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Design Optimization of the Chlorination Process

Volume II

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EPA-600/2-80-133
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DESIGN OPTIMIZATION OF THE CHLORINATION PROCESS

VOLUME II:

COMPARISON OF ACUTE TOXICITY OF CHLORINATED EFFLUENTS FROM OPTIMIZED AND EXISTING FACILITIES

by

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FOREWORD

The U. S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimonies to the deterioration of our natural environment. The complexity of that environment and the interplay of its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution; it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems to prevent, treat, and manage wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, to preserve and treat public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research and provides a most vital communications link between the researcher and the user community.

This study was concerned with comparing the disinfection efficiencies of various wastewater chlorination systems against an optimized system, and evaluating the toxicities of the resulting effluents. Knowledge of criteria which will successfully optimize chlorination systems will benefit both the discharger by reduced chemical costs (chlorine and sulfur dioxide) and improved efficiency, and man and his environment by adequate disinfection for the proper control of disease transmission and continued preservation and propagation of fish and wildlife. This investigation has greatly contributed in the quest for these goals.

Francis T. Mayo, Director
Municipal Environmental Research
Laboratory

ABSTRACT

The California Department of Health Services in cooperation with the California Department of Fish and Game developed and implemented a chlorine optimization study which investigated several design criteria that may improve the efficiency of wastewater chlorination systems and hence, provide adequate disinfection without excessive chlorination and toxicity. The study was conducted on-site at eight wastewater treatment plants in northern California. Two mobile units were constructed for the project: a pilot chlorination plant and a mobile toxicity testing and water quality laboratory. They were operated by the Department of Health Services and the Department of Fish and Game, respectively. The pilot chlorination plant tested several optimized chlorination design criteria against existing wastewater treatment plant chlorination systems. The mobile laboratory evaluated the toxicity of the optimized and existing chlorinated effluents.

The toxicity associated with the existing unchlorinated and dechlorinated effluents increased with un-ionized ammonia concentrations. Most of the toxicity associated with the unchlorinated and dechlorinated effluents, however, was the result of an artificial increase in pH created by a toxicity test design problem. The optimized chlorinated effluents, with one exception, had lower and more stable chlorine residuals than did the existing chlorinated effluents and hence, were generally less toxic. The toxicity of all effluents investigated increased proportionately with increased chlorine residual.

This report was submitted in fulfillment of Grant Number S803459 by the California Department of Fish and Game under the sponsorship of the Environmental Protection Agency. Work was completed in September 1979.

CONTENTS

FIGURES

FIGURES (Continued)

TABLES

LIST OF ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

DeCl	--	existing wastewater treatment plant chlorinated effluent which has been dechlorinated with sulfur dioxide
DOHCl	--	existing wastewater treatment plant unchlorinated effluent chlorinated by the Department of Health Services Pilot Plant
ECl	--	existing wastewater treatment plant unchlorinated effluent chlorinated by the existing wastewater treatment plant system
FH	--	fathead minnows, *Pimephales promelas*
GS	--	golden shiners, *Notemigonus crysoleucas*
LC50, 96-h	--	concentration of a substance which causes 50% mortality to the population in 96-h
m^3/d	--	cubic meters per day
mg/L	--	milligrams per liter
NH_3	--	un-ionized gas fraction of total ammonia
$NH_4^+ + NH_3$	--	total ammonia
p	--	probability of Type I error
P	--	phase of electricity
r	--	correlation coefficient
SD	--	standard deviation
ug/L	--	micrograms per liter
UnCl	--	existing wastewater treatment plant unchlorinated effluent
VAC	--	volts of alternating current
WTP	--	wastewater treatment plant

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S. Flannery, D. Yoshikawa, D. Roberts, and D. Konnoff assisted with the data collection, and D. Langdon kept financial records and prepared the final manuscript. D. Wood and H. Rectenwald helped design and construct the mobile laboratory. J. Horton of DFG, B. Anona of the Department of Environmental Studies at University of California, Davis, and the U. S. Bureau of Reclamation provided assistance with the computerized data analyses.

SECTION 1

INTRODUCTION

The practice of treating wastewater effluents with chlorine continues to be used for the control of pathenogenic organisms. A dilemma is created when chlorinated effluents are discharged into the environment since they represent a hazard to aquatic organisms. Numerous studies have defined the toxicity of chlorinated wastewaters to fish and other aquatic organisms (Zillich 1972; Brungs 1973; 1976; Arthur et al. 1975; Mattice and Zittel 1976; Ward et al. 1976; Finlayson and Hinkelman 1977). However, no studies have attempted to improve the situation by optimizing the amount of chlorine needed for disinfection, thus making the effluents less toxic.

The California Department of Fish and Game (DFG) has many times witnessed the inefficient and excessive application of chlorine to wastewater effluents at wastewater treatment plants (WTP) in California. Effluents with chlorine residuals in excess of 10 mg/L (total residual chlorine) have been observed entering the State's receiving waters (Finlayson 1977). These excessive residuals are over 1,000 times the recommended "safe" level (3 to 5 ug/L TRC) for chlorine (DeGraeve et al. 1978). Usually, excessive chlorine residuals are the result of either improper chlorine application or an ineffective residual chlorine control system or both. Because of this need to optimize wastewater chlorination systems, DFG welcomed the opportunity to participate in a chlorination optimization study. The results of such a study will help to minimize chlorine usage, chlorine residuals, and use of other chemicals such as sulfur dioxide in dechlorination.

The purpose of this study was to evaluate the influence and importance of three chlorine application optimization design criteria on wastewater chlorination systems. These design criteria which were developed by the California Department of Health Services (DOH) are:

1) a rapid and complete initial mixing between chlorine and waste;
2) a 30-min minimum contact time in a well designed tank between the chlorine and waste; and
3) a sound and workable chlorine residual control system.

Two mobile units were developed for the project. The DOH unit was a pilot chlorination plant designed to test chlorine application optimization criteria against existing WTP chlorination systems at selected sites (Sepp and Bao 1980). The DFG unit was developed to test and document the comparative toxicities between optimized and existing chlorinated effluents of WTP which employ different disinfection system designs. The purpose was to evaluate the influence and importance of various design factors which are capable of minimizing toxicity. The DFG field laboratory was designed specifically to simultaneously monitor toxicity and quality of three effluent types:

1) existing WTP unchlorinated (UnCl) effluents;
2) existing WTP chlorinated (ECl) effluents; and
3) DOH optimized pilot plant chlorinated (DOHCl) effluents.

The analyses of the data in this paper are intended to demonstrate:

1) the differences between chlorine residuals in optimized and existing chlorinated effluents;
2) the differences between toxicities of optimized and existing chlorinated effluents;
3) the differences between toxicities of chlorine in ammoniated and ammonia-stripped (nitrified) effluents;
4) the toxicity of unchlorinated and dechlorinated effluents; and
5) the toxicity of chlorine to the two test fish; fathead minnow, *Pimephales promelas*, and golden shiner, *Notemigonus crysoleucas*.

SECTION 2

CONCLUSIONS

1. The optimized pilot plant employed by the California Department of Health Services produced lower and more stable total chlorine residuals (TRC) in wastewaters than existing full-scale chlorination systems.

2. These, lower and more stable pilot plant wastewater chlorine residuals represent an average of 49.7% reduction in TRC below that of existing effluents.

3. These lower and more stable pilot plant wastewater TRC caused an average of 42.9% reduction in acute toxicity below that of existing effluents.

4. This reduction of TRC and toxicity in the optimized chlorinated effluents was much less noticeable in nitrified effluents.

5. Chlorine was the most toxic constituent of the effluents tested.

6. The toxicity [percent (%) effluent concentration] of chlorinated effluents was predictable based on mean TRC concentration of the undiluted wastewater.

7. Dechlorination of chlorinated effluents with sulfur dioxide removes all acute toxicity associated with chlorine.

8. The toxicity associated with the unchlorinated and dechlorinated effluents increased with increased un-ionized ammonia concentrations.

9. Most of the un-ionized ammonia toxicity associated with the unchlorinated and dechlorinated effluents was caused by an artificial increase in pH (0.5 pH units) in the toxicity testing aquaria. Un-ionized ammonia concentrations in the 100% effluent aquaria were 144% higher than in the undiluted waste streams. The increase in pH is a toxicity test design problem caused by aeration and partial confinement of the effluent during the test.

10. Nitrification of wastewaters prior to chlorination under some circumstances can reduce the toxicity of TRC.

11. Fathead minnows were significantly more sensitive (23.6 percent) to TRC than were golden shiners.

SECTION 3

RECOMMENDATIONS

1. The optimized design criteria effect significant savings in the amount of chlorine applied during the disinfection of wastewaters and result in less toxic effluents. Hence, they should be considered in designing chlorination systems.

2. Nitrification of wastewaters, because it can reduce the toxicity of TRC and eliminate un-ionized ammonia toxicity, should perhaps be considered as a beneficial treatment process for wastewaters.

3. Because of artificial pH increases during effluent toxicity tests, the following test designs should be used in this order of preference: (1) continuous-flow (flow-through); (2) continual-flow (intermittent-flow); and (3) static.

4. Dechlorination of wastewater effluents should be practiced to remove all toxicity associated with chlorine.

SECTION 4

MATERIALS AND METHODS

PROJECT SCHEDULE

Both the DFG mobile laboratory and DOH pilot plant were operated at eight wastewater treatment plants in northern California (Figure 1) between February 1978 and May 1979 (Table 1). We collected comparative toxicity and water quality data between optimized and existing chlorinated effluents for seven of the eight plants; the DOH pilot plant was not functioning correctly at the San Leandro WTP (Sepp and Bao 1980).

MOBILE LABORATORY

The toxicity testing and water quality monitoring were performed in a mobile field laboratory, an 8 x 4 by 2.7 m trailer (Figure 2). The laboratory was transported by a 910 kg (1-ton) stakeside truck. The material cost of the mobile laboratory was approximately $30,000.

The mobile laboratory is functionally segregated into three separate areas (Figure 3):

1) water control room;
2) toxicity testing room; and
3) laboratory.

The water control room receives up to three wastes as well as the dilution water for the toxicity tests. All plumbing in the trailer was constructed of SCH 40 and 80 polyvinyl-chloride (PVC) pipe. Equipment in this room includes a chiller, heat exchangers, and an air pump. There are four heat exchangers, one for each of the wastes and one for the dilution water. The heat exchangers were available to lower the temperatures of wastes and incoming water. They were constructed of 10.2-cm and 15.2-cm diameter (100-cm and 250-cm long) PVC pipe with stainless steel tubing (6-mm O.D. x 3-mm I.D.) coils inside. The heat exchangers work on the principle of heat transfer from the waste and water streams to chilled ethylene glycol inside the stainless tubing. Temperatures are lowered as the waste and water streams flow through the PVC pipes. The chilled ethylene glycol was supplied from a 2700 kg (3-ton) 58,000 kj (@ 29°C), air cooled, water chiller.

The toxicity testing room contains three Mount and Brungs (1967) proportional diluters and thirty-six, 10-L, over-flowing aquaria for three continual-flow toxicity tests. Predilution systems upstream of the diluters

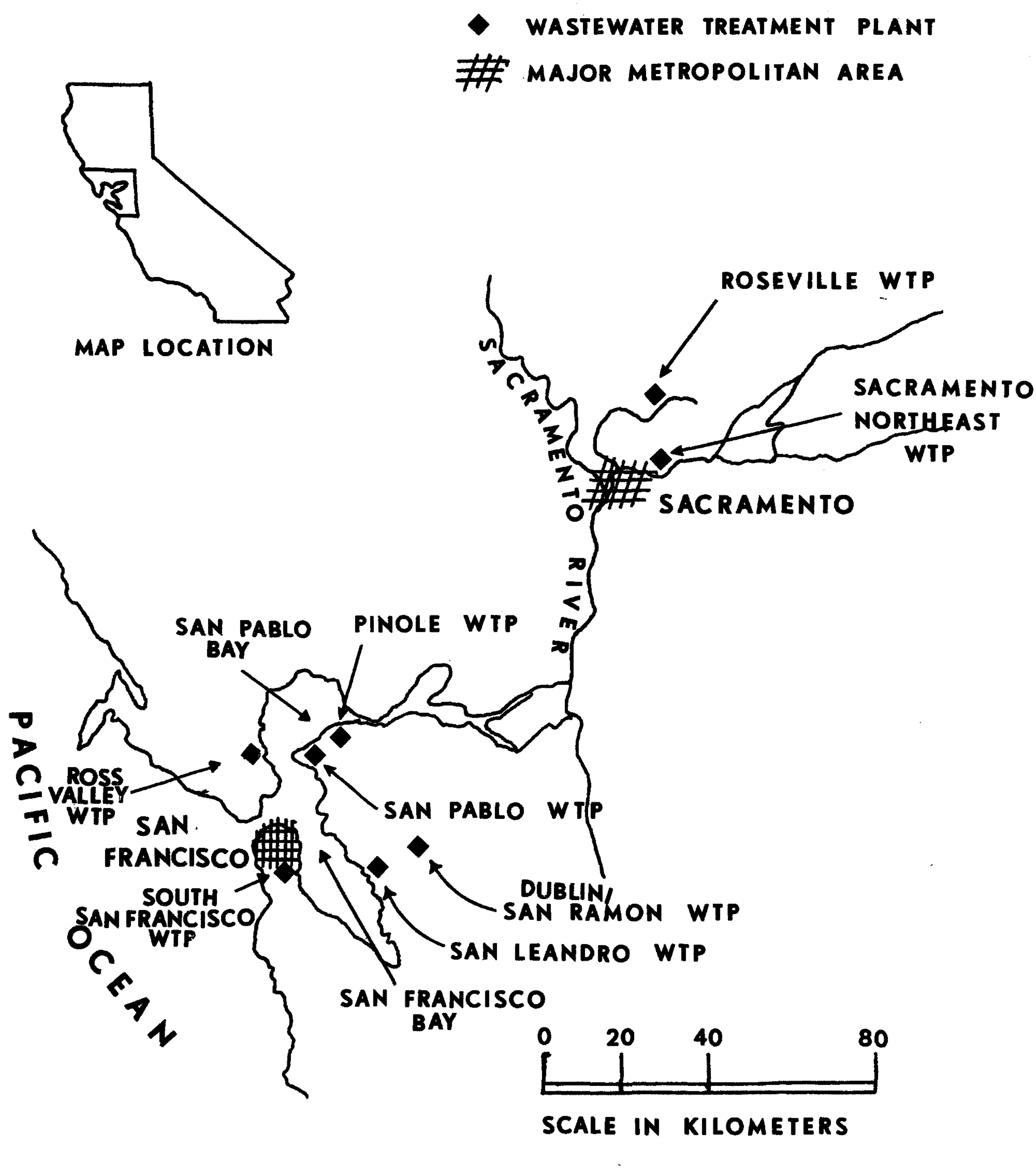

Figure 1. Locations of wastewater treatment plants investigated in the chlorine optimization study.

Table 1. SCHEDULE FOR TOXICITY TESTING OF DEPARTMENT OF HEALTH SERVICES CHLORINATED (DOHCl), AND EXISTING UNCHLORINATED (UnCl), CHLORINATED (ECl), AND DECHLORINATED (DeCl) EFFLUENTS AT VARIOUS WASTEWATER TREATMENT PALNTS (WTP) IN CALIFORNIA DURING THE PERIOD OF FEBRUARY 1978 THROUGH MAY 1979.

WTP	Date begin	Effluent type	Test species[a/]	Test series	Plant outflow (m^3/d)
San Leandro	12-II-78	UnCl & ECl	FH	SL-1 & 2	23,694
	27-II-78	UnCl & ECl	FH	SL-3 & 4	23,126
San Pablo	10-IV-78	UnCl, ECl, & DOHCl	FH	SP-1,2, & 3	26,722
	17-IV-78	UnCl, ECl, & DeCl	FH	SP-4,5, & 6	26,911
	24-IV-78	UnCl, ECl, & DOHCl	FH	SP-7,8, & 9	27,858
Pinole	12-VI-78	UnCl, ECl, & DOHCl	FH	P-1,2, & 3	4,163
	19-VI-78	UnCl, ECl, & DeCl	GS	P-4,5, & 6	4,126
	26-VI-78	UnCl, ECl, & DOHCl	GS	P-7,8, & 9	4,050
	8-VII-78	ECl	FH & GS	P-10 & 11	4,126
South San Francisco	14-VIII-78	ECl	FH & GS	SSF-1 & 2	30,658
	28-VIII-78	UnCl, ECl, & DOHCl	FH	SSF-4,5, & 6	29,901
	11-IX-78	UnCl, ECl, & DOHCl	GS	SSF-7,8, & 9	30,658
Sacramento Northeast	2-X-78	UnCl, ECl, & DOHCl	GS	SN-1,2, & 3	64,534
	10-X-78	UnCl, ECl, & DeCl	GS	SN-4,5, & 6	64,459
	16-X-78	UnCl, ECl, & DOHCl	GS	SN-7,8, & 9	64,875
Roseville	13-XI-78	UnCl, ECl, & DOHCl	GS	R-1,2, & 3	15,291
	27-XI-78	UnCl, ECl, & DOHCl	GS	R-4,5, & 6	14,761
Dublin/ San Ramon	9-IV-79	UnCl, ECl, & DOHCl	GS	DSR-1,2, & 3	12,301
	23-IV-79	UnCl, ECl, & DOHCl	GS	DSR-4,5, & 6	13,702
Ross Valley	14-V-79	UnCl, ECl, & DOHCl	GS	RV-1,2, & 3	17,449
	21-V-79	UnCl, ECl, & DOHCl	GS	RV-4,5, & 6	16,199

a/ FH = Fathead minnow, *Pimephales promelas*.
b/ GS = Golden shiner, *Notemigonus crysoleucas*.

Figure 2. The California Department of Fish and Game mobile toxicity and water quality laboratory.

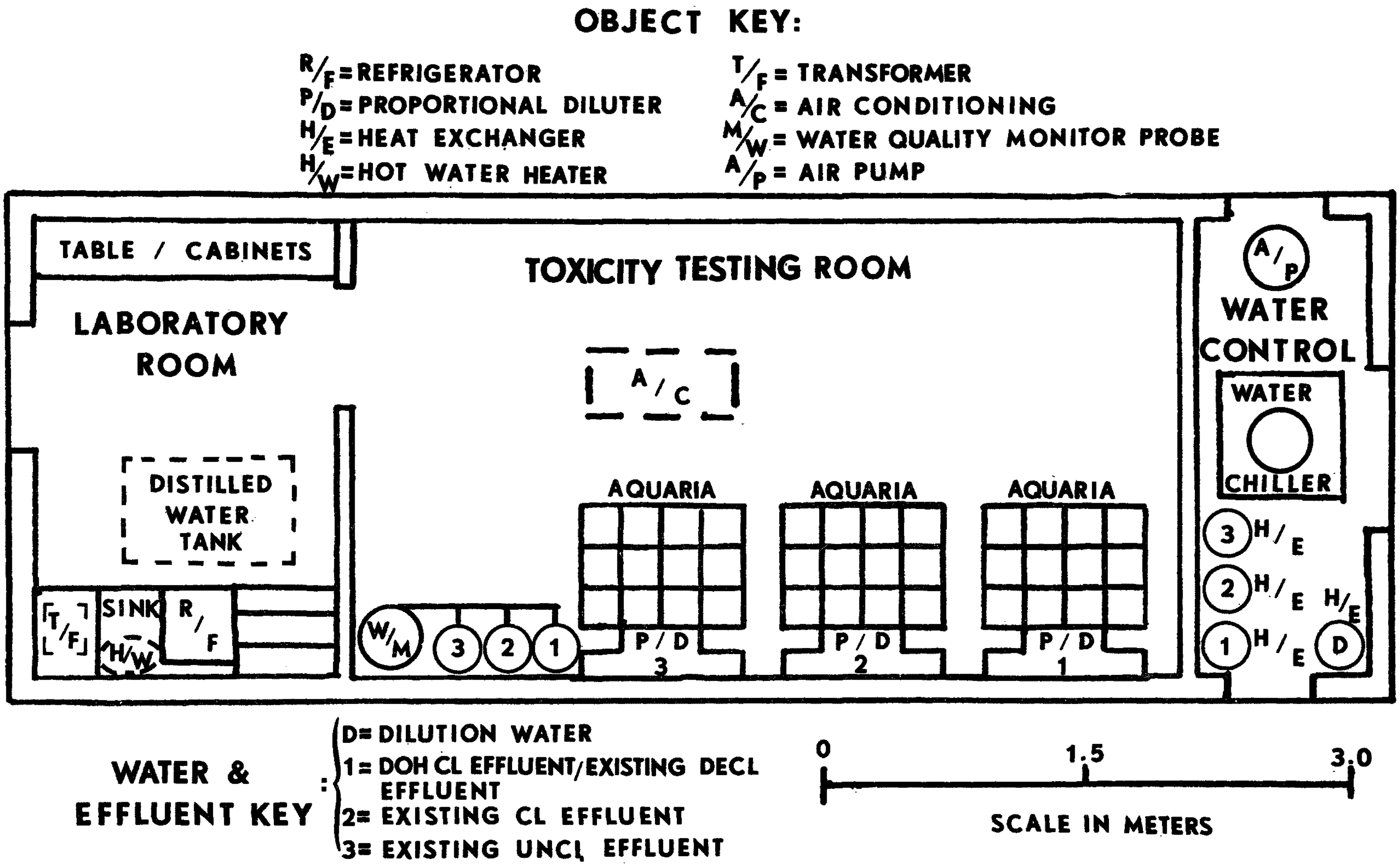

Figure 3. Floor plan of Department of Fish and Game toxicity and water quality laboratory.

have the capacity to dilute the waste to a maximum of 5% of the original strength. The proportional diluters and aquaria were constructed of 6.3-mm thick clear plexiglass. An air conditioner, a waste and dilution water delivery system, and an automatic water quality monitor system are also present. The monitor cyclically records pH, temperature, dissolved oxygen, and conductivity of each undiluted waste stream. The cycle can be adjusted from 30 min to 12 h. The automatic water quality monitor has 4 flow-through reservoirs; one contained the multiparameter probe (measuring unit) and one for each of the three wastes.

The laboratory houses the electronic controls for the proportional diluters and the water quality monitor as well as the various instruments needed for the chemical and physical monitoring of the toxicity testing aquaria. The control unit of the water quality monitor, in addition to recording the four water quality parameters on paper and cassette tapes, records a code for each waste as well as the time-of-day.

The mobile laboratory operates on 240/120 VAC electrical current which can be supplied from two sources. Generally, a 3P 480 VAC source was obtained from the WTP and connected to the trailer. The 1P of the 3P supply was converted to 1P 240/120 VAC through a 1P 480/240 VAC transformer located underneath the trailer. A 1P 240 VAC portable, diesel-powered alternator was also available to provide electricity.

Water and waste flow through the mobile laboratory is schematically diagramed (Figure 4). Nylon garden hoses connected to submersible pumps supplied wastes to the trailer. Pressurized, dechlorinated tap water from the WTP was used as the dilution water source in the toxicity tests. Complete mineral and metal analyses were conducted for all the dilution water supplies using standard methods (American Public Health Association 1975). The results of the dilution water analyses are presented in Appendix B-1. Dechlorination of tap water was accomplished by passing the water through activated charcoal inside the large (dilution water) heat exchanger. The flows of the wastes and dilution water in the mobile laboratory were controlled by a series of PVC ball valves (which functioned as shunts) located downstream of the heat exchangers. In addition to supplying the proportional diluters, proportions of the waste streams were diverted to the water quality monitor.

TOXICITY TESTING METHODS

Standard 96-h continual-flow toxicity tests (Peltier 1978) were used to evaluate toxicities of the various effluents. Fathead minnows, *Pimephales promelas*, and golden shiners, *Notemigonus crysoleucas*, were used as test organisms. The fish were obtained commercially from Golden State Fisheries* and acclimated for at least one week at the DFG Water Pollution Control Laboratory before being used as test organisms. The test fish were further acclimated to the dilution water at each WTP for 24 h prior to testing. All fish were between 30 and 51 mm fork length (length from tip of snout to notch in tail fin).

* Address: 12001 S. Carrolton Road, Escalon, CA 95320.

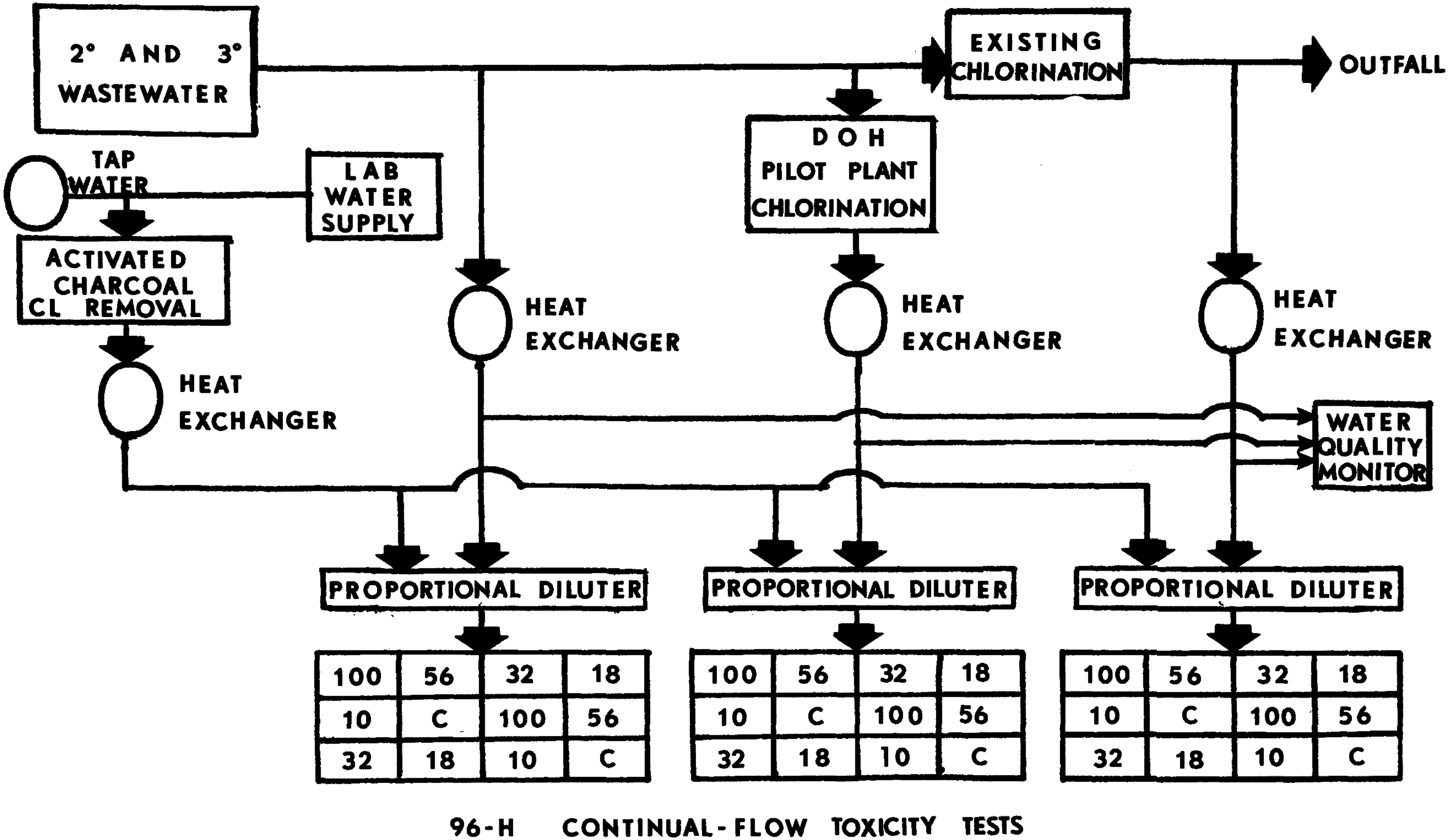

Figure 4. Schematic diagram of waste and dilution water flow through the mobile laboratory.

The proportional diluters supplied five continual waste concentrations in a geometric series of dilutions (100, 56, 32, 18, 10%) and a control (100% dilution water) to the testing aquaria. The volume of each aquarium was exchanged every 2.5 h. All waste concentrations and the control were tested in replicate. Fifteen fish were exposed in each replicate (30 fish in total per concentration). Adequate dissolved oxygen was supplied to the test aquaria by aeration, and the temperature of the aquaria was controlled by overhead air conditioning. The heat exchangers did not have to be used for temperature control.

Several chemical and physical parameters were manually measured using standard methods in each aquarium every 6 h during the tests. Dissolved oxygen and temperature were measured with a dissolved oxygen meter and probe, and pH was determined using an expanded-scale meter and combination electrode. Total residual chlorine was determined with an amperometric titrator using Method C (APHA 1975). Total ammonia ($NH_4^+ + NH_3$) was determined with a specific-ion meter and ammonia gas-sensing electrode; un-ionized ammonia was determined from the equation:

$$(1)\quad NH_3 = f(NH_4^+ + NH_3)$$

where $f = 1/(10^{pka-pH} + 1)$, $pka = 0.0901821 + 2729.92/T$, and T = test temperature (C) + 273.16.

During the tests, total residual chlorine and total ammonia were manually determined at 2-h intervals in each undiluted waste stream along with the automatically monitored levels of dissolved oxygen, pH, temperature, and conductivity.

DATA ANALYSIS

Manually collected toxicity and effluent quality data were transcribed onto computer cards from data sheets, edited, and analyzed in ALGOL® by a Burroughs® 6700 computer. The electronically collected effluent quality data of the undiluted waste streams were transcribed onto a 7-track tape from the cassette tape and analyzed in a similar manner. Standard statistics of mean and standard deviation were calculated for all effluent quality data.

Fish mortality was determined every 24 h during the 96-h test. If less than 85% survival occurred in the controls during a test, the entire test was considered invalid and no mortalities were calculated. To evaluate the toxicities of all effluents, we calculated a 96-h LC50 using log-logit (effluent and TRC concentrations vs. mortality) analysis (Finley 1971) or noted the percent mortality at the highest concentration tested. The mortality estimates used in the log-logit analysis were first adjusted for control mortality using the equation:

$$(2)\quad m = (1 - S_x/S_c)\ 100$$

where m is percent mortality, S_x is the survival in waste concentration x, and S_c is the survival in the controls.

Statistically significant ($p < 0.05$) differences among mean chlorine residuals, effluent toxicities, and other chemical parameters were determined by subjecting the data groups to two-tailed t-tests (Sokal and Rohlf 1969). Significant correlations ($p < 0.05$) between the toxicity (% effluent) and the mean chlorine residuals of the chlorinated effluents (mg/L TRC) were calculated using linear regressions by the method of least squares (Sokal and Rohlf 1969).

SECTION 5

RESULTS

Fifty-nine toxicity tests in replicate were done at eight wastewater treatment plants on unchlorinated, chlorinated, and dechlorinated effluents. Generally, little or no mortality was associated with the unchlorinated and dechlorinated effluents, and the toxicity of the chlorinated effluents increased with increased chlorine residual (Table 2).

EFFLUENT TOXICITY AND QUALITY

San Leandro WTP

The undiluted, UnCl (Series SL-1 and SL-3) effluents were not acutely toxic to fathead minnows even though un-ionized ammonia concentrations were as high as 428 ug/L NH_3 (Table 2). There was no DOHCl effluent available for toxicity testing. The ECl effluents produced a 96-h LC50 to fathead minnows of 1.8 and 3.8% effluent concentration during the first (Series SL-2) and second (Series SL-4) weeks of testing, respectively. The mean test chlorine residuals in the ECl effluents during the two weeks were 9.47 and 6.24 mg/L TRC, respectively (Table 3). Effluent toxicity and quality data for the toxicity tests are presented in Appendix B-2.

San Pablo WTP

The undiluted, UnCl (Series SP-1, SP-4, and SP-7) and DeCl (Series SP-6) effluents were not acutely toxic to fathead minnows (Table 2). The undiluted effluents had un-ionized ammonia concentrations <1.0 ug/L NH_3. The 96-h LC50 of the ECl (Series SP-2) effluent during the first week of comparative testing was not determined while that of the DOHCl (Series SP-3) effluent was 46.5% effluent concentration. During the second week of comparative testing, the toxicity of the ECl (Series SP-8) effluent (96-h LC50 = 31.5% effluent) was higher than the DOHCl (Series SP-9) effluent (96-h LC50 = 46.5% effluent). The mean test chlorine residuals of the ECl effluents were 2.29 and 2.44 mg/L TRC while those of the DOHCl effluents were 2.16 and 2.14 mg/L TRC for the first and second weeks of comparative testing, respectively (Table 3). The mean TRC of the ECl effluent was not significantly higher than that of the DOHCl effluent during the first week of comparative testing but was significantly higher during the second week of comparative testing (Table 4). The DOHCl effluent was less variable in TRC than the ECl during both the first (Figure 5) and second weeks (Figure 6) of comparative testing. The effluent toxicity and quality toxicity tests are presented in Appendix B-3.

Table 2. CONTINUAL-FLOW TOXICITY TESTING LEVELS FOR DEPARTMENT OF HEALTH SERVICES CHLORINATED (DOHCl), AND EXISTING UNCHLORINATED (UnCl), CHLORINATED (ECl), AND DECHLORINATED (DeCl) EFFLUENTS AT WASTEWATER TREATMENT PLANTS (WTP) IN CALIFORNIA FROM FEBRUARY 1978 THROUGH MAY 1979.

				Undiluted unchlorinated effluents		96-h LC50 chlorinated effluents		
WTP	Test series	Test species [a]	Effluent type	Mortality (%)	NH_3 (ug/L)	Effluent conc. (%)	TRC (mg/L)	NH_3 (ug/L)
San Leandro	SL-1	FH	UnCl	00.0	325	---	---	---
	SL-2	FH	ECl	---	---	1.8	0.08	6
	SL-3	FH	UnCl	00.0	428	---	---	---
	SL-4	FH	ECl	---	---	3.8	0.18	14
San Pablo	SP-1	FH	UnCl	00.0	<1	---	---	---
	SP-2	FH	ECl	---	---	ND	ND	ND
	SP-3	FH	DOHCl	---	---	46.5	0.45	<1
	SP-4	FH	UnCl	00.0	<1	---	---	---
	SP-5	FH	ECl	---	---	38.1	0.43	<1
	SP-6	FH	DeCl	00.0	<1	---	---	---
	SP-7	FH	UnCl	00.0	<1	---	---	---
	SP-8	FH	ECl	---	---	31.5	0.48	<1
	SP-9	FH	DOHCl	---	---	46.5	0.60	<1
Pinole	P-1	FH	UnCl	10.5	133	---	---	---
	P-2	FH	ECl	---	---	ND	ND	ND
	P-3	FH	DOHCl	---	---	4.2	0.07	13
	P-4	GS	UnCl	00.0	193	---	---	---
	P-5	GS	ECl	---	---	5.0	0.10	13
	P-6	GS	DeCl	12.5	60	---	---	---
	P-7	GS	UnCl	00.0	115	---	---	---
	P-8	GS	ECl	---	---	4.8	0.15	11
	P-9	GS	DOHCl	---	---	12.2	0.16	19

Table 2. (Continued)

WTP	Test series	Test species[a/]	Effluent type	Undiluted unchlorinated effluents: Mortality (%)	Undiluted unchlorinated effluents: NH_3 (ug/L)	96-h LC50 chlorinated effluents: Effluent conc, (%)	96-h LC50 chlorinated effluents: TRC (mg/L)	96-h LC50 chlorinated effluents: NH_3 (ng/L)
Pinole (Cont.)	P-10	GS	ECl	---	---	5.8	0.21	17
	P-11	FH	ECl	---	---	5.2	0.15	21
South San Francisco	SSF-1	FH	ECl	---	---	7.6	0.11	45
	SSF-2	GS	ECl	---	---	8.1	0.16	42
	SSF-4	FH	UnCl	40.0	615	---	---	---
	SSF-5	FH	ECl	---	---	11.8	0.07	52
	SSF-6	FH	DOHCl	---	---	4.7	0.10	32
	SSF-7	GS	UnCl	80.0	846	---	---	---
	SSF-8	GS	ECl	---	---	5.0	0.19	53
	SSF-9	GS	DOHCl	---	---	7.4	0.17	60
Sacramento Northeast	SN-1	GS	UnCl	33.3	411	---	---	---
	SN-2	GS	ECl	---	---	3.5	0.10	18
	SN-3	GS	DOHCl	---	---	5.6	0.12	14
	SN-4	GS	UnCl	6.7	600	---	---	---
	SN-5	GS	ECl	---	---	4.7	0.15	20
	SN-6	GS	DeCl	3.3	148	---	---	---
	SN-7	GS	UnCl	16.6	721	---	---	---
	SN-8	GS	ECl	---	---	4.2	0.13	33
	SN-9	GS	DOHCl	---	---	10.7	0.09	69

Table 2. (Continued)

WTP	Test series	Test species	Effluent type	Undiluted unchlorinated effluents: Mortality (%)	Undiluted unchlorinated effluents: NH_3 (ug/L)	96-h LC50 chlorinated effluents: Effluent conc. (%)	96-h LC50 chlorinated effluents: TRC (mg/L)	96-h LC50 chlorinated effluents: NH_3 (ug/L)
Roseville	R-1	GS	UnCl	00.0	197	---	---	---
	R-2	GS	ECl	---	---	6.4	0.18	15
	R-3	GS	DOHCl	---	---	12.9	0.17	19
	R-4	GS	UnCl	00.0	147	---	---	---
	R-5	GS	ECl	---	---	4.6	0.17	4
	R-6	GS	DOHCl	---	---	10.6	0.12	7
Dublin/ San Ramon	DSR-1	GS	UnCl	00.0	---	---	---	---
	DSR-2	GS	ECl	---	---	1.6	0.17	--
	DSR-3	GS	DOHCl	---	---	1.4	0.09	--
	DSR-4	GS	UnCl	00.0	---	---	---	---
	DSR-5	GS	ECl	---	---	1.9	0.17	--
	DSR-6	GS	DOHCl	---	---	2.2	0.11	--
Ross Valley	RV-1	GS	UnCl	3.3	440	---	---	---
	RV-2	GS	ECl	---	---	2.9	0.16	9
	RV-3	GS	DOHCl	---	---	5.1	0.11	15
	RV-4	GS	UnCl	6.7	540	---	---	---
	RV-5	GS	ECl	---	---	3.1	0.15	14
	RV-6	GS	DOHCl	---	---	6.4	0.12	37

a/ FH = Fathead minnow, _Pimephales promelas_
GS = Golden shiner, _Notemigonus crysoleucas_

Table 3. SUMMARY OF MEAN TOTAL RESIDUAL CHLORINE (TRC), AMMONIA, pH, AND TEMPERATURE IN THE UNDILUTED DEPARTMENT OF HEALTH SERVICES CHLORINATED (DOHCl), AND EXISTING UNCHLORINATED (UnCl), CHLORINATED (ECl), AND DECHLORINATED (DeCl) EFFLUENTS AT WASTEWATER TREATMENT PLANTS (WTP) IN CALIFORNIA FROM FEBRUARY 1978 THROUGH MAY 1979.

WTP	Test series	Effluent type	TRC residual (mg/L)	Total ammonia (mg/L)	pH	Temperature (°C)	Un-ionized ammonia (ug/L)
San Leandro	SL-1	UnCl	0.00±0.00[a/]	14.3±4.3	7.2±0.1	19.7±0.5	78.3±51.8
	SL-2	ECl	9.47±2.41	12.8±4.5	7.3±0.4	13.7±1.8	74.3±23.5
	SL-3	UnCl	0.00±0.00	18.0±3.6	6.8±0.0	21.3±1.0	18.9±13.8
	SL-4	ECl	6.24±2.00	17.6±3.2	6.5±0.1	23.5±0.8	34.9±12.2
San Pablo	SP-1	UnCl	0.00±0.00	<0.1±0.0	6.8±0.1	20.0±0.3	<1±0
	SP-2	ECl	2.29±0.66	<0.1±0.0	6.8±0.1	20.0±0.8	<1±0
	SP-3	DOHCl	2.16±0.29	<0.1±0.0	6.7±0.1	19.7±0.9	<1±0
	SP-4	UnCl	0.00±0.00	<1.0±0.0	6.9±0.1	17.4±1.4	<1±0
	SP-5	ECl	2.71±0.47	<1.0±0.0	6.9±0.1	17.1±1.4	<1±0
	SP-6	DeCl	0.00±0.00	<1.0±0.0	6.9±0.1	17.4±1.5	<1±0
	SP-7	UnCl	0.00±0.00	<1.0±0.0	6.8±0.1	20.1±0.5	<1±0
	SP-8	ECl	2.44±0.31	<1.0±0.0	6.7±0.1	19.8±1.1	<1±0
	SP-9	DOHCl	2.14±0.31	<1.0±0.0	6.6±0.1	19.0±1.1	<1±0
Pinole	P-1	UnCl	0.00±0.00	15.7±4.1	6.7±0.1	23.3±1.1	41.3±14.8
	P-2	ECl	5.03±2.32	14.8±4.0	6.3±0.1	23.2±0.9	15.2±5.9
	P-3	DOHCl	3.01±0.44	15.3±4.4	6.5±0.2	22.2±1.5	23.6±12.2
	P-4	UnCl	0.00±0.00	23.5±7.8	6.9±0.1	23.5±1.0	96.8±29.9
	P-5	ECl	4.42±2.16	22.9±6.5	6.5±0.1	23.5±0.8	40.2±13.9
	P-6	DeCl	0.14±0.52	23.9±7.3	6.3±0.1	23.4±0.7	30.1±8.7
	P-7	UnCl	0.00±0.00	19.2±8.1	6.9±0.1	23.0±0.4	97.9±50.4
	P-8	ECl	8.00±4.16	19.2±8.4	6.3±0.1	22.0±0.4	27.2±14.2
	P-9	DOHCl	2.62±0.36	19.4±7.7	6.7±0.2	21.8±0.7	56.9±30.1

Table 3. (Continued)

WTP	Test series	Effluent type	TRC residual (mg/L)	Total ammonia (mg/L)	pH	Temperature (°C)	Un-ionized ammonia (ug/L)
Pinole (Cont.)	P-10 & 11	ECl	4.39±2.19	24.2±11.7	6.3±0.2	23.8±1.2	35.1±35.4
South San Francisco	SSF-1 & 2	ECl	4.07±2.72	64.5±28.0	6.74±0.28	24.6±1.8	246.5±224.3
	SSF-4	UnCl	0.00±0.00	42.7±23.5	7.15±0.13	24.5±0.6	340.6±222.6
	SSF-5	ECl	1.50±1.42	45.4±24.0	7.02±0.14	24.2±1.0	283.0±192.5
	SSF-6	DOHCl	4.27±1.67	39.9±20.9	6.91±0.15	22.6±1.2	178.4±130.7
	SSF-7	UnCl	0.00±0.00	34.2±11.0	7.16±0.15	24.9±0.7	291.4±139.6
	SSF-8	ECl	4.51±3.78	34.4±10.3	6.93±0.16	24.3±1.2	259.3±140.1
	SSF-9	DOHCl	3.50±1.55	34.7±14.3	6.97±0.12	23.4±1.2	188.6±140.6
Sacramento Northeast	SN-1	UnCl	0.00±0.00	23.6±10.6	7.09±0.08	25.5±1.9	175.6±108.2
	SN-2	ECl	7.63±1.25	25.6±10.2	6.90±0.11	25.6±1.6	111.2±65.5
	SN-3	DOHCl	3.74±0.64	25.1±9.5	6.89±0.11	24.7±1.3	116.5±70.2
	SN-4	UnCl	0.00±0.00	22.6±2.2	7.13±0.08	25.1±1.6	177.2±43.8
	SN-5	ECl	7.63±1.05	21.6±1.9	6.96±0.09	25.4±1.3	119.8±31.0
	SN-6	DeCl	0.00±0.00	23.1±1.7	6.48±0.16	24.2±2.0	40.3±16.0
	SN-7	UnCl	0.00±0.00	23.7±1.8	7.15±0.03	24.2±1.4	182.6±39.1
	SN-8	ECl	6.37±0.79	22.4±2.0	7.00±0.05	24.5±1.2	125.4±24.9
	SN-9	DOHCl	2.16±0.46	23.3±1.9	7.02±0.04	23.7±0.09	126.0±22.5
Roseville	R-1	UnCl	0.00±0.00	17.8±1.9	6.91±0.08	18.6±0.4	55.8±10.0
	R-2	ECl	5.09±0.28	17.5±1.6	6.75±0.01	18.2±0.4	36.8±6.7
	R-3	DOHCl	2.42±0.32	16.7±1.3	6.81±0.08	17.3±0.6	37.7±6.4

Table 3. (Continued)

WTP	Test series	Effluent type	TRC residual (mg/L)	Total ammonia (mg/L)	pH	Temperature (°C)	Un-ionized ammonia (ug/L)
Roseville (Cont.)	R-4	UnCl	0.00±0.00	11.7±2.3	6.90±0.09	18.5±0.4	28.0±8.0
	R-5	ECl	4.66±0.89	11.0±2.8	6.75±0.18	18.4±0.5	17.4±6.7
	R-6	DOHCl	2.19±0.40	11.1±2.7	6.73±0.12	17.6±0.7	19.1±7.7
Dublin/ San Ramon	DSR-1	UnCl	0.00±0.00	-	7.10±0.11	19.7±1.9	-
	DSR-2	ECl	13.08±4.61	-	6.89±0.13	19.2±1.0	-
	DSR-3	DOHCl	6.12±1.48	-	6.82±0.13	19.8±0.4	-
	DSR-4	UnCl	0.00±0.00	-	7.07±0.11	20.3±1.9	-
	DSR-5	ECl	11.18±2.88	-	6.87±0.12	20.3±0.8	-
	DSR-6	DOHCl	6.94±0.99	-	6.83±0.10	20.8±0.6	-
Ross Valley	RV-1	UnCl	0.00±0.00	19.9±8.5	7.31±0.15	19.8±1.2	196.8±151.0
	RV-2	ECl	5.58±2.24	21.4±10.9	7.22±0.17	19.9±2.2	163.1±127.7
	RV-3	DOHCl	3.18±0.59	19.3±7.0	7.12±0.14	19.3±1.2	108.1±68.4
	RV-4	UnCl	0.00±0.00	19.3±6.3	7.30±0.14	20.4±1.5	173.6±99.8
	RV-5	ECl	8.40±4.42	19.0±5.8	7.14±0.15	20.2±1.9	117.2±62.5
	RV-6	DOHCl	3.40±0.53	21.2±5.2	7.12±0.12	19.9±1.1	116.5±50.1

a/ Mean ± SD.

Table 4. DIFFERENCES IN TRC BETWEEN DEPARTMENT OF HEALTH SERVICES (DOHCl), AND EXISTING (ECl) CHLORINATED EFFLUENTS.

Source of variation ECl x DOHCl	n	df	t^a
SP-2 x SP-3	37	36	1.35
SP-8 x SP-9	49	48	6.96*
P-2 x P-3	48	47	5.57*
P-8 x P-9	48	47	8.75*
SSF-5 x SSF-6	48	47	-10.86*
SSF-8 x SSF-9	44	43	1.66
SN-2 x SN-3	48	47	19.19*
SN-2 x SN-9	48	47	26.74
R-2 x R-3	48	47	42.20*
R-5 x E-6	48	47	24.55*
DSR-2 x DSR-3	47	46	14.02*
DSR-5 x DSR-6	46	45	10.37*
RV-2 x RV-3	47	46	6.59*
RV-5 x RV-6	41	40	7.24*

Asterisks denote significance at $p < 0.05$ and negative values denote a higher TRC in DOHCl than ECl.

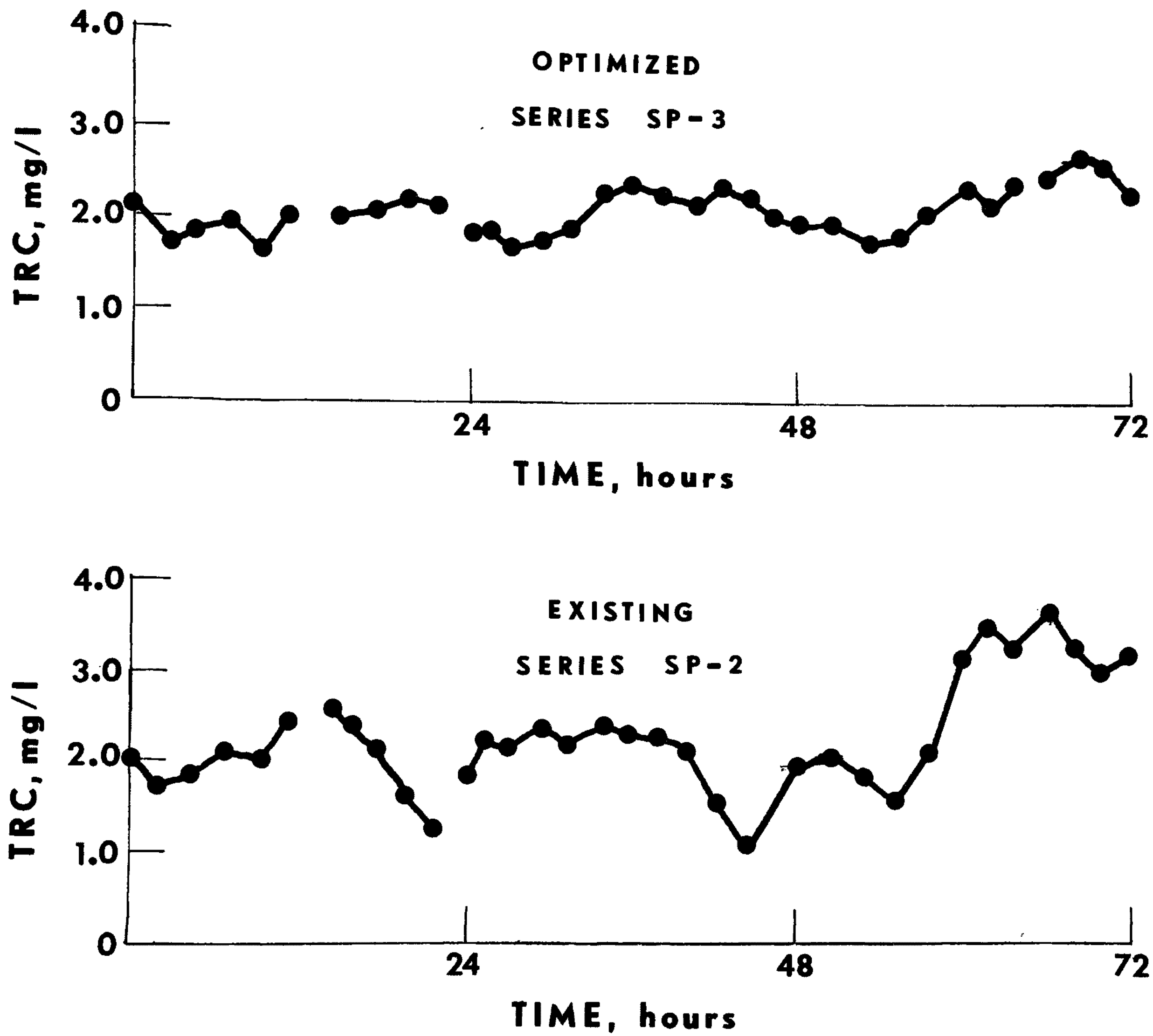

Figure 5. Chlorine residuals in optimized and existing effluents at San Pablo WTP during the first week of comparative testing.

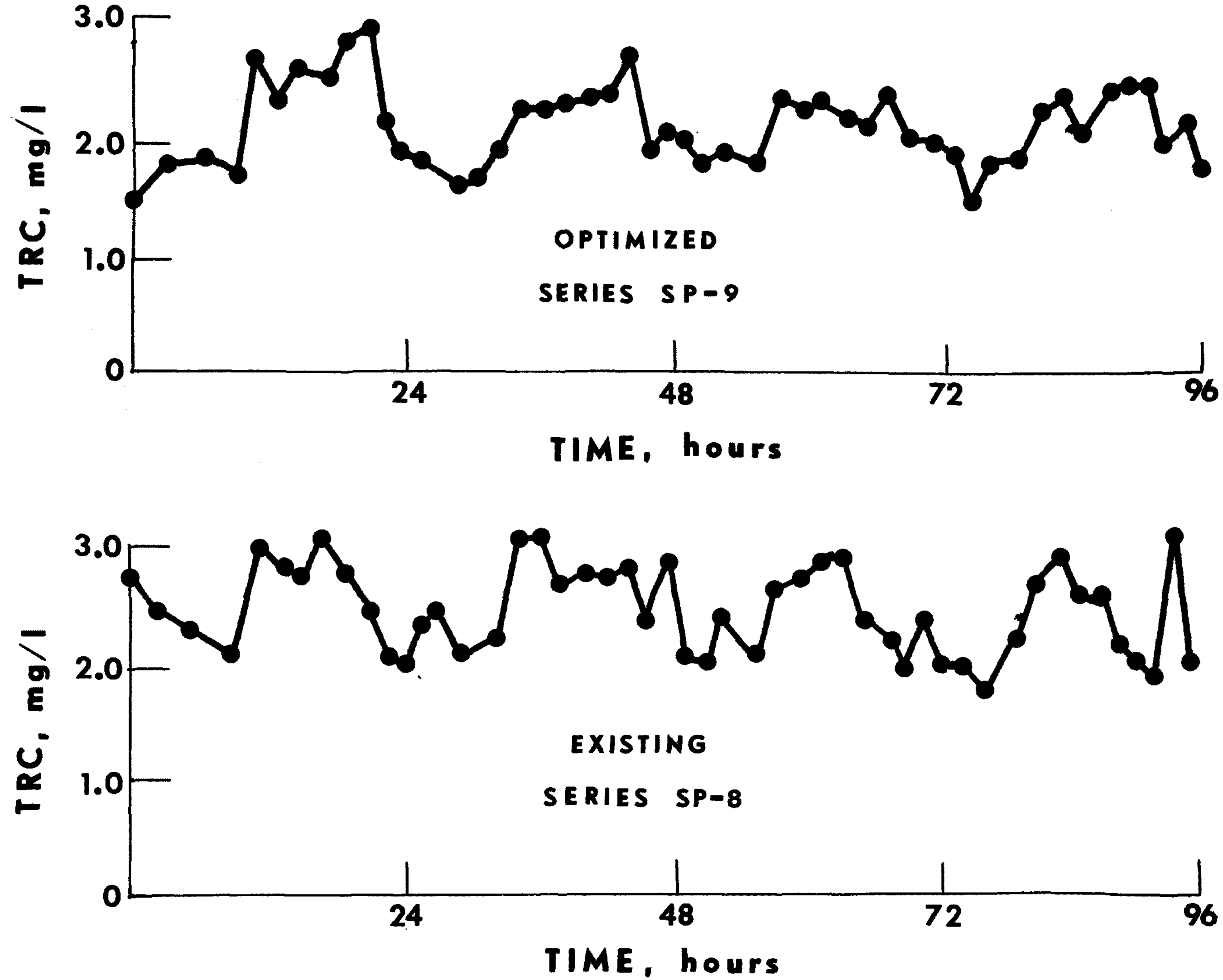

Figure 6. Chlorine residuals in optimized and existing effluents at San Pablo WTP during the second week of comparative testing.

Pinole WTP

The undiluted , UnCl (Series P-1, and P-4, and P-7) and the DeCl (Series P-6) effluents were acutely toxic (00.0 to 12.5% mortality) to fathead minnows and golden shiners (Table 2). This toxicity could be attriubuted to un-ionized ammonia since the test (Series P-4) with the highest un-ionized ammonia concentration (193 ug/L NH_3) did not produce any acute toxicity. No toxicity comparison could be made between the two chlorinated effluents (Series P-2 and P-3) during the first week of testing because of excessive mortality due to infection (Columnaris sp.) of the fathead minnow test fish. During the second week (Series P-8 and P-9) of comparative testing, the DOHCl effluent (96-h LC50 - 12.2% effluent) was less toxic to golden shiners than the ECl effluent (96-h LC50 = 4.8% effluent). The mean test chlorine residuals of the ECl effluent were 5.03 and 8.00 mg/L TRC while those of the DOHCl effluents were 3.01 and 2.62 mg/L TRC for the first and second weeks of comparative testing, respectively (Table 3). The mean chlorine residuals of the ECl effluents were significantly higher than those of the DOHCl effluents during both weeks of comparative testing (Table 4). The DOHCl effluent was less variable in TRC than the ECl during both the first (Figure 7) and second weeks (Figure 8) of comparative testing. The effluent toxicity and quality data for the toxicity tests are presented in Appendix B-4.

South San Francisco WTP

The undiluted, UnCl (Series SSF-4 and SSF-7) effluents produced acute toxicity to fathead minnows (40.0%) and to golden shiners (80.0%). In both cases, the toxicity was probably due to un-ionized ammonia which was quite high (up to 846 ug/L NH_3) in the undiluted, UnCl effluents (Table 2). During the first week of comparative testing the ECl (Series SSF-5) effluent (96-h LC50 = 11.8% effluent) was less toxic to fathead minnows than the DOHCl (Series SSF-6) effluent (96-h LC50 = 4.7% effluent). The DOHCl (Series SSF-9) effluent (96-h LC50 = 7.4% effluent) was less toxic to golden shiners than the ECl (Series SSF-8) effluent (96-h LC50 = 5.0% effluent) during the second week of comparative testing. However, the South San Francisco WTP effluents did not have to meet disinfection criteria as did the DOHCl effluents, and thus, there are no valid criteria for comparing the toxicities of the two effluents. The mean test chlorine residuals of the ECl effluent were 1.50 and 4.51 mg/L TRC while those of the DOHCl effluent were 4.27 and 3.50 mg/L TRC for the first and second weeks of comparative testing, respectively (Table 3). The mean TRC of the DOHCl effluent was significantly higher than that of the ECl effluent during the first week of comparative testing, whereas there are no significant differences in the mean TRC between the two chlorinated effluents during the second week of comparative testing (Table 4). The DOHCl effluent was slightly less variable in TRC than the ECl effluent during the first (Figure 9) and second (Figure 10) weeks of testing. The large variability in TRC of both effluents could have been caused by the noticeably large variability of the effluent quality. The effluent toxicity and quality data for the toxicity tests are presented in Appendix B-5.

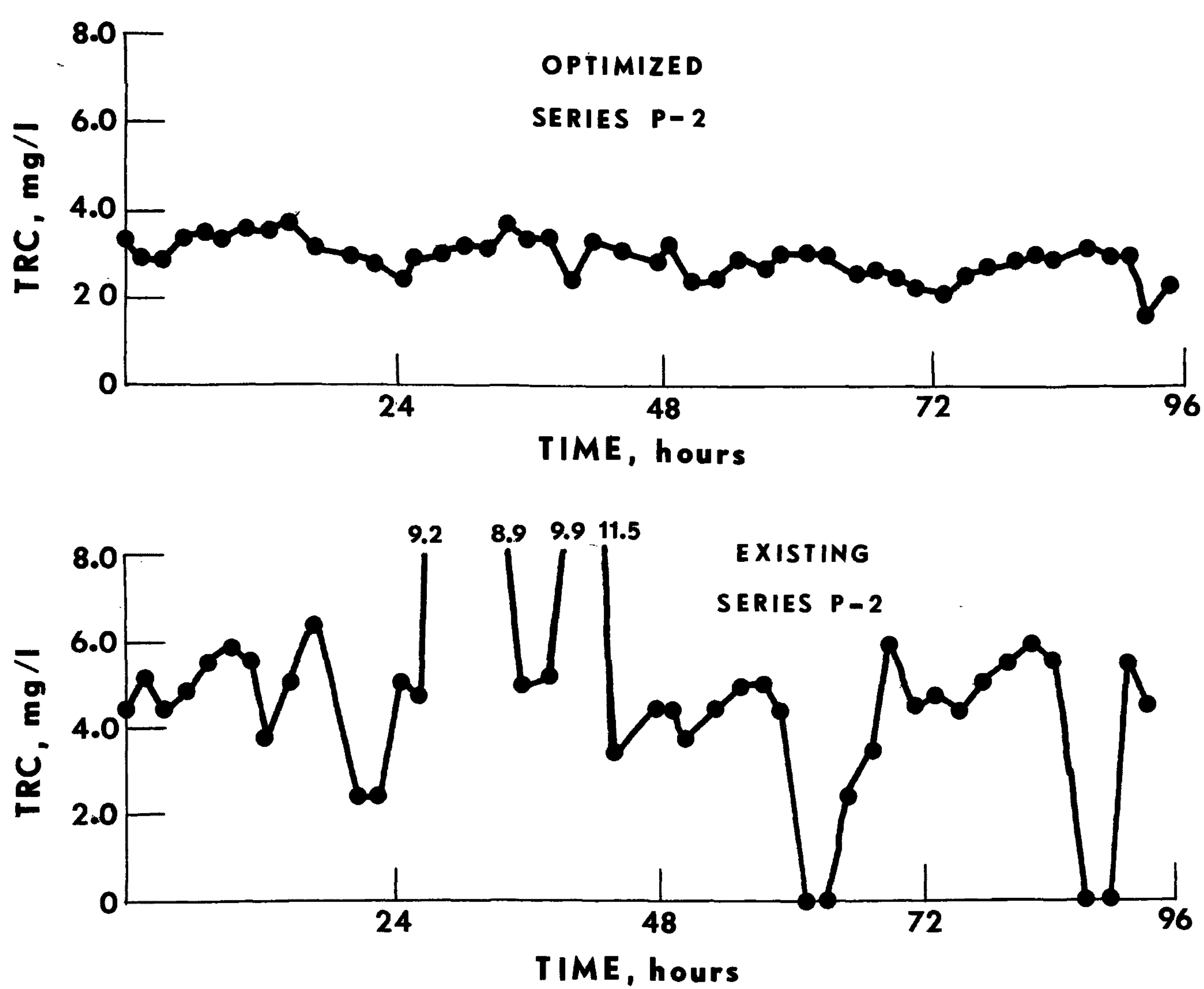

Figure 7. Chlorine residuals in optimized and existing effluents at Pinole WTP during the first week of comparative testing.

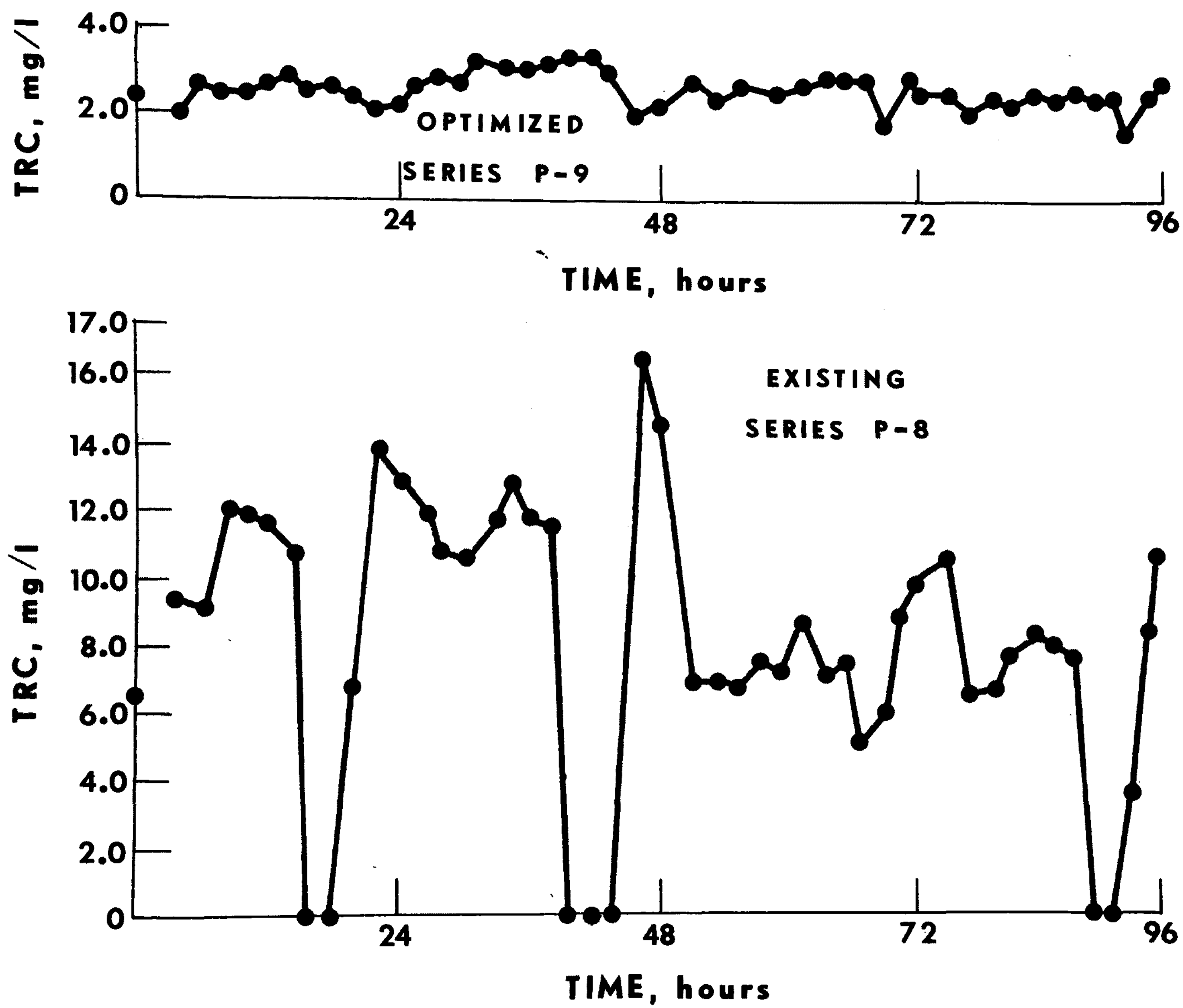

Figure 8. Chlorine residuals in optimized and existing effluents at Pinole WTP during the second week of comparative testing.

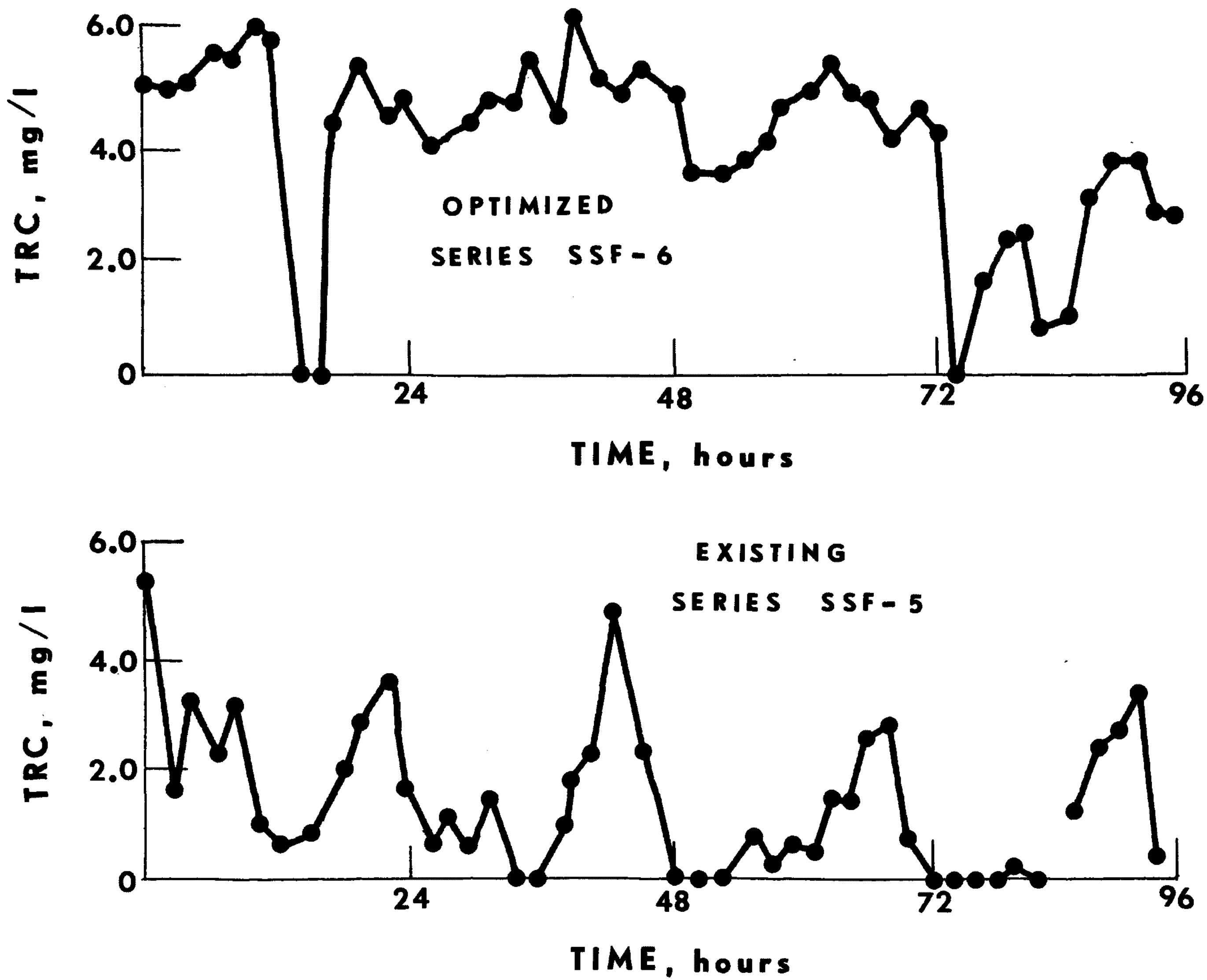

Figure 9. Chlorine residuals in optimized and existing effluents at South San Francisco WTP during the first week of comparative testing.

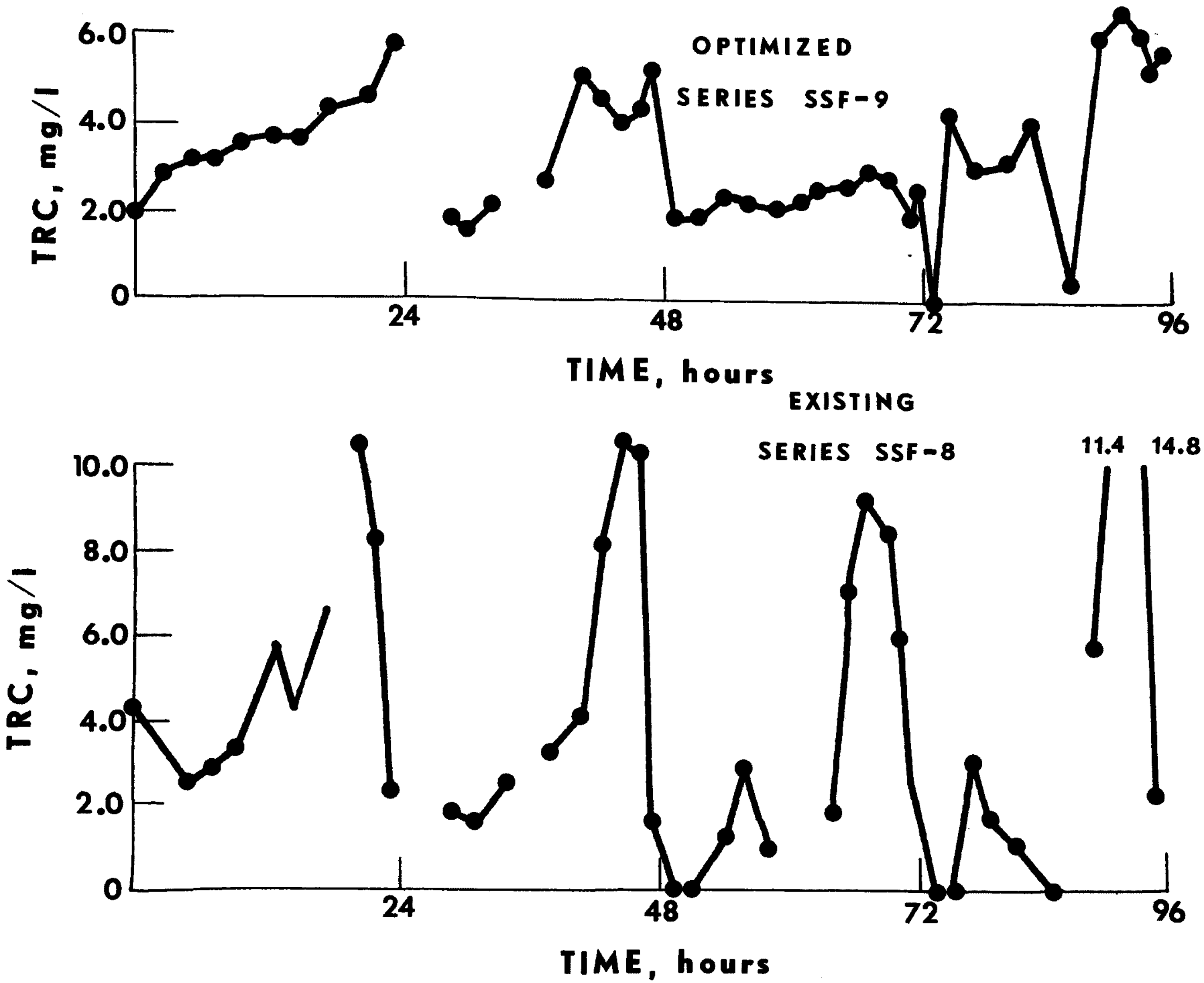

Figure 10. Chlorine residuals in optimized and existing effluents at South San Francisco WTP during the second week of comparative testing.

Sacramento Northeast WTP

The undiluted, UnCl (SN-1, SN-4, and SN-7) effluents produced variable acute toxicity (6.7 to 33.4% mortality) to golden shiners (Table 2). Some acute toxicity (3.3% mortality) was produced with the undiluted, DeCl (SN-6) effluent. There was no direct relationship between mortality and un-ionized ammonia concentrations in the UnCl and DeCl effluents. The DOHCl (Series SN-3 and SN-9) effluents (96-h LC50's = 5.6 and 10.7% effluent, respectively) during both weeks of comparative testing were less toxic than the ECl (Series SN-2 and SN-8) effluents (96-h LC50's = 3.5 and 4.2% effluent, respectively). The mean test chlorine residuals of the ECl effluents were 7.63 and 6.37 mg/L TRC while those of the DOHCl effluent were 3.74 and 2.16 mg/L TRC for the first and second weeks of comparative testing, respectively (Table 3). The mean TRC of the DOHCl effluents were significantly lower than those of the ECl effluents during both weeks of comparative testing (Table 4). The TRC of the DOHCl effluent was less variable than those of the ECl effluent during both the first (Fugure 11) and second (Figure 12) weeks of comparative testing. The effluent toxicity and quality data for the toxicity tests are presented in Appendix B-6.

Roseville WTP

The undiluted, UnCl (Series R-1 and R-4) effluents were not acutely toxic to golden shiners (Table 2). The un-ionized ammonia concentrations were quite low (197 ug/L NH_3 maximum) in the undiluted, UnCl effluents. The DOHCl (Series R-3) effluent (96-h LC50 = 12.9% effluent) was less toxic than the ECl (Series R-2) effluent (96-h LC50 = 6.4% effluent) during the first week of comparative testing. The DOHCl (Series R-6) effluent (96-h LC50 = 10.6% effluent) was also less toxic than the ECl (Series R-5) effluent (96-h LC50 = 4.6% effluent) during the second week of comparative testing. The mean test chlorine residuals of the ECl effluents were 5.09 and 4.66 mg/L TRC while those of the DOHCl effluent were 2.42 and 2.19 mg/L TRC during the first and second weeks of comparative testing, respectively (Table 3). The mean TRC of the DOHCl effluents were significantly lower than those of the ECl effluents for both weeks of comparative testing (Table 4). The TRC of the DOHCl effluent was less variable than those of the ECl effluent during both the first (figure 13) and second (Figure 14) weeks of comparative testing. The effluent toxicity and quality data for the toxicity tests are presented in Appendix B-7.

Dublin/San Ramon WTP

The undiluted, UnCl (Series DSR-1 and DSR-4) effluents were not acutely toxic to golden shiners (Table 2). No ammonia measurements were made at this location. However, the WTP employed nitrification and thus, un-ionized ammonia concentrations should have been <1 ug/L NH_3 in the undiluted effluents. The DOHCl (Series DSR-3) effluent (96-h LC50 = 1.4% effluent) was more toxic than the ECl (Series DSR-2) effluent (96-h LC50 = 1.6% effluent) during the first week of comparative testing. The DOHCl (Series DSR-6) effluent (96-h LC50 = 2.2% effluent) was less toxic than the ECl (Series DSR-5) effluent (96-h LC50 = 1.9% effluent) during the second week of comparative testing. The small differences between the toxicities of the

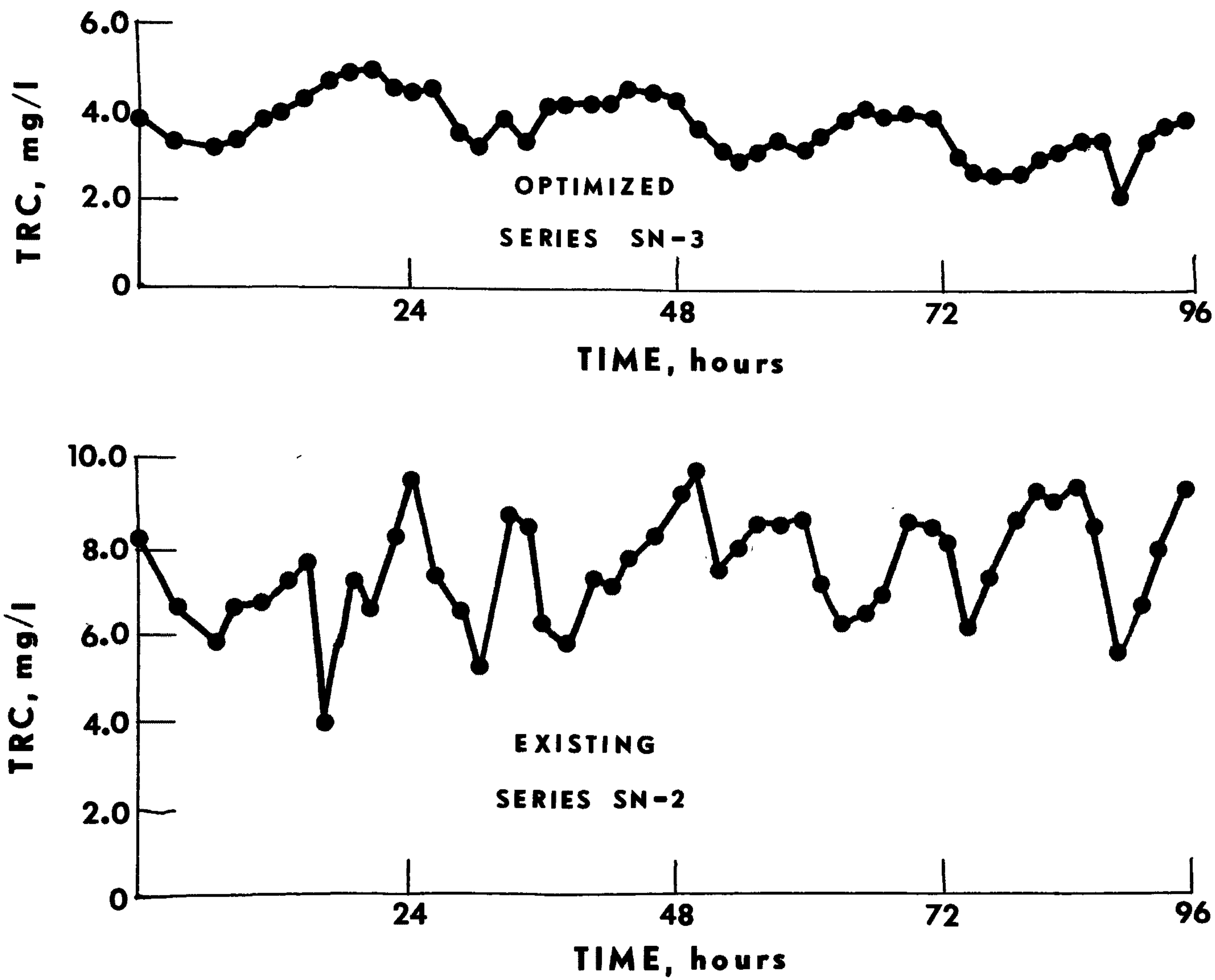

Figure 11. Chlorine residuals in optimized and existing effluents at Sacramento Northeast WTP during the first week of comparative testing.

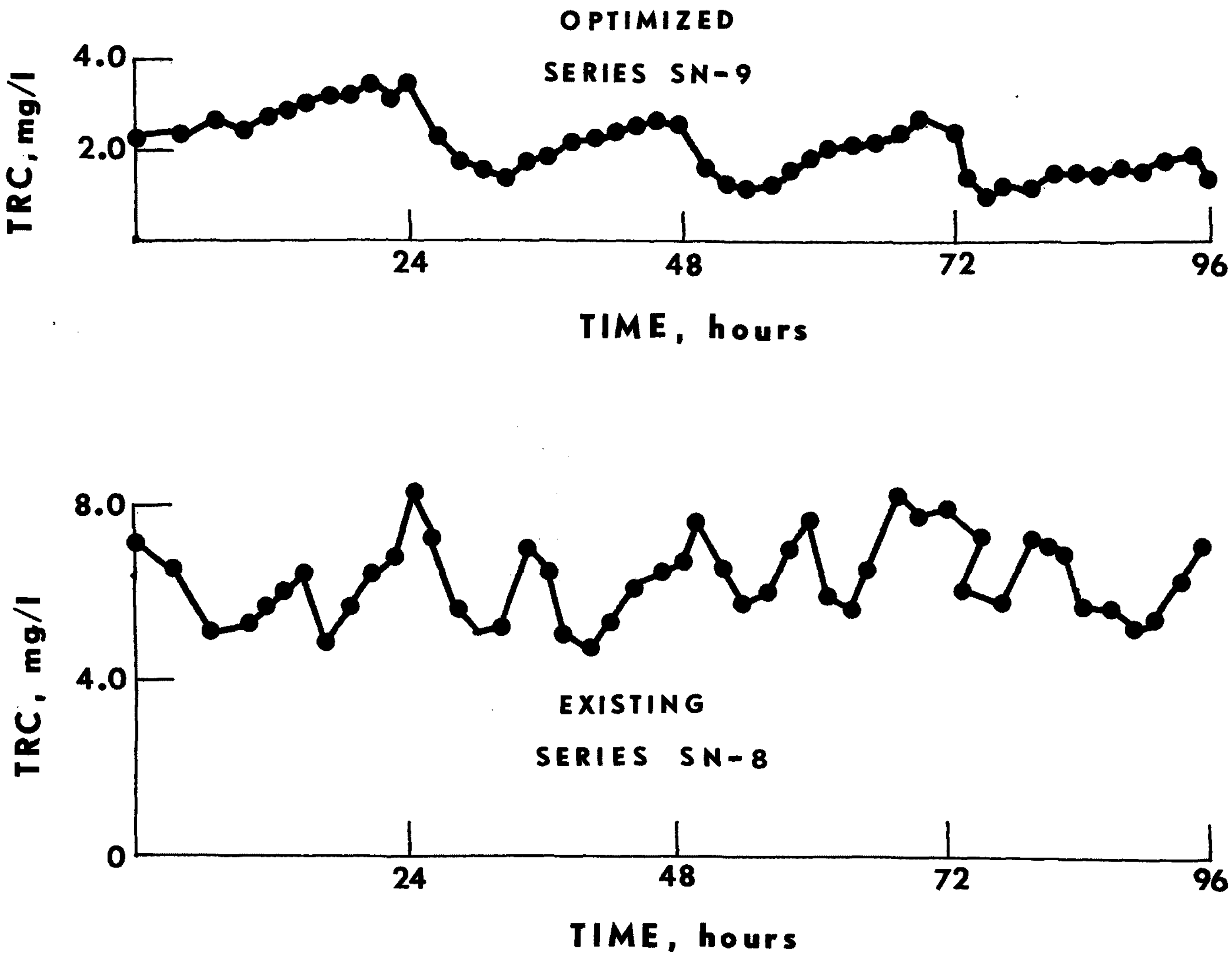

Figure 12. Chlorine residuals in optimized and existing effluents at Sacramento Northeast WTP during the second week of comparative testing.

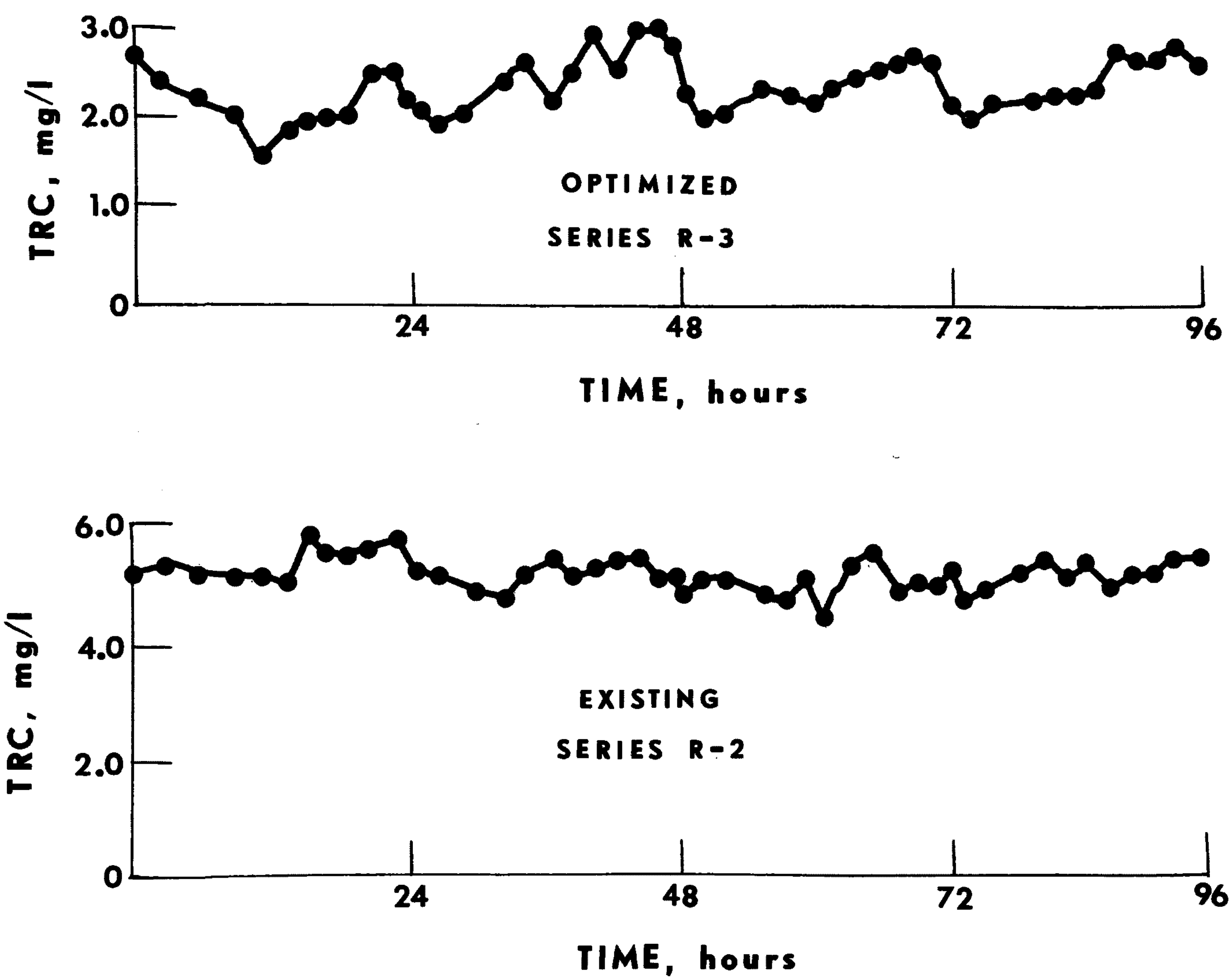

Figure 13. Chlorine residuals in optimized and existing effluents at Roseville WTP during the first week of comparative testing.

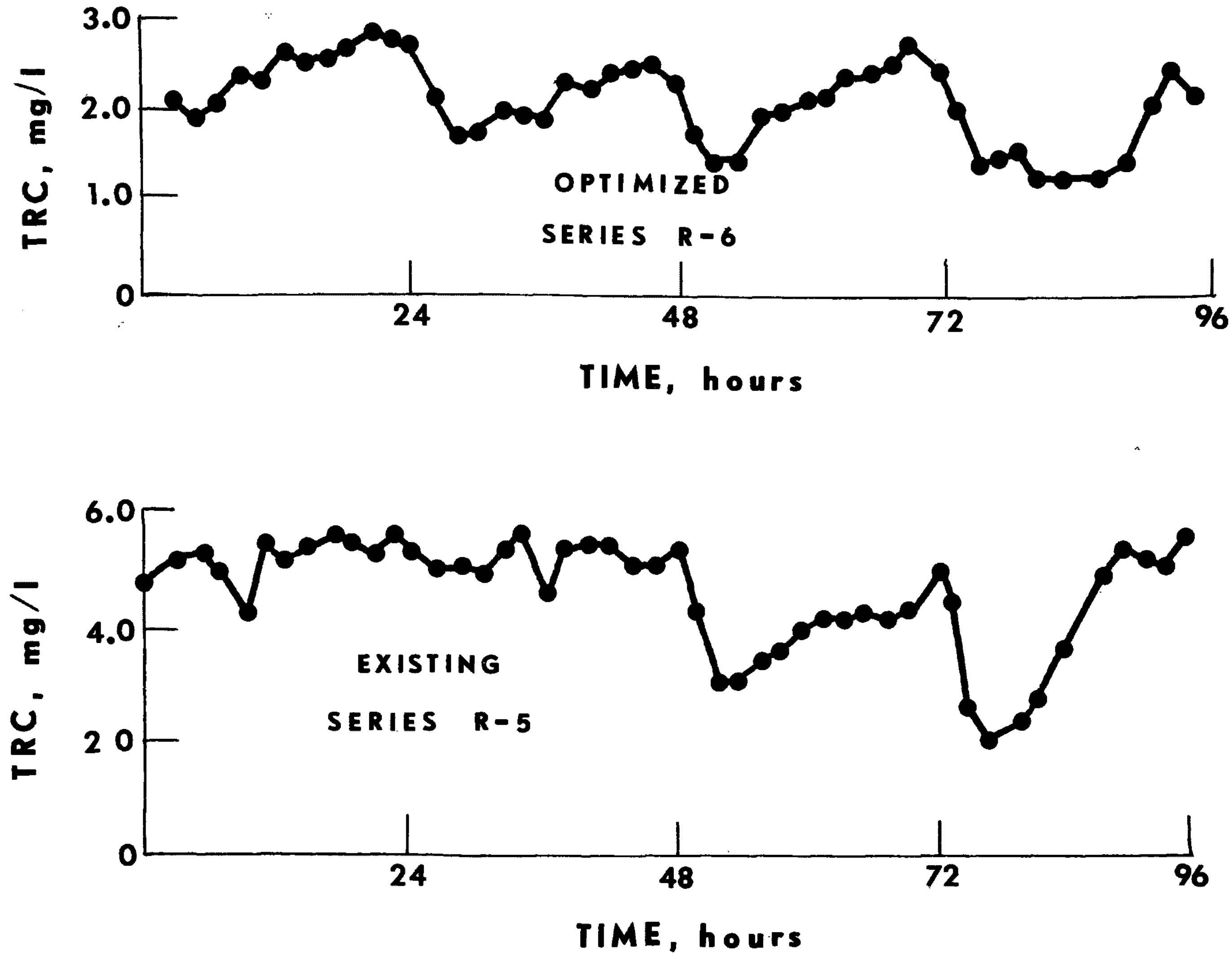

Figure 14. Chlorine residuals in optimized and existing effluents at Roseville WTP during the second week of comparative testing.

DOHCl and ECl are surprising since the ECl effluents had mean chlorine residuals approximately twice those of the DOHCl effluents. There were substantial differences in the amounts of TRC at the 96-h LC50 level between the two effluents which suggests there was some other toxic substance that was affecting the toxicity of TRC at this location. The mean test chlorine residuals of the ECl were 13.08 and 11.18 mg/L TRC while those of the DOHCl were 6.12 and 6.94 mg/L TRC during the first and second weeks of comparative testing, respectively (Table 3). The mean TRC of the DOHCl effluents were significantly lower than those of the ECl effluents for both weeks of comparative testing (Table 4). The TRC of the DOHCl effluent was less variable than those of the ECl effluent during both the first (Figure 15) and second (Figure 16) weeks of comparative testing. The effluent toxicity and quality data for the toxicity tests are presented in Appendix B-8.

Ross Valley WTP

The undiluted, UnCl (RV-1 and RV-4) effluents were toxic (3.3 to 6.7% mortality) to golden shiners (Table 2). This slight toxicity may have been due to un-ionized ammonia concentrations (440-540 ug/L NH_3). The DOHCl (Series RV-3) effluent (96-h LC50 = 5.1% effluent) was less toxic than the ECl (Series RV-2) effluent (96-h LC50 = 2.9% effluent) during the first week of comparative testing. The DOHCl (Series RV-6) effluent (96-h LC50 = 6.4% effluent) was also less toxic than the ECl (Series RV-5) effluent (96-h LC50 = 3.1% effluent) during the second week of comparative testing. The mean test chlorine residuals of the ECl were 5.58 and 8.40 mg/L while those of the DOHCl were 3.18 and 3.40 mg/L during the first and second weeks of comparative testing, respectively (Table 3). The mean TRC of the DOHCl effluents were significantly lower than those of the ECl effluents during both weeks of comparative testing (Table 4). The TRC of the DOHCl effluent was less variable than those of the ECl effluent during both the first (Figure 17) and second (Figure 18) weeks of comparative testing. The effluent toxicity and quality data for the toxicity tests are presented in Appendix B-9.

TOXICITY OF UNCHLORINATED AND DECHLORINATED EFFLUENTS

Fish mortality in the undiluted UnCl and DeCl effluents varied from 0.0 to 80.0%. In general, the toxicity in the 100% effluent concentrations increased with increased un-ionized ammonia concentrations. The 96-h LC50 for un-ionized ammonia to golden shiners derived from mortality in the 100% effluent concentrations was 1245 ug/L NH_3 using log-logit analysis.

The un-ionized ammonia concentrations used to calculate the 96-h LC50 were measured in the 100% waste aquaria and not in the undiluted, UnCl and DeCl effluent streams. By comparison, the effluent streams generally had a significantly less (64%) un-ionized ammonia concentration, a significantly higher temperature, a significantly lower total ammonia concentration, and a significantly lower pH value than the 100% waste aquaria (Table 5). The lower temperature in the aquaria was caused by the chilling of our toxicity testing room, and the slightly lower total ammonia concentration was probably the result of ammonia loss by aeration during the course of a test. The

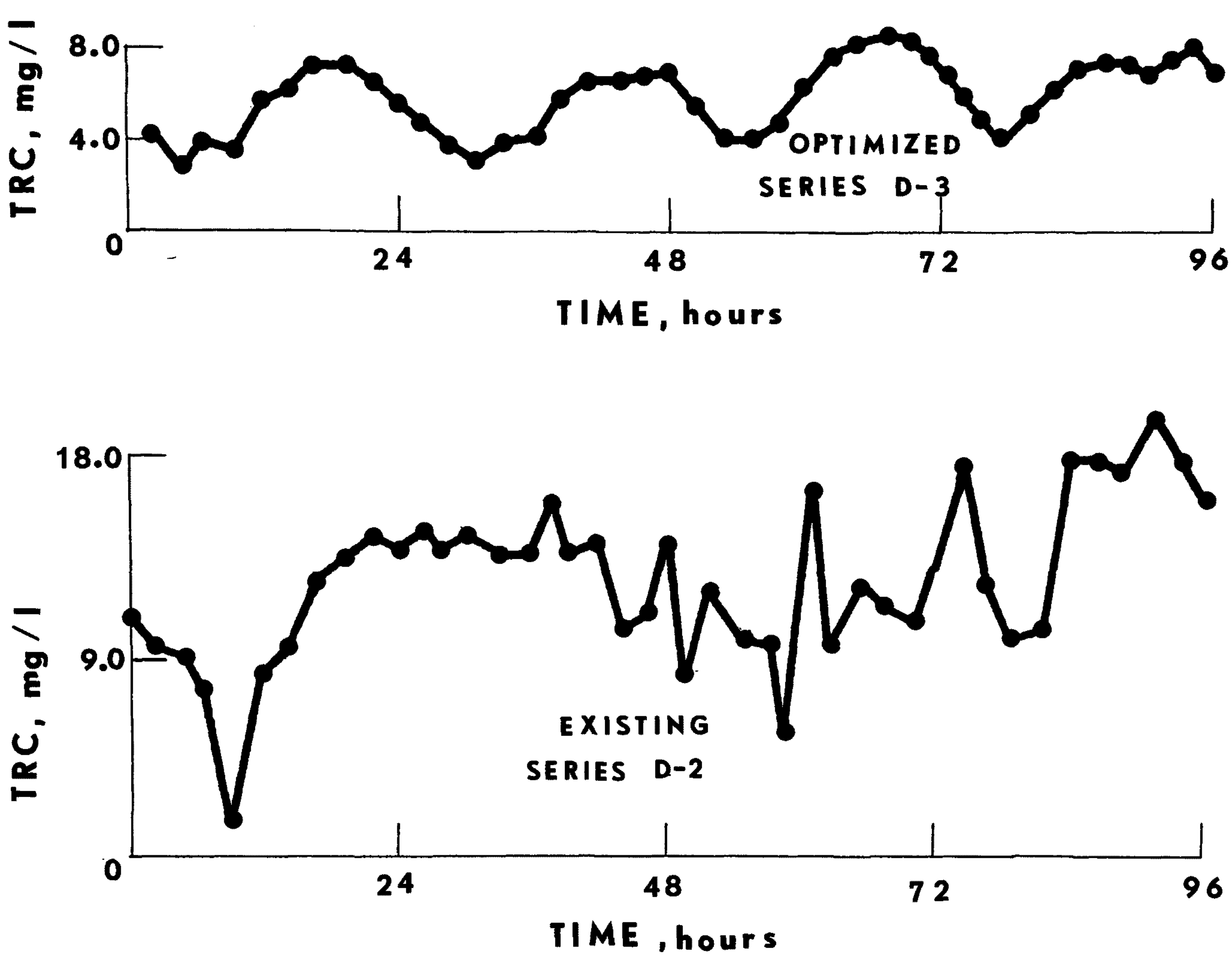

Figure 15. Chlorine residuals in optimized and existing effluents at Dublin/San Ramon WTP during the first week of comparative testing.

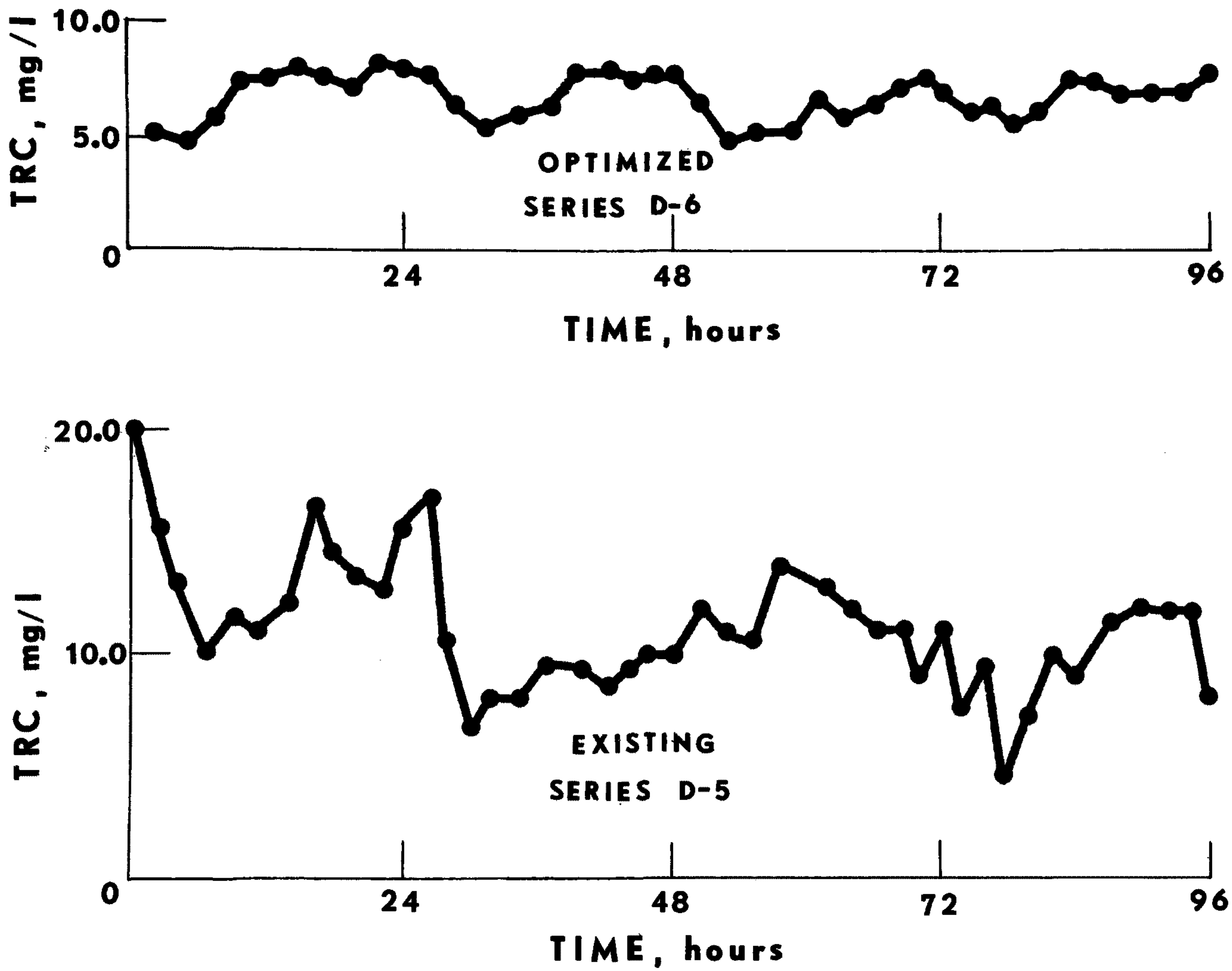

Figure 16. Chlorine residuals in optimized and existing effluents at Dublin/San Ramon WTP during the second week of comparative testing.

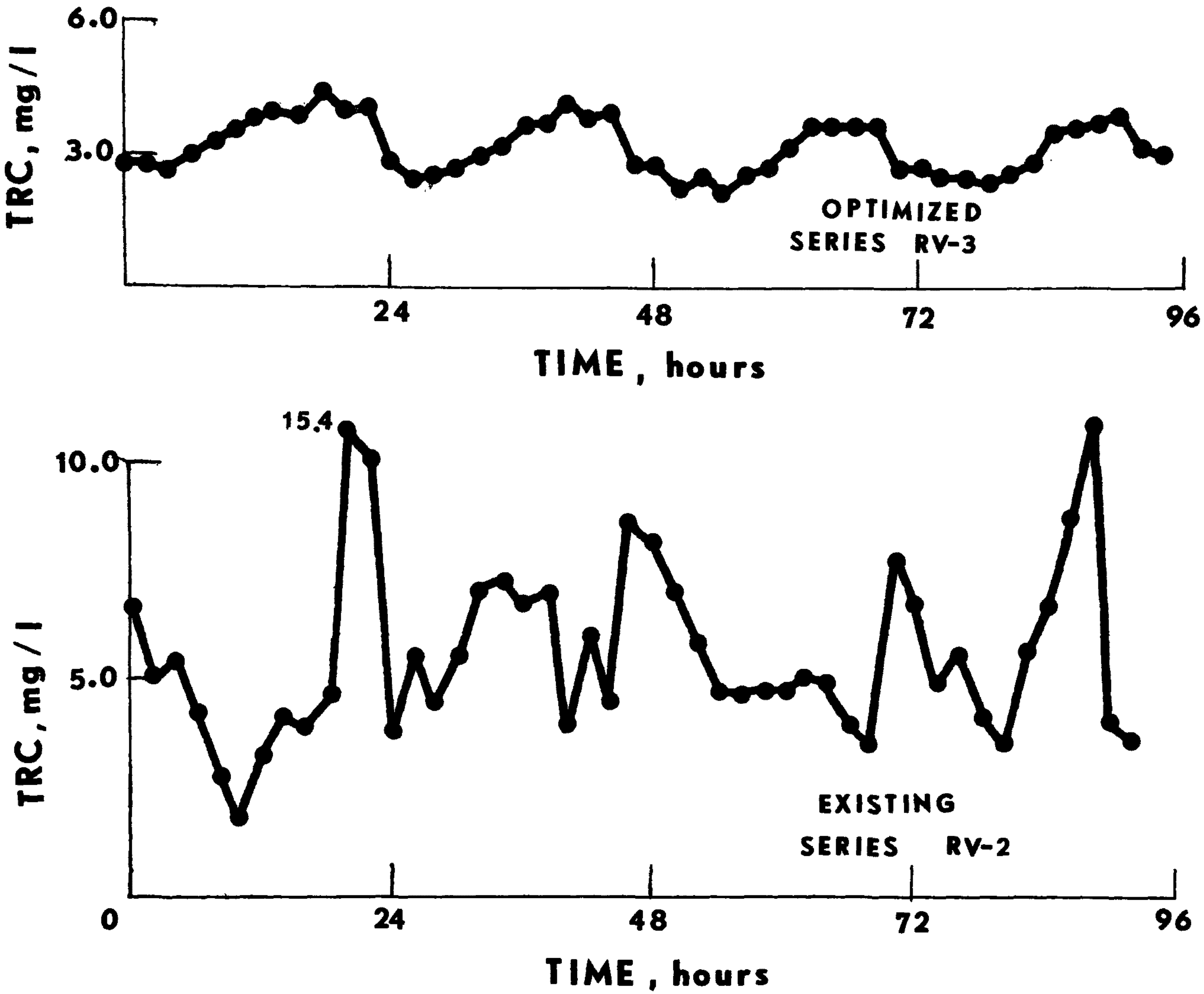

Figure 17. Chlorine residuals in optimized and existing effluents at Ross Valley WTP during the first week of comparative testing.

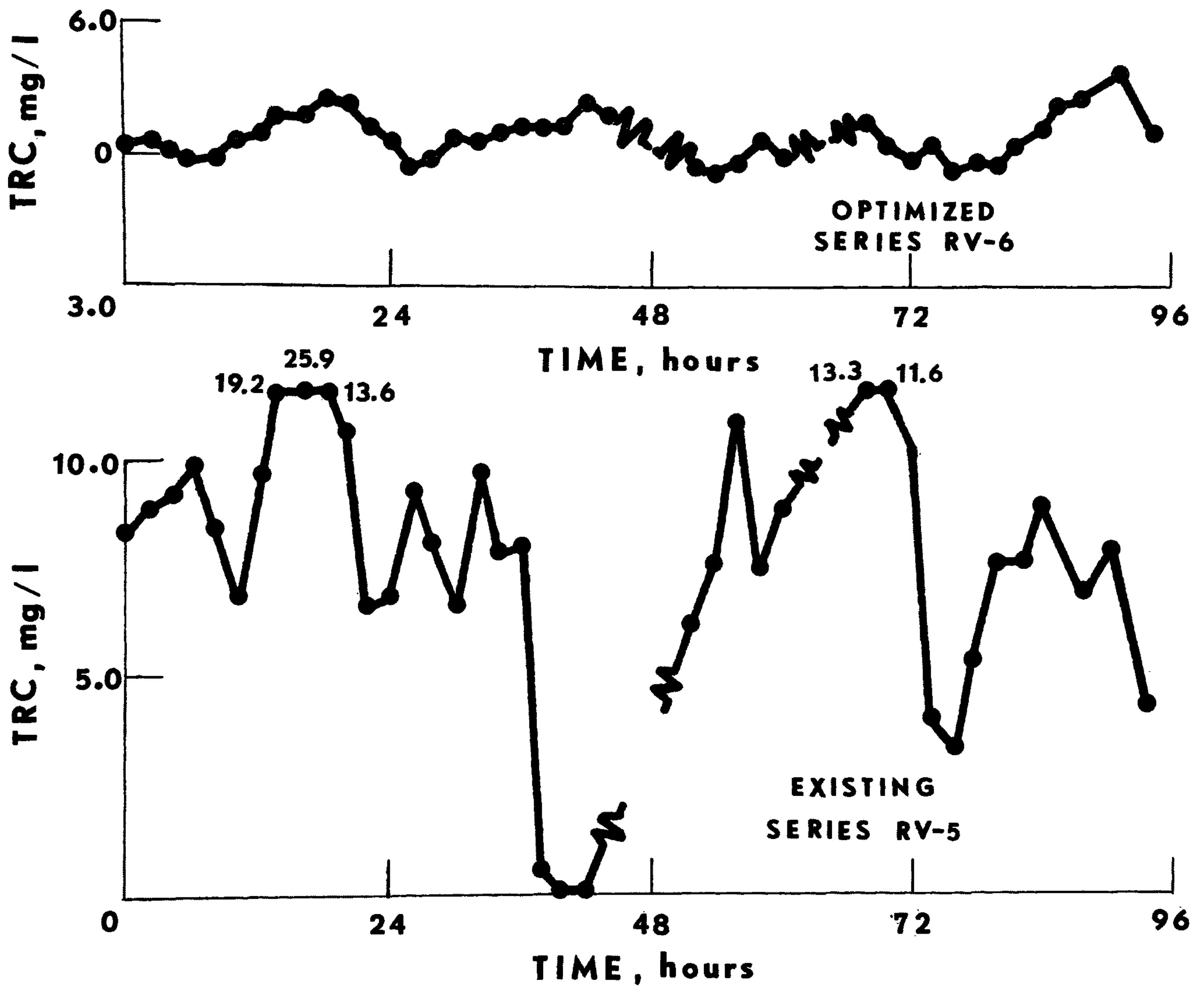

Figure 18. Chlorine residuals in optimized and existing effluents at Ross Valley WTP during the second week of comparative testing.

Table 5. DIFFERENCE BETWEEN TOTAL AMMONIA, TEMPERATURE, pH, AND UN-IONIZED AMMONIA IN THE UNCHLORINATED (UnCl) AND DECHLORINATED (DeCl) AFFLUENTS.

Parameter	Undiluted Effluent Streams mean ± SD	Undiluted Effluent Aquaria mean ± SD	Variation df	Variation t[a]
Total ammonia (mg/L)	22.01 ± 7.50[b]	18.36 ± 4.65[c]	15	2.70*
Temperature (°C)	22.4 ± 2.4	18.9 ± 1.0	15	7.98*
pH	7.0 ± 0.3	7.5 ± 0.3	15	-15.98*
Un-ionized ammonia (ug/l)	128 ± 96	370 ± 243	15	-5.60*

a/ Asterisks denote significant differences at $p < 0.05$ and negative values indicate aquaria as higher

b/ Data averaged from Table 3.

c/ Data averaged from Appendices B-2 through B-9.

increase in pH (.5 pH) in the aquaria, which caused the large increase in un-ionized ammonia concentration, was probably the result of chemical changes taking place in the effluent during its temporary confinement aeration.

COMPARATIVE CHLORINE TOXICITY

<u>Existing and Optimized Effluents</u>

Overall, the DOHCl effluents had a significantly lower (49.7%) mean TRC than did the ECl effluents (Table 6). The results from South San Francisco are not used in this comparative analysis because the ECl effluents were not meeting disinfection criteria during the tests. Coupled with the lower TRC, the DOHCl effluents (96-h LC50 $\bar{x}$ = 7.45% effluent concentration) were significantly less toxic (42.9%) than the ECl effluents (96-h LC50 $\bar{x}$ = 3.6% effluent concentration). The DOHCl effluents at the 96-h LC50 level, therefore, contained approximately twice the other effluent constituents as the ECl effluents. This increase in waste constituents may explain why the DOHCl effluents (96-h LC50 $\bar{x}$ = 0.15 mg/L TRC) had a significantly more toxic (20%) chlorine residual to golden shiners than the ECl effluents (96-h LC50 $\bar{x}$ = 0.12 mg/L TRC). Un-ionized ammonia was slightly higher in the DOHCl effluents than in the ECl effluents at this level, but the difference was not significant. Therefore, differences in un-ionized ammonia concentrations were probably not the entire cause of the differences in chlorine residual toxicities between the DOHCl and ECl effluents. Other possible toxic waste constituents, such as organics and metals, were not measured.

<u>Fathead Minnows and Golden Shiners</u>

Both fathead minnows and golden shiners were used as test organisms in the toxicity tests. The golden shiners had to be substituted for fathead minnows when disease epidemic (<u>Columnaris sp.</u>) occurred in our fathead minnow stock. We then continued to use golden shiners as our test fish even though their stocks also suffered lesser outbreaks of the disease. However, fish which noticeably had the disease were not used in the tests.

We found fathead minnows (96-h LC50 $\bar{x}$ = 0.11 mg/L TRC) to be significantly more sensitive (23.6%) to chlorine than golden shiners (96-h LC50 $\bar{x}$ = 0.14 mg/L TRC) (Table 6). Because of the obvious increased resistance of chlorine at the San Pablo WTP in fathead minnows, the results from this WTP are not used in this comparative analysis. The difference in chlorine sensitivity between the two species could not be attributed to a difference in un-ionized ammonia at the 96-h LC50 level and therefore must be a true difference in species sensitivity to chlorine.

<u>San Pablo WTP and All Other WTP</u>

Chlorine was found to be significantly less toxic (331%) to fathead minnows at San Pablo WTP (96-h LC50 $\bar{x}$ = 0.47 mg/L TRC) than the other WTP investigated (Table 6). There were no obvious differences between the effluent quality of the WTP groups. San Pablo WTP (because of nitrification) did have total ammonia levels consistently below 1.0 mg/L while the other WTP (with the exception of Dublin/San Ramon) had ammonia levels in excess of

Table 6. DIFFERENCES BETWEEN THE TRC RESIDUAL IN UNDILUTED EXISTING (EC1) AND DEPARTMENT OF HEALTH SERVICES (DOHC1) EFFLUENTS, THE TOXICITIES OF EC1 AND DOHC1 EFFLUENTS, AND THE SENSITIVITIES OF CHLORINE AND AMMONIA TO GOLDEN SHINERS (GS) AND FATHEAD MINNOWS (FH).

Variation	Source	Identification	n	mean	SD	Source of Variation	df[a]	t[b]
Effluents TRC	EC1 (mg/L TRC)[c]	A	12	6.64	3.10			
	DOHC1 (mg/L TRC)[c]	B	12	3.34	1.[illegible]2	AxB	11	5.62*
Effluent toxicity	96-h LC50, GS, EC1 (% effluent)[c]	C-1	9	3.67	1.51			
	(ug/L TRC)	C-2	11	150	35			
	(ug/L NH_3)[d]	C-3	9	23	18			
	96-h LC50, GS, DOHC1 (% effluent)[c]	D-1	9	7.45	4.23	C1xD1	8	-3.95*
	(ug/L TRC)	D-2	11	125	30	C2xD2	10	2.51*
	(ug/L NH_3)[d]	D-3	9	29	22	C3xD3	8	-1.13
Species toxicity	96-h LC50, GS, (ug/L TRC)	E-1	24	144	33			
	(ug/L NH_3)[d]	E-2	20	24	18			
	96-h LC50, FH, (ug/L TRC)[e]	F-1	7	110	43	E1xF1	29	2.25*
	(ug/L NH_3)[e]	F-2	7	26	17	E2xF2	25	-0.21
Chlorine toxicity	96-h LC50, FH, all WTP[e] (ug/L TRC)	F-1	7	110	43			
	96-h LC50, FH, San Pablo WTP (ug/L TRC)	G-1	4	491	75	F1xG1	9	-10.93*

a/ Equal sample numbers denote paired observations.
b/ Asterisks denote significant differences at $p < 0.05$.
c/ Results from SSF-1 through SSF-9 not included in comparisons.
d/ Ammonia not measured at DSR-1 through DSR-6.
e/ Results from SP-1 through SP-9 not included in comparisons.

10.0 mg/L (Table 3). The Dublin/San Ramon WTP also employed nitrification but its chlorine residuals were just as toxic as the other WTP. Therefore, there must be some other factor which accounts for the difference in chlorine toxicity.

We found significant correlations between the 96-h LC50 and the corresponding mean TRC of the undiluted ECl and DOHCl effluents for both fathead minnow (r = .89) and golden shiner (r = .86) (Figure 19). Since there was such a good correlation between fish toxicity and TRC, chlorine can be viewed as the most toxic component of chlorinated, wastewater treatment plant effluents. A nonsignificant correlation (r = .71) was found between the same two variables for the chlorinated, San Pablo WTP effluents,

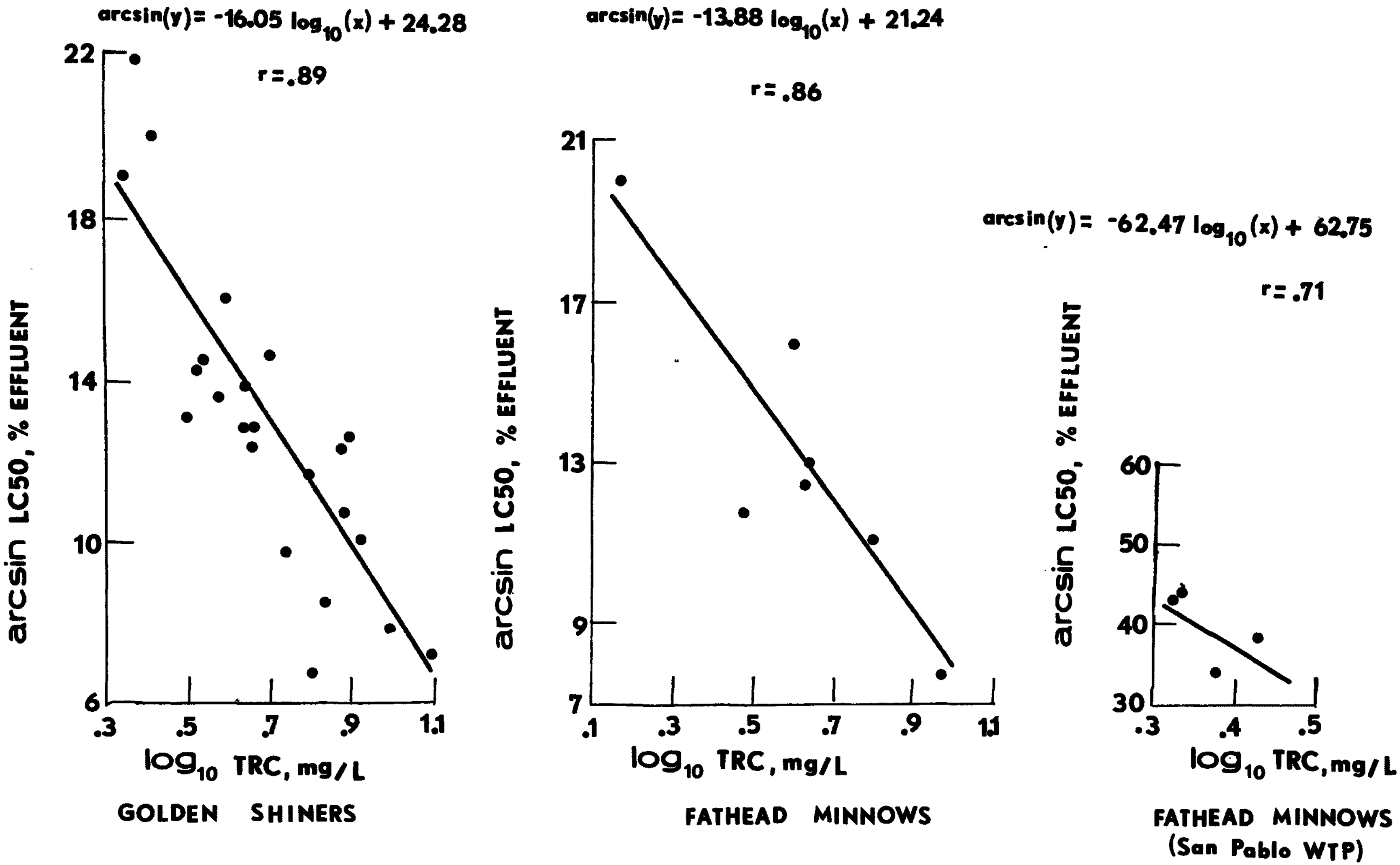

Figure 19. The LC50 effluent concentration vs. TRC content of undiluted effluents for fathead minnows and golden shiners.

SECTION 6

DISCUSSION

Toxicity tests were conducted on UnCl, ECl, DOHCl, and DeCl effluents from 8 WTP in northern California. UnCl effluents were investigated to determine if the wastewater effluents were toxic prior to chlorination. Additionally, DeCl effluents were investigated to determine if dechlorination eliminated all toxicity caused by chlorination.

Nineteen series of toxicity tests in replicate demonstrated that there was little acute toxicity ($\bar{x}$ = 10.4% mortality) associated with the undiluted, UnCl effluents. There was even less acute toxicity ($\bar{x}$ = 5.3% mortality) associated with DeCl effluents. Most of the mortality associated with the UnCl and DeCl effluents was probably caused by un-ionized ammonia since there was increasing mortality with increasing un-ionized ammonia concentrations. Mortality of golden shiners in the 100% effluent concentrations of the UnCl and DeCl effluents produced a 96-h LC50 of 1245 ug/L NH_3. Although we were unable to locate a LC50 for un-ionized ammonia to golden shiner in the literature, Willinghem et al. (1978) reported that the 96-h LC50 values for warmwater fish varied from 500 to 2000 ug/L NH_3. Our 96-h LC50 for golden shiner was within this reported range.

The mortality associated with the UnCl and DeCl effluents, if caused by un-ionized ammonia, was an artifact created by the experimental design of the toxicity tests. Confinement and aeration of the effluents in the aquaria during the tests caused the pH of the effluents to increase an average of 0.5 pH units above that of the continuous, undiluted effluent streams. This increase in pH caused the un-ionized ammonia concentrations to be 144% higher than those present in the undiluted waste streams. An average increase of 0.5 pH units (7.0 to 7.5) and decrease of temperature 3.6 C (22.0 to 18.4 C), as happened in our tests, theoretically should cause un-ionized ammonia concentrations to increase 143% (Morgan and Turner 1977). With the possible exception of the South San Francisco WTP tests, all mortality associated with the UnCl and DeCl effluents should have disappeared if continuous-flow, rather than continual-flow (intermittent-flow), toxicity tests had been used. This is because a continuous-flow system would have had a shorter hydraulic retention time than the continual-flow system we used (one aquarium volume change per 2.5 h). The concentrations of un-ionized ammonia in the effluent streams at South San Francisco WTP were $\approx$ 300 ug/L NH_3 which would have caused some mortality while all other WTP had un-ionized ammonia concentrations $<$ 200 ug/L NH_3 which should have not caused mortality.

This phenomenon of a pH increase (and subsequent increases of un-ionized ammonia concentrations) during continual-flow toxicity testing conditions suggests that this methodology may not be valid for testing the toxicity of wastewater effluents. If partial confinement and aeration of the effluent during the test are the underlying causes for these increases, the static test conditions should lead to an even greater pH increase. Therefore, we recommend that continuous-flow tests be preferred for monitoring effluents with high total ammonia concentrations ($>$10 mg/L) followed by continual-flow and static tests in that order of preference.

Three separate studies at the San Pablo (Series SP-4 through SP-6), Pinole (Series P-4 through P-6), and Sacramento Northeast (Series SN-4 through SN-6) WTP demonstrated that dechlorination with sulfur dioxide (SO_2) reduced the toxicity to a level equivalent to or less than that of the unchlorinated effluents.

The SO_2 in water forms sulfurous acid (H_2SO_3) which reacts with TRC (free chlorine, Equation 3; mono-chloramine, Equation 4) to produce small amounts of sulfuric and hydrochloric acids:

$$(3)\quad H_2SO_3 + HOCL \rightarrow H_2SO_4 + HCl$$

$$(4)\quad NH_2Cl + H_2SO_3 + H_2O \rightarrow NH_4HSO_4 + HCl$$

Dechlorination with SO_2 decreased the pH of the ECl effluents to a maximum of 0.5 pH units at the Sacramento WTP. There was no pH change at the San Pablo WTP following dechlorination.

Chlorine has been reported to be the single most toxic constituent of most wastewater effluents (Martens and Servizi 1975; Beeton, Kovacic, and Brooks 1976). The toxicities of the chlorinated effluents to golden shiner and fathead minnow were predictable with a great degree of accuracy ($r = 0.88$ and 0.86, respectively) based on the TRC content of the ECl and DOHCl effluents.

With the exception of the first week of comparative studies at South San Francisco WTP (Series SSF-4 through SSF-6), the DOHCl effluents were characteristically lower in TRC than the ECl effluents. Overall, the DOHCl effluents contained 49.7% less TRC than the ECl effluents. The results from South San Francisco WTP are not used in this comparative analysis since the WTP did not have to meet any disinfection criteria. The reductions in chlorine varied between a low of 5.7% less TRC during the first week at San Pablo WTP (Series SP-1 through SP-3) and a high of 67.2% less TRC during the second week at Pinole WTP (Series P-7 through P-9).

In conjunction with containing an average of 49.7% less TRC, the DOHCl effluents had less variable TRC than did the ECl effluents. Standard deviations of the mean TRC in the ECl effluents varied from $\pm$ 0.31 mg/L to $\pm$ 4.16 mg/L TRC with a grand mean of $\pm$ 2.14 mg/L TRC, while those of the DOHCl effluents varied from $\pm$ 0.28 mg/L to $\pm$ 4.61 mg/L TRC with a grand mean of

± 0.72 mg/L TRC. Both the ECl and DOHCl effluents appeared to be less variable at San Pablo and Roseville WTP and more variable at South San Francisco, Pinole, and Ross Valley WTP.

The DOHCl effluents on the average were significantly less toxic (42.9%) than the ECl effluents in 10 of the 12 comparative studies at 6 of the 7 WTP. Again, the results from South San Francisco WTP are not used in this analysis and no comparative studies were done at San Leandro WTP. In 9 of these 10 comparative studies, the DOHCl effluents were less toxic than the ECl effluents. The exception to this was the first comparative study at Dublin/San Ramon WTP (DSR-1 through DSR-3). The results obtained during the first week of comparative studies at San Pablo and Pinole WTP also are not included in this analysis because of problems (either too little or too much mortality) which arose during the test and therefore precluded the estimation of an LC50. However, since the DOHCl effluents at San Pablo and Pinole WTP had slightly lower mean TRC than the ECl effluents, the toxicities of the DOHCl effluents should have been less. The 42.9% reduction in toxicity corresponds to the 49.7% reduction in TRC associated with the DOHCl effluents.

Although the DOHCl effluents were, in general, significantly less toxic than comparable ECl effluents (on a % effluent basis), the ECl effluents generally had a significantly less toxic (20%) TRC to golden shiner than the DOHCl effluents at the 96-h LC50 level. However, the DOHCl effluents had approximately twice the effluent constituents at the 96-h LC50 level than did the ECl effluents. These other constituents presumably added to the toxicity of the effluent or interacted with chlorine to make it more toxic. This phenomenon cannot be entirely explained by the slightly higher un-ionized ammonia concentrations at the 96-h LC50 level in the DOHCl effluents.

We found fathead minnow to be significantly more sensitive (23.6%) to chlorine than golden shiner. Our mean 96-h LC50 values for fathead minnow (0.11 mg/L TRC) and golden shiner (0.14 mg/L TRC) agree remarkably well with those values in the published literature (Arthur et al. 1975; Esvelt, Kaufman, and Selleck 1971) for wastewater treatment plant effluents. The toxicity of chlorine in wastewater effluents to both species was fairly consistent, producing excellent regressions between the 96-h LC50 (% effluent concentration) and the mean TRC content of the undiluted waste.

We found the fathead minnow to be significantly more sensitive (331%) to TRC at the other WTP than at the San Pablo WTP. Obviously, the nitrified effluents at San Pablo WTP (which had total ammonia concentrations < 1.0 mg/L) had less toxic chlorine residuals (96-h LC50 $\bar{x}$ = 0.47 mg/L TRC). All other WTP had total ammonia concentrations > 10.0 mg/L with the exception of Dublin/San Ramon WTP, which also produced a nitrified effluent and had total ammonia levels < 1.0 mg/L (Sepp and Bao 1980). Even though the Dublin/San Ramon WTP effluent was nitrified, the effluent (96-h LC50 $\bar{x}$ = 0.12 mg/L TRC) TRC was slightly more toxic to golden shiner than the other WTP (96-h LC50 $\bar{x}$ = 0.14 mg/L TRC) where nitrification was not practiced. Hence, the practice of nitrification of wastewaters prior to chlorination by itself does not explain the drastic reduction of toxicity to fathead minnow. However, the influence of wastewater ammonia on TRC toxicity has been documented elsewhere. Finlayson (1977) found chlorine in ammoniated wastewaters to be significantly more toxic (307%) to rainbow trout, Salmo gairdneri, fry than in nitrified effluents containing < 0.5 mg/L total ammonia.

Complete nitrification (<1.0 mg/L total ammonia) of wastewaters prior to chlorination should allow for break-point chlorination if the chlorine dose is >10 times the total ammonia concentration (wt. to wt. basis). At break-point ammonia is lacking; consequently, free chlorine (Equation 5), tri-chloramine (Equation 8), and complex organic chloramines (Equation 9) are produced between the chlorine and the effluent. Conversely, when ammonia is present and abundant (>10.0 mg/L total ammonia), mono- (Equation 6) and di-chloramines (Equation 7) are the primary reaction products.

Rosenberger (1971) suspected mono- and di-chloramines to be more toxic than the reaction products formed at break-point chlorination. Rosenberger (1971) also showed that although free chlorine was the most toxic residual chlorine (TRC) species, the toxicity of mono- and di-chloramines was reduced when a small amount of free chlorine was present. However, we suspect that, because of the way Rosenberger's (1971) experiments were conducted, these less toxic mono- and di-chloramines may have been in fact tri-chloramines and organic chloramines. There is no published literature regarding the toxicities of these two latter chloramines. However, we suspect these species are less toxic than free chlorine, mono-, and di-chloramines since they are further reduced and thus less reactive in water:

$$(5)\quad Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$$

$$(6)\quad HOCl + NH_3 \rightarrow NH_2Cl + H_2O$$

$$(7)\quad HOCl + NH_2Cl \rightarrow NHCl_2 + H_2O$$

$$(8)\quad HOCl + NHCl_2 \rightarrow NCl_3 + H_2O$$

$$(9)\quad CH_3C_6H_4SO_3H + HOCl + NH_3 \rightarrow CH_3C_6H_5SO_2NCl + 2H_2O$$

All of the abovementioned TRC species will completely or partially titrate as TRC in the amperometric titration (APHA 1975). If these less toxic break-point chloramines made up the bulk of the TRC in the nitrified effluents at San Pablo WTP, the result would be that the test fish would have been able to withstand a higher TRC than fish at the other WTP. The same should be true at the Dublin/San Ramon WTP. However, 80% of the TRC at Dublin/San Ramon WTP was free chlorine (Sepp and Bao 1980) and the balance of 20% was probably tri-chloramine and organic chloramine. The abundance of free chlorine at the Dublin/San Ramon WTP probably explains why its effluent was slightly more toxic than that of the ammoniated (mono- and di-chloramines) effluents. We have no comparable data for the San Pablo WTP, although we suspect that free chlorine was probably not nearly so high. Evidently, there was a greater time-lag between chlorination of the nitrified effluent and toxicity testing at the San Pablo WTP than there was at the Dublin/San Ramon

WTP. Hence, the greater the lag time, the more time the free chlorine in nitrified effluents has to form the less toxic, more stable, tri-chloramines and organic chloramines.

REFERENCES

American Public Health Association. 1975. Standard Methods for the Examination of Water and Wastewater. 14th ed. APHA, New York, N.Y. 1193 pp.

Arthur, J.W., R.W. Andrew, V.R. Mattson, D.T. Olson, G.E. Glass, B.J. Halligan, and C.T. Walbridge. 1975. Comparative toxicity of sewage effluent disinfection to freshwater aquatic life. Environ. Prot. Agency, Ecological Res. Ser. EPA-600/3-75-012. 53 pp + Appendix.

Beeton, A.M., P.K. Kovacic, and A.S. Brooks. 1976. Effects of chlorine and sulfite reduction on Lake Michigan invertebrates. Environ. Prot. Agency, Ecological Res. Ser. EPA-600/3-76-036. 122 pp.

Brungs, W.A. 1973. Effects of residual chlorine on aquatic life. Water Poll. Contr. Fed., J., 45:2180-2193.

Brungs, W.A. 1976. Effects of wastewater and cooling water chlorination on aquatic life. Environ. Prot. Agency, Ecological Res. Ser. EPA-600/3-76-098. 46 pp.

DeGraeve, G.M., W.J. Blogoslawski, W.A. Brungs, J.A. Fava, B.J. Finlayson, T.P. Frost, T.M. Krischan, J.W. Meldrim, D.T. Michaud, R.E. Nakatani, and G.L. Seegret. 1979. Chlorine. pp 67-75. In: Review of the EPA Red Book: Quality Criteria for Water. R.V. Thurston, R.C. Russo, C.M. Fetterolf, T.A. Edsall, and Y.M. Barber, Jr. (Eds.). Water Quality Section, American Fisheries Society, Bethesda, MD.

Esvelt, L.A., W.J. Kaufman, and R.E. Selleck. 1971. Toxicity removal from municipal wastewaters. Univ. of Calif., Sanitary Engin. Res. Lab. Rep. No. 71-7. 153 pp.

Finlayson, B.J. 1977. Evaluation of four wastewater treatment facilities in Sacramento County, CA. Calif. Dept. Fish and Game, Fish and Wildlife Water Pollution Control Lab. Memo. Rep. No. 77-3. 22 pp + Appendices.

Finlayson, B.J. and L.A. Hinkelman. 1977. Effects of chlorinated power plant cooling water on aquatic life. Calif. Dept. Fish and Game, Environ. Services Br. Admin. Rep. No. 77-5. 53 pp.

Finley, D.J. 1971. Probit analysis. 3rd ed., Syndics of Cambridge University Press, New York, N.Y. 265 pp.

Martens, D.W. and J.A. Servizi. 1975. Dechlorination of municipal sewage using sulfur dioxide. Internat'l Pacific Salmon Fish. Commission, New Westminister, B.C., Prog. Rep. No. 32. 24 pp.

Mattice, J.S. and H.E. Zittel. 1976. Site-specific evaluation of power plant chlorination. A proposal. Water Poll. Contr. Fed., J., 48:2284-2308.

Morgan, N. and J. Turner. 1977. Calculation of un-ionized ammonia for fresh water. Calif. Dept. Fish and Game, Environ. Services Br. Admin. Rep. No. 77-1. 14 pp.

Mount, D.I. and W.A. Brungs. 1967. A simplified dosing apparatus for fish toxicological studies. Water Res. 1:21-29.

Peltier, W. 1978. Methods for measuring the acute toxicity of effluents to aquatic organisms. Environ. Prot. Agency, Environ. Monitoring Ser. EPA-600/4-78-012. 52 pp.

Roberts, M., R. Diaz, M. Bender, and R. Huggett. 1975. Acute toxicity of chlorine to selected marine species. Fish. Res. Bd. Can., J., 32:2525-2528.

Rosenberger, D.R. 1971. The calculation of acute toxicity of free chlorine and chloramines to coho salmon by multiple regression analysis. M.S. Dissertation, Michigan State University. March 1971. 33 pp + Appendix.

Sepp, Endel and P.Y. Bao. 1980. Design optimization of the chlorination process. Volume I: Comparison of optimized pilot system with existing full scale systems. U.S. Environ. Prot. Agency, Research and Develop. Series (in press).

Sokal, R.R. and F.J. Rohlf. 1969. Biometry. W.H. Freeman and Company, San Francisco, California. 776 pp.

U.S. Environmental Protection Agency. 1976. Quality criteria for water. 256 pp.

Ward, R.N., R.D. Giffin, G.M. DeGraeve, and R.A. Stone. 1976. Disinfection efficiency and residual toxicity of several wastewater disinfectants. Volume I - Grandville, Michigan. Environ. Prot. Agency, Environ. Prot. Tech. Ser. EPA-600/2-76-156. 131 pp.

Willinghem, W.T., J.E. Colt, J.A. Fava, B.A. Hillaby, C.L. Ho, M.Katz, R.C. Russo, D.L. Swanson, and R.V. Thurston. 1978. Ammonia. pp 51-65. In: Review of the EPA Red Book: Quality Criteria for Water. R.V. Thurston, R.C. Russo, C.M. Fetterolf, T.A. Edsall and Y.M. Barber, Jr. (Eds.). Water Quality Section, American Fisheries Society, Bethesda, MD.

Zillich, J.A. 1972. Toxicity of combined chlorine residuals to freshwater fish. Water Poll. Contr. Fed., J., 44(2):212-220.

APPENDIX B-1 CHEMICAL ANALYSES OF DILUTION WATER SUPPLIES

APPENDIX B-1. Water quality analyses for dilution water supplies at the wastewater treatment plants. Chloride, nitrate, phosphate, sulfate, calcium, sodium, potassium, magnesium, and total dissolved solids concentrations in mg/L and other metal concentrations in ug/L.

Parameter	SL	SP	P	SSF	SN	R	DSR	RV
Alkalinity ($CaCO_3$ mg/L)	21.0	37.0	78.0	91.0	80.0	25.0	241.0	67.0
Hardness ($CaCO_3$ mg/L)	26.0	54.0	118.0	140.0	65.0	37.0	304.0	86.0
pH	7.4	7.4	7.9	7.7	7.7	8.4	8.1	7.6
Specific conductance (umhos/cm)	81	170	367	436	184	90	730	208
Total dissolved solids	44	93	193	267	132	42	440	133
Al	<100	<100	400	<100	<100	<100	<100	400
Ag	<1	<1	<1	<5	<5	<5	<5	<5
As	<5	<5	<5	<5	<5	<5	<5	<5
Ca	9.0	16.0	29.0	28.0	18.0	12.0	61.0	18.0
Cd	8.0	<5.0	8.0	<5.0	<5.0	<5.0	<5.0	<5.0
Cl	3.2	13.0	32.0	49.0	4.7	4.5	54.0	11.0
Cu	10.0	70.0	10.0	<10.0	<10.0	50.0	680.0	10.0
Fe	<20	200	<20	<20	<20	<20	<20	<20

APPENDIX B-1. (continued).

Parameter	SL	SP	P	SSF	SN	R	DSR	RV
Hg	0.4	0.4	0.2	0.1	<0.1	<0.1	<0.1	<0.1
K	0.8	1.1	0.9	1.3	1.6	0.6	1.7	0.9
Mg	0.8	3.4	1.1	17.0	4.9	1.7	37.0	10.0
Mn	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Na	1.9	8.7	23.0	35.0	14.0	2.7	38.0	8.0
Ni	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
NO_3 (as N)	0.19	0.37	0.30	13.0	3.5	0.1	10.0	0.30
Se	--	--	--	--	--	--	--	--
SO_4	0.8	15.0	39.0	36.0	4.9	8.1	57.0	17.0
Zn	40.0	260.0	50.0	220.0	10.0	130.0	10.0	20.0

APPENDIX B-2 EFFLUENT TOXICITY AND QUALITY DATA FOR SAN LEANDRO WTP

APPENDIX - B-2.

Test series SL-1 Effluent type UnCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	17.9±0.9[a]	7.8±0.1	7.4±0.8	00±0	14.76±2.87	327±92	17	0.0
100.0-2	17.9±0.8	7.7±0.1	7.2±0.6	00±0	15.09±4.44	323±142	17	0.0
56.0-1	17.6±0.6	7.7±0.1	8.2±0.7	00±0	8.47±1.36	196±40	17	0.0
56.0-2	17.5±0.7	7.7±0.1	8.1±0.6	00±0	9.44±2.85	204±47	17	0.0
32.0-1	17.0±0.7	7.7±0.1	8.7±0.7	00±0	5.05±1.20	107±29	17	0.0
32.0-2	17.2±0.7	7.7±0.1	8.5±0.6	00±0	6.05±2.15	117±28	17	0.0
18.0-1	16.9±0.7	7.7±0.1	8.9±0.6	00±0	3.64±0.40	68±16	17	0.0
18.0-2	16.8±0.8	7.7±0.1	8.8±0.8	00±0	4.04±0.77	82±16	17	0.0
10.0-1	16.8±0.8	7.7±0.1	8.9±0.7	00±0	1.59±0.17	28±8	17	0.0
10.0-2	16.7±0.7	7.7±0.1	9.1±0.7	00±0	1.64±0.23	28±3	17	0.0
0.0-1& -2	16.8±0.8	7.6±0.1	9.2±0.8	00±0	0.23±0.06	3±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-2.

Test series SL-2 Effluent type EC1 Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
15.0-1	16.7±0.6[a]	7.6±0.0	9.8±0.7	700±120	2.97±1.48	40±18	5	100.0
15.0-2	16.3±0.7	7.6±0.7	9.6±0.9	640±370	3.08±1.31	40±6	5	100.0
8.4-1	16.4±0.6	7.6±0.1	9.5±0.7	340±130	1.63±0.74	19±3	5	100.0
8.4-2	16.3±0.7	7.6±0.1	9.61±0.8	350±120	221±0.13	33±12	5	100.0
4.8-1	16.4±0.7	7.6±0.2	9.5±0.8	230±90	1.45±0.08	20±8	5	100.0
4.8-2	16.2±0.7	7.6±0.1	9.1±0.7	150±50	0.94±0.06	18±8	13	100.0
2.7-1	16.2±0.7	7.6±0.1	9.3±0.7	130±30	0.55±0.22	7±3	13	100.0
2.7-2	16.1±0.6	7.6±0.1	9.3±0.6	120±38	0.40±0.22	7±3	17	60.0
1.5-1	16.0±0.7	7.6±0.1	9.3±0.6	70±21	0.44±0.17	6±3	17	50.0
1.5-2	16.0±0.7	7.6±0.1	9.3±0.7	80±25	0.35±0.14	5±2	17	0.0
0.0-1&-2	16.1±0.7	7.6±0.1	9.4±0.9	00±1	<0.10±0.00	00±0	34	15.0

[a]Mean ± SD.

APPENDIX - B-2. Test series SL-3 Effluent type UnCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	19.0±0.8[a]	7.7±0.1	7.5±0.6	00±0	19.29±3.89	484±133	17	0.0
100.0-2	19.1±0.7	7.6±0.1	7.0±0.7	00±0	18.31±3.54	372±109	17	0.0
56.0-1	18.4±0.8	7.8±0.1	8.3±0.5	00±0	10.73±1.37	288±92	17	0.0
56.0-2	18.5±0.7	7.6±0.1	8.1±0.4	00±0	9.92±1.33	160±46	17	0.0
32.0-1	18.0±0.8	7.7±0.1	8.4±0.3	00±0	5.98±1.36	121±45	17	0.0
32.0-2	18.1±0.7	7.6±0.1	8.3±0.4	00±0	6.27±0.98	95±25	17	0.0
18.0-1	17.9±0.7	7.6±0.1	8.4±0.4	00±0	3.57±0.38	62±27	17	0.0
18.0-2	17.9±0.6	7.5±0.1	8.4±0.5	00±0	3.77±0.57	52±15	17	0.0
10.0-1	17.7±0.7	7.5±0.1	8.61±0.4	00±0	1.97±0.37	27±9	17	0.0
10.0-2	17.7±0.7	7.5±0.1	8.4±0.4	00±0	1.88±0.26	23±6	17	0.0
0.0-1&-2	17.1±0.5	7.4±0.1	8.8±0.2	00±0	0.42±0.13	5±3	34	0.0

[a]Mean ± SD.

APPENDIX - B-2

Test series SL-4 Effluent type EC1 Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
10.0-1	16.6±0.4[a]	7.5±0.1	9.7±0.3	510±232	2.50±0.70	29±0	5	100.0
10.0-2	16.6±0.4	7.5±0.1	9.7±0.3	530±191	2.53±0.60	30±1	5	100.0
5.6-1	17.1±0.6	7.5±0.1	9.3±0.4	250±104	1.34±0.22	18±5	17	93.3
5.6-2	17.0±0.6	7.5±0.1	9.4±0.5	250±104	1.19±0.21	16±4	17	93.3
3.2-1	17.2±0.6	7.4±0.1	9.1±0.4	120±48	0.97±0.28	11±5	17	33.3
3.2-2	17.1±0.7	7.5±0.1	9.2±0.4	160±57	0.93±0.20	12±4	17	40.0
1.8-1	17.2±0.7	7.4±0.1	9.1±0.5	100±24	0.60±0.07	7±2	17	0.0
1.8-2	17.4±0.7	7.4±0.1	9.2±0.4	100±37	0.53±0.05	6±2	17	0.0
1.0-1	17.0±0.6	7.4±0.1	9.2±0.5	60±30	0.36±0.03	4±1	17	0.0
1.0-2	17.4±0.5	7.4±0.1	9.2±0.5	60±29	0.51±0.12	6±1	17	0.0
0.0-1&-2	16.8±0.6	7.4±0.2	9.2±9.5	00±1	0.23±0.12	3±1	34	0.0

[a] Mean ± SD.

APPENDIX B-3 EFFLUENT TOXICITY AND QUALITY DATA FOR SAN PABLO WTP

APPENDIX - B-3.

Test series SP-1 Effluent type UnCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	18.1±0.8[a]	7.4±0.0	7.1±0.8	00±0	<0.10±0.00	<1±0	16	0.0
100.0-2	17.9±0.8	7.3±0.1	7.3±0.9	00±0	<0.10±0.00	<1±0	16	0.0
56.0-1	17.7±0.7	7.4±0.1	7.5±0.9	00±0	<0.10±0.00	<1±0	16	0.0
56.0-2	17.4±0.8	7.4±0.1	7.3±0.9	00±0	<0.10±0.00	<1±0	16	0.0
32.0-1	17.4±0.8	7.4±0.1	7.6±0.9	00±0	<0.10±0.00	<1±0	16	0.0
32.0-2	17.5±0.8	7.4±0.1	7.6±0.8	00±0	<0.10±0.00	<1±0	16	0.0
18.0-1	17.4±0.8	7.4±.01	7.6±0.8	00±0	<0.10±0.00	<1±0	16	0.0
18.0-2	17.4±0.7	7.4±0.1	7.8±0.9	00±0	<0.10±0.00	<1±0	16	0.0
10.0-1	17.2±0.8	7.4±0.1	7.8±0.8	00±0	<0.10±0.00	<1±0	16	0.0
10.0-2	17.2±0.9	7.4±0.1	7.9±0.9	00±0	<0.10±0.00	<1±0	16	0.0
0.0-1&-2	17.1±0.8	7.5±0.2	7.9±0.8	00±0	<0.10±0.00	<1±0	32	0.0

[a]Mean ± SD.

APPENDIX - B-3.

Test series SP-2 Effluent type EC1 Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
50.0-1	17.4±0.8[a]	7.4±0.1	7.9±0.7	460±121	<0.10±0.00	<1±0	16	26.7
50.0-2	17.4±0.9	7.4±0.1	7.7±1.1	520±114	<0.10±0.00	<1±0	16	26.7
28.0-1	17.2±0.7	7.4±0.1	7.7±0.9	180±72	<0.10±0.00	<1±0	16	0.0
28.0-2	17.1±0.6	7.4±0.1	7.9±0.8	280±63	<0.10±0.00	<1±0	16	0.0
16.0-1	17.1±0.7	7.5±0.1	7.9±0.7	130±35	<0.10±0.00	<1±0	16	0.0
16.0-2	17.1±0.8	7.5±0.1	8.1±0.6	170±45	<0.10±0.00	<1±0	16	0.0
9.0-1	17.1±0.7	7.5±0.1	8.1±0.9	100±26	<0.10±0.00	<1±0	16	0.0
9.0-2	17.2±0.8	7.5±0.1	8.2±0.8	60±13	<0.10±0.00	<1±0	16	0.0
5.0-1	16.1±0.8	7.5±0.1	7.8±0.6	50±11	<0.10±0.00	<1±0	16	0.0
5.0-2	16.0±0.9	7.4±0.1	8.6±0.4	90±7	<0.10±0.00	<1±0	16	0.0
0.0-1&-2	16.9±0.8	7.4±0.1	7.8±0.8	00±0	<0.10±0.00	<1±0	32	0.0

[a]Mean ± SD.

APPENDIX - B-3.

Test series SP-3 Effluent type DOHCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
62.0-1	17.2±0.5[a]	7.2±0.1	6.9±0.4	690±234	<0.10±0.00	<1±0	5	100.0
62.0-2	17.5±0.4	7.4±0.2	7.6±0.6	970±562	<0.10±0.00	<1±0	5	100.0
34.7-1	17.3±0.9	7.4±0.1	8.0±0.7	270±40	<0.10±0.00	<1±0	16	0.0
34.7-2	17.1±0.8	7.4±0.1	8.1±0.6	310±52	<0.10±0.00	<1±0	16	0.0
19.8-1	17.1±0.8	7.4±0.1	8.2±0.4	170±36	<0.10±0.00	<1±0	16	0.0
19.8-2	17.1±0.9	7.5±0.1	8.3±0.6	190±42	<0.10±0.00	<1±0	16	0.0
11.2-1	17.1±0.8	7.4±0.1	7.9±0.8	130±24	<0.10±0.00	<1±0	16	0.0
11.2-2	17.2±0.6	7.5±0.1	8.0±0.5	100±66	<0.10±0.00	<1±0	16	0.0
6.2-1	17.2±0.8	7.5±0.1	8.5±0.6	240±145	<0.10±0.00	<1±0	16	0.0
6.2-2	17.3±0.7	7.5±0.1	8.4±0.5	200±148	<0.10±0.00	<1±0	16	0.0
0.0-1&-2	16.9±0.6	7.5±0.1	8.2±0.3	10+10	<0.10±0.00	<1±0	32	0.0

[a]Mean ± SD.

APPENDIX - B-3.

Test series SP-4 Effluent type UnCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	17.6±0.7[a]	7.4±0.1	7.8±0.5	00±0	<0.10±0.00	<1±0	17	0.0
100.0-2	17.9±0.8	7.3±0.1	7.6±0.4	00±0	<0.10±0.00	<1±0	17	0.0
56.0-1	17.2±0.6	7.5±0.1	8.2±0.7	00±0	<0.10±0.00	<1±0	17	0.0
56.0-2	17.4±0.4	7.4±0.1	8.1±0.7	00±0	<0.10±0.00	<1±0	17	0.0
32.0-1	17.2±0.4	7.5±0.1	8.3±0.4	00±0	<0.10±0.00	<1±0	17	0.0
32.0-2	17.0±0.5	7.5±0.1	8.6±0.5	00±0	<0.10±0.00	<1±0	17	0.0
18.0-1	17.1±0.5	7.5±0.1	8.6±0.3	00±0	<0.10±0.00	<1±0	17	0.0
18.0-2	17.2±0.4	7.5±0.1	8.7±0.5	00±0	<0.10±0.00	<1±0	17	0.0
10.0-1	16.8±0.5	7.5±0.1	8.7±0.6	00±0	<0.10±0.00	<1±0	17	0.0
10.0-2	16.7±0.6	7.5±0.1	8.9±0.9	00±0	<0.10±0.00	<1±0	17	0.0
0.0-1&-2	16.5±0.5	7.5±0.1	9.1±0.7	1±2	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-3. Test series SP-5 Effluent type EC1 Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	NH_4^+ + NH_3 (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
62.5-1	17.5±0.3[a]	7.5±0.1	8.8±0.5	700±256	<0.10±0.00	<1±0	9	100.0
62.5-2	17.3±0.4	7.5±0.1	8.7±0.4	700±277	<0.10±0.00	<1±0	9	100.0
35.0-1	16.9±0.4	7.6±0.1	9.0±0.3	450±120	<0.10±0.00	<1±0	17	27.0
35.0-2	16.8±0.4	7.6±0.1	8.8±0.2	390±120	<0.10±0.00	<1±0	17	0.0
20.0-1	16.8±0.4	7.6±0.1	8.7±0.3	200±52	<0.10±0.00	<1±0	17	0.0
20.0-2	16.7±0.5	7.6±0.1	8.8±0.4	260±74	<0.10±0.00	<1±0	17	0.0
11.2-1	16.7±0.5	7.6±0.1	8.7±0.3	130±35	<0.10±0.00	<1±0	17	0.0
11.2-2	16.6±0.6	7.6±0.1	8.7±0.4	130±37	<0.10±0.00	<1±0	17	0.0
6.21-1	16.7±0.5	7.6±0.1	8.9±0.2	110±32	<0.10±0.00	<1±0	17	0.0
6.21-2	16.5±0.4	7.7±0.1	8.8±0.4	70±27	<0.10±0.00	<1±0	17	0.0
0.0-1&-2	16.7±0.5	7.7±0.2	9.0±0.5	10±10	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-3.

Test series SP-6 Effluent type DeCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	NH_4^+ + NH_3 (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	17.7±0.6[a]	7.4±0.1	8.5±0.5	00±0	<0.10±0.00	<1±0	17	0.0
100.0-2	17.6±0.5	7.4±0.1	8.4±0.4	00±0	<0.10±0.00	<1±0	17	0.0
56.0-1	17.4±0.3	7.5±0.1	8.6±0.4	00±0	<0.10±0.00	<1±0	17	0.0
56.0-2	17.4±0.6	7.5±0.1	8.8±0.5	00±0	<0.10±0.00	<1±0	17	0.0
32.0-1	17.0±0.8	7.7±0.1	8.8±0.4	00±0	<0.10±0.00	<1±0	17	0.0
32.0-2	17.0±0.6	7.6±0.1	8.9±0.6	00±0	<0.10±0.00	<1±0	17	0.0
18.0-1	17.1±0.8	7.6±0.1	8.8±0.8	00±0	<0.10±0.00	<1±0	17	0.0
18.0-2	17.0±0.9	7.5±0.1	8.9±0.5	00±0	<0.10±0.00	<1±0	17	0.0
10.0-1	17.0±0.6	7.5+0.1	8.8±0.4	00±0	<0.10±0.00	<1±0	17	0.0
10.0-2	17.0±0.6	7.6±0.1	9.0±0.5	00±0	<0.10±0.00	<1±0	17	0.0
0.0-1&-2	16.8±0.6	7.8±0.1	8.8±0.5	00±0	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-3. Test series SP-7 Effluent type UnCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	17.8±0.6[a]	7.5±0.1	7.6±0.5	00±0	<0.10±0.00	<1±0	17	0.0
100.0-2	18.2±0.5	7.4±0.1	7.8±0.3	00±0	<0.10±0.00	<1±0	17	0.0
56.0-1	17.5±0.4	7.6±0.1	8.3±0.4	00±0	<0.10±0.00	<1±0	17	0.0
56.0-2	17.8±0.4	7.5±0.1	8.4±0.4	00±0	<0.10±0.00	<1±0	17	0.0
32.0-1	17.6±0.4	7.6±0.1	8.6±0.3	00±0	<0.10±0.00	<1±0	17	0.0
32.0-2	17.2±0.3	7.6±0.1	8.6±0.3	00±0	<0.10±0.00	<1±0	17	0.0
18.0-1	17.5±0.4	7.6±0.1	8.7±0.3	00±0	<0.10±0.00	<1±0	17	0.0
18.0-2	17.1±0.3	7.6±0.1	8.7±0.4	00±0	<0.10±0.00	<1±0	17	0.0
10.0-1	17.4±0.5	7.6±0.1	8.9±0.3	00±0	<0.10±0.00	<1±0	17	0.0
10.0-2	17.1±0.3	7.6±0.1	8.9±0.4	00±0	<0.10±0.00	<1±0	17	0.0
0.0-1&-2	17.1±0.4	7.6±0.1	8.8±0.4	00±0	<0.10±0.00	<1±0	17	0.0

[a]Mean ± SD.

APPENDIX - B-3.

Test series SP-8 Effluent type EC1 Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	18.2±0.3[a]	7.3±0.1	8.6±0.3	1610±205	<0.10±0.00	<1±0	5	100.0
100.0-2	18.5±0.6	7.2±0.1	8.5±0.6	1660±328	<0.10±0.00	<1±0	5	100.0
56.0-1	17.8±0.6	7.5±0.1	8.8±0.3	820±175	<0.10±0.00	<1±0	13	100.0
56.0-2	17.6±0.8	7.4±0.1	8.8±0.4	1000±195	<0.10±0.00	<1±0	5	100.0
32.0-1	17.7±0.5	7.5±0.1	8.7±0.6	460±77	<0.10±0.00	<1±0	17	27.0
32.0-2	17.7±0.5	7.5±0.1	8.9±0.5	510±82	<0.10±0.00	<1±0	17	87.0
18.0-1	17.5±0.4	7.6±0.1	8.8±0.3	280±41	<0.10±0.00	<1±0	17	0.0
18.0-2	17.5±0.6	7.6±0.1	8.7±0.2	250±43	<0.10±0.00	<1±0	17	0.6
10.0-1	17.5±0.5	7.6±0.1	8.5±0.5	190±42	<0.10±0.00	<1±0	17	0.0
10.0-2	17.4±0.6	7.6±0.1	8.8±0.6	280±103	<0.10±0.00	<1±0	17	6.6
0.0-1&-2	17.2±0.8	7.6±0.1	8.9±0.4	20±5	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-3.

Test series SP-9 Effluent type DOHCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	17.6±0.6[a]	7.3±0.2	8.5±0.4	1560±445	<0.01±0.00	<1±0	5	100.0
100.0-2	17.5±0.4	7.2±0.2	8.3±0.2	1620±651	<0.10±0.00	<1±0	5	100.0
56.0-1	16.9±0.5	7.5±0.1	8.8±0.2	540±158	<0.10±0.00	<1±0	17	13.0
56.0-2	16.8±0.7	7.5±0.1	9.0±0.3	600±141	<0.10±0.00	<1±0	17	60.0
32.0-1	16.7±0.5	7.6±0.1	9.1±0.2	370±60	<0.10±0.00	<1±0	17	6.0
32.0-2	16.6±0.6	7.6±0.1	9.0±0.3	400±126	<0.10±0.00	<1±0	17	0.0
18.0-1	16.5±0.8	7.6±0.1	9.0±0.3	230±31	<0.10±0.00	<1±0	17	0.0
18.0-2	16.4±0.7	7.7±0.1	8.9±0.4	230±39	<0.10±0.00	<1±0	17	0.0
10.0-1	16.5±0.8	7.7±0.1	9.2±0.3	150±24	<0.10±0.00	<1±0	17	0.0
10.0-2	16.5±0.9	7.6±0.1	8.9±0.3	120±23	<0.10±0.00	<1±0	17	0.0
0.0-1&-2	16.6±0.9	7.5±0.1	8.8±0.4	20±5	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX B-4 EFFLUENT TOXICITY AND QUALITY DATA FOR PINOLE WTP

APPENDIX - B-4.

Test series P-1 Effluent type UnCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	20.5±1.2[a]	7.3±0.3	7.6±0.6	00±0	13.24±6.73	137±91	17	16.0
100.0-2	20.2±1.3	7.2±0.3	7.7±0.6	00±0	13.51±6.56	128±86	17	7.0
56.0-1	19.3±0.8	7.6±0.2	8.8±0.3	00±0	6.50±3.99	106±69	17	16.0
56.0-2	19.5±1.0	7.6±0.1	8.6±0.3	00±0	4.37±4.92	59±61	17	7.0
32.0-1	19.5±1.0	7.6±0.1	8.6±0.3	00±0	4.45±2.89	77±45	17	9.0
32.0-2	18.7±0.7	7.7±0.1	8.7±0.3	00±0	3.79±1.52	74±32	17	14.0
18.0-1	19.3±0.8	7.6±0.1	8.6±0.3	00±0	2.37±0.95	45±16	17	0.0
18.0-2	19.1±0.8	7.7±0.1	8.6±2.4	00±0	2.44±0.75	49±12	17	7.0
10.0-1	19.4±0.9	7.6±0.2	8.6±0.4	00±5	2.47±1.34	56±35	17	0.0
10.0-2	19.1±1.0	7.6±0.1	8.7±0.4	00±5	1.63±0.86	33±18	17	7.0
0.0-1&-2	19.1±0.6	7.7±0.1	9.0±0.2	20±5	<0.10±0.00	<1±0	34	13.5

[a]Mean ± SD.

APPENDIX - B-4. Test series P-2 Effluent type EC1 Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
15.4-1	18.8±0.8[a]	7.5±0.1	9.0±0.7	650±272	0.72±0.32	11±4	5	100.0
15.4-2	19.0±0.4	7.5±0.1	9.0±0.5	700±309	0.77±0.31	11±3	5	NA
8.6-1	19.0±0.8	7.7±0.1	8.9±0.5	260±137	0.52±0.17	11±2	5	100.0
8.6-2	19.3±0.7	7.6±0.1	9.1±0.5	300±152	0.48±0.16	10±0	5	NA
4.9-1	19.1±0.6	7.7±0.1	8.9±0.3	130±93	0.81±0.31	17±7	17	NA
4.9-2	19.1±0.6	7.7±0.1	9.0±0.3	160±97	0.73±0.38	18±11	17	85.0
2.8-1	19.3±0.6	7.7±0.1	8.9±0.3	70±48	0.44±0.20	10±5	17	NA
2.8-2	19.1±0.5	7.7±0.1	8.9±0.3	70±44	0.42±0.22	10±4	17	100.0
1.5-1	19.3±0.6	7.7±0.1	9.0±0.3	50±32	0.28±0.12	7±3	17	NA
1.5-2	19.0±0.6	7.7±0.1	9.0±0.3	50±34	0.31±0.14	7±4	17	65.0
0.0-1&-2	19.5±0.6	7.7±0.1	9.0±0.3	20±10	<0.01±0.00	<1±0	34	80.0

[a]Mean ± SD.

APPENDIX - B-4. Test series P-3 Effluent type DOHCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
33.3-1	18.0±0.7[a]	7.4±0.2	9.0±0.6	730±60	2.44±1.50	23±22	5	100.0
33.3-2	17.8±0.5	7.4±0.1	8.9±0.5	750±118	2.24±1.57	20±18	5	100.0
18.5-1	18.2±0.7	7.5±0.1	8.9±0.6	350±25	1.39±0.58	18±11	5	100.0
18.5-2	17.4±0.6	7.5±0.2	9.1±0.6	260±54	1.36±0.63	19±13	5	100.0
9.6-1	18.4±0.5	7.6±0.1	8.9±0.4	190±21	1.19±0.50	20±10	9	100.0
9.6-2	17.9±0.6	7.6±0.1	8.8±0.6	190±37	1.23±0.51	23±11	9	100.0
6.0-1	18.3±0.6	7.6±0.1	9.0±0.4	90±37	1.17±0.34	21±7	17	40.0
6.0-2	18.1±0.5	7.6±0.1	9.1±0.4	110±31	1.02±0.42	18±8	17	33.0
3.3-1	18.2±0.4	7.6±0.1	9.0±0.3	50±11	0.56±0.18	10±4	17	14.0
3.3-2	18.3±0.5	7.6±0.1	9.0±0.3	60±14	0.47±0.12	8±4	17	14.0
0.0-1&-2	18.5±0.6	7.6±0.1	9.0±0.4	30±10	<0.10±0.00	<1±0	34	10.0

[a]Mean ± SD.

APPENDIX - B-4.

Test series P-4 Effluent type UnCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	19.8±0.5[a]	7.4±0.1	7.9±0.4	00±0	15.06±2.66	190±55	17	0.0
100.0-2	19.3±0.4	7.5±0.1	8.1±0.3	00±0	14.76±13.00	197±66	17	0.0
56.0-1	18.2±0.5	7.6±0.1	8.9±0.3	00±0	7.45±1.84	120±27	17	0.0
56.0-2	18.7±0.3	7.4±0.1	8.6±0.2	00±0	7.33±1.06	89±15	17	13.0
32.0-1	18.7±0.4	7.5±0.1	8.9±0.3	00±0	4.28±0.79	69±18	17	0.0
32.0-2	18.2±0.3	7.6±0.1	9.0±0.3	00±0	3.65±0.88	59±12	17	0.0
18.0-1	18.9±0.7	7.6±0.1	9.2±0.2	00±0	1.58±1.12	30±19	17	0.0
18.0-2	18.0±0.4	7.6±0.1	9.2±0.2	00±0	2.17±0.77	36±12	17	0.0
10.0-1	18.2±0.5	7.6±0.1	9.2±0.3	10±5	1.26±0.52	20±7	17	0.0
10.0-2	17.7±0.4	7.6±0.1	9.2±0.2	10±5	1.10±0.38	18±6	17	0.0
0.0-1&-2	17.9±0.3	7.6±0.1	9.3±0.3	30±4	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-4. Test series P-5 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
15.4-1	18.7±0.4[a]	7.4±0.1	9.1±0.3	310±278	2.24±0.75	25±7	5	100.0
15.4-2	18.6±0.5	7.4±0.1	9.2±0.1	290±256	2.23±0.69	23±7	5	100.0
8.6-1	18.9±0.7	7.6±0.1	9.1±0.1	160±136	1.23±0.44	18±5	5	100.0
8.6-2	18.3±0.3	7.6±0.1	9.2±0.2	180±99	1.30±0.37	20±5	17	93.0
4.9-1	18.3±0.4	7.6±0.1	9.2±0.2	70±39	0.72±0.26	13±5	17	20.0
4.9-2	18.3±0.6	7.6±0.1	9.2±0.2	110±58	0.75±0.24	12±4	17	13.0
2.8-1	18.4±0.4	7.7±0.1	9.2±0.2	50±25	0.34±0.10	6±2	17	0.0
2.8-2	18.2±0.3	7.6±0.1	9.2±0.2	60±35	0.38±0.14	6±2	17	0.0
1.5-1	18.4±0.4	7.6±0.1	9.1±0.1	30±12	0.23±0.05	4±1	17	0.0
1.5-2	18.4±0.4	7.6±0.1	9.2±0.2	40±16	0.22±0.05	4±1	17	13.0
0.0-1&-2	18.5±0.5	7.6±0.1	9.2±0.2	30±3	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-4. Test series P-6 Effluent type DeCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	17.9±0.7[a]	7.2±0.1	8.7±0.3	00±0	15.36±3.66	75±18	17	0.0
100.0-2	19.2±0.5	6.8±0.1	8.0±0.3	10±22	15.84±3.99	45±11	17	40.0
56.0-1	18.8±0.5	7.0±0.1	8.4±0.3	00±15	6.97±2.77	28±8	17	0.0
56.0-2	17.9±0.5	7.2±0.1	8.3±0.2	00±0	7.64±2.35	47±16	17	0.0
32.0-1	17.4±0.6	7.4±0.1	9.0±0.4	00±5	4.25±1.26	46±12	17	0.0
32.0-2	18.1±0.5	7.2±0.1	9.0±0.2	10±22	4.46±1.85	30±11	17	0.0
18.0-1	18.5±0.4	7.3±0.1	9.0±0.2	10±24	3.21±1.30	26±9	17	0.0
18.0-2	17.2±0.5	7.5±0.1	9.2±0.2	10±31	2.96±1.40	37±16	17	0.0
10.0-1	18.5±0.6	7.4±0.1	8.9±0.5	10±11	1.64±0.99	18±13	13	0.0
10.0-2								
0.0-1&-2	18.0±0.4	7.5±0.2	9.3±0.2	30±4	<0.10±0.00	<1±0	34	10.0

[a]Mean ± SD.

APPENDIX - B-4. Test series P-7 Effluent type UnCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	19.3±0.4[a]	7.3±0.1	7.9±0.2	00±0	13.31±3.36	118±50	17	0.0
100.0-2	19.6±0.4	7.2±0.1	7.9±0.3	00±0	13.80±2.84	112±36	17	0.0
56.0-1	18.8±0.3	7.4±0.1	8.6±0.1	00±0	7.26±1.57	83±20	17	0.0
56.0-2	18.2±0.3	7.4±0.1	8.5±0.2	00±0	6.94±1.96	65±18	17	0.0
32.0-1	18.7±0.3	7.5±0.1	8.8±0.2	00±0	4.74±1.88	60±23	17	0.0
32.0-2	18.2±0.2	7.5±0.1	8.9±0.1	00±0	4.37±1.58	55±16	17	0.0
18.0-1	18.6±0.5	7.5±0.1	8.9±0.1	10±5	2.81±0.94	36±10	17	0.0
18.0-2	17.7±0.3	7.5±0.1	8.9±0.1	10±5	2.75±0.66	31±9	17	0.0
10.0-1	18.1±0.4	7.6±0.1	9.0±0.1	20±6	1.37±0.29	21±4	17	0.0
10.0-2	18.0±0.3	7.6±0.1	9.1±0.1	10±5	1.20±0.30	19±1	17	0.0
0.0-1&-2	17.9±0.3	7.5±0.1	9.2±0.1	40±5	<0.10±0.00	<1±0	34	0.0

[a] Mean ± SD.

APPENDIX - B-4. Test series P-8 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
15.4-1	18.4±0.4[a]	7.5±0.1	9.1±0.5	770±517	2.11±0.52	32±16	5	100.0
15.4-2	18.3±0.4	7.5±0.1	9.3±0.3	840±571	2.03±1.42	30±16	5	100.0
8.6-1	18.6±0.2	7.5±0.1	9.4±0.2	300±202	0.54±0.00	11±0	5	100.0
86.-2	18.2±0.5	7.5±0.1	9.2±0.2	350±248	0.40±0.07	8±2	9	100.0
4.9-1	18.2±0.4	7.6±0.1	9.1±0.1	150±88	0.64±0.17	12±4	17	66.7
4.9-2	18.0±0.4	7.6±0.1	9.1±0.1	180±105	0.49±0.14	9±2	17	73.3
2.8-1	18.1±0.2	7.5±0.1	9.2±0.1	120±71	0.35±0.12	6±1	17	0.0
2.8-2	18.1±0.4	7.6±0.1	9.0±0.2	100±60	0.30±0.13	6±1	17	0.0
1.5-1	18.3±0.3	7.6±0.1	9.0±0.1	60±33	0.22±0.09	4±1	17	0.0
1.5-2	18.2±0.4	7.6±0.1	9.0±0.1	70±39	0.20±0.11	4±1	17	0.0
0.0-1&-2	18.2±0.3	7.6±0.1	9.1±0.1	40±7	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-4. Test series P-9 Effluent type DOHCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
43.6-1	17.7±1.0[a]	7.5±0.1	9.2±0.2	530±64	4.45±0.00	69±17	5	100.0
43.6-2	17.6±0.5	7.3±0.1	9.1±0.2	700±87	5.04±0.57	41±12	5	100.0
24.4-1	18.2±0.9	7.5±0.1	9.2±0.1	270±76	1.96±0.72	26±14	9	100.0
24.4-2	17.8±0.7	7.6±0.1	9.2±0.2	210±96	1.58±0.62	25±8	17	86.7
13.9-1	17.2±0.7	7.6±0.1	9.3±0.1	160±51	1.35±0.24	23±5	17	93.3
13.9-2	17.6±0.3	7.5±0.1	9.3±0.2	230±24	1.21±0.32	14±3	9	100.0
7.8-1	17.8±0.8	7.6±0.1	9.2±0.2	110±12	0.78±0.26	13±3	17	0.0
7.8-2	17.9±0.6	7.5±0.1	9.3±0.3	120±14	0.88±0.32	26±0	17	6.6
4.4-1	17.7±0.8	7.6±0.1	9.2±0.1	70±10	0.43±0.34	6±5	17	0.0
4.4-2	17.7±0.3	7.6±0.1	9.2±0.1	80±12	0.43±0.16	6±3	17	0.0
0.0-1&-2	17.9±0.5	7.6±0.1	9.2±0.1	40±6	<0.10±010	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-4. Test series P-10 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
18.0-1	18.0±0.4[a]	7.5±0.1	9.0±0.2	590±159	3.23±0.66	40±8	4	100.0
18.0-2	18.7±0.5	7.4±0.1	8.8±0.2	760±215	3.07±0.60	38±6	4	100.0
10.1-1	19.4±1.0	7.5±0.1	8.7±0.2	360±102	1.89±0.53	25±6	4	100.0
10.1-2	18.0±0.4	7.5±0.1	8.7±0.3	360±79	1.99±0.66	27±6	4	100.0
5.8-1	18.5±0.8	7.6±0.2	9.0±0.3	190±68	1.00±0.39	17±8	17	20.0
5.8-2	17.8±0.4	7.6±0.2	8.9±0.3	170±50	1.16±0.60	17±9	17	20.0
3.2-1	18.7±1.0	7.6±0.2	8.9±0.3	130±51	0.63±0.23	12±6	17	0.0
3.2-2	17.7±0.4	7.6±0.2	8.9±0.3	90±28	0.75±0.15	17±0	17	0.0
1.8-1	18.9±0.8	7.7±0.2	8.9±0.3	90±31	0.40±0.26	7±3	17	0.0
1.8-2	17.5±0.5	7.7±0.2	9.0±0.2	60±18	0.53±0.37	8±3	17	0.0
0.0-1&-2	18.4±0.9	7.7±0.2	8.6±0.3	40±8	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-4.

Test series P-11 Effluent type EC1 Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	NH_4^+ + NH_3 (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
16.0-1	19.4±1.0[a]	7.4±0.1	8.7±0.1	550±217	2.25±1.06	28±8	4	100.0
16.0-2	19.2±0.9	7.4±0.1	8.7±0.1	570±239	2.25±0.99	29±6	4	100.0
9.0-1	19.6±0.7	7.5±0.1	8.7±0.1	220±83	1.45±0.71	21±3	5	100.0
9.0-2	19.8±0.9	7.4±0.1	8.6±0.1	330±126	.94±0.00	18±0	4	100.0
5.1-1	18.9±0.8	7.7±0.2	8.9±0.2	100±50	1.14±.04	25±10	17	6.7
5.1-2	18.5±0.9	7.7±0.2	9.0±0.3	120±64	1.09±0.43	17±6	17	46.7
2.9-1	19.0±0.9	7.7±0.2	8.9±0.3	80±33	0.76±0.29	13±4	17	0.0
2.9-2	18.8±0.9	7.7±0.2	8.8±0.3	70±29	0.44±0.26	8±4	17	0.0
1.6-1	18.9±0.8	7.6±0.2	8.8±0.3	60±20	0.31±0.16	6±4	17	0.0
1.6-2	18.6±0.8	7.6±0.2	8.9±0.3	50±17	0.42±0.26	7±4	17	0.0
0.0-1&-2	18.9±0.9	7.6±0.2	8.9±0.3	40±9	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX B-5 EFFLUENT TOXICITY AND QUALITY DATA FOR SOUTH SAN FRANCISCO WTP

APPENDIX - B-5. Test series SSF-1 Effluent type EC1 Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
18.0-1	17.9±0.3[a]	7.9±0.2	9.3±0.3	280±183	2.83±0.79	120±101	9	100.0
18.0-2	17.8±0.4	7.9±0.1	9.3±0.3	270±170	2.61±0.55	97±66	9	100.0
10.1-1	18.4±0.5	7.7±0.2	9.1±0.3	140±90	1.65±0.98	52±41	17	53.3
10.1-2	18.1±0.4	7.8±0.2	9.2±0.3	140±99	1.70±1.06	58±48	17	53.3
5.8-1	17.4±0.4	7.8±0.3	9.3±0.2	90±46	0.83±0.16	33±19	17	0.0
5.8-2	18.5±0.4	7.7±0.3	9.2±0.3	110±73	1.04±0.48	37±23	17	13.3
3.2-1	18.7±0.4	7.7±0.3	9.1±0.2	70±38	0.61±0.32	20±14	17	6.7
3.2-2	17.4±0.5	7.8±0.2	9.3±0.2	40±20	0.65±0.48	20±15	17	0.0
1.8-1	18.4±0.4	7.8±0.2	9.2±0.3	30±19	0.37±0.21	12±13	17	0.0
1.8-2	18.3±0.3	7.7±0.3	9.1±0.2	30±15	0.31±0.18	10±11	17	0.0
0.0-1&-2	18.5±0.2	7.7±0.2	9.1±0.1	10±4	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-5.

Test series SSF-2 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
16.0-1	18.9±0.4[a]	7.9±0.2	9.2±0.3	250±245	1.95±0.0	82±0	9	100.0
16.0-2	18.8±0.2	7.9±0.2	9.1±0.3	220±164	2.25±3.5	72±14	5	100.0
9.0-1	19.1±0.5	7.7±0.2	8.9±0.2	230±181	2.08±1.35	60±40	17	60.0
9.0-2	18.6±0.5	7.8±0.2	9.1±0.2	230±166	1.36±0.61	41±15	17	40.0
5.1-1	19.1±0.4	7.8±0.2	9.0±0.3	120±95	0.81±0.32	24±11	17	0.0
5.1-2	18.5±0.5	7.7±0.2	---	90±55	1.03±0.39	21±8	17	0.0
2.9-1	19.3±0.5	7.8±0.2	9.0±0.2	60±42	0.62±0.24	16±7	17	0.0
2.9-2	18.7±0.4	7.7±0.2	8.9±0.2	50±34	0.58±0.18	14±6	17	0.0
1.6-1	18.9±0.5	7.7±0.2	9.1±0.2	30±20	0.40±0.23	11±6	17	0.0
1.6-2	18.8±0.4	7.7±0.2	9.1±0.2	30±20	0.30±0.07	10±6	17	0.0
0.0-1&-2	19.0±0.5	7.7±0.2	9.0±0.2	10±5	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-5. Test series SSF-4 Effluent type UnCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	20.6±1.9[a]	7.6±0.1	7.4±0.8	00±0	23.19±5.52	510±189	17	40.0
100.0-2	19.3±1.0	7.8±0.2	7.9±0.7	00±0	21.73±5.40	722±240	17	40.0
56.0-1	19.9±0.5	7.7±0.1	8.2±0.4	00±0	11.55±4.08	245±123	17	13.3
56.0-2	19.3±0.6	7.7±0.2	8.3±0.3	00±0	10.48±3.55	258±130	17	0.0
32.0-1	19.7±0.4	7.7±0.2	8.4±0.3	00±0	7.47±2.06	173±90	17	0.0
32.0-2	18.8±0.4	7.8±0.1	8.7±0.2	00±0	5.53±1.87	187±81	17	0.0
18.0-1	19.2±0.3	7.9±0.2	8.8±0.2	00±0	3.22±1.03	133±44	17	0.0
18.0-2	18.7±0.7	---	8.8±0.2	00±0	3.00±0.73	---	17	0.0
10.0-1	18.8±0.4	7.9±0.2	9.0±0.2	00±0	2.08±0.22	71±33	17	0.0
10.0-2	19.2±0.4	7.8±0.2	8.9±0.2	00±0	1.77±0.29	49±13	17	0.0
0.0-1&-2	18.8±0.3	7.9±0.1	---	10±4	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-5.

Test series SSF-5 Effluent type EC1 Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
25.0-1	19.1±0.4[a]	7.8±0.1	9.9±0.2	210±176	3.39±1.02	109±39	13	100.0
25.0-2	18.2±0.4	7.9±0.1	9.1±0.2	160±108	2.71±1.07	89±38	13	100.0
14.0-1	18.9±0.4	7.9±0.1	9.0±0.3	80±67	2.54±1.09	91±57	17	20.0
14.0-2	19.2±0.3	7.8±0.1	8.9±0.2	90±77	2.03±0.59	58±18	17	26.7
8.0-1	19.2±0.3	7.9±0.1	9.0±0.2	40±31	1.12±0.31	38±12	17	0.0
8.0-2	18.4±0.8	7.9±0.2	9.0±0.3	50±47	1.19±0.41	31±5	17	6.7
4.5-1	19.2±0.3	7.9±0.1	8.8±0.4	30±29	0.71±0.22	23±4	17	0.0
4.5-2	18.9±0.3	7.9±0.1	8.8±0.2	30±21	0.57±0.21	18±3	17	0.0
2.5-1	19.2±0.3	7.9±0.2	9.0±0.3	20±14	0.61±0.26	22±11	17	0.0
2.5-2	19.0±0.6	7.9±0.1	9.0±0.2	20±24	0.63±0.28	21±10	17	0.0
0.0-1&-2	19.2±0.3	8.0±0.1	9.0±0.4	10±4	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-5. Test series SSF-6 Effluent type DOHCl Test organism FH

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
25.0-1	18.7±0.5[a]	7.8±0.1	9.1±0.5	680±382	3.35±0.31	98±13	5	100.0
25.0-2	18.1±0.4	7.9±0.1	9.2±0.2	550±235	3.26±0.54	110±32	5	100.0
14.0-1	19.0±0.4	7.9±0.1	9.1±0.1	330±167	2.33±0.41	85±13	17	100.0
14.0-2	18.3±0.4	8.0±0.1	9.2±0.4	290±135	2.14±0.49	100±32	17	100.0
8.0-1	18.1±0.5	7.9±0.1	9.2±0.2	150±49	1.60±0.61	59±29	17	93.3
8.0-2	18.9±0.2	7.9±0.1	9.1±0.2	130±138	1.42±0.47	54±18	17	100.0
4.5-1	19.2±0.4	7.9±0.1	9.0±0.2	110±55	0.75±0.18	24±8	17	46.7
4.5-2	17.8±0.5	7.9±0.1	9.1±0.2	80±32	0.99±0.51	36±25	17	26.7
2.5-1	---	7.9±0.1	---	70±27	0.55±0.24	---	17	0.0
2.5-2	18.6±0.2	7.9±0.1	9.1±0.2	50±28	0.51±0.20	21±9	17	6.7
0.0-1&-2	18.7±0.3	7.9±0.1	9.1±0.2	10±4	<0.10±0.00	<1±0	34	0.0

[a] Mean ± SD.

APPENDIX - B-5. Test series SSF-7 Effluent type UnCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	21.0±0.9[a]	7.6±0.1	6.5±0.7	00±0	29.87±10.02	731±73	9	80.0
100.0-2	20.4±1.2	7.6±0.2	7.6±0.5	00±0	28.50±2.02	960±310	9	80.0
56.0-1	19.8±0.4	7.7±0.2	8.1±0.5	00±0	11.26±6.82	246±156	17	0.0
56.0-2	18.5±0.6	7.7±0.2	8.1±0.5	00±0	12.50±4.32	305±106	17	0.0
32.0-1	19.3±0.4	7.8±0.2	8.1±0.5	00±0	11.3±2.03	288±88	17	0.0
32.0-2	18.8±0.4	7.8±0.1	8.4±0.1	00±0	7.91±6.27	172±130	9	100.0
18.0-1	19.4±0.4	7.8±0.2	8.4±0.3	00±0	7.34±1.49	189±67	17	0.0
18.0-2	18.2±0.3	7.8±0.2	8.7±0.2	00±0	6.76±1.69	165±99	17	6.7
10.0-1	19.1±0.5	7.8±0.1	8.6±0.3	00±0	2.97±1.62	99±94	17	6.7
10.0-2	---	7.8±0.2	8.7±0.3	00±0	3.83±2.02	111±0	17	6.7
0.0-1&-2	18.2±0.3	8.0±0.1	9.0±0.3	00±4	<0.10±0.00	<1±0	34	0.0

[a] Mean ± SD.

APPENDIX - B-5. Test series SSF-8 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
20.0-1	19.2±0.2[a]	7.9±0.1	8.6±0.2	1110±509	6.40±0.50	247±14	5	100.0
20.0-2	19.2±0.6	7.7±0.1	8.6±0.3	1210±666	6.68±0.77	174±55	5	100.0
11.2-1	19.4±0.7	7.8±0.1	8.6±0.2	600±370	3.55±1.49	112±65	5	100.0
11.2-2	19.0±0.3	7.9±0.1	8.8±0.2	580±274	3.37±0.68	131±24	5	100.0
6.4-1	19.3±0.6	7.9±0.1	8.8±0.3	220±174	1.94±0.42	67±22	17	93.3
6.4-2	18.5±0.5	7.9±0.1	8.9±0.3	180±182	1.96±0.47	61±28	17	80.0
3.6-1	18.8±0.4	7.9±0.1	8.8±0.3	90±72	1.42±0.27	49±19	17	0.0
3.6-2	19.1±0.5	7.8±0.1	8.7±0.3	120±85	1.31±0.20	38±12	17	20.0
2.0-1	19.0±0.4	7.9±0.1	8.8±0.3	80±60	1.00±0.17	34±12	17	6.7
2.0-2	19.0±0.4	7.8±0.1	8.8±0.3	90±62	0.97±0.18	30±10	17	0.0
0.0-1&-2	19.2±0.4	7.8±0.1	8.7±0.3	10±8	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-5.

Test series SSF-9 Effluent type DOHCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
29.0-1	17.5±0.3[a]	7.9±0.1	8.7±0.4	560±223	3.50±0.49	127±14	5	100.0
29.0-2	18.4±0.1	7.8±0.2	---	890±366	4.63±0.25	148±37	5	100.0
16.2-1	18.9±0.1	7.9±0.1	---	490±268	2.85±0.71	108±14	5	100.0
16.2-2	18.2±0.1	7.8±0.1	8.5±0.5	380±132	2.80±0.21	86±4	5	100.0
9.3-1	18.9±0.4	7.8±0.1	8.5±0.5	210±134	2.37±0.38	70±21	8	100.0
9.3-2	17.6±0.3	7.9±0.1	9.0±0.4	200±95	2.22±0.41	76±25	17	86.7
5.2-1	18.5±0.6	7.9±0.1	8.8±0.4	120±57	1.62±0.30	47±15	17	33.3
5.2-2	17.9±0.3	7.8±0.1	8.8±0.4	100±46	1.67±0.34	47±12	17	0.0
2.9-1	18.5±0.5	7.8±0.1	8.8±0.4	70±31	1.09±0.17	31±11	17	0.0
2.9-2	18.1±0.4	7.8±0.1	8.9±0.3	60±26	0.98±0.15	28±12	17	0.0
0.0-1&-2	18.4±0.4	7.8±0.1	8.8±0.4	10±6	<0.10±0.00	<1±0	34	3.3

[a]Mean ± SD.

APPENDIX B-6 EFFLUENT TOXICITY AND QUALITY DATA FOR SACRAMENTO NORTHEAST WTP

APPENDIX - B-6.

Test series SN-1 Effluent type UnCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	20.4±0.6[a]	7.7±0.1	7.4±0.6	00±0	19.53±4.14	462±115	17	26.7
100.0-2	18.6±0.8	7.8±0.2	8.1±0.7	00±0	14.49±5.46	366±131	17	40.0
56.0-1	19.1±0.5	7.7±0.1	7.8±0.3	00±0	6.75±0.92	153±56	17	6.7
56.0-2	18.5±0.5	7.8±0.1	8.3±0.2	00±0	5.93±1.43	143±53	17	0.0
32.0-1	19.0±0.5	7.7±0.1	8.0±0.3	00±0	5.66±1.32	125±39	17	0.0
32.0-2	17.9±0.5	7.8±0.1	8.5±0.3	00±0	5.63±1.00	141±21	17	0.0
18.0-1	17.6±0.4	7.8±0.1	8.7±0.2	00±0	2.60±1.10	64±29	17	0.0
18.0-2	18.3±0.4	7.8±0.1	8.4±0.2	00±0	2.96±1.08	64±21	17	0.0
10.0-1	18.1±0.4	7.8±0.1	8.8±0.3	00±0	2.57±1.61	51±24	17	0.0
10.0-2	17.8±0.5	7.8±0.1	8.6±0.4	00±0	3.74±3.31	51±40	17	6.7
0.0-1&-2	17.4±0.3	7.8±0.1	8.7±0.2	00±0	<0.10±0.00	<1±0	34	0.0

[a] Mean ± SD.

APPENDIX - B-6.

Test series SN-2 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	NH_4^+ + NH_3 (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
16.0-1	16.8±0.5[a]	7.8±0.1	9.0±0.2	920±118	3.73±0.04	66±2	5	100.0
16.0-2	17.2±0.3	7.7±0.1	8.7±0.1	1160±187	3.30±0.26	63±7	5	100.0
9.0-1	17.2±0.3	7.8±0.1	8.9±0.2	480±40	2.06±0.13	50±10	5	100.0
9.6-2	17.5±0.3	7.8±0.1	8.7±0.1	640±114	1.81±0.01	46±20	5	100.0
5.1-1	17.0±0.3	7.8±0.1	8.9±0.2	160±63	0.92±0.42	24±13	17	73.3
5.1-2	16.5±0.3	7.8±0.1	9.0±0.3	200±80	0.85±0.42	18±8	17	93.3
2.9-1	16.9±0.3	7.8±0.1	8.9±0.2	120±37	0.42±0.18	10±4	17	46.7
2.9-2	16.4±0.2	7.8±0.1	8.9±0.2	80±28	0.42±0.17	11±4	17	6.7
1.6-1	16.9±0.3	7.8±0.1	9.0±0.2	20±13	0.27±0.10	7±3	17	6.7
1.6-2	16.7±0.4	7.8±0.1	8.8±0.2	30±11	0.23±0.07	5±2	17	0.0
0.0-1&-2	17.0±0.3	7.8±0.1	8.8±0.2	00±0	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-6.

Test series SN-3 Effluent type DOHCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
25.0-1	18.0±0.4[a]	7.7±0.0	8.5±0.1	800±230	3.82±1.84	69±34	5	100.0
25.0-2	17.0±0.8	7.4±0.0	8.7±0.4	650±174	4.02±0.02	76±2	5	100.0
14.0-1	17.2±0.3	7.7±0.0	8.5±0.2	320±52	1.89±0.82	40±15	5	100.0
14.0-2	17.0±0.7	7.8±0.1	9.0±0.3	340±62	2.59±0.23	53±5	5	100.0
8.0-1	17.4±0.3	7.9±0.1	8.9±0.2	140±58	1.14±0.58	27±13	17	86.7
8.0-2	17.5±0.4	7.7±0.1	8.6±0.4	240±39	1.05±0.75	20±12	9	100.0
4.5-1	17.4±0.4	7.7±0.1	8.6±0.4	120±28	0.44±0.16	11±4	17	40.0
4.5-2	16.6±0.5	7.8±0.1	8.9±0.3	70±16	0.52±0.15	12±6	17	0.0
2.5-1	17.3±0.3	7.8±0.1	8.9±0.2	40±21	0.41±0.50	10±12	17	0.0
2.5-2	17.0±0.3	7.7±0.1	8.8±0.3	60±38	0.34±0.37	7±7	17	6.7
0.0-1&-2	17.0±0.4	7.8±0.1	8.7±0.3	00±3	<0.10±0.00	<1+0	34	0.0

[a]Mean ± SD.

APPENDIX - B-6.

Test series SN-4 Effluent type UnCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	19.0±0.6[a]	7.8±0.1	8.2±0.3	00±0	23.50±4.50	703±154	17	0.0
100.0-2	19.8±0.5	7.7±0.1	7.7±0.2	00±0	22.14±5.13	517±109	17	13.3
56.0-1	18.6±0.4	7.7±0.1	8.2±0.4	00±0	10.89±2.81	243±58	17	0.0
56.0-2	18.4±0.4	7.8±0.1	8.3±0.3	00±0	11.71±2.75	283±79	17	6.7
32.0-1	18.2±0.3	7.8±0.7	8.5±0.3	00±0	6.88±1.61	168±46	17	0.0
32.0-2	17.9±0.3	7.8±0.1	8.9±0.4	00±0	7.17±1.54	189±47	17	6.7
18.0-1	17.8±0.2	7.8±0.1	8.6±0.3	00±0	3.29±0.76	82±20	17	6.7
18.0-2	17.0±0.2	7.8±0.1	9.2±0.3	00±0	3.00±0.69	79±20	17	3.3
10.0-1	17.3±0.2	7.8±0.1	9.1±0.2	00±0	1.76±0.32	47±8	17	0.0
10.0-2	16.7±0.1	7.4±1.0	8.9±0.4	00±0	1.58±0.28	37±13	17	0.0
0.0-1&-2	20.0±0.2	7.8±0.1	9.0±0.3	00±0	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-6. Test series SN-5 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
16.0-1	17.0±0.1[a]	7.9±0.0	9.1±0.2	630±128	2.04±0.17	59±6	5	100.0
16.0-2	16.8±0.1	7.8±0.1	9.0±0.2	650±138	2.02±0.12	52±6	5	100.0
9.0-1	17.2±0.2	7.9±0.1	9.0±0.2	290±80	1.24±0.07	38±5	5	100.0
9.0-2	17.0±0.1	7.9±0.1	9.1±0.3	340±83	1.19±0.06	37±5	5	100.0
5.1-1	16.9±0.2	7.8±0.1	9.2±0.2	170±37	1.06±0.32	26±7	17	46.7
5.1-2	16.8±0.2	7.8±0.1	8.8±0.3	200±48	0.91±0.26	21±5	17	33.3
2.9-1	16.8±0.2	7.8±0.1	9.2±0.2	110±17	0.62±0.19	15±3	17	13.3
2.9-2	16.6±0.2	7.8±0.1	9.1±0.1	90±13	0.53±0.15	13±2	17	0.0
1.6-1	16.9±0.1	7.8±0.1	9.1±0.2	30±7	0.41±0.12	10±3	17	0.0
1.6-2	16.9±0.2	7.8±0.1	9.1±0.2	50±11	0.32±0.08	8±2	17	0.0
0.0-1&-2	16.9±0.2	7.8±0.1	8.9±0.2	00±0	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-6.

Test series SN-6 Effluent type DeCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	19.5±0.7[a]	7.0±0.2	7.5±0.3	00±0	23.58±2.23	127±51	17	6.7
100.0-2	17.8±0.3	7.2±0.1	8.3±0.3	00±0	23.49±1.78	169±43	17	0.0
56.0-1	18.2±0.5	7.3±0.1	8.5±0.2	00±0	12.89±1.20	125±36	17	0.0
56.0-2	17.7±0.4	7.4±0.1	8.7±0.4	00±0	13.34±1.20	138±40	17	6.7
32.0-1	17.7±0.5	7.4±0.1	8.6±0.3	00±0	7.86±0.48	93±24	17	6.7
32.0-2	17.7±0.5	7.4±0.1	8.4±0.4	00±0	7.58±1.00	86±25	17	0.0
18.0-1	17.5±0.3	7.6±0.1	8.9±0.4	00±0	4.61±0.28	74±16	17	6.7
18.0-2	17.0±0.2	7.6±0.1	8.9±0.5	00±0	5.73±0.43	84±17	17	0.0
10.0-1	17.3±0.3	7.7±0.1	8.9±0.4	00±0	2.26±0.21	43±7	17	0.0
10.0-2	17.1±0.2	7.7±0.1	8.8±0.5	00±0	1.92±0.18	37±6	17	0.0
0.0-1&-2	17.0±0.1	7.9±0.0	8.7±0.6	00±0	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-6. Test series SN-7 Effluent type UnCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	18.6±0.3[a]	7.9±0.1	8.4±0.2	00±0	23.54±2.05	847±155	17	20.0
100.0-2	20.0±0.5	7.7±0.1	7.5±0.2	00±0	23.48±2.49	596±130	17	13.3
56.0-1	18.9±0.3	7.8±0.0	8.0±0.2	00±0	13.14±1.70	328±53	17	6.7
56.0-2	18.1±0.3	7.8±0.0	8.5±0.2	00±0	13.29±1.41	399±67	17	0.0
32.0-1	18.1±0.2	7.8±0.1	8.4±0.2	00±0	8.88±0.89	234±31	17	6.7
32.0-2	18.0±0.2	7.8±0.1	8.4±0.3	00±0	8.76±0.96	226±32	17	0.0
18.0-1	17.8±0.3	7.8±0.1	8.6±0.2	00±0	4.45±0.54	119±24	17	0.0
18.0-2	17.1±0.1	7.9±0.1	9.0±0.2	00±0	4.08±0.44	127±24	17	0.0
10.0-1	17.5±0.3	7.9±0.1	9.0±0.1	00±0	2.01±0.32	67±15	17	0.0
10.0-2	17.4±0.2	7.9±0.1	9.0±0.2	00±0	1.88±0.50	60±24	17	0.0
0.0-1&-2	17.1±0.15	7.9±0.1	8.9±0.2	00±0	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-6. Test series SN-8 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
16.0-1	17.2±0.4[a]	7.8±0.0	8.2±0.1	1110±299	5.93±1.16	145±29	5	100.0
16.0-2	17.0±0.3	7.8±0.0	8.7±0.2	930±133	5.21±0.69	124±13	5	100.0
9.0-1	17.5±0.4	7.8±0.1	8.6±0.4	510±135	4.81±3.69	112±77	5	100.0
9.0-2	16.8±0.5	7.9±0.0	9.1±0.1	390±219	3.02±1.38	88±44	5	100.0
5.1-1	17.1±0.2	7.9±0.1	9.0±0.2	150±48	1.51±0.59	46±26	17	53.3
5.1-2	16.8±0.2	7.9±0.1	9.0±0.2	191±125	1.31±0.72	36±22	17	100.0
2.9-1	17.0±0.1	7.9±0.1	9.0±0.2	100±46	0.90±0.48	26±22	17	6.7
2.9-2	16.8±0.2	7.9±0.1	9.1±0.1	80±31	0.81±0.50	24±21	17	0.0
1.6-1	17.0±0.1	7.9±0.1	9.0±0.3	20±9	0.56±0.33	19±17	17	0.0
1.6-2	17.0±0.3	7.9±0.1	9.0±0.2	40±14	0.50±0.34	15±14	17	0.0
0.0-1&-2	17.1±0.2	7.9±0.1	8.8±0.2	00±0	<0.10±0.00	<1±0	34	0.0

[a] Mean ± SD.

APPENDIX - B-6. Test series SN-9 Effluent type DOHCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
33.3-1	17.2±0.2[a]	7.8±0.1	8.7±0.2	450±154	8.34±0.89	194±13	5	100.0
33.3-2	16.9±0.5	7.8±0.1	8.8±0.2	490±167	8.10±1.20	178±48	5	100.0
18.6-1	16.7±0.14	7.9±0.1	9.1±0.2	190±77	4.83±0.91	139±33	9	100.0
18.6-2	16.7±0.4	7.9±0.1	9.0±0.2	200±42	4.68±0.63	117±24	9	100.0
10.7-1	16.9±0.3	7.8±0.1	9.1±0.3	80±30	2.67±0.36	68±8	17	6.7
10.7-2	16.5±0.5	7.9±0.1	9.0±0.4	110±112	2.48±0.28	69±7	17	6.0
6.0-1	16.8±0.2	7.9±0.1	9.1±0.2	50±26	1.63_0.24	44±10	17	0.0
6.0-2	16.1±0.6	7.9±0.1	9.3±0.3	40±26	2.08±0.18	57±5	17	0.0
3.3-1	16.7±0.2	7.9±0.1	9.1±0.2	10±5	0.92±0.25	26±8	17	0.0
3.3-2	16.4±0.4	7.9±0.1	8.6±0.3	20±14	0.82±0.16	23±3	17	0.0
0.0-1&-2	16.4±0.2	7.9±0.1	9.1±0.2	00±0	<0.10±0.00	<1±0	34	3.3

[a]Mean ± SD.

APPENDIX B-7 EFFLUENT TOXICITY AND QUALITY DATA FOR ROSEVILLE WTP

APPENDIX - B-7.

Test series R-1 Effluent type UnCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	17.6±0.7[a]	7.5±0.1	8.1±0.4	00±0	18.00±0.00	195±25	17	0.0
100.0-2	17.3±0.9	7.6±0.1	8.7±0.2	00±0	18.10±0.50	200±20	17	0.0
56.0-1	16.9±0.8	7.6±0.1	8.7±0.2	00±0	5.60±2.90	109±21	17	0.0
56.0-2	17.0±0.8	7.4±0.1	8.4±0.2	00±0	7.35±3.10	89±25	17	0.0
32.0-1	16.9±0.7	7.5±0.1	8.9±0.2	00±0	4.65±2.60	55±19	17	0.0
32.0-2	16.7±0.7	7.5±0.1	9.1±0.2	00±0	4.95±2.50	57±12	17	0.0
18.0-1	16.7±0.7	7.5±0.1	9.0±0.2	00±0	2.90±1.70	25±15	17	0.0
18.0-2	16.7±0.7	7.5±0.1	9.0±0.2	00±0	2.90±1.65	20±13	17	0.0
10.0-1	16.7±0.6	7.5±0.1	8.9±0.4	00±0	1.70±0.75	8±3	17	0.0
10.0-2	16.7±0.7	7.4±0.1	8.9±0.5	00+0	1.65±0.50	9±2	17	0.0
0.0-1&-2	16.6±0.8	7.5±0.2	9.1±0.2	00±0	0.25±0.12	3±1	34	0.0

[a]Mean ± SD.

APPENDIX - B-7. Test series R-2 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
20.0-1	16.8±1.9[a]	7.5±0.2	---	720±195	---	---	5	100.0
20.0-2	16.6±1.7	7.5±0.1	---	930±215	---	---	5	100.0
11.2-1	16.6±0.8	7.5±0.1	9.2±0.2	290±55	1.90±0.10	25±5	13	100.0
11.2-2	16.7±1.3	7.5±0.1	9.1±0.3	450±58	---	---	5	100.0
6.4-1	16.5±0.9	7.5±0.1	9.3±0.2	170±93	1.15±0.15	14±2	17	85.8
6.4-2	16.3±1.0	7.5±0.2	9.3±0.3	140±40	1.18±0.05	16±2	17	13.3
3.6-1	16.4±0.8	7.5±0.1	9.2±0.2	90±30	0.68±0.00	8±0	17	0.0
3.6-2	16.2±1.0	7.5±0.1	9.3±0.2	70±35	0.80±0.10	9±2	17	0.0
2.0-1	16.4±0.7	7.5±0.1	9.2±0.2	60±14	0.55±0.00	6±1	17	0.0
2.0-2	16.3±0.9	7.5±0.1	9.3±0.2	50±9	0.46±0.02	5±1	17	0.0
0.0-1&-2	16.2±0.5	7.6±0.2	9.2±0.4	00±0	0.17±0.02	2±1	34	3.3

[a] Mean ± SD.

APPENDIX - B-7.

Test series R-3 Effluent type DOHCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
33.3-1	16.4±0.8[a]	---	8.9±0.3	340±111	---	---	5	100.0
33.3-2	16.2±0.7	7.5±0.1	9.1±0.3	360±193	4.30±0.00	52±0	9	100.0
18.6-1	16.5±0.7	7.5±0.1	9.1±0.2	250±75	2.21±0.12	25±5	17	93.3
18.6-2	16.2±0.7	7.5±0.1	9.1±0.2	230±87	2.0±0.13	20±7	17	93.3
10.6-1	16.3±0.6	7.5±0.1	9.2±0.3	170±26	1.63±0.00	18±0	17	53.3
10.6-2	16.2±0.7	7.5±0.1	9.2±0.2	150±53	1.62±0.00	17±0	17	6.7
6.0-1	16.2±0.6	7.5±0.1	9.2±0.2	100±32	1.00±0.00	11±0	17	0.0
6.0-2	16.1±0.6	7.5±0.1	9.2±0.3	80±23	1.10±0.00	11±0	17	0.0
3.3-1	16.2±0.6	7.5±0.1	9.2±0.2	70±16	0.72±0.10	8±2	17	0.0
3.3-2	16.1±0.6	---	9.2±0.3	60±15	0.63±0.05	---	17	0.0
0.0-1&-2	16.2±0.6	7.6±0.1	9.2±0.3	00±0	0.15±0.05	2±1	34	0.0

[a]Mean ± SD.

APPENDIX - B-7.

Test series R-4 Effluent type UnCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	17.8±0.9[a]	7.4±0.1	7.6±0.7	00±0	12.85±2.50	120±50	17	0.0
100.0-2	17.3±1.0	7.5±0.2	8.3±0.2	00±0	13.67±4.60	175±40	17	0.0
56.0-1	16.2±0.8	7.3±0.1	8.6±0.5	00±0	6.78±3.80	36±0	17	13.3
56.0-2	16.2±0.7	7.5±0.1	8.8±0.3	00±0	6.40±2.15	45±20	17	0.0
32.0-1	16.5±0.7	7.4±0.1	8.7±0.2	00±0	4.65±1.89	41±10	17	0.0
32.0-2	16.4±1.0	7.4±0.1	8.7±0.2	00±0	4.89±1.51	32±8	17	6.7
18.0-1	16.4±0.8	7.4±0.1	8.9±0.2	00±0	2.63±0.85	18±5	17	6.7
18.0-2	16.3±1.0	7.4±0.1	8.9±0.2	00±0	2.71±0.74	17±3	17	0.0
10.0-1	16.4±0.7	7.4±0.1	8.7±0.3	00±0	2.25±0.18	14±8	17	0.0
10.0-2	16.1±0.8	7.4±0.1	8.8±0.4	00±0	2.15±0.15	15±6	17	0.0
0.0-1&-2	16.0±1.0	7.3±0.1	9.0±0.2	00±0	0.25±0.15	3±1	34	0.0

[a]Mean ± SD.

APPENDIX - B-7. Test series R-5 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
20.0-1	15.4±0.8[a]	7.4±0.1	9.1±0.3	930±174	4.35±0.15	19±2	5	100.0
20.0-2	15.2±0.8	7.4±0.1	9.1±0.3	990±209	3.80±0.70	14±2	5	100.0
11.2-1	15.0±0.6	7.4±0.1	9.1±0.4	530±130	2.27±0.10	14±2	5	100.0
11.2-2	14.7±1.1	7.3±0.1	9.2±0.3	380±86	2.10±0.18	12±1	5	100.0
6.4-1	15.8±0.9	7.3±0.1	9.0±0.3	200±53	0.85±0.25	6±2	17	80.0
6.4-2	14.9±0.5	7.3±0.1	9.3±0.3	290±33	0.75±0.25	5±1	9	100.0
3.6-1	15.6±0.7	7.3±0.1	9.1±0.2	110±31	0.50±0.25	3±1	17	33.3
3.6-2	15.4±0.8	7.4±0.1	9.1±0.3	130±24	0.40±0.20	3±1	17	13.3
2.0-1	15.4±0.7	7.4±0.1	9.1±0.2	80±15	0.35±0.15	2±1	17	0.0
2.0-2	15.3±0.7	7.3±0.1	9.1±0.2	70±13	0.31±0.10	2±1	17	0.0
0.0-1&-2	15.2±0.5	7.4±0.2	9.1±0.2	00±0	0.10±0.00	1±1	34	0.0

[a]Mean ± SD.

APPENDIX - B-7.

Test series R-6 Effluent type DOHCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
33.3-1	15.6±0.4[a]	7.4±0.1	9.2±0.3	420±149	4.25±0.15	32±19	5	100.0
33.3-2	15.4±0.4	7.4±0.1	9.2±0.3	430±159	4.50±0.20	36±15	5	100.0
18.6-1	15.4±0.5	7.3±0.2	9.3±0.4	220±91	2.27±0.10	12±0	5	100.0
18.6-2	15.5±0.5	7.3±0.1	9.3±0.3	220±86	2.06±0.18	12±2	9	100.0
10.6-1	16.0±0.6	7.3±0.1	9.0±0.4	100±54	2.00±0.50	7±3	17	53.0
10.6-2	15.9±0.7	7.3±0.1	9.0±0.4	110±48	1.70±0.25	9±2	17	40.0
6.0-1	16.0±0.7	7.3±0.1	9.1±0.4	80±35	1.00±0.45	5±2	17	0.0
6.0-2	16.1±0.8	7.3±0.1	9.0±0.3	50±28	0.96±0.48	5±2	17	0.0
3.3-1	16.0±0.8	7.3±0.1	9.1±0.4	50±19	0.55±0.24	3±1	17	0.0
3.3-2	15.8±0.7	7.3±0.1	9.0±0.4	40±13	0.57±0.13	3±1	17	0.0
0.0-1&-2	16.0±0.7	7.3±0.1	9.1±0.4	00±0	0.20±0.10	2±1	34	0.0

[a]Mean ± SD.

APPENDIX B-8 EFFLUENT TOXICITY AND QUALITY DATA FOR DUBLIN/SAN RAMON WTP

APPENDIX - B-8. Test series DSR-1 Effluent type UnCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	17.6±1.0[a]	7.7±0.2	8.9±0.4	00±0	---	---	17	0.0
100.0-2	16.9±0.6	7.8±0.2	8.9±0.6	00±0	---	---	17	0.0
56.0-1	17.0±0.6	7.7±0.1	8.9±0.4	00±0	---	---	17	0.0
56.0-2	17.0±0.7	7.8±0.1	8.9±0.4	00±0	---	---	17	0.0
32.0-1	17.1±0.6	7.7±0.2	8.9±0.4	00±0	---	---	17	0.0
32.0-2	17.0±0.6	7.8±0.1	9.0±0.3	00±0	---	---	17	0.0
18.0-1	17.1±0.1	7.8±0.2	9.2±0.3	00±0	---	---	17	0.0
18.0-2	16.8±0.5	7.8±0.2	9.1±0.4	00±0	---	---	17	0.0
10.0-1	16.9±0.5	7.8±0.2	9.1±0.4	00±0	---	---	17	0.0
10.0-2	16.8±0.6	7.8±0.2	9.2±0.3	00±0	---	---	17	0.0
0.0-1&-2	16.3±0.2	7.8±0.2	9.2±0.3	15±5	---	---	34	3.3

[a]Mean ± SD.

APPENDIX -B-8. Test series DSR-2 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
10.0-1	16.8±0.2[a]	7.8±0.2	9.5±0.6	764±275	---	---	5	100.0
10.0-2	16.8±0.2	7.7±0.1	9.5±0.6	910±364	---	---	5	100.0
5.6-1	16.8±0.3	7.7±0.1	9.4±0.6	444±116	---	---	5	100.0
5.6-2	16.7±0.3	7.8±0.1	9.6±0.2	450±131	---	---	5	100.0
3.2-1	16.7±0.4	7.9±0.2	9.3±0.5	268±61	---	---	13	100.0
3.2-2	16.6±0.5	7.9±0.2	9.2±0.5	287±77	---	---	9	100.0
18.1-1	16.7±0.5	7.9±0.2	9.3±0.4	186±43	---	---	17	66.7
18.1-2	16.7±0.4	7.8±0.1	9.3±0.4	179±45	---	---	17	27.3
1.0-1	16.6±0.4	7.9±0.2	9.3±0.4	100±30	---	---	17	0.0
1.0-2	16.7±0.4	7.8±0.1	9.3±0.4	144±39	---	---	17	20.0
0.0-1&-2	16.7±0.4	7.9±0.1	9.3±0.4	21±15	---	---	34	3.3

[a]Mean ± SD.

APPENDIX - B-8.

Test series DSR-3 Effluent type DOHCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
20.0-1	16.6±0.2[a]	7.7±0.2	9.4±0.4	646±159	---	---	5	100.0
20.0-2	16.5±0.4	7.8±0.1	9.3±0.4	578±193	---	---	9	100.0
11.2-1	16.7±0.4	7.8±0.2	9.4±0.4	382±107	---	---	9	100.0
11.2-2	16.6±0.4	7.9±0.2	9.3±0.4	344±103	---	---	9	100.0
6.4-1	16.4±0.5	7.9±0.2	9.4±0.4	240±64	---	---	17	100.0
6.4-2	16.6±0.3	7.9±0.2	9.3±0.5	256±83	---	---	9	100.0
3.6-1	16.6±0.3	7.8±0.1	9.3±0.3	209±53	---	---	17	73.3
3.6-2	16.5±0.4	7.9±0.1	9.3±0.3	198±43	---	---	13	100.0
2.0-1	16.4±0.3	7.9±0.2	9.3±0.3	126±53	---	---	17	53.3
2.0-2	16.5±0.4	7.8±0.1	8.7±0.5	117±51	---	---	17	13.3
0.0-1&-2	16.5±0.3	7.9±0.2	9.3±0.3	25±25	---	---	34	0.0

[a]Mean ± SD.

APPENDIX - B-8. Test series DSR-4 Effluent type UnCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	18.2±1.0[a]	7.7±0.1	8.9±0.3	00±0	---	---	17	0.0
100.0-2	17.4±0.5	7.8±0.2	9.0±0.2	00±0	---	---	17	0.0
56.0-1	17.4±0.4	7.9±0.1	9.0±0.2	00±0	---	---	17	0.0
56.0-2	17.6±0.6	7.8±0.1	9.0±0.2	00±0	---	---	17	0.0
32.0-1	17.8±0.6	7.8±0.1	9.0±0.2	00±0	---	---	17	0.0
32.0-2	17.3±0.4	7.8±0.1	9.1±0.3	00±0	---	---	17	6.7
18.0-1	17.6±0.4	7.8±0.1	9.1±0.3	00±0	---	---	17	6.7
18.0-2	17.4±0.4	7.9±0.1	9.2±0.2	00±0	---	---	17	0.0
10.0-1	17.5±0.5	7.9±0.2	9.1±0.3	00±0	---	---	17	0.0
10.0-2	17.2±0.4	7.9±0.2	9.2±0.3	00±0	---	---	17	0.0
0.0-1&-2	17.3±0.4	7.9±0.2	9.2±0.3	20±13	---	---	34	3.3

[a]Mean ± SD.

APPENDIX - B-8.

Test series DSR-5 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
10.0-1	17.3±0.4[a]	7.9±0.1	9.5±0.2	902±389	---	---	5	100.0
10.0-2	17.2±0.3	7.8±0.1	9.4±0.2	960±437	---	---	5	100.0
5.6-1	17.3±0.3	7.9±0.1	9.4±0.3	480±164	---	---	5	100.0
5.6-2	17.3±0.4	7.8±0.1	9.4±0.1	558±187	---	---	5	100.0
3.2-1	17.2±0.3	7.8±0.1	9.3±0.1	259±58	---	---	9	100.0
3.2-2	17.1±0.3	7.8±0.1	9.3±0.2	346±111	---	---	5	100.0
1.8-1	17.4±0.3	7.9±0.1	9,2±0.2	156±40	---	---	17	60.0
1.8-2	17.3±0.3	7.8±0.1	9.1±0.2	135±32	---	---	17	6.7
1.0-1	17.4±0.3	7.8±0.1	9.2±0.2	74±19	---	---	17	26.7
1.0-2	17.3±0.3	7.9±0.1	9.3±0.2	99±21	---	---	17	0.0
0.0-1&-2	17.4±0.4	7.8±0.7	9.2±0.3	20±15	---	---	34	6.7

[a]Mean ± SD.

APPENDIX - B-8.

Test series DSR-6 Effluent type DOHCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
20.0-1	16.9±0.6[a]	7.7±0.1	9.4±0.1	722±206	---	---	5	100.0
20.0-2	16.9±0.6	7.6±0.1	9.4±0.1	794±199	---	---	5	100.0
11.2-1	17.1±0.5	7.8±0.1	9.4±0.6	388±56	---	---	5	100.0
11.2-2	16.9±0.5	7.7±0.1	9.4±0.1	379±112	---	---	9	100.0
6.4-1	16.7±0.6	7.8±0.1	9.4±0.1	258±40	---	---	9	100.0
6.4-2	16.9±0.5	7.8±0.1	9.4±0.2	274±62	---	---	9	100.0
3.6-1	17.1±0.3	7.9±0.1	9.3±0.2	168±35	---	---	17	90.0
3.6-2	16.9±0.4	7.9±0.1	9.3±0.2	174±29	---	---	16	88.2
2.0-1	17.1±0.4	7.9±0.1	9.3±0.2	126±25	---	---	17	33.3
2.0-2	17.1±0.4	7.9±0.1	9.3±0.2	112±28	---	---	17	9.1
0.0-1&-2	17.1±0.4	7.8±0.1	9.2±0.2	20±30	---	---	34	6.7

[a]Mean ± SD.

APPENDIX B-9 EFFLUENT TOXICITY AND QUALITY DATA FOR ROSS VALLEY WTP

APPENDIX - B-9. Test series RV-1 Effluent type UNC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	18.0±0.8[a]	7.8±0.1	8.1±0.6	0±00	17.50±1.86	442±100	17	6.7
100.0-2	17.8±0.6	7.8±0.1	8.3±0.5	0±00	17.01±1.94	439±102	17	0.0
56.0-1	17.3±0.6	7.7±0.1	8.4±0.5	0±00	7.03±1.82	156±41	17	0.0
56.0-2	17.6±0.7	7.8±0.1	8.4±0.4	0±00	7.11±1.96	206±10	17	0.0
32.0-1	17.4±0.9	7.7±0.1	8.7±0.5	0±00	3.59±1.41	81±34	17	0.0
32.0-2	16.8±0.4	7.7±0.1	8.8±0.4	0±00	4.16±0.77	95±27	17	0.0
18.0-1	17.1±0.7	7.7±0.2	9.0±0.4	0±00	3.41±1.16	76±39	17	0.0
18.0-2	16.9±0.7	7.7±0.2	9.1±0.4	0±00	2.73±0.78	54±28	17	0.0
10.0-1	16.9±0.7	7.7±0.2	9.0±0.4	0±00	1.21±0.38	27±16	17	0.0
10.0-2	16.7±0.6	7.7±0.2	9.1±0.4	0±00	1.26±0.32	26±15	17	0.0
0.0-1&-2	16.4±0.5	7.9±0.4	9.2±0.4	10±7	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-9. Test series RV-2 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
10.0-1	16.2±0.4[a]	7.5±0.1	9.2±0.5	720±575	1.42±0.20	17±5	5	100.0
10.0-2	16.1±0.5	7.5±0.1	9.0±0.7	790±655	1.46±0.13	16±5	5	100.0
5.6-1	16.5±0.8	7.5±0.1	9.0±0.6	320±193	0.68±0.14	10±5	5	100.0
5.6-2	16.1±0.4	7.4±0.2	8.0±1.6	396±300	0.65±0.05	7±3	5	100.0
3.2-1	16.7±0.9	7.7±0.2	9.2±0.4	169±135	0.40±0.06	8±4	17	93.3
3.2-2	16.5±0.7	7.6±0.2	9.2±0.4	106±38	0.45±0.09	9±4	17	6.7
1.8-1	16.7±0.9	7.6±0.2	9.2±0.4	105±73	0.26±0.05	5±2	17	0.0
1.8-2	16.6±0.8	7.7±0.2	9.2±0.5	93±67	0.37±0.10	7±3	17	25.0
1.0-1	16.6±0.7	7.6±0.2	9.2±0.4	43±22	0.18±0.03	3±1	17	0.0
1.0-2	16.6±0.9	7.6±0.2	9.2±0.4	68±43	0.18±0.04	3±2	17	0.0
0.0-1&-2	16.7±0.8	7.8±0.3	9.2±0.3	20±10	<0.10±0.00	<1±1	34	0.0

[a]Mean ± SD.

APPENDIX - B-9.

Test series RV-3 Effluent type DOHCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
25.0-1	16.7±0.7[a]	7.5±0.1	8.8±0.3	526±56	3.65±1.78	50±20	5	100.0
25.0-2	16.6±0.6	7.6±0.2	8.8±0.5	484±104	3.71±2.07	56±32	5	100.0
14.0-1	16.8±0.8	7.6±0.1	8.8±0.4	252±45	1.91±0.96	28±17	5	100.0
14.0-2	16.6±0.7	7.5±0.2	8.8±0.5	230±62	2.10±1.06	27±9	5	100.0
8.0-1	16.6±0.6	7.6±0.2	9.1±0.3	158±28	0.98±0.50	16±10	13	100.0
8.0-2	16.5±0.6	7.6±0.2	9.1±0.4	188±50	1.09±0.37	17±9	13	100.0
4.5-1	16.6±0.6	7.6±0.2	9.1±0.3	95±32	0.70±0.26	12±7	17	33.3
4.5-2	16.6±0.8	7.6±0.2	9.1±0.3	125±30	0.76±0.16	13±5	17	40.0
2.5-1	16.6±0.6	7.6±0.2	9.1±0.3	51±20	0.42±0.14	6±3	17	0.0
2.5-2	16.5±0.7	7.6±0.2	9.1±0.4	62±21	0.31±0.10	5±3	17	0.0
0.0-1&-2	16.4±0.5	7.6±0.2	9.1±0.4	20±7	<0.10±0.00	<1±0	34	0.0

[a] Mean ± SD.

APPENDIX - B-9. Test series RV-4 Effluent type UnCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
100.0-1	18.5±0.8[a]	7.8±0.1	7.8±0.5	00±0	17.06±5.74	551±164	17	13.3
100.0-2	17.3±0.7	7.9±0.1	8.6±0.5	00±0	15.64±5.25	532±163	17	0.0
56.0-1	17.8±0.9	7.8±0.1	8.4±0.6	00±0	8.39±2.35	221±103	17	0.0
56.0-2	17.2±0.6	7.8±0.1	8.6±0.4	00±0	8.37±2.69	211±91	17	0.0
32.0-1	17.7±0.8	7.8±0.1	8.8±0.4	00±0	4.09±1.36	146±73	17	0.0
32.0-2	16.9±0.6	7.9±0.2	8.9±0.3	00±0	3.99±1.46	135±99	17	0.0
18.0-1	17.4±0.8	7.9±0.2	9.0±0.4	00±0	4.03±1.29	135±64	17	6.7
18.0-2	17.1±0.6	7.9±0.2	9.0±0.3	00±0	4.03±1.15	135±81	17	0.0
10.0-1	17.2±0.6	7.9±0.2	9.1±0.3	00±0	1.57±0.66	64±46	17	0.0
10.0-2	16.8±0.6	7.9±0.2	9.1±0.3	00±0	1.33±0.47	57±38	17	0.0
0.0-1&-2	16.9±0.5	7.9±0.3	9.2±0.2	20±9	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-9. Test series RV-5 Effluent type EC1 Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
15.0-1	16.5±0.1[a]	8.0±0.2	9.5±0.3	808±226	1.53±0.37	64±42	5	100.0
15.0-2	16.5±0.2	8.0±0.2	9.4±0.3	910±300	1.52±0.33	57±29	5	100.0
8.4-1	16.5±0.1	8.0±0.2	9.5±0.3	448±144	0.89±0.21	34±21	5	100.0
8.4-2	16.4±0.2	8.0±0.2	9.5±0.3	460±144	1.15±0.37	46±27	5	100.0
4.8-1	16.6±0.4	8.0±0.1	9.4±0.3	225±61	0.54±0.09	19±11	8	100.0
4.8-2	16.4±0.3	8.0±0.1	9.3±0.3	238±69	0.53±0.11	19±8	9	100.0
2.7-1	16.7±0.6	8.0±0.1	9.3±0.2	129±46	0.37±0.09	13±4	16	66.7
2.7-2	16.6±0.5	8.0±0.1	9.3±0.2	109±43	0.36±0.04	13±5	16	6.7
1.5-1	16.5±0.5	8.0±0.1	9.2±0.3	71±20	0.30±0.05	14±5	16	0.0
1.5-2	16.6±0.5	8.0±0.2	9.3±0.3	87±24	0.27±0.04	10±5	16	0.0
0.0-1&-2	16.6±0.3	8.0±0.2	9.4±0.3	30±7	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

APPENDIX - B-9.

Test series RV-6 Effluent type DOHCl Test organism GS

Diluted Concentration (%)	Temp. (C)	pH	D.O. (mg/L)	TRC (ug/L)	$NH_4^+ + NH_3$ (mg/L)	NH_3 (ug/L)	No. Obs.	Mortality (%)
25.0-1	16.6±0.3[a]	7.9±0.1	9.1±0.6	438±214	2.11±0.98	61±29	5	100.0
25.0-2	16.4±0.3	7.9±0.1	8.9±0.5	366±147	1.81±0.76	52±15	5	100.0
14.0-1	16.5±0.5	7.9±0.1	9.0±0.4	221±86	1.55±0.50	54±28	13	100.0
14.0-2	16.5±0.3	7.9±0.2	9.3±0.2	214±79	1.32±0.67	40±2	5	100.0
8.0-1	16.5±0.5	7.9±0.1	9.1±0.3	136±33	1.15±0.28	39±22	16	73.3
8.0-2	16.5±0.3	7.9±0.1	9.2±0.2	151±41	1.13±0.19	43±14	16	86.7
4.5-1	16.5±0.4	7.9±0.1	9.1±0.3	91±19	0.88±0.16	34±19	17	20.0
4.5-2	16.6±0.5	7.9±0.2	9.2±0.2	101±26	0.84±0.10	32±17	17	13.3
2.5-1	16.4±0.4	7.9±0.2	9.1±0.3	56±15	0.69±0.20	25±17	17	0.0
2.5-2	16.5±0.5	7.9±0.2	9.2±0.3	59±14	---	---	17	0.0
0.0-1&-2	16.4±0.2	8.0±0.2	9.3±0.4	25±10	<0.10±0.00	<1±0	34	0.0

[a]Mean ± SD.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

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16. ABSTRACT

The California Department of Health Services in cooperation with the California Department of Fish and Game developed and implemented a chlorine optimization study of eight wastewater treatment plants in northern California. Two mobile units were constructed for the project: a pilot chlorination plant and a mobile toxicity testing and water quality laboratory. The pilot chlorination plant tested several optimized-chlorination design criteria against existing wastewater treatment plant chlorination systems. The mobile laboratory evaluated the toxicity of the optimized and existing chlorinated effluents.

The toxicity associated with the existing unchlorinated and dechlorinated effluents increased with un-ionized ammonia concentrations. Most of the toxicity associated with the unchlorinated and dechlorinated effluents, however, was the result of an artificial increase in pH created by a toxicity test design problem. The optimized chlorinated effluents, with one exception, had lower and more stable chlorine residuals than did the existing chlorinated effluents and hence, were generally less toxic. The toxicity of all effluents investigated increased proportionately with increased chlorine residual.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Toxicity, Chlorine, Disinfection, Aquatic animals, Fishes, Waste treatment, Coliform bacteria, ammonia	LC50, Chlorine residual, Free chlorine, Fathead minnows, Golden shiners, Dechlorination	06C 13B

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