Delta Island Drainage Investigation Report

of the Interagency Delta Health Aspects Monitoring Program

A Summary of Observations During Consecutive Dry Year Conditions

Water Years 1987 and 1988

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June 1990

California Department of Water Resources
Division of Local Assistance
Sacramento, California

The cover photo is an aerial view of one of the many channels meandering through the Sacramento-San Joaquin Delta. The Delta is an intricate network of channels and islands encompassing 700,000 acres.

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Organization

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The views and opinions expressed in this Department of Water Resources report do not necessarily reflect those of the Delta Islands Drainage Investigation Technical Advisory Commitee participants nor are endorsed by them.

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The mention of trade names or brands and laboratories used for this study does not constitute an endorsement by the State of California.

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I. Summary

Study Description

The Delta Island Drainage Investigation (DIDI) was established to assess the impacts of Delta island drainages on the quality of drinking water supplies taken from the Delta. The study was initiated after data from the Interagency Delta Health Aspects Monitoring Program (IDHAMP) showed high total trihalomethane formation potential (TTHMFP) in island drainages.

The Delta Islands Drainage Investigation was developed to collect information about:

1. What is the quality and quantity of Delta island drain water?

2. What processes affect the quality and quantity of island drainages?

3. What water quality impacts in the channels and at drinking water supply intakes are due to Delta island drainages?

4. How do the contributions from Delta island drainages compare with other major sources, which may include the San Francisco Bay estuary, inflows and drainages from rivers such as the San Joaquin, from Delta channels, and from weather-related events?

5. If the treatability and cost of treatment of Delta waters are affected, what are the alternatives for managing these impacts?

The information is intended to aid in making decisions about watershed management, discharge requirements, water quality monitoring, and water treatment requirements.

At this time, the study is continuing to address the first three questions stated above. Therefore, ***only preliminary conclusions are presented***. The purpose of this report is to summarize the progress and planned direction of this study for water agencies and the general public.

The THM/DBP Problem

Water utilities are required to meet federal and state drinking water standards that have been established for the protection of human health. THMs or trihalomethanes are a class of organic compounds that are regulated. The current Maximum Contaminant Level (MCL) is 0.10 mg/L total trihalomethanes, the sum of concentrations of chloroform ($CHCl_3$), bromodichloromethane ($CHCl_2Br$), dibromochloromethane ($CHClBr_2$), and bromoform ($CHBr_3$). This MCL was not established strictly on the basis of health effects data but was set as a feasible level for compliance by water utilities. However, a much lower MCL (possibly as low as 0.025

mg/L or 0.050 mg/L) is being proposed by the U.S. Environmental Protection Agency (EPA) for human health protection and adoption by 1992.

The production of THMs and several other disinfection by-products (DBPs) can be generally shown as:

Natural Organics (Precursors)	+	Free Chlorine or other oxidants	+	Bromide ======> THMs	+	Other Disinfection By-products

When free chlorine or other oxidants are added to drinking water as a disinfectant, the above reactions occur. Natural organic matter such as from decaying algae, soils, and organisms provide the carbon source to react with chlorine. If bromide is not present, only chloroform would be formed as the chlorine reacts with natural organic precursors. Bromide, another precursor, can exacerbate the problem of meeting the THM MCL because the heavier THM compounds containing bromine atoms, will be formed. Chlorine will oxidize bromide to hypobromous acid (HOBr), which will then react with the organic precursors to form the brominated methanes. Therefore, levels of both bromide ion and organic carbon in water supplies impact the control of DBPs.

New studies by The Metropolitan Water District of Southern California and EPA (MWDSC-EPA, 1989) on treatment options to reduce THM formation now show other DBPs of health concern are being formed. Alternative disinfecting chemicals such as ozone are being studied. However, these studies have shown that new disinfection technologies may not be adequate to meet anticipated MCLs for DBPs. Therefore, the sources of organic material and bromide in supply water are being studied to see if they can also be controlled.

The concern for meeting a THM MCL has now focused on ways of complying with proposed MCLs for a variety of DBPs. DBP regulations are scheduled for promulgation in 1992. THM formation potential can serve as a surrogate for DBP formation potential for many DBPs, although sometimes a reduction of THMs may increase other DBPs.

Data from several ongoing water studies (e.g. California Urban Water Agencies Delta Water Quality Study, MWDSC-EPA treatment research, DWR IDHAMP) including this investigation on Delta island drainage will be used to examine the most cost-effective solution for meeting new drinking water standards.
The information is also needed by the State Water Resources Control Board in setting water quality objectives in the Delta to meet and protect the needs of many competing beneficial uses such as agriculture, fisheries, recreation, municipal, and industrial. The economic importance and value of each of these aforementioned beneficial uses have been presented by various parties to the State Board during the 1987-90 Bay-Delta hearings.

Delta THMFP

The Delta Islands Drainage Investigation (DIDI) began in January 1987 as an outgrowth of a Department of Water Resources study of the quality of Delta water for drinking water supplies. The study, known as the Interagency Delta Health Aspects Monitoring Program (IDHAMP), was initiated in July, 1983, in response to a 1982 scientific panel report which concluded that there were insufficient data to fully assess the present or projected quality of Delta drinking water supplies. The Panel recommended establishment of a program to monitor water quality as related to human health concerns.

Under IDHAMP, water quality at 15-18 stations is monitored each month. Samples are collected from areas representing fresh water inflow to the Delta, agricultural drainage, bay water, channels and sloughs, and water exports (Figure 1). Analyses include selected pesticides, sodium, selenium, minerals, and total trihalomethane formation potential (TTHMFP).

The THM formation potential test used in this study and in IDHAMP is used to compare the THM producing capacity of source water supplies. The test determines the maximum concentration of THMs that can be produced from any given sample. However, the concentration of THMs actually produced in drinking water systems is much lower than the THM formation potential because of pH adjustments, ammonia addition, water temperature, chlorine dosage, and other treatment practices and plant designs employed to reduce THMs.

Figure 2 shows the range of TTHMFP observed in the Delta. The Sacramento River at Mallard Island station represents the area where fresh and bay waters meet during the dry period investigated; in wet periods, freshwater can extend through Suisun Bay and even beyond Carquinez Strait. Water quality at this station typically is high in bromides and other seawater constituents because of changing tides and flows.

The Sacramento River at Greenes Landing station reflects the quality of the major source of fresh water flowing into the Delta. Water flowing into the Delta from the San Joaquin River upstream of Vernalis is a variable combination of Central Valley agricultural drainage mixed with fresh water. The monitoring station on the San Joaquin River near Vernalis station reflects these influences.

The qualities of water diverted by the Contra Costa Water District (CCWD) and SWP (State Water Project) are represented by the monitoring locations Rock Slough at Old River, and Banks Pumping Plant Headworks, respectively.

IDHAMP data from three Delta island drains suggest that peat soils can contain high concentrations of organic THM precursors, and may be a source of THM precursors. The significance of these inputs could not, however, be quantified without more information about TTHMFP concentrations in other drains, and volumes of drainage being discharged.

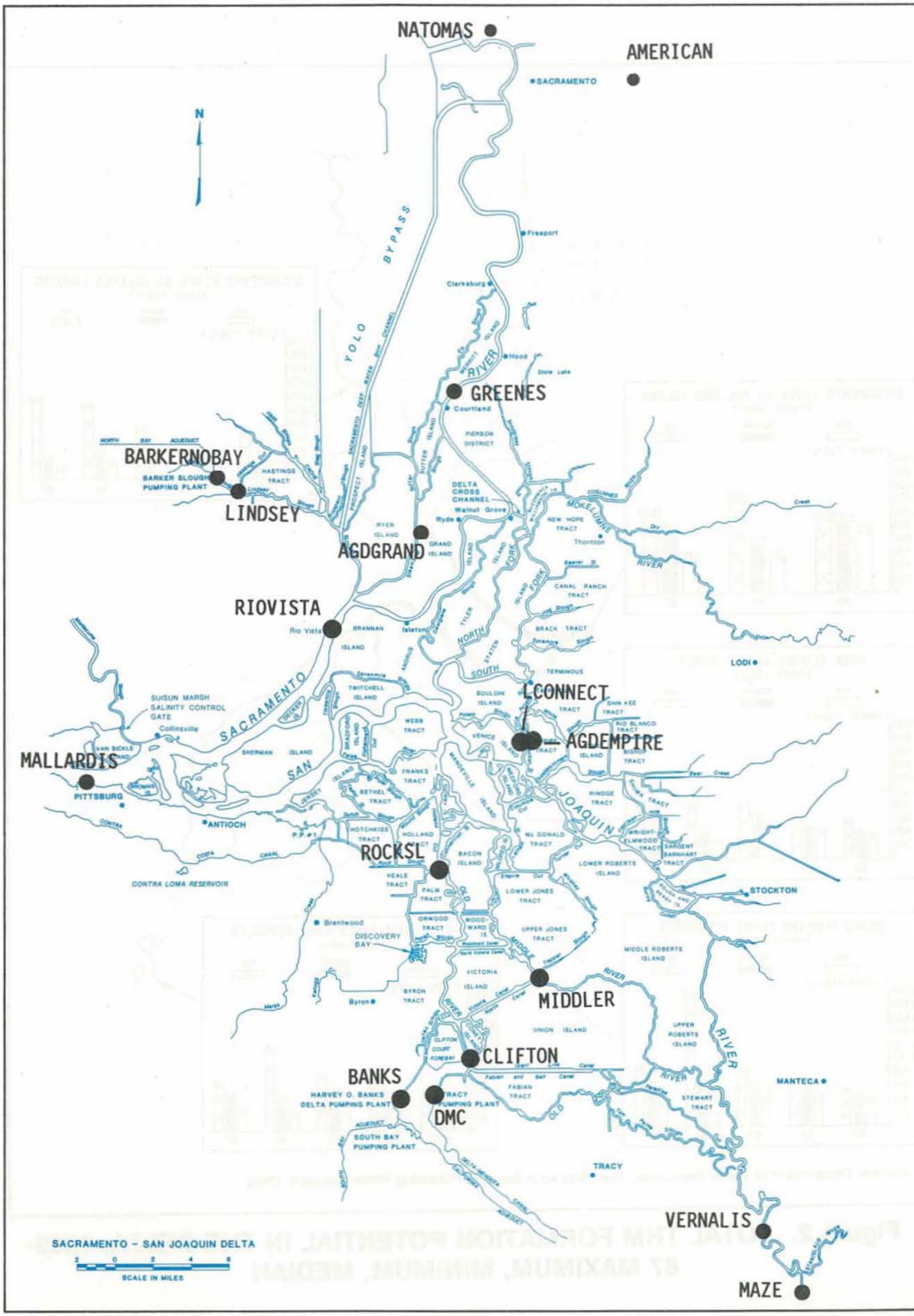
The range of TTHMFP at island drains located at Empire Tract, Tyler Island, and Grand Island are shown in Figure 3. The THMFP concentrations are significantly higher than that of the channel water samples shown in Figure 2.

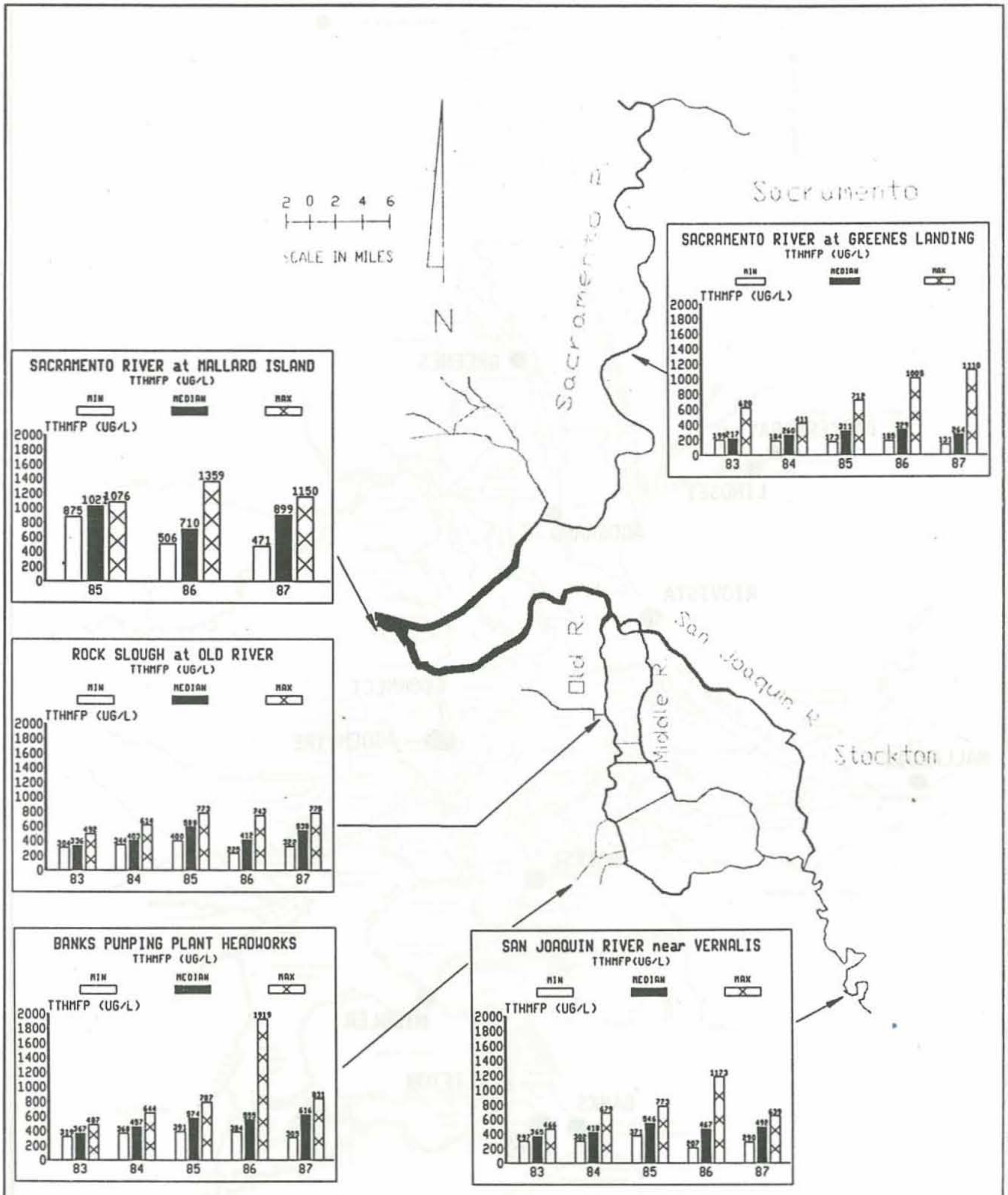
Five years of IDHAMP data demonstrate that waters diverted by the Contra Costa Water District (CCWD), State Water Project (SWP), and Federal Central Valley Project have higher TTHMFP concentrations than fresh water flowing into the Delta from the Sacramento and American Rivers. Organic matter carried in from sea water intrusion, from the San Joaquin River, and from peat soils and vegetation in the Delta Lowlands and surrounding channels are suspected to be major contributors to the increased TTHMFP. Bromides, which are salts of sea water origin, enter the Delta from San Francisco Bay. Reductions in the amount of organic matter and bromides in untreated water supplies would enable a reduction of THMFPs and other DBPs in drinking water.

Reduction of precursor substances would increase the reliability of water treatment processes in meeting more stringent drinking water criteria, and would also minimize treatment costs.

In response to these water quality concerns, the Technical Advisory Group of IDHAMP recommended that DWR initiate an investigation of the effects of agricultural drainage on Delta water quality. DWR acted on the Group's recommendation and proceeded with developing and commencing the Delta Islands Drainage Investigation (DIDI) in January 1987. This report describes the progress and results of the investigation.

Figure 1. IDHAMP Monitoring Stations

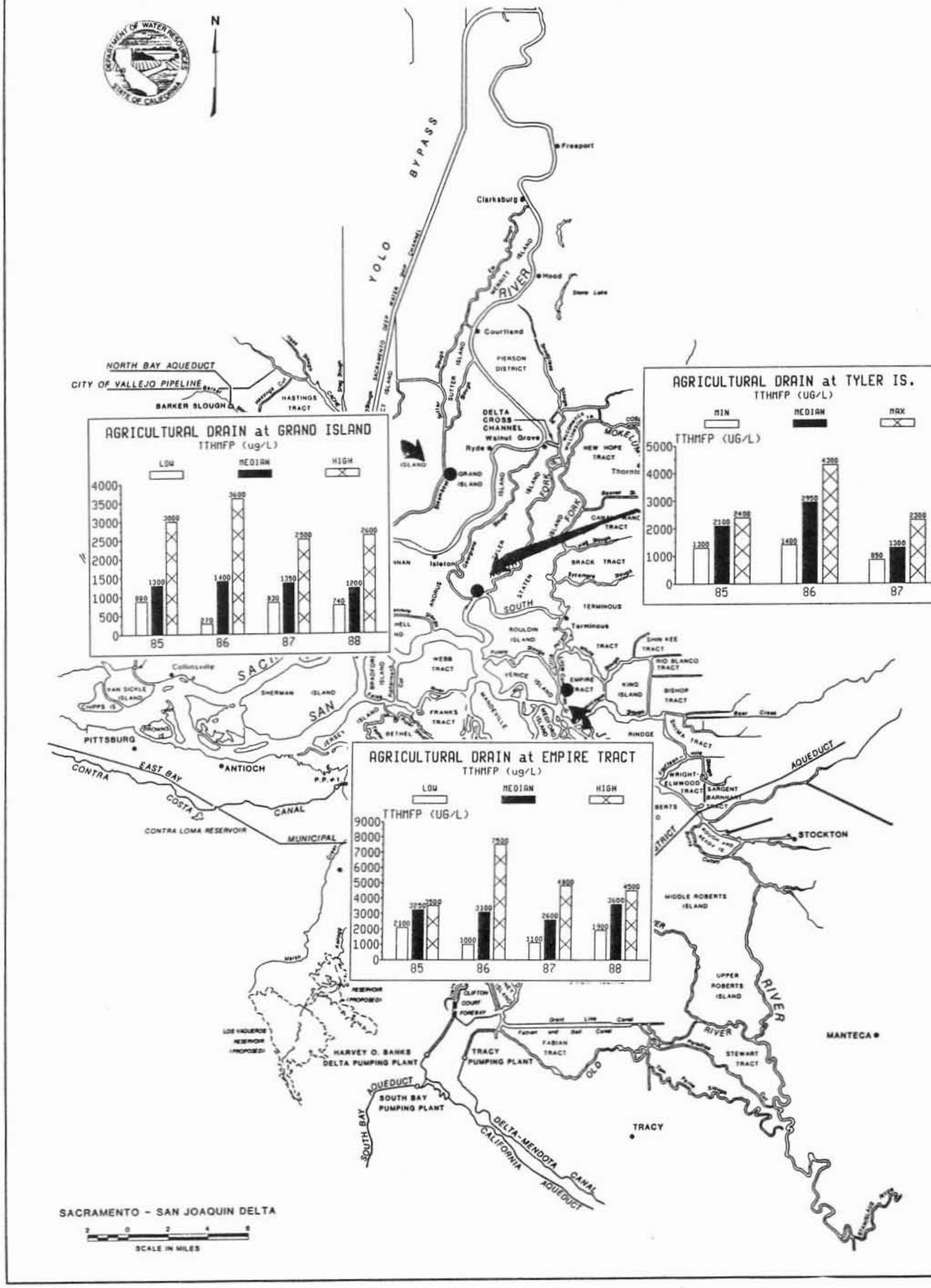




Source: Department of Water Resources, The Delta As A Source of Drinking Water (January 1989)

Figure 2. TOTAL THM FORMATION POTENTIAL IN THE DELTA, 1983-87 MAXIMUM, MINIMUM, MEDIAN

Figure 3. TOTAL THM FORMATION POTENTIAL AT THREE AGRICULTURAL DRAINAGES, MAXIMUM, MINIMUM, MEDIAN



Findings

Natural waters contain organic matter of plant and animal origin. The total amount of organic matter in water can be operationally classified into dissolved and particulate phases. Dissolved organic matter (DOM) or dissolved organic carbon (DOC) is that which passes through a 0.45 μ pore sized filter. DOM can be further classified into four major groups: (1) identifiable compounds, (2) hydrophilic acids, (3) humic acid, and (4) fulvic acid. The humic and fulvic acids are collectively refered to as humic substances. The formation of THM when humic substances in natural waters are combined with a strong oxidant such as chlorine has been extensively documented. Aquatic humic substances originate from soil humic material and terrestrial and aquatic plants.

The preliminary findings of this study show that both bromide and the types of organic matter present can affect the total THM formation potential of Delta waters.

A study of the characteristics of DOM humic and nonhumic substances showed distinct differences between drain and riverine Delta water samples (Amy et al, 1990). Drain samples when compared to river and lake water samples had a higher average molecular weight for DOM and were more propense in forming DBPs. Drainage contained heavier and larger sized humic substances (based on molecular weight measurements) than riverine Delta samples. Drainage generally had four times greater THMFP and ten or more times greater DBPs than Delta river samples.

Besides DOC, bromide will contribute to the high TTHMFP seen in various regions of the Sacramento-San Joaquin Delta. The amount of brominated methane compounds that are formed from waters of the same dissolved organic carbon (DOC) concentration will vary with bromide concentrations. This implies that bromide concentrations and the form and types of DOC material present affect TTHMFP and the distribution of brominated THMs that are formed.

The distinct characteristics of drain and nondrain organic matter indicate the potential capability to study the movement of island DOM humic substances in the Delta by tracking the molecular weight distribution of organic material in water.

The DOM or DOC characteristics (e.g. molecular weight and propensity to DBP formation) between drain and river samples are distinct enough to indicate that drainage DOC compounds are predominantly from Delta island soils and not solely the result of the concentrating effects from evapotranspiration of applied irrigation water. Historically, much of the Delta was a vast tule marsh whereby peat was formed from the decay of the marsh vegetation (the great bulrush or tule, *Scirpus lacustris*). On islands overlying peat type soils, the peat is the major source of island soil organic matter. The Delta basin soils are mostly organic soils and associated soils in which there is advanced alteration and an admixture of mineral soils.

Data collected from the Delta Islands Drainage Investigation and Interagency Delta Health Aspects Monitoring Program have shown that drain waters do have a higher potential to form trihalomethanes than Delta channel waters. These results corroborate the work reported by Amy et al. (1990).

Drainage volume discharges correspond to the seasonal farming activities on the islands. There is a summer peak of maximum drainage, typically, in July-August, that corresponds to the increased irrigation that occurs. There is also a winter peak of maximum drainage, typically observed in December-January. This winter drainage is caused by the flooding of fields by landowners to leach out salts accumulated in the soil.

In general, the highest observed range of THMFP concentrations in the island drainages during the summer and winter peak drainage months correlated with island soil type. Delta soil types can be grouped into three simple classes: mineral, intermediate organic, and peaty organic. All three soil types contain organic matter with mineral soils the least amount (less than 10%) and peaty organic the most (about 50% to 80%). The organic soils, which are confined to the Delta basin, occupy a larger aggregate acreage (about 250,000 acres) than the mineral soils, which occupy the margins of the basin. The basin organic soils are more typical of the low-lying area and the mineral soils represent a transition zone where basin organic soils begin to mix with upland mineral soils that originate from areas beyond the Delta boundaries.

The August maximum THMFP concentrations appeared to be higher on islands with the greatest amounts of peat soils and lower on islands with mineral soils. In most cases generally, the January maximum THMFP concentrations on all islands were higher than those observed in August. Higher concentrations were still observed on peat soil island drainages as compared to mineral soil island drainages.

In 1982 DWR tests showed composited Delta peat soils and mineral soil extracts had 61,000 µg/kg and 27,000 µg/kg TTHMFP, respectively. Island drainage TTHMFP is therefore most likely related to soil type and water saturation of the island soils. Organic soils are extremely permeable and have a high water-holding capacity.

There are about 2200 siphons and 260 drainage pump stations on nearly 60 islands and tracts in the Delta that were identified by DWR in 1986 and 1987. There is insufficient data to identify single islands or drainages which may be representative of large areas of the Delta.

The most comprehensive study on Delta island drainage volume was conducted by DWR in 1954-55 and published in DWR Report No. 4 (1956). Based on comparisons of past and present land use data, water year classification, and DWR's Division of Planning Consumptive Use model runs, the estimated total W.Y. 1988 drainage volume in the Delta Lowlands was between 633,195 and 773,905 acre-feet. These estimates correspond to 90 and 110% of the drainage volume estimates of the 1954-55 study.

During summers of critical water years, the volume of Delta Lowland drainage can be significant when compared to total river inflow from the Sacramento and San Joaquin rivers or the amount of Delta exports. The July 1954 drainage volume was equivalent to as much as 15% of the July 1954 combined total of Sacramento and San Joaquin river flows into the Delta.

The impact of island drainage on Delta waters will vary with location and hydrology within the Delta. The Delta Islands Drainage Investigation has been monitoring conditions during a four-year drought. Under these severe water shortage conditions, San Joaquin River (SJR) flows have been constantly low (about 1200 to 1500 cfs). DWR's State Water Project Operations and Maintenance flow data show that nearly all of the SJR flows near Vernalis were diverted to the DMC intake during W.Y. 1988. The DMC flows (pumping) were 2 to 3 times greater than the SJR flows at Vernalis. SJR water entering the Delta near Vernalis was an insignificant portion of the water flowing into the Delta past Stockton. These observations were substantiated with synoptic water quality surveys and SJR selenium monitoring that tracked the flow of SJR water to the DMC intake at Lindemann Road. Observations under other hydrologic conditions such as normal and wet years are needed as SJR flows can become a more significant portion of Delta inflow.

DOC has been observed to behave conservatively in waters of less than 5 parts per thousand salinity, the salinity range generally found in the Delta. Humic substances, the most reactive fraction of DOM in forming THMs, are very biorefractory (resistant to natural biological degradation). Carbon dating has established that humics from the Suwanee River (Florida) are 30 years old. It is the nonhumic fraction of DOM, consisting largely of biochemicals such as proteins and amino acids, which is more biodegradable. Therefore, humic substances (THM precursors) in Delta waters are not expected to decrease appreciably because of biological decay or transformation within the Delta. Also decay may not be significant in reservoirs or aqueducts if Delta humics are as biorefractory as those carbon dated from the Suwanee River.

The impact of drainage THM precursors on Delta water quality was estimated. The method converted measured TTHMFP concentrations to TTHMFP organic carbon concentrations (TFPC). These conversions were made to eliminate the bias of comparisons due to the heavier THMs that contained bromine.

A preliminary estimate of the monthly TFPC entering the Delta from river and bay inflows and Delta island drainages was made. The calculations used monthly Delta inflow data for W.Y. 1988 and the estimated monthly drainage volumes. For simplification, the preliminary impact assessment lumped together the average TFPC values of selected IDHAMP stations (Banks Headworks, Sacramento River at Mallard Island, Clifton Court Forebay intake gate, Middle River at Borden Highway) to represent the monthly water quality of the Delta. Similarly, TFPC data were averaged for mineral-intermediate organic islands versus peat islands. The monthly TFPC and river inflow and drainage discharge estimates were then used to derive monthly flow-weighted estimates of drainage plus river TFPC. These estimates were then compared against the average TFPC in the Delta.

The estimates showed that drainage contributed 40 to 45% of the TFPC in the Delta during the irrigation months (April-August) and 38 to 52% during the winter leaching period (November-February) during W.Y. 1988.

The calculated TFPC estimates showed good agreement with the general rise and fall of observed average values in the Delta during October 1987-June 1988. There was about a two-week lag period between the monthly average calculated estimates and observed data. The lag period is attributed to different sampling dates, the averaging and grouping of values, and time between observing an impact in the channels caused by island drainages.

The TFPC estimates appeared to be reasonable, since the annual average, minimum, and maximum estimates were 4.5 µg/L of their respective observed values. Overall, the estimates averaged 14.5% higher than the observed mean values based on data from the four IDHAMP stations used to represent the average TTHMFP in the Delta.

Overall, the results were good and indicated a start in the correct approach to studying TTHMFP in the Delta. Further monitoring will improve the precision of these estimates and hasten the development of a Delta TTHMFP model by DWR.

While the information produced in this study strongly indicates islands are significant sources of organic THM precursor material, we have not completed our work in measuring the impact of these discharges on the drinking water quality of Delta supplies. Due to the variety of island acreages, soil types, and drainage volume as well as different locations and flow patterns within the Delta, it is conceivable that not all Delta islands significantly impact channel water quality. Some of our synoptic water quality surveys in the channels support that thought.

The analysis showed the need for more drainage flow and drainage water quality data to improve the precision of the study. The preliminary findings are an indicator of the relative magnitude of the potential THM precursor loadings from Delta islands. The continuation of this study over different hydrologic conditions and coverage of more island drainages will aid in determining the need and best method for setting further water quality criteria or policy in the Bay-Delta.

DIDI sampling also included monitoring of pesticides in the drainages. Thirty of 260 Delta island drainages were sampled in July 1988 for pesticide residues. July is both a peak application month of most agricultural pest control chemicals and the summer peak month for drainage discharge in the Delta. Pesticide chemicals were mostly below laboratory detection limits. Where pesticide residues were detected, they were near the detection limits, and well below current established drinking water criteria or action levels established by the California Department of Health Services. Further sampling is needed before making any conclusions about pesticide residues in the remaining 230 drains throughout the Delta.

Recommendations

The need to complete the assessment of the impacts of island drainages, San Joaquin River drainage, bay water intrusion, and other significant, potentially controllable factors on the quality of Delta drinking water supplies grows stronger because of new proposed drinking water standards.

In this program, the impact of Delta island drainage on the quality of drinking water supplies was estimated both by sampling the channels and drains. Overall, the 54 drains provided valuable data in understanding the factors that affect the quality and quantity of island drainage. Further sampling of other drainages will improve the precision of data analysis and interpretation. An expanded monitoring program will be necessary.

Study activities for 1990 will need to identify the characteristics of other Delta islands and further study the impacts of discharges to the channels.

Based on these factors, the following recommendations are made:

1. The study period must include other hydrologic conditions. The study has been observing conditions during a four-year drought. The results cannot be extrapolated to other hydrologic conditions.

2. The monitoring program must be expanded to include a larger number of significant Delta island drains and associated channels. The assistance of the State or Regional Boards should be requested to encourage further cooperation from some districts.

3. Synoptic surveys must be continued and conducted more frequently, especially during these prolonged drought year conditions. These surveys provide valuable information on water quality as related to flow conditions in the Delta.

4. Analytical studies to characterize drain and nondrain humic substances as conducted by Dr. Gary Amy must be continued. Such studies provide a method of "fingerprinting" the contribution of THM organic precursor material from various sources.

5. The sampling of channel sediments and island soils for TTHMFP and other DBP formation potential should be added to the study. Sampling should include at least two depths to conduct soil and sediment profile comparisons.

6. A study of the relationship of bromide to other water quality measurements and constituents should be performed.

7. Develop a study to compare the raw water TTHMFP concentrations to finished water THM and DBP.

8. Continue laboratory studies on the effects of holding times, incubation temperature, chlorine dosage, DOC, and bromide concentration on the DWR TTHMFP test method.

9. Continue analysis of the IDHAMP and DIDI data base to examine water quality relationships and trends at individual sampling stations.

10. Work cooperatively with the DWR Delta Modeling Group on developing a Delta island salinity model and a Delta THMFP model. Develop and locate funding sources to implement the necessary studies for these models.

The Department will re-direct funds and resources to achieve some of these recommendations; however, since DWR resources are limited, outside resources will be sought from interested water agencies that would benefit from the study.

DWR's Division of Operations and Maintenance for the State Water Project have added TTHMFP testing to their existing monitoring of the SWP.

II. Study Description

Objectives

The Delta Islands Drainage Investigation was developed to address specific questions, including:

1. What is the quality and quantity of Delta island drainwater being discharged?

2. What processes affect the quality and quantity of island drainages?

3. What water quality impacts in the channels and at drinking water supply intakes are from Delta island drainages?

4. How do the contributions from Delta island drainages compare to other major sources, which may include the San Francisco Bay estuary, inflows and drainages from rivers such as the San Joaquin, from Delta channels, and from weather-related events?

5. If the treatability and cost of treatment of Delta waters are affected, what are the alternatives for managing these impacts?

The information generated from this study is intended to aid in making decisions about watershed management (e.g. State Board Delta Hearings) and water treatment practices.

At this time, the study is continuing to address the first three questions stated above. Therefore, only preliminary conclusions are presented. The purpose of this report is to summarize the progress and planned direction of this study for water agencies and the general public.

Project Team

The Delta Islands Drainage Investigation is directed through the Department's Division of Local Assistance, Water Resources Assessment Program. Data collection, laboratory coordination, and database management support was provided by the Water Quality Section, Operations Branch, of the Central District Office. Additional technical support and data analysis are provided under contract with the water quality consulting firm of Marvin Jung & Associates, Inc. of Sacramento.

Laboratory services were provided by the DWR Laboratory located in Bryte (West Sacramento), and our contract laboratories, ENSECO-CAL of West Sacramento (F.Y.s 87-88 and 88-89) and Pace Laboratories, Santa Rosa (F.Y. 89-90). Laboratory quality assurance evaluation was provided by each laboratory, and through interlaboratory checks conducted by the State Department of Health Services, Sanitation and Radiation Laboratory in Berkeley.

Quality assurance procedures are practiced by DWR staff during field sampling, data entry, retention, and storage. A complete description of our quality assurance measures can be found in Appendix E of "The Delta As A Source of Drinking Water, Monitoring Results 1983-1987," published by DWR in August 1989.

Methodology

The following sections describe sampling equipment, field measurements, study sites, sampling frequency, and laboratory analyses.

Sampling Equipment

The field crew collected drain water samples at the intakes of the pump stations. Many of the scaffolding and walkways at the pump stations provided a platform for sampling.

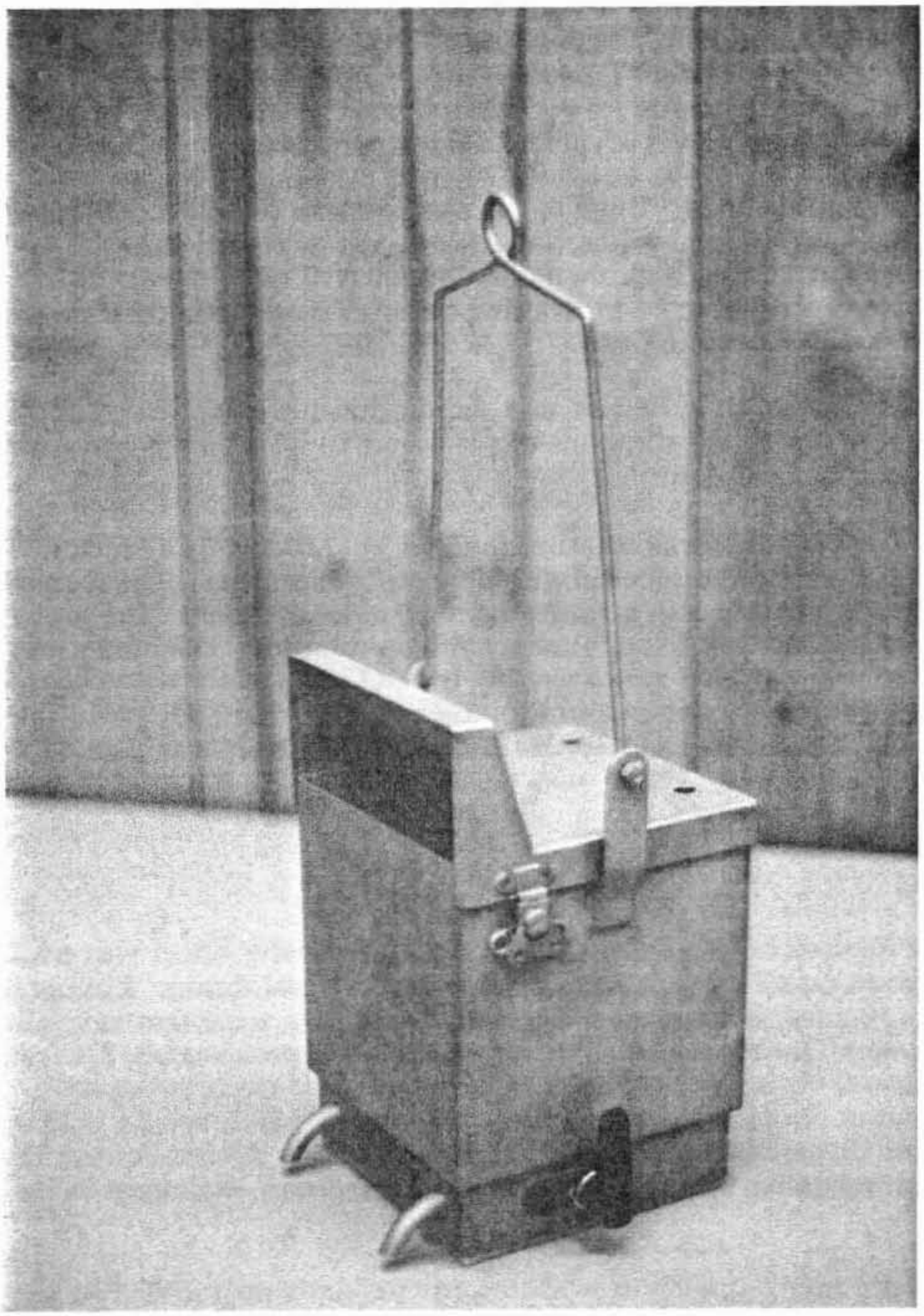
Water samples from the Delta channels were collected with a shallow water sampler, a stainless steel pail, or a Kemmerer water sampler. Samples were taken at the 1-3 foot depth.

Most drains were too shallow to use traditional devices designed to sample deeper waters (e.g., Kemmerer sampler). Consequently, a new shallow water sampling device was designed and constructed. The sampling device was a 2-gallon stainless steel box. The sampler was designed to allow water to flow into the device but keep at a minimum the admittance of foreign matter. The handle was approximately 18 inches long, with a steel cable attached to it. Two valves, constructed of stainless steel and Teflon, were attached to the bottom of the sampling device. These valves were used to fill sample containers (Figure 4).

Field crews took samples from boats, off bridges, and pier structures that provided the best and safest access to the sampling points.

Water samples were tested for selenium, minerals, turbidity, dissolved organic carbon (DOC), color, and TTHMFP. Some channel water samples were also tested for chlorophyll. Except for turbidity and color, all samples were filtered in the field through 0.45 micron pore sized Millipore membranes, using a stainless steel filtration apparatus. Selenium samples were preserved with nitric acid. Mineral samples were filtered into a one-quart bottle and a half-pint bottle and preserved with nitric acid. Chlorophyll samples required two filters. Each filter received 200 ml. of sample water. Filters were then stored in dry ice until they were delivered to the Lab. All other samples were stored on ice during delivery.

Figure 4. Shallow Water Sampler



TTHMFP samples were collected in three standard 40 ml. VOA (volatile organic analyses) vials while DOC samples were placed in amber colored 250 ml. bottles, preserved with sulfuric acid. After January 1988, TTHMFP containers remained the same while DOC samples were taken in one 40 ml. vial, preserved with hydrochloric acid.

Field Measurements

Field measurements included temperature, dissolved oxygen (DO), specific conductance (EC), and pH. Temperature and EC were taken using a Yellow Springs Instrument (YSI) Model 3000 T-L-C Electrical Conductivity meter. This meter was calibrated using two separate tests. The first test checked the meter readings against standards made at the DWR Bryte Lab. The second test required an electrical probe supplied by YSI. The probe tested the internal system of the meter with pre-programmed readings. If the meter was within a standard reading established by YSI, then the meter was in calibration. If not, it was returned to the manufacturer for re-calibration. Using both methods, the internal components of the meter and the probe were verified to be in working order. These methods were performed prior to each day's sampling run.

The Beckman Model 10 pH meter was standardized prior to each sampling trip. Commercial pH standard solutions of pH 4 and 10 were purchased from VWR Scientific and Fisher Scientific.

Dissolved Oxygen (DO) was measured with a YSI Model 50 DO meter. This meter was calibrated using a number of available calibration tests. The main method used was calibration in air in mg/L for fresh water measurements. The probe was placed in moist air and allowed to stabilize for fifteen minutes. The meter was then calibrated to the stabilized meter reading for DO. The meter was also regularly checked by using the independent Modified Winkler Method. Triplicate water samples were titrated by the Winkler method. The meter was then calibrated to the average of the 3 results. Membranes on the probes were replaced every two to three weeks, per manufacturer's recommendations.

Study Sites

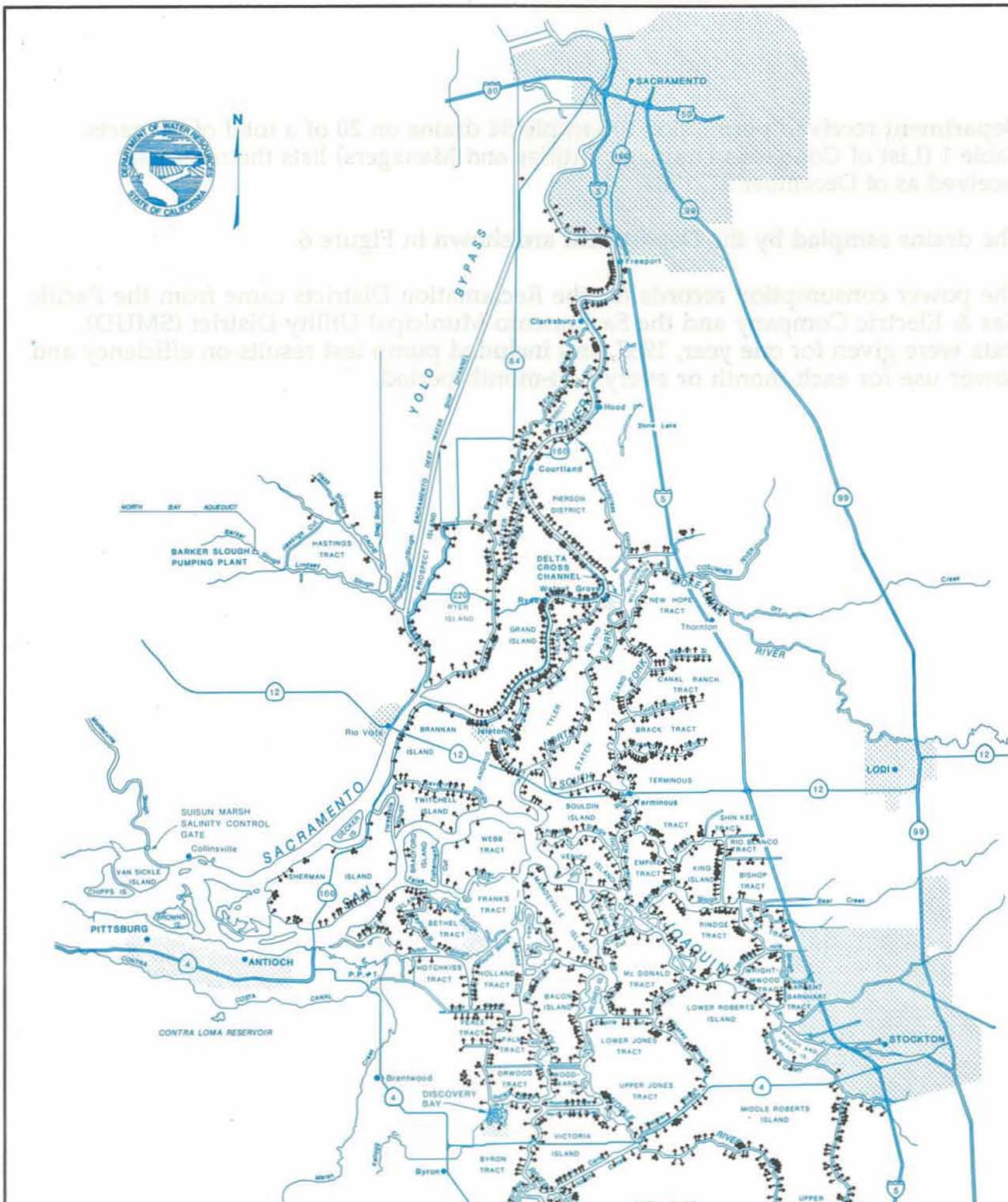
This study focused on the Delta Lowlands. An extensive effort was made to locate both irrigation water intakes (siphons) and agricultural drains. Topographic maps and navigation charts were examined and field crews were sent to confirm the size and locations of the siphons and pump stations. Approximately 2,200 siphons and 260 agricultural drains were located and identified by Department staff. Documentation for each visited site was compiled for later use by field staff. Figures 5 (Irrigation Diversions) and 6 (Agricultural Drainage Return Points) show the locations of irrigation water diversions and agricultural drainages in the Delta, respectively.

It is the Department's policy to work on private lands only after receiving permission from the landowner or land manager. Therefore, letters requesting permission to sample the 260 drains and to procure power consumption records for pump stations were sent to the Reclamation Districts that managed the drains. The

Department received permission to sample 54 drains on 20 of a total of 51 tracts. Table 1 (List of Contacted Drainage Entities and Managers) lists the responses received as of December 31, 1987.

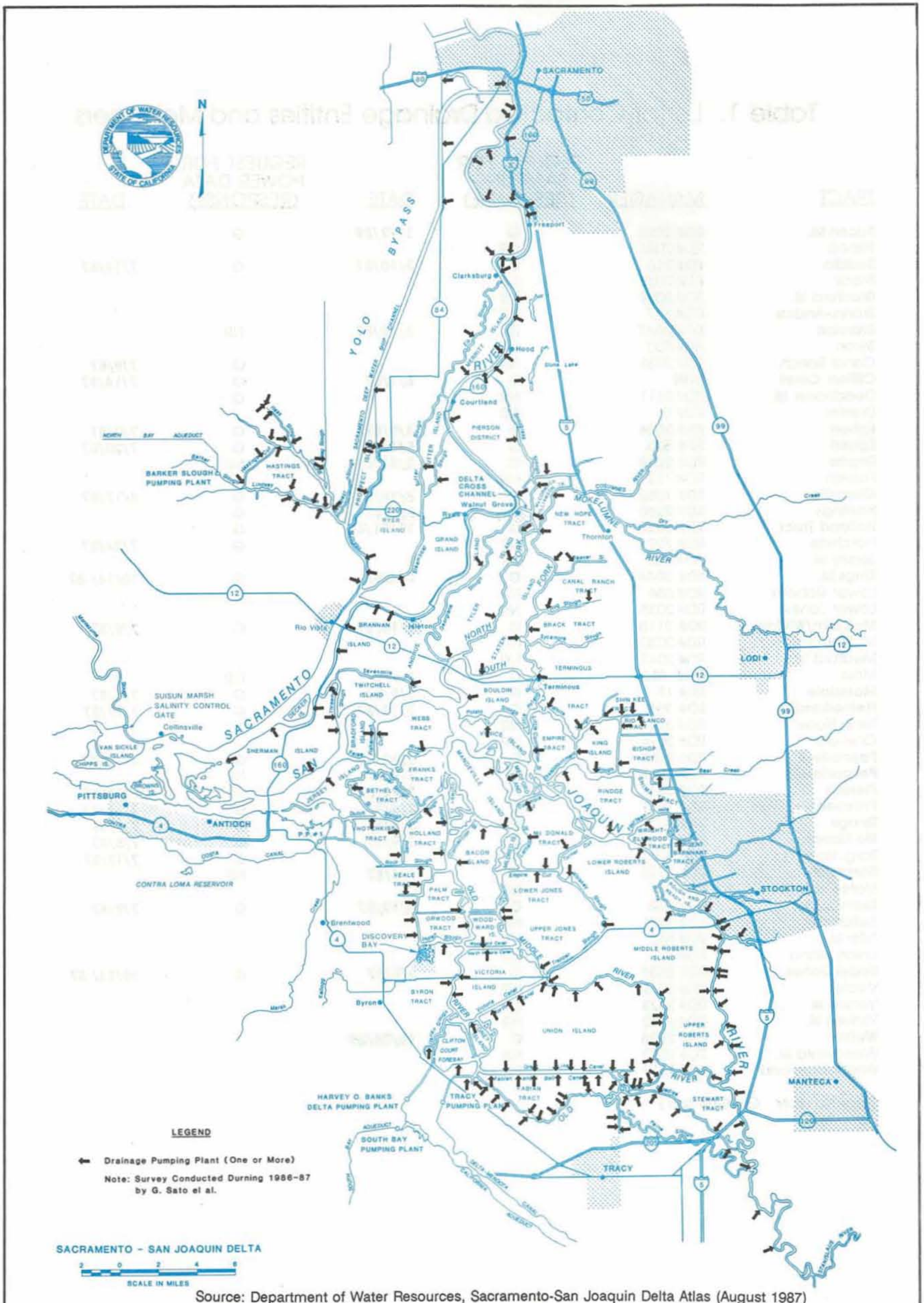
The drains sampled by the Department are shown in Figure 6.

The power consumption records for the Reclamation Districts came from the Pacific Gas & Electric Company and the Sacramento Municipal Utility District (SMUD). Data were given for one year, 1987, and included pump test results on efficiency and power use for each month or every two-month period.



Source: Department of Water Resources, Sacramento-San Joaquin Delta Atlas (August 1987)

Figure 5. Irrigation Diversions



Source: Department of Water Resources, Sacramento-San Joaquin Delta Atlas (August 1987)

Figure 6. Agricultural Drainage Return Points

Table 1. List of Contacted Drainage Entities and Managers

TRACT	MANAGER	REQUEST FOR SAMPLING (RESPONSE)	DATE	REQUEST FOR POWER DATA (RESPONSE)	DATE
Bacon Isl.	RD# 2028	G	11/2/89	G	
Bishop	RD# 2042	NR			
Bouldin	RD# 756	G	3/10/87	G	7/14/87
Brack	RD# 2033	NR			
Bradford Isl.	RD# 2059	NR			
Brann.-Andrus	RD# 317	NR			
Brannan	RD# 2067	G	3/12/87	NR	
Byron	RD# 800	NR			
Canal Ranch	RD# 2086	NR		G	7/9/87
Clifton Court	DWR	G	6/1/87	G	7/14/87
Deadhorse Isl.	RD# 2111	NR		G	
Drexler	RD# 0	NR			
Egbert	RD# 2084	G	3/9/87	G	7/9/87
Egbert	RD# 536	G	5/1/87	G	7/20/87
Empire	RD# 2029	G	3/31/87	NR	
Fabian	RD# 773	NR			
Glanville	RD# 1002	G	8/19/87	G	8/17/87
Hastings	RD# 2060	G	8/1/87	G	
Holland Tract	RD# 2025	G	10/31/89	G	
Hotchkiss	RD# 799	NR		G	7/24/87
Jersey Isl.	RD# 830	NR			
Kings Isl.	RD# 2044	G	3/6/87	G	10/14/ 87
Lower Roberts	RD# 684	NR			
Lower Jones	RD# 2038	NR			
McCorm/William	RD# 2110	G	3/16/87	G	7/8/87
McDonald	RD# 2030	NR			
Medford Isl.	RD# 2041	NR			
Moss	RD# 404	G	3/7/87	NR	
Mossdale	RD# 17	G	3/9/87	G	7/8/87
Netherlands	RD# 999	G	3/12/87	G	7/17/87
New Hope	RD# 348	NR			
Orwood	RD# 2024	NR			
Pescadero	RD# 2095	G	3/12/87	G	8/18/87
Pescadero	RD# 2058	G	4/9/87	NR	
Pierson	RD# 551	G	3/12/87	G	7/17/87
Prospect	RD# 1667	G	3/5/87	G	7/15/87
Rindge	RD# 2037	G	3/9/87	G	7/9/87
Rio Blanco	RD# 2114	G	3/9/87	G	7/8/87
Sarg.-Barnhart	RD# 2074	NR		G	7/17/87
Shima PP	RD# 2115	G	3/6/87	NR	
Staten Isl.	RD# 38	NR			
Terminous	RD# 548	G	3/19/87	G	7/9/87
Twitchell Isl.	RD# 1601	NR			
Tyler Isl.	RD# 563	NR			
Union Island	RD# 1	NR			
Upper Jones	RD# 2039	G	3/5/87	G	10/13/ 87
Veale	RD# 2065	NR			
Venice Isl.	RD# 2023	NR			
Victoria Isl.	RD# 2040	NR			
Webb	RD# 2026	G	10/26/89		
Woodward Isl.	RD# 2072	NR			
Wright-Elmwood	RD# 2119	NR			

(NR = No reply G = Granted)

Sampling Frequency

Initially, quarterly sampling was planned for each site. Sampling began in March 1987 at the 54 drains for which permission was obtained. Water samples were analyzed for minerals, selenium, Dissolved Organic Carbon (DOC), and Total Trihalomethane Formation Potential (TTHMFP). Standard field measurements of temperature, dissolved oxygen, pH, and electrical conductivity were also performed on site.

In August 1987, a decision was made to increase the sampling frequency at the available DIDI sites from the original four times per year to six times per year. The increased sampling frequency was intended to partially compensate for the smaller number of drainages sampled than planned, and to study the impacts of the dry weather conditions which began in 1987.

The program was further modified in August 1988 to include more frequent sampling during the months of June to July and November to January because of the summer and winter peak discharges of agricultural drainage.

The advisory committee suggested more frequent monitoring of drainage from two Delta tracts and their surrounding channels. Bouldin Island and Upper Jones Tract were selected because they might serve as good representatives of the northern and southern areas of the Delta, respectively. Samples were collected weekly during two 4-week periods that fell within the summer and winter peak drainage periods. The remaining drainage stations in the program continued to be sampled every two months.

In July 1989 DWR staff conducted a synoptic survey along the major channels where Sacramento and San Joaquin river water flowed toward the State and Federal water project intakes. This activity was repeated in January 1990. The channel stations are shown in Figure 7. The data provided water quality and flow mixing information across some parts of the Delta.

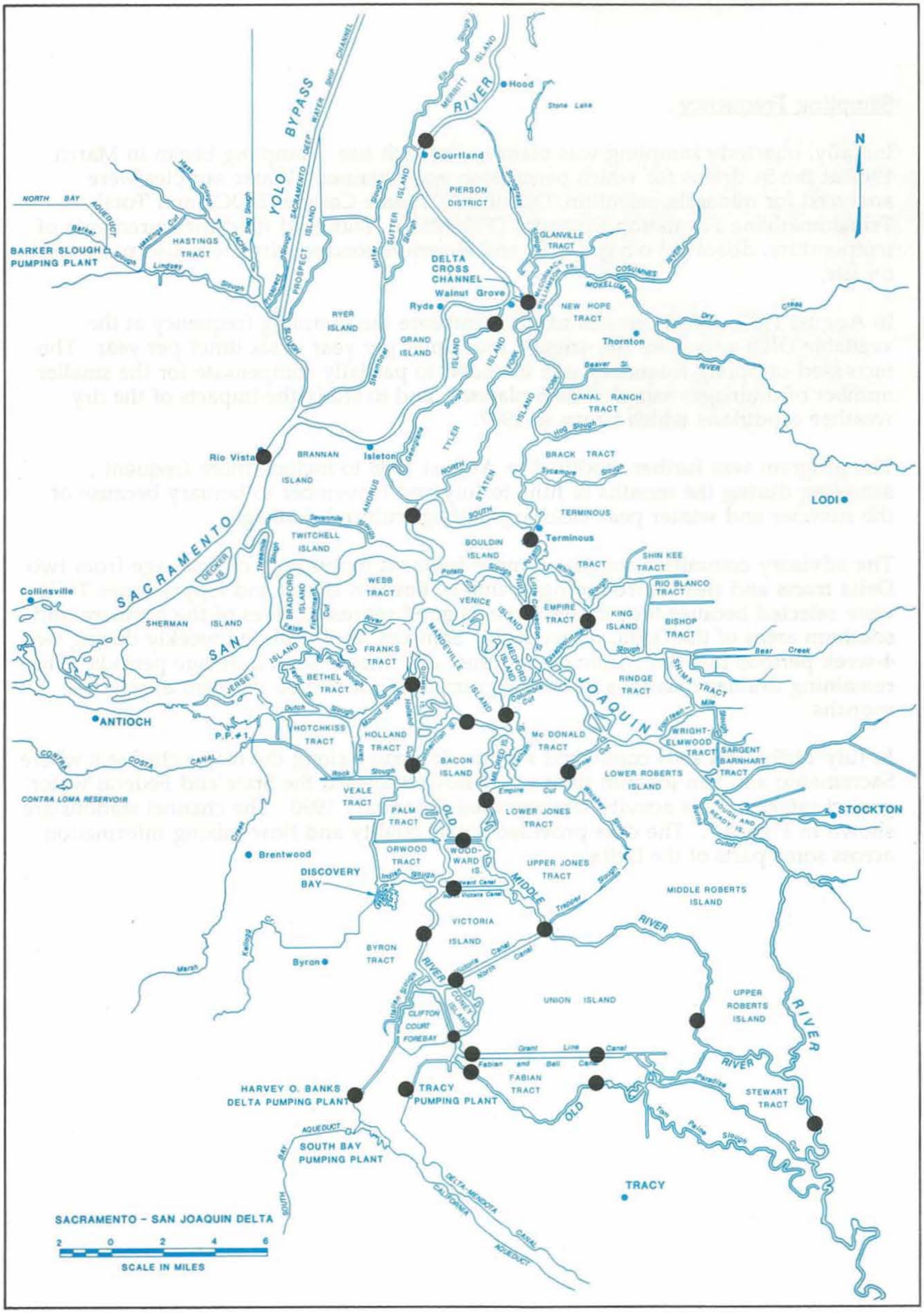


Figure 7. Deltawide Channel Survey, July 25, 1989

Laboratory Analyses

TTHMFP and TOC samples were analyzed by ENSECO-CAL Analytical Labs between July 1987 and December 1988, and between May and June 1989. DWR Bryte Lab performed the TTHMFP and TOC analyses between January and April 1988 and August 1989 to present. Pace Laboratories performed TTHMFP in July 1989. Except as noted, other constituents were analyzed at the Department's Bryte Laboratory.

In 1981 DWR developed a raw water TTHMFP test to compare the relative maximum concentrations of THM precursors in Delta waters prior to water treatment. It is one of many types of measurements used to study the quality of different sources and types of water.

This raw water TTHMFP test requires a high dose of chlorine to meet the "chlorine demand" of suspended and organic material in the samples and to maintain a chlorine residual during the holding period after adding chlorine to the sample. While the chlorine dosage and holding time may not reflect the THM concentration of a treated water sample, the Technical Advisory Group members of IDHAMP, which include water quality engineers and chemists from major water utilities and the State Department of Health Services, found the procedure acceptable for the purposes of comparing the relative levels of THM precursors in Delta waters.

Comparisons of the raw water TTHMFP to those THM concentrations in treated water have led to a multitude of correlations. The numerous correlations are a function of the unique design and operating characteristics of individual water treatment plants. These differences go far beyond the use of specific disinfection chemicals and holding times. There are differences in the operating efficiencies to reduce suspended material prior to chlorination as well as in the characteristics of the raw water quality. This, thereby, affects the chlorine demand and resulting concentrations of disinfection by products that are formed. Therefore, there is no single relationship that can be modeled for all raw water and treated water TTHMFP. The data does, however, show that there is some type of proportional relationship between raw water TTHMFP and that of treated water.

Reductions in the THM formation potential of untreated water will generally result in lowered production of THMs and other DBPs (disinfection by products) in treated drinking water.

Upon arrival at the laboratories, the TTHMFP samples were spiked with a dosage of 120 mg/L of chlorine, a concentration sufficiently high to meet the highest chlorine demand and maintain a chlorine residual after incubation for seven days at 25°C. Earlier DWR results showed this high dose was necessary for meeting the exceptionally high chlorine demand in agricultural drain water samples. After incubation, the samples were quenched with sodium thiosulfate and analyzed using a gas chromatograph, with periodic confirmation by means of gas chromatograph-mass spectrometer. ENSECO-CAL Laboratory and the DWR Bryte Lab followed EPA Methods 601 and 502.1 for total trihalomethane formation potential (TTHMFP) analyses.

Unless specified elsewhere in this report, the TOC analyses were on filtered samples (0.45 μ pore size). Therefore, these were DOC (dissolved organic carbon) results.

Pesticides were analyzed according to standard EPA procedures. All other constituents were analyzed according to the latest edition of "Standard Methods for the Examination of Water and Wastewater." These procedures are summarized in Appendix E of "The Delta As A Source of Drinking Water, Monitoring Results, 1983 to 1987," published by DWR, August 1989. The results of duplicate and spiked samples for pesticides and THMFP analyses are described in the Appendix.

III. Results

The study is currently collecting data to: (1) characterize the quality of drain water and volume of discharge to the Delta and (2) estimate their impact on water quality in the channels and at drinking water supply intakes. As this work is completed, the impacts from other sources (e.g. bay water, San Joaquin River) will be compared.

Our observations have helped develop a series of working hypotheses about the water quality (e.g. pesticides, TTHMFP) in drains and channels in some segments of the Delta.

Figure 8 illustrates the exchanges of water on a typical Delta island during the growing season. Irrigation water is siphoned from the adjacent channels into ditches about 10 feet wide. These ditches parallel the levee about 100 feet inside the inner toe and then discharge into lateral ditches 4 feet wide that divide the island into checks ranging in size from 20 to 50 acres. The water then flows from these laterals into smaller temporary spud ditches, about 10 inches wide and about 20 inches deep, which parallel the crop rows at intervals of 50 feet to 100 feet. Rainfall also contributes to irrigation. Some of this water is lost to evaporation and transpiration (ET) by growing crops and the remainder percolates through the soils to the deeper island drainages. Water also enters and leaves the islands as underground seepage. Drain water collects into open drainage ditches (6 feet to 10 feet deep) downslope of the irrigated fields. Drainage is then periodically pumped out into the channels. The drainage pump motors are electrically driven and automatically activated by float switches that operate the pumps whenever drainage reaches a certain water level at the base of the pump station platform, which sits above the drain terminus.

The magnitude of these exchanges will vary with season and hydrology. For example, rainfall contribution is insignificant during the summer and ET minimal during the winter. The annual drainage discharge cyle has two peaks and two troughs. During the growing season, drainage volumes reflect the degree of irrigation. The peak drainage period is during the summer, typically July. As irrigation decreases and crops are harvested, drainage volumes become less as the summer ends and fall begins. Drainage volume begins to increase in December through the following February as farmers flood the fields to leach out accumulated salts in the soil. This flooding is necessary to prevent crop damage and to prevent loss of crop yield. The winter peak drainage time is typically mid-January. Depending on weather conditions and seasonal hydrology, the peak summer and winter drainage months may be a few weeks earlier or later. In the late winter, drainage is again low but will increase as spring irrigation begins.

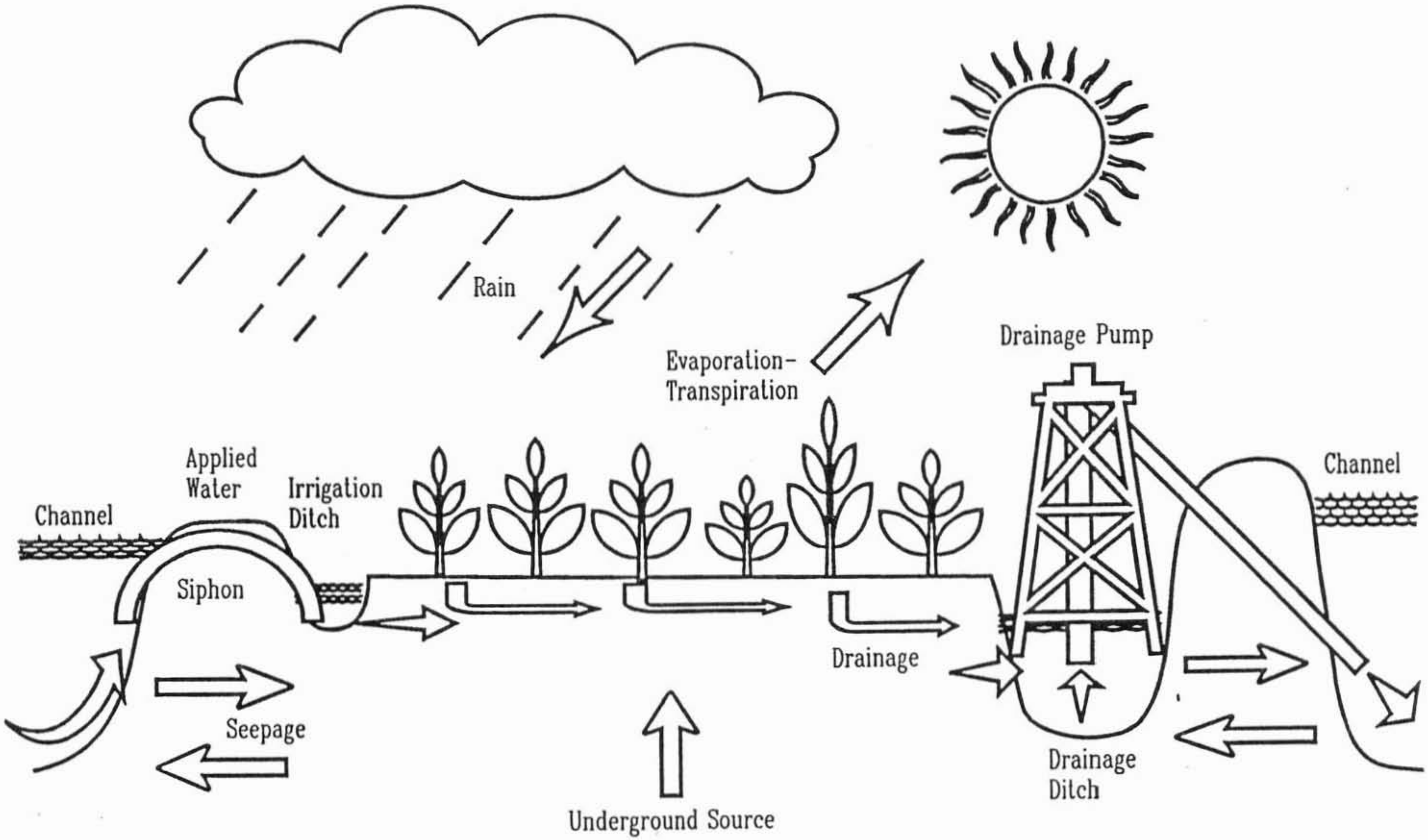


Figure 8. Typical Delta Island Water Exchange

A. Literature Review

Initial activities focused on compiling and reviewing reports from earlier DWR studies on agricultural drainages in the Delta. The most informative report was DWR Report No. 4 "Investigation of Sacramento-San Joaquin Delta Quantity and Quality of Water Applied To and Drained From Delta Lowlands." This study conducted in 1954-55 examined the quantity and quality of applied irrigation water and of agricultural drainage on a combined field and computed basis.

The study area and study subunits (groups of tracts and islands) are shown in Figure 9. Tracts within each study unit are presented in Table 2.

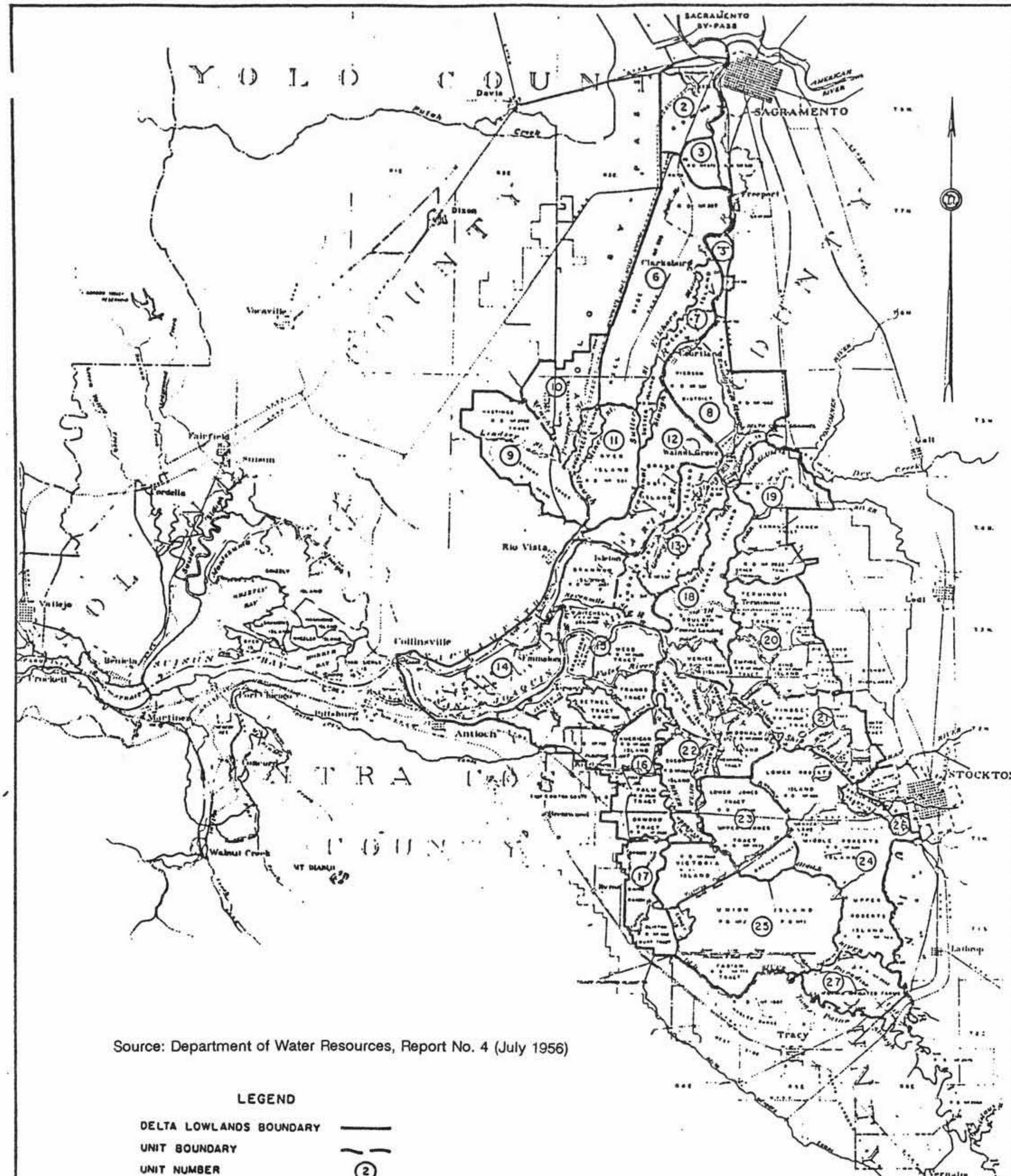


Figure 9. Subdivision Units of the Delta 1955

DEPARTMENT OF WATER RESOURCES

Table 2. Delta Study Units, DWR Report No. 4

Unit	Tract or Island or Reclamation District
2	RD 900 West Sacramento
3	RD 673
6	RD 307
7	Sutter and Merritt
8	Pierson, McCormick, and Glanville
9	Hastings and Egbert
10	Liberty
11	Ryer and Prospect
12	Grand
13	Twitchell, Brannon, Andrus, Tyler
14	Sherman
15	Bradford, Webb, Bethel, Franks, and Jersey
16	Orwood, Palm, Holland, Hotchkiss, and Quimby
17	Byron and Clifton
18	Staten, Bouldin, and Venice
19	Bract, Canal Ranch, and New Hope
20	Empire, King, Terminous
21	Bacon, Mandeville, McDonald, Mildred, and Medford
23	Upper and Lower Jones and Dressler
24	Lower, Middle, and Upper Roberts
25	Union, Fabian, Woodward, and Victoria
26	Rough and Ready Island and part of Middle Roberts
27	California Irrigated Farms (Stewart and Pescadero)

The 1954-55 study defined the Delta Lowlands to cover a land and water area of about 469,000 acres of which about 374,000 acres were developed for agricultural purposes and which about 292,000 acres were irrigated in 1955. Within the Lowland areas developed
for agricultural purposes, 33% (121,000 acres) have a north mineral soil type, 16% (61,000 acres) a south mineral type, and 51% (192,000 acres) a middle organic type.

The soils of the Delta margin are mainly mineral in character with variable admixtures of organic matter. The mineral soils were developed from valley plain materials and for the most part represent a transition between organic soils of the flat and depressed river delta basin and the better drained soils of the alluvial fans and valley floor.

The organic soils are derived from the extensive marshland vegetation that once occupied the Delta basin. A century and a half ago, the Delta was a vast tule march. Dense stands of the great bulrush, or tule (*Scirpus lacustris*) occupied the center of each island, where shallow water covered the surface most of the year (USDA, 1941). The organic content of peat soils is 50% to 80%. Areas with intermediate organic soils will have 10% to 50% organic matter and mineral soils about 10% or less.

The organic soils occupy a larger aggregate acreage (about 250,000 acres) than the mineral soil areas. Most of the central Delta has Staten and Venice peaty muck soil that have 60% to 70% organic matter. Most areas that have the intermediate organic type soils (Ryde silty clay loam) will have 30% to 50% organic matter.

DWR Report 4 (1956) was used to identify the magnitude of drainage volume on a Delta-wide basis and to determine drainage patterns associated with crop acreages, island soil types, and specific islands and tracts. The report showed that summer drainage volume was highest in July, August and winter volume highest during December, January. There was no information on TTHMFP concentrations as THM was not a water quality issue at that time. The conclusion of this report with respect to drainage impacts on salts in Delta waters was:

> *"... that agricultural practices within the Delta Lowlands during the summer, when the problem of water quality there is most critical, do not degrade good quality Sacramento River water as it moves through the Delta to the Tracy Pumping Plant but rather enhances its quality by removing a portion of its salt content. In the winter months, when the accumulated surplus salts are discharged to the channels, there is usually sufficient surplus flow through the Delta to dilute and to carry out to the ocean the leached salts. However, it should be noted that the preceding statement applied to conditions as of 1954-55. Any additional upstream regulation of a dry year, such as 1924 or 1931, will decrease winter flows through the Delta to the extent that leached salts may not be completely removed from the area."*

In 1964, the Department re-examined the qualities and quantities of agricultural drainage in the Delta. The field study, however, was selective rather than exhaustive, and ran from July through November. Figure 10 shows the location of the study's sampling stations and soil types in the Delta. Only 7 percent of the 200 pump stations in the Delta were sampled but they accounted for 20 percent (73,400 acres) of the irrigated land (367,000 acres). The findings are reported in DWR Bulletin No. 123 "Delta and Suisun Bay Water Quality Investigation" (August 1967). As found in DWR Report No. 4, drain flows, computed from power meter readings, indicated that more water per acre was drained from organic soils than mineral soils. They also noted that:

> *"Conditions of pumping from the drains varied from intermittent pumping on Grand Island, composed mostly of mineral soils, to constant and high rate pumping on Staten Island, composed almost entirely of organic peaty soils...When consumptive use is high, during July and August, the drainage is primarily tailwater. In the winter, salts are leached out of the soils and the dissolved minerals reach a maximum...Seasonal concentrations of TDS, Cl, and N during 1964 appear reasonably consistent and indicate that the poorest quality water was discharged during the winter months...Examination of the data shows that drainage waters discharged in the south-eastern Delta were of poorest quality."*

As with the 1954 study, there was no information on TTHMFP.

Source: Department of Water Resources, Bulletin No. 123 (August 1967)

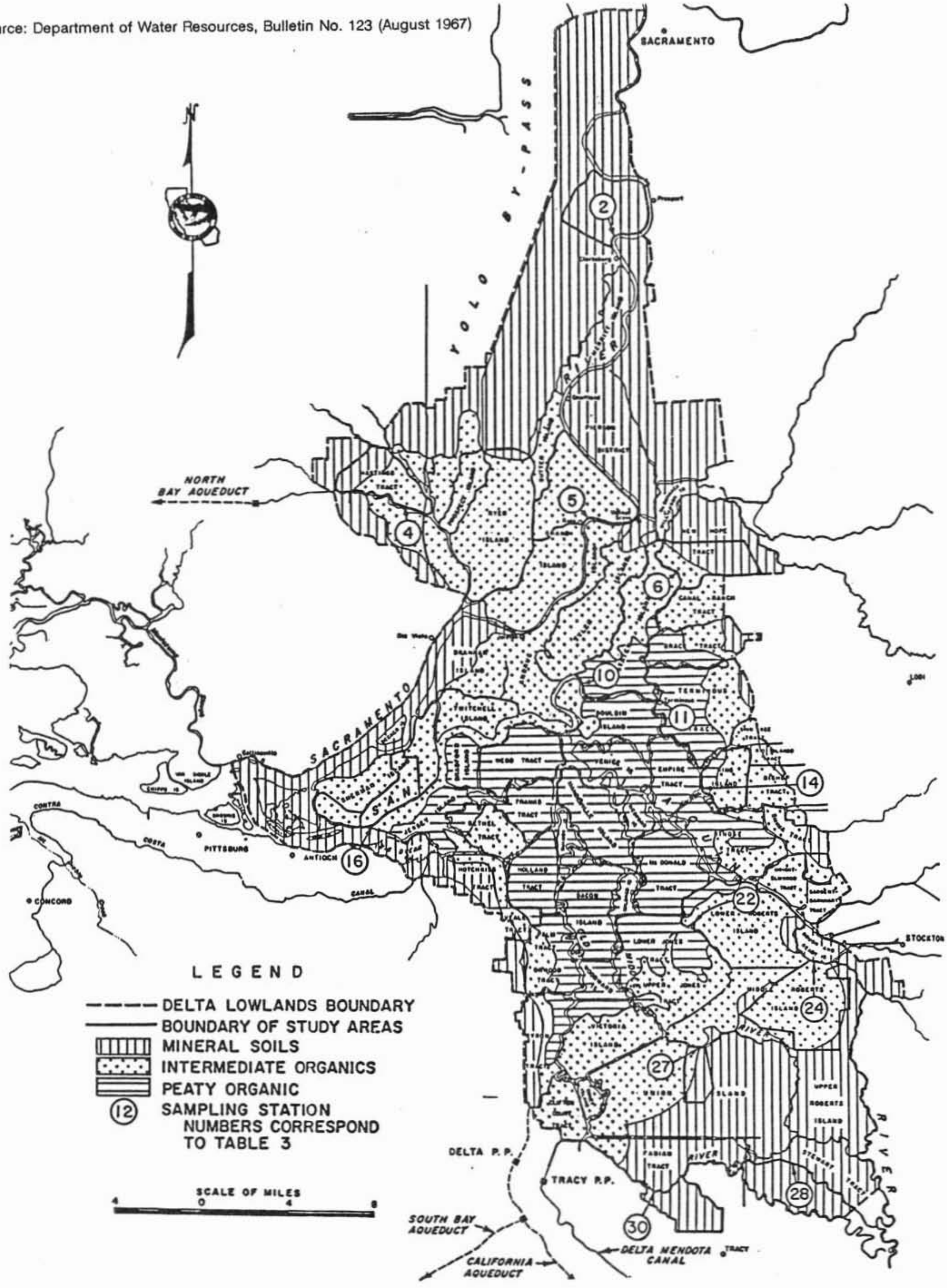


Figure 10 . Composition and Distribution of Soils in the Sacramento-San Joaquin Delta Lowlands

B. Drainage Water Quality

1. Pesticide Survey

From July 18 to July 22, 1988, 30 drains were sampled for pesticides. The list of pesticides to be analyzed by the laboratory was based on the selection scheme used in the Department's Interagency Delta Health Aspects Monitoring Program (IDHAMP).

Recognizing the cost and technical limitations associated with analyzing water samples for all pesticide contaminants, a selection procedure was developed to identify those pesticides with the most likelihood of being present at a particular sampling site and time period in the Delta. Pesticide use data compiled by the State Department of Food and Agriculture were evaluated to determine quantities used and time of application. The list of pesticides with the highest reported use was further reviewed to delete those that were insoluble in water and, therefore, would not appear in water samples but rather sediment and biota.

The final target list of 26 chemicals for monitoring represented those pesticides that had the higher probability of being detectable in Delta waters if present as a contaminant in the summer. To water treatment and distribution entities, these water soluble compounds pose difficulties in removal when compared to insoluble contaminants that can be removed by flocculation, coagulation, or filtration processes during treatment.

Sampling was conducted in July because it is the peak month of farm pest control chemical applications and peak summer drainage discharge month. Therefore, sampling in July would enable a higher likelihood of detecting pesticide residues in the island drainages.

Detailed steps of the selection scheme are reported in the IDHAMP reports.

Six pesticides were found above the analytical limit of detection in one or more of the drain water samples. The pesticides were atrazine, bentazon, carbaryl, methamidophos, ordram, and simazine.

One or more of the six detected pesticides were detected in thirteen of the drains. Atrazine was detected in drains on Bouldin, Kings, Pierson, Terminous, and Upper Egbert Islands. Bentazon and ordram were detected in Colusa Drain. Carbaryl was detected in a Egbert Island Drain. Methamidophos was detected on Upper Egbert Island. Simazine was detected in drains on Mossdale and Upper Egbert Islands and Shima Tract. In all cases, the levels found were below existing drinking water standards or action levels established by the California Department of Health Services. Table 3 summarizes the pesticide data compared to drinking water criteria. Since 30 drains are a small proportion of the 260 drains in the Delta, it is premature to conclude that similar results would be seen at all drainages. The detection of pesticides in water is also highly dependent on timing. Water samples collected on a single day of the year do not necessarily reflect pesticide concentrations during the rest of the year. Further sampling would confirm whether pesticide regulations and farming practices have effectively reduced the threat of serious contamination to the Bay-Delta environment.

Since this study focused only on drinking water quality concerns, we did not sample sediment or biota for pesticide analyses. Therefore, ecological concerns about pesticides are not addressed.

Table 3. Pesticide Monitoring Results
July 18-22, 1988
(ug/L)

STA. NAME	EC (uS/cm)	2,4-D	Alachlor	Atrazine	Bentazon	Bolero	Captan	Carbaryl	Carbofuran	Dacthal	Dicofol	Dinoseb	Diazinon	Ethyl Parathion	Methyl Parathion	MCPA	Methamidophos	Nudrin	Ordram	Orthene	Paraquat	Proparagite	Propanil	Propham	Simazine	Triforine	Ziram
BOULDIN1	178	--	--	0.60	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BOULDIN2	202	--	--	0.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BRANNANPP03	1010	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BRANNANPP04	579	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
COLUSA	554	--	--	--	2.5	--	--	--	--	--	--	--	--	--	--	--	--	--	0.76	--	--	--	--	--	--	--	--
EGBERTPP01	297	--	--	--	--	--	--	8.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
KINGISPP01	439	--	--	0.13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
KINGISPP02	652	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MCCORWIL01	166	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MOSSDALE01	1000	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MOSSDALE04	1120	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.1	--	--
MOSSDALE10	992	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.1	--	--
MOSSDALE11	1080	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.3	--	--
NETHERLAND01	222	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NETHERLAND02	206	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PESCADERO01	1280	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PESCADERO02	1560	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PESCADERO03	1850	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PESCADERO04	1890	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PIERSONPP01	268	--	--	0.34	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PROSPECTPP01	183	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RINDGEPP02	870	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RIOBLANCO01	739	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SHIMATR	577	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.2	--	--
TERMPP01	425	--	--	0.41	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TERMPP02	542	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
UPEGBERTPP01	344	--	--	0.91	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
UPEGBERTPP02	277	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
UPEGBERTPP03	331	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.6	--	--	--	--	--	--	--	8.4	--	--
UPJONESPP02	860	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Note: All other values (--) below reporting limit.

2. TTHMFP

a. Monthly Concentrations

Drains in this study were generally high in TTHMFP, as compared to water in the Delta channels. Although concentrations at any given site varied with time, they tended to fall within characteristic concentration ranges at a given drain and time of year. Overall, TTHMFP ranged from a high of 5100 µg/L in May 1987 on Egbert to a low of only 100 µg/L in October 1987 on McCormick-Williamson tract.

The range of drainage TTHMFP concentrations by calendar month is shown in Table 4. The full station names and locations of the sampled drainages are listed in the Appendix. When a range of values for a specific month (e.g., AGDEMPIRE January) appear, it is the result of combined data for 1987 and 1988 and/or reflects multiple samples having been taken in some months. The ranges indicate the magnitude of concentrations and show that changes in TTHMFP such as in the winter (December-February) will vary with the stages of flooding and draining operations on the islands. All observations are reported in the Appendix. With few exceptions, TTHMFP observations from multiple drainages of the same island are within the same range of values.

Monthly differences among the multiple drainages for the same island are thought to be due to the extent of irrigation. For example, DWR sampling crew observed farmers alternating the areas being flooded during the winter. In areas where flooded fields were being drained, the power consumption was higher for the pump stations than at pump stations that were inactive in unflooded and undrained field areas on the same island. Therefore, drainage water quality and volume probably reflected what stage of activity (e.g., initial flooding, holding, draining) was occurring on the area drained by the individual pump stations. For example, during a holding period (ponding), there was less variability in TTHMFP. However, if sampling occurred during the stage of flooding or draining the fields, the observations were more variable and reflected these stages.

Most of the drains sampled to date lie along the periphery of the Delta. The northern, eastern, and southern edges of the Delta are covered. We have not yet collected data in the central region nearest to the State and Federal water project intakes and the Contra Costa Water District intake. Recently (December 1989), written permission was granted to sample on Webb and Holland Tracts, and Bacon Island.

Table 4. Monthly Range of TTHMFP Concentrations, 1987-88
Units in micrograms per liter

STATION	JAN	FEB	APR	MAY	JUN	AUG	SEP	OCT	NOV	DEC
AGDEMPIRE	3600-4300	2300-4000	2100-4800	2700-4400	1100-4300	3400-3700	2700-2800	1600-2200	1400-1500	2500-2900
AGDGRAND	2400-2600	2200	980-1500	790-1100	860-1400	750-760	1200-1300	860-1200	950-2500	1700-1900
AGTYLER			1400		1100					
BOULDIN1	1600-2900	1600		1100		750-2100		2000		1700-3300
BOULDIN2	1600-3300	1600		2300		900-3700		1800		2800-3100
BRANNANPP01	2200-2700			2400		1300		1000		1900
BRANNANPP02	1200-2100			1800		1900		370		620
BRANNANPP03	1600-2400			980		1600		160		
BRANNANPP04	2200-3100			1300		950		1700		2000
CLIFTONCT	1000			2000						
EGBERTPP01	890-2100			3400		1300		1700		
EGBERTPP02	1300-2400			5100				3600		
KINGISPP01	1000	480		1200		2400		830		1200
KINGISPP02	1500	660		1500		2200		800		1700
KINGISPP03	1400	900		1800		2600		1400		2000
MCCORWIL01	410			660-720		410		1100		
MCCORWIL02	320			670		390		100		
MOSSDALE01*	300			460		990		230		
MOSSDALE02*	300-320			650		670				
MOSSDALE03*						1300				
MOSSDALE04*	750			970		1100		880		
MOSSDALE05*						1100				
MOSSDALE06*						2500				
MOSSDALE08*						820		700		
MOSSDALE09*						1400		560		
MOSSDALE10*	1500			1200		890		480		
MOSSDALE11*	560			1700		770				
MOSSTRPP02*	640-870			990		400		760		
MOSSTRPP03*	930			1100		730		590		
NETHERLAND01	380-900			490		690		220		
NETHERLAND02	350-900			450		880		360		
PESCADERO01	930		430	580		1500		530		
PESCADERO02	770		470			1500		550		
PESCADERO03	770		660	840		1100		630		
PIERSONPP01	940-2600			1700		640		680		
PROSPECTPP01	2000			640		650		1100		
RINDGEPP01	3100	1200		2500		2800		1100		2000
RINDGEPP02	2200	1200		2100		2000		1100		2000
RIOBLANCO01	720	410		750		620		710		610
RIOBLANCO02	720	370		870		690		710		500
SHIMATR	490	430		1000		960		870		820
TERMPP01	1300-2400			1600		1400		490		2700
TERMPP02	1500-1900			1700		990				1300
UPEGBERTPP01	540			2100		1400		960		
UPEGBERTPP02	340			860		1000		730		
UPEGBERTPP03	600			2400		1000		1600		
UPJONESPP02	670-1700	810		1400		590-1400		950		1200-1600

* Moss Tract is now a golf course. Mossdale Tract is being converted from agriculture to residential uses. Drainage volumes observed during the period of record were very small. Both of these tracts lie outside the Delta Lowlands and have been dropped from the study.

b. Soil Type Relationships

The expected maximum range of TTHMFP concentrations for sampled islands was estimated for the summer and winter peak drainage periods, respectively. Data for August were used to estimate the summer month concentrations. January data were used to estimate the winter flooding TTHMFP levels. These two months had the most data on drainages during the summer and winter peak drainage periods.

When TTHMFP data were not available, the assumption was made that concentrations observed at a sampled drain were representative of the unsampled drains on the same island. This assumption was based on the uniform soil types reported for the sampled islands or tracts. Additional data collection is needed to enable these assumptions to be further tested and revised. Three TTHMFP concentration ranges were plotted to determine if there were any geographic pattern associated with the TTHMFP concentrations. The ranges were: (1) less than 1000 μg/L, (2) between 1000 and 2000 μg/L, and (3) greater than 2000 μg/L. The range of values assigned to each sampled island were based on the values reported for August and January observations. Maximum values rather than the averages or average of maximum values for an island or tract were used when there were more than one observation.

The August TTHMFP distribution clearly showed a relationship to the soil composition of the Delta for the islands sampled (Figures 10 and 11). Drainages on islands and tracts overlying mineral soils had less than 1000 μg/L TTHMFP. Areas with intermediate organic soils had expected TTHMFP concentrations ranging from 1000 to 2000 μg/L. The highest TTHMFP concentrations (greater than 2000 μg/L) were observed from islands and tracts overlying peaty organic soils. TTHMFP in the 3000 μg/L to 4000 μg/L range were observed in drainwater samples from Empire Tract and Bouldin Island. However, these high values are in part due to bromides in connate water in that particular region of the Delta (Figure 11).

During January when fields are being flooded or drained from winter leaching, the highest observed TTHMFP concentrations in the drains were mostly over 1000 μg/L for the islands that were sampled (Figure 12). Drainage from intermediate organic soil and peaty organic soils typically had more than 2000 μg/L TTHMFP, as did drainage from northern mineral soil areas. Southern mineral soil areas had drainage below 1000 μg/L. In most cases, the January maximum TTHMFP concentrations were higher than those observed in August for the same drain. For example, the respective August and January maximum TTHMFP were 3700 and 4300 μg/L for Empire Tract (AGDEMPIRE), 2900 and 3100 μg/L for Bouldin Island (average of maximums at BOULDIN1 and BOULDIN2), 1215 and 2150 μg/L at Terminous Tract (average of maximums at TERMPP01 and TERMPP02), 1440 and 2600 μg/L at Brannan Island (average of maximums at BRANNANPP01-4), 760 and 2600 μg/L at Grand Island (AGDGRAND), and 1400 and 1700 μg/L at Upper Jones Tract (UPJONESPP02).

Figure 13 graphically shows the August and January ranges of TTHMFP at some drainages from peat, intermediate organic, and mineral soil islands or tracts. At some drainages (e.g. King and Upper Egbert), the January observations were lower than that of August. This may have been attributed to sampling late after these islands were leached or there was no leaching performed that winter. The figure demonstrates the earlier conclusion that it is difficult to assign a single expected TTHMFP value to an area. The use of ranges of TTHMFP concentrations over a specific time period is a more reasonable approach in describing the TTHMFP of a drainage.

Data from previously unsampled tracts and islands are needed to confirm the relationship between soil and TTHMFP concentrations observed thus far. Variations may occur because of non-uniform soil type on some islands or proximity to bay water influences. Islands near the western tip of the Delta may have higher TTHMFP because of bromides in bay-fresh water mixtures used for irrigation during the dry summer. Other islands such as Empire Tract have connate water that is high in salts including bromide as seen by brominated THM concentrations. Islands in the central Delta may have the greatest influence on the water quality of Delta exports.

In 1981 DWR collected soils along the alignment of the proposed Peripheral Canal project (DWR, 1982). Filtered soil extracts from composited mineral soils collected along the northern alignment and composited peat soils collected along the southern alignment were analyzed for TTHMFP. The soil samples were taken 0.6 meters below the surface with a core sampler. The extracts from the composited mineral soils had 27,000 µg/kg TTHMFP and the composited peat soils had 61,000 µg/kg TTHMFP. The TTHMFP in both composited sample extracts was comprised of chloroform with no measurable brominated THM compounds. The soil extract data may, therefore, explain the soil type relationship with drainage TTHMFP being observed during high irrigation months (summer irrigation and winter flooding to remove salts).

The island drains are open ditches that are dug to a depth of 6 feet to 10 feet on most Lowland areas. These drains collect water percolating through the soils. By design, surface runoff is not commonly channeled into these drains. The chemistry of the drainwater therefore reflects the water coming in contact with salts and organic matter in these soils (e.g. leaching, ion exchange, reactions).

Additional soil sampling at depth is planned for 1990 to further examine differences among regions of the Delta. More drainage sampling on other islands is needed to confirm the observed relationship between TTHMFP and soil type classification.

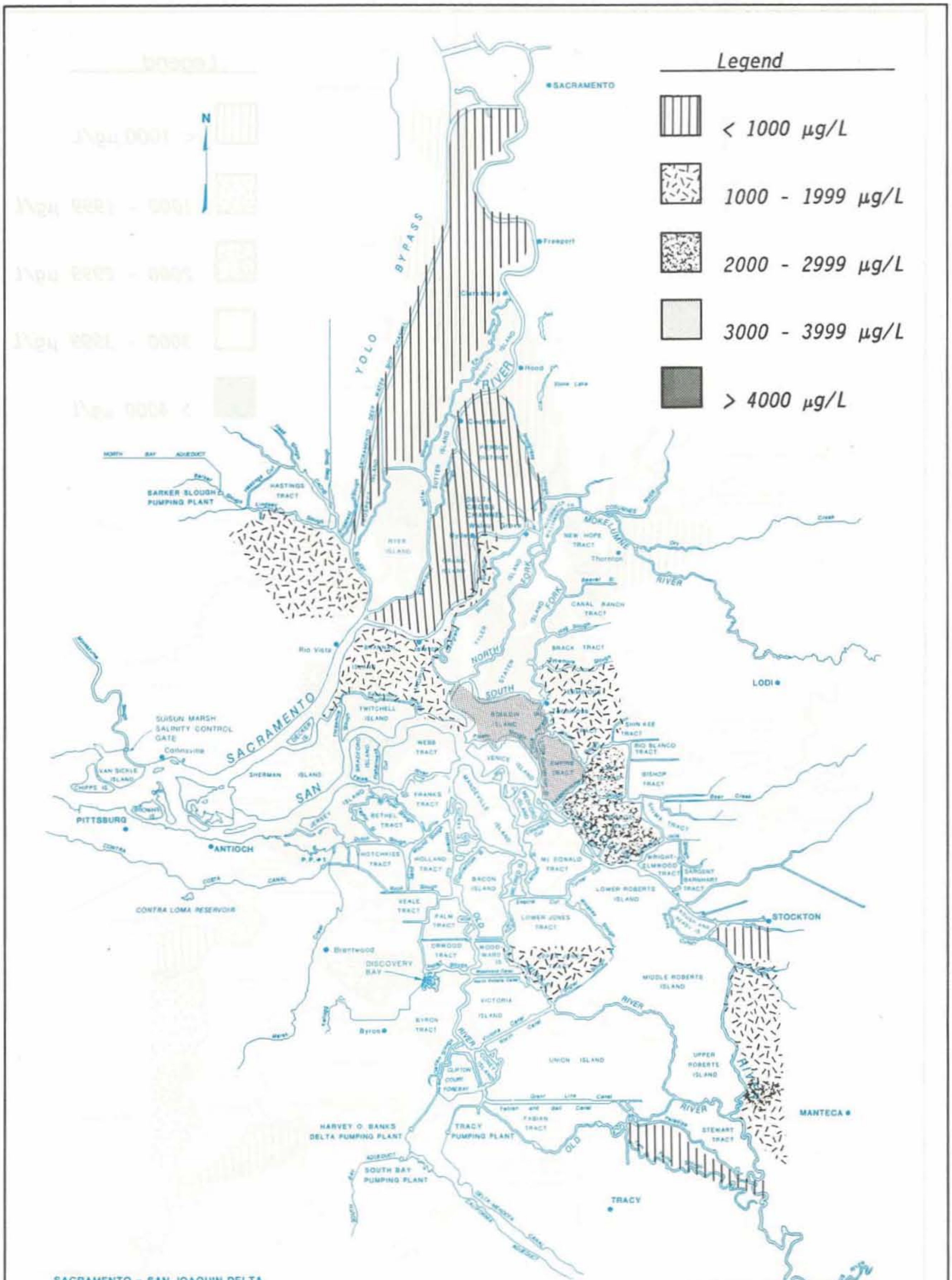


Figure 11. August THMFP Concentrations
Observed Maximums

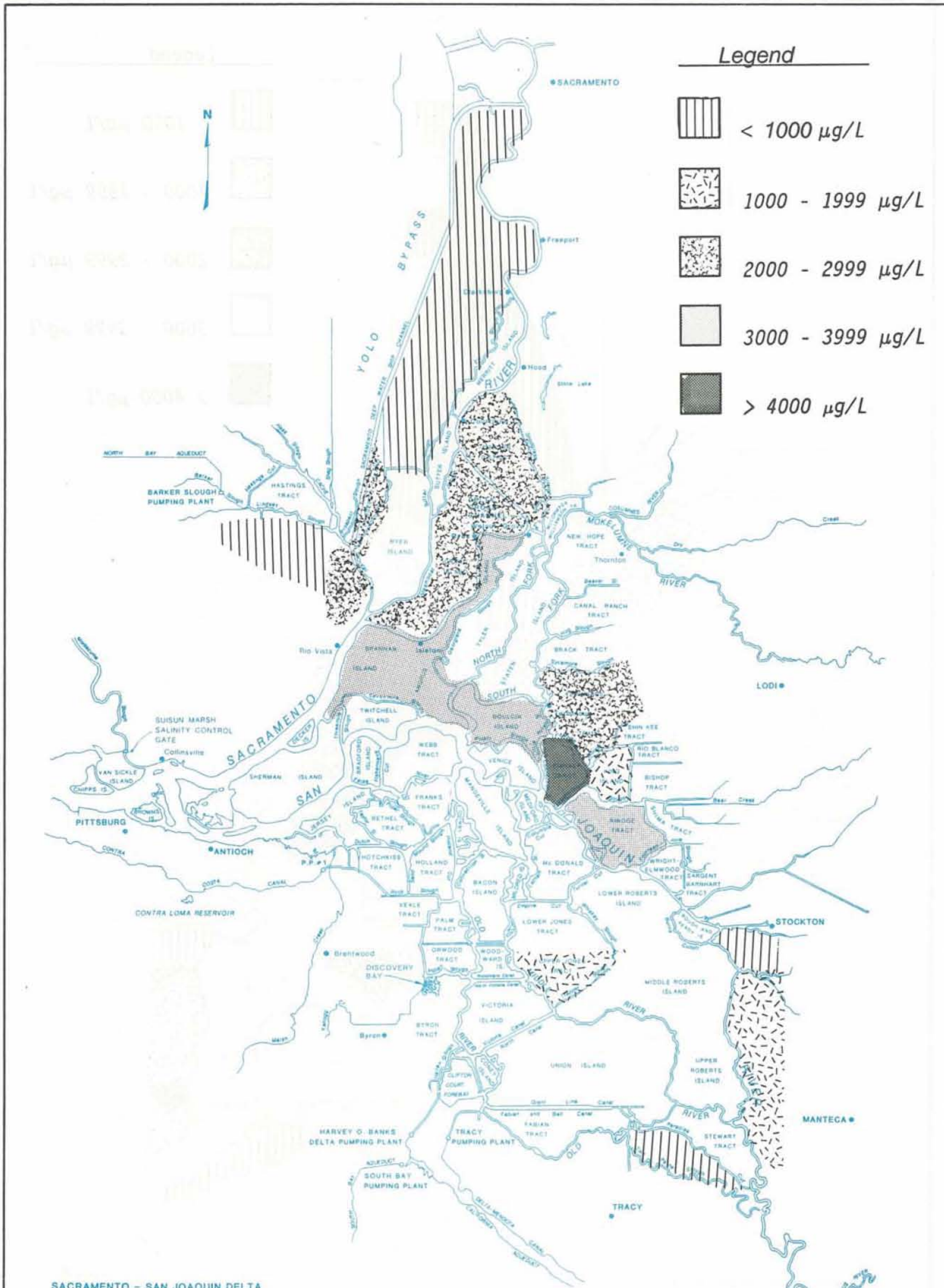
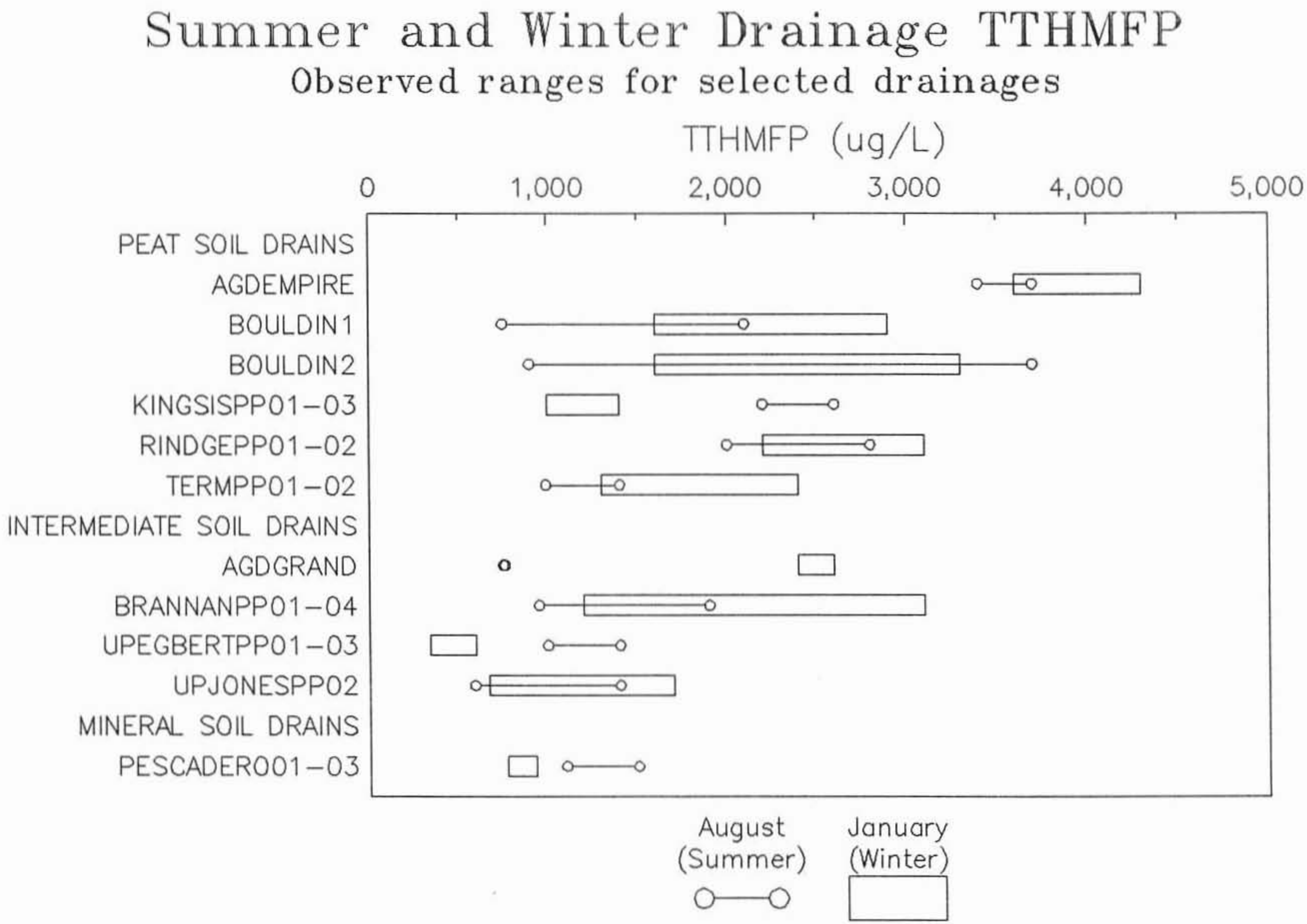


Figure 12. January THMFP Concentrations
Observed Maximums



Summer and Winter Drainage TTHMFP
Observed ranges for selected drainages
TTHMFP (ug/L)
0
1,000
2,000
3,000
4,000
5,000
PEAT SOIL DRAINS
AGDEMPIRE
BOULDIN1
BOULDIN2
KINGSISPP01-03
RINDGEPP01-02
TERMPP01-02
INTERMEDIATE SOIL DRAINS
AGDGRAND
BRANNANPP01-04
UPEGBERTPP01-03
UPJONESPP02
MINERAL SOIL DRAINS
PESCADERO01-03
August (Summer)
January (Winter)

Figure 13.

c. <u>Bouldin Island - Upper Jones Tract</u>

Drainage water from two Bouldin Island drains and one drain from Upper Jones Tract were sampled weekly during times of increased drain activity. In the summer the drains were sampled during July-August; winter sampling was conducted between December and early February. The results of the sampling are summarized in Table 5.

Based on the DWR soil composition maps (1967), Bouldin Island overlies peat soil while Upper Jones Tract overlies soil classified as intermediate organics.

All measures, including EC, DOC, and TTHMFP gradually increased and then decreased over the period of irrigation and leaching. For example, sampling during summer 1988 at Bouldin Pump Number 2, showed a smooth increase of THMFP from 1100 µg/L on July 18 to a maximum of 3700 µg/L on August 24. (EC and TOC peaked one week earlier.) All measures were beginning to drop by the final week of sampling on August 31.

Measurements during winter of 1988-89 show that drain THMFP concentrations were already elevated on December 20, and held approximately steady until January 26, when THMFP concentrations dropped by about half. Monitoring at the other stations reflect similar features.

In view of the limited sampling opportunities, there was hope that the Bouldin Island data might serve as a good representative of northern Delta islands and Upper Jones Tract representing the southern region in spite of varying soil types.

Bouldin Island data were compared to the northern area drainages which included the adjacent peat soil islands (Empire Tract and Terminous Tract) and northern intermediate organics areas (Brannan Island, Tyler Island, Grand Island). Upper Jones Tract data were compared with Pescadero Tract drainages.

The data are inconclusive to show that Bouldin Island and Upper Jones Tract drainages are representative of drainage water quality conditions that would be observed in the northern and southern Delta areas, respectively. More sampling at other islands is needed for comparison, as there is an undetermined variety of Delta island drainage conditions.

The data demonstrate the importance of monitoring during key periods of drain activity. They also demonstrate that single measurements of THMFP or other water quality parameters in island drainages should not be used to characterize drain water quality. Regular measurements over time will provide good overall information about the drains. Monthly ranges of data should be used to best characterize drain water quality rather than single values. Estimates of specific drain discharge impacts on Delta water quality will require detailed monitoring of more islands for both drainage quality and quantity to obtain flow-weighted estimates of water quality constituents.

Table 5. Bouldin Island - Upper Jones Tract THMFP
Summer irrigation and winter leaching period

Station	Date	EC	DOC	CHCL3	CHBRCL2	CHBR2CL	CHBR3	TTHMFP
BOULDIN1	07/18/88	178	6.8	840	14	1	1	860
BOULDIN1	08/10/88	186	5.9	710	33	1	1	750
BOULDIN1	08/17/88	338	19	2000	98	4	1	2100
BOULDIN1	08/24/88	323	19	2000	110	2	1	2100
BOULDIN1	08/31/88	349	25	2000	120	3	1	2100
BOULDIN2	07/18/88	202	10	1100	19	1	1	1100
BOULDIN2	08/10/88	218	14	1600	56	1	1	1700
BOULDIN2	08/17/88	440	39	1800	170	1	1	2000
BOULDIN2	08/24/88	350	32	3200	150	2	1	3400
BOULDIN2	08/24/88	351	26	3600	120	1	1	3700
BOULDIN2	08/31/88	312	25	2000	91	2	1	2100
UPJONESPP02	07/18/88	860	8.1	770	220	48	1	1000
UPJONESPP02	08/10/88	598	8.3	920	210	28	1	1200
UPJONESPP02	08/17/88	721	14	1200	210	19	1	1400
UPJONESPP02	08/24/88	766	10	1200	200	26	1	1400
UPJONESPP02	08/31/88	516	4.8	420	120	44	3	590
BOULDIN1	12/20/88		51	3100	130	22	4	3300
BOULDIN1	12/28/88		56	2500	190	23	1	2700
BOULDIN1	01/03/89		63	2400	220	22	1	2600
BOULDIN1	01/11/89			2700	170	1	1	2900
BOULDIN1	01/26/89			1400	160	8	1	1600
BOULDIN1	02/03/89			1340	230	20	1	1600
BOULDIN2	12/20/88		56	2700	120	23	4	2800
BOULDIN2	12/28/88		85	2800	67	25	1	2900
BOULDIN2	01/03/89		70	2400	220	22	1	2600
BOULDIN2	01/11/89			3100	160	8	1	3300
BOULDIN2	01/26/89			1500	96	13	1	1600
BOULDIN2	02/03/89			1500	120	11	1	1600
UPJONESPP02	12/28/88		9.8	980	200	48	3	1200
UPJONESPP02	01/03/89		9.6					
UPJONESPP02	01/11/89			1200	200	43	1	1400
UPJONESPP02	01/26/89			530	110	25	3	670
UPJONESPP02	02/03/89			510	240	52	3	810

EC (electrical conductivity) in µS/cm
DOC (total organic carbon) in mg/L
CHCL3, CHBRCL2, CHBR2CL, CHBR3, and TTHMFP in µg/L

d. Precursor Reactivities and Characteristics

Several studies have shown humic substances to be important THM precursors in natural waters (Oliver and Thurman, 1981; Rook, 1974; Rook, 1978; Stevens et al, 1976; Oliver and Lawrence, 1979). The yield of THMs from the reaction of humics with chlorine may in part be caused by the different origins and properties of the humic substances which vary widely with source (Ghassemi and Christman, 1968; Weber and Wilson, 1975).

During 1987 DWR sent water samples to the University of Arizona for characterization of dissolved organic matter (DOM). Samples from Tyler Island drain, Grand Island drain, Empire Tract drain, Upper Jones Tract drain, Sacramento River at Greenes Landing, San Joaquin River near Vernalis, and the H.O. Banks Pumping Plant Headworks were collected from the Delta. The analyses were performed by Dr. Gary Amy and reported in AWWA Journal, vol. 82, January 1990 (Amy et al, 1990).

The objective of the research was to use molecular weight and other characterizations to identify possible "fingerprints" of agricultural versus nonagricultural sources of THM precursors and humic substances. The apparent molecular weight (AMW) distributions of the nonpurgeable dissolved organic carbon (DOC) were compared.

AMW distributions, based on DOC or THMFP, can be studied as bar graphs representing the discrete molecular weight fractions. If different molecular weight fractions exhibited different THM yields and reactivities (µg THMFP/mg DOC), the calculated average molecular weight of the DOC should differ from that of the THMFP. A higher average molecular weight based on THMFP rather than DOC indicates that higher molecular weight material produces more reactive in forming THMs.

The general observations were that drain samples when compared with river and lake samples had:

1. a higher molecular weight for DOM, greater levels of DOC, UV absorbance, THMFP, and TOXFP (Total Organic Halide Formation Potential),

2. a higher percentage of humic substances,

3. a higher average THMFP:DOC ratio thus indicating more DOC and material that formed THMs,

4. values of TOXFP:DOC that showed a higher propensity to form organic halide, and

5. had four times greater TTHMFP and ten or more times greater DBPs being formed.

Amy's work indicates that the THM organic precursors in drain and nondrain water samples are significantly different in their character and propensity to form THMs and other DBPs. The drain water THM organic precursors (DOC) as characterized in this study are more reactive in forming greater levels of THMFP, TOXFP, and other DBPs than the applied source water (Sacramento and San Joaquin rivers) from the Delta channels.

Since the DOC characteristics of channel water and drain water differ, drain water THMFP concentrations are probably not due to concentrating effects of THM precursors of DOC such as from the evaporation of applied water. The higher TTHMFP in island drainages in the winter when evaporation-transpiration is lowest also strongly indicate that soil leaching is the dominant cause of increased TTHMFP in the Delta. Further study of the fate of applied water THM precursors is necessary to verify this conclusion.

Drain water had much higher AMW compounds (5,000 to 10,000 and 1,000 to 5,000) while most river source water had 1,000 or less AMW (Table 6). Empire Tract drainage samples of DOC and TTHMFP had about 16% to 18% of its organic compounds less than 1,000 AMW and about 83% to 85% above 1,000 AMW. Samples from the San Joaquin River, Sacramento River, and Banks Headworks had 45% to 60% of their DOC and TTHMFP compounds less than 1,000 AMW and 37% to 55% above 1,000 AMW.

Microbial decay would be expected to break down high molecular weight compounds to lower molecular weight compounds rather than synthesize larger and more complex compounds. The UV data also showed more humic substances in the DOC pool of the drainwater. These results agree with other studies that found marsh-bog water to have higher THM formation potential than surface water (Oliver and Thurman, 1981).

Because of the underlying decaying organic soils, Delta islands are major storage pools of soil humic substances. Soil humics are considered to be the precursor to aquatic humics over geological time frames. However, additional studies on the consistency and seasonality of the AMW distribution in drainages and river channels should be pursued further to determine the extent of impact to Delta drinking water supplies.

Other studies (Thurman, 1985) of the concentration of humic substances in natural waters support Dr. Amy's findings. In wetlands, the DOC is different from river and lake waters. This difference is the increased percentage of humic and fulvic acid which is 70% to 90% of the DOC (Figure 15).

Table 6. Percent Distribution of AMW

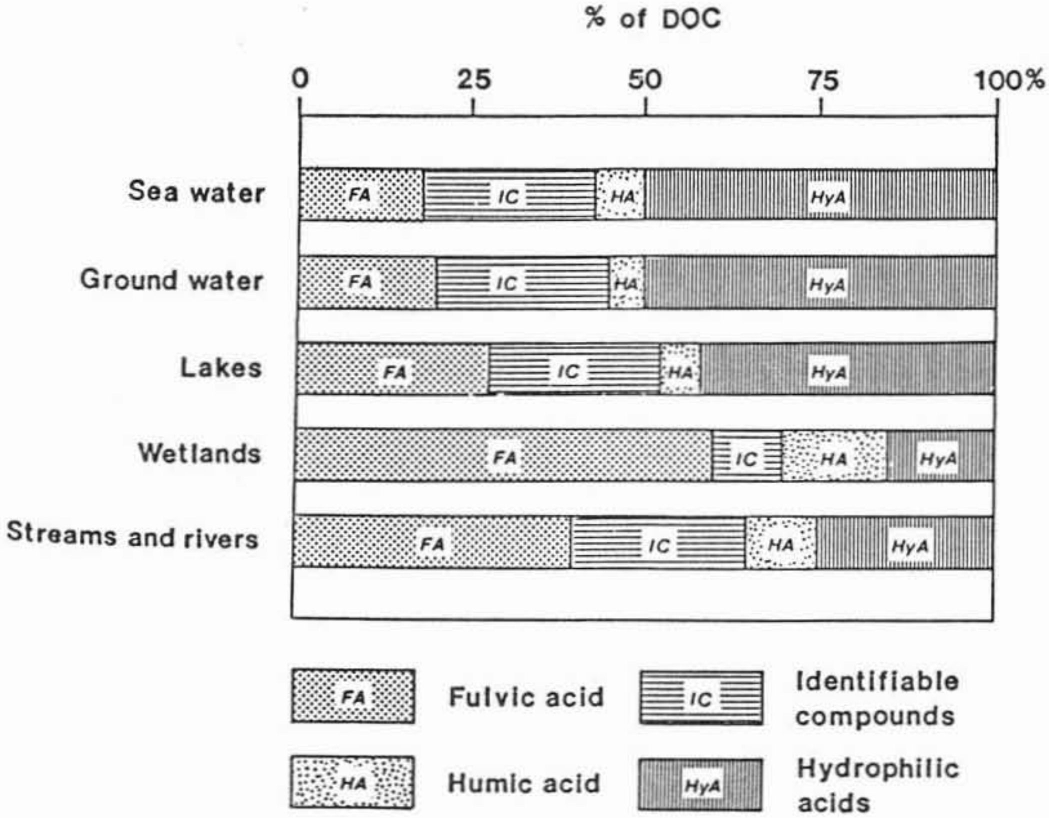
Percent distribution by wt. of DOC

Sampling Station	Number of samples	>10,000 AMW	5,000 to 10,000 AMW	1,000 to 5,000 AMW	500 to 1,000 AMW	<500 AMW
San Joaquin River (Vernalis)	2	13	4.5	29.5	26	26
Sacramento River (Greenes Landing)	2	8	12	28.5	27.5	30
Banks Headworks	3	8	12	27	27	26
Empire Tract	3	12.5	30.5	42	9	7

Percent distribution by wt. of TTHMFP

Sampling Station	Number of samples	>10,000 AMW	5,000 to 10,000 AMW	1,000 to 5,000 AMW	500 to 1,000 AMW	<500 AMW
San Joaquin River (Vernalis)	2	4	4	34	30	30
Sacramento River (Greenes Landing)	2	9.5	2.5	43	11	34
Banks Headworks	3	3	14	34	36	13
Empire Tract	3	17	27	39	14	4

Data read from bar charts in Amy et al, 1990



Reference: Figure from E.M. Thurman, Organic Geochemistry of Natural Waters, 1985.

Figure 14. Humic Substances in Natural Waters

As for the decomposition rates of DOM, Saunders (1976) proposed the following generalization. Simple low molecular weight organic compounds decompose most quickly with turnover times of less than one hour to several hours. Higher molecular weight organics released by phytoplankton and bacteria decompose in 2 to 10 days. Other higher molecular weight dissolved organics decompose on the order of 100 days and there is assumed to be at least another class of organics that decays much longer than 100 days. This suggests that the highly reactive humic substances or THM precursors in island drainages originating from the organic soils will be more persistent than humics in water applied to the islands. In fact, humic substances, the most reactive fraction of the DOM in forming THMs, are very biorefractory. Carbon dating has established that humics in the Suwannee River (Florida) are 30 years old. It is the nonhumic fraction of the DOM, consisting largely of biochemicals such as proteins and amino acids, which is more biodegradable (G. Amy, pers. comm.).

The relationship between salinity and DOC in an estuary has been studied by many. Some studies have found a conservative behavior of DOC in estuaries such as the North Dawes, the Beaulieu, the Ems, the Rhine, and the Severn (Loder and Hood, 1972; Moore and others, 1979; Laane, 1982; Eisma and others, 1982; Mantoura and Woodward, 1983).

Mantoura and Woodward (1983) found that degradation did not significantly change the DOC concentration during its 200-day residence time in the Severn Estuary. Other studies showed that precipitation and flocculation of DOC, particularly humic substances, occurred at salinities of 5 parts per thousand and more (Sholkovitz, 1976). Sholkovitz (1978) found only 1% to 6% removal of DOC in the Amazon estuary by precipitation. However, the humic acid, which accounted for 5% to 10% of the DOC was nearly all removed in the estuary (60% to 80%). It appeared that fulvic acid is not removed in the Amazon estuary.

Aquatic fulvic acids generally have molecular weights of less than 2000 and are more soluble than humic acids which have molecular weights from 2000 to 5000 or more. Humic acids are more colloidal in size and will therefore "salt out" in saline estuarine waters.

While these studies show different conservative behavior in an estuary, they agree that in waters of less than 5 parts per thousand salinity (<5,000 mg/L), DOC behaves conservatively.

The conclusion based on the above studies is that estuarine waters of 5 parts per thousand or more salinity will tend to remove by precipitation the more reactive THM precursor humic acid fractions in DOC carried downstream by river inflow.

The studies show that humic substances (fulvic and humic acids) in Delta waters may be treated as conservative constituents because of short water residence time relative to decay rates, and low salinities. With the exception of a few Delta sloughs, water flowing into the Delta is generally transported to the export pumps or out into the bay in a few days or weeks.

The relationship of bromides to the yield of brominated methane compounds (THMs containing bromide) for waters with similar DOC vary with the level of bromide in the untreated water. The wide variability is seen in the column THM-Br:THM-X percent in Table 7.

Two samples from the Empire Tract drain with DOC of 22.2 and 22.3 mg/L had 34% and 5% of the THMs as brominated THMs, respectively. This was due to 3040 µg/L bromide in the former sample while only 183 µg/L bromide was in the latter sample. However, two San Joaquin River (near Vernalis) samples had comparable DOC and bromide levels but the second sample had more brominated THMs (33% versus 48%). This suggests that the type of DOC compounds (humic versus nonhumic) may have a significant role in the TTHMFP and TBFP (total brominated methane formation potential) of water. Therefore, both bromides and organic matter influence the TTHMFP and TBFP in water supplies.

Additional samples of water, channel sediments, and island soils need to be collected for further characterization of THM precursors in the Delta. This work is needed to delineate the contribution and impact on the Delta of THM precursors from other sources besides island drainage.

Table 7. Characteristics of Drain vs. Nondrain DOC

Delta Island Drainage Samples

Date	Sample	DOC mg/L	Amy TTHMFP g/L	Modif. TTHMFP g/L	Br g/L	THM-Br: THM-X %	Humic of DOC %	AMW DOC based	Avg. AMW TTHMFP based	Avg. humic TTHMFP g/L	Non-Humic TTHMFP mol/L	Non-Humic TTHMFP g/L	Humic TTHMFP mol/L	
5/6/87	EMPIRE 1		22.2	2470	3580	3040*	34	51.4	5060	4720	1040	5.35	1430	11.8
7/28/87	EMPIRE 2		22.3	2690	2510	183	5	59.6	4530	7470	744	5.63	1950	16.4
9/22/87	EMPIRE 3		18.7	1800	2700	898	25			2780	2650			
6/10/87	GRAND 1		7.24	290	791	120*	4	61.7	2330	6930	77	0.56	213	1.81
7/28/87	GRAND 2		6.38	239	720	22	6	47.6	1440	2930	146			
6/24/87	TYLER 1		7.66	456	857	32	11	57.4	3140	2860	252	2.02	204	1.6
7/8/87	TYLER 2		10.4	642	1460	29	5	58	3880	5590	151	1.18	491	4.09
8/12/87	JONES 1		10	637	1550	175	17	40.3	2550	2700	224	1.59	413	3.29
9/28/87	JONES 2		6.36	433(-)	770	130	21			2330	2410			

Delta Non-Drainage Samples (Rivers and Channels)

Date	Sample	DOC mg/L	Amy TTHMFP g/L	Modif. TTHMFP g/L	Br g/L	THM-Br: THM-X %	Humic of DOC %	AMW DOC based	Avg. AMW TTHMFP based	Avg. humic TTHMFP g/L	Non-Humic TTHMFP mol/L	Non-Humic TTHMFP g/L	Humic TTHMFP mol/L	
6/10/87	SACTO 1		2.12	29(-)	200	12	7	38	730	440				
8/25/87	SACTO 2		3.14	164	208	22	11				985		2440	
5/6/87	BANKS 1		4.1	225	585	100*	18	55.1	790	1050	31	0.22	194	1.46
8/12/87	BANKS 2		3.37	199	426	213	56		940	920				
9/22/87	BANKS 3		3.5	241	450	173	50		1650	2000				
6/24/87	SJR 1		3.67	249	535	127	33	44.4	721	560	49	0.34	200	1.4
8/25/87	SJR 2		3.54	262	504	134	48		2100	2270				

(-) A positive chlorine residual was observed for all TTHMFP samples except Sacramento 1 and Jones 2 samples. This means for these two
samples the TTHMFP would have been higher if the chlorine dosage met the chlorine demand and residual concentrations.
* IC data
Amy TTHMFP test conditions: pH 7.0, 20 degrees C., 168 hrs. holding, Chlorine dose = 3:1 (Cl_2:DOC)
Modified TTHMFP: pH 8.0, 25 degrees C., 168 hrs. holding, Chlorine dose at 120 mg/L

Reference: Amy et al, 1990, "Evaluation of THM Precursor Contributions from Agricultural Drains"
Modified TTHMFP data, THM-Br:THM-X (% on wt. basis), and IC bromide data from Metropolitan Water District of S. Calif.

3. Other Parameters

Correlations between different water quality measurements were tested. The data included observations from the Interagency Delta Health Aspects Monitoring Program and this study. The data were divided into two sets: (1) Delta drainage samples and (2) Delta channel water samples. All observations were used in computing and plotting the following regressions. The data set included mineral and TTHMFP analyses conducted on about 650 drain and 965 channel water samples collected each month from July 1983 - September 1989 throughout the Delta.

The correlations between EC and chloride concentrations and for EC and TDS were high for both data sets. Therefore, EC can be used to predict the TDS and chloride concentrations in most parts of the Delta. However, the EC to chloride data for drain water indicated not all drainages followed a common regression line (Figures 15-18).

The correlations of TTHMFP, each of the 4 THM compounds, and the sum concentration of the bromomethane compounds (TBFP, total bromomethane formation potential) with EC were found to be poorly defined. The TBFP to EC simple linear regression lines are shown in Figures 19 and 20. Therefore, the use of EC, chloride, or TDS to predict TBFP throughout the Delta is not recommended. Separate relationships, however, may exist for each location.

Further examination of the mineral data to characterize water types, origin, and mixing of Delta waters is a major part of the scope of work of both IDHAMP and this investigation. Future work will test relationships among different water quality measurements for individual stations and model development.

Figure 15. EC - Chloride Relationship - Delta Channel Water

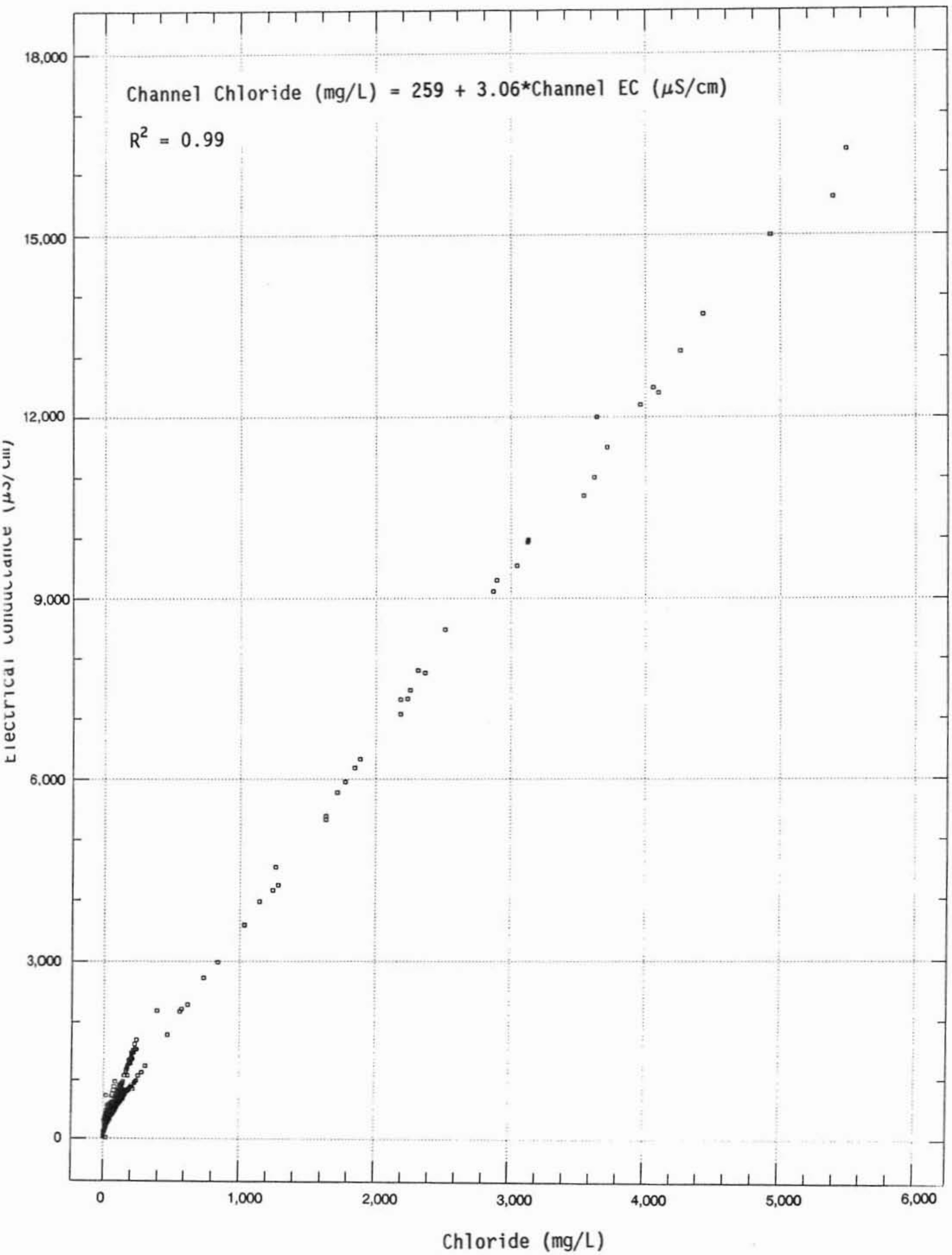


Figure 16. EC - Chloride Relationship - Delta Island Drainage

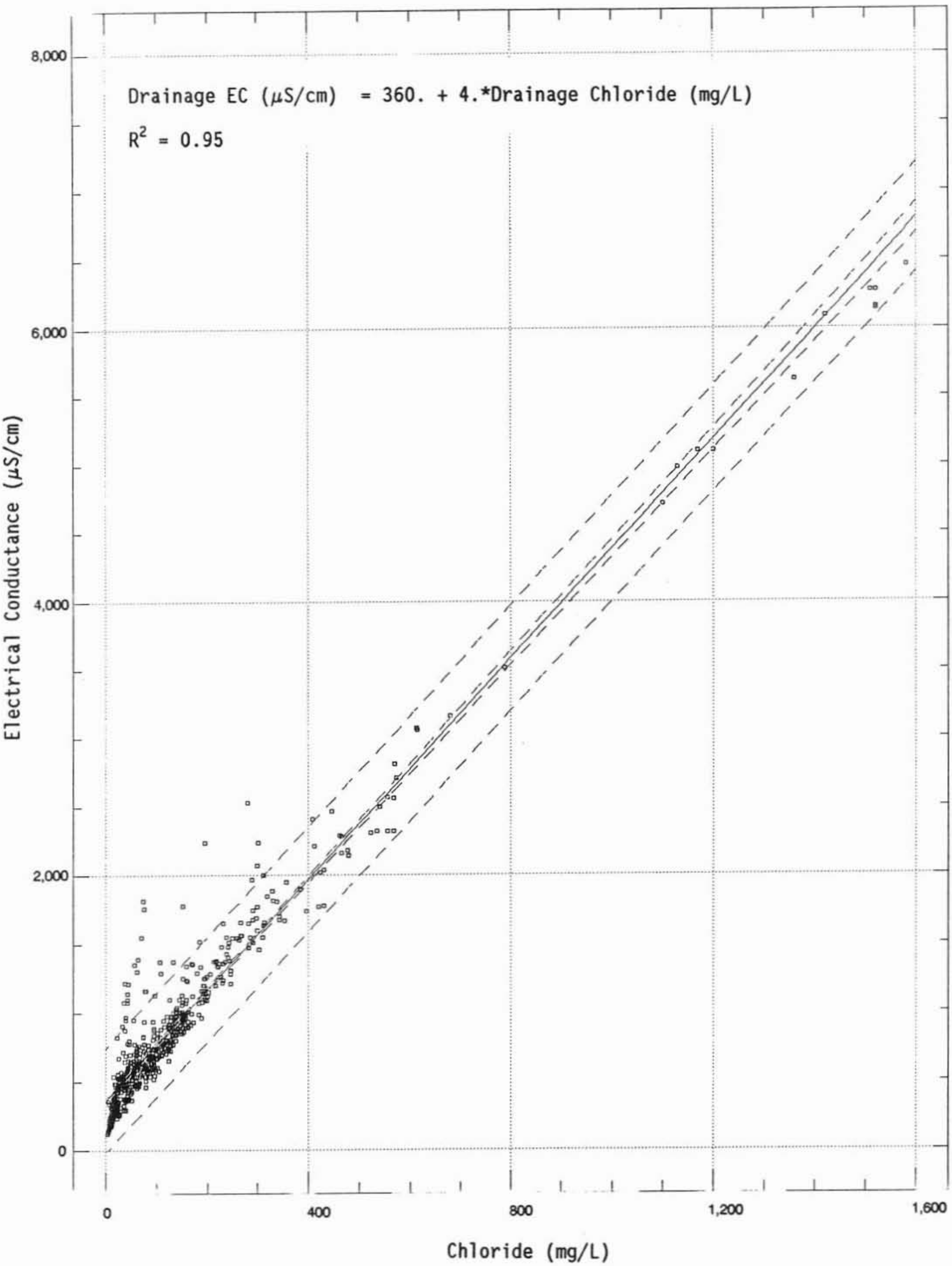


Figure 17. EC - TDS Relationship - Delta Channel Water

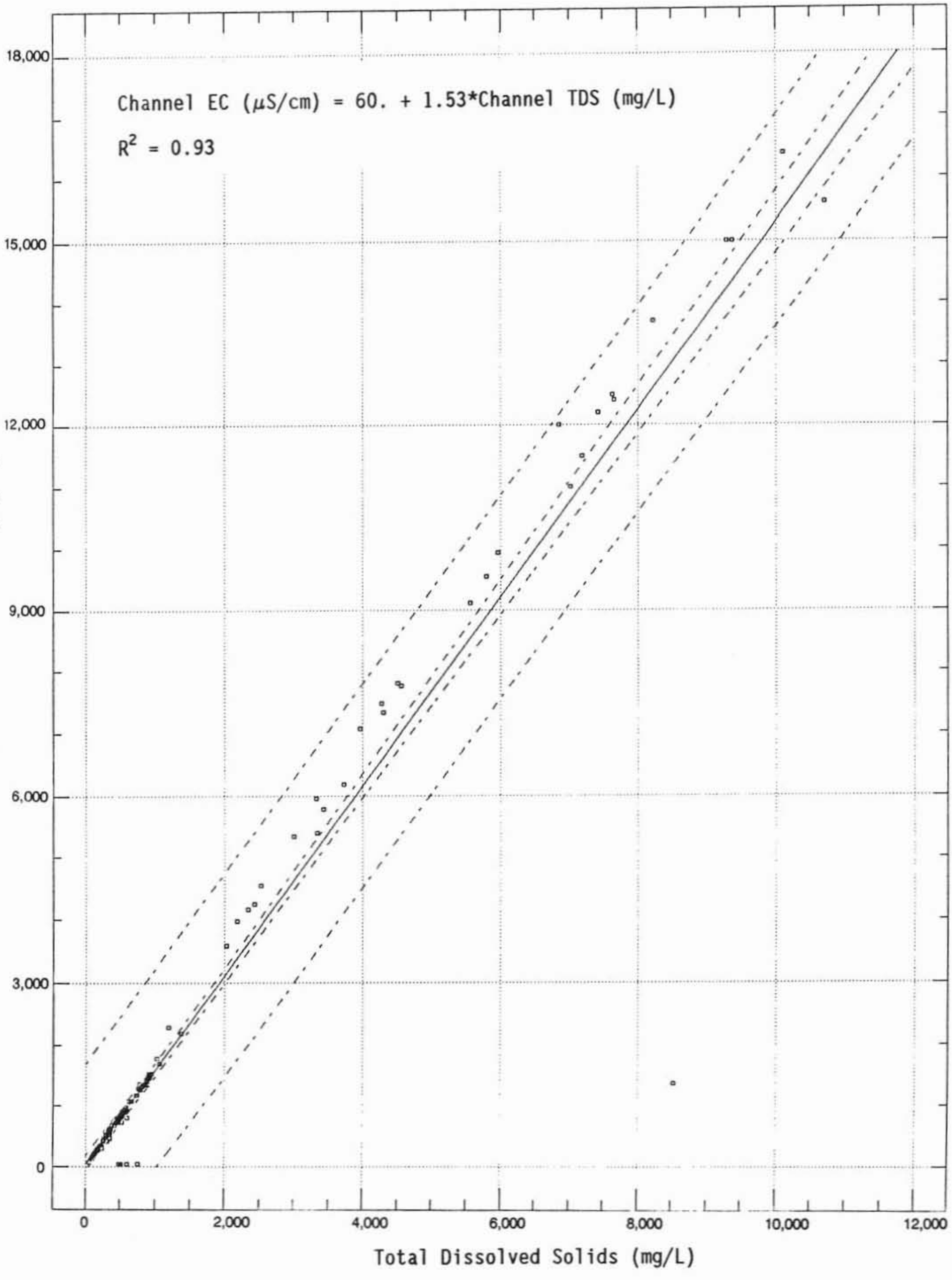


Figure 18. EC - TDS Relationship - Delta Island Drainage

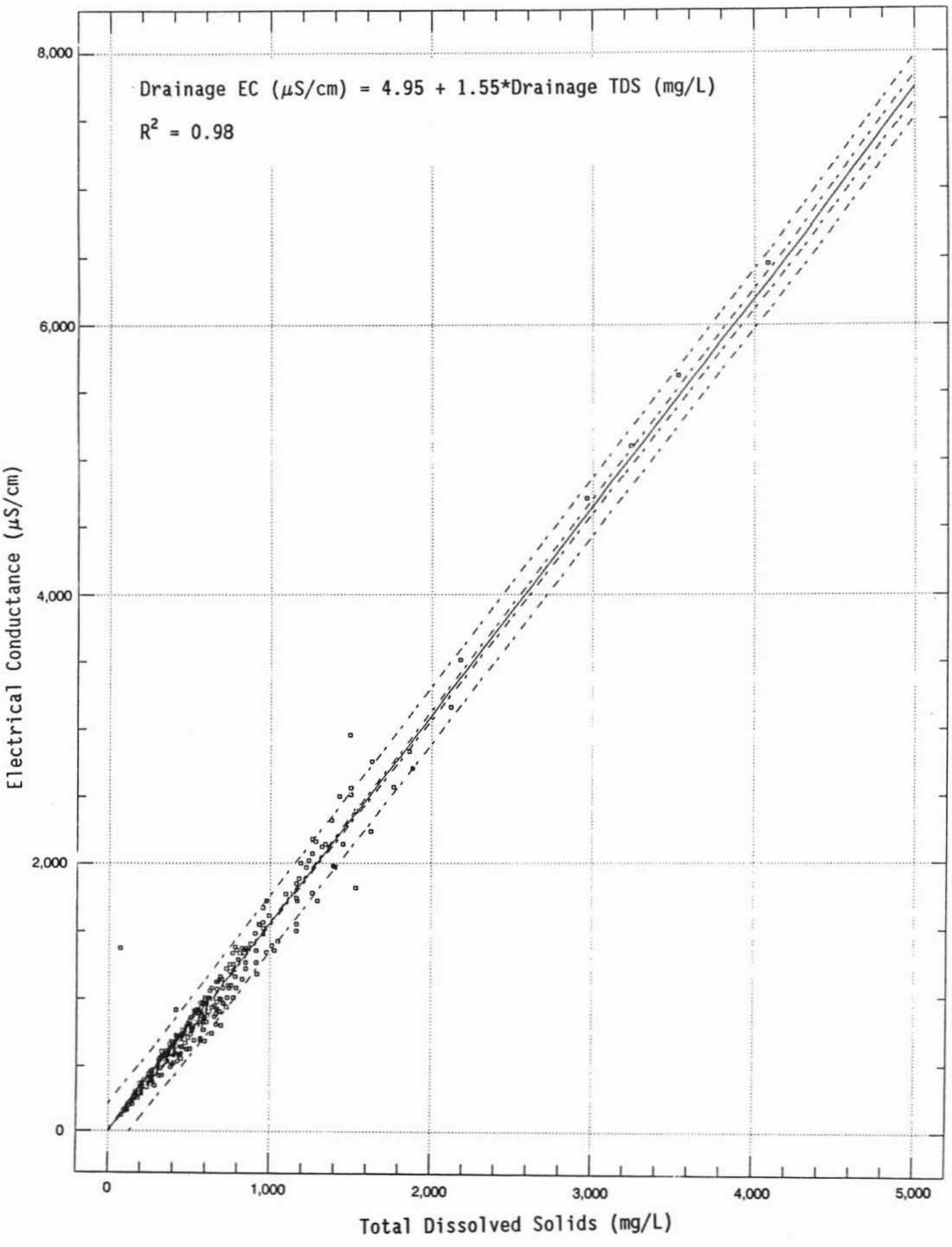


Figure 19. EC - TBFP Relationship - Delta Channel Water

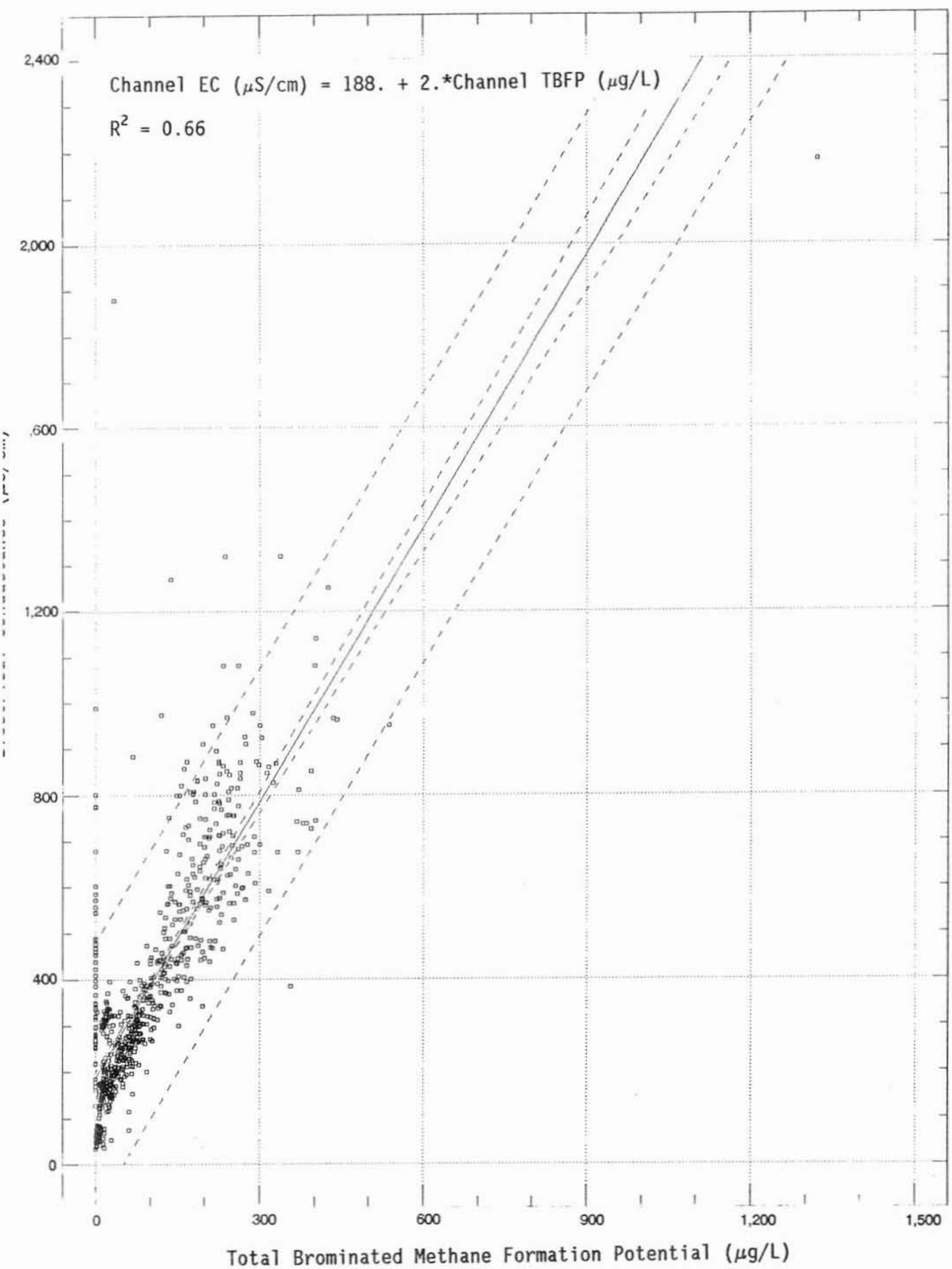
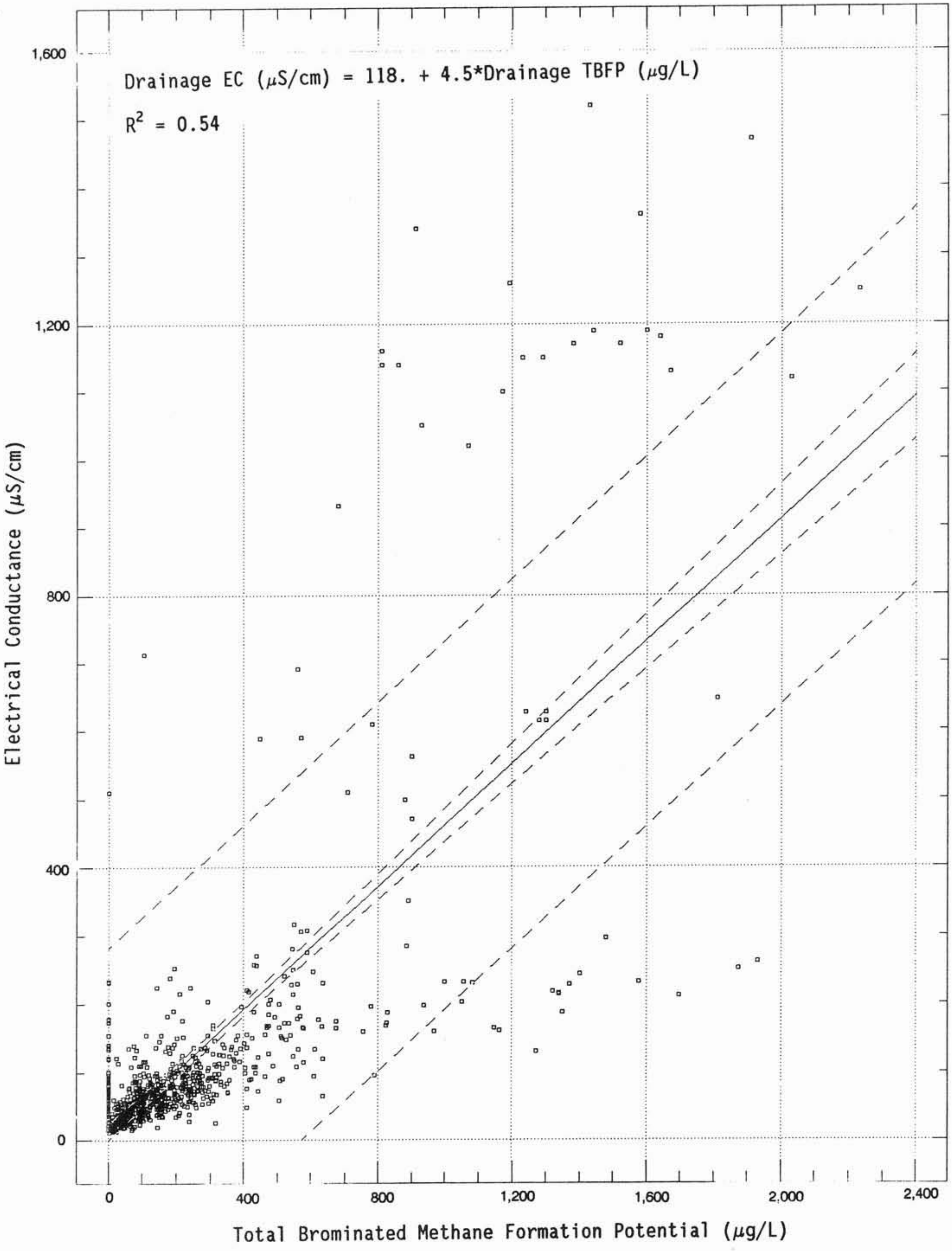


Figure 20. EC - TBFP Relationship - Delta Island Drainage



C. Drainage Volume

1. <u>1988 DIDI Survey</u>

Power consumption and pump efficiency data were released to DWR for twenty six pumps, representing twelve islands in the Delta. We found that on islands where data from more than one drain were available, data from any one drain did not represent the activities on the entire island. Power data differed among some island pump stations for the same month, because farmers flooded one area, then another a few weeks later.

Billing cycles for power consumption usually do not follow calendar months. Since much of our analysis follows calendar months, we attempted to allocate power consumption data on a calendar month basis. Billing records which spanned two months, with approximately two weeks in each month, were divided so that half of the billed power was assumed to have been consumed in each month.

For example, if the billing cycle ended on the 15th of each month, the power consumption for February was assumed to be half that on the January 15 to February 15 bill, plus half of that on the February 15 to March 15 bill. When billing extended over three or more weeks within a month, the entire power consumption was credited to the month.

Power data for SMUD (Sacramento Municipal Utility District) customers were available only in two-month blocks. Power consumption was handled in a similar fashion to single-month billings. For example, a January 15 to March 15 bill was assumed to be distributed as 1/4th each January, and March, and 1/2 February. SMUD bills spanning two complete months were simply divided by two for each month.

The agricultural drainage systems were examined for information concerning pipe diameter, type and length; static head; and pump horsepower and efficiency. The available pump efficiencies were for pumps up to 50 years old. The pumps have aged so much that their efficiencies have probably changed significantly. Rather than deal with a wide range of questionable efficiencies, an overall 50% pump system efficiency was assumed. New pump tests requested by the pump owners may be needed to obtain more recent efficiency data on older pumps.

Friction head losses and other losses were ignored because they were assumed to be within the limit of uncertainty built into the assumed pump efficiencies, and pipe lengths were assumed to be short enough to make frictional head losses very small.

The volume of drainage water discharged was calculated in acre-feet using the constants and equations shown below.

Volume of water pumped in AC-FT:

$$Q = (KWhr)(Eff.)(2.65*10^{6})/(Hs)(2.72*10^{6})$$

$$Q = (0.974)(KWhr)(Eff.)/Hs$$

Where: Q = volume of water in acre-feet.
Hs = Static head in feet.
Eff. = Efficiency (assumed to be 50%)

Kilowatt = KW = 737 ft-lbs of work in one second.
Kilowatt-hour = KWhr = $60*60*737 = 2.65*10^6$ ft-lbs of work in one hour

Weight of Water:
Acre-foot = AC-FT = 325,872 gallons
Gallon of Water = 8.34 pounds
Acre-foot = $325{,}872*8.34 = 2.72*10^6$ pounds of water

Estimates of monthly drainage volumes based on power consumption data are shown in Table 8.

Table 8 shows the seasonality of agricultural operations and the variability between islands and between drains on individual islands. Winter leaching activities can be seen on some islands or tracts, including Bouldin, Egbert, Rindge, and Terminous. Other tracts, including Mossdale, Netherlands and Upper Egbert apparently had no winter discharges.

Quantities of estimated drainage also varied widely between islands. Some areas discharged more than others. For example, the estimated volume of drainage from Terminous Island was 44% to 48% of the total estimated for the surveyed islands during July and August 1987. Terminous and Rindge Tracts, combined, accounted for nearly two-thirds of the estimated discharge during the same period.

The power consumption data gathered represents widely separated areas along the northern and eastern periphery of the Delta. These data cannot be extrapolated to estimate total drainage volumes for the entire Delta. The results of this work showed the variability in drainage on an island due to farm activities.

Table 8. Estimated Pump Station Drainage Volume

Units in acre-feet per month

PUMP STATION	JAN87	FEB87	MAR87	APR87	MAY87	JUN87	JUL87	AUG87	SEP87	OCT87	NOV87	DEC87	JAN88	FEB88
BOULDIN 01	752	1368	524	297	444	228	355	457	287	90	698		2543	
EGBERT PP1	79	129	167	146	280	478	565	1613	1370	51	54	64	83	51
EGBERT PP2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KINGISPP01	0	22	0	5	17	18	2	176	0	1				
KINGISPP02	0	0	0	0	0	0	0	0	0	0				
MCCORWILL01	62	43	67	75	101	110	56	24	10	2	7	10	10	
MCCORWILL02	0	0	17	25	146	205	151	117	42	1	5	7	6	
MOSSDALE01	0	0	0	17	8	13	9	1	0	0				
MOSSDALE02	0	0	0	159	103	176	110	27	9	0				
MOSSDALE03	0	0	0	0	3	8	0	16	0	0				
MOSSDALE04	0	2	1	0	7	30	39	40	9	0				
MOSSDALE05	0	0	152	0	153	294	189	182	0	0				
MOSSDALE11	0	0	0	82	70	248	285	102	17	1				
NETHERLAND01				387	431	382	15	370	614	1101	278	694	1383	
NETHERLAND02				219	65	0	0	0	33	143	201	97	97	
PROSPECTPP01	0	0	353	353	0	0	0	153	157	10	20	14	55	110
RINDGEPP01	3135	573	203	177	32	218	567	429	284	54				
RINDGEPP02	0	1844	5984	353	416	2899	2119	2841	699	278				
RIOBLANCO01	128		128	330	13	210	269	200	39	0				
RIOBLANCO02	0	37			280	277	204	34	6	50	62	77	83	19
TERMPP01	0	13992	1741	170	2	2067	4079	3363	114	0				
TERMPP02	3006	3742	3262	1826	2412	1854	2448	2442	1287	606	706			
UPEGBERTPP01			1230	1161	1307	778	488	340	155	104	88	71	56	
UPEGBERTPP02	0	0	0	0	0	0	0	3	3	0	0	0	0	0
UPJONESPP01	1	31	0	19	2	0	0	0	0	0	0			
UPJONESPP02			704	704	677	1047	1112	1215	760	385				

Estimates based on assumption of 50% pump efficiency rating.

2. 1954-55 Drainage

Monthly estimates of the 1954-55 drainage volumes by study unit (groups of tracts and islands) are shown in Table 9. The estimates were based on pump test data and power use from 162 pumping plants involving 255 pumps that pumped 82 percent of the Lowlands. Estimates for 64 pumps at 14 pumping plants that drained 16 percent of the Lowlands had to be estimated by assuming pump efficiency rating factors were similar to comparable measured sites or by correlation with drainage rates in adjacent areas. The remaining 2 percent of land either drained by gravity or was urbanized. These estimates were then based on drainage rates in adjacent areas.

Drainage volumes can differ significantly among the study units depending on acreage, location, crops, and soil type. The 1954-55 data show that a specific area (14%) of the Delta Lowlands discharged 45% to 48% of the total estimated drainage during June through August and 31% to 34% in December-January. This area, consisting of study units 18, 20, and 22, is shown in Figure 21 and the volumes in Table 10.

Table 9. Monthly 1954–55 Drainage Volume Estimates
(acre-feet)

UNIT NO.	ACREAGE	M 1954	J	J	A	S	O	N	D
2	11,202	45	0	0	0	0	179	0	672
3	5,465	639	552	662	526	234	147	225	387
6	33,027	617	388	339	299	359	358	1,480	2,541
7	7,510	510	117	104	60	64	44	183	379
8	22,103	4,126	2,984	2,227	2,935	2,997	3,932	2,867	1,917
9	16,085	1,238	1,628	2,074	2,081	1,495	952	696	979
10	11,085	395	865	1,057	975	350	261	313	486
11	14,365	1,620	1,697	1,337	1,350	770	530	753	1,383
12	16,877	2,408	3,144	3,559	2,971	1,450	1,029	1,481	2,916
13	16,641	886	1,529	2,022	1,602	357	459	529	1,288
14	14,671	1,730	2,131	2,053	926	648	1,227	1,483	2,166
15	26,424	2,583	2,463	3,005	2,879	2,055	2,957	3,425	4,851
16	18,343	2,114	2,434	2,321	3,181	2,147	1,521	1,076	2,804
17	10,191	992	955	1,379	1,013	739	1,159	1,185	3,597
18	18,504	4,710	8,676	11,051	8,210	6,748	6,994	4,025	5,759
19	17,917	2,507	3,570	4,636	4,307	2,688	1,516	1,268	2,753
20	21,302	5,456	9,197	10,223	10,410	4,627	4,582	5,639	10,209
21	14,846	3,154	4,000	5,245	4,705	2,698	2,691	3,792	7,388
22	19,357	12,368	15,756	15,252	12,942	8,629	9,306	8,637	10,635
23	24,493	2,396	3,032	3,917	3,259	1,974	3,790	3,514	9,308
24	32,879	2,125	2,500	2,964	2,839	1,849	2,103	2,795	8,907
25	33,212	2,335	2,197	3,773	2,289	1,237	892	971	3,812
26	2,810	96	131	144	149	99	88	140	399
27	10,148	669	627	1,231	949	343	100	60	195
TOTAL	419,457	55,719	70,573	80,575	70,857	44,557	46,817	46,537	85,731
AC-FT/DAY		1,857	2,352	2,686	2,362	1,485	1,561	1,551	2,858
EQUIV CFS		938	1,188	1,356	1,193	750	788	783	1,443
AC-FT/ACRE		0.13	0.17	0.19	0.17	0.11	0.11	0.11	0.20
MIN	2,810	45	0	0	0	0	44	0	195
AVG	17,477	2,322	2,941	3,357	2,952	1,857	1,951	1,939	3,572
MAX	33,212	12,368	15,756	15,252	12,942	8,629	9,306	8,637	10,635

UNIT NO.	J 1955	F	M	A	M	J	J	A	S	O	TOTAL
2	582	90	0	90	0	0	0	0	0	134	739,285
3	594	558	475	403	541	401	667	573	299	43	741,223
6	2,944	2,159	771	401	293	235	314	269	227	320	739,975
7	669	367	221	229	259	189	214	120	122	59	738,677
8	1,046	1,086	1,752	2,018	2,354	3,267	3,817	2,830	2,411	1577	751,724
9	841	252	401	1,057	742	1,301	1,408	1,647	1,067	710	742,588
10	637	352	245	443	535	757	874	860	624	450	737,637
11	1,516	865	637	889	792	1,349	1,433	1,411	591	417	739,196
12	3,105	1,689	1,690	2,582	2,171	3,921	3,927	3,690	971	621	745,552
13	1,303	777	767	1,081	964	1,575	2,356	2,022	1,049	435	739,457
14	1,961	1,645	1,983	2,307	1,614	1,773	2,264	846	545	891	739,380
15	5,721	2,871	2,782	2,544	1,801	2,425	2,805	3,398	2,079	2021	744,620
16	4,008	1,470	1,041	1,854	1,707	2,457	2,336	2,044	1,811	1511	741,794
17	3,198	1,039	1,291	1,823	1,585	1,613	2,000	1,499	1,153	603	736,465
18	4,836	2,425	1,942	1,439	3,509	5,603	10,156	8,081	3,432	2884	761,543
19	2,454	1,221	826	1,301	2,618	3,160	3,759	3,282	1,963	1275	735,587
20	14,637	3,840	2,016	3,533	6,521	10,456	11,726	11,870	8,521	3505	763,957
21	7,472	2,765	1,935	2,350	3,873	5,340	5,398	4,576	3,392	2175	744,925
22	12,773	7,385	5,127	3,949	10,734	16,862	15,557	12,826	6,142	5302	781,812
23	11,828	3,229	2,103	1,843	2,018	2,481	2,056	2,818	1,663	1981	727,864
24	9,189	3,410	2,053	2,135	2,355	2,649	2,862	2,929	2,285	1974	725,985
25	3,678	2,188	1,958	2,540	2,233	2,553	3,574	3,217	2,068	922	726,042
26	412	150	92	95	107	133	155	153	113	93	714,858
27	264	127	311	722	487	584	948	1,209	588	114	717,682
TOTAL	95,668	41,960	32,419	37,628	49,813	71,084	80,606	72,170	43,116	30017	1,010,856
AC-FT/DAY	3,189	1,399	1,081	1,254	1,660	2,369	2,687	2,406	1,437	1,001	698,475
EQUIV CFS	1,611	706	546	633	839	1,197	1,357	1,215	726	505	692,732
AC-FT/ACR	0.23	0.10	0.08	0.09	0.12	0.17	0.19	0.17	0.10	0.07	
MIN	264	90	0	90	0	0	0	0	0	43	
AVG	3,986	1,748	1,351	1,568	2,076	2,962	3,359	3,007	1,797	1,251	
MAX	14,637	7,385	5,127	3,949	10,734	16,862	15,557	12,826	8,521	5,302	

Refer to DWR Report No. 4 Plate 2 for location of subareas (unit nos.).

Figure 21. High Drainage Area, 1954-55

Unit 22 included Bacon, Mandeville, MacDonald, Mildred, and Medford islands. Unit 20 included Empire, King, and Terminous tracts. Unit 18 included Staten, Bouldin, and Venice Islands. The three units adjoin each other and are centrally located in the Lowlands. The soil types of these three units are peaty organic. This suggests that monitoring should focus on these islands and adjacent channels, becasuse water quality impacts, should they occur, would be observed in this area.

Table 10. Drainage Volume From 3 Study Areas, 1954-55
Monthly volume in acre-feet

Unit	Acreage	June 1954	July 1954	August 1954	December 1954	January 1955
22	19357	15756	15252	12942	10635	12773
20	21302	9197	10223	10410	10209	14637
18	18504	8676	11051	8210	5759	4836
Sum	59163	33629	36526	31562	26603	32246
Total	419457	70573	80575	70857	85731	95668
Percent	14	48	45	45	31	34

Unit	Acreage	June 1955	July 1955	August 1955
22		16862	15557	12826
20		10456	11726	11870
18		5603	10156	8081
Sum		32921	37439	32777
Total		71084	80606	72170
Percent		46	46	45

Total is Delta Lowlands acreage or total drainage from Delta Lowlands.
Percent is percent of total.

Based on these estimates, about half of the Delta Lowlands drainage volume may have been from a small area (14%) of the Delta Lowlands during the 1954 and 1955 summers. More recent and extensive data collected by this investigation would help determine if this area is as important today. It could be the key to a solution for improving export water quality without addressing Delta-wide discharges.

Drainage rate expressed as acre-feet of drainage per acre of drained land showed significant differences among the tracts. Tracts in study units 18, 20, and 22 had the highest rate of summer drainage. The June to August rates for these three units were 2 to 4 times (0.43 to 0.81 acre-feet/acre) the monthly averages (0.17 to 0.19 acre-feet/acre) for the Lowlands. Rates for all months are shown in Table 10.

The limited distribution of drainage sites in this study prevented comparison of current and past estimates of drainage volume and rates within the study units of the 1954-55 study. The current study sites did not fully correspond to those of the 1954-55 study so the inadequate overlap of study areas prevented a complete comparison.

Although power use and pump test data were available to compute volume for a particular pump station, the amount of acreage drained by each station was uncertain. At best, only about half the number of pump stations within a given 1954-55 study unit could be sampled in this study. Drained areas are not equally divided among the number of pumps or pump stations on an island. As a result, extrapolation to Delta-wide conditions based on the limited DIDI data is subject to error.

To estimate total Delta drainage volume would require a comprehensive study such as the DWR 1954-55 study. Since we were limited to 54 drains, we then examined the 1954-55 drainage volume estimates to make some present-day estimates.

Table 11. Drainage Rates in the Delta Lowlands, 1954-55
(Units in acre-feet of drainage per acre of land drained)

		1954							
UNIT NO.	ACREAGE	May	June	July	Aug	Sept	Oct	Nov	Dec
2	11,202	0.004	0.000	0.000	0.000	0.000	0.016	0.000	0.060
3	5,465	0.117	0.101	0.121	0.096	0.043	0.027	0.041	0.071
6	33,027	0.019	0.012	0.010	0.009	0.011	0.011	0.045	0.077
7	7,510	0.068	0.016	0.014	0.008	0.009	0.006	0.024	0.050
8	22,103	0.187	0.135	0.101	0.133	0.136	0.178	0.130	0.087
9	16,085	0.077	0.101	0.129	0.129	0.093	0.059	0.043	0.061
10	11,085	0.036	0.078	0.095	0.088	0.032	0.024	0.028	0.044
11	14,365	0.113	0.1	0.093	0.094	0.054	0.037	0.052	0.096
12	16,877	0.143	0.186	0.211	0.176	0.086	0.061	0.088	0.173
13	16,641	0.053	0.092	0.122	0.096	0.021	0.028	0.032	0.077
14	14,671	0.118	0.145	0.140	0.063	0.044	0.084	0.101	0.148
15	26,424	0.098	.093	0.114	0.109	0.078	0.112	0.130	0.184
16	18,343	0.115	.133	0.127	0.173	0.117	0.083	0.059	0.153
17	10,191	0.097	.094	0.135	0.099	0.073	0.114	0.116	0.353
18	**18,504**	**0.255**	**.469**	**0.597**	**0.444**	**0.365**	**0.378**	**0.218**	**0.311**
19	17,917	0.140	.199	0.259	0.240	0.150	0.085	0.071	0.154
20	**21,302**	**0.256**	**.432**	**0.480**	**0.489**	**0.217**	**0.215**	**0.265**	**0.479**
21	14,846	0.212	.269	0.353	0.317	0.182	0.181	0.255	0.498
22	**19,357**	**0.639**	**.814**	**0.788**	**0.669**	**0.446**	**0.481**	**0.446**	**0.549**
23	24,493	0.098	.124	0.160	0.133	0.081	0.155	0.143	0.380
24	32,879	0.065	.076	0.090	0.086	0.056	0.064	0.085	0.271
25	33,212	0.070	.066	0.114	0.069	0.037	0.027	0.029	0.115
26	2,810	0.034	.047	0.051	0.053	0.035	0.031	0.050	0.142
27	10,148	0.066	.062	0.121	0.094	0.034	0.010	0.006	0.019
TOTAL	419,457								
ROUNDED AVG.		0.13	**0.17**	**0.19**	**0.17**	0.11	0.11	0.11	**0.20**
MIN	2,810	0.004	0.000	0.000	0.000	0.000	0.006	0.000	0.019
MAX	33,212	0.639	**0.814**	**0.788**	**0.669**	0.446	0.481	0.446	**0.549**

Table 11 (Cont.) Drainage Rates in the Delta Lowlands, 1954-55
(Units in acre-feet of drainage per acre of land drained)

Unit No	Jan	Feb	Mar	Apr	May	June	1955 July	Aug	Sept	Oct	Total	Min	Avg	Max
2	0.052	0.008	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.012	0.160	0.000	0.005	0.060
3	0.109	0.102	0.087	0.074	0.099	0.073	0.122	0.105	0.055	0.008	1.451	0.000	0.041	0.122
6	0.089	0.065	0.023	0.012	0.009	0.007	0.010	0.008	0.007	0.010	0.433	0.000	0.012	0.089
7	0.089	0.049	0.029	0.030	0.034	0.025	0.028	0.016	0.016	0.008	0.521	0.000	0.015	0.089
8	0.047	0.049	0.079	0.091	0.107	0.148	0.173	0.128	0.109	0.071	2.088	0.000	0.060	0.187
9	0.052	0.016	0.025	0.066	0.046	0.081	0.088	0.102	0.066	0.044	1.279	0.000	0.037	0.129
10	0.057	0.032	0.022	0.040	0.048	0.068	0.079	0.078	0.056	0.041	0.945	0.000	0.027	0.095
11	0.106	0.060	0.044	0.062	0.055	0.094	0.100	0.098	0.041	0.029	1.346	0.000	0.038	0.118
12	0.184	0.100	0.100	0.153	0.129	0.232	0.233	0.219	0.058	0.037	2.567	0.000	0.073	0.233
13	0.078	0.047	0.046	0.065	0.058	0.095	0.142	0.122	0.063	0.026	1.262	0.000	0.036	0.142
14	0.134	0.112	0.135	0.157	0.110	0.121	0.154	0.058	0.037	0.061	1.922	0.000	0.055	0.157
15	0.217	0.109	0.105	0.096	0.068	0.092	0.106	0.129	0.079	0.076	1.993	0.000	0.057	0.217
16	0.219	0.080	0.057	0.101	0.093	0.134	0.127	0.111	0.099	0.082	2.063	0.000	0.059	0.219
17	0.314	0.102	0.127	0.179	0.156	0.158	0.196	0.147	0.113	0.059	2.632	0.000	0.075	0.353
18	**0.261**	**0.131**	**0.105**	**0.078**	**0.190**	**0.303**	**0.549**	**0.437**	**0.185**	**0.156**	**5.430**	**0.000**	**0.155**	**0.597**
19	0.137	0.068	0.046	0.073	0.146	0.176	0.210	0.183	0.110	0.071	2.518	0.000	0.072	0.259
20	**0.687**	**0.180**	**0.095**	**0.166**	**0.306**	**0.491**	**0.550**	**0.557**	**0.400**	**0.165**	**6.430**	**0.000**	**0.184**	**0.687**
21	0.503	0.186	0.130	0.158	0.261	0.360	0.364	0.308	0.228	0.147	4.914	0.000	0.140	0.503
22	**0.660**	**0.382**	**0.265**	**0.204**	**0.555**	**0.871**	**0.804**	**0.663**	**0.317**	**0.274**	**9.825**	**0.000**	**0.281**	**0.871**
23	0.483	0.132	0.086	0.075	0.082	0.101	0.084	0.115	0.068	0.081	2.581	0.000	0.074	0.483
24	0.279	0.104	0.062	0.065	0.072	0.081	0.087	0.089	0.069	0.060	1.762	0.000	0.050	0.279
25	0.111	0.066	0.059	0.076	0.067	0.077	0.108	0.097	0.062	0.028	1.278	0.000	0.037	0.115
26	0.147	0.053	0.033	0.034	0.038	0.047	0.055	0.054	0.040	0.033	0.979	0.000	0.028	0.147
27	0.026	0.013	0.031	0.071	0.048	0.058	0.093	0.119	0.058	0.011	0.939	0.000	0.027	0.121
ROUNDED														
AVG.	**0.23**	0.10	0.08	0.09	0.12	**0.17**	**0.19**	**0.17**	0.10	0.07	2.39	0.00	0.07	0.26
MIN	0.026	0.008	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.008	0.160	0.000	0.005	0.060
MAX	**0.687**	0.382	0.265	0.204	0.555	**0.871**	**0.804**	**0.663**	0.400	0.274	9.825	0.000	0.281	0.871

Refer to DWR Report No. 4, Plate 2 for location of subareas (unit nos.).
Note: Irrigated acreage was 291,667. Rates derived by dividing volume by total acreage of subunits, not irrigated acres. Highest monthly drainage rates observed at units 18, 20, and 22 (in bold print).

3. Present Conditions

To make present-day estimates of the current drainage volume in the Delta, the historic conditions of the 1954-55 study were compared to current conditions. These conditions included:

- Crop acreage
- Consumptive Use
- River Flows
- Precipitation

There were no recent applied water data to compare estimates made in 1954-55.

If historic and current conditions were similar, then drainage volumes could be assumed to be unchanged from the 1954-55 estimates. If conditions differed, then the 1954-55 drainage volume estimates could be higher or lower than present. If changes could not be determined because of lack of data, then the 1954-55 drainage volume data could serve as an indicator of the relative volume of drainage that might be expected under certain stated assumptions. In all cases, the 1954-55 data served as a benchmark for estimating present-day drainage volumes.

Based on the following comparisons of historic data, we believe a reasonable estimate of the current Delta Lowlands drainage volume during dry year conditions (W.Y. 1986-1990) to be 90 to 110% of the 1954-55 estimates given in DWR Report No. 4. This estimate is based on irrigated and total crop acreages, consumptive use model results, hydrology, and precipitation, which were similar in 1986-87 to those in 1954-55.

a. Crop Acreage

Crop acreage data were obtained from numerous DWR sources for comparison. We saw differences in the classification or grouping of some crops. For example, grain and hay were predominantly dry farmed prior to 1970. Spring rainfall and subsurface water were the main water supply. In the 1970s and thereafter, farmers irrigated to increase yield because studies showed this increases production. This irrigation usually occurs in April to July but varies annually and may begin as early as February (G. Sato, pers. comm.). This change affected the non-irrigated and irrigated crop acreage totals and may therefore also affect applied water and drainage estimates. Report No. 4 gave a total Delta Lowlands irrigated crop acreage of 291,667. However, this excluded 79,709 acres of grain and hay, which apparently were dry farmed. When grain and hay are included, the total Lowlands crop acreage is 371,376 acres.

Other differences in the grouping of crop acreages were related to the tabulator of the data. Some land use analysts lumped small acreages as miscellaneous while others kept them separate.

In June 1985, DWR revised their annual crop acreage data for their Consumptive Use Model. These annual estimates are shown in Table 12 and were used to make our comparisons of land use in the Delta Lowlands.

Based on the total irrigated crop acreage (1954 vs. 1984), there has been about a 7% increase (22,000 acres). The total farmed acreage has decreased by about 6 percent.

If drainage volume follows irrigated crop acreage or total crop acreage, we might expect changes to be proportionately related to those acreages.

Table 12. Delta Lowlands Land Use Summary

DWR tabulation (J. Kono, 6/85)
Units in thousands of gross acres

YEAR	PASTURE	ALFALFA	GENERAL FIELD	SUGAR BEET	GRAIN	RICE	MISC. TRUCK	TOMA-TOES	ORCHARD	VINEYRD	TOT-IRIG	DRY-GRAIN	TOT-FARM	URBAN	NATIVE VEG	RIPARIAN	H2O-SURF	TOT-V-W	TOT-AC
1955	23.0	34.5	71.5	30.2	32.0	2.1	94.8	30.1	5.1	0.1	323.4	47.7	371.1	6.9	34.5	7.6	45.9	88.0	466.0
1956	22.2	34.4	74.6	30.8	31.9	1.9	93.3	30.5	5.4	0.0	325.0	46.3	371.3	6.9	34.1	7.6	45.9	87.6	465.8
1957	21.4	34.2	77.8	31.4	31.8	1.6	91.8	30.8	5.7	0.0	326.5	44.8	371.3	6.9	34.5	7.6	45.9	88.0	466.2
1958	20.5	34.2	80.9	32.0	31.7	1.5	90.4	31.2	5.9	0.0	328.3	43.4	371.7	6.9	34.0	7.6	45.9	87.5	466.1
1959	19.7	34.2	84.1	32.7	31.5	1.2	88.8	31.5	6.1	0.0	329.8	41.8	371.6	6.9	34.1	7.6	45.9	87.6	466.1
1960	18.8	34.2	87.2	33.4	31.3	0.9	87.2	31.8	6.3	0.0	331.1	40.3	371.4	6.9	34.2	7.6	45.9	87.7	466.0
1961	18.0	34.1	90.2	34.0	31.2	0.7	85.6	32.2	6.5	0.0	332.5	38.6	371.1	6.9	34.5	7.6	45.9	88.0	466.0
1962	18.1	34.6	89.7	32.5	33.5	0.2	85.0	33.1	6.9	0.0	333.6	37.9	371.5	7.1	33.7	7.6	45.9	87.2	465.8
1963	17.4	35.1	92.5	30.8	35.7	0.2	79.4	34.2	7.2	0.0	332.5	37.3	369.8	7.3	35.4	7.6	45.9	88.9	466.0
1964	17.7	35.3	94.6	28.1	38.0	0.2	76.1	34.9	7.6	0.1	332.6	36.6	369.2	7.5	35.8	7.6	45.9	89.3	466.0
1965	17.7	35.7	96.7	25.4	40.2	0.2	72.7	36.0	7.9	0.2	332.7	36.0	368.7	7.6	36.3	7.6	45.9	89.8	466.1
1966	18.0	36.3	98.8	22.9	42.5	0.2	68.6	36.1	8.2	0.3	331.9	35.3	367.2	7.8	37.1	7.6	45.9	90.6	465.6
1967	17.7	36.6	101.2	20.2	44.8	0.2	64.5	38.0	8.6	0.4	332.2	34.6	366.8	8.0	37.7	7.6	45.9	91.2	466.0
1968	17.8	36.9	103.3	17.3	47.0	0.2	60.4	39.1	8.8	0.4	331.2	33.9	365.1	8.2	39.2	7.6	45.9	92.7	466.0
1969	18.4	36.9	106.0	17.7	48.2	0.0	58.4	37.1	8.9	0.5	332.1	29.7	361.8	8.6	41.5	7.6	45.9	95.0	465.4
1970	18.0	36.4	107.3	17.7	51.7	0.4	58.0	35.1	8.9	0.7	334.2	25.4	359.6	9.0	43.9	7.6	45.9	97.4	466.0
1971	17.7	35.1	108.2	17.8	59.4	0.4	54.0	33.1	8.9	1.1	335.7	20.6	356.3	9.4	46.8	7.6	45.9	100.3	466.0
1972	17.7	34.4	109.8	17.9	71.3	0.4	44.0	31.1	8.9	1.6	337.1	19.9	357.0	9.8	45.7	7.6	45.9	99.2	466.0
1973	17.6	33.7	111.4	18.0	81.6	0.4	39.9	29.1	8.9	2.2	342.8	14.2	357.0	10.2	45.3	7.6	45.9	98.8	466.0
1974	18.0	33.1	112.9	18.1	87.1	0.4	35.7	26.9	9.0	2.8	344.0	14.8	358.8	10.8	33.0	7.6	47.7	88.3	457.9
1975	17.1	31.0	119.8	22.0	90.0	0.4	30.6	26.2	9.0	2.9	349.0	9.8	358.8	11.7	40.5	7.3	47.7	95.5	466.0
1976	16.0	29.1	126.8	26.0	93.0	0.3	25.6	25.5	9.1	2.9	354.3	1.5	355.8	12.8	42.4	7.3	47.7	97.4	466.0
1977	17.3	34.6	118.8	16.4	105.8	0.2	23.0	30.5	9.1	2.9	358.6	0.2	358.8	12.9	39.3	7.3	47.7	94.3	466.0
1978	15.6	28.4	128.5	16.3	102.8	0.2	26.7	27.1	8.9	3.1	357.6	2.0	359.6	13.4	38.0	7.3	47.7	93.0	466.0
1979	15.5	26.6	129.9	16.6	100.5	0.0	25.3	26.0	8.9	3.3	352.6	2.0	354.6	13.8	42.6	7.3	47.7	9Sw6	466.0
1980	15.4	24.8	130.7	17.0	98.6	0.0	23.8	24.8	8.9	3.4	347.4	2.0	349.4	14.2	47.3	7.3	47.7	102.3	465.9
1981	15.4	24.8	130.7	17.1	98.3	0.0	23.9	24.8	8.9	3.5	347.4	2.0	349.4	14.6	47.0	7.3	47.7	102.0	466.0
1982	15.4	24.7	130.6	17.1	98.2	0.0	24.0	24.7	8.8	3.6	347.1	2.0	349.1	15.1	46.8	7.3	47.7	101.8	466.0
1983	15.4	24.7	130.6	17.1	98.1	0.0	24.0	24.6	8.7	3.7	346.9	2.0	348.9	15.5	46.6	7.3	47.7	101.6	466.0
1984	15.4	24.7	130.6	17.1	97.9	0.0	24.0	24.6	8.6	3.8	346.7	2.0	348.7	16.0	46.3	7.3	47.7	101.3	466.0

GENFIELD — general field crops
SUGRBEET — sugarbeets
MISCTRUK — miscellaneous truck crops
TOT-IRIG — total irrigated crop acreage
DRY-GRAN — dry farmed grains
TOT-FARM — total farmed crop acreage
NATIV-VG — native vegetation
H2O-SURF — water surface
TOT-V-W — total of native vegetation, riparian, and water surface acreages
TOTAL-AC — total acreage

b. Consumptive Use

Consumptive use is the total amount of water from transpiration, and evaporation losses from lands on which there is vegetation, plus evaporation from bare lands and water surfaces. Consumptive use requirements will vary with location and climate, especially with temperature and precipitation. Generally, consumptive use is estimated for large areas based on measurements from sample or representative plots of land. Consumptive use can be based on measurements of pan evaporation, which is the amalgamation of various climatic factors such as wind, temperature, and relative humidity. Consumptive use can also be estimated by daylight hours, and available moisture from precipitation, irrigation, or natural ground water.

Total consumptive use estimates shown in the Consumptive Use Model developed by the Department's Division of Planning (model run of November 6, 1985) are listed in Table 13.

The DWR Consumptive Use Model data for water years 1954, 1955, 1981, and 1983 are estimates of the total consumptive use for crop acreage and patterns surveyed respectively for each of those years. The data for water year 1981 were selected to compare consumptive use of present-day crop acreage under water year conditions similar to that occurring in the 1954-55 study. Water years 1955 and 1981 were classified as dry under SWRCB Decision 1485 criteria. The Four-Basin Indices were 10.98 and 11.1 million acre-feet for water years 1955 and 1981, respectively. For comparison, data for water year 1983, a classified wet year, are also shown.

The annual total consumptive use comparison suggests that water demands have not changed significantly between the mid-1950s and early 1980s. If drainage volumes relate well to consumptive use, then present-day drainage volume estimates are close to those estimated for 1954-55.

The table also includes precipitation and net consumptive use estimates. Net consumptive use is calculated by subtracting the precipitation values from the total consumptive use values. When the net consumptive use values are negative, there is excess water resulting in Delta runoff or drainage. When net consumptive use values are positive, then water must be applied or siphoned from the Delta channels to meet the year's crop demands.

The net consumptive use for water years 1954 and 1981 was nearly equal at 871 and 883 thousand acre feet, respectively. The model results should be used and interpreted with caution as with any other modeling results. Different assumptions will affect the model estimates. For example, the DWR Division of Planning Consumptive Use Model uses estimated leach water adjustments for the Delta Lowlands. These estimated values are fixed for each calendar month and used in the model for all water years regardless of hydrology. They are estimates of the amount of water applied for soil leaching from the surrounding channels.

The results of this model are shown only to compare estimated changes in consumptive use demands for 1954-56 to present which may have affected drainage volume. At this time, the historic consumptive use estimates indicate that present-day drainage volumes are at least equal to those reported in the 1954-55 study.

Table 13. DWR Consumptive Use Model Estimates

Delta Lowlands

In thousands of acre-feet

	W.Y. 1954			W.Y. 1955			W.Y. 1981			W.Y. 1983		
	TCU	Ppt.	NCU	TCU	Ppt.	NCU	TCU	Ppt.	NCU	TCU	Ppt.	NCU
Oct	63	3.9	59.1	60.5	0	60.5	52.3	2.3	50	105.5	66.2	39.3
Nov	73.7	40.8	32.9	103.8	75.1	28.7	39.5	4.2	35.3	140.1	199.1	-59
Dec	63.3	33.1	30.2	122.6	133.2	-10.6	80.8	59.3	21.5	48.1	100.1	-52
Jan	90.7	76.6	14.1	46.8	118.6	-71.8	129.1	147.5	-18.4	22.7	207.9	-185.2
Feb	77.6	68.9	8.7	59.2	43.5	15.7	65.9	37	28.9	41.2	187.9	-146.7
Mar	92.4	92	0.4	67.4	19.6	47.8	90.3	112.4	-22.1	52.5	279.2	-226.7
Apr	87.7	51.2	36.5	97.1	72	25.1	77.6	21.2	56.4	95.8	107.8	-12
May	106.8	9.2	97.6	112.9	23.1	89.8	103.3	4.2	99.1	87.1	11.6	75.5
Jun	183.3	5.4	177.9	182.3	0	182.3	222.7	0	222.7	170.7	0.8	169.9
Jul	200.3	0	200.3	203.4	0	203.4	209.9	0	209.9	198.3	0	198.3
Aug	134	1.5	132.5	134.9	0	134.9	125.5	0	125.5	131.9	1.5	130.4
Sep	80.5	0	80.5	84.8	7.3	77.5	86.2	12.3	73.9	99.5	28.1	71.4
Total	1253.3	382.6	870.7	1275.7	492.4	783.3	1283.1	400.4	882.7	1193.4	1190.2	3.2

c. River Flows

Mean daily river flows in 1954-55 and 1987-88 are shown in Table 14 for the Sacramento River at Sacramento and San Joaquin River near Vernalis. The difference between the 1987 and 1954 monthly mean daily flows are shown in the row labeled "1987-1954." The difference between the 1988 and 1955 values are shown in the row labeled "1988-1955."

Water year 1954 (October 1, 1953 to September 30, 1954) was an "above normal" water year for the Sacramento-San Joaquin Delta according to criteria set in SWRCB Decision 1485. The unimpaired runoff for the Sacramento River Basin by the Sacramento Valley Four-Basin Index was 17.43 million acre-feet. The following water year 1955 (October 1, 1954 to September 30, 1955) was a "dry" year with total unimpaired runoff at 10.98 million acre-feet.

Water year 1987 (October 1, 1986 to September 30, 1987) was classified as a "critically dry" year with a Four-Basin Index of 9.14 million acre-feet. Rainfall was 65 percent of average. The 1987 water year was the ninth driest of this century. Water year 1988 (October 1, 1987 to September 30, 1988) was also "critically dry," with a Four-Basin Index of 9.17 million acre-feet.

Because water years 1987 and 1988 were drier than water year 1955, mean daily river flows in some months during 1987 and 1988 were lower than during 1954 and 1955. This is shown by the negative values (parenthesized) in rows labelled "1987-1954" and 1988-1955."

Sacramento River mean daily flows in May, June, October, November, and December of 1987 were less than for the same months in 1954. February, March, May, and June 1988 flows in the Sacramento River were also lower than the corresponding months of 1955. Both Sacramento and San Joaquin River flows were higher in July and August 1987 and 1988 than in 1954 and 1955. July and August are typically peak months of applied water and drainage as well as low river flows. The ratio of drainage to river flow is normally higher in the summer.

The summer river flows and dry water year during the 1954-55 drainage study and that of the 1987-88 investigation were similar enough for comparison and use in estimating the present-day drainage volumes during the growing season or seasonal irrigation period.

Table 14. Sacramento and San Joaquin River Flows
Mean Daily Flow in cubic feet per second

Sacramento River	May	June	July	Aug	Sept	Oct	Nov	Dec
1954	24,830	11,030	8,097	9,236	11,130	10,580	14,550	23,690
1987	9,996	10,067	15,142	14,439	11,625	9,509	8,129	15,744
1987-1954	(14,834)	(963)	7,045	5,203	495	(1,071)	(6,421)	(7,946)
San Joaquin River								
1954	6,716	1,286	542	546	754	1,043	1,386	1,814
1987	2,178	1,990	1,632	1,627	1,597	1,370	1,548	1,278
1987-1954	(4,538)	704	1,090	1,081	843	327	162	(536)

Sacramento River	Jan	Feb	March	April	May	June	July	Aug	Sept
1955	22,770	15,110	13,650	13,780	21,600	12,190	8,990	9,025	9,845
1988	25,400	12,188	11,348	16,887	10,974	10,578	14,642	13,287	11,537
1988-1955	2,630	(2,922)	(2,302)	3,107	(10,626)	(1,612)	5,652	4,262	1,692
San Joaquin River									
1955	2,965	2,451	1,561	917	1,150	1,496	416	431	610
1988	1,483	1,389	2,241	2,146	1,781	1,711	1,357	1,557	1,452
1988-1955	(1,482)	(1,062)	680	1,229	631	215	941	1,126	842

Source: U.S. Geological Survey
Values in parentheses are negative.

d. Precipitation

Precipitation data are not critical for examining year to year differences in drainage during the summer peak drainage months, July and August, as precipitation is negligible (Table 14). However, for other months when heavy precipitation occurs, total consumptive use, applied water, and drainage volume will vary significantly among years, and precipitation can directly and indirectly affect drainage quality and quantity.

Precipitation in the Delta Lowlands by month in thousands of acre-feet for water years 1955, 1956, and the average for each month for water years 1921 to 1983 (October 1, 1920 to September 30, 1983) are shown in Table 15. The data show that, in general, summer (June - September) precipitation does not contribute to drainage volume. During water years 1987 and 1988 summer rainfall also agreed with historic trends, as these were two critically dry water years.

The precipitation data suggest that comparisons of the summer data in the 1954-55 drainage study to that of the summer 1987-88 drainage data can be made, as summer rainfalls were about the same.

Table 15. Precipitation on Delta Lowlands
In thousands of acre-feet

MONTH	W.Y. 1954	W.Y. 1955	W.Y. 1921-83 average
Oct	3.9	75.1	67.6
Dec	33.1	133.2	105.8
Jan	76.6	118.6	120
Feb	68.9	43.5	99.4
Mar	92	19.6	80
Apr	51.2	72	47.9
May	9.2	23.1	15
Jun	5.4	0	4.5
Jul	0	0	0.8
Aug	1.5	0	1.5
Sep	0	7.3	6.6
Total	382.6	492.4	580.4

Source: DWR Consumptive Use Study 10/2/85 Total Basin Precipitation, Delta Lowlands Basin area 462,100 acres.

D. Estimating Drainage Impacts

1. South Delta Flow Patterns

To study the flow patterns in the Delta, we monitored selenium entering the Delta from the San Joaquin River and we conducted synoptic water quality sampling at major channels throughout the Delta.

The Central Valley Regional Water Quality Control Board has documented that selenium-laden waters enter the San Joaquin River from Mud and Salt Sloughs during a period of winter low river flows and field leaching of salts. Selenium levels in the San Joaquin River are typically elevated for a period of 6 to 8 weeks between February and March each year. During this period, elevated selenium levels can be traced down the San Joaquin River and through the southern Delta.

The selenium data collected in this study showed that under the low flow conditions, San Joaquin River water was flowing westward toward the Delta Mendota Canal intake via Old River and Fabian-Grant Line Canals. The selenium distribution for the March 2, 1989 selenium sampling is shown in Figure 22. The hydrologic conditions are shown in Table 16.

On some occasions, selenium has been actually detected at the DMC intake at Lindemann Road but not at the Clifton Court intake on Old River or at the Banks Headworks (Figure 23). This indicates SJR water is being diverted to the DMC intake. Mineral data from over 20 additional sampling runs from 12/18/89 to 3/20/90 confirm these observations more strongly as concentrations of major ions (e.g. sodium, TDS) are much higher and easier to detect than selenium levels (mg/L vs. µg/L) and are more conservative (not biologically removed) than selenium.

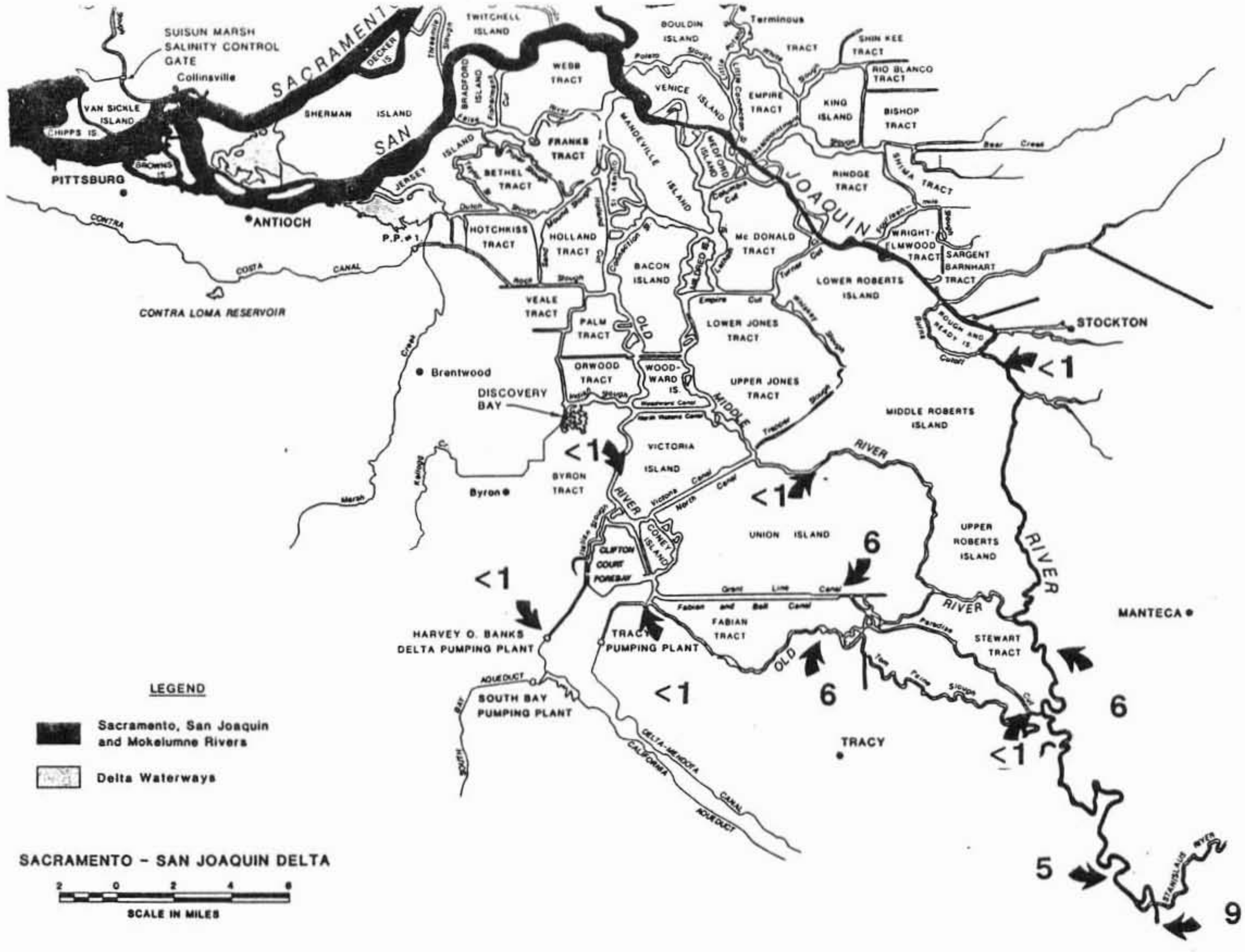


Figure 22. Delta Selenium Distribution (μg/L), March 2, 1989

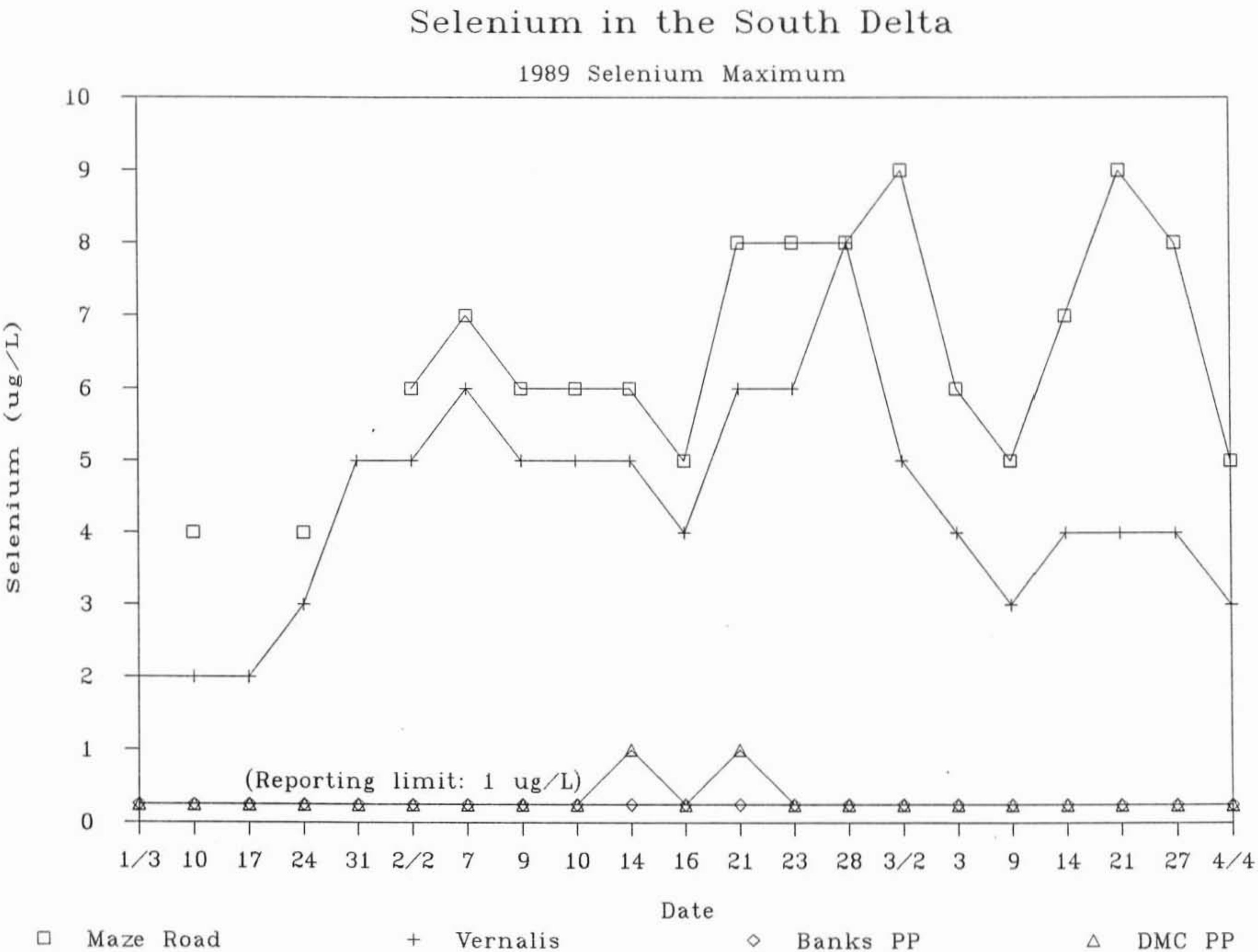


Figure 23. Selenium in the South Delta

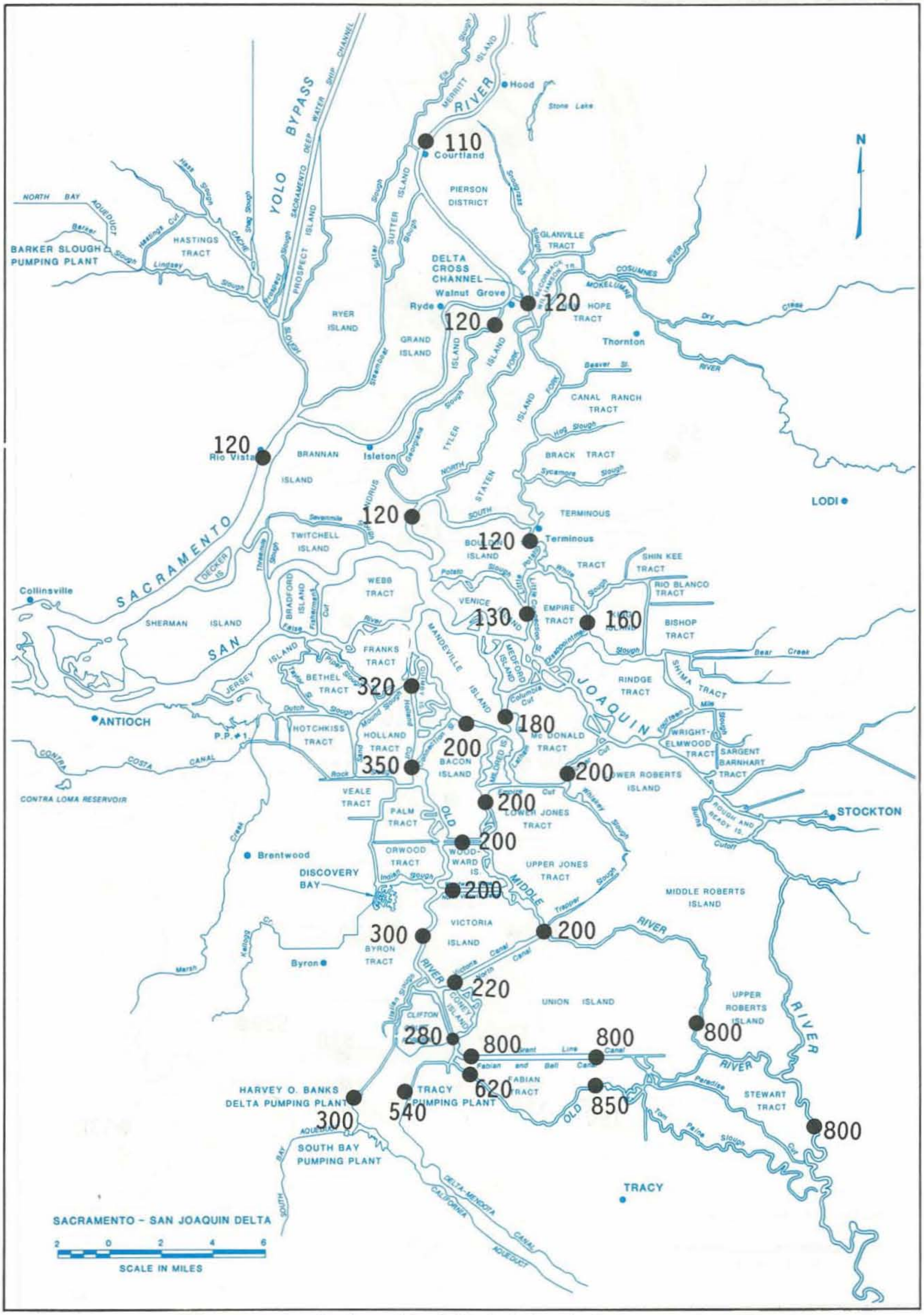


Figure 24. Deltawide EC (μS/cm) July 25, 1989

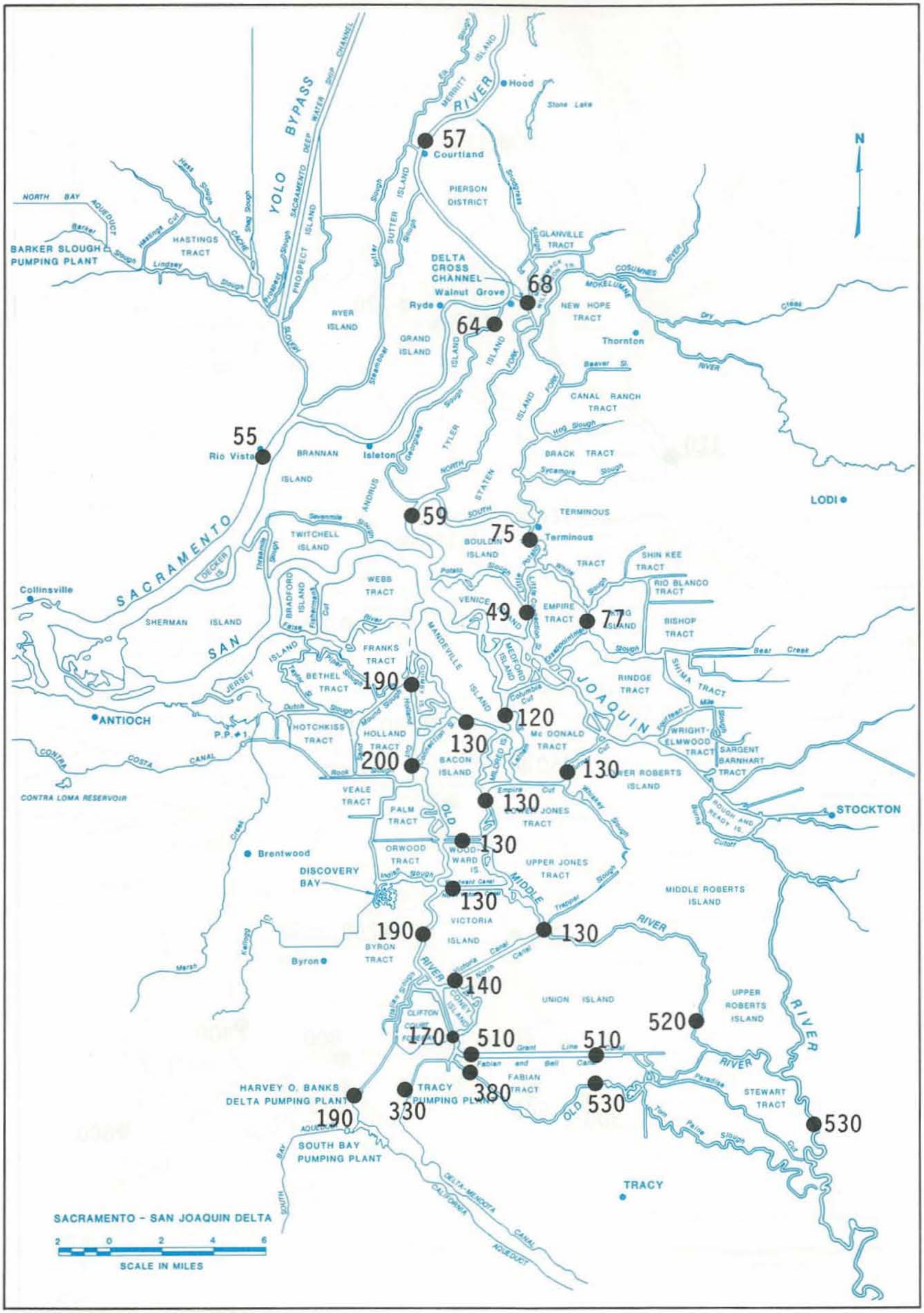


Figure 25. Deltawide TDS (mg/L) July 25, 1989

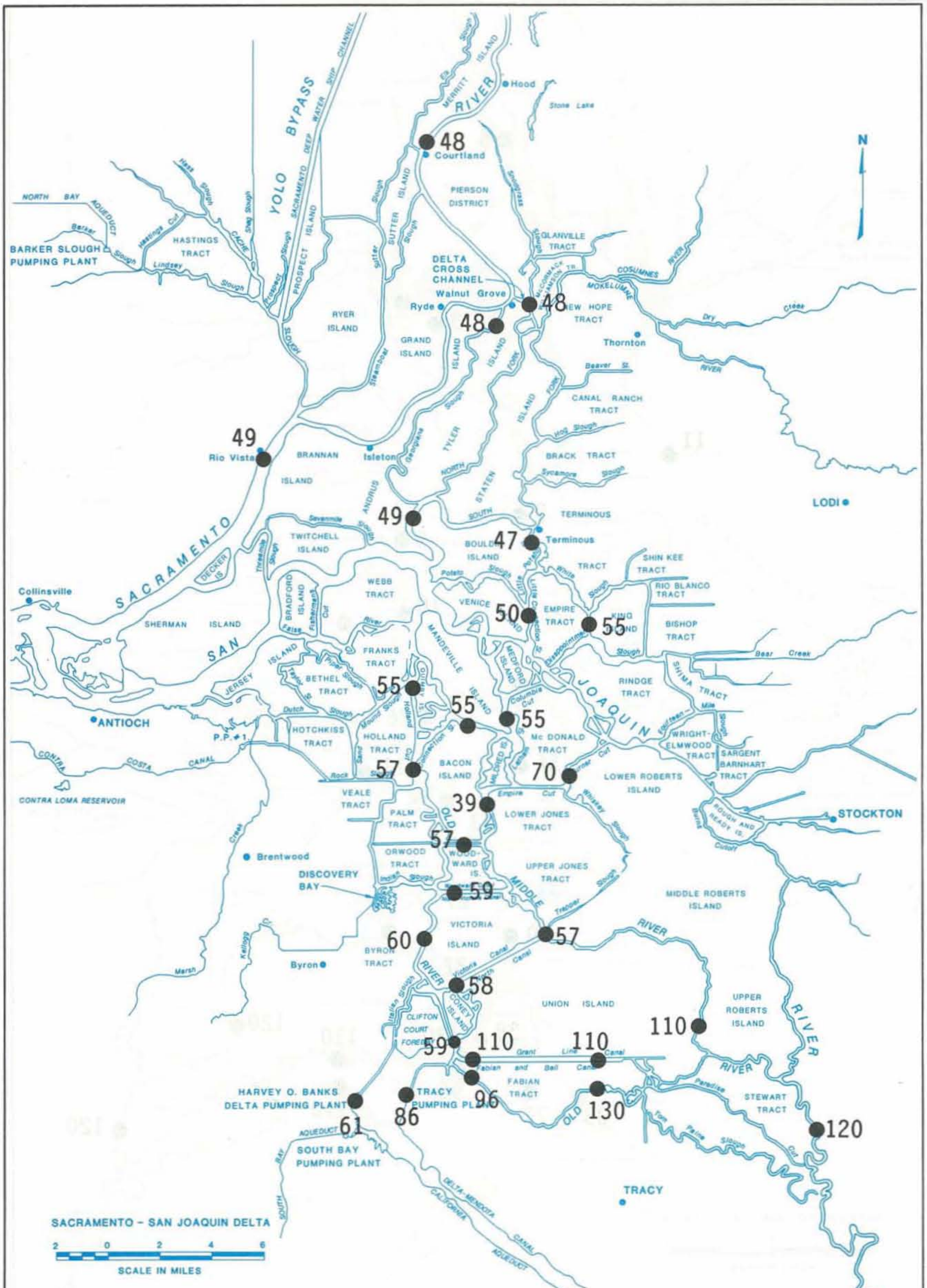


Figure 26. Deltawide Alkalinity (mg/L) July 25, 1989

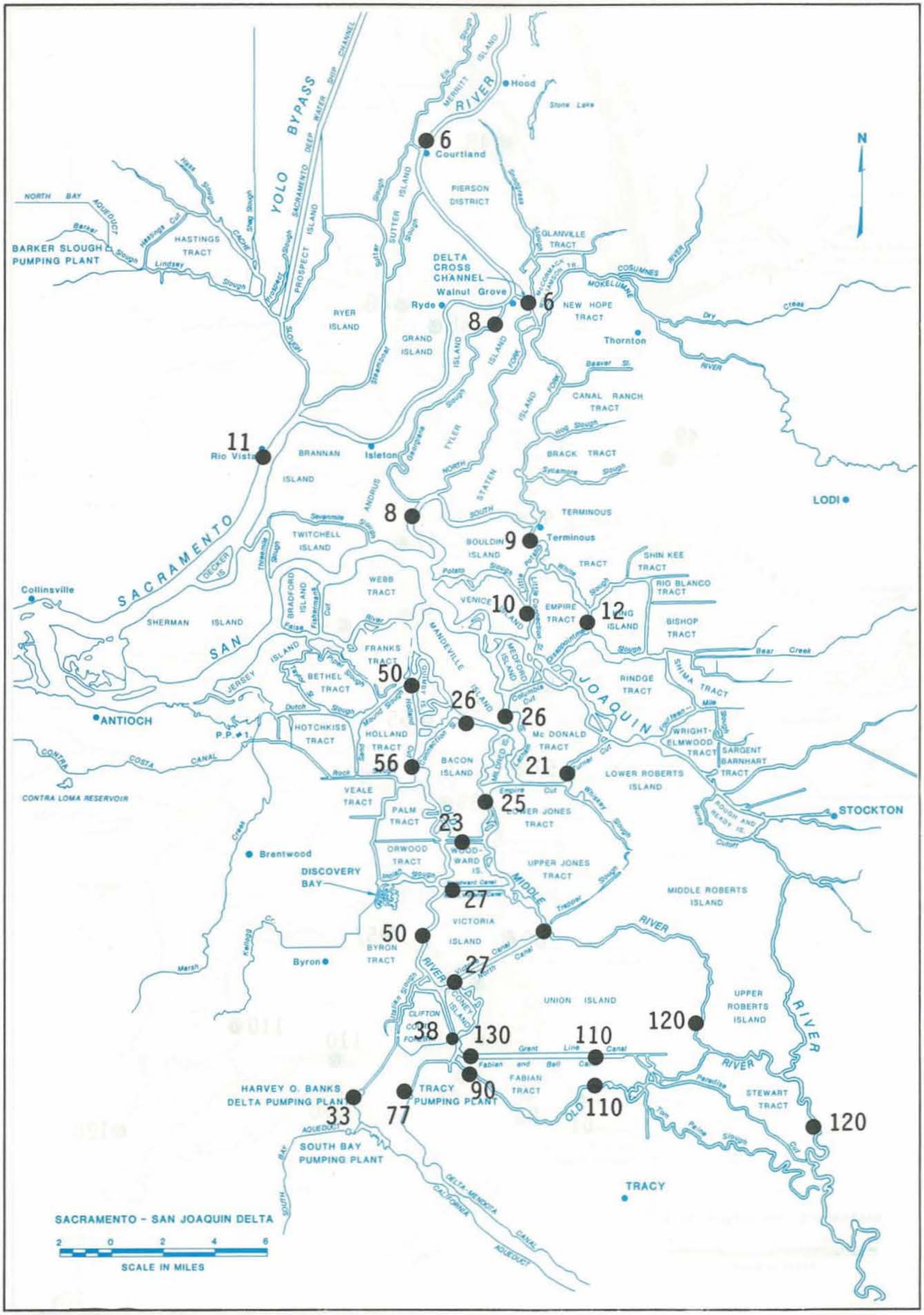


Figure 27. Deltawide Sodium (mg/L) July 25, 1989

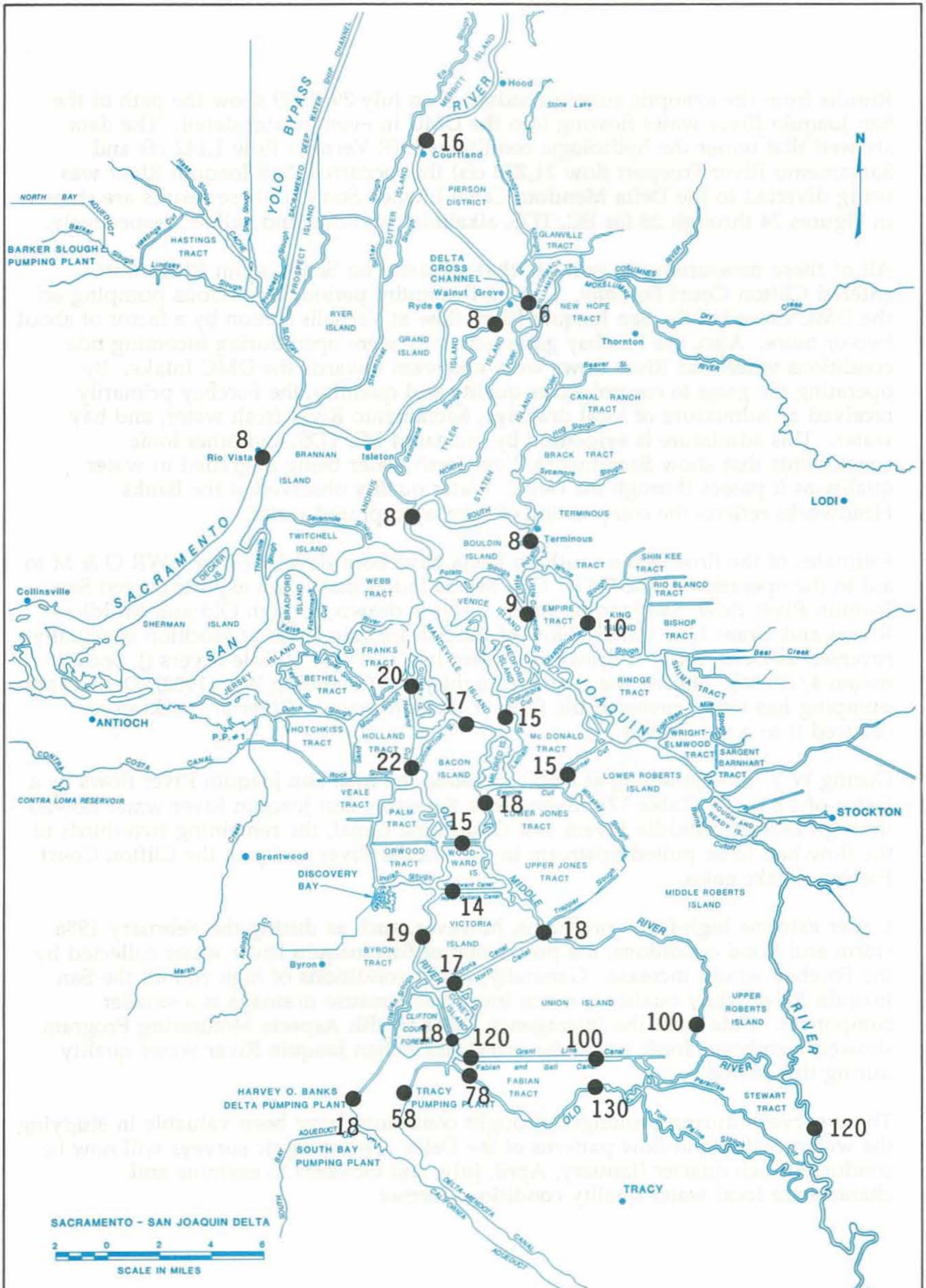


Figure 28. Deltawide Sulfate (mg/L) July 25, 1989

Results from the synoptic survey conducted on July 29, 1989 show the path of the San Joaquin River water flowing into the DMC in even greater detail. The data showed that under the hydrologic conditions (SJR Vernalis flow 1,242 cfs and Sacramento River Freeport flow 21,278 cfs) that occurred, San Joaquin River was being diverted to the Delta Mendota Canal intake. Some of these results are shown in Figures 24 through 28 for EC, TDS, alkalinity, sodium, and sulfate, respectively.

All of these measurements indicate that virtually no San Joaquin River water entered Clifton Court Forebay. During this entire period, continuous pumping on the DMC exceeded the San Joaquin River flow at Vernalis station by a factor of about two or more. Also, the Forebay gates generally were open during incoming tide conditions when Old River flows were upstream towards the DMC intake. By operating the gates to control water quality and quantity, the Forebay primarily received an admixture of local drainage, Sacramento River fresh water, and bay water. This admixture is evidenced by increased EC, TDS, and other ionic constituents that show Sacramento River fresh water being degraded in water quality as it passes through the Delta. Water quality observed at the Banks Headworks reflects the compositing of Forebay captured water.

Estimates of the flow in the southern Delta have been developed by DWR O & M to aid in the operation of the SWP. O & M has found that when exports exceed San Joaquin River flow, San Joaquin River water is drawn through Old and Middle Rivers and Grant Line Canal. Flow of the San Joaquin River at Stockton is actually reversed as Delta water is drawn upstream into Old and Middle Rivers (J. Snow, memo 4/17/86). During the recent drought years (including W.Y. 1988), Delta export pumping has either reversed the flow of the San Joaquin River at Stockton or reduced it to a net "trickle."

During W.Y. 1988 pumping at DMC exceeded the total San Joaquin River flows by a factor of 1.8 to 3.2 (Table 17). Even when the entire San Joaquin River water flowed through Old and Middle Rivers and Grant Line Canal, the remaining two-thirds of the flow had to be pulled upstream in the Middle River and past the Clifton Court Forebay intake gates.

Under extreme high-flow conditions, however, such as during the February 1986 storm and flood conditions, the proportion of San Joaquin River water collected by the Forebay would increase. Generally, under conditions of high runoff, the San Joaquin River water quality is much improved because drainage is a smaller component. Data from the Interagency Delta Health Aspects Monitoring Program showed significant fresh water characteristics in San Joaquin River water quality during this period.

These surveys during prolonged drought conditions have been valuable in studying the water quality and flow patterns of the Delta. The synoptic surveys will now be conducted each quarter (January, April, July, and October) to examine and characterize local water quality conditions further.

Table 16. Hydrology During Synoptic Surveys

Date	Delta Inflow avg. cfs	Old Middle River avg. cfs	Rio Vista avg. cfs	Cross Channel	Delta Outflow avg. cfs	Antioch Estimated avg. cfs	Stockton avg. cfs	Banks Headworks acre-ft	Tracy Plant acre-ft
3/1/89	13,339	-6,531	6,677	open 2	5,888	-613	-337	6,863	8,126
3/2/89	13,980	-5,778	6,987	open 2	7,230	211	-193	5,729	7,917
3/3/89	15,197	-7,049	7,617	open 2	6,851	-595	-199	7,269	8,221
7/23/89	23,573	-9,337	12,085	open 2	8,084	-3,221	-541	12,583	9,376
7/24/89	23,960	-9,988	12,251	open 2	7,595	-3,746	-566	11,994	9,148
7/25/89	23,531	-9,788	11,989	open 2	7,463	-3,677	-567	11,820	9,460

avg. cfs is average cfs
Negative values indicate reverse flow (upstream).
1 cfs for 24 hrs. = 1.983 acre-ft.
The number of cross channel gates that were open are noted (0, 1, or 2).

Table 17. W.Y. 1988 Flows at DMC, Vernalis and Stockton

Month	Daily Avg Pumping @ DMC (CFS)	Daily Avg Flow @ Vernalis (CFS)	Ratio: DMC to Vernalis	San Joaquin River Calculated Daily Avg Flow at Stockton (CFS)	Stockton #Days +flow/ -flow
10/87	3998	1273	3.1:1	-83.	+3/-28
11/87	3930	1573	2.5:1	83.	+29/-1
12/87	4033	1361	3.0:1	-313.	+5/-26
1/88	4063	1521	2.7:1	-371.	+2/-29
2/88	4098	1374	3.0:1	-403.	+0/-29
3/88	4083	2294	1.8:1	153.	+27/-4
4/88	4083	2120	1.9:1	37.	+18/-12
5/88	2971	1649	1.8:1	41.	+18/-13
6/88	2993	1526	2.0:1	37.	+18/-12
7/88	4479	1379	3.2:1	-283.	+0/-31
8/88	4531	1604	2.8:1	-238.	+5/-26
9/88	4592	1464	3.1:1	-194.	+1/-29

Stockton cfs calculated using flows from Vernalis, Channel Depletion, and Exports.

2. Volume Comparisons

The monthly volumes of 1954-55 drainage were compared against river inflow to the Delta (Table 18). The ratio between drainage and river volumes provides a theoretical estimate of the fraction (shown as percentage in Table 19) of recycled drain water in water flowing through the Delta and theoretical maximum dilution of drainage by river water. These comparisons are based on the assumption that 1954-55 and 1987-88 applied water use, drainage volume, and hydrology are similar.

During June and July 1954, the total drainage volumes were 9.5 and 15.6 percent, respectively, of the combined fresh water flowing into the Delta from the Sacramento and San Joaquin rivers and east side streams in June and July of 1954. In June and July 1955 drainage volumes were equal to 8.6 and 14.3 percent of the total river volume for these two months, respectively during June and July of 1955.

When June and July 1954 and 1955 drainage volumes are compared to 1987 and 1988 hydrology, these drainage volumes would have comprised 8% to 9.9 % of the total June and July river volumes. This is because the June and July 1987 and 1988 river flows were about 1.5 to 2 times greater than the June and July 1954 and 1955 river flows.

Table 18. Comparisons of Drainage to River Flows

Delta acreage 419,457 (1954-55)

	1954 M	J	J	A	S	O	N	D
Total 1954-55								
Monthly Drainage (ac-ft)	55,719	70,573	80,575	70,857	44,557	46,817	46,537	85,731
Drainage 1954-55 (ac-ft/day)	1,857	2,352	2,686	2,362	1,485	1,561	1,551	2,858
Drainage 1954-55 (cfs)	938	1,188	1,356	1,193	750	788	783	1,443
Average Daily River Flows								
Sacramento River 1954-55 cfs	25,149	11,061	8,117	9,321	11,279	10,639	14,826	24,678
San Joaquin River 1954-55 cfs	6,718	1,294	537	553	756	1,041	1,378	1,822
East side streams 1954-55 cfs	1,269	185	65	81	185	293	538	1,610
Total 1954-55 cfs	33,136	12,540	8,719	9,955	12,220	11,973	16,742	28,110
Total 1954-55 ac-ft/month	1,968,278	744,876	517,909	591,327	725,868	711,196	994,475	1,669,734
Total Monthly Drainage (as % Total 1954-55 River Flow)	2.83%	9.47%	15.56%	11.98%	6.14%	6.58%	4.68%	5.13%
Sacramento River 1987-88 cfs	9,996	10,067	15,142	14,439	11,625	9,509	8,129	15,744
San Joaquin River 1987-88 cfs	2,178	1,990	1,632	1,627	1,597	1,370	1,548	1,278
Sacramento and San Joaquin River Total ac-ft/month	723,128	716,205	996,368	954,290	785,367	646,195	574,834	1,011,103
Computed Delta Outflow 1987-88 cfs (DAYFLO)	4,951	3,496	3,829	2,851	1,790	3,789	4,291	9,455
Computed Delta Outflow 1987-88 ac-ft/month	294,116	207,647	227,445	169,353	106,350	225,055	254,897	561,600
Total 1954-55 Monthly Drainage (as % Total 1987-88 River Flow)	7.71%	9.85%	8.09%	7.43%	5.67%	7.25%	8.10%	8.48%

1 CFS * 1.98 = # Acre Ft. Per Day
CFS * 1.98 * 30 = TOTAL ACRE-FT PER MONTH (30 DAY MONTH)

Table 18 (cont). Comparisons of Drainage to River Flows

Delta acreage 419,457 (1954-55)

	1955 J	F	M	A	M	J	J	A	S
Total 1954-55									
Monthly Drainage (ac-ft)	95,668	41,960	32,419	37,628	49,813	71,084	80,606	72,170	43,116
Drainage 1954-55 (ac-ft/day)	3,189	1,399	1,081	1,254	1,660	2,369	2,687	2,406	1,437
Drainage 1954-55 (cfs)	1,611	706	546	633	839	1,197	1,357	1,215	726
Average Daily River Flows									
Sacramento River 1954-55 cfs	23,230	15,381	13,860	14,154	21,749	12,204	9,012	9,045	9,918
San Joaquin River 1954-55 cfs	2,977	2,449	1,562	925	1,155	1,496	423	423	605
East side streams 1954-55 cfs	3,823	1,387	748	689	667	151	33	16	101
Total 1954-55 cfs	30,030	19,217	16,170	15,768	23,571	13,851	9,468	9,484	10,624
Total 1954-55 ac-ft/month	1,783,782	1,141,490	960,498	936,619	1,400,117	822,749	562,399	563,350	631,066
Total Monthly Drainage (as % Total 1954-55 River Flow)	5.36%	3.68%	3.38%	4.02%	3.56%	8.64%	14.33%	12.81%	6.83%
Sacramento River 1987-88 cfs	25,400	12,188	11,348	16,887	10,974	10,578	14,642	13,287	11,537
San Joaquin River 1987-88 cfs	1,483	1,389	2,241	2,146	1,781	1,711	1,357	1,557	1,452
Sacramento and San Joaquin River Total ac-ft/month	1,596,825	806,468	807,189	1,130,521	757,657	729,986	950,324	881,764	771,527
Computed Delta Outflow 1987-88 cfs (DAYFLO)	19,593	3,045	4,542	3,496	3,829	2,851	1,790	3,789	4,291
Computed Delta Outflow 1987-88 ac-ft/month	1,163,805	180,863	269,770	207,647	227,445	169,353	106,350	225,055	254,897
Tot 1954-55 Monthly Drainage (as % Total 1987-88 River Flow)	5.99%	5.20%	4.02%	3.33%	6.57%	9.74%	8.48%	8.18%	5.59%

1 CFS * 1.98 = # Acre Ft. Per Day
CFS * 1.98 * 30 = TOTAL ACRE-FT PER MONTH (30 DAY MONTH)

Table 19. Volume Comparisons of Monthly River Flows, Drainage, and Total Exports

Units in acre-feet

	1987 M	J	J	A	S	O	N	D
Total 1987-88 Monthly Sacramento and San Joaquin River flows	723,128	716,205	996,368	954,290	785,367	646,195	574,834	1,011,103
1954-55 Monthly Drainage	55,719	70,573	80,575	70,857	44,557	46,817	46,537	85,731
Total Exports	326,118	307,888	549,482	601,514	538,742	362,617	324,308	551,547
Drainage volume as % of Total Exports	17.09%	22.92%	14.66%	11.78%	8.27%	12.91%	14.35%	15.54%

	1988 J	F	M	A	M	J	J	A	S
Total 1987-88 Monthly Sacramento and San Joaquin River flows	1,596,825	806,468	807,189	1,130,521	757,657	729,986	950,324	881,764	771,527
1954-55 Monthly Drainage	95,668	41,960	32,419	37,628	49,813	71,084	80,606	72,170	43,116
Total Exports	639,451	575,509	518,115	509,074	384,413	350,444	489,009	539,764	482,269
Drainage volume as % of Total Exports	14.96%	7.29%	6.26%	7.39%	12.96%	20.28%	16.48%	13.37%	8.94%

3. <u>THM Precursor Contributions</u>

An estimate was made of the contribution of THM precursor material from Delta islands to the Delta channels. The calculations were performed to determine the effect that Delta island drainage might have on export water quality.

The calculations focused on the TTHMFP carbon (TFPC) concentrations in the Delta during water year 1988 (October 1, 1987 through September 30, 1988). Certain types of naturally occurring organic materials are the basic and essential precursors in the formation of trihalomethanes and other disinfection by-products (DBPs) during water treatment. The TTHMFP test is a measure of the fraction or concentration of materials in the water that have the propensity to form THMs. Therefore, TTHMFP results are a good basis for assessing the amount of organic THM precursors present.

If all natural organic matter in water readily formed THM then DOC would be a good surrogate indicator. However, our comparisons of Delta water DOC versus TTHMFP show unclear and poorly defined relationships. This may be due to the seasonal and geographical variations in the type and forms of DOC compounds in the water and bromide levels as shown by Amy et al (1990). Bromide from sea water intrusion and soils also contributes to the formation of brominated DBPs during disinfection.

TTHMFP is the sum total of chloroform ($CHCl_3$), bromodichloro-methane ($CHBrCl_2$), dibromochloromethane ($CHBr_2Cl$), and bromoform ($CHBr_3$) concentrations produced during a formation potential test. Because the atomic weight of bromine is more than twice the atomic weight of chlorine, waters containing equal amounts of THM but varying amounts of bromide exhibit different TTHMFP concentrations by weight. Therefore, to assess the various sources (drainages and rivers) of organic THM precursors, the concentrations of TTHMFP organic carbon in the water were compared.

To make these comparisons, the percent of carbon in each of the four THM species that were formed in the TTHMFP test was first calculated. The percentages by weight of carbon were 10% ($CHCl_3$), 7.3% ($CHBrCl_2$), 5.8% ($CHBr_2Cl$), and 4.8% ($CHBr_3$). Then the concentrations of each of the 4 THM compounds in the data set were multiplied by their respective percentage of carbon content to obtain the concentrations of THM carbon. These carbon concentrations were then summed to yield the total amount of TFPC.

Water year 1988 river volumes and THM carbon concentrations and 1954-55 drainage volume estimates were then used to compute their respective carbon loads. River volumes used in the calculations included the Sacramento (Freeport), San Joaquin (Vernalis), Mokelumne and Cosumnes. Volumes for the Sacramento and San Joaquin rivers were adjusted to better reflect the actual volumes that are available for mixing in the Delta channels. The adjustments for San Joaquin River flows were based on DWR SWP Operations and Maintenance Dispatcher Daily Reports. All of the flow in the Mokelumne and Cosumnes Rivers was used because of their eastern Delta location and distance from the export pumps. Tidal action should make most of these flows available for mixing in the Delta channels.

For these calculations an assumption was made that all of the net Delta outflow to the bay was from the Sacramento River. This assumption, while not entirely correct, was made because most of the San Joaquin River water is pumped through Tracy Pumping Plant and would not exert enough hydraulic head to contribute significantly to the outflow. During outgoing tides most of the Sacramento River flow apparently goes out to the estuary because of the direct channel connection. Since outgoing tides occur half the time, a large proportion of the flow would be lost to mixing in the Delta. Therefore, the total net Delta outflow for the month was subtracted from the total Sacramento River flow for each month to represent Sacramento River water in the Delta.

Three estimates of present-day Lowlands drainage volumes based on estimated Lowlands crop acreages were used to compute TFPC contributions. These were 90%, 100%, and 110% of the 1954-55 drainage volume estimates given in DWR Report No. 4. The adjusted river flows and 1954-55 island drainage volumes are shown in Table 20.

Table 20. River Volumes and Estimated Island Drainage (Ac-Ft)

Month W.Y. 1988	Adjusted Sacramento	Adjusted San Joaquin	Mokelumne River	Cosumnes River	1954-55 Drainage
OCT	351639	0	3968	598	46820
NOV	228331	4938	2834	1769	46540
DEC	386624	0	3091	4012	85730
JAN	356994	0	3084	13229	95670
FEB	525792	0	2227	6280	41960
MAR	418435	9405	1767	9159	32420
APR	320506	2201	1290	8727	37630
MAY	382757	2520	906	6449	49800
JUN	439137	2201	990	2068	71080
JUL	659114	0	1138	304	80610
AUG	664809	0	675	0	72170
SEP	544096	0	1053	0	43120

Equations used for the following discussion are listed in Table 22.

Table 21. Equations for Tables 22-24

The following equations were used to calculate the percent of carbon in each of the 4 THMs:

Compound, formula, and equation	**Percent carbon by wt.**
Chloroform, $CHCl_3$, {C/(C+H+(3xCl))}x100	10.05%
Bromodichloromethane, $CHBrCl_2$, {C/(C+H+Br+(2xCl))}x100	7.33%
Dibromochloromethane, $CHBr_2Cl$, {C/(C+H+Cl+(2xBr))}x100	5.76%
Bromoform, $CHBr_3$, {C/(C+H+(3xBr))}x100	4.75%

Where: C=12, H=1, Cl=35.45 and Br=79.91

Table 22.

The equation used for the calculations was:

Dc= ((Sv)(Sc)+(SJRv)(SJRc)+(Mv)(Mc)+(Cv)(Cc))/(Sv+SJRv+Mv+Cv)

Where: Dc = Theoretical THMFP organic carbon concentration (TFPC) in Delta water in µg/L
Sv = Sacramento River volume in ac-ft
Sc = Sacramento River TFPC concentration in µg/L
SJRv = San Joaquin River volume in ac-ft
SJRc = San Joaquin River TFPC concentration in µg/L
Mv = Mokelumne River volume in ac-ft
Mc = Mokelumne River TFPC concentration in µg/L
Cv = Cosumnes River volume in ac-ft
Cc = Cosumnes River TFPC concentration in µg/L

Table 23.

The following equations were used to compute the proportioned values shown in Table 25:

For June through August estimates:
Cw=((.465)(Cm)+(.535)(Cns))

For September through May estimates:
Cw=((.325)(Cm)+(.675)(Cns))

Where:
Cw = Flow weighted TFPC concentration in µg/L
Cm = TFPC concentration from middle Delta island group in µg/L
Cns = TFPC concentration from north-south Delta island group in µg/L

Tables 24.

The equations used in these calculations are shown below.

River plus drainage:
Crd=((Fd)(Cw)+(Fr)(Cr))/(Fd+Fr)) using 1954-55 drainage volume
Crd=((0.9)(Fd)(Cw)+(Fr)(Cr))/((0.9)(Fd)+(Fr)) using 90% drainage volume
Crd=((1.1)(Fd)(Cw)+(Fr)(Cr))/((1.1)(Fd)+(Fr)) using 110% drainage volume
Concentration of river TFPC:
Conct=(2.63)(Cr)

Where:
Crd = TFPC concentration of river and drainage mixed in µg/L
Fd = Total Drainage volume in ac-ft
Fr = Total river volume in ac-ft
Cw = Flow weighted TFPC concentration of all drains in µg/L
Cr = Flow weighted TFPC concentration of rivers in µg/L
Conct = Concentration of river TFPC

TFPC concentrations in the Sacramento, Mokelumne, Cosumnes and San Joaquin rivers were flow weighted to provide a single theoretical mixed concentration in the Delta. TTHMFP data for the Mokelumne and Cosumnes rivers were not available for the 1988 water year. Instead, data collected during the 1984 water year were used. Because of the generally good quality of these rivers and their relatively low flow, monitoring of these two stations under IDHAMP was discontinued after 1984. The results are shown below in Table 22.

Table 22. River TTHMFP Carbon (TFPC)
(μg/L)

Month	Sacramento	San Joaquin	Mokelumne	Cosumnes	Flow Weighted /1
OCT	24.82	26.71	24.31	15.41	24.79
NOV	31.14	52.22	19.21	17.35	31.33
DEC	29.13	42.73	19.21	83.82	29.61
JAN	38.88	45.37	22.22	16.27	37.94
FEB	24.26	55.65	11.32	14.33	24.09
MAR	26.16	35.16	26.39	19.80	26.22
APR	16.43	35.34	23.38	20.65	16.69
MAY	22.20	35.72	20.29	13.33	22.14
JUN	26.91	39.44	23.52	23.93	26.95
JUL	21.10	54.14	36.44	24.67	21.13
AUG	19.25	48.57	31.42	32.71	19.27
SEP	31.95	43.29	42.47	30.85	31.97

/1 Flow weighted TTHMFP carbon concentration of Delta inflow represents the theoretical THMFP carbon concentration in Delta channels.

The Department conducted a study from September 1981 through January 1982 to determine the sources of THM precursors in the Sacramento-San Joaquin Delta, Sacramento River and State Water Project. Conclusions from this investigation were that (1) agricultural drainage appears to be a significant source of precursors, (2) effluent of waste water treatment plants do not appear to be a major source and (3) aquatic vegetation was not a significant source at the places and times of sampling.

There has been research on the reaction of aqueous chlorine with proteins produced by algae in natural waters (Scully et al, 1988). The study was conducted on reservoirs in Colorado and Pennsylvania. One of the conclusions points out that algae may contribute about ten percent of the TTHMFP and the contribution may be higher during months of high algal growth. Obviously, algal growth does contribute THM precursors to Delta waters. The river water flowing into the Delta contains algae and additional algal growth occurs within the Delta. For this study, there are no data available to discriminate between the THM precursors that result from algal growth in the rivers or in the Delta.

Delta channel water losses due to evaporation and additions due to precipitation were not included in this analysis because of the broad assumptions required for the analysis. We believe that employing evaporation and precipitation factors would not significantly improve the calculations because these two factors have a somewhat countering effect.

The Delta islands or tracts were divided into two groups for comparison of organic carbon concentrations. One group consisted of the middle Delta peat soil islands and the other included the north and south areas overlying mineral and intermediate organic soil areas. Data from the 1954-55 report showed that the drainage volume from the middle Delta group (study units 18, 20 and 22) contributed about 46% of the total Delta drainage volume during the period June through August and about 32.5% from September through May. These percentages were used to proportion the carbon concentration of each group and provide a single value for each month (far right column of Table 23).

Islands or tracts in the middle Delta "peat" group included Empire, Bouldin, King, Rindge and Terminous. The north-south "mineral-intermediate organic" group included Grand, Tyler, Brannan, Egbert, Upper Egbert, McCormack-Williamson, Pescadero, Prospect, Rio Blanco and Upper Jones.

TFPC data for the island drainages were categorized by group and month. All data collected from any island in the group for the same year and month were averaged to provide a single TFPC value for that group, year and month.

Table 23 calculations show peat island drains generally contain more THMFP carbon than the mineral-intermediate organic island drainages. This agrees with the higher TTHMFP concentrations observed in drainages from peat areas than from the mineral-intermediate organic areas, earlier DWR soil extract analyses for TTHMFP, and existing knowledge about the organic content of Delta soils.

Table 23. Delta Drainage TTHMFP Carbon (TFPC)

(µg/L)

Month	Delta Island Groups		Proportioned Carbon
W.Y. 1988	Peat	Mineral-Intermed. Org.	
OCT	123.69	95.40	104.59
NOV	148.73	170.21	163.23
DEC	209.98	130.36	156.24
JAN	250.49	164.08	192.16
FEB	309.86	218.81	248.40
MAR	217.77	140.54	165.64
APR	212.24	105.42	140.14
MAY	217.64	143.04	167.29
JUN	392.24	111.48	242.03
JUL	198.97	84.30	137.62
AUG	242.01	97.77	164.84
SEP	338.92	114.45	187.40

Monthly TFPC concentrations, drainage volumes, and Sacramento, Mokelumne, Cosumnes and San Joaquin River volume data were used to compute the TFPC concentrations resulting from the addition of Delta drainage to the river water (Table 24).

Table 24. Delta TTHMFP Carbon (TFPC) Concentrations from Drainage

Estimates for W.Y. 1988

Month	Drainage /1 µg/L	Rivers /2 µg/L	Drainage Plus River /3 µg/L	1954-55 Drainage 90% /4 µg/L	1954-55 Drainage 110% /5 µg/L
OCT	104.59	24.79	34.07	33.24	34.87
NOV	163.23	31.33	52.91	51.08	54.69
DEC	156.24	29.61	52.25	50.36	54.08
JAN	192.16	37.94	69.40	66.85	71.86
FEB	248.40	24.09	40.42	38.89	41.92
MAR	165.64	26.22	35.81	34.91	36.70
APR	140.14	16.69	29.24	28.10	30.35
MAY	167.29	22.14	38.47	37.01	39.91
JUN	242.03	26.95	56.61	54.02	59.13
JUL	137.62	21.13	33.80	32.66	34.92
AUG	164.84	19.27	33.51	32.21	34.78
SEP	187.40	31.97	43.37	42.30	44.42
Avg.	172.47	26.01	43.32	41.80	44.80
Min.	104.59	16.69	29.24	28.10	30.35
Max.	248.40	37.94	69.40	66.85	71.86

/1 Flow weighted TPFC concentration for island drainage (Table 23).
/2 Flow weighted TPFC concentration for Sacramento, Mokelumne, Cosumnes and San Joaquin rivers (Table 22).
/3 Flow weighted TPFC concentrations using 1954-55 island drainage volume and rivers.
/4 Flow weighted TPFC concentrations using 90% of 1954-55 island drainage volume and rivers.
/5 Flow weighted TPFC concentrations using 110% of 1954-55 island drainage volume and rivers.

The computed amount of TPFC using 90, 100, and 110% of the 1954-55 drainage volume estimates in DWR Report No. 4 were not significantly different. The exact drainage volume, therefore, is not critical in this analysis to determine the increase of TTHMFP carbon from island drains.

The estimates show that in 1988, island drainage increased the TTHMFP carbon content of the river inflows by 35% to 110% (average 66%) depending on the month (Table 25). The highest estimated increase (100-119%) occurred in June and lowest in September (32-39%).

The 90% and 110% drainage volumes bracket the estimated 1988 drainage volumes and show the greatest TFPC increase of 119% and the lowest to be 32 % with an average range of 60% to 72%. Impact on export waters would depend on the month and the volume exported. The 1988 water year was classified as "critically dry", so the impact of Delta drainage is then expected to be greater than in "normal" runoff years.

Table 25. Estimated Delta TTHMFP Carbon (TFPC) Increases from Drainage

	1954-55 Drainage Volumes		
	100%	90%	110%
Month	Percent Increase	Percent Increase	Percent Increase
OCT	37.39%	34.05%	40.66%
NOV	68.89%	63.03%	74.56%
DEC	76.47%	70.08%	82.64%
JAN	82.91%	76.17%	89.38%
FEB	67.81%	61.48%	74.06%
MAR	36.59%	33.16%	39.98%
APR	75.14%	68.32%	81.82%
MAY	73.81%	67.18%	80.28%
JUN	110.03%	100.41%	119.38%
JUL	59.97%	54.56%	65.25%
AUG	73.93%	67.19%	80.53%
SEP	35.63%	32.30%	38.91%
AVG	66.55%	60.66%	72.29%
MIN	35.63%	32.30%	38.91%
MAX	110.03%	100.41%	119.38%

These estimated TFPC increases to river waters from drainage are shown in Table 26 which estimates the proportion of TFPC in Delta waters that came from drainage.

Table 26. Estimated Proportion of Drainage TFPC in Delta Waters

Estimated values in percent for drought year W.Y. 1988

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
27	41	43	45	40	27	43	27	52	38	43	26

The estimates show that drainage contributed 40% to 45% of the TFPC in the Delta during the irrigation months (April August) and 38% to 52% during the winter leaching period (November February) during W.Y. 1988.

An important question is whether island soils actually contribute TTHMFP carbon, or whether increased THM carbon in drainage only reflects concentration due to evaporation and transpiration (ET) of the water as it passes through the agricultural cycle.

During the growing season, water losses from ET occur and therefore, salt concentrations in some drains (assuming no island salt source) are expected to increase due to these concentration effects. However, to date there are no data to indicate that organic THM precursor material behaves similarly to inorganic salts. Organic compounds exhibit different chemical behavior and physical properties than salts and, therefore, cannot be adequately modeled using salinity models developed for TDS and mineral ions. The distinct characteristics between drain and riverine humics as discussed previously (Amy et al 1990) support these conclusions.

TTHMFP carbon concentrations based on measured TTHMFP data were averaged for selected Delta monitoring stations to provide a comparison with the estimated TTHMFP carbon values. The stations included the Banks Headworks, Sacramento River at Mallard Island, Clifton Court Forebay intake, and Middle River at Borden Highway. They were selected with the thought that when the values were averaged, they would be representative of the average Delta channel TTHMFP carbon concentrations. The results are shown in Table 27. A comparison of the estimated TFPC values and the observed average TFPC values is presented in Table 28.

Table 27. Measured TTHMFP Carbon (TFPC) at Selected Delta Stations

Monthly	Banks Headworks (µg/L)	Mallard Isl. at Sac. Rv. (µg/L)	Clifton Court Intake (µg/L)	Middle River at Borden Highway (µg/L)	Monthly Average (µg/L)
OCT	28.99	32.28	38.31	35.88	33.86
NOV	36.32	45.58	33.34	42.01	39.32
DEC	50.12	47.13	43.51	56.60	49.34
JAN	56.29	47.09	62.32	73.04	59.68
FEB	79.33	70.41	78.10	29.24	64.27
MAR	41.18	58.04	40.64	33.64	43.38
APR	29.71	34.69	38.41	45.36	37.04
MAY	54.40	44.98	56.48	47.40	50.82
JUN	39.53	37.43	48.02	37.67	40.66
JUL	62.38	52.04	52.64	58.14	56.30
AUG	57.08	65.76	37.74	44.63	51.30
SEP	38.47	38.07	39.34	39.22	38.77
AVG	48.67	48.67	48.14	45.78	47.82
MIN	28.99	32.28	33.34	29.24	33.86
MAX	79.33	70.41	78.10	73.04	64.27

Table 28. Comparison of Estimated Drainage THMFP Carbon (TFPC) Impact to Observed Data

Month	Estimated Rivers plus Drainages /1 (µg/L)	Station Monthly Average /2 (µg/L)	Differences /3 (µg/L)	Percent of Station Averages /4
OCT	34.07	33.86	-0.20	99.41%
NOV	52.91	39.32	-13.60	74.30%
DEC	52.25	49.34	-2.91	94.43%
JAN	69.40	59.68	-9.72	86.00%
FEB	40.42	64.27	23.85	159.00%
MAR	35.81	43.38	7.57	121.13%
APR	29.24	37.04	7.81	126.71%
MAY	38.47	50.82	12.34	132.08%
JUN	56.61	40.66	-15.95	71.82%
JUL	33.80	56.30	22.50	166.57%
AUG	33.51	51.30	17.79	153.10%
SEP	43.37	38.77	-4.59	89.41%
ANNUAL				
AVG	43.32	47.82	4.50	
MIN	29.24	33.86	4.62	
MAX	69.40	64.27	5.13	

/1 Estimated Delta TFPC levels from river plus drainage data using the 1954-55 drainage volume (Table 24)
/2 Delta monitoring stations, average TFPC levels from Table 27
/3 Computed difference of monitoring station average (Table 27) minus estimated river + drainage TFPC levels (Table 24). Numbers are rounded off values.
/4 Percent estimated is computed by dividing the observed monthly station average by the river + drainage estimate.

The estimates appear to be reasonable as the annual average, minimum, and maximum estimates were 4 µg/L to 5 µg/L of their respective observed values. Overall, the estimates averaged 14.5% higher than the observed mean values based on data from the four Delta stations.

Figures 29 and 30 are plots of the estimated and measured TTHMFP carbon (TFPC) concentrations for the Delta. The measured values are based on the average of monthly observations recorded at 4 IDHAMP Delta stations (Banks Headworks, Clifton Court Forebay intake, Sacramento River at Mallard Island, and Middle River at Borden Highway). Also included on the plots are the flow weighted river TTHMFP carbon (TFPC) values based on data from the Sacramento River at Greenes Landing, San Joaquin River near Vernalis, Cosumnes, and Mokelumne rivers. The estimated Delta TFPC concentrations are based on the previously described calculations for drainage concentrations mixed with flow weighted river values.

One problem of comparing the estimated data with the measured data is that the samples for island drainage, river water and Delta channel water were collected at different times of the month. Although all of the data being compared was collected in the same month, in some cases, but not all, the data used to make the estimates may have been collected one to three weeks prior to the measured data.

Figure 29 shows the data plotted on a regular monthly basis. In order to compare the effects of a time delay, Figure 30 shows the estimated TTHMFP carbon concentration plotted on the month in which the data were collected but the measured TTHMFP carbon concentration is offset by one month. This means that the measured value plotted for October in Figure 30 is the value that was actually measured in November.

Figure 31 is the same plot as Figure 29 but the "Y" scale is TFPC as chloroform. In this figure, the TTHMFP carbon (TFPC) was computed to equivalent chloroform by weight.

In summary, the figures indicate a good start in the approach of estimating the potential contribution of TTHMFP carbon from Delta island drainages and from the rivers during drought year hydrology. Further work is needed to improve the method of determining the level of impact that drainage has on diverted Delta waters used for drinking water supplies. This work is described in the Recommendations section of this report.

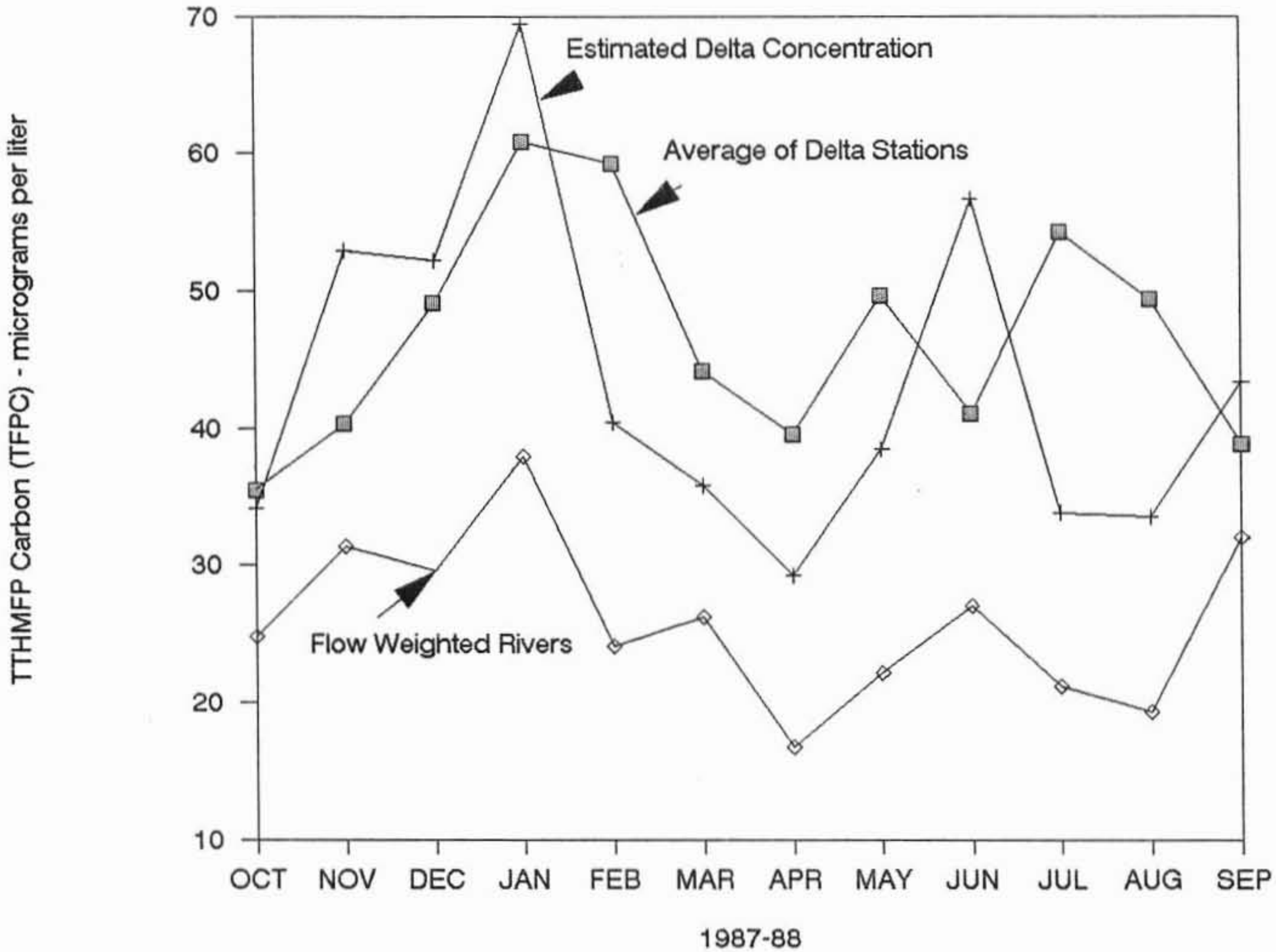


Figure 29. Estimated vs. Measured THMFP Carbon (TFPC) Values

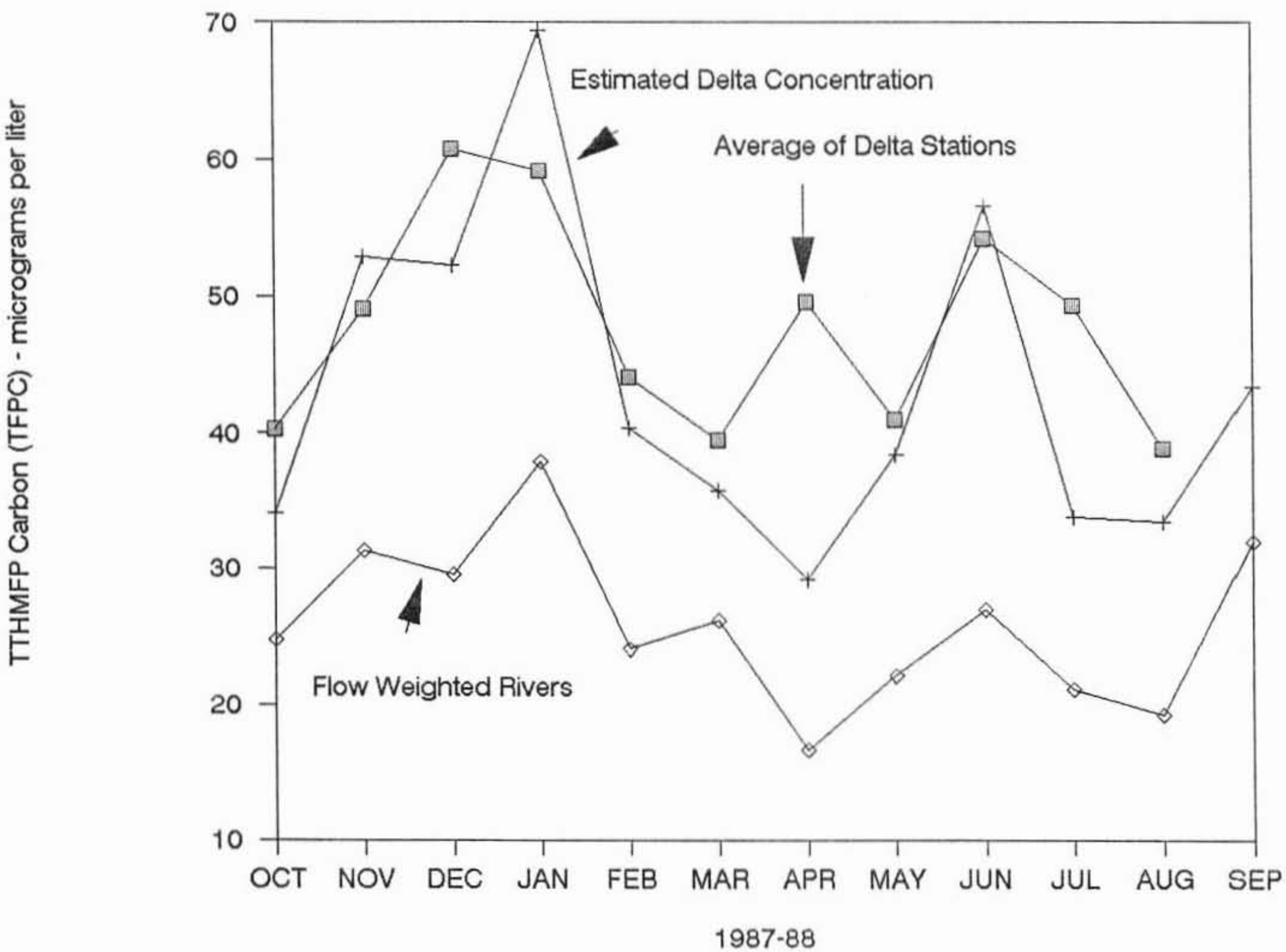


Figure 30. Time Adjusted Estimated vs. Measured TFPC

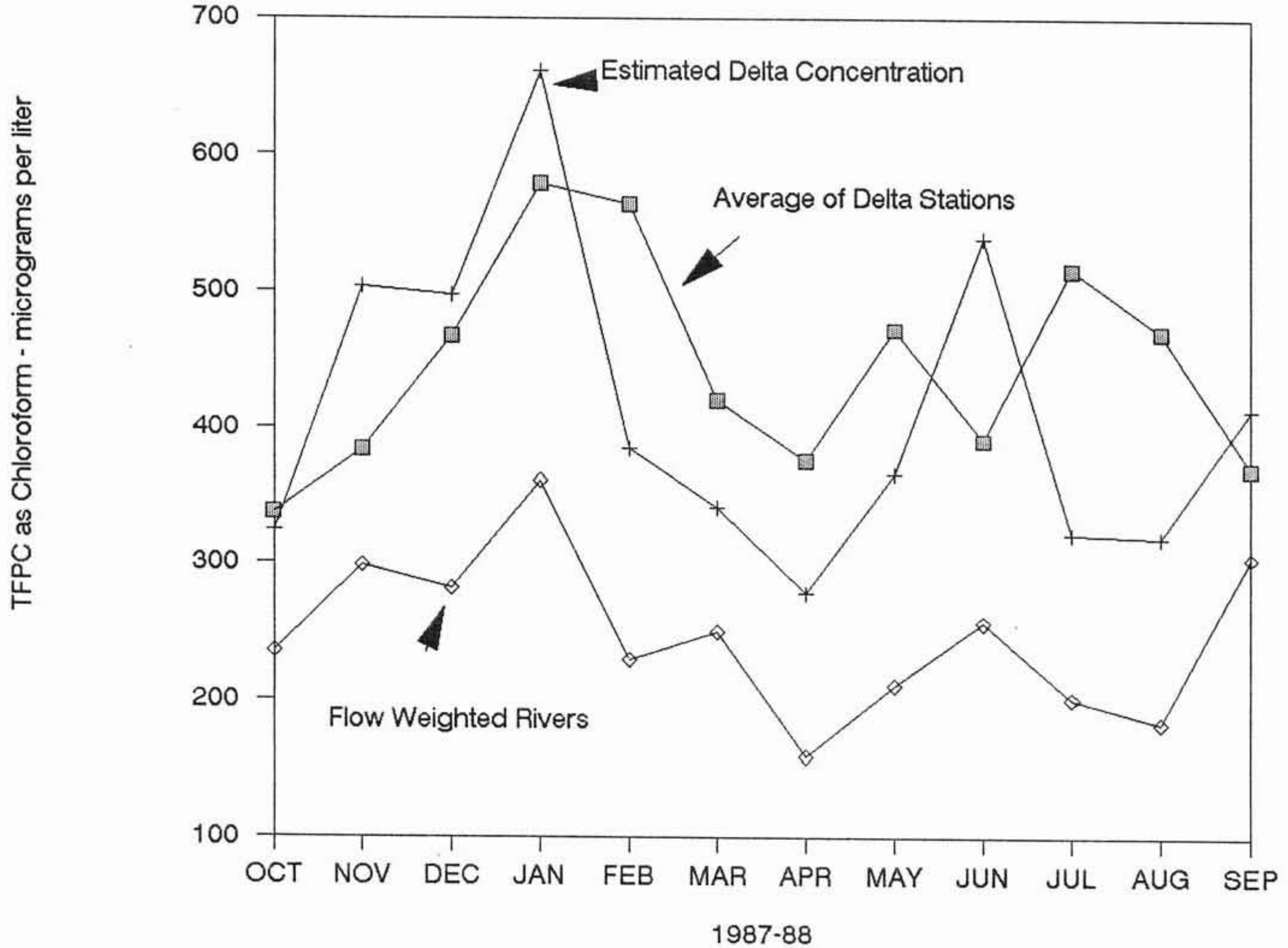


Figure 31. Estimated vs. Measured Chloroform ($CHCl_3$) Values

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Appendices

Appendix to Follow
Glossary of Acronyms
DADI Monitoring Data

Glossary of Acronyms

IDHAMP	Interagency Delta Health Aspects Monitoring Program
DIDI	Delta Islands Drainage Investigation
TTHMFP	Total Trihalomethane Formation Potential
DBP	Disinfection By-products
THM	Trihalomethanes
MCL	Maximum Contaminant Level
EPA	U.S. Environmental Protection Agency
MWDSC	Metropolitan Water District of Southern California
CCWD	Contra Costa Water District
SWP	State Water Project
CVP	Central Valley Project
TFPC	TTHMFP carbon

Appendix A

Delta Island Drainage Investigation Station Names

Short Name	Full Name
AGDCLIFTON	Ag Drain on Clifton Court
AGDEMPIRE	Ag Drain on Empire Tract, W.end 8-Mi.Rd.
AGDGRAND	Ag Drain on Grand Island
AGDTYLER	Ag Drain on Tyler Island
BOULDIN1	Ag Drain on Bouldin Tract, PP. No. 1
BOULDIN2	Ag Drain on Bouldin Tract, PP. No. 2
BRANNANPP01	Ag Drain on Brannan Island, PP. No. 1
BRANNANPP02	Ag Drain on Brannan Island, PP. No. 2
BRANNANPP03	Ag Drain on Brannan Island, PP. No. 3
BRANNANPP04	Ag Drain on Brannan Island, PP. No. 4
EGBERTPP01	Ag Drain on Egbert Tract, PP. No. 1
EGBERTPP02	Ag Drain on Egbert Tract, PP. No. 2
KINGISPP01	Ag Drain on King Island, PP. No. 1
KINGISPP02	Ag Drain on King Island, PP. No. 2
KINGISPP03	Ag Drain on King Island, PP. No. 3
MCCORWIL01	Ag Drain on McCormack/Williams Tr. No.1
MCCORWIL02	Ag Drain on McCormack/Williams Tr. No.2
MOSSDALE01	Ag Drain on Mossdale Tract, PP. No. 1
MOSSDALE02	Ag Drain on Mossdale Tract, PP. No. 2
MOSSDALE03	Ag Drain on Mossdale Tract, PP. No. 3
MOSSDALE04	Ag Drain on Mossdale Tract, PP. No. 4
MOSSDALE05	Ag Drain on Mossdale Tract, PP. No. 5
MOSSDALE06	Ag Drain on Mossdale Tract, PP. No. 6
MOSSDALE08	Ag Drain on Mossdale Tract, PP. No. 8
MOSSDALE09	Ag Drain on Mossdale Tract, PP. No. 9
MOSSDALE10	Ag Drain on Mossdale Tract, PP. No. 10
MOSSDALE11	Ag Drain on Mossdale Tract, PP. No. 11
MOSSTRPP01	Ag Drain on Moss Tract, PP. No. 1
MOSSTRPP02	Ag Drain on Moss Tract, PP. No. 2
MOSSTRPP03	Ag Drain on Moss Tract, PP. No. 3
NETHERLAND01	Ag Drain on Netherland Tr., PP. No. 1
NETHERLAND02	Ag Drain on Netherland Tr., PP. No. 2
PESCADERO01	Ag Drain on Pescadero Tr., PP. No. 1
PESCADERO02	Ag Drain on Pescadero Tr., PP. No. 2
PESCADERO03	Ag Drain on Pescadero Tr., PP. No. 3
PESCADERO04	Ag Drain on Pescadero Tract, PP. No. 4
PIERSONPP01	Ag Drain on Pierson Tr., PP. No. 1
PROSPECTPP01	Ag Drain on Prospect Island, PP. No. 1
PROSPECTPP02	Ag Drain on Prospect Island, PP. No. 2
RINDGEPP01	Ag Drain on Rindge Tract, PP. No. 1
RINDGEPP02	Ag Drain on Rindge Tract, PP. NO. 2
RIOBLANCO01	Ag Drain on Rio Blanco Tr., PP. No. 1
RIOBLANCO02	Ag Drain on Rio Blanco Tr., PP. No. 2
SHIMATR	Ag Drain on Shima Tract
TERMPP01	Ag Drain on Terminous Tract, PP. No. 1
TERMPP02	Ag Drain on Terminous Tract, PP. No. 2
UPEGBERTPP01	Ag Drain on Upper Egbert Tr., PP. No. 1
UPEGBERTPP02	Ag Drain on Upper Egbert Tr., PP. No. 2
UPEGBERTPP03	Ag Drain on Upper Egbert Tr., PP. No. 3
UPJONESPP01	Ag Drain on Upper Jones Tr., PP. No. 1
UPJONESPP02	Ag Drain on Upper Jones Tr., PP. No. 2

APPENDIX B

Page 1

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3 (THMFormation Potential, ug/L)	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
8157	AGDCLIFTON	03/08/88	14:15	18.7	6.0	9.2	3510	33	80	9.1		460	480	300	110	1400
8258	AGDCLIFTON	04/18/88	13:45	17.6	7.1	4.7	5100	30	50	6.0						
8342	AGDCLIFTON	05/09/88	11:04	18.9	7.4	6.9	6460	26	80		7.6	210	540	840	430	2000
5011	AGDEMPIRE	02/06/85	9:05	6.0	7.3	9.8	2610	26	25			1500	920	930	81	3400
5027	AGDEMPIRE	03/06/85	9:45	10.5	7.3	7.6	2330	14								
5045	AGDEMPIRE	04/05/85	8:50	21.5	7.3	3.9	2180	10	75			1800	920	370	31	3100
5061	AGDEMPIRE	05/01/85	8:30	20.0	7.6	6.5	2280	14	160			1800	900	440	29	3200
5077	AGDEMPIRE	06/05/85	8:07	20.0	7.3	4.0	629	15	75			1800	280	25	-1	2100
5107	AGDEMPIRE	07/24/85	9:07	23.0	6.8	4.1	472	10	40			2100	140	19	-1	2300
5112	AGDEMPIRE	08/01/85	8:25	22.0	6.8	5.5	360	8	100			2100	150	10	-1	2300
5128	AGDEMPIRE	09/11/85	10:20	19.5	6.9	4.5	886	4	150			3000	460	48	2	3500
5138	AGDEMPIRE	10/02/85	7:00	18.0	7.6	7.6	1640	10	50			2200	790	330	26	3300
5162	AGDEMPIRE	11/13/85	8:00	7.0	7.3	9.0	1880	4	80			2100	920	390	40	3500
5181	AGDEMPIRE	12/03/85	17:10	14.0	7.0	5.4	1070	8	200			2900	360	44	1	3300
6003	AGDEMPIRE	01/16/86	11:45	12.0	6.8	5.8	1087	3	160			6900	490	67	1	7500
6017	AGDEMPIRE	02/13/86	12:00	14.0	6.8	6.7	1880	11	150			2600	650	170	8	3400
6028	AGDEMPIRE	03/04/86	13:30	19.5	7.3	8.0	2840	7	200			1500	660	210	14	2400
6046	AGDEMPIRE	04/17/86	9:15	15.0	7.4	8.8	1610	10	160			1900	830	320	13	3100
6081	AGDEMPIRE	05/13/86	10:00	21.5	7.5	6.6	2000	15	150			570	330	160	15	1100
6112	AGDEMPIRE	06/11/86	8:00	22.0	8.1	5.7	2760	14	80			410	310	230	48	1000
6131	AGDEMPIRE	07/09/86	8:05	20.5	6.9	5.4	283	10	100			1400	94	4	-1	1500
6198	AGDEMPIRE	09/11/86	7:50	20.5	7.3	5.2	2120	10	80			1400	1000	620	78	3100
6283	AGDEMPIRE	11/19/86	10:30	16.0	6.3	2.3	808	3	360		56.0	5300	120	5	-1	5400
6300	AGDEMPIRE	12/10/86	11:30	12.0	6.3	3.0	866	4	280	48.0						
7008	AGDEMPIRE	01/13/87	11:15	7.5	6.3	1.7	996	3	300	60.0		3200	190	23	15	3400
7046	AGDEMPIRE	02/10/87	10:00	11.5	6.6	3.5	1660	8	200	54.0		2900	410	160	6	3500
7069	AGDEMPIRE	03/10/87	10:50	13.5	6.8	3.0	2390	124	120	33.0		1100	72	95	15	1300
7172	AGDEMPIRE	04/16/87	8:30	21.5	7.5	7.2	2510	17	125	28.0		2900	1300	500	74	4800
7196	AGDEMPIRE	05/06/87	6:15	23.0	7.9	7.5				28.0		1200	740	570	200	2700
7207	AGDEMPIRE	05/27/87	8:30	19.5	6.6	5.3	408	14	200	20.0		2900	200	12	-1	3100
7245	AGDEMPIRE	06/11/87	9:30	21.0	6.9	6.4	503	19	60	10.0		960	130	17	-1	1100
7406	AGDEMPIRE	09/24/87	8:15	19.3	7.3	3.6	2960	9	100		18.0	1200	780	570	130	2700
7478	AGDEMPIRE	10/19/87	7:00	16.0	7.1	2.0	1720	9	60	16.0		960	560	230	36	1800
7450	AGDEMPIRE	10/28/87	9:10								20.0	1320	638	183	25	2200
7449	AGDEMPIRE	10/28/87	9:10	19.0	7.2	2.1	1340	16	80	22.0		1010	471	119	22	1600
7547	AGDEMPIRE	11/24/87	9:30	12.5	7.2	8.1	312	24	60	12.0		1500	39	1	1	1500
7548	AGDEMPIRE	11/24/87	9:30								12.0	1400	41	1	1	1400
7578	AGDEMPIRE	12/10/87	9:54	13.5	6.2	4.9	594	5	250	58.0		2590	139	3	-1	2700
7606	AGDEMPIRE	12/16/87	8:45								94.0	2400	140	6	-1	2500
7607	AGDEMPIRE	12/16/87	8:45	8.2	6.5	6.2	695	11	250	65.0		2790	130	6	-1	2900
8026	AGDEMPIRE	01/12/88	9:00	9.2	6.3	4.7	1010	8	350	59.0		3300	240	14	-1	3600
8075	AGDEMPIRE	01/21/88	9:05	8.6	6.4	6.5	1720	4	250	55.0		3400	480	55	-1	3900
8074	AGDEMPIRE	01/21/88	9:05	8.6	6.4	6.5					56.0	3800	490	35	-1	4300
8132	AGDEMPIRE	02/23/88	8:50								62.0	1800	400	85	4	2300
8133	AGDEMPIRE	02/23/88	8:50	11.3	6.8	5.4	1980	14	350	72.0		3100	790	140	6	4000
8161	AGDEMPIRE	03/09/88	9:35	13.7	7.1		1970	13	200	48.0		2700	650	120	8	3500

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	<----- THMFormation Potential -----> CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<--------------		ug/L		------------>
8224	AGDEMPIRE	03/23/88	8:30								47.0	4300	220	16	-1	4500
8223	AGDEMPIRE	03/23/88	8:30	16.8	7.0	9.1	811	9	320	49.0		2600	170	14	-1	2800
8322	AGDEMPIRE	04/28/88	8:25	16.1	6.6	5.3	631	7	300	64.0		2000	73	4	-1	2100
8323	AGDEMPIRE	04/28/88	8:25								63.0	2100	92	5	-1	2200
8346	AGDEMPIRE	05/09/88	7:12	20.1	7.2	6.5	926	4	400		59.0	3900	270	-1	-1	4200
8400	AGDEMPIRE	05/26/88	7:30								46.0	3600	460	27	-1	4100
8399	AGDEMPIRE	05/26/88	7:30	18.8	7.5	1.1	1000	9	400	44.0		2900	400	28	8	3300
8431	AGDEMPIRE	06/22/88	6:27	22.3	7.3	2.6	674	7	240	24.0		3400	310	11	-1	3700
8432	AGDEMPIRE	06/22/88	6:27	23.0	6.8	0.6					31.0	3900	370	11	-1	4300
8467	AGDEMPIRE	07/14/88	8:55	23.0	6.8	0.6	1420				35.0	3900	320	17	1	4200
8466	AGDEMPIRE	07/14/88	8:55	23.0	6.8	0.6	1420	6	400	71.0		3600	180	15	-1	3800
8482	AGDEMPIRE	07/18/88	6:40	22.5	7.0	0.4	792	3	240		35.0	2500	260	16	-1	2800
8589	AGDEMPIRE	08/16/88	7:59	21.3	6.9	2.3	537				36.0	3100	270	9	-1	3400
8588	AGDEMPIRE	08/16/88	7:59	21.3	6.9	2.3	537	7	280	34.0		3400	250	8	-1	3700
8701	AGDEMPIRE	09/22/88	6:35	16.6	7.2	2.0					32.4	2500	1000	330	15	3800
8700	AGDEMPIRE	09/22/88	6:35	16.6	7.2	2.0	2140	7	140	33.5		2400	1000	320	18	3700
8730	AGDEMPIRE	10/20/88	7:45	19.2	5.9	2.4	1180				75.0	2300	200	17	-1	2500
8729	AGDEMPIRE	10/20/88	7:45	19.2	5.9	2.4	1180	5	280	77.0		1600	250	14	-1	1900
8752	AGDEMPIRE	11/10/88	8:25	16.0	6.8	4.2					66.0	2400	440	56	-2	2900
8751	AGDEMPIRE	11/10/88	8:25	16.0	6.8	4.2	1350	4	320	69.0		1800	330	64	-1	2200
8835	AGDEMPIRE	12/20/88	9:00	14.7	6.8	3.9					60.0	2600	140	6	-1	2700
8834	AGDEMPIRE	12/20/88	9:00	14.7	6.8	3.9	585	4	320	61.0		2600	140	5	-1	2700
5012	AGDGRAND	02/06/85	10:30	11.5	7.1	7.5	576	34	25			2100	32	4	-1	2100
5028	AGDGRAND	03/06/85	11:00	12.5	6.9	5.3	468	21								
5046	AGDGRAND	04/05/85	10:00	18.5	7.3	5.0	625	30	80			2000	100	4	-1	2100
5062	AGDGRAND	05/01/85	9:45	18.5	6.9	5.7	310	26	50			1000	41	-1	-1	1000
5078	AGDGRAND	06/05/85	9:15	21.0	7.3	6.6	265	22	35			840	37	-1	-1	880
5108	AGDGRAND	07/24/85	7:15	22.5	7.2	5.5	267	70	80			1800	60	2	-1	1900
5113	AGDGRAND	08/01/85	9:45	21.5	7.1	6.5	273	30	50			1300	49	1	-1	1400
5126	AGDGRAND	09/11/85	11:50	19.5	7.2	6.1	451	28	30			1100	94	8	-1	1200
5139	AGDGRAND	10/02/85	9:00	19.0	7.2	6.0	327	25	30			820	56	3	-1	880
5164	AGDGRAND	11/13/85	9:45	12.5	7.3	4.5	368	16	35			890	69	3	-1	960
5183	AGDGRAND	12/03/85	18:45	13.0	7.0	3.8	735	31	100			2800	160	5	-1	3000
6005	AGDGRAND	01/16/86	13:15	13.5	7.3	7.3	716	26	80			3500	130	6	-1	3600
6020	AGDGRAND	02/27/86	11:30	17.5	7.0	4.4	602	24	100			1700	83	2	-1	1800
6036	AGDGRAND	03/13/86	13:00	14.5	6.6	5.8	1060	22	160			3200	180	5	-1	3400
6051	AGDGRAND	04/23/86	12:00	18.5	7.3	7.6	513	54	50			1700	82	2	-1	1800
6086	AGDGRAND	05/28/86	11:15	22.5	7.3	7.4	323	36	50			640	29	3	1	670
6118	AGDGRAND	06/25/86	12:00	24.5	7.2	6.8	290	35	40			450	30	2	1	480
6138	AGDGRAND	07/23/86	11:15	22.5	7.1	6.0	210	24	40							
6159	AGDGRAND	08/27/86	11:45	23.5	7.2	7.6	250	24	50			1400	35	-1	-1	1400
6206	AGDGRAND	09/09/86	11:00	18.5	7.1	3.0	378	18	15			240	30	3	-1	270
6286	AGDGRAND	11/19/86	7:50	14.5	7.3	5.8	237	14	5		1.7	320	16	2	-1	340
6302	AGDGRAND	12/10/86	8:00	10.0	7.1	8.1	366	30	50	11.0		1400	30	-1	-1	1400
7013	AGDGRAND	01/13/87	8:05	7.0	7.1	7.9	458	21	80		14.0	1900	56	2	2	2000
7041	AGDGRAND	02/10/87	7:30	14.5	7.2	7.4	559	38	75	20.0		2400	77	-1	-1	2500

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential----> ug/L				
7076	AGDGRAND	03/10/87	7:45	13.0	7.1	6.6	852	76	120	28.0		1300	74	2	3	1400
7079	AGDGRAND	03/10/87	7:45				853	66	120	28.0		1400	67	2	3	1500
7179	AGDGRAND	04/16/87	6:30	17.0	7.0	6.2	358	28	30	7.8		1400	79	5	-1	1500
7214	AGDGRAND	05/20/87	6:30	17.0	7.3	8.2	251	38	30	5.4		800	30	-1	-1	830
7213	AGDGRAND	05/20/87	6:30	17.0	7.3	8.2	251	38	30		5.4	650	34	-1	-1	830
7252	AGDGRAND	06/11/87	6:40	20.0	7.3	6.3	398	29	30	5.5		920	62	5	-1	990
7390	AGDGRAND	09/03/87	9:30	23.1	7.3	5.0	499	22	35	7.8		1200	58	7	-1	1300
7437	AGDGRAND	10/08/87	6:30								6.8	980	45	1	-1	1000
7431	AGDGRAND	10/08/87	6:30	16.5	7.3	7.2	364	30	40	6.3		810	47	1	2	860
7435	AGDGRAND	10/08/87	6:30				340	30	40	6.3		1200	38	-1	-1	1200
7433	AGDGRAND	10/08/87	6:30								6.9	840	31	1	-1	870
7534	AGDGRAND	11/03/87	7:20	13.5	7.2	7.0	441	29	60	13.0		2400	73	1	-1	2500
7535	AGDGRAND	11/03/87	7:20								15.0	890	61	1	-1	950
7557	AGDGRAND	12/01/87	7:30	10.6	7.3	9.1	436	26	60	15.0		1900	43	2	3	1900
7558	AGDGRAND	12/01/87	7:30								14.0	1600	49	3	-1	1700
8007	AGDGRAND	01/06/88	8:25	9.2	7.1	8.1	832	56	160	29.0		2500	86	4	2	2600
8006	AGDGRAND	01/06/88	8:25								30.0	2300	80	3	-1	2400
8114	AGDGRAND	02/18/88	7:30	9.3	7.2	8.8	642	26	100	17.0		2100	110	4	-1	2200
8113	AGDGRAND	02/18/88	7:30								17.0	2100	98	4	-1	2200
8212	AGDGRAND	03/18/88	7:19								5.4	720	25	25	-1	770
8211	AGDGRAND	03/18/88	7:19	13.0	7.1	8.0	324	31	60	6.3		960	30	1	-1	990
8248	AGDGRAND	04/14/88	7:40								7.2	940	33	3	-1	980
8247	AGDGRAND	04/14/88	7:40	15.1	6.9	7.3	361			7.1		1100	41	3	3	1100
8393	AGDGRAND	05/19/88	6:50								5.6	760	31	1	-1	790
8392	AGDGRAND	05/19/88	6:50	18.2	7.4	6.7	278	27	80	6.0		1100	35	1	1	1100
8415	AGDGRAND	06/07/88	6:17	15.8	7.1	6.5	308				5.9	820	34	1	2	860
8414	AGDGRAND	06/07/88	6:17	15.8	7.1	6.5	308	38	60	5.8		1400	29	-4	-4	1400
8450	AGDGRAND	07/06/88	6:54	20.0	7.0	5.7	276				8.0	890	23	-1	-1	910
8449	AGDGRAND	07/06/88	6:54	20.0	7.0	5.7	276	27	60	1.4		1200	19	-1	-1	1200
8571	AGDGRAND	08/02/88	8:10	18.8	7.4	6.4			60	5.6		740	22	-1	-1	760
8572	AGDGRAND	08/02/88	8:10								6.1	720	24	-1	-1	740
8692	AGDGRAND	09/15/88	6:55	18.8	6.9	5.2					10.8	1100	52	2	-1	1200
8691	AGDGRAND	09/15/88	6:55	18.8	6.9	5.2	363	24	70			1100	50	6	-1	1200
8721	AGDGRAND	10/13/88	7:00	15.6	7.2	6.7					17.4	1400	41	-1	-1	1400
8720	AGDGRAND	10/13/88	7:00	15.6	7.2	6.7	409	32	150	19.6		2100	47	-1	-1	2100
8759	AGDGRAND	11/17/88	8:09	9.9	7.2	8.6					12.0	1200	60	7	-1	1300
8758	AGDGRAND	11/17/88	8:09	9.9	7.2	8.6	398	28	120	14.0		1500	54	6	-1	1600
8804	AGDGRAND	12/06/88	7:40	10.8	7.2	9.2	370	23	100	12.0		1400	63	1	-1	1500
8805	AGDGRAND	12/06/88	7:40	10.8	7.2	9.2					14.0	1300	35	1	-1	1300
5038	AGDTYLER	03/27/85	12:45	11.5	6.8	7.8	743	29								
5053	AGDTYLER	04/24/85	12:30	19.5	7.3	5.8	743	28	100			2100	260	27	-1	2400
5074	AGDTYLER	05/22/85	11:30	21.5	7.2	4.7	320	17	70			1800	91	4	-1	1900
5090	AGDTYLER	06/26/85	11:15	24.0	6.8	5.5	188	18	50			1400	45	3	-1	1400
5105	AGDTYLER	07/10/85	12:00	25.5	7.0	4.5	189	17	100			1600	51	1	-1	1700
5124	AGDTYLER	08/28/85	12:00	23.5	7.3	6.7	299	9	100			2100	78	3	-1	2200
5135	AGDTYLER	09/11/85	11:15	19.5	7.2	6.1	354	10	50			2200	-1	6	-1	2200

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3 (THMFormation Potential, ug/L)	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
5150	AGDTYLER	10/02/85	8:00	17.5	6.9	3.2	289	14	100			1200	70	2	-1	1300
5163	AGDTYLER	11/13/85	9:00	6.0	6.8	8.1	376	11	160			2000	120	2	-1	2100
5182	AGDTYLER	12/03/85	18:00	12.5	7.0	3.7	587	12	100			2100	85	2	-1	2200
6004	AGDTYLER	01/16/86	12:45	11.0	6.9	4.6	476	9	120			3500	83	8	-1	3600
6127	AGDTYLER	06/11/86	9:15	19.5	7.3	7.9	158	768	240			1300	66	4	1	1400
6133	AGDTYLER	07/09/86	9:30	23.5	7.3	0.5	966	18	400			1400	160	13	-1	1600
6200	AGDTYLER	09/11/86	9:45	20.5	7.3	5.5	369	38	100			2200	100	3	-1	2300
6284	AGDTYLER	11/19/86	8:45	14.0	7.1	4.4	804	21	150		26.0	4100	180	13	-1	4300
6304	AGDTYLER	12/10/86	8:55	9.0	7.3	10.4	829	26	60	23.0		3700	310	23	-1	4000
7010	AGDTYLER	01/13/87	9:00	6.0	7.1	7.6	746	29	120	20.0		2100	100	5	-1	2200
7043	AGDTYLER	02/10/87	8:30	12.5	6.9	5.5	647	25	100	24.0		2200	97	-1	-1	2300
7072	AGDTYLER	03/10/87	9:00	12.5	6.8	6.4	1100	60	100	36.0		1300	80	2	8	1400
7175	AGDTYLER	04/16/87	7:15	17.0	7.2	6.8	310	72	35	7.5		1300	95	2	-1	1400
7293	AGDTYLER	06/24/87	7:00	22.5	6.8	5.6				6.4		1000	59	5	-1	1100
7294	AGDTYLER	06/24/87	7:00	22.5	6.8	5.6					7.6	790	58	3	-1	850
5017	AMERICAN	02/13/85	13:20	10.0	7.3	11.9	63	2	15			230	6	-1	-1	240
5033	AMERICAN	03/13/85	12:15	12.0	7.3	11.2	63	5								
5057	AMERICAN	04/10/85	11:30	14.5	7.3	10.5	67	2	0			180	6	-1	-1	190
5067	AMERICAN	05/08/85	11:20	14.0	7.3	10.7	62	1	5			240	3	-1	-1	240
5084	AMERICAN	06/12/85	12:00	18.5	7.3	9.9	60	2	0			290	5	1	-1	300
5118	AMERICAN	08/14/85	11:15	20.0	7.2	9.1	56	1	2			210	8	-1	-1	220
5144	AMERICAN	10/09/85	11:30	16.5	7.2	9.2	52	1	0			180	5	-1	-1	190
5188	AMERICAN	12/03/85	20:30	12.5	7.2	10.5	64	6	5			260	6	-1	-1	270
6031	AMERICAN	03/11/86	13:15	12.0	7.1	12.0	56	76	25			370	5	-1	-1	380
6047	AMERICAN	04/17/86	11:30	14.5	7.3	11.2	55	6	15			300	5	-1	-1	310
6082	AMERICAN	05/13/86	11:45	16.5	7.3	10.0	53	3	25			190	6	1	-1	200
6113	AMERICAN	06/11/86	11:30	16.5	7.3	10.0	46	3	15			150	9	4	2	170
6132	AMERICAN	07/09/86	11:50	17.5	7.1	9.7	46	2	5			210	4	-1	-1	210
6153	AMERICAN	08/13/86	13:30	20.5	7.2	9.3	50		5							
6202	AMERICAN	09/11/86	11:30	22.0	7.3	8.5	52	2	5			160	4	-1	-1	160
6271	AMERICAN	11/05/86	6:30	16.0	6.9	10.2	46	1	5	1.8		240	4	-1	-1	240
6292	AMERICAN	12/03/86	6:45	12.5	7.3	9.2	51	1	0	1.2		250	6	-1	-1	260
7004	AMERICAN	01/08/87	6:50	9.0	7.1	12.0	64	3	0	1.0		230	6	-1	-1	240
7026	AMERICAN	02/05/87	6:30	10.0	6.9	11.2	70	2	0	1.1		190	4	-1	-1	190
7064	AMERICAN	03/03/87	6:45	11.0	7.5	11.3	69	1	0	1.7		250	19	-1	-1	270
7162	AMERICAN	04/09/87	5:30	16.0	7.2	9.2	69	2	5	1.2		240	9	-1	-1	250
7201	AMERICAN	05/13/87	5:15	19.5	7.2	8.5	80	2	5	1.8		240	10	1	-1	250
7237	AMERICAN	06/04/87	5:15	18.0	7.3	9.4	85	3	5	1.2		170	6	-1	-1	180
7409	AMERICAN	09/24/87	5:45	17.0	6.8	8.3	78	2	5	1.6		370	12	4	1	390
7452	AMERICAN	10/28/87	6:30	20.0	7.1	8.2	73	2	0	2.3		193	5	-1	-1	200
7549	AMERICAN	11/24/87	6:30	10.5	8.0	9.5	66	1	0	1.6		140	4	-1	-1	140
7608	AMERICAN	12/16/87	10:00	11.0	7.1	9.3	81	2		1.7		120	5	-1	-1	130
8076	AMERICAN	01/21/88	11:00	9.8	7.2	12.5	87	10	25	2.1		320	5	-1	-1	330
8134	AMERICAN	02/23/88	10:30	12.9	7.2	10.8	85	1	5	1.7		110	5	-1	-1	120
8225	AMERICAN	03/24/88	11:00	19.1	7.2	10.8	78	1	5	1.2		160	6	-1	-1	170
8324	AMERICAN	04/28/88	5:25	14.7	8.0	9.3	77	2	10	1.7		96	11	1	-1	110

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3 (THMFormation Potential, ug/L)	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
8401	AMERICAN	05/26/88	5:50	16.5	8.2	8.8	75	2	5	2.0		180	6	1	-1	190
8433	AMERICAN	06/22/88	9:19	19.9	7.2	8.9	76	1	5	2.3		110	4	-1	-1	110
8471	AMERICAN	07/14/88	5:50	17.8	6.7	8.5			5	1.5		230	5	-1	-1	240
8590	AMERICAN	08/16/88	5:45	20.5	7.0	7.6	72	1	5	1.8		180	6	-1	-1	180
8702	AMERICAN	09/22/88	9:00	20.4	7.0	7.9	70	1	5	1.2		170	7	-1	-1	180
8731	AMERICAN	10/20/88	5:30	19.5	6.6	8.4	74	1	5	1.3		110	64	-1	-1	170
8753	AMERICAN	11/10/88	6:15	16.2	6.5	9.1	68	2	5	1.6		210	11	-1	-1	220
8836	AMERICAN	12/20/88	7:00	11.4	6.8	10.8	82	3	10	2.7		330	9	-1	-1	340
5019	BANKS	02/27/85	9:45	13.5	7.5	9.5	335	8	35			310	71	10	-1	390
5035	BANKS	03/27/85	9:00	12.5	7.4	10.1	367	11								
5049	BANKS	04/24/85	9:15	17.5	7.6	8.7	351	11	5			410	81	17	-1	510
5070	BANKS	05/22/85	8:15	19.5	8.1	8.6	351	26	5			580	90	17	-1	690
5098	BANKS	06/07/85	8:50	23.5	7.5	7.4	322	30								
5086	BANKS	06/26/85	8:00	23.5	7.7	7.5	370	32	20			550	110	24	1	690
5101	BANKS	07/10/85	8:00	24.5	7.5	7.5	343	16	15			590	160	35	2	790
5120	BANKS	08/28/85	8:30	22.5	7.4	7.8	466	10	10			390	140	69	5	600
5131	BANKS	09/25/85	8:20	22.5	7.5	7.9	588	6	10			340	89	40	10	480
5146	BANKS	10/23/85	8:00	17.0	7.6	8.9	527	7	5			290	150	90	13	540
5173	BANKS	11/15/85	9:30	12.0	7.4	9.5	586	6	10			260	160	100	-1	520
5167	BANKS	12/03/85	14:15	11.5	7.4	10.1	676	10	10			240	210	150	10	610
6008	BANKS	01/23/86	9:20	12.0	7.3	9.2	482	12	25			1700	170	47	2	1900
6013	BANKS	02/13/86	8:45	11.5	7.7	10.5	444	17	25			780	140	28	1	950
6024	BANKS	03/04/86	9:30	16.5	7.3	8.2	332	14	30			600	70	6	-1	680
6039	BANKS	04/09/86	9:15	17.5	7.5	9.4	265	13	20			630	76	10	-1	720
6074	BANKS	05/07/86	7:45	15.5	7.3	8.9	284	11	15			460	74	10	-1	540
6105	BANKS	06/04/86	8:15	19.5	7.5	8.6	312	32	20			340	45	9	-1	390
6123	BANKS	07/02/86	8:05	24.0	7.3	6.4	305	25	15			470	78	17	-1	570
6142	BANKS	08/14/86	8:45	24.0	7.3	7.7	280	22	15							
6172	BANKS	09/24/86	8:30	19.5	7.5	8.6	297	22	10			360	89	19	-1	470
6277	BANKS	11/12/86	9:30	14.0	7.4	9.7	236	13	15	1.9		340	35	9	-1	380
6308	BANKS	12/17/86	10:00	10.0	7.3	10.1	278	9	15	1.6		350	58	7	-1	420
7017	BANKS	01/22/87	9:45	6.5	7.3	12.0	309	14	20	3.8		650	68	7	-1	730
7055	BANKS	02/24/87	9:45	11.5	7.3	10.7	446	9	20	4.3		630	160	41	-1	830
7107	BANKS	03/24/87	9:30	13.0	7.5	9.7	568	8	25	5.0		470	120	18	8	620
7184	BANKS	04/30/87	8:40	18.5	8.4	10.0	396	10	15	3.2		240	57	8	-1	310
7219	BANKS	05/28/87	10:30	18.0	7.4	11.0	397	28	15	2.5		450	120	30	-1	600
7229	BANKS	06/02/87	9:00	21.5	7.5	8.1						450	120	33	-1	600
7281	BANKS	06/23/87	10:30	22.5	7.6	8.3	487	19	15							
7399	BANKS	09/09/87	8:45	21.5	7.2	7.4	626	12	5	4.0		250	140	82	20	490
7442	BANKS	10/22/87	8:00	19.5	7.4	7.9	814	5	0	3.9		130	120	100	29	380
7540	BANKS	11/05/87	9:00	17.5	7.4	8.7	703	6	5	2.7		250	100	50	21	420
7567	BANKS	12/08/87	9:00	11.3	7.7	10.8	835	5	15	2.7		190	130	110	25	460
8011	BANKS	01/07/88	9:24	8.2	7.3	11.8	574	11	30	4.6		410	150	68	4	630
8091	BANKS	02/10/88	8:55	11.4	7.3	9.5	392	13	40			710	94	20	-1	820
8146	BANKS	03/03/88	9:00	13.7	7.6	10.5	593	5	25	3.3		300	100	57	9	470
8235	BANKS	04/05/88	7:50	15.4	7.5	9.3	661	5	20	3.4		180	100	64	13	360

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential ----> ug/L				
8330	BANKS	05/03/88	8:35	16.6	7.9	8.9	372	9	30	2.8		440	90	35	5	570
8422	BANKS	06/14/88	8:27	23.0	7.5	6.7	457	30	60	2.4		310	87	34	1	430
8457	BANKS	07/12/88	8:30	21.5	7.8	8.0	575	33	60	2.6		420	150	72	5	650
8579	BANKS	08/09/88	10:15	22.0	7.4	7.9	675	16	20	2.4		380	150	120	21	670
8682	BANKS	09/06/88	8:20	24.2	7.8	6.7	721	11	25	2.7		210	130	83	32	460
8714	BANKS	10/04/88	8:35	20.1	7.4	8.0	689	8	20	2.9		230	150	70	12	460
8744	BANKS	11/01/88	9:45	17.6	6.7	8.8	692	6	15	3.0		150	150	130	20	450
8813	BANKS	12/13/88	10:02	11.3	7.1	10.7	739	7	25	4.1		310	210	150	19	690
9054	BANKS	01/10/89	9:20	12.5	7.0	11.4	610	8	30	4.8		390	150	66	7	610
9132	BANKS	02/07/89	9:00	5.9	6.8	12.1	748	6	30	4.1		160	110	71	21	360
9213	BANKS	03/07/89	8:50	13.6	7.3	10.0	646	6	25	3.3		180	130	78	16	400
9248	BANKS	04/04/89	8:24	16.2	8.2	7.9	286	11	40	4.4		510	68	14	-1	590
9346	BANKS	05/02/89	8:30	18.4	7.8	8.0	237	8	25	3.2		330	44	6	-1	380
9428	BANKS	06/06/89	8:20	20.5	8.1	7.9	300	27	50	3.7		440	70	13	-1	520
9548	BANKS	07/05/89	10:18	23.0	7.7	8.2	291	18	40		3.1	330	60	13	0	400
9587	BANKS	07/25/89	9:00	23.8	7.7	9.2	300	14				360	120	32	1	510
7395	BARKER	09/03/87	8:00	20.5	7.3	5.5	734	65		6.7		1100	48	1	-1	1100
7438	BARKER	10/08/87	10:40	19.8	7.4	7.6	561	36	25	4.2		750	32	1	-1	780
7530	BARKER	11/03/87	8:50	15.0	7.3	7.1	568	18	10	6.1		1000	56	3	2	1100
7561	BARKER	12/01/87	9:15				599	16	15	5.8		590	39	3	2	630
8002	BARKER	01/06/88	12:10	9.3	7.3	10.4	387	84	80	9.3		1200	31	1	-1	1200
8109	BARKER	02/18/88	12:15	10.3	7.5	10.1	540	52	50	6.8		1300	57	4	-1	1400
8216	BARKER	03/17/88	9:00	13.7	7.6	10.2	639	22	60	6.7		1000	64	6	-1	1100
8251	BARKER	04/14/88	8:57	16.3	7.4	8.4	539			7.8		1200	61	5	4	1300
8396	BARKER	05/19/88	10:05	24.3	7.9	5.6	673	21	60	6.6		920	100	7	-1	1000
8419	BARKER	06/07/88	7:52	18.1	7.7	6.8	590	31	60	5.1		820	79	13	1	910
8452	BARKER	07/06/88	8:30	21.6	7.5	7.5	366	50	80	3.8		760	39	4	-1	800
8574	BARKER	08/02/88	12:30	21.8	7.9	8.0	241	60	60	3.0		530	31	1	1	560
8694	BARKERNOBAY	09/15/88	8:18	17.9	7.3	8.5	274	30	50	4.0		500	32	4	-1	540
8723	BARKERNOBAY	10/13/88	9:05	16.9	7.5	7.6	323	23	50	4.4		470	27	3	-1	500
8761	BARKERNOBAY	11/17/88	9:36	12.4	7.4	9.0	298	19	35	3.2		410	37	6	-1	450
8807	BARKERNOBAY	12/06/88	10:15	9.9	7.1	10.8	283	18	30	3.2		360	34	2	-1	400
7111	BOULDIN1	03/26/87	8:30	13.5	7.2	8.3	591	17	120	32.0		2100	120	16	-1	2200
7299	BOULDIN1	08/06/87	11:40	23.6	7.3	7.2	262	12			7.9	1300	56	5	-1	1400
7470	BOULDIN1	10/16/87	10:15	18.0	6.9	2.4	688	7	500	96.0		1800	210	25	-1	2000
7572	BOULDIN1	12/10/87	8:15	11.5	6.7	3.6	430	8	200	42.0		1700	45	2	1	1700
8017	BOULDIN1	01/12/88	7:50	10.1	6.4	4.5	937	9	350	66.0		2600	240	11	-1	2900
8151	BOULDIN1	03/08/88	8:51	9.1	7.3		936	16	350	45.0		2700	300	20	-1	3000
8336	BOULDIN1	05/09/88	8:37	18.6	7.1	8.5	201	14	100		8.8	1000	72	7	-1	1100
8472	BOULDIN1	07/18/88	8:57	23.3	7.0	5.3	178	11	60		6.8	840	14	-1	-1	850
8598	BOULDIN1	08/10/88	11:18	23.1	7.2	7.3			60		5.9	710	33	1	-1	740
8621	BOULDIN1	08/17/88	9:16	21.5	7.2	3.5	338	5	160		19.0	2000	98	4	-1	2100
8657	BOULDIN1	08/24/88	9:31	21.6	7.4	3.4	323	8	140		19.0	2000	110	2	-1	2100
8673	BOULDIN1	08/31/88	9:13	21.5	7.0	3.0			200		25.0	2000	120	3	-1	2100
8786	BOULDIN1	11/30/88	11:15	9.3	7.0	5.3	471	4	240		47.0	2600	170	14	-1	2800
8800	BOULDIN1	12/07/88	11:04	10.9	7.8	7.1	418	11	280		43.0	2500	170	15	-1	2700

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3 (THMFormation Potential, ug/L)	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
8829	BOULDIN1	12/20/88	9:00	8.1	7.2	6.5	574	10	240		51.0	3100	130	22	-4	3200
8856	BOULDIN1	12/28/88	9:25	5.0	7.3	7.8	584	12	240		56.0	2500	190	23	-1	2700
7112	BOULDIN2	03/26/87	9:00	13.5	7.0	6.2	504	13	350	55.0		2800	210	26	-1	3000
7300	BOULDIN2	08/06/87	12:20	25.5	7.1	7.1	182	18			5.4	830	74	-1	-1	900
7471	BOULDIN2	10/16/87	9:45	17.4	6.8	5.4	342	7	250	39.0		1700	75	1	-1	1800
7573	BOULDIN2	12/10/87	8:55	12.5	6.9	5.3	533	6	400	60.0		2970	126	2	-1	3100
8018	BOULDIN2	01/12/88	8:25	5.8	6.0	5.5	698	13	200	39.0		2700	110	3	-1	2800
8152	BOULDIN2	03/08/88	8:39	11.1	6.5		553	16	400	51.0		2700	110	-1	-1	2800
8253	BOULDIN2	04/18/88	8:00	17.0	6.7	4.2	494	11	400	39.0						
8337	BOULDIN2	05/09/88	7:52	18.9	7.4	7.7	279	12	160		18.0	2200	67	-1	-1	2300
8473	BOULDIN2	07/18/88	8:26	23.9	6.5	3.3	202	18	120		10.0	1100	19	-1	-1	1100
8599	BOULDIN2	08/10/88	10:44	21.2	7.1	5.5			140		14.0	1600	56	-1	-1	1700
8622	BOULDIN2	08/17/88	9:44	22.7	6.8	5.0	440	7	320		39.0	1800	170	1	-1	2000
8658	BOULDIN2	08/24/88	9:55	22.6	7.3	4.2	350	5	280		32.0	3200	150	2	-1	3400
8674	BOULDIN2	08/31/88	9:36	22.7	7.3	2.5			240		25.0	2000	91	2	-1	2100
8787	BOULDIN2	11/30/88	11:52	9.9	7.2	3.2	467	8	280		27.0	2700	170	4	-1	2900
8801	BOULDIN2	12/07/88	11:41	11.9	7.4	5.0	412	7	320		56.0	2600	170	19	-1	2800
8830	BOULDIN2	12/20/88	8:30	8.6	6.7	3.8	597	7	240		56.0	2700	120	23	-4	2800
8857	BOULDIN2	12/28/88	10:30	7.7	7.3	4.6	745	10	400		85.0	2800	67	25	-1	2900
8614	BOULDSIPH01	08/10/88	11:53	23.0	7.1	8.9	175	8	30		3.1	420	17	-1	-1	440
8630	BOULDSIPH01	08/17/88	8:54	22.3	7.4	5.5	179	15	60		2.8	310	19	-1	-1	330
8659	BOULDSIPH01	08/24/88	9:08	22.8	7.9	7.8	194	6	15		2.2	260	21	2	-1	280
8675	BOULDSIPH01	08/31/88	8:50	22.7	7.0	7.0			40		2.9	290	21	1	-1	310
8785	BOULDSIPH01	11/30/88	10:27	9.8	7.0	3.6	293	13	160		25.0	2100	97	9	3	2200
8799	BOULDSIPH01	12/07/88	10:28	12.5	7.3	6.7	267	54	200		6.9	580	41	5	-1	630
8828	BOULDSIPH01	12/20/88	8:00	10.5	6.4	6.3	263	104	160		3.5	320	30	2	-1	350
8855	BOULDSIPH01	12/28/88	7:50	6.4	7.2	12.0	196	9	20		3.0	350	28	3	-1	380
7087	BRANNANPP01	03/16/87	10:30									2300	180	16	-1	2500
7301	BRANNANPP01	08/06/87	11:05	22.1	6.9	5.5	294	13			5.5	1200	60	8	-1	1300
7472	BRANNANPP01	10/16/87	9:00	15.7	6.9	4.9	361	15	50	8.2		900	92	6	-1	1000
7574	BRANNANPP01	12/10/87	9:30	11.5	6.7	6.1	595	13	120	26.0		1740	138	5	-1	1900
8019	BRANNANPP01	01/12/88	10:00	7.5	6.5	8.1	854	17	200	34.0		2600	120	5	-1	2700
8153	BRANNANPP01	03/08/88	8:11	10.2	6.8		538	28	160	23.0		1800	120	4	-1	1900
8254	BRANNANPP01	04/18/88	7:50	15.0	6.7	4.2	356	20	300	22.0						
8338	BRANNANPP01	05/09/88	7:19	20.2	7.1	4.2	378	14	240		20.0	2200	120	-1	-1	2300
8474	BRANNANPP01	07/18/88	7:37	21.1	6.9	4.6	292	13	100	7.3		890	95	3	-1	990
8474	BRANNANPP01	07/18/88	7:37	21.1	6.9	4.6	292	13	100	7.3		890	95	3	-1	990
8474	BRANNANPP01	07/18/88	7:37	21.1	6.9	4.6	292	13	100	7.3		890	95	3	-1	990
8474	BRANNANPP01	07/18/88	7:37	21.1	6.9	4.6	292	13	100	7.3		890	95	3	-1	990
8474	BRANNANPP01	07/18/88	7:37	21.1	6.9	4.6	292	13	100	7.3		890	95	3	-1	990
7302	BRANNANPP02	08/06/87	9:45	22.6	6.9	3.0	505	25			11.0	1700	180	21	-1	1900
7473	BRANNANPP02	10/16/87	8:00	15.9	6.7	0.6	597	35	35	13.0		310	48	9	-1	370
7575	BRANNANPP02	12/10/87	9:45	13.0	6.4	1.7	649		80	11.0		453	134	27	-1	610
8020	BRANNANPP02	01/12/88	8:50	8.3	6.8	7.4	974	16	200	37.0		2000	87	5	2	2100
8154	BRANNANPP02	03/08/88	7:24	12.8	6.7		643	90	60	15.0		790	220	26	-1	1000
8255	BRANNANPP02	04/18/88	6:37	15.5	6.7	0.1	602	22	300	26.0						

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential----> ug/L				
8339	BRANNANPP02	05/09/88	6:17	17.1	6.8		585	17	280		30.0	1600	200	15	-1	1800
7303	BRANNANPP03	08/06/87	10:15	22.0	7.3	7.2	671	32			8.2	1400	170	26	-1	1600
7474	BRANNANPP03	10/16/87	8:20	15.8	6.5	1.2	1330	84	15	11.0		78	50	24	9	160
8021	BRANNANPP03	01/12/88	9:05	8.3	6.6	2.5	1000	32	200	26.0		1500	130	15	-1	1600
8155	BRANNANPP03	03/08/88	7:39	13.8	6.8		1380	150	40	14.0		260	130	49	-1	440
8256	BRANNANPP03	04/18/88	7:00	16.0	6.5	0.0	1370	156	40	11.0						
8340	BRANNANPP03	05/09/88	6:38	17.8	6.8		1250	230	100		13.0	730	190	52	8	980
8476	BRANNANPP03	07/18/88	6:49	20.0	6.6	0.0	1010	31	600		16.0	1600	180	11	1	1800
7304	BRANNANPP04	08/06/87	10:45	22.4	7.1	6.3	328	14			5.0	860	79	14	-1	950
7475	BRANNANPP04	10/16/87	8:40	16.4	6.9	3.3	599	38	60	13.0		1500	180	20	-1	1700
7577	BRANNANPP04	12/10/87	10:05	11.5	7.0	6.5	780	15	140	25.0		1800	160	14	-1	2000
8022	BRANNANPP04	01/12/88	9:40	11.2	6.8	7.1	889	12	200	32.0		3000	140	7	-1	3100
8156	BRANNANPP04	03/08/88	7:54	11.9	7.3		1000	17	140	30.0		2900	98	6	-1	3000
8257	BRANNANPP04	04/18/88	7:24	15.5	6.7	6.0	662	24	120	14.0						
8341	BRANNANPP04	05/09/88	6:57	17.4	7.5	8.0	403	18	100		9.1	1200	86	7	-1	1300
8477	BRANNANPP04	07/18/88	7:15	20.7	6.6	3.9	579	15	140		17.0	1500	130	8	-1	1600
5003	CLIFTON	01/30/85	9:25	7.0	7.1	10.5	348	8								
5021	CLIFTON	02/27/85	11:00	13.0	7.3	9.8	303	14	40			410	64	8	-1	480
5037	CLIFTON	03/27/85	10:30	12.5	7.4	9.6	334	8								
5051	CLIFTON	04/24/85	10:30	18.0	7.6	9.6	277	8	8			470	56	7	-1	530
5072	CLIFTON	05/22/85	9:30	21.5	8.1	9.2	264	21	15			610	65	11	-1	690
5088	CLIFTON	06/26/85	9:15	24.5	7.5	7.7	314	17	15			550	88	24	1	660
5103	CLIFTON	07/10/85	9:00	25.5	7.5	6.5	386	15								
5122	CLIFTON	08/28/85	10:00	23.5	7.4	7.7	458	10	10			460	110	47	3	620
5133	CLIFTON	09/25/85	9:40	22.5	7.4	6.6	602	12								
5148	CLIFTON	10/23/85	9:15	17.5	7.5	8.9	484	9	10			330	130	59	4	520
5175	CLIFTON	11/15/85	10:45	12.0	7.4	10.2	679	12								
5169	CLIFTON	12/03/85	13:05	12.0	7.4	10.1	744	10	8			310	220	170	13	710
6010	CLIFTON	01/23/86	10:45	11.5	7.3	9.0	410	8								
6015	CLIFTON	02/13/86	9:50	11.5	7.3	10.4	423	17								
6026	CLIFTON	03/04/86	10:45	16.5	7.3	7.8	306	21	20			520	64	7	-1	590
6041	CLIFTON	04/09/86	11:00	16.5	7.2	8.8	197	14	20			570	62	5	-1	640
6076	CLIFTON	05/07/86	8:50	15.5	7.3	8.8	280	13	20			350	51	7	-1	410
6107	CLIFTON	06/04/86	9:45	20.5	7.3	8.2	303	26				140	28	6	-1	170
6125	CLIFTON	07/02/86	9:20	24.5	7.3	6.5	534	11	10			310	91	36	2	440
6144	CLIFTON	08/14/86	10:45	24.5	7.4	7.4	571	15	5							
6174	CLIFTON	09/24/86	9:45	19.5	7.3	8.3	292	19	15			350	86	18	-1	450
6279	CLIFTON	11/12/86	10:30	14.0	7.3	9.7	276	13	10	2.2		350	43	14	-1	410
6310	CLIFTON	12/17/86	8:40	10.0	7.3	10.0	285	11	5	2.1		430	60	7	-1	500
7019	CLIFTON	01/22/87	8:30	6.5	7.3	11.5	300	19	15	4.1		730	26	2	-1	760
7053	CLIFTON	02/24/87	8:45	11.5	7.3	10.1	435	11	20	4.7		780	96	34	-1	910
7109	CLIFTON	03/24/87	8:30	13.5	7.3	9.6	730	10	10	4.2		400	140	27	-1	570
7186	CLIFTON	04/30/87	7:30	20.0	8.3	11.1	365	12	10	3.2		270	49	7	-1	330
7221	CLIFTON	05/28/87	8:45	19.5	7.4	9.0	401	20	10	2.4		420	140	36	-1	600
7283	CLIFTON	06/23/87	8:45	23.0	8.3	7.4	483	22	15							
7401	CLIFTON	09/09/87	9:45	22.4	7.4	8.1	646	17	5	2.8		340	130	73	21	560

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3 (ug/L)	CHBrCl2 (ug/L)	CHBr2Cl (ug/L)	CHBr3 (ug/L)	TTHMFP (ug/L)
												<---- THMFormation Potential---->				
7444	CLIFTON	10/22/87	8:45	19.5	7.4	7.3	777	6	0	3.1		210	140	120	1	470
7542	CLIFTON	11/05/87	10:30	17.5	7.4	8.3	616	6	5	2.9		240	130	76	12	460
7569	CLIFTON	12/08/87	10:00	11.3	7.4	10.2	847	7	20	3.3		260	150	93	22	530
8013	CLIFTON	01/07/88	10:36	7.3	7.3	12.0	588	13	25	4.6		460	170	60	4	690
8093	CLIFTON	02/10/88	9:25	11.2	7.1	9.8	364	12	40	4.6		720	65	18	-1	800
8148	CLIFTON	03/15/88	10:20	13.6	7.5	10.7	574	6	20	2.9		320	110	79	8	520
8237	CLIFTON	04/05/88	8:30	16.4	7.5	9.4	672	6	20	3.9		280	95	51	8	430
8332	CLIFTON	05/03/88	9:25	17.7	7.7	8.8	337	15	35	2.8		490	79	22	4	600
8424	CLIFTON	06/14/88	9:39	22.9	7.5	6.9	416	25	60	2.6		390	100	27	-1	520
8459	CLIFTON	07/12/88	9:23	23.0	7.5		560	19	30	2.6		390	120	76	6	590
8581	CLIFTON	08/09/88	11:30	23.8	7.6	7.4	616	12	20	2.4		230	120	89	15	450
8684	CLIFTON	09/06/88	9:15	24.6	7.6	7.2	713	10	20	2.5		240	150	62	14	470
8716	CLIFTON	10/04/88	9:36	20.8	7.8	7.9	617	7	20	4.3		230	110	51	6	400
8746	CLIFTON	11/01/88	10:34	17.5	7.6	8.3	844	11	20	3.0		150	130	110	5	400
8815	CLIFTON	12/13/88	10:45	11.5	7.1	10.6	726	12	30	4.4		540	230	150	15	940
5002	DMC	01/30/85	8:50	7.5	7.3	10.6	398	7								
5020	DMC	02/27/85	10:15	13.0	7.5	9.9	336	11	35			410	75	12	-1	500
5036	DMC	03/27/85	9:45	12.0	7.4	9.8	315	8								
5050	DMC	04/24/85	10:00	17.5	7.5	9.5	280	9	5			340	57	5	-1	400
5071	DMC	05/22/85	9:00	20.5	8.3	9.1	265	22	20			550	71	10	-1	630
5087	DMC	06/26/85	8:30	24.5	7.6	7.1	710	23	10			580	180	9	10	780
5102	DMC	07/10/85	8:30	24.5	7.4	6.7	544	24								
5121	DMC	08/28/85	9:20	23.0	7.4	7.7	441	17	20			410	120	70	3	600
5147	DMC	10/23/85	8:40	16.5	7.4	7.2	592	13	5			270	110	58	5	440
5174	DMC	11/15/85	10:15	12.0	7.4	10.5	545	11								
5168	DMC	12/03/85	13:05	12.0	7.4	10.1	591	10	15			360	190	120	6	680
6009	DMC	01/23/86	10:00	11.5	7.3	8.8	439	8								
6014	DMC	02/13/86	9:15	11.5	7.5	10.2	460	16								
6025	DMC	03/04/86	10:15	16.5	7.3	7.9	288	25	25			580	61	6	-1	650
6040	DMC	04/09/86	9:45	16.0	7.3	9.0	229	22	25			600	58	7	-1	670
6075	DMC	05/07/86	8:15	16.0	7.2	8.3	278	15	10			260	40	5	-1	310
6106	DMC	06/04/86	9:00	21.5	7.3	7.7	362	31				250	54	8	-1	310
6124	DMC	07/02/86	8:45	24.5	7.3	7.0	530	13	10			340	120	34	2	500
6143	DMC	08/14/86	9:30	24.5	7.3	6.6	586	27	5							
6173	DMC	09/24/86	9:10	18.5	7.3	8.1	320	18	10			340	81	20	-1	440
6278	DMC	11/12/86	10:00	13.5	7.4	9.4	545	13	5	1.9		230	64	53	2	350
6309	DMC	12/17/86	9:15	10.0	7.2	9.6	299	11	5	2.1		400	66	9	-1	480
7018	DMC	01/22/87	9:00	6.5	7.3	11.5	356	18	20	4.1		670	79	9	-1	760
7054	DMC	02/24/87	9:15	10.5	7.3	9.7	860	11	10	3.6		480	190	120	7	800
7108	DMC	03/24/87	8:45	13.0	7.5	9.6	804	13	15	3.9		340	140	33	6	520
7185	DMC	04/30/87	8:00	20.0	8.3	10.3	359	18	10	3.1		280	51	8	-1	340
7220	DMC	05/28/87	8:30	18.5	7.5	8.6	405	17	10	2.5		420	130	34	-1	580
7282	DMC	06/23/87	8:15	23.0	7.5	7.5	466	22	10							
7400	DMC	09/09/87	9:20	22.0	7.4	7.7	503	21	5	3.5		410	110	43	8	570
7443	DMC	10/22/87	8:30	19.0	7.4	7.2	751	7	0	3.3		87	68	34	33	220
7541	DMC	11/05/87	10:00	18.0	7.3	8.5	620	8	5	2.6		280	110	77	14	480

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	<---- THMFormation Potential----> CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<------------		ug/L		---------->
7568	DMC	12/08/87	9:45	11.3	7.3	10.2	847	8	20	3.2		240	160	120	33	550
8012	DMC	01/07/88	10:05	7.6	7.1	12.0	488	13	35	5.0		490	100	30	-1	620
8092	DMC	02/10/88	8:55	11.1	7.2	9.5	376	14	40	4.8		730	36	15	-1	780
8147	DMC	03/03/88	9:45	13.3	7.4	10.5	575	8	20	3.0		370	96	39	3	510
8236	DMC	04/05/88	8:10	15.0	7.5	9.6	635	8	15	2.8		230	110	70	12	420
8331	DMC	05/03/88	8:57	17.4	7.7	9.0	344	16	30	2.7		410	89	25	4	530
8423	DMC	06/14/88	8:56	22.3	7.5	6.8	441	28	40	2.4		330	90	28	-1	450
8458	DMC	07/12/88	8:55	23.0	7.6	7.8	571	15	30	2.5		190	130	120	25	470
8580	DMC	08/09/88	10:50	23.2	7.7	7.9	710	25	25	2.7		210	110	82	11	410
8683	DMC	09/06/88	8:45	24.7	7.7	6.9	814	28	25	2.1		300	160	81	18	560
8715	DMC	10/04/88	8:59	19.7	7.4	7.6	783	13	25	3.4		290	150	71	7	520
8745	DMC	11/01/88	10:11	17.0	7.4	8.2	883	18	20	3.1		180	34	20	15	250
8814	DMC	12/13/88	10:22	11.4	7.1	10.6	675	11	30	4.4		400	190	130	12	730
9055	DMC	01/10/89	9:55	13.0	6.7	11.2	563	8	35	5.0		440	110	41	4	600
9133	DMC	02/07/89	9:30	6.4	6.9	11.9	662	7	25	4.3		200	120	74	8	400
9214	DMC	03/07/89	9:10	13.2	7.3	9.9	567	8	25	3.7		280	130	68	5	480
9249	DMC	04/04/89	8:46	16.2	8.0	7.8	313	12		4.6		580	62	14	-1	660
9347	DMC	05/02/89	8:55	18.9	7.5	8.5	265	12	30	3.3		400	46	8	-1	450
9429	DMC	06/06/89	9:10	21.8	8.0	7.9	270	20	40	3.4		470	55	9	-1	530
9549	DMC	07/05/89	10:42	23.4	7.8	7.7	276	20	40		3.3	330	58	10	0	400
9586	DMC	07/25/89	8:30	24.8	7.3	8.1	540	23				350	160	67	4	580
7113	EGBERTPP01	03/30/87	8:45	13.5	7.3	5.9	1100	105	100	33.0		2200	250	11	-1	2500
7306	EGBERTPP01	08/13/87	10:05	19.3	7.0	6.5	305	120			7.1	1300	23	-1	-1	1300
7476	EGBERTPP01	10/20/87	10:00	15.0	7.4	6.6	667	172	40	14.0		1600	89	-1	-1	1700
8024	EGBERTPP01	01/12/88	9:10	6.3	7.1	9.3	968	56	100	32.0		2000	120	2	-1	2100
8159	EGBERTPP01	03/08/88	8:38	6.1	7.3		1080	46	120	25.0		2300	110	5	-1	2400
8260	EGBERTPP01	04/18/88	8:30	14.0	7.1	6.5	337	66	50	9.0						
8344	EGBERTPP01	05/09/88	8:30	15.5	7.4	3.2	903	52	160		32.0	3200	200	28	-1	3400
8480	EGBERTPP01	07/18/88	8:34	21.5	7.0	6.6	297	60	100		8.2	910	16	-1	-1	920
7114	EGBERTPP02	03/30/87	9:15	14.0	7.8	11.7	1760	60	80	37.0		2800	200	19	-1	3000
7477	EGBERTPP02	10/20/87	10:20	16.0	7.6	5.7	1220	183	100	66.0		3500	77	2	-1	3600
8025	EGBERTPP02	01/12/88	9:50	7.0	7.2	9.0	1350	64	60	10.0		1200	58	2	-1	1300
8160	EGBERTPP02	03/08/88	9:04	8.5	8.1		1820	26	160	52.0		3600	170	5	-1	3800
8261	EGBERTPP02	04/18/88	9:07	16.0	8.1	9.5	875	93	140	30.0						
8345	EGBERTPP02	05/09/88	8:55	17.1	8.2	4.5	1140	25	280		54.0	5000	30	-1	-1	5000
8481	EGBERTPP02	07/18/88	9:01	22.9	7.0	3.7	484	62	120	13.0		1400	20	-1	-1	1400
5005	GREENES	01/30/85	11:45	9.0	7.4	11.9	186	3								
5013	GREENES	02/06/85	11:30	8.0	7.5	12.1	174	8	10			360	14	1	-1	380
5029	GREENES	03/06/85	12:00	11.0	7.4	10.5	180	5								
5047	GREENES	04/05/85	10:35	19.0	7.4	9.3	176	7	2			160	13	-1	-1	170
5063	GREENES	05/01/85	10:30	19.0	7.3	8.8	167	11	10			210	12	1	-1	220
5091	GREENES	05/29/85	5:10	18.0	7.4	9.5	178	10								
5079	GREENES	06/05/85	9:55	21.0	7.4	8.5	173	9	10			290	19	1	-1	310
5109	GREENES	07/24/85	8:00	22.5	7.3	8.0	163	8								
5114	GREENES	08/01/85	10:35	22.5	7.5	7.9	163	10	10			480	14	2	-1	500
5154	GREENES	09/04/85	9:30	22.0	7.3	7.8	207	8	5			220	22	2	-1	240

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential---->				
												<------------ ug/L ------------>				
5140	GREENES	10/02/85	10:15	21.5	7.5	8.2	168	7	5			200	14	1	-1	220
5165	GREENES	11/13/85	10:40	12.0	7.3	9.7	163	6	5			290	20	1	-1	310
5184	GREENES	12/03/85	19:30	11.5	7.3	9.3	149	28	35			690	21	1	-1	710
6006	GREENES	01/16/86	14:00	10.0	7.3	10.6	218	9	15			660	22	1	-1	680
6021	GREENES	02/27/86	12:40	12.5	7.1	10.5	84	64	20			340	7	-1	-1	350
6037	GREENES	03/13/86	13:45	11.5	7.3	11.0	70	58	10			430	8	-1	-1	440
6052	GREENES	04/23/86	12:45	18.5	7.3	8.5	179	14	10			310	22	1	-1	330
6087	GREENES	05/28/86	12:00	23.5	7.3	7.5	188	14	10			170	12	2	1	190
6119	GREENES	06/25/86	12:50	24.5	7.3	7.8	161	13	15			990	10	3	2	1000
6139	GREENES	07/23/86	12:15	22.5	7.3	7.8	128	13	5							
6161	GREENES	08/27/86	12:45	24.5	7.6	7.3	179	10	10			220	17	1	-1	240
6208	GREENES	09/09/86	11:55	22.5	7.3	7.7	182	12	5			220	17	1	-1	240
6285	GREENES	11/19/86	7:00	14.5	7.3	10.0	146	7	10	1.5		180	7	-1	-1	190
6306	GREENES	12/10/86	7:10	11.0	7.3	10.7	152	8	0	1.5		210	13	-1	-1	220
7012	GREENES	01/13/87	7:15	7.5	7.3	11.0	178	8	5	1.7		200	12	-1	-1	210
7040	GREENES	02/10/87	6:45	12.0	7.3	9.4	193	15	10	2.3		470	19	-1	-1	490
7075	GREENES	03/10/87	6:45	13.5	7.1	8.4	128	72	25	3.4		1100	10	-1	-1	1100
7177	GREENES	04/16/87	5:45	16.5	7.2	5.6	178	8	5	1.4		260	18	2	-1	280
7212	GREENES	05/20/87	5:45	20.0	7.4	7.7	172	11	10	1.5		120	11	-1	-1	130
7250	GREENES	06/11/87	5:50	21.0	7.3	7.6	176	6	5	1.4		180	11	-1	-1	190
7374	GREENES	08/25/87										250	13	13	-1	280
7393	GREENES	09/03/87	10:15	23.7	7.1	9.0	204	11	5	4.9		430	17	-1	-1	450
7434	GREENES	10/08/87	5:35	20.0	7.2	8.7	159	7	5	1.6		240	11	-1	-1	250
7529	GREENES	11/03/87	6:40	16.5	7.1	8.1	180	4	0	2.8		300	15	-1	-1	320
7559	GREENES	12/01/87	6:45	11.5	7.2	10.4	210	7	0	3.2		280	15	-1	-1	300
8001	GREENES	01/06/88	7:45	8.6	7.3	10.5	172	44	35	3.3		380	11	-1	-1	390
8108	GREENES	02/18/88	6:30	10.5	7.4	10.5	224	7	10	2.0		250	15	1	-1	270
8213	GREENES	03/17/88	6:50	13.4	7.2	10.3	219	7	10	1.9		250	14	1	-1	270
8249	GREENES	04/14/88	6:23	14.6	7.2	9.4	146			1.8		96	9	-1	-1	110
8394	GREENES	05/19/88	5:50	18.1	7.7	7.9	196	6	10	2.0		210	16	-1	-1	230
8416	GREENES	06/07/88	5:30	18.0	7.1	8.5	211	8	15	1.9		250	22	4	-1	280
8448	GREENES	07/06/88	6:08	20.8	7.3	7.5	142	10	10	2.0		200	7	1	-1	210
8570	GREENES	08/02/88	7:00	21.5	7.2	7.3			10	1.9		170	10	-1	-1	180
8690	GREENES	09/15/88	6:25	20.0	7.3	7.6	226	9	15	2.5		300	23	3	-1	330
8719	GREENES	10/13/88	6:00	18.2	7.3	7.1	154	5	10	1.6		130	9	-1	-1	140
8757	GREENES	11/17/88	7:29	12.2	8.3	9.1	203	6	10	2.2		210	16	1	-1	230
8803	GREENES	12/06/88	7:00	10.6	7.0	10.5	198	8	10	2.8		240	24	1	-1	260
7115	KINGISPP01	03/26/87	11:30	12.5	6.0	1.0	757	26	40	16.0		620	120	21	5	770
7309	KINGISPP01	08/07/87	6:15	19.8	7.1	3.2	555	4			15.0	2100	270	26	-1	2400
7480	KINGISPP01	10/19/87	7:40	15.8	7.1	4.2	546	9	15	8.2		670	130	24	-1	820
7579	KINGISPP01	12/10/87	10:48	14.0	7.3	7.3	619	90	80	14.0		1020	144	14	-1	1200
8027	KINGISPP01	01/12/88	9:20	10.7	7.3	5.1	673	13	35	8.5		840	170	34	-1	1000
8162	KINGISPP01	03/08/88	10:18	13.3	7.1		420	17	40	8.6		810	84	5	-1	900
8263	KINGISPP01	04/18/88	7:33	60.0	14.6	7.1	390	7	60	9.0						
8348	KINGISPP01	05/09/88	7:52	18.8	7.5	4.7	403	9	80		9.6	1100	59	19	-1	1200
8484	KINGISPP01	07/18/88	7:09	20.5	7.4	3.1	439	7	100		8.9	930	52	9	-1	990

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<----- THMFormation Potential -----> ug/L				
7116	KINGISPP02	03/26/87	11:45	14.5	7.3	5.8	1510	7	35	11.0		480	230	160	36	910
7310	KINGISPP02	08/07/87	7:20	20.4	6.7	2.1	503	20			4.7	2000	130	23	-1	2200
7481	KINGISPP02	10/19/87	8:00	15.0	6.9	2.0	500	7	35	8.9		740	55	6	-1	800
7580	KINGISPP02	12/10/87	11:48	14.0	7.0	4.6	652	9	160	26.0		1580	123	15	-1	1700
8028	KINGISPP02	01/12/88	10:00	8.7	7.0	6.2	508		50	9.8		1400	100	8	-1	1500
8163	KINGISPP02	03/08/88	10:59	13.9	7.2		572	45	100	13.0		1300	82	9	-1	1400
8264	KINGISPP02	04/18/88	8:18	14.0	7.1	3.5	506	10	80	12.0						
8349	KINGISPP02	05/09/88	8:29	20.6	7.9	5.8	496	16	100		11.0	1300	140	31	12	1500
8485	KINGISPP02	07/18/88	7:57	23.0	7.1	2.3	652	6	140		21.0	1900	140	6	-1	2000
7117	KINGISPP03	03/26/87	12:15	17.5	7.1	3.5	443	4	50	11.0		780	100	8	-1	890
7311	KINGISPP03	08/07/87	7:00	20.1	7.1	3.1	945	12			14.0	2000	450	160	-1	2600
7482	KINGISPP03	10/19/87	7:20	16.0	7.1	3.9	689	5	30	8.3		1100	200	53	-1	1400
7581	KINGISPP03	12/10/87	11:18	13.0	7.2	7.9	598	220	200	23.0		1840	127	16	-1	2000
8029	KINGISPP03	01/12/88	9:40	9.2	7.3	6.8	1140	13	60	9.8		1000	260	79	12	1400
8164	KINGISPP03	03/08/88	10:39	15.1	7.3		848	32	60	8.1		640	250	95	6	990
8265	KINGISPP03	04/18/88	7:51		7.3	5.2	900	15	60	7.9						
8350	KINGISPP03	05/09/88	8:13	21.0	7.9	6.8	960	7	80		12.0	1000	560	210	18	1800
8486	KINGISPP03	07/18/88	7:30	23.0	7.4	4.8	895	14	140	14.0		1200	320	95	2	1600
5010	LCONNECT	02/06/85	8:45	7.0	7.4	11.2	252	5	15			660	46	6	-1	710
5026	LCONNECT	03/06/85	9:15	11.0	7.4	10.0	218	7								
5044	LCONNECT	04/05/85	8:15	21.5	7.3	3.9	2180	10	75			1800	920	370	31	3100
5060	LCONNECT	05/01/85	8:00	19.0	7.4	9.1	175	5	5			280	27	2	-1	310
5076	LCONNECT	06/05/85	7:45	20.5	7.5	8.7	180	7	5			300	26	2	-1	330
5111	LCONNECT	08/01/85	8:00	22.5	7.4	8.0	186	5	10			360	32	2	-1	390
5137	LCONNECT	10/02/85	6:40	20.0	7.5	7.8	209	4	5			240	26	3	-1	270
5161	LCONNECT	11/13/85	7:30	7.0	7.3	9.0	1880	4	80			340	34	2	-1	380
5180	LCONNECT	12/03/85	16:45	11.5	7.3	10.2	204	5	15			380	36	3	-1	420
6030	LCONNECT	03/11/86	11:45	14.5	7.3	9.0	192	22	25			650	51	3	-1	700
6045	LCONNECT	04/17/86	9:45	15.5	7.2	8.5	195	11	20			440	51	7	-1	500
6080	LCONNECT	05/13/86	9:45	19.5	7.3	8.4	162	14	25			150	16	2	-1	170
6111	LCONNECT	06/11/86	7:45	21.5	7.3	7.9	136	12	25			310	15	2	-1	330
6130	LCONNECT	07/09/86	7:15	23.0	7.3	7.7	154	9	10			280	30	1	-1	310
6150	LCONNECT	08/13/86	7:35	20.5	7.1	5.1	281	9	50							
6197	LCONNECT	09/11/86	7:30	21.5	7.4	7.6	181	12	10			280	24	3	-1	310
6282	LCONNECT	11/19/86	10:00	13.5	7.2	9.1	156	5	20	3.1		600	19	1	-1	620
6299	LCONNECT	12/10/86	11:00	11.0	7.3	10.0	168	5	10	2.8						
7007	LCONNECT	01/13/87	10:30	7.5	7.1	10.1	209	6	30		4.8	700	49	2	-1	750
7045	LCONNECT	02/10/87	10:30	11.5	7.2	9.6	235	10	15	4.8		630	41	-1	-1	670
7068	LCONNECT	03/10/87	10:30	13.5	7.1	9.1	261	14	35	4.7		1400	38	2	-1	1400
7170	LCONNECT	04/16/87	9:15	19.5	7.2	6.8	228	6	5	2.3		290	35	5	-1	330
7205	LCONNECT	05/20/87	8:30	21.5	7.4	8.5	194	9	5	1.7		280	28	3	-1	310
7243	LCONNECT	06/11/87	9:15	22.5	7.8	8.0	241	6	10	2.1		250	32	5	-1	290
7405	LCONNECT	09/24/87	8:30	20.5	7.4	7.9	270	6	10	2.3		240	25	3	-1	270
7448	LCONNECT	10/28/87	8:50	20.0	7.2	7.4	244	5	5	2.8		192	53	17	1	260
7546	LCONNECT	11/24/87	10:50	14.0	7.2	8.2	215	3	5	3.4		340	30	1	-1	370
7605	LCONNECT	12/16/87	8:30	8.2	7.3	11.3	178	18	40	4.4		800	19	1	-1	820

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<----- THMFormation Potential ----> ug/L				
8073	LCONNECT	01/21/88	8:42	8.8	7.2	10.4	262	14	40	4.7		670	63	4	-1	740
8131	LCONNECT	02/23/88	8:20	11.5	7.3	10.1	240	6	10	2.4		930	23	1	-1	950
8222	LCONNECT	03/24/88	8:45	15.3	7.4	9.6	225	3	10	1.9		220	22	3	-1	250
8321	LCONNECT	04/28/88	9:05	16.6	7.7	8.8	174	6	25	2.8		370	18	-1	-1	390
8398	LCONNECT	05/26/88	7:50	20.5	8.0	9.6	226	9	25	2.3		260	37	3	-1	300
8430	LCONNECT	06/22/88	6:08	21.9	7.4	7.4	261	7	35	5.0		630	46	4	-1	680
8465	LCONNECT	07/14/88	9:15	22.4	7.3	7.2			20	3.0		450	20	1	-1	470
8587	LCONNECT	08/16/88	8:30	22.0	7.5	7.4	184	6	15	2.1		240	24	24	-1	290
8699	LCONNECT	09/22/88	6:09	18.7	7.6	8.0	275	4	15	2.3		300	33	16	6	360
8728	LCONNECT	10/20/88	8:10	19.4	7.1	7.7	386	3	20	4.0		400	57	35	1	490
8750	LCONNECT	11/10/88	8:15	16.1	6.8	8.4	206	4	15	4.0		310	28	3	-1	340
8839	LCONNECT	12/20/88	9:30	11.2	7.3	10.1	245	5	40	7.5		830	42	2	-1	870
9097	LCONNECT	01/31/89	8:45	9.9	7.0	10.6	255	4	20	3.1		200	32	5	-1	240
9187	LCONNECT	02/28/89	8:20	13.0	6.8	9.8	228	4	15	2.6		190	33	7	-1	230
9240	LCONNECT	03/28/89	8:40	14.8	7.4	8.1	148	10	30	4.3		520	28	3	-1	550
9337	LCONNECT	04/25/89	8:02	16.8	8.1	8.5	163	5	15	2.1		220	21	2	-1	240
9367	LCONNECT	05/23/89	8:07	18.7	8.1	8.7	165	6	20	2.8		310	21	1	-1	330
9487	LCONNECT	06/21/89	7:50	21.5	7.5	8.1	204	7	20		3.5	390	45	3	0	440
9561	LCONNECT	07/18/89	8:15	23.9	7.1	7.4	176	7	35		6.0	580	27	3	0	610
9599	LCONNECT	07/25/89	9:16	25.1	7.4	7.9	130	6				360	24	1	0	390
5016	LINDSEY	02/13/85	11:50	10.5	7.3	6.7	381	110	50			1200	65	3	-1	1300
5032	LINDSEY	03/13/85	11:45	12.5	7.6	9.1	482	60								
5056	LINDSEY	04/10/85	10:15	18.0	7.7	8.6	531	20	15			580	86	9	-1	680
5066	LINDSEY	05/08/85	10:00	17.0	8.1	8.8	574	18	20			660	88	4	-1	750
5095	LINDSEY	05/29/85	10:30	20.0	7.9	8.6	571	27								
5083	LINDSEY	06/12/85	10:45	25.0	7.9	7.1	541	28	30			900	97	6	-1	1000
5106	LINDSEY	07/24/85	6:10	22.0	7.6	7.0	421	36								
5117	LINDSEY	08/14/85	9:55	21.0	7.8	8.6	405	48	30			750	69	5	-1	820
5125	LINDSEY	09/11/85	9:00	19.5	7.7	7.5	443	30	25			820	54	4	-1	880
5143	LINDSEY	10/09/85	10:05	16.5	7.6	8.1	496	31	38			1500	66	3	-1	1600
5178	LINDSEY	11/19/85	8:20	8.5	7.5	10.0	442	18	15							
5187	LINDSEY	12/03/85	7:20	11.5	7.4	8.7	569	25	60			1300	70	2	-1	1400
6001	LINDSEY	01/16/86	7:45	10.5	7.3	6.7	458	38	80			2200	56	2	-1	2300
6018	LINDSEY	02/27/86	7:50	16.5	6.8	3.0	208	46	60			790	26	-1	-1	820
6033	LINDSEY	03/13/86	7:30	13.5	7.1	6.2	221	68	100			1300	47	1	-1	1300
6048	LINDSEY	04/23/86	7:30	18.5	7.6	5.3	387	48	70			1100	84	6	-1	1200
6083	LINDSEY	05/28/86	6:00	20.0	8.0	6.0	528	26	25			380	38	5	2	430
6115	LINDSEY	06/25/86	6:35	21.5	8.0	7.2	461	38	20			350	36	4	1	390
6135	LINDSEY	07/23/86	6:35	20.5	7.7	7.4	431	32	30							
6156	LINDSEY	08/27/86	6:45	20.5	7.6	6.7	514	50	40			930	65	4	-1	1000
6203	LINDSEY	09/09/86	6:35	18.5	7.8	7.6	466	37	40			860	71	5	-1	940
6273	LINDSEY	11/05/86	9:15	14.5	7.5	8.5	490	25	25	5.2		780	59	5	-1	840
6295	LINDSEY	12/03/86	8:25				496	22	25	5.4		800	80	4	-1	880
7001	LINDSEY	01/08/87	8:30	7.5	7.3	10.1	492	24	20	4.4		520	66	-1	-1	590
7023	LINDSEY	02/05/87	8:50	10.0	7.5	9.6	547	24	20	4.7		550	76	-1	-1	630
7061	LINDSEY	03/03/87	8:15	11.0	8.0	9.9	518	37	20	6.3		1200	62	-1	-1	1300

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential----> ug/L				
7164	LINDSEY	04/09/87	7:00	16.5	7.9	8.7	606	25	20	5.8		870	120	9	-1	1000
7198	LINDSEY	05/13/87	7:00	23.5	7.9	7.3	530	24	20	5.0		160	85	12	-1	260
7234	LINDSEY	06/04/87	7:15	19.5	7.9	7.7	593	38	25	6.2		800	67	6	-1	870
7387	LINDSEY	09/03/87	8:30	21.2	7.5	6.5	461	90	25	7.2		1200	63	2	-1	1300
7428	LINDSEY	10/08/87	11:55	20.0	7.4	8.1	523	21	25	5.7		630	62	3	-1	700
7531	LINDSEY	11/03/87	8:25	15.5	7.6	8.2	513	19	20	7.2		1200	63	4	-1	1300
7554	LINDSEY	12/01/87	8:30	10.9	7.4	9.7	509	19	25	6.0		720	47	3	-1	770
8003	LINDSEY	01/06/88	12:34	11.2	7.3	10.0	723	20	60	8.6		950	72	5	-1	1000
8110	LINDSEY	02/18/88	12:30	11.7	7.3	9.7	551	50	50	7.8		1500	48	4	2	1600
8208	LINDSEY	03/17/88	8:39	14.1	7.5	10.1.	547		60	5.4		680	52	5	-1	740
8245	LINDSEY	04/14/88	9:36	18.4	7.8	8.9	593			5.6		850	56	7	3	920
8389	LINDSEY	05/19/88	10:27	20.2	7.8	4.6	605	29	60	6.0		810	66	6	-1	880
8412	LINDSEY	06/07/88	7:30	17.7	7.6	4.3	525	37	80	5.2		660	53	5	1	720
8451	LINDSEY	07/06/88	8:04	21.2	7.6	7.6	325	42	60	3.2		570	36	4	-1	610
8573	LINDSEY	08/02/88	12:48	21.7	8.1	8.3	287	42	60	3.9		590	45	2	-1	640
8693	LINDSEY	09/15/88	7:55	18.7	7.5	8.6	259	25	40	3.2		380	29	2	-1	410
8722	LINDSEY	10/13/88	8:35	17.0	8.0	9.1	274	20	50	3.0		370	33	3	-1	410
8760	LINDSEY	11/17/88	9:16	12.8	7.8	9.5	258	19	35	2.8		320	34	3	-1	360
8806	LINDSEY	12/06/88	9:15	10.2	7.2	11.0	249	17	30	3.1		330	39	3	-1	370
8554	LPOTATOWHITE	07/19/88	11:10	25.5	7.4	7.0	159	10	15		1.7	360	17	-1	-1	380
8612	LPOTATOWHITE	08/10/88	8:33	21.9	7.8		167	10	10		2.3	240	16	-1	-1	250
8627	LPOTATOWHITE	08/17/88	8:40	22.2	7.7		189	8	15		2.2	220	22	1	-1	240
8654	LPOTATOWHITE	08/24/88	8:25	21.8	8.1		192	12	15		3.6	340	20	2	-1	360
8670	LPOTATOWHITE	08/31/88	8:30	24.0	8.0				10		3.7	310	26	2	-1	340
8777	LPOTATOWHITE	11/30/88	11:48	10.6	8.2	8.5	177	22			4.8	600	29	2	-1	630
8791	LPOTATOWHITE	12/07/88	9:55	10.0	8.3	9.6	203	9	20		4.5	400	28	4	-1	430
8821	LPOTATOWHITE	12/20/88	9:55	8.6	8.0	10.3	209	7	15		2.5	310	27	2	-1	340
8848	LPOTATOWHITE	12/28/88	8:50	6.5	7.6	11.4	194	9	20		2.6	340	25	1	-1	370
8553	LPOTTERM	07/19/88	10:25	25.0	7.5	7.2	158	9	20		1.8	370	15	-1	-1	380
8611	LPOTTERM	08/10/88	8:14	22.0	7.7		169	10	10		2.2	250	17	-1	-1	270
8626	LPOTTERM	08/17/88	8:19	21.8			175	8	10		2.3	430	18	-1	-1	450
8653	LPOTTERM	08/24/88	8:10	21.2	7.7		198	10	15		4.0	260	20	2	-1	280
8669	LPOTTERM	08/31/88	8:15	23.9	7.3				10		3.1	370	17	-1	-1	390
8776	LPOTTERM	11/30/88	10:18	10.0	8.1	8.8	173	22	50		4.9	710	19	2	-1	730
8790	LPOTTERM	12/07/88	8:30	10.0	7.5		221	12	25		5.4	440	35	6	-1	480
8818	LPOTTERM	12/20/88	9:00	8.7	7.4	10.7	216	9	15		3.3	330	31	4	-1	360
8845	LPOTTERM	12/28/88	8:20	6.7	7.6	11.8	196	9	25		3.0	370	22	3	-1	390
9059	LPOTTERM	01/11/89	8:40	6.6	7.6		217	10	20		3.6	390	31	2	-1	420
9079	LPOTTERM	01/18/89	8:41	6.9	8.3	11.5	212	8	30		3.8	320	26	2	-1	350
9104	LPOTTERM	01/26/89	10:01	8.6	6.6	11.0	234	6	10			150	13	2	-1	160
9117	LPOTTERM	02/02/89	8:50	8.3	7.3	10.3	249	6	20		3.8	350	23	4	-1	380
9374	LPOTTERM	06/01/89	7:50	19.8	8.1	8.1	169	7	10		3.9	580	220	80	6	890
9387	LPOTTERM	06/08/89	7:30	19.8	8.3	10.0	161	8	5		2.4	260	15	-1	-1	270
9400	LPOTTERM	06/15/89	8:15	21.6	7.6	8.4	181	11	15		2.3	320	24	2	-1	350
9413	LPOTTERM	06/19/89	8:35	21.1	8.0	8.3	181	9	15		2.1	250	18	2	-1	270
9494	LPOTTERM	07/06/89	7:30	20.5	8.2	8.9	143	7	20		2.7	260	15	0	0	280

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential ---->				
												<---------- ug/L ---------->				
9507	LPOTTERM	07/13/89	8:18	23.2	7.9	8.9	170	7	15		1.9	260	27	38	1	330
9520	LPOTTERM	07/20/89	6:45	22.5	7.3	8.6	133	8	15		2.1	300	12	0	0	310
9597	LPOTTERM	07/25/89	8:24	22.3	7.8	9.2	120	13				360	22	1	0	380
9533	LPOTTERM	07/27/89	6:25	21.6	8.3	8.7	132	13	10		2.0	230	21	1	0	250
5064	MALLARDIS	05/08/85	7:00	16.0	7.8	8.7	9290	14	10			12	84	330	650	1100
5093	MALLARDIS	05/29/85	8:35	17.0	7.7	8.7	2720	26								
5080	MALLARDIS	06/12/85	7:00	21.5	7.8	8.0	2980	19	5			65	170	340	300	880
5115	MALLARDIS	08/14/85	7:30	19.0	8.0	8.5	8480	19	5			61	54	250	680	1000
5129	MALLARDIS	09/11/85	7:35	18.5	7.9	8.2	7320	12	5			21	94	370	500	990
5141	MALLARDIS	10/09/85	7:35	17.0	8.0	8.4	6330	10	5			21	140	340	520	1000
5179	MALLARDIS	11/19/85	10:15	11.5	8.1	9.6	13100	9	5							
5185	MALLARDIS	12/03/85	10:10	12.0	7.5	9.9	9970	8	8			11	72	340	640	1100
6002	MALLARDIS	01/16/86	9:40	10.0	7.7	10.2	10700	16	20			5	44	320	990	1400
6019	MALLARDIS	02/27/86	9:55	14.5	7.0	8.8	169	58	25			490	29	1	-1	520
6035	MALLARDIS	03/13/86	11:30	13.0	7.3	9.4	161	51	30			670	38	2	-1	710
6050	MALLARDIS	04/23/86	9:15	16.5	7.3	8.9	226	22	20			440	64	8	-1	510
6085	MALLARDIS	05/28/86	8:15	17.0	7.6	8.6	4160	26	15			39	88	260	350	740
6117	MALLARDIS	06/25/86	10:35	21.0	7.7	8.1	4250	36	10			24	84	78	320	510
6158	MALLARDIS	08/27/86	8:45	20.5	7.8	8.9	3970	36	5			44	150	350	300	840
6205	MALLARDIS	09/09/86	8:15	18.5	7.9	8.7	6180	63	5			28	130	440	690	1300
6275	MALLARDIS	11/05/86	11:45	17.5	7.7	9.5	4550	13	5	1.5		25	80	160	280	550
6297	MALLARDIS	12/03/86	11:45	13.0	7.5	9.7	7330	13	5	1.4		400	20	-1	-1	420
7003	MALLARDIS	01/08/87	11:45	9.0	7.5	10.5	7800	21	5	1.7		16	75	180	400	670
7025	MALLARDIS	02/05/87	11:30	11.0	7.7	10.6	5780	18	10	2.0		30	88	73	280	470
7063	MALLARDIS	03/03/87	11:15	11.5	7.4	9.9	2280	30	15	3.3		160	250	220	270	900
7167	MALLARDIS	04/09/87	10:00	18.0	7.6	9.2	1780	45	10	3.2		230	370	340	210	1200
7200	MALLARDIS	05/13/87	9:30	23.0	8.2	5.0	7480	20	5	2.3		26	140	290	480	940
7236	MALLARDIS	06/04/87	10:30	20.5	7.9	8.5	12000	12	10	1.9		10	57	250	500	820
7430	MALLARDIS	10/08/87	8:15	20.8	7.9	7.4	12200	12	10	1.7		3	19	160	450	630
7533	MALLARDIS	11/03/87	11:20	18.8	7.8	7.8	13700	13	5	2.1		1	28	210	660	900
7556	MALLARDIS	12/01/87	11:40	13.2	7.9	8.2	15600	22	5	1.7		-1	-1	170	790	960
8005	MALLARDIS	01/06/88	10:00	7.8	8.0	11.4	7070	18	15	3.7		17	73	250	540	880
8112	MALLARDIS	02/18/88	9:45	12.0	8.0	11.5	5400	28	20	2.6		35	170	500	540	1200
8210	MALLARDIS	03/17/88	11:09	15.0	7.8	9.0	7760	18	20	2.0		18	110	350	590	1100
8246	MALLARDIS	04/14/88	11:16	17.5	7.8	8.7	3590			2.3		35	110	220	220	590
8391	MALLARDIS	05/19/88	8:38	18.4	7.8	8.4	9110	28	35	1.6		8	50	250	550	860
8413	MALLARDIS	06/07/88	9:26	8.3	8.4	7.9	9540	21	40	1.5		8	64	200	430	700
8453	MALLARDIS	07/06/88	10:00	23.4	7.9	7.5	11500	11	20	0.8		8	44	240	720	1000
8575	MALLARDIS	08/02/88	10:30	21.7	7.9	8.0			25	1.9		160	91	310	530	1100
8696	MALLARDIS	09/15/88	9:55	19.9	7.6	8.3	11000	22	20	2.4		14	40	190	480	720
8725	MALLARDIS	10/13/88	10:40	18.2	7.8	8.4	9930	15	35	2.4		7	47	150	330	530
8763	MALLARDIS	11/17/88	11:20	15.0	7.9	9.2	15000	20	15	2.2		7	41	180	670	900
8809	MALLARDIS	12/06/88	11:15	12.9	7.4	10.4	16400	19	15	2.1		4	42	190	600	840
8335	MAZE	05/03/88	7:38	15.7	7.8	8.3	1480	28	25	3.8		390	160	120	41	710
8427	MAZE	06/14/88	7:20								4.1	250	160	120	20	550
8426	MAZE	06/14/88	7:20	23.0	7.8	6.9	1350	52	40	3.6		370	190	100	18	680

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential ---->				
												<---------- ug/L				---------->
8462	MAZE	07/12/88	7:19								4.2	440	280	160	34	910
8461	MAZE	07/12/88	7:19	23.5	7.9	7.1	1530	64	35	4.0		650	240	160	26	1100
8584	MAZE	08/09/88	9:00	22.4	7.8	6.8	1360				4.3	310	180	120	27	640
8583	MAZE	08/09/88	9:00	22.4	7.8	6.8	1360	96	40	4.0		530	160	98	16	800
8687	MAZE	09/06/88	7:20	24.6	7.8	6.1					4.2	270	210	150	42	670
8686	MAZE	09/06/88	7:20	24.6	7.8	6.1	1480	33	40	4.1		390	220	120	41	770
8712	MAZE	10/04/88	7:34	18.5	8.0	8.8			25	4.6		310	230	170	25	740
8713	MAZE	10/04/88	7:34	18.5	8.0	8.8					4.4	260	190	140	30	620
8712	MAZE	10/04/88	7:34	18.5	8.0	8.8	1530	22	25	4.6		310	230	170	25	740
8743	MAZE	11/01/88	8:54	15.8	7.5	8.3					3.6	140	150	120	18	430
8742	MAZE	11/01/88	8:54	15.8	7.5	8.3	1290	21	25	4.4		260	150	110	-1	520
8812	MAZE	12/13/88	8:57	10.4	7.4	9.3	1280	14	20	4.6		310	240	130	16	700
7118	MCCORWIL01	03/25/87	12:00	15.0	7.2	9.2	494	44	15	4.3		460	40	4	-1	500
7312	MCCORWIL01	08/07/87	12:10	22.0	6.9	6.5	186	60				400	11	-1	-1	410
7483	MCCORWIL01	10/20/87	7:00	16.4	7.3	5.5	337	34	5	6.7		1000	40	10	-1	1100
8165	MCCORWIL01	03/08/88	10:28	12.5	7.3		386	10	25	6.9		750	25	2	-1	780
8266	MCCORWIL01	04/18/88	11:23	17.5	6.9	6.1	333	22	60	7.3						
8375	MCCORWIL01	05/09/88	10:02				250	16	60		6.4	670	47	1	-1	720
8351	MCCORWIL01	05/09/88	10:27	22.2	7.1	4.8	250	16	60		6.6	610	41	7	-1	660
8487	MCCORWIL01	07/18/88	10:48	25.5	7.0	4.9	166	32	80		3.3	380	8	-1	-1	390
9016	MCCORWIL01	01/03/89	12:35	7.6	7.6	10.6	311	16	40		8.0	390	20	3	-1	410
7119	MCCORWIL02	03/25/87	12:45	17.0	7.2	9.8	487	23	5	4.2		370	36	3	-1	410
7313	MCCORWIL02	08/07/87	12:45	25.3	7.7	7.1	173	54			2.3	380	9	-1	-1	390
7484	MCCORWIL02	10/20/87	7:20	15.0	7.2	4.9	355	96	0	4.7		82	16	-1	-1	98
8166	MCCORWIL02	03/08/88	10:44	9.5	7.3		458	20	25	6.2		760	30	-1	1	790
8267	MCCORWIL02	04/18/88	11:54	17.5	6.9	6.6	153	29	80	8.1						
8352	MCCORWIL02	05/09/88	10:52	21.7	7.4	6.2	204	31	30		4.7	650	14	-1	-1	660
8488	MCCORWIL02	07/18/88	11:13	25.4	6.9	4.9	167	56	100	3.6		430	8	-1	-1	440
5009	MIDDLER	02/06/85	8:30	6.5	7.3	11.2	391	13	25			780	84	20	-1	880
5025	MIDDLER	03/06/85	9:00	10.0	7.4	10.0	339	12								
5043	MIDDLER	04/05/85	7:30	17.0	7.5	8.9	378	6	5			300	76	16	-1	390
5059	MIDDLER	05/01/85	6:50	19.0	7.6	9.3	303	9	10			410	68	10	-1	490
5075	MIDDLER	06/05/85	6:40	20.0	7.8	9.0	252	17	5			550	67	8	-1	630
5097	MIDDLER	06/07/85	8:05	23.5	7.7	8.9	256	16								
5110	MIDDLER	08/01/85	7:00	22.0	7.4	7.8	331	12	20			660	110	26	1	800
5136	MIDDLER	10/23/85	11:15	18.0	7.5	9.4	396	7	10			380	120	45	2	550
5171	MIDDLER	12/03/85	12:15	11.5	7.4	10.3	464	8	12			340	160	68	5	570
6029	MIDDLER	03/11/86	10:30	14.5	7.3	8.2	343	24	25			530	110	12	-1	650
6044	MIDDLER	04/17/86	7:30	14.0	7.3	8.8	213	12	25			440	60	9	-1	510
6079	MIDDLER	05/13/86	8:30	19.5	7.3	8.1	270	13	30			480	76	11	-1	570
6110	MIDDLER	06/11/86	6:15	22.5	7.3	7.8	272	14	20			380	35	6	-1	420
6129	MIDDLER	07/09/86	6:30	23.5	7.3	7.7	263	14	15			320	52	5	-1	380
6149	MIDDLER	08/13/86	6:30	23.0	7.3	7.3	260	16	10							
6196	MIDDLER	09/11/86	6:30	21.5	7.3	7.5	284	16	20			340	68	13	-1	420
6281	MIDDLER	11/19/86	11:55	14.5	7.4	9.1	230	9	15	2.4		380	41	6	-1	430
6298	MIDDLER	12/10/86	12:50	10.0	7.2	9.6	255	12	10	2.8						

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential ----> ug/L				
7006	MIDDLER	01/13/87	12:15	8.5	7.3	10.0	333	6	20	4.6		310	74	7	-1	390
7048	MIDDLER	02/10/87	11:45	11.5	7.2	9.8	384	9	20	5.3		520	78	280	-1	880
7067	MIDDLER	03/10/87	12:00	13.5	7.1	8.8	436	11	20	5.1		340	68	9	-1	420
7169	MIDDLER	04/16/87	10:00	20.0	7.2	7.8	440	8	10	4.1		540	100	15	-1	660
7204	MIDDLER	05/20/87	9:30	21.5	7.2	6.8	293	10	10	2.4		320	61	12	-1	390
7242	MIDDLER	06/11/87	10:45	23.0	6.9	8.9	404	9	15	2.8		290	82	21	-1	390
7404	MIDDLER	09/24/87	10:00	21.6	7.3	7.1	603	8	15	3.0		210	89	41	4	340
7447	MIDDLER	10/28/87	10:15	20.5	7.3	7.3	565	6	5	2.9		194	151	85	9	440
7545	MIDDLER	11/24/87	11:45	14.5	7.2	8.5	645	5	10	3.5		290	120	66	6	480
7604	MIDDLER	12/16/87	7:45	9.6	7.5	11.1	581	12	25	4.7		460	130	40	3	630
8072	MIDDLER	01/21/88	7:39	7.8	7.2	10.8	445	13	50	5.9		620	130	22	-1	770
8130	MIDDLER	02/23/88	7:15	12.0	7.2	10.8	321	9	20	3.7		260	40	4	-1	300
8221	MIDDLER	03/24/88	7:30	17.9	7.2	9.4	472	4	20	2.9		270	68	25	2	370
8320	MIDDLER	04/28/88	7:35	17.5	7.7	8.7	324	9	25	2.9		390	70	19	-1	480
8397	MIDDLER	05/26/88	9:30	19.5	8.2	8.6	340	25	40	2.7		380	59	15	-1	450
8429	MIDDLER	06/22/88	7:34	23.0	7.0	6.8	396	15	40	3.9		360	-1	28	-1	390
8464	MIDDLER	07/14/88	10:00	22.4	7.4	7.4			35	3.9		500	83	30	2	620
8602	MIDDLER	08/10/88	8:23	22.7	7.9				25		3.1	350	130	41	2	520
8586	MIDDLER	08/16/88	9:40	22.9	7.4	7.5	401	9	25	2.3		270	90	50	4	410
8620	MIDDLER	08/17/88	9:46	23.4	7.6		401	11	25		3.1	200	81	45	2	330
8628	MIDDLER	08/17/88	9:34	23.4	7.7		398	9	20		2.9	270	82	49	2	400
8650	MIDDLER	08/24/88	9:25	22.8	7.8		373	8	20		3.0	760	84	39	3	890
8649	MIDDLER	08/24/88	9:35	22.8	7.8		373	10	20		3.3	220	81	37	3	340
8665	MIDDLER	08/31/88	9:35	23.6	8.5				20		4.7	370	110	51	6	540
8698	MIDDLER	09/22/88	7:32	20.3	7.3	7.6	442	6	20	2.7		320	68	24	8	420
8727	MIDDLER	10/20/88	8:55	19.8	7.3	8.0	501	36	25	4.9		660	66	55	4	790
8749	MIDDLER	11/10/88	9:05	16.7	8.0	8.5	660	5	30	3.6		280	140	110	11	540
8780	MIDDLER	11/30/88	12:10	11.8	7.9	9.9	596	5	25		4.7	370	180	82	6	640
8794	MIDDLER	12/07/88	11:00	10.6	8.2	9.4	529	11	25		5.1	410	110	32	4	560
8823	MIDDLER	12/20/88	10:55	8.5	7.9	10.0	603	9	35		5.5	660	190	64	3	920
8832	MIDDLER	12/20/88	10:20	10.7	7.3	10.7	608	8	35	5.7		590	200	87	5	880
8850	MIDDLER	12/28/88	9:59	7.0	7.7	11.4	564	7	35		5.8	570	140	48	3	760
9064	MIDDLER	01/11/89	10:15	6.2	8.0		469	9	35		5.7	590	130	44	1	770
9084	MIDDLER	01/18/89	10:15	6.9	7.2	10.6	414	8	35		5.7	520	100	26	-1	650
9109	MIDDLER	01/26/89	9:40	7.5		11.2	434	7	30			330	84	16	1	430
9096	MIDDLER	01/31/89	9:45	9.6	7.0	10.9	428	6	35	4.6		320	99	25	2	450
9122	MIDDLER	02/02/89	10:45	8.1	7.6	10.3	449	5	25		4.8	320	94	29	2	450
9186	MIDDLER	02/28/89	9:20	13.1	6.8	10.4	438	6	20	3.6		700	150	58	2	910
9239	MIDDLER	03/28/89	7:49	15.5	7.0	7.7	271	10	35	4.9		570	83	18	-1	670
9336	MIDDLER	04/25/89	7:12	16.7	8.4	8.5	200	8	25	3.3		370	34	3	-1	410
9366	MIDDLER	05/23/89	7:03	19.4	8.3	8.0	259		25	3.1		340	44	6	-1	390
9379	MIDDLER	06/01/89	9:50	20.5	8.0	11.2	255	13	30		4.3	330	40	5	-1	370
9392	MIDDLER	06/08/89	9:15	21.3	7.8	9.5	240	17	35		3.2	290	27	2	-1	320
9405	MIDDLER	06/15/89	7:15	24.3	7.5	7.1	271	16	30		2.9	400	60	13	-1	470
9418	MIDDLER	06/19/89	8:11	22.4	7.5	7.1	255	16	40		2.6	330	55	9	-1	390
9486	MIDDLER	06/21/89	8:45	22.7	7.4	7.3	257	17	35		2.8	211	49	8	0	270

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential---->				
												<------------ ug/L ------------>				
9499	MIDDLER	07/06/89	6:30	23.6	7.6	7.2	248	12	35		3.1	480	53	8	0	540
9512	MIDDLER	07/13/89	9:10	24.2	8.0	8.0	229	9	25		2.8	360	49	8	0	420
9560	MIDDLER	07/18/89	9:15	26.6	7.2	7.8	244	12	25		2.8	310	44	1	0	360
9525	MIDDLER	07/20/89	9:17	24.8	6.5	7.9	248	11	35		3.2	370	55	10	0	440
9588	MIDDLER	07/25/89	9:50	25.7	7.8	8.2	200	10				360	84	11	0	460
9538	MIDDLER	07/27/89	9:05	24.2	7.4	8.1	229	10	20		2.7	320	50	10	0	380
8603	MIDWOODWARD	08/10/88	8:10	22.6	7.8				20		2.8	230	94	40	2	370
8644	MIDWOODWARD	08/10/88	8:10									210	86	33	2	330
8643	MIDWOODWARD	08/17/88	9:34							2.5		230	94	49	2	380
8651	MIDWOODWARD	08/24/88	9:25							2.4		1200	73	41	4	1300
8666	MIDWOODWARD	08/31/88	9:25	23.7	8.4				20		3.5	300	93	50	3	450
8667	MIDWOODWARD	08/31/88	9:25	23.7	8.4					2.9		260	89	46	3	400
8793	MIDWOODWARD	12/07/88	10:45	10.5	8.0	9.2	511	10	30		5.0	410	150	54	3	620
8822	MIDWOODWARD	12/20/88	10:40	8.5	7.8	9.9	611	9	30		5.3	440	170	69	3	680
8849	MIDWOODWARD	12/28/88	9:02	6.5	7.5	11.1	586	10	40		7.2	780	180	32	-1	990
8551	MOKGEORGIANA	07/19/88	9:50	24.0	7.6	7.5	151	7	10		1.5	370	15	-1	-1	380
8610	MOKGEORGIANA	08/10/88	7:56	21.8	7.6		164	8	10		2.2	290	37	9	-1	340
8625	MOKGEORGIANA	08/17/88	7:53	21.8			175	9	15		1.9	300	15	-1	-1	310
8652	MOKGEORGIANA	08/24/88	7:52	21.8	7.9		187	8	10		2.4	1200	16	-1	-1	1200
8668	MOKGEORGIANA	08/31/88	8:00	24.0	6.8				10		3.0	290	-1	15	-1	310
8775	MOKGEORGIANA	11/30/88	9:47	9.9	8.4	8.9	175	29	50		6.4	620	27	2	-1	650
8789	MOKGEORGIANA	12/07/88	9:00	10.2	8.0	10.3	196	9	15		5.4	290	28	3	-1	320
8819	MOKGEORGIANA	12/20/88	9:20	8.5	7.9	11.0	179	8	10		2.0	210	15	1	-1	230
9060	MOKGEORGIANA	01/11/89	8:55	6.4	8.1		200	13	30		3.7	360	19	1	-1	380
9080	MOKGEORGIANA	01/18/89	10:43	7.9	6.9	11.4	201	14	30		3.2	380	18	1	-1	400
9105	MOKGEORGIANA	01/26/89	7:50	7.3	7.4	11.2	261	6	20			200	18	4	-1	220
9118	MOKGEORGIANA	02/02/89	9:50	8.4	7.6	10.4	213	6	20		2.7	250	20	2	-1	270
9375	MOKGEORGIANA	06/01/89	8:10	19.6	7.8	8.7	157	7	5		2.6	210	12	-1	-1	220
9388	MOKGEORGIANA	06/08/89	7:55	20.4	7.9	9.3	152	7	5		2.1	250	12	-1	-1	260
9401	MOKGEORGIANA	06/15/89	6:45	21.5	8.5	8.2	164	9	10		3.0	480	41	5	-1	530
9414	MOKGEORGIANA	06/19/89	6:39	20.6	7.9	8.5	155	6	10		2.0	250	11	-1	-1	260
9495	MOKGEORGIANA	07/06/89	7:15	21.2	7.8	9.2	145	7	10		2.2	360	100	7	0	470
9508	MOKGEORGIANA	07/13/89	6:33	21.5	7.9	8.7	144	10	10		3.0	280	25	12	0	320
9521	MOKGEORGIANA	07/20/89	8:20	22.5	6.6	9.1	127	8	10		1.8	270	9	0	0	280
9596	MOKGEORGIANA	07/25/89	8:00	21.4	7.7	9.1	120	10				350	10	0	0	360
9534	MOKGEORGIANA	07/27/89	8:09	21.3	7.3	9.2	120	20	5		1.7	220	8	0	0	230
7123	MOSSDALE01	03/31/87	7:15	14.0	7.2	6.0	1650	6	25	12.0		800	250	59	-1	1100
7317	MOSSDALE01	08/14/87	9:20	18.9	6.9	2.9	842	72			7.2	860	110	16	-1	990
7488	MOSSDALE01	10/15/87	12:10	17.4	7.5	4.7	630	4	0	2.5		120	76	29	5	230
8355	MOSSDALE01	05/09/88	8:32	16.4	7.1	2.8	680	23	30		3.4	290	120	46	-1	460
8492	MOSSDALE01	07/18/88	7:02	24.0	7.6	8.1	1000	260	100		6.8	420	150	44	2	620
7124	MOSSDALE02	03/31/87	7:30	15.0	7.6	2.4	722	50	5	3.3		220	94	29	-1	340
7318	MOSSDALE02	08/14/87	9:05	20.0	7.3	3.6	690	22			3.7	520	120	27	-1	670
8036	MOSSDALE02	01/12/88	9:30	10.7	7.3	5.0	667	88	15	2.5		210	80	24	3	320
8173	MOSSDALE02	03/08/88	9:30	14.7	7.5	5.0	699	9	15	3.3		390	150	40	7	590
8271	MOSSDALE02	04/18/88	9:29	14.9	7.3	4.2	1770	13	50	10.0						

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<----- THMFormation Potential ug/L				----->
8356	MOSSDALE02	05/09/88	8:46	18.3	8.5	9.0	923	4	15		3.4	350	150	130	17	650
8493	MOSSDALE02	07/18/88	7:18	24.0	7.6	6.7	942	46	70	5.4		400	140	77	5	620
7125	MOSSDALE03	03/31/87	8:15	13.5	7.0	4.6	513	22	5	2.4		190	78	16	-1	280
7319	MOSSDALE03	08/14/87	8:45	16.5	6.9	3.5	980	52			8.4	1100	160	22	-1	1300
7126	MOSSDALE04	03/31/87	8:35	16.0	7.5	3.0	519	4	0	1.5		150	68	19	-1	240
7158	MOSSDALE04	03/31/87	8:35	16.0	7.5	3.0	7126			1.6		170	87	19	-1	280
7320	MOSSDALE04	08/14/87	8:10	17.8	7.3	4.3	1970	13			5.9	690	300	78	16	1100
7491	MOSSDALE04	10/15/87	11:30	15.4	7.9	4.1	1330	24	50	8.0		590	210	72	9	880
8038	MOSSDALE04	01/12/88	10:00	6.4	7.6	6.3	689	80	80	5.9		620	97	29	-1	750
8175	MOSSDALE04	03/08/88	10:07	13.0	7.5	4.7	1080	46	60	7.6		680	170	56	4	910
8273	MOSSDALE04	04/18/88	10:00	15.7	8.3	11.5	1540	16	80	9.4						
8358	MOSSDALE04	05/09/88	9:15	17.6	7.5	5.0	2070	51	40		6.0	490	270	170	39	970
8495	MOSSDALE04	07/18/88	8:00	25.0	7.7	6.9	1120	25	90		9.1	840	240	73	2	1200
7127	MOSSDALE05	03/31/87	9:00	13.5	7.0	5.6	1370	15	20	16.0		930	130	11	-1	1100
7321	MOSSDALE05	08/14/87	7:20	17.9	7.2	3.4	922	7			7.1	950	130	24	-1	1100
7128	MOSSDALE06	03/31/87	9:20	16.0	8.0	1.8	2410	34	30	14.0		640	330	170	23	1200
7322	MOSSDALE06	08/05/87	10:45	23.5	7.1	1.0	969	12			18.0	2300	210	14	-1	2500
7129	MOSSDALE08	03/31/87	10:00	13.0	7.3	0.6	1100	28	75	37.0		1500	290	30	-1	1800
7324	MOSSDALE08	08/05/87	10:05	24.6	7.3	6.1	886	32			4.4	500	200	110	7	820
7521	MOSSDALE08	10/15/87	10:40	15.2	7.0	2.8	897	230	40	10.0		730	150	39	-1	920
7495	MOSSDALE08	10/15/87	8:40	14.9	7.1	2.5	914	140	40	8.1		520	140	37	-1	700
8275	MOSSDALE08	04/18/88	10:48	15.4	7.5	11.5	896	7	80	10.0						
7131	MOSSDALE09	03/31/87	11:45	15.5	8.1	7.5	2470	2	25	10.0		330	320	240	47	940
7325	MOSSDALE09	08/05/87	9:50	22.1	7.4	7.1	917	7			9.1	1200	190	46	2	1400
7496	MOSSDALE09	10/15/87	8:50	14.5	7.3	6.2	971	38	15	7.2		310	150	93	6	560
7522	MOSSDALE09	10/15/87	10:10	14.1	7.1	5.8	958	38	10	8.8		450	150	81	3	680
8276	MOSSDALE09	04/18/88	10:37	15.6	7.3	3.9	1010	8	25	6.0						
7132	MOSSDALE10	03/31/87	12:10	19.5	7.3	10.2	773	9	25	13.0		470	74	7	-1	550
7326	MOSSDALE10	08/14/87	10:05	18.3	7.3	2.0	1370	3			5.6	640	180	67	4	890
7497	MOSSDALE10	10/15/87	12:35	14.8	7.3	1.8	1290	4	20	5.7		300	140	42	1	480
8043	MOSSDALE10	01/12/88	8:50	9.3	7.1	2.1	1520	5	50	13.0		1300	190	29	1	1500
8171	MOSSDALE10	03/08/88	8:45	11.9	6.0	1.6	1360	7	80	12.0		1000	240	45	1	1300
8277	MOSSDALE10	04/18/88	8:49	14.0	7.3	1.6	1340	4	80	17.0						
8362	MOSSDALE10	05/09/88	7:54	16.8	7.2	2.5	900	2	60		10.0	980	200	31	-1	1200
8499	MOSSDALE10	07/18/88	5:27	22.5	7.5	2.0	992	9	50		6.7	490	150	55	2	700
7327	MOSSDALE11	08/14/87	9:45	18.2	7.5	9.2	268	34			5.0	730	36	3	-1	770
8044	MOSSDALE11	01/12/88	9:10	6.8	7.3	5.5	605	250	20	3.4		460	83	20	-1	560
8172	MOSSDALE11	03/08/88	9:00	11.4	7.3	2.0	653	170	40	4.5		110	120	30	-1	260
8278	MOSSDALE11	04/18/88	9:09	15.5	7.3	4.9	564	15	80	12.0						
8363	MOSSDALE11	05/09/88	8:14	17.8	8.0	6.1	589	19	120		17.0	1600	100	5	-1	1700
8500	MOSSDALE11	07/18/88	6:00	23.0	7.4	3.2	1080	14	70		7.1	440	190	77	7	710
7120	MOSSTRPP01	03/30/87	12:00	21.5	6.8	8.8	1130	7	0	4.4		230	140	38	12	420
7121	MOSSTRPP02	03/30/87	13:15	19.0	7.2	4.8	1040	2	10	5.8		290	190	77	27	580
7315	MOSSTRPP02	08/14/87	11:05	22.6	7.5	6.2	838	21			5.9	1200	150	75	4	1400
7486	MOSSTRPP02	10/19/87	11:30	20.3	7.5	7.5	681	19	5	5.3		620	94	43	-1	760
8033	MOSSTRPP02	01/12/88	8:00	8.1	7.5	10.6	670	18	40	6.0		490	110	36	1	640

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential ---->				
												<----------		ug/L		---------->
8168	MOSSTRPP02	03/08/88	12:40	16.9	7.4	13.1	803	16	50	8.8		950	180	46	2	1200
8268	MOSSTRPP02	04/18/88	11:50	19.0	8.1	9.0	917	15	40	11.0						
8353	MOSSTRPP02	05/09/88	9:17	17.7	8.3	10.5	918	20	60		9.6	680	210	89	10	990
9019	MOSSTRPP02	01/03/89	10:24	6.4	8.0	12.5	806	7	35		7.9	610	180	76	6	870
7122	MOSSTRPP03	03/30/87	12:45	19.0	7.8	8.9	465	10	15	6.5		510	92	11	-1	610
7316	MOSSTRPP03	08/14/87	10:45	22.8	7.5	7.0	601	26		9.4		630	70	27	-1	730
7487	MOSSTRPP03	10/19/87	11:00	20.5	7.4	7.0	584	23	5	3.1		460	86	38	2	590
8034	MOSSTRPP03	01/12/88	8:20	8.2	7.3	8.2	779	20	60	13.0		830	78	16	1	930
8169	MOSSTRPP03	03/08/88	13:00	17.3	7.3	17.3	951	14	80	10.0		1100	220	55	2	1400
8269	MOSSTRPP03	04/18/88	11:33	6.6	7.7	8.9	740	21	40	7.3						
8354	MOSSTRPP03	05/09/88	8:57	16.9	8.0	8.5	512	23	80		12.0	870	190	34	-1	1100
7134	NETHERLAND01	03/25/87	15:45	17.5	8.0	9.9	1550	24		5.7		270	200	76	18	560
7328	NETHERLAND01	08/13/87	7:30	17.6	7.5	8.1	289	132			5.5	650	32	3	-1	690
7499	NETHERLAND01	10/20/87	8:30	16.5	7.4	8.6	270	106	0	3.4		180	32	3	-1	220
8045	NETHERLAND01	01/12/88	8:00	5.9	7.5	10.2	825	51	60	6.4		750	120	30	-1	900
8180	NETHERLAND01	03/08/88	7:38	9.1	8.1		1250	23	30	5.2		520	150	62	5	740
8301	NETHERLAND01	04/18/88	7:09	14.0	7.3	8.3	270	102	20	3.3						
8364	NETHERLAND01	05/09/88	7:10	18.4	7.8	8.0	396	80	40		3.5	430	54	9	-1	490
8501	NETHERLAND01	07/18/88	7:16	21.8	7.4	7.6	222	190	35		3.1	470	14	-1	-1	480
7135	NETHERLAND02	03/25/87	16:15	19.5	8.0	12.0	1030	125	15	6.5		750	170	34	-1	950
7329	NETHERLAND02	08/13/87	7:00	18.6	7.3	5.0	243	100			4.1	860	17	-1	-1	880
7500	NETHERLAND02	10/20/87	8:00	15.7	7.3	5.6	303	125	5	4.4		320	38	-1	-1	360
8046	NETHERLAND02	01/12/88	7:30	5.4	7.5	10.1	819	54	60	6.4		740	130	28	-1	900
8181	NETHERLAND02	03/08/88	7:24	7.3	8.1		1480	44	35	6.3		630	260	110	8	1000
8279	NETHERLAND02	04/18/88	6:37	14.0	7.1	7.0	261	108	60	3.5						
8365	NETHERLAND02	05/09/88	6:46	17.6	7.7	6.8	376	92	40		5.2	380	62	9	-1	450
8502	NETHERLAND02	07/18/88	6:48	22.4	7.2	4.8	206	92	35		3.2	430	10	-1	-1	440
7136	PESCADERO01	04/01/87	10:00	15.5	7.3	7.5	2040	9	0	4.2		140	180	90	23	430
7330	PESCADERO01	08/05/87	7:30	22.2	7.3	3.1	1480	32			7.3	930	360	160	8	1500
7501	PESCADERO01	10/15/87	6:30	16.2	7.3	6.3	2570	28	5	6.3		99	194	159	78	530
8047	PESCADERO01	01/12/88	6:40	8.9	7.5	7.5	2140	52	20	6.8		380	340	180	29	930
8280	PESCADERO01	04/18/88	7:06	16.3	7.3	6.5	1360	23	25	4.7						
8366	PESCADERO01	05/09/88	11:46	18.5	8.2	10.0	1250	20	35		4.5	240	210	110	20	580
8503	PESCADERO01	07/18/88	13:28	32.5	7.9	7.6	1280	51	50		5.6	340	180	110	18	650
7137	PESCADERO02	04/01/87	8:30	16.0	7.4	8.6	1700	16	5	3.8		160	180	100	29	470
7331	PESCADERO02	08/05/87	8:00	22.4	7.3	5.4	1750	26			9.0	820	450	210	15	1500
7502	PESCADERO02	10/15/87	7:00	15.3	7.3	4.0	2710	95	5	8.3		110	178	164	97	550
8048	PESCADERO02	01/12/88	7:00	7.4	7.5	7.5	2180	52	60	7.2		350	260	130	25	770
8504	PESCADERO02	07/18/88	13:56	34.5	7.7	9.0	1560	44	120		8.7	560	260	130	21	970
7138	PESCADERO03	04/01/87	9:30	16.5	7.6	4.8	2810	19	15	4.9		110	260	190	96	660
7332	PESCADERO03	08/05/87	8:30	22.2	7.3	5.9	1770	57			5.9	460	370	230	24	1100
7503	PESCADERO03	10/15/87	7:30	15.7	7.1	5.4	3160	80	5	7.5		78	190	210	150	630
8049	PESCADERO03	01/12/88	7:15	6.8	7.5	8.7	2560	33	40	9.2		330	270	140	28	770
8282	PESCADERO03	04/18/88	7:26	14.8	7.5	7.2	1200	42	80	12.0						
8367	PESCADERO03	05/09/88	12:03	19.6	8.4	12.0	1370	24	40		4.5	430	220	150	41	840
8505	PESCADERO03	07/18/88	14:14	32.5	8.1	10.1	1850	27	70		5.9	290	250	180	44	760

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential----> ug/L				
8283	PESCADER004	04/18/88	8:00	14.7	7.1	4.1	1400	34	80	16.0						
8506	PESCADER004	07/18/88	14:46	30.5	8.1	7.8	1890	10	60		6.7	360	250	140	42	790
7140	PIERSONPP01	03/25/87	13:45	19.5	7.2	8.8	638	21	50	18.0		780	160	17	-1	960
7335	PIERSONPP01	08/06/87	7:30	22.5	7.1	5.8	248	26			3.1	580	38	20	2	640
7506	PIERSONPP01	10/16/87	6:30	15.2	7.2	6.0	337	30	25	8.0		630	45	2	-1	680
8052	PIERSONPP01	01/12/88	7:00	7.4	6.7	8.2	826	30	80	24.0		2500	110	8	-1	2600
8187	PIERSONPP01	03/08/88	6:58	8.2	7.4		543	60	60	12.0		2400	180	5	-1	2600
8284	PIERSONPP01	04/18/88	6:00	14.5	7.1	5.4	635	19	100	14.0						
8369	PIERSONPP01	05/09/88	6:07	16.8	7.4	6.0	463	23	80		10.0	1600	72	8	-1	1700
8507	PIERSONPP01	07/18/88	6:15	22.1	6.9	4.5	268	40	60		5.5	700	44	2	-1	750
9035	PIERSONPP01	01/03/89	7:33	8.0		9.2	476	19	70		10.0	880	51	7	-1	940
8645	POTNODE252	08/10/88	8:51									230	29	3	-1	260
8613	POTNODE252	08/10/88	8:51	22.0	7.9		193	8	15		2.4	230	31	2	-1	260
8642	POTNODE252	08/17/88	8:57							2.0		270	36	6	-1	310
8629	POTNODE252	08/17/88	8:57	22.4	7.4		222	7	15		2.2	240	39	6	-1	280
8656	POTNODE252	08/24/88	8:40							2.0		250	33	5	-1	290
8655	POTNODE252	08/24/88	8:40	21.8	7.8		207	7	10		2.5	310	34	3	-1	350
8671	POTNODE252	08/31/88	8:45	23.2	8.4				10		3.0	200	68	29	3	300
8672	POTNODE252	08/31/88	8:45	23.2	8.4					2.1		160	60	27	3	250
8778	POTNODE252	11/30/88	12:10	10.5	8.0	9.1	252	18	40		4.9	560	62	5	-1	630
8792	POTNODE252	12/07/88	9:30	10.3	8.4	9.5	282	13	35		5.1	480	58	17	1	560
8820	POTNODE252	12/20/88	9:35	8.6	7.9	10.6	288	7	20		4.1	400	53	13	1	470
8847	POTNODE252	12/28/88	10:00	6.9	7.5	11.5	298	8	25		4.1	430	69	13	-1	510
7142	PROSPECTPP01	03/25/87	15:00	19.5	7.8	8.0	187	12	5	1.9		950	140	7	-1	1100
7336	PROSPECTPP01	08/13/87	8:45	19.4	6.9	4.8	200	19			3.4	640	12	-1	-1	650
7507	PROSPECTPP01	10/20/87	9:00	16.0	7.4	4.8	821	52	50	14.0		1100	42	-1	-1	1100
8053	PROSPECTPP01	01/12/88	8:20	7.1	7.4	8.5	1390	20	100	24.0		1900	74	3	-1	2000
8188	PROSPECTPP01	03/08/88	7:59	9.1	7.9		1080	32	100	16.0		1900	67	3	-1	2000
8285	PROSPECTPP01	04/18/88	7:38	14.0	7.3	5.3	539	57	80	10.0						
8370	PROSPECTPP01	05/09/88	7:43	16.9	7.6	7.0	222	72	60		4.2	620	21	-1	-1	640
8508	PROSPECTPP01	07/18/88	7:47	22.0	7.5	5.3	183	52	50		3.0	370	7	-1	-1	380
7141	PROSPECTPP02	03/25/87	15:30	14.5	7.2	4.2	1210	21	60	18.0		440	25	-1	-1	470
7145	RINDGEPP01	03/26/87	10:45	14.5	7.1	5.1	1550	14	50	16.0		820	300	73	12	1200
7338	RINDGEPP01	08/07/87	8:30	20.4	6.6	3.9	611	7			21.0	2700	130	5	2	2800
7509	RINDGEPP01	10/19/87	9:25	17.0	6.7	2.1	933	18	40	14.0		800	240	62	3	1100
7582	RINDGEPP01	12/10/87	13:56	15.0	6.8	6.3	992	5	100	23.0		1680	242	30	-1	2000
8054	RINDGEPP01	01/12/88	11:26	9.4	6.7	5.7	890	8	160	24.0		2800	230	25	-1	3100
8190	RINDGEPP01	03/08/88	12:21	14.4	7.1		1220	18	200	19.0		1200	370	70	4	1600
8287	RINDGEPP01	04/18/88	9:30	16.5	6.7	0.6	935	15	120	17.0						
8371	RINDGEPP01	05/09/88	9:39	20.7	7.5	5.8	910	13	160		18.0	2100	360	63	-1	2500
8509	RINDGEPP01	07/18/88	10:06	23.0	6.7	2.6	748	7	140	19.0		1700	180	17	-1	1900
7144	RINDGEPP02	03/26/87	10:00	14.5	7.0	6.7	1180	14	80	21.0		1500	310	65	-1	1900
7339	RINDGEPP02	08/07/87	9:10	22.2	6.3	3.3	363	9			12.0	1900	84	3	-1	2000
7510	RINDGEPP02	10/19/87	9:55	17.0	7.1	3.8	595	19	60	13.0		930	140	20	-1	1100
7583	RINDGEPP02	12/10/87	13:18	13.5	6.2	3.2	739	4	160	31.0		1800	143	11	-1	2000
8055	RINDGEPP02	01/12/88	11:00	9.2	6.3	4.8	588	6	175	27.0		2000	160	8	-1	2200

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3 (<---- THMFormation Potential ----> ug/L)	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
8191	RINDGEPP02	03/08/88	11:53	14.3	7.1		1100	24	120	15.0		1200	380	100	8	1700
8288	RINDGEPP02	04/18/88	10:04	16.5	7.3	8.1	236	15	25	3.4						
8372	RINDGEPP02	05/09/88	10:10	22.5	7.1	1.2	728	10	160		23.0	1600	380	65	-1	2000
8510	RINDGEPP02	07/18/88	9:23	22.0	6.7	3.9	870	16	240		27.0	2000	310	24	-1	2300
7143	RIOBLANCO01	03/26/87	13:15	20.0	8.1	11.6	1160	15	10	6.0		280	230	110	50	670
7340	RIOBLANCO01	08/07/87	10:15	21.1	7.3	8.6	1290	13			3.5	240	190	160	28	620
7511	RIOBLANCO01	10/19/87	8:40	16.5	7.5	8.7	1550	27	10	6.0		170	260	200	81	710
7584	RIOBLANCO01	12/10/87	12:43	15.5	7.4	7.6	1140	8	20	5.5		282	208	104	16	610
8056	RIOBLANCO01	01/12/88	10:30	9.6	7.3	9.2	2500	17	25	5.1		170	260	190	99	720
8192	RIOBLANCO01	03/08/88	11:27	14.2	7.5		731	8	35	5.6		690	220	73	3	990
8289	RIOBLANCO01	04/18/88	8:45	14.5	7.5	7.6	1360	13	40	6.3						
8373	RIOBLANCO01	05/09/88	9:07	20.2	7.6	7.5	647	6	40		5.7	530	160	50	6	750
8511	RIOBLANCO01	07/18/88	8:42	21.5	7.5	3.4	739	16	40		5.4	450	160	56	2	670
7146	RIOBLANCO02	03/26/87	13:45	17.0	7.6	4.0	1820	22	15	5.0		260	370	150	49	830
7341	RIOBLANCO02	08/07/87	9:55	21.2	7.1	4.1	450	14				620	59	8	-1	690
7512	RIOBLANCO02	10/19/87	8:25	14.5	7.3	6.9	979	20	10	9.7		380	220	93	15	710
7585	RIOBLANCO02	12/10/87	12:18	16.5	7.4	7.6	1160	13	25	5.8		246	156	81	19	500
8057	RIOBLANCO02	01/12/88	10:15	9.9	7.3	6.0	880	8	15	4.7		460	190	66	7	720
8193	RIOBLANCO02	03/08/88	11:15	14.2	7.5		460	14	40	4.9		900	140	19	-1	1100
8290	RIOBLANCO02	04/18/88	8:39	15.0	7.3	3.9	457	16	40	5.7						
8374	RIOBLANCO02	05/09/88	8:52	19.8	7.6	6.0	377	12	80		6.9	800	64	8	-1	870
8512	RIOBLANCO02	07/18/88	8:23	21.0	7.5	4.0	784	7	40		5.8	520	180	72	3	780
5004	ROCKSL	01/30/85	10:15	8.0	7.2	10.8	284	3								
5023	ROCKSL	02/27/85	11:45	14.0	7.5	10.3	258	6	25			350	45	5	-1	400
5039	ROCKSL	03/27/85	11:15	12.0	7.4	10.1	269	6								
5052	ROCKSL	04/24/85	11:23	18.0	7.8	10.1	232	7	2			430	42	5	-1	480
5073	ROCKSL	05/22/85	10:20	21.5	8.2	9.2	225	17	15			520	56	11	-1	590
5099	ROCKSL	06/07/85	9:30	23.0	7.9	9.1	252	16								
5089	ROCKSL	06/26/85	10:00	23.0	7.6	8.0	360	19	10			600	110	60	3	770
5104	ROCKSL	07/10/85	9:55	25.0	7.3	7.6	453	8								
5123	ROCKSL	08/28/85	10:45	23.5	7.6	8.1	630	8	10			340	160	100	19	620
5134	ROCKSL	09/25/85	10:32	22.5	7.6	8.1	776	8								
5149	ROCKSL	10/23/85	10:15	17.5	7.8	10.0	738	7	5			210	210	140	36	600
5176	ROCKSL	11/15/85	11:40	12.5	7.5	10.4	988	4								
5170	ROCKSL	12/03/85	11:25	11.5	7.4	10.5	965	6	10			140	200	210	24	570
6011	ROCKSL	01/23/86	11:45	11.0	7.3	9.6	476	6								
6016	ROCKSL	02/13/86	10:45	11.5	7.4	10.2	319	13								
6027	ROCKSL	03/04/86	11:40	17.5	7.3	6.2	342	16	35			670	67	6	-1	740
6042	ROCKSL	04/09/86	12:15	17.0	7.3	8.5	262	11	20			520	81	11	-1	610
6077	ROCKSL	05/07/86	9:45	17.0	7.2	7.4	227	13	20			510	48	5	-1	560
6108	ROCKSL	06/04/86	10:40	22.5	7.3	7.6	225	21				200	23	2	-1	230
6126	ROCKSL	07/02/86	10:00	25.5	7.3	6.3	225	15	20			390	49	4	-1	440
6145	ROCKSL	08/14/86	11:00	23.5	7.5	8.1	219	22	20							
6175	ROCKSL	09/24/86	10:25	20.0	7.5	8.1	285	17	5			300	62	18	-1	380
6280	ROCKSL	11/12/86	11:15	14.5	7.3	9.4	180	15	5	1.8		240	14	2	-1	260
6311	ROCKSL	12/17/86	7:50	10.0	7.3	9.5	272	9	5	1.1		290	59	11	-1	360

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	<---- THMFormation Potential----> CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<------------ ug/L				---------->
7020	ROCKSL	01/22/87	7:40	6.5	7.3	11.8	268	18	10	3.0		480	58	7	-1	550
7060	ROCKSL	02/24/87	7:45	11.0	7.3	10.5	355	12	20	4.0		670	83	22	-1	780
7110	ROCKSL	03/24/87	7:45	13.0	7.3	10.2	302	12	20	4.3		480	58	5	-1	540
7187	ROCKSL	04/30/87	6:30	19.5	8.3	9.8	314	13	10	2.6		260	54	8	-1	320
7222	ROCKSL	05/28/87	9:30	20.5	7.3	7.3	468	11	10	2.3		320	140	72	-1	530
7284	ROCKSL	06/23/87	9:45	23.5	7.3	7.3	488	15	5							
7402	ROCKSL	09/09/87	10:15	22.6	7.4	9.1	923	11	5	2.6		190	140	120	44	490
7445	ROCKSL	10/22/87	9:30	19.0	7.4	8.2	871	5	0	2.8		110	100	120	44	370
7543	ROCKSL	11/05/87	11:15	17.5	7.3	8.9	617	4	5	2.4		390	91	84	34	600
7570	ROCKSL	12/08/87	10:45	11.3	7.3	10.1	1140	5	15	3.1		250	190	160	53	650
8014	ROCKSL	01/07/88	11:20	9.9	7.4	13.2	755	10	25	4.2		290	140	92	21	540
8094	ROCKSL	02/10/88	10:00	12.1	7.3	10.0	385	12	30	4.0		640	81	20	-1	740
8149	ROCKSL	03/03/88	11:05	13.6	7.8	10.7	711	5	20	3.2		280	120	110	21	530
8238	ROCKSL	04/05/88	9:00	15.5	7.5	9.8	679	6	15	4.2		180	120	91	16	410
8333	ROCKSL	05/03/88	10:05	18.6	7.8	9.2	315	12	30	2.6		410	76	28	4	520
8425	ROCKSL	06/14/88	10:24	23.2	7.5	6.7	434	21	35	2.2		280	100	48	2	430
8460	ROCKSL	07/12/88	10:03	25.0	7.3	7.1	787	10	25	2.2		350	110	66	8	530
8582	ROCKSL	08/09/88	12:20	24.1	7.8	7.9	852	12	20	2.1		130	100	100	41	370
8685	ROCKSL	09/06/88	9:50	25.0	7.5	7.3	950	9	20	2.2		140	140	110	50	440
8717	ROCKSL	10/04/88	10:15	19.9	7.4	8.4	925	7	15	2.5		140	130	110	32	410
8747	ROCKSL	11/01/88	11:10	17.7	7.6	9.0	1080	6	15	2.6		120	150	190	61	520
8816	ROCKSL	12/13/88	11:24	12.0	7.1	10.7	950	9	25	3.8		410	270	230	37	950
8695	SACRRIOVISTA	09/15/88	8:51	20.9	7.9	7.7	235	14	15	2.6		270	25	5	-1	300
8724	SACRRIOVISTA	10/13/88	8:00	18.0	7.7	8.1	183	12	20	1.8		170	18	1	-1	190
8762	SACRRIOVISTA	11/17/88	10:10	14.3	7.3	9.1	242	8	10	1.9		210	37	12	-1	260
8808	SACRRIOVISTA	12/06/88	8:30	10.3	7.1	10.3	204	18	30	3.6		420	17	0	-1	440
9076	SACRRIOVISTA	01/17/89	8:50	8.5	7.2	11.6	237	10	25	2.9		300	27	2	-1	330
9156	SACRRIOVISTA	02/14/89	8:05	8.3	6.9	11.5	207	7	15	1.9		180	11	2	-5	190
9231	SACRRIOVISTA	03/14/89	10:03	11.5	7.5	8.9	122	58	100	4.7		540	12	3	-1	550
9260	SACRRIOVISTA	04/11/89	6:45	16.8	7.4	8.2	183	10	15	2.5		280	14	-1	-1	290
9356	SACRRIOVISTA	05/09/89	7:30	19.3	7.6	8.5	186	11	15	2.2		190	19	1	-1	210
9483	SACRRIOVISTA	06/13/89	7:25	19.3	7.1	8.5	173	13	20	3.0		330	18	2	-1	350
9557	SACRRIOVISTA	07/11/89	7:40	21.8	6.9	8.8	154	10	15		1.8	250	15	0	0	270
9595	SACRRIOVISTA	07/25/89	7:36	21.0	7.0	7.5	120	9				350	14	0	0	360
7147	SHIMATR	03/26/87	14:15	20.0	7.8	8.8	754	6	10	4.8		360	110	21	-1	490
7342	SHIMATR	08/07/87	11:05	21.8	7.1	4.4	631	7			5.9	860	89	9	-1	960
7513	SHIMATR	10/19/87	10:30	17.5	7.3	4.8	559	13	15	7.9		770	91	10	-1	870
7588	SHIMATR	12/10/87	9:13	14.0	7.3	5.7	585	13	40	6.1		513	299	11	-1	820
8064	SHIMATR	01/12/88	8:30	9.0	7.3	7.1	763	20	20	4.9		380	83	23	-1	490
8196	SHIMATR	03/08/88	9:05	13.5	7.5	7.7	651	32	30	5.1		530	85	16	1	630
8293	SHIMATR	04/18/88	6:33	5.1	7.2	4.2	640	72	40	6.3						
8377	SHIMATR	05/09/88	6:24	19.2	7.6	4.2	696	11	40		6.5	850	140	27	-1	1000
8514	SHIMATR	07/18/88	5:57	23.7	7.3	5.2	577	20	120		13.0	1100	120	6	-1	1200
7343	TERMPP01	08/06/87	13:15	24.7	7.0	6.1	472	7			6.5	1300	130	15	-1	1400
7514	TERMPP01	10/16/87	11:20	17.8	7.1	7.8	1310	6	35	9.3		320	110	42	16	490
7589	TERMPP01	12/10/87	7:10	11.5	6.3	4.5	646	5	140	33.0		2020	97	539	-1	2700

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

APPENDIX B

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential---->				
												<------------ ug/L ------------>				
8065	TERMPP01	01/12/88	7:20	13.8	7.2	6.5	930	6	120	25.0		2100	250	51	-1	2400
8197	TERMPP01	03/08/88	9:45	10.7	7.1		889	10	140	18.0		2200	230	38	2	2500
8294	TERMPP01	04/18/88	10:05	17.0	7.3	7.3	961	14	60	8.5						
8291	TERMPP01	04/18/88	10:45	15.0	7.1	7.6	962	14	80	8.5						
8378	TERMPP01	05/09/88	9:34	21.4	7.4	5.0	910	11	100		11.0	1100	390	120	7	1600
8515	TERMPP01	07/18/88	10:00	23.5	6.9	4.6	425	11	120		10.0	1200	140	14	1	1400
7153	TERMPP02	03/26/87	7:45	12.5	7.2	4.4	850	8	40	8.9		640	220	48	7	920
7344	TERMPP02	08/06/87	13:30	23.6	7.2	6.5	587	6			4.8	770	170	45	-1	990
7515	TERMPP02	10/16/87	10:50	16.7	7.1	5.2	571	15	20	6.3		710	190	46	2	950
7590	TERMPP02	12/10/87	7:45	11.0	6.9	7.2	546	80	100	16.0		1170	114	15	-1	1300
8066	TERMPP02	01/12/88	7:45	9.9	7.0	7.0	786	8	125	25.0		1600	250	31	-1	1900
8198	TERMPP02	03/08/88	9:28	9.8	7.3		716	12	80	9.9		1100	220	55	4	1400
8295	TERMPP02	04/18/88	9:36	16.7	6.9	7.0	798	12	80	12.0						
8379	TERMPP02	05/09/88	9:07	18.8	7.5	7.1	719	15	100		8.7	1300	280	75	-1	1700
8516	TERMPP02	07/18/88	9:30	23.0	7.0	5.0	542	11	60		5.1	580	170	48	1	800
8604	UJONESSIPH01	08/10/88	12:01	22.6	6.7	2.2	417	4	20		3.1	310	110	35	1	460
8636	UJONESSIPH01	08/17/88	7:22	20.8	6.7	1.5	407	2	20		3.2	220	65	26	-1	310
8663	UJONESSIPH02	08/24/88	7:47	22.0	7.1	3.0	378	21	60		3.5	400	97	21	-1	520
7345	UPEGBERTPP01	08/13/87	10:40	18.6	7.5	7.3	382	124			6.2	1400	37	2	-1	1400
7516	UPEGBERTPP01	10/20/87	10:45	15.7	7.4	1.0	511	96	30	18.0		930	26	1	1	960
8067	UPEGBERTPP01	01/12/88	9:45	6.3	7.3	10.1	728	42	50	24.0						
8199	UPEGBERTPP01	03/08/88	9:14	10.5	7.9		1160	22	60	11.0		1500	100	8	1	1600
8296	UPEGBERTPP01	04/18/88	9:26	15.8	7.8	7.3	704	36	100	10.0						
8380	UPEGBERTPP01	05/09/88	9:15	19.9	8.5	10.5	771	21	60		9.3	2000	51	11	-1	2100
8517	UPEGBERTPP01	07/18/88	9:20	23.1	7.5	6.5	344	88	40		5.1	720	33	1	-1	750
7346	UPEGBERTPP02	08/13/87	11:10	18.3	7.3	7.0	375	100			6.6	980	43	4	-1	1000
7517	UPEGBERTPP02	10/20/87	11:00	17.0	7.3	4.9	526	105	60	13.0		648	77	2	-1	730
8068	UPEGBERTPP02	01/12/88	10:15	6.3	7.5	10.1	506	68	140	9.7						
8297	UPEGBERTPP02	04/18/88	9:48	15.5	7.2	7.3	637	68	80	8.3						
8381	UPEGBERTPP02	05/09/88	9:35	18.4	7.9	8.8	647	116	40		5.3	800	48	10	-1	860
8518	UPEGBERTPP02	07/18/88	9:55	24.3	7.4	6.5	277	104	25		3.8	500	240	1	-1	740
7347	UPEGBERTPP03	08/13/87	11:30	20.0	7.3	6.6	538	72			9.4	1000	47	2	-1	1000
7518	UPEGBERTPP03	10/20/87	11:25	16.7	7.5	5.9	781	68	25	22.0		1500	53	10	-1	1600
8201	UPEGBERTPP03	03/08/88	9:37	7.6	7.5		716	30	60	7.6		1100	60	4	-1	1200
8298	UPEGBERTPP03	04/18/88	10:05	14.0	7.5	5.7	1780	280	60	13.0						
8382	UPEGBERTPP03	05/09/88	9:53	20.1	8.1	7.6	2240	72	40		16.0	2300	120	23	-1	2400
8519	UPEGBERTPP03	07/18/88	10:15	25.9	7.3	4.2	331	128	50		5.6	670	36	1	-1	710
7148	UPJONESPP01	03/30/87	10:45	17.5	6.8	5.0	1010	35	40	11.0		960	190	27	-1	1200
7149	UPJONESPP02	03/30/87	11:15	17.0	7.0	5.4	507	33	200	27.0		2600	160	10	-1	2800
7349	UPJONESPP02	08/12/87	8:50	20.4	6.9	3.8	626	29			7.7	1200	160	21	-1	1400
7520	UPJONESPP02	10/19/87	12:15	17.5	6.7	4.8	739	30	25	11.0		800	120	24	-1	940
7592	UPJONESPP02	12/10/87	8:10	13.5	6.5	4.4	895	24	100	13.0		1350	271	17	5	1600
8071	UPJONESPP02	01/12/88	7:30	8.4	6.6	7.0	756	66	80	16.0		1500	220	19	-1	1700
8203	UPJONESPP02	03/08/88	7:45	14.1	6.9	6.1	789	48	160			1300	180	25	-1	1500
8300	UPJONESPP02	04/18/88	12:40	18.4	6.9	2.9	960	20	120	14.0						
8384	UPJONESPP02	05/09/88	10:06	20.2	7.3	4.0	1120	46	120		10.0	1200	180	45	-1	1400

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<---- THMFormation Potential ----> ug/L				
8520	UPJONESPP02	07/18/88	10:30	27.0	7.1	0.0	860	60	120		8.1	770	220	48	1	1000
8601	UPJONESPP02	08/10/88	11:24	23.2	6.8	2.8			70		8.3	920	210	28	-1	1200
8624	UPJONESPP02	08/17/88	7:45	19.9	6.9	3.1	721	27	140		14.0	1200	210	19	-1	1400
8661	UPJONESPP02	08/24/88	8:15	20.6	7.0	3.7	766	28	100		10.0	1200	200	26	-1	1400
8677	UPJONESPP02	08/31/88	7:45	23.3	6.6	5.2			50		4.8	420	120	44	3	590
8784	UPJONESPP02	11/30/88	9:26	11.4	7.1	5.6	718	28	80		7.5	700	170	24	2	900
8798	UPJONESPP02	12/07/88	9:20	11.4	7.1	7.3	799	32	80		7.1	600	200	47	4	850
8854	UPJONESPP02	12/28/88	8:20	5.0	7.1	10.4	728	64	60		9.8	980	200	48	3	1200
5001	VERNALIS	01/30/85	7:50	8.0	7.4	10.5	483	3								
5018	VERNALIS	02/27/85	8:15	12.5	7.4	9.6	629	8	25			220	97	48	6	370
5034	VERNALIS	03/27/85	8:45	12.0	7.4	9.0	801	17								
5048	VERNALIS	04/24/85	7:45	17.0	7.4	7.9	667	19	5			360	140	61	3	560
5069	VERNALIS	05/22/85	7:00	20.5	7.4	7.2	756	31	10			400	160	68	12	640
5092	VERNALIS	05/29/85	6:45	18.0	7.7	7.9	774	28								
5085	VERNALIS	06/26/85	6:45	23.0	7.5	7.3	717	52	10			540	160	66	7	770
5100	VERNALIS	07/10/85	6:45	22.5	7.4	7.1	490	28	5			520	130	41	3	690
5119	VERNALIS	08/28/85	7:15	19.5	7.7	7.4	487	18	5			410	100	34	2	550
5130	VERNALIS	09/25/85	7:07	21.5	7.4	6.8	563	21	5			380	98	30	4	510
5145	VERNALIS	10/23/85	7:00	15.5	7.4	7.4	519	12	5			320	110	29	2	460
5172	VERNALIS	11/15/85	8:20	8.5	7.5	9.7	706	7	15			220	130	71	7	430
5166	VERNALIS	12/03/85	15:30	13.5	7.4	8.9	604	18	18			590	140	32	-1	760
6007	VERNALIS	01/23/86	7:45	12.0	7.5	8.8	790	18	15			930	160	76	7	1200
6012	VERNALIS	02/13/86	7:30	11.5	7.3	9.0	686	15	5			450	140	56	3	650
6023	VERNALIS	03/04/86	8:00	15.0	7.3	8.3	268	26	35			540	56	6	-1	600
6038	VERNALIS	04/09/86	8:00	15.0	7.3	9.2	169	20	25			650	47	4	-1	700
6073	VERNALIS	05/07/86	6:30	14.5	7.3	8.8	257	17	15			330	51	6	-1	390
6104	VERNALIS	06/04/86	7:45	20.5	7.3	8.0	254	22	10			220	41	6	-1	270
6122	VERNALIS	07/02/86	6:50	23.0	7.5	7.9	595	9	5			318	144	41	2	510
6141	VERNALIS	08/14/86	7:15	21.5	7.6	7.6	557	25	5							
6170	VERNALIS	09/24/86	7:00	17.5	7.3	8.2	317	20	15			320	85	23	-1	430
6276	VERNALIS	11/12/86	7:45	13.5	7.3	9.7	447	10	5	2.0		250	60	41	1	350
6307	VERNALIS	12/17/86	11:30	11.5	7.3	10.5	331	10	5		1.4	160	38	9	-1	210
7016	VERNALIS	01/22/87	11:20	8.5	7.3	11.1	679	10	5		2.5	220	85	41	4	350
7056	VERNALIS	02/24/87	11:15	11.5	7.5	9.9	868	12	5	2.7		310	200	120	9	640
7105	VERNALIS	03/24/87	10:45	13.0	7.3	9.6	831	16	5	3.8		320	140	38	8	510
7182	VERNALIS	04/30/87	9:45	19.0	7.3	8.4	564	27	10	2.6		200	90	40	4	330
7217	VERNALIS	05/28/87	6:45	18.0	7.4	8.2	622	25	15	2.6		410	130	53	-1	590
7280	VERNALIS	06/23/87	7:15	22.5	7.7	4.6	807	42	10	2.2		250	110	61	9	430
7279	VERNALIS	06/23/87	7:15	22.5	7.7	4.6	807	42	10		4.6	400	170	64	9	640
7292	VERNALIS	06/24/87	8:30	23.0	7.5	1.9				2.9		260	150	78	14	500
7373	VERNALIS	08/25/87	7:05	22.1	7.4	7.7						370	130	63	4	570
7396	VERNALIS	09/09/87	7:00	21.5	6.8	7.2	734	21	5	5.5		310	110	50	11	480
7398	VERNALIS	09/09/87	7:00								4.0	240	120	55	4	420
7439	VERNALIS	10/22/87	6:50	18.5	7.4	8.2	807	13	0	3.3		170	98	62	13	340
7440	VERNALIS	10/22/87	6:50								3.5	140	89	62	17	310
7539	VERNALIS	11/05/87	7:20	15.0	7.6	8.7	951	17	5	4.2		400	130	78	6	610

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

THM DATA REPORT

LAB#	STA. NAME	SAMP.DATE	TIME	TEMP oC	pH	DO mg/L	EC uS/cm	TURB T.U.	COLOR C.U.	TOC mg/L	DOC mg/L	<---- THMFormation Potential----> CHCl3	CHBrCl2	CHBr2Cl	CHBr3	TTHMFP
												<-------------- ug/L				------------>
7538	VERNALIS	11/05/87	7:20								3.7	360	120	80	8	570
7566	VERNALIS	12/08/87	8:00	13.6	7.4	9.4	974	12	10	2.6		170	70	39	11	290
7565	VERNALIS	12/08/87	8:00								4.9	410	190	85	10	700
8009	VERNALIS	01/07/88	8:05								3.9	280	160	87	9	540
8010	VERNALIS	01/07/88	8:05	10.3	7.4	11.1	1080	11	15	4.0		280	150	100	12	540
8090	VERNALIS	02/10/88	7:30	12.4	7.4	9.8	1320	16	20	4.1		440	130	88	19	680
8089	VERNALIS	02/10/88	7:30								7.1	320	170	110	14	610
8144	VERNALIS	03/15/88	7:45	12.3	7.6	10.0	800	19	20	3.0		220	83	61	5	370
8145	VERNALIS	03/15/88	7:45								2.4	250	140	48	5	440
8234	VERNALIS	04/05/88	6:40								3.4	260	110	58	8	440
8233	VERNALIS	04/05/88	6:40	14.3	7.5	4.3	801	14	20	3.2		310	110	59	9	490
8329	VERNALIS	05/03/88	7:11								2.8	170	120	81	15	390
8328	VERNALIS	05/03/88	7:11	16.6	7.8	8.7	802	18	15	2.8		270	110	68	23	470
8420	VERNALIS	06/14/88	6:35	21.6	7.7	8.3	738	21	25	2.6		290	140	72	8	510
8421	VERNALIS	06/14/88	6:35								5.4	220	120	64	8	410
8455	VERNALIS	07/12/88	6:18	22.0	7.8	7.7			35	3.1		470	140	77	9	700
8456	VERNALIS	07/12/88	6:18								3.2	320	120	77	12	530
8577	VERNALIS	08/09/88	8:00	20.8	7.2	8.2			20	3.1		400	170	50	7	630
8578	VERNALIS	08/09/88	8:00	20.8	7.2	8.2					3.5	280	120	70	7	480
8689	VERNALIS	09/06/88	6:45	22.2	7.7	6.9					3.1	240	140	57	19	460
8681	VERNALIS	09/06/88	6:45	22.2	7.7	6.9	896	24	25	3.2		330	150	55	15	550
8710	VERNALIS	10/04/88	6:58	18.1	8.0	8.0	911	15	20	3.3		210	120	55	22	410
8711	VERNALIS	10/04/88	6:58	18.1	8.0	8.0	911				6.5	270	190	75	9	540
8741	VERNALIS	11/01/88	8:15	15.3	7.3	8.9					2.8	110	84	58	10	260
8740	VERNALIS	11/01/88	8:15	15.3	7.3	8.9	857	17	15	3.3		160	91	57	14	320
8811	VERNALIS	12/13/88	8:25	10.2	7.2	10.0	869	10	20	4.2		300	140	79	7	530

Note: Negative values signify reporting limits. Concentration of analyte below reporting limit.

Appendix C

QUALITY ASSURANCE EVALUATION OF LABORATORIES PERFORMING ANALYSIS FOR THE DELTA AGRICULTURAL DRAINAGE INVESTIGATION PROGRAM

The performance of Clayton Environmental Consultants and Enseco, Inc. were evaluated for the period January, 1987 through July, 1989. Several parameters were used as a yardstick to evaluate performance including blind sample results, spiked matrix results, interlaboratory comparisons, and adherence to the standard methods for analyzing volatile organic hydrocarbons. This evaluation focuses on the analytical capabilities for THMFP and pesticides, although the laboratories also analyzed minerals and trace elements. The following is an assessment of each of these procedures:

BLIND SAMPLES

Blind samples were analyzed to help measure the variation induced by sampling procedures, as well as laboratory variability. Approximately one set of THMFP blind samples per batch were submitted to the laboratories (there were no pesticide blind samples). Table C-1 presents the results of the blind sample analyses for THMFP and $CHCl_3$. The relative percent difference was determined to assess the precision of blind duplicate measurements using the formula:

$$\text{Relative Percent Difference} = \frac{\text{Conc.1 - Conc.2}}{\text{average}} \times 100$$

The quality control limit for estimating the precision of each of the THMs is <22%. All the blind duplicate results fell inside control limit.

Also presented in Table C-1 are the holding times for the blind duplicate samples. Holding time refers to the period after the samples have been both spiked and quenched. Theoretically, if the sample is held beyond the holding time, there could be loss of the volatiles. The holding time required by EPA in all the standard methods for analyzing volatile organic hydrocarbons is 14 days. Data shows that one set of blind duplicates was held 18 days before being analyzed.

The total data base for the 2-1/2 year period of study was also examined to determine the holding times of the THM samples (other than the duplicates). Samples sent to Enseco Laboratories were first spiked, incubated, and quenched by DWR Bryte Lab, so exact holding times could be calculated. However, THM samples sent to Clayton Environmental Consultants were generally spiked, incubated and quenched at Clayton, and dates of these procedures could not be obtained from Clayton.

Table C-2 lists the holding times of the THMFP samples. Since exact holding time data was unavailable from Clayton Labs, "worst case" holding times were estimated by subtracting the 7 day incubation period from the time between the receipt and analysis of samples (except for cases where DWR Bryte Lab spiked and quenched). Clayton Environmental Consultants may have held as many as 101 samples for up to 21 days (i.e. 7 days beyond the specified holding period, worst case). Enseco Laboratories exceeded the holding period for 289 samples, holding some of them for up to 49 days (i.e. 35 days beyond the specified holding period).

Both Clayton and Enseco Laboratories was contacted about the excessive holding times. Enseco agreed to perform a degradation study to determine the usefulness of the THMFP data where holding times exceeded 14 days. The study was conducted using both Enseco, Inc. and DWR Bryte Labs. The study showed that THMs may be held up to 80 days before there is significant loss of sample. A description of this study and the results are presented in Appendix D.

Holding times for pesticide analyses were not available from either Enseco or Clayton. This deficiency will be corrected in future years. There was only one problem reported by Enseco where Dinoseb was destroyed by the hydrolysis step using the EPA Method 615. The samples had to be re-extracted and analyzed without the hydrolysis step and consequently holding times were missed due to the need for re-extraction and analysis.

SPIKED MATRIX SAMPLES

Spiked duplicate samples were performed by the laboratories to check on internal quality control procedures to help assess laboratory variability. Method blanks were also run to assess the degree to which laboratory operations and procedures cause false-positive analytical results for the samples. Method blanks can give information about background concentrations of the constituent in question.

The spiked duplicates were run once per batch analyzed. Spikes were performed on two matrices: one supplied by Central District (field matrix) and one generated by the laboratories (blank water). The results of the spiked duplicate analyses are shown in Table C-3 for THMFP: chloroform, bromodichloromethane, dibromochloromethane and bromoform. The percent accuracy and precision obtained for the spiked matrix analyses, as well as the range of acceptable control limits, are shown. For THMFP, the acceptable control limits for accuracy should range between 80-125% and for precision the control limit should be <22%.

The pound (#) or asterisk (*) values in Table C-3 identify sample recoveries outside standard control limits for accuracy or precision, respectively. The instances where recoveries fell outside of control limits are very few. However, when this occurs, the laboratory should re-analyze the samples and follow procedures to obtain acceptable control limits. If the spiked matrix results indicate that the laboratory was out of control, the sample results during this period may need to be re-examined.

Table C-4 shows the results of the spiked matrix analyses for pesticides for Clayton Environmental Consultants and Enseco, Inc. The acceptable control limits for pesticides varies and are dependent on the compound analyzed and the analytical method. The tagged values mark those results which fell outside quality control limits.

INTERLABORATORY COMPARISONS

A round robin laboratory study was conducted January 20, 1988. Table C-5 shows the THMFP results the study. Participating laboratories included the DWR Bryte Laboratory, East Bay Municipal Utility District, Clayton Environmental Consultants, Department of Health Services, and Cal Analytical (Enseco, Inc.). All laboratory results fell within the control limits for accuracy (80-125%). This assumes that the true mean is the same as the mean of the replicates. None of the replicate measurements exceeded the control limit for precision (<22%).

TABLE C-1 - BLIND SAMPLE QUALITY ASSURANCE RESULTS
(January 1987 through June 1989)

Station Location	Date Sampled	CHCL3 g/L	THMFP g/L	RPD CHCL3 %	RPD THMFP %	Control Limit %	Holding Time (days)
Bouldin1	1/26/89	1400	1600	0	0	22	6
Bouldin1	1/26/89	1400	1600				
Bouldin1	2/3/89	1340	1600	5	5	22	3
Bouldin1	2/3/89	1100	1300				
Bouldin2	8/24/88	3600	3700	3	2	22	2
Bouldin2	8/24/88	3200	3400				
Bouldsiph01	8/31/88	280	300	-1	-1	22	5
Bouldsiph01	8/31/88	290	310				
Upegbert01	3/8/88	1500	1600	6	5	22	18
Upegbert01	3/8/88	1200	1300				
Upjonespp01	3/30/87	960	1200	16	13	NC	10
Upjonespp01	3/30/87	1900	2100				
Upjonespp02	12/28/88	980	1200	3	2	22	13
Upjonespp02	12/28/88	1100	1300				

NC = Not Calculated by laboratory.

TABLE C-2 - THMFP HOLDING TIMES
(January 1987 through June 1989)

CLAYTON ENVIRONMENTAL CONSULTANTS

DWR SAMPLE NO.	SAMPLES RECEIVED	SAMPLES ANALYZED	HOLDING TIME[1] (DAYS)
	Holding Times: 0 - 14 Days		
7239	06/08/87	06/08/87	0
7255-7256	06/08/87	06/08/87	0
7061-7066	03/03/87	03/13/87	3
7295-7298	07/07/87	07/17/87	3
7169-7179	04/16/87	04/28/87	5
7229-7232	06/02/87	06/15/87	6
7052-7060	02/24/87	03/10/87	7
7198-7203	05/13/87	05/27/87	7
7206-7207	05/28/87	06/11/87	7
7216-7223	05/28/87	06/11/87	7
7227-7228	05/28/87	06/11/87	7
7242-7254	06/11/87	06/25/87	7
7279-7284	06/23/87	07/08/87	8
7001-7005	01/08/87	01/24/87	9
7181-7193	04/30/87	05/18/87	12
7204-7205	05/20/87	06/09/87	13
7209-7214	05/20/87	06/09/87	13
7233-7238	06/04/87	06/24/87	13
7140-7157	03/30/87	04/20/87	14
7196-7197	05/06/87	05/27/87	14
	Holding Times: 15 - 21 Days		
7040-7051	02/10/87	03/04/87	15
7111-7135	03/30/87	04/21/87	15
7123-7132	04/01/87	04/23/87	15
7104-7110	03/24/87	04/16/87	16
7067-7080	03/10/87	04/03/87	17
7082-7103	03/17/87	04/11/87	18
7292-7294	06/24/87	07/19/87	18
7022-7027	02/05/87	03/03/87	19
7006-7015	01/13/87	02/10/87	21
7016-7020	01/22/87	02/19/87	21

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[1] Holding times for Clayton calculated as "worst case" times; actual holding times could be shorter. Holding time estimated as: (date analyzed - date received) - 7 days.

TABLE C-2 - CONTINUED

ENSECO LABORATORIES

DWR BATCH NO.	SAMPLES RECEIVED	SAMPLES ANALYZED	HOLDING TIME (DAYS)
Holding Times: 1 - 14 Days			
9117-9129	02/13/89	02/13/89	0
9151-9158	02/23/89	02/23/89	0
9253-9254	04/14/89	04/14/89	0
8577-8585	08/18/88	08/19/88	1
8586-8593	08/24/88	08/25/88	1
8845-8858	01/17/89	01/18/89	1
9186-9193	03/08/89	03/09/89	1
9239-9245	04/06/89	04/07/89	1
8429-8436	06/30/88	07/01/88	2
8441-8443	07/12/88	07/13/88	2
8649-8664	09/07/88	09/09/88	2
9052-9058	03/06/89	03/08/89	2
9096-9103	02/08/89	02/10/89	2
9137-9144	02/15/89	02/17/89	2
9226-9233	03/21/89	03/23/89	2
8412-8419	06/21/88	06/24/88	3
8455-8471	07/22/88	07/25/88	3
8598-8614	08/22/88	08/25/88	3
8644-8645	08/22/88	08/25/88	3
8690-8697	09/23/88	09/26/88	3
8698-8705	10/03/88	10/06/88	3
8719-8726	10/24/88	10/27/88	3
9104-9116	02/06/89	02/09/89	3
9130-9136	02/15/89	02/18/89	3
8448-8454	07/14/88	07/18/88	4
8527-8529	07/22/88	07/26/88	4
8710-8718	10/13/88	10/17/88	4
8775-8788	12/12/88	12/16/88	4
8570-8576	08/11/88	08/16/88	5
8665-8680	09/15/88	09/20/88	5
8681-8689	09/16/88	09/21/88	5
9211-9217	03/15/89	03/20/89	5
9218-9219	03/16/89	03/21/89	5
7439-7446	11/03/87	11/09/87	6
7468-7469	10/27/87	11/02/87	6
8803-8808	12/15/88	12/21/88	6
9220-9225	03/15/89	03/21/89	6
7428-7438	10/27/87	11/03/87	7

TABLE C-2 - CONTINUED

ENSECO LABORATORIES (cont.)

DWR BATCH NO.	SAMPLES RECEIVED	SAMPLES ANALYZED		HOLDING TIME (DAYS)
Holding Times: 1 -14 Days (continued)				
8420-8428	06/23/88	06/30/88		7
8541-8563	08/01/88	08/08/88		7
8757-8764	11/29/88	12/05/88		7
8818-8831	12/29/88	01/04/89		7
8472-8522	08/03/88	08/11/88		8
8740-8747	11/10/88	11/18/88		8
8397-8403	06/07/88	06/16/88		9
9351-9373	06/28/89	07/07/89		9
9374-9399	06/29/89	07/08/89		9
8749-8756	10/18/88	10/28/88		10
9439-9477	06/27/89	07/07/89		10
7299-7352	08/17/87	08/28/87		11
7529-7544	11/16/87	11/27/87		11
8620-8643	08/29/88	09/09/88		11
8789-8802	12/16/88	12/27/88		11
7373-7386	09/03/87	09/15/87		12
7387-7395	09/11/87	09/23/87		12
8320-8327	05/09/88	05/21/88		12
9001-9051	01/20/89	02/01/89		12
8233-8240	04/13/88	04/26/88		13
8245-8251	04/25/88	05/08/88		13
8727-8734	10/28/88	11/10/88		13
7470-7526	11/03/87	11/06/87	11/17/87	3-14
7404-7426	10/02/87	10/16/87		14
8809-8810	12/15/88	12/29/88		14
Holding Times: 15 - 21 Days				
7565-7571	12/22/87	01/08/88		17
8336-8384	05/23/88	06/10/88		18
8208-8216	03/25/88	04/13/88		19
8389-8396	05/27/88	06/15/88		19
Holding Times: 22 - 28 Days				
7572-7592	12/21/87	01/12/88		22
7554-7564	12/14/87	01/06/88		23
8144-8150	03/23/88	04/18/88		26

TABLE C-2 - CONTINUED

ENSECO LABORATORIES (cont.)

DWR BATCH NO.	SAMPLES RECEIVED	SAMPLES ANALYZED		HOLDING TIME (DAYS)
Holding Times: 22 - 28 Days (continued)				
7447-7456	11/09/87	11/24/87	12/06/87	15-27
8328-8335	05/12/88	06/08/88		27
Holding Times: 29 - 35 Days				
7596-7603	12/22/87	01/20/88		29
8151-8203	03/21/88	04/06/88	04/20/88	16-30
7604-7611	12/28/87	01/27/88		30
8130-8137	03/02/88	04/02/88		31
8221-8228	04/01/88	05/02/88		31
8108-8115	02/29/88	04/01/88		32
Holding Times: 36 - 42 Days				
8089-8095	02/18/88	03/26/88		37
8001-8015	01/15/88	02/02/88	03/02/88	18-47
8017-8071	02/02/88	03/08/88	03/18/88	35-45
Holding Times: 43 - 49 Days				
8072-8079	02/03/88	03/23/88		49

TABLE C-3 - RESULTS OF SPIKED MATRIX SAMPLES
(January 1987 through June 1989)

ENSECO LABORATORIES

DWR Batch No.	Samples Received	Analyte	Spiked Amount	Concentration LCS1	Concentration LCS2	Accuracy (%) LCS1	Accuracy (%) LCS2	Accuracy (%) Limits	RPD	Limit
7299-7352		08/17/87	Not Found.							
7373-7386	09/03/87	$CHCl_3$	5.0	4.7	5.5	94	110	83-123	12	26
		$CHCl_2Br$	5.0	4.5	5.5	90	110	82-126	20	30
		Matrix: Water								
7387-7395	09/11/87	$CHCl_3$	5.0	4.9	4.9	98	98	83-123	0	21
		$CHCl_2Br$	5.0	4.6	4.8	92	96	82-126	4.3	30
		Matrix: Water								
7404-7426	10/02/87	$CHCl_3$	5.0	4.9	4.7					
		$CHCl_2Br$	5.0	5.1	5.2					
		Matrix: Water								
7428-7438	10/27/87	$CHCl_3$	5.0	5.4	5.2	108	104	84-122	3.8	22
		$CHCl_2Br$	5.0	5.6	5.1	112	102	81-129	9.4	27
		Matrix: Water								
7439-7446	11/03/87	$CHCl_3$	5.0	4.2	4.6	84	92	84-122	9	22
		$CHCl_2Br$	5.0	4.4	5.2	88	104	81-129	17	27
		Matrix: Water								
7447-7456	11/09/87	$CHCl_3$	5.0	4.9	5.0	98	100	84-122	2	22
		$CHCl_2Br$	5.0	5.0	5.1	100	102	81-129	2	27
		Matrix: Water								
7468-7469	10/27/87	Not Found.								
7470-7526	11/03/87	Not Found								
7529-7544	11/16/87	$CHCl_3$	5.0	5.1	5.2	102	104	84-122	2	22
		$CHCl_2Br$	5.0	5.3	5.3	106	106	81-129	0	27
		Matrix: Water								
7545-7553	11/24/87	$CHCl_3$	5.0	4.6	5.1	92	102	84-122	10.3	22
		$CHCl_2Br$	5.0	5.1	4.5	102	90	81-129	12.5	27
		Matrix: Water								
7554-7564	12/14/87	$CHCl_3$	5.0	4.7	4.7	94	94	84-122	0	22
		$CHCl_2Br$	5.0	4.8	4.9	96	98	81-129	0	27
		Matrix: Water								
7565-7571	12/22/87	$CHCl_3$	5.0	5.0	5.6	100	112	84-122	11	22
		$CHCl_2Br$	5.0	5.0	5.7	100	114	81-129	13	27
		Matrix: Water								

TABLE C-3 - (CONTINUED)

DWR Batch No.	Samples Received	Analyte	Spiked Amount	Concentration LCS1	Concentration LCS2	Accuracy (%) LCS1	Accuracy (%) LCS2	Accuracy (%) Limits	RPD	Limit
7572-7592	12/21/87	Not Found.								
7596-7603	12/22/87	$CHCl_3$	2.5	2.2	2.6	88	104	NC	0	NC
		$CHCl_2Br$	5.0	4.9	4.7	98	94	81-129	4.2	27
		Matrix: Water								
7604-7611	12/28/87	$CHCl_3$	2.5	2.35	2.14	94	86	83-124	8.9	18
		$CHCl_2Br$	5.0	4.51	4.34	90	87	78-132	3.4	21
		Matrix: Water								
8001-8015	01/15/88	$CHCl_3$	2.5	2.2	2.6	88	104	83-124	17	18
		$CHCl_2Br$	5.0	4.9	4.7	98	94	78-132	4.2	21
		Matrix: Water								
8017-8071	02/02/88	No THM's Done								
8072-8079	02/03/88	$CHCl_3$	2.5	2.56	2.27	102	91	83-124	11	18
		$CHCl_2Br$	5.0	4.79	4.06	96	81	78-132	17	21
		Matrix: Water								
8089-8095	02/18/88	$CHCl_3$	2.5	2.52	2.42	101	97	83-124	4.0	18
		$CHCl_2Br$	5.0	2.37	4.92	107	98	78-132	8.8	21
		Matrix: Water								
8108-8115	02/29/88	$CHCl_3$	2.5	2.82	2.98	113	119	83-124	5.1	18
		$CHCl_2Br$	5.0	5.04	6.10	101	122	78-132	19	21
		$CHClBr_2$	5.0	5.12	6.12	102	122	NC	18	NC
		$CHBr_3$	10	11.3	14.6	113	146	NC	25	NC
		Matrix: Aqueous								
8130-8137	03/02/88	$CHCl_3$	2.5	2.82	2.98	113	119	80-125	5.2	22
		$CHCl_2Br$	5.0	5.04	6.10	101	122	80-125	19.0	22
		$CHClBr_2$	5.0	5.12	6.12	102	122	80-125	18.0	22
		$CHBr_3$	10.0	11.3	14.6	113	146#	80-125	25.0*	22
		Matrix: Aqueous								
		(# = Recovery outside standard QC limits, * = RPD outside QC limits.)								
8144-8150	03/23/88	$CHCl_3$	2.50	2.82	2.98	113	119	80-125	5.2	22
		$CHCl_2Br$	5.00	5.04	6.10	101	122	80-125	19.0	22
		$CHClBr_2$	5.00	5.12	6.12	102	122	80-125	18.0	22
		$CHBr_3$	10	11.3	14.6	113	146#	80-125	25.0*	22
		Matrix: Aqueous								
		(# = Recovery outside standard QC limits, * = RPD outside QC limits.)								
8151-8203	03/21/88	No THM's Done								

TABLE C-3 - (CONTINUED)

DWR Batch No.	Samples Received	Analyte	Spiked Amount	Concentration LCS1	LCS2	Accuracy (%) LCS1	LCS2	Limits	RPD	Limit
8208-8216	03/25/88	$CHCl_3$	2.5	2.63	2.57	105	103	80-125	1.9	22
		$CHCl_2Br$	5.00	4.48	4.54	90	91	80-125	1.1	22
		$CHClBr_2$	5.00	4.99	4.90	100	98	80-125	2.0	22
		$CHBr_3$	10.0	10.1	9.84	101	98	80-125	3.0	22
		Matrix: Aqueous								
8221-8228	04/01/88	$CHCl_3$	2.50	2.38	2.69	95	108	80-125	13.0	22
		$CHCl_2Br$	5.00	4.35	4.87	87	97	80-125	11.0	22
		$CHClBr_2$	5.00	4.37	5.25	87	105	80-125	19.0	22
		$CHBr_3$	10.0	8.73	10.2	87	102	80-125	16.0	22
		Matrix: Aqueous								
8233-8240	04/13/88	$CHCl_3$	500	744	789	NC	NC	NC	NC	NC
		$CHCl_2Br$	1000	1090	1180	NC	NC	NC	NC	NC
		$CHClBr_2$	1000	1170	1210	NC	NC	NC	NC	NC
		$CHBr_3$	2000	2170	2090	NC	NC	NC	NC	NC
		Matrix: Aqueous								
8245-8251	04/25/88	$CHCl_3$	2.50	2.64	2.53	106	101	80-125	4.8	22
		$CHCl_2Br$	5.00	4.68	4.41	94	88	80-125	6.6	22
		$CHClBr_2$	5.00	5.06	4.67	101	93	80-125	8.2	22
		$CHBr_3$	10.0	9.94	10.1	99	101	80-125	2.0	22
		Matrix: Aqueous								
8320-8327	05/09/88	$CHCl_3$	5.00	5.20	5.25	104	105	80-125	1.0	22
		$CHCl_2Br$	5.00	5.14	5.45	103	109	80-125	5.7	22
		$CHClBr_2$	5.00	4.62	5.01	92	100	80-125	8.3	22
		$CHBr_3$	10.0	8.29	9.62	83	96	80-125	14.0	22
		Matrix: Aqueous								
8328-8335	05/12/88	$CHCl_3$	5.00	5.12	5.04	102	101	80-125	1.0	22
		$CHCl_2Br$	5.00	5.17	5.14	103	103	80-125	0.0	22
		$CHClBr_2$	5.00	5.53	5.23	111	105	80-125	5.6	22
		$CHBr_3$	10.0	10.8	10.6	108	106	80-125	1.9	22
		Matrix: Aqueous								
8336-8384	05/23/88	$CHCl_3$	5.00	5.12	5.04	102	101	80-125	1.0	22
		$CHCl_2Br$	5.00	5.17	5.14	103	103	80-125	0.0	22
		$CHClBr_2$	5.00	5.53	5.23	111	105	80-125	5.6	22
		$CHBr_3$	10.0	10.8	10.6	108	106	80-125	1.9	22
		Matrix: Aqueous								

TABLE C-3 – (CONTINUED)

DWR Batch No.	Samples Received	Analyte	Spiked Amount	Concentration LCS1	Concentration LCS2	Accuracy (%) LCS1	Accuracy (%) LCS2	Accuracy (%) Limits	RPD	Limit
8389-8396	05/27/88	$CHCl_3$	5.00	5.12	5.4	102	101	80-125	1.0	22
		$CHCl_2Br$	5.00	5.17	5.14	103	103	80-125	0.0	22
		$CHClBr_2$	5.00	5.53	5.23	111	105	80-125	5.6	22
		$CHBr_3$	10.0	10.8	10.6	108	106	80-125	1.9	22
		Matrix: Aqueous								
8397-8403	06/07/88	$CHCl_3$	5.00	5.12	5.4	102	101	80-125	1.0	22
		$CHCl_2Br$	5.00	5.17	5.14	103	103	80-125	0.0	22
		$CHClBr_2$	5.00	5.53	5.23	111	105	80-125	5.6	22
		$CHBr_3$	10.0	10.8	10.6	108	106	80-125	1.9	22
		Matrix: Aqueous								
8412-8419	06/21/88	$CHCl_3$	5.00	4.59	4.41	92	88	80-125	4.4	22
		$CHCl_2Br$	5.00	4.51	4.27	90	85	80-125	5.7	22
		$CHClBr_2$	5.00	4.60	4.54	92	91	80-125	1.1	22
		$CHBr_3$	10.0	11.3	11.0	113	110	80-125	2.7	22
		Matrix: Aqueous								
8420-8428	06/23/88	$CHCl_3$	2.50	2.47	2.51	99	100	80-125	1.0	22
		$CHCl_2Br$	5.00	4.86	4.79	97	96	80-125	1.0	22
		$CHClBr_2$	5.00	3.97	4.04	79#	81	80-125	2.5	22
		$CHBr_3$	10.0	8.89	7.85	89	78#	80-125	13.0	22
		Matrix: Aqueous								
		(# = Recovery outside standard QC limits.)								
8429-8436	06/30/88	$CHCl_3$	2.50	2.47	2.51	99	100	80-125	1.0	22
		$CHCl_2Br$	5.00	4.86	4.79	97	96	80-125	1.0	22
		$CHClBr_2$	5.00	3.97	4.04	79#	81	80-125	2.5	22
		$CHBr_3$	10.0	8.89	7.85	89	78#	80-125	13.0	22
		Matrix: Aqueous								
		(# = Recovery outside standard QC limits.)								
8441-8443	07/12/88	$CHCl_3$	5.00	4.59	4.41	92	88	80-125	4.4	22
		$CHCl_2Br$	5.00	4.51	4.27	90	85	80-125	5.7	22
		$CHClBr_2$	5.00	4.60	4.54	92	91	80-125	1.1	22
		$CHBr_3$	10.0	11.3	11.0	113	110	80-125	2.7	22
		Matrix: Aqueous								
8448-8454	07/14/88	$CHCl_3$	5.00	4.59	4.41	92	88	80-125	4.4	22
		$CHCl_2Br$	5.00	4.51	4.27	90	85	80-125	5.7	22
		$CHClBr_2$	5.00	4.60	4.54	92	91	80-125	1.1	22
		$CHBr_3$	10.0	11.3	11.0	113	110	80-125	2.7	22
		Matrix: Aqueous								

TABLE C-3 - (CONTINUED)

DWR Batch No.	Samples Received	Analyte	Spiked Amount	Concentration LCS1	LCS2	Accuracy (%) LCS1	LCS2	Limits	RPD	Limit
8455-8471	07/22/88	No THM's Done								
8472-8522	08/03/88	No THM's Done								
8527-8529	07/22/88	No THM's Done								
8541-8563	08/01/88	No THM's Done								
8570-8576	08/11/88	$CHCl_3$	5.00	4.41	4.42	88	88	80-125	0.0	22
		$CHCl_2Br$	5.00	4.36	4.25	87	85	80-125	2.3	22
		$CHClBr_2$	5.00	3.79	3.77	76#	75#	80-125	1.3	22
		$CHBr_3$	10.0	7.60	7.80	76#	78#	80-125	2.6	22
		Matrix: Aqueous								
		(# = Recovery outside standard QC limits.)								
8577-8585	08/18/88	$CHCl_3$	5.00	4.54	4.53	91	91	80-125	0.0	22
		$CHCl_2Br$	10.0	7.76	8.17	78#	82	80-125	5.0	22
		$CHClBr_2$	10.0	7.92	8.19	79#	82	80-125	3.8	22
		$CHBr_3$	20.0	15.9	16.5	80	82	80-125	2.5	22
		Matrix: Aqueous								
		(# = Recovery outside standard QC limits.)								
8586-8593	08/24/88	$CHCl_3$	5.00	4.94	5.01	99	100	80-125	1.0	22
		$CHCl_2Br$	5.00	4.94	4.96	99	99	80-125	0.0	22
		$CHClBr_2$	5.00	4.19	4.20	84	84	80-125	0.0	22
		$CHBr_3$	10.0	8.63	9.43	86	94	80-125	8.9	22
		Matrix: Aqueous								
8598-8614	08/22/88	$CHCl_3$	5.00	4.94	5.01	99	100	80-125	1.0	22
		$CHCl_2Br$	5.00	4.94	4.96	99	99	80-125	0.0	22
		$CHClBr_2$	5.00	4.19	4.20	84	84	80-125	0.0	22
		$CHBr_3$	10.0	8.63	9.43	86	94	80-125	8.9	22
		Matrix: Aqueous								
8644-8645	08/22/88	$CHCl_3$	5.00	4.94	5.01	99	100	80-125	1.0	22
		$CHCl_2Br$	5.00	4.94	4.96	99	99	80-125	0.0	22
		$CHClBr_2$	5.00	4.19	4.20	84	84	80-125	0.0	22
		$CHBr_3$	10.0	8.63	9.43	86	94	80-125	8.9	22
		Matrix: Aqueous								
8620-8643	08/29/88	$CHCl_3$	5.00	3.96	4.67	79#	93	80-125	16.0	22
		$CHCl_2Br$	10.0	8.58	9.88	86	99	80-125	14.0	22
		$CHClBr_2$	10.0	7.14	8.72	71#	87	80-125	20.0	22
		$CHBr_3$	20.0	15.0	19.6	75#	98	80-125	27.0*	22
		Matrix: Aqueous								
		(# = Recovery outside standard QC limits, * = RPD outside QC limits.)								

TABLE C-3 - (CONTINUED)

DWR Batch No.	Samples Received	Analyte	Spiked Amount	Concentration LCS1	LCS2	Accuracy (%) LCS1	LCS2	Limits	RPD	Limit
8649-8664	09/07/88	$CHCl_3$	5.00	5.99	5.25	120	105	80-125	13.0	22
		$CHCl_2Br$	5.00	5.82	5.03	116	101	80-125	14.0	22
		$CHClBr_2$	5.00	4.90	4.52	98	90	80-125	8.5	22
		$CHBr_3$	10.0	9.77	9.00	98	90	80-125	8.5	22
		Matrix: Aqueous								
8665-8680	09/15/88	$CHCl_3$	5.00	5.34	5.14	107	103	80-125	3.8	22
		$CHCl_2Br$	5.00	4.59	4.73	92	95	80-125	3.2	22
		$CHClBr_2$	5.00	4.64	4.53	93	91	80-125	2.2	22
		$CHBr_3$	10.0	7.96	9.32	80	93	80-125	15.0	22
		Matrix: Aqueous								
8681-8689	09/16/88	$CHCl_3$	5.00	5.34	5.14	107	103	80-125	3.8	22
		$CHCl_2Br$	5.00	4.59	4.73	92	95	80-125	3.2	22
		$CHClBr_2$	5.00	4.64	4.53	93	91	80-125	2.2	22
		$CHBr_3$	10.0	7.96	9.32	80	93	80-125	15.0	22
		Matrix: Aqueous								
8690-8697	09/23/88	$CHCl_3$	5.00	6.19	6.26	124	125	80-125	0.8	22
		$CHCl_2Br$	5.00	5.36	5.63	107	113	80-125	5.4	22
		$CHClBr_2$	5.00	4.93	5.48	99	110	80-125	10.0	22
		$CHBr_3$	10.0	8.94	10.4	89	104	80-125	16.0	22
		Matrix: Aqueous								
8698-8705	10/03/88	$CHCl_3$	5.00	6.19	6.26	124	125	80-125	0.8	22
		$CHCl_2Br$	5.00	5.36	5.63	107	113	80-125	5.4	22
		$CHClBr_2$	5.00	4.93	5.48	99	110	80-125	10.0	22
		$CHBr_3$	10.0	8.94	10.4	89	104	80-125	16.0	22
		Matrix: Aqueous								
8710-8718	10/13/88	$CHCl_3$	5.00	6.19	6.26	124	125	80-125	0.8	22
		$CHCl_2Br$	5.00	5.36	5.63	107	113	80-125	5.4	22
		$CHClBr_2$	5.00	4.93	5.48	99	110	80-125	10.0	22
		$CHBr_3$	10.0	8.94	10.4	89	104	80-125	16.0	22
		Matrix: Aqueous								
8719-8726	10/24/88	$CHCl_3$	5.00	5.58	5.60	112	112	80-125	0.0	22
		$CHCl_2Br$	10.0	10.6	10.1	106	101	80-125	4.8	22
		$CHClBr_2$	10.0	9.64	9.72	96	97	80-125	1.0	22
		$CHBr_3$	20	19.8	19.9	99	100	80-125	1.0	22
		Matrix: Aqueous								

TABLE C-3 - (CONTINUED)

DWR Batch No.	Samples Received	Analyte	Spiked Amount	Concentration LCS1	LCS2	Accuracy (%) LCS1	LCS2	Limits	RPD	Limit
8727-8734	10/28/88	$CHCl_3$	5.00	5.58	5.60	112	112	80-125	0.0	22
		$CHCl_2Br$	10.0	10.6	10.1	106	101	80-125	4.8	22
		$CHClBr_2$	10.0	9.64	9.72	96	97	80-125	1.0	22
		$CHBr_3$	20	19.8	19.9	99	100	80-125	1.0	22
		Matrix: Aqueous								
8740-8747	11/10/88	$CHCl_3$	5.00	5.55	5.80	111	116	80-125	4.4	22
		$CHCl_2Br$	5.00	5.35	5.52	107	110	80-125	2.8	22
		$CHClBr_2$	5.00	6.07	5.93	121	119	80-125	1.7	22
		$CHBr_3$	10.0	12.5	11.7	125	117	80-125	6.6	22
		Matrix: Aqueous								
8749-8756	10/18/88	$CHCl_3$	5.00	6.19	6.26	124	125	80-125	0.8	22
		$CHCl_2Br$	5.00	5.36	5.63	107	113	80-125	5.4	22
		$CHClBr_2$	5.00	4.93	5.48	99	110	80-125	10.0	22
		$CHBr_3$	10.0	8.94	10.4	89	104	80-125	16.0	22
		Matrix: Aqueous								
8757-8764	11/29/88	$CHCl_3$	5.00	5.55	5.80	111	116	80-125	4.4	22
		$CHCl_2Br$	5.00	5.35	5.52	107	110	80-125	2.8	22
		$CHClBr_2$	5.00	6.07	5.93	121	119	80-125	1.7	22
		$CHBr_3$	10.0	12.5	11.7	125	117	80-125	6.6	22
		Matrix: Aqueous								
8775-8788	12/12/88	$CHCl_3$	5.00	5.55	5.80	111	116	80-125	4.4	22
		$CHCl_2Br$	5.00	5.35	5.52	107	110	80-125	2.8	22
		$CHClBr_2$	5.00	6.07	5.93	121	119	80-125	1.7	22
		$CHBr_3$	10.0	12.5	11.7	125	117	80-125	6.6	22
		Matrix: Aqueous								
8789-8802	12/16/88	$CHCl_3$	5.00	5.55	5.80	111	116	80-125	4.4	22
		$CHCl_2Br$	5.00	5.35	5.52	107	110	80-125	2.8	22
		$CHClBr_2$	5.00	6.07	5.93	121	119	80-125	1.7	22
		$CHBr_3$	10.0	12.5	11.7	125	117	80-125	6.6	22
		Matrix: Aqueous								
8803-8808	12/15/88	$CHCl_3$	5.00	5.55	5.80	111	116	80-125	4.4	22
		$CHCl_2Br$	5.00	5.35	5.52	107	110	80-125	2.8	22
		$CHClBr_2$	5.00	6.07	5.93	121	119	80-125	1.7	22
		$CHBr_3$	10.0	12.5	11.7	125	117	80-125	6.6	22
		Matrix: Aqueous								

TABLE C-3 - (CONTINUED)

DWR Batch No.	Samples Received	Analyte	Spiked Amount	Concentration LCS1	Concentration LCS2	Accuracy (%) LCS1	Accuracy (%) LCS2	Accuracy (%) Limits	RPD	Limit
8809-8810	12/15/88	$CHCl_3$	5.00	5.55	5.80	111	116	80-125	4.4	22
		$CHCl_2Br$	5.00	5.35	5.52	107	110	80-125	2.8	22
		$CHClBr_2$	5.00	6.07	5.93	121	119	80-125	1.7	22
		$CHBr_3$	10.0	12.5	11.7	125	117	80-125	6.6	22
		Matrix: Aqueous								
8818-8831	12/29/88	$CHCl_3$	5.00	5.55	5.80	111	116	80-125	4.4	22
		$CHCl_2Br$	5.00	5.35	5.52	107	110	80-125	2.8	22
		$CHClBr_2$	5.00	6.07	5.93	121	119	80-125	1.7	22
		$CHBr_3$	10.0	12.5	11.7	125	117	80-125	6.6	22
		Matrix: Aqueous								
8845-8858	01/17/89	$CHCl_3$	5.00	5.26	5.16	105	103	80-125	1.9	22
		$CHCl_2Br$	5.00	5.83	5.40	117	108	80-125	8.0	22
		$CHClBr_2$	5.00	5.21	4.95	104	99	80-125	4.9	22
		$CHBr_3$	10.0	10.5	9.84	105	98	80-125	6.9	22
		Matrix: Aqueous								
9001-9051	01/20/89	$CHCl_3$	5.00	4.54	5.06	91	100	80-125	10	22
		$CHCl_2Br$	5.00	4.73	5.39	95	108	80-125	13	22
		$CHClBr_2$	5.00	4.65	5.18	93	104	80-125	11	22
		$CHBr_3$	10.0	9.11	9.64	91	96	80-125	5.3	22
		Matrix: Aqueous								
9052-9058	03/06/89	$CHCl_3$	5.00	5.12	5.26	102	105	80-125	2.9	22
		$CHCl_2Br$	5.00	4.97	4.37	99	93	80-125	6.2	22
		$CHClBr_2$	5.00	4.98	4.68	100	94	80-125	6.2	22
		$CHBr_3$	10.0	9.44	8.85	94	88	80-125	6.6	22
		Matrix: Aqueous								
9096-9103	02/08/89	$CHCl_3$	5.00	4.54	5.06	91	101	80-125	10	22
		$CHCl_2Br$	5.00	4.73	5.39	95	108	80-125	13	22
		$CHClBr_2$	5.00	4.65	5.18	93	104	80-125	11	22
		$CHBr_3$	10.0	9.11	9.64	91	96	80-125	5.3	22
		Matrix: Aqueous								
9104-9116	02/06/89	$CHCl_3$	5.00	4.54	5.06	91	101	80-125	10	22
		$CHCl_2Br$	5.00	4.73	5.39	95	108	80-125	13	22
		$CHClBr_2$	5.00	4.65	5.18	93	104	80-125	11	22
		$CHBr_3$	10.0	9.11	9.64	91	96	80-125	5.3	22
		Matrix: Aqueous								

TABLE C-3 - (CONTINUED)

DWR Batch No.	Samples Received	Analyte	Spiked Amount	Concentration LCS1	LCS2	Accuracy (%) LCS1	LCS2	Limits	RPD	Limit
9117-9129	02/13/89	$CHCl_3$	5.00	5.24	5.62	105	112	80-125	6.5	22
		$CHCl_2Br$	5.00	5.39	5.85	108	117	80-125	8.0	22
		$CHClBr_2$	5.00	5.26	5.97	105	119	80-125	12	22
		$CHBr_3$	10.0	9.73	11.5	97	115	80-125	17	22
		Matrix: Aqueous								
9130-9136	02/15/89	$CHCl_3$	5.00	5.24	5.62	105	112	80-125	6.5	22
		$CHCl_2Br$	5.00	5.39	5.85	108	117	80-125	8.0	22
		$CHClBr_2$	5.00	5.26	5.97	105	119	80-125	12	22
		$CHBr_3$	10.0	9.73	11.5	97	115	80-125	17	22
		Matrix: Aqueous								
9137-9144	02/15/89	$CHCl_3$	5.00	5.24	5.62	105	112	80-125	6.5	22
		$CHCl_2Br$	5.00	5.39	5.85	108	117	80-125	8.0	22
		$CHClBr_2$	5.00	5.26	5.97	105	119	80-125	12	22
		$CHBr_3$	10.0	9.73	11.5	97	115	80-125	17	22
		Matrix: Aqueous								
9151-9158	02/23/89	$CHCl_3$	5.00	5.24	5.62	105	112	80-125	6.5	22
		$CHCl_2Br$	5.00	5.39	5.85	108	117	80-125	8.0	22
		$CHClBr_2$	5.00	5.26	5.97	105	119	80-125	12	22
		$CHBr_3$	10.0	9.73	11.5	97	115	80-125	17	22
		Matrix: Aqueous								
9186-9193	03/08/89	$CHCl_3$	5.00	5.12	5.26	102	105	80-125	2.9	22
		$CHCl_2Br$	5.00	4.97	4.37	99	93	80-125	6.2	22
		$CHClBr_2$	5.00	4.98	4.68	100	94	80-125	6.2	22
		$CHBr_3$	10.0	9.44	8.85	94	88	80-125	6.6	22
		Matrix: Aqueous								
9211-9217	03/15/89	$CHCl_3$	5.00	5.12	5.26	102	105	80-125	2.9	22
		$CHCl_2Br$	5.00	4.97	4.37	99	93	80-125	6.2	22
		$CHClBr_2$	5.00	4.98	4.68	100	94	80-125	6.2	22
		$CHBr_3$	10.0	9.44	8.85	94	88	80-125	6.6	22
		Matrix: Aqueous								
9218-9219	03/16/89	$CHCl_3$	5.00	5.12	5.26	102	105	80-125	2.9	22
		$CHCl_2Br$	5.00	4.97	4.37	99	93	80-125	6.2	22
		$CHClBr_2$	5.00	4.98	4.68	100	94	80-125	6.2	22
		$CHBr_3$	10.0	9.44	8.85	94	88	80-125	6.6	22
		Matrix: Aqueous								

TABLE C-3 - (CONTINUED)

DWR Batch No.	Samples Received	Analyte	Spiked Amount	Concentration LCS1	LCS2	Accuracy (%) LCS1	LCS2	Limits	RPD	Limit
9220-9225	03/15/89	$CHCl_3$	5.00	5.12	5.26	102	105	80-125	2.9	22
		$CHCl_2Br$	5.00	4.97	4.37	99	93	80-125	6.2	22
		$CHClBr_2$	5.00	4.98	4.68	100	94	80-125	6.2	22
		$CHBr_3$	10.0	9.44	8.85	94	88	80-125	6.6	22
		Matrix: Aqueous								
9226-9233	03/21/89	$CHCl_3$	5.00	4.64	4.63	93	93	80-125	0.0	22
		$CHCl_2Br$	5.00	4.70	4.40	94	88	80-125	6.6	22
		$CHClBr_2$	5.00	4.74	4.67	95	93	80-125	2.1	22
		$CHBr_3$	10.0	9.32	9.21	93	92	80-125	1.1	22
		Matrix: Aqueous								
9239-9245	04/06/89	$CHCl_3$	5.00	4.64	4.63	93	93	80-125	0.0	22
		$CHCl_2Br$	5.00	4.70	4.40	94	88	80-125	6.6	22
		$CHClBr_2$	5.00	4.74	4.67	95	93	80-125	2.1	22
		$CHBr_3$	10.0	9.32	9.21	93	92	80-125	1.1	22
		Matrix: Aqueous								
9253-9254	04/14/89	$CHCl_3$	5.00	4.64	4.63	93	93	80-125	0.0	22
		$CHCl_2Br$	5.00	4.70	4.40	94	88	80-125	6.6	22
		$CHClBr_2$	5.00	4.74	4.67	95	93	80-125	2.1	22
		$CHBr_3$	10.0	9.32	9.21	93	92	80-125	1.1	22
		Matrix: Aqueous								
9351-9373	06/28/89	$CHCl_3$	5.0	4.13	4.78		89	80-125	15	22
		$CHCl_2Br$	10.0	9.32	10.3		98	80-125	10	22
		$CHClBr_2$	10.0	9.24	10.2		97	80-125	9.9	22
		$CHBr_3$	20.0	21.0	24.0		113	80-125	13	22
		Matrix: Aqueous								
9374-9399	06/29/89	$CHCl_3$	5.0	4.13	4.78		89	80-125	15	22
		$CHCl_2Br$	10.0	9.32	10.3		98	80-125	10	22
		$CHClBr_2$	10.0	9.24	10.2		97	80-125	9.9	22
		$CHBr_3$	20.0	21.0	24.0		113	80-125	13	22
2nd Test		$CHCl_3$	5.0	4.67	4.54		92	80-125	2.8	22
		$CHCl_2Br$	10.0	9.97	9.51		97	80-125	4.7	22
		$CHClBr_2$	10.0	10.5	10.2		104	80-125	2.9	22
		$CHBr_3$	20.0	21.0	20.4		104	80-125	2.9	22
		Matrix: Aqueous								
9439-9477	06/27/89	$CHCl_3$	5.0	4.74	4.87		96	80-125	2.7	22
		$CHCl_2Br$	10.0	10.1	10.5		103	80-125	3.9	22
		$CHClBr_2$	10.0	10.6	11.3		110	80-125	6.4	22
		$CHBr_3$	20.0	21.9	23.1		113	80-125	5.3	22
		Matrix: Aqueous								

TABLE C-4 - SPIKED DUPLICATE ANALYSES FOR PESTICIDES
(Clayton Environmental Consultants 1987-1988)

Date	Chemical	Concentration (ug/L)			Accuracy (%)			Precision (RPD)	
		Spiked	Test 1	Test 2	Test 1	Test 2	Limits	LCS	Limits
10/09/87	Methomyl	50	43	43	86	86	NC	0.0	NC
	Carbaryl	50	42	42	84	84	NC	0.0	NC
	Propham	50	49	50	98	100	NC	1.0	NC
	Atrazine	2.0	1.7	2.0	85	100	NC	16.2	NC
	Simazine	2.0	1.5	1.9	75	95	NC	23.5	NC
	Bentazon	10	9.57	6.4	95.7	64.0	NC	39.7	NC
	Diazinon	20	19	18	95	90	NC	5.41	NC
	Parathion,ethyl	20	17	17	85	85	55-138	0.0	36
	Ethion	20	17	18	85	90	NC	5.71	NC
	2,4-D	10	11.4	12.2	114	122	NC	6.78	NC
	DNBP	10	12.1	13.0	121	130	NC	7.17	NC
	Alachlor	2.0	2.1	2.0	105	100	NC	4.88	NC
	Dacthal	0.5	0.41	0.40	82	80	NC	0.25	NC
	Captan	4.0	3.9	3.8	98	95	NC	3.11	NC
	Dicofol	4.0	4.8	4.6	120	115	NC	4.26	NC
	Propanil	10	9.6	9.3	96	93	NC	3.17	NC
10/28/87	Bentazon	2.0	0.9	1.3	45	65	NC	36	NC
	Diazinon	20	19	18	95	90	NC	5.41	NC
	Parathion,ethyl	20	17	17	85	85	55-138	0.0	36
	Ethion	20	17	18	85	90	NC	5.71	NC
	2,4,5-TP/Silvex	10	11.4	12.2	114	122	72-98	6.78	23
	2,4,5-T	10	12.1	13.0	121	130	NC	7.17	NC
	Alachlor	2.0	2.1	2.0	105	100	NC	4.88	NC
	Dacthal	0.5	0.41	0.40	82	80	NC	0.25	NC
	Captan	4.0	3.9	3.8	98	95	NC	3.11	NC
	Dicofol	4.0	4.8	4.6	120	115	NC	4.26	NC
	Propanil	10.0	9.6	9.3	96	93	NC	3.17	NC
12/09/87	Alachlor	2.0	1.6	1.5	80	75	NC	6.4	NC
	Dacthal	0.5	0.40	0.39	80	78	NC	2.5	NC
	Captan	4.0	0.75	0.79	19	20	NC	5.0	NC
	Dicofol	4.0	3.0	3.3	75	85	NC	10	NC
	Carbofuran	100.0	144.0	102.0	144	102	NC	34.1	NC
	Methylparathion	20.0	22.5	14.9	112.5	74.5	NC	40.6	NC
	Diazinon	20.0	23.3	14.5	116.5	72.5	NC	46.6	NC
	Parathion	20.0	22.2	14.6	112.5	73.0	NC	42.6	NC
	Molinate	100.0	134	79.3	134.0	79.3	NC	51.2	NC
	Thiobencarb	100.0	119	86.6	119.0	86.6	NC	31.5	NC
	2,4-D	10.0	10.0	9.60	100	96.0	NC	4.08	NC
	DNBP	10.0	11.7	10.80	117	108	NC	8.00	NC
	Atrazine	2.0	1.7	3.73	85	186	NC	74.5	NC
	Simazine	2.0	1.63	3.88	81.5	194	NC	81.5	NC
	Carbaryl	50.0	43	46	86	92	102-117	7.1	11
	Bentazon	10.0	9.3	6.2	93	62	NC	40	NC

NA = Not Applicable   NC = Not Calculated   * = Recovery Outside Standard QC Limits or RPD outside QC limits

TABLE C-4 (Clayton cont.)

Date	Chemical	Concentration (ug/L)			Accuracy (%)			Precision (RPD)	
		Spiked	Test 1	Test 2	Test 1	Test 2	Limits	LCS	Limits
12/09/87	Glyphosate	6.0	5.7	5.6	95	93	NC	2.1	NC
(cont.)	Propanil	10.0	7.2	6.7	72	67	NC	7.1	NC
11/12/87	Alachlor	2.0	1.6	1.5	80	75	NC	6.4	NC
	Dacthal	0.5	0.4	0.39	80	78	60-130	2.5	NC
	Captan	4.0	0.75	0.79	19	20	NC	5.0	NC
	Dicofol	4.0	4.3	4.1	108	103	NC	4.7	NC
	Carbofuran	100.0	144.0	102	144	102	69-164	34.1	NC
	Methylparathion	20.0	22.5	14.9	112.5	74.5	NC	40.6	NC
	Diazinon	20.0	23.3	14.5	116.5	72.5	NC	46.6	NC
	Parathion	20.0	22.2	14.6	112.5	73.0	NC	42.6	NC
	Molinate	100.0	134.0	79.3	134.0	79.3	NC	51.2	NC
	Thiobencarb	100.0	119.0	86.6	119.0	86.6	NC	31.5	NC
	2,4,D	10.0	10.0	9.60	100.0	96.0	75-125	4.08	NC
	DNBP	10.0	11.7	10.80	117.0	108.0	NC	8.00	NC
	Carbaryl	50.0	43.0	46.0	86.0	92.0	102-117	7.1	11
	Bentazon	10.0	9.3	6.2	93.0	62.0	22-119	40.0	NC
	Glyphosate	6.0	5.7	5.6	95	93	NC	2.1	NC
	Propanil	10.0	7.2	9.5	72.0	95.0	NC	28.0	NC
11/17/87	Carbaryl	50.0	43.0	46.0	86.0	92.0	102-117	7.1	11
	Carbofuran	100.0	144.0	102.0	144.0	102.0	NC	34.1	NC
	Methylparathion	20.0	225.0	14.9	112.5	74.5	NC	40.6	NC
	Diazinon	20.0	23.3	14.5	116.5	72.5	17-118	46.6	21
	Ethylparathion	20.0	22.2	14.6	112.5	73.0	19-125	42.6	30
	Molinate	100.0	134.0	79.3	134.0	79.3	NC	51.2	NC
	Thiobencarb	100.0	119.0	86.6	119.0	86.6	NC	31.5	NC
	2,4-D	5.0	4.70	5.0	94.0	100.0	NC	6.18	NC
	DNBP	5.0	5.90	5.82	118	116	NC	1.71	NC
	Alachlor	2.0	1.60	1..50	80	75	NC	6.4	NC
	Dacthal	0.5	0.40	0.39	80	78	NC	2.5	NC
	Captan	4.0	0.75	0.79	19	20	NC	5.0	NC
	Dicofol	4.0	4.3	4.10	108	103	NC	4.7	NC
	Propanil	10.0	7.2	9.5	72	95	NC	28	NC
	Atrazine	2.0	1.7	3.73	85	186	NC	74.5	NC
	Simazine	2.0	1.63	3.88	81.5	194	NC	81.5	NC
	Bentazon	10.0	9.3	6.2	93	62	NC	40	NC

NA = Not Applicable   NC = Not Calculated   * = Recovery Outside Standard QC Limits or RPD outside QC limits

TABLE C-4 (cont.)

(Enseco Laboratory 1988 - 1989)

Date	Chemical	Concentration (ug/L) Spiked	Test 1	Test 2	Accuracy (%) Test 1	Test 2	Limits	Precision (RPD) LCS	Limits
08/24/88	Ordram (Molinate)	4.0	3.15	3.28	79	82	45-110	3.8	<30
	Bolero (Thiobencarb)	4.0	3.39	3.44	85	86	55-110	1.2	<30
	Diazinon	10.0	6.10	5.50	61	55	26-126	10.0	<26
	Ethyl parathion	10.0	6.34	5.73	63	57	30-125	10	<32
	Ethion	10.0	5.94	5.25	59	52	31-142	12.0	<18
	2,4-D	1.0	1.05	0.93	105	93	75-125	12.0	<20
	MCPA	200.0	180.0	198.0	90	99	75-125	9.5	<20
	Alachlor	1.0	1.98	1.86	198	186	NC	6.3	NC
	Propanil	1.0	1.92	1.42	192	142	NC	30.0	NC
	Orthene	50.0	NA	NA	NA	NA	NC	NA	NC
	Methamidophos Monitor	50.0	27.8	30.1	56	60	NC	6.9	NC
	Diazinon	10.0	6.10	5.50	61	55	26-126	10.0	<26
	Ethyl parathion	10.0	6.34	5.73	63	57	30-125	10.0	<32
	Ethion	10.0	5.94	5.24	59	52	31-142	12.0	<18
	Atrazine	2.0	1.89	1.95	95	98	NC	3.1	NC
	Simazine	2.0	2.0	2.07	100	104	NC	3.9	NC
	Carbofuran	10.0	11.5	10.3	115	103	73-116	11.0	<20
	Bentazon	10.0	8.60	9.0	86	90	65-120	4.5	<30
	Nudrin (Methomyl)	20.0	18.1	18.5	90	92	52-118	2.2	<37
	Triforine	200.0	196.0	193.0	98	96	51-127	2.1	<33
	by HPLC								
	Carbaryl	20.0	22.6	21.1	113*	106	62-111	6.4	<29
	Propham	20.0	18.3	19.4	92	97	57-122	5.3	<41
08/25/88	Ordram	4.0	3.57	3.47	89	87	45-110	2.3	<30
	Bolero (Thiobencarb)	4.0	3.79	3.68	95	92	55-110	3.2	<30
	Dinoseb	50.0	61.8	63.4	124	127	75-125	2.4	<20
	2,4-D	1.0	1.02	0.920	102	92	75-125	10.0	<20
	Gamma-BHC (Lindane)	0.200	0.156	0.144	78	72	56-123	8.0	<15
	Dieldrin	0.500	0.412	0.421	82	84	52-126	2.4	<18
	Heptachlor	0.200	0.146	0.130	73	65	40-131	12.0	<20
	Aldrin	0.200	0.148	0.139	74	70	40-120	5.6	<22
	Endrin	0.500	0.426	0.453	85	91	56-121	6.8	<21
	4,4'DDT	0.500	0.296	0.306	59	61	38-127	3.3	<27
	Diazinon	10.0	8.07	7.33	81	73	26-126	10.0	<26
	Ethyl Parathion	10.0	8.31	7.48	83	75	30-125	10.0	<32

NA = Not Applicable NC = Not Calculated * = Recovery Outside Standard QC Limits or RPD outside QC limits

TABLE C-4 (Enseco cont.)

Date	Chemical	Concentration (ug/L) Spiked	Test 1	Test 2	Accuracy (%) Test 1	Test 2	Limits	Precision (RPD) LCS	Limits
08/25/88	Ethion	10.0	8.24	6.97	82	70	31-142	16.0	<18
	Atrazine	2.0	1.79	1.74	90	87	NC	3.4	NC
	Simazine	2.0	1.85	1.79	93	90	NC	3.3	NC
	Orthene	50.0	NA	NA	NA	NA	NC	NA	NC
	Methamidophos (Monitor)	50.0	30.3	30.5	61	61	NC	0	NC
	Carbofuran (Furadan)	10.0	8.80	10.1	88	101	73-116	14.0	<20
	Bentazon	10.0	8.60	7.63	86	76	65-120	12.0	<30
	Bentazon	10.0	9.98	8.94	100	89	65-120	12.0	<30
	Carbaryl (Sevin)	10.0	8.40	8.0	84	80	62-111	4.9	<29
	Propham	10.0	9.10	9.0	91	90	57-122	1.1	<41
	Nudrin (Methomyl)	10.0	7.60	7.40	76	74	52-118	2.7	<37
	Triforine	100.0	NA	NA	NC	NC	51-127	NC	<33
	Propanil	1.0	0.792	0.789	79	79	NC	0	NC
	Alachlor	1.0	0.926	0.949	93	95	NC	1.1	NC
08/30/89	Alachlor	2.0	2.23	2.03	112	102	NC	9.0	NC
	Propanil	2.0	1.69	1.71	85	86	NC	2.0	NC
	Orthene	50.0	NA	NA	NA	NA	NC	NA	NC
	Methamidophos (Monitor)	50.0	29.1	28.3	58	57	NC	1.7	NC
	Atrazine	2.0	1.36	1.44	68	72	NC	5.7	NC
	Simazine	2.0	1.45	1.53	73	77	NC	5.3	NC
	Ordram	4.0	3.38	3.02	84	76	45-110	10.0	<30
	Bolero	4.0	3.86	3.52	96	88	55-110	8.7	<30
	Dinoseb	50.0	72.0	73.6	144*	147*	75-125	2.0	<20
	2,4-D	1.0	1.04	1.25	104	125	75-125	18.0	<20
	Diazinon	10.0	8.83	10.4	88	104	26-126	17.0	<26
	Ethyl parathion	10.0	9.38	10.8	94	108	30-125	14.0	<32
	Methyl para.	10.0	9.41	10.9	94	110	31-142	16.0	<18
	Carbofuran	10.0	11.5	10.3	115	103	73-116	11.0	<20
	Bentazon	10.0	8.60	9.0	86	90	65-120	4.5	<30
	Carbaryl	20.0	14.2	14.8	71	74	62-111	4.2	<29
	Propham	20.0	12.9	12.8	64	64	57-122	0.0	<41
	Nudrin	20.0	13.4	12.5	67	62	52-118	7.8	<37
	Triforine	200	133	139	66	70	51-127	5.9	<33

NA = Not Applicable NC = Not Calculated * = Recovery Outside Standard QC Limits or RPD outside QC limits

TABLE C-5
Quality Control/Quality Assurance
Trihalomethane Interlaboratory Comparison
(Samples Distributed 1-20-88)

Laboratory	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	Total	Average % Deviation*
EBMUD	130	170	190	60	550	
	130	170	180	59	540	
	130	170	190	63	550	
	130	170	200	64	560	
Average	130	170	190	62	550	
Standard Deviation	0	0	7	2	7	
Percent Deviation from Overall Average	-6	-3	-2	9		5
CAL ANALYTICAL	130	170	170	57	527	
	110	160	160	57	487	
	130	170	160	49	519	
	140	180	170	50	540	
Average	128	170	168	53	518	
Standard Deviation	11	7	4	4	20	
Percent Deviation from Overall Average	-8	-3	-13	-7		8
DWR - BRYTE	140	210	230	60	640	
	150	220	240	61	670	
Average	145	215	235	61	655	
Standard Deviation	5	5	5	1	15	
Percent Deviation from Overall Average	4	22	22	7		14

* - Average % deviation is an average of the 4 species "percent deviations" without consideration of their algebraic signs.

TABLE C-5 (Continued)
Quality Control/Quality Assurance
Trihalomethane Interlaboratory Comparison
(Samples Distributed 1-20-88)

Laboratory Deviation*	$CHCl_3$	$CHBrCl_2$	$CHBr_2Cl$	$CHBr_3$	Total	Average %
DOHS	130	160	180	50	520	
	130	170	190	48	540	
	130	160	180	47	520	
	120	160	180	47	510	
	130	160	190	48	530	
Average	128	162	180	50	522	
Standard Deviation	4	4	5	1	10	
Percent Deviation from Overall Average	-8	-8	-5	-16		9
CLAYTON	180	180	200	64	620	
	150	150	180	59	540	
(Trip Blank)	ND	ND	ND	ND	ND	
Average	165	165	190	62	582	
Standard Deviation	15	15	10	3	40	
Percent Deviation from Overall Average	19	-6	-2	9		9
Overall Average (Exclusive of Trip Blank)	139	176	193	57	565	

* - Average % deviation is an average of the 4 species "percent deviations" without consideration of their algebraic signs.

Appendix D

THM HOLDING TIME STUDY

EPA methods specify a two week holding time for all volatiles, including trihalomethanes. A review of laboratory QC revealed that one of our contract laboratories had held some THM samples up to seven weeks (see Appendix C). Normally, we would have rejected the data. However, in this case, it represented a significant fraction of the total data set.

A comparison of the data in question with data where the holding times were not violated revealed no apparent differences. All of the data appeared to be consistent according to station an time of year.

DWR consulted with our chemists at Bryte Laboratory and with representatives from the Department of Health Services, and with Enseco, Inc. The consensus was that the holding times specified in EPA methods were not based on actual studies, rather were set for entire classes of chemicals. Therefore, permissible holding times for THM's might be longer than the specified two weeks provided that the samples were stored properly.

Based on this preliminary assessment. DWR contacted Enseco Labs, Inc. and requested their assistance in conducting a holding time study for THMs. DWR Bryte Laboratory also agreed to participate in the study. Working with the two laboratories, the following protocol was developed.

THM HOLDING TIME PROTOCOL

Three and a half gallons of water from the station at Harvey O. Banks Pumping Plant were collected and filtered through a 45 .m Millipore filter.

The water was transported to the DWR Bryte Laboratory and spiked to exactly 100 mg/L Cl_2 and incubated for seven days in a separatory funnel with no head space. After incubation, the water was quenched in bulk with sodium thiosulfate, and mixed thoroughly. The water was collected, spiked, and quenched in bulk in order to minimize sample-to-sample variations.

The quenched water was then dispensed from the bottom of the separatory funnel into 40 ml vials. Since some the volatile THMs might be lost to the increasing head space in the separatory funnel (and to the air in the laboratory) during the transfer process, there was the potential that the concentration of THMs in the last bottle filled would be slightly less than in the first. In order to compensate for this potential systematic loss during the transfer process, the vials were filled, and placed randomly into holding trays. Enough vials were prepared for an eight week study, one set for immediate analysis. Eighteen samples (54 vials) were sent to Enseco for analysis.

Both laboratories refrigerated the bottles, and handle them normally, as if they were normal THM samples, except for the extended holding times.

The first samples were to be analyzed as soon as possible, the remainder analyzed at a rate of two samples each 7 days, at days 7, 14, 21, 28, 35, 42, 49, and 56 (eight weeks). Bottles were selected at random for analysis.

Enseco, Inc. included duplicate control samples in their quality assurance procedures. DWR Bryte included surrogate recovery samples. Both types of samples are used as a check for accuracy and precision.

There were a few deviations from the weekly analysis of samples. The first analyses were conducted (on a single sample) by Bryte on March 12, 1990 (day 0). Enseco conducted its first analyses on day 3. Bryte was unable to analyzed the samples on day 21. Bryte did not analyze the samples on day 56, but analyzed them on day 59, and analyzed a single sample on day 60.

Enseco analyzed the samples according to a modified the EPA Method 601; the same method that they had used when they were under contract to DWR. Bryte laboratory analyzed their samples according to a modified EPA method 502.2.

Both methods use a purge and trap method of extraction. However, Method 601 calls for use of a packed column and a halide specific detector. Method 502.2 calls for use of a capillary column and photoionization detector in series with an electric conductivity detector. The accuracy interval for Method 601 as used by Enseco was 80-125%, whereas the specified range is 80-120% for Method 502.2.

Use of two different methodologies was seen as a drawback, however it was felt that both methods should be capable of detecting real losses of analyte over time. Bryte's analyses, based on Method 502.2, were expected to be more sensitive than Enseco's because of the improved methodology in EPA method 502.2.

Data collected in this study and QA/QC results are summarized at the end of this appendix in Tables D-7 through D-10.

RESULTS

Statistical analysis of the data were performed with the aid of a statistical program called Statgraphics (no endorsement is implied). The data indicate that the holding time had little or no effect on the concentrations of the individual trihalomethanes. Figure D-1[1] is a graph of weekly average THM precursor concentrations vs time. Although the analyses varied from week to week, there is little discernable slope.

In many cases, analyses of the precursors appeared to increase or decrease together. For example the analyses for $CHCl_3$, $CHCl_2Br$, $CHClBr_2$, $CHBr_3$, all appear to decrease on day 28. This may be an artifact of variations in methodology, or other systematic source of variability. One possible factor was that Enseco used a different lot for it's

---

[1] *Analyses for days 0 and 3 (week 0) and for days 56 and 59 (week 8) are grouped together because of graphics software limitations. There was* <u>*no*</u> *grouping of data for the statistical analyses shown in Tables 1 through 6.*

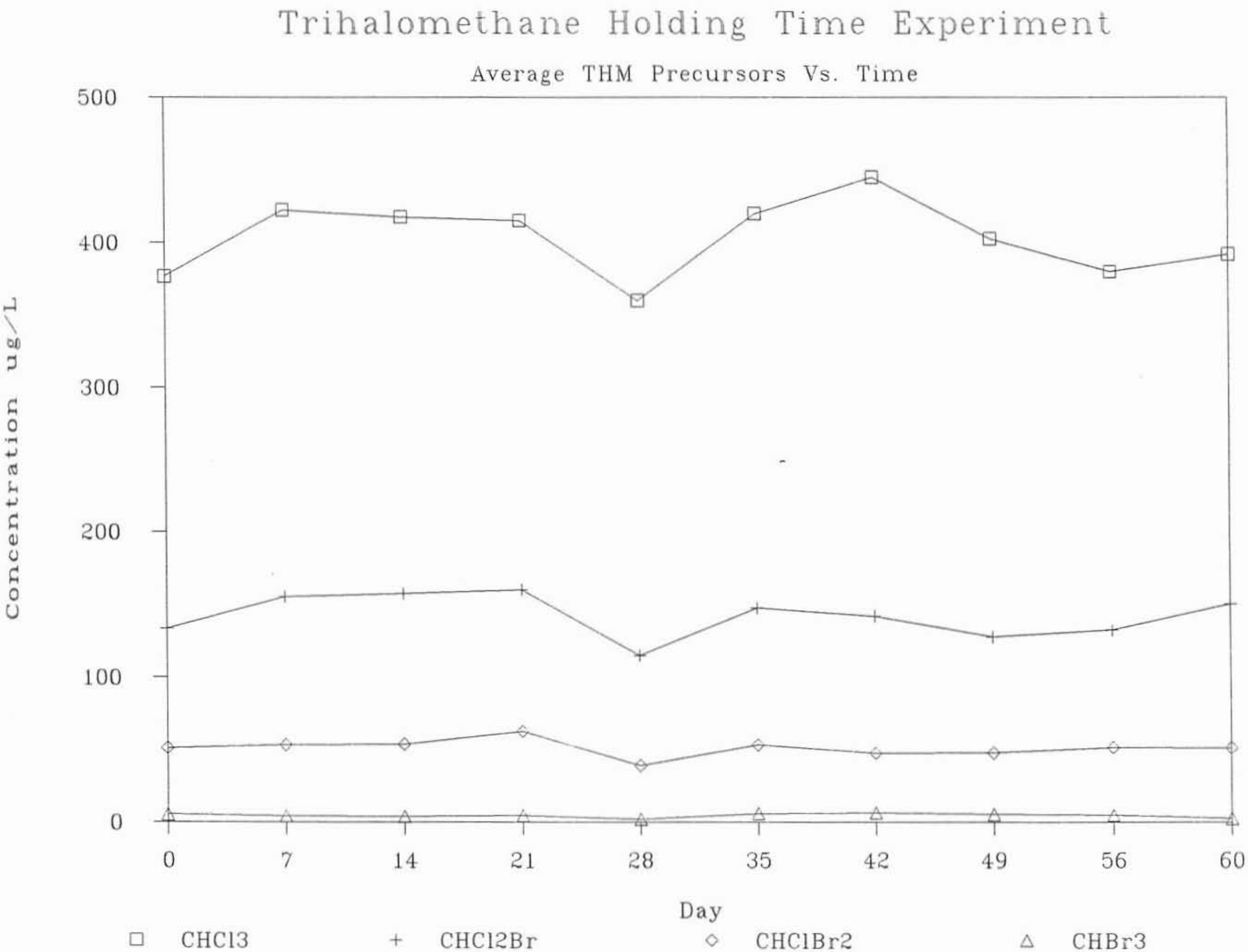
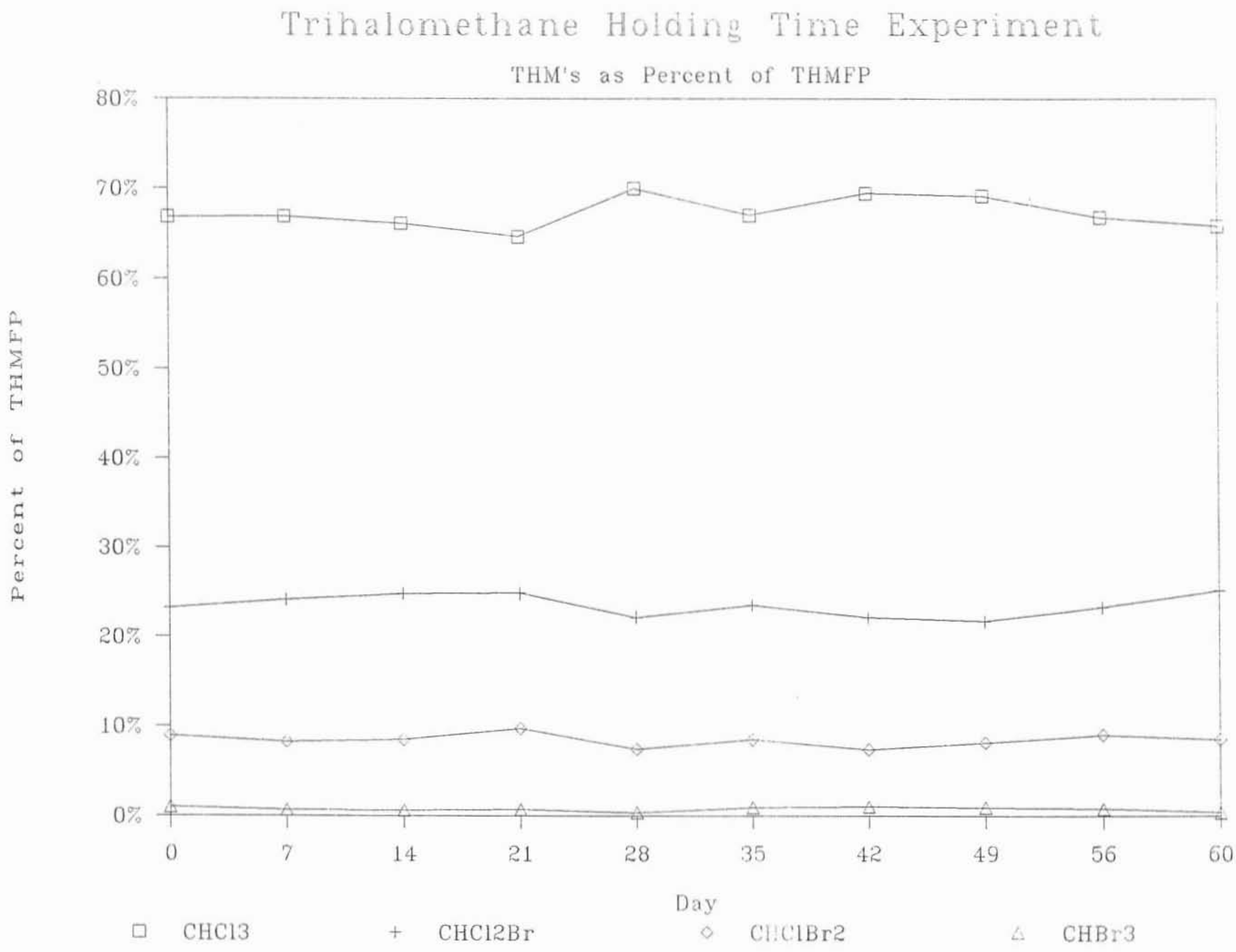

Trihalomethane Holding Time Experiment
Average THM Precursors Vs. Time
Concentration ug/L
500
400
300
200
100
0
0
7
14
21
28
35
42
49
56
60
Day
CHCl3
CHCl2Br
CHClBr2
CHBr3

Figure D-1



Trihalomethane Holding Time Experiment
THM's as Percent of THMFP
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of THMFP
0
7
14
21
28
35
42
49
56
60
Day
CHCl3
CHCl2Br
CHClBr2
CHBr3

Figure D-2

Table D-1

Statistical Comparison of $CHCL_3$ Analyses

Two-Sample Analysis Results

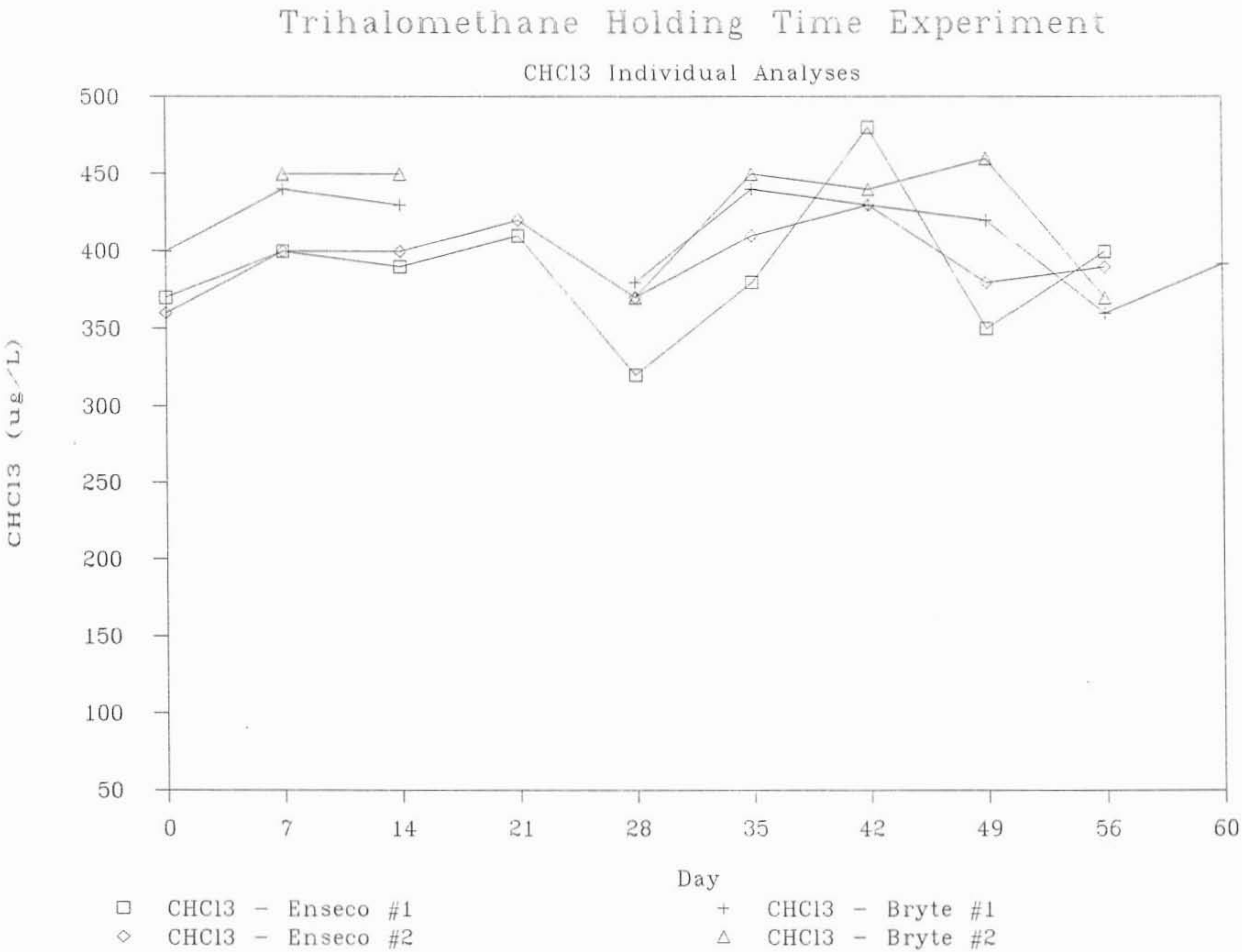
		Enseco	Bryte	Combined
Sample Statistics:	Number of Obs.	18	16	34
	Average	392.222	417.5	404.118
	Std. Deviation	34.3949	33.7639	34.1005

Difference between Means = -25.2778

Hypothesis Test for H0: Diff = 0	Computed t statistic = -2.15742
vs Alt: NE	Sig. Level = 0.0385866
at Alpha = 0.05	so reject H0.

Regression Analysis - Linear model: Y = a+bX
$CHCL_3$ vs Day

Lab	Parameter	Estimate	Standard Error	T Value	Prob. Level
Combined	Intercept	407.226	12.0153	33.8923	.00000
	Slope	-0.101732	0.335803	-0.30295	.76389
Enseco	Intercept	384.85	15.7038	24.5068	.00000
	Slope	0.260192	0.470997	0.552428	.58829
Bryte	Intercept	437.558	16.0984	27.1802	.00000
	Slope	-0.606657	0.419888	-1.44481	.17052



Trihalomethane Holding Time Experiment
CHCl3 Individual Analyses
500
450
400
350
300
250
200
150
100
50
CHCl3 (ug/L)
0
7
14
21
28
35
42
49
56
60
Day
CHCl3 - Enseco #1
CHCl3 - Enseco #2
CHCl3 - Bryte #1
CHCl3 - Bryte #2

Figure D-3

Table D-2

Statistical Comparison of $CHCL_2Br$ Analyses

Two-Sample Analysis Results

		Enseco	Bryte	Combined
Sample Statistics:	Number of Obs.	18	16	34
	Average	126.611	155.625	140.265
	Std. Deviation	19.7845	19.3111	19.564

Difference between Means = -29.0139

Hypothesis Test for H0: Diff = 0
vs Alt: NE
at Alpha = 0.05

Computed t statistic = -4.31623
Sig. Level = 1.42945E-4
so reject H0.

Regression Analysis - Linear model: Y = a+bX
$CHCL_2Br$ vs Day

Lab	Parameter	Estimate	Standard Error	T Value	Prob. Level
Combined	Intercept	149.483	7.88567	18.9563	.00000
	Slope	-0.301657	0.220388	-1.36875	.18061
Enseco	Intercept	128.546	9.10107	14.1243	.00000
	Slope	-0.0682854	0.272964	-0.250163	.80565
Bryte	Intercept	179.401	6.56639	27.3212	.00000
	Slope	-0.719136	0.171268	-4.19888	.00089

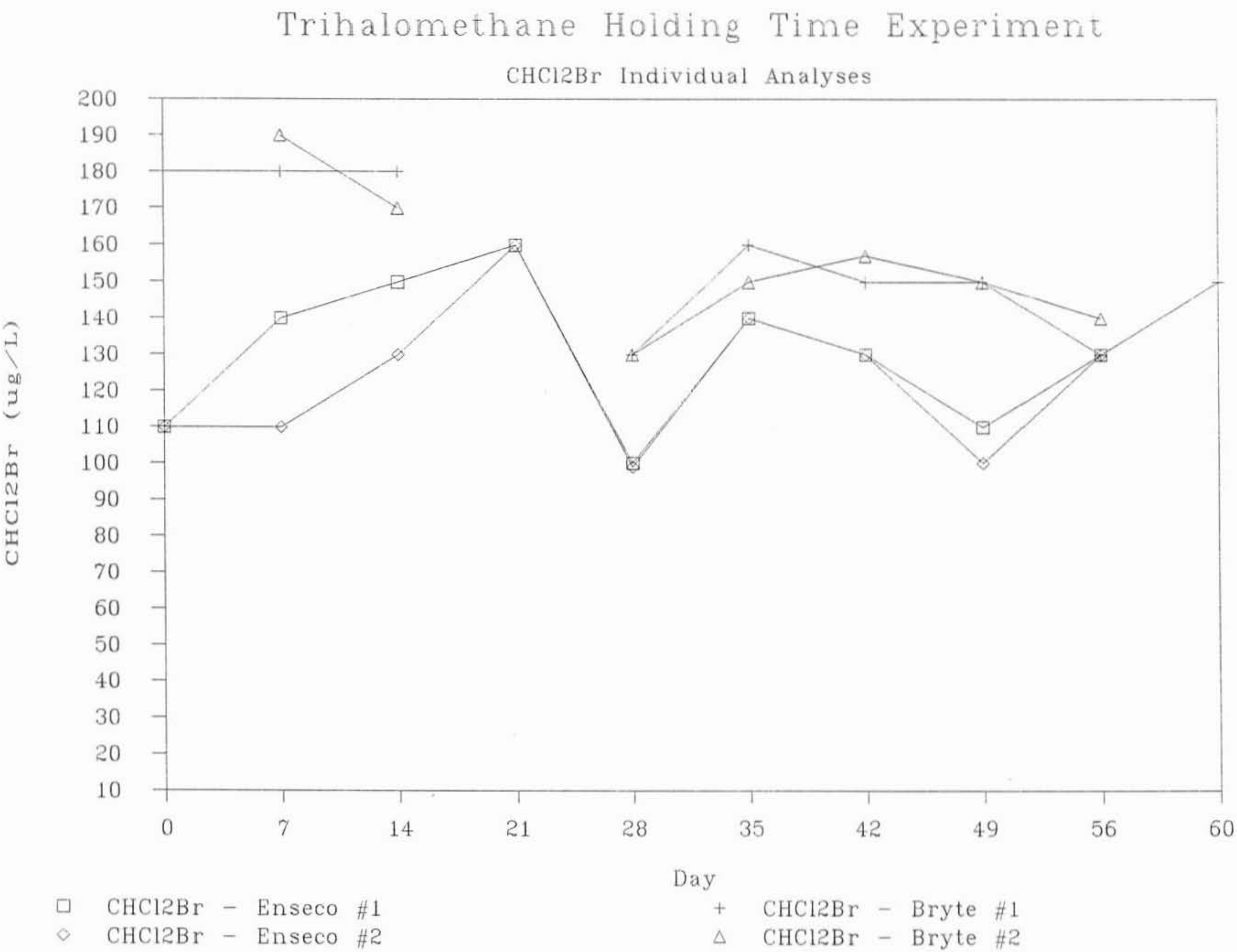

Trihalomethane Holding Time Experiment
CHCl2Br Individual Analyses
CHCl2Br (ug/L)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
7
14
21
28
35
42
49
56
60
Day
CHCl2Br - Enseco #1
CHCl2Br - Enseco #2
CHCl2Br - Bryte #1
CHCl2Br - Bryte #2

Figure D-4

standard on day 28, than for the remainder of the test. Perhaps by coincidence, the Bryte analyses were also lower than average on that date.

When the individual analyses are divided by the total THM's for that sample, and expressed as percent of total THMs, much of the variability from date to date is reduced (Figure D-2). This tends to support the idea that much of the variance seen is due to a systematic variability in the analyses.

Statistical analyses was performed for each of the THMs and for each of the laboratories. For each THM, there were 18 analyses provided by Enseco, and 16 provided by Bryte. The difference in the number of analyses is due to the fact that Bryte analyzed only one sample (instead of two) on day zero, none on day 21 and provided an extra analysis on day 60 (not in the original plan).

$_{C}HCl_3$

Enseco reported an average 392 .g/L $_{C}HCl_3$ (Table D-1, Figure A-3), Bryte reported an average 417 .g/L. Combined, the average was 404 .g/L. The standard deviation (s.d.) for all three averages was 34 .g/L. Analysis of the means revealed that the 25 .g/L difference between the means was significant at the 95% confidence level.

Regression analysis of $CHCl_3$ vs time showed a slight positive trend for the Enseco analyses and a slight negative trend for the Bryte analyses. Neither slope was significantly different from zero at the 95% probability level.

$CHCl_2Br$

Enseco reported an average 127 .g/L $_{C}HCl_2Br$ (s.d. 20 .g/L) (Table D-2, Figure D-4) Bryte reported an average 156 .g/L (s.d. 19 .g/L). The combined average was 140 .g/L (s.d. 20 .g/L). Analysis of the means revealed that the 29 .g/L difference between the means was significant at better than the 99.9% confidence level.

Regression analysis of $CHCl_2Br$ data versus time showed a slight negative trend for both laboratories. The slope for the Enseco analyses was not significant at the 95% level. The Bryte analyses showed a loss of approximately 0.7 .g/L per day (0.4%/day), significant at the 95% level. However the combined data showed no significant slope.

$CHClBr_2$

The Enseco analysis of both $CHClBr_2$ and of $CHBr_3$ showed a high variability. Enseco reported an average 47 .g/L $CHClBr_2$ (s.d. 9.1 .g/L) (Table D-3, Figure D-5) Bryte reported an average 55 .g/L (s.d. 4.1 .g/L). The combined average was 50 .g/L (s.d. 7.3 .g/L). Analysis of the means revealed that the 8 .g/L difference between the means exceeded the 99% confidence level.

Regression analysis of the $CHClBr_2$ data versus time showed a slight negative trend for both laboratories. The slope for the Enseco analyses was not significant at the 95% level. The Bryte analyses showed a loss of approximately 0.15 .g/L per day (0.25%/day), significant at the 95% level. However the combined data showed no significant slope.

Table D-3

Statistical Comparison of $CHClBr_2$ Analyses

Two-Sample Analysis Results

		Enseco	Bryte	Combined
Sample Statistics:	Number of Obs.	18	16	34
	Average	46.6667	54.5625	50.3824
	Std. Deviation	9.17157	4.14679	7.26279

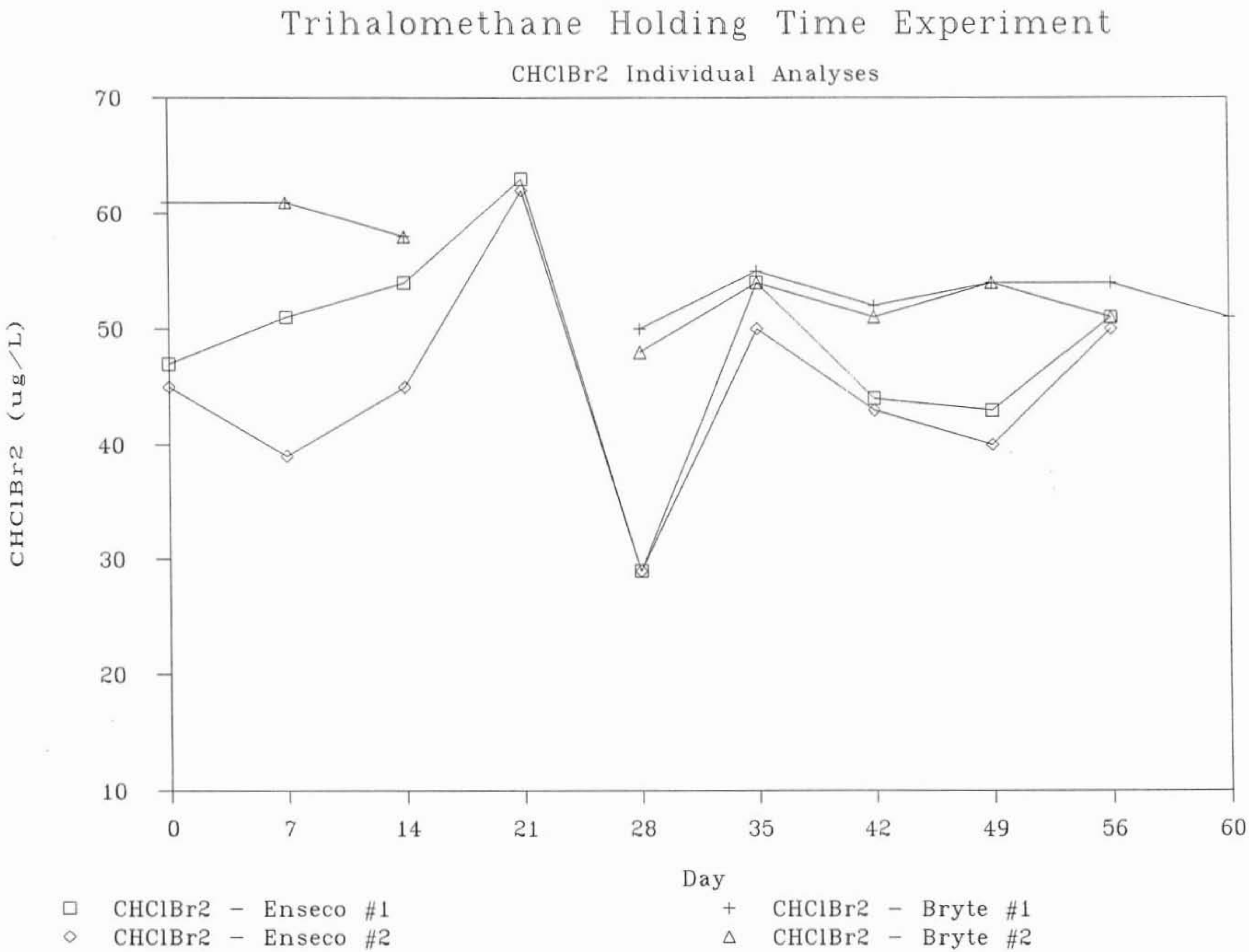
Difference between Means = -7.89583

Hypothesis Test for H0: Diff = 0
vs Alt: NE
at Alpha = 0.05

Computed t statistic = -3.16411
Sig. Level = 3.40106E-3
so reject H0.

Regression Analysis - Linear model: Y = a+bX
$CHClBr_2$ vs Day

	Parameter	Estimate	Standard Error	T Value	Prob. Level
Combined	Intercept	52.4041	2.71149	19.3267	.00000
	Slope	-0.0661606	0.0757806	-0.873054	.38914
Enseco	Intercept	47.6502	4.21734	11.2986	.00000
	Slope	-0.0347122	0.126488	-0.27443	.78727
Bryte	Intercept	59.5121	1.46251	40.6918	.00000
	Slope	-0.149705	0.038146	-3.92453	.00153



Trihalomethane Holding Time Experiment
CHClBr2 Individual Analyses
CHClBr2 (ug/L)
70
60
50
40
30
20
10
0
7
14
21
28
35
42
49
56
60
Day
CHClBr2 - Enseco #1
CHClBr2 - Enseco #2
CHClBr2 - Bryte #1
CHClBr2 - Bryte #2

Figure D-5

Table D-4

Statistical Comparison of $CHBr_3$ Analyses

Two-Sample Analysis Results

		Enseco	Bryte	Combined
Sample Statistics:	Number of Obs.	18	16	34
	Average	6.08889	2.74375	4.51471
	Std. Deviation	2.57611	0.244864	1.88512

Difference between Means = 3.34514

Hypothesis Test for H0: Diff = 0 vs Alt: NE at Alpha = 0.05

Computed t statistic = 5.16456
Sig. Level = 1.2313E-5
so reject H0.

Regression Analysis - Linear model: Y = a+bX
$CHBr_3$ vs Day

Lab	Parameter	Estimate	Standard Error	T Value	Prob. Level
Combined	Intercept	4.28738	0.840249	5.10251	.00001
	Slope	7.4391E-3	0.0234832	0.316783	.75347
Enseco	Intercept	4.74781	1.11989	4.23955	.00062
	Slope	0.0473321	0.0335882	1.40919	.17792
Bryte	Intercept	2.97157	0.103332	28.7576	.00000
	Slope	-6.89072E-3	2.69516E-3	-2.55671	.02282

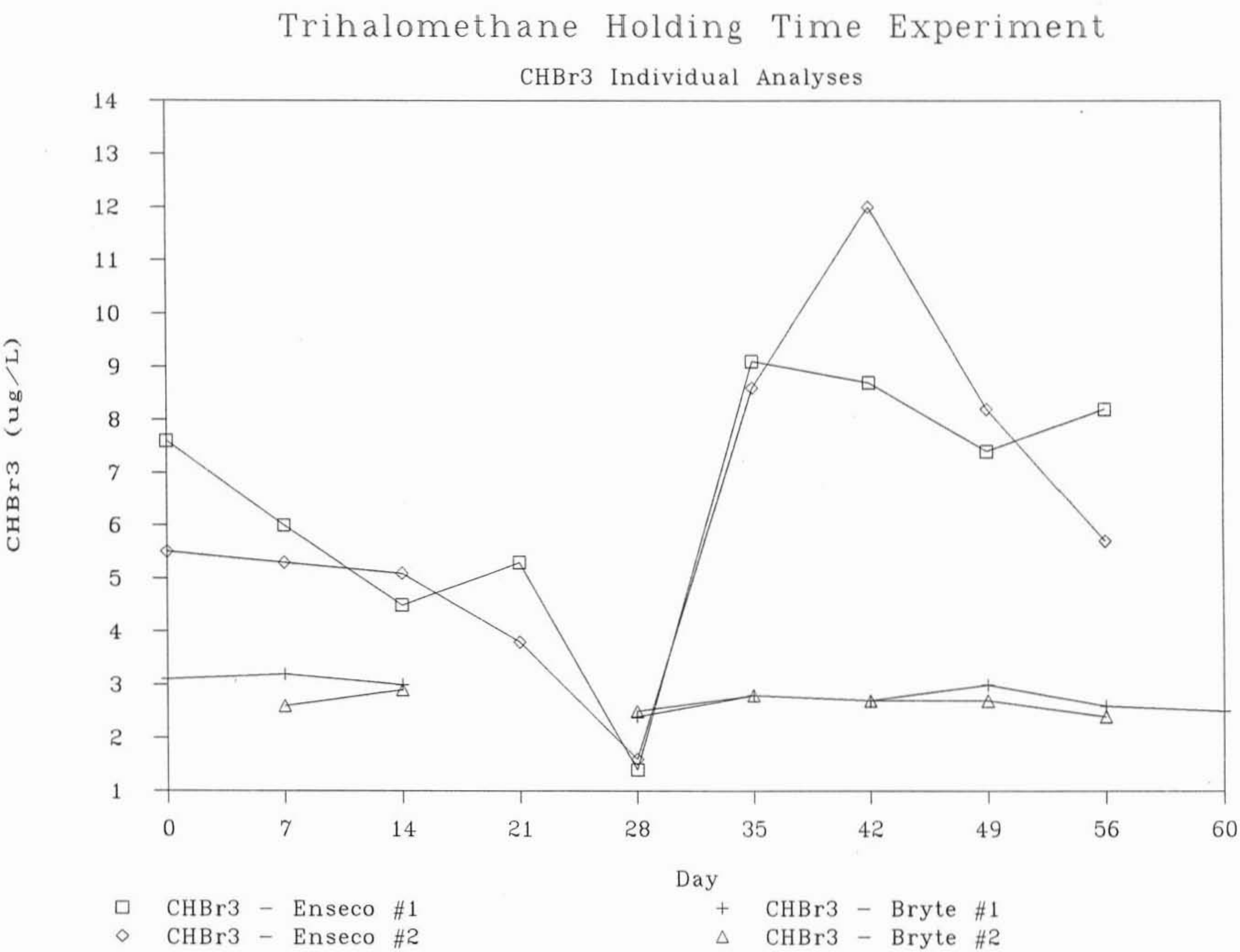

Trihalomethane Holding Time Experiment
CHBr3 Individual Analyses
CHBr3 (ug/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
7
14
21
28
35
42
49
56
60
Day
CHBr3 - Enseco #1
CHBr3 - Enseco #2
CHBr3 - Bryte #1
CHBr3 - Bryte #2

Figure D-6

Table D-5

Statistical Comparison of THMFP

Two-Sample Analysis Results

		Enseco	Bryte	Combined
Sample Statistics:	Number of Obs.	18	16	34
	Average	571.589	630.431	599.279
	Std. Deviation	55.8271	51.3111	53.7575

Difference between Means = -58.8424

Hypothesis Test for H0: Diff = 0
vs Alt: NE
at Alpha = 0.05

Computed t statistic = -3.18572
Sig. Level = 3.21441E-3
so reject H0.

Regression Analysis - Linear model: Y = a+bX
THMFP vs Day

Lab	Parameter	Estimate	Standard Error	T Value	Prob. Level
Combined	Intercept	613.401	20.1295	30.4728	.00000
	Slope	-0.46211	0.562578	-0.821415	.41749
Enseco	Intercept	565.794	25.6746	22.0371	.00000
	Slope	0.204526	0.770046	0.265603	.79394
Bryte	Intercept	679.443	21.3786	31.7814	.00000
	Slope	-1.48239	0.557609	-2.65847	.01872

$CHBr_3$

Enseco reported an average 6.1 .g/L $CHBr_3$ (s.d. 2.6 .g/L) (Table D-4, Figure D-6) Bryte reported an average 2.7 .g/L (s.d. 0.2 .g/L). The combined average was 4.5 .g/L (s.d. 1.9 .g/L). Analysis of the means revealed that the 3.3 .g/L difference between the means exceeded the 99.9% confidence level.

Regression analysis of the $CHBr_3$ data versus time showed a slight positive trend for Enseco and both laboratories combined. The slopes for the Enseco analyses and combined analyses were not significant at the 95% level. The Bryte analyses showed a loss of approximately .007 .g/L per day (0.2%/day), significant at the 95% level.

THMFP

THMFP is the sum of the four THMs. THMFP is used for most of the interpretive analysis found in this report. A comparison of the mean THMFP reported by the two laboratories shows that Bryte reported an average 630 .g/L (s.d. 51 .g/L), Enseco reported and average 571 .g/L (s.d. 56 .g/L), and that the combined average THMFP was 599 .g/L (s.d. 54 .g/L) (Table D-5). The 59 .g/L difference between the two laboratories was significantly above the 99% confidence level. Regression analysis of THMFP versus time showed a slight negative trend for Enseco and combined data. The Bryte THMFP showed a loss of approximately 1.5 .g/L per day (0.2%/day), significant at the 95% level.

Table D-6

Estimation of Holding Time Limits
Based on Bryte Results

THM	Starting Concentration (Intercept)	Loss Per Day L (g/L/day)	Standard Deviation s (g/L)	Estimated Holding Time Limit[2] 3s/L
$CHCl_3$	437	no significant loss	34	not determined
$CHCl_2Br$	179	0.72	19.3	80 days
$CHClBr_2$	59.5	0.15	4.1	82 days
$CHBr_3$	3.0	.007	0.24	103 days

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2 Based on John K. Taylor, Quality Assurance of Chemical Measurements, c.1987, Lewis Publishers, Inc.

HOLDING TIME CALCULATIONS

Holding time estimates were calculated based on the methodology described in "Quality Assurance of Chemical Measurements" c.1987, by John K. Taylor. According to Taylor, the acceptable holding time (with 95% confidence) equals the period necessary for the concentration of the sample to change by 3 standard deviations (3s). This was calculated by comparing the calculated slope of the concentration to the calculated standard deviation.

Holding time estimates for this study were based entirely on Bryte analyses, since only those analyses showed a statistically significant loss over the period of the experiment. Calculated holding time estimates are summarized in table D-6.

Estimated holding time limits for $CHCL_3$ could not be determined in this study. However, they exceed the 49 day holding time in our field data. Estimated holding times for $CHCl_2Br$ and $CHClBr_2$ are approximately 80 days. The holding time for $CHClBr_3$ may exceed 100 days.

DISCUSSION

The holding time experiment shows some significant differences between the different analytical protocols used, and perhaps some differences between the two participating laboratories. The modified EPA Method 502.2 used by Bryte laboratory appears to provide more consistent, less variable results, particularly for $CHCl_2Br$ and $_CHBr_3$. Also, except for $CHBr_3$, Bryte reported higher average concentrations than Enseco. The average $CHBr_3$ reported by Enseco was higher, but the variance (as expressed by s.d.) exceeded the average. As we begin to take a more careful look at bromides in the Delta, EPA Method 502.2 will provide us with the best data.

As for the effect of holding time on THM's, the results vary by laboratory. There is no measurable loss of $CHCL_3$ over the period of the holding time experiment. However, we were able to measure a loss of brominated THMs over time.

When the Bryte analyses are considered alone, all of the brominated THM's appear to be losing from 0.2 to 0.4% per day. The calculated holding times for $CHCl_2Br$ and $CHClBr_2$ were about 80 days, and for $CHBr_3$ about 100 days. Analysis for THMFP sould be limited to an 80 day holding period.

CONCLUSIONS

The primary objective of this holding time experiment was to validate or reject analytical results from samples which were held up to 49 days, as compared to the established 14 dy EPA holding time protocol for THM analyses. This study showed that holding times up to 80 days are permissible for analysis of THMFP. Therefore the analytical results which were held up to 49 days are valid.

DWR will continue to follow the recommended holding times specified by EPA Methodology. However, in cases where holding time requirements are unavoidably exceeded, samples held up to 80 days should produce valid data, as long as the samples are properly stored, as defined by EPA protocol.

Table D-7 THM Holding Time Data
Units: µg/L

THM	Lab/Sample	Day 0	3	7	14	21	28	35	42	49	56	59	60
$CHCl_3$	Enseco 1		370*	400	390	410	320	380	480	350	400*		
	Enseco 2		360*	400	400	420	370	410	430	380	390*		
	Bryte 1	400*		440	430		380	440	430	420		360*	392
	Bryte 2			450	450		370	450	440			460*	370
	Avg.		377*	423	418	415	360	420	445	403	380*		392
	High		400*	450	450	420	380	450	480	460	400*		392
	Low		360*	400	390	410	320	380	430	350	360*		392
	Bryte Avg		400*	445	440		375	445	435	440	365*		392
	Enseco Avg		365*	400	395	415	345	395	455	365	395*		
$CHCl_2Br$	Enseco 1		110*	140	150	160	100	140	130	110	130*		
	Enseco 2		110*	110	130	160	99	140	130	100	130*		
	Bryte 1	180*		180	180		130	160	150	150		130*	150
	Bryte 2			190	170		130	150	157	150		140*	
	Avg.		133*	155	158	160	115	148	142	128	133*		150
	High		180*	190	180	160	130	160	157	150	140*		150
	Low		110*	110	130	160	99	140	130	100	130*		150
	Bryte Avg		180*	185	175		130	155	153.5	150	135*		150
	Enseco Avg		110*	125	140	160	99.5	140	130	105	130*		
$CHClBr_2$	Enseco 1		47*	51	54	63	29	54	44	43	51*		
	Enseco 2		45*	39	45	62	29	50	43	40	50*		
	Bryte 1	61*		61	58		50	55	52	54		54*	51
	Bryte 2			61	58		48	54	51	54		51*	
	Avg.		51*	53	54	63	39	53	48	48	52*		51
	High		61*	61	58	63	50	55	52	54	54*		51
	Low		45*	39	45	62	29	50	43	40	50*		51
	Bryte Avg		61*	61	58		49	54.5	51.5	54	52.5*		51
	Enseco Avg		46*	45	49.5	62.5	29	52	43.5	41.5	50.5*		
$CHBr_3$	Enseco 1		7.6*	6	4.5	5.3	1.4	9.1	8.7	7.4	8.2*		
	Enseco 2		5.5*	5.3	5.1	3.8	1.6	8.6	12	8.2	5.7*		
	Bryte 1	3.1*		3.2	3		2.4	2.8	2.7	3		2.6*	2.5
	Bryte 2			2.6	2.9		2.5	2.8	2.7	2.7		2.4*	
	Avg.		5.4*	4.3	3.9	4.6	2.0	5.8	6.5	5.3	4.7*		2.5
	High		7.6*	6.0	5.1	5.3	2.5	9.1	12.0	8.2	8.2*		2.5
	Low		3.1*	2.6	2.9	3.8	1.4	2.8	2.7	2.7	2.4*		2.5
	Bryte Avg		3.1*	2.9	3.0		2.5	2.8	2.7	2.9	2.5*		2.5
	Enseco Avg		6.6*	5.7	4.8	4.6	1.5	8.9	10.4	7.8	7.0*		
Total (THMFP)	Enseco 1		535*	597	599	638	450	583	663	510	589*		
	Enseco 2		521*	554	580	646	500	609	615	528	576*		
	Bryte 1	644*		684	671		562	658	635	627		547*	596
	Bryte 2			704	681		551	657	651	667		563*	
	Avg.		566*	635	633	642	516	627	641	583	569*		596
	High		644*	704	681	646	562	658	663	667	589*		596
	Low		521*	554	580	638	450	583	615	510	547*		596
	Bryte Avg		644*	694	676		556	657	643	647	555*		596
	Enseco Avg		528*	576	589	642	475	596	639	519	582*		

* Enseco Laboratory performed their first analyses on day 3, instead of day 0. Bryte Laboratory performed their last analyses on days 59 and 60. In order to simplify Figures 1 through 6 (caused by graphics software limitations), analyses for week 0 (days 0 and 3) and for week 8 (days 56 and 59) are grouped together. Missing values indicate that no analysis was performed. There was <u>no</u> grouping of data for the statistical analyses.

Table D-8 THM Holding Time Data
Units: Percent of Total THMFP

THM	Lab/Sample	Day 0	3	7	14	21	28	35	42	49	56	59	60
$CHCl_3$	Enseco 1		69.2%*	67.0%	65.2%	64.2%	71.0%	65.2%	72.4%	68.6%	67.9%*		
	Enseco 2		69.2%*	72.2%	69.0%	65.0%	74.1%	67.4%	69.9%	71.9%	67.7%*		
	Bryte 1	62.1%*		64.3%	64.1%		67.6%	66.9%	67.7%	67.0%		65.9%*	65.8%
	Bryte 2			64.0%	66.1%		67.2%	68.5%	67.6%	69.0%		65.7%*	
	Avg.		66.8%*	66.9%	66.1%	64.6%	70.0%	67.0%	69.4%	69.1%	66.8%*		65.8%
	High		69.2%*	72.2%	69.0%	65.0%	74.1%	68.5%	72.4%	71.9%	67.9%*		65.8%
	Low		62.1%*	64.0%	64.1%	64.2%	67.2%	65.2%	67.6%	67.0%	65.7%*		65.8%
	Bryte Avg		62.1%*	64.1%	65.1%		67.4%	67.7%	67.7%	68.0%	65.8%*		65.8%
	Enseco Avg		69.2%*	69.6%	67.1%	64.6%	72.6%	66.3%	71.2%	70.3%	67.8%*		
$CHCl_2Br$	Enseco 1		20.6%*	23.5%	25.1%	25.1%	22.2%	24.0%	19.6%	21.6%	22.1%*		
	Enseco 2		21.1%*	19.8%	22.4%	24.8%	19.8%	23.0%	21.1%	18.9%	22.6%*		
	Bryte 1	27.9%*		26.3%	26.8%		23.1%	24.3%	23.6%	23.9%		23.8%*	25.2%
	Bryte 2			27.0%	25.0%		23.6%	22.8%	24.1%	22.5%		24.8%*	
	Avg.		23.2%*	24.2%	24.8%	24.9%	22.2%	23.5%	22.1%	21.7%	23.3%*		25.2%
	High		27.9%*	27.0%	26.8%	25.1%	23.6%	24.3%	24.1%	23.9%	24.8%*		25.2%
	Low		20.6%*	19.8%	22.4%	24.8%	19.8%	23.0%	19.6%	18.9%	22.1%*		25.2%
	Bryte Avg		27.9%*	26.7%	25.9%		23.4%	23.6%	23.9%	23.2%	24.3%*		25.2%
	Enseco Avg		20.9%*	21.6%	23.7%	24.9%	21.0%	23.5%	20.4%	20.2%	22.3%*		
$CHClBr_2$	Enseco 1		8.8%*	8.5%	9.0%	9.9%	6.4%	9.3%	6.6%	8.4%	8.7%*		
	Enseco 2		8.6%*	7.0%	7.8%	9.6%	5.8%	8.2%	7.0%	7.6%	8.7%*		
	Bryte 1	9.5%*		8.9%	8.6%		8.9%	8.4%	8.2%	8.6%		9.9%*	8.6%
	Bryte 2			8.7%	8.5%		8.7%	8.2%	7.8%	8.1%		9.1%*	
	Avg.		9.0%*	8.3%	8.5%	9.7%	7.5%	8.5%	7.4%	8.2%	9.1%*		8.6%
	High		9.5%*	8.9%	9.0%	9.9%	8.9%	9.3%	8.2%	8.6%	9.9%*		8.6%
	Low		8.6%*	7.0%	7.8%	9.6%	5.8%	8.2%	6.6%	7.6%	8.7%*		8.6%
	Bryte Avg		9.5%*	8.8%	8.6%		8.8%	8.3%	8.0%	8.4%	9.5%*		8.6%
	Enseco Avg		8.7%*	7.8%	8.4%	9.7%	6.1%	8.7%	6.8%	8.0%	8.7%*		
$CHBr_3$	Enseco 1		1.4%*	1.0%	0.8%	0.8%	0.3%	1.6%	1.3%	1.4%	1.4%*		
	Enseco 2		1.1%*	1.0%	0.9%	0.6%	0.3%	1.4%	2.0%	1.6%	1.0%*		
	Bryte 1	0.5%*		0.5%	0.4%		0.4%	0.4%	0.4%	0.5%		0.5%*	0.4%
	Bryte 2			0.4%	0.4%		0.5%	0.4%	0.4%	0.4%		0.4%*	
	Avg.		1.0%*	0.7%	0.6%	0.7%	0.4%	1.0%	1.0%	1.0%	0.8%*		0.4%
	High		1.4%*	1.0%	0.9%	0.8%	0.5%	1.6%	2.0%	1.6%	1.4%*		0.4%
	Low		0.5%*	0.5%	0.4%	0.6%	0.3%	0.4%	0.4%	0.5%	0.5%*		0.4%
	Bryte Avg		0.5%*	0.4%	0.4%		0.4%	0.4%	0.4%	0.4%	0.5%*		0.4%
	Enseco Avg		1.2%*	1.0%	0.8%	0.7%	0.3%	1.5%	1.6%	1.5%	1.2%*		
Total (THMFP)	Enseco 1		100.0%*	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%*		
	Enseco 2		100.0%*	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%*		
	Bryte 1	100.0%*		100.0%	100.0%		100.0%	100.0%	100.0%	100.0%		100.0%*	100.0%
	Bryte 2			100.0%	100.0%		100.0%	100.0%	100.0%	100.0%		100.0%*	
	Avg.		100.0%*	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%*		100.0%
	High		100.0%*	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%*		100.0%
	Low		100.0%*	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%*		100.0%
	Bryte Avg		100.0%*	100.0%	100.0%		100.0%	100.0%	100.0%	100.0%	100.0%*		100.0%
	Enseco Avg		100.0%*	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%*		

* Enseco Laboratory performed their first analyses on day 3, instead of day 0. Bryte Laboratory performed their last analyses on days 59 and 60. In order to simplify Figures 1 through 6 (caused by graphics software limitations), analyses for week 0 (days 0 and 3) and for week 8 (days 56 and 59) are grouped together. Missing values indicate that no analysis was performed. There was no grouping of data for the statistical analyses.

TABLE D-9 - SPIKED DUPLICATE ANALYSES FOR THM
HOLDING TIME STUDY
(Enseco, Inc.)

Date	Day	Chemical	Concentration µg/L			Accuracy (%)			Precision (RPD)	
			Spiked	Test 1	Test 2	Test 1	Test 2	Limits	LCS	Limits
3/12/90	0	Chloroform	5.0	5.11	5.18	102	104	80-125	1.4	<22
		Bromodichloromethane	5.0	5.42	5.66	108	113	80-125	4.3	<22
		Dibromochloromethane	5.0	5.53	5.83	111	117	80-125	5.3	<22
		Bromoform	5.0	5.16	5.08	103	102	80-125	1.6	<22
3/16/90	4	Chloroform	10.0	9.87	9.92	99	99	80-125	0.5	<22
		Bromodichloromethane	10.0	10.5	9.89	105	99	80-125	6.0	<22
		Dibromochloromethane	10.0	10.1	10.2	101	102	80-125	1.0	<22
		Bromoform	10.0	10.7	10.6	107	106	80-125	0.9	<22
3/23/90	11	Chloroform	10.0	9.17	9.26	92	93	80-125	1.0	<22
		Bromodichloromethane	10.0	10.9	11.1	109	111	80-125	1.8	<22
		Dibromochloromethane	10.0	10.9	12.0	109	120	80-125	9.6	<22
		Bromoform	10.0	10.7	11.6	107	116	80-125	8.1	<22
3/30/90	18	Chloroform	10.0	9.18	9.00	92	90	80-125	2.0	<22
		Bromodichloromethane	10.0	11.0	10.7	110	107	80-125	2.8	<22
		Dibromochloromethane	10.0	10.9	10.6	109	106	80-125	2.8	<22
		Bromoform	10.0	11.2	10.8	112	108	80-125	3.6	<22
4-6-90	25	Chloroform	5.0	4.58	4.55	92	91	80-125	0.7	<22
		Bromodichloromethane	10.0	10.4	10.3	104	103	80-125	1.0	<22
		Dibromochloromethane	10.0	10.6	11.1	106	111	80-125	4.6	<22
		Bromoform	20.0	23.3	23.9	116	120	80-125	2.5	<22
4/13/90	32	Chloroform	10.0	9.75	9.91	97	99	80-125	1.6	<22
		Bromodichloromethane	10.0	10.2	10.5	102	105	80-125	2.9	<22
		Dibromochloromethane	10.0	10.1	10.2	101	102	80-125	1.0	<22
		Bromoform	10.0	9.49	10.6	95	106	80-125	11	<22
4/20/90	39	Chloroform	10.0	9.22	9.35	92	93	80-125	1.4	<22
		Bromodichloromethane	10.0	10.5	10.2	105	102	80-125	2.9	<22
		Dibromochloromethane	10.0	10.4	10.5	104	105	80-125	1.0	<22
		Bromoform	10.0	10.6	10.6	106	106	80-125	0.0	<22
4/27/90	46	Chloroform	10.0	8.95	8.93	89	89	80-125	0.2	<22
		Bromodichloromethane	10.0	10.0	10.3	100	103	80-125	3.0	<22
		Dibromochloromethane	10.0	9.62	10.9	96	109	80-125	12	<22
		Bromoform	10.0	10.8	11.0	108	110	80-125	1.8	<22
5/4/90	53	Chloroform	10.0	8.92	8.98	89	90	80-125	0.7	<22
		Bromodichloromethane	10.0	10.4	9.20	104	92	80-125	12	<22
		Dibromochloromethane	10.0	10.1	10.3	101	103	80-125	2.0	<22
		Bromoform	10.0	9.92	9.20	99	92	80-125	7.5	<22

TABLE D-10

SURROGATE ANALYSES[1] FOR THM
HOLDING TIME STUDY

(DWR-Bryte Laboratory)

Date	Day	Chemical	Concentration (µg/L)				Accuracy (%)			Precision (RPD)	
			Spiked	Dil	Test 1	Test 2	Test 1	Test 2	Limits	LCS	Limits
3/9/90	0	Bromochloropropane	5	0	5.16		99.4		80-120		
				1/5	4.97		103		80-120		
3/16/90	7	Bromochloropropane	5	0	5.25	5.23	105	105	80-120	0	<20%
				0	4.92	5.12	98	102	80-120	4.0	<20%
				1/5	5.12	5.63	102	113	80-120	9.5	<20%
				1/5	5.22	5.78	104	116	80-120	10.2	<20%
3/23/90	14	Bromochloropropane	5	0	4.80	4.60	96	92	80-120	4.3	<20%
				1/5	5.15	5.12	103	102	80-120	0.58	<20%
3/30/90	21	(No results: bad internal standard from supplier)									
4-6-90	28	Bromochloropropane	5	0	5.46	4.99	109	100	80-120	9.0	<20%
				1/5	5.71	5.51	114	110	80-120	3.6	<20%
4/13/90	35	Bromochloropropane	5	0	5.09	5.12	102	102	80-120	0.59	<20%
				1/10	5.41	5.52	108	110	80-120	2.0	<20%
4/20/90	42	Bromochloropropane	5	0	4.98	5.03	100	101	80-120	1.0	<20%
				1/10	5.27	5.41	105	108	80-120	2.6	<20%
4/27/90	49	Bromochloropropane	5	0	5.04	5.04	101	101	80-120	0	<20%
				1/10	5.17	5.33	103	107	80-120	3.0	<20%
5/7/90	59	Bromochloropropane	5	0	4.83	4.80	97	96	80-120	0.6	<20%
				1/10	4.87	4.83	97	97	80-120	0.8	<20%
5/8/90	60	Bromochloropropane	(only % recovery given)				101	94	80-120		

Dil = dilution

µg/L = micrograms per liter (ppb)

1 Surrogate recovery involved a surrogate analyte, bromochloropropane, which is extremely unlikely to be found in any sample, and which was added to sample aliquots in known amounts before extraction. It is measured using the same methods as used for THM precursors. The purpose of the surrogate is to monitor method performance with each sample.

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