1.57 in
Total Connected Power	224 kW	357 kW
Turndown (2 Banks at Low Power Relative to 4 Banks at Full Power)	30%	25%
Nominal Channel Depth (Lamp Spacing x No. of Vertical Lamps)	32.0 in	42.6 in
Nominal Channel Width (i.d.)	28.0 in	37.4 in

7. Reliability and Redundancy

The NWRI Guidelines require that either a standby train or a standby bank on each train be provided. Otherwise, some sort of contingency plan must be provided for equipment failure. At the WNWRP, reliability and redundancy concerns are addressed by the following:

- A standby reactor train will be available during peak sanitary flow conditions at the design UVT.

- The sodium hypochlorite disinfection system will remain. It will serve as a standby system during peak storm events. This approach will be acceptable to water regulators since any DBPs produced by chlorination during this time will not enter the groundwater recharge operation. It is also possible that the chlorinated flow can be stored in the ES/CCTs if the tanks are not full at the time of the UV system failure.

- There are redundant (two) electrical power feeds that supply the plant.
- The UV system will not normally be operating under limiting conditions of flow or UVT. There will normally be additional banks or trains available.
- The plant influent flow can be varied over a wide range, since the plant is not an "end of the line" plant.
- Secondary effluent can directed to the sewer, except during some storm events.

8. DHS Approvals

a) Reactor Equipment Validation Reports

UV systems are validated to determine disinfection performance over a range of operating conditions (flows/lamp and UVTs). The validation tests are typically conducted in accordance with NWRI Guidelines and must be approved by DHS. The inactivation of a target organism (MS2) is quantified and related to collimated beam studies at known UV dosages. Comparisons of the reactor and the collimated beam inactivation are used to establish the delivered UV dose response of the reactor. The regression equation(s) that is developed in the equipment validation report must be approved by DHS. It is used for reactor sizing and to control the UV system at the target operational dose.

Design and operational allowances must be made for the lamp sleeve cleaning system and lamp age as well. Unless NWRI default factors are used, these issues must be validated and approved by the DHS. This testing generates the fouling factor (FF) and end of lamp life (EOLL - the relative intensity at the end of lamp life) factor, which are also used for reactor sizing and to control the UV system at the target operational dose.

b) Engineering Report

Prior to implementation of the UV disinfection system, an Engineering Report must be submitted to the DHS. An abbreviated report is acceptable if the proposed modifications solely involve the replacement of existing disinfection processes with UV disinfection as long as it provides an evaluation of how the new system will integrate with the new treatment process. Items that the Engineering Report should include are the following:

- The UV disinfection system design basis, including reactor train layout and dimensions
- The specific type of equipment being provided with the equipment validation report appended.
- Monitoring and control description, including the method to determine the operational UV dose
- Water levels, water level control device and velocity ranges

- Sampling information
- UV system reliability features
- Contingency plans for lamp breakage, power interruptions, activation of standby equipment and failure of the upstream treatment processes or UV system.
- Operator training program and O&M plans

The Districts are responsible for filing an engineering report with the DHS and the RWQCB for any material change or proposed change in character, location, or volume of the reclaimed water or its use. This is per Section 13522.5 of the California Water Code and Section 60323 of the California Wastewater Reclamation Criteria. Additionally, the reclaiming agency is responsible for ensuring that all users of reclaimed water comply with the specification and requirements for such use.

c) Field Commissioning Report

Per the NWRI Guidelines, after the UV facilities are complete, a field commissioning report is required to be submitted to, and approved by, DHS. The report summarizes the results of field acceptance testing demonstrating the satisfactory performance of the system.

9. Future UV Facility Expansion

The proposed UV facilities have been laid out with expansion in mind. There is space for additional UV trains to be located between the proposed trains if expansion of an open channel system is required. This could be a consideration if the plant flow is increased or, to a lesser extent, if disinfection or DBP requirements become more stringent in the future.

A more difficult challenge would be posed if the Notification Level (10 ng/L - formerly called the Action Level) of NDMA ever becomes an end of pipe limit. At this point, NDMA destruction would certainly control the design, as NDMA destruction requires many times the power necessary for disinfection. In this case, the open channel systems currently on the market would be inadequate and pressure vessel reactors would certainly be necessary. In addition, it is questionable whether LP/HO lamps would be able to deliver the high UV intensities required in an acceptable footprint. For this reason, the provision of medium pressure lamps in closed vessels might be necessary. Finally, because of the higher headloss associated with the closed vessel reactors, the filter effluent pumps would have to be changed out to pumps capable of pumping higher head. These units could conceivably pump the effluent through the closed vessels and then through the open channel system, if the latter system has any useful life or benefit remaining.

10. Crane Options

Cranes will be provided per manufacturer's recommendations to allow either a module or entire bank to be removed from the channel. Bridge, jib or davit cranes could be provided. The crane

capacity will depend on the number of lamps in one module or the number of modules in one bank. For instance, each Trojan module weighs approximately 110 lbs. If seven modules are installed in a bank, the resulting weight is approximately 950 lbs (includes the bank frame). A half-ton crane should be sufficient for this type of load. Smaller davit cranes could be provided if only modules are to be removed. Space will also have to be allotted in the design for a module and/or bank holder on top of the deck.

5.3 Effluent Conveyance System.

The following section briefly describes how the effluent will be metered and conveyed with the UV Disinfection Facilities Project.

a. Effluent Filters

Filter drain down will be limited to 1 MGD to prevent the UV reactors from seeing large flow fluctuations. Currently, filter draindown occurs rapidly and adds about 3 MGD to the effluent flow. This is equivalent to the filter draining approximately 6 ft, or about 11,500 gallons over the course of 5.5 minutes.

b. Filter Effluent/Backwash Pump Station

The existing filter effluent/backwash pumps will remain in service. After UV disinfection is implemented, the existing pumps will normally be dedicated for effluent pumping only, however, they will provide backup for filter effluent backwashing in the case where the proposed backwash pump is inoperable. The existing filter effluent/backwash pumps may see a slightly increased head because of modifications due to construction of the UV facilities.

c. Metering of Flow to UV

The existing magmeter on the discharge line of the filter effluent pumps, which is not operational at this time, will be replaced. Accurate flow measurement to the UV reactors is necessary to calculate the operational UV dosage. In order to produce a full pipe for metering purposes, either the pipeline downstream of the meter will be restricted, or it will be modified to contain a short vertical section. Alternatively, the flowmeter can be replaced with a magmeter that is able to measure a pipe flowing partially full.

d. UV/CCT Inlet Channel

The UV reactors will be fed from the existing CCT inlet channel (to be redesignated as the UV/CCT Inlet Channel). This inlet channel will have its sidewalls extended vertically for free board and to achieve the additional head requirement for the UV treatment, while maximizing the capacity of the ES/CCTs for reuse storage.

e. UV Reactors

Each reactor train will be fitted with automatic inlet gates (full open/close). The UV reactors can tolerate headloss that is approximately half the lamp spacing from the first bank of lamps to the last bank of lamps. The water level in each reactor will be controlled by an ultrasonic level sensor, so that the lamps in the last bank are at least half submerged for cooling purposes. Level control will be performed by a modulating weir gate (downward opening), which is located at the end of the reactor train. Some head will be lost as flow proceeds over the gate and then freefalls afterwards. The upper limit of the weir gate will be set so that the ballasts of the Trojan system will not be submerged under any condition. A differential pressure (DP) cell monitoring the change in water level from the inlet to outlet of each reactor train will provide flow split characterizations. One DP cell could be provided for each reactor train, or one DP cell could be manifolded to all reactor trains so that flow splits can be more reliably compared. A drain line connection on the effluent end of the UV reactor to the plant sewer will be provided for maintenance purposes.

f. UV Outlet Channel and Effluent Storage Channels

The effluent of the UV reactor trains will fall into the UV Outlet Channel that will direct the effluent to the Receiving Water Channels via the Outlet Channel weir, or to one of the two Effluent Storage Channels for reuse storage via the ES/CCTs. As long as storage volume is available, the UV reactor effluent will not develop the necessary head to overflow the UV Outlet Channel weir and the effluent will preferentially flow to storage in the ES/CCTs. Prior to entering the ES/CCT, hypochlorite (and possibly ammonia) will be added to the effluent to provide the chlorine residual in the reuse distribution system. Mixers and/or mixing tabs will be provided in the Effluent Storage Channels as necessary. Once the ES/CCTs are full, the slide gates in the Effluent Storage Channels will close to prevent the diffusion of chlorine to the water in the UV Outlet Channel.

g. UV Receiving Water Channels/Ultimate Disposal

Once the ES/CCTs are full, the water surface in the Effluent Storage Channels will rise until water overflows the UV Outlet Channel weir. The water will then flow into separate Receiving Water Channels to the existing Dechlorination Channel and then to the pipeline leading to the Effluent Diversion Structure and outfall system.

h. Effluent Storage/Chlorine Contact Tanks (ES/CCTs)

Refer to Part 4.1 of this report.

i. Recycled Water Pump Station.

Refer to Part 4.1 of this report.

j. Norman's Nursery Reuse Pump

The existing reuse pump is a Districts-supplied pump that delivers Title 22 disinfected tertiary effluent to Norman's Nursery, which is located on sub-leased property adjacent to the WNWRP.

The pump takes suction from the end of either or both CCTs, depending on the operational position of the valves immediately south of the dechlorination channel. The suction lines are located approximately 18 inches above ground level and extend through the dechlorination channel into the CCTs. Normally, if both CCTs are in service, both valves are open.

Operation of the Norman's Nursery pump is on an as-needed basis. During dry weather conditions, the nursery plants are watered every other day for approximately 10 hours. An employee from Norman's Nursery enters the WNWRP through an opening in the fence between the adjacent properties and turns the reuse pump on without plant operator involvement. When the watering is finished, Nursery personnel typically turn the pump off.

A meter on the pump discharge line records the total amount of water used for billing purposes. The Norman's Nursery flow is added to other effluent flows to total the WNWRP effluent flow. The reuse flowmeter, and the rights to sell the reuse water, are owned by the San Gabriel Valley Water Company; the same water retailer that will sell the reuse water from the proposed project constructed by USGVMWD (the local water wholesaler) to the Whittier Narrows Dam Recreation Area.

Table 7. Existing Norman's Nursery Reuse Pump

Reuse Water System	Number	Capacity Each	TDH	Horsepower	Total Additive Capacity
Norman's Nursery Pump	1	250 gpm	260 ft	30 HP	250 gpm

5.4 Sodium Hypochlorite/Sodium Bisulfite System.

a. Existing System

Existing disinfection at the WNWRP is accomplished by chloramination, using sodium hypochlorite as the source of chlorine. The sodium hypochlorite is delivered as a 12.5% Cl2 solution and stored in two elevated storage tanks. Two different modes exist for the chlorine addition, pre-chlorination and post-chlorination. Pre-chlorination, where chlorine addition occurs upstream of the effluent filters is preferred to post-chlorination, where it occurs downstream of the effluent filters. In addition to disinfection, pre-chlorination reduces the biological growths and the associated increased headloss that tend to produce filter blinding. In the pre-chlorination mode, the hypochlorite flow is injected and mechanically mixed into the secondary effluent in the chemical preconditioning tank, where alum is also added. Immediately upstream of the preconditioning tank, a small amount of ammonia is added and blended into the secondary effluent. This is done in order to form chloramines (instead of having a free chlorine residual) upon addition of hypochlorite. This is necessary because practically all ammonia is removed in the existing nitrification/denitrification activated sludge process at the WNWRP. Free chlorine enhances the formation of trihalomethanes, which are unwanted and regulated disinfection byproducts.

Following chlorination and gravity filtration, flow is pumped by the filter effluent pumps into the two existing chlorine contact tanks. The effluent flow then passes through the existing common Dechlorination Channel, where it is dechlorinated with an excess of sodium bisulfite. Dechlorination is necessary so that residual chlorine, which is harmful to aquatic life, does not reach the receiving waters. The plant effluent is then discharged via pipeline to the effluent diversion structure where the flow can be directed to the Rio Hondo or San Gabriel River. In addition, a small portion of the plant effluent is pumped directly from the CCTs without dechlorination to Norman's Nursery, which is located to the north and east of the plant.

The existing disinfection facilities include an aqueous ammonia storage tank, sodium hypochlorite storage tanks, pre-chlorination mixers, post-chlorination mixer, chlorine contact tanks, sodium bisulfite storage tanks and associated metering systems to adequately dose and control chemical flows. Design criteria associated with the existing disinfection facilities are listed in **Table 8**.

Table 8. Existing Chlorination/Dechlorination System Design Criteria

CHLORINE CONTACT TANKS	
No. of Tanks	2
No. of Passes per Tank	5
Length of Tank	131.00 ft
Inside Width of Tank	42.25 ft
Average Water Depth	15.74 ft
Volume of Two Tanks	1,303,000 gal
Contact Time at Avg. Plant Flow (15 MGD)	125 min
Contact time at Peak Sanitary Flow (20 MGD)	94 min
Contact time at Peak Storm Flow (25 MGD)	75 min
Drain Pump	180 gpm @ 25 ft TDH, 3 HP
SODIUM HYPOCHLORITE TANKS	
No. of Tanks	2
Capacity per Tank	15,250 gal
Usable Volume per Tank	14,000 gal
Tank Dimensions	14 ft diameter, 13.25 ft height
Type of Feed	Gravity
Solution Strength	12.5% as Cl2
SODIUM BISULFITE TANKS	
No. of Tanks	2
Capacity per Tank	8,000 gal
Usable Volume per Tank	7,200 gal
Tank Dimensions	11 ft diameter, 11.25 ft height
Type of Feed	Gravity
Solution Strength	25%
AMMONIA TANK	
No. of Tanks	1
Capacity per Tank	6500 gal
Usable Volume per Tank	5500 gal
Tank Dimensions	10 ft diameter, 11.0 ft height
Solution Strength	19.5%
Type of Feed	Pumped
Feed Pump	Variable Speed Peristaltic, 0.0 to 0.1 gpm

a. Proposed System

1. Disinfection of Adenovirus

For a discussion of the epidemiological concerns associated with adenovirus, refer to Appendix E.

a) Dosage Requirement

The Districts cannot typically achieve the 450 CT requirement (the product of the chlorine residual in mg/L and contact time in minutes = 450 mg/L-min) and the 90-minute modal contact time at reuse facilities. In lieu of meeting these requirements, the Districts have historically performed virus testing on a monthly basis for the past 20 years to show that viruses are not present in the effluent. To date, after numerous samples disinfected by chlorination, there have only been 2 positive virus tests. Although implementation of a UV system should make the CT requirements moot issues, the virus testing is written in the recharge permit and therefore will be necessary for some time after the implementation of UV. In order to achieve non-detectable virus levels, a multi-barrier disinfection approach will be implemented. In addition to the UV irradiation, the effluent will be chlorinated at a low dose of approximately 0.5 to 1.5 mg/L as chlorine. At these low levels, there will be insufficient contact time to produce DBPs. The utilization of chlorine as a disinfectant inherently poses a risk of occasional residual exceedances, especially due to equipment and instrumentation malfunction. This risk will still exist at the low chlorine dosage necessary for adenovirus inactivation, but the risk should be smaller since UV will be the primary disinfectant. However, it may be advisable to operate with a low dose of bisulfite constantly being fed into the system (setup to dechlorinate approximately half the dose of chlorine applied), when it is sensed that the ES/CCTs are full and flow proceeds to the receiving water.

b) Contact and Detention Time

It is also necessary to achieve a minimum contact time of the chlorine with the effluent. Although the modal contact time (MCT) is probably the most applicable parameter when it comes to contact time, the hydraulic detention time (HDT) can be used as a measure of the upper limit of the MCT. At a chlorine dosage of 0.5 to 1.5 mg/L, it is estimated that an HRT of approximately 5 minutes would be needed to guarantee complete inactivation of adenovirus. Since the volume of the channels and the UV reactor trains is relatively fixed (except that the total volume of the reactor trains is a function of the number of reactors on-line) chlorine dosage concentrations will have to be maintained by the DCS to keep the mathematical product of chlorine dosage concentration and contact time in an acceptable range. If the product is too high, the DBPs may increase; if it is too low, adenovirus may not be sufficiently inactivated.

The actual detention time that can be assigned to the UV reactors will ultimately depend on the selected UV manufacturer and ultimately, the volume of the UV reactors. At the peak sanitary flow plus sidestreams of 21 MGD, the filter effluent flume and Filter Effluent Pump Station wetwell contribute 0.22 and 2.76 minutes of detention time, respectively. The wetwell suffers

from hydraulic problems (it more closely resembles a continuously stirred tank reactor, or CSTR, rather than a plug flow reactor). The ES/CCT Inlet Channel that feeds the UV reactor will provide an additional 1.25 minutes of contact time assuming that 40% of the channel volume is available (this percentage is a function of the channel hydraulics and the particular UV reactor trains that are in service). At the design flow of 21 MGD, approximately 0.56 minutes of detention time will be experienced in the three UV reactor trains. This estimate is approximate and is based on a four bank per train system, after accounting for the volume of the sleeves and mounting brackets. By adding up all these contributions, a detention time of 4.8 minutes is obtained at 21 MGD. Note that there will be some contact time in the effluent channels after the UV system, prior to dechlorination. Contact time determinations are presented in Appendix E.

Another option would be to chlorinate at the existing pre-chlorination point. While this scheme would provide enough contact time, it is probably not advisable to add chlorine ahead of the effluent filters on a long-term basis due to DBP formation. This option would almost certainly ensure that there would be no residual remaining at the point of dechlorination. Another option would be to reserve some of the volume of the contact tank for adenovirus inactivation, but unfortunately this is at the expense of valuable reservoir storage.

c) Proposed Additional Controls

In the future, the Districts may want to consider installing oxidation/reduction potential (ORP) probes to better control low-level disinfection. Although chlorine dosage can be approximated with good metering, the strength of hypochlorite is not constant and fluctuations in ammonia may cause the disinfection system to switch back and forth between free chlorination and chloramination, thus affecting the disinfection of adenovirus. According to White's Handbook of Chlorination, ORP is a measure of disinfection regardless of chlorine species. ORP control may be the best method to control at low chlorine dosages, while also reducing the amount of chemical used and the quantity of DBPs formed.

2. Standby Disinfection for the UV System

The existing ability to add sodium hypochlorite as a primary means of disinfection will be retained to serve as a backup or standby system when the UV system is down. Hypochlorite addition will also be used when the UV system capacity is exceeded in a storm event (typically with one or more UV channels out of service) or when the UVT of the effluent falls to a value outside the validated range of the UV equipment.

3. Chlorine Residual for the Irrigation Reuse Distribution System

a) General

After applying a low chlorine dosage to all of the plant effluent for adenovirus disinfection, and following disinfection of all the plant effluent with UV, the effluent directed to irrigation reuse will be chlorinated with hypochlorite to provide a residual in the effluent storage/reuse distribution system. Chlorine residual is desirable to prevent biological growth in the distribution system. If these growths are not prevented, there could be odors associated with the reuse water,

increased frictional resistance in the reuse pipeline (leading to higher power requirements) and plugging of irrigation nozzles. Injection of hypochlorite also helps to keep the ES/CCTs free of biological growths, which can harbor coliform bacteria and also contribute to problems with bacterial regrowth. It is necessary to keep the ES/CCTs relatively coliform free, since the ES/CCTs will be used for contact time when the WNWRP is in standby chlorination mode.

Although providing a chlorine residual for the irrigation reuse water after UV disinfection at first seems counterintuitive, it should be noted that the Districts' treatment process will be considered complete and designated "end of pipe" immediately after the UV process. The UV effluent will be sampled for monitoring and reporting purposes to determine compliance with all permits (reuse, reclamation and receiving water). Downstream of the sampling point, the effluent will be discharged either to receiving waters for possible groundwater recharge or diverted to reuse storage in the ES/CCTs after chlorination. This scheme is acceptable from a regulatory perspective.

The reuse chlorine residual being provided by the Districts is really a service that the Districts are performing for, and at the expense of, USGVMWD. This arrangement allows the Districts to recoup some of the capital costs associated with the chlorination facilities, which must be kept fully operational as standby for the UV system. The Districts will also benefit in that a portion of the chlorinated water will be used for plant washwater purposes (not billed to USGVMWD).

b) Free Chlorine Versus Chloramination

The reuse purveyor has requested that a free chlorine residual be provided. After considering the environmental impacts, the Districts have decided to provide an option for chloramination as well. Since the reuse water may initially be stored in the ES/CCTs approximately 12-14 hours, a free chlorine residual may result in elevated THMs to the first reuse customer. In order to discourage THM formation, aqueous ammonia will be added (approximately 2 mg/L) to produce a chloramine residual. Although chloramination can be expected to result in NDMA formation, NDMA will be less of a concern for irrigation water than THMs, since NDMA is primarily an ingestion hazard, while THMs can also be an inhalation hazard. The chloramine will also result in a longer lasting and more stable residual than the free chlorine. Furthermore, since the amine portion of the chloramine reverts back to ammonia when the chlorine dissipates, the water will actually have a small fertilizer value for plants. Capability for ammonia addition will be provided in the Effluent Storage Channels going to the ES/CCTs and blended with mixers or mixing tabs.

Because of the uncertainty of continued ammonia addition in the future, it is not recommended at this time to upgrade the existing aqueous ammonia storage tank at the WNWRP to the standards of other recently constructed ammonia facilities at other WRPs. This means the existing fiberglass tank, which is vented to the atmosphere and provided with PVC piping, will not be changed to pressurized (unvented) carbon steel vessels and piping.

c) Proposed Chlorine Mixers

Sodium hypochlorite will be injected in the Effluent Storage Channels before the UV disinfected water drops into the ES/CCTs. It is anticipated that some mechanical flash mixing may be necessary during certain operating conditions. When the ES/CCT water levels are low, mixing of the hypochlorite should occur as a result of the turbulence associated with the drop from the channel above. However, when the ES/CCTs are relatively full, the hydraulic mixing associated with the drop is expected to disappear. Because of this, a 10-15 HP chemical flash mixer will be provided in each Effluent Storage Channel and will be operated automatically when the water in the ES/CCTs reaches a certain level.

4. Filter Growth Control

Hypochlorite piping and solenoid controls will be provided for each filter so that the filter can be chlorinated during the air scour portion of the backwash cycle. With the implementation of UV disinfection, pre-chlorination (the addition of chlorine before the effluent filters) will be discontinued. In order to prevent biological growths from blinding the filters and creating headloss problems and excessive backwashing, the filters will need to be shocked dosed with hypochlorite solution on an intermittent basis (approximately once or twice per week). This would probably be most effective during the air purge of the backwash cycle. At this point in the cycle, the filter has been drained so that the water surface over the bed is at its lowest point. This will reduce the hypochlorite requirement. The dosage requirement is expected to be around 50 ppm as Cl_2. The air scour should provide good mixing so that all the media is contacted. It may also be beneficial to increase the scour part of the cycle to increase the contact time. Since chlorination of organics is known to increase DBP's, this water will be wasted to the sewer, via the backwash recovery wetwell and pump station, for ultimate treatment at the JWPCP.

5.5 Effluent Filter Backwash System.

a. Existing System

The existing filter effluent pumps provide the filter backwash capability at the WNWRP. These pumps are always operated to maintain a set point level in the pump station wetwell. Approximately 13 mgd is needed for a backwash. If the plant flow is 13 MGD or above, the backwash portion of the effluent flow is directed to the filter being backwashed. If the plant flow is less than 13 mgd, additional "make-up (recirculation)" water is pulled from the CCTs, via the CCT Inlet Channel. This make-up water flows by gravity through a manually operated sluice gate in the side of the pump station wetwell. This water is then pumped with the rest of the backwash water to the filter being cleaned.

In addition to the local, on-off backwash valve for each filter, the system depends on two automatically positioned valves as follows. At the onset of a backwash, in the discharge pipeline from the pump station, a distribution valve goes to a set position to increase the system pressure. This is necessary to develop the head necessary for backwashing. A backwash pipeline to the filters originates from the pump station discharge pipeline upstream of the distribution valve. The master backwash valve in the backwash pipeline modulates to deliver the required flow to the filter being cleaned.

b. Proposed System

During normal operation, the three existing filter effluent/backwash pumps will be used for effluent pumping only. A dedicated backwash pump will utilize water that has been UV disinfected and stored in the ES/CCTs. Utilizing water taken downstream of the UV reactors will prevent the reactors from seeing large flow fluctuations. By using a stored water source, it will be possible to backwash at required flowrates at lower plant flows. Since the water entering the ES/CCTs will be chlorinated, and because hypochlorite will be added to the filters during the backwash cycle, waste backwash water will not be recovered (recycled to the plant) but instead will be wasted to the sewer (an approximate average of 0.3 MGD if individual filter backwashing is performed every 48 hours). This is consistent with the Districts' promise to the RWQCB that backwash at the WRPs will not be recycled, since it was discovered that backwash contains large amounts of NDMA.

The following are backwash pump design options:

- Provide a dedicated backwash pump inside CCT No. 2
- Provide a dedicated canned backwash pump inside CCT No. 2 (west)
- Provide a dedicated canned backwash pump on west side of CCT No. 2
- Install a backwash line off of the Recycled Water Pump Station discharge line and provide pressure reduction
- Provide a dedicated canned backwash pump at the empty pump bay at the Filter Effluent Pump Station with suction line connected to the CCT No. 2.

Other options for the pump were considered, but are considered to be less desirable. These options included putting the new backwash pump at the Recycled Water Pump Station, as well as remotely locating the pump but taking suction from the Recycled Water Pump Station through a pipeline.

The preferred alternative for the proposed backwash pump is to provide a dedicated pump inside CCT No. 2. The discharge piping will be hung on the west side of the CCT, along the top of the filter effluent pump discharge manifold, and then connected and valved to the existing backwash piping. A dedicated standby pump will not be provided. Instead, the existing filter effluent/backwash system will be used as standby in case the dedicated backwash pump is not available. Operation of the aforementioned recirculation valve into the filter effluent wetwell will no longer be required.

Table 9. Proposed Backwash Pump Design Criteria

Water System	Number	Capacity	TDH	Horsepower
Backwash (BW)	1	10,250 gpm	25 ft	100 HP

The actual head requirement for the backwash pump will be verified by field-testing the system curve for the backwash piping and media expansion. In addition, since the level of the ES/CCTs will vary due to reuse storage and utilization, it may be beneficial to provide a VFC on this pump to handle the varying head requirement.

5.6 In-Plant Process Water System.

a. Existing Systems

There are four existing process water systems at the WNWRP that utilize plant effluent for various in-plant needs. These are the foam spray, washwater, chemical dilution water and firewater systems.

1. Foam Spray

The existing foam spray system has been out of service for many years and currently is not functional. It formerly supplied water for aeration tank foam control. Prior to NDN operation, the WNWRP was operated in a different activated sludge mode with aeration of the return sludge at the beginning of the aeration tanks. Because complete nitrification was not necessary, foam in the aeration tanks was eventually controlled by reducing the MCRT (thinning the mixed liquor). When the mode of operation changed to NDN, the increased MCRT associated with this process once again led to foam problems. This time the foam problem was controlled by continuous cationic polymer addition into the return sludge. This was opposed to the former operation where polymer addition was implemented occasionally during high SVI episodes. Because cationic polymer is manufactured from NDMA precursors, and chloramination of precursors were linked to NDMA formation during disinfection, the WNWRP was operated without polymer for a length of time. After going two months without cationic polymer addition the foam reappeared, and polymer addition was reinstituted, albeit at a reduced amount. Currently, there are no plans to make the existing foam spray pumps operational.

2. Washwater System

The existing washwater system supplies water for hose bibs, polymer make-up and secondary clarifier water sprays. Washwater is also used for plant irrigation during early morning hours, when operators are not typically using the system for other purposes.

3. Chemical Dilution Water System

The chemical dilution water (CDW) pumps are not currently operated as a separate system, as there is very little need for chemical dilution and considerably more need for washwater pressure. One CDW pump is currently run in parallel with one washwater pump, and both pump into the CDW and washwater discharge headers. CDW needs at the plant have diminished since dry polymer, gaseous chlorine and sulfur dioxide have been replaced with other chemicals. Currently sodium hypochlorite is gravity fed at full strength into the secondary effluent for chlorination. Alum is trickled into the secondary effluent at full strength before filtration to meet RWQCB requirements for coagulation. The only current chemical dilution water need is for

polymer make-up and polymer carrying water. The polymer make-up need is estimated to be 20 gpm for 15 minutes every 12 hours. The polymer carrying water is approximately 7-10 gpm and added on a continuous basis.

4. Firewater

The existing firewater system consists of a single draft hydrant connected to Chlorine Contact Tank No. 2 (west tank). It was designed so that a fire truck (pumper) could hook up to the hydrant and pump the tertiary effluent to fight a fire. Since the existing system operates with the contact tanks running full, having enough water available to fight a fire has never been an issue.

In summary, in-plant process water systems at the WNWRP are not generally utilized at the capacities for which they were designed.

The following design criteria applies to the existing in-plant process water systems:

Table 10.

Process Water System	Number of Pumps	Capacity Each	TDH	Horsepower (each pump)	Total Additive Pump Capacity
Foam Spray (FS)	2	450 gpm	50 ft	7.5 HP	900 gpm
Washwater (WW)	1	100 gpm	230 ft	15 HP	780 gpm
	2	190 gpm	213 ft	25 HP	
	1	300 gpm	240 ft	30 HP	
Chemical Dilution Water (CDW)	2	400 gpm	260 ft	40 HP	800 gpm
Firewater*	0	-	-	-	-

*Note that the firewater system is composed of a single draft hydrant with pumping supplied by the Fire Department

b. Proposed Systems

1. Foam Spray, Washwater and Chemical Dilution Water

As part of the Recycled Water Pump Station project, the existing FS/WW/CDW suction line connection into the Dechlorination Channel is being modified. The line will now connect to the Recycled Water Pump Station wetwell, which will become the normal supply. A connection will also be made to the UV Outlet Channel, where this connection will be used to prime the washwater pumps in the case where the ES/CCTs are drawn down too far and there is a loss of prime. Continuous operation of the washwater pumps is necessary since washwater is used for cooling of the process air compressors. In the future, the Miscellaneous Plant Modifications project will provide new process air compressors that will most likely be air-cooled, negating the need for continuous washwater flow.

2. Firewater

The existing firewater supply connection in the west CCT will be augmented by a new connection off of the discharge line from the Recycled Water Pump Station. The ES/CCT drawdown by the Recycled Water Pump Station will be limited by the firewater design criteria to supply 1250 gpm for 2 hours (150,000 gal) along with 300 gpm of washwater for 3 hours (54,000) for a total reserved storage volume of 204,000 gal. It should be noted that this is a conservative allowance based on firewater requirements for pressurized systems. The WNWRP has one draft hydrant (unpressurized) and actually has lower firewater requirements due to the rural area in which it is located.

3. Polymer Make-Up and Dilution Water

UV disinfected (unchlorinated) water will be provided for polymer make-up and dilution. Chlorinated water will be used during the hypochlorite mode of operation. A new suction line will be provided to a proposed low capacity, chemical dilution pump in the blower building. The discharge of this pump will be connected to the existing CDW piping leading to the polymer facilities. Chlorinated water will be used occasionally as a back-up, through the existing CDW connection to the existing washwater and existing CDW pump discharge piping.

5.7 Sampling System.

a. Existing System

The existing final effluent sampling consists of an automatic 24-hour composite sample for routine analyses taken from the exit end of the Dechlorination Channel and a daily grab sample for coliform taken from the effluent end of one CCT. The composite sample is pumped and the grab sample is taken with a grab pole. The laboratory prefers the use of peristaltic pumps when samples have to be pumped.

Chlorine residual is measured after the flow leaves the CCTs and then again after the dechlorination process.

b. Proposed System

One of the challenges of the proposed UV flow scheme is that there will not be a channel or structure that combines all the effluent at all times after UV treatment. After UV irradiation, water will be directed to either the Receiving Water Channels or the ES/CCTs for storage of reuse water. To demonstrate that the WNWRP has produced acceptable water meeting the reuse, recharge and receiving water permits, a single 24-hour composite sample for routine analyses will be collected automatically from the outlets of all operating UV reactor trains. Samples from each operating train will flow through hydraulically similar lines to a sample trough containing a peristaltic pump. The pump will be controlled to provide a flow weighted composite sample. Each train sample line will be provided with a solenoid valve that will be open whenever the reactor train is on-line. The sample trough will be provided with an overflow to the ES/CCTs or plant sewer.

Since the effluent flow will receive a small chlorine dose for adenovirus control upstream of the UV reactor, the chlorine residual will be monitored just downstream of the existing CCTs, as with the current operation. Once the water in the ES/CCTs reaches a high level, the bisulfite system shall meter an overdose of bisulfite based on the flow measured at the diversion structure and assuming an operator-adjustable setting for chlorine residual. If the operator-adjustable setting is ever exceeded, as evidenced by the reading from the existing chlorine residual analyzer prior to dechlorination, then the bisulfite overdose shall be based on the reading from the analyzer instead. Theoretically, there should not be a measurable chlorine residual from the UV reactors, due to the small amount of chlorine that will be applied. As before, the final effluent going to the receiving water will be monitored for chlorine residual by an existing analyzer to make sure that there is no chlorine residual being discharged.

A grab sample for coliform will be taken once per day from one or more operating UV reactors.

When the hypochlorite system is utilized in standby mode, the existing sampling system will be utilized. Sampling system switchovers may require some manual intervention by the operator.

5.8 Electrical System.

a. Existing Plant Electrical Power Supply

The WNWRP is supplied electrical power by a dual power feed system. There are two Southern California Edison (SCE) Substations (Mesa and Brookline) that can feed the plant. An automatic transfer switch transfers the plant connection from one power supply to the other if the on-line connection experiences a failure. Additionally, there are two emergency standby power generators provided at the plant. A 110-volt generator supplies power to the Control Room and a 440-volt generator supplies power to operate the JO "B" Gate when there is a total loss of power from the grid (SCE).

b. Recycled Water Pump Station Power Feed

The Recycled Water Pump Station, currently being constructed for the USGVMWD, will be supplied by a separate feed coming from one of the two existing Edison power feeds. It will not be connected to any of the plant switchboards and will have its own meter for billing purposes. The pump station will not be powered by the dual power feed system, since the Districts pay extra for this uninterrupted supply. The reuse pumps will be operated mainly at night. As a result, the annual 8-hour shutdown for Edison maintenance, which occurs during the daytime hours, should not be a problem. Since the WNWRP is protected by the dual power feed system, it is possible that the Recycled Water Pump Station might not be operational due to a failure at its power supply, while the rest of the plant is operating normally. If this occurs, flow will continue to be stored in the ES/CCTs until they are full and then flow will be discharged to the receiving water.

c. Electrical Power Requirement

Trojan 3000 Plus LPHO lamps use 250 watts per lamp. Assuming 896 lamps are required for the design flow and UVT, the total power required is 0.22 MW. Wedeco's LPHO lamps use 310 watts per lamp. Assuming 1152 lamps are required for the design flow and UVT, the total power required is 0.36 MW. These loads can be accommodated by the plant's current electrical system. Additional power of about 0.11 MW will be required to operate the proposed backwash pump. The proposed chlorine mixers will also require a small amount of additional power.

d. Miscellaneous Electrical and Instrumentation

As a minimum, the following electrical/instrumentation work items will be required:

- Switchboard for UV system
- UV reactor software programming, indication and controls
- Electrical connection for proposed backwash pump
- Proposed backwash pump software programming, indication and controls
- Software programming, indication and controls for shock dosing of filters during backwashing
- Power for possible air conditioned enclosure to house Wedeco's ballasts and controls
- Integration of water level indications with flow and level controls. Addition of interlocks
- Filter effluent flowmeter
- Power and control for miscellaneous sampling modifications
- Additional lighting as required
- Controls for adenovirus chlorination

e. Power Failure Scenarios

1. Total Plant Power Failure

Because of the existing dual source of power from SCE, a total plant power failure is less likely to occur. If this should ever occur, however, any system in the plant requiring pumped flow or utilizing electrical energy (influent, effluent, RAS, mixed liquor recirculation, backwash and water system pumps along with process air compressors) will cease to operate. Under these conditions, the plant is out of service and no flow will enter or leave the plant. Power for the UV system is not necessary at this point since the flow that was being pumped into the WNWRP will continue down the JO "B" sewer to the JWPCP. The JO "B" gate downstream of the plant, powered by the standby generator, will be opened fully to better bypass flow around the WNWRP. Once power is restored and the UV lamps are allowed to warm up, flow can be UV disinfected and routed to reuse storage or discharged to the receiving water. Water that may be trapped in the UV system and inadequately disinfected can be diverted to the plant sewer before startup of the UV system.

2. Localized Power Failure

An in-plant single point power loss could be experienced by the UV system. Because of protections built into the overall disinfection scheme, a decision has been made not to provide a dedicated standby source of power for this event. Instead, interlocks will stop the filter effluent pumps and the UV reactor train inlet valves will close. Existing operation of the plant is such that although the influent pumps continue to pump with the filter effluent pumps off, the secondary effluent flow will eventually back up ahead of the filters and overflow to the JO"B" sewer.

If a localized power outage to the UV system is experienced, and it is imperative that the plant be operated to reduce the hydraulic load on the sewer downstream, operators can switch to the standby disinfection mode (sodium hypochlorite addition, preferably post-chlorination at first, to minimize the gap in disinfection). If inadequately disinfected effluent is contained in the ES/CCTs, and does not exit the plant to the receiving water or through the Recycled Water Pump Station, calcium hypochlorite pellets can be added and the plant flow bypassed to enable chlorine contact time before discharge.

6. PROJECT COST

Costs for this project include procurement of the UV equipment, modification of the CCT structures for the UV channels and conveyance, provision of a dedicated backwash pump, provision of chemical mixers, provision of a small chemical dilution water pump and appurtenant electrical equipment and controls.

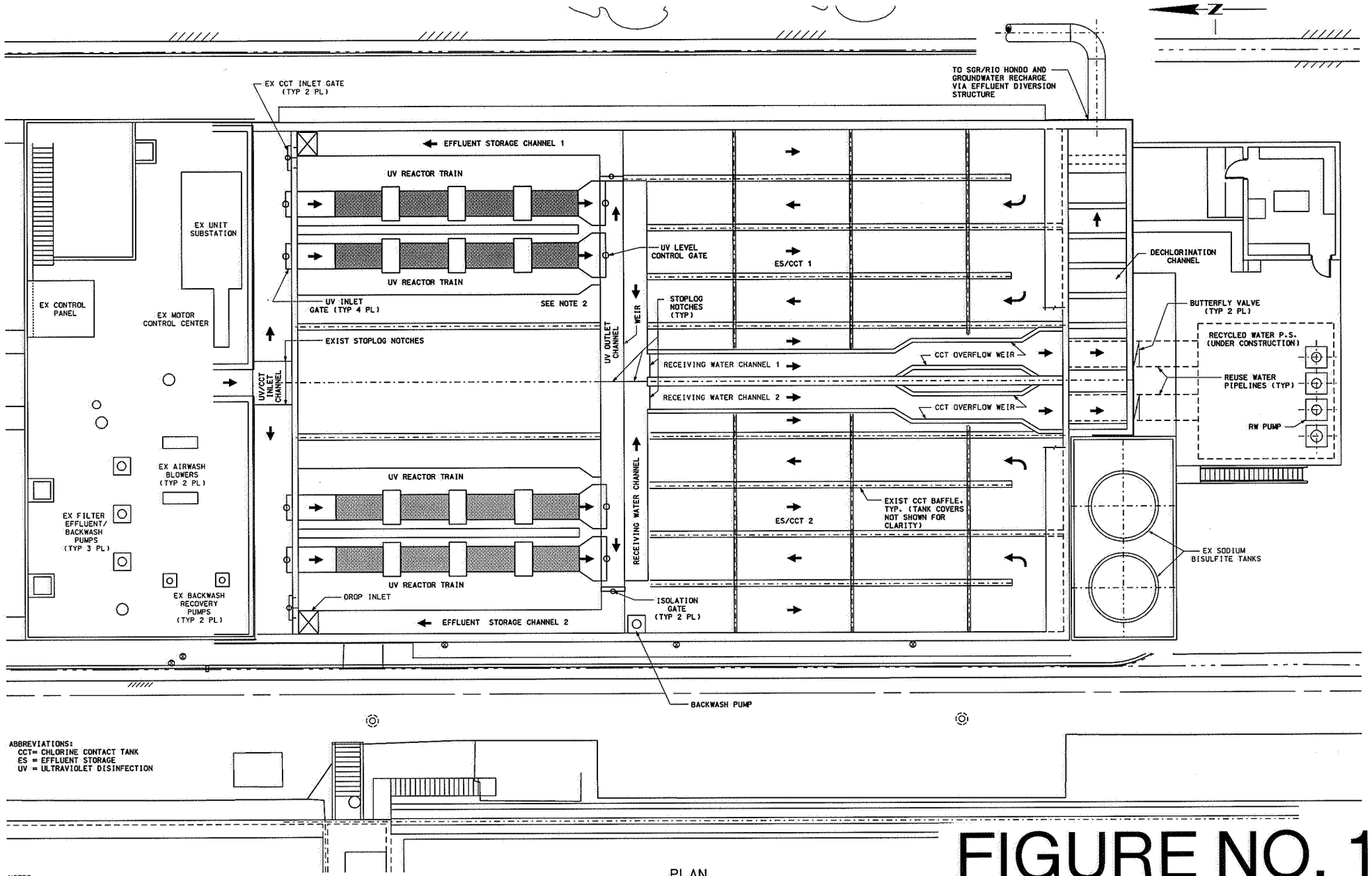
This project may receive grant funding as a result of Proposition 50. The Districts are in the first step of a multi-step grant application process in which a 50% matching grant has been requested. Since the Proposition 50 grants are watershed based, a number of potential projects have been

lumped together for review and rating purposes. One stipulation that may be unattractive is that legal remedies may be limited if money is received from the State. This may make the acceptance of grant money less attractive, if it prevents exercising the Districts' right to litigate NDMA regulatory issues in the future.

Costs associated with this project are listed in the following table:

Table 11. Cost Estimate for the WNWRP — UV Disinfection Facilities Project

Budget Category	Districts Share	State Grant Share	Total
Direct Project Administration Costs	$5 K	$5 K	$10 K
Planning, Design, Engineering and Environmental Documentation	$200 K	$200 K	$400 K
Construction and Implementation	$2,600 K	$2,600 K	$5,200 K
Environmental Compliance, Mitigation and Enhancement	$10 K	$10 K	$20 K
Construction Administration	$200K	$200K	$400K
Construction and Implementation Contingency	$260 K	$260 K	$520 K
Total	$3.275 M	$3.275 M	$6.55 M



ABBREVIATIONS:
CCT= CHLORINE CONTACT TANK
ES = EFFLUENT STORAGE
UV = ULTRAVIOLET DISINFECTION

NOTES:

1. ALL GATES ARE TO BE AUTOMATED.
2. ES/CCT'S CONTINUE UNDER UV TRAINS.

PLAN
SCALE: 1/8"=1'-0

FIGURE NO. 1

WARNING 1" IF THIS LINE IS NOT 1" LONG, THEN DWG IS NOT TO SCALE.

COUNTY SANITATION DISTRICT NO. 2
OF LOS ANGELES COUNTY, CALIFORNIA

	INITIALS	DATE
DESIGNED		MAY 2005
DRAWN		MAY 2005
CHECKED		MAY 2005
REVIEWED		MAY 2005

REVISIONS | NO. | FIELD BOOK NO. | REFERENCE DWG. NO./CMB NO.

WHITTIER NARROWS WATER RECLAMATION PLANT
U. V. DISINFECTION FACILITIES

SCHEMATIC OF PROPOSED FACILITIES

SCALE:
SHEET NO.
DWG. NO. J0-g-1141

12/7/2005 2:06:27 PM rrocela

R:\WN\J0G1141\m\114pmpstapln.dgn

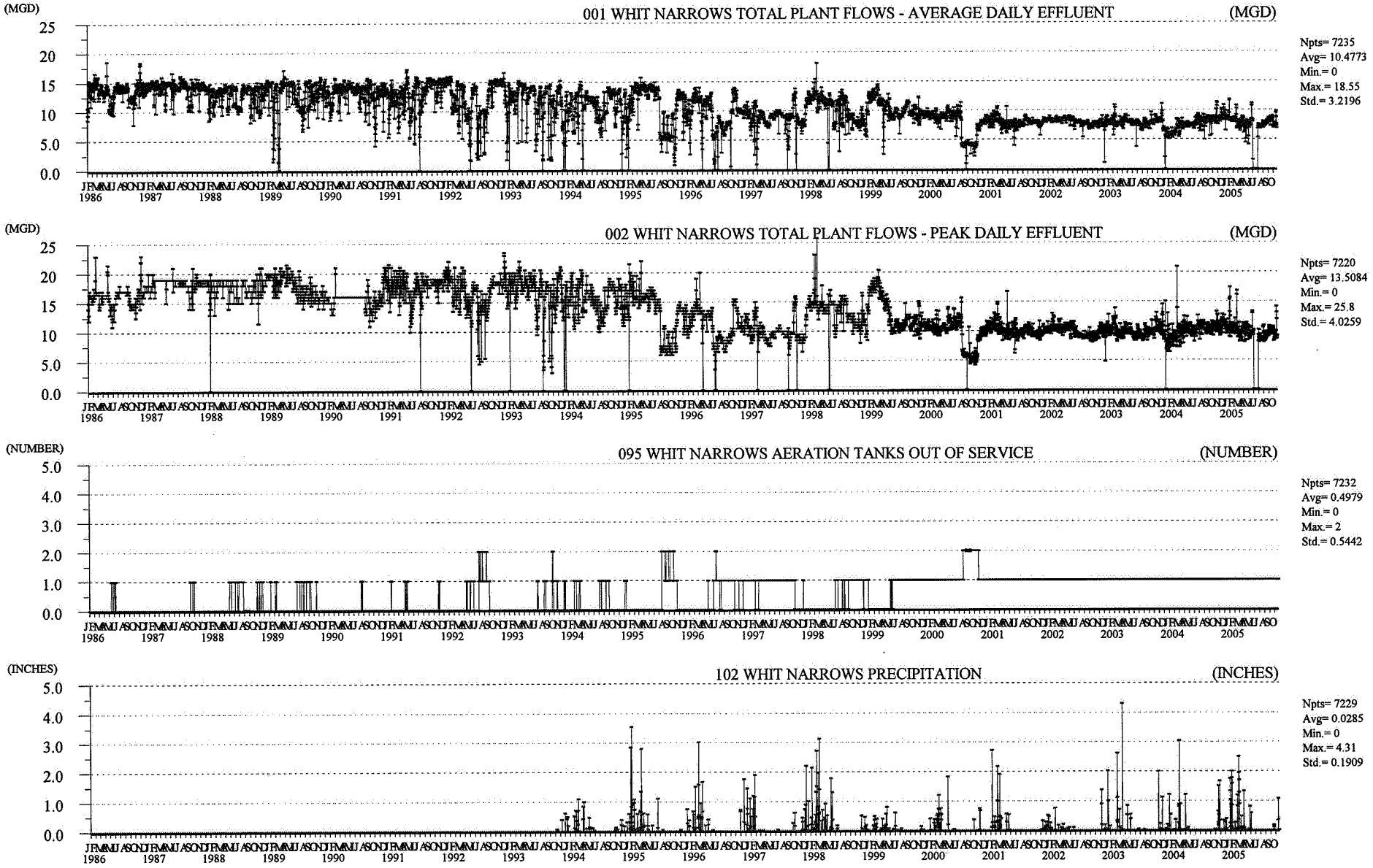
Appendix A

WNWRP Historical Wastewater Characteristics

WNWRP Historical Wastewater Characteristics					
Characteristic	Units	1 yr. Daily Avg. (2004)	5 yr. Daily Avg. (2000-2004)	5 yr. Daily Min. (2000-2004)	5 yr. Daily Max. (2000-2004)
Avg. Effluent Flow	MGD	7.8	7.8	0	11.4
Peak Effluent Flow	MGD	10.2	9.9	0	20.9
Raw TSS	mg/L	243.7	283.5	115.0	556.0
PE TSS	mg/L	103.5	99.8	58.0	176.0
SE TSS	mg/L	4.8	4.5	< 1.0	64.0
FE TSS	mg/L	1.1	1.1	< 1.0	3.0
Raw BOD5	mg/L	219.3	247.9	120.0	633.0
PE BOD5	mg/L	153.5	158.9	101.0	275.0
FE BOD5	mg/L	3.1	2.5	< 1.0	10
BOD Removal	%	98.6	99.0	98	99
Raw TCOD	mg/L	482.7	541.3	243.0	986.0
PE TCOD	mg/L	331.7	314.8	135.0	503.0
SE TCOD	mg/L	26.8	25.7	12.0	74.0
FE TCOD	mg/L	22.8	21.8	9.0	42.0
FE Soluble COD	mg/L	21.0	20.0	7.0	41.0
TCOD Removal	%	95.4	96.0	84.5	97.7
PE NH3-N	mg/L	24.4	24.1	14.0	33.6
SE NH3-N	mg/L	1.1	1.2	< 0.1	8.3
FE NH3-N	mg/L	0.8	0.9	< 0.1	3.1
FE NO2- N & NO3-N	mg/L	6.1	5.6	3.1	7.8
FE Org-N	mg/L	1.7	1.7	< 0.1	4.8
FE Tot N-N	mg/L	8.6	8.5	5.5	12.3
Raw pH	pH	7.6	7.6	6.6	9.4
FE pH	pH	7.5	7.3	6.7	7.7
Temperature	oF	76	76	66	84
FE Turbidity	NTU	1.04	0.96	0.4	2.2
FE Turb. - Daily Max	NTU	1.09	1.03	0.1	3.1
Precipitation	in/yr*	19.1*	14.8*	7.8*	4.3 in/day

* Yearly average, minimum and maximum, respectively. Daily maximum precipitation was 4.3 inches

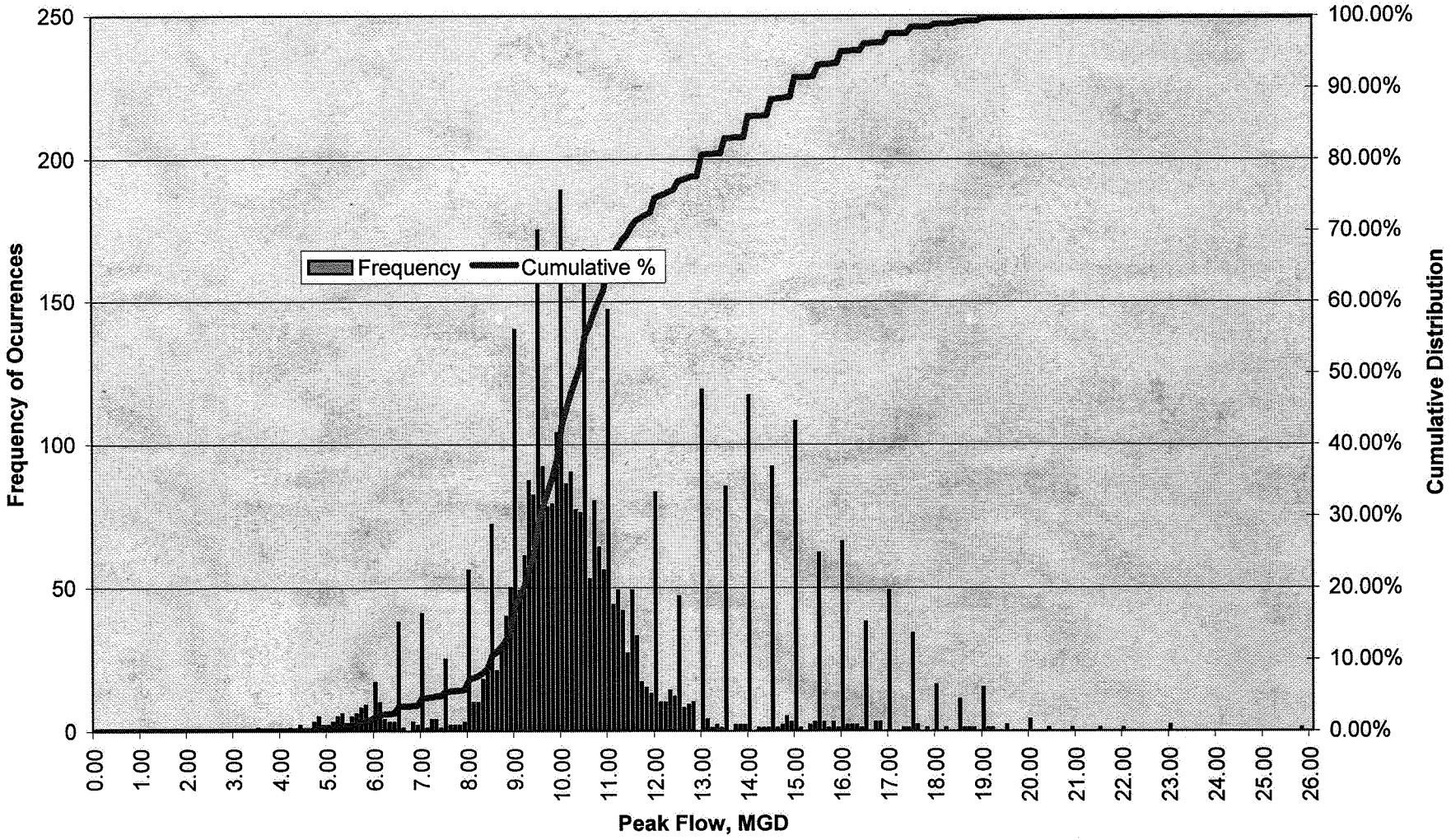
WHITTIER NARROWS WRP
(JAN 1, 1986) - (OCT 22, 2005)
7235 Days



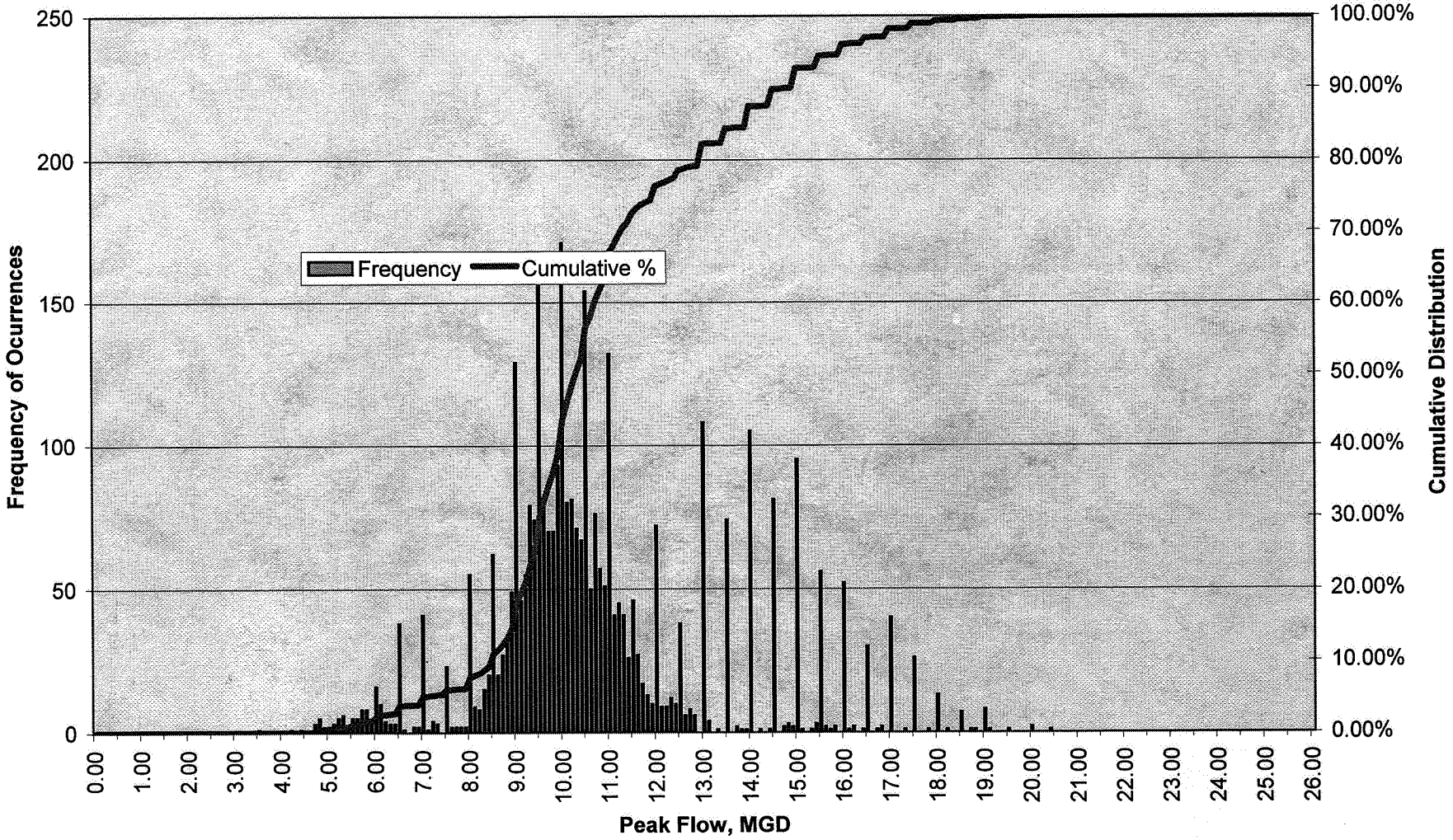
1- Custom

Run Date = 10/23/2005 20:02
Plot Date 10-27-2005 11:35:24

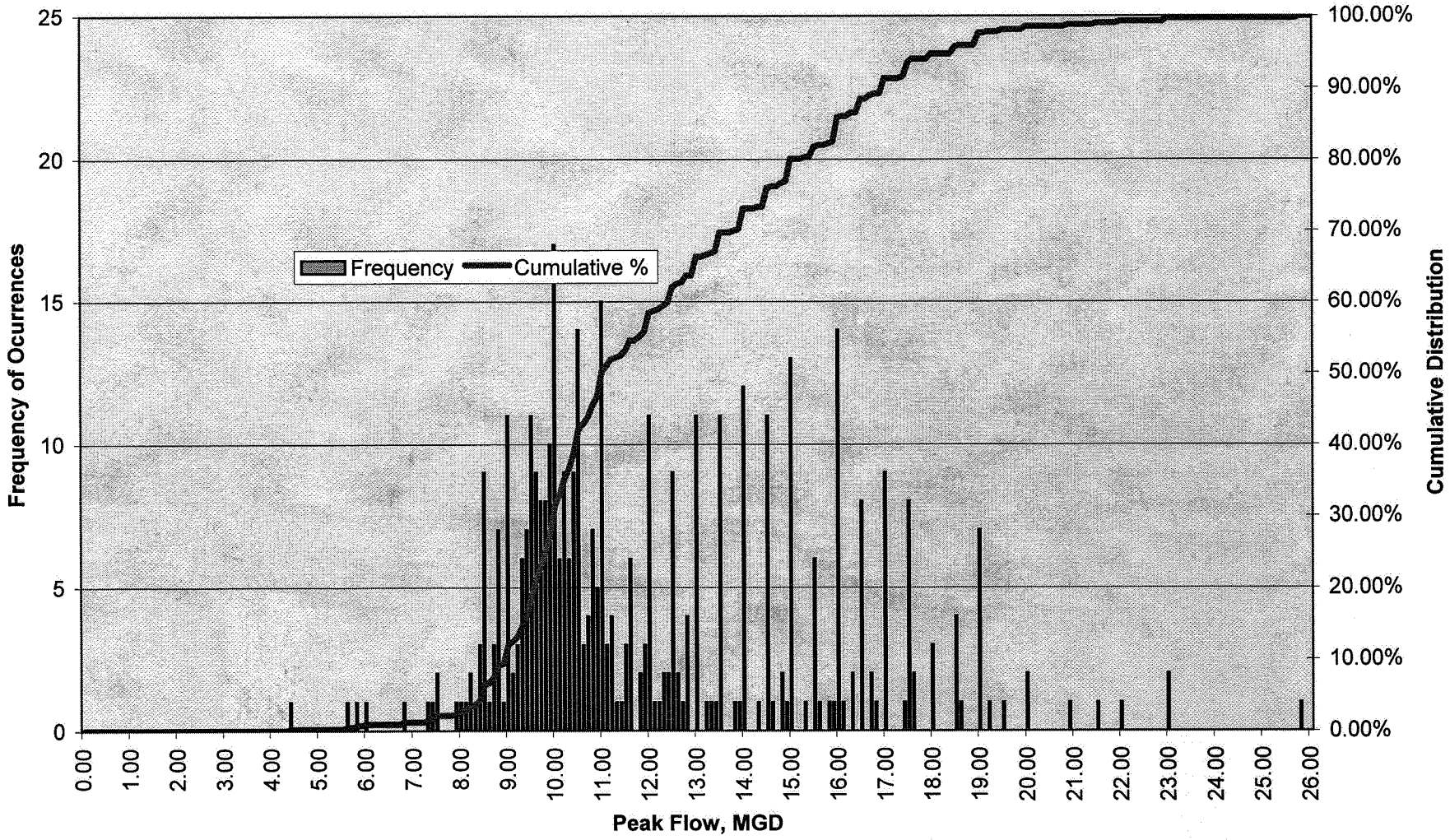
Histogram and Probabiltiy Plot
of All WNWRP Peak Flows
From 10/1/94 to 9/30/05 (11 yrs. - 3976 Pts)



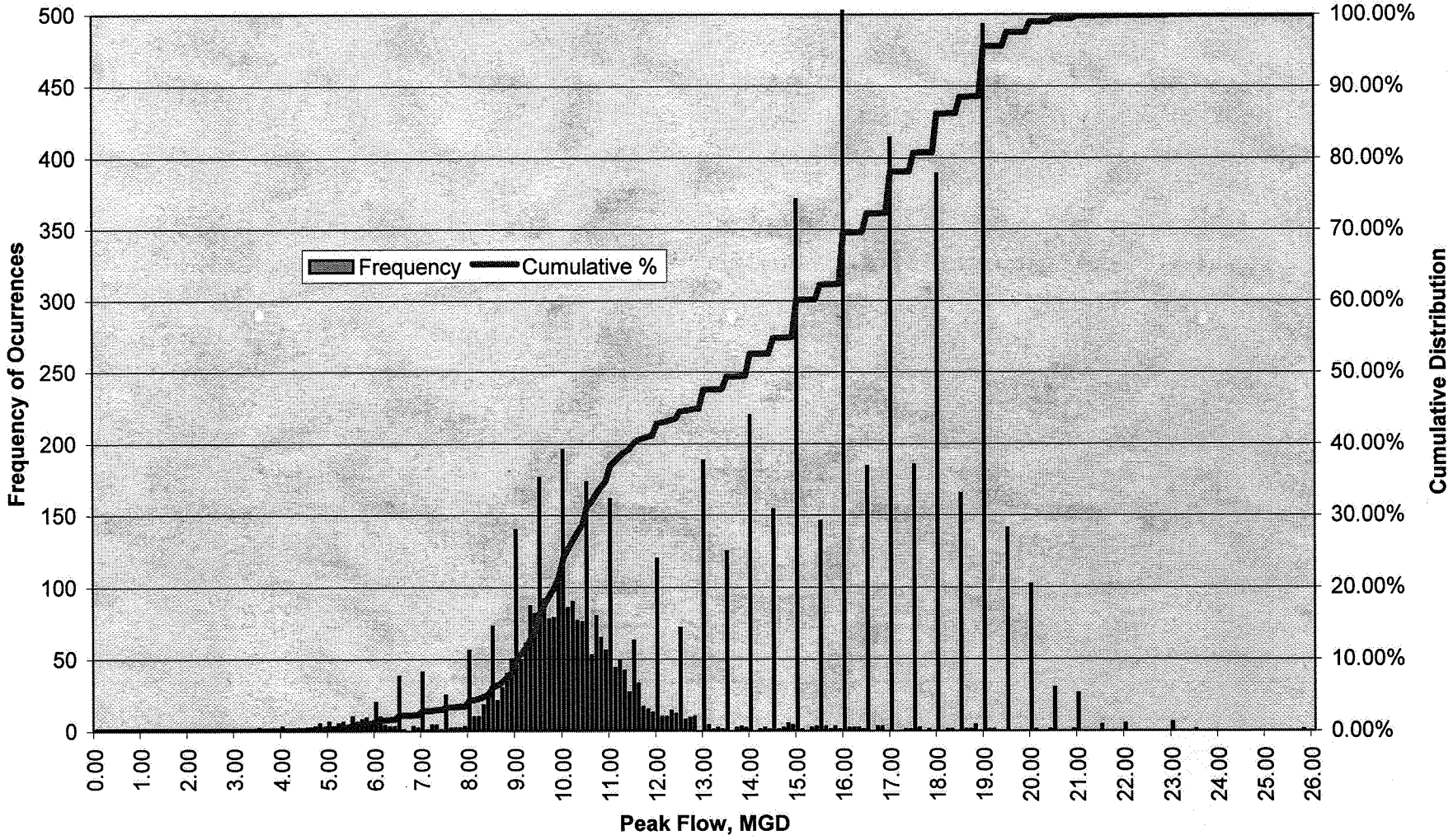
Histogram and Probabiltiy Plot
of WNWRP Peak Dry Flows
From 10/1/94 to 9/30/05 (11 yrs - 3545 Pts)



Histogram and Probabiltiy Plot
of WNWRP Wet Weather Peak Flows
From 10/1/94 to 9/30/05 (11 yrs - 416 Pts)

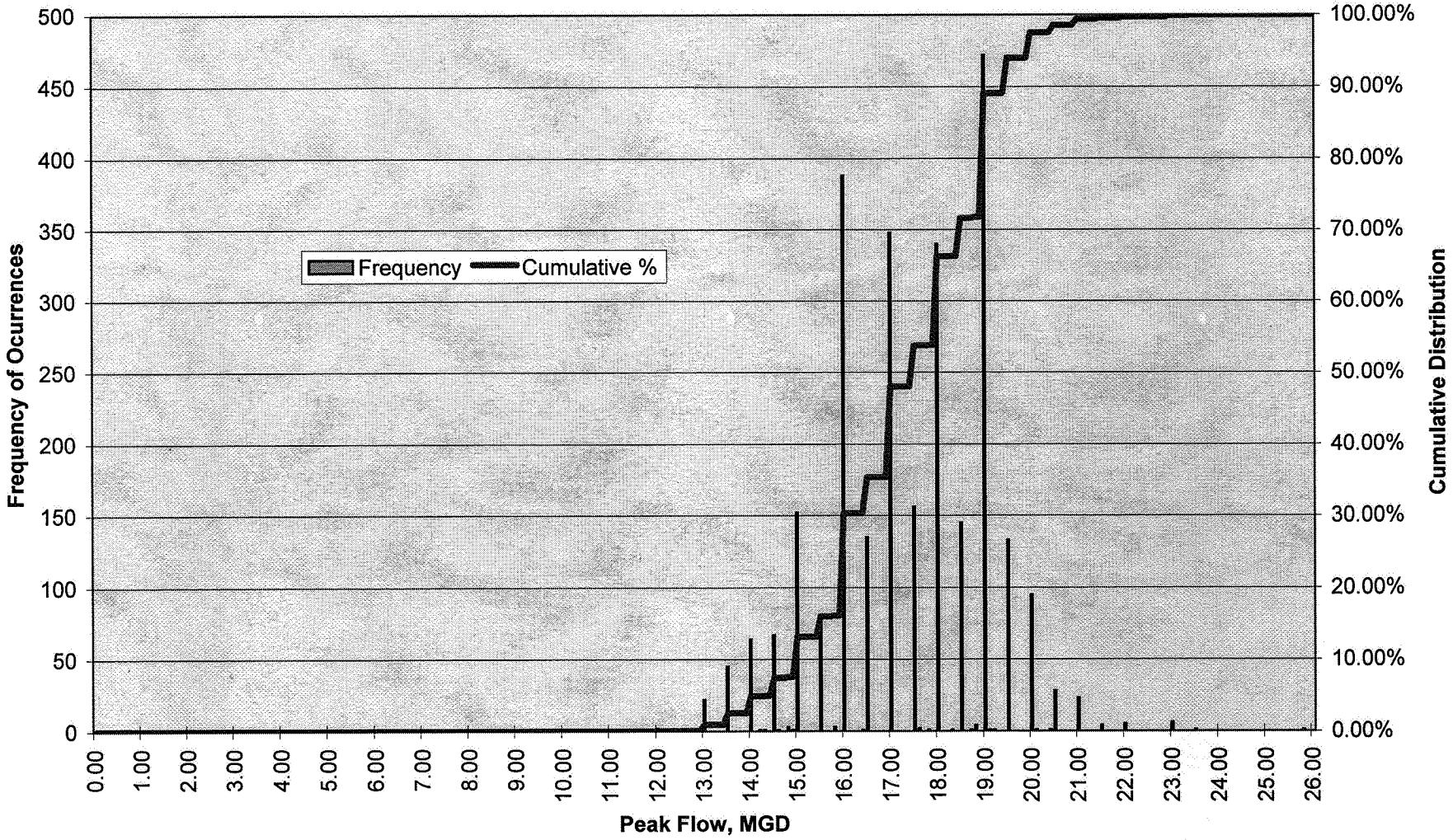


Histogram and Probabiltiy Plot
of All WNWRP Peak Flows
From 1/1/86 to 10/15/05 (19.75 yrs - 7148 Pts)



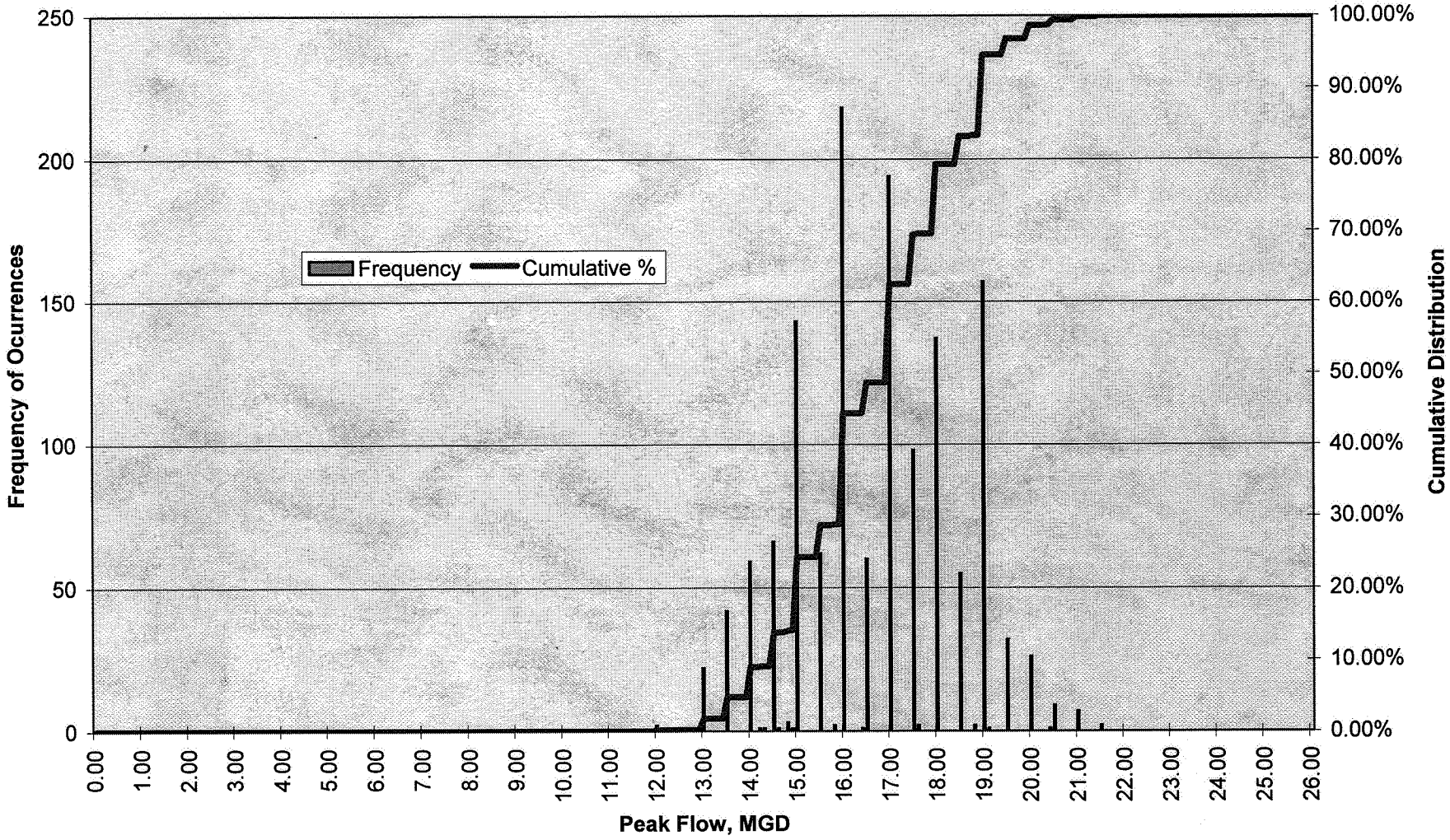
WN Peak Flow Data Analysis2.xls / All Peaks

Histogram and Probabiltiy Plot
of WNWRP Peak Flows with Average Flows > 12 MGD
From 1/1/86 to 10/15/05 (19.75 yrs - 2736 Pts)



WN Peak Flow Data Analysis2.xls / >12 MGD

Histogram and Probabiltiy Plot
of WNWRP Peak Flows with Average Flows > 12 and <14 MGD
From 1/1/86 to 10/15/05 (19.75 yrs - 1408 Pts)



Appendix B — WNWRP Filter Effluent UVT Data

General

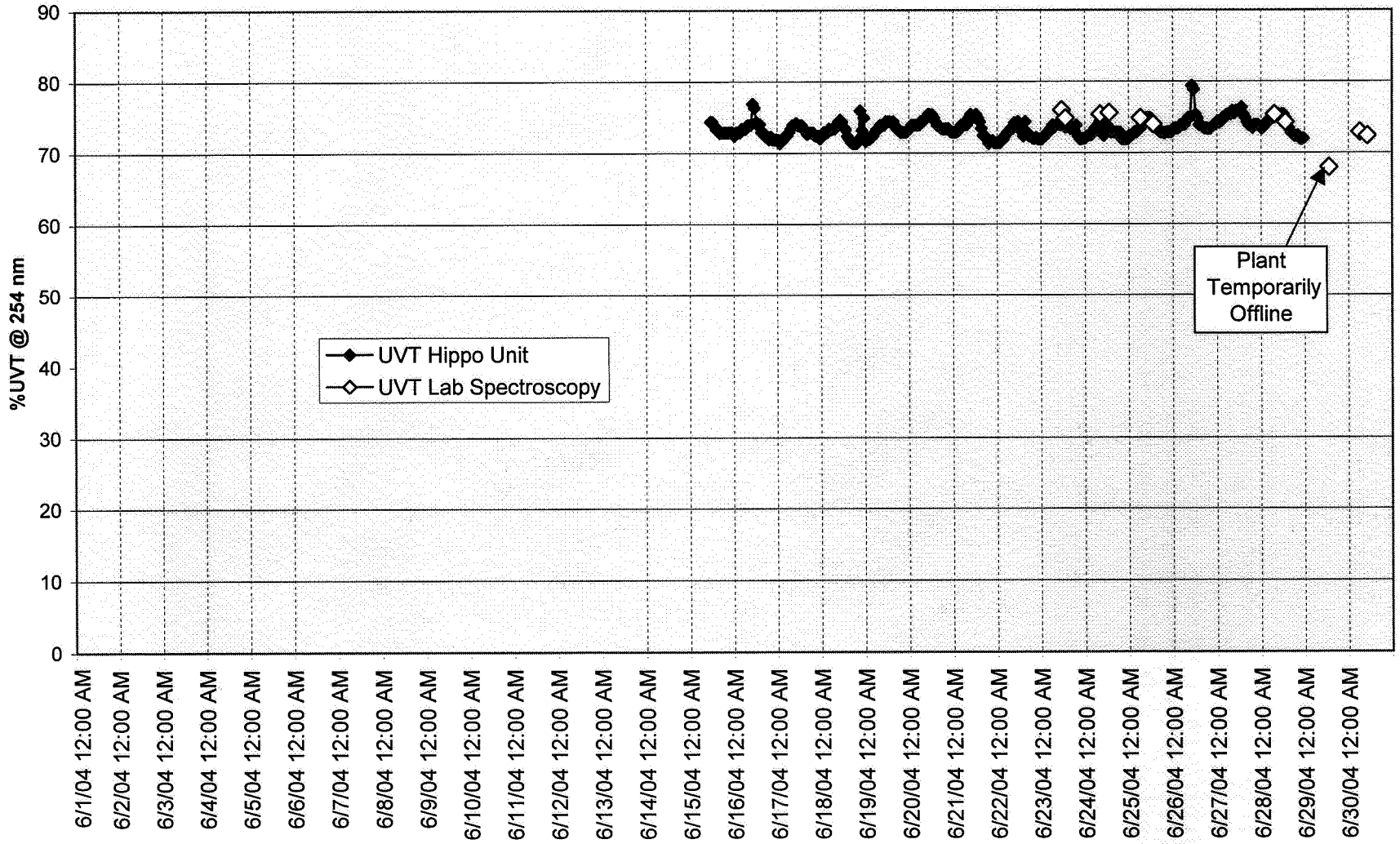
The data contained in Appendix B is mainly derived from Wedeco's On-Line UVT Analyzer (Hippo Unit). Since the number of sample points generated by the unit were too numerous to easily plot, an Excel macro was written to "grab" the UVT on the hour. Limited grab samples were also taken and brought to the Whittier Narrows WRP Laboratory for analysis by spectrophotometry. Most of the time, the two methods of analyses gave similar results, which lent confidence in the Hippo Unit's results. However, it is clear from the data for October and November 2004 and January 2005 that this was not always the case. During these months, the Hippo Unit often provided lower UVTs than the grab samples.

Note that the Hippo Unit had to be sent back to the factory on separate occasions for extended periods. The first time was for lamp replacement. The other times were due to calibration issues. Eventually Wedeco instructed the Research Section on how to field-calibrate the unit. This procedure worked for a while until the range of the adjustment screw proved inadequate. Subsequently, the Districts have lost confidence in the Hippo Unit. The Districts are currently in the process of evaluating other on-line analyzers, but to date, no units have proven to be satisfactory.

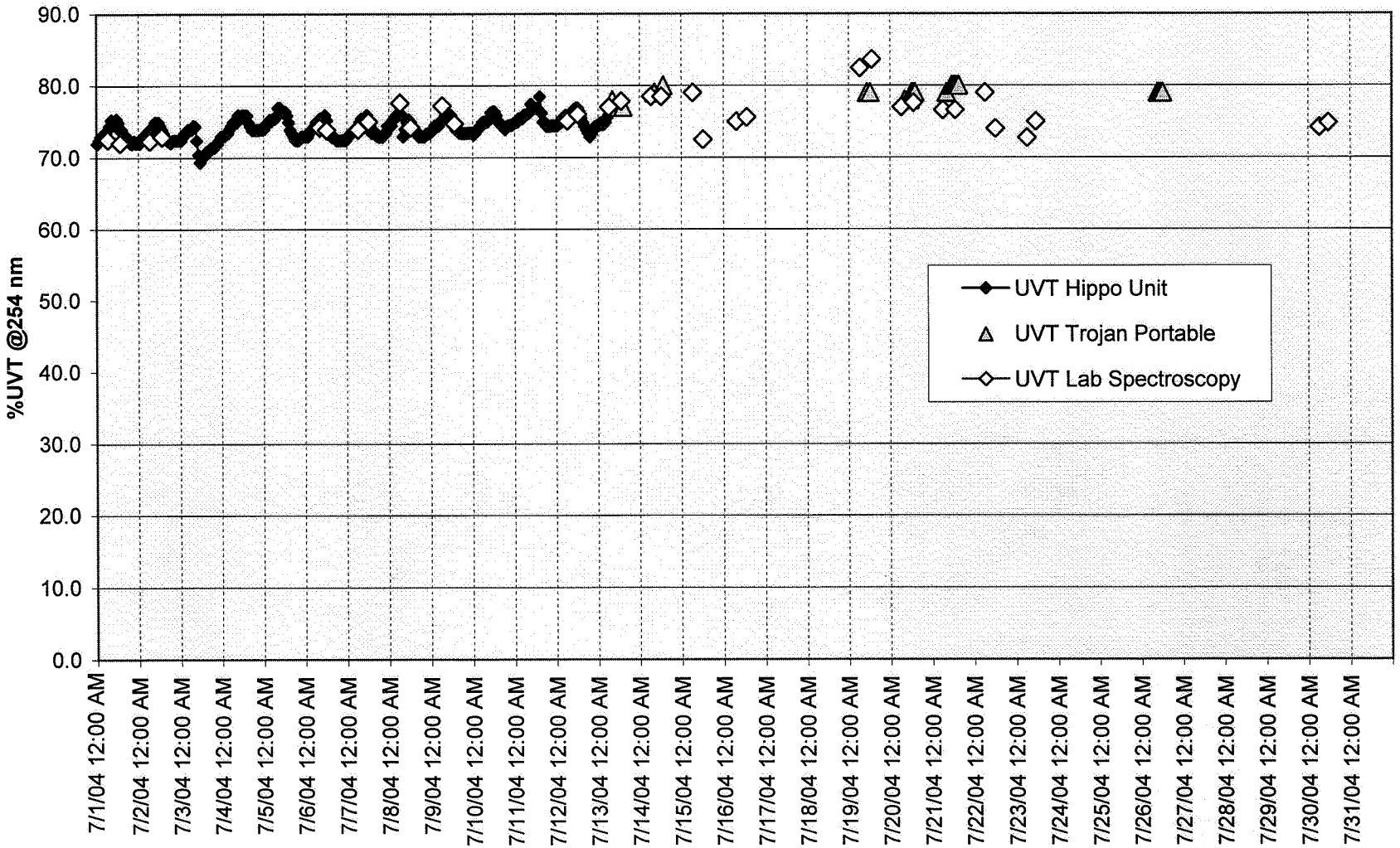
In the latter stages of evaluating the Hippo Unit, there was some discussion about whether the UVT was dropping dramatically during the evening/morning hours when the WNWRP was unmanned. After the Hippo Unit was decommissioned, special sampling was instituted with an ISCO sampler to take hourly grabs. At this point in time, the UVT data from the ISCO grab samples do not support the major swings in UVT results that were sometimes observed with the Hippo Unit. This probably means that the erratic results from the Hippo Unit were equipment or sampling related.

Based on an analysis of all results obtained to date, the lowest (most conservative) expected effluent UVT would be 69% with a normal low diurnal UVT of 72%. The 10^{th} percentile of acceptable Hippo data was calculated to be 71.3%.

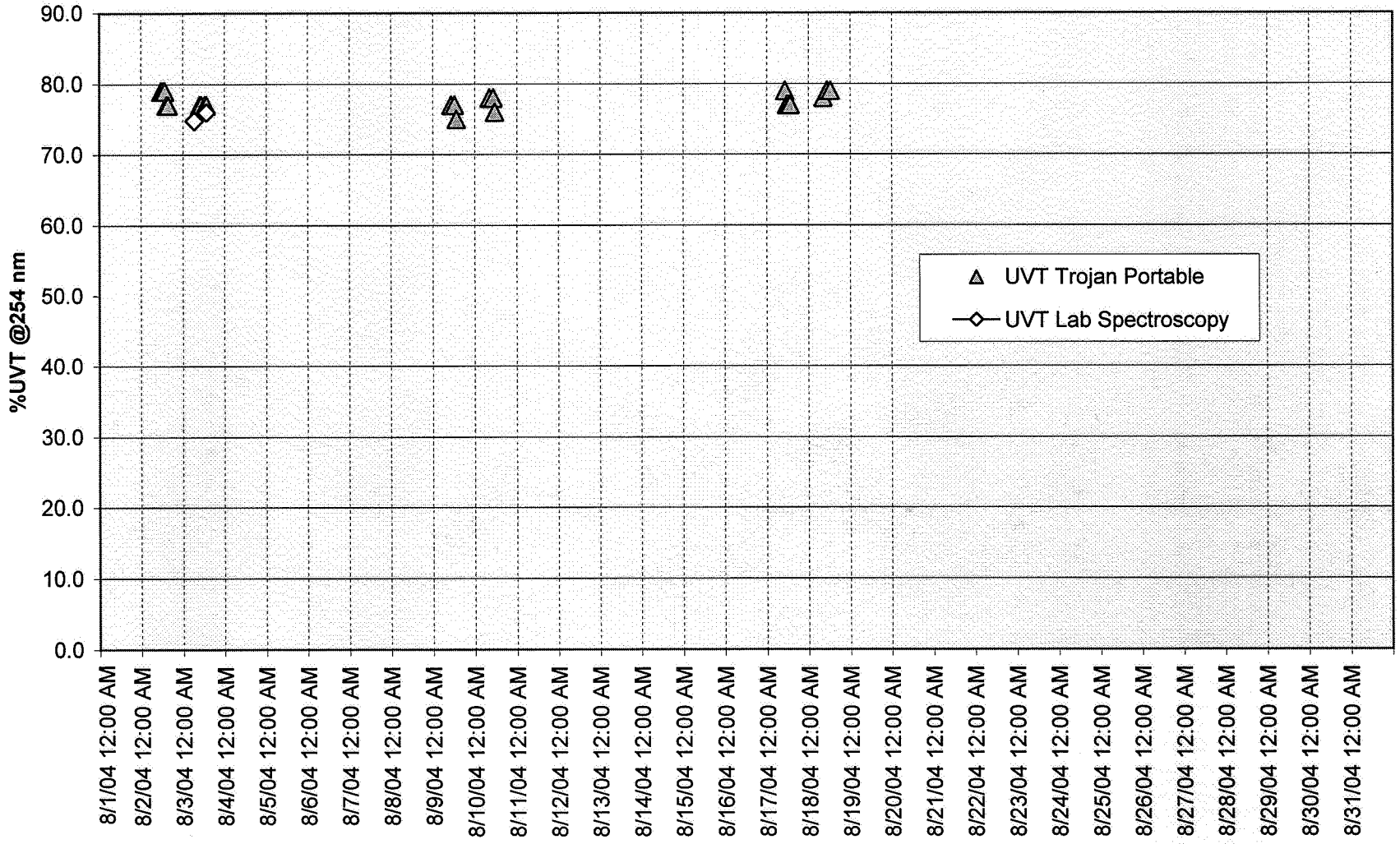
Wedeco On-Line (Hippo) Analyzer UVT Data Taken on the Hour
with Laboratory Grabs
June 2004



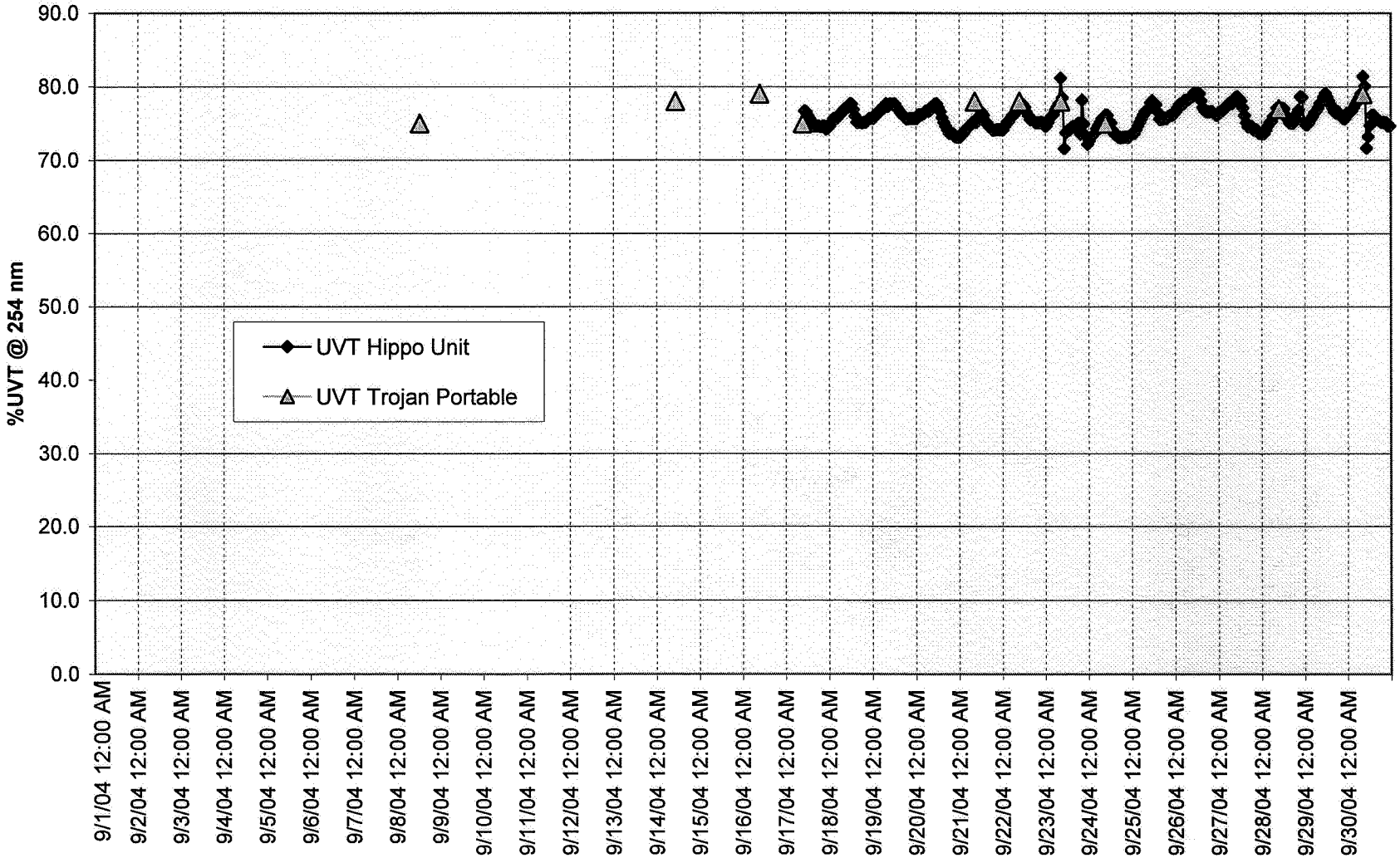
Wedeco On-Line (Hippo) Analyzer UVT Data Taken on the Hour with Trojan Portable Unit and Laboratory Grabs July 2004



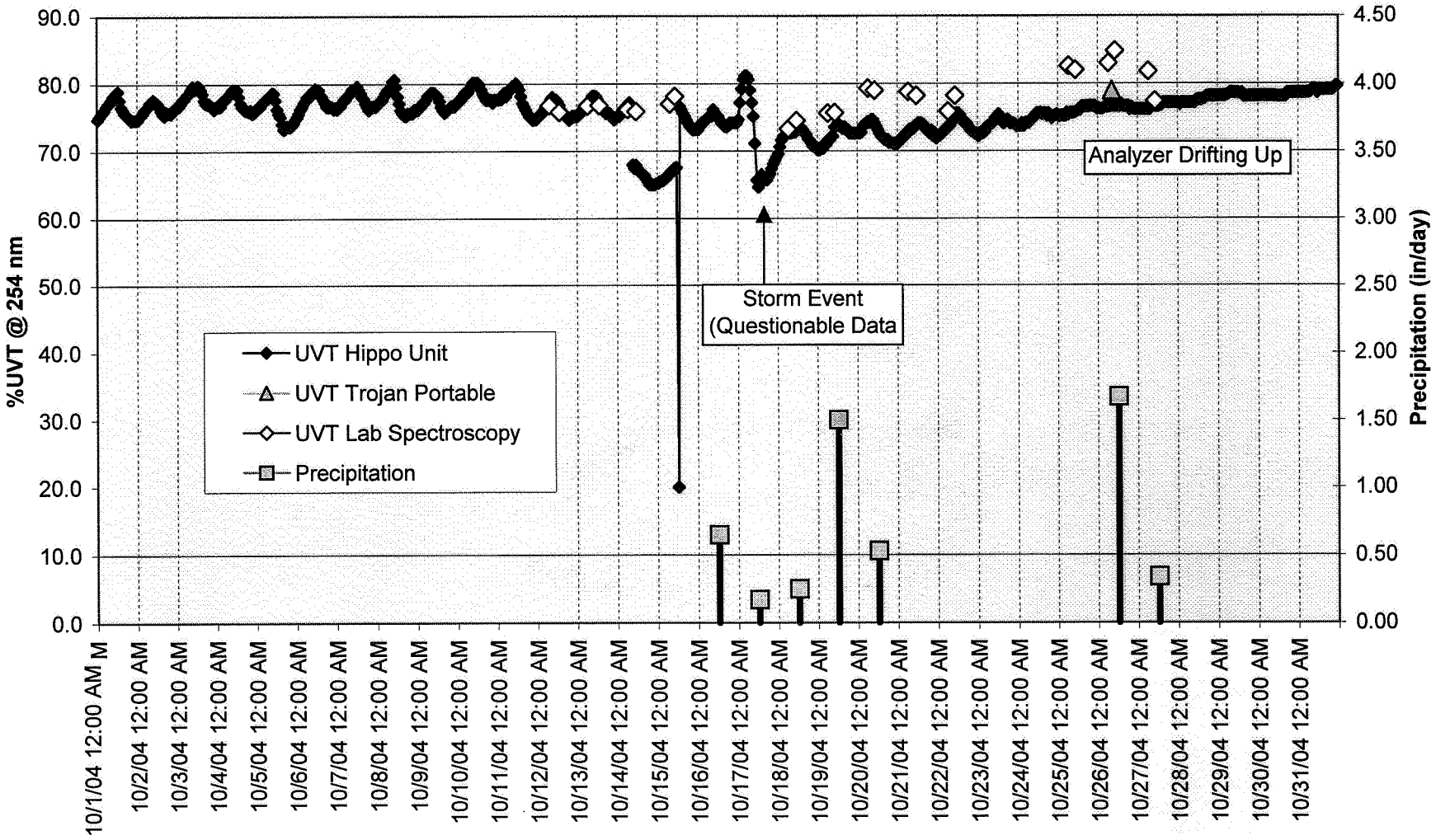
Trojan Portable Unit and Laboratory Grabs
August 2004



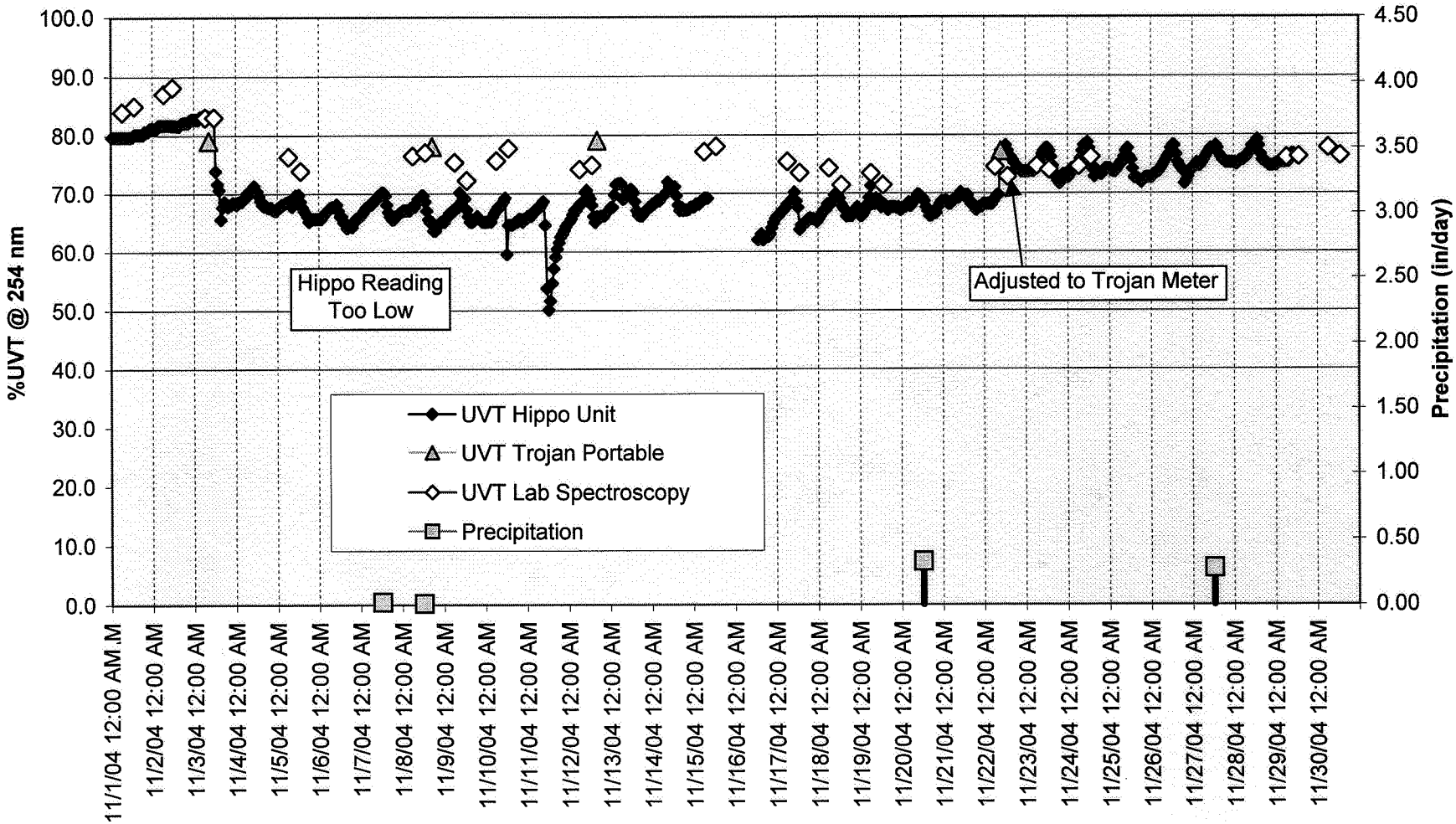
Wedeco On-Line (Hippo) Analyzer UVT Data Taken on the Hour with Trojan Portable Unit Grabs September 2004



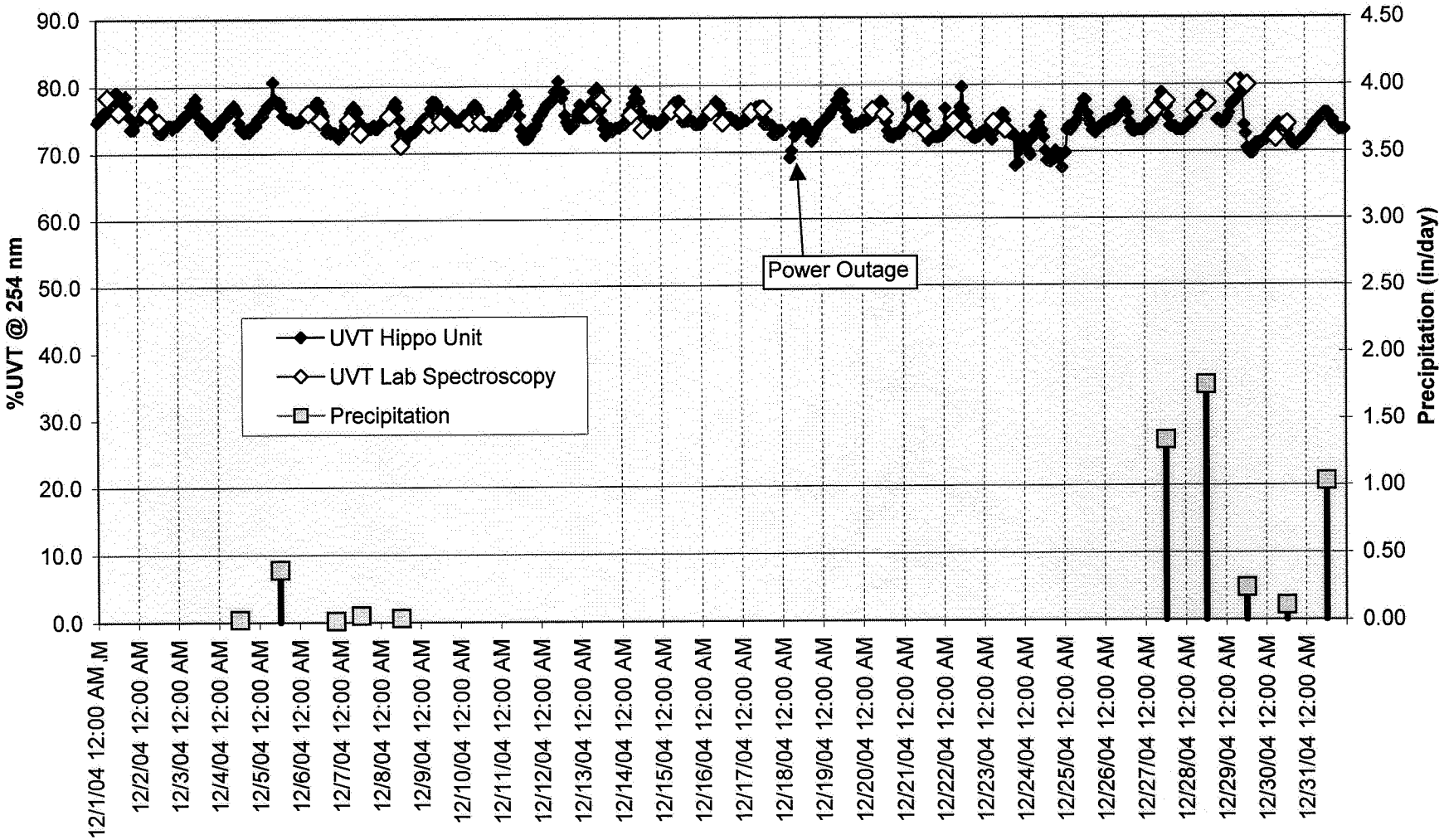
Wedeco On-Line (Hippo) Analyzer UVT Data Taken on the Hour with Trojan Portable Unit and Laboratory Grabs October 2004



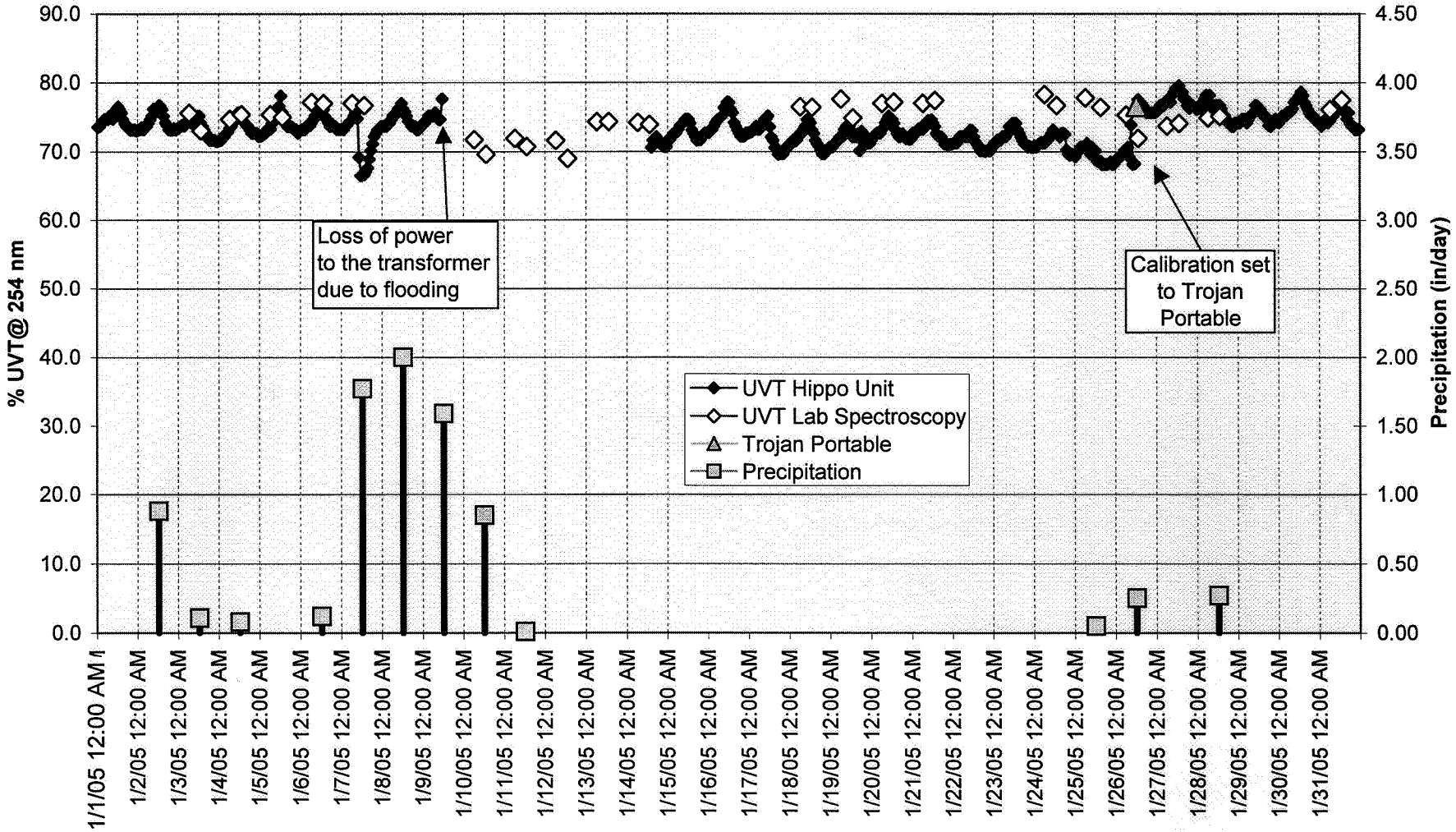
Wedeco On-Line (Hippo) Analyzer UVT Data Taken on the Hour with Trojan Portable Unit and Laboratory Grabs November 2004



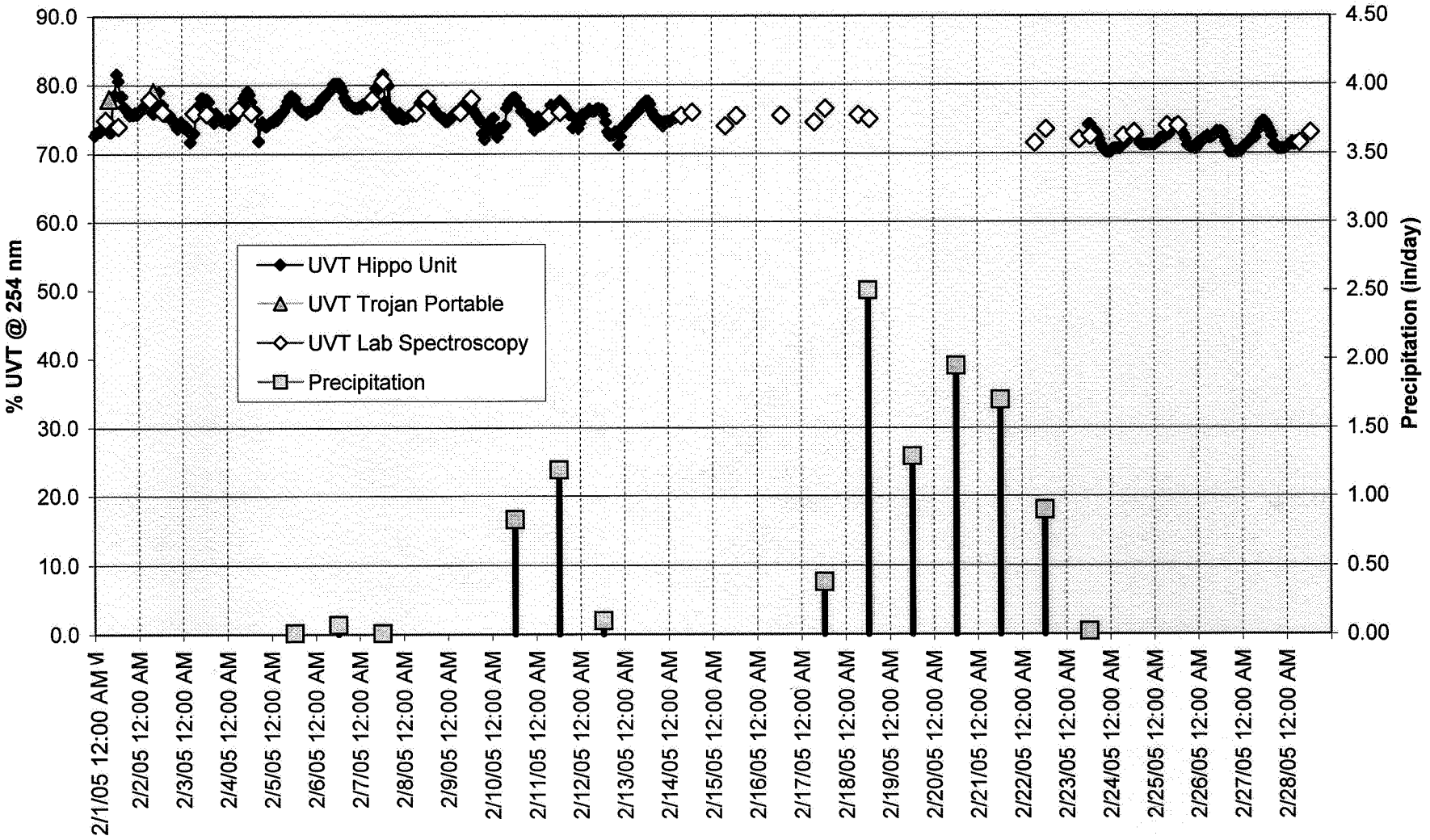
Wedeco On-Line (Hippo) Analyzer UVT Data Taken on the Hour with Laboratory Grabs December 2004



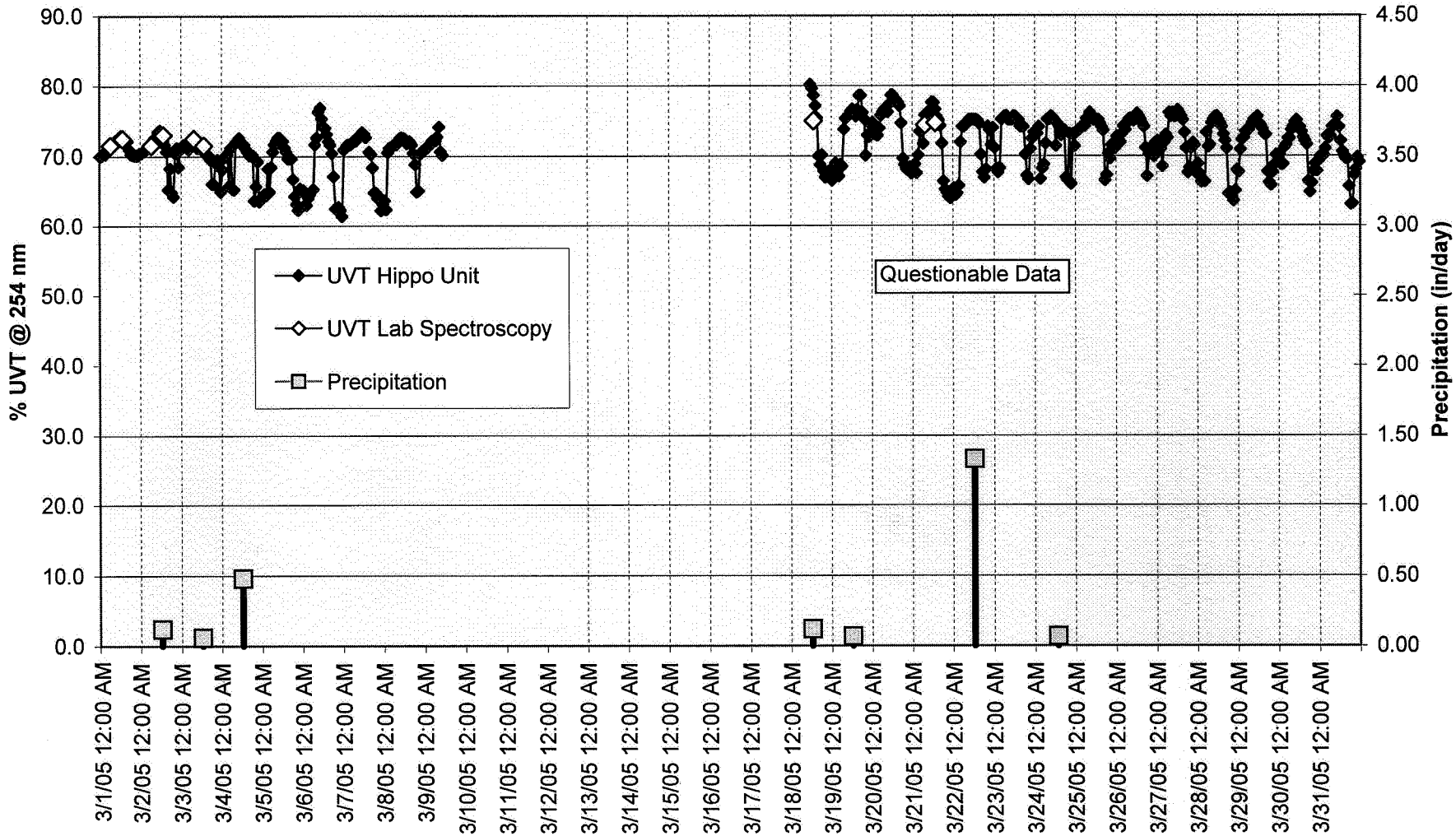
Wedeco On-Line (Hippo) Analyzer UVT Data Taken on the Hour with Trojan Portable Unit and Laboratory Grabs January 2005

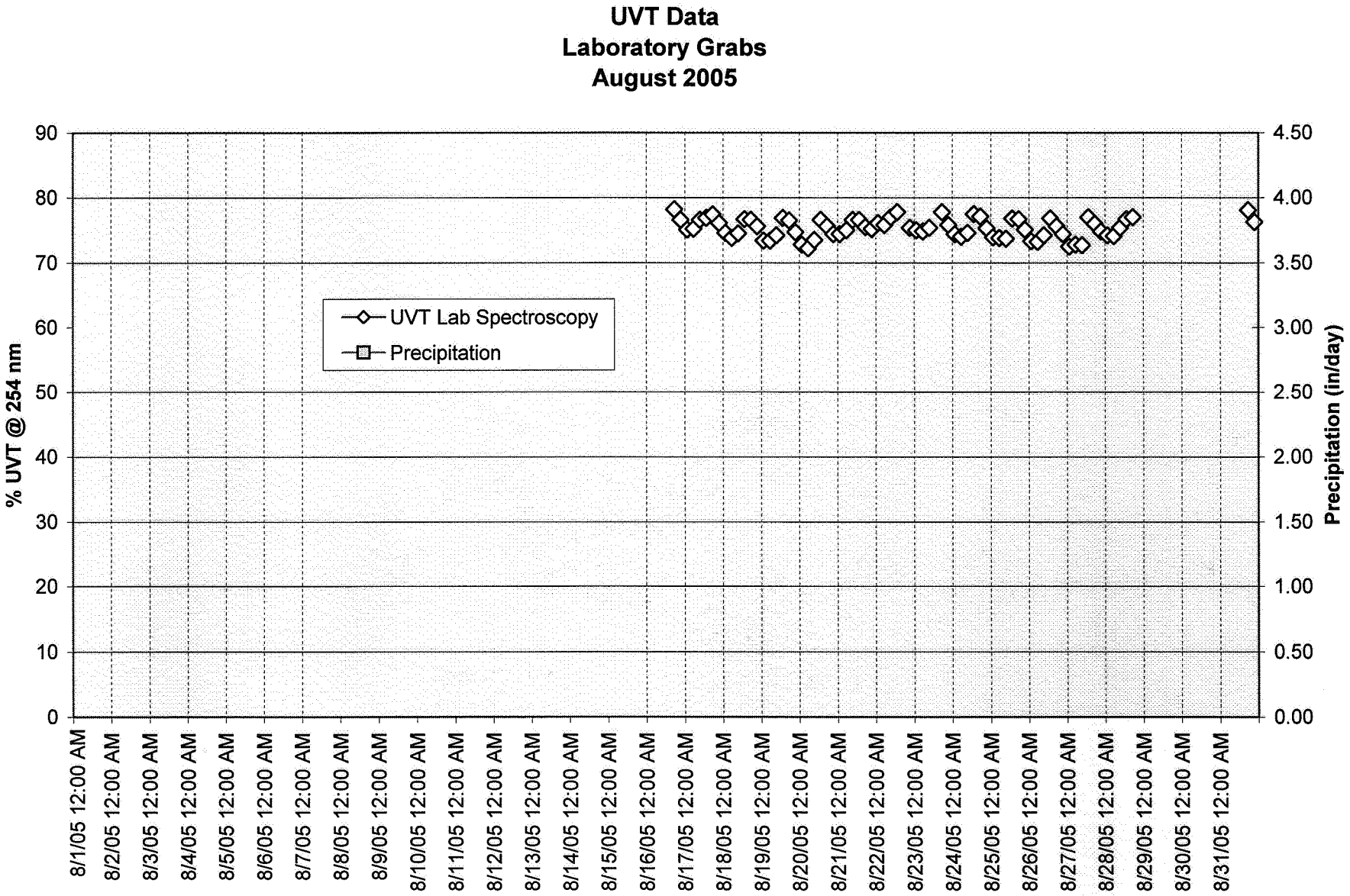


Wedeco On-Line (Hippo) Analyzer UVT Data Taken on the Hour
with Trojan Portable Unit and Laboratory Grabs
February 2005



Wedeco On-Line (Hippo) UVT Analyzer Data Taken on the Hour
with Laboratory Grabs
March 2005




UVT Data
Laboratory Grabs
August 2005
% UVT @ 254 nm
Precipitation (in/day)
UVT Lab Spectroscopy
Precipitation
90
80
70
60
50
40
30
20
10
0
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
8/1/05 12:00 AM
8/2/05 12:00 AM
8/3/05 12:00 AM
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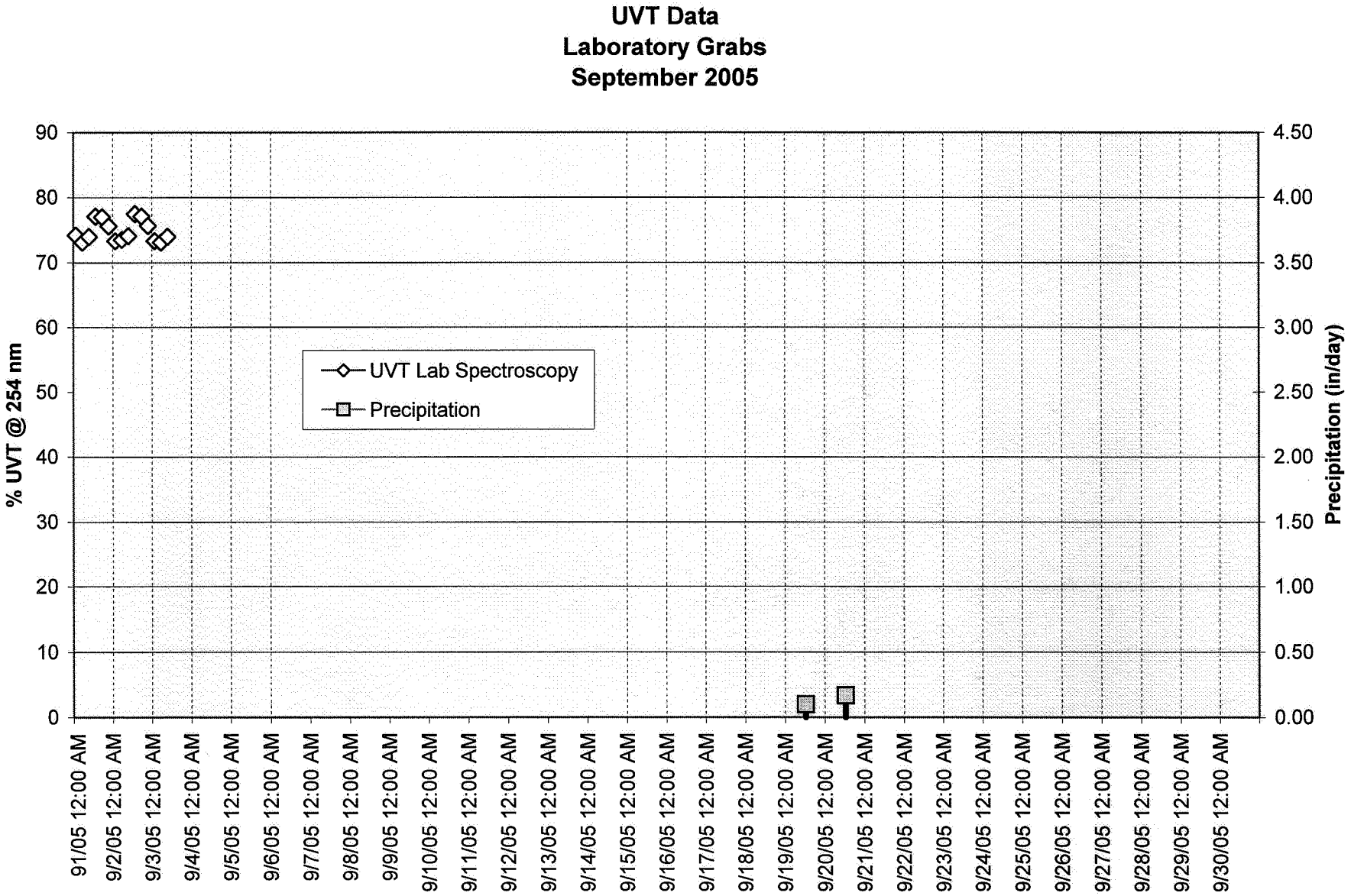
UVT Data
Laboratory Grabs
September 2005
% UVT @ 254 nm
Precipitation (in/day)
UVT Lab Spectroscopy
Precipitation
90
80
70
60
50
40
30
20
10
0
4.50
4.00
3.50
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9/11/05 12:00 AM
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9/14/05 12:00 AM
9/15/05 12:00 AM
9/16/05 12:00 AM
9/17/05 12:00 AM
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9/25/05 12:00 AM
9/26/05 12:00 AM
9/27/05 12:00 AM
9/28/05 12:00 AM
9/29/05 12:00 AM
9/30/05 12:00 AM

Appendix C

Preliminary Equipment Sizing Determinations

Appendix C — Preliminary Equipment Sizing Determinations

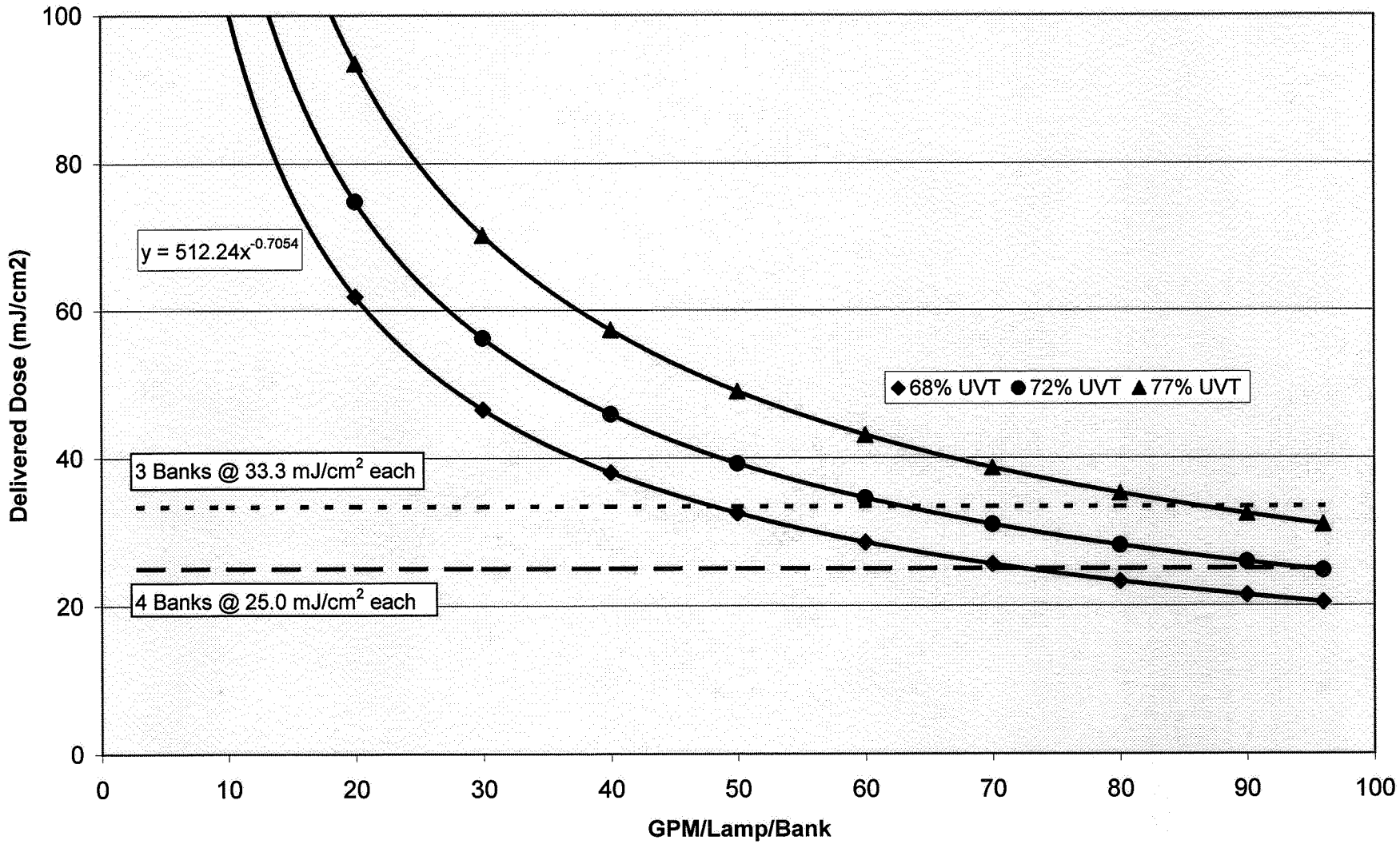
Equipment sizing is based on the DHS-approved validation studies. The target UV dosage required depends on the upstream treatment, and for media filtered wastewater is 100 mJ/cm^2. For this project, two design points have been identified. One is for the plant effluent peak wet weather flow plus sidestreams (24.2 MGD) at the worst-case UVT (69%). The other is the plant effluent peak sanitary flow plus sidestreams (21 MGD) at the typical low UVT (71%). It was determined that the peak sanitary design criteria condition was the controlling design condition for both manufacturers.

For each manufacturer, the respective regression equations and the appropriate fouling and lamp life factors were applied and utilized to determine the number of lamps required with different numbers of UV banks. The lamps per bank were rounded up to a whole number of lamps per module. For either manufacturer, headloss constraints were checked to see if they were acceptable.

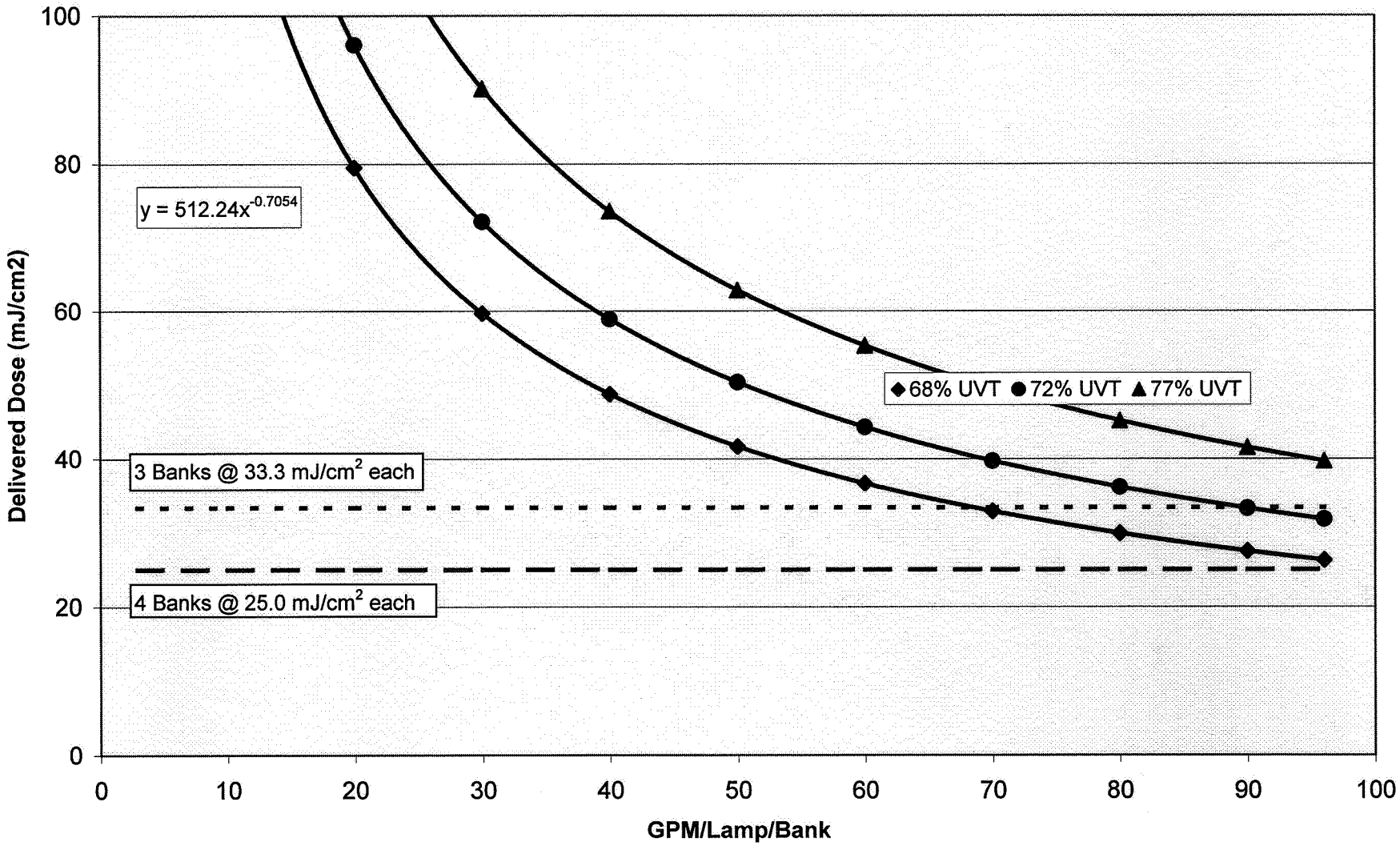
In the case of Wedeco, which can have modules with a different numbers of lamps, an iterative procedure was used to find a workable solution. Wedeco's module size can be altered to provide a more favorable lamp count or module count, which can affect power requirements and the life cycle cost evaluation. For the Wedeco example presented in this appendix, a reasonable configuration was assumed that gave a low lamp count (but not necessarily the lowest), along with the fewest number of modules.

Note that since the Districts have not yet received proposals from Trojan and Wedeco, the equipment sizing determinations herein are preliminary in nature. Within limits, either manufacturer may choose to provide a slightly different system configuration.

Trojan 3000 Plus UV System with a 4-inch Lamp Spacing
Design Delivered Dose at 60% Power and Operational UVTs
LACSD Equation with 0.95 Fouling and 0.82 EOLL Factors



Trojan 3000 Plus UV System with a 4-inch Lamp Spacing
Design Delivered Dose at 100% Power and Operational UVTs
LACSD Equation without Factors



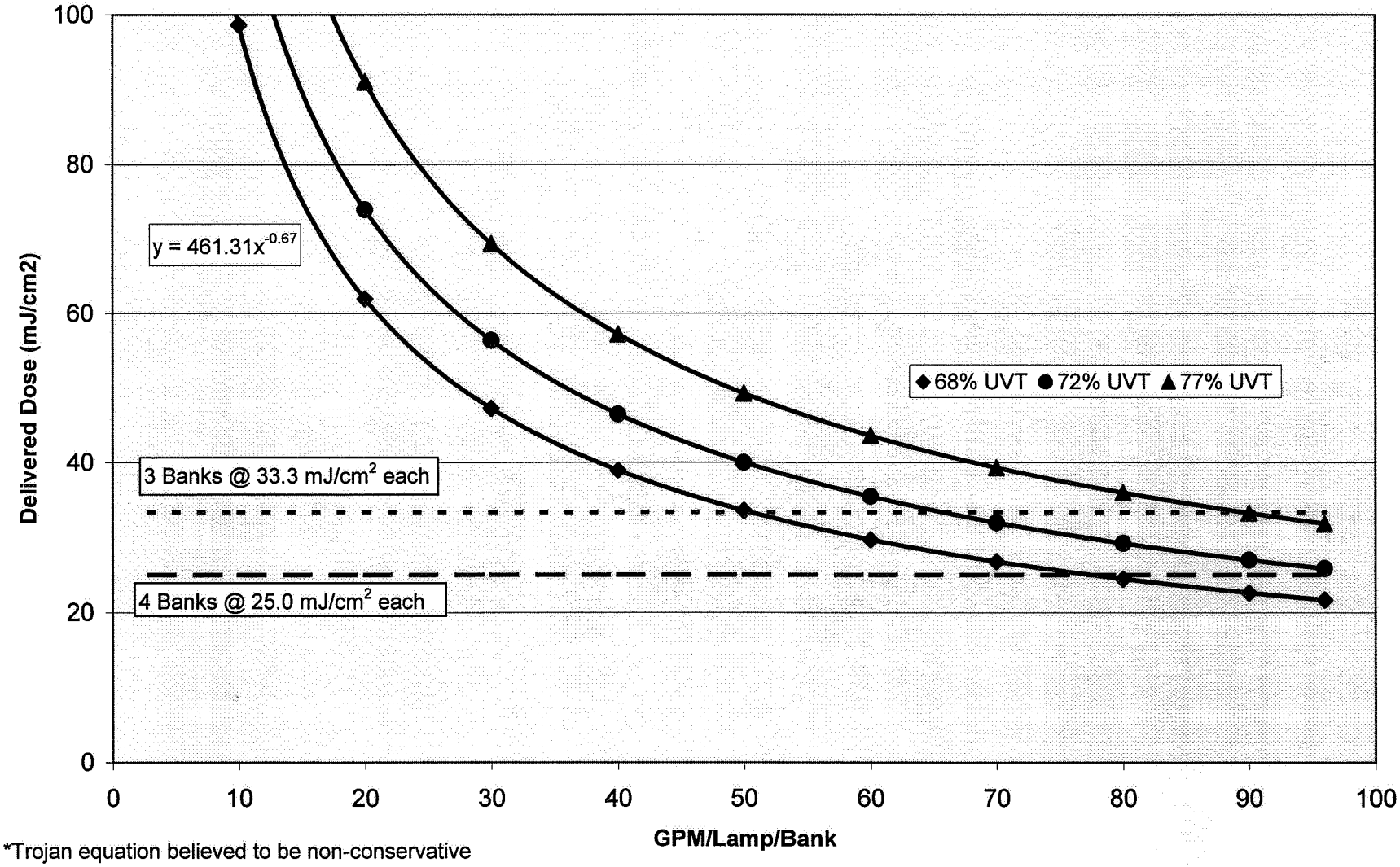
Whittier Narrows WRP - UV Disinfection
Trojan UV Systems - 4 inch
Modeled From LACSD's Eqn
Design Point 2 - 22.5 MGD @ 70% UVT

Note - Inputs Are Designated By Bold Type
Target Dose = a*(Flow^b)*(UVY^c)*(Power^d)
Flow = 10^ (((Log Dose)-(Log a) - (c*Log UVT) - (d Log Power))/b)

	% Full Power	Decimal % Reduced Power	Weighted Reduced Power	Total Weighted Reduced	Total Possible Power	System Turndown Relative to Full Power	
Bank 1	100	0.60	60				
Bank 2	100	0.60	60	120	200	0.60	**2 Banks**
Bank 3	100	0.00	0	120	300	0.40	**3 Banks**
Bank 4	100	0.00	0	120	400	0.30	**4 Banks**

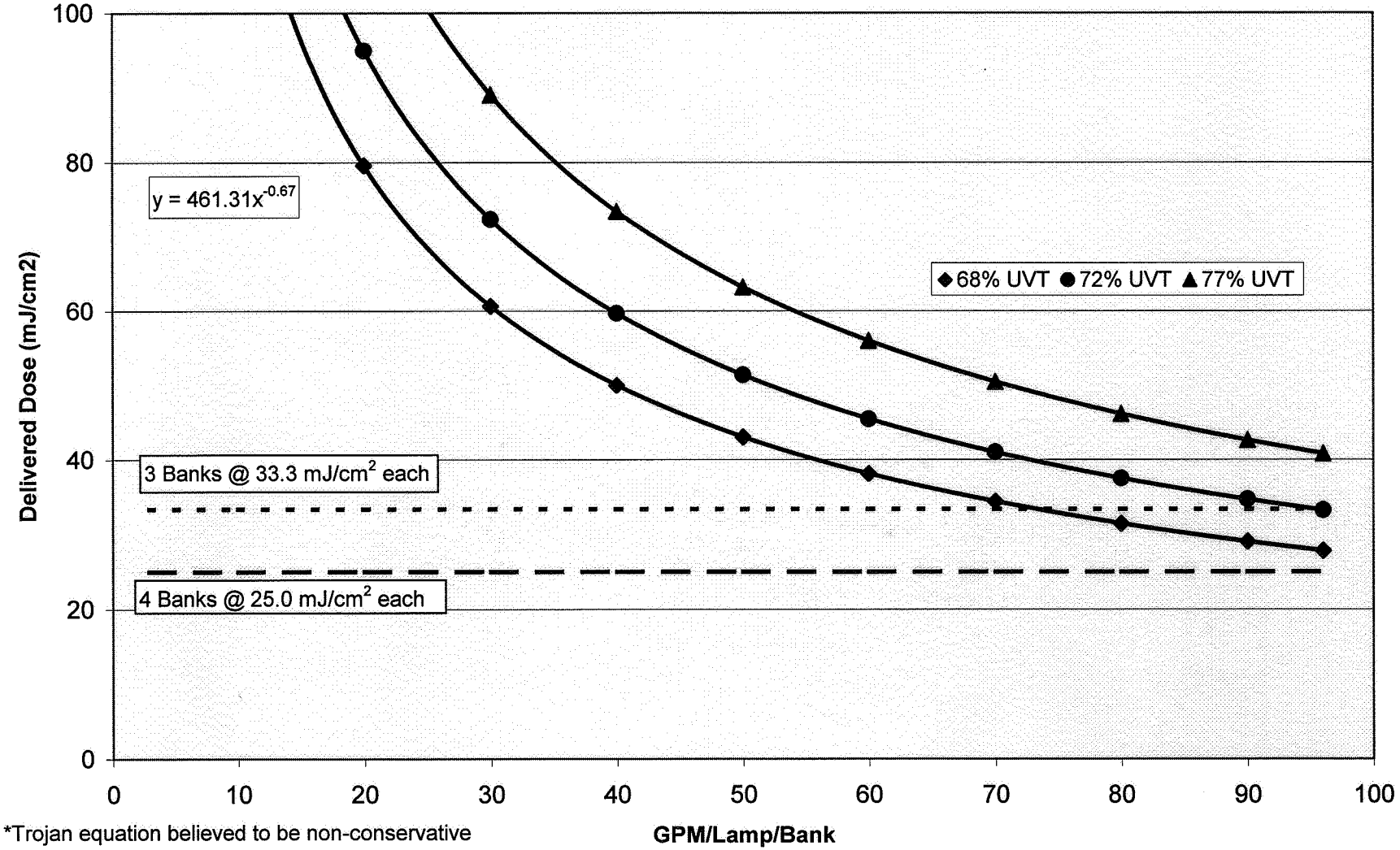
Lamp Spacing (inches)	4.00	4.00	4.00	
Plant Maximum Flow (MGD)	**21.00**	**21.00**	**21.00**	Based on Peak Storm Flow
No. of Operating Trains	**3.00**	**3.00**	**3.00**	Based on Max Day Peak Sanitary Flow. 3 Trains for 19.5 mgd
Max. Flow per Train (MGD)	7.00	7.00	7.00	Has to be below validated flow and not cause excessive headloss
No. Prop Operating Banks/Train	**3.00**	**4.00**	**5.00**	Headloss a big factor with more trains
Proposed Delivered Dose (mj/cm^2)	**100.00**	**100.00**	**100.00**	For Tertiary Filtered Effluent
Target Dose Per Bank (mj/cm^2)	33.33	25.00	20.00	Calc
Fouling Factor	0.9500	0.9500	0.9500	Validated Factor
End of Lamp Life Factor	0.8200	0.8200	0.8200	Valdiated Factor. Latest factor 9000 or 12000 hrs
Combined Lamp Factors	0.7790	0.7790	0.7790	Calc to derate the delivered dosage for higher target dosage
Target Dose per Bank after Factors	42.79	32.09	25.67	Calc based on lamp factors
Log Target Dose/Bank	1.63	1.51	1.41	Calc for simpler cell equations
Factor a	1.747E-05	1.747E-05	1.747E-05	Real factor a based on Trojan's given a'=log a
Log Factor a	**-4.7576**	**-4.7576**	**-4.7576**	Called a in Trojan Validation but really equals to log of Factor a
Flow Factor b	**-0.7054**	**-0.7054**	**-0.7054**	From Trojan Validation
UVT Factor c	**3.3140**	**3.3140**	**3.3140**	From Trojan Validation
Design UVT (%)	**71.00**	**71.00**	**71.00**	Input - Makes a big difference in number of lamps
Log Design UVT	1.851	1.851	1.851	Calc for simpler cell equations
Power Factor d	**0.7513**	**0.7513**	**0.7513**	From Trojan Validation
Power	**100.00**	**100.00**	**100.00**	Power for Design Condition
Log Power	2.000	2.000	2.000	Calc for simpler cell equations
Calc Flow/lamp/bank with factors	58.92	88.58	121.55	
Check of Eqn	42.79	32.09	25.67	Should match target dose/bank above
Headloss Limiting or Max Flow	**96.00**	**92.90**	**83.80**	Manual Input - Max Validated Flow = 96 gpm/l/b
Max Calc or Allowable Flow/Lamp/Bank	58.92	88.58	83.80	If statement concerning max flow/l/b or headloss limiting flow
Max Flow per Train (gpm)	4,861	4,861	4,861	Straightforward calculation
No. Lamps/Bank Needed for Max Flow	82.51	54.88	58.01	Straightforward calculation
Max. No. of Lamps/Bank after Scale-up	**320.00**	**320.00**	**320.00**	Based on scale-up of 10 times pilot
Lamps/Bank< Max L/Bank ?	Yes	Yes	Yes	Check to see if within allowable scale-up
Validated Low Velocity (fps)	0.058	0.058	0.058	Similar to gpm/lamp. Area of lamps not subtracted
Validated High Velocity (fps)	1.924	1.924	1.924	Similar to gpm/lamp. Area of lamps not subtracted
Maximum Water Depth (inches)	32.00	32.00	32.00	Based on lamp spacing
No. of Lamps Per Module	8.00	8.00	8.00	Trojan's standard module
No. of Modules/Bank	10.31	6.86	7.25	Straightforward calculation
No. of Modules/Bank (Round-Up)	11.00	7.00	8.00	Round-up
Actual Max Flow/Lamp/Bank (gpm)	55.24	86.81	75.95	Calculation based on rounded number
Max Q/L/B < Max Q/L ?	Yes	Yes	Yes	Should always be OK because of rounding up
Channel Width (inches)	44.00	28.00	32.00	Based on number of modules
Nominal Flow Area (sq. ft)	9.78	6.22	7.11	Straightforward calculation
Maximum Proposed Velocity (fps)	1.11	1.74	1.52	Straightforward calculation
Act. Vmax > Validated Vmax?	Yes	Yes	Yes	Check if within validated range
Headloss at Actual Max Flow (in/bank)	0.15	0.43	0.32	Need to have safety factor or shift up per graph
Total Headloss for all banks	0.45	1.73	1.61	Includes spare banks if any
Acceptable Headloss for 4" spacing	2.00	2.00	2.00	Half of lamp spacing
Acceptable Level at Last Bank (inches)	Yes	Yes	Yes	Check if acceptable submergence
Number of Lamps per Bank	88.00	56.00	64.00	
Number of Operating Lamps/Train	264.00	224.00	320.00	Straightforward calculation
No. of Spare Banks	**0.00**	**0.00**	**0.00**	Input - choose spare bank or train
No. Lamps in Spare Banks	0.00	0.00	0.00	Straightforward calculation
Total Number of Lamps per Train	**264.00**	**224.00**	**320.00**	Straightforward calculation
No. of Spare Trains	**1.00**	**1.00**	**1.00**	Input - choose spare bank or train
No. Lamps in Spare Trains	264.00	224.00	320.00	Straightforward calculation
Total No. of Spare Lamps	264.00	224.00	320.00	Straightforward calculation
Total Number of Lamps in UV System	**1056.00**	**896.00**	**1280.00**	Straightforward calculation
gpm/operating lamp/bank	55.24	86.81	75.95	From above
overall gpm/total system lamps	13.81	16.28	11.39	Want to select option with the highest value
Equivalent No. of roundup lamps %	6.7%	2.0%	10.3%	Can be viewed as extra capacity
Equivalent No. of roundup lamps	70.3	18.4	132.2	Can be viewed as extra capacity

Trojan 3000 Plus UV System with a 4-inch Lamp Spacing
Design Delivered Dose at 100% Power and Operational UVTs
Trojan Equation with 0.95 Fouling and 0.82 EOLL Factors*



*Trojan equation believed to be non-conservative

Trojan 3000 Plus UV System with a 4-inch Lamp Spacing
Design Delivered Dose at 100% Power and Operational UVTs
Trojan Equation without Factors*



*Trojan equation believed to be non-conservative

Whittier Narrows WRP - UV Disinfection
Trojan UV Systems - 4 inch
Modeled From Trojan's WNWRP Validation Eqn

Note - Inputs Are Designated By Bold Type

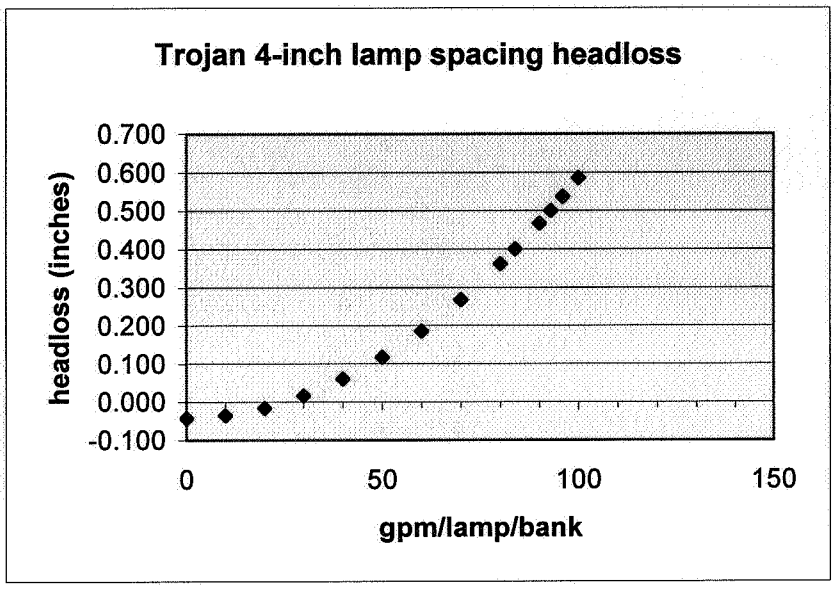
Target Dose = a*(Flow^b)*(UVY^c)*(Power^d)
Flow = 10^ (((Log Dose)-(Log a) - (c*Log UVT) - (d Log Power))/b)

Lamp Spacing (inches)	4.00	4.00	4.00	
Plant Maximum Flow (MGD)	**21.00**	**21.00**	**21.00**	Based on Peak Storm Flow
No. of Operating Trains	**3.00**	**3.00**	**3.00**	Based on Max Day Peak Sanitary Flow. 3 Trains for 19.5 mgd
Max. Flow per Train (MGD)	7.00	7.00	7.00	Has to be below validated flow and not cause excessive headloss
No. Prop Operating Banks/Train	**3.00**	**4.00**	**5.00**	Headloss a big factor with more trains
Proposed Delivered Dose (mj/cm^2)	**104.794**	**104.794**	**104.794**	For Tertiary Filtered Effluent
Target Dose Per Bank (mj/cm^2)	34.93	26.20	20.96	Calc
Fouling Factor	0.9500	0.9500	0.9500	Validated Factor
End of Lamp Life Factor	0.8200	0.8200	0.8200	Valdiated Factor. Latest factor 9000 or 12000 hrs
Combined Lamp Factors	0.7790	0.7790	0.7790	Calc to derate the delivered dosage for higher target dosage
Target Dose per Bank after Factors	44.84	33.63	26.90	Calc based on lamp factors
Log Target Dose/Bank	1.65	1.53	1.43	Calc for simpler cell equations
Factor a	5.129E-05	5.129E-05	5.129E-05	Real factor a based on Trojan's given a'=log a
Log Factor a	**-4.290**	**-4.290**	**-4.290**	Called a in Trojan Validation but really equals to log of Factor a
Flow Factor b	**-0.670**	**-0.670**	**-0.670**	From Trojan Validation
UVT Factor c	**3.090**	**3.090**	**3.090**	From Trojan Validation
Design UVT (%)	**71.00**	**71.00**	**71.00**	Input - Makes a big difference in number of lamps
Log Design UVT	1.851	1.851	1.851	Calc for simpler cell equations
Power Factor d	**0.700**	**0.700**	**0.700**	From Trojan Validation
Power	**100.00**	**100.00**	**100.00**	Power for Design Condition
Log Power	2.000	2.000	2.000	Calc for simpler cell equations
Calc Flow/lamp/bank with factors	57.45	88.2562	123.14	
Check of Eqn	44.84	33.63	26.90	Should match target dose/bank above
Headloss Limiting or Max Flow	**96.00**	**93.80**	84.60	Manual Input - Max Validated Flow = 96 gpm/l/b
Max Calc or Allowable Flow/Lamp/Bank	57.45	88.26	84.60	If statement concerning max flow/l/b or headloss limiting flow
Max Flow per Train (gpm)	4,861	4,861	4,861	Straightforward calculation
No. Lamps/Bank Needed for Max Flow	84.62	55.08	57.46	Straightforward calculation
Max. No. of Lamps/Bank after Scale-up	**320.00**	**320.00**	**320.00**	Based on scale-up of 10 times pilot
Lamps/Bank< Max L/Bank ?	Yes	Yes	Yes	Check to see if within allowable scale-up
Validated Low Velocity (fps)	0.058	0.058	0.058	Similar to gpm/lamp. Area of lamps not subtracted
Validated High Velocity (fps)	1.924	1.924	1.924	Similar to gpm/lamp. Area of lamps not subtracted
Maximum Water Depth (inches)	32.00	32.00	32.00	Based on lamp spacing
No. of Lamps Per Module	8.00	8.00	8.00	Trojan's standard module
No. of Modules/Bank	10.58	6.88	7.18	Straightforward calculation
No. of Modules/Bank (Round-Up)	11.00	7.00	8.00	Round-up
Actual Max Flow/Lamp/Bank (gpm)	55.24	86.81	75.95	Calculation based on rounded number
Max Q/L/B < Max Q/L ?	Yes	Yes	Yes	Should always be OK because of rounding up
Channel Width (inches)	44.00	28.00	32.00	Based on number of modules
Nominal Flow Area (sq. ft)	9.78	6.22	7.11	Straightforward calculation
Maximum Proposed Velocity (fps)	1.11	1.74	1.52	Straightforward calculation
Act. Vmax > Validated Vmax?	Yes	Yes	Yes	Check if within validated range
Headloss at Actual Max Flow (in/bank)	0.15	0.43	0.32	Need to have safety factor or shift up per graph
Total Headloss for all banks	0.61	2.16	1.93	Includes spare banks if any
Acceptable Headloss for 4" spacing	2.00	2.00	2.00	Half of lamp spacing
Acceptable Level at Last Bank (inches)	Yes	No	Yes	Check if acceptable submergence
Number of Lamps per Bank	88.00	56.00	64.00	
Number of Operating Lamps/Train	264.00	224.00	320.00	Straightforward calculation
No. of Spare Banks	**1.00**	**1.00**	**1.00**	Input - choose spare bank or train
No. Lamps in Spare Banks	88.00	56.00	64.00	Straightforward calculation
Total Number of Lamps per Train	**352.00**	**280.00**	**384.00**	Straightforward calculation
No. of Spare Trains	**0.00**	**0.00**	**0.00**	Input - choose spare bank or train
No. Lamps in Spare Trains	0.00	0.00	0.00	Straightforward calculation
Total No. of Spare Lamps	88.00	56.00	64.00	Straightforward calculation
Total Number of Lamps in UV System	**1056.00**	840.00	**1152.00**	Straightforward calculation
gpm/operating lamp/bank	55.24	86.81	75.95	
overall gpm/operating lamp	18.41	21.70	15.19	
overall gpm/total system lamps	13.81	17.36	12.66	

Headloss Calculations for Trojan 4-inch Spacing

Headloss per bank, in = (6.16 x 10-5)Q2 + (1.28 x 10-4)Q - (4.34 x 10-2)
Where: Q = flow divided by number of lamps in a single bank (gpm per lamp per bank)

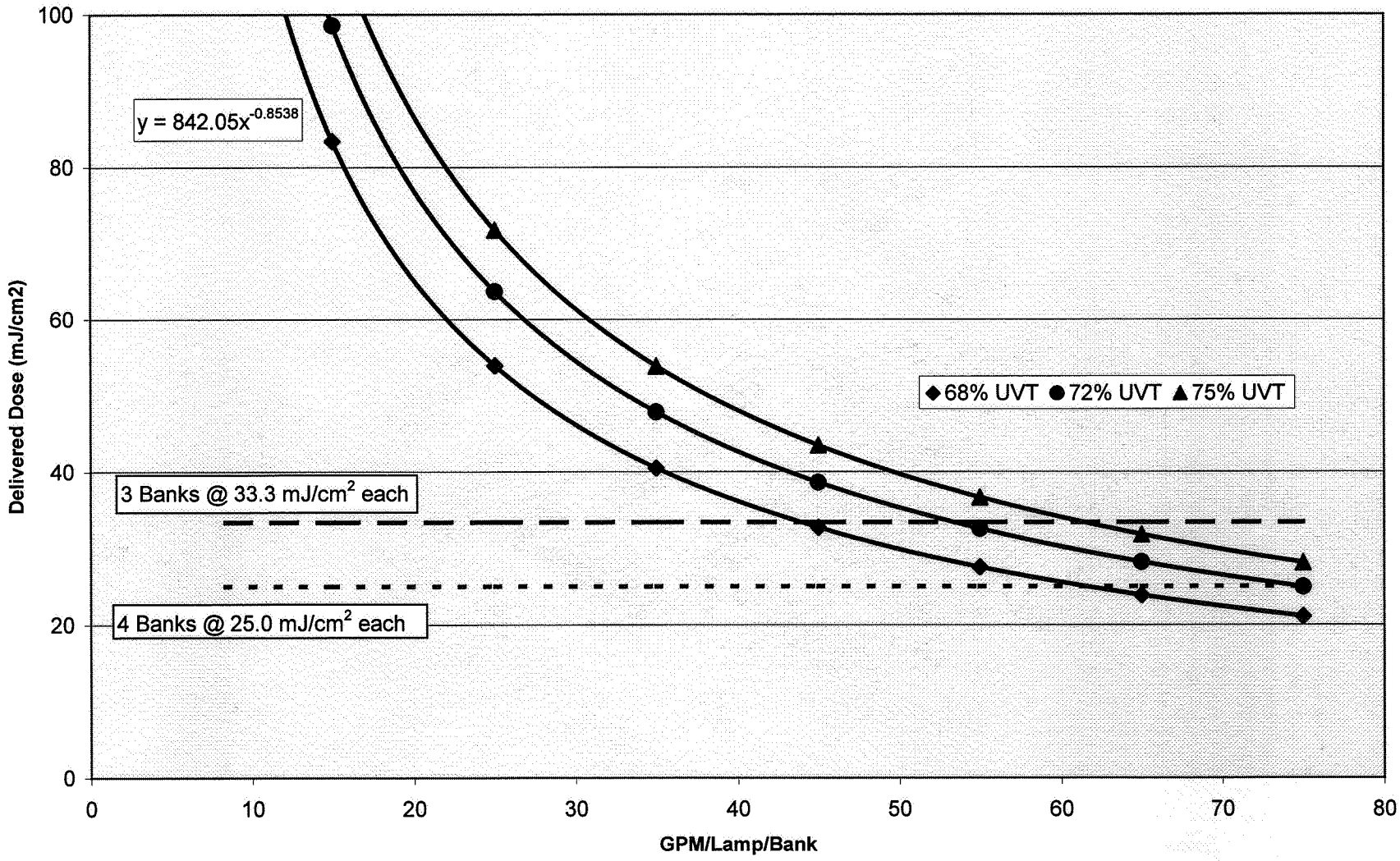
Flow gpm/l/b	Headloss/bank in
0.0	-0.043
10.0	-0.036
20.0	-0.016
30.0	0.016
40.0	0.060
50.0	0.117
60.0	0.186
70.0	0.267
80.0	0.361
83.8	0.400
90.0	0.467
92.9	0.500
96.0	0.537
100.0	0.585
106.4	0.667
110.0	0.716
117.7	0.824
120.0	0.859
130.0	1.014
129.1	1.000
140.0	1.182
150.0	1.362
160.0	1.554

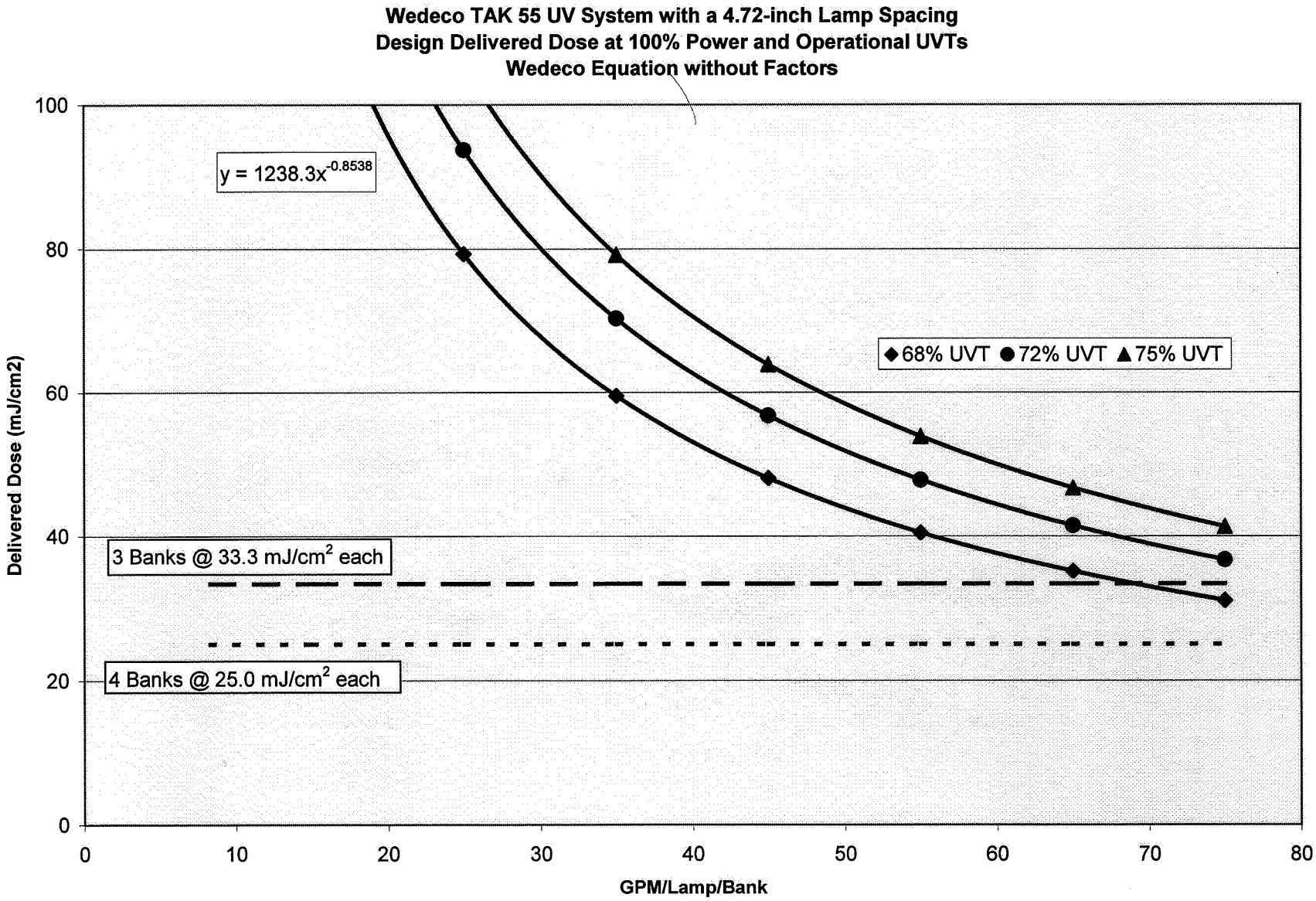


Total No. of Banks	Headloss Limiting Flows for 2" headloss		
	per Bank	Total HL	gpm/l/b
3 Banks	0.667	2.00	106.35
4 Banks	0.500	2.00	92.90
5 Banks	0.400	2.00	83.80

Note: 4 and 5 bank systems are headloss limited, while 3 bank systems are limited by maximum validated flow of 96 gpm/l/b

Wedeco TAK 55 UV System with a 4.72-inch Lamp Spacing
Design Delivered Dose at 100% Power and 68% UVT
Wedeco Equation with 0.80 Fouling and 0.85 EOLL Factors





Wedeco Design / Unfactored Graph Chart 1

WNWRP - UV Disinfection Facilities
Wedeco TAK 55
Modeled From Roseville Validation Eqn

Note - Inputs Are Designated By Bold Type

Target Dose = a*(Flow^b)*(UVY^c)*(Power^d)
Flow = 10^ (((Log Dose)-(Log a) - (c*Log UVT) - (d Log Power))/b)

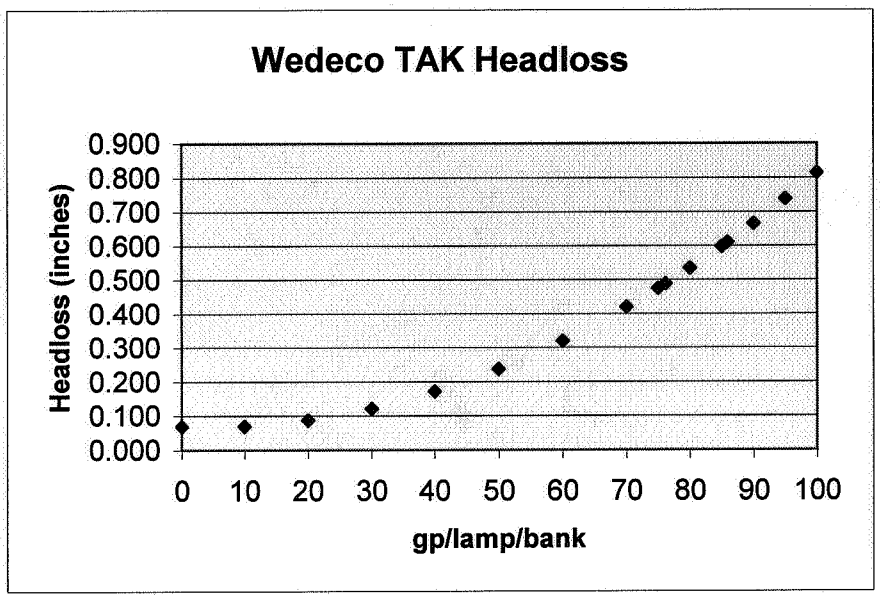
	% Full Power	Decimal % Reduced Power	Weighted Reduced Power	Total Weighted Reduced	Total Possible Power	Turndown Relative to Full Power	
Bank 1	100	0.50	50				
Bank 2	100	0.50	50	100	200	0.50	**2 Banks**
Bank 3	100	0.00	0	100	300	0.33	**3 Banks**
Bank 4	100	0.00	0	100	400	0.25	**4 Banks**
Bank 5	100	0.00	0	100	500	0.20	**5 Banks**

Lamp Spacing (mm)	120.00	120.00	120.00	Nominal spacing between lamps (not walls or bottom)
Lamp Spacing (inches)	4.72	4.72	4.72	Nominal spacing between lamps (not walls or bottom)
Plant Maximum Flow (MGD)	**21.00**	**21.00**	**21.00**	Based on Peak Storm Flow
No. of Operating Trains	**3.00**	**3.00**	**3.00**	Based on Max Day Peak Sanitary Flow. 3 Trains for 19.5 mgd
Max. Flow per Train (MGD)	7.00	7.00	7.00	Has to be below validated flow and not cause excessive headloss
No. Prop Operating Banks/Train	**3.00**	**4.00**	**5.00**	Headloss a big factor with more trains
Proposed Delivered Dose (mj/cm^2)	**137.80**	**100.00**	**100.00**	For Tertiary Filtered Effluent
Target Dose Per Bank (mj/cm^2)	45.93	25.00	20.00	Calc
Fouling Factor	0.8000	0.8000	0.8000	Validated Factor
End of Lamp Life Factor	0.8500	0.8500	0.8500	Valdated Factor for 8760 hrs
Combined Lamp Factors	0.6800	0.6800	0.6800	Calc to derate the delivered dosage for higher target dosage
Target Dose per Bank after Factors	67.55	36.76	29.41	Calc based on lamp factors
Log Target Dose/Bank	1.83	1.57	1.47	Calc for simpler cell equations
Factor a	0.0055616	0.0055616	0.0055616	Real factor a based on Trojan's given a'=log a
Log Factor a	**-2.2548**	**-2.2548**	**-2.2548**	Called a in Trojan Validation but really equals to log of Factor a
Flow Factor b	**-0.8538**	**-0.8538**	**-0.8538**	From Trojan Validation
UVT Factor c	**2.9182**	**2.9182**	**2.9182**	From Trojan Validation
Design UVT (%)	**71.00**	**71.00**	**71.00**	Input - Makes a big difference in number of lamps
Log Design UVT	1.851	1.851	1.851	Calc for simpler cell equations
Power Factor d	**0.0000**	**0.0000**	**0.0000**	Power not vaired in Wedeco validation
Power	**100.00**	**100.00**	**100.00**	Power for Design Condition
Log Power	2.000	2.000	2.000	Calc for simpler cell equations
Calc Flow/lamp/bank with factors	34.96	71.29	92.58	Real basis of comparison before rounding occurs
Check of Eqn	67.55	36.76	29.41	Should match target dose/bank above
Headloss Limiting or Max Valid Flow	**75.00**	**75.00**	**75.00**	Manual Input - Max Validated Flow = 75 gpm/l/b See Sheet Wed HL
Max Calc or Allowable Flow/Lamp/Bank	34.96	71.29	75.00	If statement concerning max flow/l/b or headloss limiting flow
Max Flow per Train (gpm)	4,861	4,861	4,861	Straightforward calculation
No. Lamps/Bank Needed for Max Flow	139.04	68.19	64.81	Straightforward calculation
Rounded No. Lamps/Bank for Max Flow	140.00	69.00	65.00	Straightforward calculation
Max. No. of Lamps/Bank after Scale-up	**120.00**	**120.00**	**120.00**	Based on scale-up of 10 times pilot
Lamps/Bank< Max L/Bank	No	Yes	Yes	Check to see if within allowable scale-up
Validated Low Velocity (fps)	0.130	0.130	0.130	Similar to gpm/lamp. Area of lamps not subtracted
Validated High Velocity (fps)	1.130	1.130	1.130	Similar to gpm/lamp. Area of lamps not subtracted
No. of Lamps Per Module	18.00	18.00	18.00	Trojan's standard module
Maximum Water Depth (mm)	1082.0	1082.0	1082.0	From validation
Maximum Water Depth (inches)	42.6	42.6	42.6	Based on lamp spacing
No. of Modules/Bank	7.78	3.83	3.61	Straightforward calculation
No. of Modules/Bank (Round-Up)	8.00	4.00	4.00	Round-up
Actual Max Flow/Lamp/Bank (gpm)	33.76	67.52	67.52	Calculation based on rounded number
Max Q/L/B < Max Q/L	Yes	Yes	Yes	Should always be OK because of rounding up
No of Lamp Columns	16.00	8.00	8.00	2 lamp columns per module
Channel Width (inches)	75.2	37.4	37.4	Based on number of modules
Nominal Flow Area (sq. ft)	22.23	11.06	11.06	Straightforward calculation
Maximum Proposed Velocity (fps)	0.49	0.98	0.98	Straightforward calculation
Act. Vmax > Validated Vmax?	Yes	Yes	Yes	Check if within validated range
Headloss at Actual Max Flow (in/bank)	0.14	0.39	0.39	May need to have safety factor
Total Headloss for all banks	0.41	1.57	1.97	Includes spare banks if any
Acceptable Headloss for Wedeco spacing	2.44	2.44	2.44	Half of lamp spacing
Acceptable Level at Last Bank (inches)	Yes	Yes	Yes	Check if acceptable submergence
Number of Lamps per Bank	144.00	72.00	72.00	
Number of Operating Lamps/Train	432.00	288.00	360.00	Straightforward calculation
No. of Spare Banks	**0.00**	**0.00**	**0.00**	Input - choose spare bank or train
No. Lamps in Spare Banks	0.00	0.00	0.00	Straightforward calculation
Total Number of Lamps per Train	**432.00**	**288.00**	**360.00**	Straightforward calculation
No. of Spare Trains	**1.00**	**1.00**	**1.00**	Input - choose spare bank or train
No. Lamps in Spare Trains	432.00	288.00	360.00	Straightforward calculation
Total No. of Spare Lamps	432.00	288.00	360.00	Straightforward calculation
Total Number of Lamps in UV System	**1728.00**	**1152.00**	**1440.00**	Straightforward calculation
gpm/operating lamp/bank	33.76	67.52	67.52	From above
overall gpm/total system lamps	8.44	12.66	10.13	Want this to be the highest
Equivalent No. of roundup lamps %	3.6%	5.6%	11.1%	Can be viewed as extra capacity
Equivalent No. of roundup lamps	61.6	64.4	159.6	Can be viewed as extra capacity

Headloss for TAK Wedeco 4.72 inch (120 mm) Spacing

Wedeco Headloss per bank=((8.13*10^-5)*(Q^2))-((6.82*10^-4)*Q)+(0.0685)

Flow gpm/l/b	Headloss in
0.0	0.069
10.00	0.070
20.00	0.087
30.00	0.121
40.00	0.171
50.00	0.238
60.00	0.320
70.00	0.419
75.00	0.475
76.15	0.488
80.00	0.534
85.00	0.598
85.90	0.610
90.00	0.666
95.00	0.737
100.00	0.813



Acceptable Headloss = 2+(120mm/2)=62 mm	
mm	in
62	2.44

Total No. of Banks	Headloss Limiting Flows for 2.44" Headloss		
	per Bank	Total HL	gpm/l/b
3 Banks	0.813	2.44	100.00
4 Banks	0.610	2.44	85.90
5 Banks	0.488	2.44	76.15

Notes: 3, 4 and 5 bank systems are limited by maximum validated flow range of 75 gpm/l/b.
5 bank systems are not headloss limited, but are very close to being headloss limited depending on safety factor

Appendix D

Trojan UV3000 Plus System Validation at the WNWRP
Comparison of Data Analysis Methods

Appendix D — Trojan UV 3000 Plus System Validation at the WNWRP Comparison of Data Analysis Methods

The Trojan/Carollo validation testing at the WNWRP was conducted with the UV 3000 Plus System using LSI lamps at a 4-inch spacing.

During the review of the Trojan/Carollo validation report, the Districts disagreed with the approach used to analyze the data from the individual collimated beam test runs. Trojan/Carollo's approach was to use a linear regression to analyze log inactivation data collected at UV dosages of 0 mJ/sq cm and above. While linear regressions have historically been used to analyze collimated beam data in the past, these analyses have typically been done at dosages considerably above 0 mJ/sq cm, where the inactivation curve is more linear. The NWRI Guidelines offer no guidance on the type of regression analysis to be used, but they do state unequivocally that no collimated beam data shall be analyzed at dosages below 20 mJ/sq cm. While the Districts do not necessarily disagree with Trojan/Carollo's inclusion of the 0 dosage point in the collimated beam analyses (and in fact, DHS is planning to allow this as well), the use of a linear regression in this case is inappropriate since it does not fit the data well. Delivered UV dosages determined in this manner are non-conservative at low to mid dosage levels. More accurate dosage determinations are obtained from collimated beam data that has been analyzed with a second order polynomial curve fit.

The dosage equation presented in Trojan's final validation report (June 22, 2005) for the UV3000 Plus System with 4-inch lamp spacing is:

Log Dose = -4.29 - (0.67 × Log Flow) + (3.09 × Log UVT) + (0.70 × Log Power Setting)

The above equation was developed by analyzing the collimated beam bioassay data with a linear regression, including the zero points.

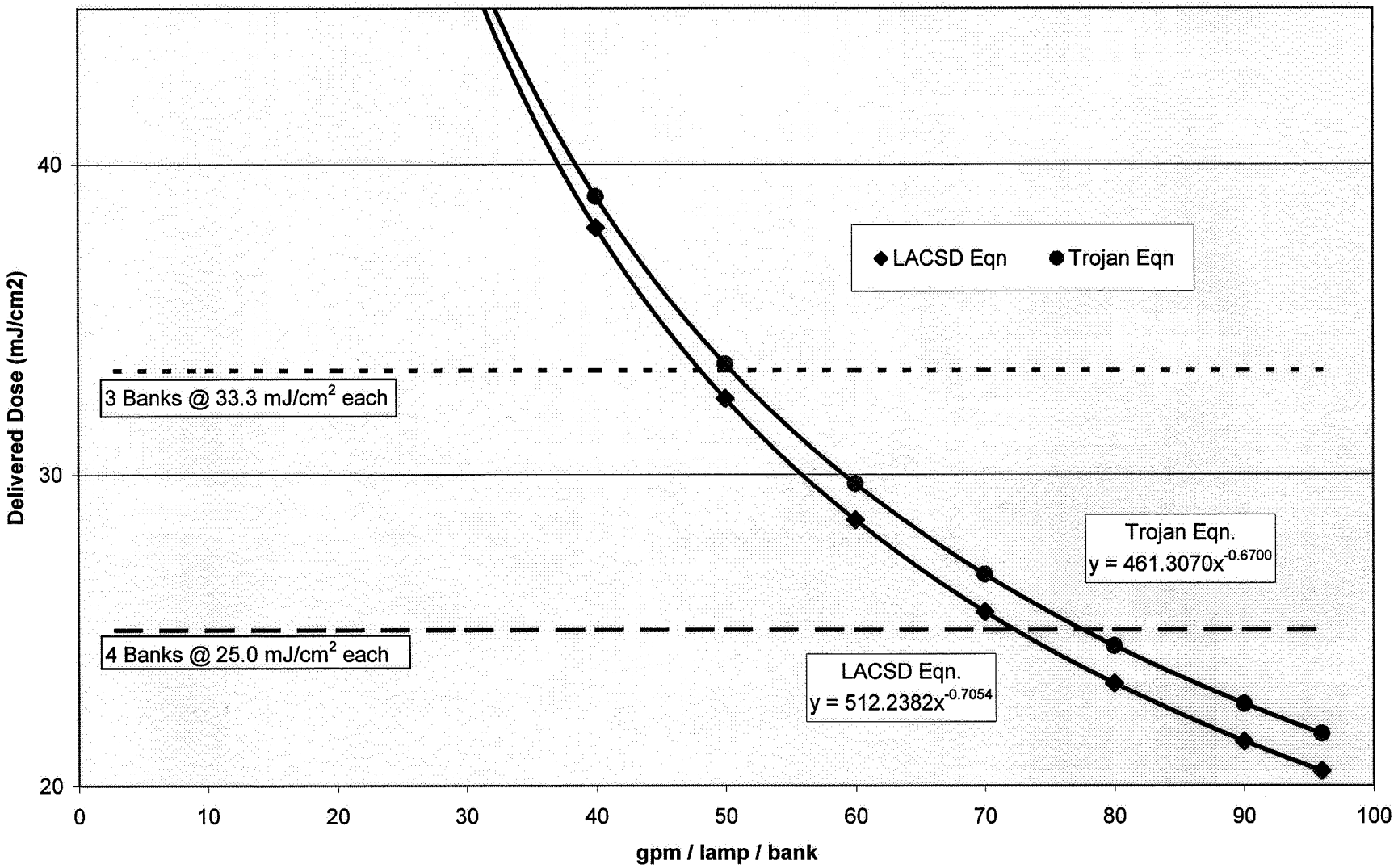
If the collimated beam data for the Whittier Narrows project, including the zero dosage points, is analyzed instead with a second order polynomial regression, the resulting dose delivery equation for the system is:

Log Dose = -4.7576 - (0.7054 × Log Flow) + (3.3140 × Log UVT) + (0.7513 × Log Power Setting)

This version of the equation provides more conservative dosage results than the validation version of the equation proposed by Trojan/Carollo above. Because of the discrepancy in calculated dosages, the Districts' equipment procurement specifications will ask Trojan to provide a dose by their validated equation (based on linear collimated beam regression analyses) that will result in the same number of U.V. lamps as a dose of 100 mJ/sq cm determined from the more accurate equation developed from non-linear collimated beam regression analyses. To be equivalent to a true dosage of 100 mJ/sq cm, the specified dosage will be a function of other specified operating conditions as well. It appears at this time that the specified dosage will end up being approximately 105 mJ/sq cm as determined by the validated equation. If Trojan is

selected and once the full-scale plant is built, the WNWRP will be operated at a dosage of 100 mJ/sq cm as determined by the more accurate, non-linear version of the equation.

Trojan UV 3000 Plus System with LSI Lamps at a 4-inch Spacing
Design Delivered Dose at 100% Power and 68% UVT
LACSD and Trojan Equations with 0.95 Fouling and 0.82 EOLL Factors



Appendix E

Adenovirus Epidemiological Concerns

Appendix E — Adenovirus Epidemiological Concerns

The NWRI Guidelines have been written with a target 5-log removal of poliovirus, which is defined as "essentially virus-free water". Since this degree of inactivation for a filtered wastewater typically occurs at a UV dose of 50 mJ/cm^2, and the mandatory delivered dose is 100 mJ/cm^2, a safety factor of 2 has been applied. This delivered dosage concept is based on pilot testing with MS2 phage as the indicator organism. Although adenovirus is less susceptible to UV inactivation than MS2 and poliovirus, a dosage of 100 mJ/cm^2 should result in an adenovirus inactivation of approximately two to three logs. Since adenovirus has been reported in the WNWRP secondary effluent from 1.5 pfu/L to 100 pfu/L, adenovirus may or may not be detected in a UV disinfected final effluent dosed at 100 mJ/cm^2, depending upon filtered effluent adenovirus titers.

The Safe Drinking Water Act (SDWA) regulates drinking water supplies throughout the nation. The purpose of the act is to protect the public health by creating multiple barriers against water pollution, which include filtration, disinfection and protection of source water. The EPA also sets national drinking water standards for biological and chemical contaminants. It publishes unenforceable maximum contaminant level goals and enforceable regulations that specify the maximum contaminant levels (MCLs) goals or treatment technique that has been shown to reduce contaminant(s) to an acceptable level. The EPA National Primary Drinking Water Standards specify that enteric viruses must be removed or inactivated by 4 logs (99.99%) from surface water, or groundwater under the influence of surface water, by filtration and disinfection or by a combination thereof.

Enteric adenoviruses are included on the EPA Drinking Water Contaminant List that was published in 1998. This list is put together for contaminants that are suspected of being a public health concern, but cannot be acted upon, or effectively regulated, because of inadequate information. Since enteric adenoviruses have greater environmental stability than other enteric viruses, and with their ubiquitous presence in sewage and surface waters, they are likely contaminants in public water supplies. Although outbreaks of disease due to enteric adenovirus are rare, it was one of the causative agents associated with a waterborne outbreak in Finland. According to the AWWA, to date there have been no positively identified waterborne outbreaks of adenovirus in the U.S. However, the etiologic agent is never identified in over half of the waterborne outbreaks of disease. Viruses may cause these outbreaks and the prevalence of adenoviruses leads one to believe they may be implicated.

Adenoviruses are transmitted via the fecal oral route and inhalation of aerosols. They are found throughout the world in polluted waters, drinking water sources, groundwater and even treated drinking water. They are detected at higher levels than enteroviruses in polluted waters and have higher resistance to environmental conditions. Of the 51 serotypes of adenovirus, 17 are pathogenic to humans. Adenovirus are reported to cause 2-7% of all lower respiratory tract illnesses in children in U.S and Great Britain, causing 200,000 children to be hospitalized. Non-enteric adenovirus has been associated with outbreaks of pharyngoconjunctivitus from swimming activities. Accidental fecal releases in swimming pools operated without sufficient chlorine residual have resulted in disease outbreaks. Boarding schools and military training

facilities have also been affected by adenovirus outbreaks, and even deaths. These outbreaks are mainly respiratory in nature and not waterborne. Some adenoviruses (AD40, AD41) are important causes of acute gastroenteritis, especially in children less than 4 years old. The gastroenteritis caused by AD40 and AD 41 is common in infants, neonatal care units and day care centers. Most children have immunity for at least one type of adenovirus by age 10. Adenovirus infections can be caused by a low number of viral particles and once infected, the host will shed these in high numbers for long periods. September is the peak month for adenovirus infection.

Recent drinking water rules promulgated by the EPA attempt to find a reasonable balance between protection against microbial pathogens (specifically Cryptosporidium and Giardia) and disinfection byproducts THMs and HAAs). These rules are the Long Term 2 Enhanced Surface Water Treatment Rule and the Stage 2 Disinfectants/ Disinfection Byproducts Rule, and they are expected to be finalized in 2005. Although UV disinfection does a very good job of reducing DBPs and inactivating Cryptosporidium, researchers have repeatedly shown that adenoviruses are more resistant to UV. This is probably due to the fact that adenoviruses have double stranded DNA (which may allow them to repair DNA damage) and a relatively high guanosine and cytosine content as compared to other viruses. A reported dose of 203-226 MJ//cm2 is required for a 4-log inactivation of serotypes AD 40 and AD 41.

It seems therefore, that if the Districts want to continue to produce a "virus-free" effluent, some sort of multi-barrier scheme of chlorination and UV disinfection would be the most effective. Drinking water plants are mandated to achieve a 4-log virus removal or inactivation, not necessarily for their disinfection scheme, but for their entire treatment process. However, since there may not be 4 logs of virus in the source water, this level of inactivation essentially becomes not-detect. However, a virus-free effluent should not to be confused with 4-log removal, which could theoretically allow some residual viruses. Additionally, some viruses are not easily cultured and may be missed depending upon the techniques used to quantify results. Although PCR techniques can have positive virus samples of approximately three times the positive samples for cell cultures, some of these viral particles can be non-viable.

Arizona Standards

The following is an excerpt from Wastewater Microbiology (Bitton,1994)

> Water reuse in Arizona is employed at 180 plants treating approximately 200 MGD. The state has established a compliance program for monitoring viruses, Giardia, and fecal coliforms in reused wastewater. Arizona is the only state in the United States that has adopted standards for enteric viruses. The standards specify that virus levels should not exceed 1 PFU/40 L for reclaimed water used for spray-irrigation of food eaten raw or for unrestricted-access water sports. For irrigated landscape area and golf courses with full access to the public, the virus level should not exceed 125 PFU/40 L. With regards to Giardia, none should be detected in 49 L of water. Virus monitoring for activated sludge plants and oxidation pond effluents showed that 60% of the samples met the compliance standard of 1 PFU/ 40 L. Furthermore, 97% of sand filtered activated sludge effluents met

the virus standard and two thirds met the Giardia standards.

To put the Districts' objective of "no (detectable) viruses in the effluent" in perspective with requirements in Arizona, the Districts' virus sampling volume of 300 gallons (1,136 L) is about 30 times the 40 L volume being sampled in Arizona. In addition, it could be argued that any numerical limit that specifies a level of detection, even if the requirement specifies a limit less than a certain level (like 1 PFU/40 L), is infinitely less restrictive than a standard of no viruses at all.

Since the Districts could not meet the 450 CT requirement at some of their facilities, they have entered into an agreement with the Regional Board to do monthly virus testing of effluent from their facilities. Results have historically been non-detectable for all but two samples over the course of 20 years. Recent testing has shown low levels of adenovirus present in UV disinfected pilot studies where the dose was 94 and 97 mJ/cm^2 and they were absent at 123 mJ/cm^2. Later tests showed no adenovirus for UV dosages of 94, 93 and 87 mJ/cm^2 with chorine dosages of 0.5, 1.0, and 1.5 mg/L, respectively. Since adenovirus is very susceptible to chlorine even at low contact times, the Districts propose to apply a low chlorine dosage to filter effluent after the filters so that viruses will not be detected in the effluent. Although this disinfection philosophy may not have a large impact on adenovirus disease transmission and is in excess of NWRI guidelines, and although non-detect does not necessarily mean there are no virus present, the Districts have determined that a double barrier approach will help perception issues and protect the groundwater reclamation interests in the Rio Hondo and San Gabriel River Spreading Basins.

The following tables show what detention times can be expected a the Whittier Narrows WRP with the low chlorine dosage for adenovirus. A contact time of 5 minutes will be targeted for the UV Disinfection Facilities design, and will be comprised of the effluent detention time in the Filter Effluent Pump wetwell, the UV/CCT Inlet Channel, the UV reactor trains and the Receiving Water Channels that precede dechlorination. At an effluent flow of 21 MGD and using half of the CCT inlet channel capacity, the cumulative detention time is approximately 4.8 minutes.

Calculation of Adenovirus Chlorine Detention Time at the WNWRP

	Water Surface Elevation (ft)	Floor Elevation (ft)	Depth (ft)	Length (ft)	Width (ft)	Volume (cu ft)	Volume (gal)	Effluent Flow (MGD)	Effluent Flow (gpm)	Detention Time (min)
Filter Effluent Wetwell	200.00	190.25	9.75	32.00	17.25	5,382	40,257	6.00	4,167	9.66
								9.00	6,250	6.44
								13.00	9,028	4.46
								19.00	13,194	3.05
								21.00	14,583	2.76
								28.00	19,444	2.07
Filter Effluent Flume			3.00	20.00	7.00	420	3,142	6.00	4,167	0.75
								9.00	6,250	0.50
								13.00	9,028	0.35
								19.00	13,194	0.24
								21.00	14,583	0.22
								28.00	19,444	0.16
40% of CCT Inlet Channel	215.60	203.75	11.85	86.00	6.00	2,446	18,295	6.00	4,167	4.39
								9.00	6,250	2.93
								13.00	9,028	2.03
								19.00	13,194	1.39
								21.00	14,583	1.25
								28.00	19,444	0.94

UV Reactor
(Based on Trojan Pilot with fourth bank. Bracket treated like one extra lamp per module)
3 trains in service

Trains I/S	Depth (ft)	Width (ft)	Length (ft)	Volume (cu ft)	Volume (gal)	Assumed Flow/lamp MGD	Assumed Flow (gpm)	Detention Time (min)
3	2.67	2.33	63.00	1,174	8,784	6.00	4,167	1.98
						9.00	6,250	1.32
						13.00	9,028	0.91
						19.00	13,194	0.62
						21.00	14,583	0.56
						24.20	16,806	0.49
						28.00	19,444	0.42

Lamps (no)	Sleeve Diameter (in)	Sleeve Area (sq ft)	Sleeve Length (ft)	Equivalent Sleeve No	Sleeve Volume (cu ft)	Sleeve Volume (gal)
672	1.40	0.0107	9.17	756	74.05	554

Net Volume Accounting for Sleeves and Brackets (gal) 8,230 — Total DT at 21 MGD 4.79

Possible Contact Time in Preconditioning Tank

L ft	W ft	H ft	cu ft	Convert gal/cu ft	Volume gal	Convert gpm/MGD	MGD	gpm	Detention Time (min)
60.00	14.50	10.33	8987.1	7.48	67224	694.4	6.00	4,166	16.1
							9.00	6,250	10.8
							13.00	9,027	7.4
							19.00	13,194	5.1
							21.00	14,582	4.6
							28.00	19,443	3.5

Possible Contact Time in CCT Pass
Note: Overall length of one pass is 131.0 ft

Contact time min	Flow mgd	gpm	Volume Required gal	Volume Required cu ft	Length of Required CCT Pass 15 ft deep by 8.5 ft wide
5.00	6.00	4,167	20,833	2,785	21.8
	9.00	6,250	31,250	4,178	32.8
	13.00	9,028	45,139	6,035	47.3
	19.00	13,194	65,972	8,820	69.2
	21.00	14,583	72,916	9,748	76.5
	28.00	19,444	97,222	12,998	101.9

Appendix F

UV Disinfection Capacity vs. UVT

Appendix F – UV Disinfection Capacity vs. UVT

General

It is interesting to see how UV disinfection capacity varies with UVT. The worst-case condition controlling the design of the UV system for the WNWRP occurs at peak sanitary flow (with sidestreams) with a typical low UVT and one reactor out of service. Thus, three reactor trains operating at a 100% power setting will have to treat a total of 21 MGD at 71% UVT. After determining the rounded number of lamps required for each system, disinfection capacities were determined as a function of UVT. The results show that at the design UVT of 71%, the rounded four bank Trojan and Wedeco systems will actually be able to treat flows of 28.6 and 29.6 MGD, respectively. The disinfection capacities of each system increase until headloss becomes limiting. This point is reached with the Trojan system at a flow of 30.0 MGD, which can treat a UVT of 71.7% or above. The limiting headloss condition for the Wedeco system is reached at 31.1 MGD, which can treat a UVT of 72.1% or above. The following table shows the variable disinfection capacities of individual reactor trains and the total system, as a function of UVT, for both Trojan and Wedeco.

Disinfection Capacities of Four Train and Four Bank UV Systems as a Function of UVT

% UVT	Trojan		Wedeco	
	Reactor Train Capacity (MGD)	Total System Capacity (MGD)	Reactor Train Capacity (MGD)	Total System Capacity (MGD)
65.00	4.72	18.87	5.47	21.86
67.00	5.44	21.76	6.06	24.25
69.00	6.25	24.98	6.70	26.81
70.00	6.68	26.73	7.04	28.17
71.00 Design Condition (without roundup)	7.00	28.00	7.00	28.00
71.00	7.14	28.57	7.39	29.57
71.72 Trojan Maximum	7.49	29.96	---	---
72.00	---	---	7.75	31.01
72.07 Wedeco Maximum	---	---	7.78	31.10

Note: This analysis was conducted at a lamp power of 100% and a dosage of 100 mJ/cm^2. All conditions are after lamp roundup, except for the design condition. The Trojan analysis is based on LACSD's equation. Note that a 1% change in the operating UVT from 70 to 71% results in an increase of treatment capacity by 5-7%.

Appendix G

Preliminary Construction Sequence

Appendix G – Preliminary Construction Sequence

The construction sequence will be predicated on the fact that at least one of the two CCTs will have to remain in service for the plant to produce effluent for reuse.

Phase I Construction in the West CCT

During Phase I of the construction project, CCT No. 2 (west) will be removed from service, drained and cleaned. CCT No. 1 (east) will remain in service and continue to provide chlorine contact time. Construction of two UV reactor trains, Effluent Storage Channel 2, the western half of the UV Outlet Channel and Receiving Water Channel, and Receiving Water Channel 2, will take place at this time. The westernmost UV drain connections will be constructed and tied into the plant sewer. The backwash pump (if available at that time) will be installed in the west CCT. Since the plant's existing fire protection will be out of service, which is solely supplied by the draft hydrant in CCT No. 2 (west), it is imperative that the Recycled Water Pump Station remains in operation. During this time, the pressurized firewater connection on the Recycled Water Pump Station discharge line will assume this function.

Phase II Construction in the East CCT

During Phase II of the construction project, CCT No. 1 (east) will be removed from service, drained and cleaned. The west CCT will remain in service and continue to provide chlorine contact time. Construction of two UV reactor trains, Effluent Storage Channel 1, the eastern half of the UV Outlet Channel and Receiving Water Channel, and Receiving Water Channel 1, will take place at this time. The chemical dilution water line will also be installed in the east CCT. It will be connected to the UV Outlet Channel to provide unchlorinated water for polymer make-up and carrying water. The easternmost UV drain connections will be constructed.

Anticipated Plant Shutdowns

When construction of the UV reactor trains has been completed, a plant shutdown(s) will be required to cut the openings for the UV reactor trains and to install the inlet gates. Tie-in of electrical power to the UV system and backwash recovery pump may require a short-term plant shutdown.

Appendix H

System Operation

Appendix H – System Operation

Operation of the Recycled Water Pump Station and CCTs Prior to Completion of the UV Disinfection Facilities

After the Recycled Water Pump Station work is completed, the WNWRP is expected to operate at a 9.4 MGD effluent flow with two or three aeration tanks on line. During this time, the plant will be providing disinfected tertiary effluent (filtered and chlorinated secondary effluent) that meets Title 22 standards as irrigation water to the Upper San Gabriel Municipal Water District. Due to funding requirements on the Recycled Water Pump Station contract, partial pumping of reuse water was originally required by September 30, 2005. Although this funding deadline has been relaxed somewhat, the plant will need to provide water to the pump station by January 2006 during startup activities. Because chlorine disinfection will still be used at this time, the CCTs will be needed to provide contact time. Therefore, the Recycled Water Pump Station will be operated without lowering the water level in the CCTs so that a nominal contact time can be maintained.

During this time, the plant effluent that does not get pumped by the Recycled Water Pump Station will be discharged to the receiving water and will require dechlorination. Level indication may need to be provided upstream of the CCT weir to ensure that enough sodium bisulfite is added for dechlorination as there is a delay in the receiving water flow measurement that is registered downstream at the effluent metering structure. During this time, it would be desirable to set the reuse pumping schedule to match flow availability and to minimize cycling of the Dechlorination System. The CCTs will only be operated as storage tanks with fluctuating water levels after the proposed UV system is operational.

Operation of the UV System with a Low UVT During times when the plant UVT is lower than the design UVT (but greater than the validated UVT limit of 55% UVT), more UV equipment will automatically be brought on line and the power ramped up to treat the plant flow. As long as the UV system can deliver 100 mJ/cm^2 with operational parameters within the system's validated range, plant flow will not have to be restricted. If this cannot be achieved, the plant flow will have to be reduced in order satisfy the required dosage.

During periods of low UVT (<70%), Operations staff will obtain a manual grab sample to determine if there is a real UVT problem or if it is just an on-line analyzer problem. If indeed the problem is real, in many cases, the operational response will be to reduce the plant influent flow and to consider diverting the secondary effluent flow to the sewer.

Operation of the UV System with a High UVT If a high UVT is encountered, the number of lamps that are on-line will be reduced, or the power of the UV system will be ramped down, in order to maintain the dose of 100 mJ/cm2. As long as this can be done with operational parameters within the system's validated range, the system should not overdose. Note that allowable system headloss may be a limitation here. **Refer also to Appendix F.**

Operational Conditions to be Avoided

During operation of the UV system, the following conditions should be avoided:

- Flow per lamp per bank outside of the validated range
- UVT's outside of the validated range
- Major lamp alarm conditions (adjacent or multiple lamp failures)
- Inadequate operational dose
- UV lamps providing inadequate irradiation because of warm-up, power quality problems, power interruption or power failure
- Lamps operating beyond their cleaning regimen guidelines or lamp age

Emergency Conditions

The following emergency conditions will be resolved automatically by the control system as follows:

1. **INADEQUATE UV DOSE** (after the system has ramped up to maximum lamp power and added all available banks and trains).

   a. Control will be transferred to the standby UVT analyzer.
   b. If the above proves inadequate, the Hypochlorite System will be activated and the UV System will be shut down.

2. **HIGH UV/CCT INLET CHANNEL WATER LEVEL**:

   a. An additional UV reactor train or trains will be activated, as long as the resulting operating conditions are within the validated range of the UV System.
   b. If the above proves inadequate, the Hypochlorite System will be activated and the UV System will be shut down.
   c. If the above proves inadequate, the Filter Effluent Pumps will be shut down manually, either locally or remotely.

3. **HIGH WATER LEVEL IN THE CCT:**

   a. An overflow weir will prevent this condition.

4. **LOW WATER LEVEL IN THE CCT:**

   a. The Recycled Water Pump Station Pumps will be stopped.

5. **FAILED PLANT EFFLUENT FLOW SIGNAL:**

   a. The Hypochlorite System will be activated and the UV System will be shut down

Notes:

- Automatic switchovers from the UV mode to the Hypochlorite mode will employ post-chlorination without ammonia addition. For a short transition time period, both systems will be operational. During operation in the Hypochlorite mode, the Recycled Water Pump Station will have to maintain high water levels in the ES/CCT's to maintain the required contact time.

- After an automatic switchover from the UV mode to the Hypochlorite mode, the existing effluent sampling system will have to be utilized. This existing system will remain operational at all times, even when in UV mode, to be ready in the event of an automatic switchover.

- Automatic switchovers from the Hypochlorite mode to the UV mode should never be required.

STATE OF CALIFORNIA GEORGE DEUKMEJIAN, Governo

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD—
LOS ANGELES REGION

SOUTH BROADWAY, SUITE 4027
LOS ANGELES, CALIFORNIA 90012-4596
(213) 620-4460

October 31, 1988

Mr. Robert W. Horvath
Head, Monitoring and Research
County Sanitation Districts of
Los Angeles County
P.O. Box 4998
Whittier, CA 90607

WATER RECLAMATION REQUIREMENTS - WHITTIER NARROWS WATER RECLAMATION PLANT (FILE NO. 88-40; CI 6844)

Reference is made to our letter dated October 5, 1988, which transmitted a draft of tentative requirements for your reuse of municipal treated wastewater from the subject wastewater treatment plant.

Pursuant to Section 13523 of the California Water Code, this California Regional Water Quality Control Board, at a public meeting held on October 24, 1988, reviewed these tentative water reclamation requirements, considered all factors in the case, and adopted Order No. 88-107 (copy attached) relative to this matter.

Enclosed are copies of the subject Order and Monitoring and Reporting Program. Please note that Provision D, Items 20 and 21 require you to submit to this Board technical reports within 90 days of the effective date of this Order.

The "Monitoring and Reporting Program" requires you to implement the monitoring program on the effective date of this Order. Your first monitoring report is due by December 15, 1988.

If you have any questions, please call Shana K. Manafian at (213) 620-5413.

HUBERT H. KANG
Senior Water Resource
Control Engineer

cc: See attached mailing list

Enclosures

Mailing List

Mr. Archie Matthews, State Water Resources Control Board, Division of Water Quality
Ms. Bonnie Wolstoncroft, State Water Resources Control Board, Office of Chief Counsel
Department of Water Resources, Southern District
Department of Fish and Game, Region 5
Department of Health Services, Public Water Supply Branch
Los Angeles County, Department of Health Services
Los Angeles County, Department of Public Works, Hydraulic/Water Conservation Division
Los Angeles County, Department of Public Works, Engineering Services Division
Central and West Basin Water Replenishment District
City of El Monte
South Coast Air Quality Management District

State of California
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION

ORDER NO. 88-107

WATER RECLAMATION REQUIREMENTS
FOR

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY
(Whittier Narrows Water Reclamation Plant)
(File No. 88-40)

The California Regional Water Quality Control Board, Los Angeles Region, finds:

1. County Sanitation Districts of Los Angeles County have filed a report of water reclamation in accordance with California Water Code, Division 7, Chapter 7, Section 13522.5 to apply for water reclamation requirements for its Whittier Narrows Water Reclamation Plant.

2. County Sanitation Districts of Los Angeles County (hereinafter referred to as "Reclaimer") operate Whittier Narrows Water Reclamation Plant, located at 301 North Rosemead Boulevard, El Monte, California, with a design capacity of 15.0 million gallons per day (mgd), and reclaim all or a portion of the treated municipal wastewater.

3. The wastewater treatment consists of primary sedimentation, activated sludge biological treatment, secondary clarification, coagulation, inert media filtration, chlorination, and dechlorination. No facilities are provided for solids processing at the plant. All sewage solids separated from the wastewater are returned to the trunk sewer for final disposal at the Reclaimer's Joint Water Pollution Control Plant.

4. Effluent from this plant is discharged to surface waters, San Gabriel River and Rio Hondo, under National Pollutant Discharge Elimination System permit (NPDES permit No. CA0053716) . Effluent is also reclaimed for groundwater recharge under separate water reclamation requirements (File Nos. 71-67 and 60-129) adopted by this Board.

5. The Reclaimer currently proposes to reuse an additional 0.05 mgd of water for irrigation of nursery stock. Additional reuse projects may also be developed in the future.

6. The areas of reclaimed water use are located within the San Gabriel Valley Hydrologic Subunit.

7. A recent total dissolved solids (TDS) analysis for the plant's influent at the Whittier Narrows Water Reclamation Plant showed 538 mg/l of TDS. The TDS analyses for the plant's effluent ranged between 440-580 mg/l for the period of July 1987 through June 1988.

8. The Board adopted a Revised Water Quality Control Plan for Los Angeles River Basin on November 27, 1978. The Plan contains water quality objectives for ground water in San Gabriel Valley Hydrologic Subunit. The Basin Plan objective for TDS in the Westerly Portion of Main San Gabriel Basin is 450 mg/l.

9. Section 13523.5 of Water Code states that " A regional board may not deny issuance of water reclamation requirements to a project which violates only a salinity standard in the basin plan."

10. Ground water in the San Gabriel Valley Hydrologic Subunit is beneficially used for municipal and domestic supply, industrial service and process supply, agricultural supply, and freshwater replenishment.

11. Section 13523 of the Water Code provides that a regional board, after consulting with and receiving the recommendations of the State Department of Health Services and after any necessary hearing, shall, if it determines such action to be necessary to protect the public health, safety, or welfare, prescribe water reclamation requirements for water which is used or proposed to be used as reclaimed water. Section 13523 further provides that such requirements shall include, or be in conformance with, the statewide reclamation criteria.

12. The use of reclaimed water for irrigation could affect the public health, safety, or welfare; requirements for such use are therefore necessary in accordance with Section 13523 of the Water Code.

13. This project involves an existing facility and as such is exempt from the provisions of the California Environmental Quality Act in accordance with California Code of Regulations, Title 14, Chapter 3, Section 15301.

The Board has notified the Reclaimer and interested agencies and persons of its intent to prescribe water reclamation requirements for the use of reclaimed water and has provided them with an opportunity to submit their written views and recommendations.

The Board in a public meeting heard and considered all comments pertaining to use of reclaimed water and to the tentative water reclamation requirements.

IT IS HEREBY ORDERED, that County Sanitation Districts of Los Angeles County, shall comply with the following:

A. Reclaimed Water Limitations

1. Reclaimed water shall be limited to treated municipal wastewater only, as proposed.

2. Reclaimed water shall not contain constituents in excess of the following limits:

		DISCHARGE LIMITATIONS		
Constituent	Unit	30-day Average	7-day Average	Daily Maximum
Total dissolved solids	mg/l	-	-	600
Chloride	mg/l	-	-	100
Sulfate	mg/l	-	-	150
Boron	mg/l	-	-	0.5
Suspended solids	mg/l	15	40	-
Settleable solids	ml/l	0.1	-	0.3
BOD $20^{0}C$	mg/l	20	30	-
Oil and grease	mg/l	10	-	15
Nitrite-N plus Nitrate- N	mg/l	10	-	-
Fluoride	mg/l	-	-	1.6

3. The pH of reclaimed water shall at all times be within the range 6.0 to 9.0.

4. Reclaimed water shall not contain trace constituents or other substances in concentrations exceeding the limits contained in the current

edition of the California Department of Health Services Drinking Water Standards.

5. Radioactivity shall not exceed the limits specified in Title 22, Chapter 15, Article 5, Sections 64441 and 64443, California Code of Regulations, or subsequent revisions.

6. Reclaimed water, used for agricultural supply, shall not contain concentrations of chemical constituents in amounts that adversely affect such beneficial use.

B. Specifications for Use of Reclaimed Water

1. Reclaimed water used for the irrigation of golf courses (away from residential area), cemeteries, freeway landscapes, and landscapes in other areas where the public has similar access or exposure shall be at all times an adequately disinfected, oxidized wastewater.

The wastewater shall be considered adequately disinfected if the median number of coliform organisms in the effluent does not exceed 23 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed, and the number of coliform organisms does not exceed 240 per 100 milliliters in any two consecutive samples.

Oxidized wastewater means wastewater in which the organic matter has been stabilized, is nonputrescible, and contains dissolved oxygen.

Disinfected wastewater means wastewater in which the pathogenic organisms have been destroyed by chemical, physical or biological means.

2. Reclaimed water used for the irrigation of parks, playgrounds, schoolyards, golf courses adjacent to residential areas, and other areas where the public has similar access or exposure shall be at all times an adequately disinfected, oxidized, coagulated, clarified, filtered wastewater or a wastewater treated by a sequence of unit processes that will assure an equivalent degree of treatment and reliability.

The wastewater shall be considered adequately disinfected if the median number of coliform organisms in the effluent does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed, and the number of coliform organisms does not exceed 23 per 100 milliliters in any sample.

A coagulated wastewater means an oxidized wastewater in which colloidal and finely divided suspended matter have been destabilized and agglomerated by the addition of suitable floc-forming chemicals or by an equally effective method.

A filtered wastewater means an oxidized, coagulated, clarified wastewater which has been passed through natural undisturbed soils or filter media, such as sand or diatomaceous earth, so that the turbidity as determined by an approved laboratory method does not exceed an average operating turbidity of 2 turbidity units and does not exceed 5 turbidity units more than 5 percent of the time during any 24-hour period.

3. Reclaimed water used as a source of supply in a nonrestricted recreational impoundment (an impoundment of reclaimed water in which no limitations are imposed on body-contact water sport activities) shall be at all times an adequately disinfected, oxidized, coagulated, clarified, filtered wastewater.

   The wastewater shall be considered adequately disinfected if at some location in the treatment process the median number of coliform organisms does not exceed 2.2 per 100 milliliters and the number of coliform organisms does not exceed 23 per 100 milliliters in more than one sample within any 30-day period. The median value shall be determined from the bacteriological results of the last 7 days for which analyses have been completed.

4. Reclaimed water used as a source of supply in a restricted recreational impoundment (a body of reclaimed water in which recreation is limited to fishing, boating, and other non-body-contact water recreation activities) shall be at all times an adequately disinfected, oxidized wastewater.

   The wastewater shall be considered adequately disinfected if at some location in the treatment process the median number of coliform organisms does not exceed 2.2 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed.

5. Reclaimed water used as a source of supply in a landscape impoundment (a body of reclaimed water which is used for aesthetic enjoyment or which otherwise serves a function not intended to include public contact) shall be at all times an adequately disinfected, oxidized wastewater.

   The wastewater shall be considered adequately disinfected if at some location in the treatment process the median number of coliform organisms does not exceed 23 per 100 milliliters, as determined from the bacteriological results of the last 7 days for which analyses have been completed.

6. Reclaimed water shall not be directly used for uses other than those enumerated above until requirements for other uses have been established by this Board in accordance with Section 13523 of the California Water Code, unless the Board waives such requirements or finds that the above cited standards are applicable to these uses.

7. Reclaimed water uses shall meet the requirements specified in the "Guidelines for Use of Reclaimed Water" issued by the State Department of Health Services.

8. Reclaimed water used for irrigation shall be retained on the areas of use and shall not be allowed to escape as surface flow except as provided for in a National Pollutant Discharge Elimination System Permit.

   For the purpose of this requirement, however, minor amounts of irrigation return water from peripheral areas shall not be considered a violation of this Order provided the discharge otherwise meets the requirements contained in a National Pollutant Discharge Elimination System Permit issued to the County Sanitation Districts of Los Angeles County (Whittier Narrows Water Reclamation Plant).

9. Reclaimed water shall be applied at such a rate and volume as not to exceed vegetative demand and soil moisture conditions. Special precautions must be taken to prevent clogging of spray nozzles, to prevent overwatering and to exclude the production of runoff. Pipelines shall be maintained so as to prevent leaks.

10. Reclaimed water used for irrigation shall not be allowed to run off into recreational lakes unless it meets the criteria for such lakes.

C. General Requirements

1. The discharge or use of raw or inadequately treated sewage at any time is prohibited.

2. Reclaimed water shall not be used for irrigation during periods of extend rainfall and/or runoff.

3. Standby or emergency power facilities and/or sufficient storage capacity shall be provided so that in the event of plant upset or outages, (due to power faileur) or other causes, discharge of raw or inadequately treated sewage does not occur.

4. Reclaimed water use or disposal shall not result in earth movement in geologically unstable areas.

5. Adequate freeboard shall be maintained in reclaimed water storage pond to ensure that direct rainfall will not cause overtopping.

6. Neither treatment of waste nor any reclaimed water use or disposal shall cause pollution or nuisance.

7. Water reclamation and reuse or disposal shall not result in problems due to breeding of mosquitoes, gnats, midges, or other pests.

8. Reclaimed water use or disposal shall not impart tastes, odors, color, foaming, or other objectionable characteristics to receiving waters.

9. Reclaimed water shall not contain any substance in concentrations toxic to human, animal, or plant life.

10. Odors of sewage origin shall not cause a nuisance.

11. Reclaimed water use or disposal shall not cause a violation of any applicable water quality standards for receiving waters adopted by this Board or the State Water Resources Control Board.

D. Provisions

1. A copy of these requirements shall be maintained at the reclamation and reclaimed water use facilities so as to be available at all times to operating personnel.

2. The Reclaimer must comply with all of the terms, requirements and conditions of this Order. Any violation of this Order constitutes a violation of the California Water Code, and is grounds for enforcement action, Order termination, Order revocation, and reissuance denial of an application for reissuance, or any combination thereof.

3. This Order may be modified, revoked and reissued, or terminated for cause. The filing of a request by the Reclaimer for a modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any condition of this Order.

4. This Order does not convey any property rights of any sort, or any exclusive privilege.

5. The Reclaimer shall furnish within a reasonable time, any information the Regional Board may request to determine whether cause exists for modifying, revoking and reissuing, or terminating the Order. The Reclaimer shall also furnish to the Regional Board, upon request, copies of records requested to be kept by this Order.

6. The Reclaimer shall take all reasonable steps to minimize or prevent any discharge that has a reasonable likelihood of adversely affecting human health or the environment.

7. In the event of any change in name, ownership, or control of these waste treatment and reclamation facilities, the Reclaimer shall notify this Board of such change and shall notify the succeeding owner or operator of the existence of this Order by letter, copy of which shall be forwarded to the Board.

8. In accordance with Section 13522.5 of the Water Code, the Reclaimer shall file with this Regional Board a report of any material change or proposed change in the character of the reclaimed water or its uses.

9. The Reclaimer shall file with the Board technical reports on self monitoring work performed according to the detailed specifications contained in the Monitoring and Reporting Program, as directed by the Executive Officer.

10. The Reclaimer shall notify this Board by telephone within 24 hours of any violations of reclaimed water use requirements or any adverse conditions as a result of the use of reclaimed water from this facility; written confirmation shall follow within one week.

11. The Reclaimer shall notify Board staff by telephone immediately of any confirmed coliform counts that could cause a violation of the 7-day median limit, including the date(s) thereof. This information shall be confirmed in the next

monitoring report; in addition, for any actual coliform limit violations that occurred, the report shall also include the reasons for the high coliform results, the steps being taken to correct the problem (including dates thereof), and the steps being taken to prevent a recurrence.

12. These requirements do not exempt the Reclaimer from compliance with any other laws, regulations, or ordinances which may be applicable; they do not legalize this reclamation facility, and they leave unaffected any further restraint on the use of reclaimed water which may be contained on other statutes or required by other agencies.

13. The Reclaimer shall be responsible to insure that all users of reclaimed water comply with the specifications and requirements for such use.

14. This Order does not alleviate the responsibility of the Reclaimer to obtain other necessary local, state, and federal permits to construct facilities necessary for compliance with this Order; nor does this Order prevent imposition of additional standards, requirements, or conditions by any other regulatory agency. Expansion of this facility from its current capacity shall be contingent upon issuance of all necessary permits, including a conditional use permit.

15. Supervisors and operators of this publicly owned wastewater treatment plant shall possess a certificate of appropriate grade as specified in California Code of Regulations, Title 23, Chapter 3, Subchapter 14, Section 2455 and 2460.

16. The Reclaimer shall provide to each user of reclaimed water from Whittier Narrows Water Reclamation Plant a copy of these requirements, to be maintained at the user's facility so as to be available at all times to operating personnel.

17. For any extension of the reclaimed water system, the Reclaimer shall submit a report detailing the extension for the approval of the Executive Officer. Following construction, as-built drawings shall be submitted to the Executive Officer for approval prior to use of reclaimed water.

18. The requirements prescribed herein do not authorize the commission of any act causing injury to the property of another, nor protect the Reclaimer from liabilities under federal, state, or local laws.

19. The Regional Board and other authorized representatives shall be allowed:

    a. Entry upon premises where a regulated facility or activity is located or conducted, or where records are kept under the conditions of this Order;

    b. Access to copy any records that are kept under the conditions of this Order;

    c. To inspect any facility, equipment (including monitoring and control equipment), practices, or operations regulated or required under this Order; and

    d. To photograph, sample, and monitor for the purpose of assuring compliance with this Order, or as otherwise authorized by the California Water Code.

20. The Reclaimer shall submit to this Board, within 90 days of the effective date of this order, a report demonstrating compliance with the requirements specified in Chapter 3, Division 4, Title 22, of California Code of Regulations.

21. The Reclaimer shall submit to this Board, within 90 days of the effective date of this Order, a technical report on his preventive (failsafe) and contingency (cleanup) plans for controlling accidental discharges, and for minimizing the effect of such events. The technical report should:

    (a) Identify the possible sources of accidental loss, untreated waste bypass, and contaminated drainage. Loading and storage areas, power outage, waste treatment unit outage, and failure of process equipment, tanks and pipes should be considered.

(b) Evaluate the effectiveness present facilities and procedures and state when they become operational.

(c) Describe facilities and procedures needed for effective preventive and contingency plans.

(d) Predict the effectiveness of the proposed facilities and procedure and provide an implementation schedule containing interim and final dates when they will be constructed, implemented, or operational.

This Board, after review of the technical report, may establish conditions which it deems necessary to control accidental discharges and to minimize the effects of such events. Such conditions may be incorporated as part of this order, upon notice to the Reclaimer.

I, Robert P. Ghirelli, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, Los Angeles Region, on October 24, 1988.

Robert P. Ghirelli

ROBERT P. GHIRELLI, D.Env.
Executive Officer

STATE OF CALIFORNIA
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, LOS ANGELES REGION

MONITORING AND REPORTING PROGRAM NO. 6844
FOR

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY
(Whittier Narrows Water Reclamation Plant)
(File No. 88-40)

The discharger shall implement this monitoring program on the effective date of this Order. All monitoring reports shall be submitted monthly, by the fifteenth day of the second month following each monthly sampling period. The first monitoring report under this program shall be submitted by December 15, 1988.

Quarterly effluent analyses shall be performed during the months of February, May, August, and November. Weekly effluent analyses shall be performed on different weekdays during each month.

By March 5 of each year, the Reclaimer shall submit an annual report to the board. The report shall contain both tabular and graphical summaries of the monitoring data obtained during the previous year. In addition, the Reclaimer shall discuss the compliance record and the corrective actions taken or planned which may be needed to bring the discharge into full compliance with the requirements.

Values obtained for the NPDES monitoring report during periods of discharge to surface waters may be reported here in lieu of duplicate testing, if representative. However, non-NPDES self-monitoring reports shall be submitted separately from the NPDES monitoring reports.

Reclaimed Water Monitoring

A sampling station shall be established where representative samples of reclaimed water can be obtained. Reclaimed water samples may be obtained at a single station provided that station is representative of the quality at all discharge points. Each sampling station shall be identified. The following shall constitute the reclaimed water monitoring program for reclaimed water used as described in the Water Reclamation Requirements:

Constituent	Units	Type of Sample	Minimum Frequency of Analysis
Turbidity[1]	NTU	continuous	-----
Total flow[2]	gallon	continuous	-----
Coliform group[3]	MPN/100ml	grab	daily
pH	pH units	grab	daily
Total dissolved solids	mg/l	24-hr composite	monthly
Chloride	mg/l	24-hr composite	monthly
Boron	mg/l	24-hr composite	monthly
Fluoride	mg/l	24-hr composite	monthly
Sulfate	mg/l	24-hr composite	monthly
BOD_5 20^0C	mg/l	24-hr composite	weekly
Oil and grease	mg/l	grab	monthly
Suspended solids	mg/l	24-hr composite	daily
Settleable solids	ml/l	grab	daily
Nitrate-N plus Nitrite-N	mg/l	24-hr composite	monthly
Arsenic	mg/l	24-hr composite	quarterly
Barium	mg/l	24-hr composite	quarterly
Cadmium	mg/l	24-hr composite	quarterly
Chromium	mg/l	24-hr composite	quarterly
Lead	mg/l	24-hr composite	quarterly
Mercury	mg/l	24-hr composite	quarterly
Selenium	mg/l	24-hr composite	quarterly
Silver	mg/l	24-hr composite	quarterly
Cyanide	mg/l	24-hr composite	quarterly
Nitrate	mg/l	24-hr composite	quarterly
Fluoride	mg/l	24-hr composite	quarterly
Radioactivity	pCi/l	24-hr composite	quarterly
Total identifiable chlorinated hydrocarbons	ug/l	grab	quarterly
Priority Pollutants	ug/l	grab	semi-annually

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[1]Required only for applications having a turbidity limit. The average value recorded each day and amount of time that 5 NTU was exceeded each day shall be reported. Turbidity samples may be obtained anywhere in the treatment process subsequent to the filtration procedure.

[2]Shall report the daily volume of reclaimed water used at each site of use.

[3]Samples shall be obtained at some point in the treatment process at a time when wastewater flow and characteristics are most demanding on the treatment facility and disinfection procedures. The location(s) of the sampling point(s) and any changes thereto

must be approved by the Executive Officer, and proposed changes shall not be made until such approval has been granted. If reclaimed water is used for irrigation of golf courses, cemeteries, freeway landscapes, parks, playgrounds, schoolyards, or other areas where the public has similar access or exposure, samples shall be obtained subsequent to the chlorination procedure. Coliform values obtained must meet the strictest requirement specified for all uses during periods of multiple use, unless separate coliform analyses are obtained at each particular point of use.

General Provisions for Sampling and Analysis

All sampling, sample preservation, and analyses shall be performed in accordance with the latest edition of "Guidelines Establishing Test Procedures for Analysis of Pollutants", promulgated by the United States Environmental Protection Agency.

All chemical, bacteriological, and bioassay analyses shall be conducted at a laboratory certified for such analyses by the State Water Resources Control Board or approved by the Executive Officer.

General Provisions for Reporting

For every item where the requirements are not met, the Reclaimer shall submit a statement of the actions undertaken or proposed which will bring the discharge into full compliance with requirements at the earliest time and submit a timetable for correction.

The Reclaimer shall maintain all sampling and analytical results, including strip charts; date, exact place, and time of sampling; dates analyses were performed; analyst's name; analytical techniques used; and results of all analyses. Such records shall be retained for a minimum of three years. This period of retention shall be extended during the course of any unresolved litigation regarding this discharge or when requested by the Board.

In reporting the monitoring data, the Reclaimer shall arrange the data in tabular form so that the date, the constituents, and the concentrations are readily discernable. The data shall be summarized to demonstrate compliance with Water Reclamation Requirements and, where applicable, shall include results of receiving water observations.

The Reclaimer shall file a report with this Board describing the purposes for which reclaimed water from this facility is used, estimating quantities used for each type of use, depicting on a map

or drawing the area(s) of use, and stating the name and address of each user of reclaimed water if other than the Reclaimer. This report shall be updated at least annually, and shall be included with the annual report due March 5 of each year.

Each monthly report shall include a statement that all reclaimed water was used only as specified in the requirements during the month.

If no water was delivered for reuse during the month, the report shall so state.

Monitoring reports shall be signed by:

a. In the case of corporations, by a principal executive officer at least of the level of vice-president or his duly authorized representative, if such representative is responsible for the overall operation of the facility from which discharge originates;

b. In the case of a partnership, by a general partner;

c. In the case of a sole proprietorship, by the proprietor;

d. In the case of municipal, state or other public facility, by either a principal executive officer, ranking elected official, or other duly authorized employee.

Each report shall contain the following completed declaration:

"I declare under penalty of perjury that the foregoing is true and correct.

Executed on the _____ day of _____ at _____.

_____(Signature)

_____(Title)"

Ordered by Robert P. Ghirelli
ROBERT P. GHIRELLI, D.Env.
Executive Officer

Date: October 24, 1988

STATE OF CALIFORNIA

31-370.10

PETE WILSON, Gover

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD—
'OS ANGELES REGION
CENTRE PLAZA DRIVE
..ONTEREY PARK, CA 91754-2156
(213) 266-7500

September 16, 1991

Mr. Charles W. Carry
Chief Engineer and General Manager
County Sanitation Districts of Los Angeles County
P.O. Box 4998
Whittier, CA 90607-4998

John W. Norman
General Manager
Central and West Basin Water Replenishment District
12621 E. 166th Street
Cerritos, CA 92701

Mr. T.A. Tidemanson
Director of Public Works
Los Angeles County Department of Public Works
900 South Fremont Avenue
Alhambra, CA 91830-1331

WATER RECLAMATION REQUIREMENTS - RIO HONDO & SAN GABRIEL RIVER SPREADING GROUNDS, MONTEBELLO FOREBAY AREA (FILE NO. 71-67)

Reference is made to our letter dated August 15, 1991, which transmitted a draft of tentative requirements for your ground water recharge project using reclaimed water.

Pursuant to Division 7 of the California Water Code, this California Regional Water Quality Control Board, at a public meeting held on September 9, 1991, reviewed these tentative revised requirements, considered all factors in the case, and adopted Order No. 91-100 (copy attached) relative to this project.

You are required to implement the monitoring program as stated in the Monitoring and Reporting Program on the effective date of the Order. All Monitoring reports should be sent to the Regional Board, Attn: Technical Support Unit.

Please reference all technical and monitoring reports to our Compliance File No. 5728. We would appreciate it if you would not combine other reports, such as progress or technical reports, with your monitoring reports but would submit each type of report as a separate document.

45

C.W. CARRY
9.24.91

If you have any questions, please call Gregg Kwey at (213) 266-7547.

Hubert H. Kang
Senior Water Resource
Control Engineer

Enclosures

cc:

State Water Resources Control Board, Division of Water Quality, Attn: Archie Matthews
State Water Resources Control Board, Office of Chief Counsel, Attn: Jorge Leon
Department of Water Resources
Department of Fish and Game, Region 5
Department of Health Services, Sanitary Engineering Branch, Sacramento; Attn: Mr. Peter Rogers, Chief,
Department of Health Services, Public Water Supply Branch, Attn: Gary Yamamoto
Department of Health Services, Public Water Supply Branch, Attn: Frank Hamamura
Department of Health Services, Environmental Management Branch, Attn: Michael Kiado
U.S. Army Corps of Engineers
South Coast Air Quality Management District
Los Angeles County, Department of Health Services, Environmental Health - Health Facilities
Los Angeles County, Department of Public Works, Waste Management Division
Los Angeles County, Department of Parks & Recreation
City of Cerritos
City of Commerce
City of Compton
City of Compton, Municipal Water Department
City of Downey
City of Huntington Park
City of Lakewood
City of La Verne
City of Long Beach, Water Department
City of Los Angeles, Department of Water and Power
City of Lynwood, Department of Public Works
City of Maywood
City of Montebello
City of Norwalk
City of Paramount

City of Pico Rivera
City of Signal Hill
City of South Gate
City of Vernon
City of Whittier
Central Basin Municipal Water District
Central Basin Water Association
Dominguez Water Company
Dominguez Water Corporation
La Habra Heights County Water District; Attn: Mr. James E. Frei
Metropolitan Water District of Southern California
Montebello Land & Water Company Mr. William F. Smith, Gen.
San Gabriel Municipal Water District
San Gabriel Valley Water Company
Southern California Water Company
Upper San Gabriel Valley Municipal Water District; Attn: Timothy C. Jochem
West Basin Municipal Water District
Bookman-Edmonston Engineering, Inc.
HYA Consulting Engineers; Attn: C. Jerry Gantney

State of California
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, LOS ANGELES REGION

ORDER NO. 91-100

WATER RECLAMATION REQUIREMENTS FOR
GROUND WATER RECHARGE

FOR

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY
CENTRAL AND WEST BASIN WATER REPLENISHMENT DISTRICT
(Rio Hondo & San Gabriel River Spreading Grounds)

(FILE NO. 71-67)

The California Regional Water Quality Control Board, Los Angeles Region, finds:

1. Los Angeles County Department of Public Works, County Sanitation Districts of Los Angeles County, and Central and West Basin Water Replenishment District (hereinafter called the Reclaimer as a whole) reclaim water for ground water recharge at Rio Hondo and San Gabriel River Spreading Grounds under water reclamation requirements contained in Order No. 87-40 adopted by this Board on March 23, 1987.

2. County Sanitation Districts of Los Angeles County (Districts) operate the Pomona Water Reclamation Plant at 295 Humane Way, Pomona, California; the San Jose Creek Water Reclamation Plant at 1965 South Workman Mill Road, Whittier, California; and the Whittier Narrows Water Reclamation Plant at 301 North Rosemead Boulevard, El Monte, California.

3. Wastewater treatment at the San Jose Creek and Whittier Narrows Plants consists of primary sedimentation, activated sludge biological treatment, secondary clarification, coagulation, inert media filtration, chlorination and dechlorination. Wastewater treatment at the Pomona Plant is similar except no coagulation occurs and carbon filtration is used along with inert media filtration. All solids separated from the wastewater at each plant are returned to the trunk sewer for final treatment and disposal at the Districts' Joint Water Pollution Control Plant.

4. Effluent from three plants is discharged to surface waters or reclaimed for irrigation and industrial process purposes. These discharges are subject to separate

National Pollutant Discharge Elimination System (NPDES) permits and water reclamation requirements.

5. A portion of the effluent discharged to surface waters is delivered to the Los Angeles County Department of Public Works spreading facilities for ground water recharge. The Central and West Basin Water Replenishment District (CWBWRD) purchases the effluent from the San Jose Creek Water Reclamation Plant and the Whittier Narrows Water Reclamation Plant from the Districts for ground water recharge through the Rio Hondo and San Gabriel Spreading Grounds. The Rio Hondo and San Gabriel River Spreading Grounds, located in the Montebello Forebay of the Central Basin, are owned and operated by the Los Angeles County Department of Public Works (LACDPW).

6. The Montebello Forebay area extends southward from the Whittier Narrows and currently is the most important area of recharge in the Central Basin. Ten fresh-water-bearing aquifers underlie the Montebello Forebay area: Gaspur, Artesia, Exposition, Gage, Gardena, Hollydale, Jefferson, Lynwood, Silverado, and Sunnyside.

7. The Reclaimer also uses both local water (dry weather runoff, rising water (when it occurs), and storm water) and imported water for ground water recharge at the spreading areas. CWBWRD purchases the imported water and LACDPW spreads it.

8. Order No. 87-40 provides that the maximum quantity of reclaimed water spread in any one water year (October through the following September) shall not exceed 50,000 acre-feet (AF) or 50 percent of the total inflow into the Montebello Forebay for that year, whichever is less.

The Reclaimer has requested that Order No. 87-40 be modified as follows:

The average quantity of reclaimed water spread, based on a running 3-year average, shall not exceed 50,000 AF per year. The maximum quantity of reclaimed water spread in any one water year shall not exceed 60,000 AF or 50 percent of the total inflow into the Montebello Forebay for that year, whichever is less; additionally, the maximum quantity of reclaimed water spread in any 3-year period shall not exceed 150,000 AF and 35 percent of the total inflow all sources into the Montebello Forebay during that period.

9. Section 60320 of the State Water Reclamation Criteria (Article 5.1, Chapter 3, Division 4, Title 22 of the Code of California Regulations) specifies that the State Department of Health Services (DHS) shall provide recommendations to the Regional Board on proposed expansions of existing ground water recharge projects. These recommendations shall be based on all relevant aspects of the project including: treatment provided, effluent quality and quantity; spreading area operations, soil characteristics, hydrogeology, residence time, and distance to withdrawal. The DHS did concur with the proposed change of ground water recharge.

10. Section 13523 of the California Water Code provides that a regional board, after consulting with and receiving the recommendations of the State Department of Health Services and after determining such action to be necessary to protect the public health, safety, or welfare, shall prescribe water reclamation requirements for treated wastewater which is used or proposed to be used as reclaimed water. Section 13523 further provides that such requirements shall conform to the statewide Water Reclamation Criteria.

    The use of reclaimed water from the Pomona, San Jose Creek and Whittier Narrows Water Reclamation Plants for ground water recharge could affect the public health, safety, or welfare, and requirements for such use are therefore necessary.

12. The Board adopted a revised Water Quality Control Plan for the Los Angeles River Basin on November 27, 1978. The Plan contains water quality objectives for ground water in the Central Hydrologic Subarea which is part of the Coastal Plain of Los Angeles County.

13. The beneficial uses of the ground waters in the Coastal Plain of Los Angeles County are municipal and domestic supply, agricultural supply, industrial service supply, and industrial process supply.

14. The requirements contained in this Order, as they are met, will be in conformance with the goals of the Wastewater Reclamation Criteria and Water Quality Control Plan for the Los Angeles River Basin.

15. These revised water reclamation requirements are being adopted for an ongoing project, and as such, this action is exempt from the provisions of the California

Environmental Quality Act (Public Resources Code, Section 21100 et seq.) in accordance with Section 15261, Chapter 3, Title 14, Code of California Regulations.

The Board has notified the dischargers and interested agencies and persons of its intent to revise requirements for the use of reclaimed water for ground water recharge and has provided them with an opportunity to submit their written views and recommendations.

The Board in a public meeting heard and considered all comments pertaining to this use of reclaimed water.

IT IS HEREBY ORDERED, that County Sanitation Districts of Los Angeles County, Central and West Basin Water Replenishment District, and Los Angeles County Department of Public Works shall comply with the following:

A. Reclaimed Water Limitations

1. Reclaimed water discharged for ground water recharge shall be limited to treated municipal wastewater only, as proposed.

2. Reclaimed water discharged for ground water recharge shall not exceed the following limits:

		Discharge Limitations		
Constituent	Units	30-Day Average	7-Day Average	Daily Maximum
Fluoride	mg/l	---	---	1.6
Chloride	mg/l	---	---	250
Boron	mg/l	---	---	1
NO_3+NO_2 as N	mg/l	10	---	---
Sulfate	mg/l	---	---	250
Settleable solids	ml/l	0.1	---	0.3
Suspended solids	mg/l	15	40	---
Total dissolved solids	mg/l	---	---	700
Oil and grease	mg/l	10	---	15

3. Reclaimed water discharged for ground water recharge shall at all times be adequately disinfected. For the purposes of this requirement, reclaimed water shall be considered adequately disinfected if the median number of coliform organisms at some point in the treatment process does not exceed 2.2 per 100 milliliters, and the number of coliform organisms does not exceed 23 per 100

milliliters in more than one sample within any 30-day period. The median value shall be determined from samples taken on seven sampling days each week, at least one sample per sampling day, collected at a time when wastewater flow and characteristics are most demanding on the treatment facilities and disinfection procedures.

4. Reclaimed water discharged for ground water recharge shall have received treatment-equivalent to that of a filtered wastewater. Filtered wastewater means an oxidized, coagulated, clarified wastewater which has been passed through natural undisturbed soils or filter media, such as sand or diatomaceous earth, so that the turbidity as determined by an approved laboratory method does not exceed an average operating turbidity of 2 turbidity units and does not exceed 5 turbidity units more than 5 percent of the time during any 24-hour period.

   For the purpose of this requirement, carbon filtration may be accepted if in the judgement of the Executive Officer it can be demonstrated to produce an equivalent quality wastewater. Nothing herein shall be construed to prevent the use of any alternative treatment process(es) provided that they can be demonstrated to the satisfaction of the Executive Officer to achieve compliance with the reclaimed water limitations and requirements.

5. The pH of reclaimed water discharged for ground water recharge shall at all times be within the range 6.0 to 9.0.

6. The temperature of reclaimed water discharged for ground water recharge shall not exceed 100°F.

7. Reclaimed water shall not contain trace constituents in concentrations in excess of values contained in the current edition of California drinking water standards or in excess of action levels established by the State Department of Health Services as determined by a running annual average.

8. Reclaimed water discharged shall not cause a measurable increase in organic chemical contaminants in the ground water.

B. Quantity Limitation

The average quantity of reclaimed water spread, based on a running 3-year average, shall not exceed 50,000 AF per year. The maximum quantity of reclaimed water spread in any one water year shall not exceed 60,000 AF or 50 percent of the total inflow into the Montebello Forebay for that year, whichever is less; additionally, the maximum quantity of reclaimed water spread in any 3-year period shall not exceed 150,000 AF and 35 percent of the total inflow all sources into the Montebello Forebay during that period.

C. General Requirements

1. Reclaimed water discharged for ground water recharge shall not cause odors, color, persistent foaming, or other objectionable characteristics in the receiving waters.

2. Reclaimed water discharged for ground water recharge shall not contain any substances in concentrations toxic to human, animal, plant, or aquatic life.

3. Reclaimed water discharged for ground water recharge shall not contain visible oil or grease, and shall not cause the appearance of grease, oil or oily slick, or persistent foam in the receiving waters or on channel banks, walls, inverts or other structures.

4. Reclaimed water discharged for ground water recharge shall not damage water conservation or flood control structures or facilities.

5. Reclaimed water discharged for ground water recharge to flood control channels or watercourses shall not result in problems due to breeding of mosquitoes, gnats, midges or other pests.

6. Reclaimed water discharged for ground water recharge shall not cause the growth of undesirable organisms in the receiving waters.

7. Reclaimed water discharged for ground water recharge shall not increase the natural turbidity of the receiving waters at the time of discharge.

8. Reclaimed water discharged for ground water recharge shall not cause the formation of sludge deposits.

9. Reclaimed water discharged for ground water recharge shall not cause a violation of any applicable water quality standard for receiving waters adopted by this Board or the State Water Resources Control Board.

10. The discharge of any radiological, chemical, or biological warfare agent or high level radiological waste is prohibited.

D. Provisions

1. Any discharge of reclaimed water at any point(s) other than specifically described in this Order is prohibited, and constitutes a violation of the Order.

2. After notice and opportunity for a hearing, this Order may be terminated or modified for cause, including, but not limited to:

   a. Violation of any term or condition contained in this Order;

   b. Obtaining this Order by misrepresentation, or failure to disclose all relevant facts;

   c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

3. This Order may be modified, revoked and reissued, or terminated for cause. The filing of a request by the discharger for a modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any condition of this Order.

4. The discharger shall furnish, within a reasonable time, any information the Regional Board may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this Order. The discharger shall also furnish to the Regional Board, upon request, copies of records required to be kept by this Order.

5. The discharger shall take all reasonable steps to minimize or prevent any discharge that has a reasonable likelihood of adversely affecting human health or the environment.

6. Bypass (the intentional diversion of waste streams from any portion of a treatment facility) is prohibited. The Regional Board may take enforcement action against the discharger for bypass unless:

   a. Bypass was unavoidable to prevent loss of life, personal injury, or severe property damage. (Severe property damage means substantial physical damage to property, damage to the treatment facilities that causes them to become inoperable, or substantial and permanent loss of natural resources that can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.);

   b. There were no feasible alternatives to bypass, such as the use of auxiliary treatment facilities, retention of untreated waste, or maintenance during normal periods of equipment down time. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass that could occur during normal periods of equipment downtime or preventive maintenance; and

   c. The discharger submitted a notice at least ten days in advance of the need for a bypass to the Regional Board.

   The discharger may allow a bypass to occur that does not cause reclaimed water limitations to be exceeded, but only if it is for essential maintenance to assure efficient operation. In such a case, the above bypass conditions are not applicable.

   The discharger shall submit notice of an unanticipated bypass as required in Standard Provision, Item 17.

7. This Order includes "Standard Provisions Applicable to Waste Discharge Requirements."

E. Rescission

Order No. 87-40 adopted by this Board on March 23, 1987, is hereby rescinded.

I, Robert P. Ghirelli, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, Los Angeles Region on September 9, 1991.

Robert P. Ghirelli

ROBERT P. GHIRELLI, D.Env.
Executive Officer

GK/

State of California
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, LOS ANGELES REGION

MONITORING AND REPORTING PROGRAM NO. 5728
FOR

LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY
CENTRAL AND WEST BASIN WATER REPLENISHMENT DISTRICT
(Rio Hondo & San Gabriel River Spreading Grounds)

(FILE NO. 71-67)

The Reclaimer shall implement this monitoring program on the effective date of the Order. All monitoring reports shall be submitted monthly, by the fifteenth day of the second month following each monthly sampling period. The first monitoring report under this program is due by October 15, 1991.

By December 15 of each year, the Reclaimer shall submit an annual report to the Board. The report shall contain both tabular and graphical summaries of the monitoring data obtained during the previous water year. In addition, the Reclaimer shall discuss the compliance record and the corrective actions taken or planned which may be needed to bring the discharge into full compliance with the water reclamation requirements.

Bimonthly analyses shall be performed during months of February, April, June, August, October, December. Quarterly reclaimed water and ground water analyses and/or measurements shall be performed during the months of February, June, August, and December. Semi-annual analyses on ground water samples shall be performed during the months of June and December.

If no water was reclaimed during the reporting period, the monitoring report shall so state.

Each monitoring report shall state whether or not there was any change in the discharge as described in the Order during the reporting period.

Flow Measurement

For recharge water monitoring the estimated quantities of individual water supplies spread in each of the spreading grounds on the day of intake water sampling shall be reported. Estimated quantities of all inflows to the Montebello Forebay shall be included in the annual monitoring report together with the calculated percentage of reclaimed water to total inflow for the year.

Recharge Water Monitoring

A sampling station shall be established for each point of discharge from the Pomona, San Jose Creek, and Whittier Narrows Water Reclamation Plants and for each point of intake to Rio Hondo spread ground and San Gabriel River spreading ground. These sampling stations shall be located where representative water samples can be obtained. Intake water samples may be obtained at a single station provided that station is representative of the water quality at all intake points.

All sampling, sample preservation, and analyses must be conducted according to test procedures under 40 CFR Part 136, except for samples taken from production wells which will be tested under requirements of Title 22 of the California Code of Regulations.

Analysis method used shall be such that no detection limits are higher than Maximum Contaminant Levels of Drinking Water Standards or Action Levels. For any constituents or parameters where the detection limits specified in these test procedures are higher than the State Department of Health Services' "Drinking Water Standards" or "action levels", the proposed method(s) and procedure(s) of analyses must be approved, in writing, by the Executive Officer prior to the use of such methods and procedures.

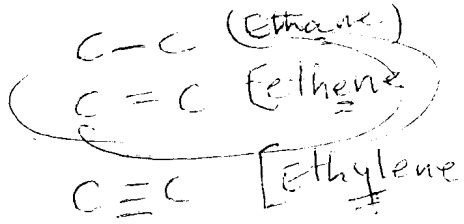
The following shall constitute the water monitoring program:

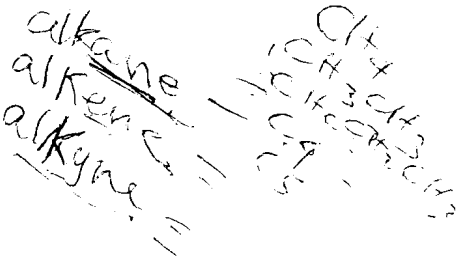
Constituent	Units	Type of Sample	Minimum Frequency of Analysis[1]
Total dissolved solids	mg/l	24-hr. composite	monthly
MAJOR MINERALS			
Calcium	mg/l	24-hr. composite	bimonthly
Magnesium	mg/l	24-hr. composite	bimonthly
Sodium	mg/l	24-hr. composite	bimonthly
Potassium	mg/l	24-hr. composite	bimonthly
Chloride	mg/l	24-hr. composite	bimonthly
Boron	mg/l	24-hr. composite	bimonthly
Hardness	mg/l	24-hr. composite	bimonthly
Alkalinity	mg/l	24-hr. composite	bimonthly
Fluoride	mg/l	24-hr. composite	bimonthly

[1]For intake water minimum frequency of analysis should be monthly for the first year after the effective date of the Order and quarterly thereafter.

Constituent	Units	Type of Sample	Minimum Frequency of Analysis[1]
Carbonate	mg/l	24-hr. composite	bimonthly
Bicarbonate	mg/l	24-hr. composite	bimonthly
Sulfate	mg/l	24-hr. composite	bimonthly
NITROGEN			
Nitrate-N	mg/l	24-hr. composite	monthly
Nitrite-N	mg/l	24-hr. composite	monthly
Ammonia Nitrogen	mg/l	24-hr. composite	monthly
Organic Nitrogen	mg/l	24-hr. composite	monthly
OXIDANTS AND REDUCTANTS			
Chemical Oxygen Demand	mg/l	24-hr. composite	monthly
Biochemical Oxygen Demand	mg/l	24-hr. composite	weekly
Total Organic Carbon	mg/l	24-hr. composite	monthly
BASE/NEUTRAL EXTRACTABLE ORGANICS			
Bis (2-ethylhexyl) phthalate	ug/l	grab	bimonthly
Phenanthrene	ug/l	grab	bimonthly
Fluoranthene	ug/l	grab	bimonthly
Aroclor 1242	ug/l	grab	bimonthly
Aroclor 1254	ug/l	grab	bimonthly
PCBs	ug/l	grab	bimonthly
ACID EXTRACTABLE ORGANICS			
1,2,4-Trichlorobenzene	ug/l	grab	bimonthly
2,4,6-Trichlorophenol	ug/l	grab	bimonthly
2,4,5-Trichlorophenol	ug/l	grab	bimonthly
2,3,4-Trichlorophenol	ug/l	grab	bimonthly
2,3,6-Trichlorophenol	ug/l	grab	bimonthly
3,4,5-Trichlorophenol	ug/l	grab	bimonthly
Pentachlorophenol	ug/l	grab	bimonthly
Phenol	ug/l	grab	bimonthly
PESTICIDES			
DDT	ug/l	grab	bimonthly
BHC	ug/l	grab	bimonthly
Aldrin	ug/l	grab	bimonthly
Dieldrin	ug/l	grab	bimonthly

Constituent	Units	Type of Sample	Minimum Frequency of Analysis[1]
Endrin	ug/l	grab	bimonthly
Toxaphene	ug/l	grab	bimonthly
Atrazine	ug/l	grab	bimonthly
Simazine	ug/l	grab	bimonthly
Methoxychlor	ug/l	grab	bimonthly
2,4-Dichlorophenoxyacetic acid	ug/l	grab	bimonthly
2,4,5-Trichlorophenoxy-propionic acid	ug/l	grab	bimonthly
Lindane	ug/l	grab	bimonthly
Heptachlor	ug/l	grab	bimonthly
Heptachlor Epoxide	ug/l	grab	bimonthly
PURGEABLE ORGANICS			
Methylene Chloride	ug/l	grab	bimonthly
Chloroform	ug/l	grab	bimonthly
Bromodichloromethane	ug/l	grab	bimonthly
Dibromochloromethane	ug/l	grab	bimonthly
Bromoform	ug/l	grab	bimonthly
Carbon Tetrachloride	ug/l	grab	bimonthly
1,1-Dichloroethane	ug/l	grab	bimonthly
1,2-Dichloroethane	ug/l	grab	bimonthly
1,1,1-Trichloroethane	ug/l	grab	bimonthly
1,1,2-Trichloroethane	ug/l	grab	bimonthly
1,1-Dichloroethylene	ug/l	grab	bimonthly
Cis-1,2-Dichloroethylene	ug/l	grab	bimonthly
Trichloroethylene	ug/l	grab	bimonthly
Tetrachloroethylene	ug/l	grab	bimonthly
Benzene	ug/l	grab	bimonthly
Toluene	ug/l	grab	bimonthly
Chlorobenzene	ug/l	grab	bimonthly
o-Dichloro			bimonthly
m-Dichloro			bimonthly
p-Dichloro			bimonthly
Trans-1,2-i ethylen			bimonthly
Bromoethane			bimonthly
Chloroethar			bimonthly
2-Chloroeth			bimonthly
Chlorometha			bimonthly
1,2-Dichlor			bimonthly
Cis-1,3-Dic			bimonthly
Trans-1,3-D			bimonthly
1,1,2,2-Tet ethane			bimonthly





Constituent	Units	Type of Sample	Minimum Frequency of Analysis[1]
Vinyl Chloride	ug/l	grab	bimonthly
Xylenes	ug/l	grab	bimonthly
Trichlorofluordmethane	ug/l	grab	bimonthly
Bromomethane	ug/l	grab	bimonthly
Dichlorodifluoromethane	ug/l	grab	bimonthly
Ethylbenzene	ug/l	grab	bimonthly
Methyl ethyl ketone	ug/l	grab	bimonthly
Methyl isobutyl ketone	ug/l	grab	bimonthly
MISCELLANEOUS ORGANICS			
Phenylacetic Acid	ug/l	grab	bimonthly
MBAS	mg/l	grab	bimonthly
PHYSICAL PROPERTIES			
pH	pH units	grab	daily
Temperature	°F	grab	daily
Color	CU	grab	monthly
Turbidity[2,3]	NTU	continuous	
BACTERIA			
Coliform Organisms[3,4]	MPN/100ml	grab	daily

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[2]The following shall be reported:
a. maximum value recorded each day,
b. total time (in minutes) each day when turbidity exceeded 5 turbidity units (TU), and
c. flow-proportioned average daily value and monthly mean.

[3]Not required for intake water sampling.

[4]Coliform samples shall be obtained at some point in the treatment process at a time when wastewater flow and characteristics are most demanding on the treatment facilities and disinfection procedures. The location(s) of the sampling point(s) and any proposed changes thereto must be approved by the Executive Officer, and the proposed changes shall not be made until such approval has been granted.

Constituent	Units	Type of Sample	Minimum Frequency of Analysis[1]
VIRUS			
Total Enteric Virus[3]	IU/gallon	grab	quarterly
IRON AND MANGANESE			
Iron	ug/l	24-hr. composite	quarterly
Manganese	ug/l	24-hr. composite	quarterly
TRACE CONSTITUENTS			
Arsenic	ug/l	24-hr. composite	quarterly
Barium	ug/l	24-hr. composite	quarterly
Cadmium	ug/l	24-hr. composite	quarterly
Chromium (Hexavalent)	ug/l	24-hr. composite	quarterly
Chromium (Total)	ug/l	24-hr. composite	quarterly
Copper	ug/l	24-hr. composite	quarterly
Lead	ug/l	24-hr. composite	quarterly
Mercury	ug/l	24-hr. composite	quarterly
Nickel	ug/l	24-hr. composite	quarterly
Selenium	ug/l	24-hr. composite	quarterly
Silver	ug/l	24-hr. composite	quarterly
Zinc	ug/l	24-hr. composite	quarterly
RADIOACTIVITY			
Gross alpha	pCi/l	24-hr. composite	quarterly
Gross beta[5]	pCi/l	24-hr. composite	quarterly
Uranium[6]	pCi/l	24-hr. composite	quarterly
Radium-226[7]	pCi/l	24-hr. composite	quarterly

[5]Whenever the gross beta particle activity exceeds 50 pCi/l, an analysis of the sample shall be performed to identify the major radioactive constituents present.

[6]Analysis for this constituent should only be done if the gross alpha radioactivity exceeds 10 pCi/l.

[7]Analysis for this constituent should only be done if the gross alpha radioactivity exceeds 5 pCi/l.

	Constituent	Units	Type of Sample	Minimum Frequency of Analysis[1]
126	Radium-228[8]	pCi/l	24-hr. composite	quarterly
122	Tritium	pCi/l	24-hr. composite	quarterly
124	Strontium-90	pCi/l	24-hr. composite	quarterly
123	Radon	pCi/l	grab	quarterly

Ground Water Monitoring

The Reclaimer shall submit to the Board a Ground Water Sampling and Analysis Plan for Executive Officer's approval within thirty days from the effective date of this monitoring program.

The following water wells are designated as the ground water monitoring stations:

Well No.	Depth(ft)	Perforation(ft)	Aquifers
		Spreading Ground Wells	
1582W	141	70-132	Gaspur
1590AL	101	51-91	Gaspur
1612T	901	60-80	Gaspur
1613V	110	35-110	Gaspur
1620RR	90	50-80	Gaspur
2909Y	125	60-115	Gaspur
		Production Wells	
1514A	883	500-600	Lynwood
1543J	290	126-275	Gage, Hollydale
1562E	590	422-556	Silverado
1566A	609	345-572	Lynwood, Silverado
1581N	660	230-648	Gaspur, Gardena, Hollydale, Jefferson, Lynwood, Silverado
1583X	492	235-422	Hollydale, Silverado
1591H	600	281-572	Silverado, Sunnyside
1600X	474	294-456	Silverado, Sunnyside
1606U	385	193-364	Gage, Hollydale, Jefferson
1612Q	520	242-446	Lynwood, Silverado
1620OO	530	305-462	Silverado

[8]Analysis for this constituent should only be done if the radium-226 radioactivity exceeds 3 pCi/l.

1620PP	570	172-520	Gardena, Jefferson, Lynwood, Silverado
1621MM	728	184-698	Jefferson, Lynwood, Silverado, Sunnyside
1621T	633	75-611	Gaspur, Jefferson, Lynwood, Sunnyside
2899I	364	60-352	Gaspur, Gage, Lynwood, Silverado
2908V	250	160-230	Sunnyside
2909V	425	148-399	Lynwood, Silverado
2947LM	820	180-800	Gardena, Jefferson, Lynwood, Silverado, Sunnyside
2958A	190	150-190	Gardena

The following shall constitute the ground water monitoring program:

Constituent	Units	Type of Sample	Minimum Frequency of Analysis[9]
Water level[10]	+/- ft MSL	----	bimonthly
Total dissolved solids	mg/l	grab	bimonthly
MAJOR MINERALS			
Calcium	mg/l	grab	bimonthly
Magnesium	mg/l	grab	bimonthly
Sodium	mg/l	grab	bimonthly
Potassium	mg/l	grab	bimonthly
Carbonate	mg/l	grab	bimonthly
Bicarbonate	mg/l	grab	bimonthly
Sulfate	mg/l	grab	bimonthly
Chloride	mg/l	grab	bimonthly
Boron	mg/l	grab	bimonthly
Hardness	mg/l	grab	bimonthly
Alkalinity	mg/l	grab	bimonthly
Fluoride	mg/l	grab	bimonthly
NITROGEN			
Nitrate-N	mg/l	grab	bimonthly
Nitrite-N	mg/l	grab	bimonthly

[9]Minimum frequency of analysis for production wells should be semiannually.

[10]Not required for production wells.

Constituent	Units	Type of Sample	Minimum Frequency of Analysis[9]
Ammonia Nitrogen	mg/l	grab	bimonthly
Organic Nitrogen	mg/l	grab	bimonthly
OXIDANTS AND REDUCTANTS			
Chemical Oxygen Demand	mg/l	grab	bimonthly
Total Organic Carbon	mg/l	grab	bimonthly
BASE/NEUTRAL EXTRACTABLE ORGANICS			
Bis (2-ethylhexyl) phthalate	ug/l	grab	bimonthly
Phenanthrene	ug/l	grab	bimonthly
Fluoranthene	ug/l	grab	bimonthly
Aroclor 1242	ug/l	grab	bimonthly
Aroclor 1254	ug/l	grab	bimonthly
PCBs	ug/l	grab	bimonthly
ACID EXTRACTABLE ORGANICS			
1,2,4-Trichlorobenzene	ug/l	grab	bimonthly
2,4,6-Trichlorophenol	ug/l	grab	bimonthly
2,4,5-Trichlorophenol	ug/l	grab	bimonthly
2,3,4-Trichlorophenol	ug/l	grab	bimonthly
2,3,6-Trichlorophenol	ug/l	grab	bimonthly
3,4,5-Trichlorophenol	ug/l	grab	bimonthly
Pentachlorophenol	ug/l	grab	bimonthly
Phenol	ug/l	grab	bimonthly
PESTICIDES			
DDT	ug/l	grab	bimonthly
BHC	ug/l	grab	bimonthly
Aldrin	ug/l	grab	bimonthly
Dieldrin	ug/l	grab	bimonthly
Endrin	ug/l	grab	bimonthly
Toxaphene	ug/l	grab	bimonthly
Atrazine	ug/l	grab	bimonthly
Simazine	ug/l	grab	bimonthly
Methoxychlor	ug/l	grab	bimonthly
2,4-Dichlorophenoxyacetic acid	ug/l	grab	bimonthly
2,4,5-Trichlorophenoxy-propionic acid	ug/l	grab	bimonthly
Lindane	ug/l	grab	bimonthly

Constituent	Units	Type of Sample	Minimum Frequency of Analysis[9]
Heptachlor	ug/l	grab	bimonthly
Heptachlor Epoxide	ug/l	grab	bimonthly
PURGEABLE ORGANICS			
Methylene Chloride	ug/l	grab	bimonthly
Chloroform	ug/l	grab	bimonthly
Bromodichloromethane	ug/l	grab	bimonthly
Dibromochloromethane	ug/l	grab	bimonthly
Bromoform	ug/l	grab	bimonthly
Carbon Tetrachloride	ug/l	grab	bimonthly
1,1-Dichloroethane	ug/l	grab	bimonthly
1,2-Dichloroethane	ug/l	grab	bimonthly
1,1,1-Trichloroethane	ug/l	grab	bimonthly
1,1,2-Trichloroethane	ug/l	grab	bimonthly
1,1-Dichloroethylene	ug/l	grab	bimonthly
Cis-1,2-Dichloroethylene	ug/l	grab	bimonthly
Trichloroethylene	ug/l	grab	bimonthly
Tetrachloroethylene	ug/l	grab	bimonthly
Benzene	ug/l	grab	bimonthly
Toluene	ug/l	grab	bimonthly
Chlorobenzene	ug/l	grab	bimonthly
o-Dichlorobenzene	ug/l	grab	bimonthly
m-Dichlorobenzene	ug/l	grab	bimonthly
p-Dichlorobenzene	ug/l	grab	bimonthly
Trans-1,2-Dichloro-ethylene	ug/l	grab	bimonthly
Bromoethane	ug/l	grab	bimonthly
Chloroethane	ug/l	grab	bimonthly
2-Chloroethylvinylether	ug/l	grab	bimonthly
Chloromethane	ug/l	grab	bimonthly
1,2-Dichloropropene	ug/l	grab	bimonthly
Cis-1,3-Dichloropropene	ug/l	grab	bimonthly
Trans-1,3-Dichloropropene	ug/l	grab	bimonthly
1,1,2,2-Tetrachlorc-ethane	ug/l	grab	bimonthly
Vinyl Chloride	ug/l	grab	bimonthly
Xylenes	ug/l	grab	bimonthly
Trichlorofluordmethane	ug/l	grab	bimonthly
Bromomethane	ug/l	grab	bimonthly
Dichlorodifluoromethane	ug/l	grab	bimonthly
Ethylbenzene	ug/l	grab	bimonthly
Methyl ethyl ketone	ug/l	grab	bimonthly
Methyl isobutyl ketone	ug/l	grab	bimonthly

Constituent	Units	Type of Sample	Minimum Frequency of Analysis[9]
MISCELLANEOUS ORGANICS			
Phenylacetic Acid	ug/l	grab	bimonthly
MBAS	mg/l	grab	bimonthly
PHYSICAL PROPERTIES			
pH	pH units	grab	bimonthly
Temperature	°F	grab	bimonthly
Color	CU	grab	bimonthly
BACTERIA			

A narrative report and analysis shall be included in the annual report which will review coliform organism monitoring by individual production wells performed during the year.

IRON AND MANGANESE			
Iron	ug/l	grab	bimonthly
Manganese	ug/l	grab	bimonthly
TRACE CONSTITUENTS			
Arsenic	ug/l	grab	bimonthly
Barium	ug/l	grab	bimonthly
Cadmium	ug/l	grab	bimonthly
Chromium (Hexavalent)	ug/l	grab	bimonthly
Chromium (Total)	ug/l	grab	bimonthly
Copper	ug/l	grab	bimonthly
Cyanide	ug/l	grab	bimonthly
Lead	ug/l	grab	bimonthly
Mercury	ug/l	grab	bimonthly
Nickel	ug/l	grab	bimonthly
Selenium	ug/l	grab	bimonthly
Silver	ug/l	grab	bimonthly
Zinc	ug/l	grab	bimonthly
RADIOACTIVITY			
Gross alpha	pCi/l	grab	bimonthly
Gross beta[5]	pCi/l	grab	bimonthly
Uranium[6]	pCi/l	grab	bimonthly
Radium-226[7]	pCi/l	grab	bimonthly
Radium-228[8]	pCi/l	grab	bimonthly
Tritium	pCi/l	grab	bimonthly
Strontium-90	pCi/l	grab	bimonthly

Constituent	Units	Type of Sample	Minimum Frequency of Analysis[9]
Radon	pCi/l	grab	bimonthly

Reporting Provisions

1. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

2. In reporting the monitoring data, the Reclaimer shall arrange the data in tabular form so that the date, the constituents, and the concentrations are readily discernable. The data shall be summarized to demonstrate compliance with water reclamation requirements and, where applicable, shall include results of receiving water observations.

3. For every item where the requirements are not met, the Reclaimer shall submit a statement of the actions undertaken or proposed which will bring the discharge into full compliance with requirements at the earliest time and submit a timetable for correction.

4. If the Reclaimer monitors any pollutant more frequently than required by this Order using test procedures approved under 40 CFR Part 136 or as specified in this Order, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the Discharge Monitoring Report.

5. Calculations for all limitations that require averaging of measurements shall utilize an arithmetic mean unless otherwise specified in this Order.

6. Each monitoring report must affirm in writing that:

   "all analyses were conducted at a laboratory certified for such analyses by the State Water Resources Control Board or approved by the Executive Officer and in accordance with current EPA guideline procedures or as specified in this Monitoring Program.

7. For any analyses performed for which no procedure is specified in the EPA guidelines or in the Monitoring and Reporting Program, the constituent or parameter analyzed and the method or procedure used must be specified in the monitoring report.

Ordered by: Robert P. Ghirelli

ROBERT P. GHIRELLI, D.Env.
Executive Officer

Date: September 9, 1991

GK/

State of California—Health and Human Services Agency
Department of Health Services

California Department of Health Services
SANDRA SHEWRY
Director

ARNOLD SCHWARZENEGGER
Governor

October 24, 2005

Mr. Michael Shortt
Trojan Technologies, Inc
3020 Gore Rd
London, Ontario, Canada N5V4T7

Dear Mr. Shortt:

TROJAN 3000PLUS UV DISINFECTION WITH 4 IN. LAMP SPACING

Based on the "UV3000™Plus Validation Report" (June 2005) that documents work conducted at the County Sanitation Districts of Los Angeles County, the Water Recycling Committee of the California Department of Health Services conditionally accepts the Trojan 3000Plus UV disinfection system with 4 in. lamp spacing. At a minimum, the Trojan 3000plus UV systems with a 4-inch lamp spacing should be designed to deliver UV dose recommendations in the NWRI/AWWARF UV Disinfection Guidelines.

Since the water quality conditions of testing ranged from 53 to 77% transmittance and a flow range of 2.9 to 37.8 gpm/lamp, design and operational settings will be restricted to these ranges. The following equation cited in the report should be used for designing and operating the UV system.

Dose per bank = [redacted]

The design example, using this equation, provides the user with practical tips on how the equation can be used to size and, once commissioned, operate the system. The terms and conditions for applying the previously accepted lamp age and quartz sleeve fouling factors for the Trojan 3000plus™ will apply.

As with all UV systems, it will be recommended that any Trojan 3000plus™ UV system be commissioned before being issued a permit. Such a test should demonstrate uniform flow distribution through each reactor train and hydrodynamic conditions within the reactor similar to that present during validation testing ultimately demonstrating that the reactor meets its design objectives.

Normally, velocity profile matching could be used in lieu of bioassay for commissioning the UV system, but the velocity measurements and profiles reported are outside the tolerance (±20% of theoretical hydraulic residence time) recommended by the NWRI/AWWARF guidelines. Based on this and other tests it is not reasonable to accept these velocity profiles as a substitute for bioassay commissioning, unless the built UV system matches the velocity profiles documented in this report (within the tolerances of the instrumentation). As always we will continue to work with you on alternatives for commissioning UV systems.

As a reminder, regulations and recommendations (by regulatory agencies) provide minimum design and operational criteria. These minimum requirements do not and should not preclude utilities from designing and installing systems with greater UV dose delivery to address pathogens that may be more difficult to disinfect than the present enteric virus surrogates. While no one can predict what the future regulatory objectives will be, we must constantly remind ourselves that, for water recycling, establishing a reliable consistent ever present barrier to human pathogens is the primary objective of disinfection in water recycling.

At present, the UV disinfection guidelines target 4 logs of enteric inactivation using poliovirus as the target organism. Poliovirus has been the surrogate enteric virus for a number of years. Until recently enteric viruses were thought to have been well represented by the poliovirus with respect to their susceptibility to UV disinfection. Recent research indicates that double stranded DNA viruses may be capable of UV repair and much more resistant to UV disinfection than poliovirus. This means the working model or surrogate for enteric viruses is probably not conservative when it comes to UV disinfection.

We do not anticipate an immediate change in public policy, but based on the UV disinfection requirements and targets in drinking water, there may be changes in the future. The proposed UV Disinfection Guidance Manual cites a reduction equivalent dose of 110 mJ/cm^2 for 1.5 logs of virus inactivation (based on adenovirus). A UV system designed and commissioned to deliver a 100 mJ/cm^2 would be short of achieving or obtaining a 1.5 log virus inactivation credit. Granted the UVDGM tables are for drinking water, nevertheless, they represent a significant change in the surrogate and subsequent UV dose required to achieve enteric virus inactivation.

Occurrence data indicates the presence of adenovirus (by tissue culture assay) in secondary effluent, an agency such as the County Sanitation Districts of Los Angeles County might consider it prudent to establish a UV system design objective at a level above that recommended in the NWRI/AWWARF UV Guidelines. Until occurrence data provides us with better information on which to base a risk assessment, the current water quality objectives and the targets used to achieve those objectives will not change. However, it might not be in the best interest of a wastewater utility to simply design a system to meet current minimum regulatory recommendations.

Should you have any questions regarding the content of this letter, please feel free to contact me at (510) 620-3499.

Very truly yours,

Original signed by

Richard H. Sakaji, PhD, PE
Senior Sanitary Engineer

cc: Water Recycling Committee
chron

Chi-Chang Tang
County Sanitation Districts of Los Angeles County
1955 Workman Mill Rd
Whittier, CA 90601

Andrew Salveson
Carollo Engineers
2700 Ygnacio Valley Road, Suite 300
Walnut Creek, CA 94598

State of California—Health and Human Services Agency
Department of Health Services

California Department of Health Services

SANDRA SHEWRY
Director

ARNOLD SCHWARZENEGGER
Governor

April 26, 2006

Mr. Michael Shortt
Trojan Technologies, Inc
3020 Gore Rd
London, Ontario, Canada N5V4T7

Dear Mr. Shortt:

TROJAN 3000PLUS UV DISINFECTION WITH 4 IN. LAMP SPACING

Based on the "UV3000™Plus Validation Report" (February 2006) which documents work conducted at the County Sanitation Districts of Los Angeles County, the Water Recycling Committee of the California Department of Health Services extends the conditional acceptance of the Trojan 3000Plus UV disinfection system with 4 in. lamp spacing to include the use of the Heraeus lamp (Trojan part number 794447). At a minimum, the Trojan 3000plus UV systems with a 4-inch lamp spacing should be designed to deliver UV dose recommendations in the NWRI/AWWARF UV Disinfection Guidelines.

Since the water quality conditions of testing ranged from 53 to 77% transmittance and a flow range of 6.2 to 126.5 gpm/lamp, design and operational settings will be restricted to these ranges. The following equation (sans lamp aging and sleeve fouling factors) cited in the report should be used for designing and operating the UV system.

Dose per bank = [redacted]

The design example contained in your report provides the user with practical tips on how the equation can be used to size and, once commissioned, operate the system. The terms and conditions for applying the quartz sleeve fouling factor for the Trojan 3000plus™ remains unchanged, but the end-of-lamp-life (EOLL) factor has been revised for the Heraeus lamp cited above.

Based on the information contained in the report titled "Trojan 3000™Plus 9,000-Hour Lamp Age Factor Report Heraeus Lamp" (December 2005), the Water Recycling Committee of the California Department of Health Services conditionally accepts the use of 0.98 as the lamp aging factor for the Heraeus lamp model GA64T6H (Trojan part

no. 794447). Should the manner in which the lamp or any of its components is manufactured be changed, it is the responsibility of Trojan Technologies, Inc to inform the Department's Water Recycling Committee so that a determination can be made regarding the need to retest and reevaluate the EOLL.

As with all UV systems, it will be recommended that any Trojan 3000plus™ UV system be commissioned before being issued a permit. Such a test should demonstrate the reactor meets its design objectives by confirming:

1. the hydrodynamic conditions within the reactor are no worse than those present during validation testing, and

2. the lamp output produces an intensity field similar to that present during validation testing.

As a reminder, regulations and recommendations (by regulatory agencies) provide minimum design and operational criteria. These minimum requirements do not and should not preclude utilities from designing and installing systems with greater UV dose delivery to address pathogens that may be more difficult to disinfect than the present enteric virus surrogates. While no one can predict what the future regulatory objectives will be, we must constantly remind ourselves that, for water recycling, establishing a reliable consistent ever present barrier to human pathogens is the primary objective of disinfection in water recycling.

At present, the UV disinfection guidelines target 4 logs of enteric inactivation using poliovirus as the target organism. Poliovirus has been the surrogate enteric virus for a number of years. Until recently enteric viruses were thought to have been well represented by the poliovirus with respect to their susceptibility to UV disinfection. Recent research indicates that double stranded DNA viruses may be capable of UV repair and much more resistant to UV disinfection than poliovirus. This means the working model or surrogate for enteric viruses is probably not conservative when it comes to UV disinfection.

We do not anticipate an immediate change in public policy, but based on the UV disinfection requirements and targets in drinking water, there may be changes in the future. The proposed UV Disinfection Guidance Manual cites a reduction equivalent dose of 110 mJ/cm^2 for 1.5 logs of virus inactivation (based on adenovirus). A UV system designed and commissioned to deliver a 100 mJ/cm^2 would be short of achieving or obtaining a 1.5 log virus inactivation credit and well short of the UV dose needed to achieve a 4 log reduction of enteric virus. Granted the UVDGM tables are for drinking water, nevertheless, they represent a significant change in the surrogate and subsequent UV dose required to achieve enteric virus inactivation.

Occurrence data indicates the presence of adenovirus (by tissue culture assay) in secondary effluent, an agency such as the County Sanitation Districts of Los Angeles County might consider it prudent to establish a UV system design objective at a level above that recommended in the NWRI/AWWARF UV Guidelines. Until occurrence data

provides us with better information on which to base a risk assessment, the current water quality objectives and the targets used to achieve those objectives will not change. However, it might not be in the best interest of a wastewater utility to simply design a system to meet current minimum regulatory recommendations.

Additional comments/recommendations/questions

"UV3000™Plus Validation Report" (February 2006)

pg. ES1 – The report references a November 2005 report. However, the original report (dated November 2005) was revised. The report is now dated February 2006 and should be referenced as such in the report. A search and replace to remove the November 2005 reference should be done and a revised report submitted to the Department.

pg. 14 – It appears as though it was over three years since the radiometer was calibrated. Is this a normal time interval? If not, this is something that should be checked. Se pg. 27 comment below.

pg. 27 – A statement regarding whether or not the collimated beam work passed the NWRI QA/QC requirement would be helpful. This should include a summary comparison of the QA/QC criteria and the actual collimated beam data.

This particular collimated beam test was very close to failing the NWRI/AWWARF QA/QC (one more data point outside the boundary). Is GAP EnviroMicrobial Services an ELAP certified laboratory for wastewater or water microbiological work? If not, you may want to consider using an ELAP certified laboratory for future work. Granted, ELAP does not certify for MS2 phage assays, but the QA/QC and good laboratory practices employed by ELAP certified laboratories may produce results that are not so close to failing the NWRI/AWWARF QA/QC criteria.

pg. 33 – Section 5.2.4 discusses the double bank testing from another report. The log removal additivity mentioned is correct, but only if the hydraulic independence between the modules is maintained. It is also possible the variability in the bioassay results might also mask any hydraulic impacts.

"Trojan 3000™Plus 9,000-Hour Lamp Age Factor Report Heraeus Lamp" (December 2005),

pg. 6 – In the description of the NFT apparatus, it is not clear how the lamp output from one lamp is isolated from the output of the second lamp. The statement makes it clear the output from the top lamp is measured, but it is unclear to one unfamiliar with the device how the output from the top lamp is isolated from any stray photons from the lower lamp.

pg. 12 – Consistently adding 20 percent to the intensity is a "key" assumption and the key is not the 20 percent, but the assumption the addition is consistent. Is there any data or fundamental understanding regarding UV sensors to support this assumption?

pg. 14 – How do you know the difference in the radiometer readings was associated with drift in the radiometer and not a combination of radiometer drift and variability in lamp output?

pg. 17 – Would you agree that the use of an EOLL based on average lamp performance is sufficient for the design of UV systems because the variability in lamp output is sufficiently accounted for the validation testing, i.e., the bioassay? Is there a way to measure the output of the lamps in the field? Velocity profiles used for commissioning will provide a partial picture of the UV dose delivered, but will not ensure the intensity field in the reactor is similar to the one in the validation study.

pg. 20 – Similarly, how does one know the source of the variability? Is it safe to assume the variability was in the radiometer and not the lamps? If so, how? One source of variability may dominate, but once that source of variability is reduced, another source will control the variability observed.

Should you have any questions regarding the content of this letter, please feel free to contact me at (510) 620-3499.

Very truly yours,

Original signed by

Richard H. Sakaji, PhD, PE
Senior Sanitary Engineer

cc: Water Recycling Committee
chron

Chi-Chang Tang
County Sanitation Districts of Los Angeles County
1955 Workman Mill Rd
Whittier, CA 90601

Andrew Salveson
Carollo Engineers
2700 Ygnacio Valley Road, Suite 300
Walnut Creek, CA 94598