APPENDIX B

RECEIVING WATER QUALITY COMPLIANCE
(NUTRIENT, DISSOLVED OXYGEN, TEMPERATURE, SALINITY AND pH)

Receiving Water Quality Data

Appendix B contains statistical summaries, in tables and charts, which demonstrate compliance with the State of Hawaii Water Quality Standards. The information in this appendix supports the City's answers in the questionnaire in Volume I of the Honouliuli 301(h) permit reapplication.

The water quality data consist of measurements performed by the City in the vicinity of the Barbers Point Ocean Outfall. Water quality parameters that are being evaluated for compliance include Total Nitrogen, Ammonia Nitrogen, Nitrate + Nitrite, Total Phosphorus, Light Extinction Coefficient, Chlorophyll a, Turbidity, pH, temperature, salinity and dissolved oxygen content.

In the 1995 Honouliuli 301(h) NPDES permit reapplication, the period reviewed for compliance with the State Water Quality Standards was from September 17, 1990, through July 10, 1995, for each of the quarterly surveys. The data provided in this Appendix will support compliance from 1995 through 2003.

CHAPTER 5
NUTRIENT EVALUATION

5.1 INTRODUCTION

All nearshore and offshore parameters were monitored during the 1994 monitoring year to demonstrate that receiving water limitations (Sections B.2 and B.3) of the permit are not being violated. The 1994, offshore monitoring dates were January 10, April 14, July 15 and November 3, 1994. All monitoring stations and protocols have not changed from the previous monitoring year. See Figure 5-1, page 5-13, for the locations of all ocean monitoring stations.

The receiving waters of the Honouliuli WWTP are classified as "Class A" "Dry" "Open Coastal Waters." In part, the State Water Quality Standard (State WQS) states the following limits (see Reference 1, Appendix G), note the double-asterisked applies:

§11-54-06 Uses and specific criteria applicable to marine waters. (b) Open coastal waters. (3) The following criteria are specific for open coastal waters: (Note that criteria for open coastal waters differ, based on fresh water discharge).

TABLE 5-1
MARINE WATER CRITERIA

	Geometric mean not to exceed the given value	*Not to exceed the given value more than ten percent of the time*	*Not to exceed the given value more than two percent of the time*
Total Nitrogen (μg N/L)	*150.00** *110.00***	*250.00** *180.00***	*350.00** *250.00**

TABLE 5-1
MARINE WATER CRITERIA

	Geometric mean not to exceed the given value	*Not to exceed the given value more than ten percent of the time*	*Not to exceed the given value more than two percent of the time*
Ammonia Nitrogen (μg NH_4-N/L)	*3.50* *2.00***	*8.50* *5.00***	*15.00* *9.00***
Nitrate + Nitrite (μg $[NO_3+NO_2]$ - N/L)	*5.00* *3.50***	*14.00* *10.00***	*25.00* *20.00***
Total Phosphorus (μg P/L)	*20.00* *16.00***	*40.00* *30.00***	*60.00* *45.00***
Light Extinction Coefficient (k units)	*0.20* *0.10***	*0.50* *0.30***	*0.85* *0.55***
Chlorophyll a (μg/L)	*0.30* *0.15***	*0.90* *0.50***	*1.75* *1.00***
Turbidity (NTU)	*0.50* *0.20***	*1.25* *0.50***	*2.00* *1.00***

** "Wet" criteria apply when the open coastal waters receive more than three million gallons per day of fresh water discharge per shoreline mile.*

*** "Dry" criteria apply when the open coastal waters receive less than three million gallons per day of fresh water discharge per shoreline mile.*

** Light extinction coefficient (LEC) is only required for dischargers who have obtained a waiver pursuant to Section 301(h) of the Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251), as amended, and are required by EPA to monitor it.*

Before compliance with the nutrient limits of Table 5-1 can be demonstrated, several procedural details must be defined. These include the methodology used to determine exceedences with each category (e.g., geometric mean, not to exceed 10% and not to exceed 2%); the selection of monitoring stations from which data was obtained and applied to determine compliance; the depths from which data was gathered; and the monitoring duration required for the compliance methodology. These details were obtained from Reference 2 (see Appendix G) and permit requirements which specify monitoring conditions.

5.2 METHODOLOGY

The methodology is based on the assumption that the data follows a lognormal distribution. Exceedences with the three compliance categories (e.g., geometric mean, not to exceed 10% and not to exceed 2%) for any parameter is done by using a graphical method, or probability plots.

By adhering to the following procedure, exceedences with any of the above StateWQS nutrient limits can be determined. We begin by establishing a work sheet.

a. In column (1) of the work sheet, number the rows from 1 to n, where n is the number of data points to be used in the compliance determination. See Table 5-2 for a sample worksheet.

b. List the data for a particular parameter (e.g., turbidity) as received in column (2). The data should include all applicable stations in the monitoring program with samples taken no deeper than 30 meters (because the State WQS were established from data taken no deeper than 30 meters). Control station data should not be included in the analysis. Furthermore, the data used should be taken over a time period of at least one year. The size of the data base should exceed thirty (30) data points, or $n \geq 30$. Larger data bases are suggested to increase statistical confidence.

c. Order the data in column (2) from smallest to largest into column (3).

d. Take the natural logarithms of the ordered data from column 3 and list these values in column (4). It doesn't matter what type of logarithm is used provided consistency is maintained. The natural logarithm is specified for consistency.

e. Find the mean and sample standard deviation of the natural logarithm values in column (4).

Mean:

$$\bar{z} = \sum \ln(x_i)/n$$

Sample standard deviation:

$$s = \sqrt{\sum (z_i - \bar{z})^2/(n-1)}$$

where both summations go from i = 1 to n.

f. To calculate the geometric mean (or 50% value) concentration, take the antilog of the mean natural logarithm value from step "e" above.

$$GM = e^{\bar{z}}$$

Multiply and divide the geometric mean value by the antilog of the sample standard deviation from step "e" to define the concentrations associated with 84% and 16%, respectively.

$$z = GM \times e^{s_z}$$

$$z = GM/e^{s_z}$$

Plot these three points [(GM, 50%), ($Z_{84\%}$, 84%), and ($Z_{16\%}$,16%)] on Log-Probability paper. A line drawn through the three points should be a straight line. Identify this line as the *calculated line*. Plot, on the same graph, the three points (or criteria for 50%, 90%, 98%)

from the State WQS for the parameter in question, connecting the points with a straight line. Identify the resulting line as the *standard line*. Compare both lines. If the *calculated line* is entirely below the *standard line*, the water quality parameters for the 50%, 90%, and 98% criteria have not been exceeded. In other words, comparison of both lines is the method used to determine exceedences with the standard, not an individual data point. From the *calculated line*, determine the parameter values corresponding to the 90% and 98% probability. Compare these values and the GM with the appropriate State WQS criteria for the parameter in question.

g. Plot all data points on Log-Probability paper, use the ranked data (column (3)) as the abscissa (y-axis) and the probability (column (5)) as the ordinate (x-axis). The purpose of plotting the data is to validate the lognormal distribution. If the plotted data points approximate the *calculated line* on Log-Probability paper, then the lognormal distribution assumption is verified. Other distributions may be applied; however, the assumption of this methodology assumes (with corresponding verification by data plotting) a lognormal distribution.

h. If the plotted data confirms a lognormal distribution, the results from step "f" above are valid.

i. If the plotted data does not correspond to the *calculated line* (e.g. confirmation of the lognormal distribution is not validated), several events could be occurring. There could be something wrong with the data or another process may be occurring in the receiving waters. Lastly, but not necessarily finally, the process may not be lognormal distributed, and therefore, compliance cannot be determined.

TABLE 5-2 SAMPLE WORKSHEET				
i	listing of raw data as received	data, xi ranking smallest to largest	logarithm of the ranked data	probability (percent) 100*(i-½)/n [%]
1	y_1	x_1	$\ln(x_1)$	(1-½)/n
2	y_2	x_2	$\ln(x_2)$	(2-½)/n
:	:	:	:	:
n	y_n	x_n	$\ln(x_n)$	(n-½)/n

where n = the number of data points.

5.3 TEMPORAL AND SPATIAL CONSIDERATIONS

The above analyses shall be done on an annual (calendar year) basis, using a minimum sample size of roughly thirty (30) data points. An analyses which includes at least five (5) years of data shall also be done at the same time as the annual analyses. The purpose of this analyses is to identify possible long term impacts. The one (1) and five (5) year analyses constitute a compliance analyses for the WQS.

Data, or sample results, obtained from samples collected from depths greater than 30 meters (roughly 100 feet) should not be included in the methodology defined above because the State WQS were developed from sample results taken from depths less than 30 meters.

In accordance with Section B.2 of the permit, data obtained from station(s) within the zone of initial dilution (ZID) and stations identified as "control" stations, shall not be included in the methodology defined above. For turbidity and light extinction coefficient, LEC (note; LEC is a required parameter for NPDES 301(h) waiver permits), stations at and beyond the ZID shall be used; e.g., ZID stations only. For the other parameters, i.e., ammonia nitrogen, total

phosphorus, etc., compliance with the State WQS shall include stations at or beyond the ZOM; e.g., ZOM stations only.

A separate set of analyses shall be done using data from the control stations only. The same depth and temporal guidelines shall be applied to the control station data. The purpose of this analysis is to compare background conditions to the conditions at the ZOM or ZID.

A noncompliant event results if any parameter above has exceeded the applicable limit of Table 5-1, accompanied by sufficient evidence that the exceedence is related to the discharge. Examples of this evidence is a comparison of the ZOM/ZID station analyses with the control station analyses. Exceedences attributable to the discharge should not be impacting the control stations. Furthermore, exceedences of one or more parameters should be associated with increases from other parameters, which may or may not have exceeded applicable limits, if the discharge is the cause of the exceedence.

5.4 RESULTS

5.4.1 ZOM and ZID Station Results

The compliance methodology, as presented above, was applied to the ZOM and ZID monitoring data obtained during the 1994 monitoring year. Results of the 1994 monitoring year analyses are tabulated in Table 5-3. Results of the analyses using five (5) years of data are tabulated in Table 5-4.

TABLE 5-3 1994 MONITORING YEAR RESULTS			
	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (μg N/L)	90.58	108	118
Ammonia Nitrogen (μg NH_4-N/L)	1.21	2.56	4.09
Nitrate + Nitrite (μg $[NO_3+NO_2]$ - N/L)	1.04	1.43	1.75
Total Phosphorus (μg P/L)	8.76	11	12.6
*Light Extinction Coefficient (k units)	0.07	0.088	0.105
Chlorophyll a (μg/L)	0.14	0.345	0.585
Turbidity (NTU)	0.14	0.24	0.33

TABLE 5-4 1990 - 1994 MONITORING PERIOD DATA			
	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (μg N/L)	91.36	120	141
Ammonia Nitrogen (μg NH_4-N/L)	1.80	5	9.3
Nitrate + Nitrite (μg [NO_3+NO_2] - N/L)	1.09	1.56	1.95
Total Phosphorus (μg P/L)	8.66	11.3	13.3
*Light Extinction Coefficient (k units)	0.06	0.082	0.098
Chlorophyll a (μg/L)	0.13	0.261	0.395
Turbidity (NTU)	0.12	0.19	0.26

For both of these analyses, there were no events which exceeded the limits found in Table 5-1, except for the 5-year, Ammonia Nitrogen, not to exceed 2% category. See Figures 5-2 to 5-8 for graphs of the *calculated and standard lines,* for all parameters. Because Ammonia Nitrogen results for the 1994 monitoring year were significantly below the 5-year analyses, and because no other parameter exceeded the State WQS, 1994 or 5-year analyses, we do not consider this a noncompliance. Compliance for each ZOM station was based on a sample size of 32 data points. For the Light Extinction Coefficient (LEC) parameter, however, only sixteen (16) samples points

FIGURE 5-2 TOTAL NITROGEN MONITORING PERIOD/YEAR DATA

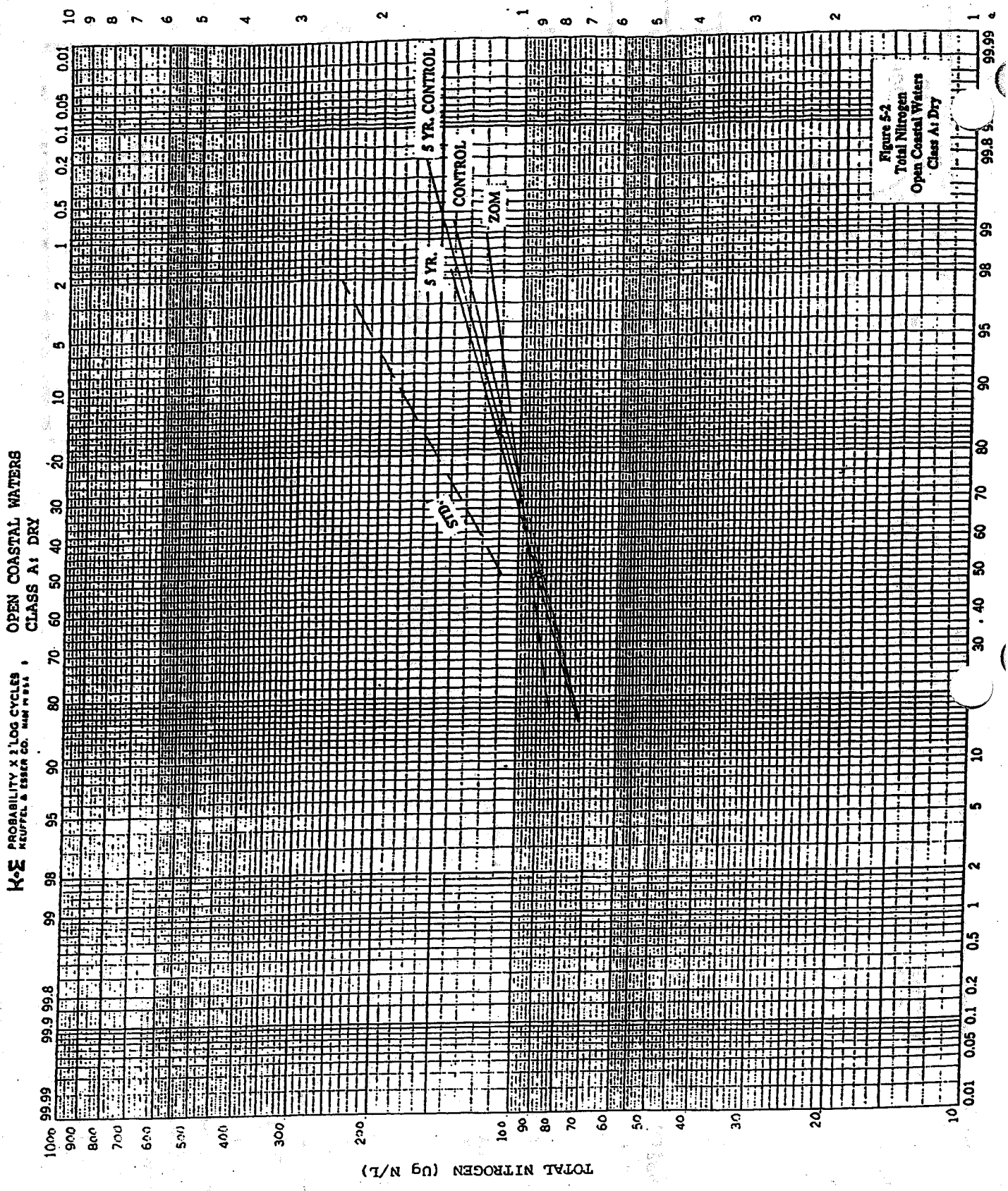


FIGURE 5-3 AMMONIA NITROGEN MONITORING PERIOD/YEAR DATA

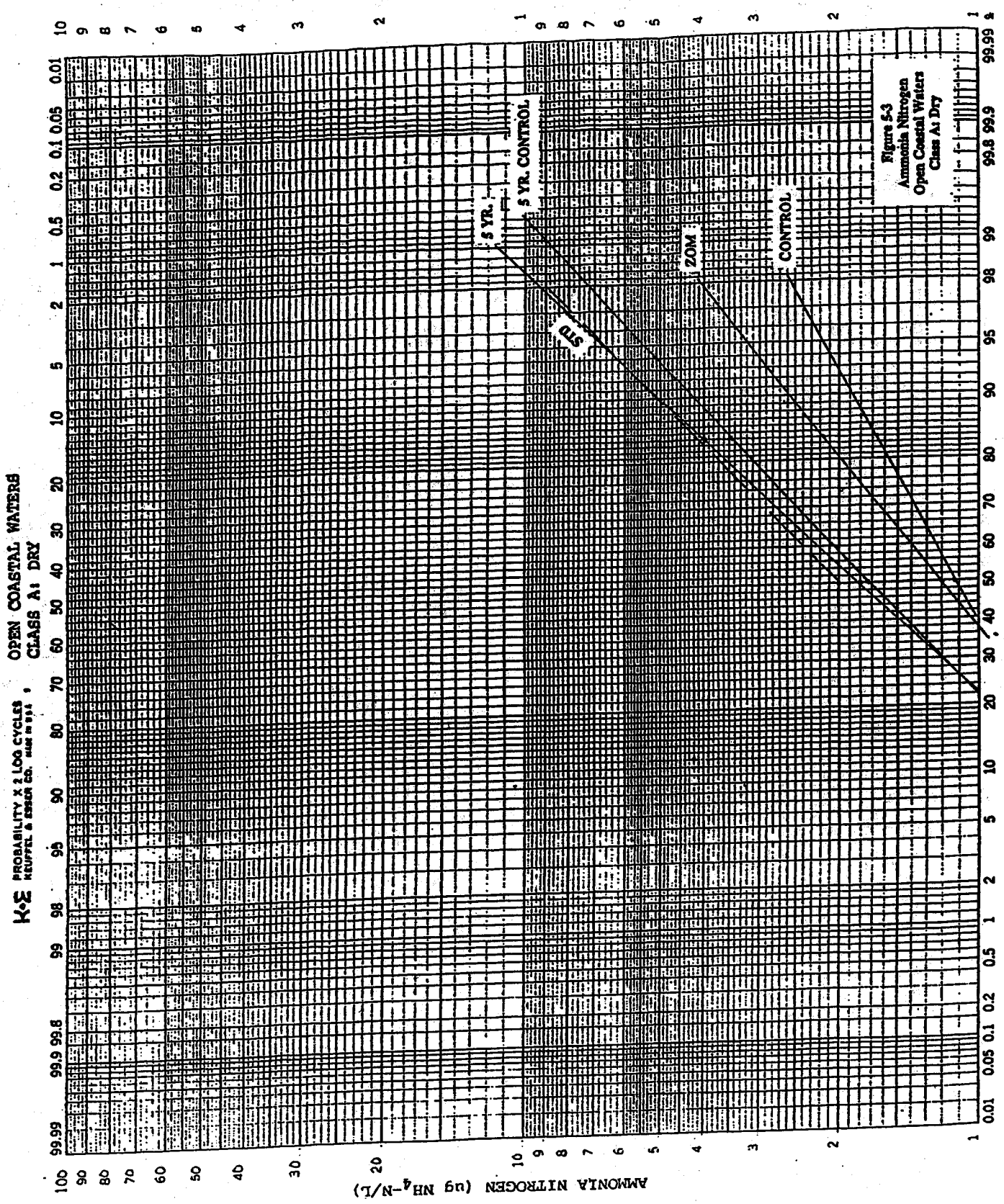


FIGURE 5-4 NITRATE + NITRITE NITROGEN MONITORING PERIOD/YEAR DATA

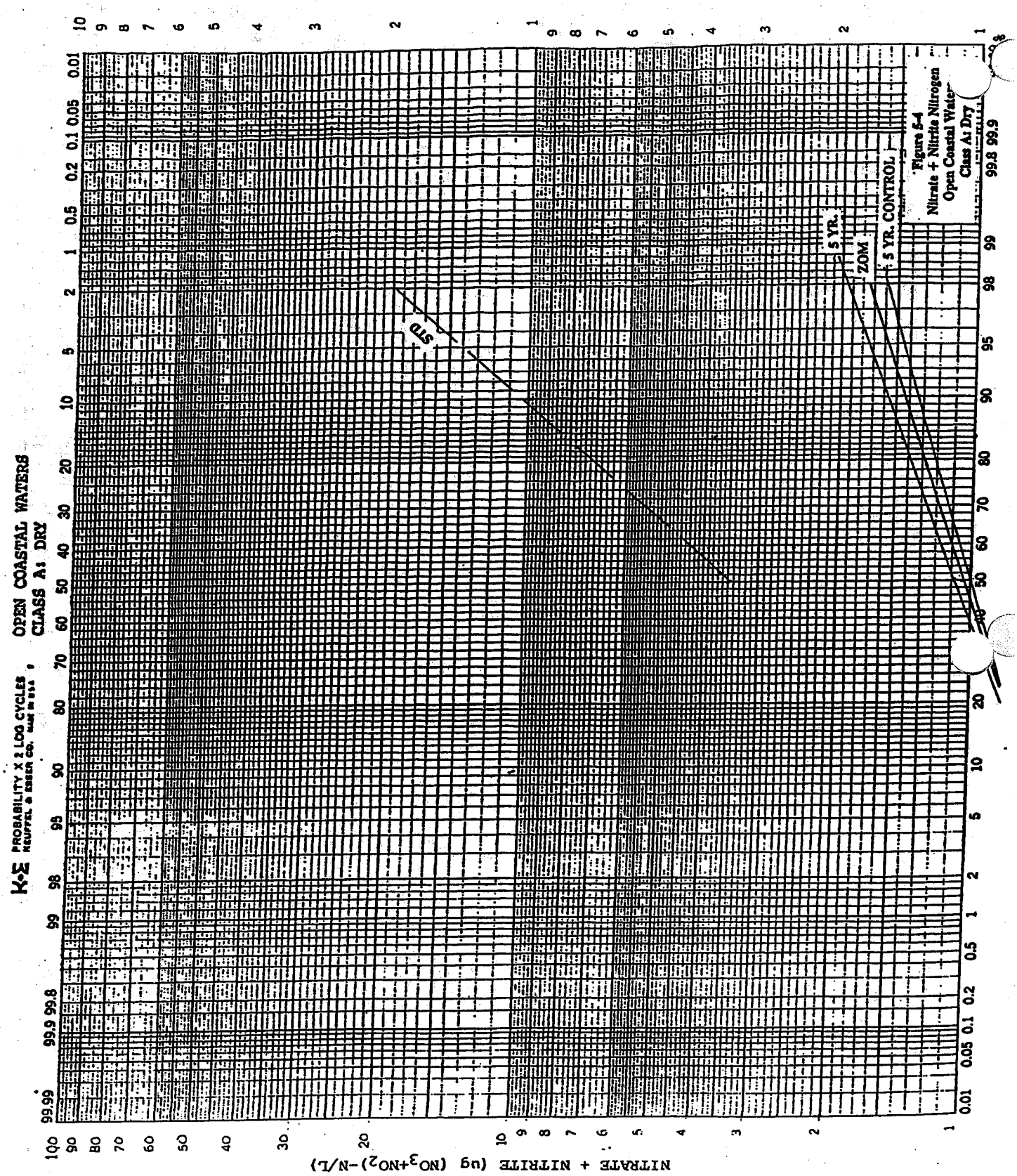


FIGURE 5-5 TOTAL PHOSPHORUS MONITORING PERIOD/YEAR DATA

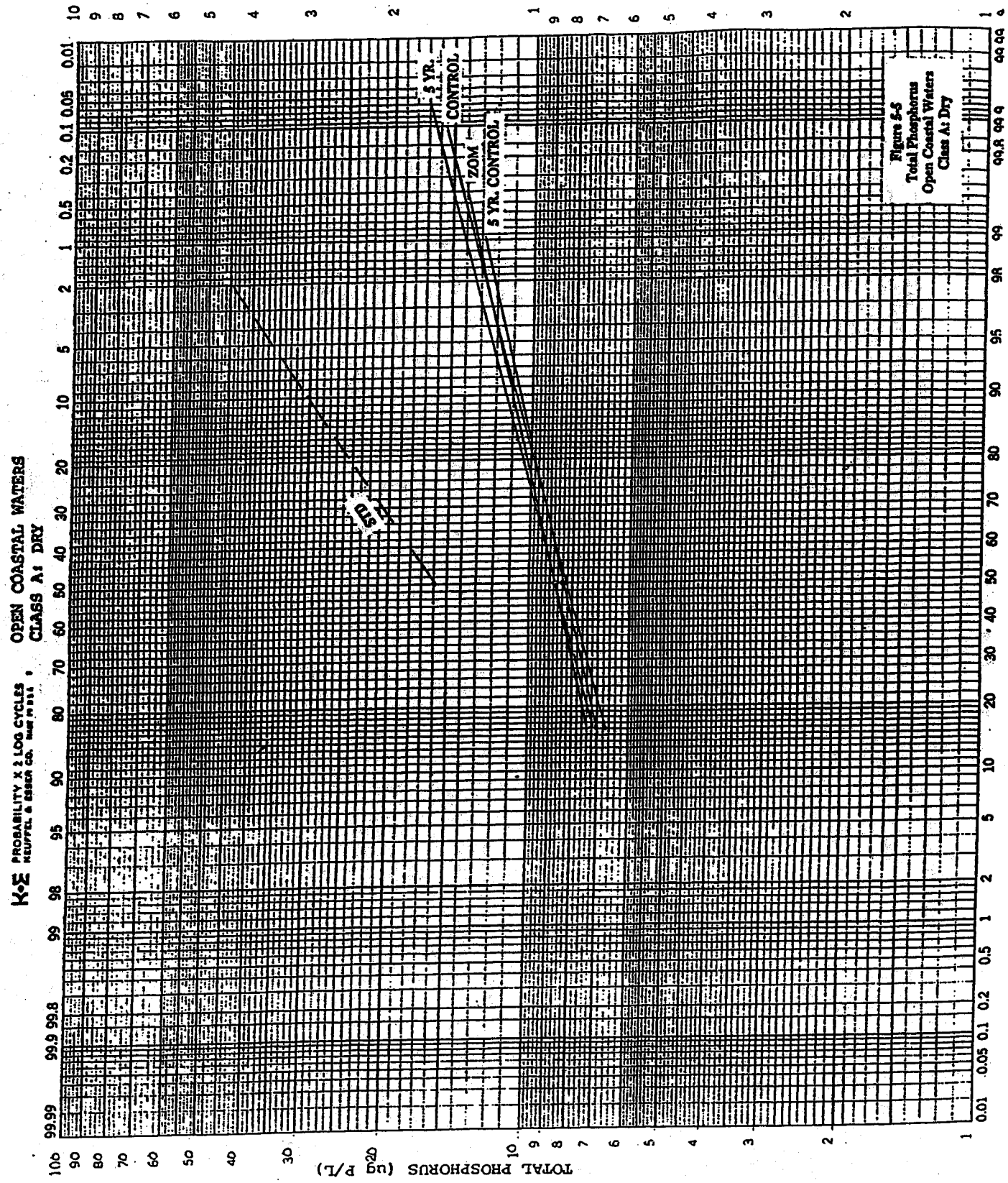


FIGURE 5-6 LIGHT EXTINCTION COEFFICIENT MONITORING PERIOD/YEAR DATA

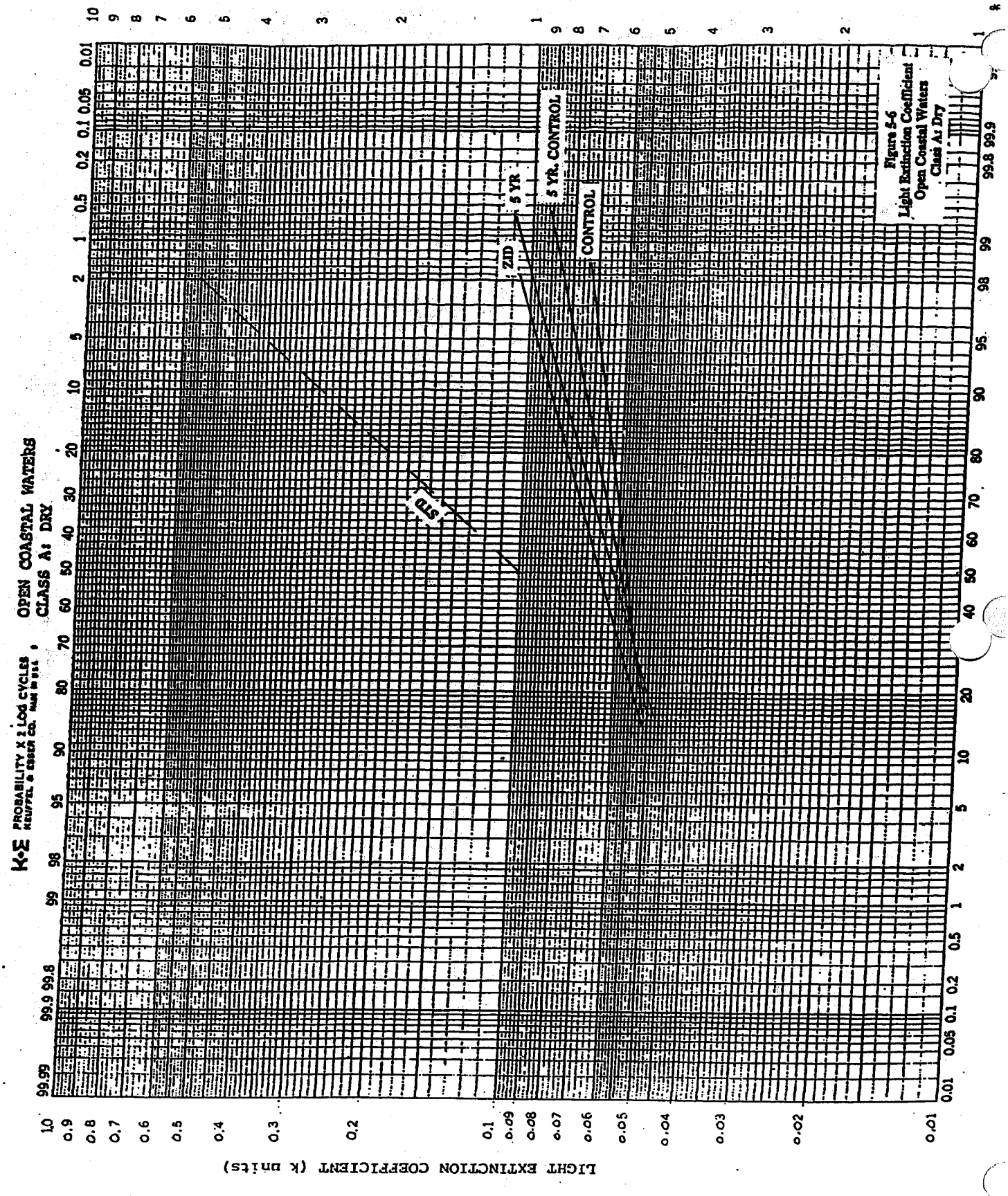


FIGURE 5-5 TOTAL PHOSPHORUS MONITORING PERIOD/YEAR DATA

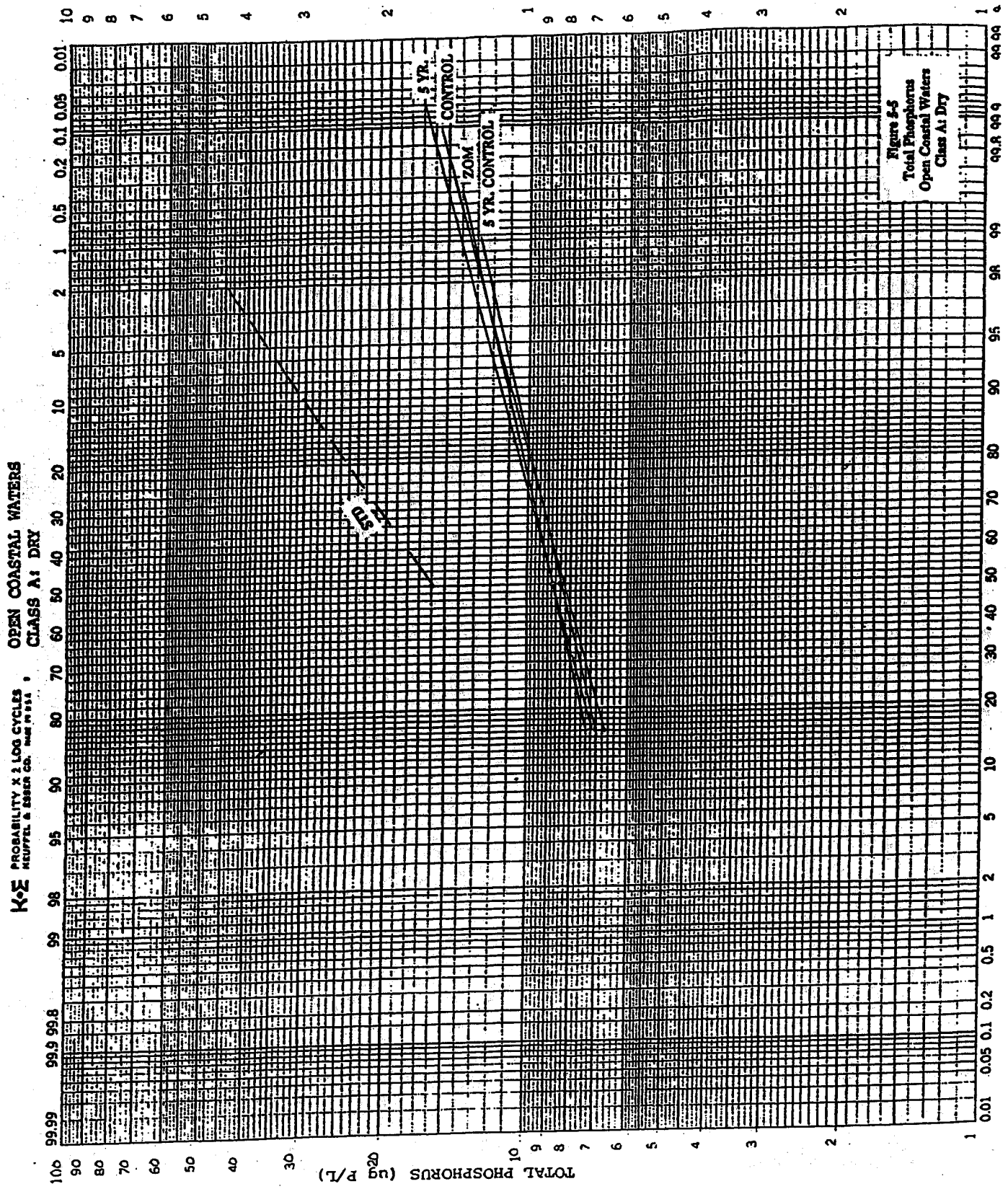


FIGURE 5-6 LIGHT EXTINCTION COEFFICIENT MONITORING PERIOD/YEAR DATA

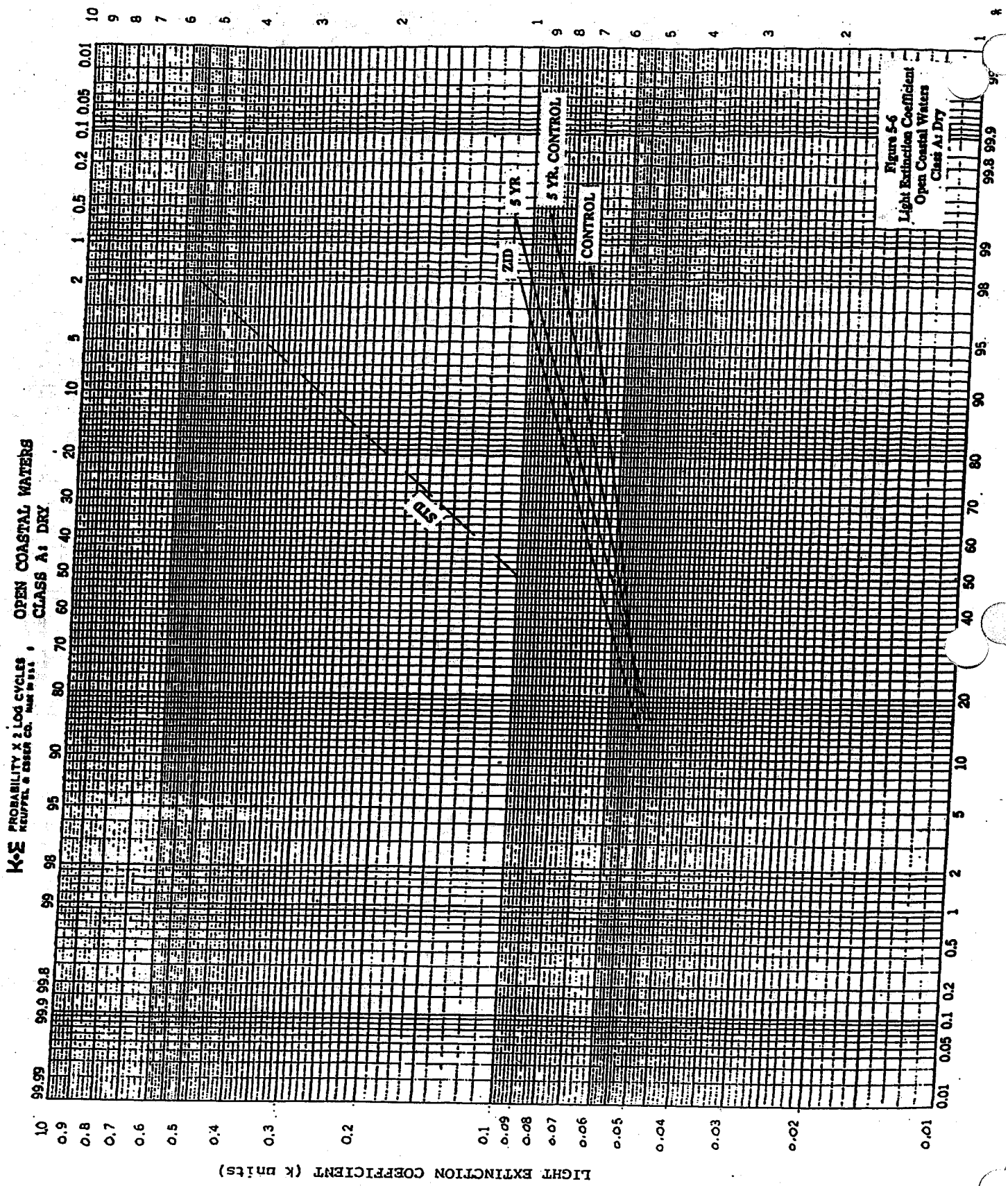


FIGURE 5-7 CHLOROPHYLL MONITORING PERIOD/YEAR DATA

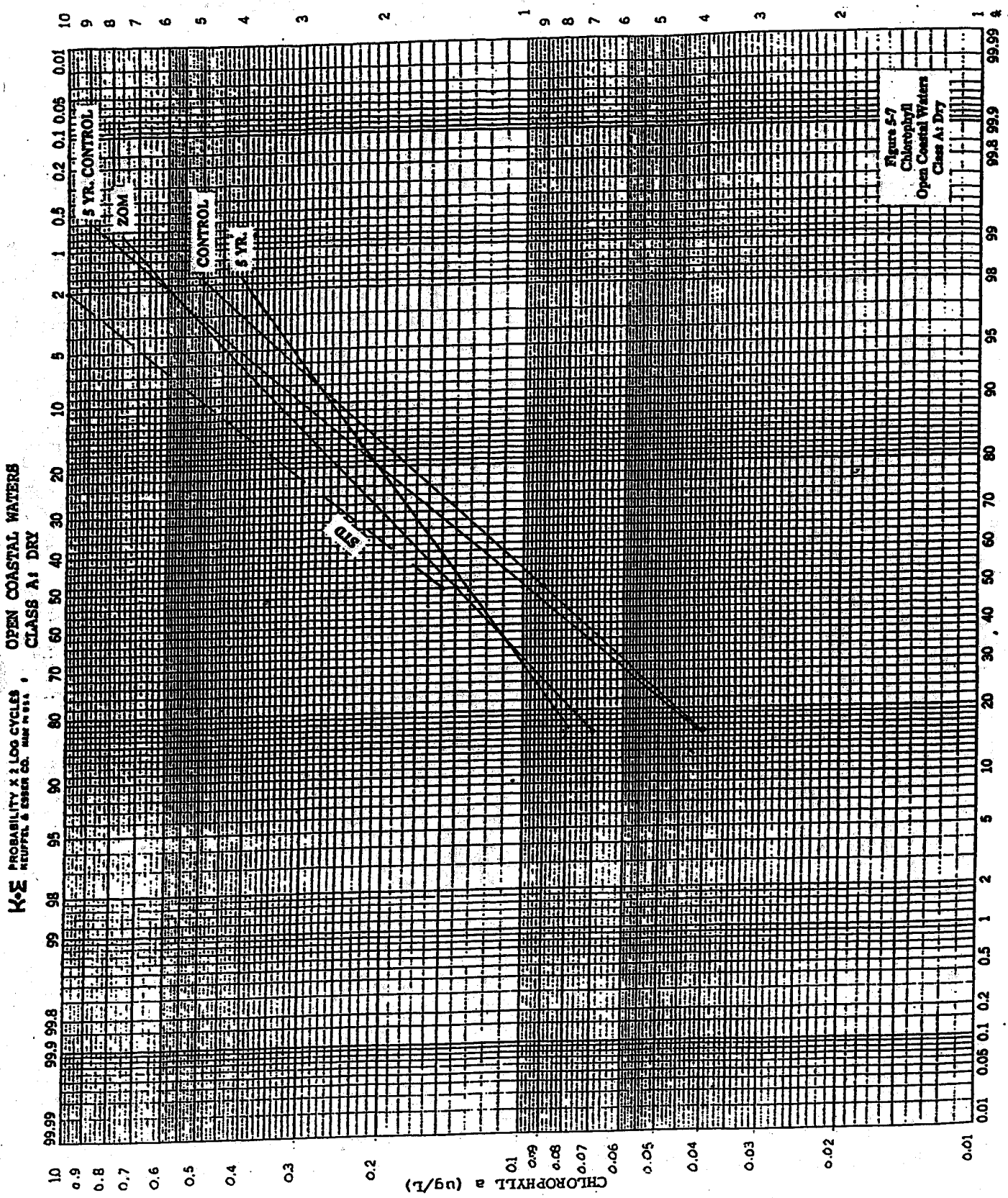
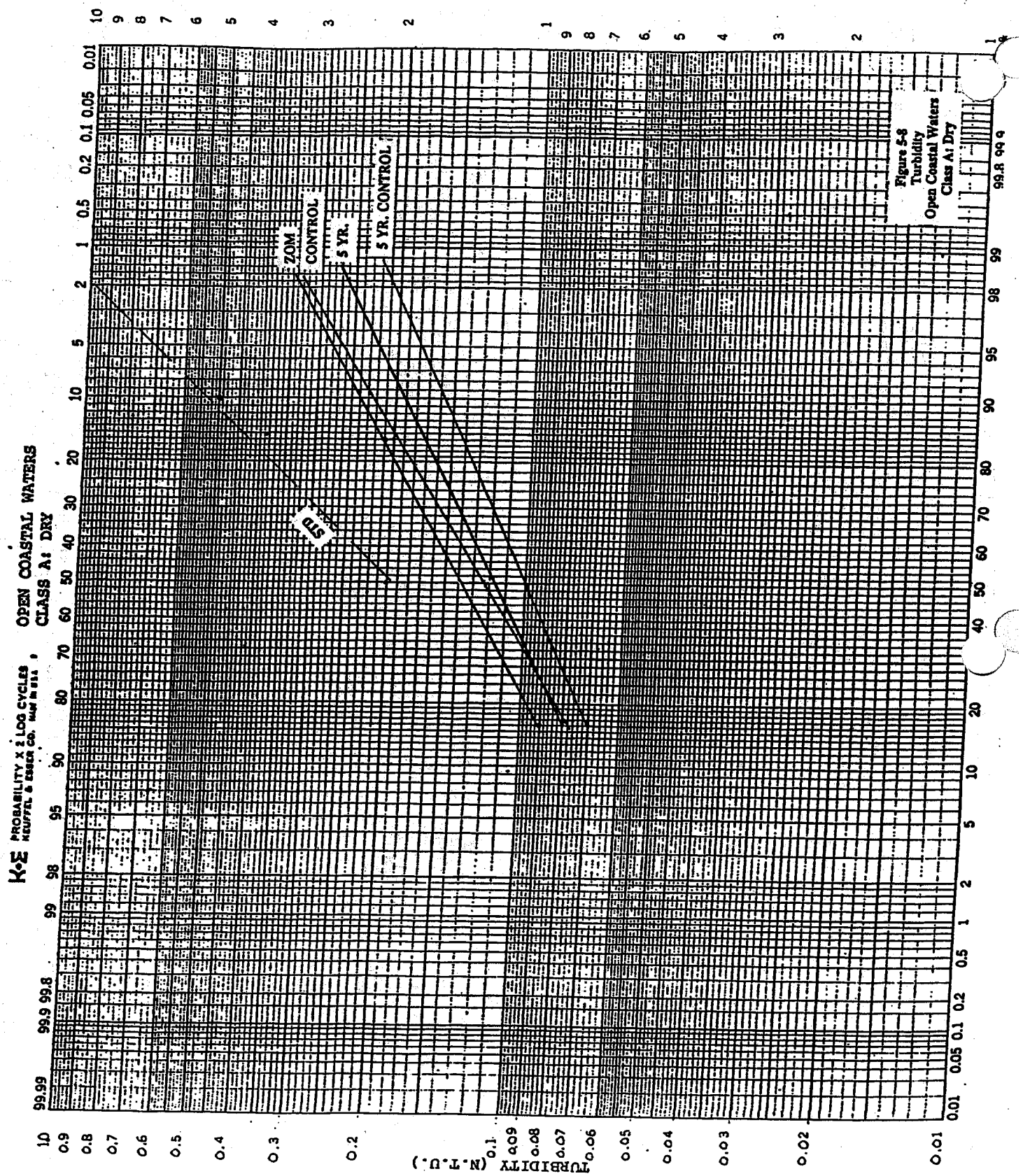


FIGURE 5-8 TURBIDITY MONITORING PERIOD/YEAR DATA



Furthermore, by plotting the data versus time (see Figures 5-9 to 5-27), we see no noticeable pattern or trend that would indicate an impending problem.

FIGURE 5-9

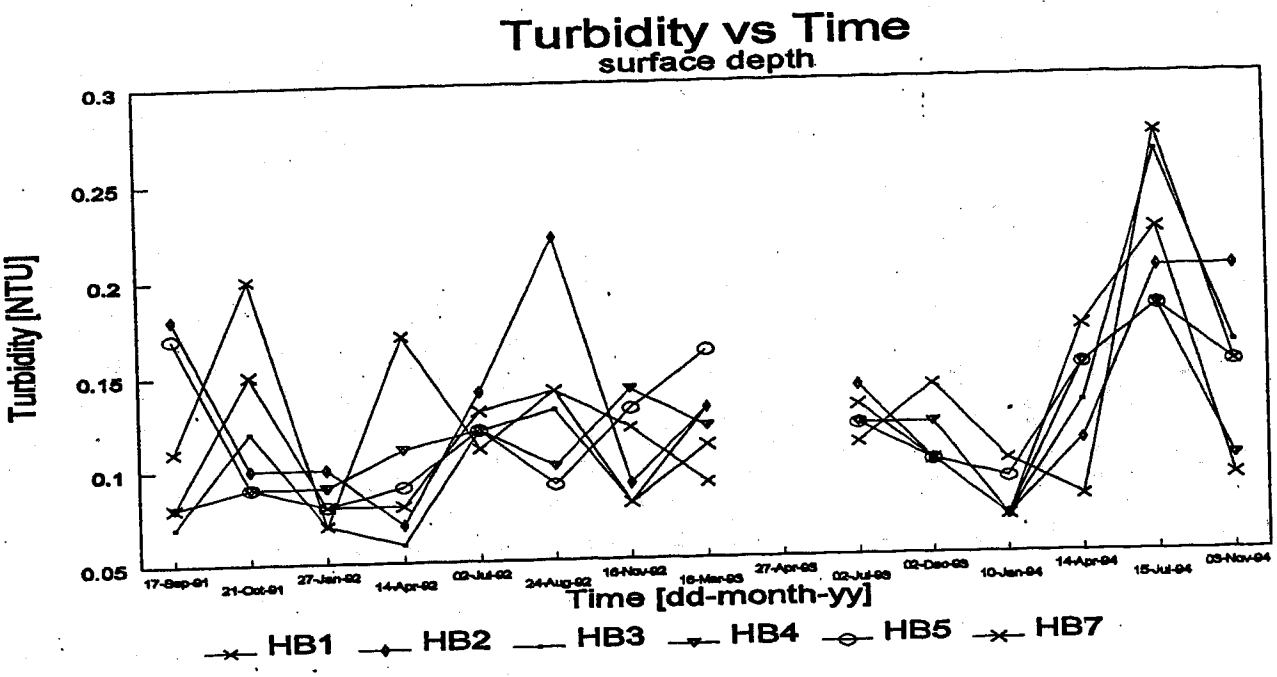


FIGURE 5-10

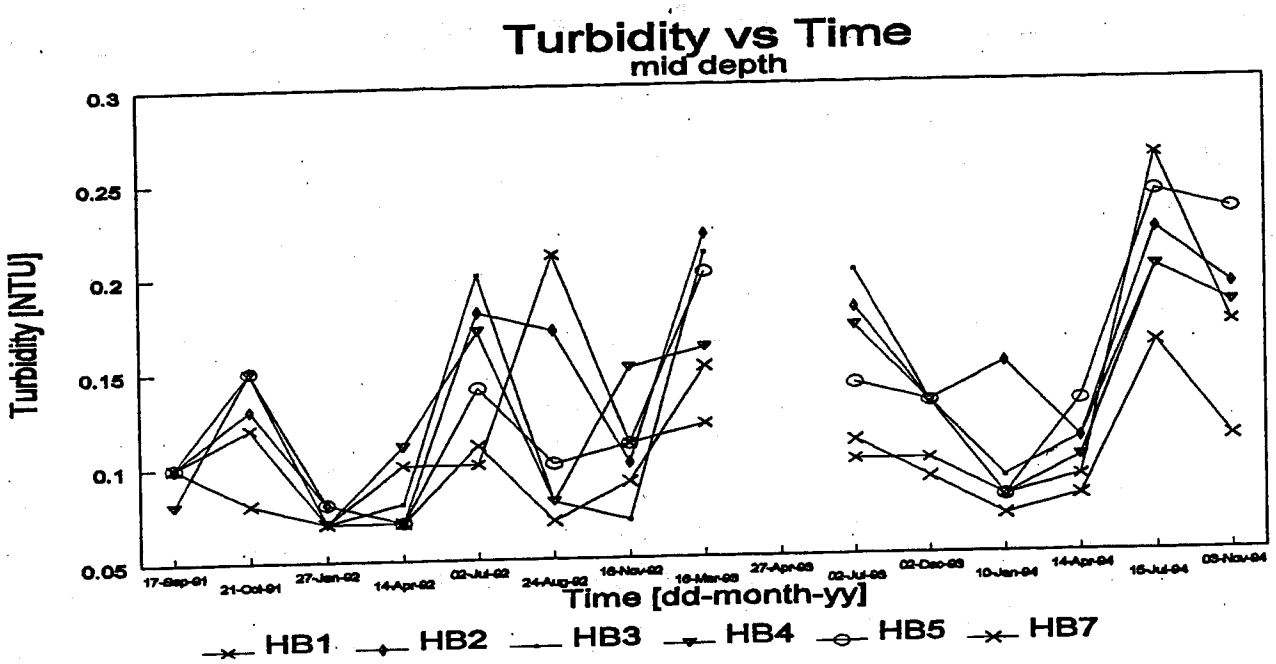


FIGURE 5-11

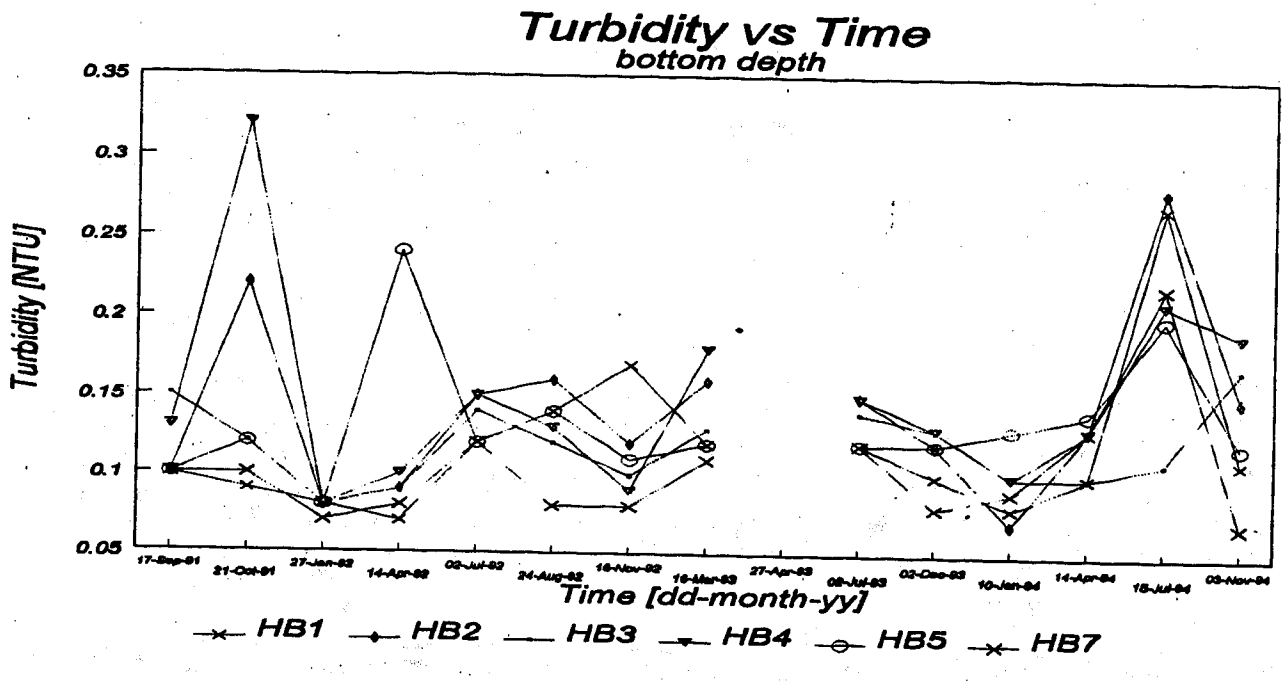


FIGURE 5-12

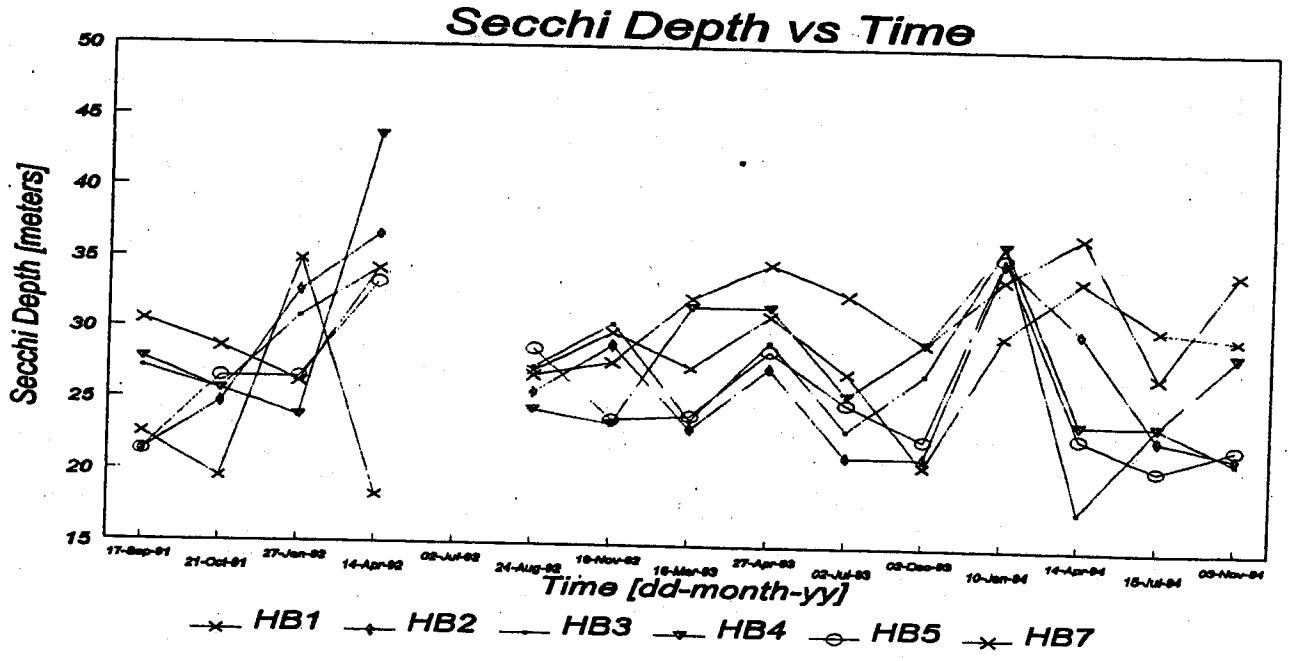


FIGURE 5-13

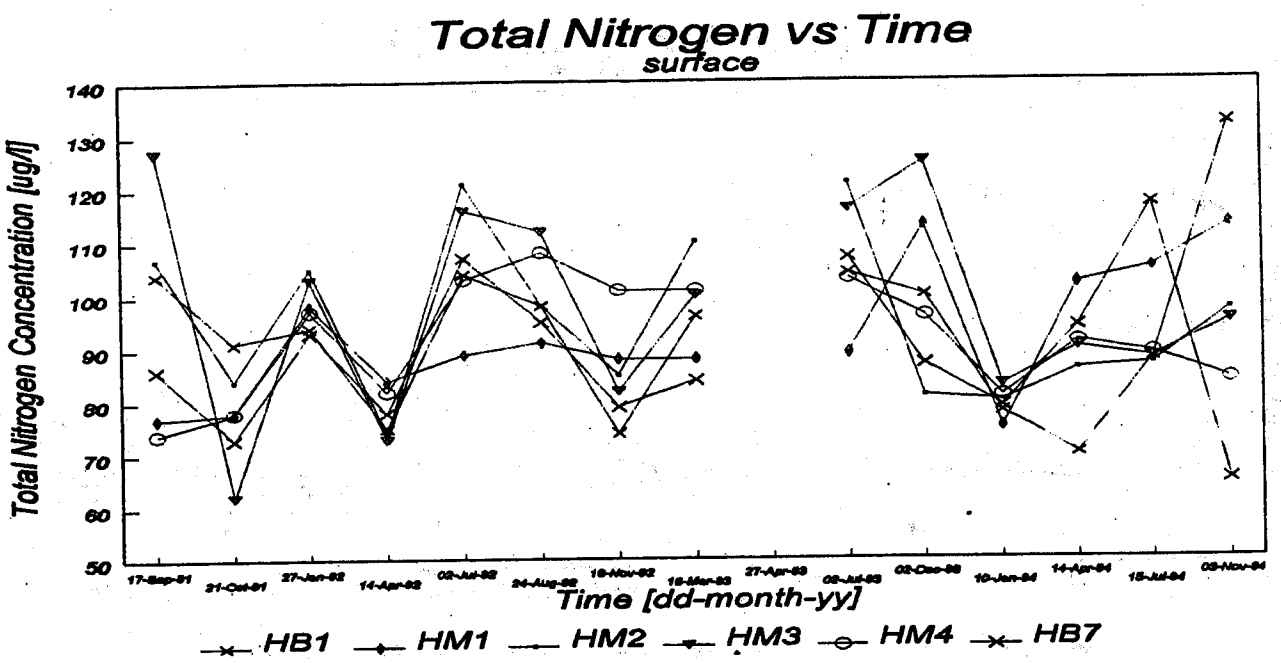


FIGURE 5-14

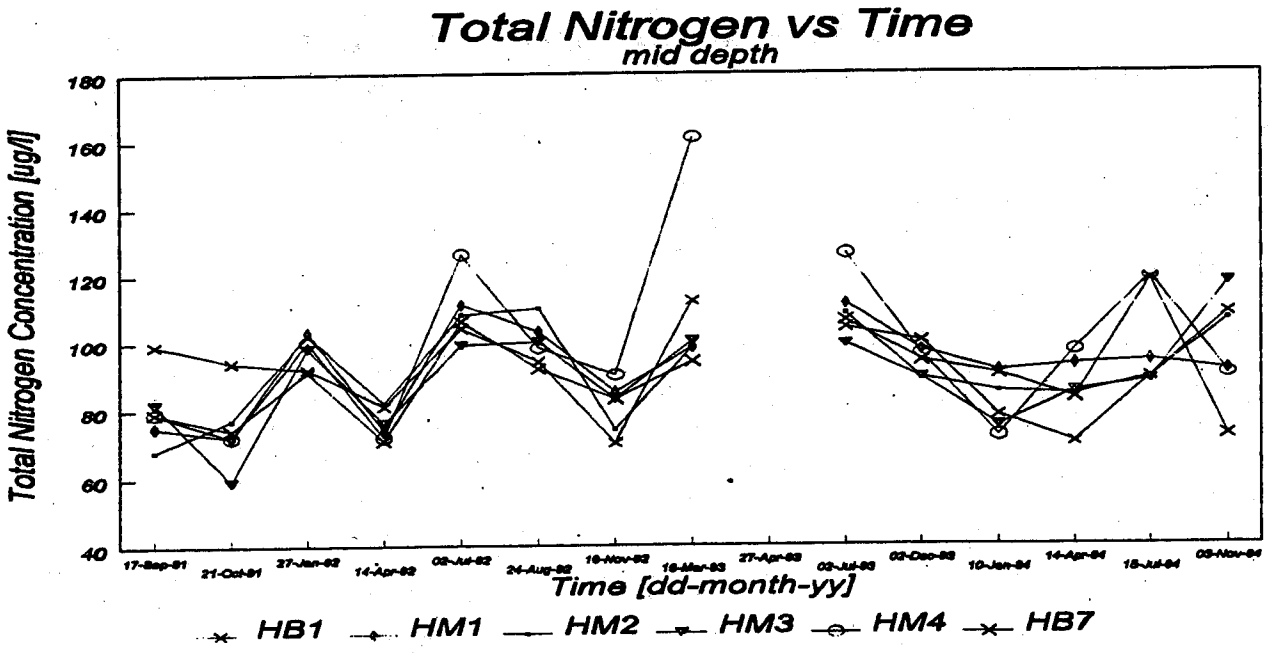


FIGURE 5-15

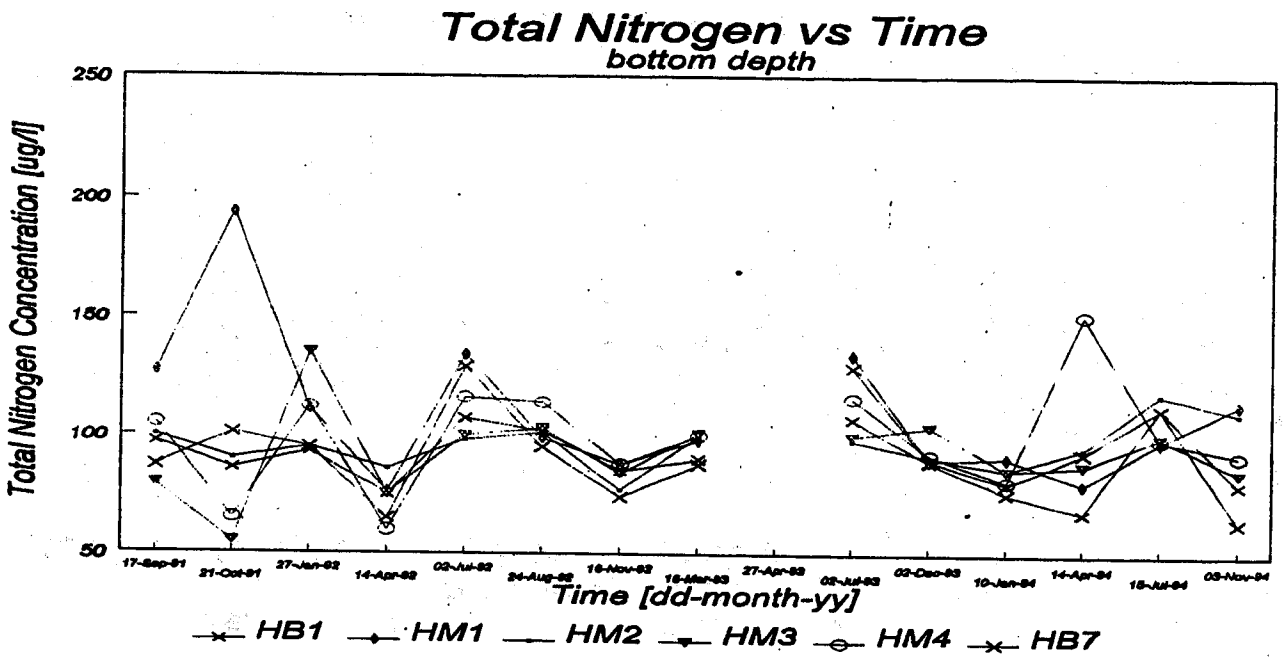


FIGURE 5-16

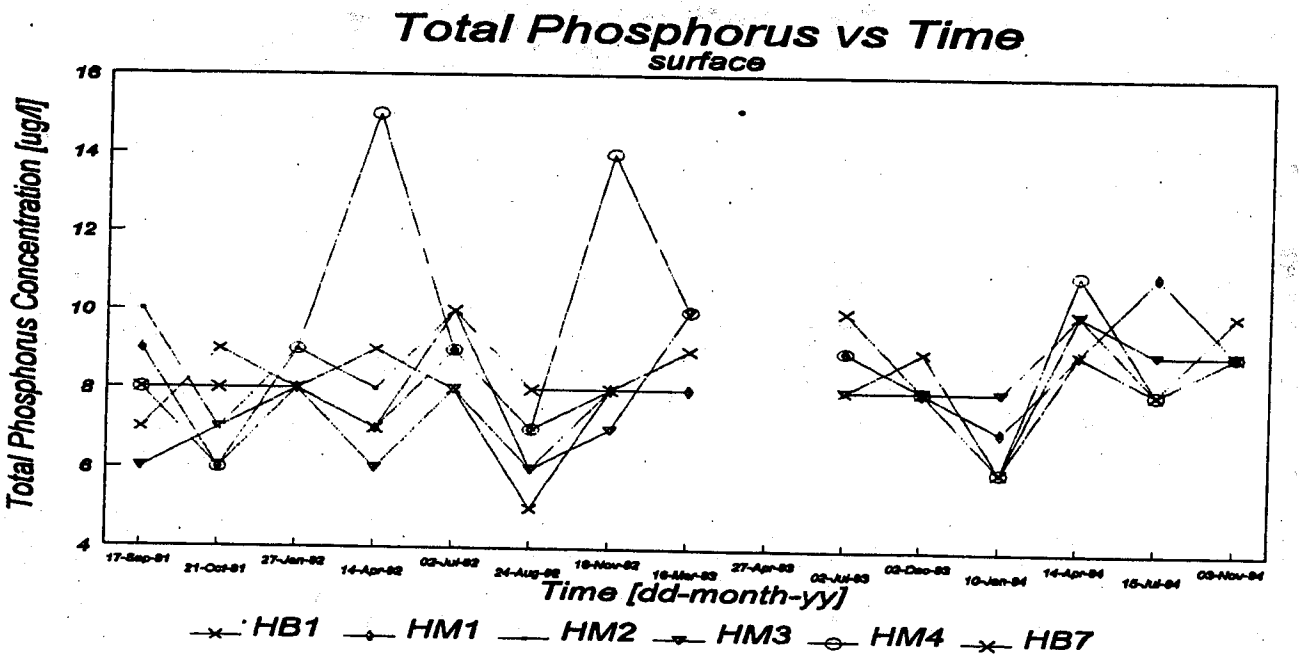


FIGURE 5-17

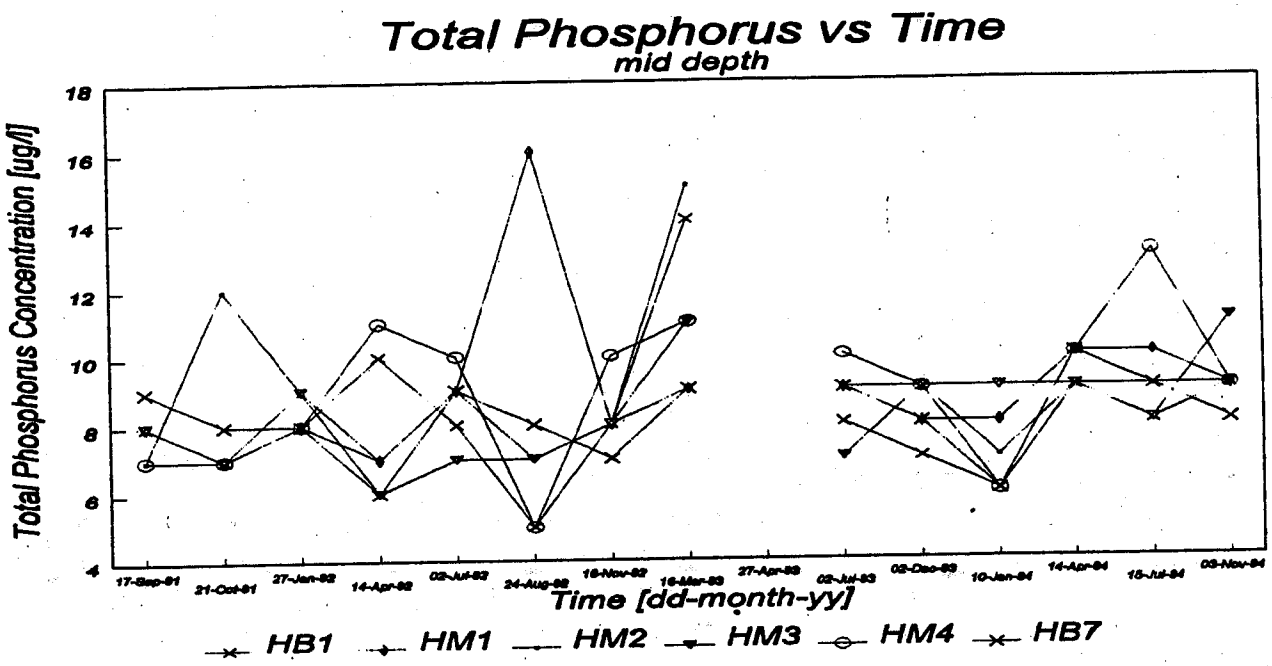


FIGURE 5-18

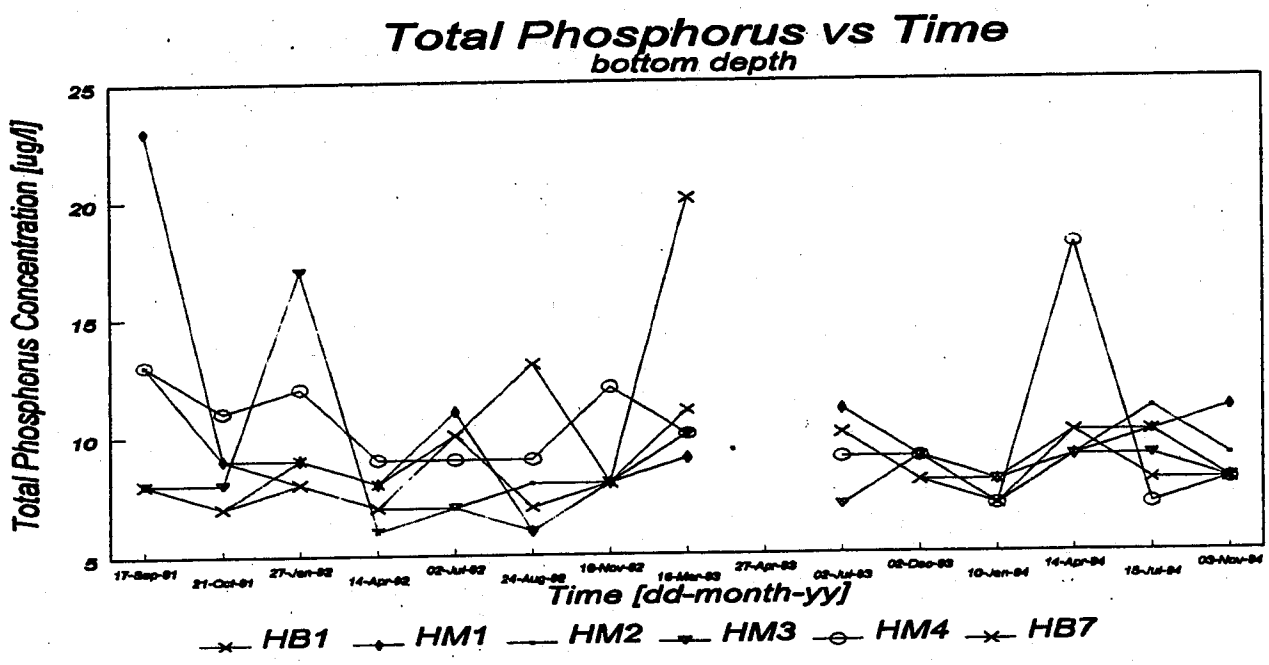


FIGURE 5-19

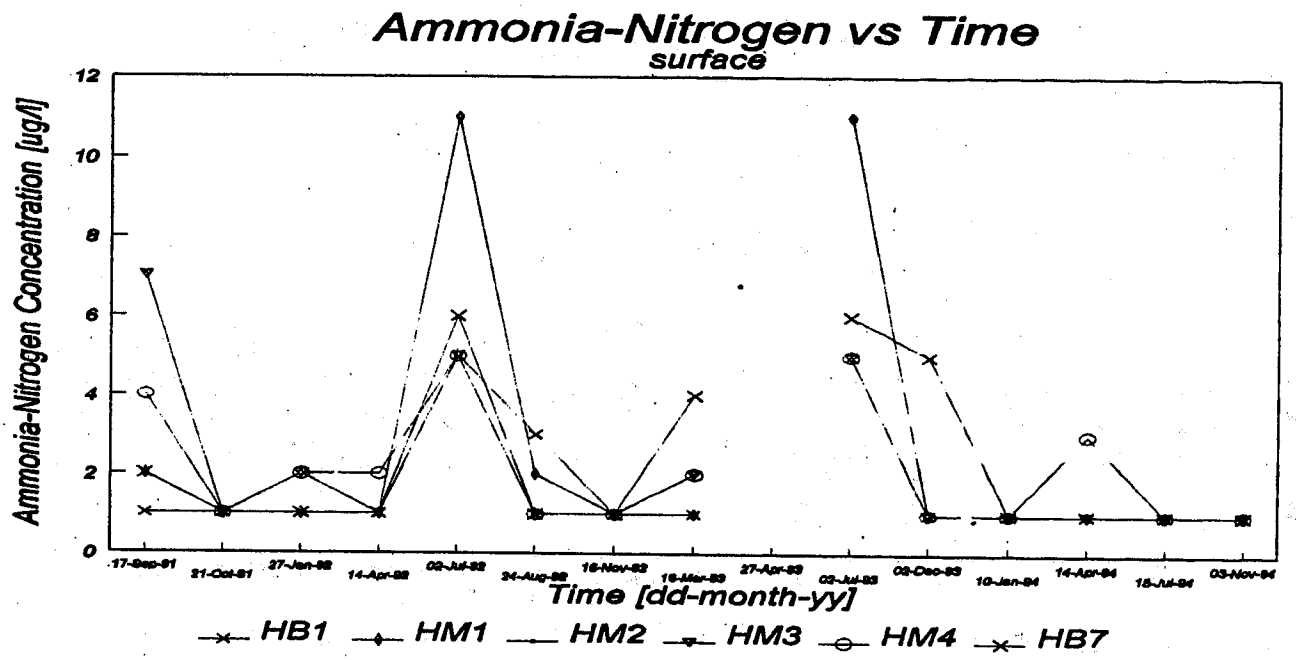


FIGURE 5-20

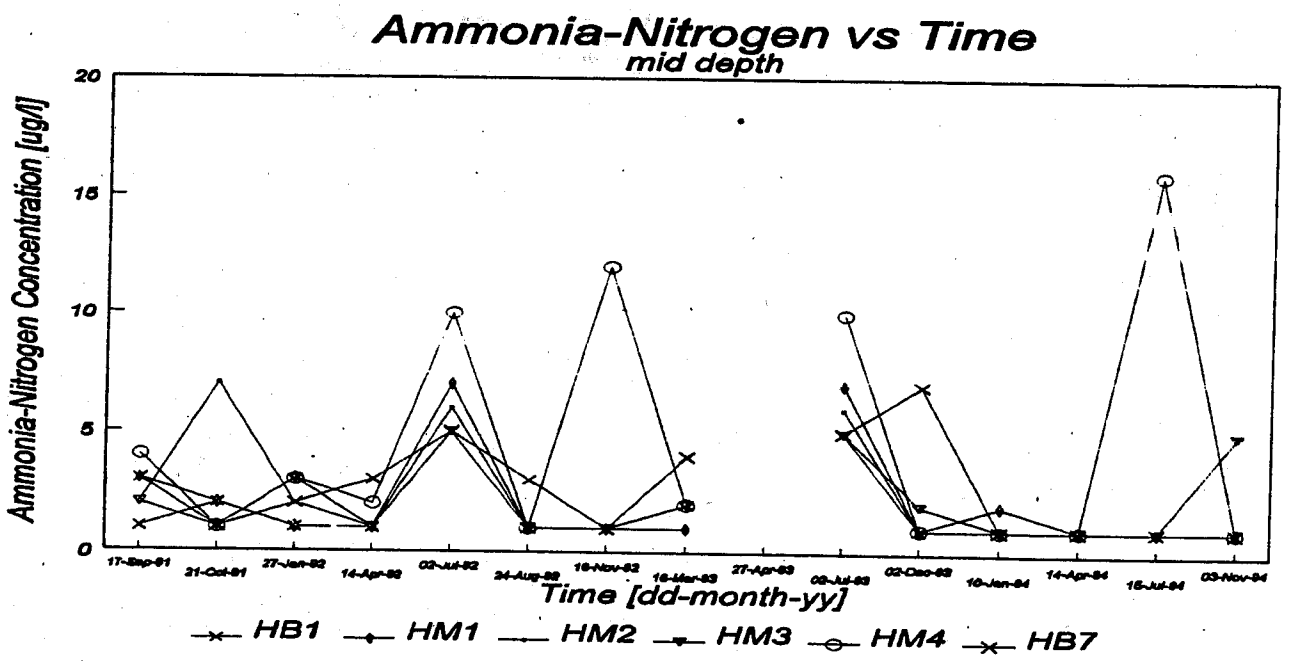


FIGURE 5-21

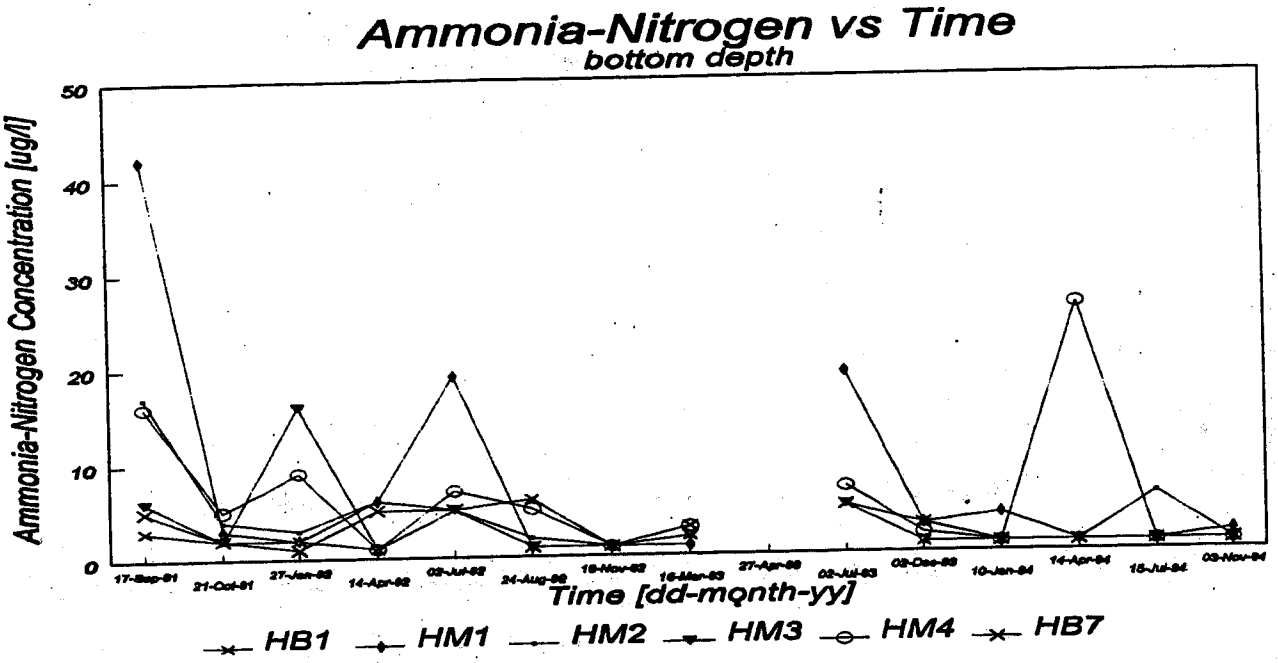


FIGURE 5-22

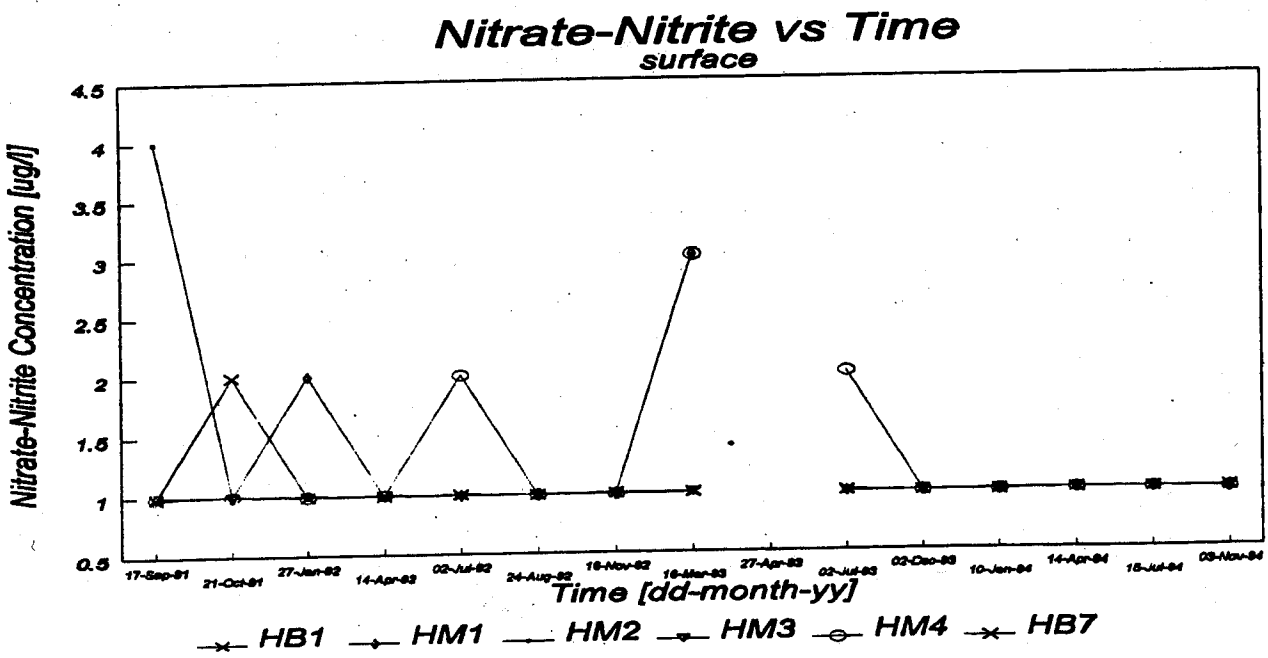


FIGURE 5-23

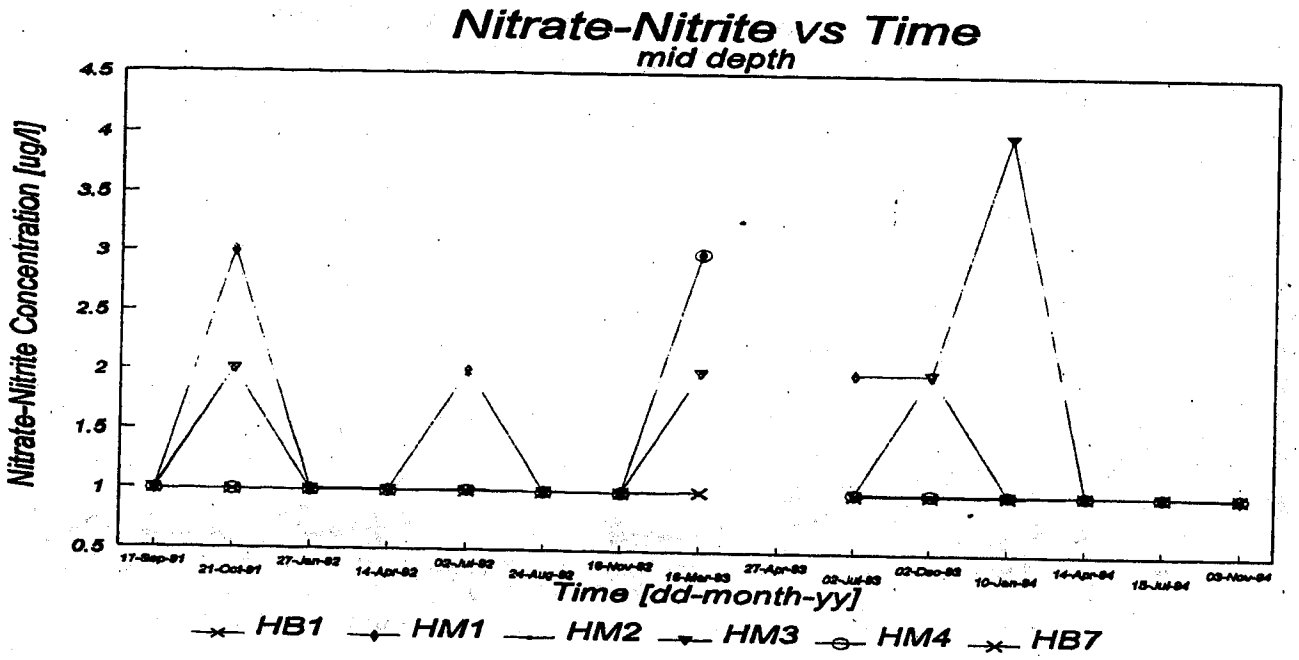


FIGURE 5-24

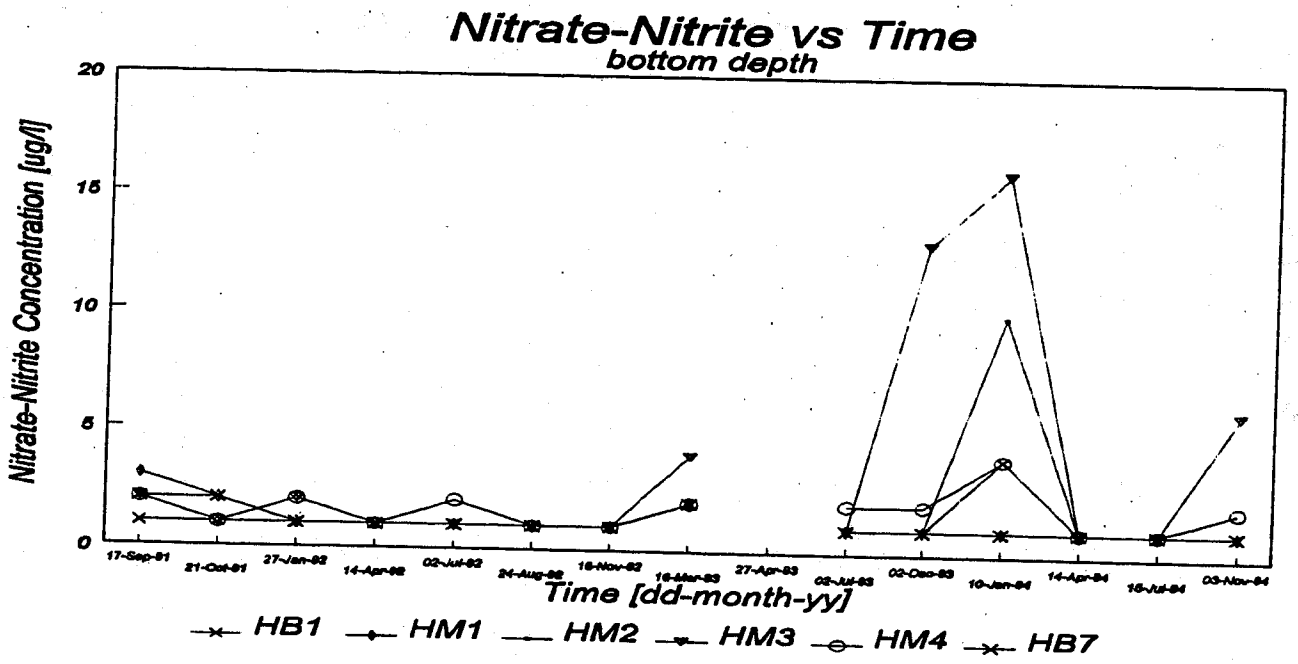


FIGURE 5-25

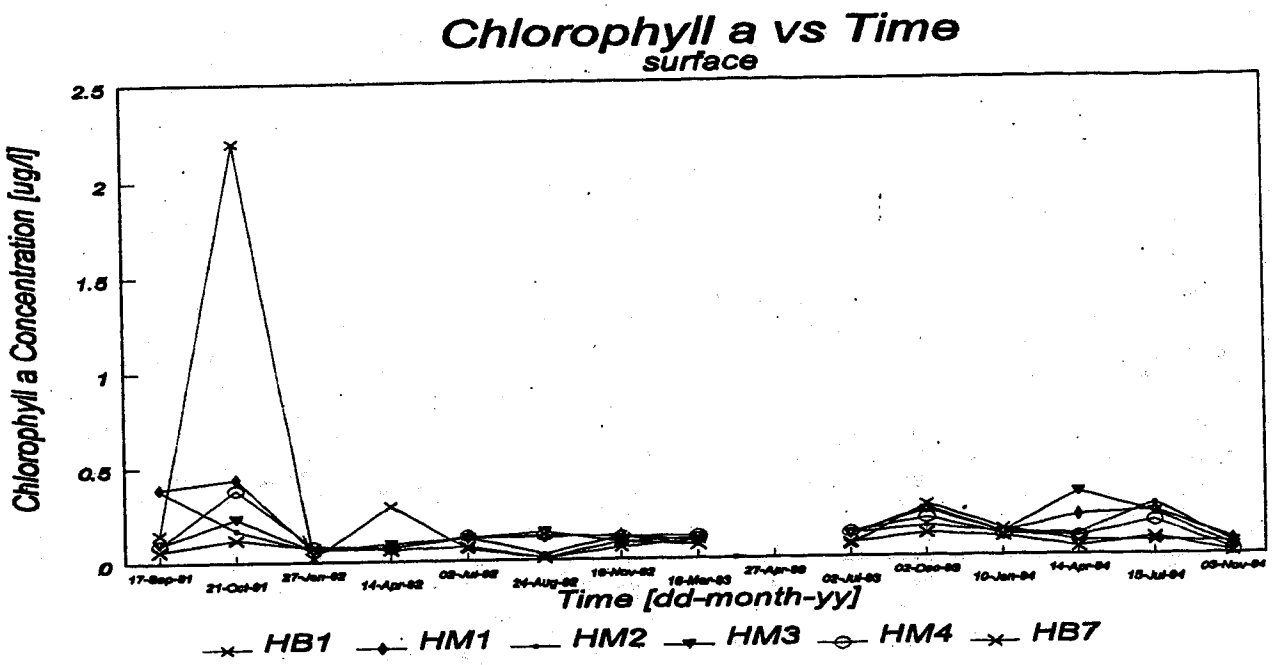


FIGURE 5-26

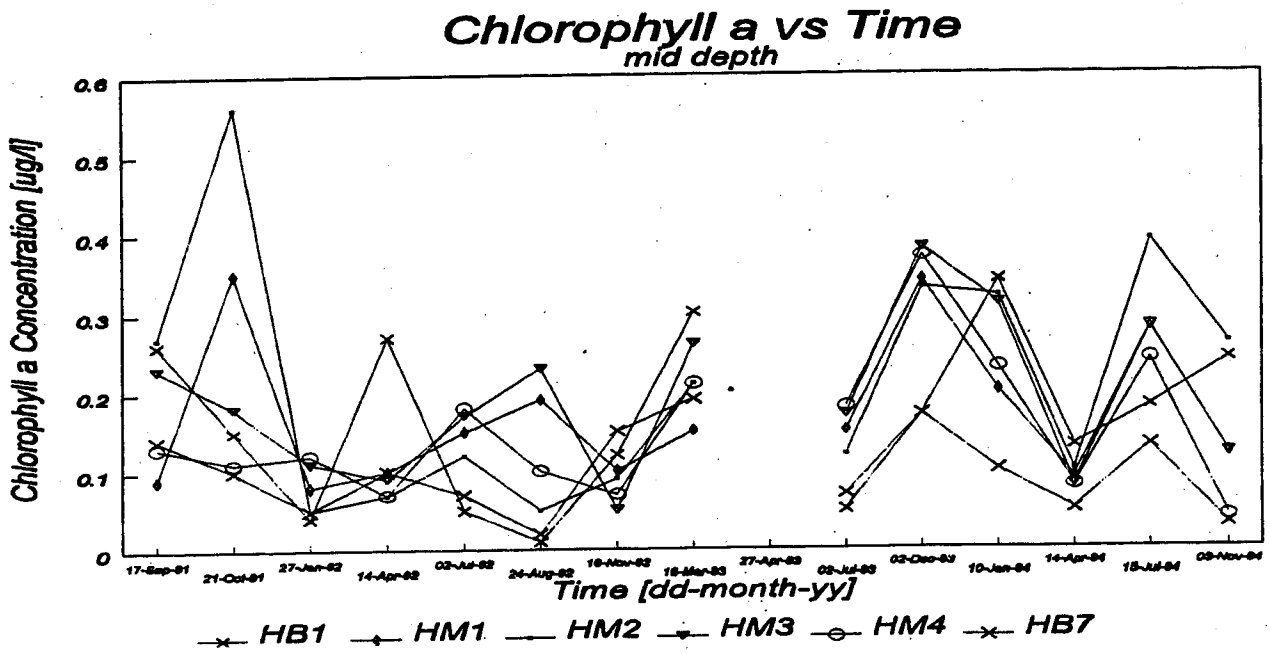
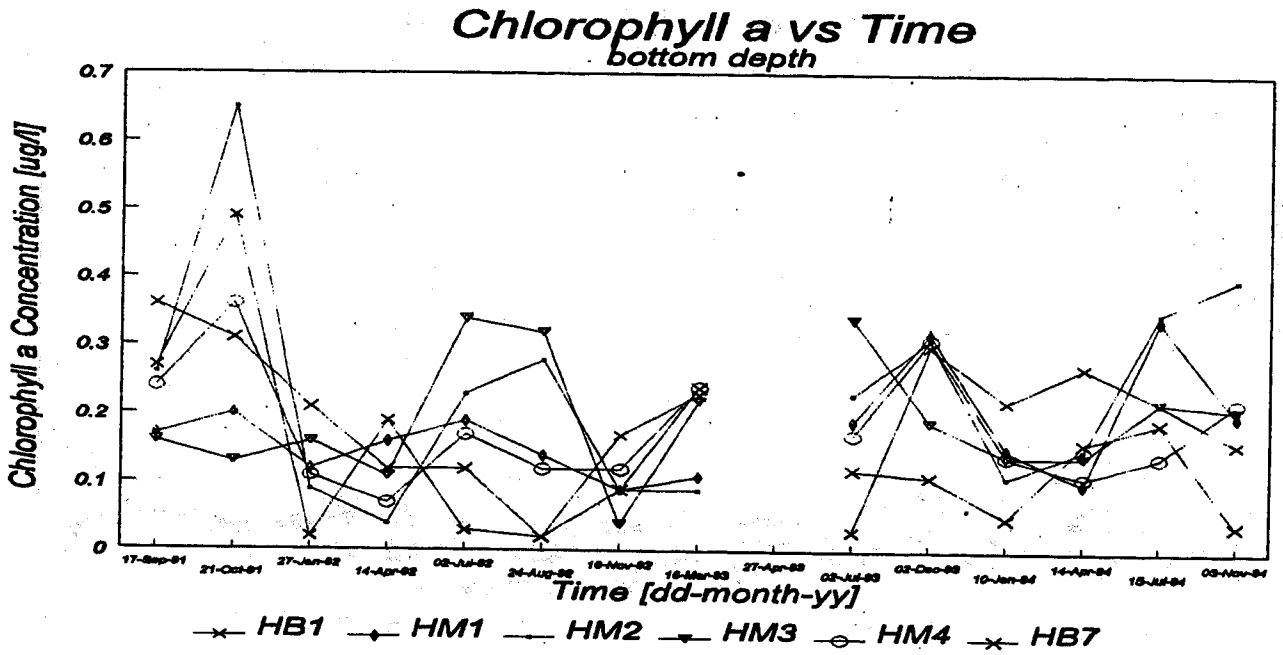


FIGURE 5-27


Chlorophyll a vs Time
bottom depth
Chlorophyll a Concentration [ug/l]
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
17-Sep-91
21-Oct-91
27-Jan-92
14-Apr-92
02-Jul-92
24-Aug-92
19-Nov-92
16-Mar-93
27-Apr-93
03-Jul-93
03-Dec-93
10-Jan-94
14-Apr-94
15-Jul-94
03-Nov-94
Time [dd-month-yy]
HB1
HM1
HM2
HM3
HM4
HB7

CHAPTER 8
CHEMISTRY EVALUATION

8.1 INTRODUCTION

All nearshore and offshore parameters were monitored during the 1994 monitoring year, as required by the Honouliuli WWTP 301(h) waiver permit. The dates for the 1994 monitoring events were January 10, April 14, July 15, and November 3, 1994. All monitoring stations and protocols were not changed from the previous monitoring year. See Figure 5-1, page 5-13, for the ocean monitoring sites. Compliance determination was based on measurements obtained by the City's Sea-Bird, CTD Profiler. Measurements of pH, potential temperature, salinity, and dissolved oxygen were taken at one (1) meter intervals for all four (4) nearshore stations and twelve (12) offshore stations during each monitoring event. The data was then compared with conditions stated in the Honouliuli WWTP 301(h) waiver permit, sections B.2. and B.3, and the State Water Quality Standards (WQS).

8.2 pH REQUIREMENT

According to the State WQS and permit requirements, pH units shall not deviate more than 0.5 units from a value of 8.1 ($7.6 \leq pH \leq 8.6$) except at coastal locations where and when freshwater from stream, storm drain or groundwater discharge may depress the pH to a minimum level of 7.0.

There is no statistical compliance methodology for this requirement. In situ measurements were obtained and compared with the above pH range; see Table 8-1. Never during the 1994 monitoring year did the monitored pH value exceed this requirement at any station or at any depth.

TABLE 8-1 1994 CTD Data			
		pH	
Sample site	n	max	min
HN1	42	8.1	7.9
HN2	42	8.2	8.0
HN3	45	8.2	8.0
HN4	46	8.2	8.0
HZ	231	8.1	8.0
HM1	102	8.1	8.0
HM2	214	8.1	8.0
HM3	364	8.1	7.8
HM4	195	8.1	7.9
HB1	244	8.1	7.8
HB2	217	8.1	7.9
HB3	256	8.1	7.9
HB4	231	8.1	7.9
HB5	243	8.1	7.9
HB6	222	8.1	8.0
HB7	244	8.1	8.1

n = number of measurements taken

8.3 TEMPERATURE REQUIREMENT

According to the State WQS and permit requirements, the receiving water temperature shall not vary more than one degree Celsius (±1°C) from ambient conditions.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. Potential temperature measurements were compared with the above temperature range condition. The ambient condition was determined by averaging the potential temperature measurements at each depth from both reference stations (e.g., HB1 and HB7) for each monitoring event. This was then compared with the monitored potential temperature at each station. This process was repeated for subsequent monitoring events. Figures 8.1 - 8.4 illustrate the results of this procedure.

FIGURE 8-1

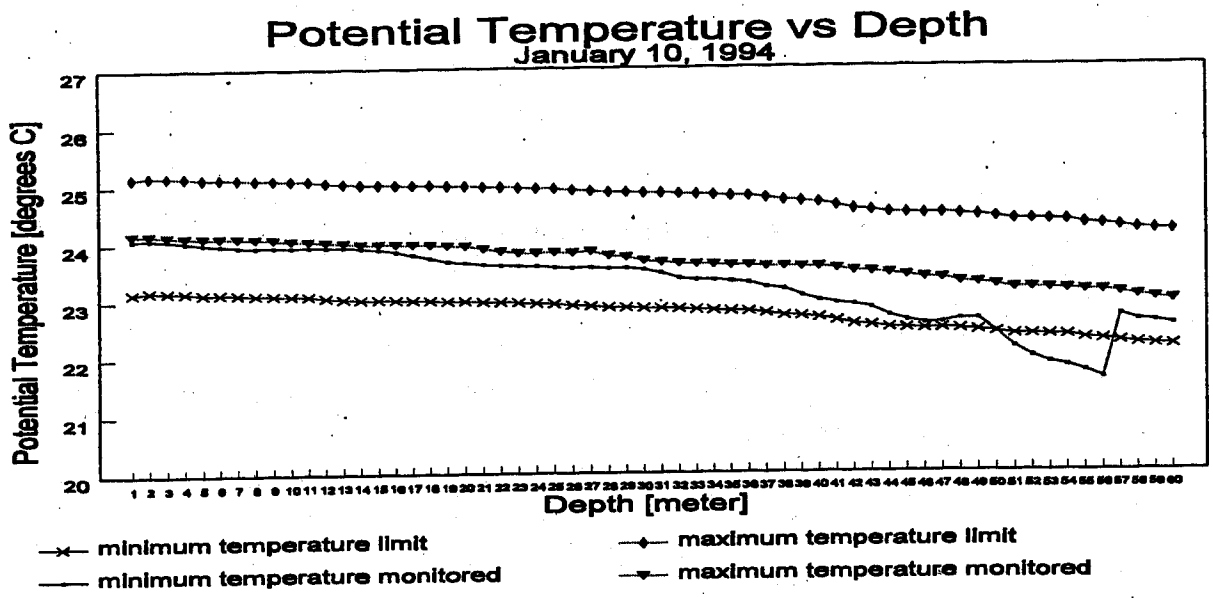


FIGURE 8-2

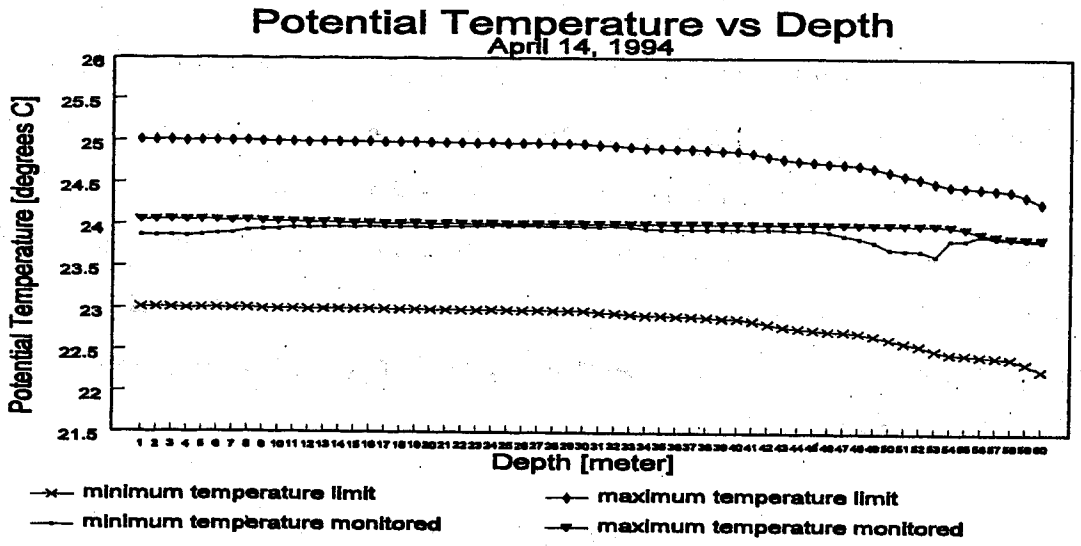


FIGURE 8-3

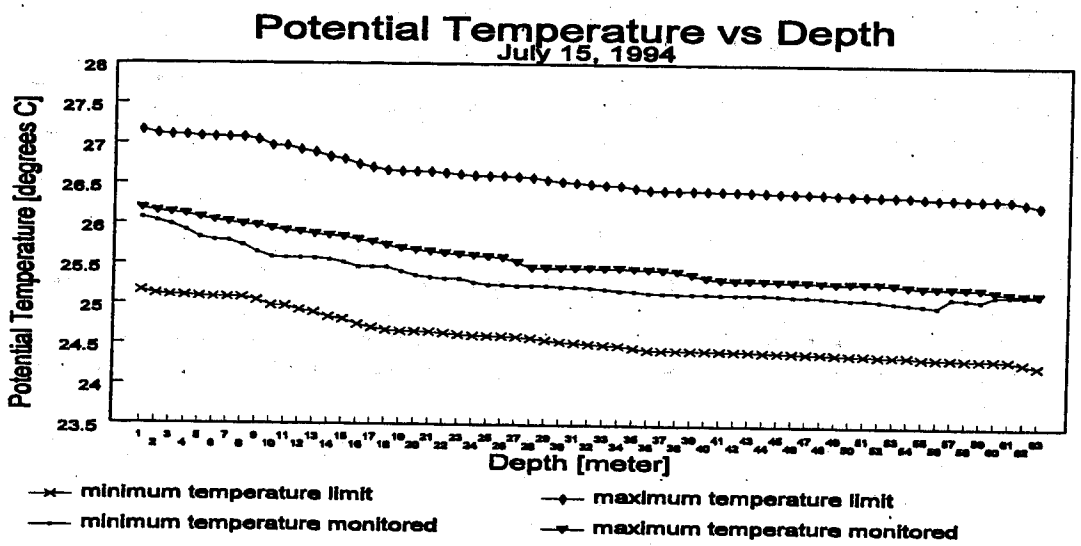
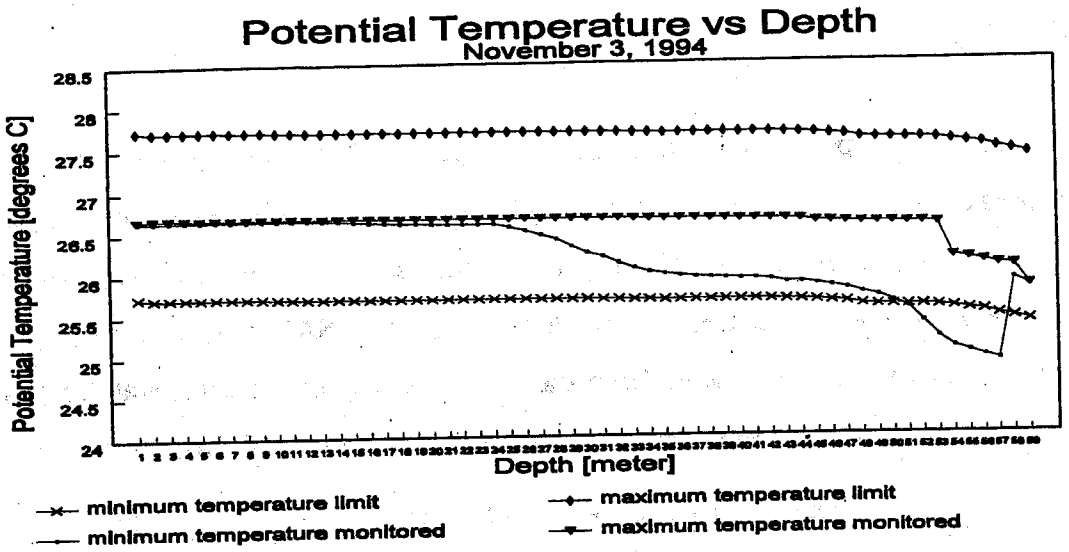


FIGURE 8-4



For the January 10 and November 3, 1994 monitoring events, the receiving water temperature was below the minimum temperature limit. We do not believe both situations can be attributed to the discharge of treated wastewater. First, the reported monthly average and daily maximum effluent temperatures for January 1994 were 25.25°C and 26.25°C, respectively (see monthly Discharge Monitoring Reports for temperature information). The reported monthly average and daily maximum effluent temperatures for November 1994 were 27.66°C and 28.20°C, respectively. Given the current discharge configuration, it is not possible for the effluent to have discharge temperatures below ambient conditions. During the January 10, 1994 monitoring event, stations HM2 and HB2 measured temperatures below the minimum temperature limit, with station HM2 having lower temperatures than station HB2. During the November 3, 1994 monitoring event, stations HB6 and HM4 monitored temperatures below the minimum temperature limit, with station HM2 having lower temperatures than station HB2. Given the arrangement of the monitoring stations and the vertical and horizontal temperature distribution, it does not suggest that the discharge of treated effluent is the cause of the minimum temperature exceedence. Both the April 14 and July 15 monitoring events complied with the temperature requirement.

8.4 SALINITY REQUIREMENT

According to the State WQS and permit requirements, the salinity shall not vary more than ten percent (10%) from natural or seasonal changes considering hydrologic input and oceanographic factors.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. For a given monitoring event, in situ salinity measurements at each depth (SAL_d) for each nearshore and offshore monitoring station were compared with the average salinity ($AVGSAL_d$) at each corresponding depth. The $AVGSAL_d$ at each depth, d, was obtained by averaging salinity measurements from the two reference (or control) stations (e.g., HB1and HB7). The salinity ratio at each depth was computed using the following equation:

$$salinity\ ratio = [1-(AVGSAL_d/SAL_d)] \times 100$$

This process was repeated throughout the depth range of the reference stations, for each monitoring event. Table 8-2 exhibits no percent deviation exceeding the 10% limit.

Table 8-2
SALINITY MEASUREMENTS FOR GIVEN MONITORING EVENTS

Monitoring event	Salinity ratio [%PSU]		Number of sample points (n)	Average salinity ratio	Sample Standard Deviation
	maximum	minimum			
January 1994	0.30%	-0.34%	587	-0.01%	0.07%
April 1994	-0.01%	-0.73%	568	-0.17%	0.14%
July 1994	0.17%	-0.22%	600	0.02%	0.06%

Table 8-2 SALINITY MEASUREMENTS FOR GIVEN MONITORING EVENTS					
Monitoring event	Salinity ratio [%PSU]		Number of sample points (n)	Average salinity ratio	Sample Standard Deviation
	maximum	minimum			
October 1994	0.38%	-0.13%	570	0.04%	0.08%

8.5 DISSOLVED OXYGEN REQUIREMENT

The State WQS and the Honouliuli WWTP 301(h) waiver permit require dissolved oxygen to be not less than seventy-five percent saturation, determined as a function of ambient water temperature and salinity. To determine the dissolved oxygen concentration ($DO_{saturation}$) for given temperature and salinity, dissolved oxygen concentration tables* were used. For each monitoring event, the maximum temperature, T_{max}, and salinity, Sal_{max}, were used to obtain a $DO_{saturation}$. Seventy five percent (75%) of $DO_{saturation}$ was used as the minimum concentration to determine compliance with the State WQS and permit requirements. To show compliance, the minimum dissolved oxygen concentration (DO) for each monitoring event was compared against the corresponding $DO_{saturation}$. Compliance is satisfied when $DO > DO_{saturation}$. Table 8-3 shows that compliance was attained.

Table 8-3 $DO_{saturation}$ Determination		
Monitoring Event	75% $DO_{saturation}$* using maximum salinity and temperature values [mg/l]	Minimum measured Dissolved Oxygen Concentration [mg/l]
January 1994	5.13	5.30
April 1994	5.15	6.19
July 1994	4.97	5.76
October 1994	4.91	5.60

* Tschobanoglous, George and Schroeder, Edward; Water Quality. Addison-Wesley Public Company; February 1987.

CHAPTER 5
NUTRIENT EVALUATION

5.1 INTRODUCTION

All specified nearshore and offshore parameters were monitored during the 1995 monitoring year to demonstrate that permit receiving water limitations (permit sections B.2 and B.3) are not being violated. The 1995, offshore monitoring dates were January 17, April 5, July 10 and October 26, 1995. No monitoring stations or protocols have changed from the previous monitoring year. See Figure 5-1, page 5-13, for the locations of all ocean monitoring stations.

The receiving waters of the Honouliuli WWTP are classified as "Class A" "Dry" "Open Coastal Waters." In part, the State Water Quality Standard (State WQS) states the following limits (see Reference 1, Appendix E), note the double-asterisked applies:

§11-54-06 Uses and specific criteria applicable to marine waters. (b) Open coastal waters. (3) The following criteria are specific for open coastal waters: (Note that criteria for open coastal waters differ, based on fresh water discharge).

TABLE 5-1
MARINE WATER CRITERIA

Parameter	*Geometric mean not to exceed the given value*	*Not to exceed the given value more than ten percent of the time*	*Not to exceed the given value more than two percent of the time*
Total Nitrogen (µg N/L)	*150.00** *110.00***	*250.00** *180.00***	*350.00** *250.00**
Ammonia Nitrogen (µg NH_4-N/L)	*3.50** *2.00***	*8.50** *5.00***	*15.00** *9.00***

TABLE 5-1 MARINE WATER CRITERIA			
Parameter	*Geometric mean not to exceed the given value*	*Not to exceed the given value more than ten percent of the time*	*Not to exceed the given value more than two percent of the time*
Nitrate + Nitrite (μg [NO_3+NO_2] - N/L)	*5.00* *3.50***	*14.00* *10.00***	*25.00* *20.00***
Total Phosphorus (μg P/L)	*20.00* *16.00***	*40.00* *30.00***	*60.00* *45.00***
ψLight Extinction Coefficient (k units)	*0.20* *0.10***	*0.50* *0.30***	*0.85* *0.55***
Chlorophyll a (μg/L)	*0.30* *0.15***	*0.90* *0.50***	*1.75* *1.00***
Turbidity (NTU)	*0.50* *0.20***	*1.25* *0.50***	*2.00* *1.00***

** "Wet" criteria apply when the open coastal waters receive more than three million gallons per day of fresh water discharge per shoreline mile.*

*** "Dry" criteria apply when the open coastal waters receive less than three million gallons per day of fresh water discharge per shoreline mile.*

ψ Light extinction coefficient (LEC) is only required for dischargers who have obtained a waiver pursuant to Section 301(h) of the Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251), as amended, and are required by EPA to monitor it.

Before compliance with the nutrient limits of Table 5-1 can be demonstrated, several procedural details must be defined. These include the methodology used to determine exceedences with each category (e.g., geometric mean, not to exceed 10% and not to exceed 2%); the selection of monitoring stations from which data was obtained and applied to determine compliance; the depths from which data was gathered; and the monitoring duration required for the compliance methodology. These details were obtained from Reference 2 (see Appendix E) and permit requirements which specify monitoring conditions.

5.2 METHODOLOGY

The methodology is based on the assumption that the data follows a lognormal distribution. Exceedences with the three compliance categories (e.g., geometric mean, not to exceed 10% and not to exceed 2%) for any parameter is done by using a graphical method, or probability plots.

By adhering to the following procedure, exceedences with any of the above State WQS nutrient limits can be determined.

a. In column (1) of the work sheet, number the rows from 1 to n, where n is the number of data points to be used in the compliance determination. See Table 5-2 for a sample worksheet.

b. List the data for a particular parameter (e.g., turbidity) as received in column (2). The data should include all applicable stations in the monitoring program with samples taken no deeper than 30 meters (because the State WQS were established from data taken no deeper than 30 meters). Control station data should not be included in the analysis. Furthermore, the data used should be taken over a time period of at least one year. The size of the data base should exceed thirty (30) data points, or $n \geq 30$. Larger data bases are suggested to increase statistical confidence.

c. Order the data in column (2) from smallest to largest into column (3).

d. Take the natural logarithms of the ordered data from column 3 and list in column (4). It doesn't matter what type of logarithm is used provided consistency is maintained. The natural logarithm is specified for consistency.

e. Find the mean and sample standard deviation of the natural logarithm values in column (4).

Mean:

$$\bar{z} = \sum \ln(x_i)/n$$

Sample standard deviation:

$$s = \sqrt{\sum (z_i - \bar{z})^2/(n-1)}$$

where both summations go from i = 1 to n.

f. To calculate the geometric mean (or 50% value) concentration, take the antilog of the mean natural logarithm value from step "e" above.

$$GM = e^{\bar{z}}$$

Multiply and divide the geometric mean value by the antilog of the sample standard deviation from step "e" to define the concentrations associated with 84% and 16%, respectively.

$$z = GM \times e^{s_z}$$

$$z = GM / e^{s_z}$$

Plot these three points [(GM, 50%), ($Z_{84\%}$, 84%), and ($Z_{16\%}$,16%)] on Log-Probability paper. A line drawn through the three points should be a straight line. Identify this line as the *calculated line*. Plot, on the same graph, the three points (or criteria for 50%, 90%, 98%) from the State WQS for the parameter in question, connecting the points with a straight line. Identify the resulting line as the *standard line*. Compare both lines. If the *calculated line* is entirely below the *standard line*, the water quality parameters for the 50%, 90%, and 98% criteria have not been exceeded. In other words, comparison of both lines is the method used to determine exceedences with the standard, not an individual data point. From the *calculated line*, determine the parameter values corresponding to the 90% and 98% probability. Compare these values and the GM with the appropriate State WQS criteria for the parameter in question.

g. Plot all data points on Log-Probability paper, use the ranked data (column (3)) as the abscissa (y-axis) and the probability (column (5)) as the ordinate (x-axis). The purpose of

plotting the data is to validate the lognormal distribution. If the plotted data points approximate the *calculated line* on Log-Probability paper, then the lognormal distribution assumption is verified. Other distributions may be applied; however, the assumption of this methodology assumes (with corresponding verification by data plotting) a lognormal distribution.

h. If the plotted data confirms a lognormal distribution, the results from step "f" above are valid.

i. If the plotted data does not correspond to the *calculated line* (e.g. confirmation of the lognormal distribution is not validated), several events could be occurring. There could be something wrong with the data or another process may be occurring in the receiving waters. Lastly, but not necessarily finally, the process may not be lognormal distributed, and therefore, compliance cannot be determined.

TABLE 5-2
SAMPLE WORKSHEET

i	Listing of raw data as received	Data, xi ranking smallest to largest	Logarithm of the ranked data	Probability (percent) 100*(i-½)/n [%]
1	y_1	x_1	$\ln(x_1)$	(1-½)/n
2	y_2	x_2	$\ln(x_2)$	(2-½)/n
:	:	:	:	:
n	y_n	x_n	$\ln(x_n)$	(n-½)/n

where n = the number of data points.

5.3 TEMPORAL AND SPATIAL CONSIDERATIONS

The above analyses shall be done on an annual (calendar year) basis, using a minimum sample size of roughly thirty (30) data points. If thirty data points are not available during a given monitoring year, the data obtained during the previous monitoring year shall be included in the compliance data

base. This procedure will be continued until a compliance data base of thirty or more data points is achieved. An analyses which includes at least five (5) years of data shall also be done at the same time as the annual analyses. The purpose of this analyses is to identify possible long term impacts. The one (1) and five (5) year analyses constitute a compliance analyses for the WQS.

Data, or sample results, obtained from samples collected from depths greater than 30 meters (roughly 100 feet) should not be included in the methodology defined above because the State WQS were developed from sample results taken from depths less than 30 meters.

In accordance with Section B.2 of the permit, data obtained from station(s) within the zone of initial dilution (ZID) and stations identified as "control" stations, shall not be included in the methodology defined above. For turbidity and light extinction coefficient, LEC (note; LEC is a required parameter for NPDES 301(h) waiver permits), stations at and beyond the ZID shall be used; e.g., ZID stations only. For the other parameters, i.e., ammonia nitrogen, total phosphorus, etc., compliance with the State WQS shall include stations at or beyond the ZOM; e.g., ZOM stations only.

A separate set of analyses shall be done using data from the control stations only. The same depth and temporal guidelines shall be applied to the control station data. The purpose of this analysis is to compare background conditions to the conditions at the ZOM or ZID.

A noncompliant event results if any parameter above has exceeded the applicable limit of Table 5-1, accompanied by sufficient evidence that the exceedence is related to the discharge. Examples of this evidence is a comparison of the ZOM/ZID station analyses with the control station analyses. Exceedences attributable to the discharge should not be impacting the control stations. Furthermore, exceedences of one or more parameters should be associated with increases from other parameters, which may or may not have exceeded applicable limits, if the discharge is the cause of the exceedence.

5.4 RESULTS

5.4.1 ZOM and ZID Station Results

The compliance methodology, as presented above, was applied to the ZOM and ZID monitoring data obtained during the 1995 monitoring year. To obtain a monitoring data base of at least thirty elements, some of the data obtained during the 1994 monitoring year were used. For Light Extinction Coefficient (LEC), all data from the 1994 monitoring year were used. For Chlorophyll a, data from the last two quarters of the 1994 monitoring year was used. For all other parameters, data from the last quarter of the 1994 monitoring year was used. Results of the 1995 monitoring year analyses are tabulated in Table 5-3. Results of the analyses using the last five (5) years of data are tabulated in Table 5-4.

TABLE 5-3
1995 MONITORING YEAR RESULTS

Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	98.30	120	139

TABLE 5-3 1995 MONITORING YEAR RESULTS			
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Ammonia Nitrogen (µg NH_4-N/L)	1.08	1.7	2.25
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	1.01	1.19	1.3
Total Phosphorus (µg P/L)	9.91	12.5	14.4
ψLight Extinction Coefficient (k units)	0.07	0.084	0.094
Chlorophyll a (µg/L)	0.15	0.52	1.1
Turbidity (NTU)	0.18	0.275	0.36

ψ See Table 5-1 footnote.

TABLE 5-4
1991 - 1995 MONITORING PERIOD DATA

Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	95.96	122	141
Ammonia Nitrogen (µg NH_4-N/L)	1.71	4.9	9.4
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	1.10	1.6	2.0
Total Phosphorus (µg P/L)	9.0	12.0	14.5
ΨLight Extinction Coefficient (k units)	0.07	0.09	0.11
Chlorophyll a (µg/L)	0.14	0.33	0.56
Turbidity (NTU)	0.13	0.21	0.285

Ψ See Table 5-1 footnote.

For both of these analyses, there were three events that exceeded the State WQS limits found in Table 5-1: the 1995 Chlorophyll a "not to exceed 10%" category; the 1995 Chlorophyll a "not to exceed 2%" category, and the 5-year, Ammonia Nitrogen, not to exceed 2% category. Of the monitored water quality parameters that could affect the Chlorophyll a concentration (i.e, LEC, nutrients, oxygen, turbidity, temperature, and salinity), only temperature posed a potential problem; see Chapter 8. All other parameters were in compliance with the State WQS and did not significantly change from last year. Figures 5-2 to 5-4, however, suggest that the discharge of treated wastewater could have contributed to the noncompliant event because the chlorophyll a concentrations of the reference stations were lower than the ZOM station concentrations.

Because Ammonia Nitrogen results for the 1995 monitoring year were significantly below the 5-year analyses for both the ZOM and Control Station analyses, we do not consider this a noncompliant event. Compliance for the ZOM stations was based on a sample size of thirty-six (36) data points for all parameters except for Chlorophyll a, which had a sample size of thirty-seven (37) data points. For Light Extinction Coefficient (LEC) and Turbidity (i.e., ZID stations) , thirty-two (32) samples were used for compliance determination. Values of LEC are obtained from secchi depth measurements. In most cases, the difference between the compliance analyses using five (5) years of data and the compliance analyses using the 1995 data was not significant.

5.4.2 Control Station Results

The compliance methodology was also applied to the data collected from control stations HB-1 and HB-7 during the 1994 monitoring year. Results of the 1994 monitoring year analyses for control station data are tabulated in Table 5-5. Results of the analyses using five (5) year of control station data are tabulated in Table 5-6.

TABLE 5-5
1995 MONITORING YEAR DATA - Control Stations

Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	86.36	114	139
Ammonia Nitrogen (µg NH_4-N/L)	1.06	1.5	1.85
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	1.02	1.19	1.3
Total Phosphorus (µg P/L)	9.09	11.0	12.4
ΨLight Extinction Coefficient (k units)	0.06	0.074	0.084
Chlorophyll a (µg/L)	0.09	0.257	0.485
Turbidity (NTU)	0.15	0.258	0.36

Ψ See Table 5-1 footnote.

TABLE 5-6 1991 - 1995 MONITORING PERIOD DATA - Control Stations			
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	91.24	105	120
Ammonia Nitrogen (µg NH_4-N/L)	1.61	3.9	6.7
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	1.04	1.35	1.59
Total Phosphorus (µg P/L)	8.44	10.9	12.8
ΨLight Extinction Coefficient (k units)	0.06	0.074	0.084
Chlorophyll a (µg/L)	0.09	0.28	0.56
Turbidity (NTU)	0.11	0.183	0.25

Ψ See Table 5-1 footnote.

For both of these analyses, there were no events that exceeded the water quality limits found in Table 5-1.

FIGURE 5-1

HWWTP OCEAN MONITORING STATIONS

Figure 5-2
Chlorophyll a vs Time

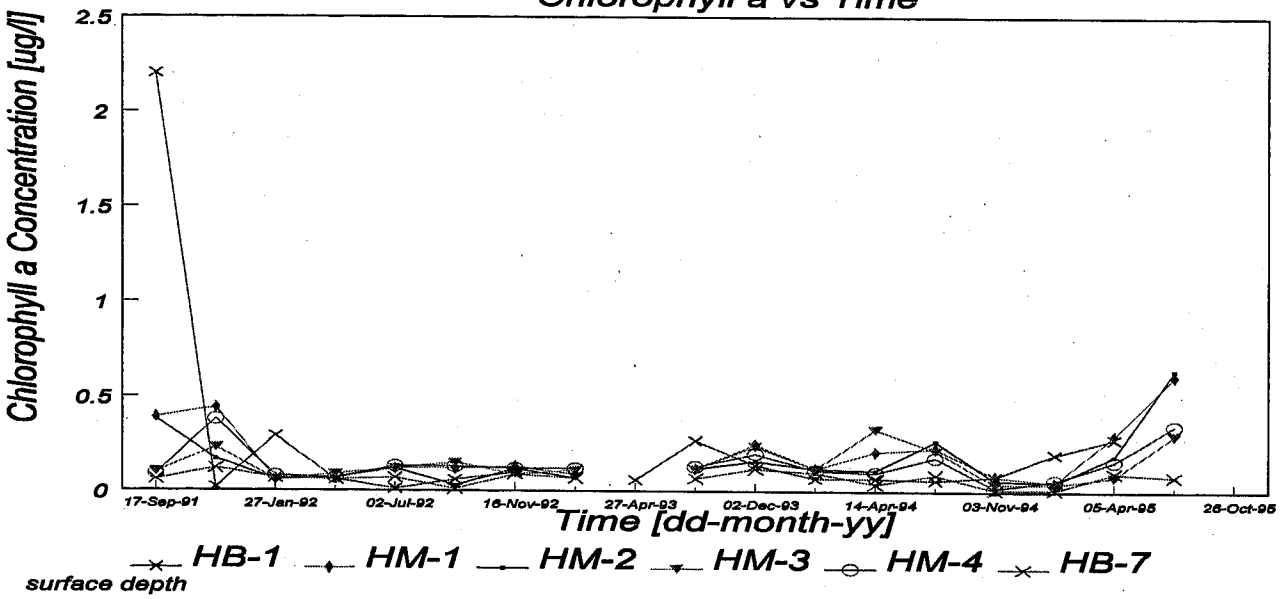


Figure 5-3
Chlorophyll a vs Time

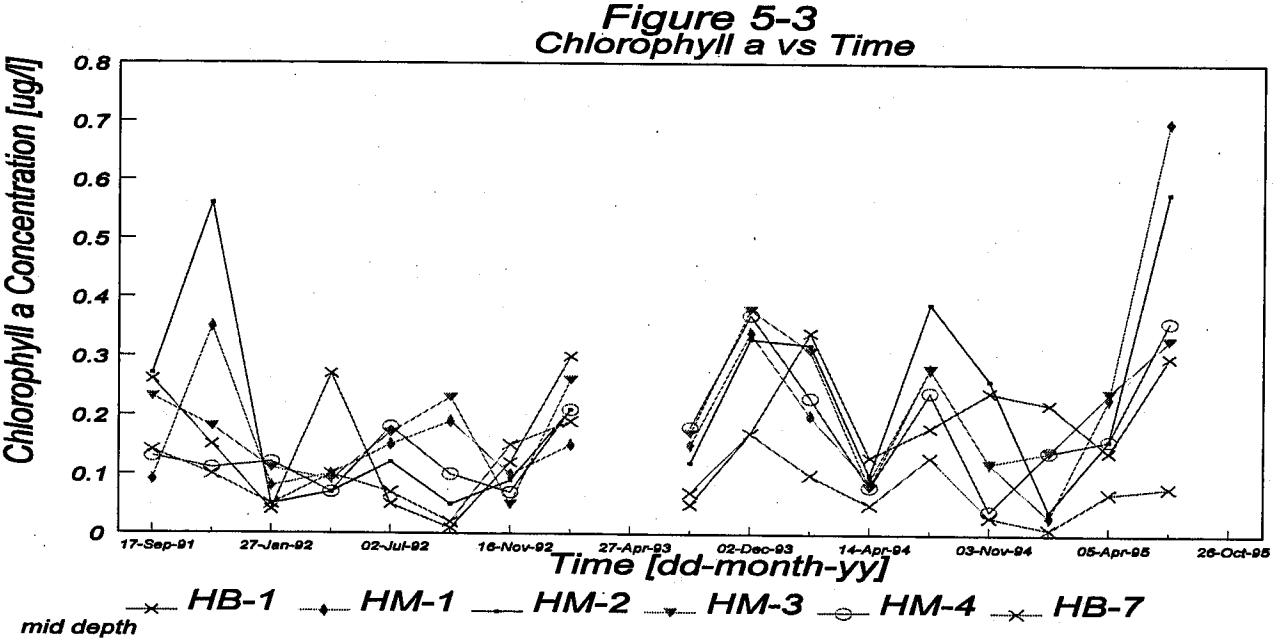
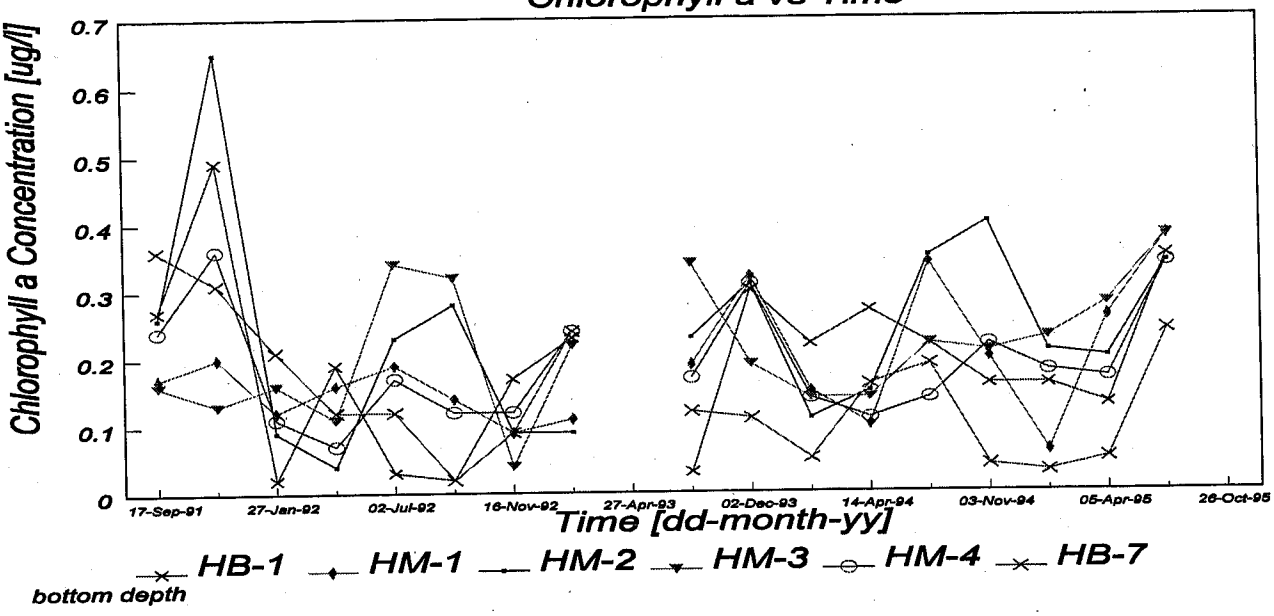


Figure 5-4
Chlorophyll a vs Time



CHAPTER 8
CHEMISTRY EVALUATION

8.1 INTRODUCTION

All nearshore and offshore parameters were monitored during the 1995 monitoring year as required by the Honouliuli WWTP 301(h) waiver permit. The dates for the 1995 monitoring events were January 17, April 5, July 10, and October 26, 1995. No monitoring stations or protocols were changed from the previous monitoring year. See Figure 5-1, page 5-13, for the ocean monitoring sites. Compliance determination was based on measurements obtained by the City's Sea-Bird, CTD Profiler. Measurements of pH, potential temperature, salinity, and dissolved oxygen were taken at one (1) meter intervals for all four (4) nearshore stations and twelve (12) offshore stations during each monitoring event. The data was then compared with conditions stated in the Honouliuli WWTP 301(h) waiver permit, sections B.2. and B.3, and the State Water Quality Standards (WQS).

8.2 pH REQUIREMENT

According to the State WQS and permit requirements, pH units shall not deviate more than 0.5 units from a value of 8.1 ($7.6 \leq pH \leq 8.6$) except at coastal locations where and when freshwater from stream, storm drain or groundwater discharge may depress the pH to a minimum level of 7.0.

There is no statistical compliance methodology for this requirement. In situ measurements were obtained and compared with the above pH range; see Table 8-1. Never during the 1995 monitoring year did the monitored pH value exceed the specified limits at any station or at any depth.

TABLE 8-1 1995 CTD Data			
Sample site	n	pH	
		max	min
HN1	47	8.2	8.1
HN2	41	8.2	8.1
HN3	46	8.2	8.1
HN4	44	8.2	8.1
HZ	226	8.2	8.1
HM1	103	8.2	8.1
HM2	200	8.2	8.1
HM3	367	8.2	8.1
HM4	207	8.2	8.1
HB1	242	8.2	8.1
HB2	205	8.2	8.1
HB3	299	8.2	8.1
HB4	239	8.2	8.1
HB5	198	8.2	8.1
HB6	224	8.2	8.1
HB7	236	8.2	8.1

n = number of measurements taken

8.3 TEMPERATURE REQUIREMENT

According to the State WQS and permit requirements, the receiving water temperature shall not vary more than one degree Celsius (±1°C) from ambient conditions.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. Potential temperature measurements were compared with the above temperature range condition. The ambient condition was determined by averaging the potential temperature measurements at each depth from both reference stations (e.g., HB1 and HB7) for each monitoring event. This was then compared with the monitored potential temperature at each station. This process was repeated for subsequent monitoring events. Figures 8-1 through 8-4 illustrate the results of this procedure.

Figure 8-1
Potential Temperature vs Depth

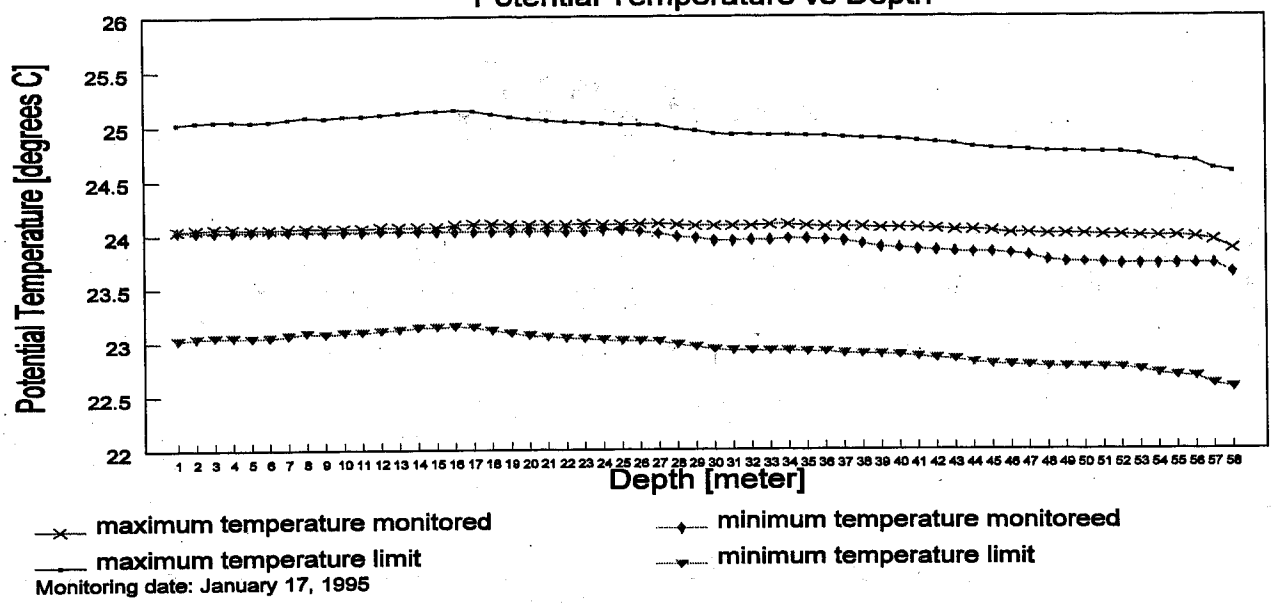
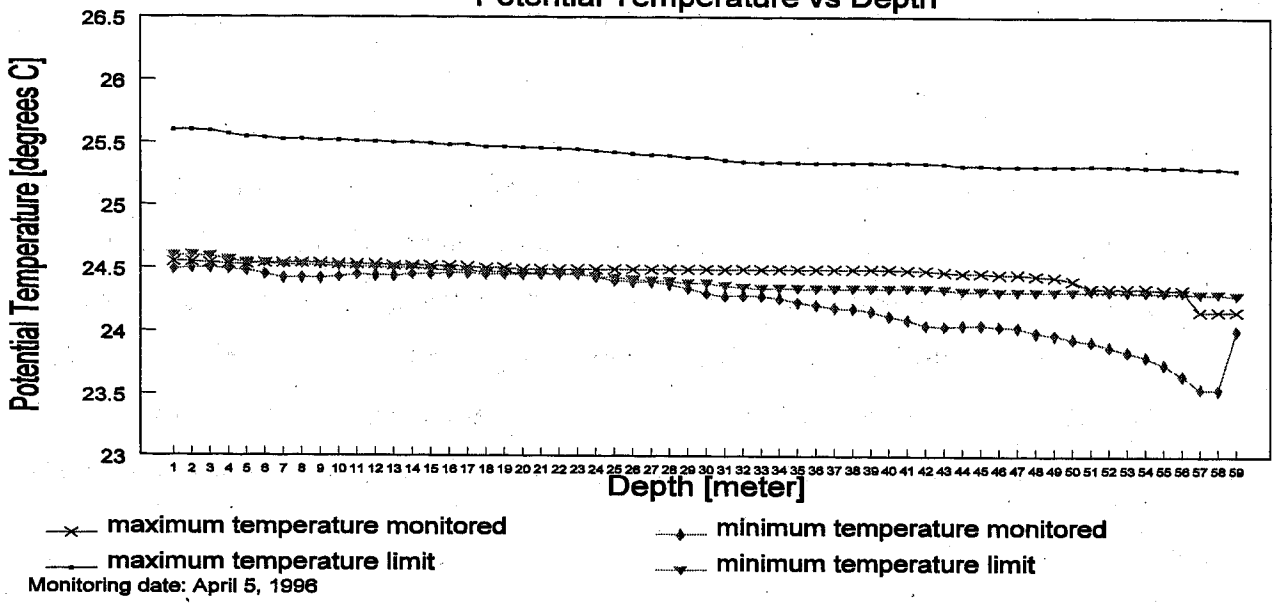
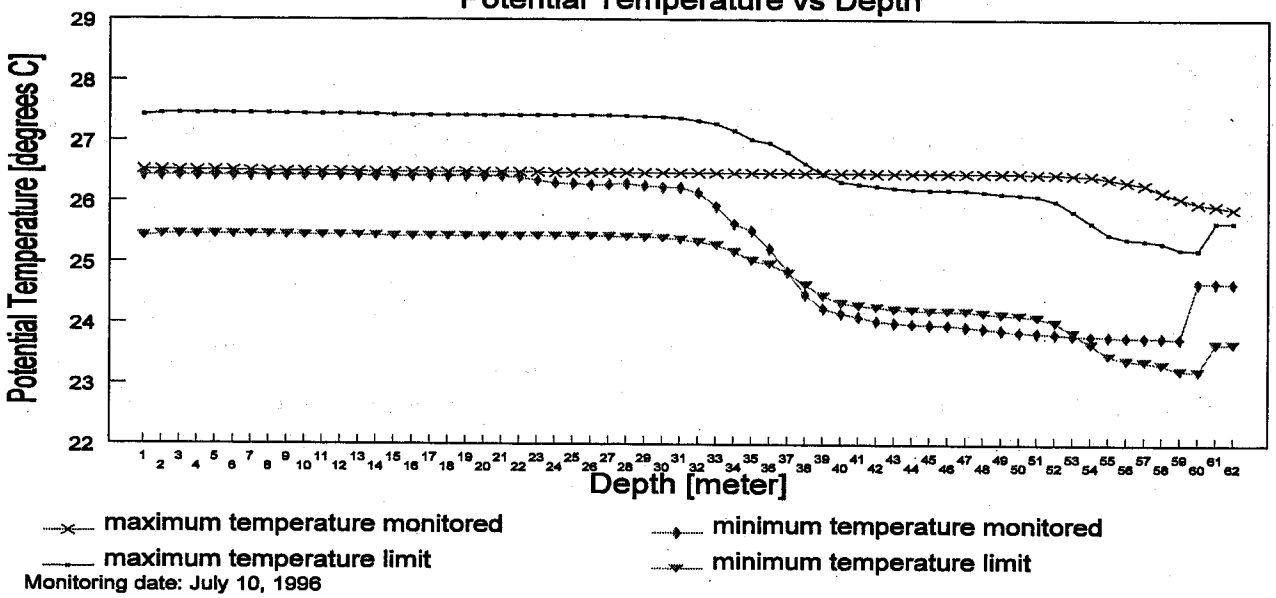


Figure 8-2
Potential Temperature vs Depth



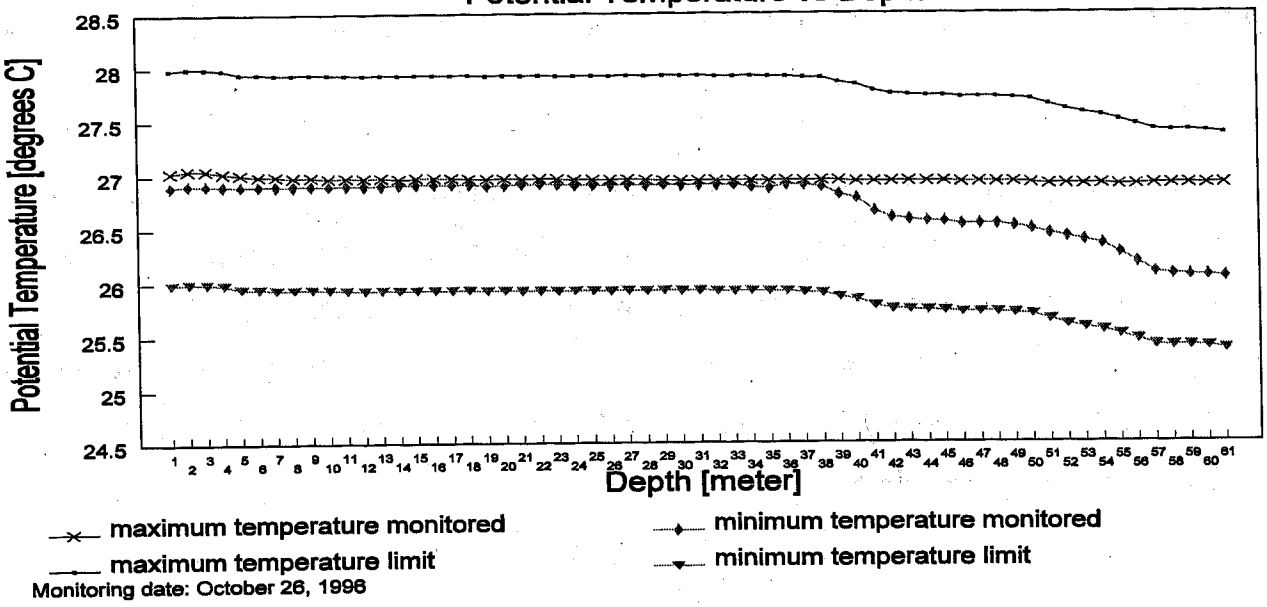
Monitoring date: April 5, 1996

Figure 8-3
Potential Temperature vs Depth



Monitoring date: July 10, 1996

Figure 8-4
Potential Temperature vs Depth



For the April 5 and July 10, 1995 monitoring events, the receiving water temperature was below the minimum temperature limit. We do not believe either situation can be associated with the discharge of treated wastewater. The reported monthly average and daily maximum effluent temperatures for April 1995 were 26.18°C and 26.5°C, respectively (see monthly Discharge Monitoring Reports for temperature information). The reported monthly average and daily maximum effluent temperatures for July 1995 were 27.73°C and 28.00°C, respectively. Given the current discharge configuration, it is not possible for the effluent to have discharge temperatures below ambient conditions. Given the arrangement of the monitoring stations and the vertical and horizontal temperature distribution, it does not suggest that the discharge of treated effluent is the cause of the minimum temperature exceedence. For the July 10, 1995 monitoring event, the receiving water temperature was above the maximum temperature limit. Given the discharge temperature, this exceedance could be attributed to the discharge. When the salinity and dissolved oxygen data are inspected, it does not appear the discharge is having a measurable influence. The January 17 and October 26, 1995 monitoring events both complied with the temperature requirement.

8.4 SALINITY REQUIREMENT

According to the State WQS and permit requirements, the salinity shall not vary more than ten percent (10%) from natural or seasonal changes considering hydrologic input and oceanographic factors.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. For a given monitoring event, in situ salinity measurements at each depth (SAL_d) for each offshore monitoring station were compared with the average salinity ($AVGSAL_d$) at each corresponding depth. The $AVGSAL_d$ at each depth, d, was obtained by averaging salinity measurements from the two reference (or control) stations HB1and HB7. The salinity ratio at each depth was computed using the following equation:

$$salinity''ratio''=''[1-(AVGSAL_d/SAL_d)]''X''100$$

This process was repeated throughout the depth range of the reference stations, for each monitoring event. Table 8-2 exhibits no percent deviation exceeding the 10% limit.

Table 8-2

SALINITY MEASUREMENTS FOR GIVEN MONITORING EVENTS

Monitoring event	Salinity ratio [%PSU]		Number of sample points (n)	Average salinity ratio	Sample Standard Deviation
	maximum	minimum			
January 1995	0.65%	-0.05%	529	0.23%	0.14%
April 1995	0.28%	-0.41%	516	0.03%	0.10%
July 1995	0.62%	0.33%	624	0.08%	0.16%
October 1995	0.95%	-0.08%	680	0.03%	0.08%

8.5 DISSOLVED OXYGEN REQUIREMENT

The State WQS and the Honouliuli WWTP 301(h) waiver permit require dissolved oxygen to be not less than seventy-five (75%) percent saturation, determined as a function of ambient water temperature and salinity. To determine the dissolved oxygen concentration ($DO_{saturation}$) for given temperature and salinity, dissolved oxygen concentration tables* were used. For each monitoring event, the maximum temperature, T_{max}, and salinity, Sal_{max}, were used to obtain a $DO_{saturation}$. Seventy-five percent (75%) of $DO_{saturation}$ was used as the minimum concentration to determine compliance with the State WQS and permit requirements. To show compliance, the minimum dissolved oxygen concentration (DO) for each monitoring event was compared against the corresponding $DO_{saturation}$. Compliance is achieved when DO > 75% $DO_{saturation}$. Table 8-3 shows that compliance was attained.

Table 8-3

$DO_{saturation}$ Determination

Monitoring Event	75% $DO_{saturation}$* using maximum salinity and temperature values [mg/l]	Minimum measured Dissolved Oxygen Concentration [mg/l]
January 1995	4.99	5.70
April 1995	5.20	6.22
July 1995	4.93	5.34
October 1995	4.77	5.70

* Tschobanoglous, George and Schroeder, Edward; Water Quality. Addison-Wesley Public Company; February 1987.

CHAPTER 5
NUTRIENT EVALUATION

5.1 INTRODUCTION

All nearshore and offshore parameters were monitored during the 1996 monitoring year to demonstrate that receiving water limitations (Section B.2 and B.3) of the NPDES permit were not violated. The 1996, offshore monitoring dates were January 18, May 23, July 10, and October 8, 1996. All monitoring stations and protocols have not changed from the previous monitoring year. See Figure 5-1 for the locations of all ocean monitoring locations.

The receiving waters of the Honouliuli WWTP are classified as "Class A" "Dry" "Open Coastal Waters." In part, the State Water Quality Standard (State WQS) states the following limits (see Reference 2, Appendix E), note the single-asterisked applies:

§11-54-06 Uses and specific criteria applicable to marine waters. (b) Open coastal waters. (3) The following criteria are specific for open coastal waters: (Note that criteria for open coastal waters differ, based on fresh water discharge).

TABLE 5-1
MARINE WATER CRITERIA

Parameter	*Geometric mean not to exceed the given value*	*Not to exceed the given value more than ten percent of the time*	*Not to exceed the given value more than two percent of the time*
Total Nitrogen (µg N/L)	*150.00** *110.00***	*250.00** *180.00***	*350.00** *250.00***

TABLE 5-1
MARINE WATER CRITERIA, ***continued***

Parameter	*Geometric mean not to exceed the given value*	*Not to exceed the given value more than ten percent of the time*	*Not to exceed the given value more than two percent of the time*

Ammonia Nitrogen (µg NH_4-N/L)	3.50* 2.00**	8.50* 5.00**	15.00* 9.00**
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	5.00* 3.50**	14.00* 10.00**	25.00* 20.00**
Total Phosphorus (µg P/L)	20.00* 16.00**	40.00* 30.00**	60.00* 45.00**
[1]Light Extinction Coefficient (k units)	0.20* 0.10**	0.50* 0.30**	0.85* 0.55**
Chlorophyll a (µg/L)	0.30* 0.15**	0.90* 0.50**	1.75* 1.00**
Turbidity (NTU)	0.50* 0.20**	1.25* 0.50**	2.00* 1.00**

** "Wet" criteria apply when the open coastal waters receive more than three million gallons per day of fresh water discharge per shoreline mile.*

*** "Dry" criteria apply when the open coastal waters receive less than three million gallons per day of fresh water discharge per shoreline mile.*

[1] Light extinction coefficient (LEC) is only required for dischargers who have obtained a waiver pursuant to Section 301(h) of the Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251), as amended, and are required by EPA to monitor it.

FIGURE 5-1

HONOULIULI WWTP OCEAN MONITORING STATIONS

Before compliance with the nutrient limits of Table 5-1 can be demonstrated, several procedural details must be defined. These include the methodology used to determine exceedences with each category (e.g., geometric mean, not to exceed 10% and not to exceed 2%), the selection of monitoring stations from which data were obtained and applied to determine compliance, the depths from which data were gathered, and the monitoring duration required for the compliance methodology. These details were obtained from Reference 1 (see Appendix E) and permit requirements that specify monitoring conditions.

5.2 METHODOLOGY

The methodology is based on the assumption that the data follows a lognormal distribution. Exceedences with the three compliance categories (e.g., geometric mean, not to exceed 10% and not to exceed 2%) for any parameter is done by using a graphical method, or probability plots.

By adhering to the following procedure, exceedences with any of the above State WQS nutrient limits can be determined:

a. In column (1) of a work sheet, number the rows from 1 to n, where n is the number of data points to be used in the compliance determination. See Table 5-2 for a sample worksheet.

b. List the data for a particular parameter (e.g., turbidity) as received in column (2). The data should include all applicable stations in the monitoring program with samples taken no deeper than 30 meters (because the State WQS were established from data taken no deeper than 30 meters). Control station data should not be included in the analysis. Furthermore, the data used should be taken over a time period of at least one year. The size of the data base should exceed thirty (30) data points, or $n \geq 30$. Larger data bases are suggested to increase statistical

c. Order the data in column (2) from smallest to largest into column (3).

d. Take the natural logarithms of the ordered data from column 3 and list in column (4). It doesn't matter what type of logarithm is used provided consistency is maintained. The natural logarithm is specified for consistenc

e. Find the mean and sample standard deviation of the natural logarithm values in column (4).

Mean:

$$\bar{z} = \sum \ln(x_i)/n$$

Sample standard deviation:

$$s_{\bar{z}} = \sqrt{\sum (z_i - \bar{z})^2 / (n-1)}$$

where both summations go from I = 1 to n.

f. To calculate the geometric mean (or 50% value) concentration, take the antilog of the mean natural logarithm value from step "e" above.

$$GM = e^{\bar{z}}$$

Multiply and divide the geometric mean value by the antilog of the sample standard deviation from step "e" to define the concentrations associated with 84% and 16%, respectively.

$$z_{84\%} = GM * e^{s_z}$$

$$z_{16\%} = GM / e^{s_z}$$

Plot these three points [(GM, 50%), ($Z_{84\%}$, 84%), and ($Z_{16\%}$, 16%)] on Log-Probability paper. A line drawn through the three points should be a straight line. Identify this line as the *calculated line*. Plot the three points (or criteria for 50%, 90%, 98%) from the State WQS for the parameter in question, connecting the points with a straight line. Identify the resulting line as the *standard line*. Compare both lines. If the *calculated line* is entirely below the *standard line*, the water quality parameters for the 50%, 90%, and 98% criteria have not been exceeded. In other words, comparison of both lines is the method used to determine exceedences with the standard, not an individual data point. From the *calculated line*, determine the parameter values corresponding to the 90% and 98% probability. With the GM, compare these values with the appropriate State WQS criteria values for the parame

g. Plot all data points on Log-Probability paper, use the ranked data (column (3)) as the abscissa (y-axis) and the probability (column (5)) as the ordinate (x-axis). The purpose of plotting the data is to validate the lognormal distribution. If the plotted data points approximate the *calculated line* on Log-Probability paper, then the lognormal distribution assumption is verified. Other distributions may be applied; however, the assumption for this methodology assumes (with corresponding verification by data plotting) a lognormal distribution.

h. If the plotted data confirms a lognormal distribution, the results from step "f" above are valid.

i. If the plotted data does not correspond to the *calculated line* (e.g. confirmation of the lognormal distribution is not validated), several events could be occurring. There could be something wrong with the data or another process may be occurring. Lastly, but not necessarily finally, the process may not be lognormal distributed, and therefore, compliance cannot be determined.

TABLE 5-2
SAMPLE WORKSHEET

i	Listing of raw data as received	Data, x_i ranking smallest to largest	Logarithm of the ranked data	Probability (percent) 100*(I-½)/n [%]
1	y_1	x_1	$\ln(x_1)$	(1-½)/n
2	y_2	x_2	$\ln(x_2)$	(2-½)/n
:	:	:	:	:
n	y_n	x_n	$\ln(x_n)$	(n-½)/n

where n = the number of data points.

5.3 TEMPORAL AND SPATIAL CONSIDERATIONS

The above analyses shall be done on an annual (calendar year) basis, using a minimum sample size of roughly thirty data points. If thirty data points are not available during a given monitoring year, the data obtained during the previous monitoring year shall be included in the compliance data base. This procedure will be continued until a compliance data base of thirty or more data points is achieved. An analyses which includes at least five (5) years of data shall also be done at the same time as the annual analyses. The purpose of this analyses is to identify possible long term impacts. The one (1) and five (5) year analyses constitute a compliance analyses for the WQS.

Data, or sample results, obtained from samples collected from depths greater than 30 meters (roughly 100 feet) should not be included in the methodology defined above because the State WQS were developed from sample results taken from depths less than 30 meters.

In accordance with Section B.2 of the permit, data obtained from station(s) within the zone of initial dilution (ZID) and stations identified as "control" stations, shall not be included in the methodology defined above. For turbidity and light extinction coefficient, LEC (Note: LEC is a required parameter for NPDES 301(h) waiver permits), stations at and beyond the ZID shall be used; e.g., ZID stations only. For the other parameters such as ammonia nitrogen, total phosphorus, etc., compliance with the State WQS shall include stations at or beyond the ZOM; e.g., ZOM stations only.

A separate set of analyses shall be done using data from the control stations only. The same depth and temporal guidelines shall be applied to the control station data. The purpose of this analysis is to compare background conditions to the conditions at the ZOM or ZID.

A noncompliant event results if any parameter above has exceeded the applicable limit of Table 5-1, accompanied by sufficient evidence that the exceedence is related to the discharge. Examples of this evidence is a comparison of the ZOM/ZID station analysis with the control station analysis. Exceedences attributable to the discharge should not be impacting the control stations. Furthermore, exceedences of one or more parameters should be associated with increases from other parameters, which may or may not have exceeded applicable limits, if the discharge is the cause of

5.4 RESULTS

5.4.1 ZOM AND ZID STATION RESULTS

The compliance methodology, as presented above, was applied to the ZOM and ZID monitoring data obtained during the 1996 monitoring year. To obtain a monitoring data base of at least thirty elements, data obtained from the 1996 and 1995 monitoring years were used. The last quarter of 1995 and all of the 1996 monitoring data were used for all parameters except turbidity, chlorophyll-a and Light Extinction Coefficient (LEC). Turbidity and chlorophyll-a required both the 1996 and the last two quarters of the 1995 monitoring data. The LEC required all of 1995 and 1996 monitoring data. Results of the 1996 monitoring year analyses are tabulated in Table 5-3. Results of the analyses using five (5) years of data are tabulated in Table 5-4.

TABLE 5-3 1996 MONITORING YEAR RESULTS			
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	92.36	122	148
Ammonia Nitrogen (µg NH_4-N/L)	1.19	2.7	4.31
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	1.00	1.00	1.00
Total Phosphorus (µg P/L)	9.82	12.0	13.2
[1]Light Extinction Coefficient (k units)	0.07	0.094	0.110
Chlorophyll a (µg/L)	0.16	0.70	1.017
Turbidity (NTU)	0.25	0.37	0.47

[1]See Table 5-1 footnote.

Shaded cells indicate noncompliances

TABLE 5-4 1992 - 1996 MONITORING PERIOD DATA			
Parameters	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	94.06	118	135
Ammonia Nitrogen (µg NH_4-N/L)	1.44	3.6	6.1
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	1.08	1.51	1.89
Total Phosphorus (µg P/L)	9.11	11.8	14.0
[1]Light Extinction Coefficient (k units)	0.07	0.088	0.105
Chlorophyll a (µg/L)	0.13	0.35	0.638
Turbidity (NTU)	0.15	0.27	0.39

[1]See Table 5-1 footnote.

In Table 5-3, the results of the 1996 analysis were compared with the "marine criteria." Noncompliances were observed for chlorophyll-a for all criteria. Turbidity exceeded the "geometric mean not to exceed the given value" criterion. No noncompliances were determined for the five-year analysis.

5.4.2 CONTROL STATION RESULTS

The compliance methodology was also applied to the data collected from control stations HB-1, HB-6 and HB-7 during the 1996 monitoring year. To obtain a monitoring data base of at least thirty elements, data from the 1995 and 1996 monitoring years were used for all parameters except for chlorophyll-a and LEC. The last quarter of 1994 in addition to 1995 and 1996 monitoring data were used for chlorophyll-a. For the light extinction coefficient, data from 1995, 1996, and the last two

quarters of 1994 were used. Results of the 1996 analyses are tabulated in Table 5-5. Results of the analyses using five (5) years of control station data are tabulated in Table 5-6.

TABLE 5-5
1996 MONITORING YEAR DATA - Control Stations

Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	82.42	110.00	131.00
Ammonia Nitrogen (µg NH_4-N/L)	1.04	1.3	1.50
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	1.02	1.19	1.3
Total Phosphorus (µg P/L)	9.50	13.0	16.0
[1]Light Extinction Coefficient (k units)	0.06	0.063	0.068
Chlorophyll a (µg/L)	0.08	0.25	0.56
Turbidity (NTU)	0.18	0.30	0.42

[1]See Table 5-1 footnote.

TABLE 5-6 1992 - 1996 MONITORING PERIOD DATA - Control Stations			
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	87.93	111.00	130
Ammonia Nitrogen (µg NH_4-N/L)	1.48	3.45	5.8
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	1.01	1.19	1.31
Total Phosphorus (µg P/L)	8.58	11.5	13.8
[1]Light Extinction Loefficient (k units)	0.06	0.072	0.082
Chlorophyll a (µg/L)	0.08	0.23	0.44
Turbidity (NTU)	0.13	0.23	0.328

[1]See Table 5-1 footnote.

For both the "annual" and the 5 year analyses, there were no events that exceeded the water quality limits found in Table 5-1. In 1996, all of the ZOM/ZID geometric mean values were higher than the control station geometric mean value except Nitrate + Nitrite. When comparing the 5 year geometric mean values of the ZOM or ZID to the control station results, we arrived at a different conclusion. All parameters had higher ZOM or ZID geometric mean values than the control station geometric mean values except Ammonia Nitrogen.

5.4.3 DISCUSSION

Because the chloropyll-a and turbidity noncompliances were observed for the annual analyses and not at the control stations, this could be due to the discharge of the Barbers Point Ocean Outfall. The five-year analyses applied for all parameters at the ZOM/ZID and control stations did not exceed the standard.

CHAPTER 8
CHEMISTRY EVALUATION

8.1 INTRODUCTION

All nearshore and offshore parameters were monitored during the 1996 monitoring year, as required by the Honouliuli WWTP 301(h) waiver permit. The dates for the 1996 monitoring events were January 18, May 23, July 10, and October 8, 1996. All monitoring stations and protocols were unchanged from the previous monitoring year. See Figure 5-1, page 5-13, for the ocean monitoring sites. Compliance determination was based on measurements obtained by the City's Sea-Bird, CTD Profiler. Measurements of pH, potential temperature, salinity, and dissolved oxygen were taken at one (1) meter intervals for all four (4) nearshore stations and twelve (12) offshore stations during each monitoring event. The data was then compared with conditions stated in the Honouliuli WWTP 301(h) waiver permit, sections B.2. and B.3, and the State Water Quality Standards (WQS).

8.2 pH REQUIREMENT

According to the State WQS and permit requirements, pH units shall not deviate more than 0.5 units from a value of 8.1 ($7.6 \leq pH \leq 8.6$) except at coastal locations where and when freshwater from stream, storm drain or groundwater discharge may depress the pH to a minimum level of 7.0.

There is no statistical compliance methodology for this requirement. In situ measurements were obtained and compared with the above pH range; see Table 8-1. Never during the 1996 monitoring year did the monitored pH value exceed this requirement at any station or at any depth.

TABLE 8-1
1996 CTD Data

		pH	
Sample site	n	max	min
HN1	42	8.2	8.0
HN2	38	8.2	8.0
HN3	43	8.2	8.0
HN4	43	8.2	8.0
HZ	233	8.2	8.0
HM1	129	8.2	8.0

HM2	212	8.2	8.0
HM3	371	8.2	8.0
HM4	215	8.2	8.0
HB1	266	8.2	8.0
HB2	209	8.2	8.0
HB3	264	8.2	8.0
HB4	229	8.2	8.0
HB5	210	8.2	8.0
HB6	222	8.2	8.0
HB7	249	8.2	8.0

n = number of measurements taken

8.3 TEMPERATURE REQUIREMENT

According to the State WQS and permit requirements, the receiving water temperature shall not vary more than one degree Celsius (±1°C) from ambient conditions.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. Potential temperature measurements were compared with the above temperature range condition. The ambient condition was determined by averaging the potential temperature measurements at each depth from both reference stations (e.g., HB1 and HB7) for each monitoring event. This was then compared with the monitored potential temperature at each offshore station. This process was repeated for subsequent monitoring events. Figures 8.1 - 8.4 illustrate the results of this procedure.

For the May 23, July 10, and October 8, 1996 monitoring events, portions of the receiving water temperature were below the minimum temperature limit. First, the reported monthly average and daily maximum effluent temperatures for May 1996 were 26.9°C and 27.0°C, respectively. The reported monthly average and daily maximum effluent temperatures for July 1996 were 28.38°C and 28.5°C, respectively. The reported monthly average and daily maximum effluent temperatures for October 1996 were 28.7°C and 29.0°C, respectively. Given the current discharge configuration, it is not possible for the effluent to have discharge temperatures below ambient conditions. During the May 23 and July 10, 1996 monitoring events, the receiving water temperature was greater than the maximum temperature limit. The discharge of treated wastewater may have caused the exceedance for the May 1996 monitoring period, because the reported maximum and minimum effluent temperatures for May 1996 were 27.0°C and 26.5°C, respectively. This corresponds to the maximum receiving water temperature. For the July 1996 monitoring event, the effluent could not have caused an exceedance of the maximum temperature limit, see Figure 8-3, because it is not possible to attribute the increasing temperature with decreasing depth to the discharge of treated effluent.

stations HM2 and HB2 measured temperatures below the minimum temperature limit, with station HM2 having lower temperatures than station HB2. During the November 3, 1995 monitoring event, stations HB6 and HM4 monitored temperatures below the minimum temperature limit, with station HM2 having lower temperatures than station HB2. Given the arrangement of the monitoring stations and the vertical and horizontal temperature distribution, it does not suggest that the discharge of treated effluent is the cause of the minimum temperature exceedence. Both the April 14 and July 15 monitoring events complied with the temperature requirement.

8.4 SALINITY REQUIREMENT

According to the State WQS and permit requirements, the salinity shall not vary more than ten percent (10%) from natural or seasonal changes considering hydrologic input and oceanographic factors.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. For a given monitoring event, in situ salinity measurements at each depth (SAL_d) for each nearshore and offshore monitoring station were compared with the average salinity ($AVGSAL_d$) at each corresponding depth. The $AVGSAL_d$ at each depth, d, was obtained by averaging salinity measurements from the two reference (or control) stations (e.g., HB1 and HB7). The salinity ratio at each depth was computed using the following equation:

$$salinity\ ''ratio'' = ''[1-(AVGSAL_d/SAL_d)]''X''100$$

This process was repeated throughout the depth range of the reference stations, for each monitoring event. Table 8-2 exhibits no percent deviation exceeding the 10% limit.

Table 8-2
SALINITY MEASUREMENTS FOR GIVEN MONITORING EVENTS

Monitoring event	Salinity ratio [%PSU]		Number of sample points (n)	Average salinity ratio	Sample Standard Deviation
	maximum	minimum			
January 1996	0.01%	-1.30%	578	-0.09%	0.16%
May 1996	1.29%	-0.82%	561	0.14%	0.35%
July 1996	0.56%	-0.26%	550	0.03%	0.16%
October 1996	0.08%	-0.65%	495	-0.10%	0.12%

8.5 DISSOLVED OXYGEN REQUIREMENT

The State WQS and the Honouliuli WWTP 301(h) waiver permit require dissolved oxygen to be not less than seventy-five percent saturation, determined as a function of ambient water temperature and salinity. To determine the dissolved oxygen concentration ($DO_{saturation}$) for given temperature and salinity, dissolved oxygen concentration tables* were used. For each monitoring event, the maximum temperature, T_{max}, and salinity, Sal_{max}, were used to obtain a $DO_{saturation}$. Seventy five percent (75%) of $DO_{saturation}$ was used as the minimum concentration to determine compliance with the State

WQS and permit requirements. To show compliance, the minimum dissolved oxygen concentration (DO) for each monitoring event was compared against the corresponding $DO_{saturation}$. Compliance is satisfied when $DO > DO_{saturation}$. Table 8-3 shows that compliance was attained.

Table 8-3
$DO_{saturation}$ Determination

Monitoring Event	Maximum Measured Temperature [°C]	Maximum Measured Salinity [o/oo]	75% $DO_{saturation}$* using maximum salinity and temperature values [mg/l]	Minimum measured Dissolved Oxygen Concentration [mg/l]
January 1996	25.93	34.92	4.99	5.78
May 1996	26.69	34.85	4.93	6.31
July 1996	26.89	35.00	4.91	6.27
October 1996	28.31	34.93	4.75	6.14

* Tschobanoglous, George and Schroeder, Edward; Water Quality. Addison-Wesley Public Company; February 1987.

CHAPTER 5
NUTRIENT EVALUATION

5.1 INTRODUCTION

All nearshore and offshore parameters were monitored during the 1997 monitoring year to demonstrate that receiving water limitations (Section B.2 and B.3) of the NPDES permit were not violated. The 1997, offshore monitoring dates were February 11, April 9, July 17, and October 9, 1997. All monitoring stations and protocols have not changed from the previous monitoring year. See Figure 5-1 for the locations of all ocean monitoring locations.

The receiving waters of the Honouliuli WWTP are classified as "Class A" "Dry" "Open Coastal Waters." In part, the State Water Quality Standard (State WQS) states the following limits (see Reference 2, Appendix E), note the single-asterisked applies:

§11-54-06 Uses and specific criteria applicable to marine waters. (b) Open coastal waters. (3) The following criteria are specific for open coastal waters: (Note that criteria for open coastal waters differ, based on fresh water discharge).

TABLE 5-1
MARINE WATER CRITERIA

Parameter	*Geometric mean not to exceed the given value*	*Not to exceed the given value more than ten percent of the time*	*Not to exceed the given value more than two percent of the time*
Total Nitrogen (µg N/L)	*150.00** *110.00***	*250.00** *180.00***	*350.00** *250.00***

TABLE 5-1
MARINE WATER CRITERIA, ***continued***

Parameter	*Geometric mean not to exceed the given value*	*Not to exceed the given value more than ten percent of the time*	*Not to exceed the given value more than two percent of the time*

Ammonia Nitrogen (µg NH_4-N/L)	3.50* 2.00**	8.50* 5.00**	15.00* 9.00**
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	5.00* 3.50**	14.00* 10.00**	25.00* 20.00**
Total Phosphorus (µg P/L)	20.00* 16.00**	40.00* 30.00**	60.00* 45.00**
[1]*Light Extinction Coefficient (k units)*	0.20* 0.10**	0.50* 0.30**	0.85* 0.55**
Chlorophyll a (µg/L)	0.30* 0.15**	0.90* 0.50**	1.75* 1.00**
Turbidity (NTU)	0.50* 0.20**	1.25* 0.50**	2.00* 1.00**

** "Wet" criteria apply when the open coastal waters receive more than three million gallons per day of fresh water discharge per shoreline mile.*

*** "Dry" criteria apply when the open coastal waters receive less than three million gallons per day of fresh water discharge per shoreline mile.*

[1] Light extinction coefficient (LEC) is only required for dischargers who have obtained a waiver pursuant to Section 301(h) of the Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251), as amended, and are required by EPA to monitor it.

FIGURE 5-1
HONOULIULI WWTP OCEAN MONITORING STATIONS

Before compliance with the nutrient limits of Table 5-1 can be demonstrated, several procedural details must be defined. These include the methodology used to determine accedences with each category (e.g., geometric mean, not to exceed 10% and not to exceed 2%), the selection of monitoring stations from which data were obtained and applied to determine compliance, the depths from which data were gathered, and the monitoring duration required for the compliance methodology. These details were obtained from Reference 1 (see Appendix E) and permit requirements that specify monitoring conditions.

5.2 METHODOLOGY

The methodology is based on the assumption that the data follows a log normal distribution. Accedences with the three compliance categories (e.g., geometric mean, not to exceed 10% and not to exceed 2%) for any parameter is done by using a graphical method, or probability plots.

By adhering to the following procedure, accedences with any of the above State WQS nutrient limits can be determined:

a. In column (1) of a work sheet, number the rows from 1 to n, where n is the number of data points to be used in the compliance determination. See Table 5-2 for a sample worksheet.

b. List the data for a particular parameter (e.g., turbidity) as received in column (2). The data should include all applicable stations in the monitoring program with samples taken no deeper than 30 meters (because the State WQS were established from data taken no deeper than 30 meters). Control station data should not be included in the analysis. Furthermore, the data used should be taken over a time period of at least one year. The size of the data base should exceed thirty (30) data points, or $n \geq 30$. Larger data bases are suggested to increase statistical confidence.

c. Order the data in column (2) from smallest to largest into column (3).

d. Take the natural logarithms of the ordered data from column 3 and list in column (4). It doesn't matter what type of logarithm is used provided consistency is maintained. The natural logarithm is specified for consistency.

e. Find the mean and sample standard deviation of the natural logarithm values in column (4).

Mean:

$$\bar{z} = \sum \ln(x_i)/n$$

Sample standard deviation:

$$s_{\bar{z}} = \sqrt{\sum (z_i - \bar{z})^2/(n-1)}$$

where both summations go from I = 1 to n.

f. To calculate the geometric mean (or 50% value) concentration, take the antilog of the mean natural logarithm value from step "e" above.

$$GM = e^{\bar{z}}$$

Multiply and divide the geometric mean value by the antilog of the sample standard deviation from step "e" to define the concentrations associated with 84% and 16%, respectively.

$$z_{84\%} = GM * e^{s_z}$$

$$z_{16\%} = GM/e^{s_z}$$

Plot these three points [(GM, 50%), ($Z_{84\%}$, 84%), and ($Z_{16\%}$,16%)] on Log-Probability paper. A line drawn through the three points should be a straight line. Identify this line as the *calculated line*. Plot the three points (or criteria for 50%, 90%, 98%) from the State WQS for the parameter in question, connecting the points with a straight line. Identify the resulting line as the *standard line*. Compare both lines. If the *calculated line* is entirely below the *standard line*, the water quality parameters for the 50%, 90%, and 98% criteria have not been exceeded. In other words, comparison of both lines is the method used to determine accedences with the standard, not an individual data point. From the *calculated line*, determine the parameter values corresponding to the 90% and 98% probability. With the GM, compare these values with the appropriate State WQS criteria values for the parameter in question.

g. Plot all data points on Log-Probability paper, use the ranked data (column (3)) as the abscissa (y-axis) and the probability (column (5)) as the ordinate (x-axis). The purpose of plotting the data is to validate the log normal distribution. If the plotted data points approximate the *calculated line* on Log-Probability paper, then the log normal distribution assumption is verified. Other distributions may be applied; however, the assumption for this methodology assumes (with corresponding verification by data plotting) a log normal distribution.

h. If the plotted data confirms a log normal distribution, the results from step "f" above are valid.

I. If the plotted data does not correspond to the *calculated line* (e.g. confirmation of the log normal distribution is not validated), several events could be occurring. There could be something wrong with the data or another process may be occurring. Lastly, but not necessarily finally, the process may not be log normal distributed, and therefore, compliance cannot be determined.

TABLE 5-2
SAMPLE WORKSHEET

I	Listing of raw data as received	Data, x_i ranking smallest to largest	Logarithm of the ranked data	Probability (percent) 100*(I-½)/n [%]
1	y_1	x_1	$\ln(x_1)$	(1-½)/n
2	y_2	x_2	$\ln(x_2)$	(2-½)/n
:	:	:	:	:
n	y_n	x_n	$\ln(x_n)$	(n-½)/n

where n = the number of data points.

5.3 TEMPORAL AND SPATIAL CONSIDERATIONS

The above analyses shall be done on an annual (calendar year) basis, using a minimum sample size of roughly thirty data points. If thirty data points are not available during a given monitoring year, the data obtained during the previous monitoring year shall be included in the compliance data base. This procedure will be continued until a compliance data

base of thirty or more data points is achieved. An analyses which includes at least five (5) years of data shall also be done at the same time as the annual analyses. The purpose of this analyses is to identify possible long term impacts. The one (1) and five (5) year analyses constitute a compliance analyses for the WQS.

Data, or sample results, obtained from samples collected from depths greater than 30 meters (roughly 100 feet) should not be included in the methodology defined above because the State WQS were developed from sample results taken from depths less than 30 meters.

In accordance with Section B.2 of the permit, data obtained from station(s) within the zone of initial dilution (ZID) and stations identified as "control" stations, shall not be included in the methodology defined above. For turbidity and light extinction coefficient, LEC (Note: LEC is a required parameter for NPDES 301(h) waiver permits), stations at and beyond the ZID shall be used; e.g., ZID stations only. For the other parameters such as ammonia nitrogen, total phosphorus, etc., compliance with the State WQS shall include stations at or beyond the ZOM; e.g., ZOM stations only.

A separate set of analyses shall be done using data from the control stations only. The same depth and temporal guidelines shall be applied to the control station data. The purpose of this analysis is to compare background conditions to the conditions at the ZOM or ZID.

A noncompliant event results if any parameter above has exceeded the applicable limit of Table 5-1, accompanied by sufficient evidence that the exceedence is related to the discharge. Examples of this evidence is a comparison of the ZOM/ZID station analysis with the control station analysis. Accedences attributable to the discharge should not be impacting the control stations. Furthermore, accedences of one or more parameters should be associated with increases from other parameters, which may or may not have exceeded applicable limits, if the discharge is the cause of the exceedence.

5.4 RESULTS

5.4.1 ZOM AND ZID STATION RESULTS

The compliance methodology, as presented above, was applied to the ZOM and ZID monitoring data obtained during the 1997 monitoring year. Results of the 1997 monitoring year analyses are tabulated in Table 5-3. Results of the analyses using five (5) years of data are tabulated in Table 5-4.

TABLE 5-3
1997 MONITORING YEAR RESULTS

Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	117.12	160	198
Ammonia Nitrogen (µg NH_4-N/L)	1.24	2.2	3.1
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	1.02	1.19	1.34

TABLE 5-3 1997 MONITORING YEAR RESULTS			
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Phosphorus (µg P/L)	8.99	14	18.5
[1]Light Extinction Coefficient (k units)	0.03	0.08	0.158
Chlorophyll a (µg/L)	0.21	0.39	0.565
Turbidity (NTU)	0.10	0.16	0.22

[1]See Table 5-1 footnote.

Shaded cells indicate noncompliances

TABLE 5-4 1993 - 1997 MONITORING PERIOD DATA			
Parameters	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	98.29	129	151
Ammonia Nitrogen (µg NH_4-N/L)	1.31	2.95	4.75
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	1.08	1.5	1.81
Total Phosphorus (µg P/L)	9.36	12.21	14.5
[1]Light Extinction Coefficient (k units)	0.06	0.12	0.19

TABLE 5-4 1993 - 1997 MONITORING PERIOD DATA			
Parameters	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Chlorophyll a (µg/L)	0.16	0.445	0.83
Turbidity (NTU)	0.15	0.275	0.39

[1]See Table 5-1 footnote.

In Tables 5-3 and 5-4, the results of the analyses were compared with the "marine criteria." Noncompliances were observed for chlorophyll-a for the "geometric mean not to exceed the given value" mean criterion for both the one-year and five-year analyses. Total Nitrogen exceeded the "geometric mean not to exceed the given value" criterion for 1997 only.

5.4.2 CONTROL STATION RESULTS

The compliance methodology was also applied to the data collected from control stations HB-1, HB-6 and HB-7 during the 1997 monitoring year. The methodology was applied only for the parameters and time frames in which the monitoring at the ZID/ZOM stations exceeded the "marine criteria." Results of the 1997 analyses are tabulated in Table 5-5. Results of the analyses using five (5) years of control station data are tabulated in Table 5-6.

TABLE 5-5 1997 MONITORING YEAR DATA - Control Stations			
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	127	180	225
Chlorophyll a (µg/L)	0.12	0.36	0.71

[1]See Table 5-1 footnote.

TABLE 5-6 1993 - 1997 MONITORING PERIOD DATA - Control Stations			
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Chlorophyll a (µg/L)	0.10	0.29	0.56

[1]See Table 5-1 footnote.

The "geometric mean not to exceed the given value" criterion was exceeded for the one-year analysis for total nitrogen.

5.4.3 DISCUSSION

Because the exceedance of total nitrogen were observed at the control stations, then the background levels are already high. In the case for chlorophyll-a, there was no exceedance at the control stations for the one-year andfive-year analyses. This could be due to the discharge of the Barbers Point Ocean Outfall. All other nutrient parameters did not exceed the marine criteria.

CHAPTER 8
CHEMISTRY EVALUATION

8.1 INTRODUCTION

All nearshore and offshore parameters were monitored during the 1997 monitoring year, as required by the Honouliuli WWTP 301(h) waiver permit. The dates for the 1997 monitoring events were February 11, April 9, July 17, and October 9, 1997. All monitoring stations and protocols were unchanged from the previous monitoring year. See Figure 5-1, page 5-13, for the ocean monitoring sites. Compliance determination was based on measurements obtained by the City's Sea-Bird, CTD Profiler. Measurements of pH, potential temperature, salinity, and dissolved oxygen were taken at one (1) meter intervals for all four (4) nearshore stations and twelve (12) offshore stations during each monitoring event. The data was then compared with conditions stated in the Honouliuli WWTP 301(h) waiver permit, sections B.2. and B.3, and the State Water Quality Standards (WQS).

8.2 pH REQUIREMENT

According to the State WQS and permit requirements, pH units shall not deviate more than 0.5 units from a value of 8.1 ($7.6 \leq pH \leq 8.6$) except at coastal locations where and when freshwater from stream, storm drain or groundwater discharge may depress the pH to a minimum level of 7.0.

There is no statistical compliance methodology for this requirement. In situ measurements were obtained and compared with the above pH range; see Table 8-1. Never during the 1997 monitoring year did the monitored pH value exceed this requirement at any station or at any depth.

TABLE 8-1
1997 CTD Data

		pH	
Sample site	n	max	min
HN1	59	8.269	8.076
HN2	53	8.264	8.096
HN3	55	8.256	8.086
HN4	55	8.246	8.069
HZ	311	8.256	8.054
HM1	180	8.254	8.06

TABLE 8-1 1997 CTD Data			
		pH	
Sample site	n	max	min
HM2	277	8.252	8.049
HM3	479	8.257	8.048
HM4	283	8.256	8.066
HB1	334	8.252	8.043
HB2	269	8.256	8.049
HB3	341	8.259	8.06
HB4	295	8.256	8.061
HB5	275	8.248	8.055
HB6	287	8.265	8.071
HB7	316	8.261	8.08

n = number of measurements taken

8.3 TEMPERATURE REQUIREMENT

According to the State WQS and permit requirements, the receiving water temperature shall not vary more than one degree Celsius (±1°C) from ambient conditions.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. Potential temperature measurements were compared with the above temperature range condition. The ambient condition was determined by averaging the potential temperature measurements at each depth from both reference stations (e.g., HB1 and HB7) for each monitoring event. This was then compared with the monitored potential temperature at each offshore station. This process was repeated for subsequent monitoring events. Figures 8.1 - 8.4 illustrate the results of this procedure.

For the February 11 and July 17, 1997 monitoring events, portions of the receiving water temperature were above the maximum temperature limit. First, the reported monthly average and daily maximum effluent temperatures for February 1997 were 26.75°C and 27.0°C, respectively. The reported monthly average and daily maximum effluent temperatures for July 1997 were 28.00°C and 29.20°C, respectively. Given the current discharge configuration, it is possible for the

effluent to have discharge temperatures above the ambient conditions. Naturally, the receiving water temperature decreases with depth. The exceedance of the maximum temperature occurred about the same depth as the outfall diffusers. The discharge of treated wastewater may have caused the exceedance for the February and July 1997 monitoring period, because the reported maximum and minimum effluent temperatures were above the receiving water temperatures.

For October 9, 1997, at the same depth as the outfall diffusers, i.e., approximately 60 meters, the actual minimum temperature was below the minimum temperature limit of the receiving water (See Figure 8-4). This phenomena was not caused by the discharge of treated wastewater because the temperature of the effluent was much higher than the receiving water temperature. The monthly average effluent temperature for October was 28.16°C. The maximum temperature was 28.80 °C. These temperatures are significantly above the ambient temperature of above 23 °C at depths between 60 to 70 meters.

Figure 8-1

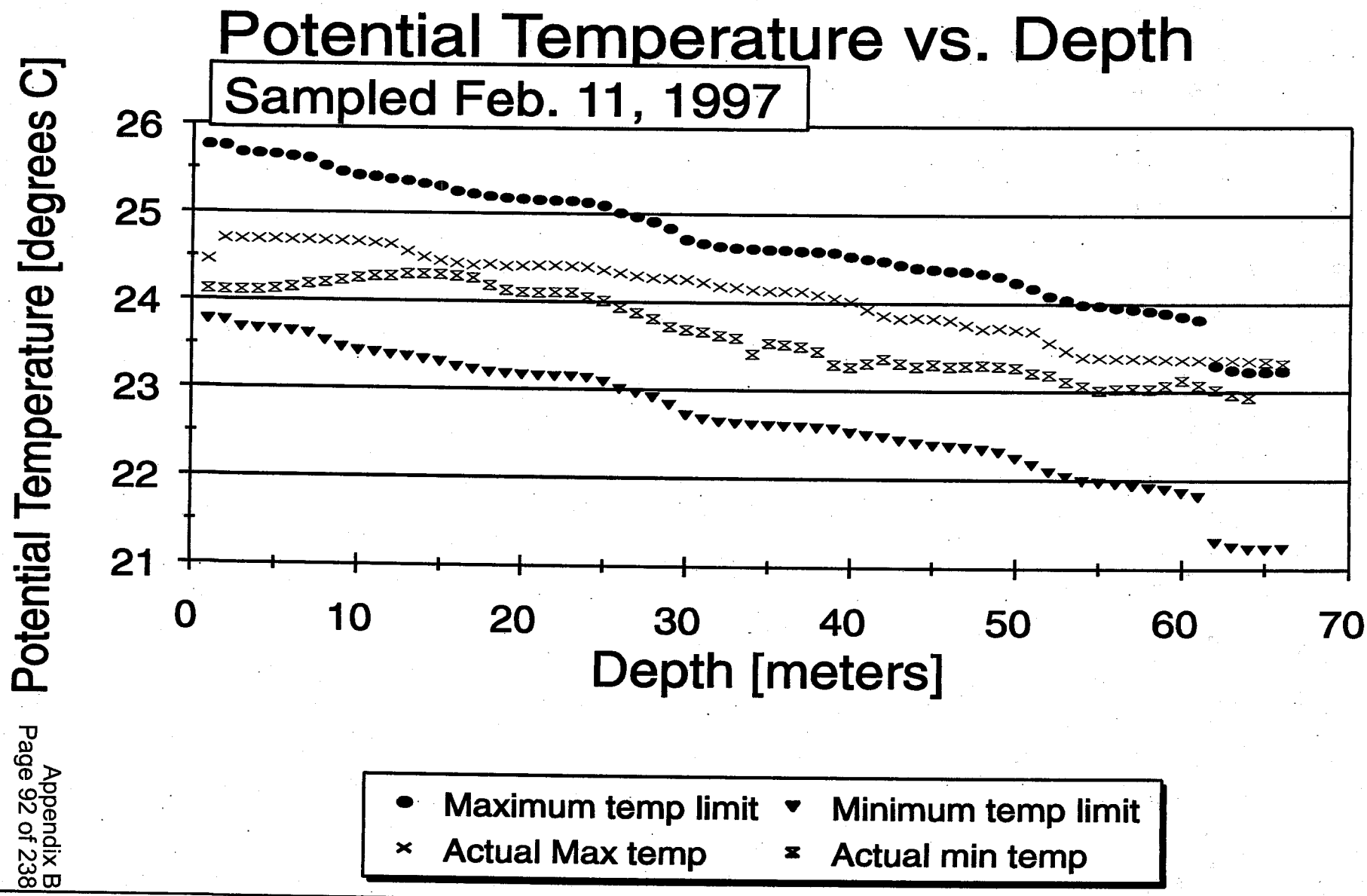

Potential Temperature vs. Depth
Sampled Feb. 11, 1997
Potential Temperature [degrees C]
26
25
24
23
22
21
0
10
20
30
40
50
60
70
Depth [meters]
Maximum temp limit
Minimum temp limit
Actual Max temp
Actual min temp

Figure 8-2

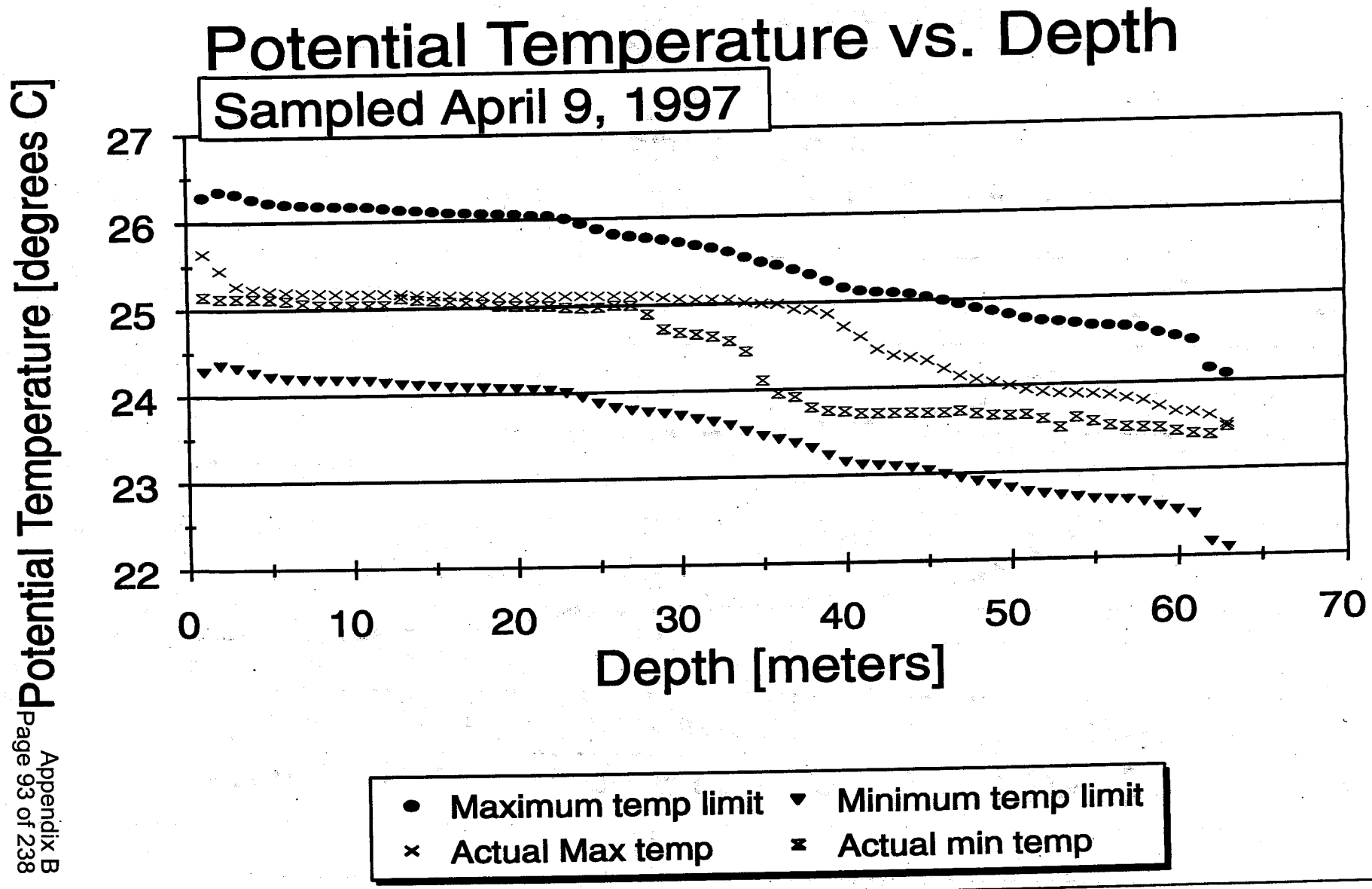

Potential Temperature vs. Depth
Sampled April 9, 1997
Potential Temperature [degrees C]
27
26
25
24
23
22
0
10
20
30
40
50
60
70
Depth [meters]
Maximum temp limit
Minimum temp limit
Actual Max temp
Actual min temp

Figure 8-3

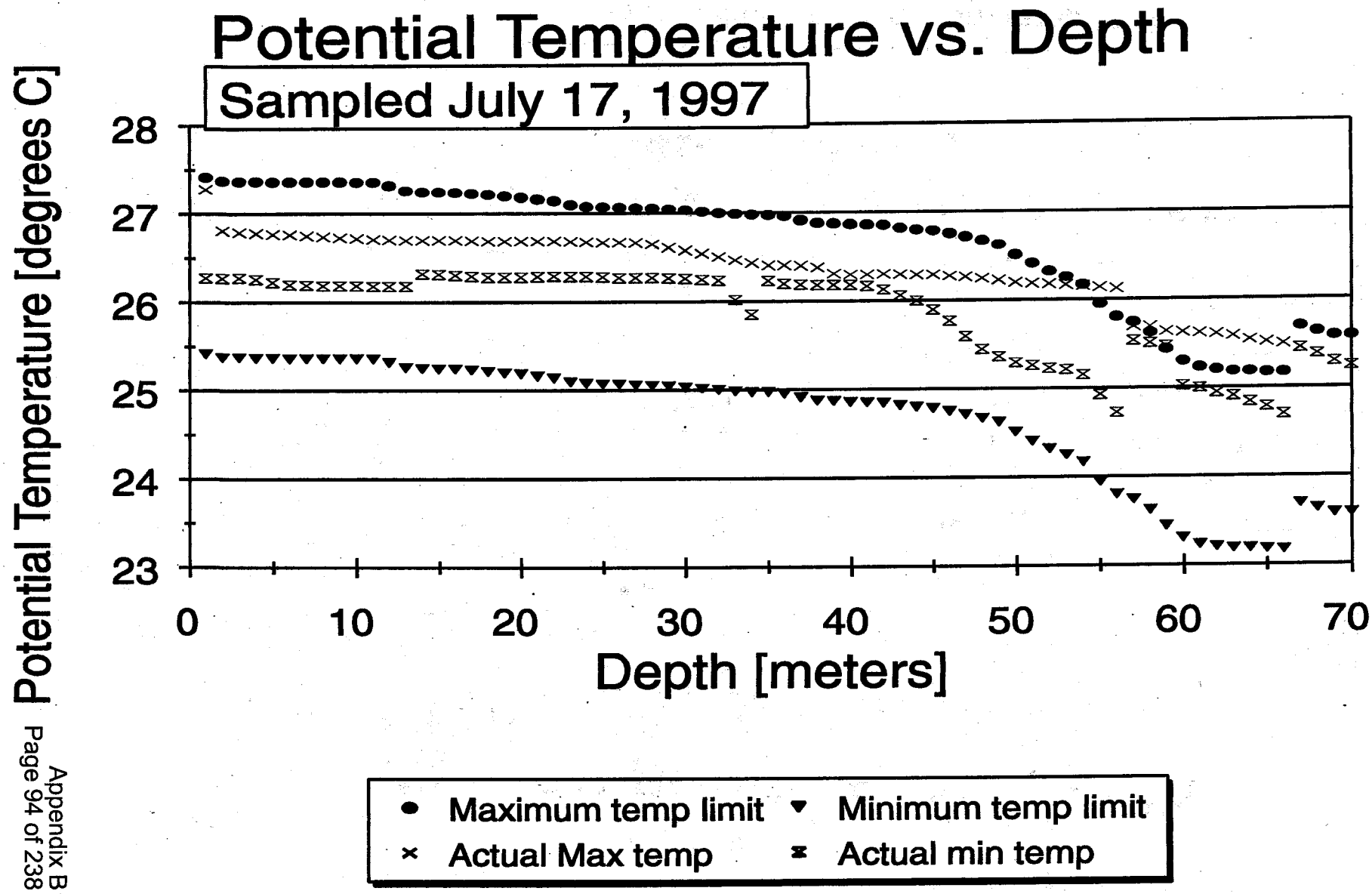
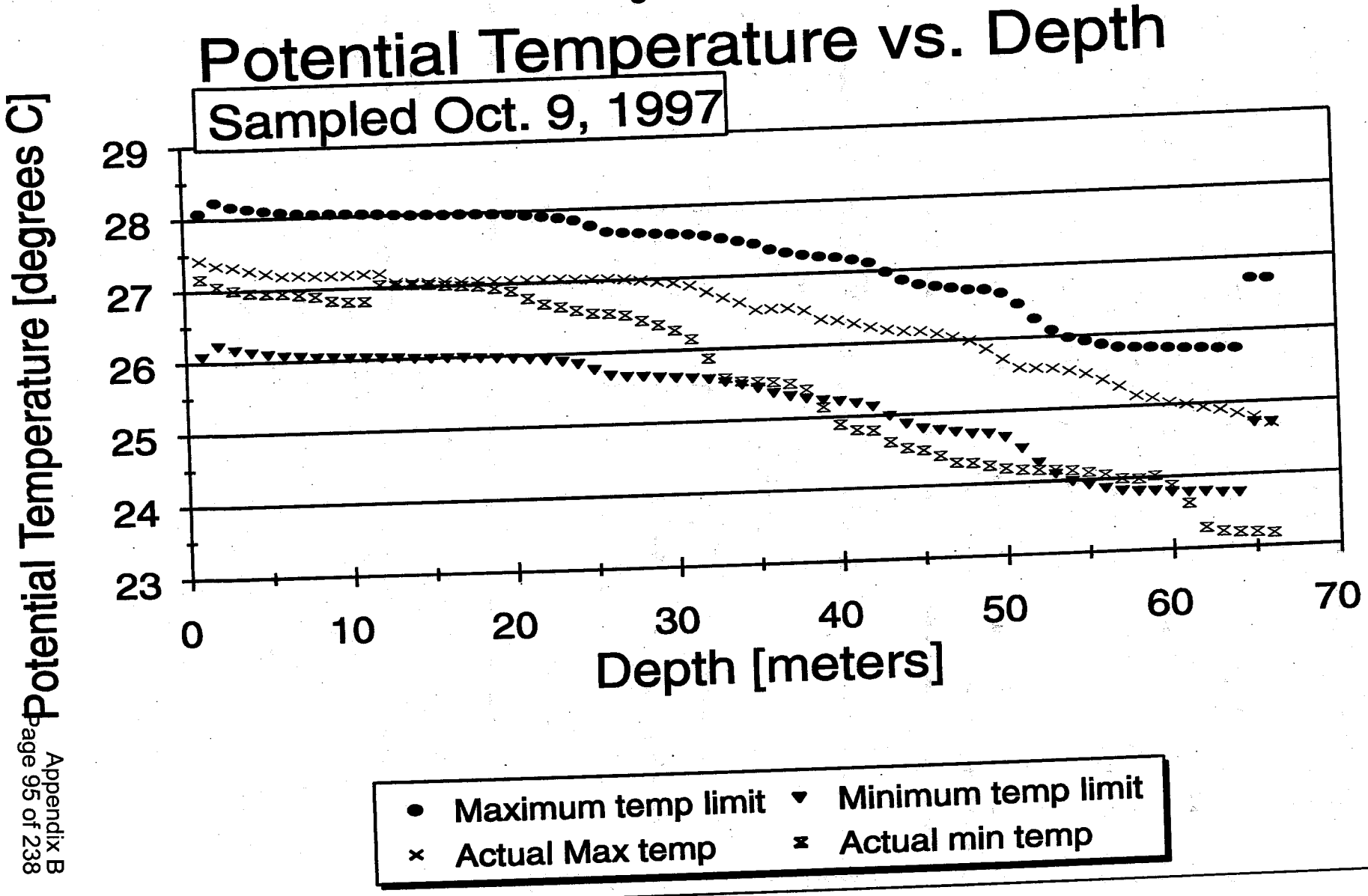

Potential Temperature vs. Depth
Sampled July 17, 1997
Potential Temperature [degrees C]
28
27
26
25
24
23
0
10
20
30
40
50
60
70
Depth [meters]
Maximum temp limit
Minimum temp limit
Actual Max temp
Actual min temp

Figure 8-4


Potential Temperature vs. Depth
Sampled Oct. 9, 1997
Potential Temperature [degrees C]
29
28
27
26
25
24
23
0
10
20
30
40
50
60
70
Depth [meters]
Maximum temp limit
Minimum temp limit
Actual Max temp
Actual min temp

8.4 SALINITY REQUIREMENT

According to the State WQS and permit requirements, the salinity shall not vary more than ten percent (10%) from natural or seasonal changes considering hydrologic input and oceanographic factors.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. For a given monitoring event, in situ salinity measurements at each depth (SAL_d) for each nearshore and offshore monitoring station were compared with the average salinity ($AVGSAL_d$) at each corresponding depth. The $AVGSAL_d$ at each depth, d, was obtained by averaging salinity measurements from the two reference (or control) stations (e.g., HB1 and HB7). The salinity ratio at each depth was computed using the following equation:

$$salinity\ ratio = [1 - (AVGSAL_d / SAL_d)] \times 100$$

This process was repeated throughout the depth range of the reference stations, for each monitoring event. Table 8-2 exhibits no percent deviation exceeding the 10% limit.

Table 8-2
SALINITY MEASUREMENTS FOR GIVEN MONITORING EVENTS

Monitoring event	Salinity ratio [%PAU]		Number of sample points (n)	Average salinity ratio	Sample Standard Deviation
	maximum	minimum			
February 11, 1997	0.10%	-0.82%	586	-0.12%	0.11%
April 9, 1997	0.19%	-0.45%	616	-0.05%	0.08%
July 17, 1997	0.52%	-0.65%	608	-0.03%	0.15%
October 9, 1997	0.47%	-0.78%	643	-0.04%	0.13%

8.5 DISSOLVED OXYGEN REQUIREMENT

The State WQS and the Honouliuli WWTP 301(h) waiver permit require dissolved oxygen to be not less than seventy-five percent saturation, determined as a function of ambient water temperature and salinity. To determine the dissolved oxygen concentration ($DO_{saturation}$) for given temperature and salinity, dissolved oxygen concentration tables* were used. For each monitoring event, the maximum temperature, T_{max}, and salinity, Sal_{max}, were used to obtain a $DO_{saturation}$. Seventy five percent (75%) of $DO_{saturation}$ was used as the minimum concentration to determine compliance with the State WQS and permit requirements. To show compliance, the minimum dissolved oxygen concentration (DO) for each monitoring event was compared against the corresponding $DO_{saturation}$. Compliance is satisfied when DO > .75 x $DO_{saturation}$. Table 8-3 shows that compliance was attained.

Table 8-3
$DO_{saturation}$ Determination

Monitoring Event	Maximum Measured Temperature [°C]	Maximum Measured Salinity [o/oo]	75% $DO_{saturation}$* using maximum salinity and temperature values [mg/l]	Minimum measured Dissolved Oxygen Concentration [mg/l]
February 11, 1997	24.764	35.0048	5.08	6.967
April 9, 1997	25.6437	34.9545	5.01	6.834
July 17, 1997	27.2781	35.0732	4.87	5.906
October 9, 1997	27.4692	35.1819	4.85	5.824

* Tschobanoglous, George and Schroeder, Edward; Water Quality. Addison-Wesley Public Company; February 1987.

CHAPTER 5
NUTRIENT EVALUATION

5.1 INTRODUCTION

All nearshore and offshore parameters were monitored during the 1998 monitoring year to demonstrate that receiving water limitations (Section B.2 and B.3) of the NPDES permit were not violated. The 1998, offshore monitoring dates were February 13, April 7, July 6, and October 22, 1998. All monitoring stations and protocols have not changed from the previous monitoring year. See Figure 5-1 for the locations of all ocean monitoring locations.

The receiving waters of the Honouliuli WWTP are classified as "Class A" "Dry" "Open Coastal Waters." In part, the State Water Quality Standard (State WQS) states the following limits (see Reference 2, Appendix E), note the double-asterisked applies:

§11-54-06 Uses and specific criteria applicable to marine waters. (b) Open coastal waters. (3) The following criteria are specific for open coastal waters: (Note that criteria for open coastal waters differ, based on fresh water discharge).

TABLE 5-1
MARINE WATER CRITERIA

Parameter	*Geometric mean not to exceed the given value*	*Not to exceed the given value more than ten percent of the time*	*Not to exceed the given value more than two percent of the time*
Total Nitrogen (µg N/L)	*150.00** *110.00***	*250.00** *180.00***	*350.00** *250.00***

TABLE 5-1

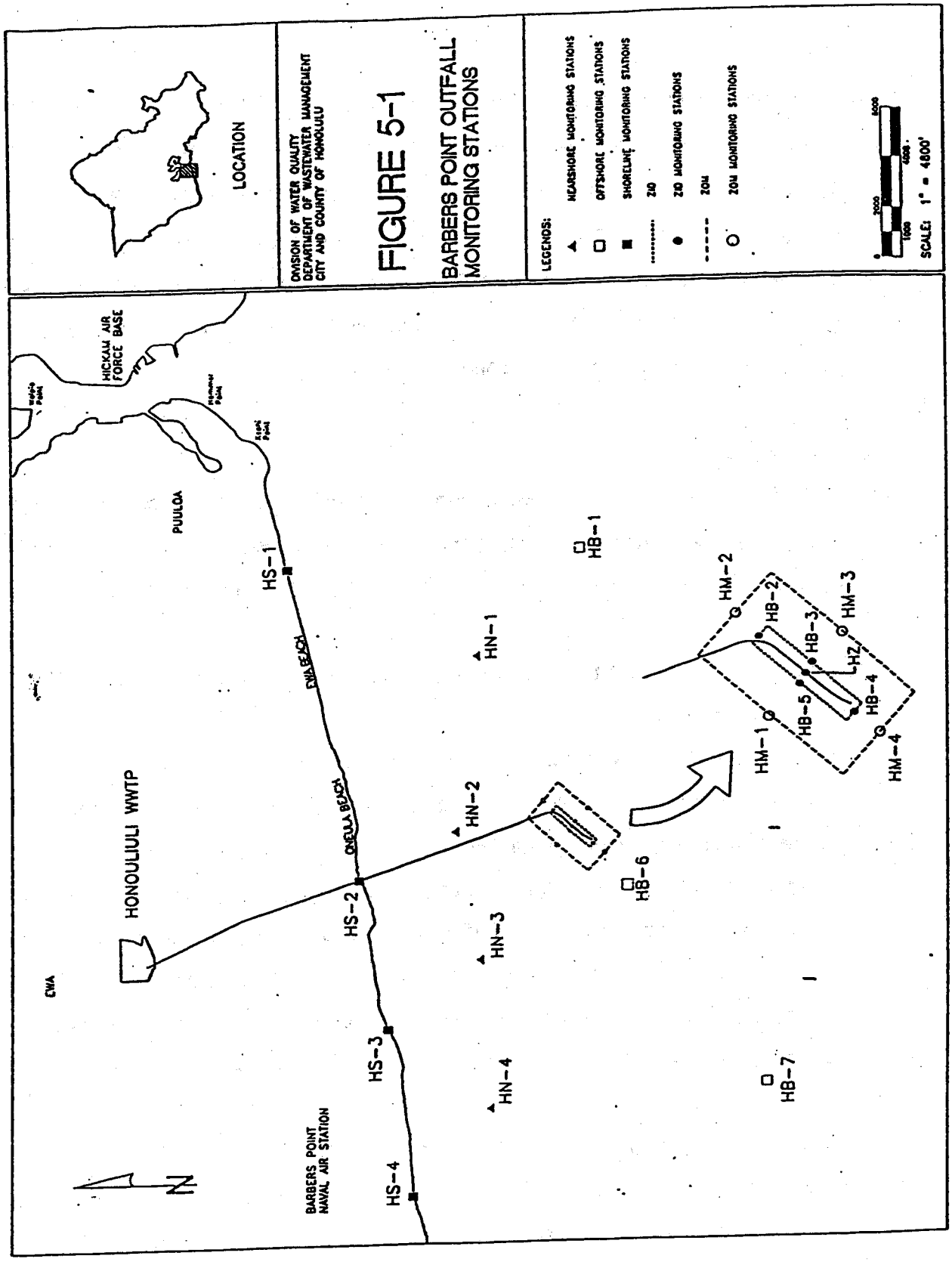
MARINE WATER CRITERIA, *continued*

Parameter	*Geometric mean not to exceed the given value*	*Not to exceed the given value more than ten percent of the time*	*Not to exceed the given value more than two percent of the time*
Ammonia Nitrogen (μg NH_4-N/L)	*3.50** *2.00***	*8.50** *5.00***	*15.00** *9.00***
Nitrate + Nitrite (μg [NO_3+NO_2] - N/L)	*5.00** *3.50***	*14.00** *10.00***	*25.00** *20.00***
Total Phosphorus (μg P/L)	*20.00** *16.00***	*40.00** *30.00***	*60.00** *45.00***
[1]Light Extinction Coefficient (k units)	*0.20** *0.10***	*0.50** *0.30***	*0.85** *0.55***
Chlorophyll a (μg/L)	*0.30** *0.15***	*0.90** *0.50***	*1.75** *1.00***
Turbidity (NTU)	*0.50** *0.20***	*1.25** *0.50***	*2.00** *1.00***

** "Wet" criteria apply when the open coastal waters receive more than three million gallons per day of fresh water discharge per shoreline mile.*

*** "Dry" criteria apply when the open coastal waters receive less than three million gallons per day of fresh water discharge per shoreline mile.*

[1] Light extinction coefficient (LEC) is only required for dischargers who have obtained a waiver pursuant to Section 301(h) of the Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251), as amended, and are required by EPA to monitor it.


LOCATION
DIVISION OF WATER QUALITY
DEPARTMENT OF WASTEWATER MANAGEMENT
CITY AND COUNTY OF HONOLULU
FIGURE 5-1
BARBERS POINT OUTFALL
MONITORING STATIONS
LEGENDS:
NEARSHORE MONITORING STATIONS
OFFSHORE MONITORING STATIONS
SHORELINE MONITORING STATIONS
ZID
ZID MONITORING STATIONS
ZOM
ZOM MONITORING STATIONS
SCALE: 1" = 4800'
HICKAM AIR FORCE BASE
PUULOA
EWA BEACH
ONEULA BEACH
HONOULIULI WWTP
EWA
BARBERS POINT NAVAL AIR STATION
HS-1
HS-2
HS-3
HS-4
HN-1
HN-2
HN-3
HN-4
HB-1
HB-6
HB-7
HM-1
HM-2
HM-3
HM-4
HB-2
HB-3
HB-4
HB-5
HZ

Before compliance with the nutrient limits of Table 5-1 can be demonstrated, several procedural details must be defined. These include the methodology used to determine exceedences with each category (e.g., geometric mean, not to exceed 10% and not to exceed 2%), the selection of monitoring stations from which data were obtained and applied to determine compliance, the depths from which data were gathered, and the monitoring duration required for the compliance methodology. These details were obtained from Reference 1 (see Appendix E) and permit requirements that specify monitoring conditions.

5.2 METHODOLOGY

The methodology is based on the assumption that the data follows a log normal distribution. Exceedences with the three compliance categories (e.g., geometric mean, not to exceed 10% and not to exceed 2%) for any parameter is done by using a graphical method, or probability plots.

By adhering to the following procedure, exceedences with any of the above State WQS nutrient limits can be determined:

a. In column (1) of a work sheet, number the rows from 1 to n, where n is the number of data points to be used in the compliance determination. See Table 5-2 for a sample worksheet.

b. List the data for a particular parameter (e.g., turbidity) as received in column (2). The data should include all applicable stations in the monitoring program with samples taken no deeper than 30 meters (because the State WQS were established from data taken no deeper than 30 meters). Control station data should not be included in the analysis. Furthermore, the data used should be taken over a time period of at least one year. The size of the data base should exceed thirty (30) data points, or $n \geq 30$. Larger data bases are suggested to increase statistical confidence.

c. Order the data in column (2) from smallest to largest into column (3).

d. Take the natural logarithms of the ordered data from column 3 and list in column (4). It doesn't matter what type of logarithm is used provided consistency is maintained. The natural logarithm is specified for consistency.

e. Find the mean and sample standard deviation of the natural logarithm values in column (4).

Mean:

$$\bar{z} = \sum \ln(x_i)/n$$

Sample standard deviation:

$$s_{\bar{z}} = \sqrt{\sum (z_i - \bar{z})^2/(n-1)}$$

where both summations go from I = 1 to n.

f. To calculate the geometric mean (or 50% value) concentration, take the antilog of the mean natural logarithm value from step "e" above.

$$GM = e^{\bar{z}}$$

Multiply and divide the geometric mean value by the antilog of the sample standard deviation from step "e" to define the concentrations associated with 84% and 16%, respectively.

$$z_{84\%} = GM * e^{s_z}$$

$$z_{16\%} = GM / e^{s_z}$$

Plot these three points [(GM, 50%), ($Z_{84\%}$, 84%), and ($Z_{16\%}$,16%)] on Log-Probability paper. A line drawn through the three points should be a straight line. Identify this line as the *calculated line*. Plot the three points (or criteria for 50%, 90%, 98%) from the State WQS for the parameter in question, connecting the points with a straight line. Identify the resulting line as the *standard line*. Compare both lines. If the *calculated line* is entirely below the *standard line*, the water quality parameters for the 50%, 90%, and 98% criteria have not been exceeded. In other words, comparison of both lines is the method used to determine exceedences with the standard, not an individual data point. From the *calculated line*, determine the parameter values corresponding to the 90% and 98% probability. With

the GM, compare these values with the appropriate State WQS criteria values for the parameter in question.

g. Plot all data points on Log-Probability paper, use the ranked data (column (3)) as the abscissa (y-axis) and the probability (column (5)) as the ordinate (x-axis). The purpose of plotting the data is to validate the log normal distribution. If the plotted data points approximate the *calculated line* on Log-Probability paper, then the log normal distribution assumption is verified. Other distributions may be applied; however, the assumption for this methodology assumes (with corresponding verification by data plotting) a log normal distribution.

h. If the plotted data confirms a log normal distribution, the results from step "f" above are valid.

i. If the plotted data does not correspond to the *calculated line* (e.g. confirmation of the log normal distribution is not validated), several events could be occurring. There could be something wrong with the data or another process may be occurring. Lastly, but not necessarily finally, the process may not be log normal distributed, and therefore, compliance cannot be determined.

TABLE 5-2

SAMPLE WORKSHEET

I	Listing of raw data as received	Data, x_i ranking smallest to largest	Logarithm of the ranked data	Probability (percent) 100*(I-½)/n [%]
1	y_1	x_1	$\ln(x_1)$	(1-½)/n
2	y_2	x_2	$\ln(x_2)$	(2-½)/n
:	:	:	:	:
n	y_n	x_n	$\ln(x_n)$	(n-½)/n

where n = the number of data points.

5.3 TEMPORAL AND SPATIAL CONSIDERATIONS

The above analyses shall be done on an annual (calendar year) basis, using a minimum sample size of roughly thirty data points. If thirty data points are not available during a given monitoring year, the data obtained during the previous monitoring year shall be included in the compliance data base. This procedure will be continued until a compliance data base of thirty or more data points is achieved. An analyses which includes at least five (5) years of data shall also be done at the same time as the annual analyses. The purpose of this analyses is to identify possible long term impacts. The one (1) and five (5) year analyses constitute a compliance analyses for the WQS.

Data, or sample results, obtained from samples collected from depths greater than 30 meters (roughly 100 feet) should not be included in the methodology defined above because the State WQS were developed from sample results taken from depths less than 30 meters.

In accordance with Section B.2 of the permit, data obtained from station(s) within the zone of initial dilution (ZID) and stations identified as "control" stations, shall not be included in the methodology defined above. For turbidity and light extinction coefficient, LEC (Note: LEC is a required parameter for NPDES 301(h) waiver permits), stations at and beyond the ZID shall be used; e.g., ZID stations only. For the other parameters such as ammonia nitrogen, total phosphorus, etc., compliance with the State WQS shall include stations at or beyond the ZOM; e.g., ZOM stations only.

A separate set of analyses shall be done using data from the control stations only. The same depth and temporal guidelines shall be applied to the control station data. The purpose of this analysis is to compare background conditions to the conditions at the ZOM or ZID.

A noncompliant event results if any parameter above has exceeded the applicable limit of Table 5-1, accompanied by sufficient evidence that the exceedence is related to the discharge. Examples of this evidence is a comparison of the ZOM/ZID station analysis with the control station analysis. Exceedences attributable to the discharge should not be impacting the control stations.

Furthermore, exceedences of one or more parameters should be associated with increases from other parameters, which may or may not have exceeded applicable limits, if the discharge is the cause of the exceedence.

5.4 RESULTS

5.4.1 ZOM AND ZID STATION RESULTS

The compliance methodology, as presented above, was applied to the ZOM and ZID monitoring data obtained during the 1998 monitoring year. Results of the 1998 monitoring year analyses are tabulated in Table 5-3. Results of the analyses using five (5) years of data are tabulated in Table 5-4.

TABLE 5-3
1998 MONITORING YEAR RESULTS

Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (μg N/L)	116.81	271	460
Ammonia Nitrogen (μg NH_4-N/L)	1.98	5.25	9.8
Nitrate + Nitrite (μg [NO_3+NO_2] - N/L)	1.08	1.5	1.81
Total Phosphorus (μg P/L)	8.78	11	12.5
[1]Light Extinction Coefficient (k units)	0.02	0.02	0.02

TABLE 5-3 1998 MONITORING YEAR RESULTS			
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Chlorophyll a (μg/L)	0.15	0.27	0.375
Turbidity (NTU)	0.11	0.209	0.3

[1]See Table 5-1 footnote.

Shaded cells indicate noncompliances

TABLE 5-4 1994 - 1998 MONITORING PERIOD DATA			
Parameters	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (μg N/L)	101.18	165	220
Ammonia Nitrogen (μg NH_4-N/L)	1.32	3	4.8
Nitrate + Nitrite (μg [NO_3+NO_2] - N/L)	1.03	1.29	1.4
Total Phosphorus (μg P/L)	9.27	12.5	15

TABLE 5-4 1994 - 1998 MONITORING PERIOD DATA			
Parameters	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
[1]Light Extinction Coefficient (k units)	0.04	0.11	0.2
Chlorophyll a (μg/L)	0.15	0.42	0.79
Turbidity (NTU)	0.14	0.27	0.4

[1]See Table 5-1 footnote.

In Tables 5-3 and 5-4, the results of the analyses were compared with the "marine criteria." Noncompliances were observed for Total Nitrogen's three criteria for 1998 only. Ammonia Nitrogen was noncompliant in 1998 for all criteria except for "Geometric mean not to exceed the given value. There were no criteria exceedences for the five-year monitoring period data.

5.4.2 CONTROL STATION RESULTS

The compliance methodology was also applied to the data collected from control stations HB-1, HB-6 and HB-7 during the 1998 monitoring year. The methodology was applied for all parameters and time frames, but only the results at where the ZID/ZOM stations exceeded the "marine criteria" are shown. Results of the 1998 analyses are tabulated in Table 5-5. Results of the analyses using five (5) years of control station data are tabulated in Table 5-6.

TABLE 5-5 1998 MONITORING YEAR DATA - Control Stations			
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (μg N/L)	130.16	380	730
Ammonia Nitrogen (μg N/L)	1.6	2.9	4.2

Shaded cells indicate noncompliances.

TABLE 5-6 1994 - 1998 MONITORING PERIOD DATA - Control Stations			
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (μg N/L)	101.06	190	280

For 1998, all criteria were exceeded at the control stations for Total Nitrogen. None of the Ammonia Nitrogen criteria were exceeded for 1998. For the five-year study, all but the "Geometric mean not to exceed the given value" criteria were exceeded for the control stations' Total Nitrogen.

5.4.3 DISCUSSION

Because Total Nitrogen exceedences were observed at the control stations, it could be surmise that the background levels are already high. In the case for Ammonia Nitrogen, there were no exceedences at the control stations for either the one-year or five-year analyses. The values for this parameter could possibly be attributed to the discharge of the Barbers Point Ocean Outfall in 1998. All other nutrient parameters did not exceed the marine criteria.

CHAPTER 8
CHEMISTRY EVALUATION

8.1 INTRODUCTION

All nearshore and offshore parameters were monitored during the 1998 monitoring year, as required by the Honouliuli WWTP 301(h) waiver permit. The dates for the 1998 monitoring events were February 12, April 7, July 6, and October 22, 1998. All monitoring stations and protocols were unchanged from the previous monitoring year. See Figure 5-1 for the ocean monitoring sites. Compliance determination was based on measurements obtained by the City's Sea-Bird, CTD Profiler. Measurements of pH, potential temperature, salinity, and dissolved oxygen were taken at one (1) meter intervals for all four (4) nearshore stations and twelve (12) offshore stations during each monitoring event. The data was then compared with conditions stated in the Honouliuli WWTP 301(h) waiver permit, sections B.2. and B.3, and the State Water Quality Standards (WQS).

8.2 pH REQUIREMENT

According to the State WQS and permit requirements, pH units shall not deviate more than 0.5 units from a value of 8.1 ($7.6 \leq pH \leq 8.6$) except at coastal locations where and when freshwater from stream, storm drain or groundwater discharge may depress the pH to a minimum level of 7.0.

There is no statistical compliance methodology for this requirement. In situ measurements were obtained and compared with the above pH range; see Table 8-1. Never during the 1998 monitoring year did the monitored pH value exceed this requirement at any station or at any depth.

TABLE 8-1
1998 CTD Data

		pH	
Sample site	n	max	min
HN1	45	8.399	8.253
HN2	43	8.397	8.251
HN3	43	8.397	8.244
HN4	44	8.397	8.21
HZ	245	8.397	8.179
HM1	136	8.403	8.196
HM2	224	8.401	8.165
HM3	381	8.401	8.171
HM4	226	8.393	8.232
HB1	270	8.406	8.192
HB2	231	8.401	8.17
HB3	275	8.401	8.197
HB4	244	8.394	8.212
HB5	222	8.385	8.179
HB6	229	8.396	8.235
HB7	255	8.406	8.244

n = number of measurements taken

8.3 TEMPERATURE REQUIREMENT

According to the State WQS and permit requirements, the receiving water temperature shall not vary more than one degree Celsius (±1°C) from ambient conditions.

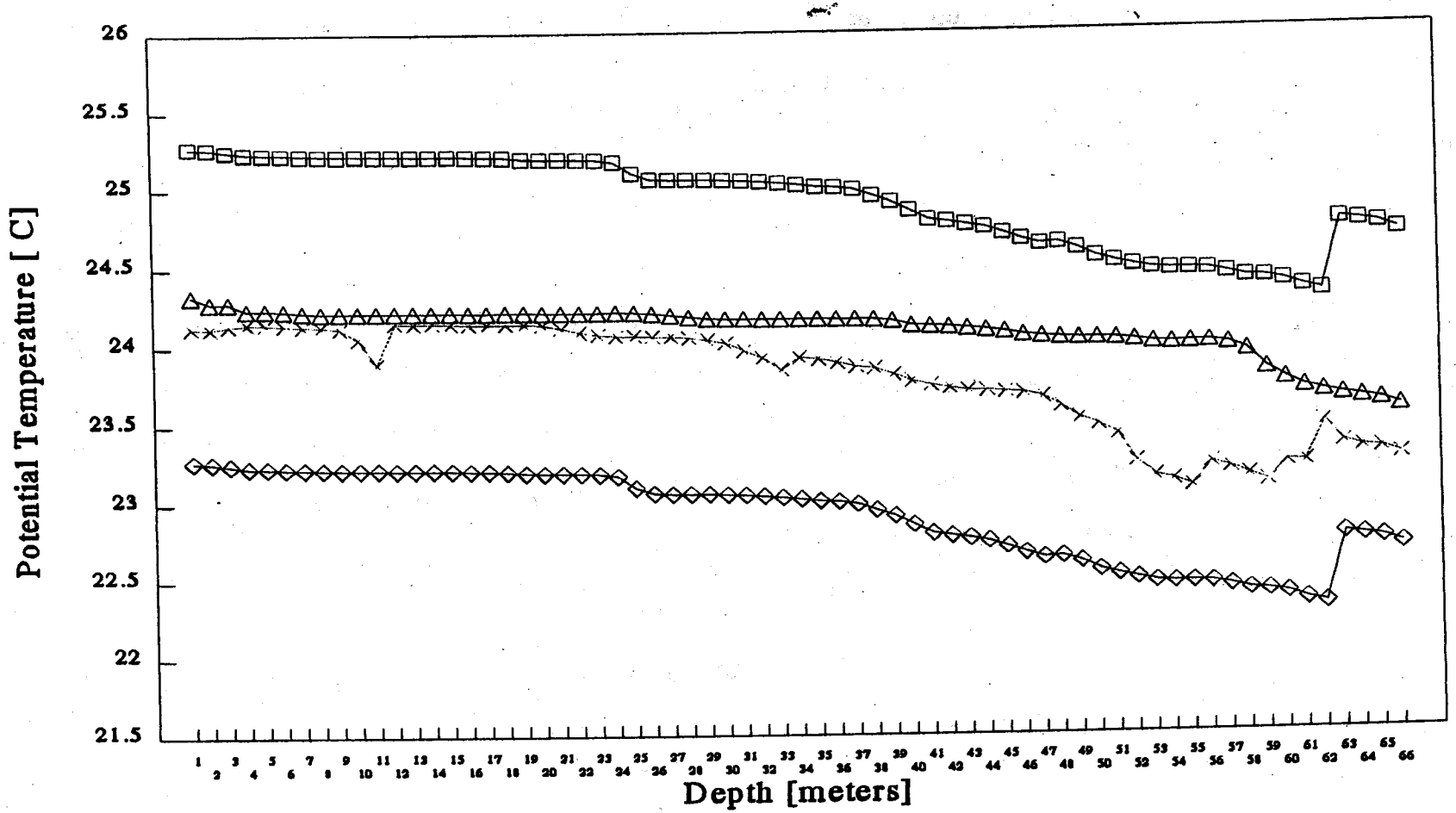
Because there is no specific Federal or State compliance methodology, the City has established its own methodology. Potential temperature measurements were compared with the above temperature range condition. The ambient condition was determined by averaging the potential temperature measurements at each depth from both reference stations (e.g., HB1 and HB7) for each monitoring event. In the event there was only a temperature reading from a reference station at a given depth, that reading was taken to be the ambient temperature. The ambient temperature was compared with the monitored potential temperature at each nearshore and offshore station. This process was repeated for subsequent monitoring events. Figures 8.1 - 8.4 illustrate the results of this procedure.

For the October 22, 1998 monitoring event, receiving water station HB4 temperature (24.6632° C) was above the maximum temperature limit of 24.0672 °C at a depth of 63 meters. This maximum temperature was calculated from reference station HB1. The reported monthly average and daily maximum effluent temperatures for October 1998 were 27.25°C and 28.0°C, respectively. Given the current discharge configuration, it is possible for the effluent to have discharge temperatures above the ambient conditions. Naturally, the receiving water temperature decreases with depth. The exceedance of the maximum temperature occurred about the same depth (60.96 to 62.48 meters) as the outfall diffusers. The discharge of treated wastewater may have caused the exceedance for the February 1998 monitoring period, because the reported maximum and minimum effluent temperatures were above the receiving water temperatures.

For April 7 and July 6, 1998, at the same depth as the outfall diffusers, the minimum temperature monitored at the receiving water monitoring stations was below the minimum temperature limit of the receiving water (See Figures 8-2 and 8-3). Interestingly, at the same depth ranges, the maximum temperature monitored on April 7, 1998 was below the minimum temperature limit (See Figure 8-2). Nevertheless, this phenomena cannot be caused by the discharge of treated

wastewater because the temperature of the effluent was much higher than the receiving water temperature. The monthly average effluent temperature for April was 26.5°C. The maximum temperature was 27.0 °C. For July 1998, the monthly average and maximum effluent temperatures were 27.25°C and 27.50°C, respectively. These temperatures are above maximum temperature monitored in the receiving waters at these depths.

FIGURE 8-1
POTENTIAL TEMPERATURE VS. DEPTH



maximum temperature limit

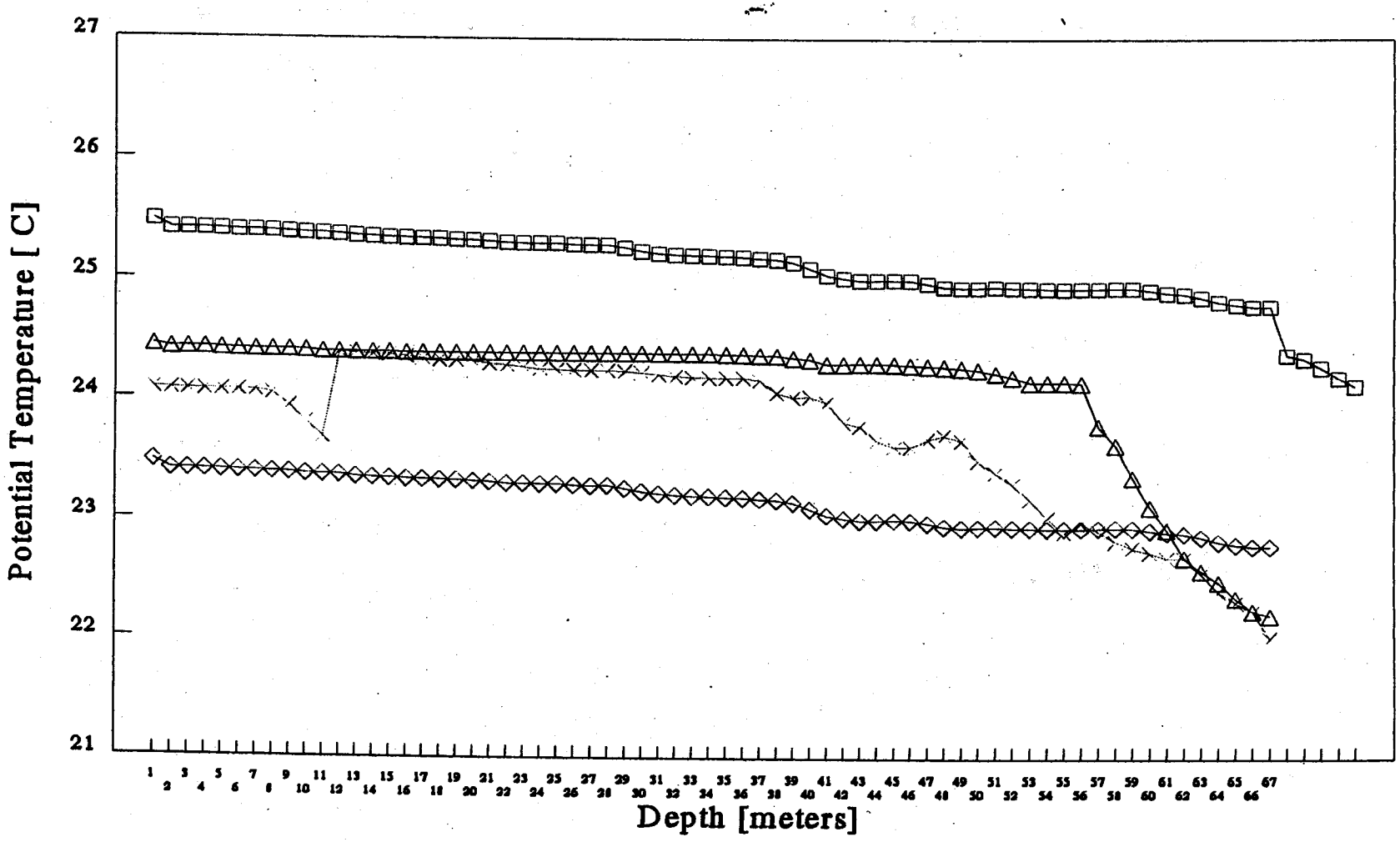
maximum temperataure monitored

minimum temperature limit

minimum temperature monitored

monitoring date: April 12, 1998

FIGURE 8-2
POTENTIAL TEMPERATURE VS. DEPTH



maximum temperature limit

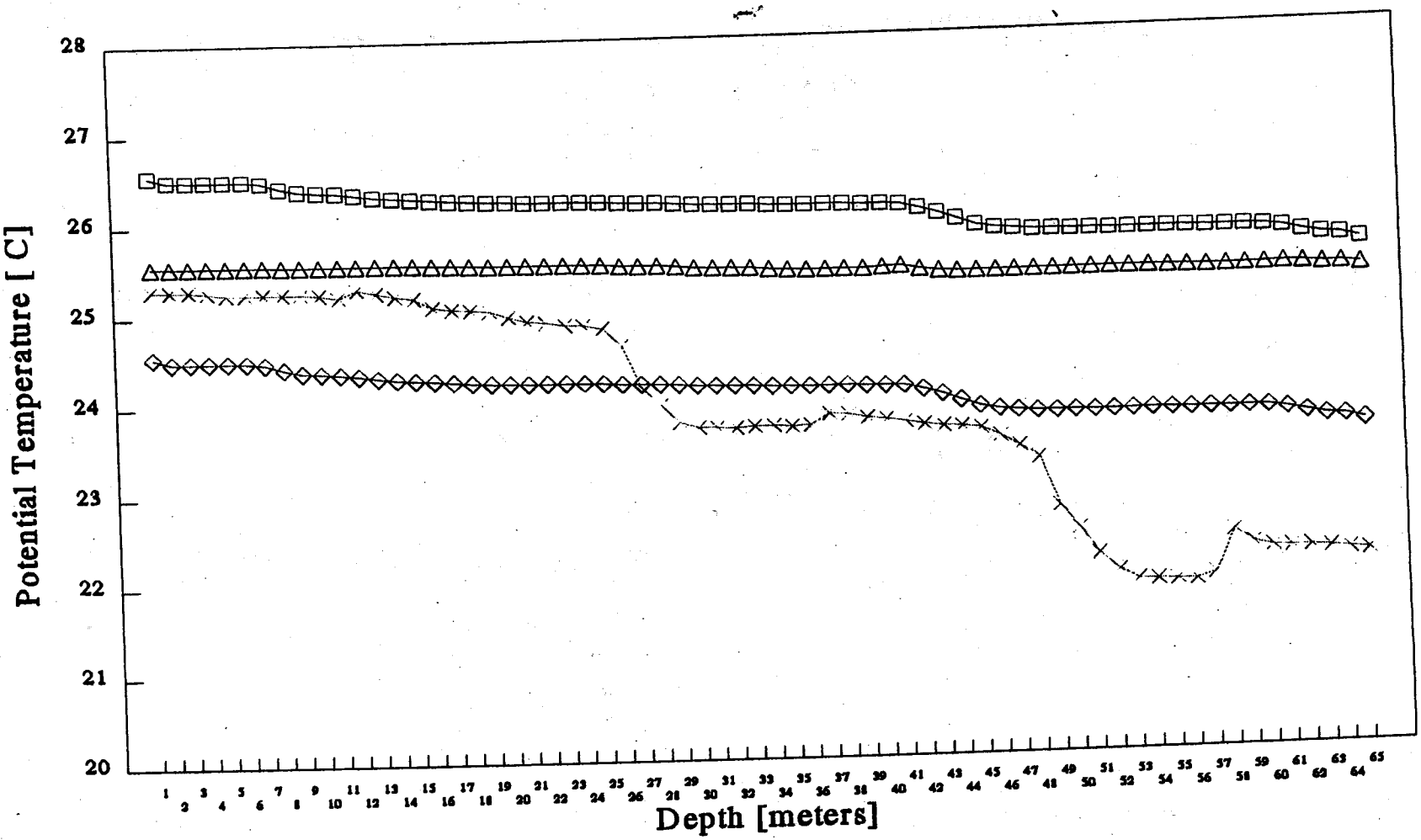
maximum temperature monitored

minimum temperature limit

minimum temperature limit

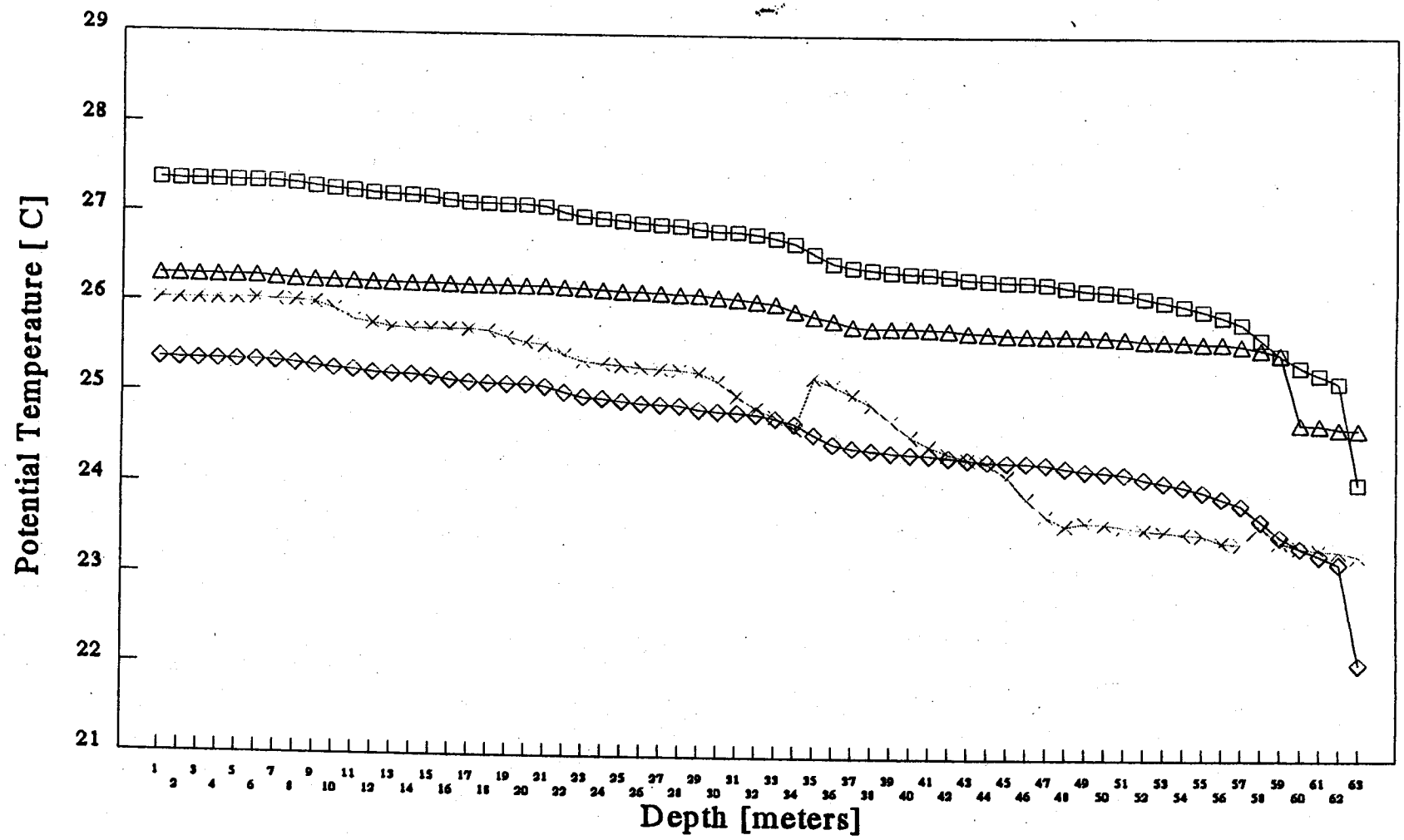
monitoring date: April 7, 1998

FIGURE 8-3
POTENTIAL TEMPERATURE VS. DEPTH



monitoring date: July 6, 1998

FIGURE 8-4
POTENTIAL TEMPERATURE VS. DEPTH



monitoring date: October 22, 1998

8.4 SALINITY REQUIREMENT

According to the State WQS and permit requirements, the salinity shall not vary more than ten percent (10%) from natural or seasonal changes considering hydrologic input and oceanographic factors.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. For a given monitoring event, in situ salinity measurements at each depth (SAL_d) for each nearshore and offshore monitoring station were compared with the average salinity ($AVGSAL_d$) at each corresponding depth. The $AVGSAL_d$ at each depth, d, was obtained by averaging salinity measurements from the two reference (or control) stations (e.g., HB1 and HB7). In the event at a given depth the salinity was measured at only one reference station, the value was used as the $AVGSAL_d$. The salinity ratio at each depth was computed using the following equation:

$$\text{Salinity ratio} = [1 - SAL_d/AVGSAL_d] \times 100$$

This process was repeated throughout the depth range of the reference stations, for each monitoring event. Table 8-2 exhibits no percent deviation exceeding the 10% limit.

Table 8-2

SALINITY MEASUREMENTS FOR GIVEN MONITORING EVENTS

Monitoring event	Salinity ratio [%]		Number of sample points (n)	Average salinity ratio	Sample Standard Deviation
	maximum	minimum			
February 12, 1998	0.23%	0.0%	681	0.02%	0.03%
April 7, 1998	0.64%	0.0%	613	0.06%	0.08%
July 6, 1998	0.92%	0.0%	675	0.06%	0.08%

Table 8-2 SALINITY MEASUREMENTS FOR GIVEN MONITORING EVENTS					
Monitoring event	Salinity ratio [%]		Number of sample points (n)	Average salinity ratio	Sample Standard Deviation
	maximum	minimum			
October 22, 1998	0.65%	0.0%	621	0.06%	0.07%

8.5 DISSOLVED OXYGEN REQUIREMENT

The State WQS and the Honouliuli WWTP 301(h) waiver permit require dissolved oxygen to be not less than seventy-five percent saturation, determined as a function of ambient water temperature and salinity. To determine the dissolved oxygen concentration ($DO_{saturation}$) for given temperature and salinity, dissolved oxygen concentration tables* were used. For each monitoring event, the maximum temperature, T_{max}, and salinity, Sal_{max} were used to obtain a $DO_{saturation}$ Seventy five percent (75%) of $DO_{saturation}$ was used as the minimum concentration to determin compliance with the State WQS and permit requirements. To show compliance, the minimum dissolved oxygen concentration (DO) for each monitoring event was compared against the corresponding $DO_{saturation}$. Compliance is satisfied when $DO > .75 \times DO_{saturation}$. Table 8-3 shows that compliance was attained.

Table 8-3

$DO_{saturation}$ Determination

Monitoring Event	Maximum Measured Temperature [°C]	Maximum Measured Salinity [o/oo]	75% $DO_{saturation}$* using maximum salinity and temperature values [mg/l]	Minimum measured Dissolved Oxygen Concentration [mg/l]
February 12, 1998	24.3297	35.1806	5.12	6.238
April 7, 1998	24.4404	35.2177	5.11	6.12
July 6, 1998	25.5568	35.5037	5.0	5.808
October 22, 1998	26.2991	35.2976	4.95	5.623

* Tschobanoglous, George and Schroeder, Edward; Water Quality. Addison-Wesley Public Company; February 1987.

CHAPTER 5
NUTRIENT EVALUATION

5.1 INTRODUCTION

All offshore stations were monitored in 1999 to determine if the waters near the discharge of the Barbers Point Ocean Outfall complied with the receiving water quality limitations (Part B, RECEIVING WATER LIMITATIONS), Sections 2 and 3) of the HWWTP 301 (h) NPDES permit and the Hawaii Administrative Rules (HAR), Chapter 11-54, State Water Quality Standards. Water quality sampling at the offshore monitoring stations were performed on February 25, April 8, July 1 and November 10, 1999. All sampling protocols and location of the water quality monitoring stations have not changed from the previous calendar year. See Figure 5-1 for the location of all HWWTP's receiving water quality monitoring stations.

According HAR, Chapter 11-54, the receiving waters of the Honouliuli WWTP are classified as "Class A", "Dry", "Open Coastal Waters." In part, the State Water Quality Standard (State WQS) states the following limits (see Reference 2, Appendix E) specified in Table 5-1:

TABLE 5-1
MARINE WATER CRITERIA

Parameter	*Geometric mean not to exceed the given value*	*Not to exceed the given value more than ten percent of the time*	*Not to exceed the given value more than two percent of the time*
Total Nitrogen (µg N/L)	*110.00*	*180.00*	*250.00*

TABLE 5-1
MARINE WATER CRITERIA, ***continued***

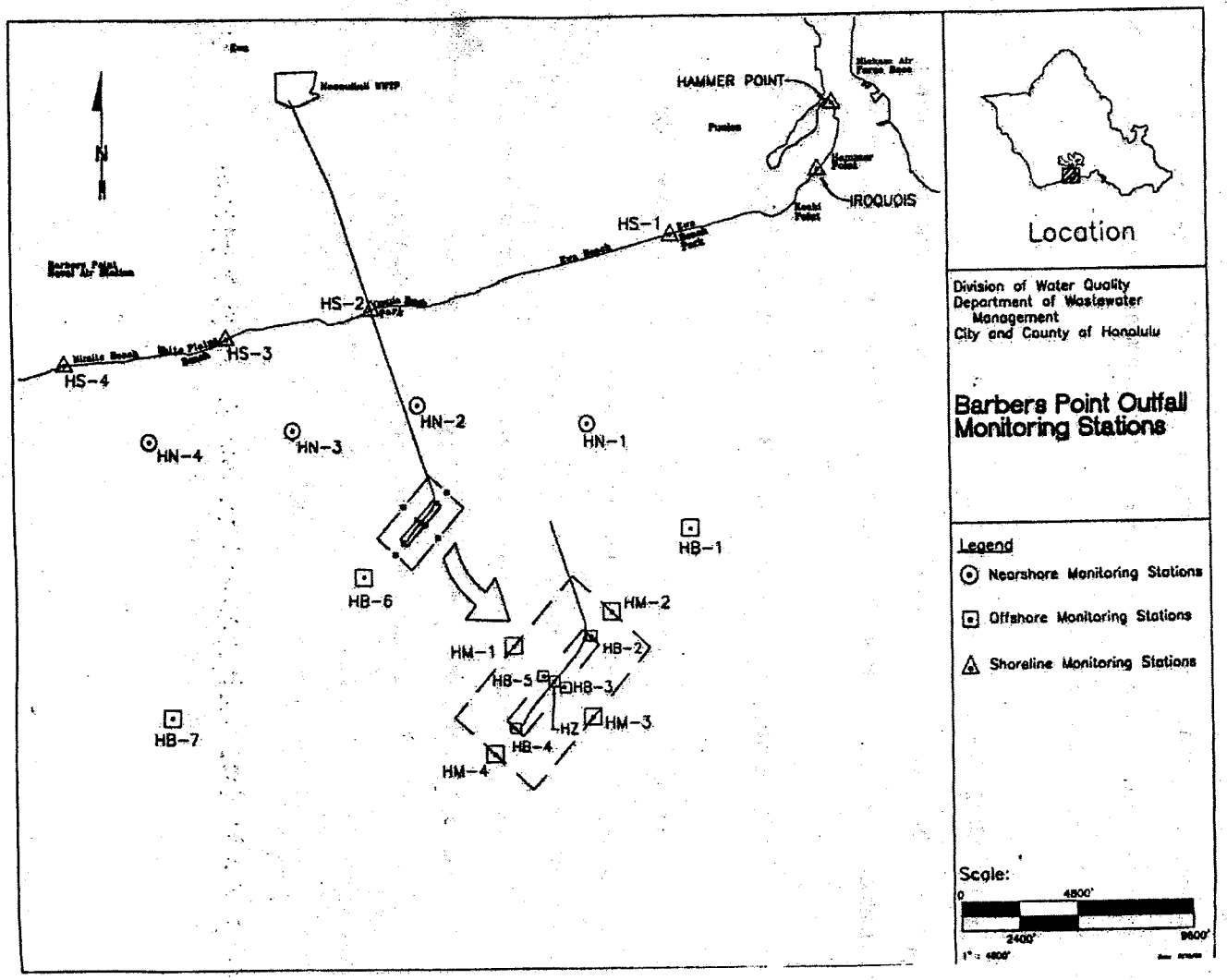
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Ammonia Nitrogen (µg NH_4-N/L)	2.00	5.00	9.00
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	3.50	10.00	20.00
Total Phosphorus (µg P/L)	16.00	30.00	45.00
[1,2]Light Extinction Coefficient (k units)	0.10	0.30	0.55
Chlorophyll a (µg/L)	0.15	0.50	1.00
Turbidity (NTU)[2]	0.20	0.50	1.00

[1] *Light extinction coefficient (LEC) is only required for dischargers who have obtained a waiver pursuant to Section 301(h) of the Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251), as amended, and are required by EPA to monitor it.*

[2] *According to Part B, Section 2, of the NPDES Permit, the stated limits shall not be exceeded beyond the Zone of Initial Dilution.*

FIGURE 5-1

HONOULIULI WWTP OCEAN MONITORING STATIONS



Before compliance with the nutrient limits of Table 5-1 can be demonstrated, several procedural details must be defined. These include the methodology used to determine noncompliance with each WQS standard (i.e., geometric mean, not to exceed 10% of the time and not to exceed 2% of the time), the selection of monitoring stations from which data were obtained and applied to determine compliance, the depths from which data were gathered, and the monitoring duration required for the compliance methodology. These details were obtained from Reference 1 (see Appendix E) and permit requirements that specify monitoring conditions.

5.2 METHODOLOGY

The methodology is based on the assumption that the data follows a log normal distribution. Determining compliance with the three limit categories for any water quality parameter is done by using a graphical method, or probability plots.

By adhering to the following procedure, compliance determination with any of the above State WQS nutrient limits can be determined:

a. In column (1) of a work sheet, number the rows from 1 to n, where n is the number of data points to be used in the compliance determination. See Table 5-2 for a sample worksheet.

b. List the data for a particular parameter (e.g., turbidity) as received in column (2). The data should include all applicable stations in the monitoring program with samples taken no deeper than 30 meters (because the State WQS were established from data taken no deeper than 30 meters). Control station data should not be included in the analysis. Furthermore, the data used should be taken over a time period of at least one year. The size of the data base should be at least thirty (30) data points, or more. Larger data bases are suggested to increase statistical confidence.

c. Order the data in column (2) from smallest to largest into column (3).

d. Take the natural logarithms of the ordered data from column 3 and list in column (4). It doesn't matter what type of logarithm is used provided consistency is maintained. The natural logarithm is specified for consistency.

e. Find the mean and sample standard deviation of the natural logarithm values in column (4).

Mean:

$$\bar{z} = \sum \ln(x_i)/n$$

Sample standard deviation:

$$s_{\bar{z}} = \sqrt{\sum (z_i - \bar{z})^2 / (n-1)}$$

where both summations go from i = 1 to n.

f. To calculate the geometric mean (or 50% value) concentration, take the antilog of the mean natural logarithm value from step "e" above.

$$GM = e^{\bar{z}}$$

Multiply and divide the geometric mean value by the antilog of the sample standard deviation from step "e" to define the concentrations associated with 84% and 16%, respectively.

$$z_{84\%} = GM * e^{s_z}$$

$$z_{16\%} = GM / e^{s_z}$$

Plot these three points [(GM, 50%), ($Z_{84\%}$, 84%), and ($Z_{16\%}$,16%)] on Log-Probability paper. A line drawn through the three points should be a straight line. Identify this line as the *calculated line*. Plot the three points (or criteria for 50%, 90%, 98%) from the State WQS for the parameter in question, connecting the points with a straight line. Identify the resulting line as the *standard line*. Compare both lines. If the *calculated line* is entirely below the *standard line*, the water quality parameters for the 50%, 90%, and 98% criteria have not been exceeded. In other words, comparison of both lines is the method used to determine compliance with the standard, not an individual data point. From the *calculated line*, determine the parameter values corresponding to the 90% and 98% probability. With the GM, compare these values with the appropriate State WQS criteria values for the parameter in question.

g. Plot all data points on Log-Probability paper, use the ranked data (column (3)) as the abscissa (y-axis) and the probability (column (5)) as the ordinate (x-axis). The purpose of plotting the data is to validate the log normal distribution. If the plotted data points approximate the *calculated line* on Log-Probability paper, then the log normal distribution assumption is verified. Other distributions may be applied; however, the assumption for this methodology assumes (with corresponding verification by data plotting) a log normal distribution.

h. If the plotted data confirms a log normal distribution, the results from step "f" above are valid.

i. If the plotted data does not correspond to the *calculated line* (e.g. confirmation of the log normal distribution is not validated), several events could be occurring. There could be something wrong with the data or another process may be occurring. Lastly, but not necessarily finally, the process may not be log normal distributed, and therefore, compliance cannot be determined.

TABLE 5-2
SAMPLE WORKSHEET

I	Listing of raw data as received	Data, x_i ranking smallest to largest	Logarithm of the ranked data	Probability (percent) 100*(I-½)/n [%]
1	y_1	x_1	$\ln(x_1)$	(1-½)/n
2	y_2	x_2	$\ln(x_2)$	(2-½)/n
:	:	:	:	:
n	y_n	x_n	$\ln(x_n)$	(n-½)/n

where n = the number of data points.

5.3 TEMPORAL AND SPATIAL CONSIDERATIONS

The above analyses shall be done on an annual (calendar year) basis, using a minimum sample size of roughly thirty data points. If thirty data points are not available during a given monitoring year, the data obtained during the previous monitoring years shall be included in the compliance data base. This procedure will be continued until a compliance data base of thirty or more data points is achieved. An analyses which include at least five (5) years of data shall also be done at the same time as the annual analyses. The purpose of this analyses is to identify possible long term impacts. The one (1) and five (5) year analyses constitute a compliance analyses for the WQS.

For Turbidity and Light Extinction Coefficient (LEC), stations at and beyond the ZID shall be used. Thus, the data used to determine compliance with the WQS were obtained from only the ZID stations, i.e., HB2, HB3, HB4 and HB5. For the other parameters such as Ammonia Nitrogen, Total Nitrogen, Nitrate + Nitrite Nitrogen, Total Phosphorus, and Chlorophyll a,

compliance with the State WQS shall include stations at or beyond the ZOM. In this case the monitoring data from only the HWWTP ZOM stations, i.e., HM1, HM2, HM3 and HM4, were used.

A separate set of analyses was performed on the monitoring data from the control stations. The same depth and temporal guidelines was applied to the control station data. The purpose of this analysis is to compare background water quality conditions to the conditions at the ZOM/ZID boundary.

A noncompliant event results if any water quality parameter above has exceeded the applicable limits of Table 5-1, accompanied by sufficient evidence that the noncompliance is related to the discharge of the Barbers Point Ocean Outfall. Examples of this evidence is a comparison of the ZOM/ZID station analysis with the control station analysis. Noncompliance attributable to the discharge should not be impacting the control stations. Furthermore, noncompliance of one or more parameters should be associated with increases from other parameters, which may or may not have exceeded the applicable limits, if the discharge is the cause of the exceedance.

5.4 RESULTS

5.4.1 ZOM AND ZID STATION RESULTS

The compliance methodology, as presented above, was applied to the ZOM and ZID monitoring data obtained during the 1999 monitoring year. The graphical results are shown in Table 5-3. Results of the analyses using five (5) years of data are tabulated in Table 5-4.

TABLE 5-3
ONE-YEAR ANALYSES
ZOM/ZID STATIONS

Parameter		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	Result	105.0	175.0	240.0
	Limit	110.00	180.00	250.00
Ammonia Nitrogen (µg NH_4-N/L)	Result	2.46	7.1	13.5
	Limit	2.00	5.00	9.00
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	Result	1.02	1.28	1.41
	Limit	3.50	10.00	20.00
Total Phosphorus (µg P/L)	Result	8.20	10.5	12.3
	Limit	16.00	30.00	45.00
[1]Light Extinction Coefficient (k units)	Result	0.029	0.037	0.425
	Limit	0.10	0.30	0.55
Chlorophyll a (µg/L)	Result	0.180	0.29	0.385
	Limit	0.15	0.50	1.00
Turbidity (NTU)	Result	0.12	0.235	0.35
	Limit	0.20	0.50	1.00

[1]See Table 5-1 footnote.

Shaded cells indicate noncompliances

TABLE 5-4
FIVE-YEAR ANALYSES
ZOM/ZID STATIONS

Parameters		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	Result	97.8	144	181
	Limit	110.00	180.00	250.00
Ammonia Nitrogen (µg NH_4-N/L)	Result	1.54	3.85	6.70
	Limit	2.00	5.00	9.00
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	Result	1.03	1.25	1.4
	Limit	3.50	10.00	20.00
Total Phosphorus (µg P/L)	Result	9.15	12.3	14.5
	Limit	16.00	30.00	45.00
[1]Light Extinction Coefficient (k units)	Result	0.033	0.045	0.054
	Limit	0.10	0.30	0.55
Chlorophyll a (µg/L)	Result	0.162	0.415	0.74
	Limit	0.15	0.50	1.00
Turbidity (NTU)	Result	0.140	0.28	0.44
	Limit	0.20	0.50	1.00

[1]See Table 5-1 footnote.

Thirty-two (32) data points were used for the one-year compliance determination for all water quality parameters. In the five-year analyses, one hundred forty eight (148) data points were used for Nitrate + Nitrite Nitrogen, Ammonia Nitrogen and

Total Phosphorus analyses. One hundred forty (140) data points were used for Total Nitrogen, one hundred thirty six (136) data points for Turbidity and eighty (80) data points for LEC.

Tables 5-3 and 5-4, shows that the WQS geometric mean limit for Chlorophyll a was exceeded for the one and five year analyses. All three WQS limits for Ammonia Nitrogen was exceeded for the one-year analyses.

5.4.2 CONTROL STATION RESULTS

The compliance methodology was also applied to the water quality data collected from the control stations HB-1 and HB-7. Like the ZOM/ZID analyses, compliance was determined for a one and five year period. Results of the one and five year analyses are tabulated in Table 5-5 and 5-6, respectively.

TABLE 5-5
ONE-YEAR ANALYSES
CONTROL STATIONS

Parameter		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	result	59.1	140	190
	limit	110.00	180.00	250.00
Ammonia Nitrogen (µg NH_4-N/L)	result	1.71	2.99	4.15
	limit	2.00	5.00	9.00
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	result	1	1	1
	limit	3.50	10.00	20.00
Total Phosphorus (µg P/L)	result	8.00	10.4	12.0
	limit	16.00	30.00	45.00
Chlorophyll a (µG/L)	result	0.133	0.242	0.35
	limit	0.15	0.50	1.00
Turbidity (NTU)	result	0.10	0.19	0.285
	limit	0.20	0.50	1.00

Shaded cells indicate noncompliances.

TABLE 5-6
FIVE-YEAR ANALYSES
CONTROL STATIONS

Parameter		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	result	89.8	139	182
	limit	110.00	180.00	250.00
Ammonia Nitrogen (µg NH_4-N/L)	result	1.43	2.53	3.6
	limit	2.00	5.00	9.00
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	result	1.0	1.0	1.0
	limit	3.50	10.00	20.00
Total Phosphorus (µg P/L)	result	8.57	11.5	13.8
	limit	16.00	30.00	45.00
Chlorophyll a (µg/L)	result	0.115	0.285	0.505
	limit	0.15	0.50	1.00
Turbidity (NTU)	result	0.116	0.232	0.353
	limit	0.20	0.50	1.00

In the one year analyses, data dating back to February 12, 1998 were needed to gather at least thirty (30) data points to maintain statistical confidence for Nitrate + Nitrite Nitrogen, Ammonia Nitrogen, Total Phosphorus, Turbidity and Chlorophyll a (Each of these parameters contained thirty two (32) data points). For Total Nitrogen, thirty data points were achieved by going back to October 9, 1997. For LEC, thirty (30) data points were obtained by using data dating back to May 23, 1996.

For the five-year analyses, data from 1995 to 1999 was needed to obtain at least thirty data points. Fifty six (56) data points were gathered for Nitrate + Nitrite Nitrogen, Ammonia Nitrogen, Total Phosphorus and Turbidity. Fifty four (54), fifty two (52) and forty (40) data points were used for the compliance determination analyses for Chlorophyll a, Total Nitrogen, and LEC, respectively.

The WQS for the one and five year analyses were not exceeded by any of the water quality parameters at these two control stations

5.4.3 DISCUSSION

The one year statistical analyses applied to the ZOM/ZID monitoring data showed that the WQS was exceeded for the Ammonia Nitrogen parameter; however, this was not so for the five year analyses. Thus, exceeding the WQS in this case is due to a recent rather than an ongoing cause. The cause is not known at this time. On the other hand, exceeding the Chlorophyll a parameter may be due to an ongoing cause since the WQS limit for this parameter was exceeded in the one and five year analyses.

The WQS limits were not exceeded when using the monitoring data from the control stations. This indicates that perhaps the discharge from the Barbers Point Ocean Outfall may be responsible for the limits to be exceeded for Ammonia Nitrogen

and Chlorophyll a parameters. Although the total nitrogen and ammonia nitrogen values were higher for the one year than the five year analyses, total phosphorus, chlorophyll a, and turbidity did not show a similar increase.

It is possible that the nutrient concentrations may be enhanced by the freshwater input of the receiving water. The water quality limits are different for "wet" areas (receiving more than 3 mgd of freshwater discharge per shoreline mile) than for "dry" areas. Based on hydrologic calculations, the receiving waters of the Barbers Point Outfall appear to be incorrectly classified as a "dry" region. The City will therefore be requesting a reclassification of the receiving waters from "dry" to "wet."

The "wet" limits for the Ammonia Nitrogen are 3.50, 8.50 and 15.00 ug/L for the "not to exceed the geometric mean", "not to exceed ten percent of the time," and " not to exceed ten percent of the time" limits, respectively. The "wet" Chlorophyll a limits are 0.30, 0.90, and 1.75 ug/L, respectively. Using these limits, the ZOM/ZID station analyses would be compliant with the standards for both the one and five year analyses.

5.5 Summary

1. The Ammonia Nitrogen Water Quality standard was exceeded at the ZOM for the geometric mean, 10%, and 2 % criteria using about one year of data. The Chlorophyll a criteria was exceeded at the ZOM for the geometric mean criteria using both one year and five years of data. There was no corresponding exceeded limits at the two chosen control stations. Thus, the outfall could be a possible cause of these exceeded limits.

2. The receiving waters at the ZOM may be incorrectly classified, based on hydrologic calculations. Using the water quality limits for the correct classification, all of the nutrient limits would be met. The City will be requesting that the receiving waters be reclassified correctly.

CHAPTER 8
CHEMISTRY EVALUATION

8.1 INTRODUCTION

Physical/chemical measurements for pH, temperature, salinity, and dissolved oxygen were monitored quarterly during 1999 using the Sea-Bird CTD Profiler at nearshore, ZID, ZOM, and offshore stations. Measurements were taken at various depths at one meter depth intervals. See Figure 5-1 for a map of the monitoring stations. The Honouliuli WWTP 301(h) waiver permit requires quarterly monitoring. Monitoring dates were February 25, April 8, July 1, and November 10, 1999. For July 1, sampling was done in the morning , but errors in the dissolved oxygen readings for station HN4 mandated resampling in the afternoon at all nearshore stations.

All monitoring stations and protocols were unchanged from the previous monitoring year. The monitoring data was compared with the Water Quality criteria stated in the Honouliuli WWTP 301(h) waiver permit, sections B.2. and B.3, and the State Water Quality Standards (WQS).

8.2 pH REQUIREMENT

According to the State WQS and permit requirements, pH units shall not deviate more than 0.5 units from a value of 8.1 ($7.6 \leq pH \leq 8.6$) except at coastal locations where and when freshwater from stream, storm drain or groundwater discharge may depress the pH to a minimum level of 7.0.

To determine compliance, in situ measurements of the ocean water were compared with the above pH range. Throughout 1999, all measured pH values at all stations and depths fell within the allowable range. See Table 8-1 for the maximum and minium pH's measured at each station.

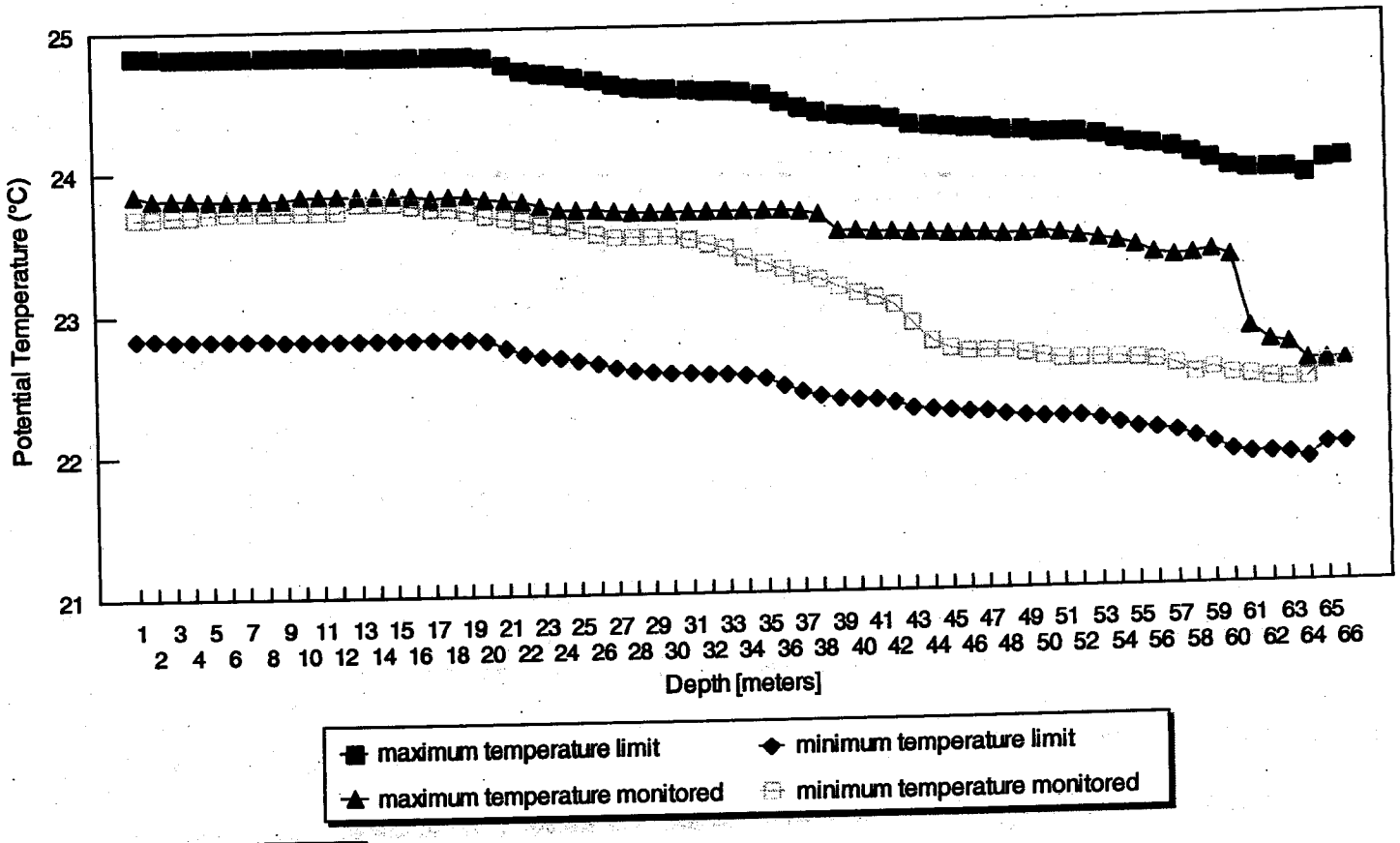
TABLE 8-1 1999 CTD pH Data			
Sample site	number of measurements	pH	
		max	min
HN1	59	8.104	8.280
HN2	54	8.095	8.284
HN3	59	8.083	8.267
HN4	52	8.100	8.272
HZ	253	8.081	8.251
HM1	163	8.078	8.244
HM2	232	8.081	8.245
HM3	394	8.083	8.255
HM4	230	8.092	8.261
HB1	264	8.084	8.240
HB2	231	8.081	8.250
HB3	284	8.088	8.251
HB4	252	8.083	8.264
HB5	226	8.080	8.246
HB6	234	8.099	8.269
HB7	264	8.103	8.281

8.3 TEMPERATURE REQUIREMENT

According to the State WQS and permit requirements, the receiving water temperature shall not vary more than one degree Celsius (±1°C) from ambient conditions.

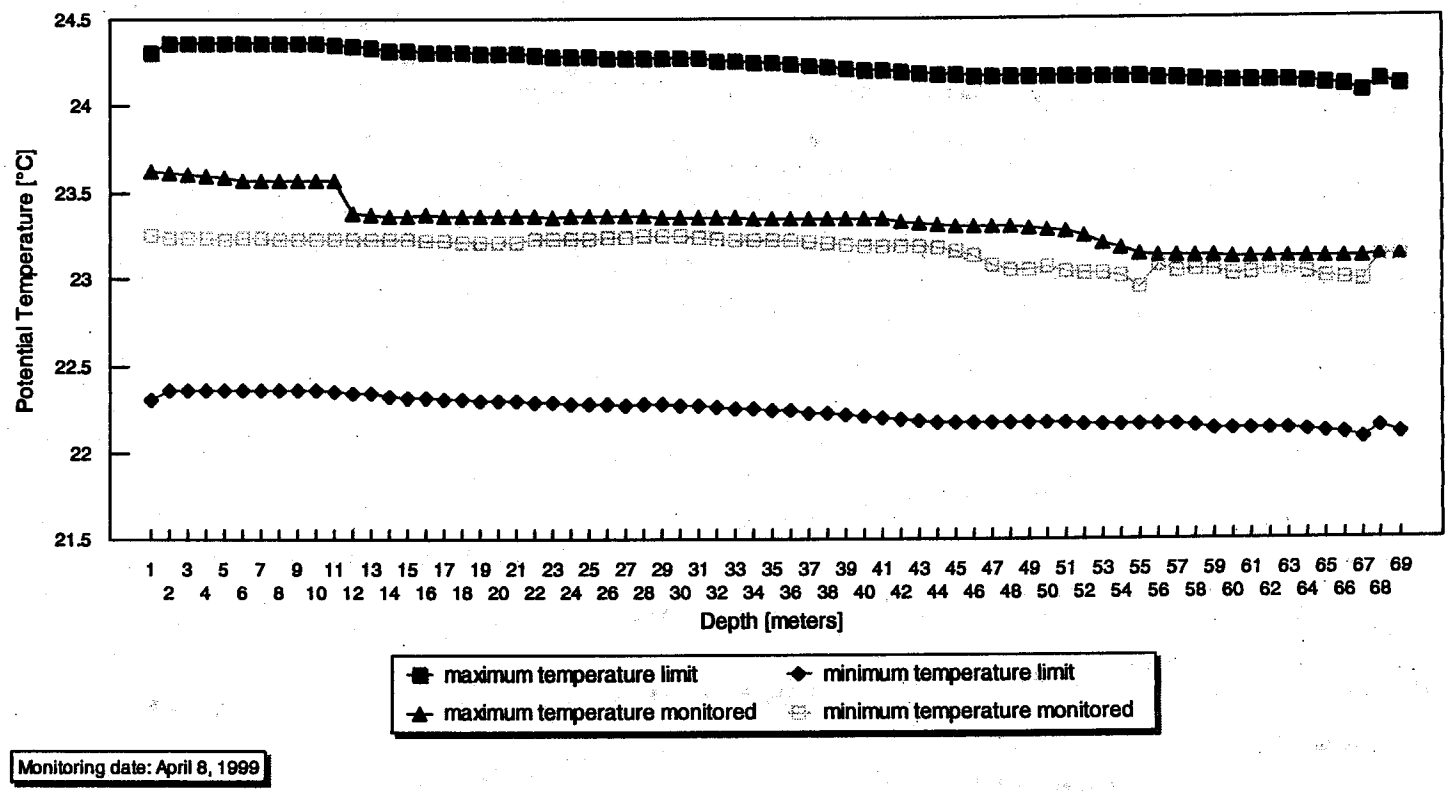
Because there is no specific Federal or State compliance methodology, the City has established its own methodology. Potential temperature measurements were compared with the above temperature range condition. The ambient condition was determined by averaging the potential temperature measurements at each depth from both reference stations (e.g., HB1 and HB7) for each monitoring event. In the event there was only a temperature reading from one reference station at a given depth, that reading was taken to be the ambient temperature. At each depth, the ambient temperature was compared with the monitored potential temperature at each nearshore and offshore station at the same depth. Some offshore stations were deeper than the control stations. Potential temperatures at elevations lower than the bottom of the control stations (66 meters) had no ambiant values to be compared to. Figures 8.1 - 8.4 are the graphs of (1) the derived ambiant temperature limits from the control stations, and (2) the maximum and minimum temperatures monitored at each depth from among the other stations' data.

FIGURE 8-1
POTENTIAL TEMPERATURE VS. DEPTH



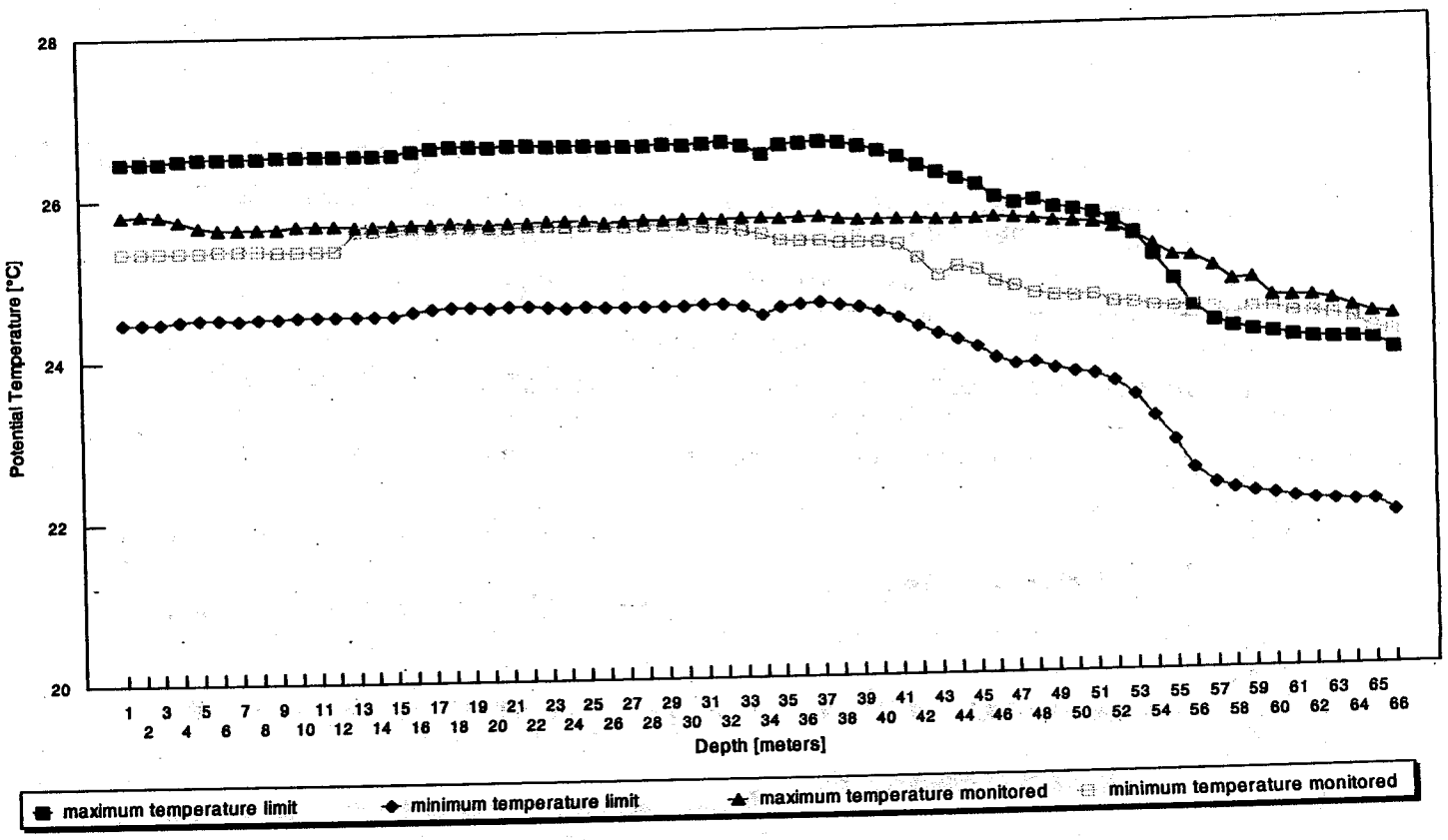
Monitoring date: February 25, 1999

FIGURE 8-2
POTENTIAL TEMPERATURE VS. DEPTH



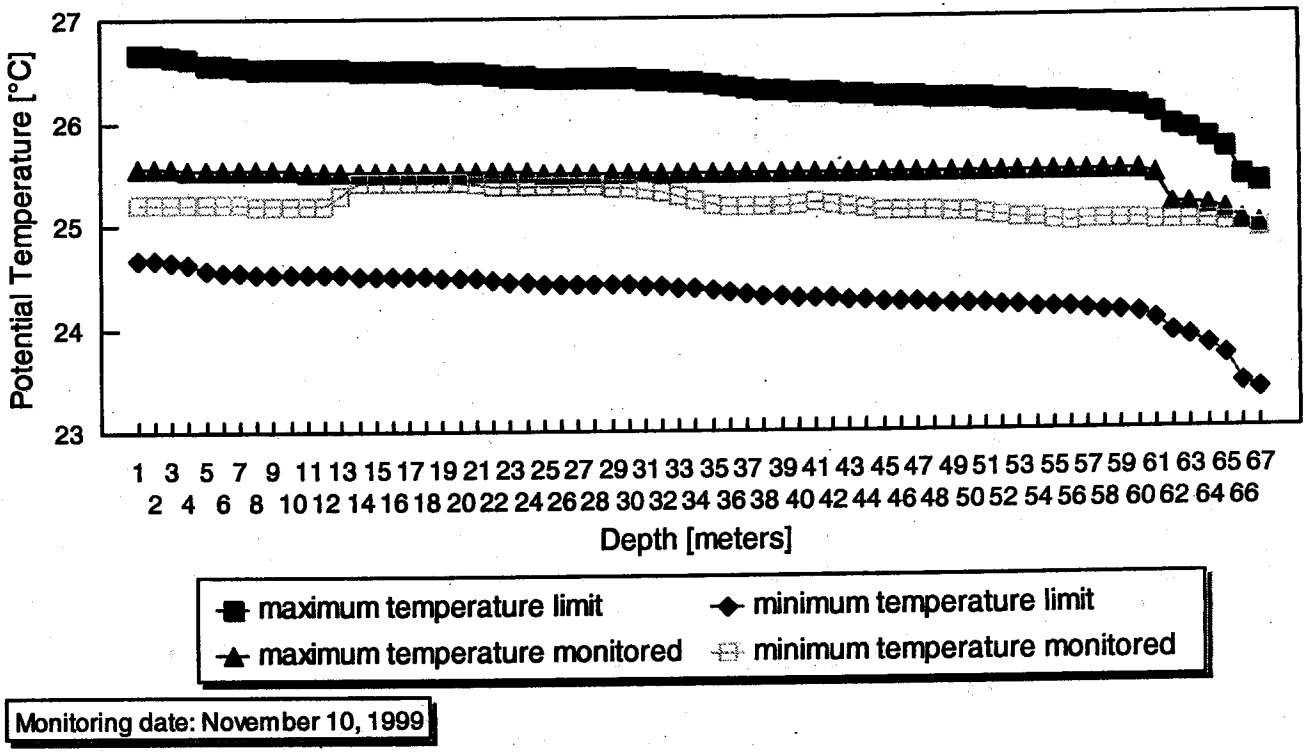
Monitoring date: April 8, 1999

FIGURE 8-3
POTENTIAL TEMPERATURE VS. DEPTH



Monitoring date: July 1, 1999

FIGURE 8-4
POTENTIAL TEMPERATURE VS. DEPTH



Monitoring date: November 10, 1999

The graphs show that all measured temperature met the WQS limits except on July 1, 1999 from fifty four (54) to sixty six (66) meters deep (See Figure 8-3). Both the minimum and the maximum potential temperatures at those depths on that date were greater than the ambiant derived maximum temperature limit.

The range of depths measured at all of the stations for the July 1, 1999 monitoring event are provided in Table 8-2. Table 8-3 provides the depths and corresponding temperature limits for July 1, 1999, and the stations which exceeded the limits . All stations at the Zone of Initial Dilution (i.e., HB2 to HB5), Zone of Mixing (i.e., HM1 to HM4) and on the diffuser (i.e., HZ) and at the near field (HB6) had temperature data which exceeded the maximum temperature limit at those depths; except for HM-1, which did not reach those depths.

A review of the graphs indicates that for July, starting at a depth of 39 meters, the ambiant temperature dropped rapidly as depth increased. A similar rapid drop with depth is not seen with the other sampling dates. The difference between the highest ambiant water quality temperature limit (at shallow depths) and the lowest ambiant water quality temperature limit (at deeper depths) was about 3° C for July. This is compared to differences of about 0.3 to 1.4 ° C for the other three sampling dates.

Table 8-4 compares the temperatures of the HWWTP effluent with the approximate lowest maximum water quality temperature limits for each date. The table indicates that the temperature difference between the lowest water quality limit and the effluent was greatest for the July sampling, compared to the other three sampling dates. The reason is that the effluent temperature was higher than the effluent temperature on the other three dates, while the lowest maximum temperature limit was lower than the limits on the other three dates.

A temperature plot of station HZ (located at approximately midpoint of the diffuser pipe) shows that temperatures were above all the ZID stations from 59 to 65 meters deep on the July samplng date (See Figure 8-5). This indicates that at depths 54 to 58, where HB3 and HB4 temperatures were higher than HZ, the exceeded ambiant limits may be due to other causes such as differences in heating near the surface between these stations and the ambiant reference stations. Another possibility is that the effluent plume dispersion somehow affected stations HB3 and HB4 more than station HZ. The latter is possible, but would be less likely if discharge was occurring evenly from all diffuser ports.

In summary, based on the methodology outlined, the Water Quality Limit was exceeded at the ZID and ZOM stations for one sampling date. Further investigation would be needed to determine the extent and reasons for the noncompliance. The effluent discharge, with temperatures higher than the receiving waters, would be a contributing factor; however, limits were not exceeded on other sampling days.

TABLE 8-2
Monitored Ranged of Depths Monitored at Station
Monitoring date: July 1, 1999

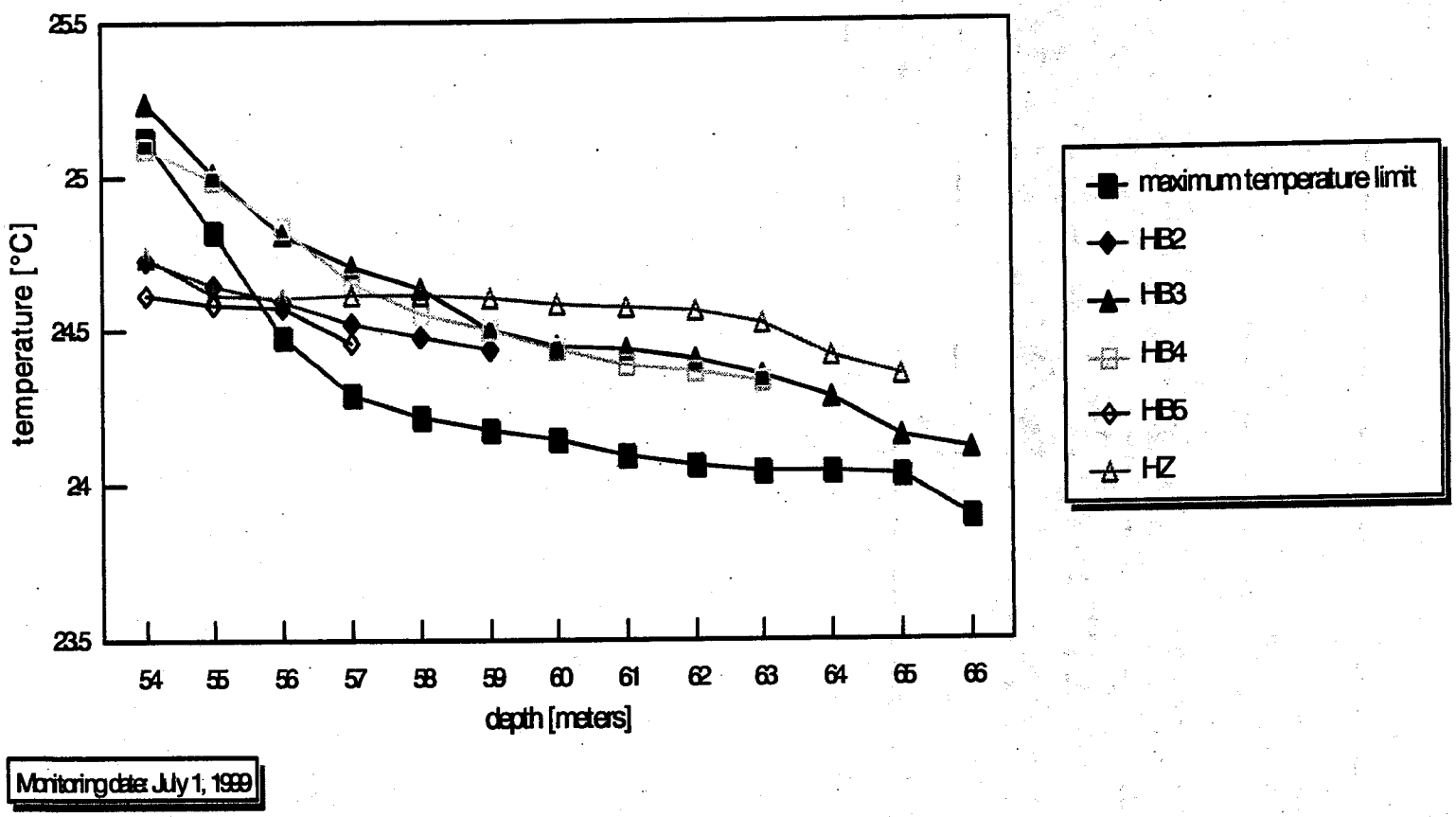
Receiving Water Monitoring Stations	Maximum Monitored Depth (meters)
HB1 (reference station)	1 to 65
HB7 (reference station)	1 to 66
HB2 (ZID station)	1 to 59
HB3 (ZID station)	1 to 75
HB4 (ZID station)	1 to 63
HB5 (ZID station)	1 to 57
HM1 (ZOM station)	1 to 43
HM2 (ZOM station)	1 to 58
HM3 (ZOM station)	1 to 103
HM4 (ZOM station)	1 to 57
HZ (station above the diffuser)	1 to 65
HN1 (nearshore station)	1 to 12
HN2 (nearshore station)	1 to 11
HN3 (nearshore station)	1 to 12
HN4 (nearshore station)	1 to 7
HB6 (station southwest of diffuser)	1 to 59
HN1 (nearshore station) - 2nd monitoring	1 to 10
HN2 (nearshore station) - 2nd monitoring	1 to 11
HN3 (nearshore station) - 2nd monitoring	1 to 12
HN4 (nearshore station) - 2nd monitoring	1 to 11

TABLE 8-3 Receiving Water Monitoring Stations That Exceeded the Ambient Temperature Limit on July 1, 1999		
Depth (meters)	Maximum temperature limit [ambiant plus 1° C] (°C)	Stations exceeding the maximum temperature limit
54	25.12325	HB3 and HM4
55	24.82675	HB3, HB4, HB6 and HM4
56	24.48345	HB2, HB3, HB4, HB5, HB6, HM2, HZ, HM3 and HM4
57	24.29155	HB2, HB3, HB4, HB5, HB6, HM2, HM3, HM4 and HZ
58	24.2177	HB2, HB3, HB4, HB6, HM2, HM3 and HZ
59	24.17295	HB2, HB3, HB4, HB6, HM3 and HZ
60	24.14805	HB3, HB4, HM3 and HZ
61	24.09185	HB3, HB4, HM3 and HZ
62	24.06345	HB3, HB4, HM3 and HZ
63	24.0439	HB3, HB4, HM3 and HZ
64	24.0376	HB3, HM3, HZ
65	24.02635	HB3, HM3 and HZ
66	23.8948	HB3 and HM3

TABLE 8-4 Honouliuli WWTP Effluent Temperature			
Monitoring Date	**Effluent Temperature (°C)**	**Lowest maximum water quality temperature limit (°C)**	**Difference in temperature between effluent & WQ limit (°C)**

02/24/99	26.00		2.1
02/25/99	25.50	23.9	1.6
02/26/99	26.00		2.1
04/07/99	26.00		1.9
04/08/00	26.00	24.1	1.9
04/09/00	26.00		1.9
06/30/99	27.00		3.1
07/01/99	27.50	23.9	3.6
07/02/99	27.00		3.1
11/9/99	27.00		1.6
11/10/00	26.00	25.4	0.6
11/11/00	28.00		2.6

FIGURE 8-5
TEMPERATURE VS DEPTH
STATION HZ COMPARED WITH
THE ZID STATIONS



8.4 SALINITY REQUIREMENT

According to the State WQS and permit requirements, the salinity shall not vary more than ten percent (10%) from natural or seasonal changes considering hydrologic input and oceanographic factors.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. For a given monitoring event, in situ salinity measurements at each depth (SAL_d) for each nearshore and offshore monitoring station were compared with the average salinity ($AVGSAL_d$) at each corresponding depth. The $AVGSAL_d$ at each depth, d, was obtained by averaging salinity measurements from the two reference stations (i.e, HB1 and HB7). In the event at a given depth the salinity was measured at only one reference station, the value was used as the $AVGSAL_d$. As with the potential temperature analysis, compliance determination for some of the salinity measurements at the offshore monitoring stations could not be performed for depths greater than the depths monitored at the reference stations. The salinity ratio at each depth was computed using the following equation:

$$\text{Salinity ratio} = ABS[1\text{-}SAL_d/AVGSAL_d] \times 100$$

This process was repeated throughout the depth range of the reference stations, for each monitoring event. Table 8-6 indicates that the measured salinities did not vary more than 10% from the control stations' salinity.

Table 8-6

SALINITY MEASUREMENTS FOR GIVEN MONITORING EVENTS

Monitoring event	Salinity ratio [%]		Number of sample points (n)	Average salinity ratio	Standard Deviation
	maximum	minimum			
February 25, 1999	0.55%	0.0%	638	0.07%	0.08%
April 8, 1999	0.82%	0.0%	612	0.08%	0.08%
July 1, 1999	0.93%	0.0%	668	0.23%	0.16%
November 10, 1999	0.29%	0.0%	650	0.08%	0.06%

8.5 DISSOLVED OXYGEN REQUIREMENT

The State WQS and the Honouliuli WWTP 301(h) waiver permit require dissolved oxygen to be not less than seventy-five percent saturation, determined as a function of ambient water temperature and salinity. To determine the dissolved oxygen concentration ($DO_{saturation}$) for given temperature and salinity, dissolved oxygen concentration tables* were used. For each monitoring event, the maximum temperature, T_{max}, and salinity, Sal_{max}, were used to obtain a $DO_{saturation}$. Seventy five percent (75%) of $DO_{saturation}$ was used as the minimum concentration to determine compliance with the State WQS and permit requirements. To show compliance, the minimum dissolved oxygen concentration (DO) among the nearshore and offshore monitoring stations for each monitoring event was compared against the corresponding $DO_{saturation}$. Compliance is satisfied when $DO > .75 \times DO_{saturation}$. Table 8-7 shows that compliance was attained.

Table 8-7 $DO_{saturation}$ Determination				
Monitoring Event	Maximum Measured Temperature [°C]	Maximum Measured Salinity [o/oo]	75% $DO_{saturation}$* using maximum salinity and temperature values [mg/l]	Minimum measured Dissolved Oxygen Concentration [mg/l]
February 25, 1999	23.8484	35.2628	5.159	6.10305
April 8, 1999	23.627	35.1796	5.181	6.09645
July 1, 1999	25.818	35.1671	4.990	6.04195
October 10, 1999	25.5578	35.2861	5.009	5.9276

* Tschobanoglous, George and Schroeder, Edward; Water Quality. Addison-Wesley Public Company; February 1987.

8.6 SUMMARY

1. Based on the methodology used, the Water Quality Standards were met for pH, salinity, and dissolved oxygen at the ZID, and ZOM, diffuser, nearfield, and nearshore stations.
2. The Water Quality Standards were not met for maximum temperature during one sampling event for diffuser,ZID, ZOM and nearfield stations at depths 54 meters and greater. The effluent is a likely contributor due to its higher temperature than the receiving water; however, it did not create a noncompliance during three other sampling events. The data indicates other factors or environmental conditions may also be involved. Further investigation would be needed to determine the extent and reasons for the noncompliance.
3. No ambiant reference temperatures or salinity could be determined for depths greater than 66 meters under the present methodology. HB3 and HM3 stations had depths greater than 66 meters which were not compared to Water Quality limits for temperature or salinity.

CHAPTER 5
NUTRIENT EVALUATION

5.1 INTRODUCTION

All offshore stations were monitored in 2000 to determine if the water quality near the discharge of the Barbers Point Ocean Outfall complied with the receiving water quality limitations (Part B, RECEIVING WATER LIMITATIONS), Sections 2 and 3) of the HWWTP 301 (h) NPDES permit and the Hawaii Administrative Rules (HAR), Chapter 11-54, State Water Quality Standards. Water quality sampling at the offshore monitoring stations were performed on February 8, April 20, August 30 and October 11, 2000. All sampling protocols and location of the water quality monitoring stations have not changed from the previous calendar year. However, we have decided to consider HB-6 as a reference station instead of a monitoring stations (as we did last year). This decision was based on a lack of a diffuser-proximity pattern in the monitoring data. See Figure 5-1 for the location of all HWWTP's receiving water quality monitoring stations.

The Hawaii State Water Quality Standards designates different standards for Open Coastal Waters depending upon whether area is considered "wet" or "dry." The"wet" criteria applies when the waters receive more than 3 million gallons per day of freshwater per shoreline mile. In 2000, ENV reviewed the hydrologic information of freshwater being discharged to Open Coastal Waters from Barbers Point to Pearl Harbor. ENV concluded that the proper designation for the subject waters should be the "wet" criteria. ENV held a Public Hearing on the conclusion and submitted the report to independent hydologists for review. By letter dated December 11, 2000, the State Department of Health concurred that the subject waters would come under the "wet" criteria. This chaper will therefore analyze the receiving water quality using the "wet" criteria. Previous analyses in the Annual Assessment Reports had been based on the "dry" criteria.

According HAR, Chapter 11-54, the receiving waters of the Honouliuli WWTP are classified as "Class A", "Wet", "Open Coastal Waters." In part, the State Water Quality Standard (State WQS) states the following limits (see Reference 2, Appendix E) specified in Table 5-1:

TABLE 5-1
MARINE WATER CRITERIA

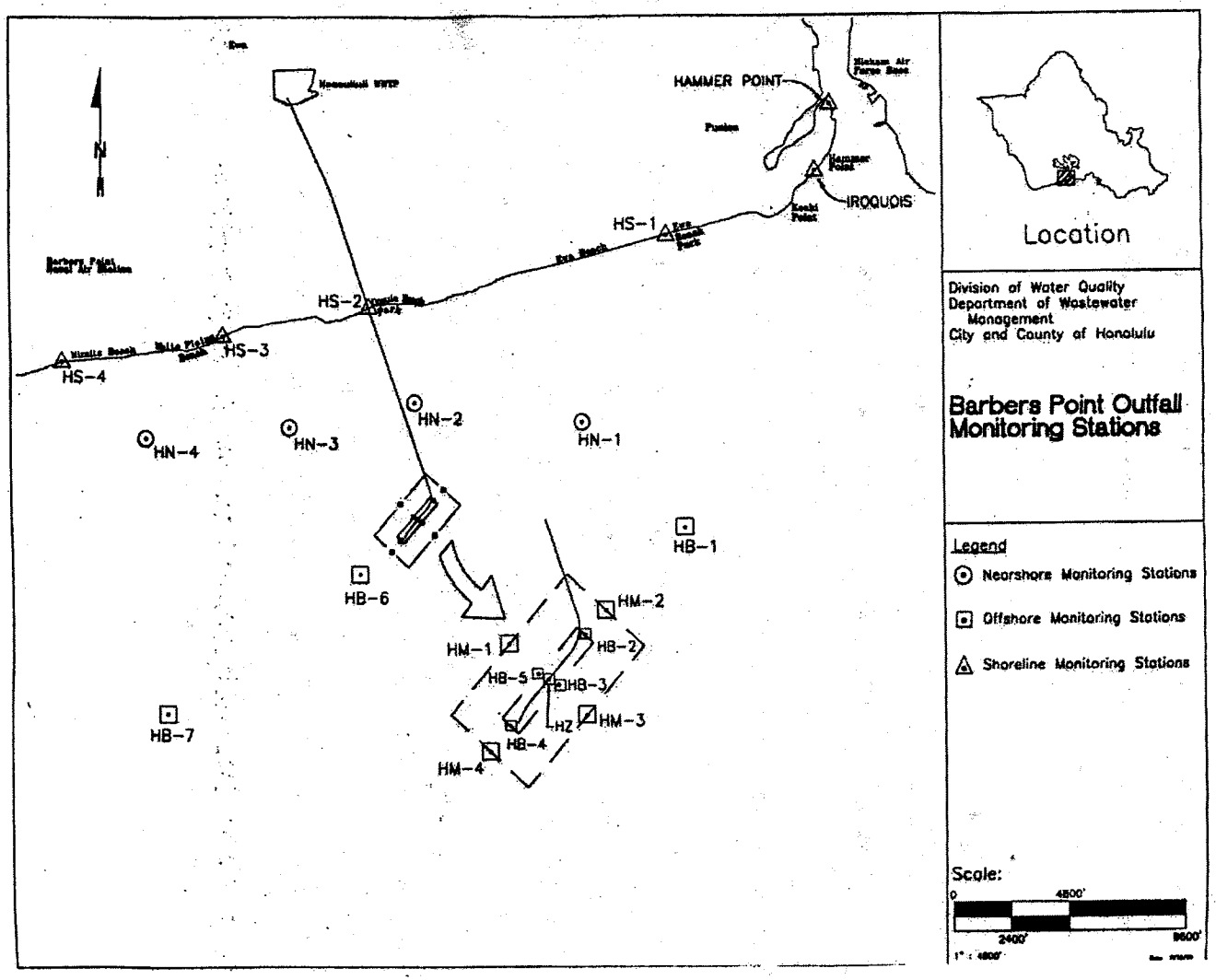
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	150.00	250.00	350.00
Ammonia Nitrogen (µg NH_4-N/L)	3.50	8.50	15.00
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	5.00	14.00	25.00
Total Phosphorus (µg P/L)	20.00	40.00	60.00
[1,2]Light Extinction Coefficient (k units)	0.20	0.50	0.85
Chlorophyll a (µg/L)	0.30	0.90	1.75
Turbidity (NTU)[2]	0.50	1.25	2.00

[1] *Light extinction coefficient (LEC) is only required for dischargers who have obtained a waiver pursuant to Section 301(h) of the Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251), as amended, and are required by EPA to monitor it.*

[2] *According to Part B, Section 2, of the NPDES Permit, the stated limits shall not be exceeded beyond the Zone of Initial Dilution.*

FIGURE 5-1

HONOULIULI WWTP OCEAN MONITORING STATIONS



Before compliance with the nutrient limits of Table 5-1 can be demonstrated, several procedural details must be defined. These include the methodology used to determine noncompliance with each WQS standard (i.e., geometric mean, not to exceed 10% of the time and not to exceed 2% of the time), the selection of monitoring stations from which data were obtained and applied to determine compliance, the depths from which data were gathered, and the monitoring duration required for the compliance methodology. These details were obtained from Reference 1 (see Appendix E) and permit requirements that specify monitoring conditions.

5.2 METHODOLOGY

The methodology is based on the assumption that the data follows a log normal distribution. Determining compliance with the three limit categories for any water quality parameter is done by using a graphical method, or probability plots.

By adhering to the following procedure, compliance determination with any of the above State WQS nutrient limits can be determined:

a. In column (1) of a work sheet, number the rows from 1 to n, where n is the number of data points to be used in the compliance determination. See Table 5-2 for a sample worksheet.

b. List the data for a particular parameter (e.g., turbidity) as received in column (2). The data should include all applicable stations in the monitoring program with samples taken no deeper than 30 meters (because the State WQS were established from data taken no deeper than 30 meters). Control station data should not be included in the analysis. Furthermore, the data used should be taken over a time period of at least one year. The size of the data base should be at least thirty (30) data points, or more. Larger data bases are suggested to increase statistical confidence.

c. Order the data in column (2) from smallest to largest into column (3).

d. Take the natural logarithms of the ordered data from column 3 and list in column (4). It doesn't matter what type of logarithm is used provided consistency is maintained. The natural logarithm is specified for consistency.

e. Find the mean and sample standard deviation of the natural logarithm values in column (4).

Mean:

$$\bar{z} = \sum \ln(x_i)/n$$

Sample standard deviation:

$$s_{\bar{z}} = \sqrt{\sum (z_i - \bar{z})^2 / (n-1)}$$

where both summations go from i = 1 to n.

f. To calculate the geometric mean (or 50% value) concentration, take the antilog of the mean natural logarithm value from step "e" above.

$$GM = e^{\bar{z}}$$

Multiply and divide the geometric mean value by the antilog of the sample standard deviation from step "e" to define the concentrations associated with 84% and 16%, respectively.

$$z_{84\%} = GM * e^{s_z}$$

$$z_{16\%} = GM / e^{s_z}$$

Plot these three points [(GM, 50%), ($Z_{84\%}$, 84%), and ($Z_{16\%}$,16%)] on Log-Probability paper. A line drawn through the three points should be a straight line. Identify this line as the *calculated line*. Plot the three points (or criteria for 50%, 90%, 98%) from the State WQS for the parameter in question, connecting the points with a straight line. Identify the resulting line as the *standard line*. Compare both lines. If the *calculated line* is entirely below the *standard line*, the water quality parameters for the 50%, 90%, and 98% criteria have not been exceeded. In other words, comparison of both lines is the method used to determine compliance with the standard, not an individual data point. From the *calculated line*, determine the parameter values corresponding to the 90% and 98% probability. With the GM, compare these values with the appropriate State WQS criteria values for the parameter in question.

g. Plot all data points on Log-Probability paper, use the ranked data (column (3)) as the abscissa (y-axis) and the probability (column (5)) as the ordinate (x-axis). The purpose of plotting the data is to validate the log normal distribution. If the plotted data points approximate the *calculated line* on Log-Probability paper, then the log normal distribution assumption is verified. Other distributions may be applied; however, the assumption for this methodology assumes (with corresponding verification by data plotting) a log normal distribution.

h. If the plotted data confirms a log normal distribution, the results from step "f" above are valid.

i. If the plotted data does not correspond to the *calculated line* (e.g. confirmation of the log normal distribution is not validated), several events could be occurring. There could be something wrong with the data or another process may be occurring. Lastly, but not necessarily finally, the process may not be log normal distributed, and therefore, compliance cannot be determined.

TABLE 5-2
SAMPLE WORKSHEET

I	Listing of raw data as received	Data, x_i ranking smallest to largest	Logarithm of the ranked data	Probability (percent) 100*(I-½)/n [%]
1	y_1	x_1	$\ln(x_1)$	(1-½)/n
2	y_2	x_2	$\ln(x_2)$	(2-½)/n
:	:	:	:	:
n	y_n	x_n	$\ln(x_n)$	(n-½)/n

where n = the number of data points.

5.3 TEMPORAL AND SPATIAL CONSIDERATIONS

The above analyses shall be done on an annual (calendar year) basis, using a minimum sample size of roughly thirty data points. If thirty data points are not available during a given monitoring year, the data obtained during the previous monitoring years shall be included in the compliance data base. This procedure will be continued until a compliance data base of thirty or more data points is achieved. An analyses which include at least five (5) years of data shall also be done at the same time as the annual analyses. The purpose of this analyses is to identify possible long term impacts. The one (1) and five (5) year analyses constitute a compliance analyses for the WQS.

For Turbidity and Light Extinction Coefficient (LEC), stations at and beyond the ZID shall be used. Thus, the data used to determine compliance with the WQS were obtained from only the ZID stations, i.e., HB2, HB3, HB4 and HB5. For the other

parameters such as Ammonia Nitrogen, Total Nitrogen, Nitrate + Nitrite Nitrogen, Total Phosphorus, and Chlorophyll a, compliance with the State WQS shall include stations at or beyond the ZOM. In this case the monitoring data from only the HWWTP ZOM stations, i.e., HM1, HM2, HM3 and HM4, were used.

A separate set of analyses was performed on the monitoring data from the control stations. The same depth and temporal guidelines was applied to the control station data. The purpose of this analysis is to compare background water quality conditions to the conditions at the ZOM/ZID boundary.

A noncompliant event results if any water quality parameter above has exceeded the applicable limits of Table 5-1, accompanied by sufficient evidence that the noncompliance is related to the discharge of the Barbers Point Ocean Outfall. Examples of this evidence is a comparison of the ZOM/ZID station analysis with the control station analysis. Noncompliance attributable to the discharge should not be impacting the control stations. Furthermore, noncompliance of one or more nutrient parameters should be associated with increases from other parameters, which may or may not have exceeded the applicable limits, if the discharge is the cause of the exceedance.

5.4 RESULTS

5.4.1 ZOM AND ZID STATION RESULTS

The compliance methodology, as presented above, was applied to the ZOM and ZID monitoring data obtained during the 2000 monitoring year. The statistical results are shown in Table 5-3. Results of the analyses using five (5) years of data are tabulated in Table 5-4.

TABLE 5-3
ONE-YEAR ANALYSES
ZOM/ZID STATIONS

Parameter		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	Result	92.3	120	140
	Limit	150.00	250.00	350.00
Ammonia Nitrogen (µg NH_4-N/L)	Result	1.59	3.5	5.7
	Limit	3.50	8.50	15.00
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	Result	1.02	1.2	1.31
	Limit	5.00	14.00	25.00
Total Phosphorus (µg P/L)	Result	5.3	7.2	8.6
	Limit	20.00	40.00	60.00
[1]Light Extinction Coefficient (k units)	Result	0.062	0.064	0.066
	Limit	0.20	0.50	0.85
Chlorophyll a (µg/L)	Result	0.12	0.189	0.25
	Limit	0.30	0.90	1.75
Turbidity (NTU)	Result	0.134	0.272	0.43
	Limit	0.50	1.25	2.00

[1]See Table 5-1 footnote

TABLE 5-4
FIVE-YEAR ANALYSES
ZOM/ZID STATIONS

Parameters		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	Result	96.5	143	182
	Limit	150.00	250.00	350.00
Ammonia Nitrogen (µg NH_4-N/L)	Result	1.7	4.3	7.6
	Limit	3.50	8.50	15.00
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	Result	1.03	1.21	1.35
	Limit	5.00	14.00	25.00
Total Phosphorus (µg P/L)	Result	8.02	12.2	15.5
	Limit	20.00	40.00	60.00
[1]Light Extinction Coefficient (k units)	Result	0.084	0.205	0.35
	Limit	0.20	0.50	0.85
Chlorophyll a (µg/L)	Result	0.152	0.34	0.56
	Limit	0.30	0.90	1.75
Turbidity (NTU)	Result	0.133	0.272	0.42
	Limit	0.50	1.25	2.00

[1]See Table 5-1 footnote.

With the exception of the Light Extinct Coefficient (LEC), thirty-two (32) data points, which represented year 2000, were used for the one-year compliance determination for all water quality parameters. The monitoring data for year 1999 had to be included for the LEC analysis in order to obtain at least thirty (30) data points. In the five-year analyses, which covered

from 1996 to 2000, one hundred fifty-two (152) data points were used for Nitrate + Nitrite Nitrogen, Ammonia Nitrogen, Total Phosphorus and Chlorophyll a analyses. One hundred forty-four (144) data points were used for Total Nitrogen and Turbidity, and eighty (80) data points for LEC.

Tables 5-3 and 5-4, shows statistically that the compliance determination for one and five years of monitoring data did not exceed the WQS for all water quality parameters.

5.4.2 CONTROL STATION RESULTS

The compliance methodology was also applied to the water quality data collected from the control stations HB-1, HB-6 and HB-7. Like the ZOM/ZID analyses, compliance was determined for a one and five year period. Results of the one and five year analyses are tabulated in Table 5-5 and 5-6, respectively.

TABLE 5-5
ONE-YEAR ANALYSES
CONTROL STATIONS

Parameter		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	result	82.6	104	119
	limit	150.00	250.00	350.00
Ammonia Nitrogen (µg NH_4-N/L)	result	1.5	2.6	3.65
	limit	3.50	8.50	15.00
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	result	1	1	1
	limit	5.00	14.00	25.00
Total Phosphorus (µg P/L)	result	5.16	6.5	7.4
	limit	20.00	40.00	60.00
Chlorophyll a (µG/L)	result	0.118	0.198	0.27
	limit	0.30	0.90	1.75
Turbidity (NTU)	result	0.145	0.29	0.44
	limit	0.50	1.25	2.00
LEC	result	0.053	0.068	0.0785
	limit	0.20	0.50	0.85

Shaded cells indicate noncompliances.

TABLE 5-6
FIVE-YEAR ANALYSES
CONTROL STATIONS

Parameter		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	result	89.3	133	170
	limit	150.00	250.00	350.00
Ammonia Nitrogen (µg NH_4-N/L)	result	1.55	3.1	4.7
	limit	3.50	8.50	15.00
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	result	1	1	1
	limit	5.00	14.00	25.00
Total Phosphorus (µg P/L)	result	7.5	11.5	14.9
	limit	20.00	40.00	60.00
Chlorophyll a (µg/L)	result	0.115	0.258	0.42
	limit	0.30	0.90	1.75
Turbidity (NTU)	result	0.118	0.24	0.38
	limit	0.50	1.25	2.00
LEC	result	0.074	0.158	0.245
	limit	0.20	0.50	0.85

In the one year analyses, data dating back to November 10, 1999 were needed to gather at least thirty (30) data points to maintain the statistical confidence for Nitrate + Nitrite Nitrogen, Ammonia Nitrogen, Total Nitrogen, Total Phosphorus, Turbidity and Chlorophyll a. For LEC, thirty data points were achieved by going back to July 6, 1998.

For the five-year analyses, data from 1996 to 2000 was used. One hundred four (104) data points were gathered for Nitrate + Nitrite Nitrogen, Ammonia Nitrogen, Total Phosphorus, Turbidity and Chlorophyll a. Ninety eight (98) and sixty (60) data points were used for the compliance determination analyses for Total Nitrogen and LEC, respectively.

The WQS for the one and five year analyses were not exceeded by any of the water quality parameters at the control stations.

5.4.3 DISCUSSION AND SUMMARY

The one year and five years statistical analyses applied to the ZOM/ZID monitoring data showed that the WQS was not exceeded for all water quality parameters. This was also observed for the control station data. Statistically for all of the discharge limitation categories, i.e., 50%, 90% and 98%, the nutrient levels at the ZOM/ZID stations were generally higher than the control stations but yet, they were below the WQS. Later in the year 2001, the designation of the waters near the Barbers Point Ocean Outfall was changed from "dry" to "wet." The "wet" nutrient limitations in the WQS are higher than the "dry" limitations. With this correct receiving water classification, the treated wastewater discharge from the Barbers Point Ocean Outfall have not violated the WQS.

CHAPTER 5
NUTRIENT EVALUATION 5-1

CHAPTER 8
CHEMISTRY EVALUATION

8.1 INTRODUCTION

Physical/chemical measurements for pH, temperature, salinity, and dissolved oxygen were monitored quarterly during 2000 using the Sea-Bird CTD Profiler at nearshore, ZID, ZOM, and offshore stations. Measurements were taken at various depths at one meter depth intervals. See Figure 5-1 for a map of the monitoring stations. The Honouliuli WWTP 301(h) waiver permit requires quarterly monitoring. Monitoring dates were February 8, April 20, August 30, and October 11, 2000.

In 1999, we had considered HB-6 as a monitoring station rather than as a reference station because it appeared to be much closer to the diffuser than the other two reference stations (HB-1 and HB-7). However, we have decided to consider HB-6 as a reference station based on the lack of a proximity pattern in the monitoring data. Also, HB-6 was originally considered as a reference station. Otherwise, the method of analyses remains the same as in previous years. The monitoring data was compared with the Water Quality criteria stated in the Honouliuli WWTP 301(h) waiver permit, sections B.2. and B.3, and the State Water Quality Standards (WQS).

8.2 pH REQUIREMENT

According to the State WQS and permit requirements, pH units shall not deviate more than 0.5 units from a value of 8.1 ($7.6 \leq pH \leq 8.6$) except at coastal locations where and when freshwater from stream, storm drain or groundwater discharge may depress the pH to a minimum level of 7.0.

To determine compliance, in situ measurements of the ocean water were compared with the above pH range. Throughout 2000, all measured pH values at all stations and depths fell within the allowable range. See Table 8-1 for the maximum and minimum pH's measured at each station.

Table 8-1
2001 ctd pH data

Sampling Station	Maximum pH	Minimum pH	Number of samples
HB1	8.238	8.159	261
HB2	8.215	8.165	237
HB3	8.229	8.186	291
HB4	8.224	8.184	259
HB5	8.225	8.173	230
HB6	8.224	8.184	239
HB7	8.228	8.189	249
HM1	8.213	8.18	175
HM2	8.206	8.165	228
HM3	8.231	8.14	412
HM4	8.229	8.186	239
HN1	8.225	8.189	44
HN2	8.225	8.189	43
HN3	8.217	8.181	46
HN4	8.221	8.186	43
HZ	8.23	8.171	254

8.3 TEMPERATURE REQUIREMENT

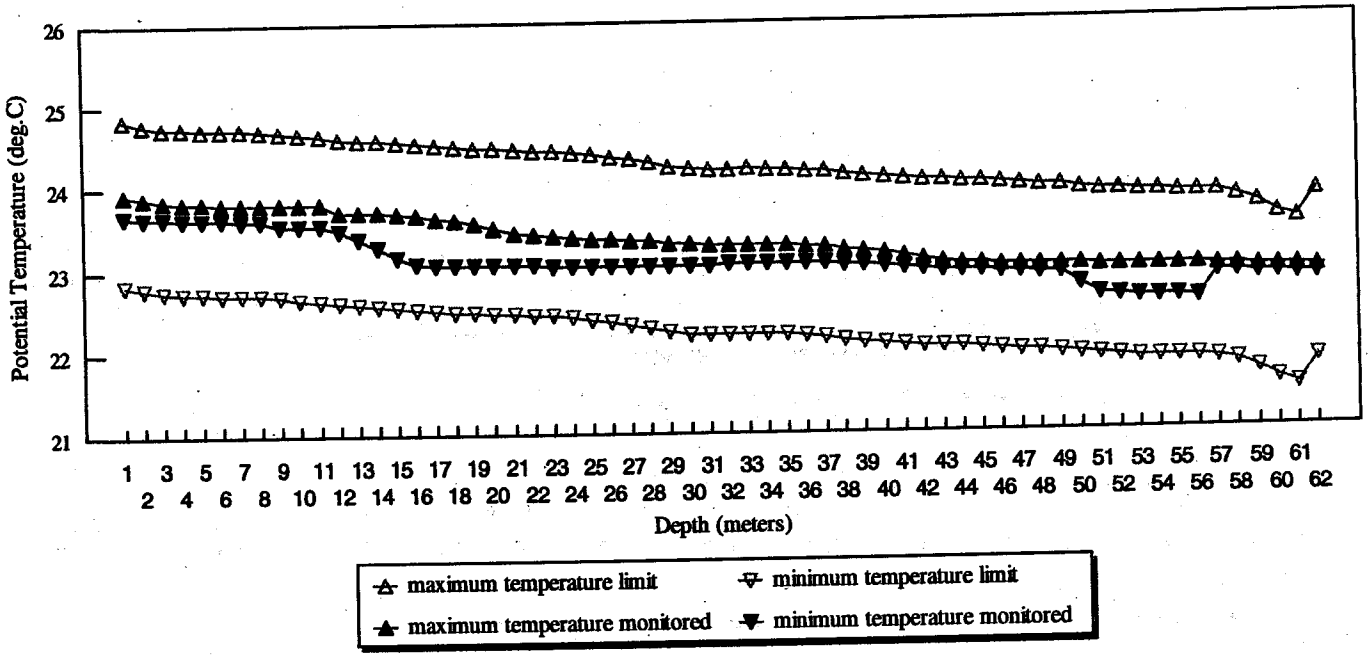
According to the State WQS and permit requirements, the receiving water temperature shall not vary more than one degree Celsius (±1°C) from ambient conditions.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. Potential temperature measurements were compared with the above temperature range condition. The ambient condition was determined by averaging the potential temperature measurements at each depth from the reference stations (e.g., HB1, HB6, and HB7) for each monitoring event. In the event there was only a temperature reading from one reference station at a given depth, that reading was taken to be the ambient temperature. At each depth, the ambient temperature was compared with the monitored potential temperature at each nearshore and offshore station at the same depth. Some offshore stations were deeper than the control stations. Potential temperatures at elevations lower than the bottom of the control stations (62 meters in February, 63 meters in April, 69 meters in August, and 68 meters in October) had no ambient values to be compared to. Figures 8.1 through 8.4 are the graphs of (1) the derived ambient temperature limits

from the control stations, and (2) the maximum and minimum temperatures monitored at each depth from among the other stations' data.

FIGURE 8.1

POTENTIAL TEMPERATURE VS. DEPTH

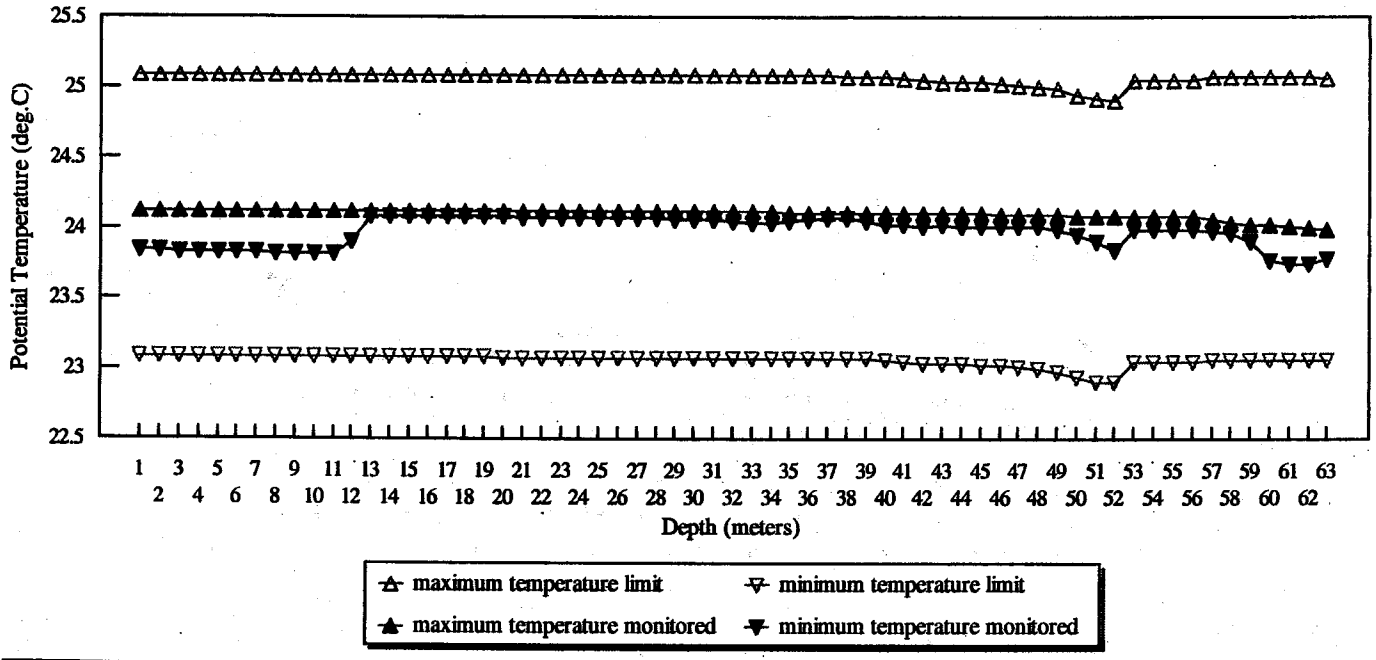


Monitoring date: February 8, 2000

8-1 Potential Temperature vs. Depth, 2/8/00

FIGURE 8.2

POTENTIAL TEMPERATURE VS. DEPTH

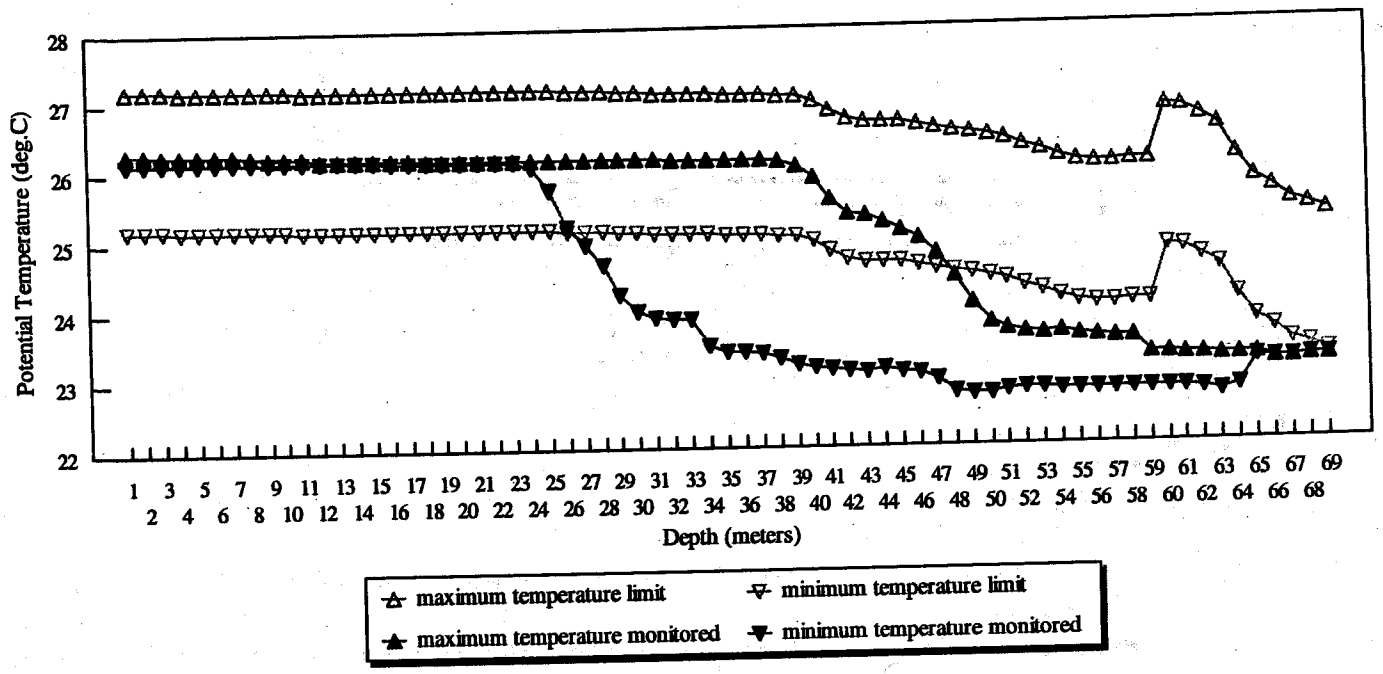


Monitoring date: April 20, 2000

8-2 Potential Temperature vs. Depth, 4/20/00

FIGURE 8.3

POTENTIAL TEMPERATURE VS. DEPTH

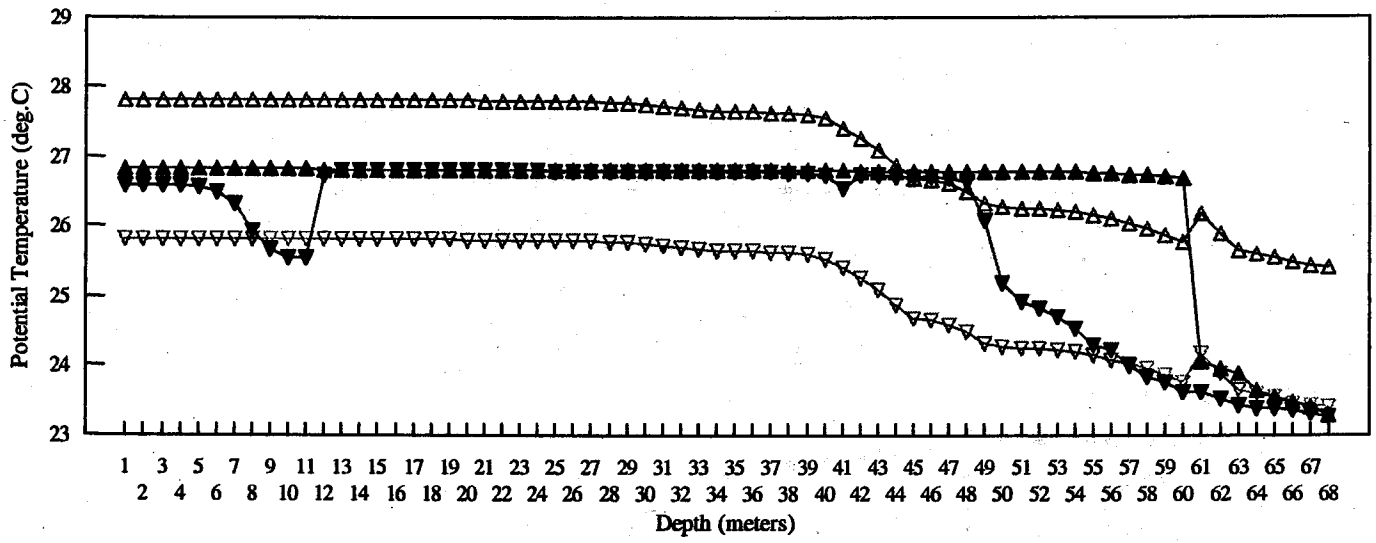


Monitoring date: August 30, 2000

8-3 Potential Temperature vs. Depth, 8/20/00

FIGURE 8.4

POTENTIAL TEMPERATURE VS. DEPTH



Monitoring date: October 11, 2000

8-4 Potential Temperature vs. Depth, 10/11/00

The graphs show that all measured temperature met the WQS limits except during the August and October 2000 monitoring periods (See Figures 8.3 and 8.4). Several minimum and maximum potential temperatures on those monitoring dates were less than the ambient derived minimum temperature limit.

As part of the compliance evaluation, the presence and influence of thermoclines must be accounted for. Thermoclines occur when colder water underlies warmer water resulting in distinct, abrupt temperature changes with depth. The depth at which thermoclines occur vary with the season, time of day, stage of tide, etc. It can be fairly constant to highly variable. Multiple thermoclines can exist naturally at different depths. When wastewater is discharged from the outfall, it is less dense than ambient waters due to both its slightly higher temperature and lower salinity. As wastewater rises, it mixes with the ambient waters which dilutes it and slows its rise to the water surface. When the rising dilute plume, now essentially the same temperature and almost the same salinity as the water around it encounters a thermocline, it generally lacks the buoyancy to continue its rise. It is therefore trapped at that depth.

Figures 8.1 through 8.4 show the presence of thermoclines during each monitoring period, as indicated by the sudden drop in temperature. Although the change in temperature on the graph could be due to a change in which station had the lowest temperature, examination of each stations data indicated thermoclines were present.

Some of the low temperature measurements recorded during the August and October monitoring events were out of permit limits due to relatively strong thermoclines. Temperatures recorded during the February and April monitoring events indicated the presence of weak thermoclines with all of the temperatures being within permit limits.

During the August and October 2000 monitoring events, some of the minimum temperatures monitored were below the minimum temperature limit. We do not believe these situations are associated with the discharge of treated wastewater. In all cases, strong thermoclines appear to be the cause for the drop in temperatures below the minimum temperature limit. A few of the maximum temperatures monitored during the August 2000 monitoring event were even below the minimum temperature limit at depths greater than 48 meters. Also, in all cases, the effluent temperature measured on the sampling day was higher than the water quality minimum temperature limit.

As shown in Figure 8.3 (August monitoring event), a strong thermocline occurred between 23 to 33 meter depths followed by several smaller thermoclines at subsequent depths. Temperatures dropped by approximately 2.3°C with the initial thermocline.

During the October monitoring event (see Figure 8.4), two strong thermoclines occurred between the 5 to 11 and 39 to 45 meter depths. The thermoclines produced temperature changes of 1.0 and 2.5°C, respectively. Smaller thermoclines also occurred after the 45 meter depth.

In the first three of four monitoring events, the maximum temperatures measured did not exceed the maximum temperature limits. In October 2000, the measured maximum temperature exceeded the maximum temperature limits from 45 feet to 60 feet in depth. Further investigation would be needed to determine the cause.

8.4 SALINITY REQUIREMENT

According to the State WQS and permit requirements, the salinity shall not vary more than ten percent (10%) from natural or seasonal changes considering hydrologic input and oceanographic factors.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. For a given monitoring event, in situ salinity measurements at each depth (SAL_d) for each nearshore and offshore monitoring station were compared with the average salinity ($AVGSAL_d$) at each corresponding depth. The $AVGSAL_d$ at each depth, d, was obtained by averaging salinity measurements from the three reference stations (i.e. HB1, HB6, and HB7). In the event at a given depth the salinity was measured at only one reference station, the value was used as the $AVGSAL_d$. As with the potential temperature analysis, compliance determination for some of the salinity measurements at the offshore monitoring stations could not be performed for depths greater than the depths monitored at the reference stations. The salinity ratio at each depth was computed using the following equation:

$$\text{Salinity ratio} = ABS[1\text{-}SAL_d/AVGSAL_d] \times 100$$

This process was repeated throughout the depth range of the reference stations, for each monitoring event. Table 8-2 indicates that the measured salinities did not vary more than 10% from the control stations' salinity.

Table 8-2

SALINITY MEASUREMENTS FOR GIVEN MONITORING EVENTS

Monitoring event	Salinity ratio [%]		Number of sample points (n)	Average salinity ratio	Standard Deviation
	maximum	minimum			
February 8, 2000	0.33%	0.0%	596	0.06%	0.05%
April 20, 2000	0.41%	0.0%	570	0.05%	0.08%
August 30, 2000	1.05%	0.0%	619	0.19%	0.22%
October 11, 2000	0.97%	0.0%	638	0.05%	0.11%

8.5 DISSOLVED OXYGEN REQUIREMENT

The State WQS and the Honouliuli WWTP 301(h) waiver permit require dissolved oxygen to be not less than seventy-five percent saturation, determined as a function of ambient water temperature and salinity. To determine the dissolved oxygen concentration ($DO_{saturation}$) for given temperature and salinity, dissolved oxygen concentration tables* were used. For each monitoring event, the maximum temperature, T_{max}, and salinity, Sal_{max}, were used to obtain a $DO_{saturation}$. Seventy five percent (75%) of $DO_{saturation}$ was used as the minimum concentration to determine compliance with the State WQS and permit requirements. To show compliance, the minimum dissolved oxygen concentration (DO) among the nearshore and offshore monitoring stations for each monitoring event was compared against the corresponding $DO_{saturation}$. Compliance is satisfied when $DO > 0.75 \times DO_{saturation}$. Table 8-3 shows that compliance was attained.

Table 8-3

$DO_{saturation}$ Determination

Monitoring Event	Maximum Measured Temperature [°C]	Maximum Measured Salinity [ppt]	75% $DO_{saturation}$* using maximum salinity and temperature values [mg/l]	Minimum measured Dissolved Oxygen Concentration [mg/l]
February 8, 2000	23.9364	35.3221	5.149	7.00325
April 20, 2000	24.1117	35.2198	5.136	6.13559
August 30, 2000	26.2753	35.3984	4.947	6.63472
October 11, 2000	26.8254	35.5043	4.898	6.09364

* Tchobanoglous, George and Schroeder, Edward; Water Quality. Addison-Wesley Public Company; February 1987.

8.6 SUMMARY

1. Based on the methodology used, the Water Quality Standards were met for pH, salinity, and dissolved oxygen at the ZID, and ZOM, diffuser, nearfield, and nearshore stations.

2. The Water Quality Standards were not met for minimum temperatures during two sampling events. The effluent is probably not a contributor due to its higher temperature than the receiving water. The plotted data indicates the occurrence of thermoclines to be the cause. Further investigation would be needed to determine the extent and reasons for the noncompliance.
3. The Water Quality Standards were not met for maximum temperatures during one sampling event. Further investigation would be needed to determine the cause.
4. Under the present methodology, no ambient reference temperatures or salinity could be determined for depths greater than the deepest reference station for each monitoring date. HB3 (ZID station) and HM3 (ZOM station) stations had depths greater than the deepest reference station which were not compared to Water Quality limits for temperature or salinity.

CHAPTER 5
NUTRIENT EVALUATION

5.1 INTRODUCTION

All offshore stations were monitored in 2001 to determine if the water quality near the discharge of the Barbers Point Ocean Outfall complied with the receiving water quality limitations (Part B, RECEIVING WATER LIMITATIONS), Sections 2 and 3) of the HWWTP 301 (h) NPDES permit and the Hawaii Administrative Rules (HAR), Chapter 11-54, State Water Quality Standards. Water quality sampling at the offshore monitoring stations were performed on February 8, May 15, September 12 and October 18, 2001. All sampling protocols and location of the water quality monitoring stations have not changed from the previous calendar year. See Figure 5-1 for the location of all HWWTP's receiving water quality monitoring stations.

The Hawaii State Water Quality Standards designates different standards for Open Coastal Waters depending upon whether area is considered "wet" or "dry." The "wet" criteria applies when the waters receive more than 3 million gallons per day of freshwater per shoreline mile. In 2000, ENV reviewed the hydrologic information of freshwater being discharged to Open Coastal Waters from Barbers Point to Pearl Harbor. ENV concluded that the proper designation for the subject waters should be the "wet" criteria. ENV held a Public Hearing on the conclusion and submitted the report to independent hydrologists for review. By letter dated December 11, 2000, the State Department of Health concurred that the subject waters would come under the "wet" criteria. This chapter will therefore analyze the receiving water quality using the "wet" cri

According HAR, Chapter 11-54, the receiving waters of the Honouliuli WWTP are classified as "Class A", "Wet", "Open Coastal Waters." In part, the State Water Quality Standard (State WQS) states the following limits (see Reference 2, Appendix E) specified in Table 5-1:

TABLE 5-1
MARINE WATER CRITERIA

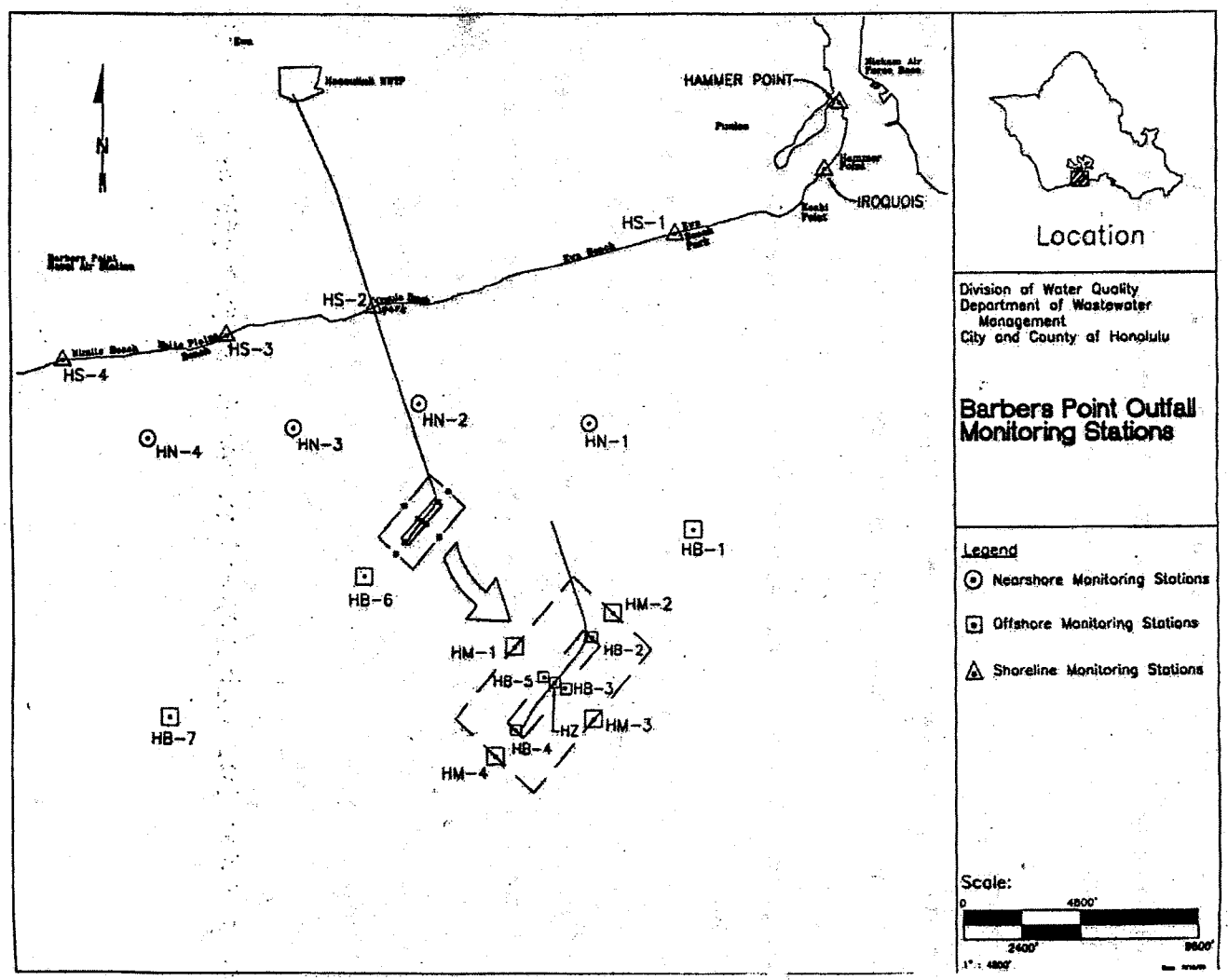
Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (μg N/L)	150.00	250.00	350.00
Ammonia Nitrogen (μg NH_4-N/L)	3.50	8.50	15.00
Nitrate + Nitrite (μg $[NO_3+NO_2]$ - N/L)	5.00	14.00	25.00
Total Phosphorus (μg P/L)	20.00	40.00	60.00
[1,2]Light Extinction Coefficient (k units)	0.20	0.50	0.85
Chlorophyll a (μg/L)	0.30	0.90	1.75
Turbidity (NTU)[2]	0.50	1.25	2.00

[1] *Light extinction coefficient (LEC) is only required for dischargers who have obtained a waiver pursuant to Section 301(h) of the Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251), as amended, and are required by EPA to monitor it.*

[2] *According to Part B, Section 2, of the NPDES Permit, the stated limits shall not be exceeded beyond the Zone of Initial Dilution.*

FIGURE 5-1

HONOULIULI WWTP OCEAN MONITORING STATIONS



Before compliance with the nutrient limits of Table 5-1 can be demonstrated, several procedural details must be defined. These include the methodology used to determine noncompliance with each WQS standard (i.e., geometric mean, not to exceed 10% of the time and not to exceed 2% of the time), the selection of monitoring stations from which data were obtained and applied to determine compliance, the depths from which data were gathered, and the monitoring duration required for the compliance methodology. These details were obtained from Reference 1 (see Appendix E) and permit requirements that specify monitoring conditions.

5.2 METHODOLOGY

The methodology is based on the assumption that the data follows a log normal distribution. Determining compliance with the three limit categories for any water quality parameter is done by using a graphical method, or probab

By adhering to the following procedure, compliance determination with any of the above State WQS nutrient limits can be determined:

a. In column (1) of a work sheet, number the rows from 1 to n, where n is the number of data points to be used in the compliance determination. See Table 5-2 for a sample worksheet.

b. List the data for a particular parameter (e.g., turbidity) as received in column (2). The data should include all applicable stations in the monitoring program with samples taken no deeper than 30 meters (because the State WQS were established from data taken no deeper than 30 meters). Control station data should not be included in the analysis. Furthermore, the data used should be taken over a time period of at least one year. The size of the data base should be at least thirty (30) data points, or more. Larger data bases are suggested to increase statistical confidence.

c. Order the data in column (2) from smallest to largest into column (3).

d. Take the natural logarithms of the ordered data from column 3 and list in column (4). It doesn't matter what type of logarithm is used provided consistency is maintained. The natural logarithm is specified for con

e. Find the mean and sample standard deviation of the natural logarithm values in column (4).

Mean:

$$\bar{z} = \sum \ln(x_i)/n$$

Sample standard deviation:

$$s_{\bar{z}} = \sqrt{\sum (z_i - \bar{z})^2 / (n-1)}$$

where both summations go from i = 1 to n.

f. To calculate the geometric mean (or 50% value) concentration, take the antilog of the mean natural logarithm value from step "e" above.

$$GM = e^{\bar{z}}$$

Multiply and divide the geometric mean value by the antilog of the sample standard deviation from step "e" to define the concentrations associated with 84% and 16%, respectively.

$$z_{84\%} = GM * e^{s_z}$$

$$z_{16\%} = GM / e^{s_z}$$

Plot these three points [(GM, 50%), ($Z_{84\%}$, 84%), and ($Z_{16\%}$, 16%)] on Log-Probability paper. A line drawn through the three points should be a straight line. Identify this line as the *calculated line*. Plot the three points (or criteria for 50%, 90%, 98%) from the State WQS for the parameter in question, connecting the points with a straight line. Identify the resulting line as the *standard line*. Compare both lines. If the *calculated line* is entirely below the *standard line*, the water quality parameters for the 50%, 90%, and 98% criteria have not been exceeded. In other words, comparison of both lines is the method used to determine compliance with the standard, not an individual data point. From the *calculated line*, determine the parameter values corresponding to the 90% and 98% probability. With the GM, compare these values with the appropriate State WQS criteria values for the parameter in question.

g. Plot all data points on Log-Probability paper, use the ranked data (column (3)) as the abscissa (y-axis) and the probability (column (5)) as the ordinate (x-axis). The purpose of plotting the data is to validate the log normal distribution. If the plotted data points approximate the *calculated line* on Log-Probability paper, then the log normal distribution assumption is verified. Other distributions may be applied; however, the assumption for this methodology assumes (with corresponding verification by data plotting) a log normal distribution.

h. If the plotted data confirms a log normal distribution, the results from step "f" above are valid.

i. If the plotted data does not correspond to the *calculated line* (e.g. confirmation of the log normal distribution is not validated), several events could be occurring. There could be something wrong with the data or another process may be occurring. Lastly, but not necessarily finally, the process may not be log normal distributed, and therefore, compliance cannot be determined.

TABLE 5-2
SAMPLE WORKSHEET

I	Listing of raw data as received	Data, x_i ranking smallest to largest	Logarithm of the ranked data	Probability (percent) 100*(I-½)/n [%]
1	y_1	x_1	$\ln(x_1)$	(1-½)/n
2	y_2	x_2	$\ln(x_2)$	(2-½)/n
:	:	:	:	:
n	y_n	x_n	$\ln(x_n)$	(n-½)/n

where n = the number of data points.

5.3 TEMPORAL AND SPATIAL CONSIDERATIONS

The above analyses shall be done on an annual (calendar year) basis, using a minimum sample size of roughly thirty data points. If thirty data points are not available during a given monitoring year, the data obtained during the previous monitoring years shall be included in the compliance data base. This procedure will be continued until a compliance data base of thirty or more data points is achieved.

The station which requires the earliest data date in order to obtain 30 samples determines the starting data date for all the other stations. That is, the starting dates and ending dates of the data used in the analyses were kept the same for all stations (ZOM/ZID and Controls) for a particular parameter. Usually, the Control stations were the determining stations for the starting data date.

An analyses which include at least five (5) years of data shall also be done at the same time as the annual analyses. The purpose of this analyses is to identify possible long term impacts. The one (1) and five (5) year analyses constitute a compliance analyses for the WQS.

For Turbidity and Light Extinction Coefficient (LEC), stations at and beyond the ZID shall be used. Thus, the data used to determine compliance with the WQS were obtained from only the ZID stations, i.e., HB2, HB3, HB4 and HB5. For the other parameters such as Ammonia Nitrogen, Total Nitrogen, Nitrate + Nitrite Nitrogen, Total Phosphorus, and Chlorophyll a, compliance with the State WQS shall include stations at or beyond the ZOM. In this case the monitoring data from only the HWWTP ZOM stations, i.e., HM1, HM2, HM3 and HM4, were used.

A separate set of analyses was performed on the monitoring data from the control stations. The same depth and temporal guidelines was applied to the control station data. The purpose of this analysis is to compare background water quality conditions to the conditions at the ZOM/ZID boundary.

A noncompliant event results if any water quality parameter above has exceeded the applicable limits of Table 5-1, accompanied by sufficient evidence that the noncompliance is related to the discharge of the Barbers Point Ocean Outfall. Examples of this evidence is a comparison of the ZOM/ZID station analysis with the control station analysis. Noncompliant events attributable to the discharge should not be impacting the control stations. Furthermore, a violation of one or more nutrient parameter limits should be associated with increases from other parameters, which may or may not have exceeded the applicable limits, if the discharge is the cause of the violation.

5.4 RESULTS

5.4.1 ZOM AND ZID STATION RESULTS

The compliance methodology, as presented above, was applied to the ZOM and ZID monitoring data obtained during the 2001 monitoring year. The statistical results are shown in Table 5-3. Results of the analyses using five (5) years of data are tabulated in Table 5-4.

TABLE 5-3
ONE-YEAR ANALYSES
ZOM/ZID STATIONS

Parameter		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	Result	95.8	122	140
	Limit	150.00	250.00	350.00
Ammonia Nitrogen (µg NH_4-N/L)	Result	1.59	4.3	7.8
	Limit	3.50	8.50	15.00
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	Result	1.10	1.55	1.93
	Limit	5.00	14.00	25.00
Total Phosphorus (µg P/L)	Result	6.5	9.0	10.8
	Limit	20.00	40.00	60.00
[1]Light Extinction Coefficient (k units)	Result	0.059	0.078	0.083
	Limit	0.20	0.50	0.85
Chlorophyll a (µg/L)	Result	0.12	0.21	0.30
	Limit	0.30	0.90	1.75
Turbidity (NTU)	Result	0.15	0.68	1.70
	Limit	0.50	1.25	2.00

[1]See Table 5-1 footnote

TABLE 5-4
FIVE-YEAR ANALYSES
ZOM/ZID STATIONS

Parameters		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	Result	103.7	170	230
	Limit	150.00	250.00	350.00
Ammonia Nitrogen (µg NH_4-N/L)	Result	1.87	5.5	10.5
	Limit	3.50	8.50	15.00
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	Result	1.05	1.33	1.51
	Limit	5.00	14.00	25.00
Total Phosphorus (µg P/L)	Result	7.52	11.2	14.3
	Limit	20.00	40.00	60.00
[1]Light Extinction Coefficient (k units)	Result	0.060	0.078	0.092
	Limit	0.20	0.50	0.85
Chlorophyll a (µg/L)	Result	0.15	0.27	0.39
	Limit	0.30	0.90	1.75
Turbidity (NTU)	Result	0.13	0.34	0.61
	Limit	0.50	1.25	2.00

[1]See Table 5-1 footnote.

Tables 5-3 and 5-4, shows statistically that the compliance determination for one and five years of monitoring data did not exceed the WQS for all water quality parameters.

5.4.2 CONTROL STATION RESULTS

The compliance methodology was also applied to the water quality data collected from the control stations HB-1, HB-6 and HB-7. Like the ZOM/ZID analyses, compliance was determined for a one and five year period. Results of the one and five year analyses are tabulated in Table 5-5 and 5-6, respectively.

TABLE 5-5
ONE-YEAR ANALYSES
CONTROL STATIONS

Parameter		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	result	93.6	123	145
	limit	150.00	250.00	350.00
Ammonia Nitrogen (µg NH_4-N/L)	result	1.44	2.78	4.13
	limit	3.50	8.50	15.00
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	result	1.02	1.20	1.31
	limit	5.00	14.00	25.00
Total Phosphorus (µg P/L)	result	6.27	8.58	10.5
	limit	20.00	40.00	60.00
Chlorophyll a (µG/L)	result	0.099	0.208	0.328
	limit	0.30	0.90	1.75
Turbidity (NTU)	result	0.11	0.17	0.22
	limit	0.50	1.25	2.00
LEC	result	0.053	0.069	0.081
	limit	0.20	0.50	0.85

Shaded cells indicate noncompliances.

TABLE 5-6
FIVE-YEAR ANALYSES
CONTROL STATIONS

Parameter		Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (µg N/L)	result	99.0	180	260
	limit	150.00	250.00	350.00
Ammonia Nitrogen (µg NH_4-N/L)	result	1.54	3.1	4.7
	limit	3.50	8.50	15.00
Nitrate + Nitrite (µg $[NO_3+NO_2]$ - N/L)	result	1.01	1.10	1.15
	limit	5.00	14.00	25.00
Total Phosphorus (µg P/L)	result	7.02	10.2	12.7
	limit	20.00	40.00	60.00
Chlorophyll a (µg/L)	result	0.12	0.23	0.36
	limit	0.30	0.90	1.75
Turbidity (NTU)	result	0.11	0.20	0.29
	limit	0.50	1.25	2.00
LEC	result	0.055	0.068	0.079
	limit	0.20	0.50	0.85

The WQS for the one and five year analyses were not exceeded by any of the water quality parameters at the control stations.

5.5 Comparison to Dry-Area Water Quality Standards

The State Department of Health had approved the change to wet-area Water Quality Standards for the Barbers Point Outfall area based on hydrologic analyses. However, the NPDES permit still indicates that the area still comes under the dry-area Water Quality Standards. Using the dry-area standards, the turbidity standards for the 50% and 2% limits would have been exceeded for a one year analyses of the ZOM/ZID stations. Also, the ammonia standards for the 50% and 2% limits would have been exceeded for a five-year analyses of the ZOM/ZID stations. The control stations would have met the dry-area Water Quality Standards.

5.6 Correction of Past LEC Analyses

During preparation of the Honouliuli 2000 Annual Assessment Reports, an error was discovered in the LEC data. The The Secchi disk depth is used to estimate the LEC based on a conversion factor. Different researchers may use different conversion factors. Our original intent was to use LEC= 1.7 divided by Secchi disk depth in meters. This is a common conversion factor.

The conversion is done automatically by computer, which prints out a report showing both the Secchi disk depth and the LEC. The error discovered was that the computer was reporting LEC values which were only half what they should have been. The error had not been caught or corrected when the computer program was originally set up over e

The LEC data was recalculated based on the correct conversion factor. The LEC data was then re-analyzed to determine compliance with the Water Quality Standards. The revised analyses showed that both the wet and the dry Water Quality Standards were met with the corrected LEC data.

Tables 5-7a and 5-7b show the corrected LEC analyses.

Table 5-7a. 1 year compliance determinations for LEC using corrected LEC values For Barbers Point Outfall ZID Stations (HB2, HB3, HB4, & HB5)			
Year	Geometric mean not to exceed given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Wet Limits	0.20	0.50	0.85
Dry Limits	0.10	0.30	0.55
2000	0.0617	0.077	0.088
1999	0.0599	0.075	0.086
1998	0.0622	0.084	0.102
1997	0.0704	0.102	0.127
1996	0.0712	0.096	0.114
1995	0.0680	0.088	0.105
1994	0.0660	0.084	0.098
1993	0.0620	0.077	0.088

Table 5-7b. 5 year compliance determinations for LEC using corrected LEC values For Barbers Point Outfall ZID Stations (HB2, HB3, HB4, & HB5)			
[illegible]	[illegible]	[illegible]	[illegible]
Wet Limits	0.20	0.50	0.85
Dry Limits	0.10	0.30	0.55
2000	0.0639	0.086	0.103
1999	0.0659	0.089	0.103
1998	0.0665	0.090	0.108
1997	0.0686	0.092	0.110
1996	0.0664	0.088	0.104
1995	Less than 5 years data		
1994	Less than 5 years data		
1993	Less than 5 years data		

5.7 SUMMARY

The one year and five years statistical analyses applied to the ZOM/ZID monitoring data showed that the wet-area Water Quality Standards were met for all the nutrient water quality parameters. The State Department of Health had approved the change to wet area standards based on hydrologic analyses.

However, the permit still indicates that the area still comes under the dry area Water Quality Standards. Using the dry area standards, the turbidity standards for the 50% and 2% limits would have been exceeded for a one year analyses of the ZOM/ZID stations. Also, the ammonia standards for the 50% and 2% limits would have been exceeded for a five-year analyses of the ZOM/ZID stations.

The ZOM/ZID results were about the same or slightly greater than at the Control Stations, except for Total Nitrogen. The Total Nitrogen results at the Control Stations were slightly higher than at the ZOM/ZID stations for the 10% of the time and 2% of the time exceeded values.

CHAPTER 8

CHEMISTRY EVALUATION

8.1 INTRODUCTION

Physical/chemical measurements for pH, temperature, salinity, and dissolved oxygen were monitored quarterly during 2001 using the Sea-Bird CTD Profiler at nearshore, ZID, ZOM, and offshore stations. Measurements were taken at various depths at one meter depth intervals. See Figure 5-1 for a map of the monitoring stations. The Honouliuli WWTP 301(h) waiver permit requires quarterly monitoring. Monitoring dates were February 8, May 15, September 12, and October 18, 2001.

8.2 pH REQUIREMENT

According to the State WQS and permit requirements, pH units shall not deviate more than 0.5 units from a value of 8.1 ($7.6 \leq pH \leq 8.6$) except at coastal locations where and when freshwater from stream, storm drain or groundwater discharge may depress the pH to a minimum level of 7.0.

To determine compliance, in situ measurements of the ocean water were compared with the above pH range. Throughout 2001, all measured pH values at all stations and depths fell within the allowable range. See Table 8-1 for the maximum and minimum pH's measured at each station.

Table 8-1
2001 ctd pH data

Sampling Station	Maximum pH	Minimum pH	Number of samples
HB1	8.238	8.159	261
HB2	8.215	8.165	237
HB3	8.229	8.186	291
HB4	8.224	8.184	259
HB5	8.225	8.173	230
HB6	8.224	8.184	239
HB7	8.228	8.189	249

Table 8-1 2001 ctd pH data			
Sampling Station	Maximum pH	Minimum pH	Number of samples
HM1	8.213	8.18	175
HM2	8.206	8.165	228
HM3	8.231	8.14	412
HM4	8.229	8.186	239
HN1	8.225	8.189	44
HN2	8.225	8.189	43
HN3	8.217	8.181	46
HN4	8.221	8.186	43
HZ	8.23	8.171	254

8.3 TEMPERATURE REQUIREMENT

According to the State WQS and permit requirements, the receiving water temperature shall not vary more than one degree Celsius (±1°C) from ambient conditions.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. Potential temperature measurements were compared with the above temperature range condition. The ambient condition was determined by averaging the potential temperature measurements at each depth from the reference stations (e.g., HB1, HB6, and HB7) for each monitoring event. In the event there was only a temperature reading from one reference station at a given depth, that reading was taken to be the ambient temperature.

At each depth, the ambient temperature was compared with the monitored potential temperature at each nearshore and offshore station at the same depth. Some offshore stations were deeper than the control stations. Potential temperatures at elevations lower than the bottom of the control stations had no ambient values to be compared to.

Figures 8.1 through 8.4 are the graphs of (1) the derived ambient temperature limits from the control stations, and (2) the maximum and minimum temperatures monitored at each depth from among the other stations' data.

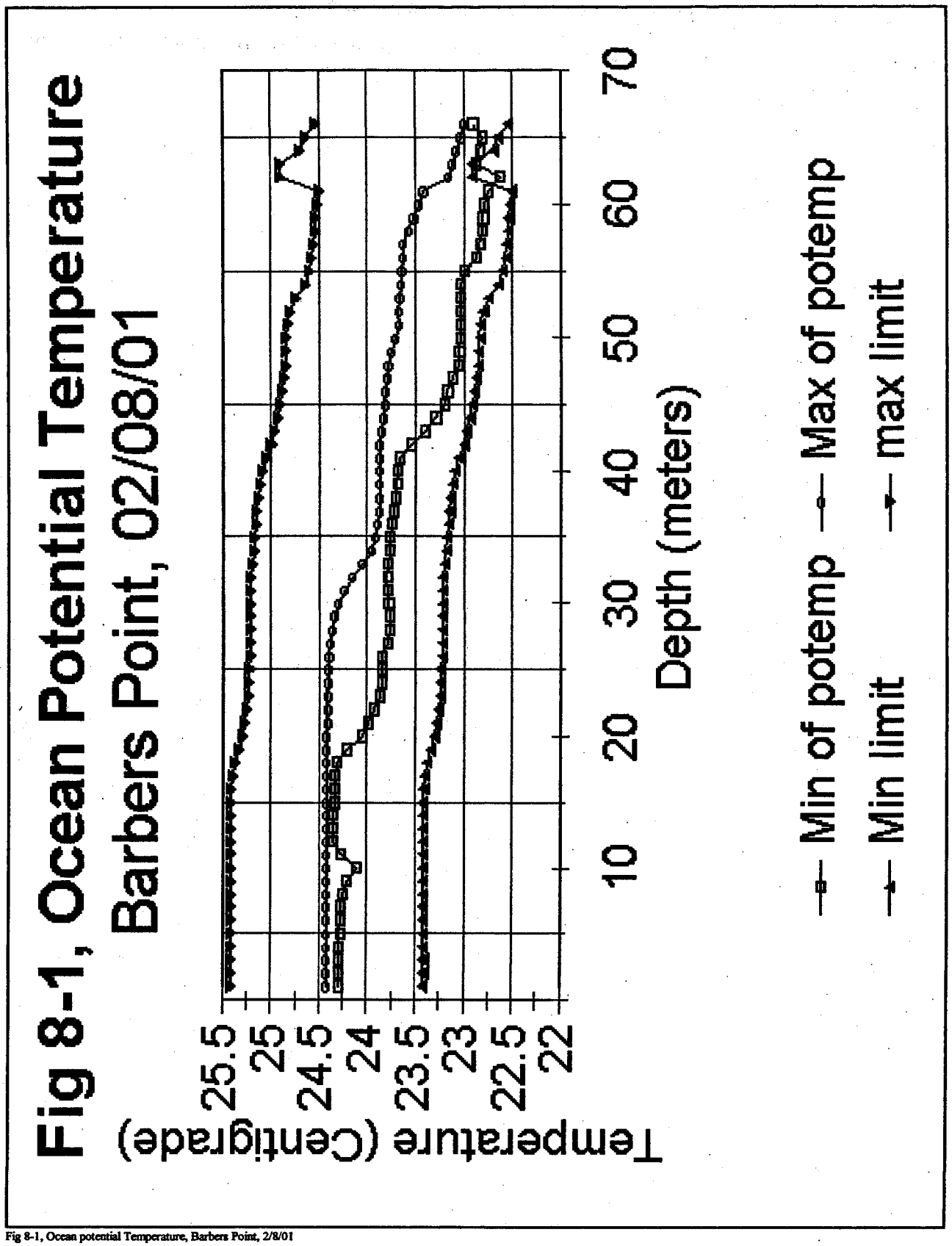


Fig 8-1, Ocean potential Temperature, Barbers Point, 2/8/01

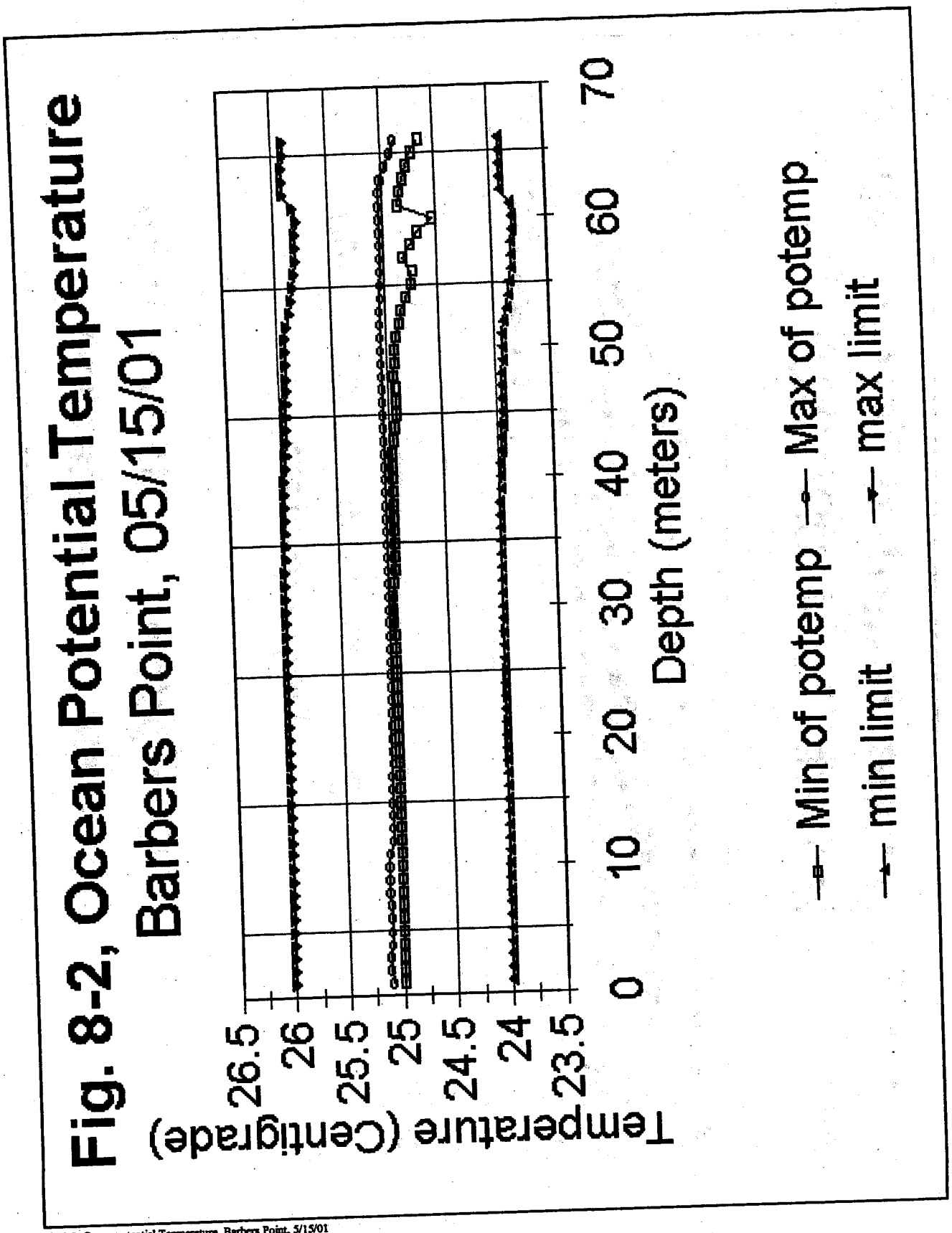


Fig 8-2, Ocean potential Temperature, Barbers Point, 5/15/01

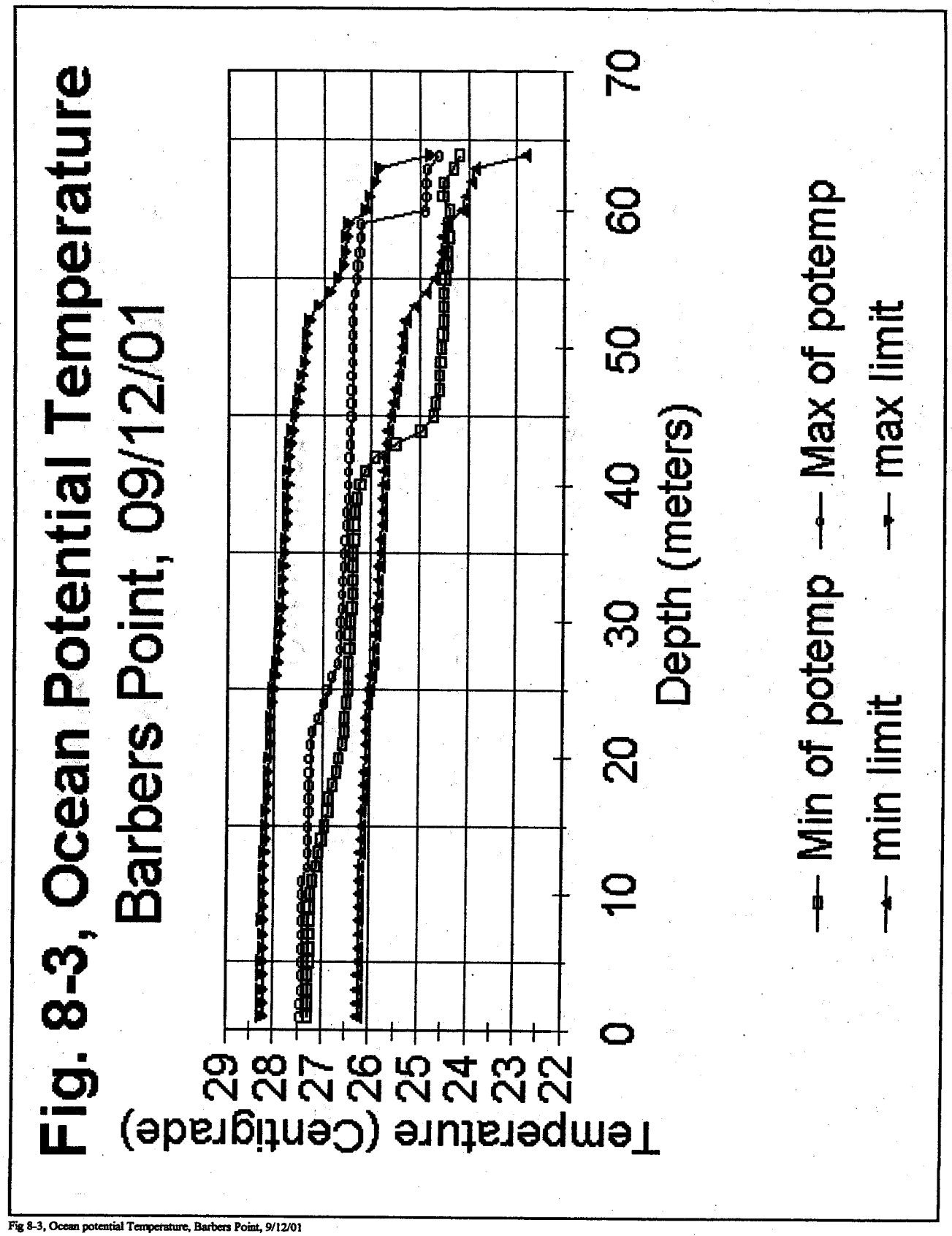


Fig 8-3, Ocean potential Temperature, Barbers Point, 9/12/01

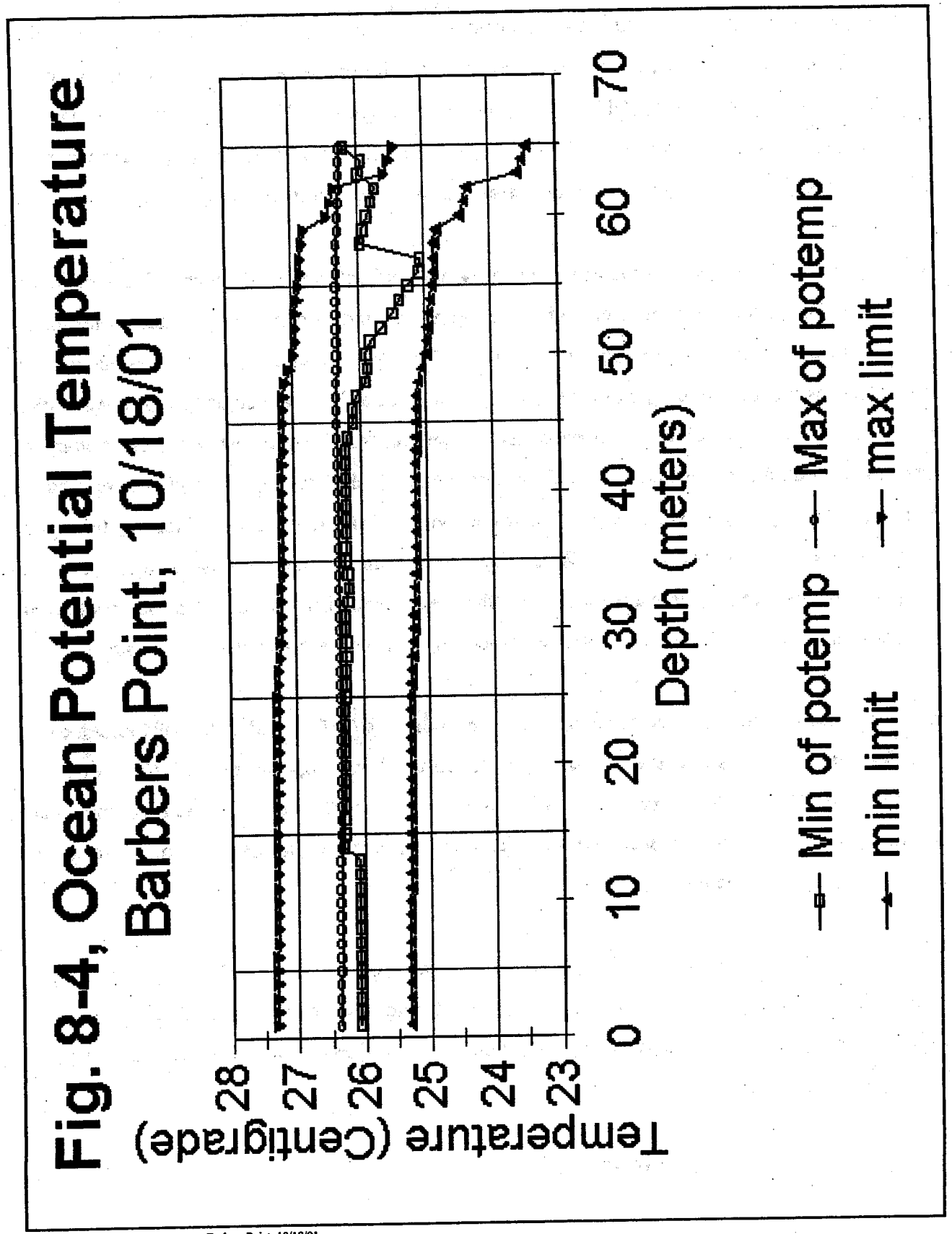


Fig 8-4, Ocean potential Temperature, Barbers Point, 10/18/01

The graphs show that all measured temperatures met the WQS limits except during the September and October 2001 monitoring periods (See Figures 8-3 and 8-4). On September 12, 2001, several sampling points at 43 meters to 59 meters depths had lower temperatures than the limits based on the control stations. On October 18, several sampling points at 63 to 65 meters depths had higher temperatures than the limits based on the control stations.

As part of the compliance evaluation, the presence and influence of thermoclines must be accounted for. Thermoclines occur when colder water underlies warmer water resulting in distinct, abrupt temperature changes with depth. The depth at which thermoclines occur vary with the season, time of day, stage of tide, etc. It can be fairly constant to highly variable. Multiple thermoclines can exist naturally at different depths. When wastewater is discharged from the outfall, it is less dense than ambient waters due to both its slightly higher temperature and lower salinity. As wastewater rises, it mixes with the ambient waters which dilutes it and slows its rise to the water surface. When the rising dilute plume, now essentially the same temperature and almost the same salinity as the water around it encounters a thermocline, it generally lacks the buoyancy to continue its rise. It is therefore trapped at that depth.

Figures 8.3 shows the presence of a thermocline as indicated by the sudden drop in temperature. The drop in temperature at the outfall sites caused the low temperature limit (25.5 degrees centigrade and below) to be exceeded. This is likely not due to the outfall discharge, which had a temperature of 30 degrees centigrade recorded.that morning and a temperature of 28.5 degrees centigrade recorded the next morning.

Figure 8-4 also shows a thermocline in the control waters. This caused the high temperature limit to drop suddenly from 26.3 to 25.6 degrees centigrade over one meter of depth. Since the highest temperatures at the outfall site remained steady at these depths, the high temperature limit was exceeded.

8.4 SALINITY REQUIREMENT

According to the State WQS and permit requirements, the salinity shall not vary more than ten percent (10%) from natural or seasonal changes considering hydrologic input and oceanographic factors.

Because there is no specific Federal or State compliance methodology, the City has established its own methodology. For a given monitoring event, in situ salinity measurements at each depth (SAL_d) for each nearshore and offshore monitoring station were compared with the average salinity ($AVGSAL_d$) at each corresponding depth. The $AVGSAL_d$ at each depth, d, was obtained by averaging salinity measurements from the three reference stations (i.e. HB1, HB6, and HB7). In the event at a given depth the salinity was measured at only one reference station, the value was used as the $AVGSAL_d$. As with the potential temperature analysis, compliance determination for some of the salinity measurements at the offshore monitoring stations could not be performed for depths greater than the depths monitored at the reference stations. The salinity ratio at each depth was computed using the following equation:

$$\text{Salinity ratio} = ABS[1-(SAL_d/AVGSAL_d)] \times 100$$

This process was repeated throughout the depth range of the reference stations, for each monitoring event. Table 8-2 indicates that the measured salinities did not vary more than 10% from the control stations' salinity.

Table 8-2 Ocean Salinity at Barbers Point

Date of sampling	Maximum salinity difference	Depth of maximum salinity difference (meters)	Number of samples compared to control stations data
02/08/01	0.87 %	34	592
05/15/01	0.18 %	60	573
09/12/02	0.67 %	55	579
10/18/02	0.24 %	54	574

8.5 DISSOLVED OXYGEN REQUIREMENT

The State WQS and the Honouliuli WWTP 301(h) waiver permit require dissolved oxygen to be not less than seventy-five percent saturation, determined as a function of ambient water temperature and salinity. To determine the dissolved oxygen concentration ($DO_{saturation}$) for given temperature and salinity, dissolved oxygen concentration tables were used. [The tables were from Tchobanoglous, George and Schroeder, Edward; Water Quality. Addison-Wesley Public Company; February 1987.] For each sampling data, the temperature and salinity were used to obtain a $DO_{saturation}$. The actual DO measured was then compared against the $DO_{saturation}$. Seventy five percent (75%) of $DO_{saturation}$ was used as the minimum concentration to determine compliance with the State WQS and permit requirements.

Table 8-3 shows that compliance was attained at all sampling points.

Table 8-3 - Minimum % of Dissolved Oxygen Saturation
Barbers Point Ocean Monitoring

Date of sampling	Station with minimum % saturation of oxygen	Temp at sampling	Salinity at sampling	Calculated D.O. saturation	D.O. measured	% of D.O. saturation
02/08/01	HM3	21.5501	35.1637	7.1716	6.03325	84
05/15/01	HN3	25.1044	34.7939	6.7467	6.00582	89
09/12/01	HM3	22.7927	35.2801	7.0056	6.18268	88
10/18/01	HN2	26.2498	35.1774	6.6061	5.72020	87

8.6 SUMMARY

1. Based on the methodology used, the Water Quality Standards were met for pH, salinity, and dissolved oxygen at the ZID, and ZOM, diffuser, nearfield, and nearshore stations.

2. The Water Quality Standards were not met for minimum temperatures during one sampling event. The effluent is probably not a contributor due to its higher temperature than the receiving water. The plotted data indicates the occurrence of a thermocline to be the cause. Further investigation would be needed to determine the extent and reasons for the noncompliance.
3. The Water Quality Standards were not met for maximum temperatures during one sampling event. The plotted data indicates the occurrence of a thermocline in the control waters to be a contributing factor. Further investigation would be needed to determine the cause.
4. Under the present methodology, no ambient reference temperatures or salinity could be determined for depths greater than the deepest reference station for each monitoring date. HB3 (ZID station) and HM3 (ZOM station) stations had depths greater than the deepest reference station which were not compared to Water Quality limits for temperature or salinity.

CHAPTER 5
NUTRIENT EVALUATION

5.1 INTRODUCTION

In accordance with the Honouliuli WWTP (HWWTP) 301(h) NPDES permit effective December 16, 1993, all water quality parameters listed in the permit were monitored during the 2002 monitoring year to determine if the State Water Quality Standards (WQS) for the receiving water near the Barbers Point Ocean Outfall were violated. The 2002 quarterly offshore monitoring dates were February 21, April 16, August 20, September 13 and October 1. The September 13 monitoring was conducted after it was found during the August 20 monitoring that one Oil and Grease sample was not acidified in the field.

Under the criterion specified in the Hawaii Administrative Rules (HAR) Chapter 11-54, the receiving waters in the vicinity of the Barbers Point Ocean Outfall are classified as "Class A", "Wet" and "Open Coastal Waters." This classification was changed from "Dry" after a public hearing and acceptance by the State Department of Health by letter dated December 11, 2000. Table 5-1 below lists the applicable Class A. Wet, criteria limits are found in HAR section 11-54-06 of Chapter 11-54.

TABLE 5-1
MARINE WATER CRITERIA

Parameter	Geometric mean not to exceed the reference value	Not to exceed the reference value more than ten percent of the time	Not to exceed the reference value more than two percent of the time
Total Nitrogen (□g N/L)	150.00	250.00	350.00
Ammonia Nitrogen (□g NH_4-N/L)	3.50	8.50	15.00
Nitrate + Nitrite (□g [NO_3+NO_2] - N/L)	5.00	14.00	25.00
Total Phosphorus (□g P/L)	20.00	40.00	60.00
[1]Light Extinction Coefficient (k units)	0.20	0.50	.85
Chlorophyll a (□g/L)	0.30	0.90	1.75
Turbidity (NTU)	0.50	1.25	2.00

[1] *Light extinction coefficient (LEC) is only required for dischargers who have obtained a waiver pursuant to Section 301(h) of the Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251), as amended, and are required by EPA to monitor it.*

FIGURE 5-2

BARBERS POINT OUTFALL ZONE OF MIXING STATIONS

(Under permit effective December 16, 1993)

than 30 meters). Reference station data should not be included in the analysis. Furthermore, the data used should be taken over a time period of at least one year. The size of the data base should exceed thirty (30) data points, or n □ 30. Larger databases are suggested to increase statistical confidence.

c. Order the data in column (2) from smallest to largest into column (3).

d. Take the natural logarithms of the ordered data from column 3 and list in column (4). It doesn't matter what type of logarithm is used provided consistency is maintained. The natural logarithm is specified for consistency.

e. Find the mean and sample standard deviation of the natural logarithm values in column (4).

Mean:

$$\bar{z} = \Sigma \ln(x_i)/n$$

Sample standard deviation:

$$s_{\bar{z}} = \sqrt{\Sigma(z_i - \bar{z})^2/(n-1)}$$

where both summations go from I = 1 to n and $Z_i = \ln(x_i)$.

f. To calculate the geometric mean (or 50 percent value) concentration, take the antilog of the mean natural logarithm value from step "e" above.

$$GM = e^{\bar{z}}$$

Multiply and divide the geometric mean value by the antilog of the sample standard deviation from step "e" to define the concentrations associated with 84 percent and 16 percent, respectively.

$$z_{84\%} = GM * e^{s_z}$$

$$z_{16\%} = GM / e^{s_z}$$

TABLE 5-2
SAMPLE WORKSHEET

I	Listing of raw data as received	Data, x_i ranking smallest to largest	Logarithm of the ranked data	Probability (percent) 100*(I-½)/n [%]
1	y_1	x_1	$\ln(x_1)$	(1-½)/n
2	y_2	x_2	$\ln(x_2)$	(2-½)/n
:	:	:	:	:
n	y_n	x_n	$\ln(x_n)$	(n-½)/n

where n = the number of data points.

impacting the reference stations. Furthermore, exceedences of one or more nutrient parameters should be associated with increases from other parameters, which may or may not have exceeded applicable limits, if the discharge is the cause of the exceedence.

5.4 RESULTS

5.4.1 ZOM /ZID STATION RESULTS

The compliance methodology, as presented above, was applied to the 1998 to 2002 monitoring data for the stations noted above. The interpolated values for the one-year and five-year calculated lines are reported in Tables 5-3 and 5-4. To obtain the minimum required thirty data points, for the reference stations for the one-year analysis LEC data back to and including April 2000 was used. For all other parameters calendar year 2002 data was used. For ZID/ZOM stations this resulted in 50 to 99 data points being used, depending upon parameter. For the five-year analysis 189 to 336 data points were available at ZID/ZOM stations depending upon parameter. Due to the use of back data for the one year LEC analysis there is some overlap in the one-year and five-year results. No exceedences were observed in the one-year or five-year ZID/ZOM analyses.

5.4.2 REFERENCE STATION RESULTS

For the one-year analysis, to obtain the minimum required 30 data points, water quality data back to and including April 2000 was used for LEC. For all other data calendar year 2002 data was used resulting in 30 to 33 data points, depending upon parameter. The five-year reference station analysis was performed using 63 to 126 data points, depending upon parameter. Tables 5-5 and 5-6 shows the interpolated values from the calculated lines for the one-year and five-year analyses, respectively. No exceedences were observed in the one-year or five-year /reference station analyses.

TABLE 5-4
FIVE-YEAR (1998 - 2002) MONITORING RESULTS - ZID/ZOM

Parameter	Geometric mean and the not to exceed reference value	Result and the value not to exceed more than ten percent of the time	Result and the value not to exceed more than two percent of the time
Total Nitrogen (µg N/L)	97.1 150.00*	158 250.00*	213 350.00*
Ammonia Nitrogen (µg NH_4-N/L)	1.91 3.50*	5.75 8.50*	11.3 15.00*
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	1.05 5.00*	1.1 14.00*	1.15 25.00*
Total Phosphorus (µg P/L)	6.94 20.00*	9.9 40.00*	12.2 60.00*
[1]Light Extinction Coefficient (k units)	0.059 0.20*	0.075 0.90*	0.086 1.75*
Chlorophyll a (µg/L)	0.136 0.30*	0.24 0.90*	0.33 1.75*
Turbidity (NTU)	0.12 0.50*	0.31 1.25*	0.56 2.00*

*State Water Quality Standard

Shaded cells indicate exceedence of the Standard

TABLE 5-6

FIVE-YEAR (1998 - 2002) MONITORING RESULTS

Barbers Point Outfall Reference Stations

Parameter	Geometric mean and the not to exceed reference value	Result and the value not to exceed more than ten percent of the time	Result and the value not to exceed more than two percent of the time
Total Nitrogen (µg N/L)	92.3 150.00**	160 250.00**	226 350.00**
Ammonia Nitrogen (µg NH_4-N/L)	1.47 3.50**	2.79 8.50**	4.1 15.00**
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	1.01 5.00**	1.07 14.00**	1.13 25.00**
Total Phosphorus (µg P/L)	6.48 20.00**	9.05 40.00**	11.2 60.00**
[1]Light Extinction Coefficient (k units)	0.054 0.20**	0.067 0.90**	0.076 1.75**
Chlorophyll a (µg/L)	0.111 0.30**	0.206 0.90**	0.298 1.75**
Turbidity (NTU)	0.106 0.50**	0.194 1.25**	0.28 2.00**

* State Water Quality Standard

CHAPTER 8
CHEMISTRY EVALUATION

8.1 INTRODUCTION

This chapter reviews receiving waters data from the area around the Barbers Point deep ocean outfall for compliance of its discharge to State Water Quality Standards (WS) for pH, temperature, salinity and dissolved oxygen (DO). All nearshore, Zone of Initial Dilution (ZID), Zone of Mixing (ZOM) and reference stations were monitored for these parameters during the 2002 monitoring year, as required by the Honouliuli WWTP (HWWTP) 301(h) waiver permit. The monitoring dates in 2002 were February 21, April 16, August 20, September 13, and October 01. None of the monitoring protocols were changed from the previous monitoring year. Figures 5-1 and 5-2 show the receiving water monitoring locations in 2002.

Compliance determination was based on measurements obtained by the City's Sea-Bird CTD Profiler. Measurements of pH, potential temperature, salinity, and dissolved oxygen concentration were taken at one (1) meter intervals for all stations during each monitoring event. The compliance of discharges from the Barbers Point outfall to WQS is determined by comparing measurements at stations around the outfall to measurements at the two reference stations.

8.2 pH REQUIREMENT

According to the State WQS and permit requirements, pH units shall not deviate more than 0.5 units from a value of 8.1 ($7.6 < pH < 8.6$) except at coastal locations where and when freshwater from stream, storm drain or groundwater discharge may depress the pH to a minimum level of 7.0.

There is no statistical compliance methodology for this requirement. In-situ measurements were directly taken and compared with the above pH range; see Table 8-1. At no time during the 2002 monitoring year did the monitored pH value exceed this requirement at any station or at any depth.

As part of the compliance evaluation, the presence and influence of thermoclines must be accounted for. Thermoclines occur when colder water underlies warmer water resulting in distinct, abrupt temperature changes with depth. The depth at which thermoclines occur vary with the season, time of day, stage of tide, etc. Their depth can be fairly constant to highly variable. Multiple thermoclines can exist naturally at different depths. When wastewater is discharged from the outfall, it is less dense than ambient waters due to both its slightly higher temperature and lower salinity. As wastewater rises, it mixes with the ambient waters which dilute it and slow its rise to the water surface. When the rising dilute plume, now essentially the same temperature and almost the same salinity as the water around it, encounters a thermocline, it generally lacks the buoyancy to continue its rise. It is therefore trapped at that depth.

Figures 8.3, 8.4 and 8.5 show the presence of thermoclines. In all figures except 8.1, the minimum temperature line drops below the minimum temperature line. Since the effluent temperature normally exceeds this minimum temperature line, the City does not believe these situations are associated with the discharge of treated wastewater. The ambient water temperature dropping below the minimum temperature lines is probably due to ambient conditions and not the discharge of effluent from the outfall.

Table 8-2 shows the reported monthly average and daily maximum effluent temperatures for the months when monitoring was done.

Table 8-2
HWWTP EFFLUENT TEMPERATURE (°C)

Monitored Month	Average Monthly Temperature	Maximum Monthly Temperature
February 2002	27.00	28.50
March 2002	27.00	29.50
April 2002	27.17	29.00
July 2002	29.29	29.50
October 2002	28.30	30.00

Figure 8-2
Potential Temperature vs Depth - Monitoring Period April 16, 2002

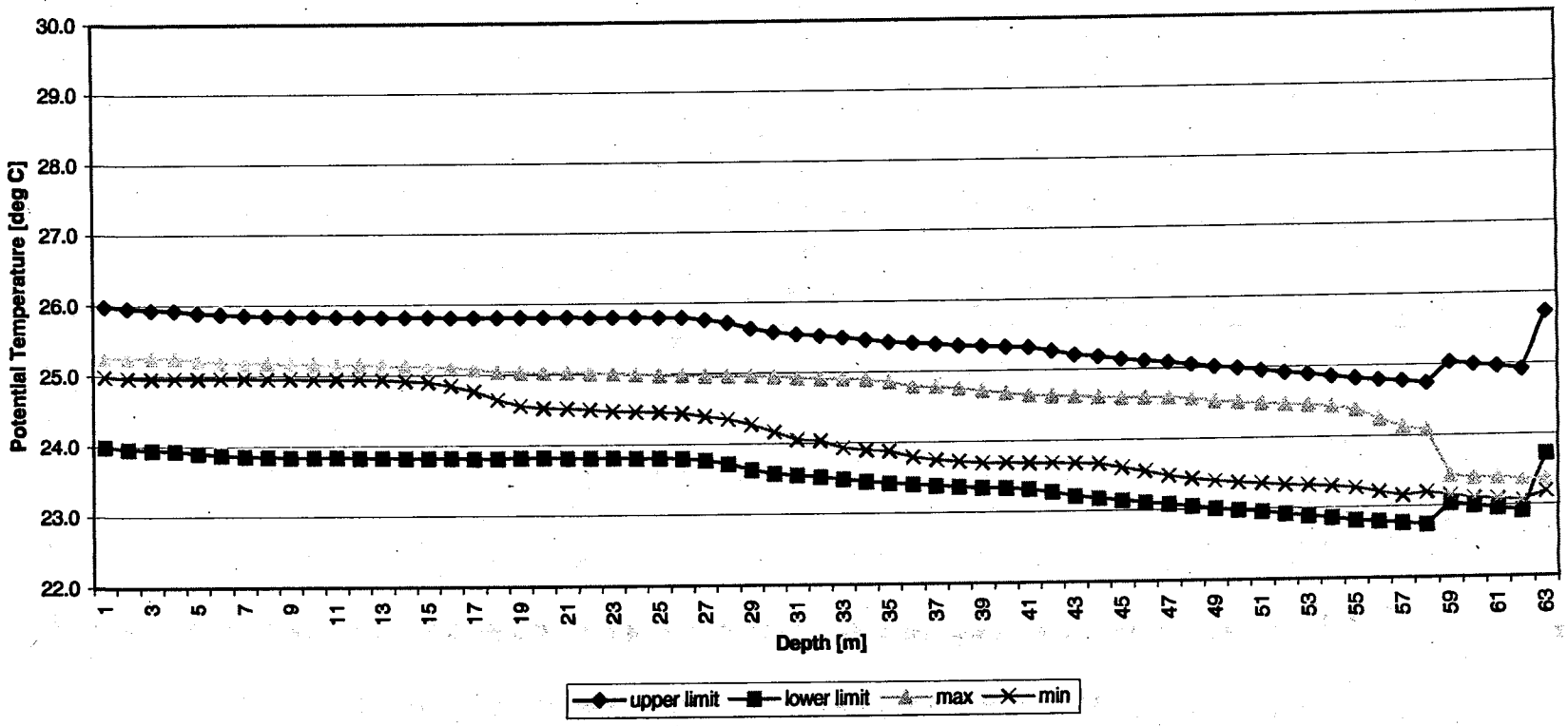
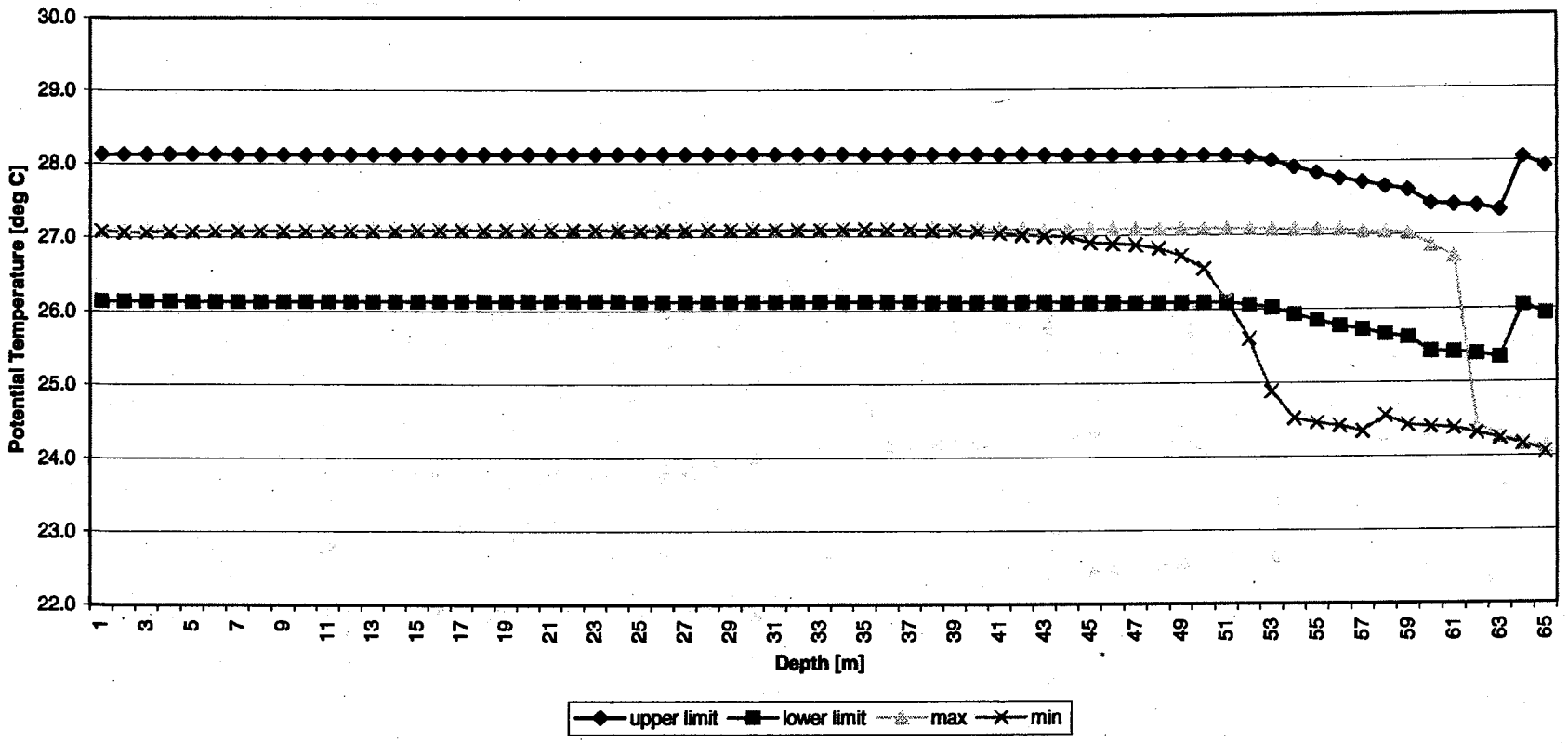


Figure 8-4
Potential Temperature vs Depth, Monitoring Period September 13, 2002



8.4 SALINITY REQUIREMENT

According to the State WQS and permit requirements, the salinity shall not vary more than ten percent (10%) from natural or seasonal changes considering hydrologic input and oceanographic factors.

8.5 DISSOLVED OXYGEN REQUIREMENT

State WQS and the Sand Island WWTP 301(h) waiver permit requires dissolved oxygen to not be less than seventy-five percent (75%) saturation, determined as a function of ambient water temperature and salinity. To determine the dissolved oxygen concentration ($DO_{saturation}$) for given temperature and salinity, dissolved oxygen concentration tables* were used. For each monitoring event, the temperature T and salinity, Sal, measured at each station at each depth were used to obtain $DO_{saturation}$ for that station and depth. The measured DO at each station and depth was then compared to the corresponding $DO_{saturation}$ value. If the measured value was at least equal to Seventy-five percent (75%) of the corresponding $DO_{saturation}$ value then the State WQS and permit requirements were met. Compliance is achieved when the minimum dissolved oxygen concentration for all depths at each station except the reference station for each monitoring event is greater than 75% $DO_{saturation}$. Table 8-4 shows that compliance was attained.

Table 8-4
$DO_{saturation}$ Determination

Monitoring Event	Maximum Temperature Monitored [°C]	Maximum Salinity Measured [parts per thousand]	75% $DO_{saturation}$* using maximum salinity and temperature values [mg/l]	Minimum measured Dissolved Oxygen Concentration [mg/l]
February	24.6063	35.2739	5.358	6.100
March	24.5838	35.3588	5.4232	5.5897
April	26.5864	35.3588	5.4232	5.6606
July	27.0531	35.2219	5.2935	5.135
October	26.9166	35.2496	5.4386	5.1901

* Tchobanoglous, George and Schroeder, Edward; Water Quality. Addison-Wesley Public Company; February 1987.

CHAPTER 5
NUTRIENT EVALUATION

5.1 INTRODUCTION

In accordance with the Honouliuli WWTP (HWWTP) 301(h) NPDES permit effective December 16, 1993, all water quality parameters listed in the permit were monitored during the 2003 monitoring year to determine if the State Water Quality Standards (WQS) for the receiving water near the Barbers Point Ocean Outfall were violated. The 2003 quarterly offshore monitoring dates were February 4, April 29, September 8, September 20 and October 8. The September 20 monitoring was conducted after it was found during the September 8, monitoring that **one Oil and Grease sample was not acidified in the field.**

Under the criterion specified in the Hawaii Administrative Rules (HAR) Chapter 11-54, the receiving waters in the vicinity of the Barbers Point Ocean Outfall are classified as "Class A", "Wet" and "Open Coastal Waters." This classification was changed from "Dry" after a public hearing and acceptance by the State Department of Health by letter dated December 11, 2000. Table 5-1 below lists the applicable Class A. Wet, criteria limits are found in HAR section 11-54-06 of Chapter 11-54.

TABLE 5-1
MARINE WATER CRITERIA

Parameter	Geometric mean not to exceed the reference value	Not to exceed the reference value more than ten percent of the time	Not to exceed the reference value more than two percent of the time
Total Nitrogen (µg N/L)	150.00	250.00	350.00
Ammonia Nitrogen (µg NH_4-N/L)	3.50	8.50	15.00
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	5.00	14.00	25.00
Total Phosphorus (µg P/L)	20.00	40.00	60.00
[1]Light Extinction Coefficient (k units)	0.20	0.50	.85
Chlorophyll a (µg/L)	0.30	0.90	1.75
Turbidity (NTU)	0.50	1.25	2.00

[1] *Light extinction coefficient (LEC) is only required for dischargers who have obtained a waiver pursuant to Section 301(h) of the Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251), as amended, and are required by EPA to monitor it.*

FIGURE 5-2

BARBERS POINT OUTFALL

ZONE OF MIXING STATIONS

(Under permit effective December 16, 1993)

than 30 meters). Reference station data should not be included in the analysis. Furthermore, the data used should be taken over a time period of at least one year. The size of the data base should exceed thirty (30) data points, or n □ 30. Larger databases are suggested to increase statistical confidence.

c. Order the data in column (2) from smallest to largest into column (3).

d. Take the natural logarithms of the ordered data from column 3 and list in column (4). It doesn't matter what type of logarithm is used provided consistency is maintained. The natural logarithm is specified for consistency.

e. Find the mean and sample standard deviation of the natural logarithm values in column (4).

Mean:

$$\bar{z} = \sum \ln(x_i)/n$$

Sample standard deviation:

$$s_{\bar{z}} = \sqrt{\sum(z_i - \bar{z})^2/(n-1)}$$

where both summations go from I = 1 to n and $Z_i = \ln(x_i)$.

f. To calculate the geometric mean (or 50 percent value) concentration, take the antilog of the mean natural logarithm value from step "e" above.

$$GM = e^{\bar{z}}$$

Multiply and divide the geometric mean value by the antilog of the sample standard deviation from step "e" to define the concentrations associated with 84 percent and 16 percent, respectively.

$$z_{84\%} = GM * e^{s_z}$$

$$z_{16\%} = GM / e^{s_z}$$

TABLE 5-2
SAMPLE WORKSHEET

I	Listing of raw data as received	Data, x_i ranking smallest to largest	Logarithm of the ranked data	Probability (percent) $100*(I-½)/n$ [%]
1	y_1	x_1	$\ln(x_1)$	$(1-½)/n$
2	y_2	x_2	$\ln(x_2)$	$(2-½)/n$
:	:	:	:	:
n	y_n	x_n	$\ln(x_n)$	$(n-½)/n$

where n = the number of data points.

impacting the reference stations. Furthermore, exceedences of one or more nutrient parameters should be associated with increases from other parameters, which may or may not have exceeded applicable limits, if the discharge is the cause of the exceedence.

5.4 RESULTS

5.4.1 ZOM /ZID STATION RESULTS

The compliance methodology, as presented above, was applied to the 1999 to 2003 monitoring data for the stations noted above. The interpolated values for the one-year and five-year calculated lines are reported in Tables 5-3 and 5-4. To obtain the minimum required thirty data points, for the reference stations for the one-year analysis LEC data back to and including April 2001 was used. For all other parameters calendar year 2003 data was used. For ZID/ZOM stations this resulted in 40 to 95 data points being used, depending upon parameter. For the five-year analysis 185 to 342 data points were available at ZID/ZOM stations depending upon parameter. Due to the use of back data for the one year LEC analysis there is some overlap in the one-year and five-year results. No exceedences were observed in the one-year or five-year ZID/ZOM analyses.

5.4.2 REFERENCE STATION RESULTS

For the one-year analysis, to obtain the minimum required 30 data points, water quality data back to and including May2001 was used for LEC which resulted in 33 data points. For all other parameters calendar year 2003 data was used resulting in 30 data points. The five-year reference station analysis was performed using data from 2/99 to 10/03 resulting in 132 data points except for LEC data which had 63 data points. Tables 5-5 and 5-6 shows the interpolated values from the calculated lines for the one-year and five-year analyses, respectively. No exceedences were observed in the one-year or five-year /reference station analyses.

TABLE 5-4
FIVE-YEAR (1999 - 2003) MONITORING RESULTS - ZID/ZOM

Parameter	Geometric mean and the not to exceed reference value	Result and the value not to exceed more than ten percent of the time	Result and the value not to exceed more than two percent of the time
Total Nitrogen (µg N/L)	88.1 150.00*	113 250.00*	130 350.00*
Ammonia Nitrogen (µg NH_4-N/L)	1.57 3.50*	2.5 8.50*	3.62 15.00*
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	1.03 5.00*	1.19 14.00*	1.33 25.00*
Total Phosphorus (µg P/L)	6.17 20.00*	8.2 40.00*	9.9 60.00*
[1]Light Extinction Coefficient (k units)	0.055 0.20*	0.066 0.90*	0.075 1.75*
Chlorophyll a (µg/L)	0.135 0.30*	0.21 0.90*	0.31 1.75*
Turbidity (NTU)	0.12 0.50*	0.19 1.25*	0.26 2.00*

*State Water Quality Standard

Shaded cells indicate exceedence of the Standard

TABLE 5-6

FIVE-YEAR (1998 - 2002) MONITORING RESULTS

Barbers Point Outfall Reference Stations

Parameter	Geometric mean and the not to exceed reference value	Result and the value not to exceed more than ten percent of the time	Result and the value not to exceed more than two percent of the time
Total Nitrogen (µg N/L)	94.4 150.00**	122 250.00**	143 350.00**
Ammonia Nitrogen (µg NH_4-N/L)	3.05 3.50**	5.49 8.50**	10.5 15.00**
Nitrate + Nitrite (µg [NO_3+NO_2] - N/L)	1.06 5.00**	1.28 14.00**	1.47 25.00**
Total Phosphorus (µg P/L)	6.70 20.00**	9.2 40.00**	11.5 60.00**
[1]Light Extinction Coefficient (k units)	0.051 0.20**	0.076 0.90**	0.088 1.75**
Chlorophyll a (µg/L)	0.151 0.30**	0.235 0.90**	0.325 1.75**
Turbidity (NTU)	0.30 0.50**	0.31 1.25**	0.54 2.00**

* State Water Quality Standard

CHAPTER 8
CHEMISTRY EVALUATION

8.1 INTRODUCTION

This chapter reviews receiving waters data from the area around the Barbers Point deep ocean outfall for compliance of its discharge to State Water Quality Standards (WS) for pH, temperature, salinity and dissolved oxygen (DO). All nearshore, Zone of Initial Dilution (ZID), Zone of Mixing (ZOM) and reference stations were monitored for these parameters during the 2003 monitoring year, as required by the Honouliuli WWTP (HWWTP) 301(h) waiver permit. The monitoring dates in 2003 were February 4, April 29, September 8 and 20, and October 8. None of the monitoring protocols were changed from the previous monitoring year. Figures 5-1 and 5-2 show the receiving water monitoring locations in 2003.

Compliance determination was based on measurements obtained by the City's Sea-Bird CTD Profiler. Measurements of pH, potential temperature, salinity, and dissolved oxygen concentration were taken at one (1) meter intervals for all stations during each monitoring event. The compliance of discharges from the Barbers Point outfall to WQS is determined by comparing measurements at stations around the outfall to measurements at the two reference stations.

8.2 pH REQUIREMENT

According to the State WQS and permit requirements, pH units shall not deviate more than 0.5 units from a value of 8.1 ($7.6 < pH < 8.6$) except at coastal locations where and when freshwater from stream, storm drain or groundwater discharge may depress the pH to a minimum level of 7.0.

There is no statistical compliance methodology for this requirement. In-situ measurements were directly taken and compared with the above pH range; see Table 8-1. At no time during the 2003 monitoring year did the monitored pH value exceed this requirement at any station or at any depth.

Table 8-1 2003 CTD pH Data							
Sample site	N	pH		Sample Site	n	pH	
		max	Min			Max	Min
HB1	326	8.09	7.99	HN2	54	8.03	7.94
HB2	293	8.08	7.97	HN3	58	8.02	7.95
HB3	372	8.10	7.98	HN4	54	8.04	7.95
HB4	315	8.09	7.99	HM1	209	8.08	7.97
HB5	284	8.08	7.98	HM2	291	8.09	7.98
HB6	294	8.08	7.98	HM3	515	8.11	7.98
HB7	317	8.08	7.98	HM4	293	8.08	7.98
HN1	55	8.03	7.94	ZM	315	8.08	7.98

8.3 TEMPERATURE REQUIREMENT

According to the WQS and permit requirements, the temperature shall not vary more than one degree Celsius (1°C) from ambient conditions.

There is no statistical compliance methodology for this requirement. Potential temperature measurements were compared directly with the above temperature range. The ambient condition for each monitoring event was determined by averaging the potential temperature measurements at each depth for the reference stations HB1, and HB7. For depths where the potential temperature was taken from only one reference station, the ambient potential temperature for those depths were taken to be the temperature readings from that reference station. The ambient potential temperature was then compared with the potential temperature measurement at each offshore station for all depths. This process was repeated for subsequent monitoring events. Figures 8-1 to 8-5 illustrate the results of this procedure.

As part of the compliance evaluation, the presence and influence of thermoclines must be accounted for. Thermoclines occur when colder water underlies warmer water resulting in distinct, abrupt temperature changes with depth. The depth at which thermoclines occur vary with the season, time of day, stage of tide, etc. Their depth can be fairly constant to highly variable. Multiple thermoclines can exist naturally at different depths. When wastewater is discharged from the outfall, it is less dense than ambient waters due to both its slightly higher temperature and lower salinity. As wastewater rises, it mixes with the ambient waters which dilute it and slow its rise to the water surface. When the rising dilute plume, now essentially the same temperature and almost the same salinity as the water around it, encounters a thermocline, it generally lacks the buoyancy to continue its rise. It is therefore trapped at that depth.

During the 2003 monitoring year there was no strong evidence of thermoclines during any monitoring event at the depths displayed. In a few cases, especially at the maximum depth for a station there were distinct drops in ambient temperature. This is seen in all figures except Figure 8-2. In Figure 8-4 this results in one reading that is below the minimum temperature line. Since the effluent temperature normally exceeds this minimum temperature line, the City does not believe these situations are associated with the discharge of treated wastewater. The ambient water temperature dropping below the minimum temperature lines is probably due to ambient conditions and not the discharge of effluent from the outfall.

Table 8-2 shows the reported monthly average and daily maximum effluent temperatures for the months when monitoring was done.

Table 8-2
HWWTP EFFLUENT TEMPERATURE (°C)

Monitored Month	Average Monthly Temperature	Maximum Monthly Temperature
February 2003	26.80	28.00
April 2003	27.75	29.00
September 2003	29.36	30.50
September 2003	29.36	30.50
October 2003	29.21	30.50

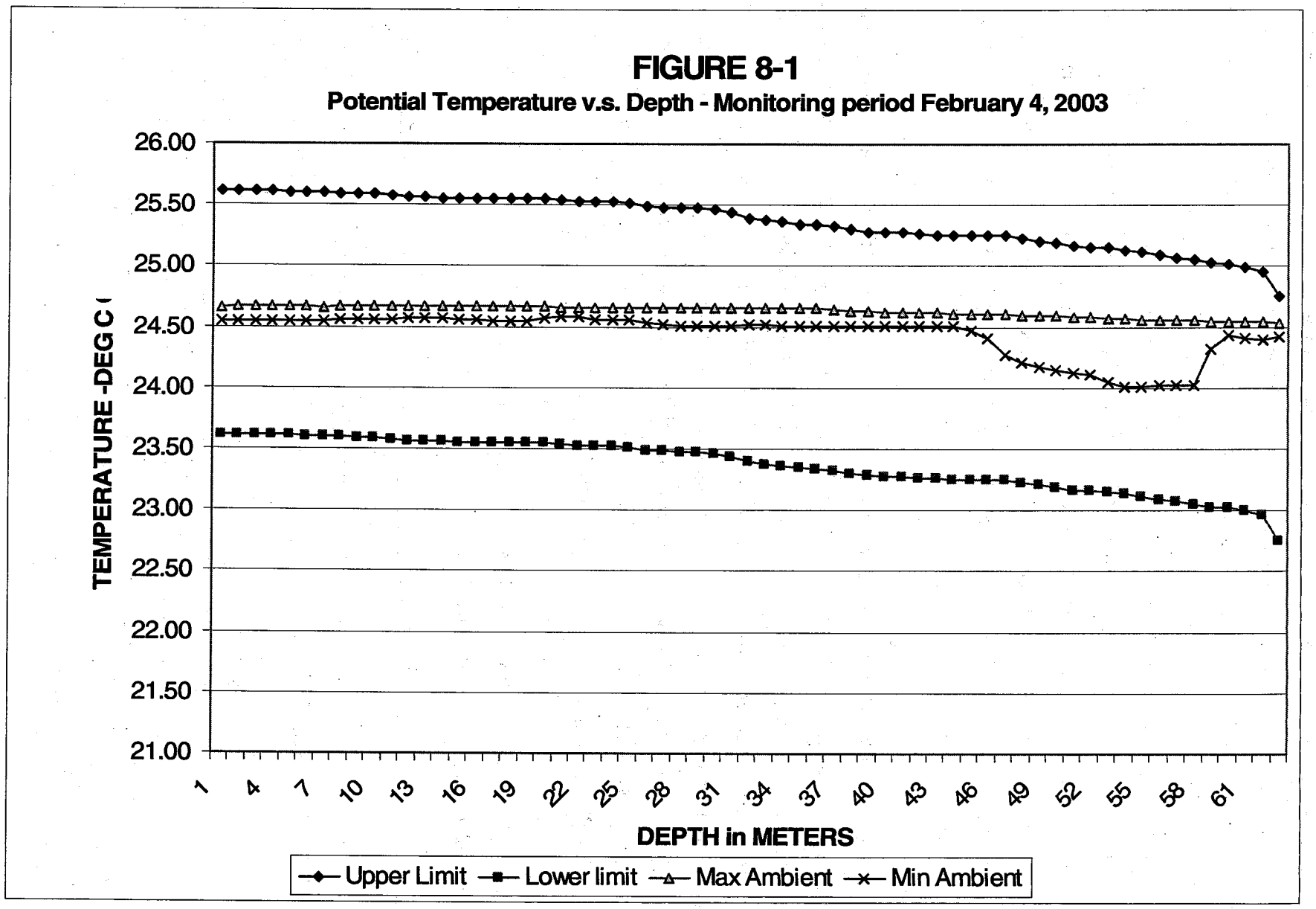


FIGURE 8-1
Potential Temperature v.s. Depth - Monitoring period February 4, 2003
TEMPERATURE -DEG C
26.00
25.50
25.00
24.50
24.00
23.50
23.00
22.50
22.00
21.50
21.00
1
4
7
10
13
16
19
22
25
28
31
34
37
40
43
46
49
52
55
58
61
DEPTH in METERS
Upper Limit
Lower limit
Max Ambient
Min Ambient

FIGURE 8-2

Potential Temperature v.s. Depth - Monitoring Period April 29, 2003

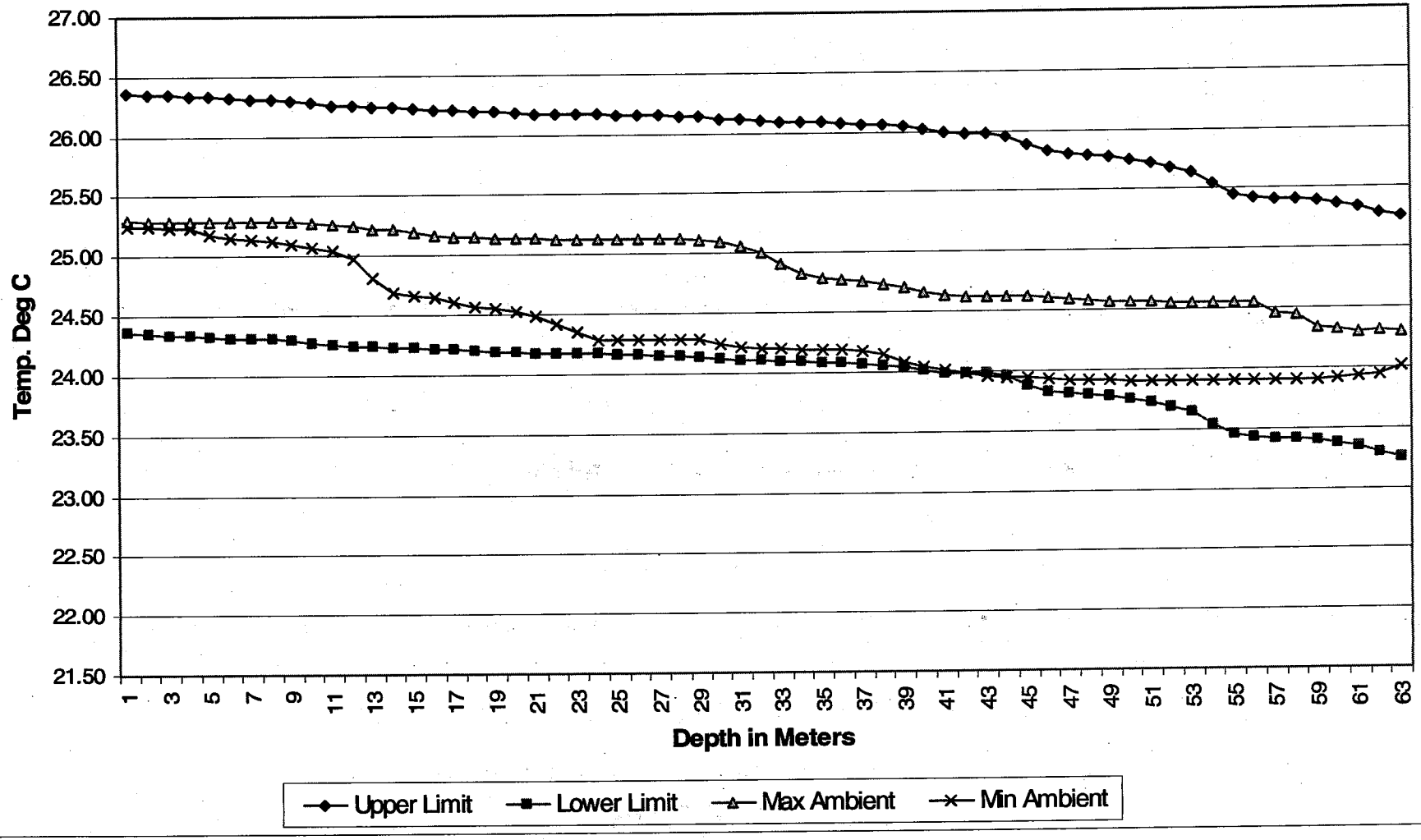


FIGURE 8-3

Potential Temperature VS Depth - Monitoring Period September 8, 2003

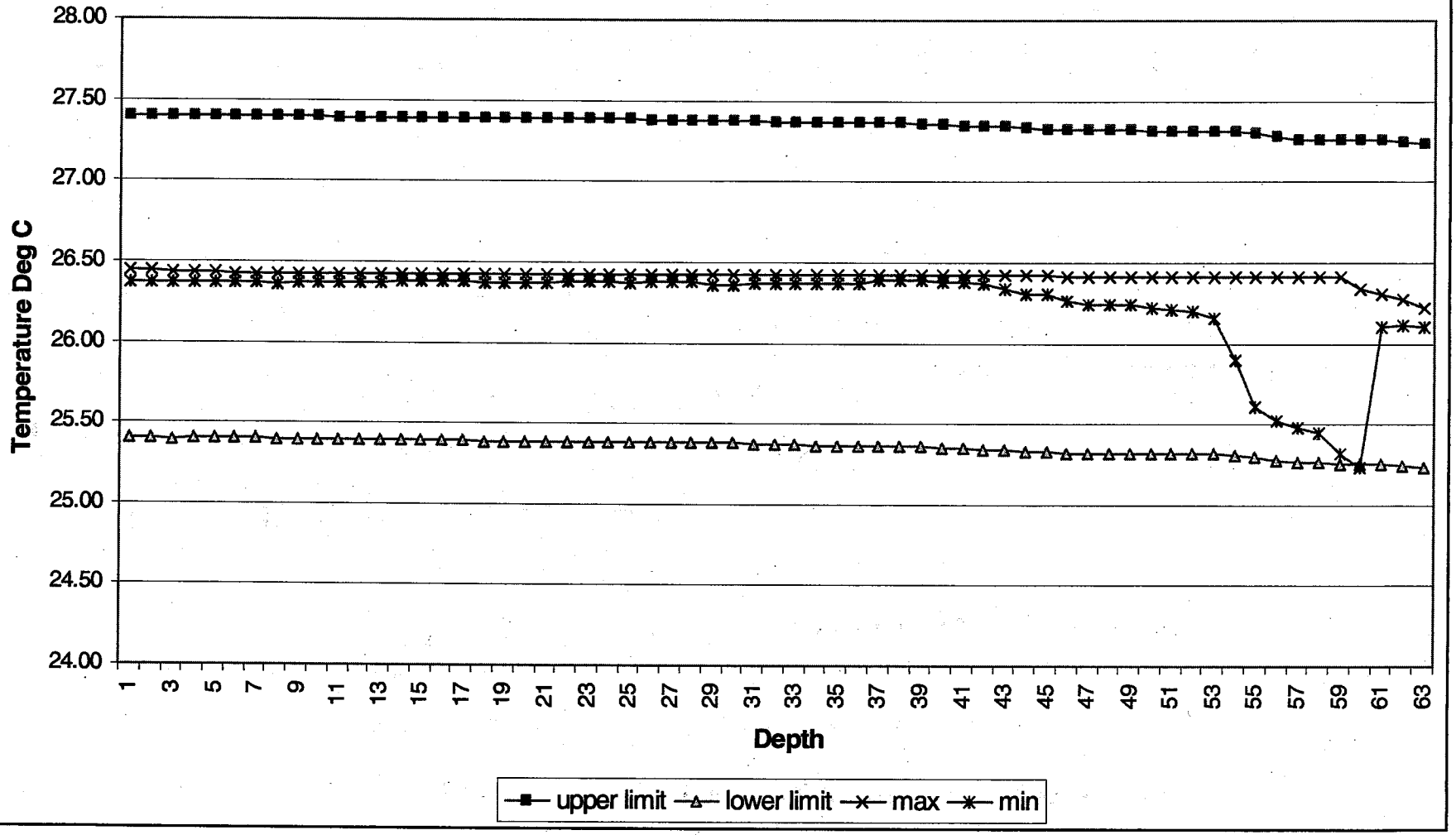


Figure 8.4

Potential Temperature v.s. Depth - Monitoring Period September 20, 2003

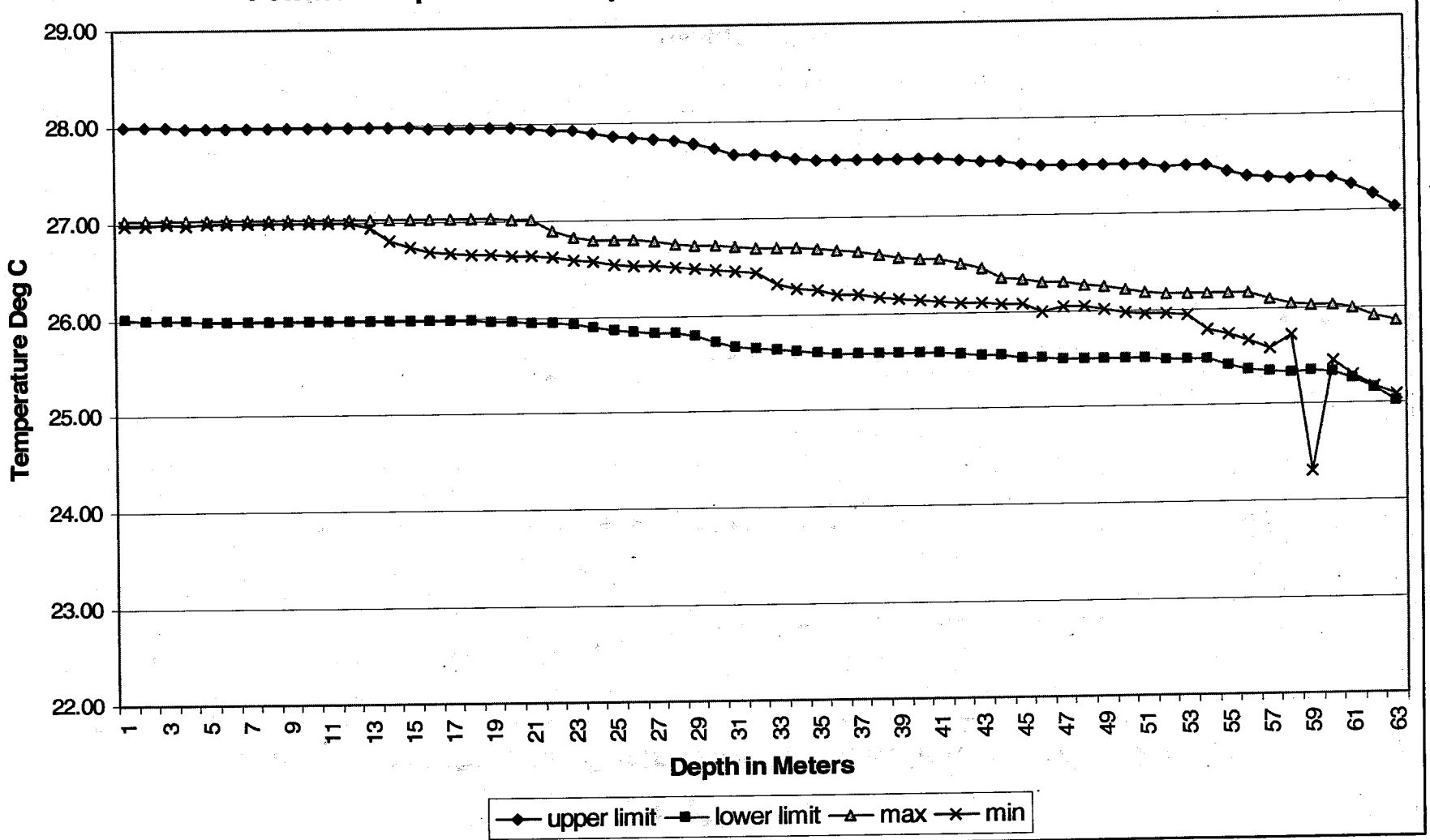
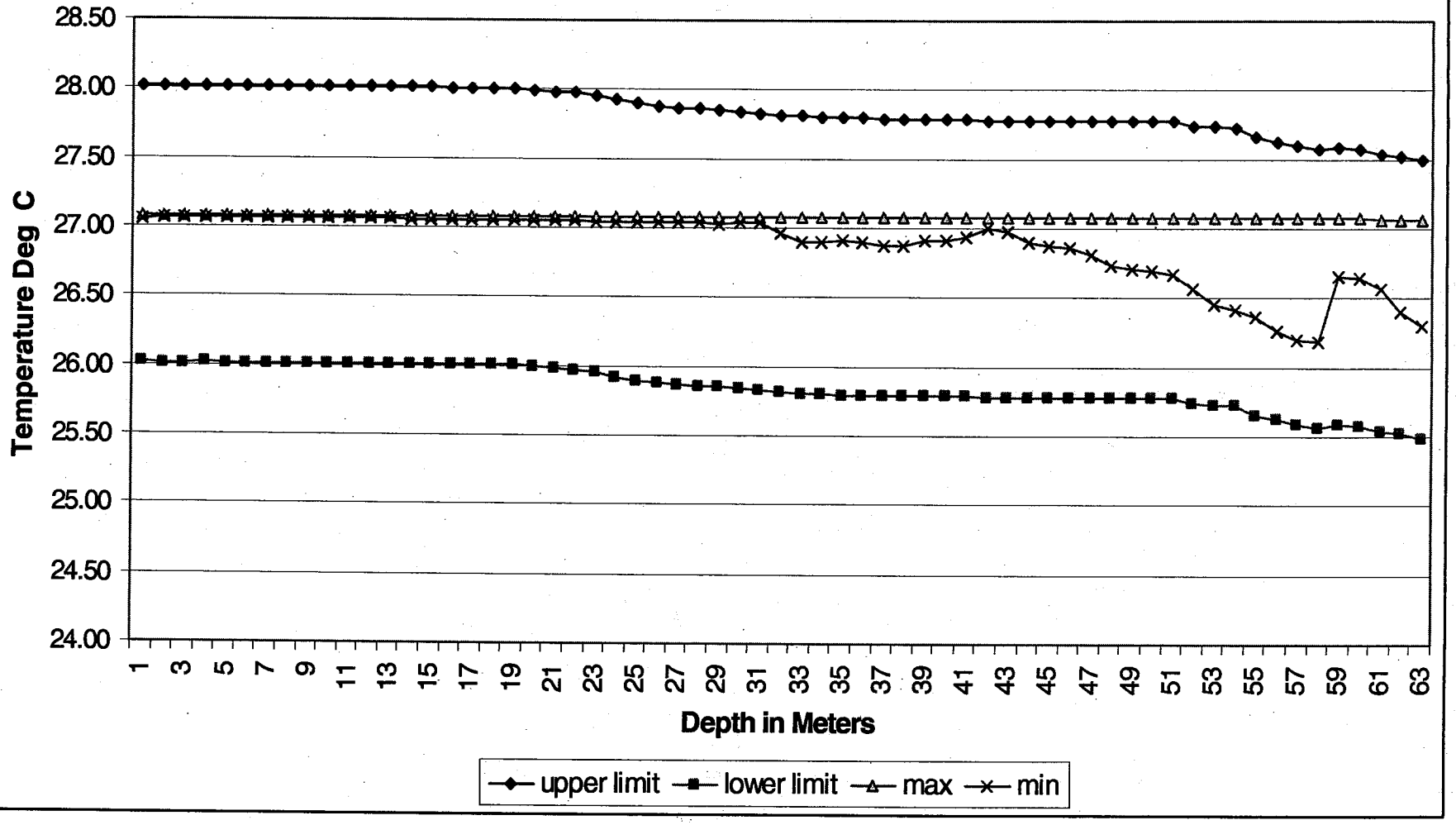


FIGURE 8-5

Potential Temperature v.s. Depth - Monitoring Period October 8, 2003



8.4 SALINITY REQUIREMENT

According to the State WQS and permit requirements, the salinity shall not vary more than ten percent (10%) from natural or seasonal changes considering hydrologic input and oceanographic factors.

There is no statistical compliance methodology for this requirement. For a given monitoring event, in situ salinity measurements at each depth (SAL_d) for each offshore monitoring station were compared with the average salinity ($AVGSAL_d$) at each corresponding depth. The $AVGSAL_d$ at each depth, d, was obtained by averaging salinity measurements from the two reference stations HN1 and HN7. For depths where salinity measurements were taken from one reference station, the $AVGSAL_d$ at those depths was taken to be the measurement taken at the reference station. The salinity ratio at each depth was computed using the following equation:

$$\text{Salinity ratio} = ABS[1-SAL_d/AVGSAL_d] \times 100$$

This process was repeated throughout the depth range of the reference stations for every CTD monitoring event. Table 8-3 exhibits no percent deviation exceeding the 10% limit.

Table 8-3
SALINITY MEASUREMENTS FOR GIVEN MONITORING EVENTS

Monitoring event	Salinity ratio		Number of sample points (n)	Average salinity ratio	Sample Standard Deviation
	maximum	minimum			
February 2003	0.54%	0.00%	601	0.16%	0.091%
April 2003	0.26%	0.00%	601	0.09%	0.063%
September 2003	0.56%	0.00%	607	0.06%	0.100%
September 2003	0.74%	0.00%	609	0.06%	0.100%
October 2003	0.23%	0.03%	591	0.13%	0.030%

8.5 DISSOLVED OXYGEN REQUIREMENT

State WQS and the Sand Island WWTP 301(h) waiver permit requires dissolved oxygen to not be less than seventy-five percent (75%) saturation, determined as a function of ambient water temperature and salinity. To determine the dissolved oxygen concentration ($DO_{saturation}$) for given temperature and salinity, dissolved oxygen concentration tables* were used. For each monitoring event, the temperature T and salinity, Sal, measured at each station at each depth were used to obtain $DO_{saturation}$ for that station and depth. The measured DO at each station and depth was then compared to the corresponding $DO_{saturation}$ value. If the measured value was at least equal to Seventy-five percent (75%) of the corresponding $DO_{saturation}$ value then the State WQS and permit requirements were met. Compliance is achieved when the minimum dissolved oxygen concentration for all depths at each station except the reference station for each monitoring event is greater than 75% $DO_{saturation}$. Table 8-4 shows that compliance was attained.

Table 8-4

$DO_{saturation}$ Determination 2003

Monitoring Event	Maximum Temperature Monitored [°C]	Maximum Salinity Measured [parts per thousand]	75% $DO_{saturation}$* using maximum salinity and temperature values [mg/l]	Minimum measured Dissolved Oxygen Concentration [mg/l]
February	24.588	35.224	5.108	5.901
April	25.252	35.194	4.995	6.0337
September	26.384	35.156	4.815	6.0736
September	26.9921	35.194	4.7635	5.978
October	27.0676	35.068	4.7636	6.0241

* Tchobanoglous, George and Schroeder, Edward; Water Quality. Addison-Wesley Public Company; February 1987.

8.6 CONCLUSIONS

Discharge from the Barbers Point Deep Ocean Outfall did not result in any exceedences of applicable State regulations on pH, dissolved oxygen, temperature or salinity during 2003.