Appendix D

Chlordane/Dieldrin

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Chlordane/Dieldrin

I. BACKGROUND

When the SIWWTP NPDES 301(h) permit was issued September 30, 1998 it included influent and effluent test requirements and effluent limits for chlordane and dieldrin, two very persistent chlorinated pesticides. The permit limits are based on the initial dilution numbers included in the permit as calculated for the SIWWTP diffuser by EPA and on Hawaii State Water Quality Standards (WQS) for these chemicals; see Appendix F. The WQS limits are multiplied by the calculated dilution numbers to set the permits acute and chronic limits.

Since reissuance of the SIWWTP NPDES 301(h) permit the discharge has exceeded the acute discharge limits once for chlordane in February of 1999 and once for dieldrin in May 2002, apparently due to a slug discharges. The SIWWTP has exceeded the chronic (annual average) effluent discharge limit for chlordane and dieldrin since a valid annual average was established twelve months after the permit went into effect. Since 1998 Chlordane levels have averaged roughly 10 times the chronic permit limit while dieldrin has averaged roughly 5 times the chronic discharge limit.

Chlordane was first marketed in 1948 and dieldrin in 1950. They were popular agricultural pesticides and were also widely used for termite control. Dieldrin was banned for agricultural uses in 1974 and for termite control in 1987. Chlordane was banned for agricultural uses in 1983 and for termite control in 1988. They were both heavily used in Honolulu, before being banned, for ground treatment of termites and were sold to the public through home and harden outlets up until approximately 1984. Based on research of records at the State Department of Agriculture, hundreds of thousands of gallons of these chemicals were applied for termite control in addition to that imported for agricultural purposes. Personal communication with exterminator for domestic termite control, indicate copious quantities were applied (e.g., saturating the soil) as the standard practice. It is, therefore, hypothesized that the source of chlordane and dieldrin in the SIWWTP wastewater (influent and effluent) is from chemicals applied from 1950 to 1988 leaching from the soil and entering the sewer system as a component of infiltration and inflow (I/I). Since these were essentially the only chemicals in use for ground control of termites during much of this period, all areas of the City were probably affected. Due to the methods of construction and to application trends, residential areas were more heavily treated than commercial or industrial areas. In addition, based on stories told by appliers to regulators and retold by the regulators, Asian residents had their yards treated more frequently than other

ethnic groups. Also, during this period, homes (their yards) were required to be treated for termites before they could receive federal loan guarantees. This practice led to almost universal contamination of residential areas by these pesticides.

The chemical limits in HAR, Title 11, Chapter 54 are based on US EPA limits, divided by three. The limit was reduced to be protective of fishermen and others in Hawaii since the consumption of fish in Hawaii is higher than on the mainland. The State of Hawaii is planning to review limits based on data gathered since the limits were set and may raise the allowable limits to the EPA limit for some chemicals.

From December 14, 1976 until August of 1978 screened wastewater, wastewater containing grit and sludge was discharged through the SIWWTP deep ocean outfall. After August 1978 grit was removed but sludge continued to be discharged with the wastewater until June of 1979. Based on studies of the area around the original shallow Sand Island Outfall, used until December 1978, some solids in the less than primary treated wastewater would have settled in the vicinity of the deep ocean outfall until the current treatment plant was completed and full primary treatment provided. To check on the possible effect of past discharges, samples of grit and sludge were tested for these chemicals during the second sampling, to be discussed later in this report.

II. THE PERMIT REQUIREMENT FOR CHLORDANE AND DIELDRIN

The acute and chronic standards for chlordane and dieldrin for receiving waters are contained in HAR, Title 11, Chapter 54. For purposes of compliance to the acute standard the permit converts these standards to an effluent concentration by using a dilution ratio of 94 to one. The average annual discharge limitation is the fish consumption (carcinogen) criterion times the long-term dilution value of 476:1. The effluent discharge limits calculated by these dilution values in µg/L contained in the permit are:

	Acute (Avg. Daily)	Chronic (Annual Avg.)
Chlordane	0.38	0.0076
Dieldrin	0.18	0.012

Assuming a density for chlordane and dieldrin of 1.6, these values equate, for chlordane for acute exposure to 1.4 gm per million gallons and for chronic exposure to 0.03 gm per million gallons. For dieldrin the Acute level is 0.68 gm per million gallons and for chronic 0.045 gm per million gallons.

II.a. EFFLUENT DISCHARGE LEVELS FOR CHLORDANE AND DIELDRIN

The recorded effluent discharge levels for chlordane and dieldrin from the SIWWTP are shown in Table 1 and in Figures 1 and 2. For the plant in 2002

average actual discharge, total for both chemicals was less than a tablespoon per day in 69.56 million gallons of wastewater.

II.b. COLLECTION SYSTEM SAMPLING - PLAN FOR CHLORDANE AND DIELDRIN

As noted above the manufacture and use of chlordane and dieldrin has been banned since the 1980s. These chemicals are very stable and have very low solubility and therefore persist in the soil for very long periods. In discussions, regulators have mentioned that soil samples taken adjacent to houses in Manoa and Palolo have ranged as high as tens of parts per million for these chemicals. In urban streams the highest levels of contamination have been recorded when essentially all stream flow was from groundwater discharge. It is therefore conjectured that the probable source of these chemicals in the collection system is from soil leaching and the I/I of contaminated water and soil into sewer lines of the wastewater collection system.

A sampling program was undertaken to test for these chemicals when the majority of the flow in the collection system should be ground water infiltration (I/I). This was done by collecting samples from drainage basins with both high and low dry weather infiltration (DWII) and areas known or thought to have received high and much lower levels of chemical application. The samples were collected at times (1:30 am to 3:30 am) when residential water use is low.

In the initial set of tests, samples collected February 25, 2002, the MDL/PQL levels were too high to measure chlordane in any of the samples. Dieldrin was measured in seven of 12 samples tested, despite the high MDL/PQL. As a result of the high PQL in the first set of tests a second set of testing was scheduled. Since the object was to obtain samples representative of what is transported to the SIWWTP it was necessary to avoid periods of rain when inflow rates are high. This resulted in multiple delays when sampling had to be rescheduled, funding renewed, again scheduled and rescheduled and the second set of samples were not obtained until November 26, 2002. All samples from the second set of samples tested positive for chlordane and dieldrin. However all samples were flagged and one of two trip blanks tested positive for a low level of chlordane. The results of both sets of tests are presented in Table 2 and discussed in section II.c. below.

The Division of Collection System Maintenance, based on extensive knowledge of the collection system and neighborhoods, and the Division of Environmental Quality, who set the criteria for locating sampling stations, selected locations sampled with input. The selection criteria included: 1) Areas having received both heavy and lighter applications of chlordane and dieldrin. 2) Areas with both high and low rates of DWII, and therefore having marked variations or peaks in flow. 3) Areas of different ages, densities and zoning. 4) And areas with reported high levels of pesticides in the surface drainage system (stream[1]) and therefore

probably having high levels in the ground water entering the collection system. Locations selected include areas known to have termite problems[2] and therefore assumed to have a history of use of chlordane and dieldrin for termite control. The only areas in the collection system thought to have received minimal applications are recently developed residential areas and industrial areas. Even these areas, as former agricultural lands, may have received repeated applications of the chemicals, used for years as agricultural pesticides before their use was restricted to termite control.

II.c. COLLECTION SYSTEM LEVELS FOR CHLORDANE AND DIELDRIN

Samples were collected during the early morning hours to maximize the percentage of infiltration in the samples. Maps of the specific sites from which samples were collected are included in Appendix D1.

It was concluded, from the first set of tests, that none of the areas tested had exceptionally high levels of chlordane. This was conformed during the second set of tests when the highest level of chlordane was 0.38 µg/L, equal to the daily limit and almost double the second highest level detected. The second set of tests also indicates that there is significant variation in the levels of chlordane in samples from different areas, ranging from 0.0468 to 0.38 µg/L, a variation of 8 fold. For dieldrin the range in the second sampling was much less, ranging from 0.0024 to 0.00443 µg/L a variation of less than two. This was much less than the variation in the first set of samples when the seven samples in which Dieldrin was detected ranged from 0.00837 to 0.102 µg/L a range of over 12 times. In absolute numbers, the highest level detected in the second sampling was approximately half of the minimum level detected in the first sampling. If these levels of dieldrin had been present in the first sampling, most or all samples would have tested negative for dieldrin. This leads us to conclude that there is significant variation in the amount of these chemicals leached into the collection system at any specific time, probably due to such factors as temperature, amount of recent rainfall and or outside watering, level of the water table, etc. The amount of rainfall in the two to three weeks before the second sampling was significantly higher than the amount of rain in the two to three weeks before the first sampling.

In the first sampling Dieldrin was detected in seven of the twelve drainage areas sampled. The areas where dieldrin was detected have many or have mostly older homes and many or the majority of residents are predominantly Asian. Areas that conform to this pattern are Waialae Nui, Waialae, Palolo Valley, St Louis Heights, Moiliili/McCully and Pacific Heights/Nuuanu. This was true even though four of the areas where dieldrin was detected had low or very low infiltration levels. No dieldrin was detected in areas classed as new (much or mostly built after the mid 1970's) or as mixed commercial/residential (Ala Moana) or mixed single/multifamily (Salt Lake and Makiki). These areas generally had low or low to moderate infiltration and a more uniform ethnic mix. Fort Shafter, which had relatively low I/I and which is mostly non-asian, is thought to have treated for

termites less frequently and perhaps with chemicals other than chlordane and dieldrin, had no dieldrin detected.

Wilhemina Rise, one of the two remaining areas, has a mix of older and newer single family homes, low infiltration and mixed ethnicity. Dieldrin was detected in this area at a very low level (0.008 µg/L, approx. 40% of the PQL).

In Manoa, the final area, no dieldrin was detected. Since the age, density and ethnicity of Manoa Valley is very similar to Palolo Valley, the areas with the highest detected dieldrin levels, the I/I study was checked. It was found that the sub-basins in the Manoa drainage area had low dry weather I/I rates, one tenth to one half those in the Palolo basin. This low dry weather I/I rate appears to be the most likely explanation for dieldrin not being detected.

During the second sampling chlordane and dieldrin was measured in every sample. The pattern seen of concentrations generally supports the original hypothesis. The one newer area, Salt Lake, had the lowest results for both chlordane and dieldrin. Fort Shafter, an area with a low Asian population and one of the ND areas in the first sampling tested very low for dieldrin and moderate for chlordane. On a comparative basis the sub basins with significant Asian populations again tested high to moderate for dieldrin and high to moderate for chlordane.

There were some changes in the base flow between the two sampling events, assumed to be due to changes in the infiltration rates, probably due to local showers in the time period shortly before the sampling event. The changes appeared to be in the expected range for the areas involved.

The biggest surprise from comparing the data was the relative insensitivity of the results and infiltration rates. The levels of chlordane and dieldrin detected appeared relatively insensitive to the rates as long as there was some infiltration. The variations in levels detected appear to be more effected by other factors but it is not fully clear what those factors are. It seems reasonable that the factors include the ground temperature, the amount of rainfall and the rate at which it fell and the timing of rainfall. It is assumed that gentle rainfall in relatively small doses so that the residence time of the water in the soil zone treated with chlordane and dieldrin is maximized would result in higher contamination levels while frequent heavy rain would probably result in lower levels of contamination due to dilution and to lover average residence time in the zone of soil contaminated with these organochlorine pesticides.

[1]. USGS data – see Tables 3 and 4.
[2]. Based on knowledge of housing materials used.

TABLE 1

SIWWTP - CHLORDANE AND DIELDRIN DATA - INF & EFF µg/L

Date	Chlordane Influent	Chlordane Effluent	Dieldrin Influent	Dieldrin Effluent	Date	Chlordane Influent	Chlordane Effluent	Dieldrin Influent	Dieldrin Effluent
1985		0		0	3/00	0	0	0.013	0.009
1988		0		0	4/00	0.279	0.23	0.095	0.066
1990		0		0	5/00	0	0	0.025	0.02
1991		0		0	6/00	0	0	0	0.018
1991		0		0	7/00	0.156	0.374	0.015	0.009
1992		0		0	8/00	0.126	0	0.086	0.043
1992		0		0	9/00	0.082	0.091	0.021	0.02
1993		0		0	10/00	0.083	0.078	0.02	0.02
1993		0		0	11/00	0	0	0.007	0.007
1994	0	0	0	0	12/00	0.057	0	0.017	0.013
1994	0	0	0	0	1/01	0.078	0.063	0.017	0
1995	0	0	0	0	2/01	0.131	0.084	0.045	0.031
1995	0.13	0.185	0	0.016	3/01	0.087	0	0.02	0.014
1996	0	0	0	0	4/01	0.066	0	0.023	0.015
1996	0	0	0	0	5/01	0.113	0.084	0.046	0.029
1997	0	0	0	0	6/01	0.091	0.056	0.039	0.022
1997	0	0	0.03	0	7/01	0.064	0	0.02	0.013
1998	0	0	0.09	0.06	8/01	0.069	0	0.026	0.019
1998	0	0	0	0	9/01	0.063	0	0.018	0.014
11/98	0.14	0	0.04	0.02	10/01	0.091	0	0.03	0.023
12/98	0.194	0.135	0.044	0.015	11/01	0.094	0.075	0.031	0.024
1/99	0.083	0.064	0.016	0.01	12/01	0.09	0.057	0.024	0.014
2/99	0	**2.96**	0.018	0.018	1/02	0.077	0.062	0.008	0.01
3/99		0.062		0.013	2/02	0.247	0.177	0.097	0.065
4/99	0	0.085	0	0.04	3/02	0.084	0.068	0.02	0.015
5/99	0.089	0.111	0.028	0.024	4/02	0.093	0.072	0.023	0.017
6/99	0.092	0.157	0.017	0.032	5/02	0.162	0.106	0.232	**0.189**
7/99	0.07	0.07	0.04	0.03	6/02	0.077	0	0.018	0.015
8/99	0.09	0.062	0.03	0.02	7/02	0.101	0	0.024	0.016
9/99	0.065	0	0.014	0.02	8/02	0.098	0.067	0.028	0.017
10/99	0	0	0.018	0.016	9/02	0.094	0.074	0.024	0.015
11/99	0.09	0.067	0	0	10/02	0.198	0.128	0.016	0.011
12/99	0.093	0.062	0.021	0.016	11/02	0.082	0	0.019	0.012
1/00	0	0	0.018	0.011	12/02	0	0	0.019	0.014
2/00	0	0	0.018	0					

All samples tested are 24 hour composite samples * Not sampled

All results are parts per billion ppb or µg/L

A "0" result indicates that chemical was not detected in the sample.

FIGURE 1
SIWWTP
CHLORDANE - INFLUENT AND EFFLUENT VALUES AND PERMIT LIMITS

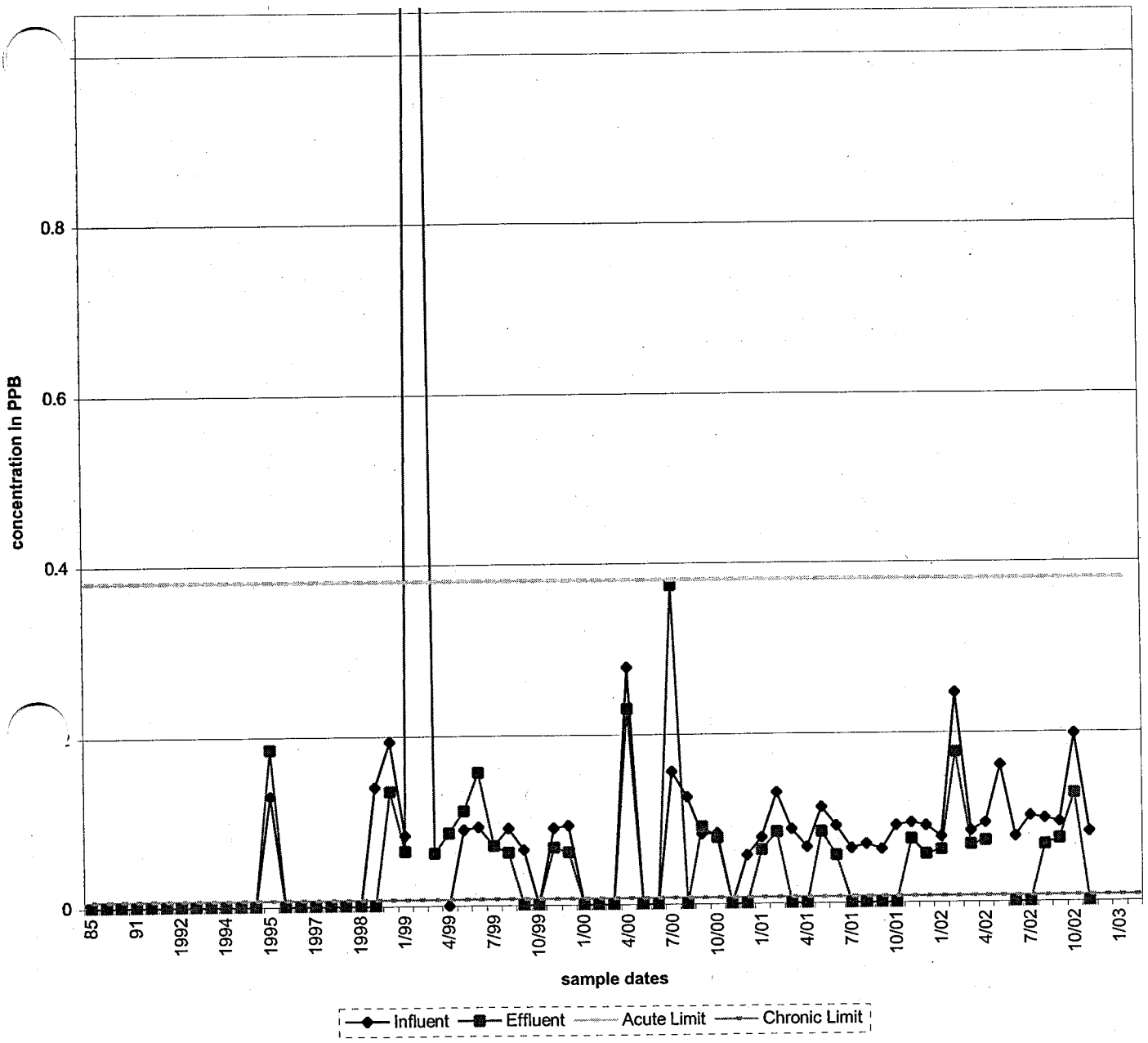


FIGURE 2
SIWWTP
DIELDRIN - INFLUENT AND EFFLUENT VALUES AND PERMIT LIMITS

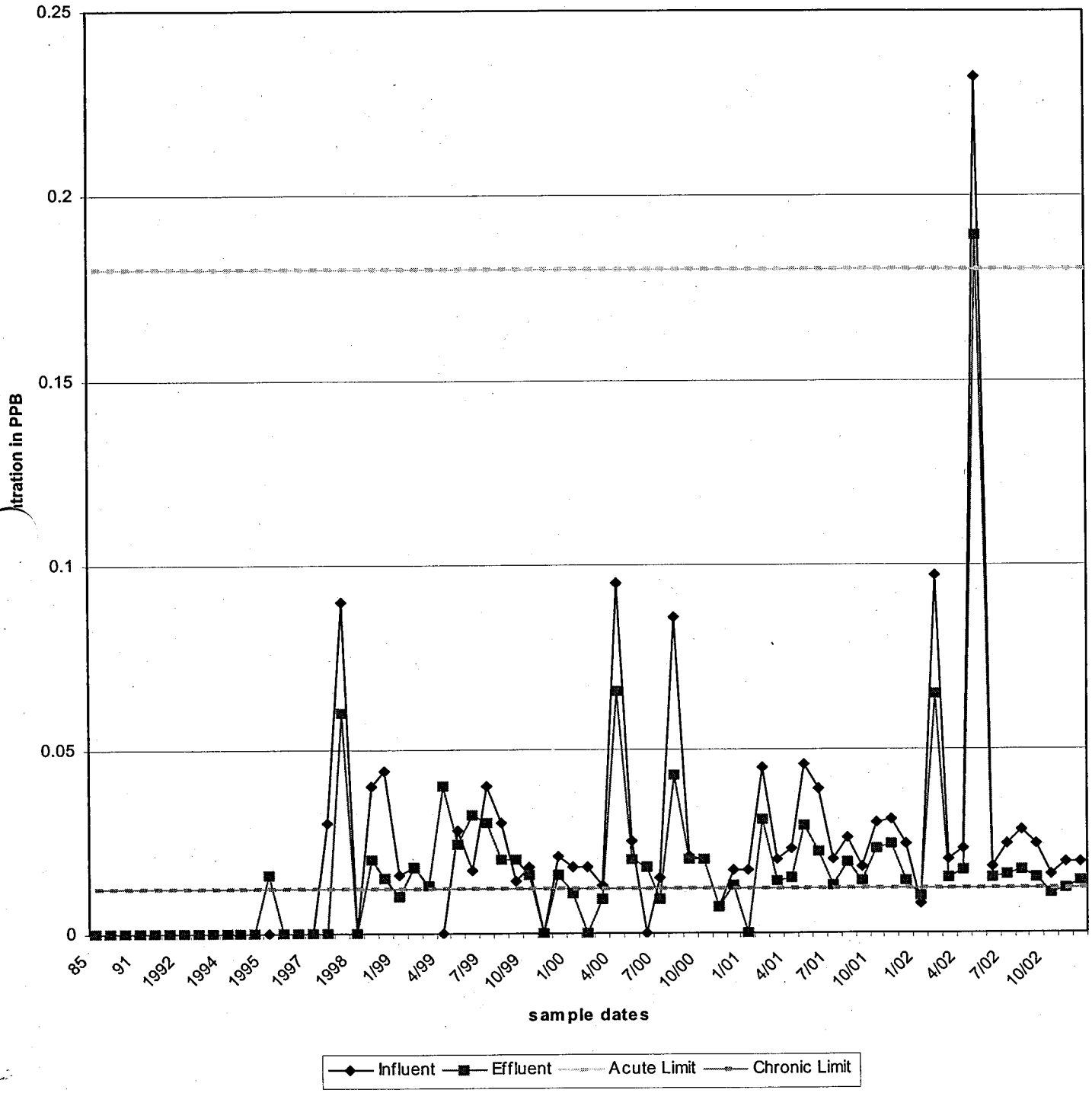


TABLE 2
SAND ISLAND WASTEWATER COLLECTION SYSTEM
CHLORDANE AND DIELDRIN SAMPLING RESULTS

Site No.	MH depth 24 hr clock TIME/TIME	Infiltration Rate 1ST/2ND	Water Depth 1ST/2ND	Flow Velocity 1ST/2ND	Relative Age/type Ethnicity	Chlordane□g/ First sample/second sample [PQL/MDL]/[PQL/MDL]	Dieldrin□g/ First sample/second sample [PQL/MDL]/[PQL/MDL]
3 Waialae Nui	7' 3" 0128/0140	"Very low/ Low	2/2	0/3	Old/single Mixed	ND/**0.201** [4.0/0.40]/[0.0121/0.0039]	**0.0135/0.0203** [0.02/0.002]/[0.00242/0.00036]
4 Wilhemina Rise	6' 8" 0157/0158	Low/ Low	2/2	1/1	Mixed/single Mixed	ND/**0.196** [0.106/0.034]/[0.0157/0.005]	**0.00837/0.0211** [0.021/0.0032]/[0.0031/0.00047]
5 Waialae	9' 4" 0142/0208	Moderate/ Moderate-high	3.5/4	2/4	Old/single Asian	ND/**0.19** [0.165/0.053]/[0.0125/0.004]	**0.135/0.0222** [0.033/0.0050]/[0.0025/0.00038]
6 Palolo Valley	11' 0224/0219	Low-moderate/ Low-moderate/	3/3	2/2	Old/single	ND/**0.192** [0.115/0.038]/[0.012/ 0.0038]	**0.0346/0.0182** [0.024/0.0036]/[0.0024/0.00036]
8 St Louis Heights	5' 6" 0243/0231	Low/ Low	2/2	1/1	Old/single Asian	ND/**0.141** [0.106/0.034]/[0.0127/0.004]	**0.0197/ 0.0242** [0.021/0.0032]/[0.0025/0.00038]
9 Manoa	12' 0308/0314	Low/ Low	8/4	1/2	Old/single Asian	ND/**0.38** [4.0/0.40]/[0.0189/0.006]	ND/ **0.0652** [0.02/0.002]/[0.00377/0.00057]
10 Moiliili/McCully	13' 0308/0239	High/ Low	10/4	3/1	Old/single Asian	N D/**0.114** [0.183/]/[0.0126/0.004]	**0.0307/ 0.0266** [0.037/0.0032]/[0.0025/0.00038]
11 Makiki	6' 2" 0213/0223	Low-moderate/ Low	2/3	3/1	Old/mixed* Mixed	ND/**0.0557** [0.176/]/[0.0126/0.004]	ND/ **0.00422** [0.035/0.0032]/[0.0025/0.00038]
12 Ala Moana	6' 8" 0230/0248	Moderate/ Low-moderate	3/2	3/4	Old/mixed Mixed	ND/**0.288** [0.157/]/[0.0222/0.0071]	ND/ **0.0126** [0.031/0.0032]/[0.0044/0.00067]
13 Pacific Heights/Nuuanu	5' 8" 0213/0210	Low/ Low	4/4	1/1	Old/single Asian	ND/**0.162** [0.173/]/[0.0139/0.0044]	**0.102/ 0.0363** [0.035/0.0032]/[0.0028/0.00042]
15 Salt Lake	25' 0137/0143	High/ Moderate-high	8/7	2/2	Newer/mixed Mixed	ND/**0.0468** [0.117/]/[0.0134/0.0043]	ND/ **0.00307** [0.023/0.0032]/[0.0027/0.0004]
16 Fort Shafter	4' 7" 0157/0157	Low/ Low	2/2	1/1	Old/single Mixed	ND/**0.148** [0.179/0.032]/[0.0146/0.0047]	ND/ **0.00327/**] [0.036/0.0032]/[0.0029/0.00044]

Note: infiltration rating is based on observed velocity and depth and the size of the drainage area.

III. PRIOR CHLORDANE AND DIELDRIN TESTING

As noted above the manufacture and use of chlordane and dieldrin have been banned for both agricultural use and for the treatment of termites since the 1980's. These chemicals are very stable with very low solubility in water and therefore persist in the soil for very long periods. Minute quantities are leached from the soil by rain and watering of lawns and gardens into the ground water. Rain and over-watering can result in the washing of contaminated soil overland into drainage courses and probably also into sewer lines that have open joints, cracks and other defects. It can also be washed off vegetables, out of clothes and off hands to enter the collection system. The USGS has done limited testing of the streams in the Metro Honolulu area. The results are presented in Tables 3 and 4, below. Not included in these tables are remarks by USGS personnel that the highest levels of dissolved Dieldrin were detected when stream flows were at their lowest. Low stream flows correspond to periods when much or most of the flow in the stream is from shallow ground water seeping into the streams from adjacent developed land and from surface drainage from potable water use in adjacent residential neighborhoods that flows to storm drains and into streams.

TABLE 3
CHLORDANE AND DIELDRIN IN KALIHI STREAM – USGS DATA

Results in µg/L or µg/kg Stream and Location	Date Tested	Chlordane Technical Total (aqueous)	Chlordane in Sediment	Dieldrin Total (aqueous)	Dieldrin in Sediment
Kalihi Stream @ Kalihi	6-16-75	U		U	
Kalihi Stream @ Kalihi	9-15-75	U		0.480	
Kalihi Stream @ Kalihi	11-17-75	U	230	0.180	230
Kalihi Stream @ Kalihi	2-19-76	U		U	
Kalihi Stream @ Kalihi	4-27-76	U	330	U	48
Kalihi Stream @ Kalihi	8-24-76	U		0.030	
Kalihi Stream @ Kalihi	11-22-76	U		0.040	
Kalihi Stream @ Kalihi	2-22-77	M		0.040	
Kalihi Stream @ Kalihi	6-27-77	U	2100	0.010	320
Kalihi Stream @ Kalihi	9-26-77	U		0.030	
Kalihi Stream @ Kalihi	12-27-77	U	910	U	170
Kalihi Stream @ Kalihi	5-16-78	U		0.030	
Kalihi Stream @ Kalihi	8-15-78	U		U	
Kalihi Stream @ Kalihi	11-07-78	U		0.020	
Kalihi Stream @ Kalihi	3-19-79	U		U	
Kalihi Stream @ Kalihi	5-21-79	U	410	U	79
Kalihi Stream @ Kalihi	8-20-79	U		0.040	
Kalihi Stream @ Kalihi	12-10-79	U		U	
Kalihi Stream @ Kalihi	2-19-80	U		U	

TABLE 3
CHLORDANE AND DIELDRIN IN KALIHI STREAM – USGS DATA (CONTINUE)

Results in µg/L or µg/kg Stream and Location	Date Tested	Chlordane Technical Total (aqueous)	Chlordane in Sediment	Dieldrin Total (aqueous)	Dieldrin in Sediment
Kalihi Stream @ Kalihi	5-27-80	U		U	
Kalihi Stream @ Kalihi	8-25-80	U		U	
Kalihi Stream @ Kalihi	12-01-81	U	830		87
Kalihi Stream @ Kalihi	2-23-82	0.1		0.030	
Kalihi Stream @ Kalihi	4-27-82	0.1	410	0.020	48
Kalihi Stream @ Kalihi	7-18-00		*72/77		180

U = analyzed for, not detected
M = presence verified, not quantified
* cis-chlordane/trans-chlordane

IV. CHLORDANE AND DIELDRIN IN RECEIVING WATERS

Since 1990 The City and County of Honolulu has conducted compliance sampling of ocean sediment at locations designated by its NPDES 301(h) permits to determine the effect of the discharge of wastewater on receiving waters. The sampling points are shown in Figure 3 for 1990 through 1998, Figure 4 for 1999, 2000 and 2002 and in Figure 5 for 2001. The results of tests for chlordane and dieldrin are shown in Table 5. For a list of stations sampled for Priority Pollutants see Table 7. Chlordane was found in 10 of approximately 275 sediment samples, all from near the Sand Island deep Ocean diffuser. Dieldrin was not detected.

Starting in 1991 three species of fish living in the immediate vicinity of the SIWWTP deep ocean outfall have been sampled and tested for priority pollutants including chlordane and dieldrin. In 1993 chlordane was detected in two species at low levels, and in 1994 in one species. Since 1994 neither chlordane nor dieldrin has been detected in the flesh of fish tested. In 1995 in addition to the standard test of fish flesh, the livers of the fish caught were also tested but neither chlordane nor dieldrin was detected. In 1999 the number of species tested each year was reduced to two. Dieldrin has never been detected in any tests. For a summary of results see Table 6.

TABLE 4
CHLORDANE AND DIELDRIN IN MANOA STREAM – USGS DATA

Stream and Location	Date Tested	Chlordane Technical	Dieldrin Dissolved	Dieldrin Total
Manoa Stream @ Kanewai Fld	7-20-99	-	<0.001	-
Manoa Stream @ Kanewai Fld	7-22-99	-	0.073	-
Manoa Stream @ Kanewai Fld	7-22-99	-	0.018	-
Manoa Stream @ Kanewai Fld	8-17-99	-	0.052	-
Manoa Stream @ Kanewai Fld	9-14-99	-	0.043	-
Manoa Stream @ Kanewai Fld	10-05-99	-	0.064	-
Manoa Stream @ Kanewai Fld	10-19-99	-	<0.001	-
Manoa Stream @ Kanewai Fld	10-25-99	-	0.032	-
Manoa Stream @ Kanewai Fld	11-02-99	-	0.050	-
Manoa Stream @ Kanewai Fld	11-07-99	-	0.040	-
Manoa Stream @ Kanewai Fld	12-10-99	-	0.015	-
Manoa Stream @ Kanewai Fld	12-20-99	-	0.076	-
Manoa Stream @ Kanewai Fld	1-18-00	-	0.029	-
Manoa Stream @ Kanewai Fld	1-18-00	-	0.037	-
Manoa Stream @ Kanewai Fld	1-19-00	-	0.025	-
Manoa Stream @ Kanewai Fld	2-16-00	-	0.056	-
Manoa Stream @ Kanewai Fld	3-14-00	-	0.047	-
Manoa Stream @ Kanewai Fld	4-02-00	-	0.050	-
Manoa Stream @ Kanewai Fld	4-02-00	-	0.054	-
Manoa Stream @ Kanewai Fld	4-11-00	-	0.077	-

Manoa Stream @ Kanewai Fld	5-24-00	-	0.062	-
Manoa Stream @ Kanewai Fld	6-20-00	-	0.045	-
Manoa Stream @ Kanewai Fld	11-03-00	-	0.024	-
Manoa Stream @ Kanewai Fld	12-13-00	-	0.056	-
Manoa Stream @ Kanewai Fld	1-17-01	-	0.032	-
Manoa Stream @ Kanewai Fld	2-21-01	<0.1	0.048	0.049
Manoa Stream @ Kanewai Fld	6-05-01	-	0.034	-

TABLE 5

SI NPDES Sediment Sampling Test Program

Locations where detected	Year – Number of Samples	Chlordane		Dieldrin		Refer to Figure
		Test Result, PPB	Avg PQL	Test Result, PPB	Avg PQL	
	1990 - 17		0.2		0.2	3
	1992 - 17		0.22		0.24	3
	1993 - 17		15		0.1	3
	1994 - 18		0.5		0.1	3
B3,Z3	1995 - 18	0.17, 3.4	0.15	ND	0.31	3
B3,Z1,Z2	1996 - 19	2.1, 1.9, 2.1	1.5		0.30	3
Z1,Z2	1997 - 23	1.7, 3.6	1.5		0.29	3
B3,Z3	1998 - 23	1.7, 1.7	1.5		0.3	3
	1999 - 23		2		2	4
	2000 - 25		1		1	4
	2001 - 46		1.7		1.7	5
	2002 - 25				1.7	4

ND or no entry – Not detected

All data in ppb - µg/kg dry wt

TABLE 6
SI Outfall NPDES Fish Sampling Test Program

Year	Akule [chlordane]	Menpachi [chlordane]	Ta'ape [chlordane]	Moray Eel (94) or other ND [chlordane]	Avg PQL
1991			*	*	0.06
1992	*		*	*	0.79
1993	2.1		7.7	*	0.5
1994	*		*	0.55	0.5
1995	*	*	*		0.5
1995-liver	*	*	*		
1996	*	*	*		5
1997	*	*	*		5
1998	*	*	*		4
1999	*	*	*		2
2000	*		*		4
2001	*		*		4
2002	*		*		1

ND or no entry –Not detected
*Three fish species sampled per year until 1998. In 1999 to 2002 two species were sampled each year. Dieldrin has never been detected in fish tissue tests.
All data in PPB / µg/kg dry wt of fish tissue

TABLE 7
Sediment Sampling Sites

	Nearshore N and C Stations	Deep Water B and Z Stations	Regional Monitoring Stations
1990 to 1998	N1 to N5	B1 to B6, Z, Z1 to Z3	
1999, 2000, 2002	C1a to C3a, C5a, C6	D1 to D6, E1 to E6	
2001			61 to 100

V. CORRELATION OF DATA FROM VARIOUS SOURCES.

The maximum level of chlordane found in stream sediments is 600 times the maximum level found in ocean sediments. The highest level of dieldrin measured in stream waters is about twice the highest level found in the sewer collection system. Chlordane has been confirmed as being present in urban streams and at higher levels in the collection system.

VI. DISCUSSION

Trace amounts of Chlordane found in the sediment near the outfall may have been deposited during the time that grit and/or sludge was not removed from the wastewater discharged from the SIWWTP outfall from December 1976 to June of 1979. No chlordane has been detected in sediment samples beyond the zone of mixing. All samples in which chlordane was detected were replicate samples and chlordane was generally found in only one or occasionally two of three or four replicates, and was never found in all of the replicates. This would appear compatible with the contamination of discrete particles that were transported to the vicinity of the outfall, possibly grit particles. Contaminated sediments might also account for the low levels of chlordane detected in fish harvested near the outfall in 1993 and 1994, however based on USGS data, the sediment in urban streams, and by extension in the submerged estuaries of these streams, is a significant and much more contaminated sources of chlordane and fish in urban streams have higher levels of contamination than fish sampled near the outfall. Dieldrin has never been detected in fish caught in the vicinity of the Sand Island outfall or in sediment samples. Both chlordane and dieldrin accumulate in the liver but in 1995, tests on the livers of the fish caught for testing did not detect their presence (detection limits of 5 ppb for chlordane and 10 ppb for dieldrin). If these chemicals were being discharged at harmful levels it should be present in easily detectable levels in both the fish, especially in their livers, and in all sediment sampled near the outfall.

For human consumption the EPA IRIS database NOAEL for chlordane is: 0.15 mg/kg-day while the human RfD is 5E-4 mg/kg-day. For a 70 kg adult this would require drinking one liter of water per day with concentrations of 10,500 ppb for the NOAEL dose and 35 ppb for the RfD dose. For dieldrin the concentrations in the liter of water would be 3,500 ppb for the NOAEL and 3.5 ppb for the RfD dose. For a daily four ounce serving of fish to provide the NOAEL and RfD dosages the concentrations in the meat would be 9 times as great or 92,400 ppb (NOAEL) and 308 ppb (RfD) for chlordane and 30,800 ppb and 30.8 ppb for dieldrin. These are orders of magnitude greater concentrations than the highest concentration found in fish or ocean sediments.

The limits for chlordane and dieldrin in receiving waters and comparable limits for drinking water in ppb are:

	Acute (Avg. Daily)	Chronic (Annual Avg.)	Drinking water standard
Chlordane	0.0039	0.000016	2.0
Dieldrin	0.0019	0.000025	N/A

Note for dieldrin the 10*-6 risk level for cancer is 0.02 ppb per kg of body weight per day.

The State Recreational Water Standard for chlordane is 10,000 times as strict as the drinking water standard. There is currently no drinking water standard for dieldrin but before it was withdrawn it is believed to have been the same as for chlordane.

CONCLUSIONS AND RECOMMENDATIONS

The second testing, with its lower MDLs, confirmed that all areas are contaminated with chlordane and dieldrin. The levels of contamination are generally as expected with older neighborhoods having generally higher levels of contamination and the newest areas having the lowest. Comparing results from the two samplings concentrations generally decrease as infiltration rates decrease, however this is not always the case, suggesting that the infiltration rate at the moment of sampling is not the only criteria controlling concentration. It is probable that ground temperature and the contact time of the water with contaminated soils are significant factors.

Chlordane and dieldrin contamination appears to be ubiquitous in the SIWWTP collection area. These chemicals are very persistent and there is a large reservoir of material in the soil, therefore, these chemicals are expected to remain at detectable levels for many years. The areas with the highest concentrations, based on verbal information from regulators and confirmed by testing that has been done are older neighborhoods, especially those with residents of predominantly Asian extraction.

The low levels of chlordane and dieldrin being discharged through the SIWWTP deep ocean outfall are having no measurable impact on the ocean or the sea life adjacent to the outfall. Tests on fish caught at the outfall have proven negative for these chemicals since 1994. Prior detections of these chemicals were infrequent and at low levels and may have been related to the discharge of sludge and grit through the outfall when the outfall was first put into service in 1976. The discharge of grit stopped in August 1978 and the discharge of sludge stopped in June of 1979.

In Mamala Bay chlordane has been detected only occasionally in ocean sediments collected near the SI outfalls, most recently in 1998. Sediment concentrations have varied from 0.17 to 3.6 ppb. The chlordane detected could be related to the discharge of grit and sludge in screened wastewater through the outfall from December 1976 until August 1978 and the discharge of sludge with the wastewater until June of 1979. Samples collected at the SIWWTP December 9, 2002 tested 25.4 µg/kg for Dieldrin in grit and 20.1 µg/kg for dieldrin in sludge. The PQLs for chlordane were 45 µg/kg for the grit sample and 150 µg/kg for the sludge sample. If the results are representative of long-term levels and historical ratios of chlordane to dieldrin in grit and the sludge were similar to those in effluent, then the discharges from 1976 to 1979 could account for the detection of chlordane in

sediment samples. It is recommended that grit and sludge be tested periodically as a further check on the contamination levels of materials being transported to the SIWWTP. It is also recommended that samples of both raw and heat-treated sludge be tested so that a better comparison of historical sludge priority pollutant data can made. Grit might also be processed before testing to separate it into organic and inorganic portions. If the contamination is from groundwater infiltration the inorganic portion of the sludge will test significantly higher for chlordane and dieldrin than the organic portion.

FIGURE 3
SIWWTP – OCEAN SEDIMENT SAMPLING LOCATIONS 1990 TO 1998

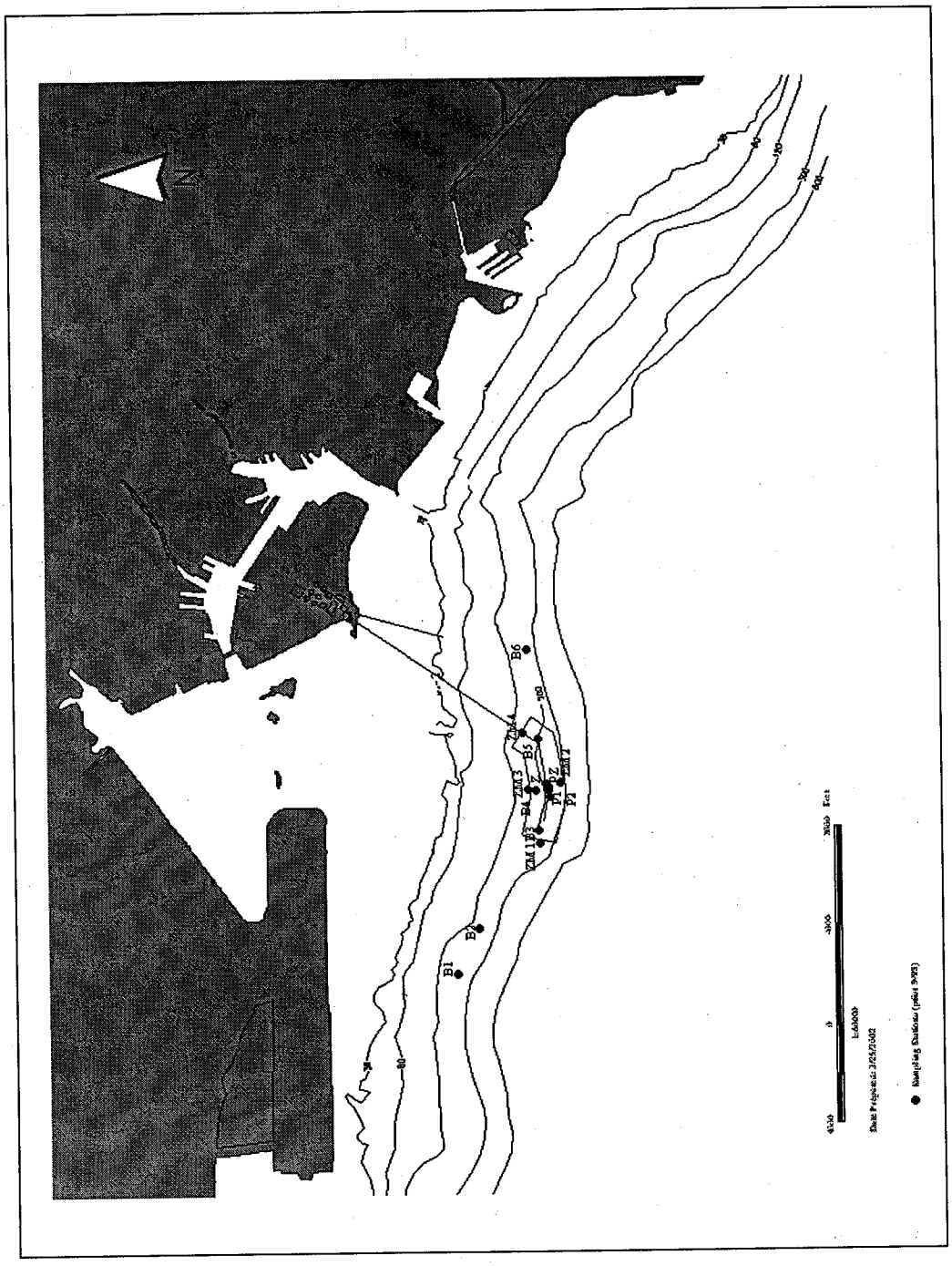


FIGURE 4
SIWWTP–OCEAN SEDIMENT SAMPLING LOCATIONS 1999, 2000&2002

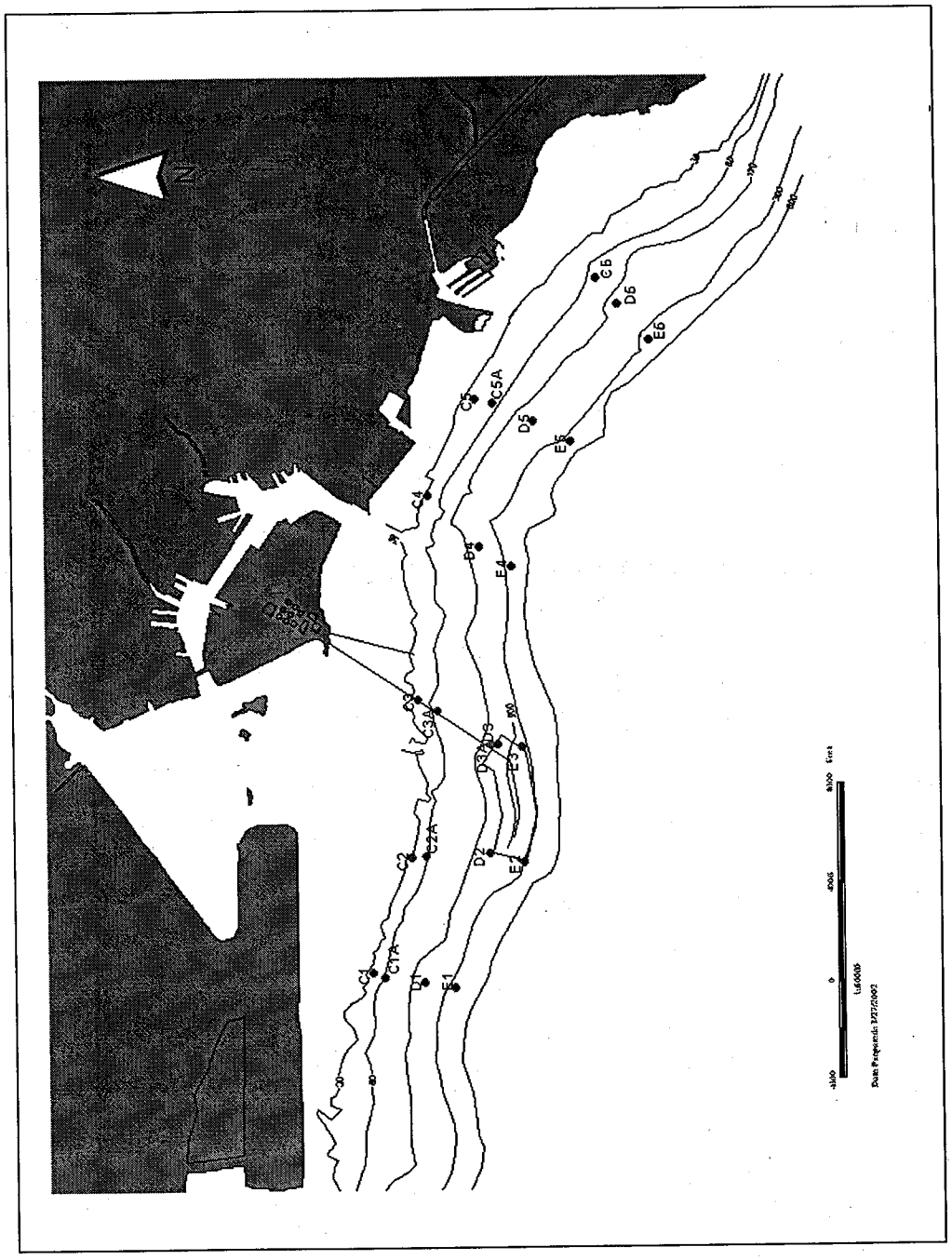
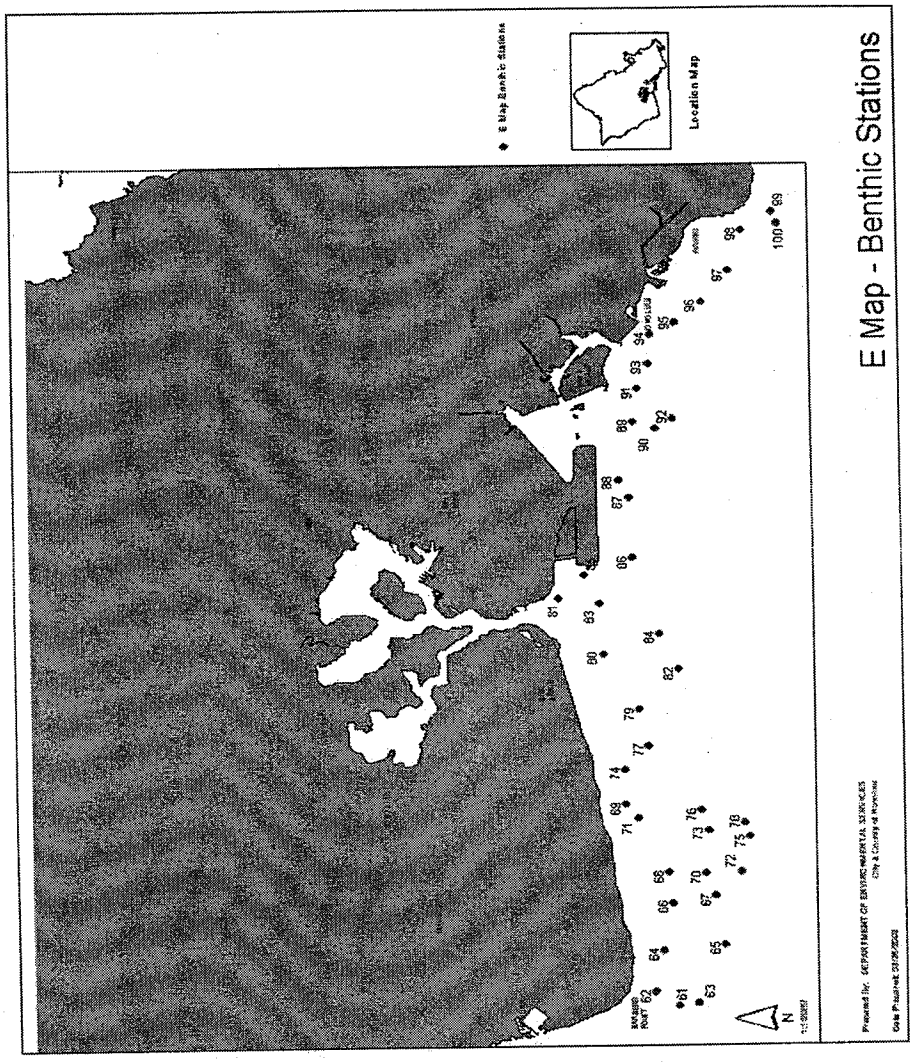


FIGURE 5
SIWWTP – OCEAN SEDIMENT SAMPLING
REGIONAL MONITORING LOCATIONS 2001



APPENDIX D1
SIWWTP – COLLECTION SYSTEM SAMPLING LOCATIONS

Site No. 3	Waialae Nui
Site No. 4	Wilhemina Rise
Site No. 5	Waialae
Site No. 6	Palolo Valley
Site No. 8	St Louis Heights
Site No. 9	Manoa
Site No. 10	Moiliili/McCully
Site No. 11	Makiki
Site No. 12	Ala Moana
Site No. 13	Pacific Heights/Nuuanu
Site No. 15	Salt Lake
Site No. 16	Fort Shafter