APPENDIX G

Assessment of Impact on Beneficial Uses

Attachment 1 - Recreational Waters Impact Assessment

Attachment 2 - Commercial and Recreational Fisheries Assessment

Attachment 3 - Bioaccumulation Data Evaluation

Assessment of Impact on Beneficial Uses

Introduction

The nearshore waters and beaches of Hawaii are our most valuable resource, and preservation of high water quality in coastal areas is of primary importance. The following data are submitted to support the discussions and conclusions in Section III and other sections in the text of this report. The three attachments to this appendix present recent data on recreational uses, commercial and recreational fishing, catch-per-unit efforts, and bioaccumulation data.

APPENDIX G - ATTACHMENT 1 [UPDATED]

Recreational Waters Impact Assessment

Recreational Waters Impact Assessment

Introduction

This technical analysis contains background information on the use of indicator bacteria for assessing marine water quality and standards designed to protect the pubic health when beneficially using the ocean. This analysis reviews relevant data to evaluate the present impact on the beneficial uses of the recreational waters of Mamala Bay that may be attributable to wastewater discharges, particularly the discharge of treated wastewater from the Barbers Point Deep Ocean Outfall.

Measuring Bacteria in Marine Water Samples

A wide variety of pathogenic microorganisms can be transmitted to humans through use of marine waters contaminated by wastewater. These include enteropathogenic agents, such as *Salmonella, Shigella,* enteroviruses, protozoa, and multicellular parasites; human pathogens or "opportunists" such as *Pseudomonas aeruginosa, Klebseilla, Vibrio parahaemolyticus, V. vulnificus, Aeromonas hydrophilla,* and *Candida albicans,* which may multiply in recreational waters in the presence of sufficient nutrients. Also, *Staphylococcus aureus* and other organisms carried into the water from the skin and upper orifices of swimmers and bathers may be of local concern.

Approved procedures for the isolation of certain pathogenic bacteria and protozoa are routinely published in Standard Methods. The latest version is the 20th edition of *Standard Methods for the Examination of Water and Wastewater*. It is published by the American Public Health Association, American Water Works Association and the Water Environment Federation and routinely used by all laboratories, and this publication is available to EPA staff in its library.

Many of the procedures for detecting specific pathogens are tedious and complicated and are not recommended for routine use. Likewise, tentative procedures for enteric viruses are included, but their routine use is not advocated because special laboratory conditions are required.

Instead of specific pathogen analyses, two groups of bacterial indicators are used to measure water quality. These are the coliform group of bacteria present in the gut and feces of warm-blooded animals. These bacteria generally include organisms capable of producing gas from lactose in a suitable culture medium of 44.5 plus or minus 0.2°C (Centigrade).

The other group is the enterococcus group which is a subgroup of the fecal streptococci that includes *Streptococcus faecalis,* S. *faecium, S. gallinarum* and *S. avium.* The enterococci are differentiated from other streptococci by their ability to grow in 6.5 percent sodium chloride, at pH 9.6, and at 10°C and 45°C. Enterococci have been shown to be the most efficient bacterial indicator of water quality in most marine situations (Cabelli, 1983; EPA, 1986) and have been adopted by the State of Hawaii as the bacterial indicators used in establishing water quality standards for marine waters.

Because it is impossible to obtain the true population parameters, water quality assessment for bacterial quality is based on evaluation of data (statistics) showing trends over time and statistical evaluations of multiple samples. In evaluating such data it is important to use certain techniques. Statistical evaluation of skewed distribution data, such as bacterial densities, requires the conversion of the data to a normal distribution by converting the values to logarithms. The best estimate of central tendency of the log-normal data is the geometric mean. The geometric mean is equal to the antilogy of the arithmetic mean of the logarithms. The EPA proposed marine water quality guidelines and the Hawaii State water quality standard were based on the calculation of a geometric mean of at least five samples per 30-day period during the swimming season (EPA, 1986).

Use of the Enterococci Indicator

After much research and study, the EPA proposed the abandonment of the fecal coliform standard and the adoption of enterococci as the indicator of health risk for marine recreation waters (Cabelli, 1983; EPA, 1986). The recommended standard for marine waters was a steady-state geometric mean of 35 colonies per 100 ml, and the single sample maximum allowable concentration is 158 colonies per 100 mL for designated beach areas for moderately full-body contact recreation. For infrequently used full-body contact recreation, the standard is 500 per 100 mL. These standards correspond to a risk of swimming-associated gastroenteritis incidence rate at 19 illnesses reported per 1,000 bathers, which is reportedly the same as it was for the risk with a concentration of 200 fecal coliform bacteria per 100 mL.

The direct correlation established by EPA's investigators between observed health effects and enterococci concentrations is significant and is gaining wider acceptance.

Different standards apply to freshwater recreational quality for enterococci with a steady-state geometric mean indicator concentration slightly less (at 33 per 100 ml), and the single sample maximum allowable concentrations are far less than the standards for marine waters. Moreover, *E. coli* is allowed as an alternative indicator organism. Hawaii still maintains a fecal coliform standard for fresh water.

Applicable Water Quality Standards

As noted in the present NPDES Permit, issued on the basis of the 1983 Revised 301(h) application (M&E, 1983), previous analyses of recreational impacts were based solely on the basis of fecal coliform bacteria concentrations. This was logical and appropriate at the time because Hawaii's water quality standards were based on this bacteriological indicator organism.

Subsequently, Hawaii marine bacterial indicator standards have changed. First, a new state standard was adopted in 1988 that used enterococcus as the indicator of choice. This new standard was applicable within 305 meters (1,000 feet) of shoreline, required that "the enterococci content shall not exceed a geometric mean of 35 colonies/100 mL in not less than 5 samples equally spaced over a 30-day period."

The adoption of this standard was based on EPA's national criteria document (EPA, 1986) suggesting the use of enterococcus as the best risk-based marine indicator bacteria. The recommendation was based on extensive epidemiological studies conducted by the U. S. EPA (Cabelli, 1983, as cited in the permit). In January of 1990, the standard was made much more restrictive (by a five-fold factor). It is this revised 1990 standard that is contained in the present Honouliuli 301(h)-modified NPDES permit. This standard is as follows; "The enterococci content shall not exceed a geometric mean of 7 colonies/100 mL in not less than 5 samples equally spaced over a 30-day period." This restrictive limit, the most stringent of any state, has been adopted to reduce estimated risk to 10 cases or less per 1,000 swimmers, based on the curves developed in the EPA criteria document (Cabelli, 1983).

EPA Permit Calculations for Compliance with New Enterococcus Standard

In issuance of the present NPDES permit (attachments to Fact Sheet), EPA described its recalculation of projected bacterial indicator concentrations using the new enterococci standard stated above and peak flow projections for 1995. The calculations, based on a model described in the Honouliuli Technical Review Report (TRR) (Tetra Tech, Inc., 1987), were performed on several different combinations of conditions at the projected 1995 peak flow of 46.46 mgd.

EPA's first scenario assumed the "worst case" conditions, which include an estimated initial dilution of 127 for a nonsurfacing plume in a stratified water column and at nighttime. This data is entered into the computer model with the given inputs of a geometric mean of enterococci concentrations (4.1 X 10^5 colonies/100 mL) from available (7/19/88 to 12/28/88) effluent data provided by the applicant, a farfield dilution factor of 2.40, a travel time of 5.4 hours to reach the HB3 and HB4 nearshore monitoring stations, and the same procedure established in the 1987 Honouliuli TRR. The result of the calculation was a final receiving water concentration of 801 colonies/100 mL, well over the limit where the standard applies. The die-off time (T90) required, as a function of the effluent concentration, to exceed the initial dilution of 7 colonies/100 mL standard would be 2 hours 22 minutes, which is considerably less than the required T90 (24 hours) estimated for nighttime conditions and indicated that the standard limit could be exceeded under these most conservative conditions. EPA noted, however, that the probability of all of the above oceanographic and atmospheric conditions occurring at the same time is very small. Also worth noting is the probability of violations is based on a geometric mean of five samples equally spaced over a 30-day period.

Another scenario evaluated assumed all the above conditions but substituted mid-day sampling. In this case, the result is 5.4 X 10^{-3} (0.0054) colonies/100 mL, which is considerably below the state geometric mean of 7 colonies/100 mL. A T90 time of 2 hours 22 minutes would be sufficient to meet the 7 colonies/100 mL standard. This is more than twice the minimum time (1 hour) required to kill off enterococci in seawater during daylight conditions.

A third scenario described in the permit was the "usual case" assumption in which there is a surfacing plume in an unstratified water column which allows an initial dilution of 889:1 and daylight sampling conditions. Using the other default inputs above, a final receiving water concentration of 7.7 X 10^{-4} colonies/100 mL (0.00077 colonies/l00 mL) was predicted. At this dilution, the minimum T90 required to exceed the 7 colonies/100 mL standard would then be 3 hours and 45 minutes. This is considerably longer than the 1 hour estimated T90 for enterococci during daylight hours in Hawaiian offshore waters and revealed a comfortable margin of safety under the usual conditions.

EPA Conclusions About Enterococcus Levels Under Revised Flow Rate

The analyses undertaken by EPA showed that the enterococci indicator colony densities at the new projected flow rates (46.6 mgd peak flow in 1995) are the same as those that were developed in the 1987 TRR for fecal coliform at the projected 1993 flow rates. Exposure to solar insolation appears to be the most critical determining factor for meeting state bacterial standards. Based on several of the most conservative assumptions, the Hawaii bacterial standards may be exceeded at stations when samples are taken under nighttime, early morning, or very cloudy conditions. However, it should be noted that many of the other worst-case assumptions used in this model are extremely rare, such as zero ambient current and the use of constant onshore current speeds for calculating travel times, farfield dilutions, and bacterial die-off rates. Without a better understanding of nearshore circulation patterns, it is impossible to estimate how all these factors will affect the final enterococci concentrations. In summary, EPA determined as part of its prior permit issuance technical evaluation that the Honouliuli discharge was expected to meet all Hawaii water quality standards at the requested 1995 end-of-permit effluent flow rate of 46.6. Conditions have not changed, and similar conclusions can be drawn from the data collected since the time of the EPA analysis.

Issues Regarding Recreational Impact Assessment

The concerns over the impacts of the Honouliuli discharge on recreational water quality have focused on risks to public health. Prior assessments of risks were based on fecal coliform bacteria as an indicator or the water's quality. Since 1988, the State of Hawaii has adopted a new standard based on use of enterococci bacteria. An updated assessment of water quality risks was performed using this new indicator. This test has been adopted because of its probabilistic prediction abilities that relate concentrations in the receiving water to the possibility of developing gastroenteritis from swimming. Compliance with Hawaii's strict enterococcus standard is evidence that public health is being protected.

A key point in making any assessment is that a single event or single high measurement does not equate to a violation of a standard or necessarily pose a risk. The stringent water quality standards for enterococcus are based on a geometric mean calculated from a minimum of five monthly samples. Thus, a single or even more than one high count does not mean that a water quality violation has occurred.

Monitoring Station Locations and Descriptions

The locations of the shoreline stations monitored (HS1-HS4) and nearshore (HN1-HN4) and offshore stations, along with two other non-permit specified, shoreline stations at Hammer Point and Iroquois Beach, are shown on Figure G.l-1. These consist of the nearshore (four HN designation stations located 2000 feet offshore) and four HS stations located along the shoreline over a distance of 5.5 miles and twelve offshore stations (four ZID boundary stations (HB2 – HB5), four ZOM boundary stations (HM1 – HM4), three reference stations (HB1, HB6, and HB7), and a station at the center of the diffuser (HZ)).

Surf Zone Water Quality

Surf zone monitoring is conducted to assess bacterial conditions (both enterococcus and fecal coliform) in areas used for body-contact activities (e.g., swimming, surfing, etc.) and to assess aesthetic conditions for general recreational uses (e.g., picnicking, harvesting ogo, etc.).

There are four shoreline (surf zone) sampling stations which bracket the point of intercept of the outfall pipe to the shore with a total distance of 5.0 miles between the extremes. HSl is about 2.5 miles east of the base of the outfall between Ewa Beach Park and Oneula Beach, HS2 is at the base of the outfall at Oneula Beach, HS3 is slightly over one mile west of the outfall base at Oneula Beach, and HS4 is located 2.5 miles west of the outfall base at Nimitz Beach (Figure G.l-1). Sampling is conducted five times a month to measure enterococcus and fecal coliform (indicator bacteria) levels and make visual observations.

In addition to the Honouliuli discharge, there are several other sources recognized as having the ability to impact shoreline test results. These are the outflow from Pearl Harbor, local storm drains, the Fort Kamehameha WWTP discharge near the mouth of Pearl Harbor (but soon to initiate a deeper ocean outfall), human activities on the beach and in the nearshore waters, storm runoff and animals on the beaches.

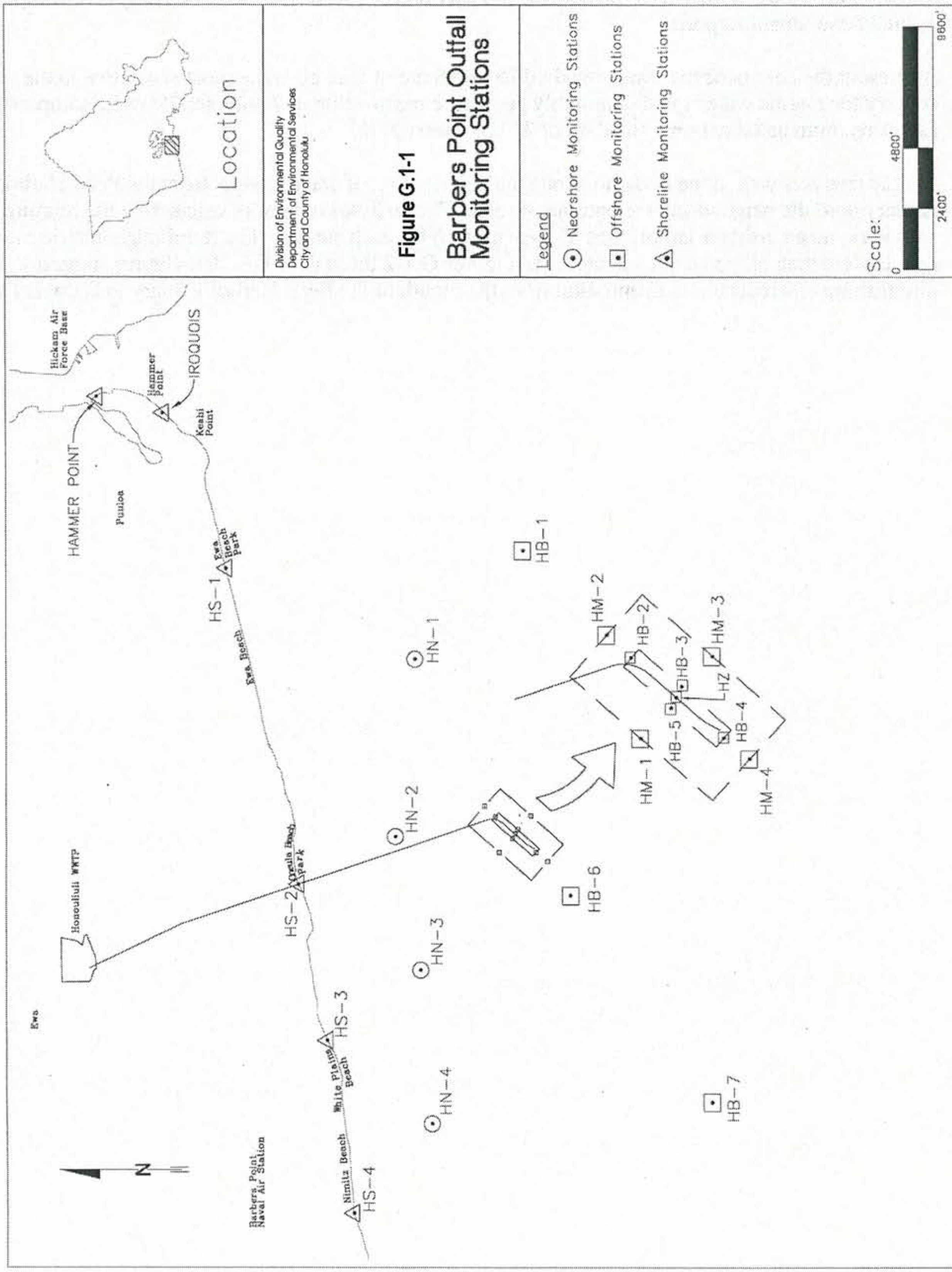
The city conducts sampling at two other shoreline stations routinely to provide supplemental information which is useful in interpreting the results from the four permit-designated sampling stations. These stations are located at Hammer Point near the mouth of Pearl Harbor and at Iroquois Point about a half mile west.

Rainfall events and the subsequent storm runoff and outflow from Pearl Harbor and local storm drains have the greatest impact on surf zone test results. Greatest impact occurs during winter months following storm activity when stormwater runoff is greatest.

Annually, over 300 surf zone samples are collected and analyzed. These samples were analyzed, and the monthly geometric mean values were calculated for enterococcus for all stations monitored. The data base used included the period from January 1989 through May 2004. Although parallel testing for enterococcus and fecal coliform bacteria was initiated in July of 1988, the data for the fecal coliform bacteria have not been used in the analysis done for this application. Analyses and comparisons between the two indicators have been done as part of the City & County of Honolulu's Annual Assessment Reports.

At present the enterococcus water standard for the State of Hawaii is the most restrictive in the country for marine waters, with a monthly geometric mean value of 7 colonies/100 mL, compared to EPA's recommended national standard of 35 colonies/100 mL

Simple analyses were done to demonstrate the contribution of enterococcus from the Pearl Harbor Estuary onto the neighboring recreational waters. The analyses consist of calculating the running geometric mean, using a sample size of five (or n=5) for each station. The running geometric mean results were then plotted and evaluated; see Figures G.1-2 through G.1-7. The figures suggest a diminishing enterococcus concentration from the mouth of the Pearl Harbor Estuary to Barbers Point.



Location
Division of Environmental Quality
Department of Environmental Services
City and County of Honolulu
Figure G.1-1
Barbers Point Outfall
Monitoring Stations
Legend
Nearshore Monitoring Stations
Offshore Monitoring Stations
Shoreline Monitoring Stations
Scale:
0
2400'
4800'
9600'
1" : 4800'
HAMMER POINT
IROQUOIS
Hickam Air Force Base
Hammer Point
Keahi Point
Puuloa
Ewa Beach Park
Ewa Beach
Oneula Beach Park
Honouliuli WWTP
Ewa
White Plains Beach
Nimitz Beach
Barbers Point Naval Air Station
N
HS-1
HS-2
HS-3
HS-4
HN-1
HN-2
HN-3
HN-4
HB-1
HB-2
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HB-4
HB-5
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HM-1
HM-2
HM-3
HM-4
HZ

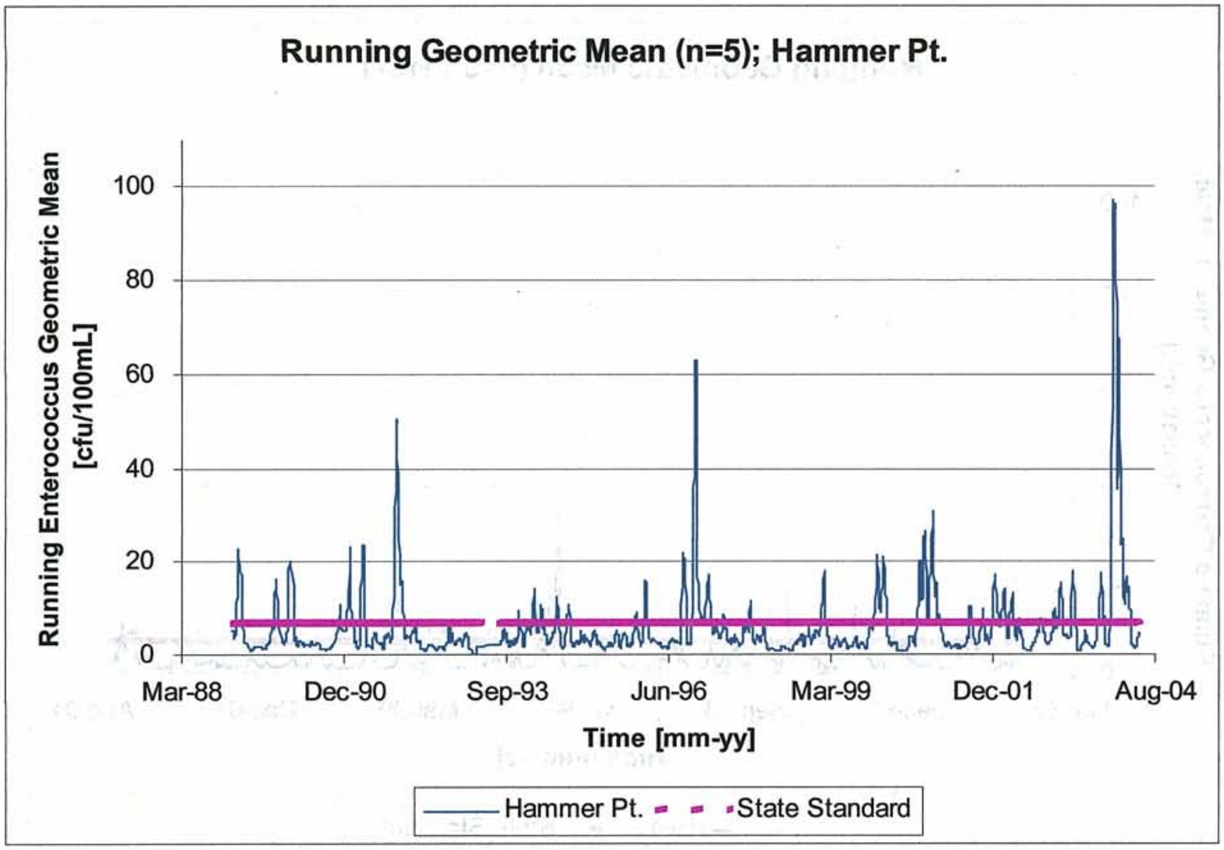


Figure G.1-2

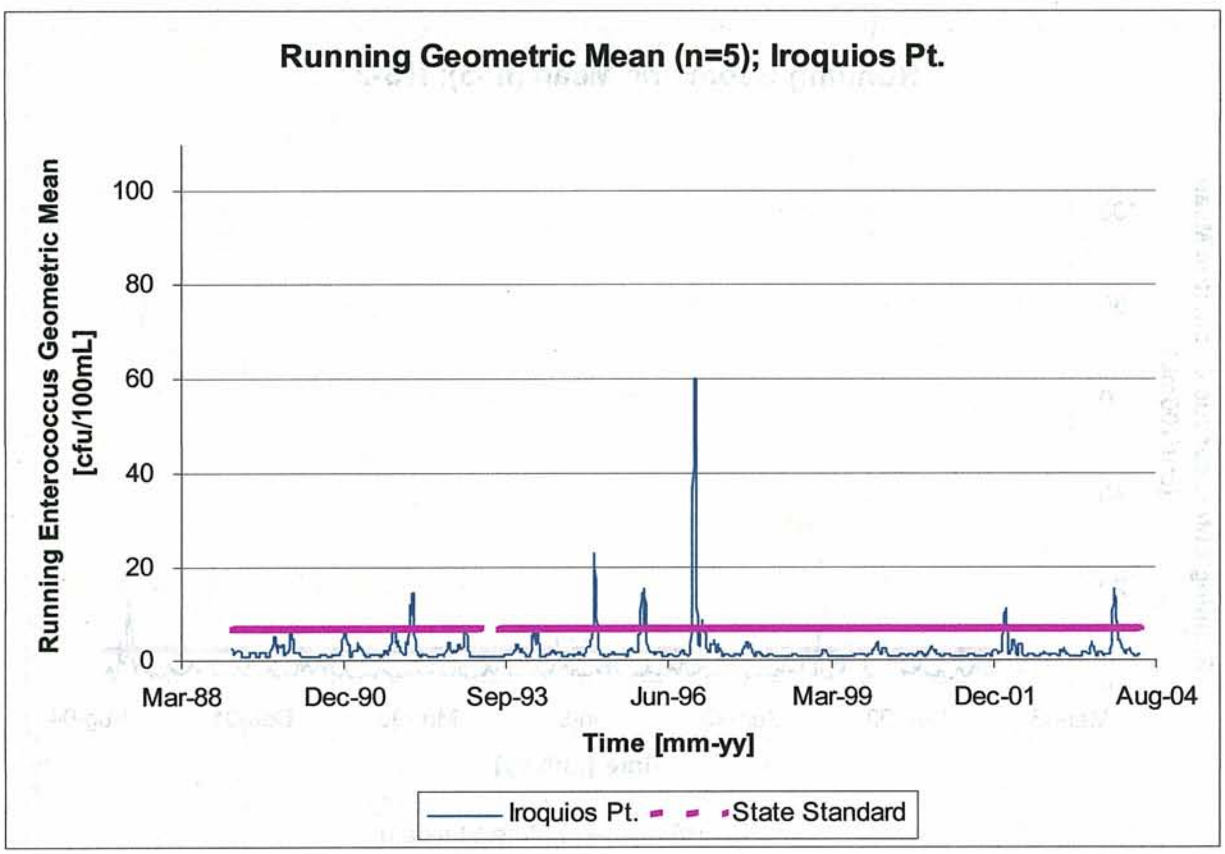


Figure G.1-3

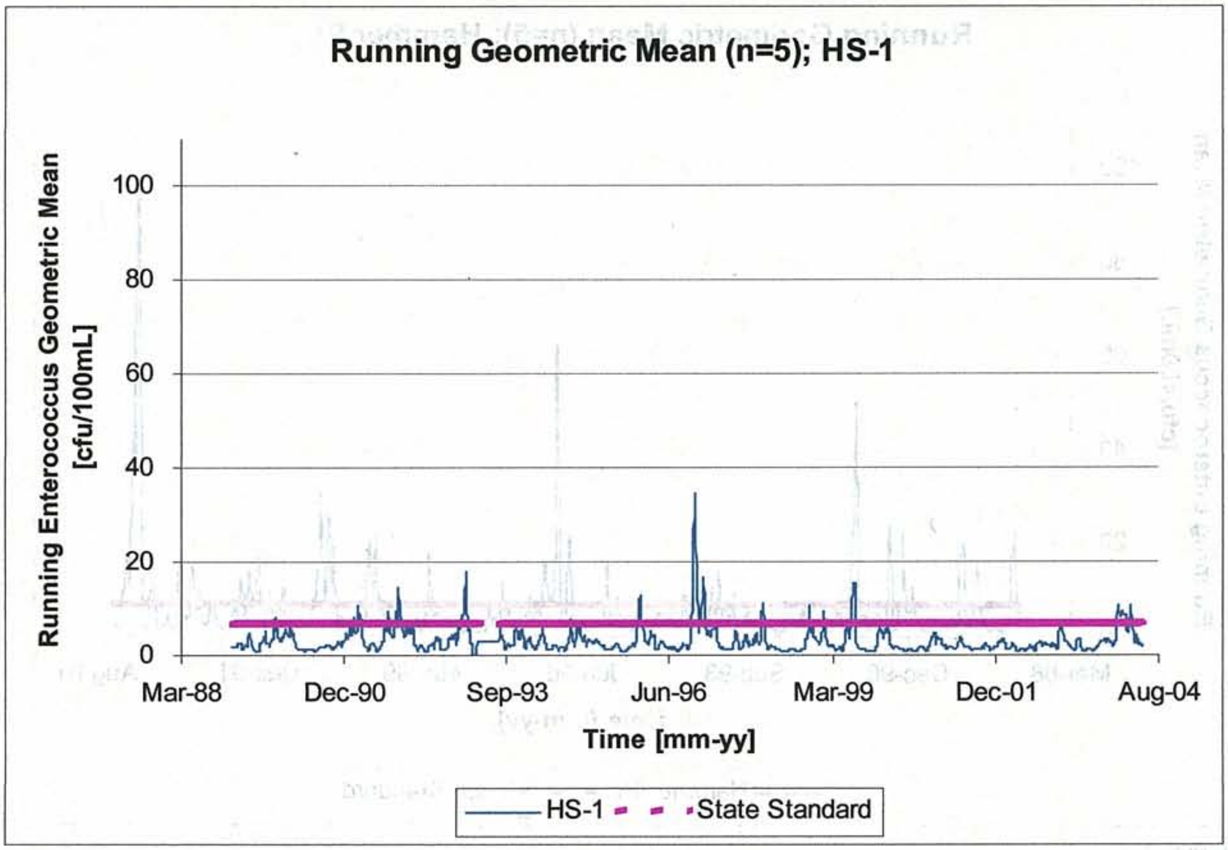


Figure G.1-4

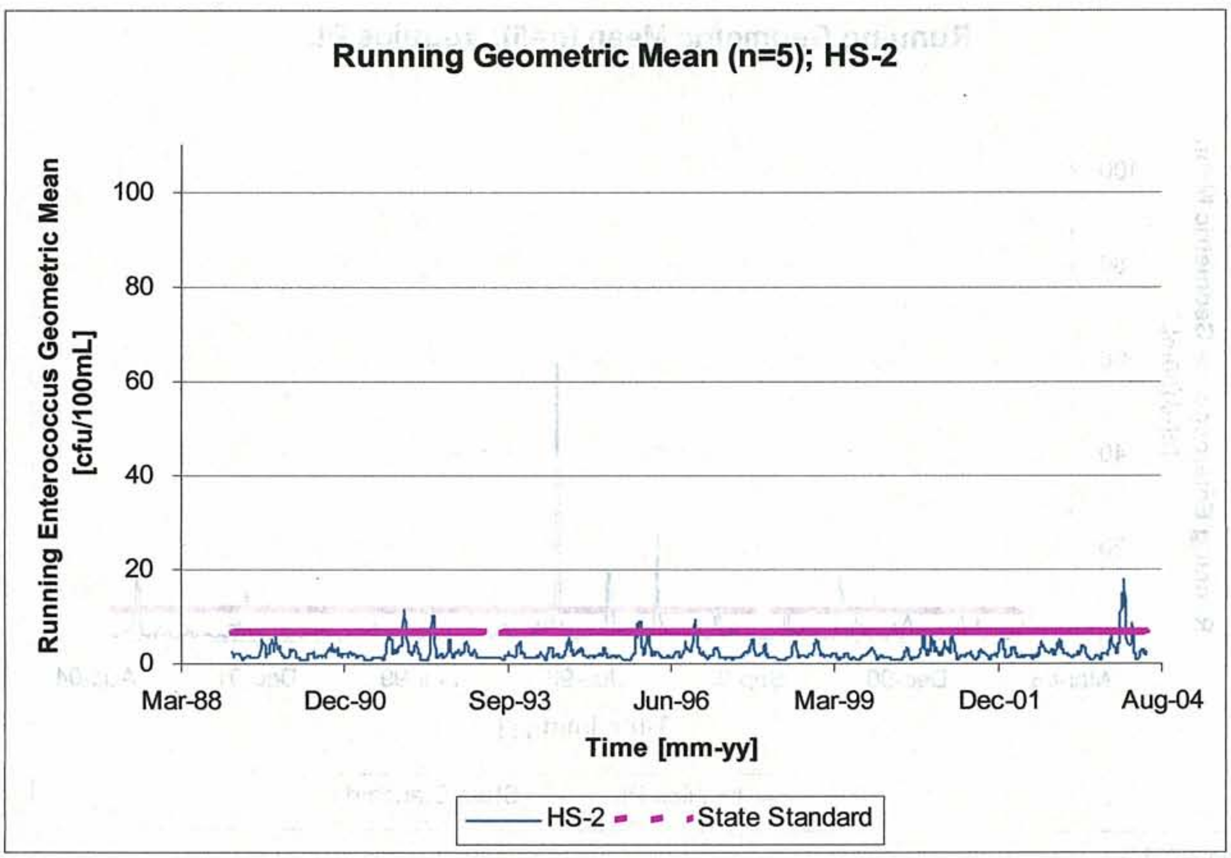


Figure G.1-5

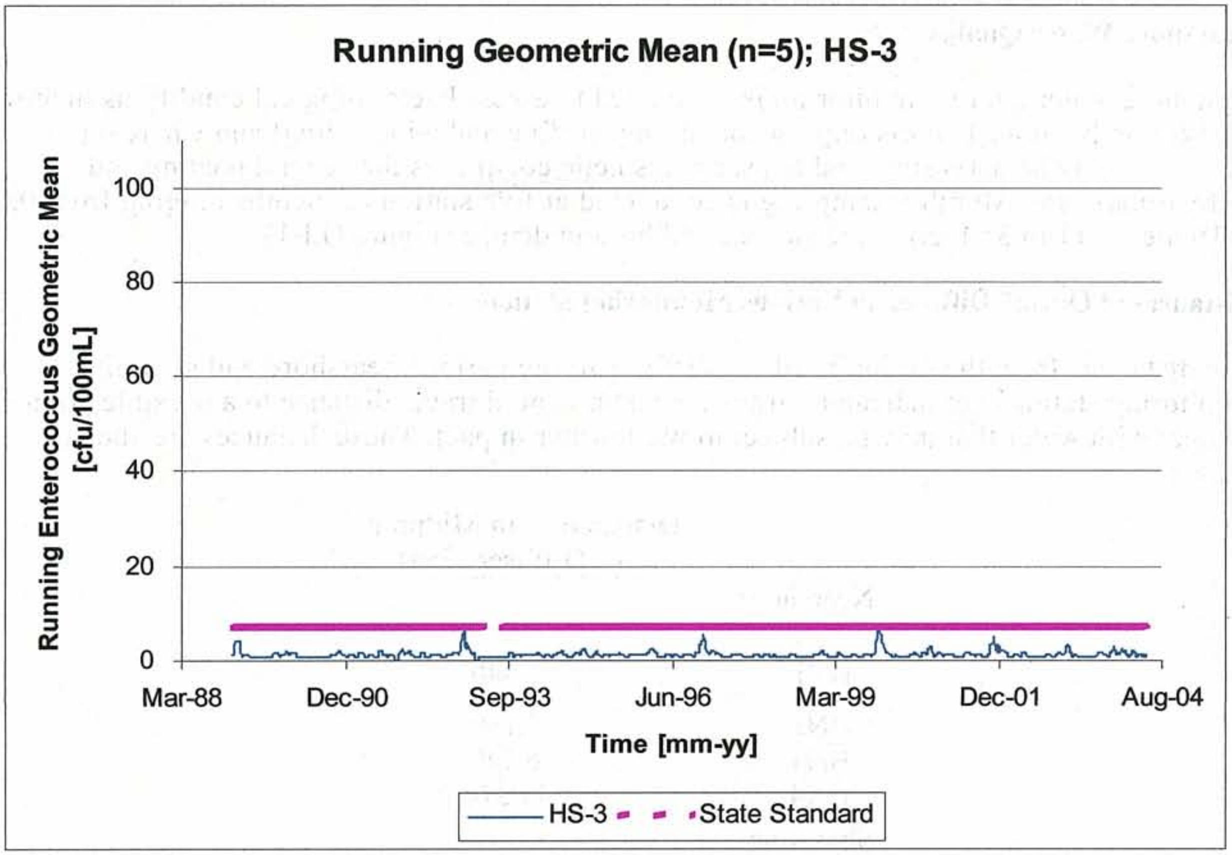


Figure G.1-6

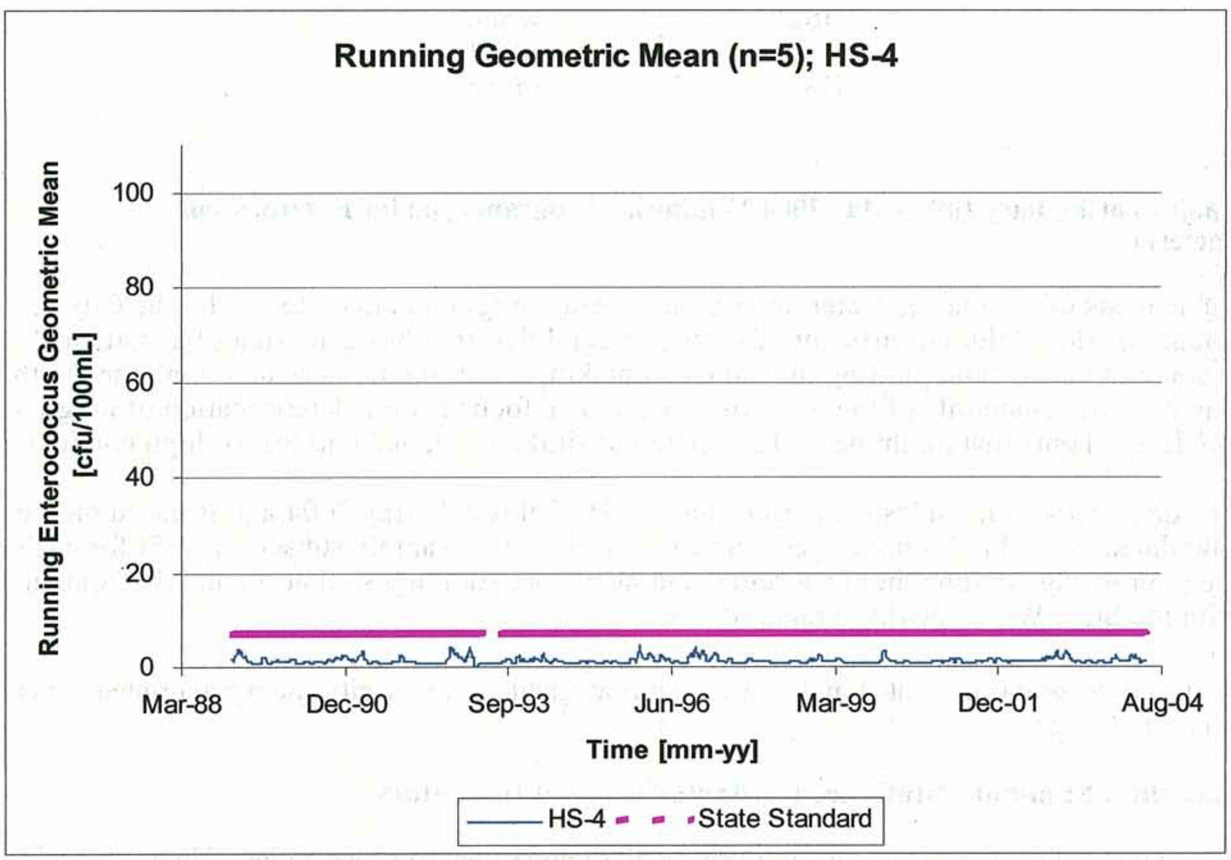


Figure G.1-7

Nearshore Water Quality

Nearshore water quality monitoring is conducted to assess bacteriological conditions in areas used for body-contact sports (e.g., scuba diving, surfing and windsailing) and where ogo (seaweed) may be harvested; and to assess aesthetic conditions for general boating and recreational uses. Monthly sampling is conducted at five stations at depths ranging from 0.0 to 10 meters (1 to 35 feet) at the surface and bottom depths (Figure G.l-1).

Distances of Outfall Diffuser to Various Monitoring Stations

The distances from the midpoint of the diffuser to the various nearshore and shoreline monitoring stations are indicators of the nearest potential travel distance to a possible point of contact with water that may be subject to wastewater impact. These distances are shown below:

	Distance from Midpoint of Diffuser (feet)
Nearshore	
HN1	8,940
HN2	5,110
HN3	6,140
HN4	11,310
Shoreline	
HSl	16,480
HS2	8,880
HS3	10,580
HS4	15,690

Analysis of January 1989 - May 2004 Monitoring Program Data for Enterococcus Bacteria

An analysis of the marine water quality monitoring program data collected by the City & County of Honolulu, Department of Environmental Services has consisted of a statistical evaluation of the data, plotting the data, and making determinations as to compliance with water quality standards of the State of Hawaii. The focus is on a determination of long-term trends, gradients that might be outfall-related or -influenced, and patterns of high counts.

The data analysis includes the period January 1989 through May 2004 and is based on the calculated "monthly" running geometric mean (for a five sample subset, or n=5) for each of the monitoring stations (both shoreline and nearshore stations) so that it could be compared with the State Water Quality Standard.

The data base used is presented in its entirety; it is available from the city and when printed out is well over 80 pages.

Honouliuli Summary Statistics for Bacteriological Indicators

Past analyses of the data were done to focus on all samples that exceeded an individual value of 50 colonies/100 mL which might be considered high, based on the EPA geometric mean criterion of 35 enterococcus/100 mL. This simple tabulation was done for each of the six shoreline sampling stations routinely sampled by the city and for the four nearshore stations (both surface and bottom samples). For the period examined (January 1989 through May 2004) a total of 5,862 samples were taken at shoreline stations (roughly 896 samples at each) and 6,847 at all of the nearshore stations (roughly 815 samples at each depth with two depths per station). A map on Figure G.l-1 shows the locations of these stations. The results for the number of times that sampling showed high counts (higher than 50,100 and 200 colonies/100 ml) are summarized in Table G.l-1 for the shoreline samples.

Two of the shoreline stations sampled by the city (Hammer Point and Iroquois Beach) (not designated-in the permit but are done to document the influence of other sources) he near the mouth of Pearl Harbor and are influenced by the outflow of fresh water (and contamination) from the harbor area and other nonpoint sources. The four Honouliuli shoreline (hence the HS designation) stations are those that are designed to serve as stations to monitor the influence of potential shoreline contamination by the onshore movement of the wastewater field.

Table G.1-1. Shoreline Enterococcus Sampling Results January 1989 through May 2004 Samples with Greater than 50 colonies/100 ml

	Enterococcus [colonies/ 100 mL]			
Station	**>50**	**>100**	**>200**	**Percent >50**
Hammer Point	**58**	**29**	**20**	**6.0**
Iroquois	**26**	**18**	**13**	**2.7**
HS-1	**23**	**10**	**6**	**2.4**
HS-2	**15**	**5**	**4**	**1.5**
HS-3	**9**	**5**	**4**	**1.5**
HS-4	**6**	**0**	**0**	**1.0**
TOTAL	**137**	**67**	**47**	

The results of the sampling data show that the four stations HS-1 through HS-4 (non-Pearl Harbor influenced) had a total of 137 of 5105 samples which had enterococcus counts exceeding 50 per 100 mL. This is an average of 2.7 percent exceeded of the samples for the period January 1989 through May 2004. This compares with the findings of Dr. Noda that the probability of the plume hitting the shoreline is about 1 percent of the time or less. If the two stations are not required to be monitored (Hammer and Iroquois) and are excluded, the percentage is only 1.7 percent (53 of 3,150 samples for Stations HS-1, HS02, HS-3 and HS-4). This is more consistent with predictions. Also, it is noteworthy that Station HS-1 is still influenced by nonpoint source pollution emanating from Pearl Harbor and local storm drains as cited above. The percentage is even lower if this station is excluded.

Evaluation of data from the State of Hawaii's monitoring program for the HS-1 station at Ewa Beach Park showed a similar result (for the period from 1988 through 1992, as cited in Lindstrom, 1993) based on a much smaller sample size. The number of colonies exceeding 7 colonies /100 mL was only 4 of 122 samples or 3.2 percent.

Further analysis and comparison of the shoreline samples, based on calculated monthly geometric means for the period January 1989 through May 2004, showed a similar overall trend in sampling results with those monthly geometric means exceeding the state standard.

The tabulated data show that Hammer Point has the highest geometric mean (4.74) with a maximum running geometric mean of 95 cfu/100mL (December 2003). The next highest single running geometric mean value recorded during this time frame was 63 cfu/100mL at Hammer Point (December 1996) followed by an 60 cfu/100 mL at Iroquois Pt. (November 1996). These highs are most often associated with significant rainfall events, as was shown in the testimony provided as part of the court trial and evidentiary hearing (Lindstrom, 1993).

Nearshore Sampling Station Analysis

The analysis of the nearshore sampling data began with a simple "worst case" tabulation of all those enterococcus counts which exceeded a numeric value of 50 colonies/100 ml.

These were individual counts and not the number which exceeded the monthly geometric mean. This was done to get an idea of the distribution of counts between stations and whether there were more high bottom counts than at the surface.

This analysis indicated that about 2.5 percent (170 events out of 6,839 samples) of the samples taken exceeded a count of 50 colonies /100 mL over the entire sampling period examined (January 1989 through May 2004). When broken down by depth, there were roughly 1.8 percent (63 events out of 3,583 samples) and 3.3 percent (107 events out of 3,256 samples) of the samples taken exceeded a count of 50 colonies/100 mL for surface and bottom depths, respectively. This analysis is summarized in Table G.l-2. Because of the constant nature of the the discharge, the low overall percentage (2.5 percent) would suggest that the discharge of treated wastewater could not be a major contributor to the shoreline or nearshore enterococcus concentrations.

The running (n=5) geometric mean trends for each station are presented on Figures G.l-8 through G.l-11.

The median MPN for fecal coliform for the nearshore stations (2000 feet offshore and beyond the 1500 foot recreational use zone) was <1 MPN/100 ml (MPN = Most Probable Number) with 70.4 percent of the samples (959 of 1362) were <1 MPN/100 ml (lindstrom, 1993).

Theoretical Shellfish-Growing Water Safety Achieved

Note that although there are no shellfish in the area and Hawaii has not adopted shellfish-growing water standards for marine waters, the national median MPN for shellfish-growing waters that is most universally applied is a median MPN 70/100 mL with no more than 10 percent of the samples >230 MPN/100 mL. Lindstrom noted in 1993 that for the nearshore fecal coliform samples only 8 of 1,362 samples exceeded a MPN of 70/100 mL and only 0.6 percent exceeded an MPN of 230/100 mL. This indicated a very sanitary condition which is 17 times below the margin of safety in which concern would be expressed if shellfish were being grown and harvested in these waters.

Time Series Plots of individual Counts

The time series plots for each data set for the nearshore and shoreline stations presented as Figures G.l-2 through G.l-7 for the shoreline stations and Figures G.l-8 and G.l-11 for the nearshore stations show that the counts are slightly higher at the nearshore stations than the shoreline stations, except at Hammer Point and Iroquios Point, near the mouth of Pearl

Harbor. It is difficult to determine if the discharge of treated effluent is contributing to the existing monitoring results.

Long-Term Geometric Mean Calculations

Tables G.l-1 and G.l-2 and the Figures G.1-2 through G.1-11 show the running geometric means for the various monitoring stations. After fifteen years of data gathering and analyses, there does not appear to be a trend that would tend towards noncompliance.

What is key to the examination of the data is that there exists a demonstration of compliance with the State of Hawaii water quality standard. Results indicate that the standards are being met on a routine basis. There are occasions where individual samples exceed the standards, particularly during wet weather periods when the influence of storm runoff is high (Lindstrom, 1993).

The Mamala Bay Study also concluded no adverse impact to the environment or public health from the discharge of treated wastewater through the Barbers Point Deep Ocean Outfall.

Individual Count Values Comparisons

In a detailed comparison of individual samples over the period July 1988 through December 1992, prepared for the evidentiary hearing to be conducted in 1993, Lindstrom (1993) found that the shoreline counts were higher than the nearshore over time; comparing the individual counts for the shoreline samples which exceeded 7 (223 of 1657 samples or 13.4 percent for the shoreline sampling stations) with the nearshore totals (126/1362 individual samples greater than 7 for a total of 9.2 percent). This is not what one would predict if the plume were moving onshore from the outfall area. One would expect to find a higher number of samples of detectable enterococcus in samples closer to the outfall (less dilution and less die-off). Also, the surface sampling shows lower counts than the bottom samples, which is indicative of the influence of sunlight on the die-off of indicator bacteria. Most samples are taken in the morning hours, taking into account this natural die-off caused by exposure to sunlight.

Other Sources Are Influencing the Shoreline

Overall, the statistical evaluations done of the existing data base clearly show that the shoreline counts on average are higher or around the offshore counts. This is evidence that there are other sources that contribute to the higher shoreline counts. Visual inspection of the shoreline shows the presence of storm drains in the area that discharge directly to the shallow nearshore waters. Also dogs and other animals (birds) present on the beaches can contribute to higher bacterial counts, which are occasionally observed.

Further evidence that there are no significant problems with bacterial contamination as a result of wastewater discharge is the fact that there has been no posting of beaches. Criteria for posting include that 50 percent of the monthly geometric means (minimum of five samples per month used for calculations) for the proceeding months exceed the enterococcus of 7 counts/100 mL.

Other monitoring data confirm a lack of impact. This includes the fact that the median MPN of coliform in the nearshore waters is <1 MPN/100 ml.

Less than 0.1 percent of the fecal coliform samples exceeded an MPN of 70/100 ml. This is a value which has been used nationally (although the State of Hawaii has not adopted any shellfish-growing waters standard) as a standard for shellfish growing. The standard for maximum contamination of shellfish waters in California is that no more than 10 percent should exceed 230 MPN/100 ml. In the 1993 analysis of the receiving water monitoring data for Honouliuli, only 0.6 percent of the samples exceeded the 230 MPN versus the standard of 10 percent used as a guideline for taking action to close sheHfish-growing waters (Lindstrom, 1993). This is further evidence that shellfish (if there were any of significance) would be protected from adverse impacts by the Honouliuli discharge).

Mouth of Pearl Harbor Water Quality

The city samples Hammer Point at the western shoreline near the mouth of Pearl Harbor. Results of this work indicated that about 1 percent of the 1,657 samples taken for the period July 1988 through December 1994 have exceeded an enterococcus count of 50 colonies (Lindstrom, 1993). This accounts for almost half of all the samples taken which exceeded a count of 50 for all the six shoreline stations sampled during the period under study. The number of high counts at this particular station is over twice the average number of counts which exceeded 50 at all six stations sampled. It indicates there is a source influencing the bacteriological quality of this sampling point.

Daily Examples of the Impact of Rainfall and Nonpoint Sources

Also included as Figures G.l-2 through G.l-7 are summaries of individual station values which are for days when very high shoreline counts were measured. These data summaries show the high shoreline counts and indicate the movement of wastewater onshore through the nearshore stations. These data are typical of the long-term trends which have been observed. Again, higher shoreline counts are usually observed when the nearshore waters have low counts or the counts at the mouth of Pearl Harbor exceed the nearshore counts. All of these confirm the influence of sources other than wastewater from the Barbers Point Deep Ocean Outfall.

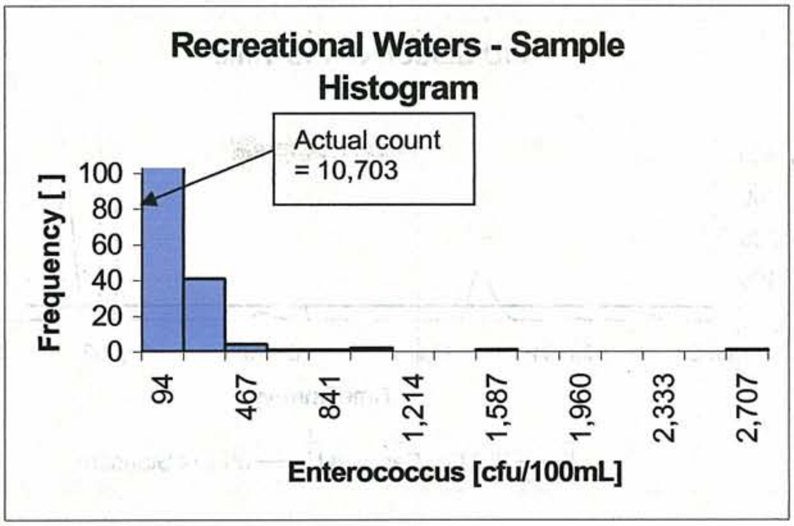
Standards Compliance Determination Calculation

Hawaii State Water Quality Standards compliance is based on a population parameter; in this case, the not to exceed geometric mean value of 7 cfu/100 mL for enterococci. Because it is impossible to ever know the population parameter, an evaluation must be conducted using sample results (i.e., an estimation of the population parameter through sample statistics. To support this process we should be somewhat confident we have a relatively homogeneous medium for which data was obtained. Here, the standard applies to recreational waters, shoreline to one thousand feet offshore. From this definition, both shoreline and nearshore monitoring results defined the body of water for which compliance evaluation is required. Data from the Hammer Point and Iroquois Point stations were not included because they do not comply with the criterion of relatively homogenous; e.g., brackish water instead of open coastal. We define the body of water from the shoreline out to the nearshore stations as open coastal and relatively homogenous. Because of this, all shoreline and nearshore data can be used to evaluate compliance with the recreational standards, instead of evaluating compliance at a specific monitoring station or a monitoring station depth. From a temporal perspective, data from January 1989 to May 2004 were used for the compliance evaluation. There is no evidence to show that the data is incorrect. Moreover, the more data points we obtain, the closer the sample statistic approach the population parameters.

The sample geometric mean (based on all shoreline and nearshore station results from January 1989 to May 2004) was calculated to be 2 cfu/100mL.

Because an estimate approach is being applied, specifically, the sample geometric mean, a method to include the associated error must be addressed. Here, the Upper Confident Limit (UCL) for 95% confidence will be applied; i.e., compliance will be determined by comparing the UCL of the sample geometric mean against the standard (7 cfu/100 mL enterococcus).

To initiate the process, we assume the statistic is lognormal distributed. The assumption is based on plotting the histogram of the sample results obtained from January 1989 to May 2004; see figure below.



Performing the W test for the logarithms of the data showed that the null hypotheses (H_o; The population has a lognormal distribution) could not be rejected, so the assumption of a lognormal distribution is acceptable.

The next step was to determine the 95% Upper Confidence Limit ($UCL_{95\%}$) of the sample geometric mean. A proven theorem shown to produce reasonably conservative estimates of the 95% UCL of the sample geometric mean is the Chebychev Theorem, which defines the $UCL_{95\%}$ as:

$$UCL_{95\%} = \bar{x} + 4.47 \frac{sd}{\sqrt{n}}$$

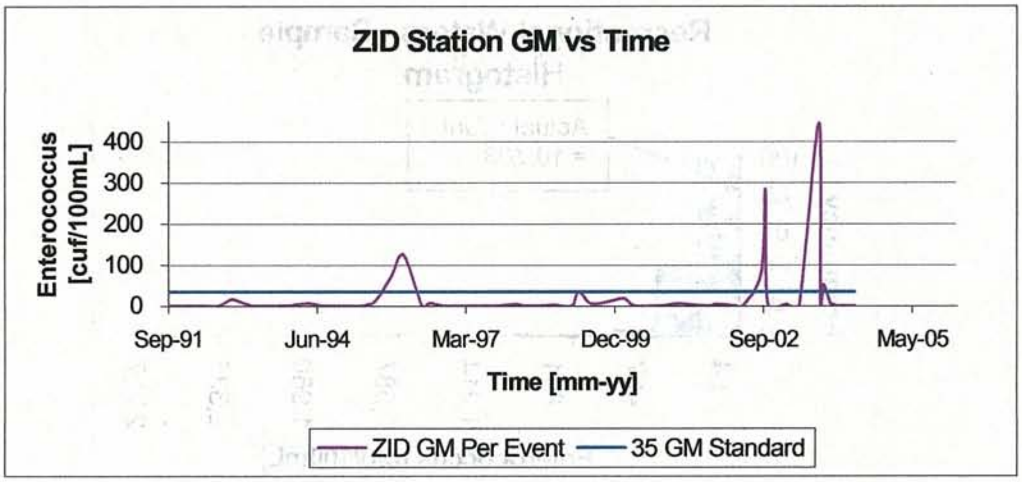
where $\bar{x}$ = 2: sample geometric mean; sd = 1.06: sample standard deviation; and n = 10,754: sample size.

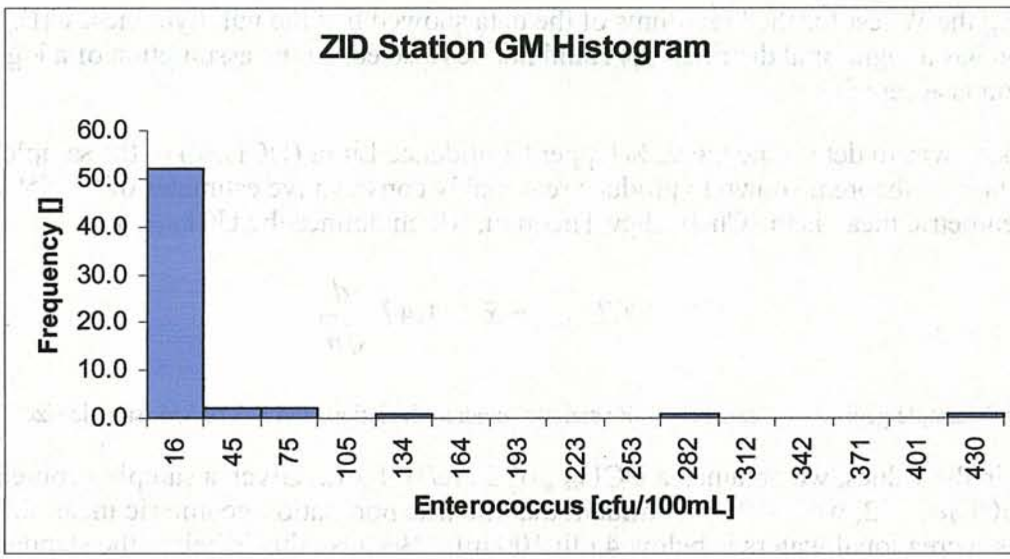
Plugging in the values, we obtained a $UCL_{95\%}$ of 2 cfu/100 mL. Given a sample geometric mean of 2 and a $UCL_{95\%}$ of 2, we are 95% confident that the true population geometric mean for the region defined as recreational waters is below 4 cfu/100 mL. Because this is below the standard of 7 cfu/100mL, we are compliant with the Hawaii Water Quality standard for enterococcus.

A similar analysis were performed on the offshore stations. Here the relatively homogeneous region is defined as the Zone of Initial Dilution (ZID) boundary. ZID surface stations HB-2, HB-3, HB-4, and HB-5 were included in the analyses. The data set duration was September 1991 to May 2005 because the offshore monitoring program was changed around the September 1991 period. The W test for the logarithms of the data was done and the null hypotheses (H_o; The population has a lognormal distribution) could not be rejected, so our assumption of a lognormal distribution is acceptable.

The sample geometric mean and $UCL_{95\%}$ were calculated to be 3 cfu/100 mL and the 4 cfu/100 mL, respectively, based on a sample size of 101 and a sample standard deviation of 1.83. We are 95% confident that the true population geometric mean for the region around the ZID boundary is below 7 cfu/100 mL.

Additional analyses was done, see figures below, to evaluate obvious trends or departures from the established assumptions. The figures below do not show an obvious pattern or trend and does support the lognormal distribution determination.





Corroborating Data from the Hawaii Department of Health

The Hawaii Department of Health conducts its own independent water quality monitoring program at some 159 stations throughout the state. Two of these can be used to compare with the data collected by the city through its NPDES permit monitoring program. These are Station 189 at Ewa Beach and Station 213 at Barbers Point. Data obtained from the state's Annual Blue Water Reports for 1989 through 1991 show that the enterococci annual geometric means for 1989, 1990 and 1991 at Ewa Beach were 1.8, 1.3 and 2.0, respectively, which are well below the 7.0 standard. Barbers Point data (no values in 1989) for 1990 and 1991 had reported calculated values of 1.2 and 1.0, respectively, again well below the 7 standard for enterococcus.

No Warnings Posted on Local Beaches

Posting of beaches to warn users of potential health risks has not occurred in the area. The criterion used by the Hawaii Department of Health for the posting of beaches is that 50 percent of the geometric mean values for the preceding 12 months must exceed the 7 colonies/100 mL standard.

Table G.1-2. Nearshore Enterococcus Sampling Results
January 1989 through May 2004
Samples with Greater than 50 colonies/100 ml

Nearshore Sampling Results Summary – Honouliuli
(total of 6,839 samples)

		Colonies Greater Than or Equal to:			
Station	**No. of Samples**	**>50**	**>100**	**>200**	**Percent >50**
HN-1					
Surface	**834**	**8**	**2**	**1**	**0.96**
Bottom	**811**	**15**	**7**	**5**	**1.9**
HN-2					
Surface	**1036**	**28**	**12**	**6**	**2.7**
Bottom	**821**	**41**	**11**	**9**	**5.0**
HN-3					
Surface	**893**	**18**	**6**	**11**	**2.0**
Bottom	**818**	**33**	**7**	**6**	**4.0**
HN-4					
Surface	**820**	**9**	**4**	**3**	**1.1**
Bottom	**806**	**18**	**10**	**3**	**2.2**
TOTAL	**6,839**	**170**	**59**	**44**	

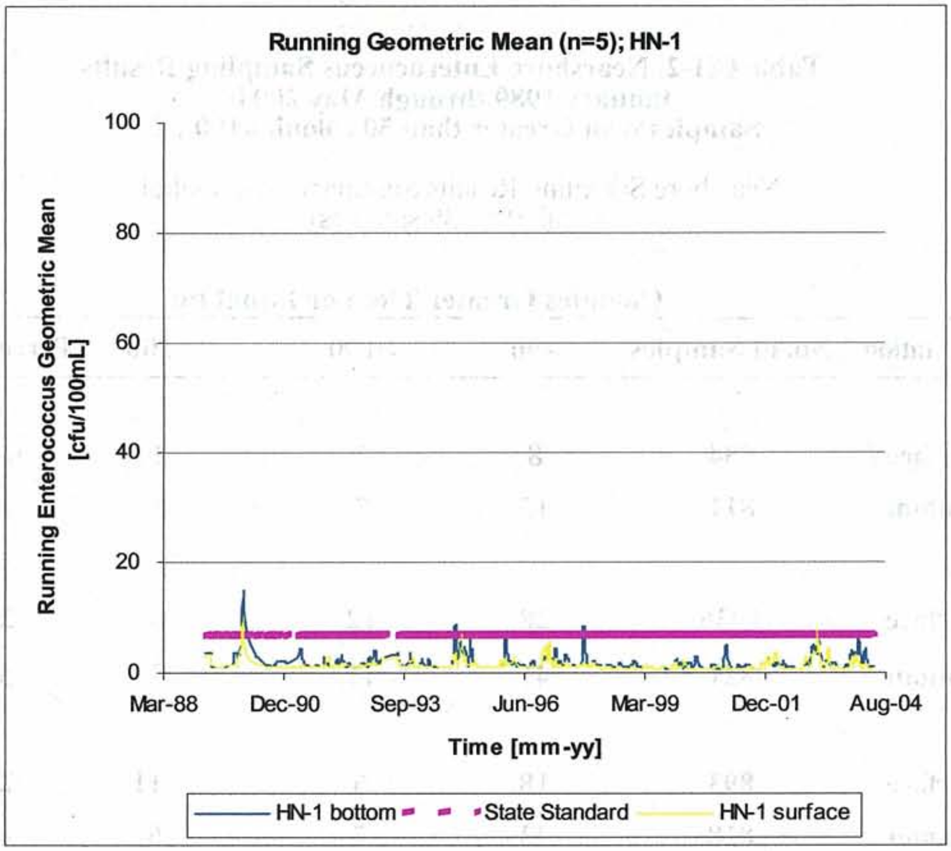


Figure G.1-8

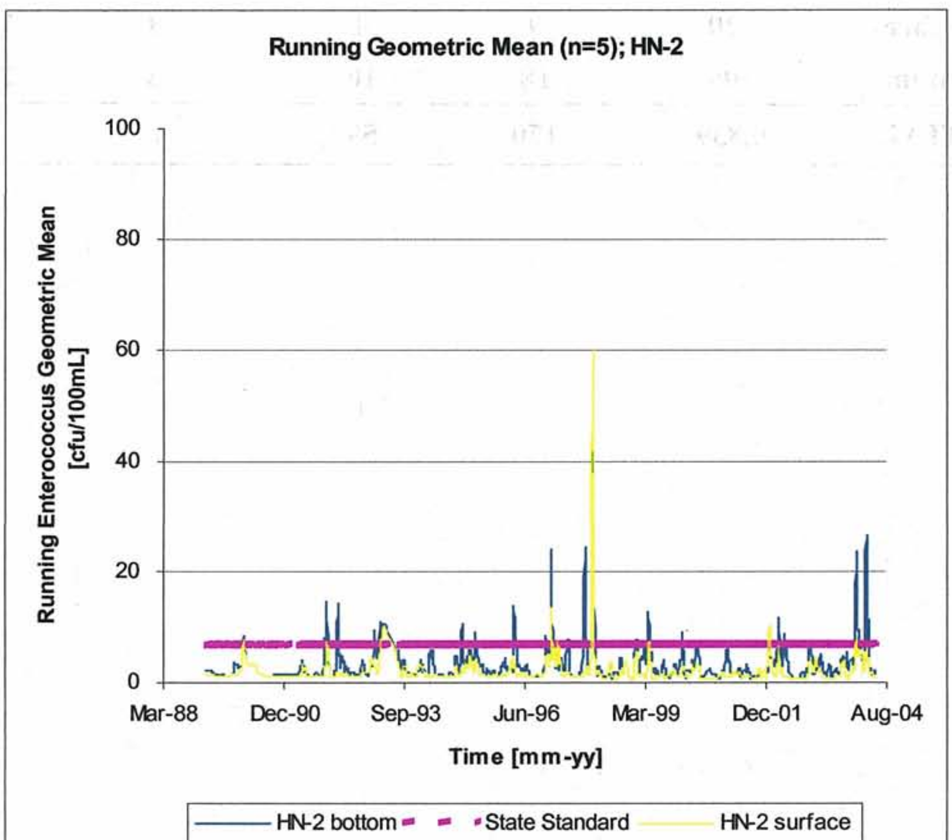


Figure G.1-9

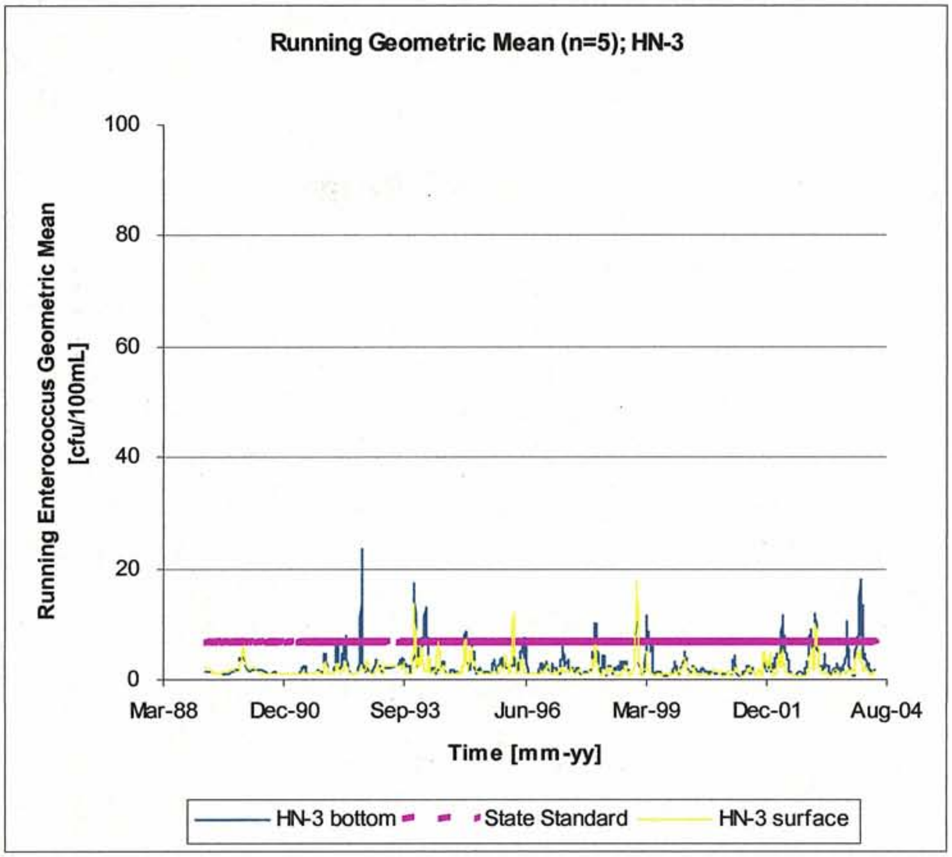


Figure G.1-10

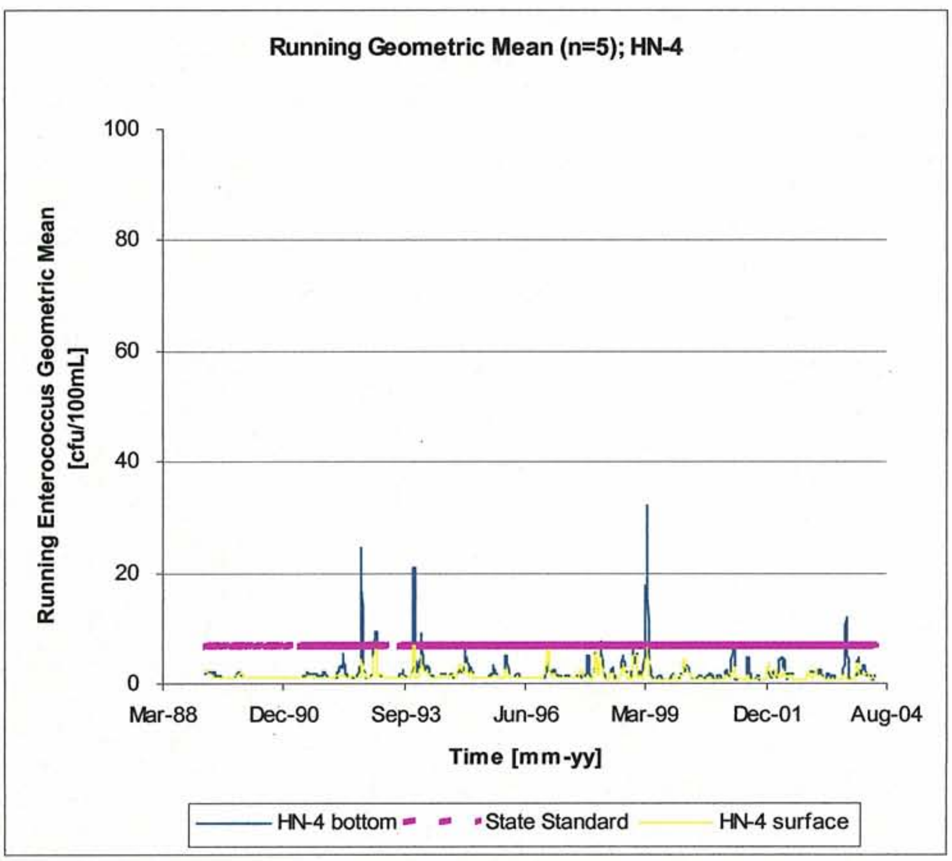


Figure G.1-11