WehranEnviroTech

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KIN-BUC LANDFILL
OPERABLE UNIT 2
DRAFT FINAL FEASIBILITY STUDY REPORT

VOLUME II - APPENDICES A THROUGH D

Prepared For
KIN-BUC, INC.
AND
SCA SERVICES, INC.
Edison Township, Middlesex County, New Jersey

Draft March 1992
Revised Draft June 1992
Draft Final July 1992
WEHRAN ENGINEERING CORPORATION
Middletown, New York

Environmental Engineers • Scientists • Constructors

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666 East Main Street
Middletown, New York 10940

WE Project No. 09406 F9

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Draft Final July 1992

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APPENDIX A
USEPA CORRESPONDENCE AND REPORTS

RECEIVED
DEC 26 1991
Wehran Engineering
Massachusetts

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, NEW YORK 10278

DEC 20 1991

Kevin Burger, C.E.P.
Wehran Engineering Corporation
Andover Research Park
Six Riverside Drive, Suite 101
Andover, Massachusetts 01810-1121

Re: Operable Unit 2 Feasibility Study, Kin Buc Landfill Superfund Site, Edison New Jersey. Administrative Order No. II-CERCLA-00114 (Order).

Dear Mr. Burger:

The U. S. Environmental Protection Agency (EPA) has determined appropriate remediation goals for the wetlands sediments to be addressed in the selected remedy for Operable Unit 2 of the Kin Buc Landfill Superfund Site, Edison, New Jersey. On the basis of the Remedial Investigation report and its supplements, as well as the draft Risk Assessment prepared by EPA, EPA has identified PCBs as the primary contaminant of concern in the wetlands, and has developed a cleanup level of 5.0 parts per million (ppm) for all contaminated wetlands sediment in Operable Unit 2. This area includes the Edmonds Creek and Connecting Channel.

This goal reflects several different contributing factors: EPA's preliminary calculations based on an evaluation of bioavailability using the Interim Equilibrium Partitioning (EP) Method, biological effects data from literature studies, as well as remediation goals for PCBs in sediments at other Superfund sites. These factors were considered against such competing factors as the technical feasibility of full remediation and the desire to minimize, as much as possible, the impact of remediation on the existing wetlands. EPA believes that the remediation goal will greatly reduce the ecological threats associated with the contaminated sediment while preserving a significant portion of the existing ecosystem. Sediments contaminated by PCBs at lower levels (<5 ppm) will remain undisturbed.

The Interim EP Method has been developed by EPA as a means of evaluating sediment quality, and applies to nonpolar organics and inorganic contaminants. The sediment quality criteria (SQC) developed with this method are based on the partitioning of contaminants between the sediment and the water in contact with that sediment. For a particular contaminant, the Interim EP method may be utilized to back-calculate from the Ambient Water Quality Criteria (AWQC) the concentration of that contaminant in the sediment which will have no adverse effects on organisms exposed to the sediment-water interface. For each contaminant, the method provides a range of SQCs based on the range of partitioning coefficients reported in literature. The lower value represents the concentration, normalized to the organic carbon content, with which 97.5% certainty will protect organisms from adverse chronic effects, while the upper value represents the normalized concentration with which 97.5% certainty will not protect organisms from adverse chronic effects. For PCBs, the lower, mean, and upper SQCs are 3.87, 19.5, and 99.9 ug PCB/g carbon.

The attached document describes the basis and application of this method to sediment quality data. As part of the Feasibility Study, Wehran should apply the Interim Equilibrium Partitioning Method to all wetlands sediment data points for which both PCB and Total Organic Carbon (TOC) concentrations are available. All PCB data should be normalized to the fraction of organic carbon contained in the sediment at that data point. The normalized data should be mapped, with contour intervals representing the lower, upper and mean sediment quality criteria as described. This information will assist EPA in confirming the preliminary calculations which led to the establishment of the 5 ppm cleanup goal, should be submitted to EPA within 18 working days from receipt of this letter.

Because the Risk Assessment has not been finalized, EPA will transmit a summary of those portions it considers necessary for Wehran to complete the draft Feasibility Study as soon as possible. These portions include the human health and ecological pathways considered, the contaminants of concern, and the results of the quantitative risk assessment. At that time, a schedule for the Feasibility Study will be established. Until that time, Wehran should begin the revision of the October 1990 Feasibility Study submittals (Chapters 1.0, 2.0, 3.0, 4.0) based on the draft Final Remedial Investigation Report and the contents of this letter.

If you have any questions or comments concerning these matters, please contact Alison Barry, of my staff, at (212) 264-8678.

Sincerely yours,

Raymond Basso

Raymond Basso, Chief
New Jersey Superfund Branch II

Attachments

cc: Ralph Sundstrom, Kin Buc (w/o attachment)
Richard Karr, Waste Management NA (w/o attachment)
Ian Curtis, NJDEPE
Robert Miller, Wehran
Jeanne Litwin, CDM FPC

INTERIM SEDIMENT CRITERIA VALUES FOR NONPOLAR HYDROPHOBIC ORGANIC COMPOUNDS

INTRODUCTION

Toxic contaminants in the bottom sediments of lakes, rivers and coastal waters can degrade the environment. Available data indicate many locations where existing sediment contaminant concentrations are now causing significant adverse environmental effects on aquatic life, even when water column contaminant concentrations comply with established water quality criteria (Malins et al. 1980, 1982). Since 1985, the Criteria and Standards Division of EPA has been pursuing the Equilibrium Partitioning (EP) approach for estimating sediment quality criteria for nonpolar and metal contaminants. In anticipation of favorable review of the approach by EPA's Science Advisory Board, interim sediment criteria values based on the EP approach for selected nonpolar, hydrophobic organic compounds were developed. These interim criteria values can be used to evaluate the appropriate applications of sediment criteria in existing regulatory programs. This report describes how the interim numbers were developed and briefly how the criteria values can be used to evaluate the extent of sediment contamination. Preparation of this report has resulted in a great deal of discussion regarding choice of partition coefficients and methods for determining the uncertainty in the interim criteria values. Therefore, it is very likely that the final values that EPA will recommend will differ from these values although not substantially. Any user of these numbers should be aware that these numbers are indeed interim and not final criteria values.

The main part of this report describes the development of interim criteria values for nonpolar organic contaminants for which chronic water quality criteria have been generated. In Appendix E of the report, additional interim criteria for selected PAHs are given.

EQUILIBRIUM PARTITIONING APPROACH

Before describing how the interim criteria were estimated, the technical approach that forms the basis for the sediment criteria development effort will be discussed. The approach that is being pursued by the Criteria and Standards Division for establishing sediment quality criteria, on the recommendation of participants in the technical workshops and steering committees, is the EP approach (Neff 1985, Cowan 1986, Cowan 1987). The EP approach is based on two interrelated assumptions. First, that the interstitial water concentration of the contaminant is controlled by partitioning between the sediment and the water at contaminant concentrations well below saturation in both phases. Thus, the partitioning can be calculated from the quantity of the sorbent(s) on the sediment and the appropriate sorption coefficient(s). For nonpolar organic contaminants, the primary sorbent is the organic carbon on the sediment; therefore, the partition coefficient is called the organic carbon normalized partition coefficient, K_{oc}. Second, the toxicity and accumulation of the contaminant by benthic organisms is correlated to the interstitial, or pore water concentration and not directly to the total concentration of the contaminant on the sediment.

When the EP approach is used to estimate sediment quality criteria, chronic water quality criteria (WQC) are used to establish the "no-effect" concentration in the interstitial water. Chronic water quality criteria are used to protect benthic organisms from effects due to their long-term exposure to low ambient concentrations in the sediment. The use of WQC assumes that the sensitivities of water column and benthic species to a compound are similar. This assumption is being evaluated. This interstitial water concentration (C_w) is then used with the partition coefficients (K_{oc}) and the following equation

$$C_{sed} = K_{oc} * C_w \tag{1}$$

to calculate the concentration of the contaminant on the sediment (C_{sed}) that at equilibrium will result in this interstitial water concentration. This concentration on the sediment will be the numerical criteria value (SQC). For compounds where chronic water quality criteria are not available, the EP approach can still be useful. For example, using upper-bounds effects concentrations will give comparable (i.e, upper-bounds effects) sediment concentrations. The interpretation of such sediment values is analogous to the interpretations of the comparable water column values used in their derivation.

DEVELOPMENT OF INTERIM NUMBERS

To estimate interim sediment criteria values, two sets of data are needed for each compound for which criteria values are required. These data are the water quality criteria and the partition coefficients.

WATER QUALITY CRITERIA VALUES

Water Quality Criteria (WQC) concentrations are available for 17 nonpolar organic chemicals (Hansen 1987). The criteria values are summarized in Table 1. The procedures for deriving these criteria are described in Appendix A. The WQC concentrations consist of the Criteria Maximum Concentration (CMC) and the Criteria Continuous Concentration (CCC). The CMC is not applicable for derivation of SQC concentrations because it protects aquatic life from acutely lethal effects of a chemical. The CCC is the lower of the Final Chronic Value (FCV), the concentration protecting aquatic life from chronic toxicity, and the Final Residue Value (FRV), the concentration protecting uses of aquatic life. These uses include marketability of aquatic life based on FDA or other action levels or consumption of aquatic life by wildlife. The CCC is the appropriate value to use in deriving SQC because it protects aquatic life from effects due to long-term exposure to contaminated sediments. Both the FCV and FRV are presented in Table 1.

Important limitations of Table 1 should be mentioned. First, the WQC concentrations for acenaphthene, aniline, diethylhexylphthalate, methyl-parathion, phenanthrene, and 1,2,4-trichlorobenzene must be used with caution because they are preliminary values until criteria documents have been peer reviewed and accepted. Second, the PCB criteria is based on the FDA action level of 5 mg/kg and bioaccumulation factors measured in the laboratory. Since 1980 when this criteria was developed, the FDA action level has been changed to 2 mg/kg. Furthermore, the residue values do not account for bioconcentration in the food chain which results in bioaccumulation factors for fish at least 10 times higher than those measured in the laboratory. This bioconcentration has been shown to be important for DDT and PCB.

PARTITION COEFFICIENTS

For estimating the interim sediment quality criteria values presented here, it is assumed that the sediment organic carbon partition coefficient,

K_{oc}, can be accurately calculated from the octanol-water partition coefficient, K_{ow}, using the following equation (DiToro 1985):

$$\mathrm{Log}_{10}(K_{oc}) = 0.00028 + 0.983*\mathrm{Log10}(K_{ow}) \qquad (2)$$

The K_{oc} values used in the regression analysis were carefully screened to remove data for experiments that were conducted at high particle concentrations and to ensure that only nonpolar organic compounds were included. This screening is important because particle interactions at high particle concentrations can result in errors in the K_{oc} values (DiToro 1985). This relationship is chosen to calculate K_{oc} values rather than using tabulated Koc values because K_{ow} values have been determined by more researchers and the procedure for determining K_{ow} values is simpler than that used for determining K_{oc} values because interferences caused by dissolved organic carbon and particle effects do not have to be considered or accounted for in the experimental design and data analysis.

Because K_{ow} is used to estimate K_{oc}, and ultimately the interim sediment quality criteria, it is important that both an estimate of the mean K_{ow} and a quantification of its uncertainty be determined. To provide a preliminary estimate of the K_{ow} values and their uncertainty, for each compound in Table 1, the following alternative methods were used.

- Review of all measured values and calculation of the geometric mean and standard deviation of the mean from the data
- Determine recommended value from Leo-Hanch database
- Estimate log K_{ow} from correlations with aqueous solubility
- Estimate log K_{ow} from structure-activity relationships.

The results of the four methods are presented in Table 2. The estimates derived from the four methods compared for overall consistency.

The review of all measured values was conducted using the database developed by Envirosphere for the report by Pavlou et al. (1987). Because this database has been updated since that report was prepared the values in Table 2 may differ slightly from those presented in that report. The recommended value for the log K_{ow} from the Leo and Hanch Log P Database (Leo 1984) was also tabulated for comparison.

The methods used for estimating the log K_{ow} values from the solubility and from the chemical structure of the compound are outlined in Appendices B and C, respectively. Estimates of K_{ow} based on aqueous solubility, which were corrected for solids melting point (Bowman and Sans 1983), were calculated from solubility and melting point data reported in the Arizona Database of Aqueous Solubility (Yalkowsky et al. 1987). The log mean K_{ow} for solubilities measured in the range of 15 to 25°C is reported in Table 2.

PCB Aroclor K_{ow} values reported in the "measured" column in Table 2 were calculated using the median of the log mean K_{ow} values for the homologs and the Aroclor homolog composition as illustrated in Appendix D. Log mean K_{ow} values for the homologs were compiled from six sources (Rapaport and Eisenrich 1984, Rapaport and Eisenrich 1985, Shiu and MacKay 1986, Woodburn et al. 1984, Miller et al. 1984, Chiou et al. 1977) and the median of the reported values determined. The Aroclor homolog composition was taken from Verschueren (1983).

The K_{ow} values in Table 2 for the four methods do in general agree; however, for some compounds the values range over several orders of magnitude. For these compounds, the wide range in uncertainty, the disagreement between the recommended value of Leo-Hanch and the geometric mean of all reported values, or lack of confirmatory data makes it difficult to chose a definitive log K_{ow} value. Based on the review of all the data, log K_{ow} values for 11 of the 17 nonpolar compounds, for which there are WQC, are considered acceptable at this time and are used to calculate interim criteria values. Further review is ongoing to determine the most acceptable mean and uncertainty values to represent the K_{ow} values for these compounds. The accepted mean, standard deviation (S.D.), and the 95% confidence intervals for the log K_{ow} value; and the mean, S.D., and 95% confidence intervals for the log K_{oc} value for each of the 11 compounds are presented in Table 3. The 95% confidence intervals for the K_{ow} values were calculated assuming a t statistic of 1.96, which is the value for large sample size, rather than the statistic for the specific sample size used to estimate the mean and S.D. for the compound. The mean log K_{oc} values in this table were estimated using Equation (2) and the mean log K_{ow} value. The S.D. of the log K_{oc} value was estimated using the following equation:

$$\text{S.D.} = \sqrt{(\text{S.D. of } \log K_{ow})^2 + (0.3)^2}$$

where 0.3 represents the standard error due to the regression relationship. This estimate of the standard error of the regression is large because the least squares regression method assumes that all uncertainty is in the log K_{oc} value. As part of the ongoing review, the most appropriate methods for estimating the mean and S.D. of the log K_{ow} values are being examined. Also, alternative regression methods will be used to determine the most appropriate value for the standard error due to the regression. As a result of this review, the final log K_{ow} values and the final criteria values may change slightly from those presented in this report.

INTERIM SEDIMENT QUALITY CRITERIA

Table 4 summarizes the interim sediment criteria values calculated using Equations (1) and (2) and the FCV and FRV criteria, respectively, for freshwater (Table 1) as the basis of the interim criteria. Table 5 summarizes the criteria values using FCV and FRV criteria, respectively, for saltwater (Table 1). When both FCV and FRV values are available for a compound, the FCV concentrations should only be used to calculate SQC when they are lower than the corresponding FRV concentrations. However, SQC values derived from both FCV and FRV values are presented to permit the user to determine what end use is being protected for.

Estimates of the SQCs are shown for the mean and 95% confidence interval of the log K_{oc} values. The confidence interval is reported to illustrate the uncertainty in the interim criteria values and to permit the user to estimate the likelihood that the sediment does or does not exceed the criteria value. The confidence interval represents the range within which with 95% certainty the sediment criteria value will fall. The lower value of the confidence interval represents the concentration which with 97.5% certainty will result in protection from chronic effects or of uses depending on the WQC value used in the SQC derivation. Any contaminant in a sediment at concentrations less than this value would not be of concern; however, the sediment can not be considered "safe" because the sediment may contain other contaminants above safe levels but for which criteria do not exist. The upper value of the confidence interval represents the concentration which with 97.5% certainty will result in hazardous long-term impacts on the benthic fauna. Thus, any sediments with concentrations above this level are considered hazardous. Concentrations within the confidence intervals can be considered either "safe" or hazardous with respect to that compound with certainties between 2.5 and 97.5%.

APPLICATION OF INTERIM NUMBERS

To determine if the sediment concentration of a nonpolar contaminant exceeds the sediment criteria values, the concentration of the contaminant and the organic carbon content of the sediment must both be known. The analytical methodologies for measuring the concentration of nonpolar organic compounds and the organic carbon content in sediments are described in Cowan and Riley (1987). Because the sediment criteria values are presented as normalized to organic carbon content (i.e., presented on a per organic carbon weight basis), the normalized sediment concentrations of the contaminants must be calculated. These normalized concentrations can then be directly compared with the interim values in Tables 4 and 5. Alternatively, the sediment criteria values could be multiplied by the lowest organic carbon content and the total concentrations compared with these criteria values. To facilitate this second type of comparison, Tables 6 and 7 contain the sediment criteria values for specific organic carbon contents of 1 and 10% for fresh and saltwater, respectively. These organic carbon contents represent the average range over which the EP approach has been examined (Karickhoff 1984, DiToro 1985).

SAMPLE CALCULATION

To illustrate the use of the interim sediment criteria values, an example calculation is presented.

For example, consider a site where previous analyses have indicated that DDT is present in the freshwater sediments at a concentration of 0.1 mg/kg of sediment and that the organic carbon (f_{oc}) content is 2% or 0.02 kg of C/kg of sediment. To calculate the normalized sediment concentration in terms of organic carbon content, the formula is as follows:

Normalized Concentration = Sediment Concentration/f_{oc} .

For this specific example,

Concentration (mg/kg C) = (0.1 mg/kg)/(0.02 kg C/kg)

= 5 mg/kg C

Comparing this value to the values in Table 4, the normalized concentration exceeds the criteria values based on the FRV for freshwater.

Alternatively, the criteria value in Table 4 could be multiplied by the organic carbon content of the sediment to calculate the criteria value for a specific organic carbon content. The formula is as follows:

Sediment Concentration = (SQC)(f_{oc})

The calculation for this same case (i.e., 2% organic carbon) using the lower confidence interval value would be

SQC at 2% O.C. (mg/kg) = 0.183 mg/kg C x 0.02 kg C/kg

= 3.66E-3 mg/kg

Comparison of this value with the measured concentration indicates that the criteria value is again exceeded. Using the upper confidence interval value also indicates that the criteria are exceeded.

The first calculation method would be most appropriately used when several contaminant concentrations are available across a site that varies in organic carbon content. In that case, the calculation of the organic carbon normalized values and contours of concentration could be used to indicate the approximate area or sampling sites that are above the criteria value. The second calculation method would be most appropriate when several contaminant concentrations are available, but the organic carbon content of the sediment is constant.

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TABLE 1. Final Residue Values (FRV) and Final Chronic Values (FCV) for Nonpolar Organic Compounds

Compound (Pub. Date)	C.A.S. Number	Freshwater µg/L		Saltwater µg/L	
		FCV	FRV	FCV	FRV
Acenaphthene*	83-32-9	57	-	-	-
Aniline*	62-53-3	7.2	-	27	-
Chlordane (1980)	57-74-9	0.17	0.004	0.0064	0.004
Chlorpyrifos (1986)	2921-88-2	0.041	-	0.0056	-
DDT (1980)	50-29-3	-	0.0010	-	0.0010
Dieldrin (1980)	60-57-1	0.29	0.0019	0.084	0.0019
Diethylhexylphthalate*	117-81-7	360	-	360	-
Endosulfan(1980)	115-29-7	0.056	-	0.0087	
Endrin (1980)	72-20-8	0.045	0.0023	0.0093	0.0023
Ethyl Parathion (1986)	56-38-2	0.013	-	-	-
Hepatachlor (1980)	76-44-8	-	0.0038	-	0.0036
Hexachlorocyclohexane (1980)***	608-73-1	0.080	-	-	-
Methyl Parathion*	298-00-0	0.15	-	0.076	-
Phenanthrene*	85-01-8	6.3	-	4.6	-
Polychlorinated Biphenyls (1980)		-	0.014	-	0.030
Toxaphene (1986)	8001-35-2	<0.039	0.0002**	0.21	0.0002**
1,2,4-Trichlorobenzene*	120-82-1	23	-	-	-

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* Draft criteria documents.

** See criteria document for explanation of this residue-based value.

*** Also known as Lindane

TABLE 2. K_{ow} Values for Compounds in Table 1

		LOG K_{ow}					
		LEO-HANCH		LEO-HANCH	PAVLOU ET AL. (1987)		
CHEMICAL (PUB. DATE)	C.A.S. No.	MEASURED	FRAGMENT ANALYSIS	AQUEOUS SOLUBILITY	GEOMETRIC MEAN	S.D.	95%CI
ACENAPHTHENE	83-32-9	3.92	4.07	3.72	4.18	0.0032	4.02 - 4.34
ANILINE	62-53-3	0.98	0.92	0.83	0.98	0.0360	0.91 - 1.06
CHLORDANE(1980)	57-74-9	-	5.54	4.78	4.01	0.407	3.06 - 4.97
CHLORPYRIFOS(1980)	2921-88-2	4.98	4.00	5.11	4.98	0.0141	4.96 - 5.01
DDT(1980)	50-29-3	6.37	5.91	6.10	6.02	0.1479	5.73 - 6.31
DIELDRIN(1980)	60-57-1	4.32	2.92	4.40	4.02	0.490	3.08 - 5.00
DIETHYLHEXYLPHTHALATE	117-81-7	-	8.00	5.70			
ENDOSULFAN(1980)	115-29-7	3.83	4.07	-			
ENDRIN(1980)	72-20-8	-	2.92	3.01	4.44	0.365	3.74 - 5.14
ETHYL PARATHION(1980)	56-38-2	3.83	3.47	3.94	3.86	0.198	3.47 - 4.25
HEPTACHLOR	76-44-8	-	4.01	5.10	4.54	0.320	3.89 - 5.19
HEXACHLOROCYCLOHEXANE(1980)*	608-73-1	3.72	3.76	3.41	3.35	0.063	3.23 - 3.47
METHYL PARATHION	298-00-0	2.86	2.79	3.34			
PHENANTHRENE	85-01-8	4.46	4.49	4.04	4.42	0.110	4.19 - 4.65
POLYCHLORINATED BIPHENYLS:							
AROCLOR 1242		5.10	-	-			
AROCLOR 1254		6.73	-	-	6.26	0.196	5.87 - 6.63
AROCLOR 1260		6.94	-	-			
TOXAPHENE(1986)	8001-35-2	-	-	4.77	3.28	0.0203	3.20 - 4.77
1,2,4-TRICHLOROBENZENE	120-82-1	4.02	4.20	3.30			

---

* Also known as Lindane

TABLE 3. K_{ow} and K_{oc} Values for Selected Nonpolar Organic Compounds

	Log K_{ow}				Log K_{oc}			
Compound	Mean(a)	S.D.	95%(b) Confidence Interval		Mean	S.D.(c)	95%(b) Confidence Interval	
Acenaphthene	4.18	0.0832	4.02	4.34	4.11	0.311	3.50	4.73
Aniline	0.98	0.0350	0.91	1.05	0.96	0.302	0.37	1.56
Chlorpyrifos	4.98	0.0141	4.95	5.01	4.90	0.300	4.31	5.49
DDT	6.02	0.148	5.73	6.31	5.92	0.334	5.26	6.58
Dieldrin	4.92	0.490	3.96	5.88	4.84	0.574	3.71	5.97
Endrin	4.44	0.355	3.74	5.14	4.36	0.465	3.45	5.29
Ethyl-parathion	3.86	0.197	3.47	4.25	3.79	0.359	3.09	4.51
Heptachlor	4.54	0.329	3.90	5.18	4.46	0.445	3.59	5.34
Lindane	3.35	0.063	3.23	3.47	3.29	0.306	2.69	3.90
Phenanthrene	4.42	0.116	4.19	4.65	4.35	0.322	3.71	4.98
PCB (1254)	6.25	0.196	5.87	6.63	6.14	0.358	5.44	6.85

(a) Geometric mean

(b) 95% confidence interval calculated assuming log normal distribution of K_{ow} values and 1.96 for t(@95%).

(c) Standard error of log K_{oc} calculated using following formula:

$$S.D. = \sqrt{(S.D.\ of\ log\ K_{ow})^2 + (0.3)^2}$$

where 0.3 is the standard error from regression relationship

TABLE 4. Sediment Quality Criteria Values for Selected Nonpolar Organic Compounds for Freshwater

		Sediment Quality Criteria (µg/gC)				Sediment Quality Criteria (µg/gC)		
Compound	Freshwater FCV	Mean	95% Confidence Interval		Freshwater FRV	Mean	95% Confidence Interval	
Acenaphthene	57	732	180	3,030				
Aniline	7.2	0.0662	0.0169	0.262				
Chlorpyrifos	0.041	3.22	0.831	12.7				
DDT					0.001	0.828	0.183	3.80
Dieldrin	0.29	19.9	1.49	273	0.0019	0.130	0.00976	1.79
Endrin	0.045	1.04	0.128	8.68	0.0023	0.0532	0.00654	0.443
Ethyl Parathion	0.013	0.0810	0.0160	0.416				
Heptachlor					0.0038	0.110	0.0148	0.840
Lindane	0.08	0.157	0.0394	0.636				
Phenanthrene	6.3	139	32.6	605				
PCB (1254)					0.014	19.5	3.87	99.9

TABLE 5. Sediment Quality Criteria Values for Selected Nonpolar Organic Compounds for Saltwater

Compound	Saltwater FCV	Sediment Quality Criteria (µg/gC)			Saltwater FRV	Sediment Quality Criteria (µg/gC)		
		Mean	95% Confidence Interval			Mean	95% Confidence Interval	
Acenaphthene								
Aniline	27	0.248	0.0635	0.984				
Chlorpyrifos	0.0056	0.440	0.114	1.73				
DDT					0.001	0.828	0.183	3.80
Dieldrin	0.084	5.77	0.431	79.2	0.0019	0.130	0.00976	1.79
Endrin	0.0093	0.215	0.0264	1.793	0.0023	0.0532	0.00654	0.443
Ethyl Parathion								
Heptachlor					0.0038	0.104	0.0140	0.796
Lindane								
Phenanthrene	4.6	102	23.8	442				
PCB (1254)					0.030	41.8	8.29	214

TABLE 6. Sediment Quality Criteria Values for Selected Nonpolar Organic Compounds for Freshwater at 1 and 10% Organic Carbon Content (all criteria with units of ppm or mg/kg)

Compound	FCV						FRV					
	1%			10%			1%			10%		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Acenaphthene	7.33	1.00	30.3	73.3	10.0	303						
Aniline	0.60E-3	0.100E-3	2.63E-3	6.01E-3	1.00E-3	0.0262						
Chlorpyrifos	0.0322	0.31E-3	0.127	0.322	0.003	1.27						
DDT							8.28E-3	1.03E-3	0.0300	0.0828	0.0102	0.300
Dieldrin	0.199	0.015	2.73	1.99	0.149	27.3	1.30E-3	0.0970E-3	0.0170	0.0130	0.976E-3	0.170
Endrin	0.010	1.20E-3	0.0067	0.0104	0.0120	0.060	0.533E-3	0.0664E-3	4.43E-3	5.330E-3	0.664E-3	0.0443
Ethyl Parathion	0.010E-3	0:100E-3	4.10E-3	0.10E-3	1.00E-3	0.0410						
Heptachlor							1.10E-3	0.140E-3	8.40E-3	0.0110E-3	1.400E-3	0.0840
Lindane	1.67E-3	0.394E-3	8.38E-3	0.167	3.94E-3	0.0838						
Phenanthrene	1.39	0.326	6.05	13.9	3.26	60.5						
PCB (1254)							0.196	0.0387	0.999	1.96	0.387	9.99

TABLE 7. Sediment Quality Criteria Values for Selected Nonpolar Organic Compounds for Saltwater at 1 and 10% Organic Carbon Content (all criteria with units of ppm or mg/kg)

Compound	FCV						FRV					
	1%			10%			1%			10%		
	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
Acenaphthene												
Aniline	2.40E-3	0.636E-3	9.04E-3	0.0240	6.36E-3	0.0904						
Chlorpyrifos	4.40E-3	1.14E-3	0.0173	0.0440	0.0114	0.173						
DDT							0.20E-3	1.83E-3	0.0300	0.0020	0.0182	0.200
Dieldrin	0.0577	4.31E-3	0.792	0.577	0.0431	7.92	1.30E-3	0.0970E-3	0.0179	0.0130	0.976E-3	0.179
Endrin	2.15E-3	0.204E-3	0.0179	0.0215	2.04E-3	0.179	0.533E-3	0.0654E-3	4.43E-3	5.320E-3	0.654E-3	0.0443
Ethyl Parathion												
Heptachlor							1.04E-3	0.140E-3	7.90E-3	0.0104E-3	1.40E-3	0.0790
Lindane												
Phenanthrene	1.02	0.230	4.42	10.2	2.30	44.2						
PCB (1254)							0.410	0.0020	2.14	4.10	0.020	21.4

CONTRIBUTORS

- Dr. Dom DiToro, Mr. Paul Paquin, and Mr. Benjamin Wu of HydroQual, Inc., tabulated K_{ow} and K_{oc} values for the nonpolar contaminants, with assistance from Dr. Spyros Pavlou and Mr. Roger Kadeg of Envirosphere Co, Inc.

- Mr. David Hansen of EPA's Narragansett Laboratory, and Mr. Nelson Thomas and Mr. Ron Carlson of EPA's Duluth Laboratory provided water quality criteria for nonpolar contaminants, the QSAR based criteria for PAHs, and the appendix on criteria development procedures.

- All of the above people as well as Dr. Herb Allen of Drexel University, Ms. Alexis Steen and Dr. James Fava of Battelle, and Mr. Chris Zarba, the EPA Work Assignment Manager, provided valuable comments on the draft of this report.

Appendix A. Water Quality Criteria Derivation Procedures

The water quality criteria listed in Table 1 were obtained from published or draft aquatic-life water quality criteria documents. These numerical water quality criteria concentrations were derived using the "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" (Stephan et al. 1985). These "National Guidelines" specify minimum data requirements and data synthesis procedures which allow calculation of numerical criteria concentrations to protect the presence and uses of aquatic life.

Water quality criteria concentrations to protect the presence of aquatic life are derived using the following procedure. First, all available data on the toxicity of the chemical are collected, reviewed for acceptability, and sorted by test type. If minimum database requirements for acute and chronic toxicity as specified in the "National Guidelines" are met, Criteria Maximum Concentrations (CMC) and Criteria Continuous Concentrations (CCC) are calculated to protect important aquatic life from acute and chronic toxicity, respectively. If the toxicity of the chemical is dependent on a water quality characteristic, then the CMC or CCC values are derived as a function of the appropriate characteristic. Because aquatic ecosystems can tolerate some stress and occasional adverse additions, protection of all species at all times and places is not necessary. Therefore, criteria derivation procedures result in criteria concentrations intended to protect most species most of the time but not all of the species all of the time.

Water quality criteria concentrations to protect the uses of aquatic life are derived using the following procedure. A Criteria Continuous Concentration to limit residues in aquatic life can be derived if maximum permissible tissue concentrations and data on bioaccumulation or bioconcentration factors are available. Maximum permissible tissue concentrations are based on either (a) a FDA action level for fish oil or edible portions of fish or shellfish, (b) a maximum acceptable dietary intake based on a wildlife feeding study, or (c) residue-effects data for aquatic life. Either bioconcentration or bioaccumulation factors are required to calculate the water concentrations expected to limit chemical uptake by organisms to below the permissible tissue concentration. Bioconcentration factors, the concentration of the chemical in the organism divided by the concentration in the exposure water, are calculated from laboratory studies where steady-state conditions are achieved. Bioaccumulation factors, the concentration of chemical in the organism from all sources (e.g., food, water) divided by the concentration in the water, are calculated from data obtained in field studies. It is important to note that if food-chain transfer is an important uptake route, criteria concentrations derived using bioconcentration factors, such as those for DDT and PCBs, will probably be underprotective.

The water quality criteria statement contains a concentration limit, averaging period, and return frequency and is stated as follows: "The procedures described in the "Guidelines for Deriving National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" indicate that, except possibly where a locally important species is very sensitive, (1) aquatic organisms and their uses should not be affected unacceptably if the four-day average concentration of (2) does not exceed (3) µg/L more than once every three years on the average and if the one-hour average concentration does not exceed (4) µg/L more than once every three years on the average." In this statement insert either "freshwater" or "saltwater" at (1), the name of the chemical at (2), the lower of the chronic-effect or residue-based concentrations as the Criteria Continuous Concentration at (3) and the acute effect-based Criteria Maximum Concentration at (4).

The Criteria Continuous Concentration based on either chronic effect or residue data can be used to derive sediment quality criteria for nonpolar organic chemicals using the equilibrium partitioning approach. Detailed knowledge of the National Guidelines and the water quality criteria document as a basis for understanding the water quality criteria that are used in the derivation of sediment quality criteria is highly recommended.

Appendix B. Aqueous Solubility and Octanol-Water Partition Coefficient

Estimates of K_{ow} from solubility are based on a thermodynamically inspired correlation developed for 61 organophosphorus and carbamate insecticides (Bowman and Sans 1983). The relationship includes a melting point (MP) correction for chemicals that are solids at room temperature. The regression analysis using K_{ow} and the estimated aqueous solubility of the liquid (or supercooled liquid for solids) yields the following relationship (Bowman and Sans 1983):

$$\text{Log } K_{ow} = 0.280 - 0.839 \log S_{scl}$$

where S_{scl} is the molar aqueous solubility of the supercooled liquid. The relationship between the molar solubility of the solid, S_{solid}, and the supercooled liquid, S_{scl}, is given by the following relationship (Bowman and Sans 1983, Miller et al. 1985):

$$\text{Log } S_{scl} = \log S_{solid} + \frac{\overline{\Delta H}_f}{2.303\ RT_m} \left(\frac{T_m}{T} - 1\right)$$

where $\overline{\Delta Hf}/T_m = \Delta S$, the entropy of fusion, is reported to be 13.5 cal/mole °K for most low melting point compounds and R = 1.987 cal/mole °K.

Appendix C. Estimating K_{ow} using CLOGP

The CLOGP program, based on Leo's Fragment Constant Method (Lyman et al. 1982), estimates log K_{ow} using fragment constants (f_i) and structural factors (F_i) that have been empirically derived for many molecular groups. The estimated K_{ow} is obtained from the sum of constants and factors for each of the molecular subgroups comprising the molecule as follows:

$$\log K_{ow} = \sum_{i=1}^{n} (f_i + F_i)$$

The method assumes that log K_{ow} is a linear additive function of the structure of the solute and its constitutive parts, and that the most important structural effects are described by available factors. The structure of the compound is specified using the Simplified Molecular Interactive Linear Entry System (SMILES) notation (Weininger and Weininger 1986). The notation uniquely describes the empirical formula and molecular structure of the compound of interest.

Appendix D. Example Calculation of Aroclor K_{ow}

Aroclor $K_{ow} = \Sigma K_{ow,i} f_i$

Homolog	Aroclor 1242 Homolog Fraction	Homolog log K_{ow}
mono	0.03	4.33
di	0.13	5.12
tri	0.28	5.57
tetra	0.30	5.84
penta	0.22	6.35
hexa	0.04	7.05

For Aroclor 1242:

$$\log K_{ow} = \log_{10} [0.03(10^{4.33}) + 0.13(10^{5.12}) + 0.28(10^{5.57}) + 0.30(10^{5.84}) + 0.22(10^{6.35}) + 0.04(10^{7.05})$$

$$= \log_{10} [1,270,684]$$

$$\log K_{ow} = 6.10$$

Appendix E. Interim Sediment Criteria Values for Polycyclic Aromatic Hydrocarbons

In the main part of this report, interim sediment criteria values are shown for 11 nonpolar organic compounds for which chronic water quality criteria have been generated. During visits to regional Superfund offices to discuss the application of these interim criteria values, the need for interim criteria for several of the polycyclic aromatic hydrocarbons (PAHs) was identified. The PAHs are Fluoranthene, Pyrene, Benzo(a)pyrene and Benzo(a)anthracene. This appendix describes how those interim criteria values were developed and provides all supporting data for their calculation.

The freshwater chronic water quality criteria values for the four PAHs given in Table E.1 were determined by Mr. Anthony (Ron) Carlson of EPA-Duluth using the computer automated method system developed by that laboratory. The calculated criteria values for Phenanthrene and Acenaphthene are given for comparison. Accepted chronic criteria for these compounds are 0.006 mg/L and 0.057 mg/L, respectively. The computerized method which uses the K_{ow} and solubility values for the compound to calculate both the acute and chronic water quality criteria is based on the work of Veith et al. (1983) and Call et al. (1985). The values given are based on toxicity to chronically exposed fathead minnows. This method is estimated to provide acute and chronic toxicity values that are within a factor of 3 and 5, respectively, of the actual values for approximately 80% of the known industrial compounds.

The log K_{ow} values for the four PAHs given in Table E.2 were developed as described in the main part of the report. The log K_{oc} values and the 95% confidence interval for the log K_{oc} values given in Table E.3 were also estimated using the same methods and assumptions described previously.

The final criteria values are given in Table E.4 on an organic carbon normalized basis and for 1% and 10% organic carbon in Table E.5. These interim criteria values can be used in the same way as the interim values in the main part of the report to determine if a sediment sample exceeds or does not exceed the criteria values.

Table E.1. Predicted Fathead Minnow Toxicity Values

Compound Name	C.A.S. Number	Mode of Action(a)	Log K_{ow}	Solubility (mg/l)	Acute	Chronic
					(mg/l)	
Phenanthrene	85018	NN	4.49	1.26	0.6	0.035
Acenaphthene	83329	NN	4.07	4.44	1.3	0.086
Fluoranthene	206440	NN	4.95	0.24	0.25	0.013
Pyrene	129000	NN	4.95	0.13	0.25	0.013
Benzo(a)pyrene	50328	NN(?)	6.12	0.004	0.025	0.0012
Benzo(a)anthracene	56553	NN(?)	5.66	0.014	0.061	0.0030

---

a) NN = Nonpolarnarcosis. The question mark indicates that the mode of action is not known with certainty.

Table E.2. Log K_{ow} values for the four PAHs in Table 1

	Log Kow						
Compound	Leo-Hanch Measured	Fragment Analysis	Aqueous Solubility	Geometric Mean	S.D.	95% Confidence Interval	
Fluoranthene	5.2	4.95	4.61	5.25	0.139	4.98	5.52
Pyrene	4.88	4.95	4.44	5.09	0.187	4.72	5.46
Benzo(a)pyrene	5.97	6.12	5.81	6.05	0.168	5.72	6.38
Benzo(a)anthracene	-	5.66	6.34	5.74	0.264	5.22	6.26

Table E.3. Log K_{ow} and log K_{oc} values for the for PAHs.

	Log Kow				Log Koc			
Compound	Geometric Mean	S.D.	95% Confidence Interval		Mean	S.D.	95% Confidence Interval	
Fluoranthene	5.25	0.139	4.98	5.52	5.16	0.33	4.51	5.81
Pyrene	5.09	0.187	4.72	5.46	5.00	0.35	4.31	5.70
Benzo(a)pyrene	6.05	0.168	5.72	6.38	5.95	0.34	5.27	6.62
Benzo(a)anthracene	5.74	0.264	5.22	6.26	5.64	0.40	4.86	6.43

Table E.4. Interim Sediment Quality Criteria values for four PAHs.

		Sediment Quality Criteria (ug/g C)		
Compound	WQC	Mean	95% Confidence Interval	
Fluoranthene	13	1,883	423	8,375
Pyrene	13	1,311	265	6,465
Benzo(a)pyrene	1.2	1,063	225	5,018
Benzo(a)anthracene	3	1,317	217	7,999

Table E.5. Interim Sediment Quality Criteria values for four PAHs for 1 and 10% Organic Carbon Contents. (All criteria with units of ppm or mg/kg.)

	1%			10%		
Compound	Mean	95% Confidence Interval		Mean	95% Confidence Interval	
Fluoranthene	18.8	4.24	83.8	188	42.7	838
Pyrene	13.1	2.66	64.6	131	26.6	646
Benzo(a)pyrene	10.6	2.25	50.2	106	22.5	502
Benzo(a)anthracene	13.2	2.17	80.0	132	21.7	800

RECEIVED
JAN 23 1992
Wehran Engineering
Massachusetts

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, NEW YORK 10278

JAN 21 1992

EXPRESS MAIL
RETURN RECEIPT REQUESTED

Kevin Burger, C.E.P.
Facility Coordinator
Wehran Engineering Corporation
Andover Research Park
Six Riverside Drive, Suite 101
Andover, Massachusetts 01810-1121

Re: Operable Unit 2 Feasibility Study, Kin Buc Landfill Superfund Site, Edison, New Jersey. Administrative Order No. II-CERCLA-00114.

Dear Mr. Burger:

The U.S. Environmental Protection Agency (EPA) is in the process of finalizing the Endangerment Assessment for Operable Unit 2 of the Kin Buc Landfill Site, Edison, New Jersey. As discussed with Wehran and confirmed in EPA's February 8, 1991 letter, EPA has identified those portions of the Endangerment Assessment it considers necessary for Wehran to complete the Feasibility Study. The attached documents include the draft Executive Summary, which describes the conclusions of the Human Health and Environmental Assessments. The attached draft tables provide the chemicals of concern for each media and the exposure pathways evaluated during the Human Health Assessment, as well as the chemicals of concern identified during the Environmental Assessment. Final quantitative results will be transmitted shortly.

In accordance with the February 8, 1991 correspondence, EPA has established February 28, 1992, as the new deadline for submittal of the draft Feasibility Study. As discussed in the December 23, 1991 meeting between EPA and Wehran, EPA chose not to provide detailed comments on the December 1990 draft Feasibility Study submittals on the grounds that these documents were submitted prior to the revisions of the draft Remedial Investigation Report and the completion of several supplementary studies. In addition, as indicated in EPA's December 20, 1991 letter, and discussed in the December 1991 meeting, EPA has determined a preliminary remediation goal of 5 ppm for PCBs in the wetlands sediments. Consequently, Wehran is directed to revise the initial Feasibility Study deliverables, as appropriate, to reflect these changes.

To assist Wehran in preparing the revised Feasibility Study, EPA offers the following comments:

1. Development and evaluation of alternatives involving the excavation and treatment of PCB-contaminated sediment should be consistent with the guidelines described in the attached fact sheet, "A Guide on Remedial Actions at Superfund Sites with PCB Contamination." This fact sheet outlines the primary regulatory requirements of the RCRA and TSCA programs concerning PCBs.

2. Development and evaluation of alternatives involving the remediation of contaminated ground water should consider several general response actions, such as various degrees of active restoration, limited or no active response measures, and plume containment. A range of treatment technologies and extraction technologies should also be considered, to the extent appropriate. In addition, evaluation of treatment options should also include a discussion of the feasibility of treating ground water at the facility currently in design as part of the Operable Unit 1 remedy.

If you have any questions or comments, please contact Alison Barry, of my staff, at (212) 264-8678.

Sincerely yours,

Raymond Basso

Raymond Basso, Chief
New Jersey Superfund Branch II

Attachments

cc: Ralph Sundstrom, Kin Buc
Richard Karr, Waste Management NA
Robert Miller, Wehran
Ian Curtis, NJDEPE
Jeanne Litwin, CDM FPC

EXECUTIVE SUMMARY

This risk assessment (RA) for the Kin-Buc Landfill site - Operable Unit 2 is composed of two parts. Part I, Human Health Assessment, focuses on the human health effects of contaminants released from the site through ground water, surface water, and sediment. Part II, Environmental Assessment, addresses the risks to flora and fauna in the vicinity of the site, due to exposure to site-related contaminants in surface water and sediment. Biota data are used to evaluate risks to selected species. Contaminant fate and transport information presented in the Human Health Assessment applies to Environmental Assessment also. The two parts of the report will be presented as two stand alone sections, each with a distinctive and directed approach, to allow better access to the information contained therein.

DRAFT

To allow periodic review of the approach used in this RA, while it was still in progress, the EPA was informed about Data Handling, Indicator Chemical Selection, Exposure Pathways and Assumptions, and Risk Assessment in a series of milestones.

The following sections present details on the Human Health Assessment and the Environmental Assessment.

Human Health Assessment

The contaminants identified in samples from the Kin-Buc Landfill site were screened to identify the most hazardous compounds. The contaminant screening process identified 19 chemicals of potential concern: nine metals and ten organic compounds. These compounds or elements were selected because of their toxicological properties, potentially critical exposure routes, frequency of occurrence, and higher concentrations present in comparison to other contaminants.

Contaminant migration mechanisms were evaluated for each of the indicator chemicals based on the site's physical setting and the physical and chemical properties of each contaminant. Exposed populations include local residents who fish and swim in the area streams, and potential future residential users of ground water.

Toxicology assessments, which include pharmacokinetics, human health effects, and dose response assessment, for each of the indicator chemicals were developed based on current U.S. EPA accepted health effects documents, and established toxicological sources.

Risk characterization included an assessment of risk associated with carcinogenic and noncarcinogenic effects. Noncarcinogenic risks were addressed using a hazard quotient computed by comparing the daily intake levels to a reference dose, above which no human health effects are anticipated, and summed to obtain a hazard index. This index should not exceed one, according to the NCP Superfund site remediation goals (U.S. EPA, 1989).

Many of the hazard indices computed indicated that the intake levels were below the reference doses (i.e., hazard indices were below one). However, five of the exposure scenarios had hazard indices (HI) above reference doses:

- ground-water ingestion by adults and children,
- fish ingestion by adults, and
- dermal contact with sediments by children.

Potential carcinogenic risks were computed by multiplying the chronic daily intakes by the chemical-specific carcinogenic slope factor. The resulting carcinogenic risks were then compared to the Superfund Site remediation goal of 10^{-4} to 10^{-6} (EPA, 1989).

The following risks calculated for the potential exposure scenarios exceeded the upper limit of the guideline range:

- ingestion of ground water by adults and children,
- ingestion of fish by adults and children, and
- dermal contact with sediments by adults and children.

Overall, the greatest noncarcinogenic hazard indices and carcinogenic risks result from oral ingestion of and dermal contact with the following constituents: arsenic, antimony, bis(2-ethylhexyl)phthalate, 4,4'-DDT, manganese, PCBs, and vinyl chloride.

Environmental Assessment

The potential impacts to fish, wildlife, and plants were evaluated in the environmental assessment. Because the environmental assessment estimates risks to discrete populations, the site was first divided into subsets representing separate areas for contaminant exposure. Media-specific chemicals of potential concern were identified for each area of the site. Spatial patterns in contaminant concentrations were evaluated to determine whether chemicals in specific media are likely to occur from site-related activities. Ecological receptors and potential exposure pathways were identified.

Aquatic life and marsh plants may be exposed to chemicals in surface water and sediments. Estimates were made of the exposure of predatory bird species through the food chain and surface water ingestion. After toxicity data were obtained, risks to aquatic life were assessed by comparing surface water and sediment concentrations with toxicity guidance values. Risks to birds were evaluated by comparing estimated dosages with toxicity reference values (TRVs) derived from the literature, which are measured or estimated "no observed effect" dosages. Risks to fish, fiddler crabs, and mammals were assessed by comparing tissue levels in Kin Buc animals with levels reported to be associated with toxic effects.

Organic chemical concentrations in surface water do not pose risks to aquatic life. Although several metals were found in surface waters at concentrations above ambient water quality criteria, the spatial pattern of concentrations does not implicate site-related activities. The major site-related risks to aquatic life are posed by the presence of PCBs in sediments at Pool C and the Connecting Channel and tidal Edmonds Creek. These concentrations greatly exceeded guidance levels and, therefore, assumed to be toxic to bottom-dwelling organisms. Sediment concentrations of antimony, lead, mercury, nickel, and zinc also slightly exceeded guidance values for sediment toxicity and the concentrations appear to be site-related. Sediments can be a source of PCBs to fish and fiddler crabs; PCB tissue levels in mummichogs collected at tidal Edmonds Creek exceeded levels associated with toxic effects. Tissue concentrations of mammals were less than levels associated with toxic effects. Marsh plants may be at risk from exposure to arsenic, copper, and lead; but, there are considerable uncertainties in the plant toxicity guidance values.

Table 1-4. Chemicals of Potential Concern

	I. Surface Water			
	A. Pool C+ Channel	B. Edmonds Tidal	C. Edmonds Non-Tidal	D. Low Lying Area
VOCs:				
2 Butanone	X			
Chlorobenzene	X			
Styrene	X			
Xylenes	X		X	
PAHs:				
2- Methylnaphthalene	X		X	
Other semivolatiles:				
N-Nitrosodiphenylamine	X			
Pesticides/PCBs:				
DDT	X			
Aroclor 1254	X			
Metals:				
Aluminum	X	X	X	X
Arsenic	X	X	X	X
Barium	X	X	X	X
Chromium	X	X	X	X
Cobalt	X	X	X	
Copper	X	X	X	X

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Table 1-4. Continued

I. Surface Water (Continued)

	A. Pool C and Channel	B. Edmonds Tidal	C. Edmonds Non-Tidal	D. Low Lying Area
Iron	X	X	X	X
Lead	X	X	X	X
Nickel	X	X	X	X
Vanadium	X	X	X	X
Zinc	X	X	X	X
Inorganics:				
Ammonia	X	X	X	X
Cyanide		X		X

Table 1-4. Continued

II. Sediments								
	A. Pool C and Channel	B. Edmonds Tidal	C. Edmonds Non-tidal	D. Low Lying Area	E. Martins Creek	F. Mill Brook	G. Raritan River	H. Unnamed Ditch
PAHs:								
Phenanthrene	X		X	X	X	X		
Pyrene	X		X			X	X	
Total PAHs	X	X		X	X	X		X
PCB's:								
Aroclor 1254	X	X		X		X	X	X
Total PCBs	X	X		X		X	X	X
Metals:								
Antimony	X	X			X			
Arsenic	X	X						X
Cadmium					X			
Chromium								
Copper		X						
Lead		X						
Mercury		X						X
Nickel	X	X						
Silver								X
Zinc		X						

Table 1-4. Continued

III. Biota			
	Edmonds Tidal	**Martin Creek**	**Mill Brook**
Mummichog			
PCBs:			
Aroclor 1248	X	X	X
Aroclor 1254	X	X	X
Aroclor 1260		X	
Metals:			
Cadmium			X
Chromium	X	X	X
Lead		X	X
Fiddler Crab			
PCBs:			
Aroclor 1248	X		
Aroclor 1254	X		
Aroclor 1260		X	
Metals:			
Cadmium	X		
Chromium	X		
Lead	X		

Table 1-4. Continued

III. Biota		
	Edmonds Tidal	Martin's Creek
Muskrat		
PCBs:		
Aroclor 1254	X	X
Metals:		
Chromium	X	X
Lead	X	X
Norway rat:		
PCBs:		
Aroclor 1260	X	
Metals:		
Cadmium	X	
Chromium	X	
Lead	X	
House mouse		
PCBs:		
Aroclor 1260	X	

DRAFT

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MILESTONE II TABLE 1-8
INDICATOR CHEMICALS CHOSEN FOR EACH MEDIA
AT THE KIN-BUC SUPERFUND SITE
OPERABLE UNIT 2

COMPOUND	SEDIMENTS	SURFACE WATER	GROUND WATER	AIR
VOCS:				
BENZENE		X	X	X
CARBON DISULFIDE				X
CHLOROBENZENE		X	X	X
1,2-DICHLOROETHENE			X	
VINYL CHLORIDE			X	
XYLENE				X
PAHS:				
NAPHTHALENE		X	X	
PHTHALATES:				
BIS(2-ETHYLHEXYL)PHTHALATE	X			
PESTICIDES/PCBs:				
4,4'-DDT		X		
PCBs	X	X		
METALS:				
ANTIMONY		X	X	
ARSENIC		X	X	
BARIUM		X	X	
BERYLLIUM		X	X	
CADMIUM			X	
COPPER		X		
MANGANESE		X	X	
NICKEL		X		
VANADIUM		X	X	

NOTE:
This table presents the contaminants of concern for the human health evaluation of the Kin Buc RA. Note that all of the contaminants selected above will be evaluated for all of the pathways in which they were detected. For example: cadmium was only selected for ground water, it will be evaluated for sediments, surface water, and ground water. Since the air pathway involves volatilization, cadmium will not be evaluated for air.

TABLE 3-1
EVALUATION OF EXPOSURE PATHWAYS

SOIL

Onsite
Ingestion - Not evaluated. Access is controlled
Absorption - Not evaluated. Access is controlled
Offsite - Not evaluated. No data

Sediments
Ingestion - Evaluated for expsoure during recreation activities
Absorption - Evaluated for exposure during recreation activities

WATER

Ground Water
Inhalation - Evaluated for exposure during showering
Ingestion - Evaluated for exposure from water consumption
Absoprtion - Evaluated for exposure during showering

Surface Water
Inhalation - Not evaluated. Other routes are adequate to assess surface water risks
Ingestion - Evaluated for exposure during recreation activities
Absorption - Evaluated for exposure during recreation activities
Fish Ingestion - Evaluated for exposure from fish consumption

AIR

Onsite
Dust Inhalation - Not evaluated. No mechanism for dust release
VOC Inhalation - Not evaluated. Access controlled

Offsite
Dust Inhalation - Not evaluated. No mechanism for dust release
VOC Inhalation - Not evaluated. Early reports indicate landfill cap eliminated much of the vapor migration

RECEIVED
FEB 07 1992
Wehran Engineering
Massachusetts

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, NEW YORK 10278

[illegible] 6 1992

Kevin Burger, C.E.P.
Facility Coordinator
Wehran Engineering Corporation
Andover Research Park
Six Riverside Drive, Suite 101
Andover, Massachusetts 01810-1121

Re: Additional Biological Sampling Reports, Operable Unit 2 Remedial Investigation (RI), Kin Buc Landfill Superfund Site, Edison, New Jersey. Administrative Order No. II-CERCLA-00114.

Dear Mr. Burger:

The purpose of this letter is to transmit the results of the additional biological sampling conducted by the U.S. Environmental Protection Agency (EPA) to supplement the draft final Operable Unit 2 Remedial Investigation Report submitted by Wehran on behalf of the Respondents to the above-referenced Order. The Environmental Services Division (EPA-Region 2) report presents evidence for bioaccumulation of PCBs in fiddler crabs within the Operable Unit 2 study area. The Emergency Response Division (EPA-OERR) report presents the results of analyses conducted on muskrats obtained from the Edmonds Creek/Marsh system.

These reports are provided for informational purposes only. Written comments may be submitted to EPA during the public comment period which follows the issuance of the Proposed Plan. If you have any questions or comments regarding these reports, please contact me at (212) 264-8678.

Sincerely yours,

Alison Barry

Alison Barry
Remedial Project Manager

Attachments

cc: Ralph Sundstrom, Kin Buc (w/o attachments)
Richard Karr, Waste Management NA
Bob Miller, Wehran
Ian Curtis, NJDEPE (attachments)
Jeanne Litwin, CDM FPC

U.S. ENVIRONMENTAL PROTECTION AGENCY

Kin-Buc Landfill
Biological Sampling

May 1991 (draft)
January 1992 (final)

ENVIRONMENTAL SERVICES DIVISION
REGION 2
NEW YORK, NEW YORK 10278

Kin-Buc Landfill
Biological Sampling

May 1991 (draft)
January 1992 (final)

Participating Personnel: U.S. Environmental Protection Agency
Darvene Adams, Region II
Mark Sprenger, HQ-ERT
WESTON/ESAT
Lynn Vukovich
Joseph Gebler
Mark Denno
WESTON/REAC
David Miller
TES (consultants to Kin-Buc PRPs)

Prepared by: Darvene Adams 1/24/92
Darvene Adams,
Environmental Scientist
Lynn Vukovich,
Environmental Scientist

Approved for the Director by: 1/28/92
Richard D. Spear, Ph.D., Chief
Surveillance & Monitoring Branch

INTRODUCTION

The Kin-Buc Landfill is located on Meadow Road in Edison, New Jersey. It is an inactive site with a total size of approximately 220 acres. Operations began as early as 1947. The site was operated as a landfill by Kin-Buc, Inc. from about 1968 to 1976. It was a state-approved landfill for industrial and municipal wastes from 1971 to 1976.

Major features of the site (Figure 1) include two large mounds and one smaller mound, and a natural depression, called Pool C, which accumulates PCB laden oil and leachate. East of Pool C, across from Edmonds Creek, is a large tidal estuary with numerous ditches dug for mosquito control. Pool C is connected to Edmonds Creek by a channel and Edmonds Creek flows into the Raritan River.

The site is presently divided into three operable units. The Operable Unit 2 Remedial Investigation (RI) was conducted by Wehran Inc., a contractor for the Potentially Responsible Parties (PRPs). Included in this operable unit are Mound B, Mill Brook, Martins Creek, Edmonds Creek (including the connecting channel from Pool C), the adjacent wetlands, and groundwater emanating from the site.

Sediment and biota sampling and analysis were included in the operable unit II RI workplan to determine the extent of bioaccumulation of site-related contaminants. Targeted for collection and analysis were fish (mummichogs), benthic invertebrates (fiddler crabs, shrimp) and mammals (muskrats). However, the Wehran subcontractor (TES) for the biota sampling was not able to obtain fiddler crabs (Uca sp.) from Martins Creek and shrimp (Palaeomonetes sp.) for analysis. Because of the importance of addressing this route of potential contaminant exposure in the food chain, the Surveillance and Monitoring Branch (SMB) was requested to try to provide this additional information.

On July 12, 1990, sampling was conducted by the following personnel:

Darvene Adams, USEPA-Region II, SMB
Lynn Vukovich, WESTON/ESAT
Mark Denno, WESTON/ESAT
Joseph Gebler, WESTON/ESAT
Mark Sprenger, USEPA-ERT
David Miller, WESTON-REAC

Additionally, personnel from Wehran and their subcontractor, Terrestrial Environmental Specialists (TES) attended and obtained split samples, when sample volumes allowed. In some instances they collected samples concurrently with EPA.

OBJECTIVE

To determine if bioaccumulation is occurring in lower trophic level organisms in the Operable Unit 2 area of the Kin-Buc Landfill site.

SAMPLING AND ANALYSIS PROCEDURES

Sampling locations are shown in Figure 1. General water quality measurements were taken at all locations using a Hydrolab. These measurements included pH, dissolved oxygen, temperature, oxygen reduction potential (ORP), depth and salinity.

A total of 5 sediment samples were collected from four locations:

1. Upper Edmonds Creek,
2. Lower Edmonds Creek (2 samples),
3. Martins Creek, and
4. an upstream reference location on the Raritan River.

Sediment samples were collected from areas that would be submerged during high tide. Appropriately cleaned stainless steel trowels were used for collection and sediment samples were homogenized in a stainless steel bowl. Trowels and bowls were dedicated to each sampling location. The samples were preserved on wet ice at approximately 4°C until shipment to the laboratory the next day. Sediment samples were analyzed for:

semivolatiles,
PCBs,
5 metals (cadmium, chromium, copper, mercury and zinc),
Total Organic Carbon (TOC), and
grain size.

Organic and inorganic sediment analyses were done according to the Contract Laboratory Program (CLP) scopes of work (SOWs). Total Organic Carbon (TOC) was analyzed according to the Region II method, "Determination of Total Organic Carbon in Sediment" (Lloyd Kahn, July 27, 1988) and grain size was determined using ASTM method D422-83, "Particle-Size Analysis of Soils".

Fiddler crabs (Uca minax) were obtained from the same locations as the sediment samples. These were collected by hand into stainless steel buckets. The fiddler crabs were identified to species and sexed; only males were utilized in the composite samples to reduce variability due to sex differences. Samples were stored on wet ice at 4°C until delivered to the laboratory for analysis. Analyses were done according to "Test Methods for Evaluation of Solid Wastes" (USEPA, 1986), as follows:

semivolatiles - procedure 8270,
PCBs - procedure 8080,
cadmium, chromium, copper and zinc - procedure 6010,
mercury - procedure 7471.

Although the reference location was in close proximity to the Kin-Buc Landfill, it was selected because it was the only area upstream of the Kin-Buc Landfill site that fiddler crabs could be obtained. It is a less than ideal reference location because of the possibility that tidal effects could transport contaminants to this location from the Kin-Buc site. The reference location was also close to the New Jersey Turnpike and could receive contaminants from that source.

An attempt was made to collect shrimp utilizing dip nets and a small seine net. However, the number of individuals collected was insufficient for analysis.

RESULTS and DISCUSSION

Water Quality

Results of the general water quality measurements are given in Table 1. Salinity ranged from <1 to 5.4 parts per thousand; pH ranged from 6.5 to 7.0; dissolved oxygen from 4.6 to 6.1 mg/l and temperature from 21 to 23°C. These ranges are expected in an estuarine system.

Sediments

Volatile organics were not determined to be of concern for this study and therefore were not analyzed in the sediment samples.

The U.S. Environmental Protection Agency (EPA) does not yet have standards or criteria for sediment contamination. Levels are therefore compared to reference location values and literature values known to have adverse biological effects.

After data review, some results were qualified with a "J", meaning that the contaminant was present but the value given is estimated. The "Risk Assessment Guidance for Superfund - Volume I" (USEPA, 1989), allows the use of "J"ed data for risk evaluation.

Semivolatile organics analysis

Table 2 presents the levels of semivolatile organics detected in sediment samples. Detection limits and raw data are found in Appendix A.

These data show a variety of polynuclear aromatic hydrocarbons (PAHs) and phthalates are present at the Kin-Buc Landfill site as well as at the reference location. The Martins Creek location appears to be the most heavily contaminated with semivolatiles as the number of contaminants appear to be more extensive and the levels higher than those from the Edmonds Creek location. This may be due to a different source material on this side of the Kin-Buc Landfill site (since several mounds are present on this side of the site) and/or upstream contributions. There are also several closed auto salvage yards in the upstream section of Martins Creek.

PCBs/pesticides analysis

Table 3 presents the results of the PCBs/pesticides analyses of the sediments. Detection limits for the pesticide fraction ranged from 14 to 650 ug/kg, dependent on the sample. Detection limits for PCBs were between 140 and 650 ug/kg. Specific detection limits and raw data are found in Appendix A.

PCBs were not detected in sediments from Martins Creek or the reference location. Total PCBs were highest in Upper Edmonds Creek sediments (3,090J ug/kg). Concentrations in Lower Edmonds Creek sediments were 1,450 and 2,030 ug/kg (includes the duplicate analysis).

Long and Morgan (1990) compiled sediment PCB data from many locations in the United States. They state: "With very few exceptions, effects were almost always associated with PCB concentrations of 370 ppb (ug/kg) or more".

When compared to the non-detect from the reference location (detection limit from 190 to 390 ug/kg) and literature values for other estuaries, the values from the Kin-Buc site are indicative of contamination by a source of PCBs and potentially injurious to biota.

Inorganics

The levels of metals detected in sediments are shown in Table 4. Some of the levels are at or near levels shown to cause adverse impacts in biota (Long and Morgan, 1990). However, the reference location had similar concentrations of some metals, indicating another source in that location (e.g., the NJ Turnpike). The elevated levels of metals combined with the PCBs found in Edmonds Creek could have synergistic effects on biota.

Fiddler Crabs

Volatile organics analysis was not done on the fiddler crab samples. Semivolatile compounds were not detected in the fiddler crab samples. Detection limits and raw data are found in Appendix B.

Concentrations of the five metals analyzed in the crab samples are shown in Table 5. Chromium, copper and zinc were detected in crabs from Lower and Upper Edmonds Creek and the reference location. Copper and zinc were detected in the Martins Creek fiddler crabs. A low level of cadmium (0.6 mg/kg) was also detected in the reference location sample. Mercury was not detected in any of the crab samples.

Table 5 also shows the results of the PCB analyses of the fiddler crab samples. Percent lipids were determined and the lipid-adjusted PCB concentrations are reported in this table. Fiddler crabs were prepared for analysis in two ways. At all locations crabs were analyzed for PCBs with the outer covering (carapace) intact. In addition, a sample of crabs obtained from Upper Edmonds Creek was analyzed with the carapaces removed. This type of sample was used to simulate the consumption of crabs by small shore birds and mammals which do not consume fiddler crabs whole but ingest the internal organs and small appendages.

Since PCBs are lipophilic and the amounts of lipids present in biological samples vary, lipid-adjusted concentrations are often used to give an indication of the normalized PCB concentration present in the sample. They allow for a more accurate comparison between tissues and across species. The concentrations of PCBs (Aroclor 1248) in the Lower Edmonds Creek sample and duplicate were 47 and 98 ug PCBs/g lipid, respectively. The Upper Edmonds Creek sample contained 107 ug PCBs/g lipid (Aroclor 1248). Martins Creek fiddler crabs had 7 ug PCBs/g lipid (Aroclor 1260) and the reference location was non-detect for PCBs. These crabs were all analyzed with their carapaces intact. These concentrations indicate that bioaccumulation of PCBs is occurring in the fiddler crabs from Edmonds Creek and to a lesser extent in Martins Creek organisms.

A very significant finding was the concentration of 500 ug PCBs/g lipid in the Upper Edmonds Creek fiddler crab sample which had the carapaces removed from the crabs. Fiddler crabs are consumed by several species of birds and small mammals which inhabit marsh ecosystems. Some of these predators do not consume the entire organism but selectively eat the internal organs and small appendages. These organisms would receive a significantly higher exposure to PCBs from the food route. Studies have shown that the dose of PCBs which is lethal to 50% of the birds tested (LD-50) varied from 604 to over 6,000 mg/kg in their diet (Eisler, 1986).

The Kin-Buc Operable Unit 2 Draft RI report stated that great blue herons and black crowned night herons were observed in a Spartina stand, presumably feeding on fiddler crabs. These crabs are also consumed by other birds such as green herons, willets, and seagulls. Mammals which may consume fiddler crabs include raccoons, muskrats and red fox, all of which were observed at the site. In addition, some fish and blue claw crabs will also consume fiddler crabs.

Levels of concern

Several organizations have set levels of concern for PCBs in biota. The International Joint Commission (IJC) uses a level of 0.1 ppm (ug/g) to protect piscivorous wildlife (cancer risk). The State of New York has proposed a fish flesh criterion of 0.13 ppm to protect piscivorous wildlife. The Food and Drug Administration (FDA) has an action level of 2 ppm for PCBs in seafood. However, this level is aimed at seafood that is involved in interstate commerce and is for human consumption.

SUMMARY

The results from this sampling and analysis indicate that food chain bioaccumulation of site-related contaminants at the Kin-Buc Landfill site is taking place. Most notable of these contaminants are PCBs. The organisms potentially at the greatest risk from these contaminants are the predators that consume the internal organs and small appendages of the fiddler crabs. The level of PCBs in this type of sample was 500 ug/g lipid.

RECOMMENDATIONS

A site-specific ecological risk assessment could be conducted to determine if the levels found pose a significant risk to site or transitory biota.

If any additional sampling is done, an attempt should be made to better define sediment background levels of contaminants in the Raritan River basin.

REFERENCES

Eisler, R. 1986. Polychlorinated Biphenyl Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 85(1.7). Fish and Wildlife Service, U.S. Department of the Interior. Laurel, Maryland.

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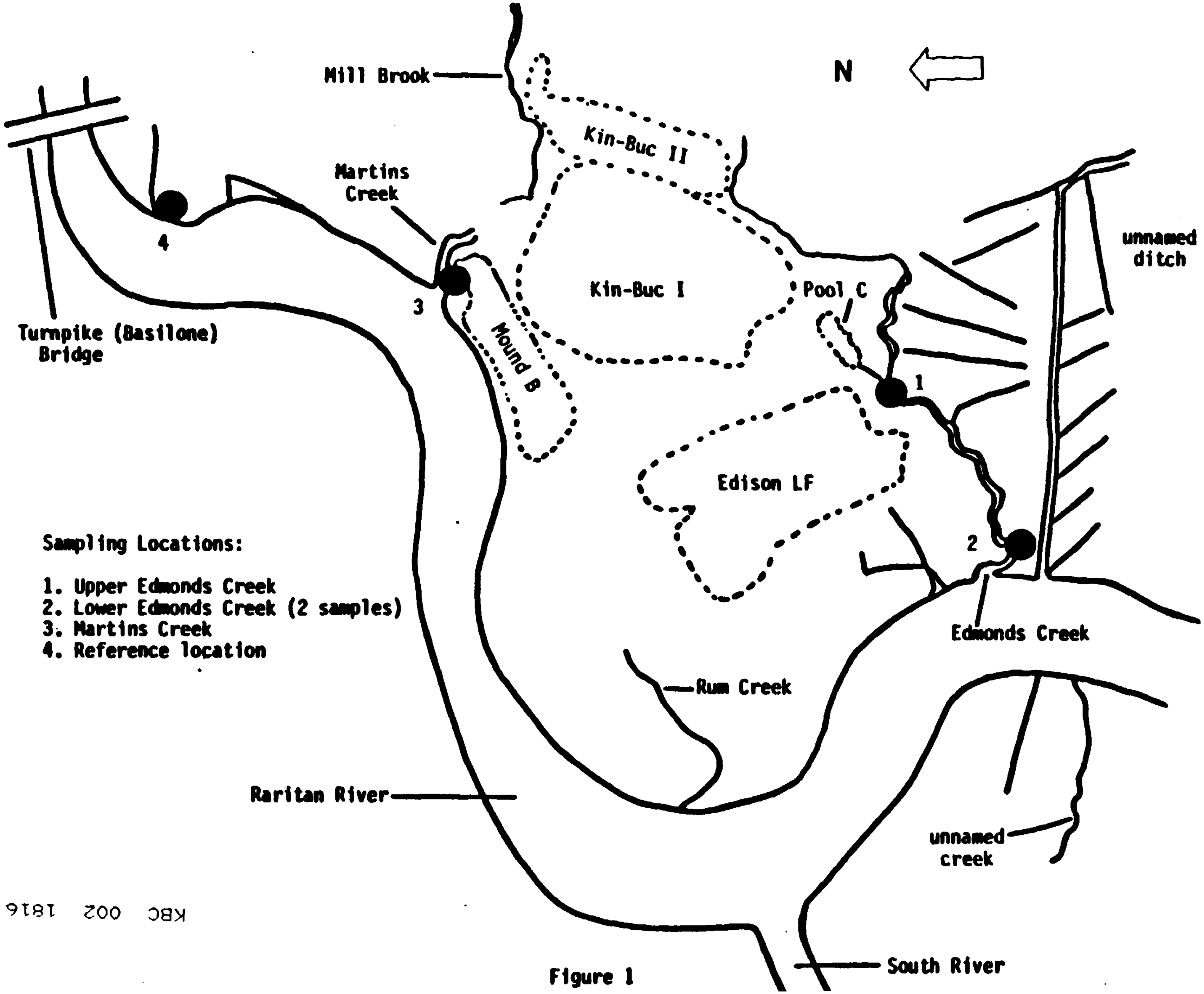

Sampling Locations:

1. Upper Edmonds Creek
2. Lower Edmonds Creek (2 samples)
3. Martins Creek
4. Reference location

Figure 1

Table 1

Water Chemistry Measurements

Parameter	Lower Edmonds Creek	Upper Edmonds Creek	Martins Creek	Upstream Reference Location
pH	6.5	6.7	6.6	7.0
dissolved oxygen (ppm)	4.6	4.7	6.1	6.1
temperature (°C)	23	21	21	22
depth (m)	0.5	0.5	1.0	0.5
salinity (ppt)	5.4	2.3	1.0	<1

Water chemistry measurements were done at high or outgoing tides.

Table 2

Semivolatile Organics in Sediments (concentrations in ug/kg, wet wt.)

Analyte	Lower Edmonds Creek	Lower Edmonds Creek - dup	Upper Edmonds Creek	Martins Creek	Upstream Reference Location
Acenapthene				74J	
Fluorene				94J	
Phenanthrene	200J	200J	160J	910	300J
Anthracene				250J	
Fluoranthene	430J	440J	400J	1600	640J
Pyrene	510J	490J	430J	1600	730J
Butylbenzylphthalate	89J	78J	120J	160J	
Benzo(a)Anthracene	210J	210J	190J	740	290J
Chrysene	280J	270J	260J	870	390J
bis(2-ethylhexyl) phthalate	3900J	3400J	5900J	5200	1500J
Di-n-Octyl phthalate				140J	
Benzo(b)fluoranthene	340J	470J	290J	720	520J
Benzo(k)fluoranthene	320J	210J	210J	840	390J
Benzo(a)pyrene	280J	280J	230J	780	370J
Indeno(1,2,3-cd) pyrene		120J	130J	380J	130J
Dibenz(a,h) anthracene				86J	
Benzo(g,h,i)perylene	85J	100J	110J	350J	
TICs					
1-Octadecanamine	400J	410JN			570JN
Benzenemethanamine			530JN		

"J" indicates an estimated value

"JN" indicates an estimated value with presumptive evidence for the preesence of the material at an estimated value

"TIC" indicates a tentatively identified compound

Table 3

PCBs/Pesticides in Sediments
(concentrations in ug/kg, wet wt.)

Analyte	Lower Edmonds Creek	Lower Edmonds Creek - dup	Upper Edmonds Creek	Martins Creek	Upstream Reference Location
Aroclor 1248	1300J	870J	2300J		
Aroclor 1254	730J	580J	790J		
Total PCBs	2030J	1450J	3090J		
TOC (mg/kg)	48800	49500	73400	27800	114000
-lab dup			69500		
grain sz.					
%sand	16.6	19.9	17.6	58.1	16.5
%silt	53.2	50.3	46.6	26.1	56.1
%clay	30.2	29.8	35.8	15.8	27.4

"J" indicates an estimated value

Table 4

Inorganics in Sediments
(concentrations in mg/kg, dry wt.)

Analyte	Lower Edmonds Creek	Lower Edmonds Creek-dup	Upper Edmonds Creek	Martins Creek	Upstream Reference Location
Aluminum	20400	18200J	18300J	7480J	17800J
Antimony					
Arsenic	27.8J	48.0J	36.1J	23.5J	31.5J
Barium	86.6	80.5J	94.8J	146J	117J
Beryllium	1.7	1.5J	1.7J	0.49J	1.4J
Cadmium				2.3J	
Calcium	1950	1980J	2540J	2280J	2520J
Chromium	80.7	82.9J	72.1J	40.4J	67.8J
Cobalt	17.3	15.9J	25.1J	15.5J	18.1J
Copper	215	221J	207J	87.4J	162J
Iron	38700	37900J	42500J	23400J	34300J
Lead	151	164J	125J	227J	148J
Magnesium	6500	6320J	6450J	3430J	5990J
Manganese	326	289J	374J	220J	404J
Mercury	1.1J	1.3J	0.85J	0.39J	1.0J
Nickel	34.6	33.7J	48.3J	26.7J	32.5J
Potassium	2170	2260J	2500J	1260J	1680J
Selenium	2.2J	2.4J	1.3J		1.1J
Silver	3.8	3.5J			3.5J
Sodium	3420	3600J	2760J	1240J	1670J
Thallium					
Vanadium	63.5	65.5J	60.6J	37.3J	54.5J
Zinc	280	296J	360J	292J	268J
TOC	48800	49500	73400	27800	114000
lab dup			69500		
grain sz.					
%sand	16.6	19.9	17.6	58.1	16.5
%silt	53.2	50.3	46.6	26.1	56.1
%clay	30.2	29.8	35.8	15.8	27.4

blank spaces refer to non-detects
"J" indicates an estimated value

Table 5

Contaminants Detected in *Uca minax* (fiddler crabs)

Analyte	Lower Edmonds Creek	Lower Edmonds Creek - dup	Upper Edmonds Creek	Upper Edmonds Creek (no carapaces)	Martins Creek	Upstream Referenc Location
Metals (mg/kg, wet wt.)						
cadmium						0.6
chromium	1.8	62.5	1.2			1.2
copper	37.9	17.1	37.7		42.6	47.9
mercury						
zinc	25.6	40.0	26.8		26.5	29.1
PCBs (ug/kg, wet wt.)						
Aroclor 1248	250	580	990	14000		ND
Aroclor 1254						
Aroclor 1260					170	
% lipids	0.53	0.59	0.93	2.8	2.4	1.1
lipid-adjusted concentrations (ug PCBs/g lipid)	47	98	107	500	7	-

Appendix A

(Sediment raw data, including TOC and grain size)

1B
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA01

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-01

ample wt/vol: 30.4 (g/mL) G Lab File ID: A4767

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 51 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/10/90

PC Cleanup: (Y/N) N pH: 6.3 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	670	U J✓
111-44-4	bis(2-Chloroethyl)Ether	670	U
95-57-8	2-Chlorophenol	670	U
541-73-1	1,3-Dichlorobenzene	670	U
106-46-7	1,4-Dichlorobenzene	670	U
100-51-6	Benzyl Alcohol	670	U
95-50-1	1,2-Dichlorobenzene	670	U
95-48-7	2-Methylphenol	670	U
39638-32-9	bis(2-Chloroisopropyl)Ether	670	U
106-44-5	4-Methylphenol	670	U
621-64-7	N-Nitroso-Di-n-Propylamine	670	U
67-72-1	Hexachloroethane	670	U
98-95-3	Nitrobenzene	670	U
78-59-1	Isophorone	670	U
88-75-5	2-Nitrophenol	670	U
105-67-9	2,4-Dimethylphenol	670	U
65-85-0	Benzoic Acid	3300	U
111-91-1	bis(2-Chloroethoxy)Methane	670	U
120-83-2	2,4-Dichlorophenol	670	U
120-82-1	1,2,4-Trichlorobenzene	670	U
91-20-3	Naphthalene	670	U
106-47-8	4-Chloroaniline	670	U
87-68-3	Hexachlorobutadiene	670	U
59-50-7	4-Chloro-3-Methylphenol	670	U
91-57-6	2-Methylnaphthalene	670	U
77-47-4	Hexachlorocyclopentadiene	670	U
88-06-2	2,4,6-Trichlorophenol	670	U
95-95-4	2,4,5-Trichlorophenol	3300	U
91-58-7	2-Chloronaphthalene	670	U
88-74-4	2-Nitroaniline	3300	U
131-11-3	Dimethyl Phthalate	670	U
208-96-8	Acenaphthylene	670	U
606-20-2	2,6-Dinitrotoluene	670	U

079

1C
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA01

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-01

ample wt/vol: 30.4 (g/mL) G Lab File ID: A4767

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 51 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/10/90

PC Cleanup: (Y/N) N pH: 6.3 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	3300	UJ
83-32-9	Acenaphthene	670	U
51-28-5	2,4-Dinitrophenol	3300	U
100-02-7	4-Nitrophenol	3300	U
132-64-9	Dibenzofuran	670	U
121-14-2	2,4-Dinitrotoluene	670	U
84-66-2	Diethylphthalate	670	U
7005-72-3	4-Chlorophenyl-phenylether	670	U
86-73-7	Fluorene	670	U
100-10-6	4-Nitroaniline	3300	U
534-52-1	4,6-Dinitro-2-Methylphenol	3300	U
86-30-6	N-Nitrosodiphenylamine (1)	670	U
101-55-3	4-Bromophenyl-phenylether	670	U
118-74-1	Hexachlorobenzene	670	U
87-86-5	Pentachlorophenol	3300	U ↓
85-01-8	Phenanthrene	200	J
120-12-7	Anthracene	670	UJ
84-74-2	Di-n-Butylphthalate	670	UJ
206-44-0	Fluoranthene	430	J
129-00-0	Pyrene	510	J
85-68-7	Butylbenzylphthalate	89	J
91-94-1	3,3'-Dichlorobenzidine	1300	UJ
56-55-3	Benzo(a)Anthracene	210	J
218-01-9	Chrysene	280	J
117-81-7	bis(2-Ethylhexyl)Phthalate	3900	J
117-84-0	Di-n-Octyl Phthalate	670	UJ
205-99-2	Benzo(b)Fluoranthene	340	J
207-08-9	Benzo(k)Fluoranthene	320	J
50-32-8	Benzo(a)Pyrene	280	J
193-39-5	Indeno(1,2,3-cd)Pyrene	670	UJ
53-70-3	Dibenz(a,h)Anthracene	670	UJ
191-24-2	Benzo(g,h,i)Perylene	85	J

(1) - Cannot be separated from Diphenylamine

KBC 002 1824

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BFA01

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-01

ample wt/vol: 30.4 (g/mL) G Lab File ID: A4767

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 51 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/10/90

PC Cleanup: (Y/N) N pH: 6.3 Dilution Factor: 1.0

umber TICs found: 21

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	Unknown	4.72	2100	~~BJ~~ R
2. 123422	4-Hydroxy-4-methyl-2-pentano	5.38	36000	~~ABJ~~ R
3. 000000	Unknown	21.64	340	~~B~~J
4. 000000	Unknown	23.47	340	~~B~~J
5. 000000	C12H6Cl4 isomer	25.07	600	~~B~~J
6. 000000	C12H6Cl4 isomer	26.57	470	~~B~~J
7. 124287	1-Octadecanamine, N,N-dimeth	26.87	400	J
8. 000000	Aromatic	27.19	340	~~B~~J
9. 000000	Unknown	27.29	270	~~B~~J
10. 000000	Unknown	29.04	270	~~B~~J
11. 000000	Unknown	31.14	540	~~B~~J
12. 000000	Aromatic	31.74	400	~~B~~J
13. 000000	Aromatic	31.89	1000	~~B~~J
14. 000000	Aromatic	32.06	600	~~B~~J
15. 000000	Aliphatic hydrocarbon	33.07	2100	~~B~~J
16. 000000	Aromatic	37.07	670	~~B~~J
17. 000000	Unknown	37.77	670	~~B~~J
18. 000000	Unknown	38.19	940	~~B~~J
19. 000000	Unknown	39.94	740	~~B~~J
20. 000000	Unknown	41.01	670	~~B~~J
21. 000000	Unknown	42.18	540	~~B~~J

1D

PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA01

ab Name: CEIMIC CORP Contract: 68D90029

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-01

ample wt/vol: 30 (g/mL) G Lab File ID: ________

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 51 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 07/31/90

PC Cleanup: (Y/N) N pH: 6.3 Dilution Factor: 2

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	33	U J
319-85-7	beta-BHC	33	U
319-86-8	delta-BHC	33	U
58-89-9	gamma-BHC (Lindane)	33	U
76-44-8	Heptachlor	33	U
309-00-2	Aldrin	33	U
1024-57-3	Heptachlor epoxide	33	U
959-98-8	Endosulfan I	33	U
60-57-1	Dieldrin	65	U
72-55-9	4,4'-DDE	65	U
72-20-8	Endrin	65	U
33213-65-9	Endosulfan II	65	U
72-54-8	4,4'-DDD	65	U
1031-07-8	Endosulfan sulfate	65	U
50-29-3	4,4'-DDT	65	U
72-43-5	Methoxychlor	330	U
53494-70-5	Endrin ketone	65	U
5103-71-9	alpha-Chlordane	330	U
5103-74-2	gamma-Chlordane	330	U
8001-35-2	Toxaphene	650	U
12674-11-2	Aroclor-1016	330	U
11104-28-2	Aroclor-1221	330	U
11141-16-5	Aroclor-1232	330	U
53469-21-9	Aroclor-1242	330	U
12672-29-6	Aroclor-1248	✓1300	J
11097-69-1	Aroclor-1254	730	J
11096-82-5	Aroclor-1260	650	U J

FORM I PEST

1B
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA02

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-02

ample wt/vol: 30.2 (g/mL) G Lab File ID: A4753

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 52 dec. ____ Date Extracted: 07/19/90

traction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/09/90

C Cleanup: (Y/N) N pH: 6.1 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	690	U J
111-44-4	bis(2-Chloroethyl)Ether	690	U
95-57-8	2-Chlorophenol	690	U
541-73-1	1,3-Dichlorobenzene	690	U
106-46-7	1,4-Dichlorobenzene	690	U
100-51-6	Benzyl Alcohol	690	U
95-50-1	1,2-Dichlorobenzene	690	U
95-48-7	2-Methylphenol	690	U
39638-32-9	bis(2-Chloroisopropyl)Ether	690	U
106-44-5	4-Methylphenol	690	U
621-64-7	N-Nitroso-Di-n-Propylamine	690	U
67-72-1	Hexachloroethane	690	U
98-95-3	Nitrobenzene	690	U
78-59-1	Isophorone	690	U
88-75-5	2-Nitrophenol	690	U
105-67-9	2,4-Dimethylphenol	690	U
65-85-0	Benzoic Acid	3300	U
111-91-1	bis(2-Chloroethoxy)Methane	690	U
120-83-2	2,4-Dichlorophenol	690	U
120-82-1	1,2,4-Trichlorobenzene	690	U
91-20-3	Naphthalene	690	U
106-47-8	4-Chloroaniline	690	U
87-68-3	Hexachlorobutadiene	690	U
59-50-7	4-Chloro-3-Methylphenol	690	U
91-57-6	2-Methylnaphthalene	690	U
77-47-4	Hexachlorocyclopentadiene	690	U
88-06-2	2,4,6-Trichlorophenol	690	U
95-95-4	2,4,5-Trichlorophenol	3300	U
91-58-7	2-Chloronaphthalene	690	U
88-74-4	2-Nitroaniline	3300	U
131-11-3	Dimethyl Phthalate	690	U
208-96-8	Acenaphthylene	690	U
606-20-2	2,6-Dinitrotoluene	690	U

1C
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA02

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Samole ID: 900536-02

ample wt/vol: 30.2 (g/mL) G Lab File ID: A4753

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 52 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/09/90

PC Cleanup: (Y/N) N pH: 6.1 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	3300	UJ
83-32-9	Acenaphthene	690	U
51-28-5	2,4-Dinitrophenol	3300	U
100-02-7	4-Nitrophenol	3300	U
132-64-9	Dibenzofuran	690	U
121-14-2	2,4-Dinitrotoluene	690	U
84-66-2	Diethylphthalate	690	U
7005-72-3	4-Chlorophenyl-phenylether	690	U
86-73-7	Fluorene	690	U
100-10-6	4-Nitroaniline	3300	U
534-52-1	4,6-Dinitro-2-Methylphenol	3300	U
86-30-6	N-Nitrosodiphenylamine (1)	690	U
101-55-3	4-Bromophenyl-phenylether	690	U
118-74-1	Hexachlorobenzene	690	U
87-86-5	Pentachlorophenol	3300	U ✓
85-01-8	Phenanthrene	200	J
120-12-7	Anthracene	690	UJ
84-74-2	Di-n-Butylphthalate	690	UJ
206-44-0	Fluoranthene	440	J
129-00-0	Pyrene	490	J
85-68-7	Butylbenzylphthalate	78	J
91-94-1	3,3'-Dichlorobenzidine	1400	UJ
56-55-3	Benzo(a)Anthracene	210	J
218-01-9	Chrysene	270	J
117-81-7	bis(2-Ethylhexyl)Phthalate	3400	J
117-84-0	Di-n-Octyl Phthalate	690	UJ
205-99-2	Benzo(b)Fluoranthene	470	J
207-08-9	Benzo(k)Fluoranthene	210	J
50-32-8	Benzo(a)Pyrene	280	J
193-39-5	Indeno(1,2,3-cd)Pyrene	120	J
53-70-3	Dibenz(a,h)Anthracene	690	UJ
191-24-2	Benzo(g,h,i)Perylene	100	J

(1) - Cannot be separated from Diphenylamine

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BFA02

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

trix: (soil/water) SOIL Lab Sample ID: 900536-02

ample wt/vol: 30.2 (g/mL) G Lab File ID: A4753

vel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 52 dec. ___ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/09/90

PC Cleanup: (Y/N) N pH: 6.1 Dilution Factor: 1.0

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

mber TICs found: 21

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	Unknown	4.73	2700	~~BJ~~ R
2. 123422	4-Hydroxy-4-methyl-2-pentano	5.43	49000	~~ABJ~~ R
3. 000000	Unknown	21.72	550	~~B~~J N
4. 000000	Unknown	23.55	340	~~B~~J
5. 000000	Unknown	24.12	620	~~B~~J
6. 000000	C12H6Cl4 isomer	26.66	550	~~B~~J
7. 7124287	1-Octadecanamine	26.94	410	J N
8. 000000	Aromatic	27.27	280	~~B~~J N
9. 000000	Unknown	31.24	1100	~~B~~J
10. 000000	Aromatic	31.84	340	~~B~~J
11. 000000	Aromatic	31.97	830	~~B~~J
12. 000000	Aromatic	32.16	480	~~B~~J
13. 000000	Unknown	32.56	280	~~B~~J
14. 000000	Aliphatic hydrocarbon	33.17	2800	~~B~~J
15. 000000	Aliphatic hydrocarbon	37.27	2500	~~B~~J
16. 000000	Unknown	37.34	2400	~~B~~J
17. 000000	Unknown	38.39	1100	~~B~~J
18. 000000	Unknown	40.14	830	~~B~~J
19. 000000	Unknown	40.37	620	~~B~~J
20. 000000	Unknown	41.24	830	~~B~~J
21. 000000	Unknown	42.44	970	~~B~~J

KBC 002 1829

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1D
FESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA02

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-02

ample wt/vol: 30.2 (g/mL) G Lab File ID: ______

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 52 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 07/31/90

PC Cleanup: (Y/N) N pH: 6.1 Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	17	U J
319-85-7	beta-BHC	17	U
319-86-8	delta-BHC	17	U
58-89-9	gamma-BHC (Lindane)	17	U
76-44-8	Heptachlor	17	U
309-00-2	Aldrin	17	U
1024-57-3	Heptachlor epoxide	17	U
959-98-8	Endosulfan I	17	U
60-57-1	Dieldrin	33	U
72-55-9	4,4'-DDE	33	U
72-20-8	Endrin	33	U
33213-65-9	Endosulfan II	33	U
72-54-8	4,4'-DDD	33	U
1031-07-8	Endosulfan sulfate	33	U
50-29-3	4,4'-DDT	33	U
72-43-5	Methoxychlor	170	U
53494-70-5	Endrin ketone	33	U
5103-71-9	alpha-Chlordane	170	U
5103-74-2	gamma-Chlordane	170	U
8001-35-2	Toxaphene	330	U
12674-11-2	Aroclor-1016	170	U
11104-28-2	Aroclor-1221	170	U
11141-16-5	Aroclor-1232	170	U
53469-21-9	Aroclor-1242	170	U
12672-29-6	Aroclor-1248	870	J
11097-69-1	Aroclor-1254	580	J
11096-82-5	Aroclor-1260	330	U J

FORM I PEST

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA03

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-03

ample wt/vol: 30.1 (g/mL) G Lab File ID: A4754

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 59 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/09/90

PC Cleanup: (Y/N) N pH: 6.5 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	800	U
111-44-4	bis(2-Chloroethyl)Ether	800	U
95-57-8	2-Chlorophenol	800	U
541-73-1	1,3-Dichlorobenzene	800	U
106-46-7	1,4-Dichlorobenzene	800	U
100-51-6	Benzyl Alcohol	800	U
95-50-1	1,2-Dichlorobenzene	800	U
95-48-7	2-Methylphenol	800	U
39638-32-9	bis(2-Chloroisopropyl)Ether	800	U
106-44-5	4-Methylphenol	800	U
621-64-7	N-Nitroso-Di-n-Propylamine	800	U
67-72-1	Hexachloroethane	800	U
98-95-3	Nitrobenzene	800	U
78-59-1	Isophorone	800	U
88-75-5	2-Nitrophenol	800	U
105-67-9	2,4-Dimethylphenol	800	U
65-85-0	Benzoic Acid	3900	U
111-91-1	bis(2-Chloroethoxy)Methane	800	U
120-83-2	2,4-Dichlorophenol	800	U
120-82-1	1,2,4-Trichlorobenzene	800	U
91-20-3	Naphthalene	800	U
106-47-8	4-Chloroaniline	800	U
87-68-3	Hexachlorobutadiene	800	U
59-50-7	4-Chloro-3-Methylphenol	800	U
91-57-6	2-Methylnaphthalene	800	U
77-47-4	Hexachlorocyclopentadiene	800	U
88-06-2	2,4,6-Trichlorophenol	800	U
95-95-4	2,4,5-Trichlorophenol	3900	U
91-58-7	2-Chloronaphthalene	800	U
88-74-4	2-Nitroaniline	3900	U
131-11-3	Dimethyl Phthalate	800	U
208-96-8	Acenaphthylene	800	U
606-20-2	2,6-Dinitrotoluene	800	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA03

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-03

ample wt/vol: 30.1 (g/mL) G Lab File ID: A4754

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 59 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/09/90

PC Cleanup: (Y/N) N pH: 6.5 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	3900	U J
83-32-9	Acenaphthene	800	U
51-28-5	2,4-Dinitrophenol	3900	U
100-02-7	4-Nitrophenol	3900	U
132-64-9	Dibenzofuran	800	U
121-14-2	2,4-Dinitrotoluene	800	U
84-66-2	Diethylphthalate	800	U
7005-72-3	4-Chlorophenyl-phenylether	800	U
86-73-7	Fluorene	800	U
100-10-6	4-Nitroaniline	3900	U
534-52-1	4,6-Dinitro-2-Methylphenol	3900	U
86-30-6	N-Nitrosodiphenylamine (1)	800	U
101-55-3	4-Bromophenyl-phenylether	800	U
118-74-1	Hexachlorobenzene	800	U
87-86-5	Pentachlorophenol	3900	U
85-01-8	Phenanthrene	300	J
120-12-7	Anthracene	800	U J
84-74-2	Di-n-Butylphthalate	800	U
206-44-0	Fluoranthene	640	J
129-00-0	Pyrene	730	J
85-68-7	Butylbenzylphthalate	800	U J
91-94-1	3,3'-Dichlorobenzidine	1600	U J
56-55-3	Benzo(a)Anthracene	290	J
218-01-9	Chrysene	390	J
117-81-7	bis(2-Ethylhexyl)Phthalate	1500	J
117-84-0	Di-n-Octyl Phthalate	800	U
205-99-2	Benzo(b)Fluoranthene	520	J
207-08-9	Benzo(k)Fluoranthene	390	J
50-32-8	Benzo(a)Pyrene	370	J
193-39-5	Indeno(1,2,3-cd)Pyrene	130	J
53-70-3	Dibenz(a,h)Anthracene	800	U J
191-24-2	Benzo(g,h,i)Perylene	800	U

(1) - Cannot be separated from Diphenylamine

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BFA03

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-03

ample wt/vol: 30.1 (g/mL) G Lab File ID: A4754

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 59 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/09/90

PC Cleanup: (Y/N) N pH: 6.5 Dilution Factor: 1.0

umber TICs found: 21

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	Unknown	4.73	2700	~~BJ~~
2. 123422	4-Hydroxy-4-methyl-2-pentano	5.43	49000	~~ABJ~~ J
3. 000000	Unknown	24.94	730	~~B~~J
4. 000000	Aliphatic hydrocarbon	25.19	970	~~B~~J
5. 10544500	Sulfur, mol. (S8)	26.32	1100	J
6. 000000	Unknown	26.66	1400	~~B~~J
7. 124287	1-Octadecaneamine, N,N-dimet	26.94	570	J
8. 000000	Aliphatic hydrocarbon	31.22	810	~~B~~J
9. 000000	Aliphatic hydrocarbon	33.16	5300	~~B~~J
10. 000000	Unknown	36.04	1100	~~B~~J
11. 000000	Unknown	37.26	4100	~~B~~J
12. 000000	Unknown	37.32	2600	~~B~~J
13. 000000	Unknown	37.56	1500	~~B~~J
14. 000000	Unknown	37.92	2100	~~B~~J
15. 000000	Unknown	40.14	1100	~~B~~J
16. 000000	Aliphatic hydrocarbon	40.36	1100	~~B~~J
17. 000000	Unknown	41.22	3200	~~B~~J
18. 000000	Unknown	41.42	1500	~~B~~J
19. 000000	Unknown	41.64	890	~~B~~J
20. 000000	Unknown	42.44	2000	~~B~~J
21. 000000	Unknown	42.93	1100	~~B~~J

1D

PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA03

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-03

ample wt/vol: 30.3 (g/mL) G Lab File ID: ______

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 59 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 07/31/90

PC Cleanup: (Y/N) N pH: 6.5 Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	19	U
319-85-7	beta-BHC	19	U
319-86-8	delta-BHC	19	U
58-89-9	gamma-BHC (Lindane)	19	U
76-44-8	Heptachlor	19	U
309-00-2	Aldrin	19	U
1024-57-3	Heptachlor epoxide	19	U
959-98-8	Endosulfan I	19	U
60-57-1	Dieldrin	39	U
72-55-9	4.4'-DDE	39	U
72-20-8	Endrin	39	U
33213-65-9	Endosulfan II	39	U
72-54-8	4.4'-DDD	39	U
1031-07-8	Endosulfan sulfate	39	U
50-29-3	4.4'-DDT	39	U
72-43-5	Methoxychlor	190	U
53494-70-5	Endrin ketone	39	U
5103-71-9	alpha-Chlordane	190	U
5103-74-2	gamma-Chlordane	190	U
8001-35-2	Toxaphene	390	U
12674-11-2	Aroclor-1016	190	U
11104-28-2	Aroclor-1221	190	U
11141-16-5	Aroclor-1232	190	U
53469-21-9	Aroclor-1242	190	U
12672-29-6	Aroclor-1248	190	U
11097-69-1	Aroclor-1254	390	U
11096-82-5	Aroclor-1260	390	U

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA04

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-04

ample wt/vol: 30.1 (g/mL) G Lab File ID: A4764

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 44 dec. Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/10/90

PC Cleanup: (Y/N) N pH: 7.6 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	590	U
111-44-4	bis(2-Chloroethyl)Ether	590	U
95-57-8	2-Chlorophenol	590	U
541-73-1	1,3-Dichlorobenzene	590	U
106-46-7	1,4-Dichlorobenzene	590	U
100-51-6	Benzyl Alcohol	590	U
95-50-1	1,2-Dichlorobenzene	590	U
95-48-7	2-Methylphenol	590	U
39638-32-9	bis(2-Chloroisopropyl)Ether	590	U
106-44-5	4-Methylphenol	590	U
621-64-7	N-Nitroso-Di-n-Propylamine	590	U
67-72-1	Hexachloroethane	590	U
98-95-3	Nitrobenzene	590	U
78-59-1	Isophorone	590	U
88-75-5	2-Nitrophenol	590	U
105-67-9	2,4-Dimethylphenol	590	U
65-85-0	Benzoic Acid	2900	U
111-91-1	bis(2-Chloroethoxy)Methane	590	U
120-83-2	2,4-Dichlorophenol	590	U
120-82-1	1,2,4-Trichlorobenzene	590	U
91-20-3	Naphthalene	590	U
106-47-8	4-Chloroaniline	590	U
87-68-3	Hexachlorobutadiene	590	U
59-50-7	4-Chloro-3-Methylphenol	590	U
91-57-6	2-Methylnaphthalene	590	U
77-47-4	Hexachlorocyclopentadiene	590	U
88-06-2	2,4,6-Trichlorophenol	590	U
95-95-4	2,4,5-Trichlorophenol	2900	U
91-58-7	2-Chloronaphthalene	590	U
88-74-4	2-Nitroaniline	2900	U
131-11-3	Dimethyl Phthalate	590	U
208-96-8	Acenaphthylene	63	J
606-20-2	2,6-Dinitrotoluene	590	U

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1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA04

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-04

ample wt/vol: 30.1 (g/mL) G Lab File ID: A4764

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 44 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/10/90

PC Cleanup: (Y/N) N pH: 7.6 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	2900	U
83-32-9	Acenaphthene	74	J
51-28-5	2,4-Dinitrophenol	2900	U
100-02-7	4-Nitrophenol	2900	U
132-64-9	Dibenzofuran	590	U
121-14-2	2,4-Dinitrotoluene	590	U
84-66-2	Diethylphthalate	590	U
7005-72-3	4-Chlorophenyl-phenylether	590	U
86-73-7	Fluorene	94	J
100-10-6	4-Nitroaniline	2900	U
534-52-1	4,6-Dinitro-2-Methylphenol	2900	U
86-30-6	N-Nitrosodiphenylamine (1)	590	U
101-55-3	4-Bromophenyl-phenylether	590	U
118-74-1	Hexachlorobenzene	590	U
87-86-5	Pentachlorophenol	2900	U
85-01-8	Phenanthrene	910	
120-12-7	Anthracene	250	J
84-74-2	Di-n-Butylphthalate	590	U
206-44-0	Fluoranthene	1600	
129-00-0	Pyrene	1600	
85-68-7	Butylbenzylphthalate	160	J
91-94-1	3,3'-Dichlorobenzidine	1200	U
56-55-3	Benzo(a)Anthracene	740	
218-01-9	Chrysene	870	
117-81-7	bis(2-Ethylhexyl)Phthalate	5200	
117-84-0	Di-n-Octyl Phthalate	140	J
205-99-2	Benzo(b)Fluoranthene	720	
207-08-9	Benzo(k)Fluoranthene	840	
50-32-8	Benzo(a)Pyrene	780	
193-39-5	Indeno(1,2,3-cd)Pyrene	380	J
53-70-3	Dibenz(a,h)Anthracene	86	J
191-24-2	Benzo(g,h,i)Perylene	350	J

(1) - Cannot be separated from Diphenylamine

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BFA04

b Name: CEIMIC CORP Contract: 68D90028

b Code: CEIMIC Case No.: 14523 SAS No.: ____ SDG No.: BFA01

trix: (soil/water) SOIL Lab Sample ID: 900536-04

mple wt/vol: 30.1 (g/mL) G Lab File ID: A4764

vel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 44 dec. ____ Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/10/90

C Cleanup: (Y/N) N pH: 7.6 Dilution Factor: 1.0

CONCENTRATION UNITS:
umber TICs found: 21 (ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	Unknown	4.70	1400	[illegible]
2. 123422	4-Hydroxy-4-methyl-2-pentano	5.38	25000	[illegible]
3. 000000	Unknown	19.34	770	BJ N
4. 000000	Aliphatic hydrocarbon	21.64	1000	BJ
5. 000000	Unknown	22.14	530	BJ
6. 000000	Aliphatic hydrocarbon	23.07	950	BJ
7. 000000	Aromatic	24.64	650	BJ
8. 000000	Unknown	24.90	1500	BJ
9. 000000	Aliphatic monobasic carboxyl	25.17	1700	BJ
10. 000000	Unknown	26.69	950	BJ
11. 000000	Unknown	26.97	470	BJ
12. 000000	Unknown	27.21	470	BJ
13. 620406	Benzenemethanamine. N,N-bis(	29.16	530	J N
14. 000000	Aliphatic hydrocarbon	33.09	1800	BJ N
15. 000000	Unknown	37.09	650	BJ N
16. 57885	Cholesterol	37.81	3100	J N
17. 000000	Unknown	38.22	830	BJ N
18. 000000	Unknown	39.97	890	BJ
19. 000000	Aromatic	41.06	2500	BJ
20. 000000	Unknown	41.26	1100	BJ
21. 000000	Aromatic	41.46	1100	BJ

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1D
PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA04

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

Matrix: (soil/water) SOIL Lab Sample ID: 900536-04

Sample wt/vol: 30.2 (g/mL) G Lab File ID: ________

Level: (low/med) LOW Date Received: 07/18/90

% Moisture: not dec. 44 dec. ____ Date Extracted: 07/19/90

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 07/31/90

GPC Cleanup: (Y/N) N pH: 7.6 Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	14	U
319-85-7	beta-BHC	14	U
319-86-8	delta-BHC	14	U
58-89-9	gamma-BHC (Lindane)	14	U
76-44-8	Heptachlor	14	U
309-00-2	Aldrin	14	U
1024-57-3	Heptachlor epoxide	14	U
959-98-8	Endosulfan I	14	U
60-57-1	Dieldrin	28	U
72-55-9	4,4'-DDE	28	U
72-20-8	Endrin	28	U
33213-65-9	Endosulfan II	28	U
72-54-8	4,4'-DDD	28	U
1031-07-8	Endosulfan sulfate	28	U
50-29-3	4,4'-DDT	28	U
72-43-5	Methoxychlor	140	U
53494-70-5	Endrin ketone	28	U
5103-71-9	alpha-Chlordane	140	U
5103-74-2	gamma-Chlordane	140	U
8001-35-2	Toxaphene	280	U
12674-11-2	Aroclor-1016	140	U
11104-28-2	Aroclor-1221	140	U
11141-16-5	Aroclor-1232	140	U
53469-21-9	Aroclor-1242	140	U
12672-29-6	Aroclor-1248	140	U
11097-69-1	Aroclor-1254	280	U
11096-82-5	Aroclor-1260	280	U

1B

EPA SAMPLE NO.

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

BFA05

ab Name: CEIMIC CORP Contract: 68D90028

ab Code: CEIMIC Case No.: 14523 SAS No.: SDG No.: BFA01

atrix: (soil/water) SOIL Lab Sample ID: 900536-05

ample wt/vol: 30.3 (g/mL) G Lab File ID: A4765

evel: (low/med) LOW Date Received: 07/18/90

Moisture: not dec. 67 dec. Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/10/90

PC Cleanup: (Y/N) N pH: 7.0 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	1000	U J
111-44-4	bis(2-Chloroethyl)Ether	1000	U
95-57-8	2-Chlorophenol	1000	U
541-73-1	1,3-Dichlorobenzene	1000	U
106-46-7	1,4-Dichlorobenzene	1000	U
100-51-6	Benzyl Alcohol	1000	U
95-50-1	1,2-Dichlorobenzene	1000	U
95-48-7	2-Methylphenol	1000	U
39638-32-9	bis(2-Chloroisopropyl)Ether	1000	U
106-44-5	4-Methylphenol	1000	U
621-64-7	N-Nitroso-Di-n-Propylamine	1000	U
67-72-1	Hexachloroethane	1000	U
98-95-3	Nitrobenzene	1000	U
78-59-1	Isophorone	1000	U
88-75-5	2-Nitrophenol	1000	U
105-67-9	2,4-Dimethylphenol	1000	U
65-85-0	Benzoic Acid	4800	U
111-91-1	bis(2-Chloroethoxy)Methane	1000	U
120-83-2	2,4-Dichlorophenol	1000	U
120-82-1	1,2,4-Trichlorobenzene	1000	U
91-20-3	Naphthalene	1000	U
106-47-8	4-Chloroaniline	1000	U
87-68-3	Hexachlorobutadiene	1000	U
59-50-7	4-Chloro-3-Methylphenol	1000	U
91-57-6	2-Methylnaphthalene	1000	U
77-47-4	Hexachlorocyclopentadiene	1000	U
88-06-2	2,4,6-Trichlorophenol	1000	U
95-95-4	2,4,5-Trichlorophenol	4800	U
91-58-7	2-Chloronaphthalene	1000	U
88-74-4	2-Nitroaniline	4800	U
131-11-3	Dimethyl Phthalate	1000	U
208-96-8	Acenaphthylene	1000	U
606-20-2	2,6-Dinitrotoluene	1000	U

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1C
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA05

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

Matrix: (soil/water) SOIL Lab Sample ID: 900536-05

Sample wt/vol: 30.3 (g/mL) G Lab File ID: A4765

Level: (low/med) LOW Date Received: 07/18/90

% Moisture: not dec. 67 dec. ____ Date Extracted: 07/19/90

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 08/10/90

GPC Cleanup: (Y/N) N pH: 7.0 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
99-09-2	3-Nitroaniline	4800	U J
83-32-9	Acenaphthene	1000	U
51-28-5	2.4-Dinitrophenol	4800	U
100-02-7	4-Nitrophenol	4800	U
132-64-9	Dibenzofuran	1000	U
121-14-2	2.4-Dinitrotoluene	1000	U
84-66-2	Diethylphthalate	1000	U
7005-72-3	4-Chlorophenyl-phenylether	1000	U
86-73-7	Fluorene	1000	U
100-10-6	4-Nitroaniline	4800	U
534-52-1	4.6-Dinitro-2-Methylphenol	4800	U
86-30-6	N-Nitrosodiphenylamine (1)	1000	U
101-55-3	4-Bromophenyl-phenylether	1000	U
118-74-1	Hexachlorobenzene	1000	U
87-86-5	Pentachlorophenol	4800	U
85-01-8	Phenanthrene	160	J
120-12-7	Anthracene	1000	U J
84-74-2	Di-n-Butylphthalate	1000	U J
206-44-0	Fluoranthene	400	J
129-00-0	Pyrene	430	J
85-68-7	Butylbenzylphthalate	~~4~~20	J
91-94-1	3.3'-Dichlorobenzidine	2000	U J
56-55-3	Benzo(a)Anthracene	190	J
218-01-9	Chrysene	260	J
117-81-7	bis(2-Ethylhexyl)Phthalate	5900	UJ
117-84-0	Di-n-Octyl Phthalate	1000	UJ
205-99-2	Benzo(b)Fluoranthene	290	J
207-08-9	Benzo(k)Fluoranthene	210	J
50-32-8	Benzo(a)Pyrene	230	J
193-39-5	Indeno(1.2,3-cd)Pyrene	130	J
53-70-3	Dibenz(a,h)Anthracene	1000	U J
191-24-2	Benzo(g,h,i)Perylene	110	J

(1) - Cannot be separated from Diphenylamine

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

BFA05

ab Name: CEIMIC CORP   Contract: 68D90028

ab Code: CEIMIC   Case No.: 14523   SAS No.: ______   SDG No.: BFA01

atrix: (soil/water) SOIL   Lab Sample ID: 900536-05

ample wt/vol: 30.3 (g/mL) G   Lab File ID: A4765

evel: (low/med) LOW   Date Received: 07/18/90

Moisture: not dec. 67 . dec. ____   Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC   Date Analyzed: 08/10/90

PC Cleanup: (Y/N) N   pH: 7.0   Dilution Factor: 1.0

umber TICs found: 21   CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 000000	Unknown	4.72	3300	~~BJ~~ R
2. 123422	4-Hydroxy-4-methyl-2-pentano	5.42	62000	~~ABJ~~ R
3. 000000	Aliphatic monobasic carboxyl	22.40	900	BJ N
4. 000000	C12H7Cl3 isomer	24.04	1000	~~B~~J
5. 000000	Unknown	24.87	2500	~~B~~J
6. 000000	Unknown	26.27	2200	~~B~~J
7. 000000	Unknown	26.94	600	~~B~~J
8. 000000	Unknown	31.07	700	~~B~~J
9. 000000	Aromatic	31.74	1400	~~B~~J
10. 000000	Aromatic	31.89	2600	~~B~~J
11. 000000	Aromatic	31.94	700	~~B~~J
12. 000000	Aromatic	32.06	1400	~~B~~J
13. 000000	Aliphatic hydrocarbon	33.07	2100	~~B~~J
14. 000000	Unknown	37.12	1100	~~B~~J
15. 000000	Unknown	37.24	2100	~~B~~J
16. 57885	Cholesterol	37.77	3000	JN
17. 000000	Unknown	39.96	1000	~~B~~J N
18. 000000	Unknown	41.01	1700	~~B~~J
19. 000000	Unknown	41.42	800	~~B~~J
20. 000000	Unknown	42.19	1100	~~B~~J
21. 000000	Unknown	42.18	800	~~B~~J

1D
PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA05

Lab Name: CEIMIC CORP Contract: 68D90028

Lab Code: CEIMIC Case No.: 14523 SAS No.: ______ SDG No.: BFA01

Matrix: (soil/water) SOIL Lab Sample ID: 900536-05

Sample wt/vol: 30.4 (g/mL) G Lab File ID: ______

Level: (low/med) LOW Date Received: 07/18/90

% Moisture: not dec. 67 dec. ____ Date Extracted: 07/19/90

Extraction: (SepF/Cont/Sonc) SONC Date Analyzed: 07/31/90

GPC Cleanup: (Y/N) N pH: 7.0 Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	24	U J
319-85-7	beta-BHC	24	U
319-86-8	delta-BHC	24	U
58-89-9	gamma-BHC (Lindane)	24	U
76-44-8	Heptachlor	24	U
309-00-2	Aldrin	24	U
1024-57-3	Heptachlor epoxide	24	U
959-98-8	Endosulfan I	24	U
60-57-1	Dieldrin	48	U
72-55-9	4,4'-DDE	48	U
72-20-8	Endrin	48	U
33213-65-9	Endosulfan II	48	U
72-54-8	4,4'-DDD	48	U
1031-07-8	Endosulfan sulfate	48	U
50-29-3	4,4'-DDT	48	U
72-43-5	Methoxychlor	240	U
53494-70-5	Endrin ketone	48	U
5103-71-9	alpha-Chlordane	240	U
5103-74-2	gamma-Chlordane	240	U
8001-35-2	Toxaphene	480	U
12674-11-2	Aroclor-1016	240	U
11104-28-2	Aroclor-1221	240	U
11141-16-5	Aroclor-1232	240	U
53469-21-9	Aroclor-1242	240	U
12672-29-6	Aroclor-1248	2300	J
11097-69-1	Aroclor-1254	790	J
11096-82-5	Aroclor-1260	480	U J

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U.S. EPA - CLP

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INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBDM01

Lab Name: ROCKY MOUNTAIN ANALYTICAL Contract: 68-D9-0090

Lab Code: ENSECO Case No.: 14523 SAS No.: ______ SDG No.: MBDM01

Matrix (soil/water): SOIL Lab Sample ID: 10446-1

Level (low/med): LOW Date Received: 07/18/90

% Solids: 50.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	20400			P
7440-36-0	Antimony	9.6	U	N J	P
7440-38-2	Arsenic	27.8		N J	F
7440-39-3	Barium	86.6			P
7440-41-7	Beryllium	1.7	B		P
7440-43-9	Cadmium	2.0	U		P
7440-70-2	Calcium	1950	B		P
7440-47-3	Chromium	80.7			P
7440-48-4	Cobalt	17.3	B		P
7440-50-8	Copper	215			P
7439-89-6	Iron	38700			P
7439-92-1	Lead	151			P
7439-95-4	Magnesium	6500			P
7439-96-5	Manganese	326			P
7439-97-6	Mercury	1.1		*N J	CV
7440-02-0	Nickel	34.6			P
7440-09-7	Potassium	2170			P
7482-49-2	Selenium	2.2		SN J	F
7440-22-4	Silver	3.8	B		P
7440-23-5	Sodium	3420			P
7440-28-0	Thallium	0.40	U	N J	F
7440-62-2	Vanadium	63.5			P
7440-66-6	Zinc	280			P
	Cyanide				NR

Color Before: BROWN Clarity Before: ______ Texture: COARSE

Color After: BROWN Clarity After: ______ Artifacts: ______

Comments:

FORM I - IN 7/88

0000003

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INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBDM02

Lab Name: ROCKY MOUNTAIN ANALYTICAL Contract: 68-D9-0090

Lab Code: ENSECO Case No.: 14523 SAS No.: ______ SDG No.: MBDM01

Matrix (soil/water): SOIL

Lab Sample ID: 10446-2

Level (low/med): LOW

Date Received: 07/18/90

% Solids: 49.4

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	18200			P
7440-36-0	Antimony	9.7	U	N	P
7440-38-2	Arsenic	48.0		SN	F
7440-39-3	Barium	80.5	B		P
7440-41-7	Beryllium	1.5	B		P
7440-43-9	Cadmium	2.0	U		P
7440-70-2	Calcium	1980	B		P
7440-47-3	Chromium	82.9			P
7440-48-4	Cobalt	15.9	B		P
7440-50-8	Copper	221			P
7439-89-6	Iron	37900			P
7439-92-1	Lead	164			P
7439-95-4	Magnesium	6320			P
7439-96-5	Manganese	289			P
7439-97-6	Mercury	1.3		*N	CV
7440-02-0	Nickel	33.7			P
7440-09-7	Potassium	2260			P
7482-49-2	Selenium	2.4		SN	F
7440-22-4	Silver	3.5	B		P
7440-23-5	Sodium	3600			P
7440-28-0	Thallium	0.40	U	WN	F
7440-62-2	Vanadium	65.5			P
7440-66-6	Zinc	296		✓	P
	Cyanide				NR

Color Before: BROWN

Color After: BROWN

Clarity Before: ______

Clarity After: ______

Texture: COARSE

Artifacts: ______

Comments:

KBC 002 1844

U.S. EPA - CLP

1
INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBDM03

Lab Name: ROCKY MOUNTAIN ANALYTICAL **Contract:** 68-D9-0090

Lab Code: ENSECO **Case No.:** 14523 **SAS No.:** ______ **SDG No.:** MBDM01

Matrix (soil/water): SOIL **Lab Sample ID:** 10446-3

Level (low/med): LOW **Date Received:** 07/18/90

% Solids: 42.6

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	17800		J	P
7440-36-0	Antimony	11.3	U	N	P
7440-38-2	Arsenic	31.5		SN	F
7440-39-3	Barium	117			P
7440-41-7	Beryllium	1.4	B		P
7440-43-9	Cadmium	2.3	U		P
7440-70-2	Calcium	2520			P
7440-47-3	Chromium	67.8			P
7440-48-4	Cobalt	18.1	B		P
7440-50-8	Copper	162			P
7439-89-6	Iron	34300			P
7439-92-1	Lead	148			P
7439-95-4	Magnesium	5990			P
7439-96-5	Manganese	404			P
7439-97-6	Mercury	1.0		*N	CV
7440-02-0	Nickel	32.5			P
7440-09-7	Potassium	1680	B		P
7482-49-2	Selenium	1.1	B	N	F
7440-22-4	Silver	3.5	B		P
7440-23-5	Sodium	1670	B		P
7440-28-0	Thallium	0.47	U	N	F
7440-62-2	Vanadium	54.5			P
7440-66-6	Zinc	268		✓	P
	Cyanide				NR

Color Before: BROWN **Clarity Before:** ______ **Texture:** COARSE
Color After: BROWN **Clarity After:** ______ **Artifacts:** ______

Comments:

U.S. EPA - CLP

1
INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBDM04

Lab Name: ROCKY MOUNTAIN ANALYTICAL **Contract:** 68-D9-0090

Lab Code: ENSECO **Case No.:** 14523 **SAS No.:** ______ **SDG No.:** MBDM01

Matrix (soil/water): SOIL **Lab Sample ID:** 10446-4

Level (low/med): LOW **Date Received:** 07/18/90

% Solids: 45.6

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	7480		J	P
7440-36-0	Antimony	10.5	U	N	P
7440-38-2	Arsenic	23.5		SN	F
7440-39-3	Barium	146			P
7440-41-7	Beryllium	0.49	B		P
7440-43-9	Cadmium	2.3			P
7440-70-2	Calcium	2280			P
7440-47-3	Chromium	40.4			P
7440-48-4	Cobalt	15.5	B		P
7440-50-8	Copper	87.4			P
7439-89-6	Iron	23400			P
7439-92-1	Lead	227			P
7439-95-4	Magnesium	3430			P
7439-96-5	Manganese	220			P
7439-97-6	Mercury	0.39		*N	CV
7440-02-0	Nickel	26.7			P
7440-09-7	Potassium	1260	B		P
7782-49-2	Selenium	0.88	U	N	F
7440-22-4	Silver	2.6	U		P
7440-23-5	Sodium	1240	B		P
7440-28-0	Thallium	0.44	U	N	F
7440-62-2	Vanadium	37.3			P
7440-66-6	Zinc	292			P
	Cyanide				NR

Color Before: BROWN **Clarity Before:** ______ **Texture:** COARSE
Color After: BROWN **Clarity After:** ______ **Artifacts:** ______

Comments:

U.S. EPA - CLP

1
INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

MBDM05

Lab Name: ROCKY MOUNTAIN ANALYTICAL Contract: 68-D9-0090

Lab Code: ENSECO Case No.: 14523 SAS No.: ______ SDG No.: MBDM01

Matrix (soil/water): SOIL Lab Sample ID: 10446-5

Level (low/med): LOW Date Received: 07/18/90

% Solids: 35.5

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	18300			P
7440-36-0	Antimony	13.5	U	N	P
7440-38-2	Arsenic	36.1		SN	F
7440-39-3	Barium	94.8	B		P
7440-41-7	Beryllium	1.7	B		P
7440-43-9	Cadmium	2.8	U		P
7440-70-2	Calcium	2540	B		P
7440-47-3	Chromium	72.1			P
7440-48-4	Cobalt	25.1	B		P
7440-50-8	Copper	207			P
7439-89-6	Iron	42500			P
7439-92-1	Lead	125			P
7439-95-4	Magnesium	6450			P
7439-96-5	Manganese	374			P
7439-97-6	Mercury	0.85		*N	CV
7440-02-0	Nickel	48.3			P
7440-09-7	Potassium	2500	B		P
7782-49-2	Selenium	1.3	B	N	F
7440-22-4	Silver	3.4	U		P
7440-23-5	Sodium	2760	B		P
7440-28-0	Thallium	0.56	U	WN	F
7440-62-2	Vanadium	60.6			P
7440-66-6	Zinc	360		✓	P
	Cyanide				NR

Color Before: BROWN Clarity Before: ______ Texture: COARSE
Color After: BROWN Clarity After: ______ Artifacts: ______

Comments:

FORM I - IN 7/88

HUNTINGDON ANALYTICAL SERVICES
ENVIRONMENTAL

Inorganic Wet Chemical Analyses

Analyte: Total Organic Carbon in Sediment

EPA Method No.: Lloyd Kahn/EPA Region II Method - July 27, 1988

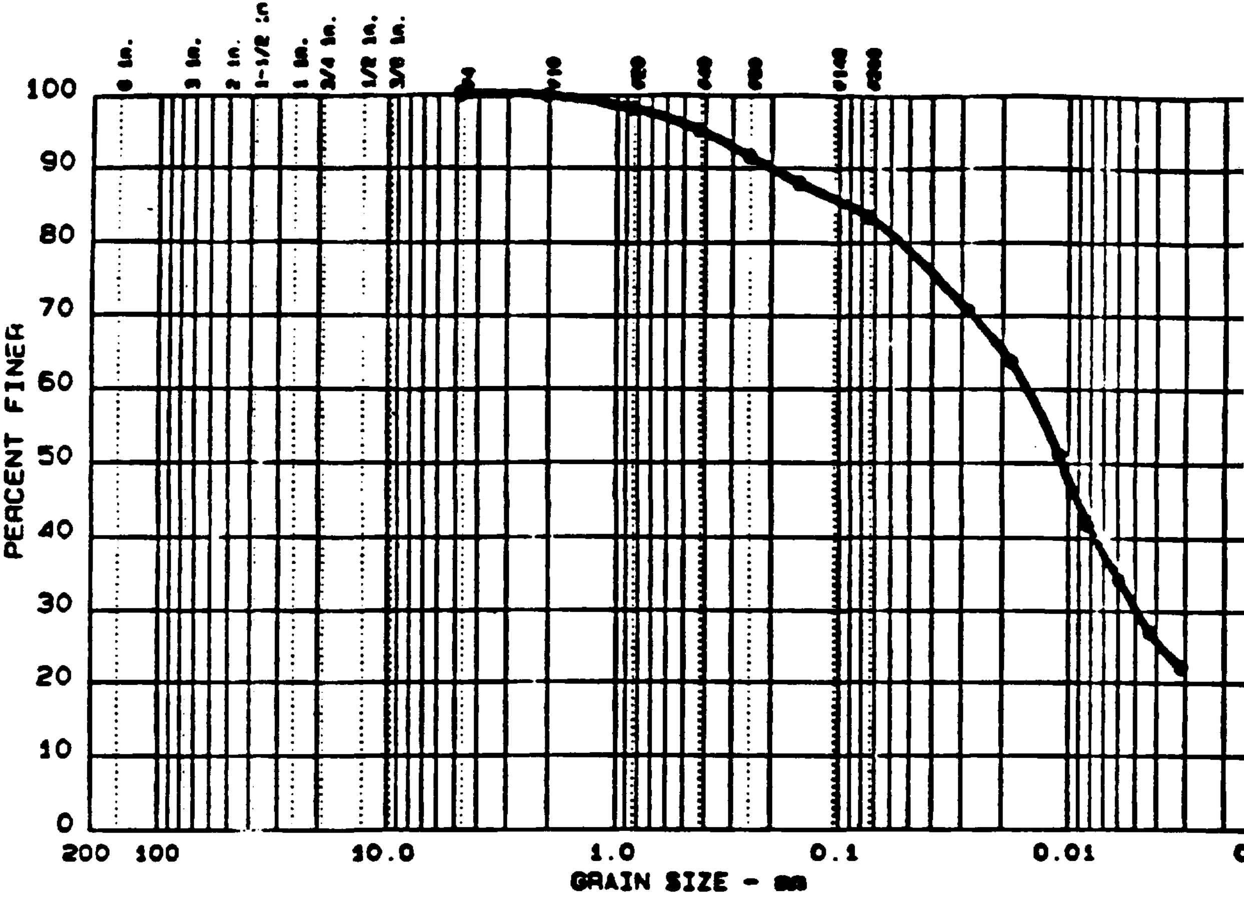
Sample Date	HAS Sample #90-	Client I.D.	Date Prepared	Date Analyzed	Method Detection Limit	* Result	Units	QC in %
7/12/90	943-001	5544B-01 1	7/25/90	7/25/90	100	48,800	mg/kg	102**
7/12/90	943-002	5544B-02 1	7/25/90	7/25/90	100	49,500	mg/kg	102**
7/12/90	943-003	5544B-03 4	7/25/90	7/25/90	100	114,000	mg/kg	102**
7/12/90	943-004	5544B-04 3	7/25/90	7/25/90	100	27,800	mg/kg	102**
7/12/90	943-005	5544B-05 2	7/25/90	7/25/90	100	73,400	mg/kg	102**
7/12/90	943-005Dup	5544B-05 5	7/25/90	7/25/90	100	69,500	mg/kg	102** 5.5***

* Results are based on dry weight of material as listed elsewhere in this report.

** A known standard of the analyte of interest was analyzed along with this sample with the percent recovery indicated above.

*** This sample was analyzed in quadruplicate with the maximum RPD as indicated above and a calculated standard deviation of 1874 mg/kg.

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLA
●	1	0.0	0.0	16.6	53.2	30.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c
●			0.09		0.01	0.005			

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN SILT, Some Clay, little sand, organics		

Project No.: 6019.005

Project: SAS # 5544B

● Location: CLP SAMPLE MANAGEMENT OFFICE U.S. EPA

Date: JULY 30, 1990

Remarks:

LOC-1 TROWEL

TAG # 02-4983

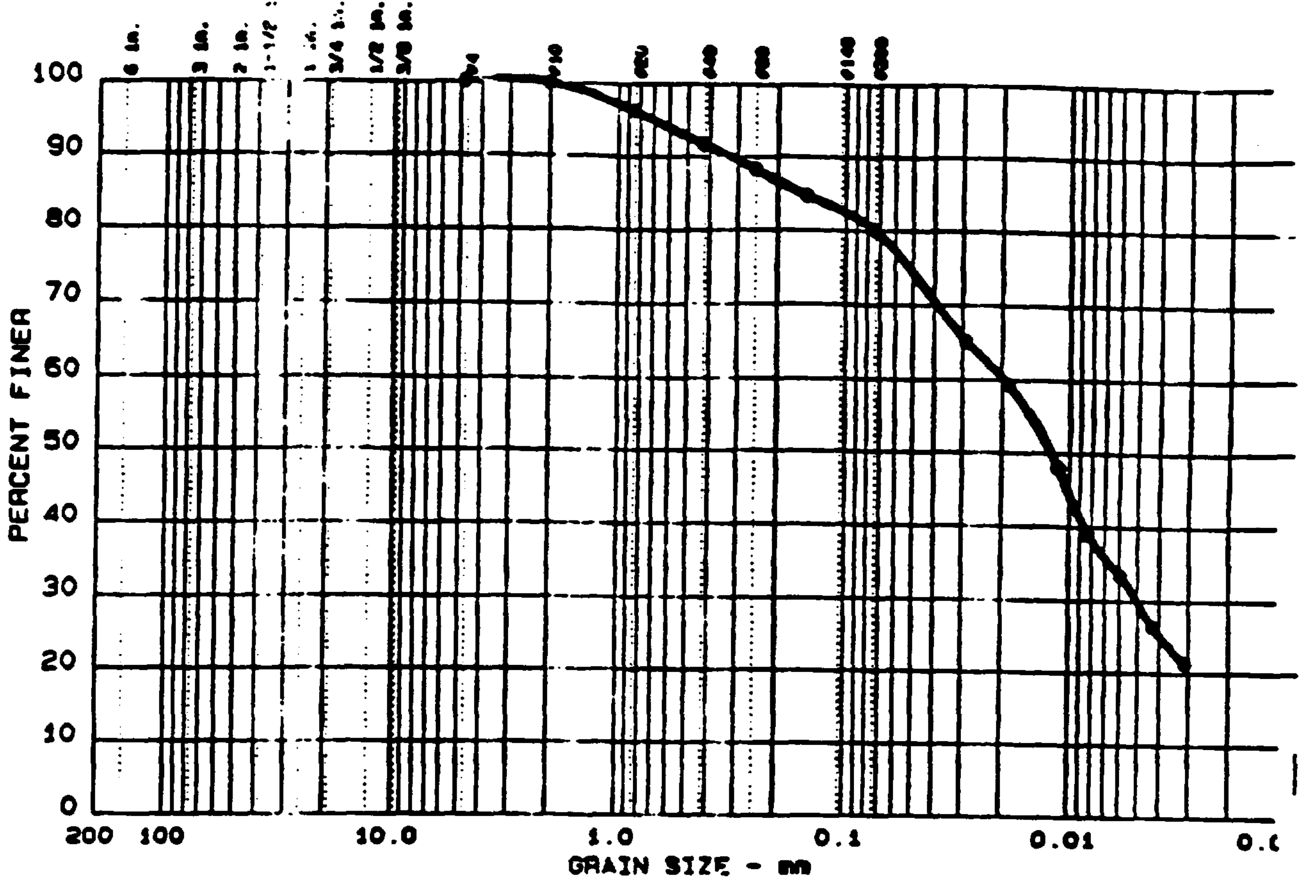
LAB NO. 419.001

GRAIN SIZE DISTRIBUTION TEST REPORT

EMPIRE SOILS INVESTIGATIONS, INC

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	0.0	19.9	50.3	29.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.15		0.01	0.005				

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN SILT, Some Clay, little sand, organics		

Project No.: 8019.005

Project: SAS # 5544B

● Location: CLP SAMPLE MANAGEMENT OFFICE U.S. EPA

Date: JULY 30, 1990

GRAIN SIZE DISTRIBUTION TEST REPORT

EMPIRE SOILS INVESTIGATIONS, INC

Remarks:

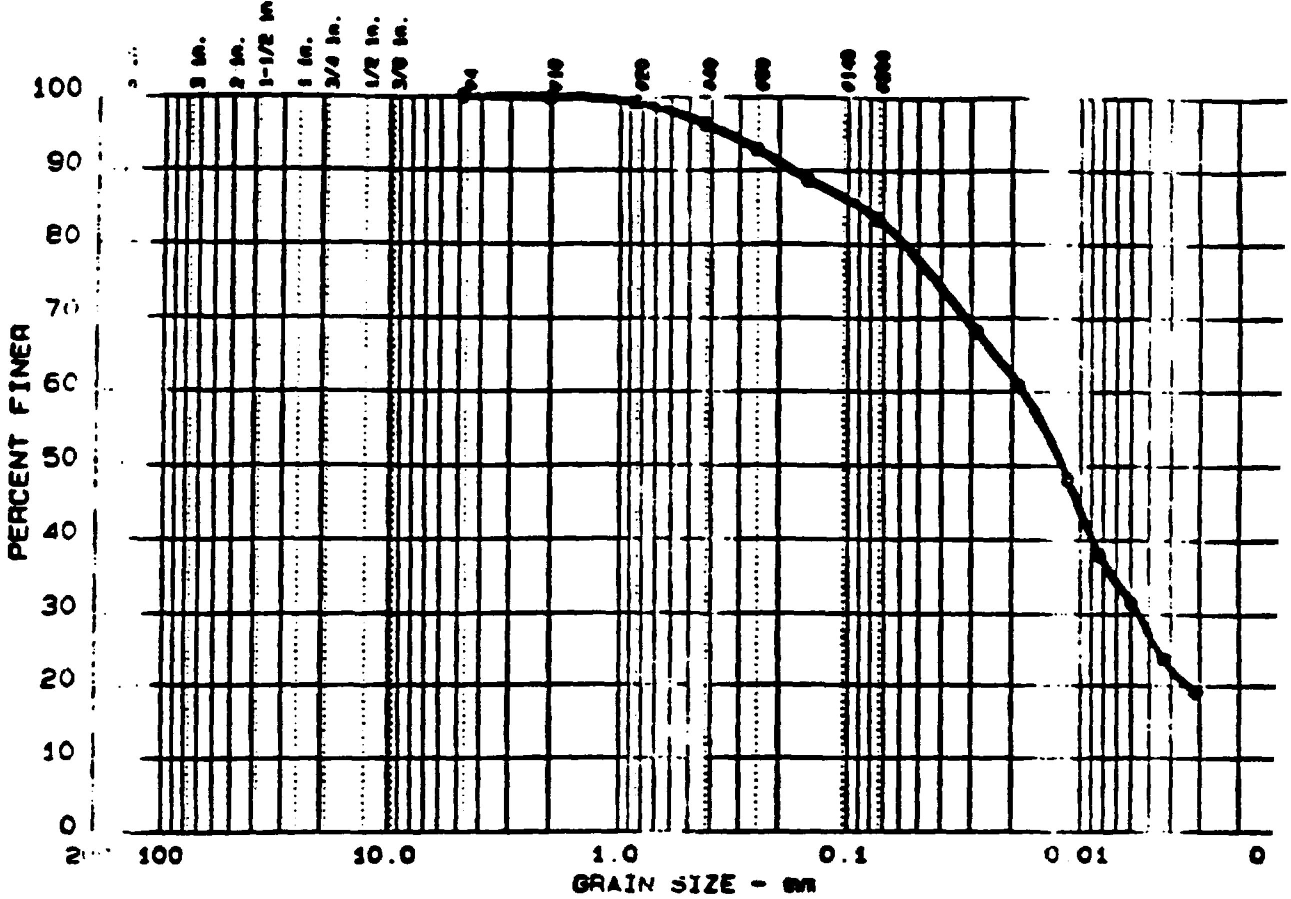
LOC-2 TROWEL

TAG # 02-4984

LAB NO. 419.002

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLA
●	3	0.0	0.0	16.5	56.1	27.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C
●			0.09		0.01	0.006				

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN SILT, Some Clay, little sand, organics		

Project No.: 8019.005
Project: SAS # 5544B
● Location: CLP SAMPLE MANAGEMENT OFFICE U.S. EPA

Date: JULY 30, 1990

Remarks:
LOC-3 TROWEL
TAG # 02-4985

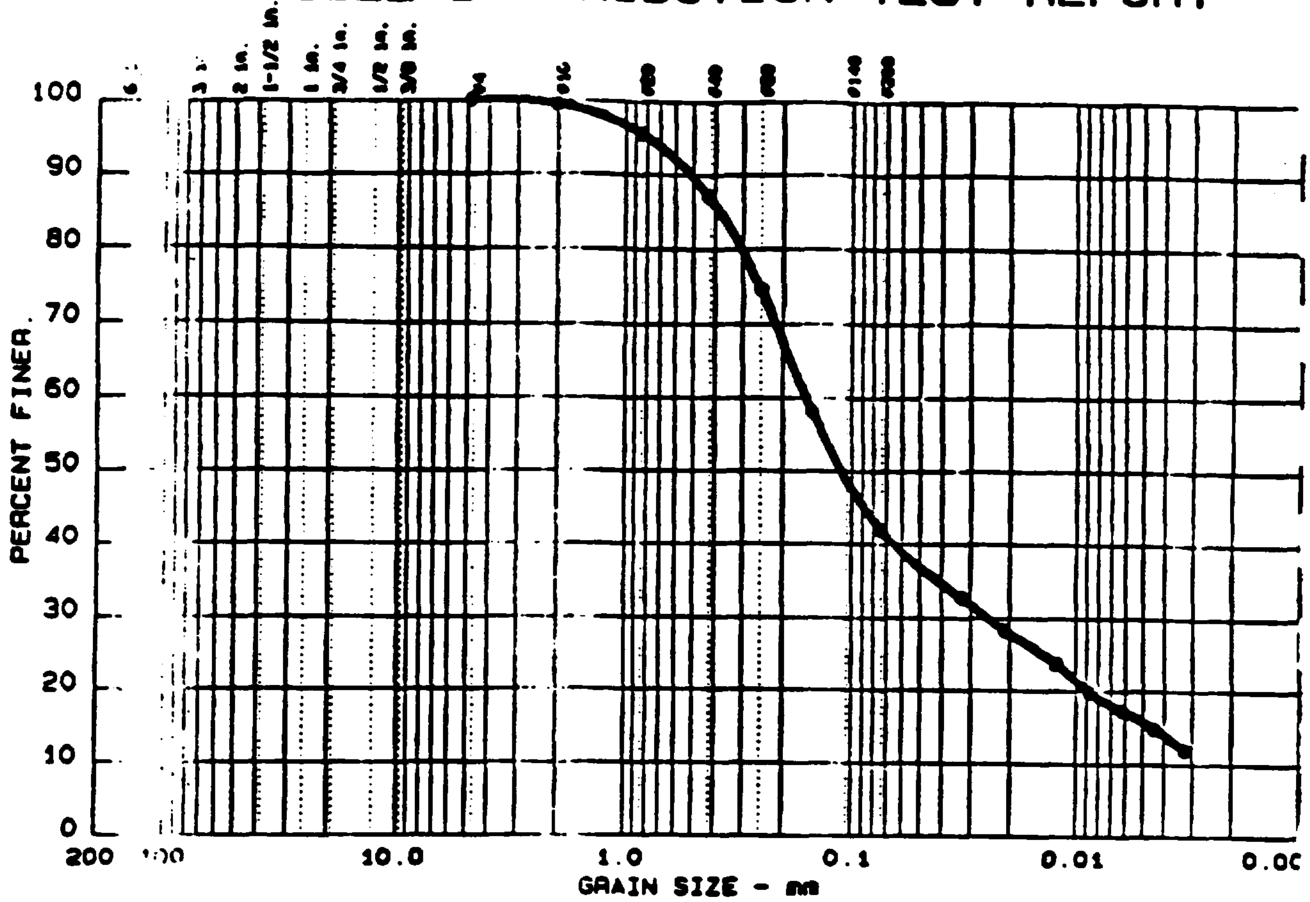
LAB NO. 419.003

GRAIN SIZE DISTRIBUTION TEST REPORT

EMPIRE SOILS INVESTIGATIONS, INC

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	0.0	58.1	26.1	15.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.38	0.16	0.11	0.025	0.0045			

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN SA[illegible], Some Silt, little clay, organics		

Project No G019.005

Project: S[illegible] # 5544B

● Locatio[illegible] [illegible]LP SAMPLE MANAGEMENT OFFICE U.S. EPA

Date: JULY 30, 1990

Remarks:

LOC-4 TROWEL

TAG # 02-4986

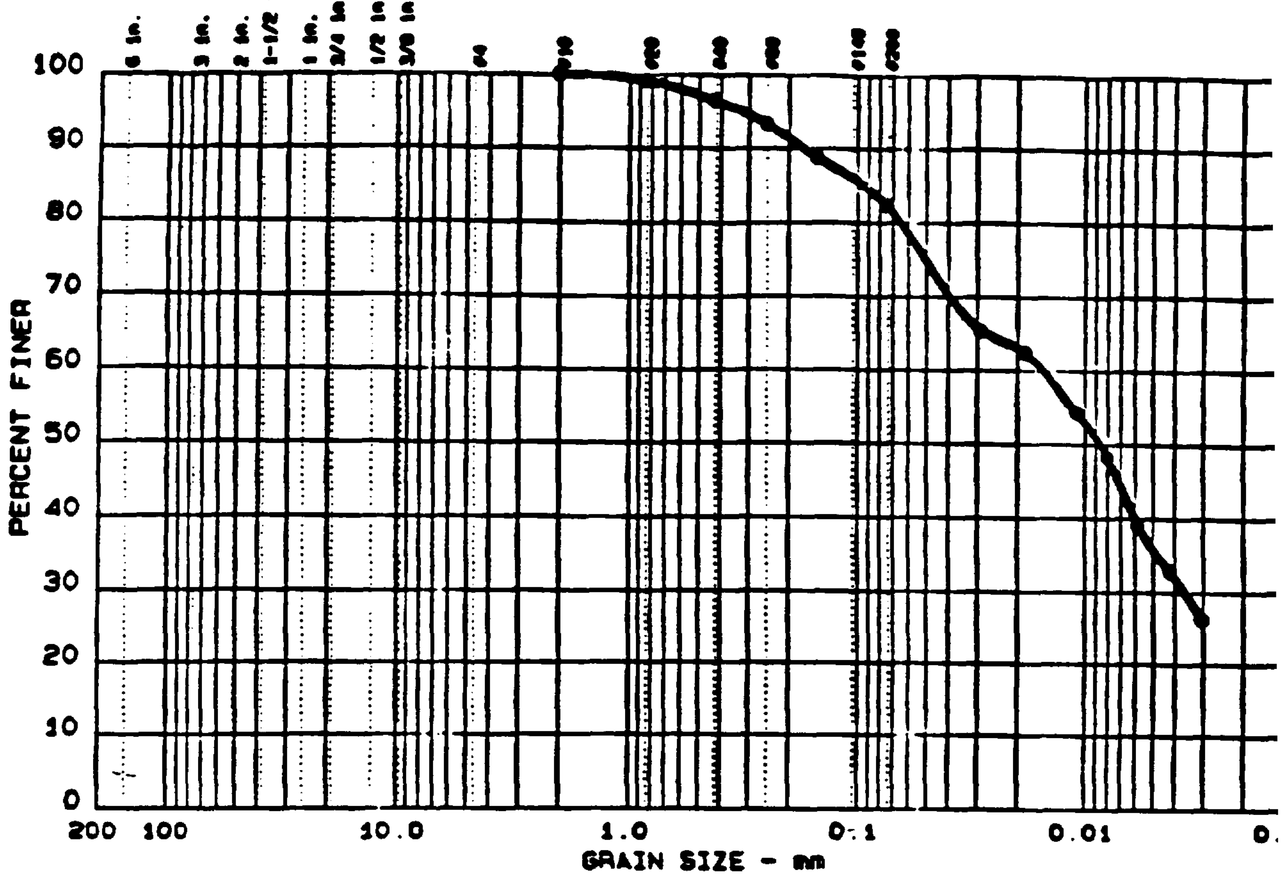
LAB NO. 419.004

[illegible]AIN SIZE DISTRIBUTION TEST REPORT

EMPIRE SOILS INVESTIGATIONS, INC

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	5	0.0	0.0	17.6	46.6	35.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C
●			0.09		0.01	0.004				

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN SILT & CLAY, Little Sand, organics		

Project No.: 8019.005
Project: SAS # 5544B
● Location: CLP SAMPLE MANAGEMENT OFFICE U.S. EPA

Date: JULY 30, 1990

GRAIN SIZE DISTRIBUTION TEST REPORT
EMPIRE SOILS INVESTIGATIONS, INC

Remarks:
LOC-5 TROWEL
TAG # 02-4987

LAB NO. 419.005

Figure No. 1

Appendix B

(Fiddler Crab raw data)

Table 1.1 RESULTS OF THE BASE NEUTRAL/ACID EXTRACTABLES ANALYSIS

Project	Kin Buc 3409					
Client ID		6832	6834	6835	6836	6837
Location	Method Blank	Martins Creek	Reference	Upper Edmonds Creek	Lower Edmonds Creek	Lower Edmonds Creek
Matrix	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Compound						
Phenol	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Bis(2-chloroethyl) ether	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
2-Chlorophenol	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
1,3-Dichlorobenzene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
1,4-Dichlorobenzene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Benzyl alcohol	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
1,2-Dichlorobenzene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
2-Methylphenol	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Bis(2-chloroisopropyl) ether	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
4-Methylphenol	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
N-Nitrosodi-n-propylamine	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Hexachloroethane	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Nitrobenzene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Isophorone	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
2-Nitrophenol	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
2,4-Dimethylphenol	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Benzoic Acid	1600 U	26000 U	26000 U	6400 U	6400 U	13000 U
Bis(2-chloroethoxy) methane	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
2,4-Dichlorophenol	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
1,2,4-Trichlorobenzene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Naphthalene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
4-Chloroaniline	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Hexachlorobutadiene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
4-Chloro-3-methylphenol	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
2-Methylnaphthalene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Hexachlorocyclopentadiene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
2,4,6-Trichlorophenol	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
2,4,5-Trichlorophenol	1600 U	26000 U	26000 U	6400 U	6400 U	13000 U
2-Chloronaphthalene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
2-Nitroaniline	1600 U	26000 U	26000 U	6400 U	6400 U	13000 U
Dimethyl phthalate	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Acenaphthylene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
3-Nitroaniline	1600 U	26000 U	26000 U	6400 U	6400 U	13000 U
Acenaphthene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
2,4-Dinitrophenol	1600 U	26000 U	26000 U	6400 U	6400 U	13000 U
4-Nitrophenol	1600 U	26000 U	26000 U	6400 U	6400 U	13000 U
Dibenzofuran	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
2,4-Dinitrotoluene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U

J denotes that the compound was detected at less than the Method Detection Limit
ND denotes that the compound was Not Detected

Table 1.1 RESULTS OF THE BASE NEUTRAL/ACID EXTRACTABLES ANALYSIS

Project	Kin Buc 3409					
Client ID		6832	6834	6835	6836	6837
Location	Method Blank	Martins Creek	Reference	Upper Edmonds Creek	Lower Edmonds Creek	Lower Edmonds Creek
Matrix	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Compound						
2,6-Dinitrotoluene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Diethylphthalate	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
4-Chlorophenyl phenyl ether	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Fluorene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
4-Nitroaniline	1600 U	26000 U	26000 U	6400 U	6400 U	13000 U
4,6-Dinitro-2-methylphenol	1600 U	26000 U	26000 U	6400 U	6400 U	13000 U
N-Nitrosodiphenylamine	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
4-Bromophenyl phenyl ether	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Hexachlorobenzene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Pentachlorophenol	1600 U	26000 U	26000 U	6400 U	6400 U	13000 U
Phenanthrene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Anthracene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Di-n-butyl phthalate	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Fluoranthene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Pyrene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Butyl benzyl phthalate	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
3,3'-Dichlorobenzidine	660 U	11000 U	11000 U	2600 U	2600 U	5400 U
Benzo(a)anthracene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Bis(2-ethylhexyl) phthalate	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Chrysene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Di-n-octyl phthalate	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Benzo(b)fluoranthene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Benzo(k)fluoranthene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Benzo(a)pyrene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Indeno(1,2,3-cd)pyrene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Dibenzo(a,h)anthracene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U
Benzo(g,h,i)perylene	330 U	5300 U	5300 U	1300 U	1300 U	2700 U

J denotes that the compound was detected at less than the Method Detection Limit
ND denotes that the compound was Not Detected

Table 1.2 RESULTS OF THE AROCLOR ANALYSIS

Project	Kin Buc 3409						
Client ID		6832	6834	6835	6836	6837	6835
Location	Method Blank	Martins Creek	Reference	Upper Edmonds Creek	Lower Edmonds Creek	Lower Edmonds Creek	MS
Matrix	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Compound							
Aroclor 1016	80 U	170 U	80 U	330 U	80 U	170 U	3300 U
Aroclor 1221	80 U	170 U	80 U	330 U	80 U	170 U	3300 U
Aroclor 1232	80 U	170 U	80 U	330 U	80 U	170 U	3300 U
Aroclor 1242	80 U	170 U	80 U	330 U	80 U	170 U	3300 U
Aroclor 1248	80 U	170 U	80 U	990	250	580	14000
Aroclor 1254	160 U	170 U	160 U	330 U	160 U	170 U	3300 U
Aroclor 1260	160 U	170	160 U	330 U	160 U	170 U	3300 U

U denotes Detection Limot

Table 1.3 Results of the Metals Analysis for Tissue
Project # 3409 Kin Buc Landfill

Sample #	Location	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Mercury mg/kg	Zinc mg/kg
Method Blank		ND	ND	ND	ND*	ND
6832	Martins Creek	ND	ND	42.6	ND	26.5
6834	Reference	0.6	1.2	47.9	ND	29.1
6835	Upper Edmonds Creek	ND	1.2	37.7	ND	26.8
6836	Lower Edmonds Creek	ND	1.8	37.9	ND	25.6
6837	Lower Edmonds Creek	ND	62.5	17.1	ND	40.0
Detection Limit		0.5	1.0	2.0	0.04	2.0

* denotes that the detection limit is 0.10 mg/kg

ND - denotes not detected at or above the quantitation

Table 1.4 Results of the Percent Lipid Analysis
for the Tissue Samples for the Kin Buc Site # 3409

Sample ID	Location	% Lipid	Reporting Limit
6832	Martins Creek	2.4	NA
6834	Reference	1.1	NA
6835	Upper Edmonds Creek	0.93	NA
6836	Lower Edmonds Creek	0.53	NA
6837	Lower Edmonds Creek	0.59	NA
6835	MS	2.8	NA

NA denotes Not Applicable

FINAL REPORT

FOR

KIN BUC LANDFILL

EDISON, NEW JERSEY

PREPARED BY:

David W. Charters, Ph.D.
Environmental Response Team

CONTRIBUTORS:

Ken Munney, ERT/REAC
Philip Y. Kim, ERT/REAC

Environmental Response Branch
Emergency Response Division
Office of Emergency & Remedial Response

KIN-BUC LANDFILL

INTRODUCTION

Site Background

The Kin-Buc property covers an area of approximately 220 acres with three landfill mounds: Kin-Buc I, is approximately 30 acres, the Kin-Buc II and Mound B, are approximately 12 acres each. The remainder of the property consists of vegetated lowlands, wetlands and Kin-Buc, Inc. facilities. The site is located at the end of Meadow Road in the Township of Edison, Middlesex County, New Jersey (Figure 1). The site is surrounded by the Edison Township Municipal Landfill, approximately 600 feet to the south, an industrial complex to the north, marshlands to the east, and the Raritan River to the west.

A wide variety of organic and other uncharacterized hazardous wastes were disposed of at this landfill during its operative years. The majority of hazardous waste disposal is believed to have occurred in the Kin-Buc I mound; but, there is little evidence as to the content of Mound B. Wastes disposed of in Kin-Buc II are presumed to be of normal sanitary landfill character. The landfill is officially closed and covered with a low permeability cap or a one- to five-foot sandy, clayey-loam soil. Surface and groundwater drainage can potentially enter the lower Raritan River to the southwest, Mill Brook/Martins Creek to the west, and the wetlands and Edmonds Creek to the east (Figure 2).(1)

Kin-Buc and the surrounding wetlands have been extensively studied since the mid-1970's. Groundwater monitoring, and soil and sediment sampling have been conducted by several contractors in conjunction with the United States Environmental Protection Agency (USEPA). Wetlands east of the Kin-Buc Landfill are part of an extensive freshwater tidal marsh along the Raritan River. They are dominated by common reed (*Phragmites communis*) with isolated islands of cattail *(Typha spp.)* and upland shrub and tree species. Numerous vertebrate and invertebrate species are supported by the interlocking network of channels comprising these wetlands.(2) Species inhabiting the area surrounding Edmonds Creek are potentially at risk from contaminants emanating from the Kin-Buc Landfill. These wetlands are known to be contaminated with polychlorinated biphenyls (PCBs), principally Arochlors 1248 and 1254, in concentrations ranging from less than 10 to above 700 parts-per-million (ppm).

The primary source of current PCB contamination of the Edmonds Creek marsh area is Pool C, which discharges into the marsh. Pool C has received its contaminants from groundwater and surface water discharges from the Kin-Buc I mound. The Pool C connecting channel and Edmonds Creek, in the vicinity of the junction of the connecting channel, are believed to be secondary sources of contamination, due to historic drainage from Pool C as well as from the low lying area between Kin-Buc and the Edison Landfill. These areas have PCBs in the sediment ranging from 100 to 730 ppm. The remaining wetland area has been contaminated due to water and sediment dispersion of contaminants through normal tidal flows and flood periods; the majority of sediment contamination is at or below 10 ppm. The exception to this is the northeastern backwater region of the marsh and the tidal pond adjacent to Pool C where PCB levels are between 10 and 100 ppm.(2)

Elevated heavy metal concentrations of arsenic (70.6 milligrams per kilogram) (mg/kg), copper (169.7 mg/kg), mercury (1.57 mg/kg), silver (2.04 mg/kg), and zinc (337.0 mg/kg) were detected in the sediments at the mouth of Edmonds Creek. Copper and mercury remain slightly elevated throughout the Edmonds Creek marsh area whereas arsenic, silver, and zinc approach background concentrations of 19.0 mg/kg, 0.76 mg/kg, and 101.5 mg/kg, respectively.(2)

Wehran EnviroTech conducted an investigation on ecological indicator species for Kin-Buc, Inc., in the Fall of 1989. Aquatic invertebrates and vertebrates as well as terrestrial vertebrates were collected and select tissues submitted for PCB analysis. The results of these analyses and sediment chemistry were submitted to USEPA Region II in accordance with the previously drafted RI/FS. In the Fall of 1990, in response to the data received from this study, the USEPA Region II requested that the USEPA/Environmental Response Team (USEPA/ERT) conduct a more extensive ecological investigation on the dominant vertebrate species residing in the wetlands.

Objectives

The objective of this ecological study were:

1. To determine the presence of and/or extent of bioaccumulation of PCBs and/or heavy metals in semi-aquatic biota residing in the wetlands east of the Kin-Buc Landfill, along and surrounding Edmonds Creek.
2. To determine if exposure or accumulation of contaminants is causing adverse physiological impacts within individuals or on population dynamics of a target species.

This report addresses the results of analyses conducted on tissues of muskrats obtained from the wetlands east of the Kin-Buc Landfill and an off-site reference area. The study addresses the exposure of mammals to sediments in the wetlands. This assessment does not address accumulations related to the sediment in the channels as muskrats do not feed in these areas. This assessment does address the vegetated wetland areas.

Fate and Effects of PCBs

A prime contaminant of concern at the Kin-Buc study site are polychlorinated biphenyls. PCBs are known to be widely distributed throughout both terrestrial and aquatic communities across the United States. The largest single use of PCBs is related to their dielectric and thermal properties and are employed as insulation and coolant fluids in transformers and capacitors. A wide variety of other applications include their use as plasticizers of vinyl chloride and polymer freons, heat transfer agents, high pressure hydraulic fluids, and formulations in epoxy resins, paints, printing inks, waxes, adhesives and dyes. PCBs have also been incorporated in pesticides such as lindane, chlordane, aldrin, dieldrin, and toxaphene, to suppress their volatilization and extend their effective life.(3) A variety of PCBs and pesticides may have been disposed of at the Kin-Buc Landfill over the life of its operation. Degradation of PCB-laden products within the confines of the landfill in combination with surface and groundwater leaching has resulted in releases of PCBs to the surrounding drainage areas.

Sediment within the Edmonds Creek marsh area are known to be contaminated with PCBs in concentrations exceeding 700 ppm.(2) Although the marsh sediment is contaminated with PCBs, the major ecological concern is the bioavailability of the PCBs present. If the PCBs are bound by the sediments, then influences on the ecological community may be minimal. PCBs in an aquatic medium have characteristic properties. Aqueous solubilities of PCBs are typically low; concentrations of Arochlors 1248 and 1254, the predominant PCBs detected in water collected from the site, were 54 and 42 parts per billion (ppb), respectively.(2) Low solubilities are due to the high percentage content of tetra- and heptachlorinatedbiphenyls in those Arochlors. Lower chlorinated forms are reported to be of increasingly higher solubilities, up to 3500 ppb.(4) The high hydrophobicity exhibited by PCB molecules in conjunction with their high octanol/water partition coefficients indicates a high affinity for solids. This is especially the case in solids or sediment high in organic matters. Experiments have shown that in aqueous environments, PCBs are rapidly adsorbed and the majority of PCBs present are associated with the soil or sediment in soil-water systems. In addition to the affinity for organic matter, sorption of PCBs is also highly influenced by increasing surface area. Therefore, those sediments with high organic matter and fine particle sizes will characteristically adsorb larger percentages of PCBs and preferentially adsorb higher chlorinated forms such as Arochlors 1248 and 1252.(4)

PCBs are generally immobile in the soil profile when leached with water and sanitary landfill leachates. However, nonpolar solvents such as carbon tetrachloride, benzene, acetone or methanol cause high mobility.(5) Soil types and clay content are an important factor in this process and may strongly influence the concentrations of PCBs found in the upper soil horizons. Studies indicate that a large percentage of PCBs are found within 40 centimeters of the surface in soils with high clay and/or organic matter content, years after exposure.(4) Based solely on solubilities and leaching potential, this indicates that PCBs which have migrated into the Edmonds Creek marsh area may still be present in the upper soil or sediment profiles. This is contingent on the soil sorptive capacity and the presence of additional contaminants that could potentially increase solubilities. Historic deposition, erosion, sedimentation or tidal fluxes may be responsible for covering or redistributing the PCBs to lower concentrations along the bottom of the creekbed or to the tidal floodplain. The exact location of PCBs in the sediment is important in determining the possible availability of the PCBs to vegetation. If most PCBs are contained in creekbottom sediment and not along the channel peripheries or on the tidal floodplains, they will be relatively unavailable to the shallow rooting wetland plant species. Position of the PCBs in the soil or sediment profile is also important.

Plant species are known to adsorb PCBs onto their roots and subsequently absorb them into their tissues. Different plant species respond to PCB concentrations depending on their threshold values for tolerance, medium of growth, and detoxifying mechanisms. Aerobic soil-plant systems, such as beets, carrots, soybeans, and fescue have exhibited almost no biomagnification.(6) However, several aquatic species have shown to accumulate and bioconcentrate PCBs. Bush demonstrated that the major route of uptake of PCBs in purple loosestrife (Lythrum salacaria) was through the root system.(7) The possible route for the intake of PCBs was thought to be systemic transport. Even at the low water solubilities of PCBs, they may be transported into various plant tissues via water transport. PCBs would then accumulate in lipid-containing components, such as the cell wall. Moza also demonstrated that bioconcentration factors (the relative ability of an organism to bioconcentrate a specific contaminant) for the aquatic species, Ranunculus fluitans, Callitriche spp., and red mangrove were 814, 289, and 0.25, respectively.(8) Red mangrove accumulated PCBs in the lower stem and leaves at low concentrations but did show root accumulation at above 6 ppm in the soil.

Pal, et al(6), stated that the potential for PCB bioaccumulation is directly related to the degree of chlorination of the molecules. The more highly chlorinated species have a higher affinity for lipophilic substances and are more persistent than the less chlorinated species. However, research has shown that less chlorinated species were more preferentially taken up by some plants due to their low absorbance to soil particles.(6) Additionally, higher chlorinated molecules are larger, their aqueous solubilities are lower, and their subsequent uptake and translocation within plants may be reduced in comparison to lower chlorinated forms. It should also be noted that since higher chlorinated forms are more persistent and resistant to degradation, once they are absorbed into any plant system they will probably be retained for the life of the plant. Translocation of PCBs from the roots to different tissues is minimal in some plants.(9) For those plants that do translocate PCBs out of their root systems, PCBs are most likely retained in the plant stem or leaves rather than lost through transpiration or volatilization.(10) The cutin, suberin or waxes comprising the outer covering of plants will preferentially retain PCBs translocated to stomatal openings. A study contradicting these results has shown that corn will preferentially accumulate PCB congeners during the seedling stage but metabolizes or emits PCBs at later life stages to reduce PCB levels to background concentrations.(11) Grass species, such as corn, have stomates on both sides of their leaves, thereby creating an increased potential to emit the water-dissolved, lesser-chlorinated congeners during transpiration.

The possible routes of PCB exposure to mammals are highly varied. The principal route assumed is ingestion through the respective food items consumed. Terrestrial and aquatic food chains have been shown to possess PCB contamination at all levels of organization in varying levels of concentration dependent on individual bioconcentration potentials. Another main route may include ingestion through preening behavior. Sediment can become heavily embedded in the fur and frequent contact with PCB laden sediments may cause an increased potential for direct ingestion. The insolubility of PCBs may also create oil films on water surfaces that semi-aquatic mammals may swim through with resulting adherence to the fur. Other avenues of potential exposure include water consumption, skin absorption, or inhalation of volatilized lower chlorinated PCBs from the sediments, water surfaces or plants. Indirect exposure may also result from transplacental migration or consumption of breast milk.

Numerous studies have shown PCB accumulation and effects in a variety of wild and laboratory mammals. Reproductive failure, fetotoxicity, and death of mink have been widely documented at low PCB concentrations.(12,13) Acute sensitization to PCBs by mink may be due to the biological modification of PCBs through metabolism and/or the selective retention of more toxic congeners by the respective species utilized as food.(14) Upper trophic level consumers typically accumulate higher chlorinated congeners. PCBs, being strongly lipophilic, will accumulate in several organs or tissues and preferentially in those containing higher proportions of lipids. Adipose tissue, both subcutaneous and visceral, is a primary site of accumulation.(15) Other tissues may include the liver, kidney, brain and muscle.(16) The liver is commonly believed to be the main site of PCB metabolism.(17) Hexa- and octachlorobiphenyl injected into rats were initially concentrated homogeneously in the liver with delayed localizations around the lobulus. Consequent dispersal was through biliary excretions to the small intestine, other visceral organs and fat depots. Excretion of the higher chlorinated form was minimal and considerable amounts of both forms were still retained in the fat, liver, and kidneys 15 months after exposure.(16) Another study showed that only lower chlorinated forms, mono-, di- and penta-chlorobiphenyls, may be metabolized into more polar forms through hydroxylation and excreted in the bile while higher forms were retained in fat reserves for more than 2.5 years.(18)

Effects of PCB exposure on mammalian systems are most prominent in the liver, although many other sites are also affected. Arochlor 1254 has been shown to significantly increase the size of the liver and percent lipid content.(19) Liver to body weight ratios were also significantly increased.(20) Liver lesions, including fatty infiltration, centrolobular atrophy necrosis, and hyaline degeneration have been evidenced in rats dying from PCB induction.(21) Other effects include a marked increase in smooth endoplasmic reticulum,(22) and increased microsomal mixed function oxidase activity.(21) Dosing of Wistar rats with Arochlor 1254 showed several of these symptoms but were not correlated to either age or sex.(23) Gross pathological symptoms of dosing with Arochlor 1254 and 1260 included soft, and often yellowish brown or dark olive livers. Grayish-white, firm, glistening areas, diagnosed as adenofibrosis or bile duct proliferation, were also commonly incurred.(18)

Reproductive effects from PCBs in male and female mammals have been evidenced in sex organs, fertility menstrual cycles, fetotoxicity and offspring survival. Rats given Arochlor 1254 by gavage showed significantly increased testes weights while those dosed with Arochlor 1221 evidenced increased uterine weights. Different PCB congeners have produced varied effects in female reproductive cycles. The length of the estrous cycle has increased in mice, reduction in follicle numbers were reported in rats, and arrhythmic timing of menstrual cycles in rhesus monkeys was also shown.(24) Chronic low-level exposure of rats to Arochlor 1254 was significantly more harmful to pregnancy than acute levels. Female rabbits were particularly sensitive to Arochlor 1254 during pregnancy and experienced high rates of abortions, resorptions, stillbirths and maternal deaths.(25) Additionally, lactating females impart significant quantities of PCBs to nursing young in their lipid rich milk. In utero exposure, if not fatal, may alter subsequent adult reproductive success. Reduced fertility may be a more functional impairment of individuals rather than identifiable effects such as changes in organ weight, or sperm/follicle numbers. Generally, PCB exposure is more chronically destructive to developing mammals than adults, and females are more sensitive than males. PCBs may directly affect reproductive function or act indirectly on the hepatic enzyme induction system, or on nonreproductive endocrine functions in mammals. The outcome is essentially a reduced capacity of the organism to reproduce itself and sustain a healthy population.(24)

Fate and Effects of Selected Heavy Metals

Lead is neither essential nor beneficial to any living organism and at present, there is no clearly recognized biological requirement for lead(26,27,28). On the other hand, copper, manganese, and zinc are essential elements necessary for the function of various enzymes(29,30).

Biological Presence

Lead is a ubiquitous and toxic element found in virtually all species of plants and animals(31). Copper is found in all animal organs, with the highest concentrations occurring in the liver(29). Manganese is widely distributed in the earth's crust(32).

Absorption, Distribution, and Excretion

For most mammals, including man, 1 to 5 percent of the lead taken orally, either ingested or inhaled, will be absorbed(33). The main long-term storage site for absorbed lead is the skeletal system, followed by the kidneys(34). Smaller concentrations are subsequently stored in the liver, brain, and muscle, in that order(34). Dietary calcium influences intestinal absorption and retention of lead by changing the ratio of distribution between skeletal and soft tissues(34). Under conditions of stress such as illness, starvation, or senility, lead may be reabsorbed from bone tissue and distributed to soft tissues(35). Mammals excrete at least 90 percent of the total lead ingested via the digestive tract without further absorption occurring(33).

In contrast to most other metals, ingested copper is absorbed to a large extent by the stomach(29). Absorbed copper is initially bound to albumin then stored mainly in the liver, followed by the brain, heart, kidney, and muscles(29). Copper is excreted mainly via the bile(29).

Absorption of manganese through ingestion occurs at varying localities along the intestinal tract with different species(32). Absorbed manganese is rapidly eliminated from the blood and is distributed throughout the body in uniform concentrations(32). Organs and tissues do not generally accumulate large concentrations of manganese(32). The majority of manganese excretion occurs through the intestinal wall, but also via perspiration, hair, placenta, and milk(32).

The existence of a homeostatic mechanism for the absorption an
excretion of zinc creates difficulty in tracing this meta
throughout the mammalian body(30). Zinc is primarily stored i

bone tissue, followed by the liver and kidney(30). The majority of zinc is excreted through the feces and the remainder through the urine(30).

Mammalian Effects of Lead Toxicity

Toxic, trace metals can function through the inhibition or perturbation of enzyme systems that have specific functions in metabolic pathways(36). Lead disrupts substrate-enzyme binding(37). The effects of lead intoxication in kidney tissue, the hematopoietic system, and the nervous system is well documented for mammals(38).

Several enzymes known to be inhibited by lead are among the group suspected of being involved in renal tubular support(31). Laboratory animals dosed with lead typically exhibit acid-fast intranuclear inclusion bodies within the kidney tubular epithelial cells(34). Inclusion bodies in young female rat kidneys have been found to occur as early as 24 hours after a single injection of lead at 0.05 milligrams per gram (mg/g) body weight(39). The administration of 1 percent lead acetate to albino rats for a duration of 3 to 8 weeks led to the appearance of intranuclear inclusion bodies(40). These inclusion bodies possess similar ultrastructural characteristics found in wild deer mice (*Peromyscus maniculatus*) and Norway rats (*Rattus norvegicus*) that inhabit areas of known lead contamination(34,40). Mitochondrial functions are very sensitive to the presence of lead(37). The affected tubule cells are characterized by mitochondrial swelling, autophagic vacuoles, and nuclear swelling or pyknosis(33). Lead is the precipitating cause of intranuclear inclusions as well as renal carcinomas, both of which arise primarily in proximal convoluted tubules(40).

As intoxication becomes severe, inclusion bodies are also seen in the outer cortex of the kidney(33). Captive deer mice dosed with 0.5 percent lead acetate added to their diet did not develop inclusion bodies in the renal cortex, however, those individuals receiving a dosage of 1 percent lead developed inclusion bodies in the medullary region of the renal cortex as well as the outer cortex(33).

A decrease in aminolevulinic acid dehydratase (ALAD) activity is a highly significant parameter observable in determining lead intoxication of rats(38,41). This phenomenon is often accompanied by an increase in the levels of aminolevulinic acid (ALA) excreted in urine(38). The effects of lead on this enzyme system occurs rapidly. A decrease in ALAD activity was observed within 12 hours in 100 gram (g) rats that had been fed a single dose of 100 micrograms (ug) of lead(38). However, there is no evidence that decreases in ALAD activity in response to lead are correlated to ultimate lead toxicity(38). Male Wistar rats dosed with lead ranging from 5 ppm lead to 50 ppm lead did not exhibit any significant changes in hematocrit of hemoglobin(42).

The level of biogenic amines in discrete brain areas is a sensitive indicator of the central nervous system's toxicity to lead and cadmium(42). Chronic exposure to lead and cadmium is deleterious to the central nervous system(42). Male Wistar rats receiving dosages of 5 ppm lead or 5 ppm lead plus 0.1 ppm cadmium exhibited hyperactivity(42). Higher doses of 50 ppm lead or 50 ppm lead and 5 ppm cadmium resulted in hypoactivity(42).

Other indications of lead intoxication in mammals that are less sensitive include decreased body weight(33), renal oedema (an increase in kidney weight expressed as a percentage of body weight) and reticulocytosis(33,34). Changes in energy metabolism and protein and nucleic acid synthesis may occur with lead exposure(37). These changes may contribute to disturbances in cellular growth, thus playing a role in carcinogenesis(37). An increase in tumor incidence is most often observed in the kidney with lead intoxication(37). These tumors have also been found to occur in the testes, lungs, pituitary, prostate, and adrenal glands(37). The appearance of cerebral gliomes have also been reported(37).

Although there is a general lack of agreement on what constitutes a safe level of lead intake for extended periods of time(31), a kidney cortex lead concentration of 25 mg/kg has been utilized as a diagnostic indicator of lead poisoning in domestic animals(41). Wild house mice collected from sites with significant lead contamination revealed lead concentrations (2 to 8 ppm) comparable to those expected from a pristine environment (5 to 8 ppm)(43). Male Wistar rats that were dosed with 5 ppm lead and 50 ppm lead had liver lead concentrations from $2.3^{+/-}0.2$ ppm to $3.2^{+/-}0.3$ ppm respectively, and kidney lead concentrations ranging from $2.1^{+/-}0.3$ ppm to $2.3^{+/-}0.2$ ppm respectively(42).

Mammalian Effects of Zinc Toxicity

General symptoms of zinc intoxication in animals are lassitude, slowed tendon reflexes, bloody enteritis, diarrhea, a lowered leokocyte count, paralysis of extremities, and a depression in the activities of the central nervous system(44). Younger animals are more susceptible to these effects of zinc intoxication than mature animals(45).

Rabbits, rats, and cats exposed to zinc oxide fumes for 3.5 hours reacted with a fall in body temperature followed by a marked leukocytosis(30). Autopsies of heavily exposed mammals revealed signs of bronchopneumonia(30).

Excessive additions of zinc (1000 mg/kg) to the diet of pigs for a period of one month depressed the rate of growth and food intake. In addition, arthritis, lameness, and inflammation of the gastrointestinal tract occurred(30). Similar symptoms have been observed in sheep and horses(30).

A single intratracheal injection of 50 milligrams (mg) zinc stearate killed 50 percent of experimental rats, but microscopic examination of lung tissue revealed no pathological changes. However, a recent experiment using the same dose revealed signs of chronic alveolar emphysema and bronchitis(30).

METHODS

Target Species Selection

The muskrat is an important mammalian factor, in terms of biomass, in the Edmonds Creek wetlands. The role of the muskrat is apparent from the extensive network of tunnels and runs, prolific number of bank vegetation digouts, and widespread signs. The habitat provided by the wetlands, primarily dense stands of Phragmites sp., has been documented to be favorable for supporting viable muskrat populations.(46) The chiefly herbivorous diet of muskrats consists mainly of various portions of aquatic or wetland plants, such as the shoots, roots, and tubers.(47) The herbivorous food base in Edmonds Creek, although essentially a monoculture, is extensive and should not pose a limiting factor on the residing population. Under favorable habitat conditions, several studies have shown that muskrats may exhibit fairly limited home ranges. Muskrat activity centers were found to be within 15 meters of the den or lodge site during 50 percent or more of the time. Most foraging occurred within a 5 to 10 meter radius of a lodge or feeding platform and few muskrat movements exceeded 150 meters.(48) Given these conditions, muskrats can then be utilized as reasonably reliable monitors of natural and introduced perturbations occurring in relatively small isolated areas of wetland communities.

Reference Site Selection

A reference area was selected based on the following criteria:

1. Is reasonably close to the study area;
2. The habitat quality is approximately equivalent to the study area;
3. Supports a muskrat population large enough to satisfy study requirements;
4. Is reasonably free of study area environmental contaminants, yet, still reflects ambient conditions.

The reference area chosen is located on tidal floodplains of the South River, in the Township of Old Bridge, New Jersey (Figure 1). The South River is part of the Raritan River watershed and the two merge upstream of the study area. A preliminary assessment of the habitat was conducted to evaluate the potential to support a viable, healthy muskrat population. The area assessed included floodplains on both sides of the South River, which varied between 100 and 1600 meters wide. The dominant form of vegetation was Phragmites communis with dense isolated stands of wild rice (Zizania aquatica) along the river's edge on the southern plain, and scattered islands of Typha spp. on both the southern and northern sides. Large areas of the wetland were covered solely by vegetative ground cover primarily consisting of climbing hempweed (Mikania sp.), arrow arum (Peltandra virginica) and nodding bur marigold (Bidens cornua). Several active muskrat lodges were located on the western side indicating the presence of an active muskrat population. Extensive channeling and runs were also evident on both plains. The preliminary ecological evaluation indicated that the wetland area contained vegetative features and tidal influence comparable to the Kin-Buc study area. The selected area is designated as a potable water area for the city of Perth Amboy, New Jersey and showed no visible signs of contamination.

Muskrat Sampling

Sampling efforts for this study were performed in three phases. The reference location was sampled in October 1990, followed by Kin-Buc study area sampling in December 1990 and January 1991.

Reference Area

On October 16 through 19, 1990, the USEPA/ERT assisted by the Response Engineering and Analytical Contract (REAC), and the ERT/Technical Assistance Team (TAT) conducted muskrat and sediment sampling operations at the South River reference area (Figure 3). The trapping technique utilized for all muskrat captures were spring-loaded Conibear 110 traps. Traps were placed in muskrat channels or runs that appeared to be most active based on tracks, scats, cutting or scouring. Trap placement was accomplished using a four-foot wooden lathe through the trap handle. Each lathe was flagged, numbered with the trap location, and noted on a detailed map of the floodplains. A total of forty traps were place on the southern plain during the initial day of trapping. Twenty-five additional traps were placed on the northern plain on the second day of trapping operations. Trap success was monitored on a daily basis. All captured muskrats were dead at the time of trap checks. Individuals captured were removed from traps and numbered tags were affixed to their right hind foot. All successful traps were reset and repositioned in their previous locations. A field-data sheet was filled out for each individual with the unique animal number, trap location, and time of collection noted. Animals were then transported back to field vehicles where they were secured in coolers on wet ice.

Animals secured were completely processed on a daily basis at the REAC biological laboratory, GSA Raritan Depot, Edison, New Jersey. Processing procedures were as follows: Specimens were first washed of extraneous surficial dirt and organic matter with tap water. Specimens were then assigned a number based on the area and location of capture. They were then dried and total wet weights taken. Metric measurements were then taken of their total length, tail length, and right hind foot. Individuals were then "case" skinned. The pelt was then fleshed, stretched and hung to dry for three to five days for subsequent pelt-age characterization. Carcasses then underwent partial necropsies for removal of specific tissues. Processing included gross external and internal observation for abnormalities or ecto/endoparasites, and opening of the thorax for removal of the thymus, heart, lung, liver, kidneys, adrenals, spleen, duodenum, and testes or ovaries/uterus. The gastrointestinal tract was removed, grossly observed and discarded. All removed organs except for the testes and liver were preserved in 10% buffered paraformaldehyde. The testes were initially fixed in Bouins solution and then transferred to a 70 percent ethyl alcohol solution. The testes/ovary, kidneys, adrenals, and thymus were weighed and measured after preservation. The liver was removed whole, wet weighed, and two small sections excised and preserved in 10 percent buffered paraformaldehyde for histopathology. The major portion of the liver was then wrapped in aluminum foil, placed in a labeled ziploc bag and stored on dry ice. Eight of the largest males and females, for a total of sixteen individuals, were submitted for pesticide/PCB, percent lipid, and Target Analyte List (TAL) metals analyses to Precision Analytics, Inc., Pullman, WA. Those 16 individuals also had liver sections, one kidney, and one testis or ovary submitted for histopathological analysis to the Northeastern Research Center for Wildlife Diseases - University of Connecticut, Storrs, CT. The remaining 26, of the total 42, individuals had only liver tissue submitted for histopathology. The carcasses and remaining organs were stored in five-gallon buckets with 10 percent buffered paraformaldehyde.

All specimens were dissected with surgical instruments on stainless steel trays. Trays and instruments were decontaminated between dissections with deionized water/soap, 10 percent nitric acid, deionized water and acetone in accordance with ERT/REAC Standard Operating Procedure (SOP) #2006, Sample Equipment Decontamination.

At the conclusion of the reference trapping period, sediment samples were secured at five representative sites corresponding to locations of high muskrat activity and trap success (Figure 3). A duplicate sample was collected at one location. Sediment was submitted for Total Organic Carbon (TOC), Total Carbon (TC), and grain size analyses to subcontract laboratories. Sediments were thoroughly homogenized in a stainless steel bucket. Buckets and trowels were decontaminated between each sampling event.

Kin-Buc Study Area

The wetland region, to the east of the Kin ı : Landfill, was broken down into four sampling areas (Figure 2; The areas were selected based upon the physical features of ıe wetlands and the PCB contamination levels reported by W .ran EnviroTech (February 1990). The proximity of the Edis Landfill also influenced area selections.

Sampling Area 1 (AI) was the area within the f .lowing borders (Figure 4):

- north - the tree line at the northern ɛ ʒe of the marsh;
- east - the edge, but not inclusive of, ˥ e Unnamed Ditch:
- south - mosquito channel C1, inclusive of e channel and fifty feet south along the channel;
- west - east bank of Edmonds Creek north o: C1.

Previous sediment/soil sampling in the Area I ıckwater marsh area reported PCB levels between 9.7 and 79. ppm.(2) The southern border was set south of C1 to iɛ late specific waterways used by muskrats. Sampling was conc ıtrated around C0 and C1A.

Sampling Area 2 (AII) was the area within the fo :owing borders (Figure 5):

- north - mosquito channel C2, inclusive of t: : channel and 50 feet north along the channel;
- east - the edge, but not inclusive of, th Unnamed Ditch;
- south - mosquito channel C4, inclusive of th channel and fifty feet south along the channel;
- west - east bank of Edmonds Creek, north ‹ C4 and south of A1.

Previous sediment/soil sampling reported the mɛ ority of AII having PCB concentrations below 10 ppm.(2) Howeve , the stretch of Edmonds Creek adjacent to AII receives water from the low lying area and the Pool C connecting channel. Sampling was concentrated along C2, C3 and C4.

Sampling Area 3 (AIII) was the area within the fol: wing borders (Figure 6):

- northeast - AII;
- east - the edge, but not inclusive of, the Jnnamed Ditch;
- south - the north bank of the Raritan Rive: South west - mosquito channel 10 (C10), inclusive of the channel and fifty feet west along the channe

- west - east periphery of the Edison Landfill, east of C10, including the low lying area north of the Edison Landfill;
- northwest - south of the wooded area located north of the low lying area, going east below the EPA facility, and half-way between where the Pool C connecting channel and the low lying area drainage enter Edmonds Creek.

The majority of the PCB contamination in this area is below 10 ppm. AIII was delineated to address the influence of low PCB concentrations on muskrats. Sampling was concentrated around C6, C7, C8 and C11.

Sampling Area 4 (AIV) was the area within the following borders (Figure 7):

- north - the tree line north of the marsh area;
- east - the west bank of edmonds Creek, south to AIII;
- south - AIII and the EPA Facility;
- west - the Kin-Buc Landfill and the three man-made pools south to the EPA Facility.

AIV contains the highest levels of PCBs reported in sediment/soils within the study area. The majority of the contamination is within the Pool C drainage channel (greater than 100 ppm). The rest of AIV is near or below 10 ppm.

The delineation of these areas for muskrat sampling and analyses was based on general concentrations of PCBs. Although individual muskrats can not be assumed to inhabit solely those areas defined, chances are higher that they spend more of their time in those areas they are caught in given their home range habits.(49) This would especially be true for those individuals captured in non-border areas within each respective delineation.

Prior to field sampling operations, personnel conducted a preliminary survey of the channels intersecting with Edmonds Creek in the study area. Channels were surveyed for navigability, tidal influence, signs of muskrat activity and potential health and safety considerations. The tidal cycle exerts a marked influence on the channel and habitat accessibility throughout the length of Edmonds Creek and the side channels. The majority of muskrat burrows, channels and runs were totally obscured during high tide and for large portions of time on either side of high tide. Due to this condition, all muskrat trapping activities were scheduled on either side of slack low tide. Most of the area was accessed on foot after initial arrival into the southern portion of Edmonds Creek by boat.

The US EPA/ERT, assisted by the REAC and the ERT/TAT, performed muskrat sampling activities in the wetlands east of the Kin-Buc Landfill during the weeks of December 17-21, 1990 and January

7-12, 1991. Entrance to the study area was accomplished by boats via the Raritan River, Edmonds Creek, and the unnamed channel. Initial field study activities during the week of December 17-21 included exploration of available habitat throughout the delineated areas (Figure 2). Extensive networks of runs and channels, both abandoned and those in current usage, were evident adjacent to waterways throughout all areas. Muskrat tracks, scats, runs, and bank digouts were also widely distributed. Two lodges were located in each of two areas, Area I and II. Conibear 110 spring traps were set out in muskrat runs adjacent to waterways. Area I and IV were trapped the first day with Area II and III added on the following day. A total of 116 traps were eventually placed in all four areas.

All trapping techniques followed similar procedures as those performed at the reference site. All traps were removed from each area at the end of the week but location stakes remained in position for future sampling reference. All individuals captured were handled and processed in accordance with the standard techniques employed in the reference area. The largest males and females from each area, a total of twenty-four individuals, had liver tissue submitted for Pesticide/PCB, percent lipids, and TAL metals analyses. Those individuals also had liver, kidney and testis or ovary submitted for histopathological analyses.

Field sampling activities resumed during the week of January 7-12, 1991 in order to augment the number of specimens submitted for analysis from each delineated area. All procedural methods followed previous sampling criteria. Trapping was performed in the same delineated areas but specific trap locations changed dependent on previous trap success and distribution. At the conclusion of trapping activities, all traps and stakes were removed and locations noted on area maps for future sampling reference. The largest males and females from each area, for a total of 36 individuals, were submitted for Pesticide/PCB, percent lipids, and TAL metals analyses. Those individuals also had liver, kidney, and testis or ovary submitted for histopathological analyses.

RESULTS

Reference Area

Muskrats

There were a total of seven pesticides detected above the quantitation limit in nine individuals (Table 1). Dieldrin and Endosulfan(I), the most common contaminants found, were detected in seven individuals ranging from 1.9 up/kg to 107 ug/kg and 0.87 ug/kg to 44 ug/kg, respectively. The next highest level of detection was evidenced by p,p'-DDT, 13.9 ug/kg, at KBR-7. All other individuals had pesticides detected at low detection levels, or below detection or quantitation limits. No PCBs were detected in any of the individuals analyzed.

Lipids extracted from liver tissue were measured as a percentage of tissue and ranged from 2.21 percent to 3.34 percent (Table 2).

Sediments

Pesticides and PCBs were below detection limits in all of the sediments analyzed. TAL Metals analysis detected a total of 19 metals distributed at all five locations sampled (Table 3). Aluminum was elevated relative to what might be expected ranging from 6400 mg/kg to 38000 mg/kg. Other concentrations which may be elevated include arsenic (7 mg/kg to 36 mg/kg), chromium (17 mg/kg to 67 mg/kg), and zinc (47 mg/kg to 150 mg/kg). All other metals were detected at low levels or levels commonly encountered in natural systems. All the levels were accepted as appropriate reference sediments for the areas being assessed.

Total Organic Carbon was generally in the 3 - 4% range and total carbon ranged from 1.33 - 4% (Table 4).

Grain size analysis showed that most sediments were characterized by a large proportion of fine particle sizes (Table 5).

Kin Buc Study Area

Muskrats

PCBs were not detected in any of the livers analyzed. Pesticide analysis detected eight separate compounds at low levels in three individuals (Table 6). Methoxychlor, at 19.7 mg/kg, was the highest contaminant detected and was evidenced in only one individual, KB-29. The individual, KB-36, had six of the eight compounds detected in its tissues at low levels, equal to or less than 17 mg/kg. The third individual had four pesticides detected ranging from 1.7 mg/kg to 6.3 mg/kg.

Lipid analysis on liver tissue for the twenty-four individuals captured in December yielded percentages ranging from 1.10% to 3.08% (Table 7). Analysis on the 36 individuals captured in January yielded decreased percentages ranging from 0.19% to 1.99% (Table 8).

Standard individual parameters, including sex, age (based on "pelt" age and testis length), total weight and length, and tail, hind foot and testes/ovary length, on all muskrats captured are presented in Tables 9 (Reference) and 10 (Study Area). Total weight ranges for reference area adults and juveniles were 981.9g to 1496.6g, and 245.3g to 1400g, respectively.

Table 11 presents mean values of total weights, liver weights, liver weight/total weight ration, % lipids, and testes/ovary length in muskrats based on age and sex per area from the Kin-Buc study area. As expected, adult males were generally larger than females, and adults were characteristically larger than juveniles. The physiologic index of liver weight/total weight was relatively constant across both sex and age, although a slight elevation was apparent in Area 4 males.

Table 12 summarizes the data from all areas of the Kin-Buc study area in comparison to the reference for all the parameters presented in Table 15. The liver weight/total weight ratio is again very constant within and between both areas for age and sex. Total weight and liver weight differences approximate those conditions reflected by age and sex in the four sections of the study area.

Table 13 summarizes the data on male-female and adult-immature ratios as evidenced in both areas. The male-female ratio was almost consistently 1:1 throughout all areas and between the reference and the study area; however, Area 2 did yield a 1:2.2 ratio. The adult-immature ratio was also relatively constant approximating the 1:1.4 ratio evidenced in the reference area; however, Area 1 in the Kin-Buc study area exhibited a 1:2.8 ratio.

Trap success for the reference area and the Kin-Buc study area is presented in Table 14. Trap nights and captures in the study area exceeded the reference area but trap success was almost three times greater in the reference area, 24.1%, when compared to the total trap effort at Kin-Buc, 7.1%. Trap success in both areas tended to be highest on the initial day of trapping with reduced success on successive days. As the trap effort was not consistent and not conducted in a random or grid fashion, this should not be interpreted as evidence of population differences between areas.

The histopathological analyses evidenced a common incidence of infestation of the liver by the parasite *Capillaria hepatica*. A total of 37 individuals from the study area, or 60.7%, were diagnosed with either minimal, mild, moderate, or severe capillariasis in comparison to eleven cases, or 26.2%, from the reference area. The largest proportion of the individuals exhibiting symptoms of capillariasis were those submitted from the January Kin-Buc specimens. Hepatic granulomas exhibiting pathological symptoms similar to capillariasis in December Kin-Buc individuals was also slightly elevated in comparison to those found in reference animals. Dual infections with capillariasis and cestodes was common in both the reference individuals. There were no effects diagnosed as specifically attributable to exposure to PCBs, heavy metals, or other pathologic conditions that would manifest themselves in a similar manner.

Kidney analysis revealed tubular degeneration in numerous individuals from the study area. Those individuals submitted from January, again, had the largest proportion of incidence. Mild interstitial nephritis was found in several individuals from the reference, and both groups of the Kin-Buc individuals.

Analysis of the testes and ovaries of both the reference and study area individuals showed no signs of specific abnormalities. The gonads of both sexes were found in varying stages of development, from immature to development of follicles or spermatogenesis.

Kin-Buc Muskrats and PCBs

The muskrat population in the Edmonds Creek marsh area is unquestionably residing in a PCB-contaminated environment. However, those individuals that were captured and submitted for analysis showed no accumulation of PCBs in their livers or histopathological signs of toxicity in their liver, kidneys or testes/ovaries.

Due to the uncertain potential and mechanisms for PCB accumulation in varied plant systems, it is unknown if PCBs are accumulating in the vegetative component in the Edmonds Creek marsh area. However, there is a high potential for uptake owing to the favorable conditions of high concentrations, anaerobic medium, and mixed chlorination states of the PCBs present. Vegetative considerations need to be addressed in relation to the sustenance of any herbivorous species. Muskrats chiefly feed on the roots, shoots and tubers of plants. Although Phragmites is not often cited as a preferred food for the muskrat, it is the dominant form of vegetation in the marsh area and the primary food source. There is ample evidence for the utilization of the Phragmites stands throughout the confines of the marsh. Since muskrats are feeding on plant parts that are in direct contact with the sediments, consumption of the plants themselves or sediment adhering to the root systems is a potential pathway for contamination ingestion. Many of the studies indicating plant uptake of PCBs have already been discussed. Aquatic plants or those that grow in semi-aquaticenvironments have been documented to have high potentials for PCB uptake. The tidal wetlands of Edmonds Creek exemplify this condition as evidenced by the bi-daily inundation of the root zones or lower stems of the Phragmites lining the creekbanks. It is possible that Phragmites has the capability to uptake PCBs into its root tissue, translocate them to lead tissue and then rid itself of them through transpiration much the same as corn, another grass family species, has been cited to do. However, this is most likely only for the lower chlorinated congeners and probably does not hold true for the more highly chlorinated forms known to be more evident in the sediments. It is also unlikely that all PCBs whether they are lower or higher chlorinated forms would be totally depleted by transpiration after initial uptake. (For these reasons, it is important to determine the presence or absence of PCBs in the plant roots and any translocation to the various internal plant tissues.) Confirmation of these conditions, would further elucidate the mechanisms of PCB transformation in the food chain.

Assuming that PCBs are present in the vegetative community, (the most conservative assumption), speculation must then be directed at uptake into the mammalian component. PCB uptake by mammals has been discussed relative to tissue distribution. PCB detections should be evidenced principally in the adipose tissue, due to its lipophilic nature, and also may be found in the liver, kidney, brain or mammalian tissues. Since the liver is the primary site of metabolism, liver tissue should have detectable levels of PCBs under chronic exposure conditions. However, if muskrats are being exposed at varying rates and over varying time frames, then PCB metabolism may be completed at any given time. Redistribution of PCBs into other tissues primarily subcutaneous of visceral fat tissue, may lead to a greater chance of detection in tissues other than liver.

Metabolism and excretion of PCBs is another possibility for the lack of PCB detection. Once again, it is likely that only the lower chlorinated forms would undergo this process due to the stability of the higher chlorinated forms. Therefore, if muskrats are ingesting PCBs then some retention of higher chlorinated forms should be expected. Additionally, regardless of excretion, if uptake is occurring then tissues should be at least exposed to the PCBs before depuration. The muskrats analyzed showed no diagnostic symptoms of chronic or acute PCB exposure.

Gross anatomical measurements do not indicate the documented effects of PCB exposure. Liver weights were higher in certain areas, but not without a corresponding increase in body size. The liver weight/total weight ratio increases evidenced in another study were not observed in the Kin-Buc animals as a whole in comparison to the reference animals. There was a slight elevation in male adult and juvenile ratios for Area 4, but these did not appear in any other areas. The decreased lipid content in Kin-Buc area individuals may be a manifestation of lower overall seasonal fat reserves due to being captured later in the winter. Storage of lipids in the form of glycogen in the liver will decrease in times of metabolic need. Mid-winter usage of stored body fats is a normal physiologic condition. A side effect of PCB exposure is increased lipid proliferation in the liver and this was not evidenced. Testes sizes were larger in Areas 1 and 4 versus the other two areas. The testes lengths were also larger in Kin-Buc versus the reference area. Testes size increase is a documented effect of PCB exposure so this may be a possible avenue to further explore. However, testes weight and size are also a function of age and this may be a more likely contributor to size differentiation. Delayed spermatogenesis is another side effect of PCB exposure. (24) Very few individuals that were considered male adults had undergone spermatogenesis. Males were classified as adults based on a testes length of greater than or equal to 11.65mm and/or pelt primeness.(50) Pelt primeness is most reliable in individuals less than one year old and spermatogenesis may not have fully developed in yearling males. Testes length is one cited method for age determination but there are several others utilized. The average life-span of muskrats is less than one year(49); therefore, many of the individuals may be yearlings and have not yet initiated reproductive capabilities. Body weights and metric body measurements are within the bounds of other muskrat populations studied in the Northeast. Similarly, male-female and adult-juvenile ratios were within the wide ranges evidenced in populations studied in the continental United States.(46,47)

Natural variation in animals and exposure levels make extrapolation of laboratory findings difficult at best. Additionally, the levels of exposure in laboratory studies are generally markedly higher than many environmental conditions encountered. Many studies have dosage levels at 100 ppm or greater for several months in order to evidence exposure effects. No effect levels of PCB exposure are highly varied dependent on the target organ or tissue. However, many no effect levels approach concentrations of 25 ppm or greater. Bioavailability and uptake factors are key components in determining the level of PCB exposure. Tissue detection limits of 10-50 ppb for all Arochlors (utilized for this study), should be sufficiently low enough to detect uptake of ppm concentrations of PCBs even with reduced bioconcentration factors. It is apparent that PCBs are either not readily bioavailable in the Edmonds Creek Marsh areas outside of the channels or are available at highly reduced bioconcentration factors in muskrats that lead to no discernable effect exposure levels or exposure effects that were not elucidated by this study.

The muskrat livers from animals trapped at the Kin-Buc Landfill show significant elevations in levels of several heavy metals, including lead, iron, zinc and magnesium (Tables 15-19). The metal levels are indicative of typical leachate from municipal and industrial landfills and all the areas studied in this study exclusive of the reference area showed the elevations. If all the groups in the wetland east of the Kin-Buc Landfill and south of the Edison Landfill were combined, additional significant differences were seen, including significant elevations of copper and manganese, additional elevations included potassium and calcium. At the present, time we are unable to attribute the elevations to a specific landfill or any other potential source.

The high incidence of infestations of muskrats with Capillaria hepatica is unknown. Capillaria infestations have been documented in muskrat populations previously as well as numerous other mammals.(52) Pathogens normally manifest themselves in a higher proportion in individuals in reduced states of health. Substandard health conditions can be induced by a variety of factors including diet, habitat, and/or introduced toxicants. Although the incidence of Capillaria is notable, a definitive statement linking it to PCB or metals contamination cannot be made.

CONCLUSIONS

The study of the area to the east of the Kin-Buc Landfill directly addressed the uptake of PCBs and heavy metals in the dominant mammalian species, muskrats. The study was developed to address the questions of impacts from the Edison Landfill as well as the Kin-Buc Landfill. The species selected was at the lower end of the foodchain and was anticipated to be representative of herbivours in the area. This study was conducted with the understanding that the effects of sediments in the channels would be addressed by a second study conducted by EPA Region II with the assistance of ERT. In that light, the conclusions of this study only addresses the areas out of the channels in the areas where the muskrats are feeding.

The PBCs present in the soil in the study areas are not being accumulated in the livers of the muskrats in the areas studied. Detection limits of 10 - 50 ppb were sufficiently low to address most concerns for herbivours.

Heavy metal accumulation is occurring in the area both to the east of the Kin-Buc Landfill and to the south of the Edison Landfill. The specific location of the metal contamination can at this point not be attributed, or assumed to be originating at any particular source. Difficulties establishing a closer watershed reference area which might assist in establishing the source or sources were not surmounted.

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1D
PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

BFA03

b Name: CEIMIC CORP   Contract: 68D90028

b Code: CEIMIC   Case No.: 14523   SAS No.: ______   SDG No.: BFA01

trix: (soil/water) SOIL   Lab Sample ID: 900536-03

mple wt/vol: 30.3 (g/mL) G   Lab File ID: ______

vel: (low/med) LOW   Date Received: 07/18/90

Moisture: not dec. 59   dec. ____   Date Extracted: 07/19/90

xtraction: (SepF/Cont/Sonc) SONC   Date Analyzed: 07/31/90

C Cleanup: (Y/N) N   pH: 6.5   Dilution Factor: 1.00

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	19	UJ
319-85-7	beta-BHC	19	U
319-86-8	delta-BHC	19	U
58-89-9	gamma-BHC (Lindane)	19	U
76-44-8	Heptachlor	19	U
309-00-2	Aldrin	19	U
1024-57-3	Heptachlor epoxide	19	U
959-98-8	Endosulfan I	19	U
60-57-1	Dieldrin	39	U
72-55-9	4.4'-DDE	39	U
72-20-8	Endrin	39	U
33213-65-9	Endosulfan II	39	U
72-54-8	4.4'-DDD	39	U
1031-07-8	Endosulfan sulfate	39	U
50-29-3	4.4'-DDT	39	U
72-43-5	Methoxychlor	190	U
53494-70-5	Endrin ketone	39	U
5103-71-9	alpha-Chlordane	190	U
5103-74-2	gamma-Chlordane	190	U
8001-35-2	Toxaphene	390	U
12674-11-2	Aroclor-1016	190	U
11104-28-2	Aroclor-1221	190	U
11141-16-5	Aroclor-1232	190	U
53469-21-9	Aroclor-1242	190	U
12672-29-6	Aroclor-1248	190	U
11097-69-1	Aroclor-1254	390	U
11096-82-5	Aroclor-1260	390	U

Table 1. Pesticides/PCBs Detected in Liver Tissue of Muskrats Collected From South River Reference Area, Old Bridge, NJ October 16-19, 1990

(concentrations reported in ug/kg)

Parameter	Specimen														
	KBR-3	KBR-7	KBR-8	KBR-10	KBR-12	KBR-13	KBR-19	KBR-23	KBR-24	KBR-26	KBR-27	KBR-28	KBR-29	KBR-32	KBR-36	KBR-41
Endosulfan (I)	0.525u	0.525u	44	0.525u	40	0.24J	0.525u	0.955	0.525u	3.6	0.525u	10	0.34J	30	0.87	0.525u
Endosulfan (II)	0.085u	0.085u	0.29	0.085u	0.085u	0.085u	0.085u	0.085u	0.085u	0.085u	0.085u	0.085u	0.085u	0.085u	0.085u	0.085u
Dieldrin	0.075u	107	1.9	0.075u	2.8	0.075u	0.075u	1.9	0.075u	6.8	0.075u	2.8	0.075u	6.16	0.075u	0.075u
Heptachlor Epoxide	0.140u	0.06J	0.03J	0.03J	0.04J	0.05J	0.04J	0.087J	0.140u	0.04J	0.140u	0.140u	0.140u	0.04J	0.02J	0.140u
p,p'-DDT	0.35u	13.9	0.35u	0.35u	0.35u	0.35u	0.35u	0.35u	0.35u	0.35u	0.35u	0.35u	0.35u	0.35u	0.35u	0.35u
p,p'-DDD	0.325u	0.325u	0.325u	0.325u	0.325u	0.325u	0.325u	0.325u	0.325u	0.325u	0.325u	0.375u	0.08J	0.325u	0.325u	0.325u
p,p'-DDE	0.075u	0.075u	0.02J	0.075u	0.06J	0.02J	0.06J	0.13	0.075u	0.06J	0.075u	0.05J	0.05J	0.04J	0.05J	0.075u
Arochlor 1016	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u
Arochlor 1221	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u
Arochlor 1232	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u
Arochlor 1242	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u
Arochlor 1248	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u
Arochlor 1254	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u
Arochlor 1260	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u	5.0u

u - Denotes not detected at indicated detection limit
J - Denotes below quantitation limit.

Table 2. Lipids Detected in Liver Tissue of Muskrats Collected From South River Reference Area, Old Bridge, NJ
October 16-19, 1990

(concentrations reported as percent of total)

Specimen	Lipid
KBR-3	2.92
KBR-7	2.52
KBR-8	2.95
KBR-10	2.34
KBR-12	2.83
KBR-13	2.31
KBR-19	3.10
KBR-23	2.90
KBR-24	3.11
KBR-26	3.34
KBR-27	3.25
KBR-28	2.48
KBR-29	2.80
KBR-32	2.50
KBR-36	2.21
KBR-41	2.86

Table 3. TAL Metals Detected in Sediment Collected From South River Reference Area, Old Bridge, NJ October 16-19, 1990

(concentrations reported in mg/kg)

Metal	Location					
	9	19	38	44	44*	53
Aluminum	17000	12000	9100	6400	38000	28000
Arsenic	31	25	9	7	36	29
Barium	160	180	160	100U	340	300
Calcium	650	1100	1400	790	1400	680
Chromium	33	35	20	17	67	63
Cobalt	13	15	11	6	24	22
Copper	52	59	19	25	43	55
Iron	40000	52000	18000	18000	59000	33000
Lead	84	160	42	88	80	76
Magnesium	730	740	740	430	2800	1400
Manganese	67	99	54	38	220	160
Mercury	0.28	0.36	0.18	0.08	0.33	0.51
Nickel	18	23	15	11	36	36
Potassium	2000	1100	1200	740	4300	1800
Selenium	1	1	1u	1u	1	1u
Silver	2.5u	3	2.5u	2.5u	2.5u	2.5u
Sodium	290	380	520	290	610	320
Vanadium	76	58	50u	50u	110	98
Zinc	73	140	73	47	140	150

u - Denotes below detection limit.
* - Field duplicate

TABLE 4. Total Organic Carbon (TOC) and Total Carbon (TC) Detected in Sediment Collected from South River Reference Area, Old Bridge, NJ October 16-19, 1990

(concentrations reported as percent of total)

Parameter	Location					
	9	19	38	44	44*	53
TC	4.0	3.8	3.6	2.9	2.1	3.0
TOC	3.97	1.83	3.49	1.83	1.33(1)	1.87

* field duplicate

(1) expressed in dry weight

Table 5. Grain Size Analysis of Sediment Collected From South River Reference Area, Old Bridge, NJ
October 16-19, 1990

(values expressed as percent of total)

Location	Gravel	Particle Size Sand			Silt/Clay
		Coarse	Medium	Fine	
9	0	0	7	43	50
19	0	0	10	60	30
38	0	0	5	78	17
44	5	8	15	14	58
44*	15	20	25	9	31
53	1	8	15	14	58

* field duplicate

Table 6. Pesticides/PCBs Detected in Liver Tissue of Muskrats Collected from Kin-Buc Study Area, Edison, N.J. December 17-21, 1990; January 7-12, 1991

(concentrations reported in ug/kg)

Parameter	Specimen		
	KB-29	KB-31	KB-36
alpha DBC	U	1.7	4.0
beta BHC	U	6.3	17
gamma BHC	U	2.1	5.3
delta BHC	U	U	6.6
Heptachlor	U	U	0.74J
Aldrin	U	2.8	U
Endosulfan Sulfate	U	U	3.6J
Methoxychlor	19.7	U	U
Arochlor 1016	10u	10u	10u
Arochlor 1221	50u	50u	50u
Arochlor 1232	50u	50u	50u
Arochlor 1242	10u	10u	10u
Arochlor 1248	10u	10u	10u
Arochlor 1254	10u	10u	10u
Arochlor 1260	10u	10u	10u

U Denotes not detected at indicated concentration.

J Denotes an estimated concentration.

* Note: No pesticides or PCBs were detected in the liver tissues analyzed from all other locations.

Table 7. Lipids Detected in Liver Tissue of Muskrats Collected From Kin-Buc Landfill Study Area, Edison, NJ December 17-21, 1990

(concentrations reported as percent of total)

Specimen	Lipid Content
KB-1	1.20
KB-2	3.00
KB-3	1.57
KB-4	1.64
KB-5	1.99
KB-6	1.77
KB-7	1.63
KB-8	1.60
KB-9	1.10
KB-10	1.98
KB-11	1.43
KB-12	2.57
KB-13	1.72
KB-14	1.29
KB-15	1.20
KB-17	1.90
KB-18	1.69
KB-19	1.66
KB-21	1.72
KB-23	3.08
KB-25	1.79
KB-26	2.87
KB-27	1.58
KB-29	1.93

Table 8. Lipids Detected in Liver Tissue of Muskrats Collected from Kin-Buc Study Area, Edison, N.J. January 7-12,1991

(concentrations reported as percent of total)

Specimen	Lipid Content
KB-30	0.33
KB-31	0.68
KB-32	1.69
KB-33	0.4
KB-34	1.99
KB-35	0.51
KB-36	0.3
KB-37	0.43
KB-39	0.63
KB-40	0.61
KB-42	0.62
KB-43	0.56
KB-44	1.35
KB-45	0.74
KB-46	0.9
KB-47	0.19
KB-48	0.53
KB-49	0.65
KB-50	0.66
KB-51	0.61
KB-52	0.54
KB-53	0.67
KB-54	0.39
KB-56	1.03
KB-57	0.62
KB-58	0.67
KB-59	0.77
KB-60	1.13
KB-61	0.65
KB-62	0.94
KB-63	0.65
KB-64	1.18
KB-65	0.84
KB-66	0.51
KB-67	1.16
KB-68	0.78

Table 9. Vital Statistics on Muskrats Collected from South River Reference Area, Old Bridge, N.J. October 16-19,1990

Sample ID#	Sex	Maturity[1]	Total Weight (g)	Total Length (mm)	Tail Length (mm)	Hind Foot Length (mm)	Testes/ Ovary Length (mm)
KBR-1	M	JUVENILE	261.4	320	125	67	5
KBR-2	F	JUVENILE	699.3	487	230	75	6
KBR-3*	F	ADULT	1354.3	605	265	77	9
KBR-4	M	ADULT	1040.9	556	225	79	12
KBR-5	M	JUVENILE	245.3	328	123	65	6
KBR-6	F	ADULT	984.8	548	237	80	12
KBR-7*	F	ADULT	1176.1	561	242	83	8.5
KBR-8*	F	ADULT	981.9	555	235	77	8
KBR-9	F	JUVENILE	423.6	419	175	74	6
KBR-10*	M	SUB-ADULT	1202.2	584	258	88	7
KBR-11	M	JUVENILE	EATEN	—	—	72	6
KBR-12*	F	ADULT	1494.8	556	250	79	8
KBR-13*	M	SUB-ADULT	1400	585	245	82	11
KBR-14	M	ADULT	1171.3	542	223	74	17
KBR-15	M	JUVENILE	1050.9	530	236	81	8
KBR-16	F	SUB-ADULT	972.6	516	225	79	8
KBR-17	F	SUB-ADULT	1140.8	540	217	71	7
KBR-18	F	JUVENILE	495	422	178	69	6
KBR-19*	M	SUB-ADULT	1223.9	566	235	79	9
KBR-20	M	ADULT	1021.6	537	220	74	8
KBR-21	M	ADULT	1270.7	531	213	77	22
KBR-22	M	JUVENILE	734.8	485	204	77	6
KBR-23*	M	SUB-ADULT	1161.7	572	251	78	8
KBR-24*	F	ADULT	1380.6	589	255	78	11
KBR-25	M	SUB-ADULT	1154.3	545	234	81	8
KBR-26*	F	ADULT	1249.9	540	218	75	10
KBR-27*	F	SUB-ADULT	1172.2	562	230	77	8
KBR-28*	M	ADULT	1365.2	550	240	82	13
KBR-29*	M	ADULT	1296.2	573	230	76	16
KBR-30	M	JUVENILE	300.6	350	130	--	5
KBR-31	M	SUB-ADULT	1165.5	543	218	81	11
KBR-32*	M	ADULT	1496.6	582	247	81	15
KBR-33	M	SUB-ADULT	1225.2	591	253	81	6
KBR-35	M	SUB-ADULT	916.7	476	240	79	7
KBR-36*	F	ADULT	1428.3	584	247	80	9
KBR-37	F	SUB-ADULT	1136.5	574	249	78	9
KBR-38	F	JUVENILE	871.8	590	280	80	6
KBR-39	M	JUVENILE	661.8	463	200	76	7
KBR-40	M	JUVENILE	1147.6	543	243	85	11
KBR-41*	M	ADULT	1477.9	587	250	82	11
KBR-42	F	ADULT	1318.2	564	246	75	8

* Liver sent for chemical and histopathological analysis.

(1) Based on pelt, testes/ovary/uterus size and/or uterine scars.

Table 10. Vital Statistics on Muskrats Collected from Kin-Buc Study Area, Edison, N.J. December 17-21, 1990; January 7-12, 1991

Sample ID#	Sex	Maturity[1]	Total Weight (g)	Total Length (mm)	Tail Length (mm)	Hind Foot Length (mm)	Testes/ Ovary Length (mm)
KB-1*	F	JUVENILE	875.1	498	199	74	7
KB-2*	M	JUVENILE	1176.8	538	231	79	10
KB-3*	F	JUVENILE	1196.2	525	220	76	7
KB-4*	F	SUB-ADULT	1120	525	237	74	8
KB-5*	M	SUB-ADULT	1260.1	544	242	81	11
KB-6*	F	ADULT	1160.6	525	226	79	9
KB-7*	M	ADULT	1103.9	550	230	80	14
KB-8*	M	ADULT	1105.4	567	260	85	12
KB-9*	M	JUVENILE	1002	500	223	82	8
KB-10*	F	JUVENILE	910.6	490	214	81	6
KB-11*	M	SUB-ADULT	1392	545	228	81	13
KB-12*	M	JUVENILE	1248.7	525	225	85	14
KB-13*	M	ADULT	1540.8	572	235	78	16
KB-14*	M	JUVENILE	1137.4	540	246	79	8
KB-15*	F	JUVENILE	926.9	490	220	83	5
KB-16	M	JUVENILE	830.4	492	210	72	7
KB-17*	M	ADULT	1134.6	543	246	78	15
KB-18*	F	JUVENILE	1133.8	559	243	75	8
KB-19*	F	ADULT	1002.6	513	214	74	8.5
KB-20	M	JUVENILE	901.8	498	215	72	7
KB-21*	F	ADULT	1199.9	545	240	74	8.5
KB-22	F	SUB-ADULT	1069.8	511	209	77	5.5
KB-23*	M	ADULT	972.8	510	210	75	13
KB-24	F	JUVENILE	950	521	242	78	7
KB-25*	M	JUVENILE	1004.8	543	231	74	14
KB-26*	F	ADULT	1446.8	593	260	79	9.5
KB-27*	M	JUVENILE	1103.6	521	221	77	14
KB-28	F	SUB-ADULT	733.7	460	190	76	5.5
KB-29*	F	ADULT	1226.7	590	270	80	7
KB-30*	F	SUB-ADULT	1036.5	509	220	79	11
KB-31*	M	SUB-ADULT	1026.1	510	210	75	16
KB-32*	F	ADULT	1325.4	560	240	77	8.5
KB-33*	M	ADULT	1296.4	560	235	81	19

* Liver sent out for chemical and histopathological analysis.

(1) Based on pelt, testes/ovary/uterus size and/or uterine scars.

Table 10 (cont'd). Vital Statistics on Muskrats Collected from
Kin-Buc Study Area, Edison, N.J.
Dec. 17-21, 1990; Jan. 7-12, 1991

Sample ID#	Sex	Maturity[1]	Total Weight (g)	Total Length (mm)	Tail Length (mm)	Hind Foot Length (mm)	Testes/ Ovary Length (mm)
KB-34•	M	ADULT	1169.9	561	241	82	22
KB-35•	M	JUVENILE	1165.6	561	238	78	18
KB-36•	F	SUB-ADULT	1071.8	531	220	78	10
KB-37•	M	ADULT	1206.4	570	241	75	20
KB-38	M	JUVENILE	829.3	490	195	74	9
KB-39•	M	SUB-ADULT	1078.4	533	213	77	13
KB-40•	F	JUVENILE	1060.5	540	215	75	7.5
KB-41	F	JUVENILE	860	485	200	73	5.5
KB-42•	M	JUVENILE	1275.3	527	224	77	16
KB-43•	M	ADULT	1398.9	570	238	80	20
KB-44•	M	JUVENILE	1016	504	215	72	16
KB-45•	F	JUVENILE	1106.1	532	232	77	7.5
KB-46•	F	JUVENILE	1102.6	512	220	78	7.5
KB-47•	M	SUB-ADULT	1034.5	518	220	79	6
KB-48•	F	ADULT	1183	568	246	78	6
KB-49•	F	ADULT	1042.8	515	214	78	8.5
KB-50•	F	ADULT	1356.8	531	222	78	7
KB-51•	F	JUVENILE	1006.1	505	210	76	6.5
KB-52•	F	JUVENILE	1118.6	510	220	80	9
KB-53•	F	ADULT	1251.1	527	217	75	9
KB-54•	F	SUB-ADULT	984.5	500	210	79	7
KB-55•	F	JUVENILE	933.9	485	225	77	6.5
KB-56•	F	JUVENILE	1135.5	540	240	80	6
KB-57•	F	SUB-ADULT	1103.4	540	245	78	7.5
KB-58•	M	ADULT	1410	566	241	81	15
KB-59•	F	SUB-ADULT	982.4	506	209	75	7.5
KB-60•	F	ADULT	1146.6	513	209	72	8
KB-61•	M	ADULT	1541.8	548	222	84	19
KB-62•	F	JUVENILE	1213.1	537	222	80	6.5
KB-63•	M	JUVENILE	932	492	203	72	8
KB-64•	F	ADULT	1065.2	573	250	79	7.5
KB-65•	F	ADULT	1426.2	576	264	79	7
KB-66•	M	SUB-ADULT	1008.3	535	251	77	9
KB-67•	M	ADULT	1162.2	577	282	15	16
KB-68•	M	ADULT	1202	535	231	80	16

• Liver sent out for chemical and histopathological analysis.

[1] Based on pelt, testes/ovary/uterus size and/or uterine scars.

TABLE 11. Means of Selected Body Parameters
of Muskrats Collected from
Kin-Buc Study Area
December 17-21, 1990; January 7-12, 1991

	AREA 1				AREA 2				AREA 3				AREA 4			
*	MA	FA	MJ	FJ	MA	FA	MJ	FJ	MA	FA	MJ	FJ	MA	FA	MJ	FJ
Total Weight (gm)	1267.6	1152.1	1113.4	1023.4	1250.4	1246.1	1052.8	986.5	1089.9	1158.3	962.0	1045.6	1279.8	1212.3	892.2	1092.4
n	3	2	7	7	3	4	2	7	3	3	5	3	4	4	5	4
Liver Weight (gm)	43.8	48.8	36.9	31.8	43.0	37.7	30.8	32.8	35.4	39.6	28.2	31.86	58.5	41.0	38.3	42.9
n	3	2	7	7	3	4	2	7	3	3	5	5	4	4	5	4
Liver Weight / Total Weight	0.036	0.031	0.033	0.031	0.035	0.031	0.029	0.034	0.033	0.034	0.029	0.031	0.046	0.034	0.086	0.039
n	3	2	7	7	3	4	2	7	3	3	5	3	4	4	5	4
% Lipids (liver)	0.54	1.71	1.49	1.07	1.29	1.10	1.34	0.97	2.05	1.21	0.79	0.89	1.23	1.46	1.29	0.81
n	3	2	6	5	3	4	2	6	3	3	4	3	4	4	4	4
Testes / Ovary (mm)	18.0	8.0	12.0	6.86	15.0	8.25	11.0	6.66	14.7	6.67	8.80	6.75	18.5	8.0	13.40	8.0
n	3	2	7	7	3	4	2	6	3	3	5	4	4	4	5	4

* MA = Male Adult
FA = Female Adult
MJ = Male Immature
FJ = Female Immature
Immature = Juvenile and Sub-adult

Table 12. Means of Selected Body Parameters of Muskrats Collected from South River Reference Area and Kin-Buc Study Area October 16-19, 1990; December 17-21, 1990; January 7-12, 1991

		KB - Areas 1-4				REFERENCE			
	*	MA	FA	MJ	FJ	MA	FA	MJ	FJ
Total Weight (9)		1249.6	1218.0	1008.9	1029.0	1267.6	1152.1	865.7	863.9
	n	13	13	19	23	8	9	16	8
Liver Weight (9)		47.6	39.29	34.3	34.0	43.8	48.8	32.4	34.3
	n	13	13	19	23	8	9	16	8
Liver Weight / Total Weight		0.038	0.032	0.046	0.03	0.034	0.046	0.037	0.090
	n	13	13	19	23	8	9	16	8
% Lipids (Liver)		1.27	1.33	1.24	0.94	2.66	2.84	2.66	3.25
	n	13	13	16	18	4	7	4	1
Testes/Ovary (mm)		16.7	7.8	11.4	7.0	14.3	9.22	7.56	7.00
	n	13	13	19	21	8	9	16	8

* MA = Male Adult
FA = Female Adult
MJ = Male Immature
FJ = Female Immature
Immature = Juvenile and Sub-adult

TABLE 13. Sex and Age Ratios for Muskrats Collected from South River Reference Area and Kin-Buc Study Area, October 16-19, 1990, December 17-21, 1990, January 7-12, 1991

		Kin-Buc Study Area				
	Reference	Area 1	Area 2	Area 3	Area 4	Total
MALES	24	10	5	8	9	32
FEMALES	17	9	11	8	8	36
MALE-FEMALE RATIO	1.4:1	1.1:1	1:2.2	1.1:1	1.1:1	1:1.1
ADULTS	17	5	7	6	8	26
IMMATURES	24	14	9	10	9	42
ADULT-IMMATURE RATIO	1:1.4	1:2.8	1:1.3	1:1.6	1:1.2	1:1.6

IMMATURES = Sub-adults and juveniles

Table 14. Trap Success for Muskrats Collected from South River Reference Area and Kin-Buc Study Area October 16-19, 1990; December 17-21, 1990; January 7-12, 1991

		KIN-BUC		
	Reference	December	January	Total
Trap Nights	170	403	549	952
Captures	41	29	39	68
% Success	24.1	7.2	7.1	7.1

TABLE 15. Results of ANOVA, Dunnett's Multiple Comparison of Means
and One Tailed T-Tests for All Areas vs. Reference Area
With All Age Groups Combined
Kin-Buc Landfill Site
Edison, New Jersey
August, 1991

	Fe	Pb	Mg	K	Zn
All Groups Area 1	*	*	*	*	*
All Groups Area 2	*	*	*	*	*
All Groups Area 3	*	*	*	*	*
All Groups Area 4	*	*	*	*	*
All Groups, All Areas	*	*	*	*	*

* Indicates a significant difference between the specified area and the reference area.

TABLE 16. Mean Metal Concentrations in Liver Tissue of Juvenile Female Muskrats
Kin-Buc Study Area
Edison, NJ
August, 1991

(Concentrations reported in mg/kg)

AREA		Ca	Cu	Fe	Pb	Mg	Mn	K	Na	Zn
I	N=5	55.60 +/- 26.75	17.32 +/- 0.84	247.80 +/- 51.03	0.44 +/- 0.23	255.40 +/- 35.37	9.76 +/- 15.28	2138.40 +/- 326.93	1119.0 +/- 235.92	41.20 +/- 4.76
II	N=6	51.83 +/- 46.90	38.83 +/- 52.83	216.0 +/- 66.48	0.56 +/- 0.31	213.67 +/- 30.22	3.24 +/- 0.66	2181.83 +/- 336.37	979.33 +/- 196.66	38.50 +/- 5.36
III	N=3	38.0 +/- 27.71	21.33 +/- 3.06	348.33 +/-154.37	.06 +/- 0.11	224.0 +/- 4.58	2.60 +/- 0.50	2097.0 +/- 110.73	892.33 +/- 53.67	44.33 +/- 2.08
IV	N=4	73.0 +/- 41.84	19.58 +/- 2.74	311.75 +/- 55.51	0.53 +/- 0.12	240.75 +/- 34.64	2.82 +/- 0.76	2083.75 +/- 419.09	1301.50 +/- 673.77	44.25 +/- 2.63
REFERENCE	N=1	122.0	14.0	150.0	0.18	188.0	2.40	2900.0	1500.0	11.0

TABLE 17. Mean Metal Concentrations in Liver Tissue of Adult Female Muskrats
Kin-Buc Study Area
Edison, NJ
August, 1991

(Concentrations reported in mg/kg)

AREA	Ca	Cu	Fe	Pb	Mg	Mn	K	Na	Zn
I N=2	43.50 +/- 21.92	19.00 +/- 8.49	240.50 +/- 4.95	0.39 +/-0.08	244.50 +/- 40.31	2.91 +/- 0.27	2311.0 +/- 94.75	1020.50 +/- 279.31	41.00 +/- 7.07
II N=4	40.00 +/- 20.31	16.50 +/-1.0	183.50 +/- 37.31	0.31 +/- 0.13	203.50 +/- 10.12	2.76 +/- 0.32	2118.75 +/- 201.28	1092.25 +/- 147.20	37.50 +/- 1.29
III N=3	62.33 +/- 53.16	17.10 +/- 1.85	273.67 +/- 66.79	0.78 +/- 0.20	204.33 +/- 5.13	1.94 +/- 0.16	2225.33 +/- 253.96	1107.67 +/- 135.47	40.67 +/- 1.53
IV N=4	70.75 +/- 39.74	16.18 +/- 0.59	270.50 +/- 65.68	0.56 +/- 0.31	204.75 +/-10.05	2.16 +/- 0.42	1996.75 +/- 285.20	1453.0 +/- 795.96	38.50 +/- 2.08
REFERENCE N-6	90.50 +/- 7.15	7.83 +/- 1.02	140.67 +/- 42.98	0.20 +/- 0.07	133.67 +/- 26.95	1.77 +/- 0.52	3030.83 +/- 314.78	1193.83 +/- 122.51	19.0 +/- 5.18

TABLE 18. Mean Metal Concentrations in Liver Tissue of Adult Male Muskrats
Kin-Buc Study Area
Edison, NJ
August, 1991

(Concentrations reported in mg/kg)

AREA	Ca	Cu	Fe	Pb	Mg	Mn	K	Na	Zn
I N=3	47.00 +/- 25.06	18.33 +/- 2.52	232.67 +/- 79.07	0.45 +/- 0.07	213.33 +/- 20.55	2.53 +/- 0.30	1976.67 +/- 363.47	970.33 +/- 134.14	35.67 +/- 5.13
II N=3	50.33 +/- 20.74	17.36 +/- 2.05	213.33 +/- 40.10	0.41 +/- 0.09	218.0 +/- 22.65	2.74 +/-0.13	1994.33 +/- 218.30	1292.7 +/-240.05	38.00 +/-6.24
III N=3	139.66 +/- 135.12	22.83 +/- 7.29	252.00 +/- 19.97	0.71 +/- 0.04	306.67 +/-112.93	3.37 +/- 1.71	2880.67 +/- 949.91	1636.33 +/- 897.71	54.33 +/- 16.44
IV N=4	80.75 +/- 8.82	17.55 +/- 1.93	218.50 +/- 47.91	0.48 +/- 0.23	275.25 +/- 145.91	2.21 +/- 0.54	2029.50 +/- 273.86	994.75 +/- 262.06	38.0 +/- 4.08
REFERENCE N=4	84.75 +/- 14.73	8.98 +/- 4.09	150.00 +/- 41.63	0.20 +/- 0.04	114.0 +/- 7.35	1.20 +/- 0.14	3435.0 +/- 423.04	1121.50 +/- 204.21	20.23 +/- 4.03

TABLE 19. Mean Metal Concentrations in Liver Tissue of Juvenile Male Muskrats

Kin-Buc Study Area
Edison, NJ
August, 1991

(Concentrations reported in mg/kg)

AREA	Ca	Cu	Fe	Pb	Mg	Mn	K	Na	Zn
I N=6	52.83 +/- 19.68	18.41 +/- 1.05	219.16 +/- 54.86	0.39 +/- 0.11	253.0 +/- 23.38	3.22 +/- 0.34	2086.00 +/- 321.03	1295.50 +/- 482.23	40.16 +/- 2.64
II N=2	123.0 +/- 115.96	17.70 +/- 3.53	184.00 +/- 4.24	0.42 +/- 0.12	242.0 +/- 45.25	3.40 +/- 0.09	1992.0 +/- 31.11	1052.0 +/- 260.21	44.00 +/- 1.41
III N=4	63.75 +/- 76.85	17.75 +/- 3.40	286.25 +/- 74.37	0.60 +/- 0.21	235.25 +/- 80.09	3.02 +/- 0.65	2219.75 +/- 178.26	988.75 +/- 86.47	44.25 +/- 15.13
IV N=4	72.25 +/- 43.15	19.92 +/- 1.18	286.25 +/- 100.97	0.495 +/- 0.23	240.50 +/- 86.10	2.45 +/- 0.36	1918.0 +/- 265.94	1051.25 +/- 274.18	38.50 +/- 3.32
REFERENCE N=4	95.00 +/- 22.00	8.18 +/- 2.35	129.50 +/- 35.54	0.16 +/- 0.05	113.50 +/- 14.66	1.77 +/- 0.17	3197.50 +/- 476.82	1900.0 +/- 968.15	28.25 +/- 5.56

U.S. GEOLOGICAL SURVEY, NEW BRUNSWICK, N.J. QUADRANGLE
U.S. GEOLOGICAL SURVEY, SOUTH AMBOY, N.J. QUADRANGLE
7.5 MINUTE SERIES-PHOTOREVISED 1981

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68-03-3482

FIGURE 1. KIN-BUC STUDY AREA, EDISON, N.J.

SOUTH RIVER REFERENCE AREA, OLD BRIDGE, N.J.

W.A.# 3347-21-01-3409

OCT, DEC 1990; JAN 1991

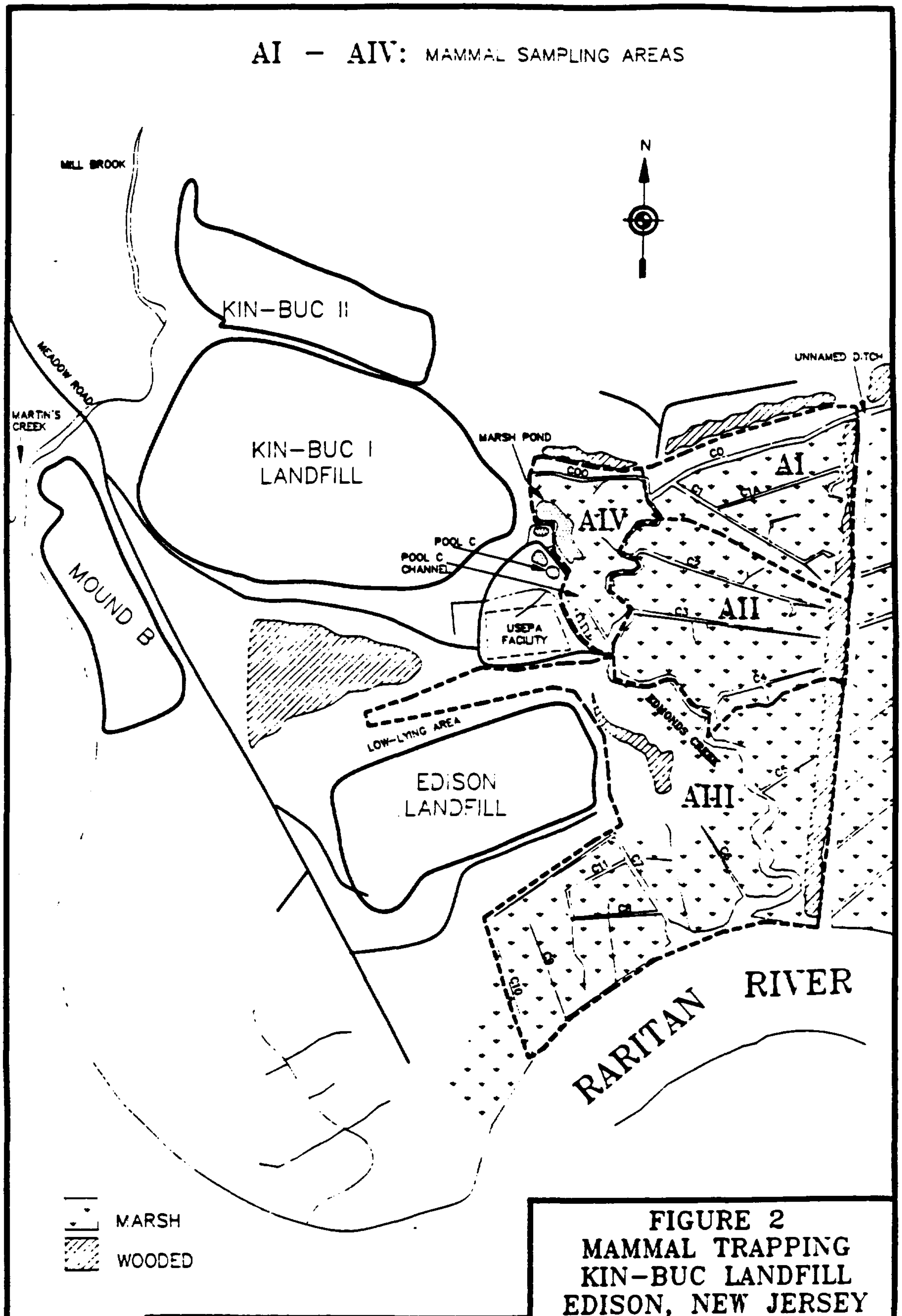
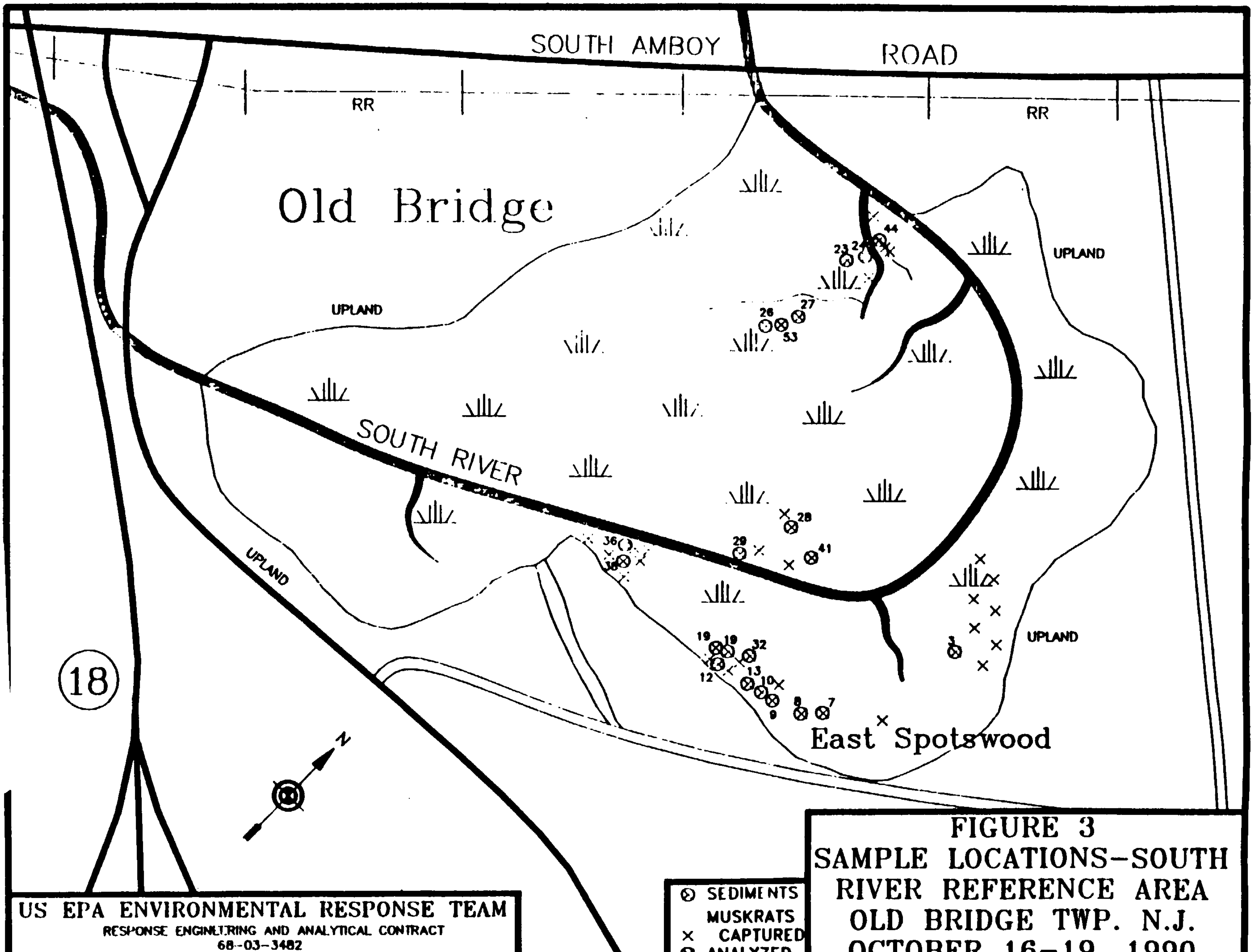


FIGURE 2
MAMMAL TRAPPING
KIN-BUC LANDFILL
EDISON, NEW JERSEY
DECEMBER 17-21, 1990
JANUARY 7-12, 1991

US EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-21-01-3408



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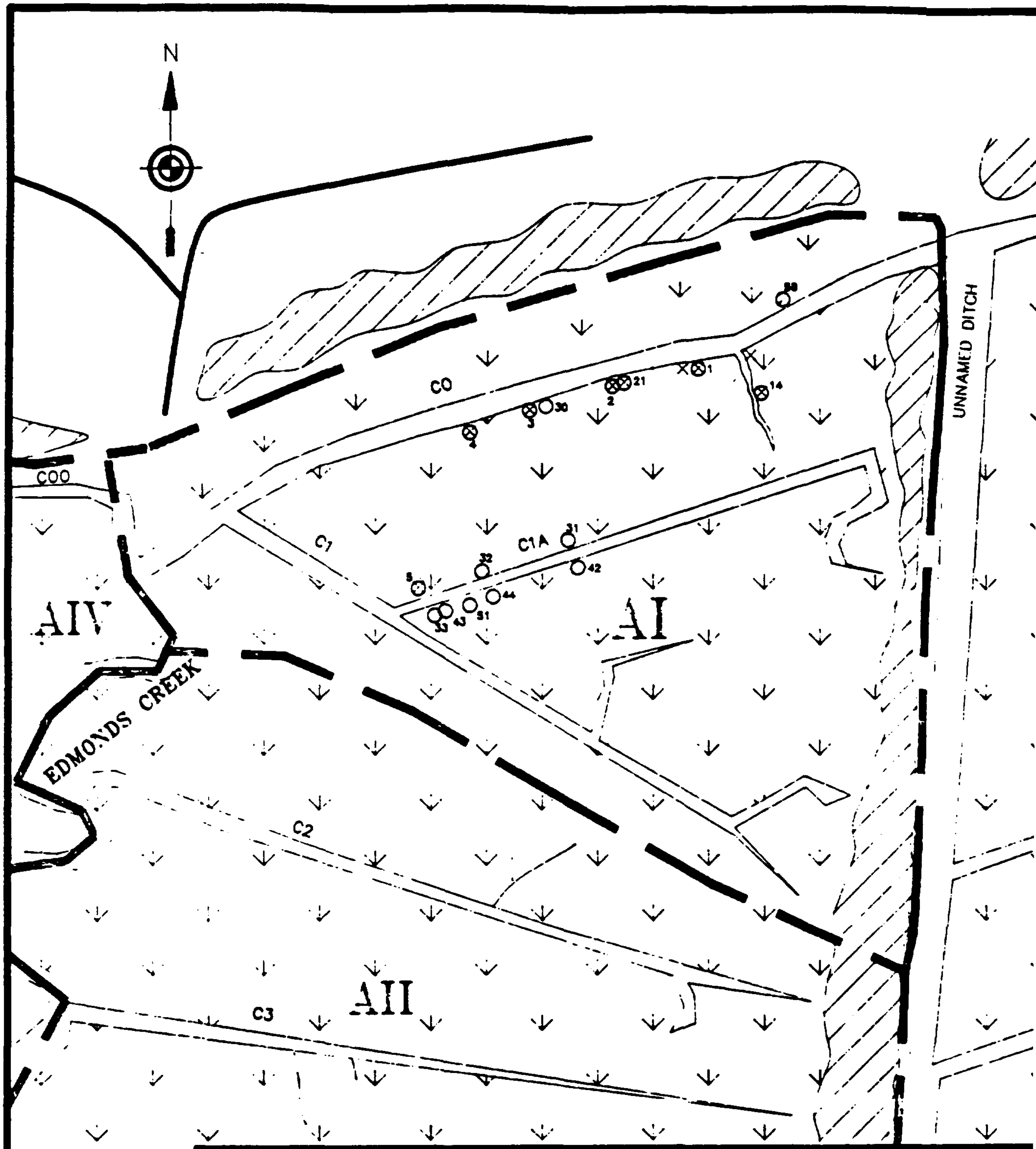
68-03-3482

⊗ SEDIMENTS
MUSKRATS
× CAPTURED
⊗ ANALYZED

FIGURE 3
SAMPLE LOCATIONS–SOUTH RIVER REFERENCE AREA
OLD BRIDGE TWP. N.J.
OCTOBER 16–19, 1990



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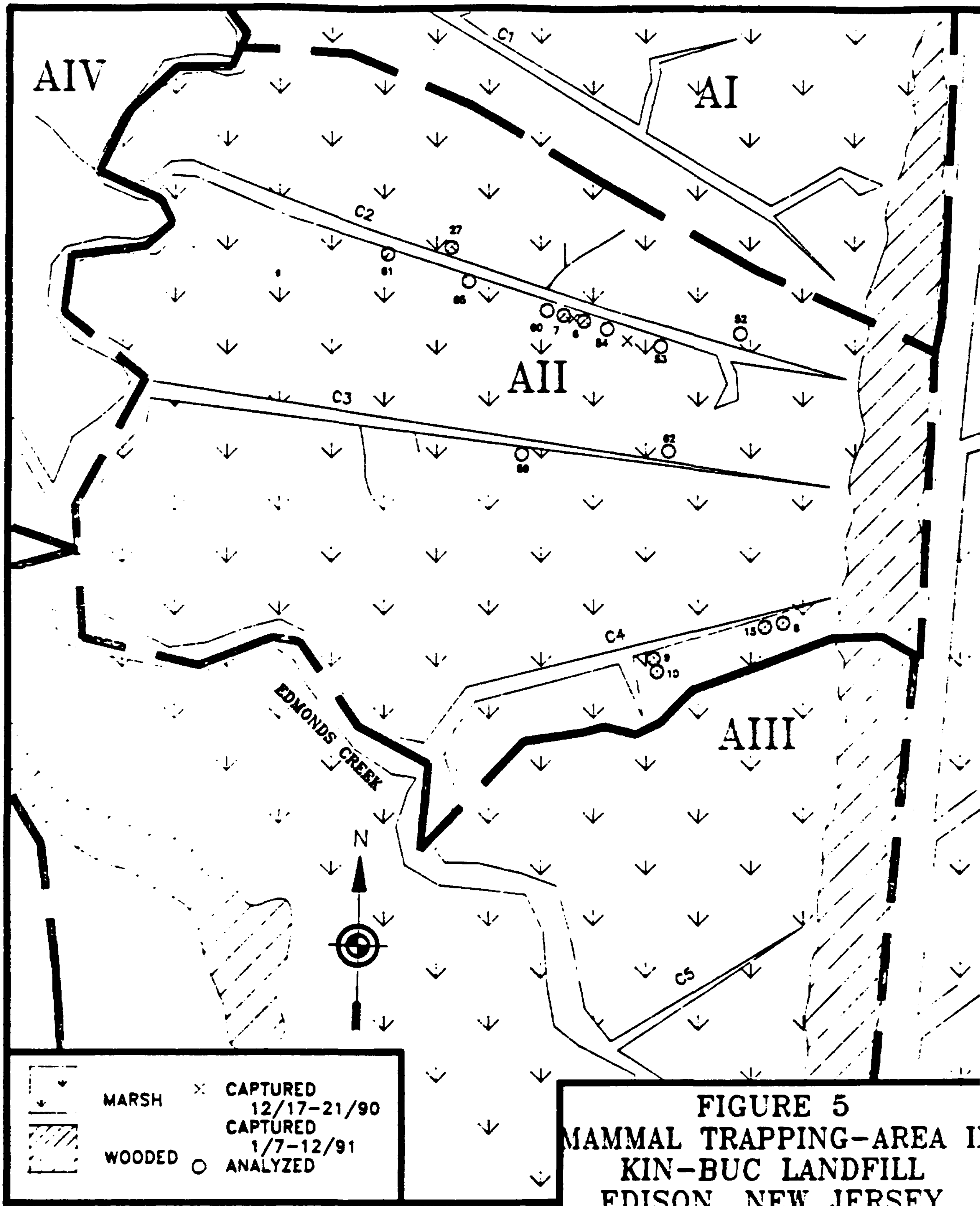
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-21-01-3409

FIGURE 4
MAMMAL TRAPPING–AREA
KIN–BUC LANDFILL
EDISON, NEW JERSEY
DECEMBER 17–21, 1990 &
JANUARY 7–12, 1991



US EPA ENVIRONMENTAL RESPONSE TEAM
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
68-03-3482
W.O.# 3347-21-01-3409

FIGURE 5
MAMMAL TRAPPING-AREA I
KIN-BUC LANDFILL
EDISON, NEW JERSEY
DECEMBER 17-21, 1990
JANUARY 7-12, 1991

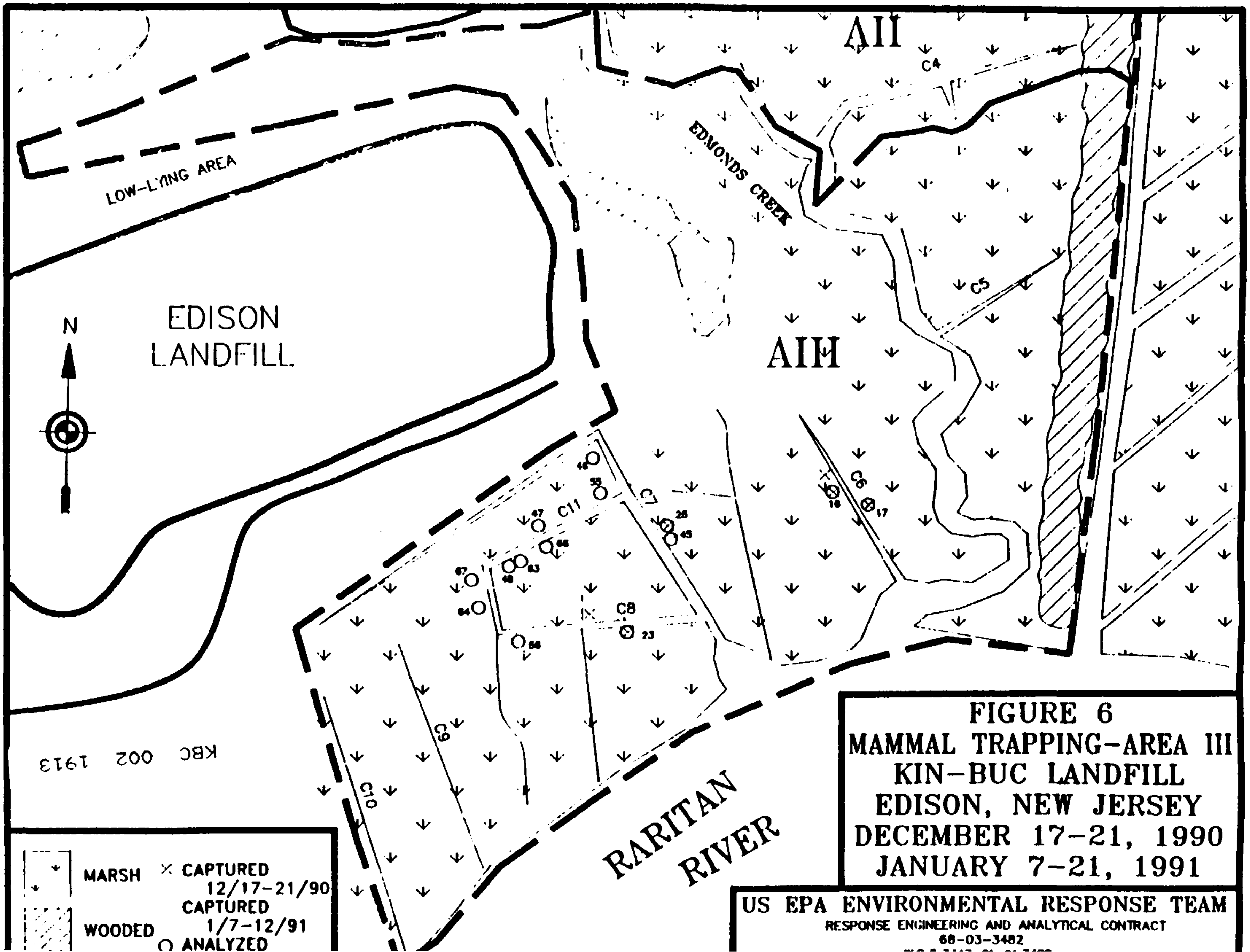


FIGURE 6
MAMMAL TRAPPING-AREA III
KIN-BUC LANDFILL
EDISON, NEW JERSEY
DECEMBER 17-21, 1990
JANUARY 7-21, 1991

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68-03-3482

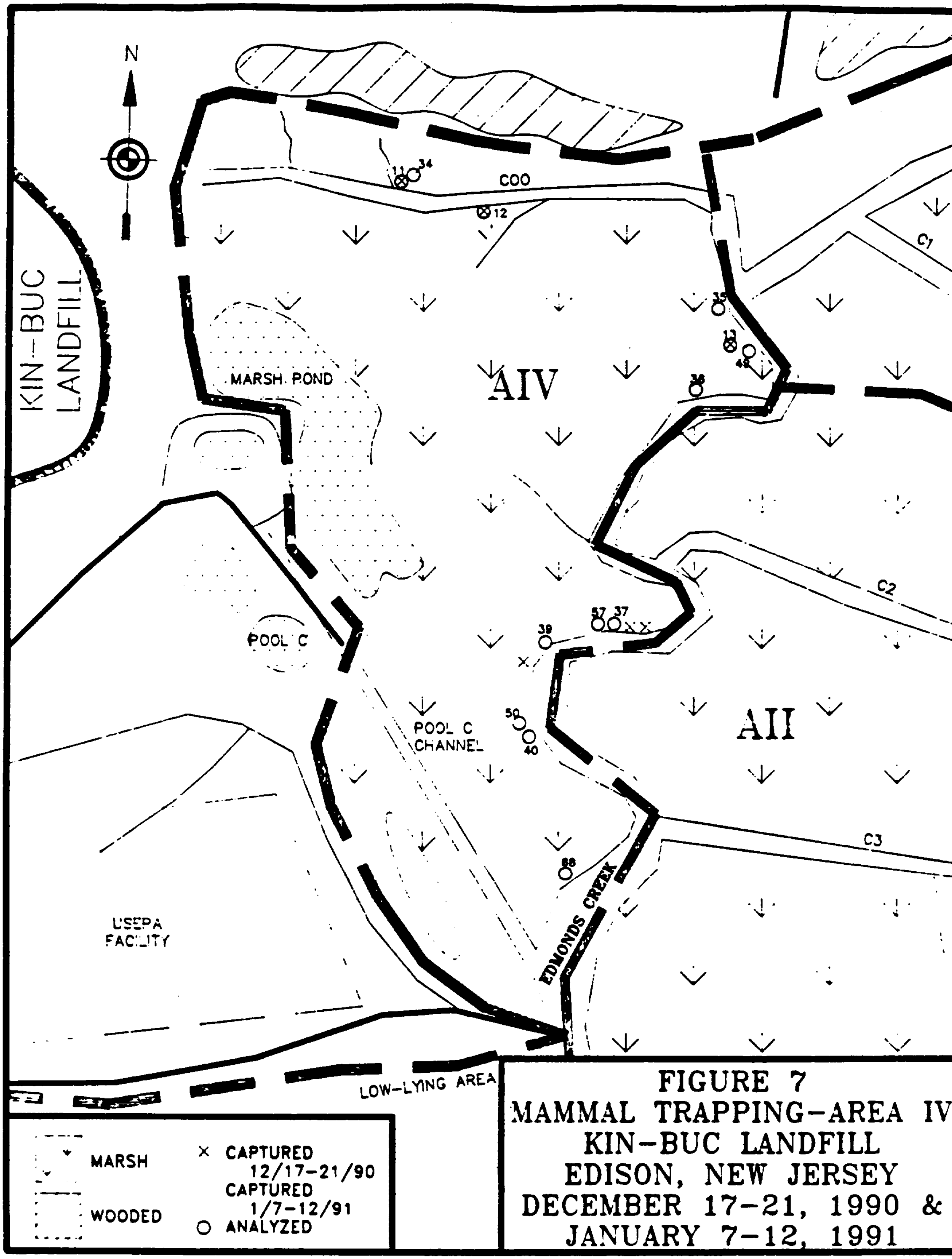

FIGURE 7
MAMMAL TRAPPING-AREA IV
KIN-BUC LANDFILL
EDISON, NEW JERSEY
DECEMBER 17-21, 1990 &
JANUARY 7-12, 1991

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, NEW YORK 10278

FEB 25 1992

EXPRESS MAIL
RETURN RECEIPT REQUESTED

Kevin Burger, C.E.P.
Facility Coordinator
Wehran Engineering Corporation
Andover Research Park
Six Riverside Drive, Suite 101
Andover, Massachusetts 01810-1121

Re: Application of NJDEPE Ground Water Corrective Action Criteria, Kin-Buc Landfill Superfund Site, Edison, New Jersey. Administrative Order No. II-CERCLA-00114 (Order).

Dear Mr. Burger:

The purpose of this letter is to respond to your letter of January 29, 1992, which requested, on behalf of the Respondents to the above-referenced Order, clarification of the applicability of the N.J. Department of Environmental Protection and Energy's (NJDEPE's) ground water corrective action criteria to the Kin Buc Landfill Site. This letter confirms the U.S. Environmental Protection Agency's (EPA's) position on issues related to the use of NJDEPE standards and criteria as expressed in the January 30, 1992 conference call between Wehran and Janet Feldstein and Alison Barry of my staff.

EPA's November 8, 1991 letter transmitted NJDEPE's site-specific ground water corrective action criteria for Kin Buc, as well as the existing and proposed New Jersey Safe Drinking Water Act (NJSDWA) Maximum Contaminant Levels (MCLs), and the New Jersey Water Pollution Control Act (NJWPCA) primary standards for ground water classes GW-1 and GW-2. NJDEPE stated, in its December 13, 1991 letter to EPA, that the site-specific ground water corrective action criteria are clean-up requirements for the Operable Unit 2 remedial action. Because these numbers are criteria, not promulgated standards, EPA views them as To Be Considered (TBC) requirements rather than applicable or relevant and appropriate requirements (ARARs). Therefore, although they are not ARARs, these criteria should be considered as cleanup goals for the OU 2 remedial action.

NJDEPE developed these criteria for volatile organics based on available toxicological information and decided to limit the total concentrations of volatile organic compounds to a conservative level (50 ug/l) which is designed to avoid any potential synergistic health effects due to combinations of these compounds. This approach has been used consistently for both federal and state-lead site remediations in New Jersey. Recently, NJDEPE has issued proposed ground water cleanup standards which include many of these compounds. These proposed standards, if they are promulgated prior to the Operable Unit 2 Record of Decision (ROD), will be considered ARARs for the Kin-Buc Operable Unit 2 remedial action, and will supersede the site-specific criteria transmitted in EPA's November 8, 1991 letter. EPA believes that these standards may become final before the ROD is signed. Therefore, it is appropriate to consider them as remedial objectives for the Operable Unit 2 cleanup. A copy of the proposed regulations, N.J.A.C. 7:26D, Subchapter 4, is attached.

Numerical standards such as MCLs promulgated by the State of New Jersey are considered ARARs, because they are legally enforceable requirements which are consistently applied to site remediations, including Superfund actions, in New Jersey. NJSDWA MCLs supersede the corresponding federal standards when they are more conservative than SDWA MCLs developed by EPA. The New Jersey standards may also be lower than EPA's PQLs, as cited in Table 2 of your letter. EPA has developed analytical methods for drinking water capable of detection limits lower than the PQLs. In addition, the NJDEPE laboratory certification program requires analytical work to achieve lower detection limits than EPA's Contract Laboratory Program (CLP). Therefore, there is no technical inconsistency between EPA's PQLs and the New Jersey MCLs.

When a site-specific risk assessment has determined that risks associated with the site exceed the 10-4 through 10-6 risk range, EPA is required to take an action to reduce the risk to acceptable levels. Implementing a remedial action at a site triggers the statutory requirement to meet all ARARs. Because the OU 1 remedy calls for containment of the landfill, EPA and NJDEPE have determined that ground water cleanup standards do not apply within the slurry wall, which is considered to be the boundary of the waste management unit. However, the OU 2 risk assessment identified unacceptable risks associated with ingestion of ground water from the sand and gravel aquifer, warranting remediation of ground water in OU 2. Numerical standards, such as federal and state MCLs and NJDEPE ground water cleanup standards, are ARAR for ground water in all three hydrostratigraphic units at the site because they are hydrologically connected units. However, as we discussed, a system designed to achieve compliance with ARARs in all three units is not required to actively pump and treat all three. During the Feasibility Study, the description and evaluation of ground water alternatives should discuss several possible approaches to achieving compliance.

Because the Feasibility Study has not been completed, and EPA has not selected a remedy for OU 2, it is not possible to assess the appropriateness of any potential ARARs waivers or alternate concentration limits (ACLs) at Kin Buc. All alternatives discussed in the Feasibility Study must be evaluated in terms of their ability to satisfy EPA's nine criteria, as described in the National Contingency Plan, which include the ability to meet ARARs. When EPA has selected a remedy, based on the RI/FS, EPA will determine the need, if any, to waive the ground water cleanup standards (if they have been promulgated) or NJSDWA MCLs and develop ACLs for the contaminant plume.

Lastly, with respect to the issue of the Edison Landfill's potential impact on achieving compliance with ground water cleanup goals, EPA reiterates its position that this issue should be evaluated in the Feasibility Study on the basis of information collected during the Remedial Investigation. As we discussed during our February 7, 1992 meeting, the Feasibility Study should not screen out active ground water alternatives in the preliminary analysis, but should address their implementability in the detailed analysis. EPA, in coordination with NJDEPE, will select an appropriate remedy based on the remedial alternatives presented in the Feasibility Study and all available information relevant to these alternatives.

If you have any additional questions regarding these matters, please do not hesitate to call Alison Barry, of my staff, at (212) 264-8678.

Sincerely yours,

Raymond Basso

Raymond Basso, Chief
New Jersey Superfund Branch II

Attachment

cc: Ralph Sundstrom, Kin Buc, Inc.
Richard Karr, Waste Management NA
Bob Miller, Wehran
Ian Curtis, NJDEPE
Jeanne Litwin, CDM FPC

SUBCHAPTER 4. GROUND WATER CLEANUP STANDARDS

7:26D-4.1 Scope

This subchapter constitutes the Department's ground water cleanup standards, except when more stringent cleanup standards are developed pursuant to N.J.A.C. 7:26D-5.

7:26D-4.2 Identification of ground water cleanup standards

(a) In addition the the ground water cleanup standards identified in (c) below, this section identifies the ground water cleanup standards for all areas where contaminated ground water has migrated, or has the potential to migrate, to a receptor.

1. When the contaminant in the ground water has the potential to affect more than one receptor, the ground water cleanup standard for a contmainant shall be the most stringent of all applicable ground water cleanup standards developed pusuant to this subchapter.

2. The ground water cleanup standard for a contaminant in ground water which is, or has the potential of, discharging to FW1, PL or Category 1 surface water, the ground water cleanup standard shall be the natural background ground water concentration of that contaminant.

3. The ground water cleanup standard for a contaminant in ground water which has migrated, or has the potential to migrate, to an ecosystem, such as a wetlands or critical habitat, will be developed by the Department on a site-specific basis utilizing site-specific data which may include, without limitation, bioassays and biota studies.

4. The ground water cleanup standard for a contaminant in ground water which creates an explosive hazard or human health-based risk due to vapors reaching any structure, will be developed by the Department on a site-specific basis utilizing site-specific data which may include, without limitation, air monitoring.

5. The ground water cleanup standard for a contaminant in ground water which has migrated, or has the potential to migrate to a commercial, agricultural or industrial non-potable well will be developed by the Department on a site-specific basis considering the uses of the well.

6. The ground water cleanup standard for any contaminant either within Class I ground water or which is in any ground water which is, or has the potential of, migrating to Class I ground water, shall be as follows:

i. For Class IA and I-Pinelands (Preservation Area) ground water, the ground water cleanup standard for a contaminant shall be the natural ground water concentration of that contaminant; and

ii. For Class I-Pinelands (Protection Area) ground water, the ground water cleanup standard for a contaminant shall be the background ground water concentration of that contaminant.

7. The ground water cleanup standard for any contaminant in a Class IIA ground water, is the cleanup standard in Table 4-1.

8. The cleanup standard, for each contaminant which has migrated, or has the potential to migrate a Class IIA ground water, but does not have a ground water cleanup standard in Table 4-1, shall be as follows:

i. The cleanup standard developed pursuant to N.J.A.C. 7:26D-6 for a contaminant for which the Department determines that appropriate toxicological data exist in the sources listed in 7:26D-6.5; or

ii. For a contaminant for which the Department determines that appropriate toxicological data do not exist in the sources listed in 7:26D-6.5:

(1) 5 ppb for any organic contaminant for which the Department determines there is sufficient evidence of carcinogenicity, with a total of such potentially carcinogenic contaminants not to exceed 25 ppb;

(2) 100 ppb for any organic contaminant for which the Department determines that no evidence of carcinogenicity exists, with a total of all such potentially non-carcinogenic contaminants not to exceed 500 ppb;

(3) Background ground water concentration for an inorganic contaminant; or

(4) For a contaminant which is the driving force behind a Department remedial decision, the Department may develop a cleanup standard pursuant to N.J.A.C. 7:26D-6.

(b) In addition to the ground water cleanup standards identified in (c) below, the ground water cleanup standard for contaminants in all areas that do not have a ground water cleanup standard developed pursuant to (a) above shall be as follows:

1. The ground water cleanup standard for an individual organic contaminant is 1 ppm;

2. The ground water cleanup standard for the total of all organic contaminants is 10 ppm; and

3. The ground water cleanup standard for an inorganic contaminant, is the background ground water concentration for that contaminant.

(c) The following narrative cleanup standards, in addition to the ground water cleanup standards in (a) and (b) above, apply to all contaminated sites:

1. Removal of free product and residual product that is capable of becoming free product;

2. Removal and/or control of all sources of ground water conamination; and

3. Implementation of one or more of the following source or receptor controls when imminent risks to human or an ecological receptor are identified:

i. Control of all or a portion of a contaminant plume to minimize, mitigate or eliminate the further movement of the contaminant plume toward human or ecological receptors;

ii. Provision of alternate water supplies or treatment of existing supplies within all areas where potable wells have been or have potential to become contaminated above the cleanup standards in Table 4-1; and

iii. Venting of vapors from subsurface or surface structures.

(d) Any person may initiate the process, pursuant to N.J.A.C. 7:26D-7, for an alternate ground water cleanup standard or for a deferral of a ground water cleanup standard.

7:26D-4.3 Natural remediation compliance program

(a) The person responsible for conducting a cleanup may request that the Department approve a compliance program which relies on the degradation and natural attenuation of contaminants by submitting to the Department the following:

1. Sufficient evidence to support a Department determination that:

i. All sources of contamination and free product have been controlled pursuant to N.J.A.C. 7:2CD-4.2(c);

ii. The contaminants present exist in concentrations that do not currently and are not expected to migrate to any potential human or ecological receptor above applicable standards;

2. Written documentation regarding the contaminant's degradabililty and/or attentuation capacity;

3. Identification and discussion of site-specific characteristics which indicate that conditions are favorable for degradation and/or natural attenuation;

4. A proposed ground water monitoring program which shall include:

i. The collection of ground water quality data from monitoring wells to evaluate the adequacy of source control and to track contaminant concentrations over time;

ii. The collection of ground water quality data from monitoring wells which track the degradation and attenuation of contaminants within and downgradiant of the contaminant plume; and

iii. A sentinel well system, pursuant to N.J.A.C. 7:26D-4.5, designed to detect contamination in ground water prior to reaching any potential human or ecological receptor, and which is located between the contaminated plume and the human or ecological receptor at least 1 year's time of travel upgradient of the receptor.

5. Written documentation, utilizing municipal and water purveyor planning data, of current and potential ground water uses based on a 25-year planning horizon;

6. Copies of written notices provided to all property owners and occupants of property under which the contaminated ground water is expected to migrate stating that fact; and

7. Evidence that all necessary access agreements needed to monitor ground water quality pursuant to 4 above, have been or can be obtained.

(b) If at any time the Department determines that a contaminant being monitored under a natural remediation compliance program has the potential to migrate to a human or ecological receptor above applicable ground water cleanup standards, or if contaminant concentrations are not decreasing, the person responsible for conducting the remediation shall implement an active ground water remediation program.

(c) The Department may approve the use of a natural remediation compliance program for an entire, or any portion of, a contaminant plume.

(d) The Department may require the use of institutional controls pursuant to 7:26D-8 as a condition to the approval of a natural remediation compliance program when necessary to protect current or future ground water uses.

7:26D-4.4 Achievement of steady state conditions under an active remediation program

(a) If the Department determines that steady state conditions have developed prior to reaching applicable site-specific cleanup standards identified pursuant to 7:26D-4.2, the person responsible for conducting the remediation shall meet one or more of the following narrative cleanup standards as the Department directs:

1. Implementation of additional remedial actions, if innovative technologies or alternate pumping scenarios are available, which would enhance ground water quality beyond the steady state;

2. Control of the contaminated ground water if the contaminated ground water has the potential to migrate to a human or ecological receptor above applicable ground water cleanup standards; or

3. Implementation of a natural remediation compliance program.

7:26D-4.5 Sentinel well system

(a) A sentinel well system shall:

1. Be designed to serve as an early warning system tracking the migration of contaminants toward a human or ecological receptor;

2. Be located at a distance no closer than 1 year time of travel to the nearest human or ecological receptor, and no greater than the distance the ground water at the contaminated site could travel in 5 years; and

3. Include periodic monitoring for at least 5 years.

(b) If contaminants are detected above the applicable ground water cleanup standard in the sentinel well system, the person responsible for conducting the remediation shall resample the wells, to confirm the results, within 4 weeks after receipt of verbal results from the laboratory, or within 2 weeks after receipt of written results from the laboratory, whichever is earlier.

(c) If during the monitoring period, contaminant concentrations above the applicable ground water cleanu standard associated with the contaminated site are confirmed i any sentinel well, additional remedial action may be required as determined by the Department.

7:26D-4.6. Determining compliance with ground water cleanup standards

(a) Compliance with the applicable ground water cleanup standards shall be determined based on a statistical analysis which is consistent with statistical analysis requirements of N.J.A.C. 7:14A-6.15, 40 CFR Part 264.97, and associated EPA guidance documents.

(b) Compliance with the applicable ground water cleanup standard identified pursuant to 7:26D-4.2 shall be determined as follows:

1. For two consecutive sampling rounds, separated by at least 90 days, but no more than 120 days, the concentration in ground water of each contaminant shall be less than or equal to the applicable ground water cleanup standard for that contaminant in all monitoring wells in the monitoring program;

2. Upon submission of data that demonstrate the requirement in (b)1 above, and upon receipt of written approval of the Department, the person responsible for conducting the remediation may cease the active remediation and shall implement a Department-approved, post-remediation statistical analysis to demonstrate that applicable ground water cleanup standards are not exceeded by a statistically significant amount;

i. This analysis may consider individual wells or all monitoring wells as a group in the post-remediation program; and

ii. The monitoring program and statistical analysis shall be performed for 12 consecutive quarters (three years), unless the Department approves in writing a shorter timeframe; and

3. If concentrations of a contaminant in ground water are less than or equal to the applicable cleanup standard for all 12 consecutive quarters, statistical analysis of the data is not required and the site will be considered to be in compliance with this subchapter.

(c) Ground water samples used to determine compliance with the applicable ground water cleanup standards shall be collected consistent with accepted remedial investigation requirements or as approved by the Department.

(d) Compliance with a natural remediation compliance program approved pursuant to 7:26D-4.3 is determined as follows:

1. Upon submission of 20 consecutive quarters (5 years) worth of ground water quality data and statistical analyses of that data, the person responsible for conducting the cleanup can demonstrate that:

i. Contaminant concentrations have not been increasing in site-wide monitoring wells selected for the monitoring program; and

ii. Contaminant concentrations have been steadily decreasing in source control monitoring wells; and

2. Upon completion of the monitoring program established for a sentinel well system, if required, no contamination above the applicable ground water cleanup standards is discovered in the sentinel well system.

(e) If the Department determines, based on ground water data developed pursuant to (a), (b) and (c) above, that contamination is not detected in any sentinel well during the required monitoring period, the ground water at the contaminated site is in compliance with this subchapter.

SUBCHAPTER 5. ECOLOGY-BASED CLEANUP STANDARDS

7:26D-5.1 Scope

This subchapter constitutes the Department's ecology-based cleanup standards.

7:26D-5.2 Basis and objectives of ecology-based cleanup standards

(a) The objective of developing ecology-based cleanup standards is to prevent direct and indirect toxicity effects on ecological receptors.

(b) The Department will use site-specific baseline ecological evaluation to determine if an ecological risk assessment is necessary, and will use ecological risk assessments to both identify potential risks to ecological receptors and to develop appropriate cleanup standards based on those risks.

7:26D-5.3 Baseline Ecological Evaluation

(a) The person responsible for conducting the remediation of a contaminated site shall, as part of the site investigation, conduct a baseline ecological evaluation pursuant to (b) below.

(b) A baseline ecological evaluation shall:

1. Identify the contaminants at the site that are of particular concern from an ecological perspective;

2. Identify whether or not sensitive ecological receptors are present or may have been (or should have been) present in the vicinity of the contamianted site, which shall include without limitation those identified pursuant to (c) below.

3. Identify potential exposure pathways to sensitive ecological receptors which exist or may have existed; and

4. Determine whether or not sensitive ecological receptors are being adversely impacted or potentially adversely impacted by the contamination.

(c) Sensitive ecological receptors include, without limitation:

1. Pinelands and other sensitive ecosystems as defined in the Pinelands Comprehension Management Plan regulations, N.J.A.C. 7:50;

2. Surface waters;

TABLE 4-1
GROUND WATER CLEANUP STANDARDS (mg/L)
FOR CLASS II-A GROUNDWATERS

Contaminant	CASRN	STANDARD
Acenaphthene	83-32-9	0.4
Acetone	67-64-1	0.7
Acrylamide	79-06-1	0.000008
Acrylonitrile	107-13-1	0.02
Alachlor	15972-60-8	0.002
Aldrin	309-00-2	0.00004
Anthracene	120-12-7	2.0
Antimony	7440-36-0	0.02
Arsenic (Total)	7440-38-2	0.008
Asbestos	1332-21-4	30,000 (a)
Atrazine	1912-24-9	0.003
Barium	7440-39-3	2.0
Benzene	71-43-2	0.001
Benzidine	92-87-5	0.05
Benz (a) anthracene	56-55-3	0.01
Benzyl Alcohol	100-51-6	2.0
Benzo (a) pyrene (BaP)	50-32-8	0.02
Benzo (b) fluoranthene	205-99-2	0.01
Benzo (k) fluoranthene	207-08-9	0.02
Beryllium	7440-41-7	0.02
alpha-BHC (alpha-HCH)	319-84-6	0.00002
beta-BHC (beta-HCH)	319-85-7	0.0002
gamma-BHC (gamma-HCH/Lindane)	58-89-9	0.0002
Bis(2-chloroethyl) ether	111-44-4	0.01
Bis(2-chloroisopropyl) ether	39638-32-9	0.3
Bis(2-ethylhexyl) phthalate	117-81-7	0.03
Bromoform	75-25-2	0.004
2-Butanone (MEK)	78-93-3	0.3
Butylbenzyl phthalates	85-68-7	0.1
Cadmium	7440-43-9	0.004
Carbofuran	1563-66-2	0.04
Carbon tetrachloride	56-23-5	0.002
Chlordane	57-74-9	0.0005
Chlorobenzene	108-90-7	0.005
Chloroform	67-66-3	0.006
Chloropyrifos	2921-88-2	0.02
2-Chlorophenol	95-57-2	0.04

Chromium (Total)	7440-47-3	0.1
Chrysene	218-01-9	0.02
Cyanide	57-12-5	0.2
2,4-D	94-75-7	0.07
4,4'-DDD (p,p'-TDE)	72-54-8	0.0001
4,4'-DDE	72-55-9	0.0001
4,4'-DDT	50-29-3	0.0001
Dibromochloromethane (Chlorodibromomethane)	124-48-1	0.01
Demeton	8065-48-3	0.0003
Di-n-butyl phthalate	84-74-2	0.9
Di-n-octyl phthalate	117-84-0	0.1
Di-n-propylnitrosamine	621-64-7	0.02
Dibenz (a,h) anthracene	53-70-3	0.02
1,2-Dichlorobenzene	95-50-1	0.6
1,3-Dichlorobenzene	541-73-1	0.6
1,4-Dichlorobenzene	106-46-7	0.07
3,3'-Dichlorobenzidine	91-94-1	0.06
Dichlorobromomethane	75-27-4	0.001
Dichloroethyl ether	111-44-4	0.01
1,1-Dichloroethane	75-34-3	0.07
1,2-Dichloroethane	107-06-2	0.002
1,1-Dichloroethylene	75-35-4	0.002
1,2-Dichloroethylene (cis)	156-59-2	0.01
1,2-Dichloroethylene (trans)	156-60-5	0.1
2,4-Dichlorophenol	120-83-2	0.02
1,2-Dichloropropane	78-87-5	0.001
2,2-Dichloropropionic acid (Dalapon)	75-99-0	0.2
Dieldrin	60-57-1	0.00003
Diethyl phthalate	84-66-2	5.0
2,4-Dimethyl phenol	105-67-9	0.1
Dimethyl phthalate	131-11-3	7.0
2,4-Dinitrophenol	51-28-5	0.04
2,4-Dinitrotoluene	121-14-2	0.01
2,6-Dinitrotoluene	606-20-2	0.01
Dinoseb	88-85-7	0.007
1,2-Diphenylhydrazine	122-66-7	0.00004
Diquat	85-00-7	0.02
Endosulfan	115-29-7	0.0004
alpha-Endosulfan (Endosulfan I)	959-98-8	0.0004
beta-Endosulfan (Endosulfan II)	33213-65-9	0.0004

Endosulfan sulfate	1031-07-8	0.0004
Endothall	145-73-3	0.1
Endrin	72-20-8	0.002
Epichlorohydrin	106-89-8	0.004
Ethylbenzene	100-41-4	0.7
Ethylene dibromide	106-93-4	0.00005
Fluoranthene	206-44-0	0.3
Fluorene	86-73-7	0.3
Heptachlor	76-44-8	0.0004
Heptachlor epoxide	1024-57-3	0.0002
Hexachloro-1,3-butadiene	87-68-3	0.001
Hexachlorobenzene	118-74-1	0.01
Hexachlorocyclopentadiene	77-47-4	0.05
Hexachloroethane	67-72-1	0.01
Hydrogen sulfide	7783-06-4	0.02
Indeno (1,2,3-cd) pyrene	193-39-5	0.02
Isophorone	78-59-1	0.1
Lead (Total)	7439-92-1	0.01
Lindane	58-89-9	0.0002
Malathion	121-75-5	0.2
Mercury (Total)	7439-97-6	0.002
Methoxychlor	72-43-5	0.04
Methyl bromide (bromomethane)	74-83-9	0.01
Methyl chloride (chloromethane)	74-87-3	0.03
4-Methyl-2-pentanone (MIBK)	108-10-1	0.4
Methylene chloride	75-09-2	0.003
Mirex	2385-85-5	0.00001
Naphtalene	91-20-3	0.03
Nickel (Soluble salts)	7440-02-0	0.1
Nitrobenzene	98-95-3	0.01
N-Nitrosodiphenylamine	86-30-6	0.02
N-Nitrosodimethylamine	62-75-9	0.02
N-Nitrosodi-n-propylamine	621-64-7	0.02
Oxamyl	23135-22-0	0.2
PCBs (Polychlorinated biphenyls)	1336-36-3	0.0005
Pentachlorophenol	87-86-5	0.001
Phenol	103-95-2	4.0
Pyrene	129-00-0	0.2
Selenium (Total)	7782-49-2	0.05
Silver	7440-22-4	0.02
Styrene	100-42-5	0.1
TCDD (2,3,7,8-Tetrachlorodibenzo-p-dioxin)	1746-01-6	0.00001

1,1,2,2-Tetrachloroethane 1,1,1,2-Tetrachloroethane Tetrachloroethylene Thallium	79-34-5 630-20-6 127-18-4 7440-28-0	0.002 0.01 0.001 0.01
Toluene Toxaphene 2,4,5-TP (Silvex) 1,2,4-Trichlorobenzene Trichloroethene	108-88-3 8001-35-2 93-72-1 120-82-1 79-01-6	1.0 0.003 0.05 0.009 0.001
1,1,1-Trichloroethane 1,1,2-Trichloroethane 2,4,5-Trichlorophenol 2,4,6-Trichlorophenol	71-53-6 79-00-5 95-95-4 88-06-2	0.03 0.003 0.7 0.02
Vinyl chloride Xylenes (Total) Zinc	75-01-4 1330-29-7 7440-6606	0.002 0.04 5.0

(a) Asbestos units are fibers, greater than 10 microns in length, per liter.

DRAFT FINAL RISK ASSESSMENT
PART I - HUMAN HEALTH ASSESSMENT
PART II - ENVIRONMENTAL ASSESSMENT

KIN BUC LANDFILL OPERABLE UNIT II
EDISON, NEW JERSEY

CDM FEDERAL PROGRAMS CORPORATION

5.0 HUMAN HEALTH RISK CHARACTERIZATION

The objective of this risk characterization is to integrate information from the human exposure evaluation (Section 3.0) and the toxicity evaluation (Section 4.0) in order to evaluate present and future human health impacts associated with the Kin-Buc Landfill site - Operable Unit 2. Carcinogenic risk is estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. Carcinogenic risk is generally expressed in scientific notation. An individual lifetime risk of one in 10,000 is represented as 1×10^{-4} or 1E-04.

Impacts of noncarcinogenic chemicals on human health are evaluated by comparing projected or estimated intakes with reference levels for the chemicals of concern. A reference level represents an estimated exposure level at which there is not expected to be an appreciable risk of deleterious effects. Noncarcinogenic reference levels used in risk assessment are referred to as reference doses (RfD) or reference concentration (RfC). The impact of carcinogenic chemicals is assessed by comparing predicted risks with target risks for known or suspected carcinogens. Target risks for carcinogens are referred to as slope factors.

Noncarcinogenic Effects

Versar evaluated the potential noncarcinogenic effects due to exposures to the contaminants of concern for all applicable exposure routes. Any potential health effects are identified by computing hazard indices derived from chronic daily intake levels. The hazard index is computed as follows:

$$\text{Hazard Index} = \frac{CDI_1}{RfD_1} + \frac{CDI_2}{RfD_2} \ldots + \frac{CDI_n}{RfD_n}$$

for oral exposure routes, and,

$$\text{Hazard Index} = \frac{CDI_1}{RfC_1} + \frac{CDI_2}{RfC_2} \ldots + \frac{CDI_n}{RfC_n}$$

for inhalation exposures.

The assumption that the combined effects of the chemicals will be additive may not be accurate. Actual effects may be multiplicative or may not be related at all. However, it is generally agreed that if the hazard index is less than one, deleterious health effects are unlikely. If the hazard index is greater than one, then the individual effects of each chemical should be considered to determine the likelihood of ill effects.

Hazard indices for ground-water exposure scenarios for adults and children are presented in Table 5-1a and 5-1b. Exposures during showering/bathing, such as vapor inhalation and dermal absorption, have hazard indices less than 1. Hazard indices for ground-water ingestion for both adults and children exceed 1, with values of 5.37 and 6.01, respectively. The compounds or chemicals that contribute the greatest to the hazard indices are antimony, at 2.53 for adults and 2.83 for children, and manganese, at 1.18 for adults and 1.32 for children. These two metals contribute approximately 70 percent of the hazard indices for ground-water ingestion for both adults and children. Exposures to arsenic, barium, vanadium, and chlorobenzene contribute an additional 24 percent to the hazard indices for adults and children.

Surface water hazard indices for adults and children are presented in Tables 5-2a and 5-2b. For adults, the highest hazard index occurs from ingestion of contaminated fish caught in surface water on or adjacent to the site. The hazard index of 1.66 is due mostly to the hazard quotient for 4,4'-DDT (1.47) which is responsible for approximately 88 percent of the hazard index. The remaining hazard indices for adult exposures to surface water are less than one. For children, the highest hazard index also occurs for fish ingestion (4.66). 4,4'-DDT, which has a hazard quotient of 4.11 is responsible for approximately 88 percent of the hazard index.

Sediment exposure hazard indices, which are shown in Table 5-3a and 5-3b, are all less then one. Approximately 89 percent of the hazard indices is from arsenic, bis(2-ethylhexyl)phthalate, and antimony.

Carcinogenic Effects

For potential carcinogens, risks are estimated by the probability of increased cancer incidence. A carcinogenic slope factor (SF) represents the upper 95-percent confidence limit of the probability of response per unit intake of the contaminant over a lifetime, and converts estimated intakes directly to incremental risk (EPA, 1989a).

The carcinogenic risks via exposure pathways for the Kin-Buc Landfill - Operable Unit 2 were calculated as:

Risk = CDI x SF

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Where

CDI = chronic daily intakes (mg/kg-day)
SF = carcinogenic slope factor 1/(mg/kg-day)

21-Jan-92

TABLE 5-1a
GROUND-WATER HAZARD INDICES
ADULTS

CHEMICAL	GW Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)	GW Inhalation CDI (mg/kg-day)	Inhalation RfC (mg/kg-day)	Hazard Index (Intake/RfC)	GW Dermal Abs. CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)
Benzene (C)	8.72E-04	NA	NA	3.99E-05	NA	NA	6.49E-06	NA	NA
Carbon Disulfide (NC)	2.42E-04	1.00E-01	2.42E-03	2.43E-05	3.00E-03	8.11E-03	2.42E-05	1.00E-01	2.42E-04
Chlorobenzene (NC)	5.66E-03	2.00E-02	2.83E-01	1.71E-04	6.00E-03	2.86E-02	8.62E-06	2.00E-02	4.31E-04
1,2-Dichloroethene (NC)	8.26E-04	9.00E-03	9.17E-02	4.75E-05	NA	NA	1.26E-06	9.00E-03	1.40E-04
Vinyl Chloride (C)	1.47E-04	NA	NA	1.83E-05	NA	NA	2.24E-07	NA	NA
Xylene (NC)	1.56E-03	2.00E+00	7.81E-04	9.02E-05	9.00E-02	1.00E-03	2.38E-06	2.00E+00	1.19E-06
Naphthalene (NC)	3.23E-04	4.00E-03	8.07E-02	NA	NA	NA	4.92E-07	4.00E-03	1.23E-04
bis(2-Ethylhexyl)phthalate (NC)	5.11E-04	2.00E-02	2.56E-02	NA	NA	NA	7.80E-07	2.00E-02	3.90E-05
bis(2-Ethylhexyl)phthalate (C)	2.19E-04	NA	NA	NA	NA	NA	3.34E-07	NA	NA
PCBs (C)	2.45E-05	NA	NA	NA	NA	NA	3.73E-08	NA	NA
4,4'-DDT (NC)	NA	5.00E-04	NA	NA	NA	NA	NA	5.00E-04	NA
4,4'-DDT (C)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony (NC)	1.01E-03	4.00E-04	2.53E+00	NA	NA	NA	1.54E-06	4.00E-04	3.86E-03
Arsenic (NC)	4.86E-04	1.00E-03	4.86E-01	NA	NA	NA	7.41E-07	1.00E-03	7.41E-04
Arsenic (C)	2.08E-04	NA	NA	NA	NA	NA	3.17E-07	NA	NA
Barium (NC)	2.04E-02	7.00E-02	2.91E-01	NA	NA	NA	3.11E-05	7.00E-02	4.44E-04
Beryllium (NC)	4.54E-05	5.00E-03	9.09E-03	NA	NA	NA	6.93E-08	5.00E-03	1.39E-05
Beryllium (C)	1.95E-05	NA	NA	NA	NA	NA	2.97E-08	NA	NA
Cadmium (NC)	4.00E-05	5.00E-04	8.00E-02	NA	NA	NA	6.10E-08	5.00E-04	1.22E-04
Manganese (NC)	1.18E-01	1.00E-01	1.18E+00	NA	NA	NA	1.79E-04	1.00E-01	1.79E-03
Nickel (NC)	1.31E-03	2.00E-02	6.56E-02	NA	NA	NA	2.00E-06	2.00E-02	1.00E-04
Vanadium (NC)	1.73E-03	7.00E-03	2.47E-01	NA	NA	NA	2.64E-06	7.00E-03	3.76E-04
(C) - Carcinogen (NC) - Noncarcinogen	Total Hazard Index =		5.37E+00 *	Total Hazard Index =		3.77E-02	Total Hazard Index =		8.42E-03

NA - Not Analyzed, Not Applicable, or Not Available
* - Hazard Index exceeds 1 for the exposure route.

TABLE 5-1b
GROUND WATER HAZARD INDICES
CHILDREN

CHEMICAL	GW Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)	GW Inhalation CDI (mg/kg-day)	Inhalation RfC (mg/kg-day)	Hazard Index (Intake/RfC)	GW Dermal Abs. CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)
Benzene (C)	2.93E-06	NA	NA	3.35E-05	NA	NA	2.78E-06	NA	NA
Carbon Disulfide (NC)	2.71E-06	1.00E-01	2.71E-03	6.82E-05	3.00E-03	2.27E-02	3.45E-05	1.00E-01	3.45E-06
Chlorobenzene (NC)	6.34E-03	2.00E-02	3.17E-01	4.80E-06	6.00E-03	8.00E-02	1.23E-05	2.00E-02	6.15E-06
1,2-Dichloroethene (NC)	9.25E-06	9.00E-03	1.03E-01	1.33E-06	NA	NA	1.80E-06	9.00E-03	2.00E-06
Vinyl Chloride (C)	4.94E-05	NA	NA	1.54E-05	NA	NA	9.59E-08	NA	NA
Xylene (NC)	1.75E-03	2.00E+00	8.75E-06	2.52E-06	9.00E-02	2.81E-03	3.40E-06	2.00E+00	1.70E-06
Naphthalene (NC)	3.62E-06	4.00E-03	9.06E-02	NA	NA	NA	7.02E-07	4.00E-03	1.76E-06
bis(2-Ethylhexyl)phthalate (NC)	5.73E-06	2.00E-02	2.86E-02	NA	NA	NA	1.11E-06	2.00E-02	5.56E-05
bis(2-Ethylhexyl)phthalate (C)	7.36E-05	NA	NA	NA	NA	NA	1.43E-07	NA	NA
PCBs* (C)	8.23E-06	NA	NA	NA	NA	NA	1.60E-08	NA	NA
4,4'-DDT (NC)	NA	5.00E-04	NA	NA	NA	NA	NA	5.00E-04	NA
4,4'-DDT (C)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony (NC)	1.13E-03	4.00E-04	2.83E+00	NA	NA	NA	2.20E-06	4.00E-04	5.50E-03
Arsenic (NC)	5.44E-04	1.00E-03	5.44E-01	NA	NA	NA	1.06E-06	1.00E-03	1.06E-03
Arsenic (C)	6.99E-05	NA	NA	NA	NA	NA	1.36E-07	NA	NA
Barium (NC)	2.28E-02	7.00E-02	3.26E-01	NA	NA	NA	4.44E-05	7.00E-02	6.34E-04
Beryllium (NC)	5.09E-05	5.00E-03	1.02E-02	NA	NA	NA	9.80E-08	5.00E-03	1.90E-05
Beryllium (C)	6.54E-06	NA	NA	NA	NA	NA	1.27E-08	NA	NA
Cadmium (NC)	4.48E-05	5.00E-04	8.96E-02	NA	NA	NA	1.12E-08	5.00E-04	2.24E-05
Manganese (NC)	1.32E-01	1.00E-01	1.32E+00	NA	NA	NA	2.56E-04	1.00E-01	2.56E-03
Nickel (NC)	1.47E-03	2.00E-02	7.34E-02	NA	NA	NA	2.85E-06	2.00E-02	1.43E-04
Vanadium (NC)	1.94E-03	7.00E-03	2.77E-01	NA	NA	NA	4.84E-07	7.00E-03	6.91E-05
	Total Hazard Index =		6.01E+00 *	Total Hazard Index =		1.06E-01	Total Hazard Index =		1.14E-02

(C) - Carcinogen
(NC) - Noncarcinogen

NA - Not Analyzed, Not Applicable, or Not Available
* - Hazard index exceeds 1 for the exposure route.

22-Jan-92

TABLE 5-2a
SURFACE WATER HAZARD INDICES
ADULTS

CHEMICAL	Fish Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)	Incidental Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)	Dermal Absorption CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)
Benzene (C)	6.09E-06	NA	NA	8.98E-08	NA	NA	1.34E-05	NA	NA
Carbon Disulfide (NC)	NA	1.00E-01	NA	NA	1.00E-01	NA	NA	1.00E-01	NA
Chlorobenzene (NC)	1.35E-04	2.00E-02	6.76E-03	1.04E-06	2.00E-02	5.18E-05	3.16E-07	2.00E-02	1.58E-05
1,2-Dichloroethene (NC)	7.26E-07	9.00E-03	8.06E-05	3.48E-08	9.00E-03	3.87E-06	1.06E-08	9.00E-03	1.18E-06
Vinyl Chloride (C)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Xylene (NC)	3.05E-03	2.00E+00	1.52E-03	1.99E-06	2.00E+00	9.93E-07	6.06E-07	2.00E+00	3.03E-07
Naphthalene (NC)	3.05E-04	4.00E-03	7.63E-02	1.02E-07	4.00E-03	2.55E-05	3.11E-08	4.00E-03	7.78E-06
bis(2-Ethylhexyl)phthalate (NC)	NA	2.00E-02	NA	NA	2.00E-02	NA	NA	2.00E-02	NA
bis(2-Ethylhexyl)phthalate (C)	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCBs (C)	3.93E-03	NA	NA	3.02E-09	NA	NA	9.20E-10	NA	NA
4,4'-DDT (NC)	7.35E-04	5.00E-04	1.47E+00	1.04E-09	5.00E-04	2.09E-06	3.18E-10	5.00E-04	6.37E-07
4,4'-DDT (C)	3.15E-04	NA	NA	4.47E-10	NA	NA	1.36E-10	NA	NA
Antimony (NC)	5.32E-06	4.00E-04	1.33E-02	4.08E-07	4.00E-04	1.02E-03	1.24E-07	4.00E-04	3.11E-04
Arsenic (NC)	2.49E-05	1.00E-03	2.49E-02	4.34E-08	1.00E-03	4.34E-05	1.32E-08	1.00E-03	1.32E-05
Arsenic (C)	1.07E-05	NA	NA	1.86E-08	NA	NA	5.67E-09	NA	NA
Barium (NC)	2.84E-05	7.00E-02	4.06E-04	2.18E-06	7.00E-02	3.11E-05	6.64E-07	7.00E-02	9.49E-06
Beryllium (NC)	3.70E-06	5.00E-03	7.40E-04	1.49E-08	5.00E-03	2.99E-06	4.55E-09	5.00E-03	9.11E-07
Beryllium (C)	1.58E-06	NA	NA	6.40E-09	NA	NA	1.95E-09	NA	NA
Cadmium (NC)	NA	5.00E-04	NA	NA	5.00E-04	NA	NA	5.00E-04	NA
Manganese (NC)	8.00E-05	1.00E-01	8.00E-04	6.14E-06	1.00E-01	6.14E-05	1.87E-06	1.00E-01	1.87E-05
Nickel (NC)	1.39E-03	2.00E-02	6.97E-02	2.27E-06	2.00E-02	1.14E-04	6.93E-07	2.00E-02	3.47E-05
Vanadium (NC)	6.93E-06	7.00E-03	9.90E-04	5.32E-07	7.00E-03	7.59E-05	1.62E-07	7.00E-03	2.32E-05
(C) - Carcinogen (NC) - Noncarcinogen	Hazard Index =		1.66E+00 *	Hazard Index =		1.43E-03	Hazard Index =		4.37E-04

NA - Not Analyzed, Not Applicable, or Not Available
* - Hazard index exceeds 1 for the exposure route.

TABLE 5-2b
SURFACE WATER HAZARD INDICES
CHILDREN

CHEMICAL	Fish Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)	Incidental Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)	Dermal Absorption CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)
Benzene (C)	5.11E-06	NA	NA	4.53E-07	NA	NA	3.43E-05	NA	NA
Carbon Disulfide (NC)	NA	1.00E-01	NA	NA	1.00E-01	NA	NA	1.00E-01	NA
Chlorobenzene (NC)	3.79E-04	2.00E-02	1.89E-02	1.74E-05	2.00E-02	8.71E-04	2.71E-06	2.00E-02	1.35E-04
1,2-Dichloroethene (NC)	2.03E-06	9.00E-03	2.26E-04	5.85E-07	9.00E-03	6.49E-05	9.08E-08	9.00E-03	1.01E-05
Vinyl Chloride (C)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Xylene (NC)	8.54E-03	2.00E+00	4.27E-03	3.34E-05	2.00E+00	1.67E-05	5.19E-06	2.00E+00	2.59E-06
Naphthalene (NC)	8.53E-04	4.00E-03	2.13E-01	1.71E-06	4.00E-03	4.29E-04	2.66E-07	4.00E-03	6.66E-05
bis(2-Ethylhexyl)phthalate (NC)	NA	2.00E-02	NA	NA	2.00E-02	NA	NA	2.00E-02	NA
bis(2-Ethylhexyl)phthalate (C)	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCBs (C)	3.30E-03	NA	NA	1.52E-08	NA	NA	2.36E-09	NA	NA
4,4'-DDT (NC)	2.06E-03	5.00E-04	4.11E+00	1.75E-08	5.00E-04	3.51E-05	2.73E-09	5.00E-04	5.45E-06
4,4'-DDT (C)	2.65E-04	NA	NA	2.25E-09	NA	NA	3.50E-10	NA	NA
Antimony (NC)	1.49E-05	4.00E-04	3.73E-02	6.86E-06	4.00E-04	1.71E-02	1.07E-06	4.00E-04	2.66E-03
Arsenic (NC)	6.97E-05	1.00E-03	6.97E-02	7.30E-07	1.00E-03	7.30E-04	1.13E-07	1.00E-03	1.13E-04
Arsenic (C)	8.97E-06	NA	NA	9.30E-08	NA	NA	1.44E-08	NA	NA
Barium (NC)	7.95E-05	7.00E-02	1.14E-03	3.66E-05	7.00E-02	5.23E-04	5.69E-06	7.00E-02	8.12E-05
Beryllium (NC)	1.04E-05	5.00E-03	2.07E-03	2.51E-07	5.00E-03	5.02E-05	3.90E-08	5.00E-03	7.80E-06
Beryllium (C)	1.33E-06	NA	NA	3.23E-08	NA	NA	5.01E-09	NA	NA
Cadmium (NC)	NA	5.00E-04	NA	NA	5.00E-04	NA	NA	5.00E-04	NA
Manganese (NC)	2.24E-04	1.00E-01	2.24E-03	1.03E-04	1.00E-01	1.03E-03	1.60E-05	1.00E-01	1.60E-04
Nickel (NC)	3.90E-03	2.00E-02	1.95E-01	3.82E-05	2.00E-02	1.91E-03	5.94E-06	2.00E-02	2.97E-04
Vanadium (NC)	1.94E-05	7.00E-03	2.77E-03	8.93E-06	7.00E-03	1.28E-03	1.39E-06	7.00E-03	1.98E-04
(C) - Carcinogen (NC) - Noncarcinogen	Hazard Index =		4.66E+00 *	Hazard Index =		2.41E-02	Hazard Index =		3.74E-03

NA - Not Analyzed, Not Applicable, or Not Available
* - Hazard Index exceeds 1 for the exposure route.

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TABLE 5-3a
SEDIMENT HAZARD INDEX
ADULTS

CHEMICAL	Dermal Contact CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)	Incidental Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)
Benzene (C)	4.77E-09	NA	NA	1.53E-10	NA	NA
Carbon Disulfide (NC)	3.22E-09	1.00E-01	3.22E-08	1.03E-10	1.00E-01	1.03E-09
Chlorobenzene (NC)	2.74E-08	2.00E-02	1.37E-06	8.77E-10	2.00E-02	4.38E-08
1,2-Dichloroethene (NC)	NA	9.00E-03	NA	NA	9.00E-03	NA
Vinyl Chloride (C)	NA	NA	NA	NA	NA	NA
Xylene (NC)	8.00E-07	2.00E+00	4.00E-07	2.56E-08	2.00E+00	1.28E-08
Naphthalene (NC)	1.33E-07	4.00E-03	3.31E-05	1.06E-08	4.00E-03	2.65E-06
bis(2-Ethylhexyl)phthalate (NC)	4.49E-05	2.00E-02	2.24E-03	3.59E-06	2.00E-02	1.79E-04
bis(2-Ethylhexyl)phthalate (C)	1.92E-05	NA	NA	1.54E-06	NA	NA
PCBs (C)	4.43E-06	NA	NA	3.55E-07	NA	NA
4,4'-DDT (NC)	NA	5.00E-04	NA	NA	5.00E-04	NA
4,4'-DDT (C)	NA	NA	NA	NA	NA	NA
Antimony (NC)	2.45E-07	4.00E-04	6.13E-04	1.96E-07	4.00E-04	4.90E-04
Arsenic (NC)	2.18E-06	1.00E-03	2.18E-03	1.75E-06	1.00E-03	1.75E-03
Arsenic (C)	9.35E-07	NA	NA	7.48E-07	NA	NA
Barium (NC)	2.93E-06	7.00E-02	4.19E-05	2.35E-06	7.00E-02	3.35E-05
Beryllium (NC)	4.55E-08	5.00E-03	9.11E-06	3.64E-08	5.00E-03	7.29E-06
Beryllium (C)	1.95E-08	NA	NA	1.56E-08	NA	NA
Cadmium (NC)	7.19E-08	5.00E-04	1.44E-04	5.75E-08	5.00E-04	1.15E-04
Manganese (NC)	7.43E-06	1.00E-01	7.43E-05	5.95E-06	1.00E-01	5.95E-05
Nickel (NC)	1.70E-06	2.00E-02	8.48E-05	1.36E-06	2.00E-02	6.78E-05
Vanadium (NC)	1.81E-06	7.00E-03	2.59E-04	1.45E-06	7.00E-03	2.07E-04
(C) - Carcinogen (NC) - Noncarcinogen	Hazard Index =		5.68E-03	Hazard Index =		2.91E-03

NA - Not Analyzed, Not Applicable, or Not Available

TABLE 5-3b
SEDIMENT HAZARD INDEX
CHILDREN

CHEMICAL	Dermal Contact CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)	Incidental Ingestion CDI (mg/kg-day)	Oral RfD (mg/kg-day)	Hazard Index (Intake/RfD)
Benzene (C)	6.93E-09	NA	NA	7.69E-10	NA	NA
Carbon Disulfide (NC)	1.56E-08	1.00E-01	1.56E-07	1.73E-09	1.00E-01	1.73E-08
Chlorobenzene (NC)	1.33E-07	2.00E-02	6.63E-06	1.47E-08	2.00E-02	7.36E-07
1,2-Dichloroethene (NC)	NA	9.00E-03	NA	NA	9.00E-03	NA
Vinyl Chloride (C)	NA	NA	NA	NA	NA	NA
Xylene (NC)	3.87E-06	2.00E+00	1.94E-06	4.30E-07	2.00E+00	2.15E-07
Naphthalene (NC)	6.42E-07	4.00E-03	1.60E-04	1.78E-07	4.00E-03	4.45E-05
bis(2-Ethylhexyl)phthalate (NC)	2.17E-04	2.00E-02	1.09E-02	6.03E-05	2.00E-02	3.01E-03
bis(2-Ethylhexyl)phthalate (C)	2.79E-05	NA	NA	7.75E-06	NA	NA
PCBs (C)	6.44E-06	NA	NA	1.79E-06	NA	NA
4,4'-DDT (NC)	NA	5.00E-04	NA	NA	5.00E-04	NA
4,4'-DDT (C)	NA	NA	NA	NA	NA	NA
Antimony (NC)	1.19E-06	4.00E-04	2.97E-03	3.30E-06	4.00E-04	8.24E-03
Arsenic (NC)	1.06E-05	1.00E-03	1.06E-02	2.93E-05	1.00E-03	2.93E-02
Arsenic (C)	1.36E-06	NA	NA	3.77E-06	NA	NA
Barium (NC)	1.42E-05	7.00E-02	2.03E-04	3.94E-05	7.00E-02	5.63E-04
Beryllium (NC)	2.21E-07	5.00E-03	4.41E-05	6.12E-07	5.00E-03	1.22E-04
Beryllium (C)	2.84E-08	NA	NA	7.87E-08	NA	NA
Cadmium (NC)	3.48E-07	5.00E-04	6.97E-04	9.67E-07	5.00E-04	1.93E-03
Manganese (NC)	3.60E-05	1.00E-01	3.60E-04	9.99E-05	1.00E-01	9.99E-04
Nickel (NC)	8.21E-06	2.00E-02	4.10E-04	2.28E-05	2.00E-02	1.14E-03
Vanadium (NC)	8.77E-06	7.00E-03	1.25E-03	2.43E-05	7.00E-03	3.48E-03
(C) - Carcinogen (NC) - Noncarcinogen		Hazard Index =	2.75E-02		Hazard Index =	4.89E-02

NA - Not Analyzed, Not Applicable, or Not Available

Evaluation of carcinogenic risks are used to determine if the site contaminants pose sufficient risk to human health to exceed 10^{-4} to 10^{-6} (EPA, 1989).

Carcinogenic risks for ground-water exposures are presented in Tables 5-4a and 5-4b. For adults, the risk from ground-water ingestion dominates ground-water exposure, with a total risk value of 6.39E-04. Approximately 82 percent of the risk is due to the ingestion of vinyl chloride and PCBs, whose chemical-specific risks are 3.38E-04 and 1.89E-04 respectively. For children, the risk from ground-water ingestion also dominates ground-water exposure. Approximately, 96 percent of the total value of 2.15E-04 is a result of exposure to vinyl chloride, PCBs, and beryllium at 1.14E-04, 6.34E-05, and 2.81E-05, respectively. The risk values for ground-water ingestion exposures exceed the EPA-specified target range of 10^{-4} to 1.0^{-6}. Risks due to dermal absorption and inhalation ground-water exposures do not exceed 10^{-4} and fall within the target range.

Risk values for surface water exposures (Tables 5-5a and 5-5b) were greatest for fish ingestion, which yielded 3.04E-02 for adults and 2.55E-02 for children. The major contaminant yielding risk as PCBs, with risks of 3.03E-02 and 2.54E-02 for adults and children, respectively. These high risk values are due to the conservative assumptions used (i.e., an exposure frequency of 365 days per year for 70 years) as per EPA 1989a.

Sediment-related risk values, presented in Table 5-6a and 5-6b, were also within the target level of 10^{-4} to 10^{-6}. Dermal contact resulted in a risk of 3.45E-05 for adults and 5.01E-05 for children. The dominant risk driving compound was again PCBs. Sediment ingestion exposure risks for adults were also within the target range at 2.82E-06 and 1.42E-05 for adults and children respectively.

Summary

In summary, four exposure scenarios have hazard indices above 1: ground-water ingestion by adults (5.37), ground water ingestion by children (6.01), fish ingestion by adults (1.66) and fish ingestion by children (4.66).

Exposure pathways resulting in an excess cancer risk include: ingestion of ground water by adults (6.39E-04) and children (2.15E-04), and, fish ingestion by adults (3.04E-02) and children 2.55E-02).

Risks associated with multiple exposure pathways were also evaluated. Risks were grouped by population, i.e., residential, recreational, and fishers. Residential risks included

TABLE 5-4a
CARCINOGENIC RISK ESTIMATES FOR GROUND-WATER
ADULTS

CHEMICAL	GW Ingestion CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	GW Inhalation CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	GW Dermal Abs. CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)
Benzene (C)	8.72E-04	2.90E-02	2.53E-05	3.99E-05	2.90E-02	1.16E-06	6.49E-04	2.90E-02	1.88E-05
Carbon Disulfide (NC)	2.42E-04	NA	NA	2.43E-05	NA	NA	2.42E-05	NA	NA
Chlorobenzene (NC)	5.66E-03	NA	NA	1.71E-04	NA	NA	8.62E-06	NA	NA
1,2-Dichloroethene (NC)	8.26E-04	NA	NA	NA	NA	NA	1.26E-06	NA	NA
Vinyl Chloride (C)	1.47E-04	2.30E+00	3.38E-04	1.83E-05	2.94E-01	5.38E-06	2.24E-07	2.30E+00	5.15E-07
Xylene (NC)	1.56E-03	NA	NA	9.02E-05	NA	NA	2.38E-06	NA	NA
Naphthalene (NC)	3.23E-04	NA	NA	NA	NA	NA	4.92E-07	NA	NA
bis(2-Ethylhexyl)phthalate (NC)	5.11E-04	NA	NA	NA	NA	NA	7.80E-07	NA	NA
bis(2-Ethylhexyl)phthalate (C)	2.19E-04	1.40E-02	3.07E-06	NA	NA	NA	3.34E-07	1.40E-02	4.68E-09
PCBs (C)	2.45E-05	7.70E+00	1.89E-04	NA	NA	NA	3.73E-08	7.70E+00	2.87E-07
4,4'-DDT (NC)	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT (C)	NA	3.40E-01	NA	NA	NA	NA	NA	3.40E-01	NA
Antimony (NC)	1.01E-03	NA	NA	NA	NA	NA	1.54E-06	NA	NA
Arsenic (NC)	4.86E-04	NA	NA	NA	NA	NA	7.41E-07	NA	NA
Arsenic (C)	2.08E-04	NA	NA	NA	NA	NA	3.17E-07	NA	NA
Barium (NC)	2.04E-02	NA	NA	NA	NA	NA	3.11E-05	NA	NA
Beryllium (NC)	4.54E-05	NA	NA	NA	NA	NA	6.93E-08	NA	NA
Beryllium (C)	1.95E-05	4.30E+00	8.37E-05	NA	NA	NA	2.97E-08	4.30E+00	1.28E-07
Cadmium (NC)	4.00E-05	NA	NA	NA	NA	NA	6.10E-08	NA	NA
Manganese (NC)	1.18E-01	NA	NA	NA	NA	NA	1.79E-04	NA	NA
Nickel (NC)	1.31E-03	NA	NA	NA	NA	NA	2.00E-06	NA	NA
Vanadium (NC)	1.73E-03	NA	NA	NA	NA	NA	2.64E-06	NA	NA
(C) - Carcinogen (NC) - Noncarcinogen	Total Carcinogenic Risk =		6.39E-04 *	Total Carcinogenic Risk =		6.54E-06	Total Carcinogenic Risk =		1.90E-05

NA - Not Analyzed, Not Applicable, or Not Available

* Total carcinogenic risk exceeds the target range of 1E-04 to 1E-06.

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TABLE 5-4b
CARCINOGENIC RISK ESTIMATES FOR GROUND-WATER
CHILDREN

CHEMICAL	GW Ingestion CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	GW Inhalation CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	GW Dermal Abs. CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)
Benzene (C)	2.93E-04	2.90E-02	8.50E-06	3.35E-05	2.90E-02	9.72E-07	2.78E-04	2.90E-02	8.06E-06
Carbon Disulfide (NC)	2.71E-04	NA	NA	6.82E-05	NA	NA	3.45E-05	NA	NA
Chlorobenzene (NC)	6.34E-03	NA	NA	4.80E-04	NA	NA	1.23E-05	NA	NA
1,2-Dichloroethene (NC)	9.25E-04	NA	NA	1.33E-04	NA	NA	1.80E-06	NA	NA
Vinyl Chloride (C)	4.94E-05	2.30E+00	1.14E-04	1.54E-05	2.94E-01	4.52E-06	9.59E-08	2.30E+00	2.21E-07
Xylene (NC)	1.75E-03	NA	NA	2.52E-04	NA	NA	3.40E-06	NA	NA
Naphthalene (NC)	3.62E-04	NA	NA	NA	NA	NA	7.02E-07	NA	NA
bis(2-Ethylhexyl)phthalate (NC)	5.73E-04	NA	NA	NA	NA	NA	1.11E-06	NA	NA
bis(2-Ethylhexyl)phthalate (C)	7.36E-05	1.40E-02	1.03E-06	NA	NA	NA	1.43E-07	1.40E-02	2.00E-09
PCBs (C)	8.23E-06	7.70E+00	6.34E-05	NA	NA	NA	1.60E-08	7.70E+00	1.23E-07
4,4'-DDT (NC)	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT (C)	NA	3.40E-01	NA	NA	NA	NA	NA	3.40E-01	NA
Antimony (NC)	1.13E-03	NA	NA	NA	NA	NA	2.20E-06	NA	NA
Arsenic (NC)	5.44E-04	NA	NA	NA	NA	NA	1.06E-06	NA	NA
Arsenic (C)	6.99E-05	NA	NA	NA	NA	NA	1.36E-07	NA	NA
Barium (NC)	2.28E-02	NA	NA	NA	NA	NA	4.44E-05	NA	NA
Beryllium (NC)	5.09E-05	NA	NA	NA	NA	NA	9.88E-08	NA	NA
Beryllium (C)	6.54E-06	4.30E+00	2.81E-05	NA	NA	NA	1.27E-08	4.30E+00	5.46E-08
Cadmium (NC)	4.48E-05	NA	NA	NA	NA	NA	1.12E-08	NA	NA
Manganese (NC)	1.32E-01	NA	NA	NA	NA	NA	2.56E-04	NA	NA
Nickel (NC)	1.47E-03	NA	NA	NA	NA	NA	2.85E-06	NA	NA
Vanadium (NC)	1.94E-03	NA	NA	NA	NA	NA	4.84E-07	NA	NA
(C) - Carcinogen (NC) - Noncarcinogen	Total Carcinogenic Risk =		2.15E-04 *	Total Carcinogenic Risk =		5.49E-06	Total Carcinogenic Risk =		8.46E-06

NA - Not Analyzed, Not Applicable, or Not Available
* Total carcinogenic risk exceeds the target range of 1E-04 to 1E-06.

TABLE 5-5a
CARCINOGENIC RISK ESTIMATES FOR SURFACE WATER
ADULTS

CHEMICAL	Fish Ingestion CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	SW Ingestion CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	Dermal Absorption CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specifi Risk (Intake*SF)
Benzene (C)	6.09E-06	2.90E-02	1.77E-07	8.90E-08	2.90E-02	2.60E-09	1.34E-05	2.90E-02	3.88E-07
Carbon Disulfide (NC)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chlorobenzene (NC)	1.35E-04	NA	NA	1.04E-06	NA	NA	3.16E-07	NA	NA
1,2-Dichloroethene (NC)	7.26E-07	NA	NA	3.48E-08	NA	NA	1.06E-08	NA	NA
Vinyl Chloride (C)	NA	2.30E+00	NA	NA	2.30E+00	NA	NA	2.30E+00	NA
Xylene (NC)	3.05E-03	NA	NA	1.99E-06	NA	NA	6.06E-07	NA	NA
Naphthalene (NC)	3.05E-04	NA	NA	1.02E-07	NA	NA	3.11E-08	NA	NA
bis(2-Ethylhexyl)phthalate (NC)	NA	NA	NA	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate (C)	NA	1.40E-02	NA	NA	1.40E-02	NA	NA	1.40E-02	NA
PCBs (C)	3.93E-03	7.70E+00	3.03E-02	3.02E-09	7.70E+00	2.32E-08	9.20E-10	7.70E+00	7.09E-09
4,4'-DDT (NC)	7.35E-04	NA	NA	1.04E-09	NA	NA	3.18E-10	NA	NA
4,4'-DDT (C)	3.15E-04	3.40E-01	1.07E-04	4.47E-10	3.40E-01	1.52E-10	1.36E-10	3.40E-01	4.64E-11
Antimony (NC)	5.32E-06	NA	NA	4.08E-07	NA	NA	1.24E-07	NA	NA
Arsenic (NC)	2.49E-05	NA	NA	4.34E-08	NA	NA	1.32E-08	NA	NA
Arsenic (C)	1.07E-05	NA	NA	1.86E-08	NA	NA	5.67E-09	NA	NA
Barium (NC)	2.04E-05	NA	NA	2.18E-06	NA	NA	6.64E-07	NA	NA
Beryllium (NC)	3.70E-06	NA	NA	1.49E-08	NA	NA	4.55E-09	NA	NA
Beryllium (C)	1.58E-06	4.30E+00	6.82E-06	6.40E-09	4.30E+00	2.75E-08	1.95E-09	4.30E+00	8.39E-09
Cadmium (NC)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese (NC)	8.08E-05	NA	NA	6.14E-06	NA	NA	1.87E-06	NA	NA
Nickel (NC)	1.39E-03	NA	NA	2.27E-06	NA	NA	6.93E-07	NA	NA
Vanadium (NC)	6.93E-06	NA	NA	5.32E-07	NA	NA	1.62E-07	NA	NA
	Total Carcinogenic Risk =		3.04E-02 *	Total Carcinogenic Risk =		5.35E-08	Total Carcinogenic Risk =		4.03E-07

(C) - Carcinogen
(NC) - Noncarcinogen

NA - Not Analyzed, Not Applicable, or Not Available
* - Total carcinogenic risk exceeds the target range of 1E-04 to 1E-06.

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TABLE 5-5b
CARCINOGENIC RISK ESTIMATES FOR SURFACEWATER
CHILDREN

CHEMICAL	Fish Ingestion CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	SW Ingestion CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	Dermal Absorption CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specifi Risk (Intake*SF)
Benzene (C)	5.11E-06	2.90E-02	1.48E-07	4.53E-07	2.90E-02	1.31E-08	3.43E-05	2.90E-02	9.96E-07
Carbon Disulfide (NC)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chlorobenzene (NC)	3.79E-04	NA	NA	1.74E-05	NA	NA	2.71E-06	NA	NA
1,2-Dichloroethene (NC)	2.03E-06	NA	NA	5.85E-07	NA	NA	9.08E-08	NA	NA
Vinyl Chloride (C)	NA	2.30E+00	NA	NA	2.30E+00	NA	NA	2.30E+00	NA
Xylene (NC)	8.54E-03	NA	NA	3.34E-05	NA	NA	5.19E-06	NA	NA
Naphthalene (NC)	8.53E-04	NA	NA	1.71E-06	NA	NA	2.66E-07	NA	NA
bis(2-Ethylhexyl)phthalate (NC)	NA	NA	NA	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate (C)	NA	1.40E-02	NA	NA	1.40E-02	NA	NA	1.40E-02	NA
PCBs (C)	3.30E-03	7.70E+00	2.54E-02	1.52E-08	7.70E+00	1.17E-07	2.36E-09	7.70E+00	1.82E-08
4,4'-DDT (NC)	2.06E-03	NA	NA	1.75E-08	NA	NA	2.73E-09	NA	NA
4,4'-DDT (C)	2.65E-04	3.40E-01	8.99E-05	2.25E-09	3.40E-01	7.67E-10	3.50E-10	3.40E-01	1.19E-10
Antimony (NC)	1.49E-05	NA	NA	6.86E-06	NA	NA	1.07E-06	NA	NA
Arsenic (NC)	6.97E-05	NA	NA	7.30E-07	NA	NA	1.13E-07	NA	NA
Arsenic (C)	8.97E-06	NA	NA	9.38E-08	NA	NA	1.46E-08	NA	NA
Barium (NC)	7.95E-05	NA	NA	3.66E-05	NA	NA	5.69E-06	NA	NA
Beryllium (NC)	1.04E-05	NA	NA	2.51E-07	NA	NA	3.90E-08	NA	NA
Beryllium (C)	1.33E-06	4.30E+00	5.72E-06	3.23E-08	4.30E+00	1.39E-07	5.01E-09	4.30E+00	2.16E-08
Cadmium (NC)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese (NC)	2.24E-04	NA	NA	1.03E-04	NA	NA	1.60E-05	NA	NA
Nickel (NC)	3.90E-03	NA	NA	3.82E-05	NA	NA	5.94E-06	NA	NA
Vanadium (NC)	1.94E-05	NA	NA	8.93E-06	NA	NA	1.39E-06	NA	NA
	Total Carcinogenic Risk =		2.55E-02 *	Total Carcinogenic Risk =		2.70E-07	Total Carcinogenic Risk =		1.04E-06

(C) - Carcinogen
(NC) - Noncarcinogen

NA - Not Analyzed, Not Applicable, or Not Available
* - Total carcinogenic risk exceeds the target range of 1E-04 to 1E-06.

22-Jan-92

TABLE 5-6a
CARCINOGENIC RISK ESTIMATES FOR SEDIMENTS
ADULTS

CHEMICAL	Dermal Contact CDI (mg/kg-day)	Dermal Contact SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	Sediment Ingestion CDI (mg/kg-day)	Sediment Ingestion SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)
Benzene (C)	4.77E-09	2.90E-02	1.38E-10	1.53E-10	2.90E-02	4.43E-12
Carbon Disulfide (NC)	3.22E-09	NA	NA	1.03E-10	NA	NA
Chlorobenzene (NC)	2.74E-08	NA	NA	8.77E-10	NA	NA
1,2-Dichloroethene (NC)	NA	NA	NA	NA	NA	NA
Vinyl Chloride (C)	NA	2.30E+00	NA	NA	2.30E+00	NA
Xylene (NC)	8.00E-07	NA	NA	2.56E-08	NA	NA
Naphthalene (NC)	1.33E-07	NA	NA	1.06E-08	NA	NA
bis(2-Ethylhexyl)phthalate (NC)	4.49E-05	NA	NA	3.59E-06	NA	NA
bis(2-Ethylhexyl)phthalate (C)	1.92E-05	1.40E-02	2.69E-07	1.54E-06	1.40E-02	2.15E-08
PCBs (C)	4.43E-06	7.70E+00	3.41E-05	3.55E-07	7.70E+00	2.73E-06
4,4'-DDT (NC)	NA	NA	NA	NA	NA	NA
4,4'-DDT (C)	NA	3.40E-01	NA	NA	3.40E-01	NA
Antimony (NC)	2.45E-07	NA	NA	1.96E-07	NA	NA
Arsenic (NC)	2.18E-06	NA	NA	1.75E-06	NA	NA
Arsenic (C)	9.35E-07	NA	NA	7.48E-07	NA	NA
Barium (NC)	2.93E-06	NA	NA	2.35E-06	NA	NA
Beryllium (NC)	4.55E-08	NA	NA	3.64E-08	NA	NA
Beryllium (C)	1.95E-08	4.30E+00	8.39E-08	1.56E-08	4.30E+00	6.72E-08
Cadmium (NC)	7.19E-08	NA	NA	5.75E-08	NA	NA
Manganese (NC)	7.43E-06	NA	NA	5.95E-06	NA	NA
Nickel (NC)	1.70E-06	NA	NA	1.36E-06	NA	NA
Vanadium (NC)	1.81E-06	NA	NA	1.45E-06	NA	NA
(C) - Carcinogen (NC) - Noncarcinogen	Total Carcinogenic Risk =		3.45E-05	Total Carcinogenic Risk =		2.82E-06

NA - Not Analyzed, Not Applicable, or Not Available

22-Jan-92

TABLE 5-6b
CARCINOGENIC RISK ESTIMATES FOR SEDIMENTS
CHILDREN

CHEMICAL	Dermal Contact CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)	Sediment Ingestion CDI (mg/kg-day)	SF 1/(mg/kg-day)	Chemical-specific Risk (Intake*SF)
Benzene (C)	6.93E-09	2.90E-02	2.01E-10	7.69E-10	2.90E-02	2.23E-11
Carbon Disulfide (NC)	1.56E-08	NA	NA	1.73E-09	NA	NA
Chlorobenzene (NC)	1.33E-07	NA	NA	1.47E-08	NA	NA
1,2-Dichloroethene (NC)	NA	NA	NA	NA	NA	NA
Vinyl Chloride (C)	NA	2.30E+00	NA	NA	2.30E+00	NA
Xylene (NC)	3.87E-06	NA	NA	4.30E-07	NA	NA
Naphthalene (NC)	6.42E-07	NA	NA	1.78E-07	NA	NA
bis(2-Ethylhexyl)phthalate (NC)	2.17E-04	NA	NA	6.03E-05	NA	NA
bis(2-Ethylhexyl)phthalate (C)	2.79E-05	1.40E-02	3.91E-07	7.75E-06	1.40E-02	1.09E-07
PCBs (C)	6.44E-06	7.70E+00	4.96E-05	1.79E-06	7.70E+00	1.38E-05
4,4'-DDT (NC)	NA	NA	NA	NA	NA	NA
4,4'-DDT (C)	NA	3.40E-01	NA	NA	3.40E-01	NA
Antimony (NC)	1.19E-06	NA	NA	3.30E-06	NA	NA
Arsenic (NC)	1.06E-05	NA	NA	2.93E-05	NA	NA
Arsenic (C)	1.36E-06	NA	NA	3.77E-06	NA	NA
Barium (NC)	1.42E-05	NA	NA	3.94E-05	NA	NA
Beryllium (NC)	2.21E-07	NA	NA	6.12E-07	NA	NA
Beryllium (C)	2.84E-08	4.30E+00	1.22E-07	7.87E-08	4.30E+00	3.38E-07
Cadmium (NC)	3.48E-07	NA	NA	9.67E-07	NA	NA
Manganese (NC)	3.60E-05	NA	NA	9.99E-05	NA	NA
Nickel (NC)	8.21E-06	NA	NA	2.28E-05	NA	NA
Vanadium (NC)	8.77E-06	NA	NA	2.43E-05	NA	NA
(C) - Carcinogen (NC) - Noncarcinogen	Total Carcinogenic Risk =		5.01E-05	Total Carcinogenic Risk =		1.42E-05

NA - Not Analyzed, Not Applicable, or Not Available

inhalation, ingestion, and absorption of ground water for both children and adults. Recreational risks included ingestion and absorption of sediments, and ingestion and absorption of surface water for both children and adults. The total noncarcinogenic health effects of each group was determined by summing the hazard indices for each pathway. The total carcinogenic risk for each group was determined by summing the carcinogenic risks for each pathway. This evaluation is shown in Table 5-7.

The highest noncarcinogenic hazard indices for both adults and children is from residential exposure with hazard indices of 5.42 and 6.13 respectively. Fish ingestion for adults (1.66) and children (4.66) also exceeded one. All other population hazard indices for both adults and children were less than one.

Adult carcinogenic risks were 6.65E-04 for residents, 3.78E-05 for recreational users of the site, and 3.04E-02 for recreational fishers. The highest carcinogenic risk to children was 2.55E-02 from the ingestion of contaminated fish tissue. The carcinogenic risk for child recreational users of the site was 6.56E-05, and for residential children 2.29E-04.

Risks were also evaluated across all reasonable exposure pathway combinations for both noncarcinogens and carcinogens. Table 5-8 shows a summary of all possible combinations of exposure pathways for adults and children. All pathway combinations for noncarcinogenic exposure to adults are greater than one. The highest noncarcinogenic hazard index to adults occurs by combining the total residential and total fish ingestion pathways yeilding a hazard index of 7.08. The risk to adults from the combination of total recreational and total residential exposure is 5.43. The risk to adults from combining fish ingestion and recreational exposures is 1.67. All combinations of carcinogenic risks were above the target range of 1E-04 to 1E-06. The highest carcinogenic risk (3.11E-02) resulted from combining the fish ingestion and residential scenarios, accounting for the case where site residents utilize site streams for recreational fishing. The combined carcinogenics risks for adults ranged from 7.03E-04 to 3.11E-02.

For children, the highest noncarcinogenic hazard index is associated with combining fish ingestion and residential exposures yielding a hazard index of 10.8. The total recreational and residential and total fish ingestion and recreational hazard indices for children are also greater than one, with hazard indices of 6.23 and 4.76, respectively. For children, all combinations of carcinogenic risks were above the target range. A carcinogenic risk of 2.57E-02 resulted from combining the fish ingestion and residential scenarios. While fish ingestion and recreationa scenarios yielded a carcinogenic risk of 2.56E-02, the total recreational and residential scenaric combination resulted in a carcinogenic risk of 2.95E-04.

TABLE 5-7
SUMMARY OF RISKS BY EXPOSURE PATHWAY

Route of Exposure	Noncarcinogenic Hazard Index	Carcinogenic Risk
RESIDENTIAL		
ADULT		
Ground water		
Inhalation	3.77E-02	6.54E-06
Ingestion	5.37E+00	6.39E-04
Absorption	8.42E-03	1.98E-05
TOTAL	5.42E+00	6.65E-04
CHILD		
Ground water		
Inhalation	1.06E-01	5.49E-06
Ingestion	6.01E+00	2.15E-04
Absorption	1.14E-02	8.46E-06
TOTAL	6.13E+00	2.29E-04
RECREATIONAL		
ADULT		
Sediments		
Ingestion	2.91E-03	2.82E-06
Absorption	5.68E-03	3.45E-05
TOTAL	8.59E-03	3.73E-05
Surface Water		
Ingestion	1.43E-03	5.35E-08
Absorption	4.37E-04	4.03E-07
TOTAL	1.87E-03	4.57E-07
TOTAL RECREATIONAL:	1.05E-02	3.78E-05
CHILD		
Sediments		
Ingestion	4.89E-02	1.42E-05
Absorption	2.75E-02	5.01E-05
TOTAL	7.64E-02	6.43E-05
Surface Water		
Ingestion	2.41E-02	2.70E-07
Absorption	3.74E-03	1.04E-06
TOTAL	2.78E-02	1.31E-06
TOTAL RECREATIONAL:	1.04E-01	8.56E-05
FISH INGESTION		
ADULT	1.66E+00	3.04E-02
CHILD .	4.66E+00	2.55E-02

TABLE 5-8
SUMMARY OF RISKS ACROSS EXPOSURE PATHWAYS

Routes of Exposure	Noncarcinogenic Hazard Index	Carcinogenic Risk
ADULT		
Total Recreational:	1.05E-02	3.78E-05
Total Residential:	5.42E+00	6.65E-04
TOTAL	5.43E+00	7.03E-04
CHILD		
Total Recreational:	1.04E-01	6.56E-05
Total Residential:	6.13E+00	2.29E-04
TOTAL	6.23E+00	2.95E-04
ADULT		
Fish Ingestion:	1.66E+00	3.04E-02
Total Residential:	5.42E+00	6.65E-04
TOTAL	7.08E+00	3.11E-02
CHILD		
Fish Ingestion:	4.66E+00	2.55E-02
Total Residential:	6.13E+00	2.29E-04
TOTAL	1.08E+01	2.57E-02
ADULT		
Fish Ingestion:	1.66E+00	3.04E-02
Total Recreational:	1.05E-02	3.78E-05
TOTAL	1.67E+00	3.04E-02
CHILD		
Fish Ingestion:	4.66E+00	2.55E-02
Total Recreational:	1.04E-01	6.56E-05
TOTAL	4.76E+00	2.56E-02

6.0 AREAS OF UNCERTAINTY AND DATA GAPS

Because all inputs into the exposure assessments are conservatively based, the resulting risks identified for the Kin-Buc Landfill site represent upper-bound risk estimates, and may overestimate the actual risk from exposure to the chemicals of concern studied. Additional data would be required to derive a statistically valid estimate of error in the exposure and risk calculations.

Although the methods used to calculate carcinogenic risk comply with EPA and industry standards, there are uncertainties associated with the carcinogenic risk estimates discussed above. These uncertainties are introduced because of (1) the need to extrapolate below the dose range of experimental tests, (2) the variability of the receptor population (e.g., smoker vs. nonsmoker, genetic predisposition), (3) assumed dose-response relationship between animals and humans, (4) differences in exposure routes expected onsite, (5) overly conservative assumptions, and (6) ignoring background risks. The recognized uncertainties in this issue listed are raised to point out the limitations of this type of study. The assumptions used to estimate exposure were consistently conservative in nature and biased towards protecting human health and may have overestimated the risks associated with exposure. Parameters such as the absorption factor (AF) and diet fraction may also have been over estimated.

In addition to contaminant concentration, route, and duration of exposure, there are many other factors that may influence the likelihood of developing cancer. These include differences in individual nutrition, health status, age, sex, and inherited characteristics which may affect susceptability (U.S. DHHS, 1985). Risk addition across scenarios for a given population also assumes that intake levels will be small without synergistic or antagonistic chemical effects, and that individuals will be exposed to each of the indicator chemicals that elicit a carcinogenic response.

Additionally, there are chemicals that do not have toxicity values and therefore could not contribute a quantifiable risk. These chemicals of concern are primarily copper, lead and trichloroethene. Toxicity profiles including pharmacokinetics, non-cancer toxicity, and carcinogenicity, for these chemicals are provided in Section 4. The arithmetic mean, maximum and 95 percent UCL concentrations for copper are below the PMCL and SMCL of 1.3 and 1.0 ppm respectively. The arithmetic mean and the 95 percent UCL concentrations for lead are below the MCL of 0.05 ppm. The trichloroethene mean concentration of 6.24E-03 ppm and the 95 percent UCL of 1.12E-02 ppm are both greater than the MCL of 5E-03 ppm and may cause some health effects to humans.

7.0 CONCLUSIONS

Contaminant screening was performed on analytical results from Wehran's sediment, surface water, and ground water samples from the Kin-Buc Landfill Operable Unit II Superfund site. The contaminant screening process identified 19 chemicals of concern: nine metals and ten organic compounds. The indicator chemicals chosen for this risk assessment were antimony, arsenic, barium, benzene, beryllium, bis(2-ethylhexyl)phthalate, cadmium, carbon disulfide, chlorobenzene, copper, 1,2-dichloroethene, 4,4'-DDT, manganese, napthalene, nickel, polychlorinated biphenyls (PCBs), vanadium, vinyl chloride, and xylene. These compounds or elements were selected because of their toxicological properties, potentially critical exposure routes, and higher concentrations present in comparison to other contaminants.

Applicable or relevant and appropriate requirements (ARARs) are presented in Tables 4-2 and 4-3 for the chosen contaminants of concern. These ARARs include National Primary Drinking Water Regulations (NPDWR) Maximum Contaminant Levels (MCLs), which are enforceable drinking water regulations first established under the Safe Drinking Water Act (SDWA) that are protective of public health to the extent feasible; MCL goals (MCLGs), which are nonenforceable health goals for public water systems; proposed MCLs (PMCLs) and proposed MCLGs (PMCLGs); and Occupational Safety and Health Act (OSHA) Permissible Exposure Limits (PELs), both Time Weighted Average (TWA) and Short Term Exposure Limit (STEL).

Environmental fate and transport mechanisms were evaluated for each of the indicator chemicals based on an assessment of the site's physical setting and the physical and chemical properties of each contaminant. Predominant transport mechanisms for originally landfilled contaminants include leachate percolation into soils, leachate migration through soils to ground-water supply wells, and vapor releases from contaminated ground water. Exposed populations include local residents and potential future residential users of ground water.

Eight possible exposure scenarios were evaluated: (1) residential ingestion of contaminated ground water from on-site sand & gravel wells, (2) dermal absorption of contaminated ground water during showering, (3) inhalation of vapors released from contaminated ground water during showering, (4) ingestion of contaminated fish from on-site and adjacent streams, (5) accidental ingestion of surface water while recreating in on-site and adjacent streams, (6) dermal absorption of contaminated surface water while recreating in local streams, (7) dermal absorption of contaminated sediments within the on-site and adjacent streams, and (8) accidental ingestion of sediments from within the on-site and adjacent streams.

Total body burden rates were computed based on all potential exposure routes using an average adult body weight of 70 kg, and a childrens body weight of 25 kg. It was assumed that ingestion and showering in ground water from on site would occur for 30 years for adults and 9 years for children. The noncarcinogenic exposures were averaged over a 9-year period for children. For adults, the noncarcinogenic exposures were averaged over a 30-year period. An exposure period of 70 years was used for carcinogenic compounds.

Time-weighted average doses for chemicals of concern varied considerably. The lowest chronic daily intake (CDI) was 1.03E-10 milligrams per kilogram per day (mg/kg-day) for incidental ingestion of carbon disulfide (noncarcinogenic effects) in sediments by adults during recreational activities. The highest CDI was 1.32E-01 mg/kg-day for ingestion of manganese in ground water by children.

Toxicity profiles for each of the contaminants of concern were developed based on current EPA accepted health effects documents, and established toxicological sources. Toxicity evaluation included pharmacokinetics, human health effects, and dose-response assessment. Toxicity information is dependent to a large extent on animal models upon which any potential adverse human health effects must be extrapolated.

Risk characterization included an assessment of risk associated with carcinogenic and non-carcinogenic effects caused by the contaminants of concern. Non-carcinogenic effects were addressed using a hazard index computed by multiplying the daily intake level by the inverse of the reference dose. The number should not exceed one, according to the NCP Superfund site remediation goals (EPA, 1989).

Many of the hazard indices computed indicated that the intake levels were below the reference doses (i.e., hazard indices were below one). However, four of the exposure scenarios have hazard indices (HI) above one: ground-water ingestion by adults (HI = 5.37), ground-water ingestion by children (HI = 6.01), fish ingestion by adults (HI = 1.66), and fish ingestion by children (4.66).

Potential carcinogenic risks were computed by multiplying the chronic daily intakes by the chemical-specific carcinogenic slope factor. The resulting carcinogenic risks were then compared to the target of 10^{-4} to 10^{-6}.

Several of the risks calculated for the potential exposure scenarios exceeded the target range. The following risk values were in excess of the upper limit of the target range:

- ingestion of ground water by adults (6.39E-04)
- ingestion of ground water by children (2.15E-04)
- fish ingestion by adults (3.04E-02)
- fish ingestion by children (2.55E-02)

Overall, the greatest non-carcinogenic hazard indices and carcinogenic risks result from oral ingestion and dermal absorption of the following compounds and metals: arsenic, antimony, beryllium, bis(2-ethylhexyl)phthalate, chlorobenzene, 4,4'-DDT, manganese, PCBs, and vinyl chloride. Any corrective action implemented at the site to eliminate risks posed by site contaminants should reduce concentrations of these indicator chemicals and other contaminants with similar physical and chemical characteristics.

Upon evaluation of all available information on the site and the most recent analytical data collected from the site, potential threat to human health exists. This conclusion is based on an evaluation of the site history and operations, the overall physical setting, and on chemical analysis of affected media.

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DRAFT FINAL RISK ASSESSMENT
PART II - ENVIRONMENTAL ASSESSMENT

KIN BUC LANDFILL OPERABLE UNIT II
EDISON, NEW JERSEY

CDM FEDERAL PROGRAMS CORPORATION

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1.0 INTRODUCTION

In addition to the potential exposure of human populations, flora and fauna may also be exposed to contamination at the Kin-Buc Operable Unit 2 (Op-2) site. Chemicals present at the site may be toxic to plants and animals exposed via air, water, soil, sediment, or food. This chapter of the risk assessment identifies possible environmental receptors, addresses the potential pathways by which these receptors may be exposed to the chemicals of potential concern at the site, and estimates the risks to terrestrial and aquatic wildlife that may exist at the site.

The steps for the environmental assessment are similar to those for the human health risk assessment. In both assessments, information on exposure and toxicity are combined to generate an estimate of risk. The major difference is that human health risk assessments focus on individual risks while environmental assessments are generally aimed at assessing risks to populations, communities, and ecosystems. Risks to individuals are the focus of concern for the health and welfare of rare, threatened, or endangered species potentially exposed to contaminants at the site.

The EPA Risk Assessment Guidance for Superfund, Volumes 1 and 2 (1989) were used as guidance for the preparation of the environmental assessment. These reports provide information on the selection of chemicals of concern, evaluation of exposure and toxicity, identification of ecological endpoints, and assessment of risk. The data used in this assessment was taken from the Draft Remedial Investigation (RI) (Wehran 1990). Additional studies (Adams et al. 1990; Charters et al. 1991, Wehran 1991) were performed to supplement the RI. These data have been incorporated into the assessment. Sediment chemistry data from these three studies were only incorporated for the chemicals of potential concern.

In the following sections, the potential impacts to fish, plants, and wildlife are assessed. Following a discussion of the objectives and scope of the assessment (Section 1.1) and a description of the site (Section 1.2), chemicals of potential concern are identified (Section 1.3). The ecological species (receptors) potentially affected by chemicals associated with the Kin-Buc II site are identified in Section 2.1. Potential exposure pathways are identified and exposure is quantified in Section 2.2. The methods used to assess toxicity data and the summaries of toxicity information on key chemicals are provided in Section 3. In Section 4, risks are assessed by combining the toxicity information with estimates of exposure. In Section 5, uncertainties are analyzed and in Section 6, the conclusions of the environmental assessment are presented.

1.1 Objectives and Scope

DRAFT

1.1.1 Objectives of the Environmental Assessment

As specified in CERCLA and SARA, remedial investigations are required to be sufficient to protect both human health and the environment (EPA 1989b). A special concern of the environmental assessment is to identify rare, threatened, or endangered species that are potential receptors for environmental contaminants at the site and evaluate risks to these species.

1.1.2 Scope of the Environmental Assessment

The environmental assessment is restricted to an evaluation of present risks at the site. It does not evaluate risks of various remediations at the site. The boundaries for the assessment are the areas delineated as Kin Buc II by the 1988 EPA Record of Decesion (ROD).

1.2 Site Description

1.2.1 Description of The Ecosystems and Habitats That May Be Impacted

The Operable Unit II study area includes the following areas: Mound B, the Low Lying Area. Edmonds Creek and associated wetlands, Mill Brook, Martins Creek, the Raritan River at the mouths of Edmonds Creek and Martins Creek, and ground water emanating from the site. Thus, the vegetative communities include a deciduous forest (adjacent to Mill Brook), a scrub-shrub community (in the Low Lying Area), and wetlands (tidal Edmonds Creek area). Although aquatic, wetlands, and terrestrial ecosystems exist on-site, it is not possible to estimate exposures to species inhabiting the forest and scrub-shrub areas because there were no soil or biota samples collected there. Therefore, assessment of the ecological impacts will be restricted to the creeks and the wetlands (including their mouths at the Raritan River).

1.2.2 Division of Site For Analysis of Contaminant Pathways and Effects

The environmental assessment is aimed at estimating risks to discrete populations inhabiting the site. Because contaminant migration depends on tidal range and topography, these factors were used to organize the samples collected at the site into subsets representing discrete areas (Figure 1-1). Designation of tidal and nontidal areas were based on the New Jersey National Wetlands Inventory delineations (Figure 1-1). Designation of tidal and nontidal areas. and relative topographical isolation resulted in the summarizing of surface water data into four areas for risk assessment purposes: tidal Edmonds Creek (including marsh area), non-tidal Edmonds Creek, Pool C and Connecting Channel, and the Low Lying Area.

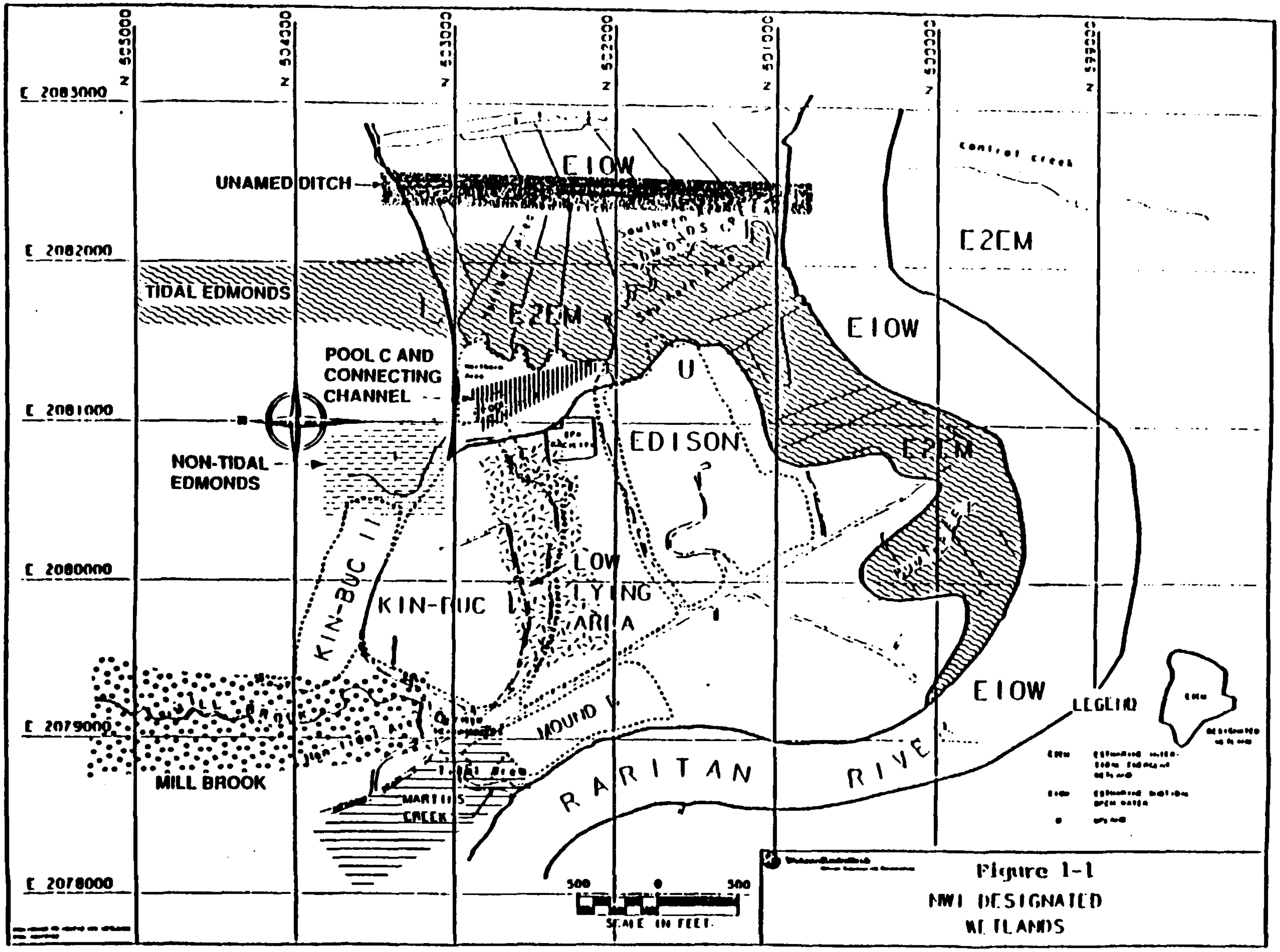

Figure 1-1
NWI DESIGNATED WETLANDS

These four areas delineated for surface water were also used as site divisions for the sediment data. All of the mosquito channels were included with the Edmonds Creek tidal area because they are part of the same tidal system. The Martins Creek/Mill Brook drainage was divided by tidal range into a tidal area (Martins Creek) and a non-tidal area (Mill Brook). Raritan River sites located within 100 feet of the mouth of a creek were included in the tidal portion of that creek since those sites are likely to be depositional areas for contaminants migrating from the creek. Raritan River sites greater than 100 feet from the mouth of a creek were grouped separately. The Unnamed Ditch was considered a separate area. Thus, a total of eight site areas for sediments were identified: tidal Edmonds Creek (including marsh area),non-tidal Edmonds Creek, Pool C and Connecting Channel, Low Lying Area, Unnamed Ditch, Martins Creek, Mill Brook, and Raritan River.

The site was divided in a similar manner for the analysis of contaminant body burdens in fish, invertebrate, and mammals. Because the species sampled tend to be localized, populations collected in discrete areas of the site can be expected to reflect contaminant levels in these areas. For example, muskrat tissue samples designated by Wehran (1990) as "North Edmonds Creek" and "South Edmonds Creek" were treated as samples from the same area because of the probable overlap of home ranges (movements of up to 200 meters have been reported (Errington 1963; Schwartz and Schwartz 1981)) and extensive tidal mixing in the drainage. Based on tidal range, topography, and home range data, the designated areas for biota samples are: tidal Edmonds Creek (including marsh), Martins Creek, and Mill Brook. Biota samples were not collected from other areas of the site.

Samples of muskrats were collected from a reference area on the South River as part of the Charters et al. (1991) study. Samples of fiddler crabs were obtained from an upstream location on the Raritan River, which was used as a reference area for the Adams et al. (1990) study.

The site divisions for surface water, sediment, and biota data and the sample identification numbers included for each area are listed in Table 1-1.

1.3 Identification of Chemicals of Potential Concern

1.3.1 Calculation of Summary Statistics

For each division of the site, the frequency of detection, geometric mean, and maximum concentrations were listed separately for surface water, sediments, and biota. In order to calculate geometric means for censored data (data with one or more values reported as less than the detection limit), an estimate of the non-detected values was required. For this report, all

Table 1-1. Sample identification numbers and assigned site areas.

Area	**Sample Identification Numbers**
Surface Water	
Tidal Edmonds Creek	SW07, SWM23, SWM15, SWM17
Non-tidal Edmonds Creek	SW08, SW10
Pool C and Connecting Channel	SWM24, SWPC04
Low Lying Area	SW12
Sediment	
Tidal Edmonds Creek	M1-M13 M15-M23, M-25 SD1-1 to 2B-11[a], 6, 7, 11 RR3
Non-Tidal Edmonds Creek	SD8-10
Upstream References	Upstream Reference 1[b]
South River Reference	South River 9, 19, 38, 44, 53[c]
Pool C and Connecting Channel	PC01-10, M24C, M24N, M24S
Low Lying Area	SD 12, 13
Martins Creek	SD 1,2; RR 9,10
Mill Brook	SD 3-5
Unnamed Ditch	UD1-2, RR1, SD3-1 to 4-6[a]
Raritan River	RR4-8
Biota	
Mummichog	
Tidal Edmonds Creek	MC-EN 76-78, MC-ES 79-81
Martins Creek	MC-MT 28-30; MC-MT 82-84
Mill Brook	MC-MT 26,27; MC-MNT 85-87
Fiddler Crab	
Tidal Edmonds Creek	FC-EMN1-3, FC-EMS 4-6, FC-ECN 7-9, FC-ECS 10-12, FC-EMN 67-69, FC-EMS 70-72, FC ECN 61-63, FC ECS 64-66; Ed-Low[b], Ed-low[a], Dup[b], Ed-Up[b], Ed-Up (No Carapace)[b]

Table 1-1. (Continued)

Area	**Sample Identification Numbers**
Martins Creek	Martins Crk. 1[b]
Upstream Reference	Upstream Ref. 1[b]
Muskrat	
Tidal Edmonds Creek	ML-ECN 33,49,50; ML-ECSD-35; ML-ECSU-34 ML-ECS 51,96; MK-ECN 42,52,53; MK-ECS 43-44;54,97 ML-MC 31,45,46,95; MK-MC 40,55,56 KB 1-68[c]
Martins Creek	ML-MC31,45,46,95; MK-MC 40,55,56
South River Reference Site	KBR 1-41[c]
Norway Rat	
Tidal Edmonds Creek	NRL 39,91,92; NRK-E59,93,94
Mouse	
Tidal Edmonds Creek	HML-E36

[a] - Wehran (1991)
[b] - Adams et al. (1990)
[c] - Charters et al. (1991)

non-detected values were reported as one-half the detection limit. A geometric mean was not calculated if (due to a large number of non-detected values or to abnormally high detection limits for several samples) it would exceed the maximum. Samples in which the detection limit was greater than or equal to ten times the usual detection limit were deleted. These procedures generally follow the suggestions of Vollmerhausen and Turnham (1988).

1.3.2 Comparisons With Background Locations

In many environmental assessments, samples are collected from an upstream or nearby area that has been selected to reflect chemical concentrations in the local area that are not impacted by the site. In the RI, Wehran (1990) selected a "Control Creek" area to be used to represent "background" for comparison to the site for the purpose of selecting chemicals of potential concern and assessing risks. Upon EPA's recommendation, the Control Creek area (which is downstream of the site) will not be used as an estimate of background concentrations.

For the purposes of this risk assessment, sediment chemistry data from the reference locations used in the Adams et al. (1990) and Charters et al. (1991) studies were combined and used to represent background concentrations. The reference location used in Adams et al. (1990) is located on the Raritan River, upstream of Kin-Buc near the New Jersey Turnpike Bridge. Although sediments from this area could be impacted by tidal transport of contaminants from Kin-Buc or by other local sources of contaminants, PCBs were not detected in the single sediment sample that was analyzed. The Charters et al. (1991) reference area is on the South River. Although it may also receive contaminants from other local sources, PCBs were not detected in any of the five sample locations analyzed.

Comparisons of site areas to the background concentrations for selecting chemicals of concern in sediments are described in section 1.3.4. Tissue concentrations in animals collected from reference areas identified in the Adams et al. (1990) and Charters et al. (1991) reports were compared with concentrations determined in animals collected from the site. No other areas were identified for characterizing background water or biota concentrations.

1.3.3 Chemicals in Surface Water

The frequency, geometric mean, and maximum concentrations of detected chemicals in surface waters at the site are listed in Table 1-2. Chemicals of potential concern in surface water were identified based on frequency of occurrence and concentration relative to levels of concern for aquatic toxicity. A guidance that chemicals of potential concern should be detected in at least five percent of the samples (EPA 1989a) was not used because no more than five samples were

TABLE 1-2. Compounds Detected in Surface Water at Kin-Buc II Site

Compound	A. POOL C AND CHANNEL			B. EDMONDS TIDAL			C. EDMONDS NON-TIDAL			D. LOW LYING AREA		
	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM
VOCs: (ug/l)												
Benzene	1/2	NC	57.0	1/5	NC	0.6	1/2	NC	2.0	0/1		
2-Butanone (a)	1/1	NC	12.0	0/5			0/2			0/1		
Chlorobenzene (a)	1/2	NC	310.0	0/5			0/2			0/1		
Ethylbenzene	2/2	7.3	53.0	0/5			0/2			0/1		
Methylene Chloride	0/2			0/5			1/2	NC	2.0	0/1		
Styrene (a)	1/2	NC	0.6	0/5			0/2			0/1		
Tetrachloroethene	1/2	NC	2.0	0/5			0/2			0/1		
Toluene	0/2			1/5	NC	0.8	1/2	NC	1.0	0/1		
Xylene (total) (a,c)	2/2	42.4	600.0	0/5			1/2	NC	0.8	0/1		
PAHs: (ug/l)												
2-Methylnaphthalene (a)	1/2	NC	1.0	0/5			0/2			0/1		
Naphthalene	1/2	NC	13.0	0/5			0/2			0/1		
Other Semivolatiles: (ug/l)												
N-Nitrosodiphenylamine (a)	1/2	NC	4.0	0/5			0/2			0/1		
Phenol	1/2	NC	8.0	0/5			0/2			0/1		
Phthalates: (ug/l)												
Di-n-butylphthalate	1/2	NC	1.0	0/5			0/2			0/1		
Pesticides/PCBs: (ug/l)												
Aldrin	1/3	NC	0.049	0/5			0/2			0/1		
4,4'-DDT (a)	1/3	NC	0.16	0/5			0/2			0/1		
Aroclor 1254 (a)	1/3	NC	0.33	0/5			0/2			0/1		
Metals: (ug/l)												
Aluminum (a,b,c,d)	2/2	702.0	764.0	5/5	885.7	4380.0	2/2	2703.0	2970.0	1/1	NC	24700.0
Antimony	0/2			4/5	30.2	48.2	0/2			0/1		
Arsenic (a)	2/2	3.0	7.0	1/5	NC	1.3	0/2			1/1	NC	3.5
Barium (a,b,c,d)	2/2	94.8	346.0	5/5	53.3	100.0	2/2	91.6	95.7	1/1	NC	312.0
Beryllium	0/2			1/5	0.7	1.9	2/2	1.2	1.2	1/1	NC	1.6
Calcium	2/2	57048.4	73300.0	5/5	103278.6	154000.0	2/2	19273.0	30700.0	1/1	NC	54700.0
Chromium (a,b,c,d)	2/2	3.2	6.8	1/5	NC	6.2	2/2	4.6	6.4	1/1	NC	120.0
Cobalt (a,b,c,d)	2/2	39.4	70.7	1/5	NC	220.0	2/2	128.3	163.0	1/1	NC	27.8
Copper (a,b,c,d)	R			5/5	27.5	129.0	2/2	90.8	127.0	1/1	NC	133.0
Iron (a,b,c,d)	2/2	5439.2	30500.0	5/5	1545.0	5900.0	2/2	3159.7	5200.0	1/1	NC	54100.0
Lead	2/2	8.1	15.3	3/5	1.4	3.8	2/2	2.8	3.1	1/1	NC	47.2
Magnesium	2/2	42131.6	48900.0	5/5	192073.8	455000.0	2/2	8000.5	12600.0	1/1	NC	25900.0
Manganese (a,b,c,d)	2/2	330.9	468.0	2/5	149.6	652.0	2/2	542.1	563.0	1/1	NC	790.0
Mercury (d)	0/2			0/5			0/2			1/1	NC	0.11
Nickel (a,b,c,d)	2/2	103.2	162.0	4/5	15.4	407.0	2/2	203.9	295.0	1/1	NC	59.0

TABLE 1-2. Compounds Detected in Surface Water at Kin-Buc II Site

Compound	A. POOL C AND CHANNEL			B. EDMONDS TIDAL			C. EDMONDS NON-TIDAL			D. LOW LYING AREA		
	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM
Potassium	2/2	48528.3	94200.0	5/5	75697.7	143000.0	2/2	8513.0	14700.0	1/1	NC	47600.0
Sodium	2/2	279749.9	301000.0	5/5	1383242.4	4190000.0	2/2	22322.6	54300.0	1/1	NC	72300.0
Vanadium (a,b,c,d)	1/2	NC	5.0	1/5	NC	8.8	1/2	NC	6.0	1/1	NC	152.0
Zinc (a,b,c,d)	2/2	54.4	56.6	1/5	NC	397.0	2/2	227.7	247.0	1/1	NC	153.0
Inorganics: (mg/l)												
Ammonia-Nitrogen	2/2	45.7	158.0	5/5	0.8	7.4	2/2	1.1	7.4	1/1	NC	13.1
Cyanide (ug/l)	0/2			1/5	NC	11.5	0/2			1/1	NC	22.2

R - Rejected
NC - Not calculated

a - Selected as chemical of potential concern: Pool C and Connecting Channel Area
b - Selected as chemical of potential concern: Edmonds Tidal Area
c - Selected as chemical of potential concern: Edmonds Non-Tidal Area
d - Selected as chemical of potential concern: Low Lying Area

collected from each site area. Therefore, none of the detected chemicals were removed from consideration based on a low frequency of detection.

Toxicity to aquatic biota was used as an initial screening procedure. Chemicals detected at a maximum concentration that was less than one-half the EPA (1986) ambient water quality criteria or lowest observed effect level (LOEL) were removed from further consideration. Toxicity values used for this screening are listed in Table 1-3. Chemicals removed for this reason were: aldrin, antimony, benzene, beryllium, di-n-butylphthalate, ethylbenzene, naphthalene, phenol, tetrachloroethene, and toluene. Four metals (calcium, magnesium, potassium, and sodium), which are only toxic to aquatic and terrestrial wildlife at extremely high levels, were also removed from further consideration.

Methylene chloride, which was detected in one of two samples from the non-tidal Edmonds Creek area and in no other samples, is a common laboratory contaminant. Therefore, it was not considered to be a chemical of potential concern.

The remaining chemicals are selected as chemicals of potential concern (Table 1-4).

1.3.4 Chemicals in Sediments

Frequency of detection, geometric mean, and maximum concentrations for chemicals detected in sediments are listed in Table 1-5.

A series of procedures was used to select chemicals of potential concern. The 5 percent frequency guideline was first applied to eliminate infrequently detected chemicals. The following chemicals were eliminated from further consideration on this basis: methylene chloride, 1,1-dichloroethane, vinyl acetate, isophorone, 1,2,4-trichlorobenzene, 4-methylphenol, and di-n-butylphthalate. Toxicity criteria were applied to eliminate the following chemicals of low toxic potential to aquatic life: calcium, magnesium, potassium, and sodium.

Scientists have long been concerned about contaminants in sediments for several reasons. Many chemicals tend to accumulate in sediments which frequently results in sediment contaminant concentrations much greater than surface water concentrations. In addition to serving as a sink for contaminants, sediments can also release contaminants into the overlying water (EPA 1987). Recently, EPA has begun a program to establish sediment quality criteria SQC which will be numeric guidelines for evaluating hazards of contaminants in sediments. SQC may be applied in the evaluation of dredged materials, the assessment of risks and setting of goals for remediation at hazardous waste sites, the monitoring of habitat quality, and the permitting of discharges (EPA 1987).

Table 1-3. Ambient water quality criteria (AWQC), lowest observed effect levels (LOELs), and fish LC_{50s} used as guidance for selecting chemicals of potential concern in surface water[a]

Chemicals	AWQC (µg/L)[b]		LOEL (µg/L)		Fish LC_{50s} (µg/L)[c]
	Acute	Chronic	Acute	Chronic	
VOCs:					
Benzene			5100	700	
2-Butanone					5,600,000[d]
Chlorobenzene			160	50	
Styrene					25,100-74,800[d]
Ethylbenzene			430		
Tetrachlorethene			5280	450	
Toluene			6300	5000	
Total Xylenes					9,200-36,800[d]
PAHs:					
Naphthalene			2300	620	
2-Methylnaphthalene					NA
Other semivolatiles:					
N-nitrosodiphenylamine					NA
Phenol			5800	2560	
Phthalates:					
Di-n-butylphthalate			940	3	
Pesticides/PCBs:					
Aldrin	1.3				
4-4'-DDT	0.13	0.001			
Aroclor 1254	2.0	0.014			
Metals:					
Aluminum	750	87			
Antimony			9000	1600	
Arsenic	69	36			
Barium					76,000[e]
Beryllium			130	5.3	
Chromium	16	11			

Table 1-3. (Continued)

Chemicals	AWQC (μg/L)[a]		LOEL (μg/L)		Fish LC_{50s} (μg/L)[b]
	Acute	Chronic	Acute	Chronic	
Metals (Continued):					
Cobalt					48,000[e]
Copper	2.9	2.9			
Iron		1000			
Lead	82	3.2			
Manganese					1,000[f]
Mercury	2.1	0.012			
Nickel	75.0	8.3			
Vanadium					4,800-17,400[g]
Zinc	95	86			
Inorganics:					
Cyanide	1	1			
Ammonia (total NH_3-N)	24,000	1,730			

*Lower of freshwater and marine AWQC or LOEL is presented.

[a] See section 3.1.1 for details on selection of appropriate AWQC.

[b] Range of 96-hour values with freshwater fish.

[c] Verschueren (1983).

[d] Sprague and Logan (1979).

[e] Ewell et al. (1986).

[f] Suggested as non-deleterious level by McKee and Wolf (1963).

[g] Lee (1983).

Table 1-4. Chemicals of Potential Concern

I. Surface Water

	A. Pool C+ Channel	B. Edmonds Tidal	C. Edmonds Non-Tidal	D. Low Lying Area
VOCs:				
2 Butanone	X			
Chlorobenzene	X			
Styrene	X			
Xylenes	X		X	
PAHs:				
2- Methylnaphthalene	X		X	
Other semivolatiles:				
N-Nitrosodiphenylamine	X			
Pesticides/PCBs:				
DDT	X			
Aroclor 1254	X			
Metals:				
Aluminum	X	X	X	X
Arsenic	X	X	X	X
Barium	X	X	X	X
Chromium	X	X	X	X
Cobalt	X	X	X	X
Copper	X	X	X	X

Table 1-4. Continued

I. Surface Water (Continued)				
	A. Pool C and Channel	B. Edmonds Tidal	C. Edmonds Non-Tidal	D. Low Lying Area
Iron	X	X	X	X
Lead	X	X	X	X
Nickel	X	X	X	X
Vanadium	X	X	X	X
Zinc	X	X	X	X
Inorganics:				
Ammonia	X	X	X	X
Cyanide		X		X

Table 1-4. Continued

II. Sediments								
	A. Pool C and Channel	**B. Edmonds Tidal**	**C. Edmonds Non-tidal**	**D. Low Lying Area**	**E. Martins Creek**	**F. Mill Brook**	**G. Raritan River**	**H. Unnamed Ditch**
PAHs:								
Phenanthrene	X		X	X	X	X		
Pyrene	X		X			X	X	
Total PAHs	X	X		X	X	X		X
PCB's:								
Aroclor 1254	X	X		X		X	X	X
Total PCBs	X	X		X		X	X	X
Metals:								
Antimony	X	X			X			
Arsenic	X	X						X
Cadmium					X			
Chromium								
Copper		X						
Lead		X						
Mercury		X						X
Nickel	X	X						
Silver								X
Zinc		X						

Table 1-4. Continued

III. Biota			
	Edmonds Tidal	**Martin Creek**	**Mill Brook**
Mummichog			
PCBs:			
Aroclor 1248	X	X	X
Aroclor 1254	X	X	X
Aroclor 1260		X	
Metals:			
Cadmium			X
Chromium	X	X	X
Lead		X	X
Fiddler Crab			
PCBs:			
Aroclor 1248	X		
Aroclor 1254	X		
Aroclor 1260		X	
Metals:			
Cadmium	X		
Chromium	X		
Lead	X		

Table 1-4. Continued

	III. Biota	
	Edmonds Tidal	**Martin's Creek**
Muskrat		
PCBs:		
Aroclor 1254	X	X
Metals:		
Cadmium	X	X
Chromium	X	X
Lead	X	X
Norway rat:		
PCBs:		
Aroclor 1260	X	
Metals:		
Cadmium	X	
Chromium	X	
Lead	X	
House mouse		
PCBs:		
Aroclor 1260	X	

Table 1-5. Compounds detected in sediments at Kin-Buc II site.*

	A. POOL C AND CHANNEL			B. EDMONDS CREEK - TIDAL			C. EDMONDS - NONTIDAL			D. LOW LYING AREA		
Compound	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM
VOCs: (mg/kg)												
Acetone	1/8	NC	0.220	4/28	0.008	0.260	0/3			0/2		
Benzene	3/8	0.005	0.044	1/28	NC	0.019	1/3	NC	0.120	1/2	NC	0.078
2-Butanone	2/8	0.006	0.082	6/28	0.007	1.300	0/3			0/2		
Carbon Disulfide	0/8			1/28	NC	0.005	0/3			0/2		
Chlorobenzene	3/8	0.010	0.069	1/28	NC	0.310	0/3			1/2	NC	0.042
1,1-Dichloroethane	0/8			1/28	NC	0.039	0/3			0/2		
Ethylbenzene	3/8	0.007	0.036	3/28	0.004	16.000	1/3	NC	0.015	0/2		
Methylene Chloride	0/8			1/28	NC	0.004	0/3			0/2		
Tetrachloroethene	0/8			2/28	0.004	0.360	0/3			0/2		
Toluene	2/8	0.005	0.040	1/28	NC	0.009	0/3			0/2		
1,1,1-Trichloroethane	0/8			2/28	0.004	1.300	0/3			0/2		
Vinyl Acetate	0/8			1/28	NC	0.027	0/3			0/2		
Xylene (total)	3/8	0.012	0.056	3/28	0.004	16.000	1/3	NC	0.019	1/2	NC	0.011
PAHs: (mg/kg)												
Acenaphthene	0/8			4/58	0.340	2.600	0/3			2/2	0.017	0.018
Acenaphthylene	3/8	NR	0.060	34/59	0.119	1.350	0/3			2/2	0.039	0.055
Anthracene	3/8	NR	0.051	41/59	0.108	1.200	0/3			2/2	0.045	0.076
Benzo(a)anthracene	1/8	NC	0.250	34/59	0.212	1.200	0/3			2/2	0.267	0.420
Benzo(a)pyrene	1/8	NC	0.190	40/59	0.218	1.500	0/3			2/2	0.280	0.460
Benzo(b)fluoranthene	3/8	0.188	0.340	28/58	0.281	1.600	0/3			2/2	0.255	0.310
Benzo(g,h,i)perylene	0/8			21/58	0.197	1.500	0/3			0/2		
Benzo(k)fluoranthene	1/8	NC	0.200	31/59	1.330	0.850	0/3			2/2	0.134	0.380
Chrysene	3/8	0.199	0.320	33/59	0.239	1.100	0/3			2/2	0.325	0.480
Fluoranthene	7/8	0.706	2.900	54/59	0.322	7.900	3/3	0.028	0.039	2/2	0.422	0.660
Fluorene	1/8	NC	0.018	9/58	0.276	1.500	0/3			2/2	0.029	0.032
Indeno(1,2,3-cd)pyrene	0/8			29/59	0.183	1.500	0/3			2/2	0.133	0.220
2-Methylnaphthalene	2/8	0.176	3.900	12/58	0.225	1.500	0/3			1/2	NC	0.089
Naphthalene	3/8	0.101	0.110	12/58	0.249	1.500	1/3	NC	0.007	1/2	NC	0.160
Phenanthrene (a,c,d)	6/8	0.386	14.000	45/59	0.251	5.900	1/3	NC	0.019	2/2	0.215	0.330
Pyrene (a,c)	8/8	0.969	25.000	27/58	0.382	4.900	3/3	0.036	0.049	2/2	0.626	0.900
Total PAHs (a,b,e,f,h)	8/8	5.746	54.000	56/59	0.864	15.970	3/3	0.007	0.008	2/2	3.012	4.421
Other Semi-Volatile Compounds: (mg/kg)												
2-Chlorophenol	0/8			4/27	NR	0.014	0/3			0/2		
1,2-Dichlorobenzene	0/8			2/27	0.006	0.190	0/3			0/2		
1,4-Dichlorobenzene	1/8	NC	0.038	2/27	0.006	0.180	0/3			1/2	NC	0.190
2,4-Dinitrophenol	0/8			0/27			0/3			0/2		
4-Methylphenol	0/8			1/27	NC	0.066	0/3			0/2		
Benzoic acid	2/8	0.050	1.100	16/27	0.164	8.800	2/3	0.072	0.190	2/2	0.104	0.160
Benzyl alcohol	0/8			0/27			0/3			0/2		
Dibenzofuran	0/8			3/27	0.007	0.160	0/3			2/2	0.009	0.010
Isophorone	0/8			1/27	NC	0.012	0/3			0/2		
N-Nitrosodiphenylamine	2/8	0.018	12.000	2/27	0.006	0.390	0/3			1/2	NC	0.098
1,2,4-Trichlorobenzene	0/8			1/27	NC	0.017	0/3			0/2		
Phthalates												
bis(2-Ethylhexyl)phthalate	6/8	14.553	3500.000	21/27	2.377	440.000	1/3	NC	1.100	0/2		
Butylbenzylphthalate	5/8	0.447	42.000	3/27	0.166	0.500	0/3			2/2	0.062	0.083
Diethylphthalate	4/8	0.129	0.150	6/27	NR	0.060	1/3	NC	0.029	1/2	NC	0.018
Dimethylphthalate	0/8			0/27			0/3			0/2		

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Table 1-5 (cont.). Compounds detected in sediments at Kin-Buc II site.*

Compound	A. POOL C AND CHANNEL			B. EDMONDS CREEK - TIDAL			C. EDMONDS - NONTIDAL			D. LOW LYING AREA		
	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM
Di-n-butylphthalate	0/8			1/27	NC	0.380	0/3	0.165		0/2		
Di-n-octylphthalate	0/8			18/27	0.109	8.700	3/3	0.051	0.510	2/2	0.040	0.056
PCB's: (mg/kg)												
Aroclor-1242	3/13	0.240	600.000	12/91	0.900	300.000	0/3			0/2		
Aroclor-1248	9/13	1.828	290.000	48/90	0.349	69.000	0/3			1/2	NC	0.700
Aroclor-1254 (a,b,d)	7/13	0.531	130.000	66/102	0.264	37.000	0/3			1/2	NC	0.200
Aroclor-1260	0/13			11/91	0.137	3.600	0/3			1/2	NC	0.220
Total PCBs** (a,b,d)	13/13	30.621	730.000	85/102	0.423	300.000	0/3			2/2	0.450	0.700
Metals: (mg/kg)												
Aluminum	8/8	11820.05	22000.00	27/27	15750.30	29800.00	3/3	13261.97	17800.00	2/2	8431.14	8690.00
Antimony (a,b,e)	5/8	5.26	13.10	2/59	5.89	25.25	0/3			0/2		
Arsenic (a,b,h)	8/8	20.92	174.00	56/56	42.12	257.00	1/1	NC	2.70	R		
Barium	8/8	65.95	166.00	27/27	57.93	142.00	3/3	52.65	58.50	2/2	63.30	93.40
Beryllium	8/8	1.03	2.20	25/27	1.03	1.90	3/3	1.29	1.50	2/2	0.97	1.10
Cadmium (e)	2/8	1.08	2.80	19/59	1.13	3.30	0/3			0/2		
Calcium	5/5	1492.30	2680.00	27/27	1751.83	5150.00	3/3	1255.18	2240.00	2/2	1923.90	1990.00
Chromium	8/8	58.93	110.00	59/59	57.46	116.00	3/3	37.65	44.30	2/2	24.48	31.70
Cobalt	8/8	16.92	41.20	26/27	17.10	57.80	3/3	14.74	19.00	2/2	13.93	16.30
Copper (b)	8/8	133.51	242.00	59/59	98.21	441.00	3/3	43.02	53.70	2/2	74.81	77.20
Iron	8/8	22577.07	48000.00	27/27	28033.57	59500.00	3/3	16035.82	18200.00	2/2	19889.70	34400.00
Lead (b)	8/8	115.51	258.00	50/50	76.34	372.00	3/3	19.53	22.20	2/2	51.27	60.30
Magnesium	6/6	3691.94	6140.00	27/27	5276.74	8930.00	3/3	5046.35	8020.00	2/2	2440.98	2660.00
Manganese	8/8	97.72	366.00	27/27	160.89	423.00	3/3	74.49	105.00	2/2	112.47	149.00
Mercury (b,h)	7/8	0.53	1.50	46/59	0.49	3.30	0/3			2/2	0.06	0.07
Nickel (a,b)	8/8	34.34	85.80	59/59	43.47	176.00	3/3	28.73	39.50	2/2	18.39	21.00
Potassium	8/8	2143.62	4010.00	27/27	2898.16	4800.00	3/3	4647.81	7990.00	2/2	2075.72	5580.00
Selenium	5/8	1.19	3.80	12/27	0.96	13.80	0/3			0/2		
Silver (h)	5/8	1.02	4.10	11/45	0.94	4.70	0/3			1/2	NC	0.81
Sodium	5/5	1977.43	3750.00	27/27	2491.16	12600.00	3/3	779.33	1940.00	2/2	293.07	352.00
Thallium	0/8			0/27			1/3	NC	0.76	0/2		
Vanadium	8/8	53.19	97.60	27/27	44.16	82.30	3/3	43.66	48.10	2/2	35.78	44.60
Zinc (b)	8/8	238.77	526.00	54/54	190.68	662.00	1/1	NC	63.70	R		
Cyanide	0/8			2/26	0.71	24.00	0/3			0/3		

a - Selected as chemical of potential concern: Pool C and Connecting Channel
b - Selected as chemical of potential concern: Edmonds Tidal Area
c - Selected as chemical of potential concern: Edmonds Non-tidal Area
d - Selected as chemical of potential concern: Edmonds Non-tidal Area
e - Selected as chemical of potential concern: Low Lying Area
f - Selected as chemical of potential concern: Martins Creek
g - Selected as chemical of potential concern: Mill Brook
h - Selected as chemical of potential concern: Unnamed Ditch
NC - Not calculated
NR - Not reported because geo. mena exceeded maximum value
R - Rejected
* - Data from Wehran (1990); additional data from Wehran (1991), Adams et al (1990), and Charters et al. (1991) added for PCBs, PAHs, and metals identified as contaminants of concern.
** - Total PCBs calculated using a value of 80 ug/Kg for non-detects. For some samples, data were only presented for Arochlors 1248 and 1254.

Table 1-5 (cont.). Compounds detected in sediments at Kin-Buc II site.

Compound	E. MARTINS CREEK			F. MILL BROOK			G. RARITAN RIVER			H. UNNAMED DITCH			I. BACKGROUND AREAS		
	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM
VOCs: (mg/kg)															
Acetone	2/4	0.033	0.230	1/3	NC	0.920	0/2			0/3					
Benzene	1/4	NC	0.002	0/3			0/2			0/3					
2-Butanone	3/4	0.019	0.071	2/3	0.044	1.100	0/2			0/3					
Carbon Disulfide	1/4	NC	0.014	0/3			0/2			2/3	0.007	0.015			
Chlorobenzene	1/4	NC	0.160	0/3			0/2			0/3					
1,1-Dichloroethane	0/4			0/3			0/2			0/3					
Ethylbenzene	0/4			0/3			0/2			0/3					
Methylene Chloride	0/4			0/3			0/2			0/3					
Tetrachloroethene	0/4			0/3			0/2			0/3					
Toluene	0/4			0/3			0/2			0/3					
1,1,1-Trichloroethane	0/4			0/3			0/2			0/3					
Vinyl Acetate	0/4			0/3			0/2			0/3					
Xylene (total)	2/4	0.004	0.006	1/3	NC	0.025	0/2			0/3					
PAHs: (mg/kg)															
Acenaphthene	4/5	0.138	0.360	1/3	NC	0.021	1/2	NC	0.026	1/15	NR	0.260	0/1	NC	
Acenaphthylene	4/5	0.103	0.190	3/3	0.010	0.016	1/2	NC	0.019	8/15	0.140	0.170	0/1	NC	
Anthracene	4/5	0.321	1.100	3/3	0.030	0.130	2/2	0.061	0.072	8/15	NR	0.110	0/1	NC	
Benzo(a)anthracene	4/5	0.650	1.200	2/3	0.185	0.390	2/2	0.216	0.260	11/15	0.140	0.360	1/1	NC	0.29
Benzo(a)pyrene	4/5	0.574	0.830	3/3	0.106	0.310	2/2	0.183	0.240	10/15	0.180	0.390	1/1	NC	0.37
Benzo(b)fluoranthene	4/5	0.462	0.810	3/3	0.102	0.310	2/2	0.108	0.130	5/15	0.240	1.000	1/1	NC	0.52
Benzo(g,h,i)perylene	4/5	0.154	0.350	3/3	0.052	0.160	1/2	NC	0.091	6/15	0.170	0.320	1/1	NC	0.11
Benzo(k)fluoranthene	3/5	0.286	0.840	3/3	0.060	0.094	1/2	NC	0.110	9/15	0.090	0.120	1/1	NC	0.39
Chrysene	4/5	0.687	1.300	3/3	0.135	0.410	1/2	0.177	0.190	11/15	0.150	0.460	1/1	NC	0.39
Fluoranthene	5/5	0.699	1.600	3/3	0.238	0.720	2/2	0.365	0.380	13/15	0.170	0.800	1/1	NC	0.64
Fluorene	5/5	0.087	0.570	1/3	NC	0.043	1/2	NC	0.035	5/15	0.170	0.290	1/1	NC	
Indeno(1,2,3-cd)pyrene	4/5	0.198	0.380	3/3	0.077	0.200	1/2	NC	0.110	8/15	0.150	0.320	1/1	NC	0.13
2-Methylnaphthalene	2/5	NR	0.037	0/3			1/2	NC	0.009	4/15	0.190	0.270	0/1	NC	
Naphthalene	4/5	0.070	0.120	3/3	0.010	0.011	1/2	NC	0.016	5/15	0.140	0.280	0/1	NC	
Phenanthrene (a,c,d)	4/5	0.910	1.200	3/3	0.128	0.450	2/2	0.126	0.170	12/15	0.150	0.380	0/1	NC	0.30
Pyrene (a,c)	5/5	1.223	3.600	3/3	0.283	0.790	2/4	0.377	0.430	6/15	0.220	0.740	1/1	NC	0.73
Total PAHs (a,b,e,f,h)	5/5	4.253	14.794	3/3	1.353	4.018	2/2	1.750	1.957	14/15	0.800	5.220	1/1	NC	3.87
Other Semi-Volatile Compounds: (mg/kg)															
2-Chlorophenol	0/4			0/3			0/2			0/3					
1,2-Dichlorobenzene	0/4			0/3			0/2			0/3					
1,4-Dichlorobenzene	2/4	0.009	0.018	0/3			0/2			0/3					
2,4-Dinitrophenol	0/4			0/3			0/2			0/3					
4-Methylphenol	1/4	NC	0.033	0/3			0/2			0/3					
Benzoic acid	3/4	0.077	0.330	3/3	0.068	0.220	1/2	NC	0.087	0/3					
Benzyl alcohol	1/4	NC	0.040	0/3			0/2			0/3					
Dibenzofuran	1/4	NC	0.066	0/3			0/2			0/3					
Isophorone	0/4			0/3			0/2			0/3					
N-Nitrosodiphenylamine	2/4	0.022	0.270	0/3			0/2			0/3					
1,2,4-Trichlorobenzene	0/4			0/3			0/2			0/3					
Phthalates															
bis(2-Ethylhexyl)phthalate	3/4	1.777	4.300	0/3			1/2	NC	8.700	0/3					
Butylbenzylphthalate	1/4	NC	0.750	0/3			0/2			0/3					
Diethylphthalate	1/4	NC	0.011	3/3	0.024	0.051	0/2			0/3					
Dimethylphthalate	1/4	NC	0.032	0/3			0/2			0/3					

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Table 1-5 (cont.). Compounds detected in sediments at Kin-Buc II site.

Compound	E. MARTINS CREEK			F. MILL BROOK			G. RARITAN RIVER			H. UNNAMED DITCH			I. BACKGROUND AREAS		
	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM
Di-n-butylphthalate	0/4			0/3			0/2			0/3					
Di-n-octylphthalate	1/5	NC	0.140	1/3	NC	0.008	1/2	NC	0.025	0/3					
PCB's: (mg/kg)															
Aroclor-1242	0/4			0/3			0/5			0/10					
Aroclor-1248	0/4			0/3			1/5	NC	3.300	1/10	0.100	2.100			
Aroclor-1254	0/5			1/3	0.085	0.096	1/5	NC	0.140	9/15	0.240	0.870			
Aroclor-1260	0/5			0/3			0/5			0/10					
Total PCBs	0/4			1/3	0.085	0.096	2/5	0.250	3.300	9/15	0.320	2.970			
Metals: (mg/kg)															
Aluminum	5/5	10555.40	20400.00	3/3	8075.41	22800.00	1/1	NC	24600.00	3/3	16882.90	18300.00			
Antimony	1/5	NC	4.00	0/3			0/1			0/26			0/1		
Arsenic	2/2	21.79	23.50	R			R			14/14	22.99	125.00	6/6	22.70	31.50
Barium	5/5	113.88	276.00	3/3	65.84	80.00	1/1	NC	123.00	3/3	48.10	52.60			
Beryllium	5/5	98.00	1.70	3/3	1.17	2.10	1/1	NC	1.60	1/3	NC	0.86			
Cadmium	2/5	1.62	29.40	0/3			0/1			9/15	1.02	2.50	0/1		
Calcium	5/5	3085.15	17100.00	3/3	1166.08	1680.00	1/1	NC	2010.00	3/3	2454.79	5600.00			
Chromium	5/5	50.95	62.80	3/3	30.66	39.20	1/1	NC	41.10	15/15	43.14	117.00	6/6	40.10	67.80
Cobalt	5/5	9.88	18.90	3/3	9.13	21.50	1/1	NC	14.10	2/3	9.72	17.50			
Copper	5/5	63.58	126.00	3/3	47.64	57.00	1/1	NC	35.40	13/14	58.36	297.00	6/6	51.00	162.00
Iron	5/5	24662.00	32400.00	3/3	17715.54	21100.00	1/1	NC	31700.00	3/3	36432.01	50300.00			
Lead	5/5	77.73	227.00	3/3	80.90	163.00	1/1	NC	49.10	10/10	25.36	172.00	6/6	90.00	160.00
Magnesium	5/5	4326.22	7100.00	3/3	2792.44	8380.00	1/1	NC	7150.00	3/3	5713.97	7120.00			
Manganese	5/5	200.92	279.00	3/3	145.89	230.00	1/1	NC	704.00	3/3	182.41	219.00			
Mercury	4/5	0.18	0.69	1/3	NC	0.07	1/1	NC	0.18	8/15	0.39	3.40	6/6	0.35	1.00
Nickel	5/5	23.41	25.80	3/3	27.27	35.30	1/1	NC	29.10	15/15	23.65	57.40	6/6	23.60	36.00
Potassium	5/5	1908.00	3910.00	3/3	1626.15	5880.00	1/1	NC	3010.00	3/3	2916.96	3620.00			
Selenium	2/5	0.51	1.40	0/3			0/1			2/3	1.21	3.20			
Silver	2/5	0.88	2.20	2/3	0.44	0.77	1/1	NC	0.98	7/11	1.43	7.50	2/6	1.72	3.50
Sodium	5/5	939.29	1110.00	3/3	175.18	324.00	1/1	NC	2480.00	3/3	6366.78	16900.00			
Thallium	0/5			1/3	NC	0.68	0/1			0/3					
Vanadium	5/5	43.22	57.50	3/3	24.66	55.70	1/1	NC	51.00	3/3	46.05	49.90			
Zinc	2/2	218.83	292.00	R			R			15/15	110.82	293.00	6/6	118.80	268.00
Cyanide	0/4			0/3			0/1			0/3					

a - Selected as chemical of potential concern: Pool C and Connecting Channel
b - Selected as chemical of potential concern: Edmonds Tidal Area
c - Selected as chemical of potential concern: Edmonds Non-tidal Area
d - Selected as chemical of potential concern: Edmonds Non-tidal Area
e - Selected as chemical of potential concern: Low Lying Area
f - Selected as chemical of potential concern: Martins Creek
g - Selected as chemical of potential concern: Mill Brook
h - Selected as chemical of potential concern: Unnamed Ditch
NC - Not calculated
NR - Not reported because geo. mean exceeded maximum value
R - Rejected
* - Data from Wehran (1990); additional data from Wehran (1991), Adams et al (1990), and Charters et al. (1991) added for PCBs, PAHs, and metals identified as contaminants of concern.
** - Total PCBs calculated using a value of 80 ug/Kg for non-detects. For some samples, data were only presented for Arochlors 1248 and 1254.

Although SQC analogous to AWQC have not been formally adopted by EPA, sediment guidance values are available and were used as a toxicity screen. EPA (1988) published interim SQC for the following chemicals which were detected in Kin-Buc sediments: Aroclor 1254, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, flouranthene, phenanthrene, and pyrene. Site-specific criteria (Table 1-6) were calculated for each site area based on organic carbon content (EPA 1988). For these calculations, the geometric mean total organic carbon content for each site area was used. For each site area, chemicals detected at a maximum concentration less than one-half of the organic carbon adjusted SQC were removed from consideration as chemicals of potential concern.

In this risk assessment, the ER-L (Effects Range-Low) and ER-M (Effects Range-Median) values (Table 1-6) listed in Long and Morgan (1990) were used as guidance for the chemicals of potential concern (total PCBs, total PAHs, and metals) for which EPA SQC have not been proposed. The derivation of these sediment guidance values is discussed in Section 3.1.2. These values are not adjusted for organic carbon content. All site areas where maximum concentrations were less than the ER-L values were removed from consideration.

Versar is aware that there are concerns over the accuracy and applicability of the interim SQC and the ER-L and ER-M values. These values are used in the absence of other guidance values for sediment contamination. EPA's Science Advisory Board (1990) reviewed the Equilibrium Partitioning Approach which is the basis for the interim SQC. They concluded that there were considerable uncertainties associated with the Approach (and therefore the derivation of the SQC), which would limit its application. Long and Morgan (1990) state that whereas the ER-L and ER-M values may be used as guidance values, they are not to be construed as NOAA standards or criteria. They state further that their degree of confidence in the individual values varies from chemical to chemical.

A number of chemicals measured in on-site sediments do not have guidance values. These chemicals were removed from further consideration as chemicals of potential concern because, due to the sparse database on the toxic effects of contaminants in sediments, it is highly unlikely that data linking sediment concentrations with toxic effects exist. Applying this criterion resulted in the elimination of the following chemicals from further consideration: acetone, aluminum, barium, benzene, benzoic acid, benzyl alcohol, beryllium, bis(2-ethylhexyl)phthalate, 2-butanone, butylbenzylphthalate, carbon disulfide, chlorobenzene, 2-chlorophenol, cobalt, cyanide, dibenzofuran, 1,4-dichlorobenzene, diethylphthalate, dimethylphthalate, di-n-octylphthalate, ethylbenzene, iron, manganese, N-nitrosodiphenylamine, selenium, 1,1,1-tetrachloroethene, thallium, toluene, trichloroethane, vanadium, and total xylenes.

Table 1-6. Sediment quality values used as guidance for selecting chemicals of potential concern in sediments (mglkg)

I. EPA Sediment Quality Criteria (mg/kg)*								
	A. Pool C and Channel	B. Edmonds Tidal	C. Edmonds Non-tidal	D. Low Lying Area	E. Martins Creek	F. Mill Brook	G. Raritan River	H. Unnamed Ditch
PAHs:								
Acenaphthene	ND	7.56	ND	4.50	6.48	0.90	3.78	4.67
Benzo(a) anthracene	12.80	9.11	ND	5.42	7.81	1.08	4.56	5.63
Benzo(a) pyrene	13.82	9.45	ND	5.62	8.10	1.12	4.72	5.84
Fluoranthene	24.96	17.77	4.65	10.58	15.23	2.16	8.88	11.00
Phenanthrene	1.40	1.00	0.26	0.60	0.86	0.12	0.50	0.62
Pyrene	15.64	11.3	2.96	6.62	9.54	1.32	5.56	6.89
PCBs:								
Aroclor 1254	0.23	0.16	ND	0.097	ND	0.019	0.080	0.100

ND = Not detected; sediment quality criteria not calculated.

* EPA Sediment Quality Criteria are calculated using the lower of the freshwater and saltwater values adjusted for the geometric mean total organic carbon content for the area.

Table 1-6. Continued

II. ER-L, ER-M Values (all areas) (mg/kg)		
	ER-L	**ER-M**
Total PAHs:	4	35
Total PCBs:	0.05	0.400
Metals:		
Antimony	2	25
Arsenic	33	85
Cadmium	5	9
Chromium	80	145
Copper	70	390
Lead	35	110
Mercury	0.15	1.3
Nickel	30	50
Silver	1	2.2
Zinc	120	270

Concentrations of PAHs and metals in sediments may also be attributed to natural and regional anthropogenic inputs as well as site-related contamination. The background areas (from Adams et al. (1990) and Charters et al. (1991) were fairly well characterized for metals (6 samples) but not for PAHs (only 1 sample). Therefore, maximum metal concentrations in the background areas were compared against metal concentrations in the site areas. If any of the site area samples for a metal exceeded twice the maximum background concentration, and this concentration was greater than the ER-M, the site area was considered to be elevated for that metal. Because only one sample was analyzed for PAHs at the background areas, comparisons to background were not used for selecting chemicals of concern for PAHs. Site areas were considered to be elevated for individual PAHs if mean concentrations exceed site-specific SQCs, and if mean total PAHs exceed the ER-L.

The chemicals of potential concern for sediments are listed in Table 1-4.

1.3.5 Biota

A small number of chemicals (PCBs, cadmium, chromium, lead, and mercury) were analyzed in aquatic and terrestrial biota in order to characterize contaminant bioavailability and potential effects. Detected concentrations in biota are listed in Table 1-7a, b, and c. Mercury was not detected in any of the samples. These data are from three separate investigations and cannot be combined because of differences in sampling and compositing procedures. For example, Charters et al. (1991) analyzed juvenile and adult muskrats of each sex separately whereas the Wehran (1990) data is not segregated by sex or age.

PCBs were selected as a contaminant of concern in fiddler crabs because these chemicals were detected in all analyses of animals collected from tidal Edmonds Creek reported by Wehran (1990). Adams et al. (1990) reported detecting PCBs in crabs from tidal Edmonds Creek, and from Martins Creek but not from the reference area.

Cadmium, chromium, and lead were also selected as chemicals of potential concern because they were detected in tidal Edmonds Creek animals in the Wehran (1990) study. The maximum chromium concentration measured in crabs in tidal Edmonds Creek in the Adams et al. (1990) study was nearly 30 times the concentration in crabs from the reference area. Although Adams et al. (1990) also measured copper and zinc in animals collected from the site, the levels in on-site and reference animals were similar (Table 1-7b). Therefore, copper and zinc were not selected as chemicals of potential concern.

PCBs were selected as chemicals of concern in muskrats, rats, and mice because of their detection in livers of 6/7 muskrats, 3/3 rats, and the only mouse sampled by Wehran (1990). To

TABLE 1-7a. Compounds Detected in Biota at Kin-Buc II Site (data from Wehran 1990).

Organism/ Compound	A. EDMONDS CREEK - TIDAL			B. MARTINS CREEK			C. MILL BROOK		
	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM
Mummichog									
PCB's: (mg/kg)									
Aroclor-1248	6/6	2.070	2.900	3/3	0.400	0.430	2/2	0.640	0.880
Aroclor-1254	6/6	0.890	1.200	3/3	0.640	0.780	3/3	0.580	0.910
Total PCBs	6/6	2.970	4.100	3/3	1.040	1.200	2/2	1.380	1.390
Metals: (mg/kg)									
Cadmium	0/6			0/3			1/3	NC	0.180
Chromium	6/6	0.970	2.300	3/3	0.500	0.950	3/3	0.490	0.740
Lead	0/6			1/3	NC	0.580	1/3	NC	0.580
Fiddler crab									
PCBs: (mg/kg)									
Aroclor 1248	12/12	0.490	1.600						
Aroclor 1254	12/12	0.330	0.570						
Total PCBs	12/12	0.830	2.090						
Metals: (mg/kg)									
Cadmium	12/12	0.300	0.360						
Chromium	12/12	0.840	1.300						
Lead	12/12	1.510	1.800						
Muskrat									
PCBs: (mg/kg) (liver)									
Aroclor 1254	6/7	0.06	0.20						
Metals: (mg/kg) (kidney)									
Cadmium	5/7	0.280	1.800	3/3	0.620	2.300			
Chromium	7/7	0.280	0.450	3/3	0.240	0.440			
Lead	0/7			1/3	NC	0.500			
Norway rat									
PCBs: (mg/kg) (liver)									
Aroclor 1260	3/3	0.230	0.370						
Metals: (mg/kg) (kidney)									
Cadmium	2/3	0.100	0.110						
Chromium	3/3	0.280	0.340						
Lead	3/3	1.500	2.000						
House mouse (liver)									
PCBs: (mg/kg)	1/1	NC	0.067						
Aroclor 1260									

NC - Not calculated

Table 1-7b. Compounds detected in fiddler crabs at Kin-Buc II (from Adams et al. 1990).
Samples were composites of males only.

	A. EDMONDS CREEK (TIDAL)			B. MARTINS CREEK			C. REFERENCE (RARITAN RIVER & NJ TURNPIKE)		
Compound	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM	FREQUENCY	GEO. MEAN	MAXIMUM
PCBs: (mg/kg)									
Aroclor 1248	2/2	0.64	0.990	0/2			0/1		
without carapace	1/1	NC	14.00						
Aroclor 1254	0/2			0/2					
Aroclor 1260	0/2			1/1	NC	0.17			
Metals: (mg/kg)									
cadmium							1/1	NC	0.60
chromium	2/2	5.13	32.15				1/1	NC	1.20
copper	2/2	32.20	37.70	1/1	NC	42.60	1/1	NC	47.90
zinc	2/2	29.65	32.80	1/1	NC	26.50	1/1	NC	29.10

NC - Not Calculated

Table 1-7c. Compounds detected in muskrat liver at Kin-Buc II site and a South River reference site (from Charters et al. 1991).

	A. EDMONDS CREEK - TIDAL			B. SOUTH RIVER		
Compound	FREQUENCY	MEAN	MAXIMUM	FREQUENCY	MEAN	MAXIMUM
PCBs: (mg/kg)						
Aroclor 1016	0/61			0/16		
Aroclor 1221	0/61			0/16		
Aroclor 1232	0/61			0/16		
Aroclor 1242	0/61			0/16		
Aroclor 1248	0/61			0/16		
Aroclor 1254	0/61			0/16		
Aroclor 1260	0/61			0/16		
Pesticides: (mg/kg)						
alpha DBC	2/24	NR	0.004			
beta BHC	2/24	NR	0.017			
gamma BHC	2/24	NR	0.005			
delta BHC	1/24	NC	0.007			
Heptachlor	1/24	NC	0.007			
Aldrin	1/24	NC	0.003			
Endosulfan sulfate	1/24	NC	0.004			
Methoxychlor	1/24	NC	0.020			
Endosulfan I				9/16	1.2E-03	4.4E-02
Endosulfan II				1/16	5.0E-05	2.9E-04
Dieldrin				7/16	3.3E-04	1.1E-01
Heptachlor epoxide				10/16	5.0E-05	9.0E-05
DDT				1/16	2.4E-04	1.4E-02
DDD				1/16	1.6E-04	1.9E-04
DDE				10/16	4.0E-05	1.3E-04
Metals: (mg/kg)						
Copper						
Juvenile males	16/16	18.52	*	4/4	8.18	*
Juvenile Females	18/18	24.19	*	1/1	NC	14.00
Adult Males	13/13	18.79	*	4/4	8.98	*
Adult Females	13/13	16.90	*	6/6	7.83	*
Lead						
Juvenile males	16/16	0.47	*	4/4	0.16	*
Juvenile Females	18/18	0.32	*	1/1	NC	0.18
Adult Males	13/13	0.50	*	4/4	0.20	*
Adult Females	13/13	0.48	*	6/6	0.20	*
Manganese						
Juvenile males	16/16	2.98	*	4/4	1.77	*
Juvenile Females	18/18	3.50	*	1/1	NC	2.40
Adult Males	13/13	2.64	*	4/4	1.20	*
Adult Females	13/13	2.38	*	6/6	1.77	*
Zinc						
Juvenile males	16/16	41.18	*	4/4	28.25	*
Juvenile Females	18/18	41.95	*	1/1	NC	11.00
Adult Males	13/13	40.67	*	4/4	20.23	*
Adult Females	13/13	39.05	*	6/6	19.00	*

NC - Not Calculated.
NR - Not reported because geometric mean exceeded maximum value.
* - Only means reported.

be conservative, PCBs were retained as a chemical of potential concern in muskrats, despite the Charters et al. (1991) study which did not detect PCBs in 61 animals collected from tidal Edmonds Creek.

Cadmium, chromium, and lead were detected in kidney tissues of muskrats and rats, and were selected as chemicals of potential concern. In the Wehran (1990) study, 5/7 muskrat kidneys had detectable concentrations of cadmium, and 7/7 muskrats had detectable levels of chromium. Lead was detected in all three rat kidneys. Lead was also detected in all muskrat livers sampled by Charters et al. (1991). Although maximum concentrations were not reported, the mean concentrations from on-site animals were about twice those reported from reference animals. Cadmium, chromium, and lead were also selected as chemicals of concern because of their known mammalian toxicity. Copper, manganese, and zinc, which were also measured in muskrat livers, are all essential elements and of generally less toxicological concern in mammals (Hammond and Beliles 1980).

The chemicals of potential concern in biota are listed in Table 1-4.

2.0 ENVIRONMENTAL EXPOSURE

2.1 Potential Ecological Receptors

2.1.1 Aquatic Biota

Aquatic receptors include fish and invertebrates living in the creeks and marshes on the site. Sampling performed as part of the RI investigation identified the following fish species on the site: mummichog (*Fundulus heteroclitus*), American eel (*Anguilla rostrata*), and bluegill (*Lepomis macrochirus*). Mummichogs were the most abundant species by far (TES 1990) and were found in both the Edmonds and Mill Brook/Martins Creek systems. Because minnow traps were the only sampling equipment used, it is unknown whether larger species are also present.

Fish species likely to feed at the site include the striped bass (*Morone saxatilis*) and white perch (*Morone americana*), which have been reported in the Raritan River in Middlesex County (New Jersey Natural Heritage Data Base 1989) and are known to feed on mummichogs (Abraham 1985).

The most abundant macroinvertebrate was the fiddler crab (*Uca minax*) which was found exclusively in Edmonds Creek (TES 1990). Occasional blue crabs (*Callinectes sapidus*) were collected in both creeks. A small number of grass shrimp (*Hippolyte* sp.) were collected in Edmonds Creek. The benthic community was not sampled during RI activities.

The failure to sample larger fish species or the benthic community are sources of uncertainty in the analysis. This issue is addressed in Section 5.0.

Amphibians and reptiles observed on-site include the Fowler's toad (*Bufo woodhousei fowleri*), common snapping turtle (*Chelydra serpentina serpentina*), Northern diamondback terrapin (*Malaclemys terrapin terrapin*), and the Eastern garter snake (*Thamnophis sirtalis*).

2.1.2 Plants

The dominant wetland plant species are *Phragmites communis* and *Spartina cynosuroides*. In some areas, *Phragmites* is mixed with the following species: rose mallow (*Hibiscus mosheutos*), narrow-leaved cattail (*Typha angustifolia*), salt marsh fleabane (*Pluchea purpurascens*), water hemp (*Amaranthus cannabinus*), and water smartweed (*Polygonum pujnctatum*). In the *Spartina*-dominated area, the marsh elder (*Iva frutescens*) has also been observed.

2.1.3 Birds

Bird species identified on-site are listed in Table 2-1. Wehran (1990) stated that mammalian predator activity is likely to be limiting the populations of ground nesting species. The primary species observed to nest in the marsh was the marsh wren (*Cistothorus palustris*).

2.1.4 Mammals

Mammals observed in the marsh are listed in Table 2-1. The dominant species were the muskrat (*Ondatra zibethicus*), house mouse (*Mus musculus*), and Norway rat (*Rattus norvegicus*).

2.1.5 Identification of Rare, Threatened, and Endangered Species

Rare, threatened, and endangered species in the vicinity of the Kin-Buc II site were identified through a review of the Draft RI and searches of the New Jersey Natural Heritage Data Base (NHDB). Cautions and restrictions on the use of NHDB data are provided in Appendix A. No confirmed occurrences of rare, threatened, or endangered species were found in NHDB records. However, five rare, threatened, or endangered bird species were observed on or adjacent to the site by TES (1990) as part of the Draft RI (Table 2-2). NHDB records for rare, threatened, or endangered species found within a five mile radius identified 14 species including one reptile, five birds, and eight plants (Table 2-2). The results of an earlier NHDB search for Middlesex County are also included in Table 2-2.

2.2 Exposure Assessment

An exposure pathway consists of four elements: (1) a source and mechanism for chemical release to the environment; (2) an environmental transport medium (e.g., surface water) for the released chemical; (3) a point of potential contact between the receptor and the chemical; and (4) an exposure route at the contact point. All four of these elements are likely to be present at the site. A potential source of on-site contaminants at Kin-Buc is the Pool C and Connecting Channel area (Wehran 1990). Release of the chemicals of potential concern has resulted in their detection in surface waters and sediments at the site. Potential contact with receptors is demonstrated by the measurement of chemicals of concern in biota sampled on the site (although it is necessary to determine whether portions of the body burdens are attributable to other sources). In this section, the identification of potential exposure pathways and the quantification of exposure are addressed.

Table 2-1 Birds and mammals observed by TES (1990) on or adjacent to Kin-Buc II

Common Name	Latin Name
A. Birds	
Double-crested cormorant(a)	*Phalacrocorax auritus*
Great egret(a)	*Casmerodius alba*
Snowy egret(a)	*Egretta thula*
Great blue heron(a)	*Ardea herodias*
Little blue heron(a)	*Florida careluea*
Green-baked heron(a)	*Butorides striatus*
Black-crowned night-heron(a)	*Nycticorax nycticorax*
Yellow-crowned night-heron(a)	*Nyctanassa violacea*
Canada goose(a)	*Branta canadensis*
Snow goose(a)	*Chen caerulescens*
American black duck(a)	*Anas rubripes*
Mallard(a)	*Anas platyrhynchos*
Northern harrier(a)	*Circus cyaneus*
Red-tailed hawk(a)	*Buteo jamaicensis*
Osprey(a)	*Pandion halieatus*
Ring-necked pheasant(a)	*Phasianus colchicus*
Northern bobwhite(a)	*Colinus virginianus*
Clapper rail(b)	*Rallus longirostris*
Greater yellowlegs(a)	*Tringa melanoleuca*
Willet(a)	*Catoptrophorus semipalmatus*
Spotted sandpiper(a)	*Actitis macularia*
Laughing gull(a)	*Larus atricilla*
Ring-billed gull(a)	*Larus delawarensis*
Herring gull(a)	*Larus marinus*
Mourning dove(a)	*Zenaida macroura*
Belted kingfisher(a)	*Ceryle alcyon*
Willow flycatcher(ab)	*Empidonax traillii*

Table 2-1 Continued	
Common Name	**Latin Name**
Eastern kingbird(a)	*Tyrannus tyrannus*
American crow (a)	*Corvus brachyrynchos*
Fish crow (a)	*Corvus ossifragus*
Marsh wren(a)	*Cistothorus palustris*
American robin(b)	*Turdus migratorius*
Gray catbird(a,b)	*Dumetalla carolinensis*
Northern mockingbird(b)	*Mimus polyglottis*
Brown thrasher(b)	*Toxastoma rufum*
European starling(a,b)	*Sturnus vulgaris*
Yellow warbler((a,b)	*Dendroica petechia*
Common yellowthroat(b)	*Geothylpis trichas*
Northern cardinal(a,b)	*Cardinal cardinalis*
Indigo bunting(b)	*Passerella cyanea*
Field sparrow(b)	*Spizella pusilla*
Song sparrow(a,b)	*Melospiza melodia*
Swamp sparrow(b)	*Melospiz georgiania*
White-throated sparrow(a)	*Zonotrichia albicollis*
Red-winged balckbird(a,b)	*Agelaius phoeniceus*
Common grackel(a,b)	*Quiscalus quiscula*
house finch(b)	*Carpodacus mexicanus*
American goldfinch(a,b)	*Carduelis tristis*
B. Mammals	
Least shrew	*Cryptotis parval*
Eastern conntail	*Sylvilagus floridanus*
White-footed mouse	*Peromyscus leucopus*
Meadow vole	*Mircotus pennsylvanicus*
Muskrat	*Ondatra zibethicus*

Table 2-1 Continued

Common Name	Latin Name
Norway rat	*Rattus norvegicus*
House mouse	*Mus musculus*
Feral cat	*Felis domesticus*
Red fox	*Vulpes vulpes*
Raccoon	*Procycon lotor*
Domestic dog	*Canis familiaris*
Stripe skunk	*Mephitis mephitis*
White-tailed deer	*Odocoileus virginianus*

[a] = Observed
[b] = Evidence of breeding

Table 2-2. Rare, threatened species identified in the vicinity of the Kin-Buc site.

Common Name	Species	Federal Status *	State Status*	A	B	C
Fish:						
Atlantic sturgeon	*Acipenser oxyrhynchus*		T			X
Shortnose sturgeon	*Acipenser brevirostrum*	E	E			X
Reptiles:						
Bog turtle	*Clemmys muhlenbergii*		E		X	
Birds:						
American bittern	*Botaurus lentiginosus*		T			X
Bald eagle	*Haliaeetus leucocephalus*	E/T	E			X
Great blue heron	*Ardea herodias*		T	X		X
Henslow's sparrow	*Ammondramus henslowii*		E		X	
Little blue heron	*Florida caerulea*		T(b)	X		
Northern harrier	*Circus cyaneus*		E	X	X	X
Osprey	*Pandion halietus*		T	X		
Peregrine Falcon	*Falco peregrinus*	E	E		X	
Savannah sparrow	*Passreculus sandwichensis*	T				X
Short-eared owl	*Asio flammeus*		E			X
Upland sandpiper	*Bartramia longicauda*		E		X	
Yellow-crowned night heron	*Nyctanassa violaceus*		T	X	X	
Vascular Plants:						
Nuttall's mudwort	*Micranthemum micranthemoides*	PE	E		X	X
Sea-beach knotweed	*Poygonum glaucum*		E		X	
Small skullcap	*Scutellaria leonardii*		E		X	
Stiff goldenrod	*Solidago rigida*		E		X	
Swam-pink	*Helonias bullata*	T	E		X	
Variable bunchflower	*Melanthium birginicum*		E		X	
Whorled water-milfoil	*Myriophyllum verticillatum*		E		X	

*E = Endangered, T = Threatened, T(b) = Identified as Threatened (breeding status only) by TES (1990).
A = Observed on or adjacent to Kin-Buc site by TES (1990).
B = Rare, threatened and endangered species occurring within one mile of Kin-Buc. New Jersey Natural Heritage Data Base search initiated by Versar (1990).
C = Rare, threatened and endangered species occurring in Middlesex County, NJ. New Jersey Natural Heritage Data Base search initiated by FWS (1989).

2.2.1 Pathways for Exposure of Aquatic Biota

Aquatic biota may be exposed to chemical contaminants at the Kin-Buc II site through the water column (via respiration for fish and invertebrates), by contact and incidental ingestion of sediments, and through the food web. Hydrophobic chemicals such as PCBs released to surface waters tend to partition from the water column into sediments (Eisler 1986a). Sediments can serve both as a sink and a source for hydrophobic chemicals (Jennett et al. 1980). Processes such as storm events, sedimentation, and foraging and burrowing movements of aquatic biota influence the transfer of chemicals between the water column and sediments. Aquatic organisms can also accumulate contaminants such as PCBs through the food chain (Thomann 1981).

Relevant environmental fate processes for the chemicals of potential concern in biota are provided in Section 2.0 of the Human Health Assessment portion of this RA.

2.2.2 Pathways for Exposure of Wetland Species

Plants may be exposed to contaminants in air, soil, or water. Because phytotoxicity data generally link soil concentrations with effects, the focus of the hazard assessment for plants will be on exposure to contaminants in marsh sediments.

Birds that inhabit the marsh areas may be exposed to contaminants through the drinking of surface water, contact and incidental ingestion of sediments, and through the diet. Two potential pathways for contamination will be evaluated based on the species observed in the marsh. The red-tailed hawk (*Buteo jamaicensis*) has been observed in the marsh area and is known to feed on small rodents such as mice and rats which are also present in the marsh. The great blue heron (*Ardea herodias*) has also been observed on the banks of the Raritan River and has been observed to feed on fiddler crabs in a nearby marsh (Wehran 1990).

In birds, dietary exposures appear to be a major route for the uptake of PCBs, and several heavy metals (Eisler 1986a, 1987a, 1988a). Exposures of the heron and hawk will be estimated for the chemicals of potential concern that have been measured in their prey: PCBs, cadmium, chromium, and lead. For these chemicals, dietary and drinking water exposures will be added. There is insufficient information to estimate contaminant exposure through incidental ingestion of sediment. The assessment is restricted to these chemicals because prey concentrations would need to be modeled from sediment or surface water concentrations for the other chemicals of concern. Because bioconcentration factors vary considerably among species and because the relationships between sediment and biota concentrations are also variable, these estimates cannot be made with any confidence.

Estimates of exposure will be made for each area where concentrations were measured in prey species. For the heron, exposures will be estimated at tidal Edmonds Creek, Martins Creek, and Mill Brook. For the hawk, exposures will be estimated at tidal Edmonds Creek. Exposure through drinking water will be estimated only at tidal Edmonds Creek because no samples were collected from Martins Creek or Mill Brook.

Both an average and a maximum exposure will be estimated. For the average exposure, estimates of the geometric mean surface water or diet concentration will be used. For the estimation of maximum exposure, the maximum concentrations will be used. Where data permit, the average and maximum percentage of the year spent feeding on-site will be used for the average exposure and maximum exposure estimates, respectively.

Drinking and feeding rates for the hawk and heron will be estimated using equations developed by the Wisconsin Department of Natural Resources (1989), which relate these rates to body weight. For both birds, information on the amount of time likely to be spent feeding on the site was gathered through the literature and from personal communications with local experts. Year-round populations of red-tailed hawks have been observed at nearby landfills (R. Kane, New Jersey Audubon Society, personal communication). According to R. Kane, these hawks frequently feed exclusively in a single landfill because of the abundant rodent population. Thus, for the hawk, it was assumed that the birds would spend 100 percent of the year feeding. Onsite PCB concentrations measured in liver tissues of rats, will be used in estimating exposures to the hawk. Metal concentrations in rat kidneys will also be used. It is recognized that these concentrations may only approximate whole body concentrations, which were not measured at the site. Uncertainties associated with this approximation are addressed in Section 5.0.

Herons feeding onsite tend to travel from nest sites in the Great Swamp (NJ), Staten Island, (NY), or East River (NY) (R. Kane, personal communication). Thus, it is likely that many herons should feed at a number of marshes rather than exclusively at tidal Edmonds Creek. PCB concentrations in fiddler crabs were determined in two manners. Wehran (1990) reported whole body residues, whereas Adams et al. (1990) measured one sample for residues with the carapace removed. Separate estimates of chemical dosages will be computed using Wehran (1990) whole body and Adams et al. (1990) carapace-free data. However, it is difficult to estimate a percentage of the time herons would feed at any one location. Therefore, to be conservative, for the purposes of this assessment, it was assumed that herons would feed exclusively at the site.

Recher and Recher (1980) reported that the diet of New Jersey Great Blue Herons consisted of 91.9 percent fish, 6.3 percent crustaceans, and 1.8 percent "other". Based on these data, diet in tidal Edmonds Creek is presumed to be 90 percent mummichog and 10 percent fiddler crab for the purposes of estimating exposure.

Both year-round (12 month) and migratory (6-month) residents exists in the area (R. Kane, personal communication). It was therefore assumed that an average heron would spend 9 months feeding onsite and a maximally exposed heron would spend 12 months feeding onsite.

The parameters used to model bird exposures and the chemical dosages are summarized in Tables 2-3 and 2-4. The uncertainties of these model assumptions are discussed in Section 5.0.

Mammals may be exposed to contaminants through drinking of surface water, contact and incidental ingestion of sediments, and through the diet. Although risks from ingestion of surface water can be estimated, there are insufficient data to estimate exposure through the other routes. The diet of mice and rats is largely vegetation; no samples of marsh plants were analyzed for contaminants. Therefore, since these species are residing in the marsh, it will be assumed that contaminant exposure is through a combination of these routes. In view of the uncertainties involved, rather than attempting to model mammalian exposure, risk assessment will be performed by comparing body burdens in Kin-Buc species with levels associated with effects in studies found in the literature.

Table 2-3. Parameters used to model exposure of birds to contaminants at Kin-Buc

A. Great Blue Heron

Body wt.	3.0 kg	Forbush (1925)
Feeding rate	0.119 kg/day	Estimated; equation from Wisconsin DNR (1990)
Drinking rate	0.123 L/day	Estimated; equation from Wisconsin DNR (1990)
Diet	90% mummichog; 10% fiddler crab	Recher and Recher (1980)
Number of months on-site	9 (average); 12 (maximum)	Average of year-round (12 month) and migrant (6-month) populations (R. Kane, personal communication)
Fraction feeding performed on-site	1.0	Conservative assumption
Site areas	Tidal Edmonds Creek Martins Creek Mill Brook	Use 90% fish + 10% crab as diet 100% fish diet (no crab body burden data) 100% fish diet (no crab body burden data)
Dietary Exposure Equation	$\frac{(0.9 \cdot \text{Mean [fish]} \frac{mg}{kg} + 0.1 \cdot \text{Mean [crab]} \frac{mg}{kg}) \times \frac{0.119\ kg}{day} \times 1.0\text{(fraction of year onsite)}}{3.0\ \text{kg body wt.}}$	
Drinking Water Equation	$\frac{\text{Mean [surface water]} \frac{mg}{L} \times \frac{0.123L}{day} \times 1.0\text{(fraction of year onsite)}}{3.0\ \text{kg body weight}}$	

Table 2-3 . (Continued)

B. Red-tailed Hawk

Parameter	Value	Comments/Reference
Body Wt.	1.1 kg	Clark (1987)
Feeding rate	0.062 kg/day	Wisconsin DNR (1989)
Drinking rate	0.063 L/day	Wisconsin DNR (1989)
Diet	100% rat	R. Kane (personal communication)
Number of months on-site	12	R. Kane (personal communication)
Fraction of feeding on-site	1.0	R. Kane (personal communication)
Dietary Exposure Equation	$\dfrac{[\text{rat}]\ \frac{\text{mg}}{\text{kg}} \times \frac{0.062\ \text{kg}}{\text{day}}}{1.1\ \text{kg body weight}}$	
Drinking Water Equation	$\dfrac{[\text{surface water}]\ \frac{\text{mg}}{\text{L}} \times 0.063\ \frac{\text{L}}{\text{day}}}{1.1\ \text{kg. body weight}}$	

Table 2-4. Estimated chemical dosages for birds exposed to PCBs cadmium, chromium, and lead.

A. Great Blue Heron (mg/kg/day)									
	Tidal Edmonds			**Martins Creek**			**Mill Brook**		
Chemical	**Diet**	**Drinking Water**	**Total Exposure**	**Diet**	**Drinking Water**	**Total Exposure**	**Diet**	**Drinking Water**	**Total**
Average Exposure									
PCBs$^{(a)}$	8.20E^{-2}; 1.21E^{-1}	0$^{(a)}$	8.20E^{-2}; 1.21E^{-1}	3.10E^{-2}	0$^{(a)}$	3.10E^{-2}	4.10E^{-2}	0$^{(a)}$	4.10E^{-2}
Cadmium	0$^{(b)}$	0$^{(a)}$	0	0$^{(b)}$	0$^{(a)}$	0	5.36E$^{-3(c)}$	0$^{(a)}$	5.36E^{-3}
Chromium	2.85E^{-3}	1.91E$^{-5(d)}$	2.87E^{-3}	1.49E^{-3}	0$^{(a)}$	1.49E^{-3}	1.46E^{-2}	0$^{(a)}$	1.46E^{-2}
Lead	0$^{(b)}$	4.31E^{-6}	4.31E^{-6}	1.73E^{-3}	0$^{(a)}$	1.73E^{-3}	1.72E$^{-2(c)}$	0$^{(a)}$	1.72E$^{-2(c)}$
Maximum Exposure									
PCBs	1.55E^{-1}; 2.02E-1	0$^{(a)}$	1.55E^{-1}. 2.02E 1	4.76E^{-2}	0$^{(a)}$	4.76E^{-2}	5.51E^{-2}	0$^{(a)}$	5.51E^{-2}
Cadmium	0$^{(b)}$	0$^{(a)}$	0	0$^{(b)}$	0$^{(a)}$	0	7.14E^{-3}	0$^{(a)}$	7.14E^{-3}
Chromium	8.73E^{-2}	2.54E^{-4}	8.75E^{-2}	3.77E^{-2}	0$^{(a)}$	3.77E^{-2}	2.94E^{-2}	0$^{(a)}$	2.94E^{-2}
Lead	0$^{(b)}$	1.56E^{-4}	1.56E^{-4}	2.30E^{-2}	0$^{(a)}$	2.30E^{-2}	2.30E^{-2}	0$^{(a)}$	2.30E^{-2}

Table 2-4. (Continued)

B. Red-tailed Hawk (mg/kg/day)									
	Tidal Edmonds			Martins Creek			Mill Brook		
Chemical	Diet	Drinking Water	Total Exposures	Diet	Drinking Water	Total Exposure	Diet	Drinking Water	Total
Average Exposure									
PCBs	1.30E^{-2}	0(a)	1.30E^{-2}						
Cadmium	5.64E^{-3}	0(a)	5.64E^{-3}						
Chromium	1.58E^{-2}	3.55E^{-4}	1.94E^{-2}						
Lead	8.45E^{-2}	8.02E^{-4}	8.54E^{-2}						
Maximum Exposure									
PCBs	2.08E^{-2}	0(a)	2.08E^{-2}						
Cadmium	6.20E^{-3}	0(a)	6.20E^{-3}						
Chromium	1.92E^{-2}	3.55E^{-4}	1.96E^{-2}						
Lead	1.13E^{-1}	2.18E^{-4}	1.13E^{-1}						

(a) Not detected in surface water.
(b) Not detected in fish tissue.
(c) Based on single measured concentration in fish.
(d) Based on single, measured concentration in water.
(e) *First value is based on Wehran (1990) data for whole fiddler crabs; second value is based on Adams et al. (1990) data for fiddler crabs without carapace.*

3.0 TOXICITY ASSESSMENT

3.1 Methods for Assessing Toxicity and Risks of Contaminants to Aquatic Species

3.1.1 Surface Water Exposure

Potential risks to aquatic life are assessed by comparing the measured surface water concentrations with the EPA (1980, 1986) Ambient Water Quality Criteria (AWQC), which were developed to protect 95 percent of all aquatic species. Geometric mean surface water concentrations are compared with chronic (4-day average) AWQC, and maximum surface water concentrations are compared with acute (1-hour maximum) AWQC. For the contaminants for which no AWQC exist, concentrations are compared with measured or estimated chronic toxicity values (preferably lowest observed effect levels (LOELs) or no observed effect levels (NOELs)) obtained from the literature. Chemicals at concentrations that equal or exceed the LOELs, or exceed the NOELs, may pose an increased risk to the aquatic life of the area.

For several of the chemicals of potential concern in surface water, chronic toxicity data such as NOELs or LOELs, were unavailable. In these cases, fish acute toxicity data (LC$_{50}$s) were located and included in the report to provide the reader with some indication of the chemical's toxicity. It is recognized that LC$_{50}$s are measures of toxicity whereas AWQC are protective concentrations. However, LC$_{50}$s were listed because values associated with less mortality (such as LC$_{5}$s) are rarely calculated.

Various water quality parameters must be known in order to apply the correct AWQC value. Although no measurements of salinity were made for the RI, salinity was reported to vary from 0 to 7.5 parts per thousand in samples collected from the Raritan River about 3 river miles downstream of the site (Schmid and Company 1987). Because this is an estuarine area, the lower of the freshwater and marine AWQC was selected for assessing risk (as recommended by T. Purcell, U.S. EPA, Water Quality Standards Branch, personal communication). Hardness varied from 40 to 1,000 mg CaCO$_3$/l at this location with a geometric mean of 120 mg CaCO$_3$/l (Schmid and Company 1987). Therefore, for the metals with hardness-based freshwater criteria, a value of 100 mg CaCO$_3$/l was used. Schmid and Company (1987) reported that pH varied from 2.72 to 8.15 with a median value of 5.6-5.7. For calculating ammonia criteria, a pH of 6.5 (the lowest value for which criteria exist) and a temperature of 20°C (representative of spring and fall temperatures) was used.

3.1.2 Sediment Exposure

Toxicity of sediment contaminants are assessed by comparing geometric mean concentrations with recommended criteria or guidance values. EPA (1988) interim SQC are available for six PAHs and one PCB present at the site. Following EPA (1988) procedures, criteria are calculated for each area of the site by multiplying the geometric mean total organic carbon concentration measured at locations in the area by the criteria value. EPA interim SQC are presented as a mean and a 95 percent confidence interval. As recommended by EPA, the lower value of the 95 percent confidence interval for the criteria was used to represent the limiting concentration which, with 97.5 percent certainty, will result in protection from chronic effects. Geometric mean rather than maximum sediment concentrations are compared because the SQC are analogous to chronic AWQC. Maximum concentrations are evaluated in the assessment as providing evidence of "hot spots" and therefore, provide valuable data on the pattern of contamination.

EPA has not issued SQC for the following chemicals of concern: antimony, arsenic, cadmium, copper, lead, mercury, nickel, silver, zinc, total PAHs, and total PCBs. Long and Morgan (1990) summarized available field and laboratory studies on the toxicity of chemicals in sediments. By listing the measured sediment concentrations in ascending order along with the observed effects, they calculated an ER-L and an ER-M (Effect Range-Median). The ER-L is the 10th percentile concentration and is used as an estimate of the concentration above which adverse effects may begin. The ER-M is the 50th percentile and is used as the concentration at which effects were frequently observed. In this report, both the ER-L and the ER-M concentrations are used as guidance values for assessing toxic effects on benthic species.

Uncertainty in the use of sediment guidance values is discussed in Section 5.0.

3.1.3 Evaluation of The Significance of Body Burdens of Chemicals of Potential Concern

A small body of literature exists in which both body burdens and toxic effects are described in fish and macrocrustaceans. For each of the chemicals of concern in biota, these data will be obtained. Toxicity will be assessed by comparing body burdens associated with adverse effects (Table 3-1) with geometric mean and maximum concentrations measured in fish and crabs at Kin-Buc II.

Table 3-1 . Concentrations of PCBs, cadmium, chromium, and lead associated with toxic effects in fish and mammals

A. Fish

Chemical	Concentration	Species	Effects	Reference
PCBs	2.7 mg/kg (eggs)	Rainbow trout (*Oncorhynchus mykiss)*	Reduced hatch; increased larvae deformities	Hogan and Braughn (1975)
	0.12 mg/kg (ovaries)	Baltic flounder (gonads) (*Platichthys flesus*)	Association with population declines	Von Westernhagen et al. (1981)
	0.2 mg/kg (ovaries)	Starry flounder (*Slatichthys stellaetus)*	Decreased reproductive success	Spies et al. (1985)
	3.6 mg/kg (whole body) (Hexachloro-biphenyl)	Chinook salmon (*Oncorhynchus tshawytsch)*	Death	Broyles and Noveck (1979)
	17.0 mg/kg (eggs)	Atlantic salmon (*Salmo salar)*	50% mortality	Johnansson et al. (1970)
	15 mg/kg (adult, whole body)	Minnow (*Phoxinus phoxinus*)	Excess fry mortality from premature hatching of eggs	Bengtsson (1980)
	1.6 mg/kg (adult, whole body)	Minnow (*Phoxinus phoxinus*)	No effect on reproduction	Bengtsson (1980)
Cadmium	5.0 mg/kg (whole body)	Mummichog (*Fundulus heteroclitus*)	"Life threatening"	Eisler (1985a)
	"< 1 mg/kg" (testes)	Brook trout (*Salvelinus fontinalis*)	Testicular necrosis	Sangalang et al. (1979)
Chromium	NA			
Lead	~17 mg/kg (ovary)	*Climbing perch (Anabas testudineus*)	Reduced reproduction	Tulasi et al. (1989)

B. Mammals

Chemical	Concentration	Species	Effects	Reference
PCBs	2.3 mg/kg (whole body)	White-footed mouse (*Peromyscus leucospus*)	Elevated liver weight; decreased reproduction [Field study; results may be partially attributable to PCBs]	Batty et al. (1990)
	24.8 mg/kg (adipose)	Mink (*Mustela vison*)	Reproductive failure	Hornshaw et al. (1983)

Table 3-1 (continued)

Chemical	Concentration	Species	Effects	Reference
Cadmium	117 mg/kg (renal cortex)	Rabbit (*Oryctolagus cuniculus)*	Depressed kidney function	Nomiyama (1981)
Chromium			No effects in chronic oral exposure studies	ATSDR (1989c)
Lead	> 10 mg/kg	Raccoons (*Procyon lotor*)	Brain lesions characteristic of lead poisoning	Diters and Nielsen (1978)

NA No studies found relating whole body or organ levels with toxicity effects.

3.2 Methods for Assessing Toxicity To Wetland Species

3.2.1 Birds and Mammals

Although EPA has not issued criteria for the protection of wildlife from chemicals in surface water, the State of Wisconsin recently issued wild and domestic animal criteria (WDAC) (Wisconsin Department of Natural Resources (DNR) 1989). These values are expressed as surface water concentrations and are designed to protect wildlife species from adverse effects resulting from drinking of surface waters and from ingestion of aquatic organisms taken from surface waters. For the chemicals of concern in surface waters, values are available for mercury (0.002 µg/l), DDT (0.00015 µg/l) and PCBs (0.003 µg/l). Geometric mean and maximum surface water concentrations of these three chemicals will be compared with Wisconsin WDAC.

For the purposes of this assessment, toxicity reference values (TRVs), listed in Table 3-2, will be derived to assess the risks of exposures of birds to PCBs, cadmium, chromium, and lead at the site. TRVs will be derived for each chemical by locating appropriate laboratory studies and applying safety factors. The guidance provided by Wisconsin DNR (1990) for developing toxicity values to protect wildlife will be followed. When available, long-term studies which reported a no observed effect level (NOEL) will be used as a basis for TRVs. Wisconsin DNR applied safety factors to toxicity values to account for differences in species sensitivity, to extrapolate from short-term studies to chronic studies, and to extrapolate from LOELs to NOELs. For chemicals in which many bird species have been tested, the lowest NOEL will be used as a TRV without dividing by a safety factor. In cases where few data exist, Wisconsin DNR recommended that a NOEL may be divided by a factor of 1-100 to account for differences in species sensitivity. For studies in which a LOEL rather than NOEL was identified, a TRV can be estimated by dividing the lowest LOEL by a safety factor of 1-10 depending on the severity of the observed effects.

For the mammals, the lack of data for contaminants in diet organisms precludes the use of this approach. Therefore, effects in the mammalian species will be evaluated by comparing body burdens associated with toxic effects in laboratory studies (Table 3-1) with geometric mean and maximum tissue concentrations measured in mammals at Kin-Buc II.

3.2.2 Plants

The toxicity of chemicals of potential concern will be evaluated by comparing soil or sediment concentrations reported to be phytotoxic (Table 3-2) with geometric mean concentrations in Kin-Buc II sediments. It is recognized that use of soil data to estimate sediment exposure is subject to considerable uncertainty (see Section 5.0).

Table 3-2. Toxicity Reference Values (TRVs) for birds and plants*

A. Birds	
Chemical	**TRV (mg/kg/day wet wt)**
PCBs	0.375
Cadmium	0.05
Chromium	0.125
Lead	0.312
B. Plants	
Chemical	**TRV (mg/kg/dry wt)**
PCBs	26
PAHs	NA
Antimony	5
Arsenic	15
Cadmium	2.5
Chromium	64
Copper	60
Lead	46
Mercury	8
Nickel	100
Silver	2
Zinc	260

* = Derivations of TRVs are described in Section 3.0

3.3 Toxicity Profiles For Key Chemicals of Potential Concern

For the chemicals of concern in biota, toxicity profiles describe: (1) effects on aquatic life from water and sediment exposure; (2) effects on marsh plants from sediment exposures; and (3) toxicity to wildlife species. For the chemicals of concern in sediments, toxicity profiles describe effects on aquatic life from water and sediment exposure and effects on marsh plants from sediment exposure. For the chemicals of concern in surface water, AWQC and other toxicity data are listed in Table 1-3.

3.3.1 Chemicals of Concern in Biota

Polychlorinated Biphenyls (PCBs)

Uses of polychlorinated biphenyls (PCBs) included applications as heat transfer agents, lubricants, dielectric agents, flame retardants, plasticizers, and waterproofing agents (Eisler 1986a). Although uses were severely restricted in the mid-1970s, PCBs continue to be contaminants of concern due to their global distribution, persistence, tendency to bioaccumulate, and toxic effects. Reviews of the environmental toxicity of PCBs include those prepared by EPA (1980), Eisler (1986a), Field and Dexter (1988), and ATSDR (1989a).

In general, the acute toxicity of PCBs to aquatic organisms increases as the degree of chlorination decreases (Eisler 1986a). However, the more chlorinated PCBs tend to bioaccumulate to a greater extent than the less chlorinated PCBs (Shaw and Connell 1982). Sublethal effects in fish include decreased growth, skeletal abnormalities, anemia, and interferences with osmoregulation. Reproductive effects include decreased egg hatchability, increased frequency of larval deformities, poor larval survival, and total reproductive failure. PCBs cause induction of mixed function oxygenase (MFO) enzymes which may be related to reproductive function (Field and Dexter 1988). MFO induction has been used as a biological marker for PCB exposure.

EPA (1980) established acute and chronic average criteria of 2.0 and 0.014 µg/l total PCBs in freshwater. For saltwater, the acute and chronic criteria are 10 and 0.03 µg/l, respectively.

PCBs tend to partition into sediments where they may cause adverse effects on benthic species and other aquatic organisms. EPA (1988) has proposed interim SQC for Aroclor 1254 in freshwater and saltwater sediments. At a total organic carbon concentration of one percent, the lower 95 percent confidence value is 0.195 mg/kg for freshwater and 0.418 mg/kg for saltwater. Long and Morgan (1990) listed 0.050 mg/kg as an ER-L value and 0.400 mg/kg as an ER-M value for total PCBs. All sediment values in this assessment are as dry weight.

There is also concern that PCBs in sediments can be bioaccumulated by fish and other organisms in the water column through partitioning from sediment into water, ingestion of sediments while feeding, and through the food web. These processes have been verified in laboratory, field, and model ecosystem studies (Larsson 1986; Seelye et al. 1982; Rice and White 1987; Rubinstein et al. 1984). Field and Dexter (1988) summarized studies in which fish/sediment ratios ranged from 0.4 to 20. The authors concluded that a tissue/sediment bioaccumulation factor of one is more likely to underestimate than to overestimate concentrations in resident biota.

Fiddler crabs (*Uca pugilator* and *Uca minax*) accumulated PCBs from sediments in laboratory studies by Clark et al. (1986). Crabs were exposed to PCB contaminated mud (1.0 mg/kg dry wt.) and a PCB contaminated mud-sand mixture (0.37-0.55 mg/kg dry wt.) for 28-42 days. Bioaccumulation factors [wet wt. tissue(including carapace)/dry wt. sediment] ranged from 0.19 to 1.07. Clark et al. (1986) concluded that sediments can serve as a PCB source for fiddler crabs, although uptake is considerably less than that from water. PCB accumulation from sediments is strongly affected by the organic carbon content of the sediments. Rubinstein et al. (1983) reported tissue/sediment ratios for sandworms (*Nereis virens*) were 0.15 in a highly organic sediment and 1.59 in a low organic sediment.

As summarized by Eisler (1986a), PCB exposure in birds has been associated with biochemical, histopathological, and behavioral abnormalities. In field studies, PCB concentrations were inversely related to eggshell thickness but these effects may be due to other organochlorines such as DDT and dieldrin. No effects on survival or reproduction were observed in screech owls (*Otus asio*) fed at a dietary level of 3 ppm Aroclor 1248 over two breeding seasons (McLane and Hughes 1980). This corresponds to a dose of 0.375 mg/kg/day based on a dietary conversion factor of 0.125 mg/kg body weight per ppm food, which was developed for birds of similar size (USDA 1984). This value is used as a TRV in this assessment.

Whereas no feeding tests with PCBs and great blue herons (*Ardea herodias*) were found, several studies have shown that herons are sensitive to PCB exposure. Hoffman et al. (1986) found a negative correlation between the growth of embryonic black-crowned night heron (*Nycticorax nycticorax*) and PCB levels in eggs collected from the same nest. PCB concentrations ranged from 0.8-52.0 mg/kg (geometric mean: 4.1 mg/kg). Although DDE was also reported in the eggs, there was no correlation between DDE levels and embryonic weight.

PCBs can affect wild mammals by causing mortality, behavioral changes, or interfering with reproduction. In his literature review, Eisler (1986a) stated that mink are especially sensitive to PCBs, with a dietary level of 0.64 ppm producing reproductive failure and a level of 1.0 ppm causing mortality. Hornshaw et al. (1983) fed mink PCB-contaminated fish and monitored reproductive effects and tissue residues. Mink fed a diet containing 1.5 ppm PCBs did not give birth to any live kits. The mean PCB concentration in adipose tissues was 24.8 mg/kg. In minks fed at 0.48 ppm, there were no effects on reproduction. Mean adipose tissue PCB concentration was 6.0 mg/kg. All tissue concentrations in this assessment are as wet weight unless stated otherwise.

While no studies were found on the muskrat, house mouse, or Norway rat, several multigenerational studies have been reported on the white-footed mouse (*Peromyscus leucospus*). Linzey (1987, 1988) reported that chronic exposure to a dietary level of 10 ppm resulted in decreased growth of young, longer intervals between births, and smaller litter sizes at birth and weaning. In a field study, white-footed mice exposed to PCBs, cadmium, copper, and zinc had significantly elevated relative liver, kidney, spleen, and adrenal weights (Batty et al. 1990). PCB body burdens averaged 2.3 mg/kg and were correlated with relative elevated liver weights. The authors noted an absence of young during the breeding season and concluded that decreased reproduction was attributable to exposure to PCB and/or cadmium. According to the authors, the effect on liver weights was most likely attributable to PCBs, since, in a previous feeding study with rats, cadmium exposure did not affect liver weights.

PCBs are not very toxic to terrestrial plants, probably because of their strong sorption to soils. A soil PCB concentration of 100 mg/kg resulted in a 27 percent reduction in growth in soybean plants (Weber and Mrozek 1979). Significant reduction in growth was also observed in corn at 100 mg/kg PCBs (Strek et al. 1979, as cited in EPA 1985a). Strek et al. (1981, as cited in EPA 1985a) reported that reduction in growth was not, however, significant for soybeans and beets at 100 mg/kg PCBs. Fries and Marrow (1981, as cited in EPA 1985a) observed no significant effects on soybean growth at 2 to 3 mg/kg PCBs. Ostrich ferns growing on sediments with PCB residues of 26 mg/kg (mostly Aroclor 1254) showed five-fold increase in somatic mutations as compared to ostrich ferns from control areas (Klekowski 1982 as cited in Eisler 1986a). Other plants in the contaminated area were not genetically damaged. Based on the above discussion, a TRV of 26 mg/kg was used in this assessment.

Plant uptake of PCBs was reviewed by Pal et al. (1980). They cited the study of Walsh et al. (1974) who grew red mangrove seedlings on soil containing 0.03-6.0 mg/kg Aroclor 122. An uptake factor (plant concentration/soil concentration [both using dry weight]) of 0.25 was calculated at the highest concentration. At soil concentrations below 0.3 mg/kg, PCBs were not detected in plant tissues.

Cadmium

EPA (1985b) and Eisler (1985) reviewed the aquatic toxicity of cadmium. Cadmium toxicity in freshwater decreases with increasing water hardness. EPA (1985b) established freshwater acute and chronic criteria of 3.9 µg/l and 1.1 µg/l, respectively at a hardness of 100 mg $CaCO_3$/l. EPA (1985b) marine acute and chronic criteria are 43 µg/l and 9.3 µg/l, respectively.

Bioconcentration factors for cadmium range from 3 for brook trout muscle (Benoit et al. 1976) to 12,400 for whole body residues in mosquito fish (Giesy et al 1977). Cadmium is preferentially accumulated in the liver, thus reducing concentrations in the muscle. Accumulated cadmium is slowly depurated by freshwater fish (Benoit et al. 1976, Kumada et al. 1980; as cited in EPA 1985b). Kumada et al (1980) found faster depuration of cadmium that was consumed in the diet versus that taken from the water column. In fish, metal-binding proteins (metallothioneins) provide some protection against cell injury.

Eisler (1985) reported that whole body residues equal to or greater than 5 mg/kg were associated with increased mortality. These data are from Eisler's earlier studies with mummichogs. Sangalang and Freeman (1979) reported that, after a chronic laboratory exposure, two brook trout with cadmium concentrations of "less than one" mg/kg in the testes showed histopathologic lesions in the organ.

There are considerable data on the toxicity of cadmium in sediments to aquatic biota. Long and Morgan (1990) summarized the results of 10-day spiked-sediment bioassays with the marine amphipod (*Rhepoxynius abronius*). LC_{50} ranged from 1.0 to 25.9 mg/kg. Based on laboratory and field studies, an ER-L of 5.0 mg/kg and an ER-M of 9.0 mg/kg were proposed.

Rubinstein et al. (1983) found that sandworms (*Nereis virens*), hard clams (*Mercenaria mercenaria*), or grass shrimp (*Palaemonetes pugio*) did not accumulate cadmium after 100 days exposure to contaminated sediments. They attributed the lack of uptake to the binding of cadmium to organics and the formation of metal sulfides. DiToro et al. (1990) found that the bioavailability and toxicity of cadmium in sediments varied inversely with the amount of acid volatile sulfides, which are thought to bind with metals in sediments.

The effects of cadmium on birds and terrestrial wildlife were reviewed by Eisler (1985). Behavioral changes were observed in young black ducks (*Anas rubripes*) produced from parents fed 4 ppm dietary cadmium for approximately 4 months before egg laying (Heinz and Haseltine 1983). A bird TRV of 0.05 mg/kg/day was derived based on this study. A dietary conversion factor of 0.125 mg/kg body weight per ppm food (ingestion rate/body weight; based on USDA (1984) and safety factor of 10 (for a LOEL) were used.

A more recent study by Bache et al. (1986) supports the use of this value. In a four generation feeding study with Japanese quail (*Coturnix coturnix*) fed oats containing 0.55 ppm cadmium, there were increases in cadmium concentrations in the livers and kidneys. No effects were observed on egg production or hatchability or on blood chemistry. This corresponds to a no adverse effect dosage of 0.069 mg/kg/day (derived by multiplying by a dietary conversion factor of 0.125 mg/kg body wt. per ppm (USDA 1984).

Mammals have no effective mechanism for the elimination of ingested cadmium. With time it tends to accumulated in the liver and kidney. However, increased syntheses of metallothioneins (metal-binding proteins) occurs with exposure (ATSDR 1989b).

Studies with humans and laboratory animals have shown that depressed kidney function occurs at renal cortex tissue levels of about 100-300 mg/kg (reviewed by ATSDR 1989b). A study by Nomiyama (1981) was cited in which depressed reabsorption of enzymes occurred in rabbits with renal cortex cadmium concentrations of 117 mg/kg. Tohyama et al. (1987) reported that, in rats, kidney cadmium tissue concentrations in the 100-200 mg/kg range were associated with adverse effects on kidney function. A value of 100 mg/kg is used in this assessment to compare the measured concentrations in Kin Buc mammals with critical concentrations for kidney toxicity.

Traynor and Knezek (1973) reported that corn grown on cadmium-enriched soils readily absorbed and translocated the element. They also found growth reduction in corn when 281 mg/kg cadmium was added to the soil resulting in plant concentrations of 131 mg/kg (ash weight basis). Cadmium has been found to concentrate in plants as high as ten times the soil concentrations (Chaney and Hornick 1977, as cited in Kabata-Pendias and Pendias, 1984). Haghiri (1973) reported that a cadmium soil concentration of 2.5 mg/kg produced a 21 percent reduction in wheat yield and a 40 percent reduction in lettuce yield. This value is used as a TRV in this assessment.

Chromium

Chromium exists in trivalent and hexavalent states. For freshwater aquatic organisms, hexavalent chromium is more toxic than trivalent chromium. EPA (1985c) established freshwater acute and chronic criteria for trivalent chromium of 1700 and 210 μg/l at a hardness of 100mg $CaCO_3$/l. For hexavalent chromium, freshwater acute and chronic criteria are 16 and 11 μg/l, respectively. Marine acute and chronic criteria for hexavalent chromium are 1100 and 50 µg/l. No marine criteria have been published for trivalent chromium.

EPA (1985c) reported whole-body bioconcentration factors of less than three for rainbow trout. However, Buhler et al. (1977) reported whole-body bioconcentration factors of 18 to 116 for rainbow trout. Removal of fish to control water resulted in a rapid depletion from muscle and a slower loss from the kidney, liver, gill, gall bladder, and bile.

Long and Morgan (1990) reviewed the literature on the effects of chromium in sediments on aquatic biota. No laboratory spiked sediment studies were found. A number of field studies report biological effects as well as chromium concentrations and there "co-occurrence" studies were used to estimate an ER-L of 80 mg/kg and an ER-M of 145 mg/kg. The lowest chromium concentration associated with toxic effects used to estimate the ER-L and ER-M was the observation of decreased richness of benthic species in Massachusetts by occurring at 60.9 mg/kg.

Seelye et al. (1982) exposed yellow perch to (*Perca flavesceus*) to contaminated Great lakes sediments which contained chromium levels of 33-38 mg/kg dry weight for 10 days. Chromium concentrations were similar in fish exposed to sediments vs. fish exposed only to water.

Eisler (1986b) cited a study by Haseltine et al. (in preparation) in which growth and survival of ducklings was reduced in a two-generation feeding study in which black ducks (*Anas rubripes*) were fed a dietary level of 10 ppm. A bird TRV of 0.125 mg/kg/day was derived based on this study. A safety factor of 10 was applied to adjust the LOEL to a NOEL and a dietary conversion factor of 0.125 mg/kg body weight per ppm food (USDA 1984) was used.

Chromium toxicity to humans and laboratory animals was reviewed by ATSDR (1989c). In Eisler's (1986b) review, no studies of chromium effects on wild mammals were reported. Although acutely lethal doses can be received from oral exposure, chronic oral studies in rats, mice and dogs have not identified adverse effects. Thus, although chromium appears to be accumulated in mammalian tissues (ATSDR 1989c), no concentration associated with toxic effects has been identified.

The chromium content of plants is controlled mainly by the amount of soluble chromium in the soils. Chromium (VI) is the most soluble and available form to plants, but it is also the most unstable form under normal soil conditions. Usually chromium distribution in plants results in the highest concentrations in the roots, then the leaves and stems and the lowest concentrations in the grain (Kabata-Pendias and Pendias 1984). Typical symptoms of chromium phytotoxicity are wilting of plant tops, root injury, chlorosis in young leaves, brownish-red leaves and chlorotic bands on cereals (Kabata-Pendias and Pendias 1984).

Turner and Rust (1971) reported that the addition of potassium dichromate to soil at a rate of 10 mg/kg soil resulted in severe wilting in soybeans. Plants receiving chromium at 30 and 60 mg/kg were killed. Since the average chromium content of U.S. soils is reported to be 54 mg/kg (Kabata-Pendias and Pendias 1984), a TRV of 64 mg/kg is estimated by adding the 10 mg/kg application rate to the mean background concentration.

Lead

In freshwater, lead toxicity decreases with increasing water hardness. EPA (1985d) has established acute and chronic freshwater criteria of 82 and 3.2 µg/l, respectively, at a hardness of 100 mg $CaCO_3$/l. The maximum acceptable toxicant concentration (MATC) from chronic studies with the rainbow trout (*Oncorhynhus mykiss*) was 19 µg/l at a water hardness of 128 mg/kg $CaCO_3$ (Davies et al. 1976). Bioconcentration factors have ranged from 42 in fish to 1700 in snails (EPA, 1985d).

Lead concentrations in the brain and ovary of a freshwater fish from India (climbing perch [*Anabas testudineus*]) were correlated with deleterious reproductive effects (Tulasi et al. 1989). In fish exposed for 30 days to sublethal concentrations of lead nitrate, there were reductions in the gonadosomatic index (ovary weight as a percentage of body weight) and in the number of eggs in the ovary. The authors found that the lead-exposed fish spawned over a shorter time period and were likely to have released immature oocytes. These effects occurred at the lowest exposure concentration, in which fish had average ovary lead residues of 3.43 mg/kg dry wt. (~17 mg/kg wet weight) and average brain residues of 29.30 mg/kg dry weight (~146 mg/kg wet weight).

Long and Morgan (1990) summarized date on the toxicity of lead in sediments to aquatic life. Since no spiked sediment studies were found, only co-occurrence field studies were used to propose an ER-L of 35.0 mg/kg and an ER-M of 110.0 mg/kg. The lowest concentration used to propose the ER-L and ER-M values was the observation of toxicity to *Daphnia magna* in sediments containing 26.6 mg/kg lead.

Eisler (1988a) reviewed the toxic effects of lead in birds. A number of studies report toxic effects and accumulation in game birds that ingested lead shot. These exposures are often lethal. Lead-poisoned birds show the following symptoms: loss of appetite, lethargy, weakness, emaciation, tremors, drooped wings, and impaired locomotion and balance. Decreased levels of delta amino levulinic acid dehydrogenase (ALAD) (an enzyme involved in hemoglobin synthesis) are frequently an early symptom of poisoning.

In an experimental exposure with mallard ducks (*Anas platyrhynchos*), the only observed effects from 12 week exposure to a diet containing 25 ppm lead (as lead nitrate) were decreases in blood ALAD activity and increases in blood lead levels. This concentration can be converted to a dose of 3.12 mg/kg by multiplying by a dietary conversion factor of 0.125 mg/kg body weight per ppm diet (USDA 1984). A bird TRV of 0.312 mg/kg was obtained by adding a safety factor of 10 for LOEL:NOEL.

Lead toxicity to wild and domestic mammals has been reviewed by Demayo et al. (1982) and Eisler (1988a). Lead causes adverse effects on survival, growth, reproduction, develoopment, behavior, learning, and metabolism. Lead levels in blood are often measured and have been correlated with these effects. Lead accumulates preferentially in bone tissue (Demayo et al. 1982). Levels in kidney and liver tissues are much less commonly measured than levels in bone and blood. One of the major metabolic effects is the inhibition of delta-aminolevulinic acid dehydratase (ALA-D), which regulates hemoglobin production.

Lead effects were examined in woodchucks *(Marmota monax)* fed plants grown adjacent to a highway for 58 days (Young et al. 1986). Plants contained an average concentration of 50.65 mg/kg dry weight. Kidney concentrations in these animals averaged 5.78 mg/kg dry weight (approximately 28.9 mg/kg wet weight). Hematological screening of exposed woodchucks and control animals indicated no significant differences. There were no effects on feeding or weight gain.

A field study with raccoons *(Procyon lotor)* indicated that animals with liver concentrations greater than 10 mg/kg had brain lesions characteristic of lead poisoning (Diters and Nielsen 1978). The authors stated that liver concentrations between 5 and 10 mg/kg can be regarded as evidence of possible toxicity and that levels above 10 are diagnostic for lead poisoning.

Lead inhibits plant growth, photosynthesis, and water absorption (Eisler 1988a). Inhibition of photosynthesis is attributed to the blocking of protein sulfhydryl groups and to changes in phosphate levels in the cell (Eisler 1988a). Exposure of two weed species to soils containing 46 mg/kg resulted in a 30-40 percent decrease in the percentage of seeds germinating (Krishnayya and Bedi, 1986). This value is used as a TRV in this assessment.

3.3.2 Chemicals of Potential Concern in Surface Water and Sediments

Antimony

EPA (1986) has not published AWQC for antimony. Acute and chronic LOELS were 9,000 µg/l and 1,600 µg/l, respectively. However, these levels may exceed the water solubility of some antimony compounds.

In an early life stage text with fathead minnows (*Pimephales promelas*), LeBlanc and Dean 1984) found that antimony (as antimony trioxide) had no adverse effects. Tests were initiated with embryos 48-hours after fertilization and continued through 30-days after hatching. No effects were found on hatching, larval survival, or larval growth at the highest concentration (7.5 µg/l) that could be maintained in solution.

Sediment toxicity data were evaluated by Long and Morgan (1990). All data were from field studies rather than "spiked sediment" tests in which known amounts of arsenic are added to sediments and toxicity is measured. The lowest concentration associated with toxic effects was 2.0 mg/kg. In this study, sediment from Commencement Bay (WA) was toxic to oyster larvae. In tests with sediments from San Francisco Bay containing 2.7 mg/kg antimony, there was significantly increased mortality. An ER-L of 2.0 and an ER-M of 25.0 mg/kg were proposed.

Very limited information is available on the toxicity of antimony to plants. Kabata-Pendias and Pendias (1984) report a phytotoxic level in soil of 5 mg/kg which is used as a TRV in this assessment.

Arsenic

The mechanism of arsenic toxicity is through enzyme inhibition. Arsenic replaces phosphorus and sulfur in metabolic processes. There are two ionic forms (trivalent and pentavalent) with the trivalent form being more toxic. The environmental effects of arsenic have been reviewed by Sorensen (1987) and Eisler (1988b).

For trivalent arsenic, EPA (1985e) established acute and chronic freshwater criteria of 360 µg/l and 190 µg/l. Marine acute and chronic criteria are 69 and 36 µg/l, respectively. For pentavalent arsenic, acute and chronic freshwater LOELS are 850 and 48 µg/l, while marine acute and chronic LOELs are 2319 and 13 µg/l.

Human activities that have caused releases of arsenic to the environment include the burning of coal in power plants and the use of arsenic in biocides. Arsenic is released as particulates from the stack and through the leaching of fly ash (Sorensen 1987). In aquatic systems arsenic appears to partition into sediments. Bioconcentration factors of up to 17 have been reported for fish (Eisler 1988b). Sorensen (1987) cited studies which showed that bottom feeding fish accumulate greater concentrations of arsenic than top feeders. Routes of accumulation include feeding on bottom-dwelling invertebrates and incidental ingestion of sediments.

Sediment toxicity data for arsenic were summarized by Long and Morgan (1990) who proposed an ER-L of 33.0 mg/kg and an ER-M of 85.0 mg/kg. All studies were field or laboratory studies which reported the occurrence of toxic effects at measured sediment concentrations. No spiked sediment test studies were reported. The lowest concentration used to calculate the ER-L and ER-M was 22.1 mg/kg. In this study, exposure of bivalve larvae to San Francisco Bay sediments containing 22.1 mg/kg arsenic resulting in a high incidence of abnormalities.

Arsenic can interfere with essential plant processes such as mitosis, photosynthesis, and nucleic acid and protein synthesis. Concentrations of arsenic as low as 15 mg/kg have been reported to be phytotoxic (Kabata-Pendias and Pendias 1984). This value is used as a TRV in this assessment.

Copper

Copper toxicity has been tested on a wide variety of aquatic species. In freshwater, copper toxicity is inversely related to water hardness. EPA (1985f) freshwater acute and chronic AWQC, at a hardness of 100 mg $CaCO_3$/l, are 18 and 12 µg/l, respectively. Marine acute and chronic criteria are both 2.9 µg/l. Environmental effects of copper have been reviewed by Demayo et al. (1982).

Fish and invertebrate species seem to be about equally sensitive to the chronic toxicity of copper. In a chronic life-cycle test with the amphipod, *Gammarus pseudoliminaeus*, a maximum allowable toxicant concentration (MATC) of 6.1 µg/l was reported at a water hardness of 45 mg $CaCO_3$/l. In an early life stage-test using *Salvelinus fontinalis* (brook trout), a MATC of 3.9 µg/l was reported at a water hardness of 37.5 mg $CaCO_3$/l (EPA 1985f).

Human activities that cause copper to be released to the environment include mining and smelting operations, industrial discharges, and biocidal uses (ATSDR 1989d). Copper released to surface waters tends to bind to organic matter in sediments. ATSDR (1989d) reported bioconcentration factors in fish of 10-100. Oysters have a high capacity to bind copper; a bioconcentration factor of 30,000 was reported (Perwak et al. 1980; as cited in ATSDR 1989d).

Sediment toxicity data were reviewed by Long and Morgan (1990). Two spiked sediment tests were reported. In one test. the burrowing behavior of the little neck clam (*Protothaca staminea*) was altered at concentrations equal to or greater than 17.8 mg/kg. In a series of tests with various freshwater organisms, LC_{50}s ranged from 681 mg/kg in Daphnia magna to 2296 mg/kg in the midge, *Chironomus tentans*. In a test which surveyed sediment toxicity in a Lake Michigan harbor with the amphipod, *Hyalella azteca*, toxicity was correlated with copper concentrations. The lowest level associated with toxic effects was 19.5 mg/kg. Long and Morgan (1990) proposed an ER-L of 70 mg/kg and an ER-M of 390 mg/kg.

Dowdy and Larson (1975) and Furr et al. (1976) tested plant growth on soils amended with sludge. They reported no effects on plant growth at concentrations of 245 and 395 mg/kg, respectively. However, Kabata-Pendias and Pendias (1984) reported that soil copper levels as low as 60 mg/kg have been phytotoxic. This value is used as a TRV in this assessment.

Mercury

Mercury has no known biological function, and any presence of the metal in organisms is considered undesirable (NAS 1978). Inorganic mercury is relatively non-toxic to organisms. Inorganic mercury, however, may be transformed through biological processes to form methyl mercury which can be bioaccumulated and biomagnified. Methyl mercury has been found to be mutagenic and teratogenic in various species and is also associated with neurotoxic and other histopathological effects. Mercury generally tends to accumulate rapidly and be eliminated slowly (Eisler 1987a). The EPA (1985g) freshwater acute and chronic criteria are 2.4 and 0.012 µg/l respectively. Marine acute and chronic criteria are 2.1 and 0.021 µg/l, respectively. These values are based on methyl mercury and are therefore very conservative estimates for inorganic mercury which is neither as toxic or as easily bioaccumulated as methyl mercury.

Mercury toxicity to fish and wildlife was reviewed by Eisler (1987a). Human activities resulting in environmental releases include the burning of fossil fuels, mining and processing of other metals, chemical manufacturing, and use and disposal of batteries. Methylating bacteria are present in freshwater and marine sediments; methylation serves to remobilize inorganic mercury (Eisler 1987a).

In their summary of mercury sediment toxicity data, Long and Morgan (1990) proposed an ER-L of 0.15 mg/kg and an ER-M of 1.3 mg/kg. The data base includes two spiked sediment tests. In one study, an LC_{50} of 13.1 mg/kg was reported for the amphipod, *Rhepoxynius abronius*, in a 10-day test. In the second study, there was a significant reduction in activity in the amphipod *Pontoporeia affinis* in a 5-day test. Tests with contaminated sediments have indicated toxic effects in locations with mercury concentrations as low as 0.15 mg/kg.

Mercury is not known to be readily taken up by plants. Symptoms of phytotoxicity include stunting of seedling growth and root development, and inhibition of photosynthesis resulting in yield reduction (Kabata-Pendias and Pendias 1984). Weaver et al. (1984) reported that 8 mg/kg in soil reduced growth in Bermuda grass and this value is used as a TRV.

Nickel

The adverse effects of nickel on aquatic organisms include alteration of cell membranes, formation of precipitates on gills, hematological effects, and reproductive impairment. The EPA (1986) freshwater criteria for nickel vary with water hardness. The acute and chronic criteria at a hardness of 100 mg $CaCO_3$/l are 1400 and 160 µg/l, respectively. The EPA (1986) acute and chronic marine criteria are 75 and 8.3 µg/l, respectively. EPA (1986) reported freshwater bioconcentration factors to range from 0.8 in fish muscle to 193 for a cladoceran. Marine bioconcentration factors ranged from 262 in an oyster to 675 in a brown alga.

Sediment toxicity data were reviewed by Long and Morgan (1990) who proposed an ER-L of 30 mg/kg and an ER-M of 50 mg/kg. No spiked sediment studies were reported. Field studies indicated low benthic species richness occurred in Massachusetts Bay sediments with mean nickel concentrations of 33 mg/kg. Significant mortality was observed in *Daphnia magna* exposed to Trinity River (TX) sediments containing 29 mg/kg nickel.

Kabata-Pendias and Pendias (1984) reviewed the literature on metal phytotoxicity and identified the total concentrations of selected metals in surface soils that were phytotoxically excessive. The concentration for nickel was 100 mg/kg (dry weight).

Polynuclear Aromatic Hydrocarbons

PAH toxicity to fish and wildlife was reviewed by Eisler (1987a). EPA (1986) reported a marine acute LOEL of 300 µg/l for PAHs. Freshwater LOELs for naphthalene of 2300 µg/l (acute) and 620 µg/l (chronic) and a marine acute LOEL of 2350 µg/l were reported by EPA (1986).

Human and natural processes both release PAHs to the environment. Major anthropogenic sources are the combustion of fossil fuels, municipal incineration, and the use of petroleum products (Eisler 1987a). Urban runoff contributes substantial amounts of PAHs to aquatic systems. In water, PAHs tend to associate with particles and elevated levels can persist in sediments.

Concern about PAH concentrations in sediments arises from the association between these concentrations and tumors in fish (reviewed by Eisler (1987a) and Mix (1986). Although

PAHs tend to be rapidly metabolized by fish, metabolites may be carcinogenic. Uptake through the food chain was demonstrated by McCain et al. (1990) who measured PAHs in the stomach contents of chinook salmon (*Oncorhynchus tshawytscha*) from the Duwamish Waterway which has PAH- and PCB-contaminated sediments. PAH metabolites were detected in the bile of these fish.

EPA (1988) proposed interim sediment quality criteria for acenaphthene, benzo(a)anthracene, benzo(a)pyrene, fluoranthene, phenanthrene, and pyrene. For total PAHs, Long and Morgan (1990) proposed ER-L and ER-M values of 4 and 35 mg/kg, respectively. They stated that it is difficult to assess total PAH data since investigators frequently measure different PAHs. The ER-L of 4 is supported by a study showing that San Francisco Bay sediments with this concentration of total PAHs were toxic to oyster larvae and to amphipods (Rhepoxynius abronius).

Insufficient data were available to estimate a plant TRV.

Silver

EPA (1986) proposed a hardness-based freshwater acute criterion for silver. At 100 mg $CaCO_3$/l, the acute criterion is 4.1 µg/l. The chronic criterion of 0.12 µg/l is not hardness-based. The acute marine criterion is 2.3 µg/l. There were insufficient data to establish a chronic criterion.

Two major sources of silver release are through mining and smelting activities and photographic uses (ATSDR 1990). Silver tends to become particle-bound and reside in sediments. Bioconcentration factors of less than 10 were reported for freshwater fish. The highest factors (1055-7650) were reported in the mussel (*Mytilus edulis*). Field studies have shown elevated levels in clams and scallops in areas near sewage outfalls or sludge disposal sites.

Long and Morgan (1990) stated that few studies evaluated silver toxicity in sediments. The data base did not include any spiked sediment tests. They proposed an ER-L of 1.0 mg/kg and an ER-M of 2.2 mg/kg. The ER-L is supported by the observation that San Francisco Bay sediments containing 1.1 mg/kg were toxic to bivalve larvae. Studies with Puget Sound sediments have reported toxicity in the amphipod, *Rhepoxynius abronius*, at 0.6 mg/kg.

Zinc

Zinc is an essential trace nutrient important for cell growth and differentiation. Exposure of fish to lethal concentrations of zinc results in extensive edema and necrosis of gill tissue with death resulting from a lack of oxygen uptake. Zinc toxicity is dependent on water hardness. EPA

(1985h) proposed freshwater acute and chronic criteria of 120 and 110 µg/l, respectively at a hardness of 100 mg $CaCO_3$/l. The marine acute and chronic criteria are 95 and 86 µg/l, respectively.

The environmental toxicity of zinc was reviewed by Taylor et al. (1982) and EPA (1985h). Bioconcentration factors have ranged from 521 to 1130 in fresh water and 3.7 to 23,820 in salt water. Zinc released to surface water tends to be sorbed to particles and can reside in sediments. Accumulation of zinc from sediments was reported in the review by Taylor et al. (1982). Concentrations in sediments along a pollution gradient were found to be reflected in tissue residues in benthic species.

Zinc sediment toxicity was reviewed by Long and Morgan (1990), who proposed an ER-L of 120 mg/kg and ER-M of 270 mg/kg. Three spiked sediment studies were reported. An LC_{50} of 276 mg/kg was reported in a 10-day test with the marine amphipod, *Rhepoxynius abronius*. In a 5-day test with the freshwater amphipod, *Pontoporeia hoya*, there was a significant decrease in activity between 59 and 124 mg/kg. In a 72-hour bioassay with *R. abronius*, an LC_{50} of 79 mg/kg was reported. The ER-L value is supported by the observation of decreased species richness in Massachusetts Bay benthos at a zinc concentration of 117 mg/kg.

Zinc toxicity to plants was reviewed by Taylor et al. (1982). Although zinc is essential for plants, excess levels are toxic and toxicity appears to be greater at lower soil pH levels. Several studies report the rate of application rather than the soil concentration associated with toxic effects. In calculating a TRV, a value of 100 mg/kg will be added to account for soil concentrations in non-enriched soil. This value approximates the mean concentration reported in several Canadian surveys and the value reported in untreated controls from an enrichment study.

MacLean and Dekker (1978, as cited in Taylor et al. 1982) reported that lettuce yield was decreased in soils with added zinc concentrations of 120 mg/kg (clay, pH 5.3) and 240 mg/kg (loam, pH 6.3). A report by Mitchell et al. (1978, as cited in Taylor et al. 1982) indicated that lettuce yield was reduced by 25 percent when zinc was added to pH 5.7 soil at a rate of 130 mg/kg.

By adding a background concentration of 100 mg/kg, and averaging the three toxic loadings, a TRV of 260 mg/kg is derived for this assessment.

4.0 RISK CHARACTERIZATION

Risks to aquatic and wetland species may occur through the various routes of exposure discussed above. Potential risks are discussed for each receptor and pathway.

4.1 Risks to Fish and Aquatic Life

Risks are evaluated from exposure to surface water and sediments and by evaluating the significance of the tissue residue data. Patterns in concentrations are used to determine if the contaminants are site related. Chemicals that show a strong gradient with the highest concentrations in the source area (Pool C and the Connecting Channel) are most likely site-related. The primary concern for ecological effects is in receiving waters (e.g., Edmonds Creek, Martins Creek/Mill Brook, Raritan River) where populations of ecological receptors have been sampled. Concerns may also exist at Pool C and the Connecting Channel, although the area was not sampled for biota by Wehran (1990).

4.1.1 Surface Water

Potential risks are assessed by comparing the geometric mean concentration of the chemicals of potential concern with the chronic AWQC and the maximum concentration with the acute AWQC. If the chemical was only detected in a single sample, no average concentration was calculated and the chemical was compared to the acute rather than chronic AWQC. Other guidance values were used if AWQC were unavailable (see Section 3.1.1). Comparisons of surface water concentrations and AWQC and other guidance levels are provided in Table 4-1.

Organics

Only one organic chemical of potential concern, DDT was detected at a concentration exceeding an acute AWQC. In one of three samples collected from the source area (Pool C and the Connecting Channel), the DDT concentration of 0.16 µg/l slightly exceeded the acute AWQC of 0.13 µg/l and exceeded the chronic AWQC of 0.001 µg/l. PCBs were only detected in one out of three samples from Pool C. The concentration (0.33 µg/l) did not exceed the acute AWQC of 2.0 µg/l but exceeded the chronic AWQC of 0.014 µg/l. Both compounds do not appear to pose substantial risks to ecological receptors from surface water exposure since they were not detected in receiving waters which were sampled for biota. The only other organic chemical of potential concern that exceeds a guidance value is chlorobenzene. It was detected in one of two samples from Pool C and the Connecting Channel at a concentration roughly twice the EPA LOEL. In view of the absence of detectable concentrations of chlorobenzene from receiving waters, this compound does not appear to pose risks to major ecological receptors.

Table 4-1. Comparison of surface water concentrations with Ambient Water Quality Criteria (AWQC) or other toxicity data for chemicals of potential concentrations

	Chronic AWQC (µg/L)	Geometric Mean Surface Water Concentrations (µg/L) Site Area				Acute AWQC (µg/L)	Maximum Surface Water Concentrations (µg/L) Site Area			
		A[a]	B[b]	C[c]	D[d]		A[a]	B[b]	C[c]	D[d]
VOCs:										
2-Butanone		--	--	--	--	5,600,000[e]	12 0	--	--	--
Chlorobenzene		--	--	--	--	160[f]	310 0	--	--	--
Styrene		--	--	--	--	25,100-74,800[e]	0 6	--	--	--
Xylenes		42 4	--	--	--	9,200 36,800[e]	600 0	--	0 8	--
PAHS:										
2-Methylnaphthalene		--	--	--	--	NA	1.0	--	--	--
Other Semi-volatiles										
N-Nitrosodiphenylamine		--	--	--	--	NA	4.0	--	--	--
Pesticides/PCBs										
4,4-DDT	0.001	--	--	--	--	0.13	0.16	--	--	--
Arocolor 1254	0.014	--	--	--	--	2 0	0.33	--	--	--
Metals:										
Aluminum	87	702 0	885.7	2703	--	750	764.0	4380	2970	24700
Arsenic	13	3 0	--	--	--	69	7 0	1 3	--	3 5
Barium	NA	94 8	53 3	91.6	--	76,000[e]	346.0	100.0	95.7	312 0
Chromium	11	3.2	--	4 6	--	16	6.8	6.2	6.4	120 0

Table 4-1. (Continued)

	Chronic AWQC (µg/L)	Geometric Mean Surface Water Concentrations (µg/L) Site Area				Acute AWQC (µg/L)	Maximum Surface Water Concentrations (µg/L) Site Area			
		A[a]	B[b]	C[c]	D[d]		A	B	C	D
Metals (Continued):										
Cobalt		39.4	--	128.3	--	48,000[e]	70.7	220.0	163.0	27.8
Copper	2.9	--	27.5	90.8	--	2.9	--	129.0	127.0	133.0
Iron	1000	5439	1545	3160	--	1000	30,500	5,900	5,200	54,100
Lead	3.2	8.1	1.4	2.8	--	82	15.3	3.8	3.1	47.2
Manganese		330.9	149.6	542.1	--	1000[g]	468.0	652.0	563.0	790.0
Mercury		--	--	--	--	2.1	--	--	--	0.11
Nickel	8.3	103.2	15.4	203.9	--	75.0	162.0	407.0	295.0	59.0
Vanadium	0.012	--	--	--	--	4,800-17,400[e]	5.0	8.8	6.0	152.0
Zinc	86	54.4	--	227.7	--	95	56.6	397.0	247.0	153.0
Inorganics:										
Ammonia-N	1730	45,700	800	100	--	24,000	158,000	7,400	7,400	13,100
Cyanide	1	--	--	--	--	1	--	--	11.5	22.2

[a] = Pool C and Channel.

[b] = Tidal Edmonds.

[c] = Non-tidal Edmonds.

[d] = Low Lying Area.

[e] = 96-hour LC50s for fish species found in the literature.

[f] = EPA (1986) LOEL.

[g] = Suggested as non-deleterious level by McKee and Wolf (1963).

NA = Not Available

Inorganics

The following metals were identified in both a source and a receiving water at levels exceeding AWQC: aluminum, iron, lead, and nickel. Chromium was detected in the one Low Lying Area sample collected at a level of 120 µg/l, which greatly exceeds both the acute AWQC of 16 µg/l and concentrations in Pool C and the Connecting Channel (maximum: 6.8 µg/l). The Low Lying Area covers a relatively small area of the site and may receive runoff from the adjacent Edison Landfill. The Low Lying Area has not been sampled for ecological receptors, and therefore, is not considered a primary area for ecological concern and is not viewed as a receiving water for risk assessment. Whereas copper was found at levels exceeding AWQC in receiving waters, the rejection of sample data for Pool C and the Connecting Channel precludes analysis of the relation of the chemical to the site. Zinc was found at concentrations exceeding AWQC in receiving waters but not in Pool C and the Connecting Channel.

Concentrations of iron greatly exceed the AWQC of 1000 µg/l at all locations. According to Schmid and Company (1987), iron is elevated in the area due to natural substrate materials. Schmid and Company (1987) stated that aquatic life of the Meadowlands Region may be impacted by the elevated iron concentrations. Although few samples were collected, the pattern of iron levels suggests the importance of offsite sources. Although the maximum concentration was higher in Pool C and the Connecting Channel (30,500 µg/l) than in tidal Edmonds (5,900 µg/l), the highest concentration was found in the Low Lying Area (54,100 µg/l), which may receive input from the adjacent Edison landfill.

An examination of the concentration data for aluminum indicates that levels were considerably higher in receiving waters then in Pool C and the Connecting Channel. These data suggest that concentrations may result from natural substrates and regional inputs rather than site-related contamination.

Lead concentrations were several fold higher in Pool C and the Connecting Channel than in either Edmonds Creek site area. Because sediment concentrations of lead are elevated above background concentrations in Pool C and the Connecting Channel, and sediment-bound metals may be released to the water column, the Pool C area may serve as a source for the surface water concentrations. However, the concentration measured in the Low Lying Area (47.2 µg/l) was about three times the maximum concentration measured in Pool C and the Connecting Channel (15.3 µg/l). In view of this pattern in concentrations, it is not possible to conclude that Pool C is the only source of lead contamination in surface waters at Kin-Buc.

Nickel concentrations in surface waters do not show a gradient from the source area. Maximum concentrations were greatest in tidal Edmonds (407 µg/l vs. 162 µg/l in Pool C and the Connecting Channel), while mean concentrations were greatest in non-tidal Edmonds (203.9 µg/l vs. 103.2 µg/l in Pool C and the Connecting Channel). Nickel contamination in surface waters cannot be attributed exclusively to site sources, although elevated concentrations in Pool C sediments may be a contributing factor.

Zinc surface water concentrations show a similar pattern. Maximum concentrations were greatest in tidal Edmonds while mean concentrations were greatest in non-tidal Edmonds. These data indicate that zinc contamination in surface water cannot be attributed exclusively to site sources although sediments from Pool C and the Connecting Channel may be contributing factors.

Ammonia-nitrogen was found at levels exceeding AWQC in Pool C and the Connecting Channel but not in receiving waters. Ammonia contamination may be site-related since there is a strong concentration gradient with the maximum concentration 10-20 times greater at the source area than in receiving waters. There are likely to be risks to aquatic life (if they exist) in Pool C and the Connecting Channel from these ammonia levels.

Cyanide concentrations in non-tidal Edmonds and the Low Lying Area exceed AWQC. However, cyanide contamination does not appear to be site-related since the compound was not detected in the Pool C and Connecting Channel area.

4.1.2 Sediments

Polychlorinated biphenyls

Sediment concentrations in each of the sections of the site are compared with interim sediment quality criteria and other guidance levels (Table 4-2). The primary chemicals of potential concern are PCBs where greater than 100 mg/kg have been reported in Pool C and tidal Edmonds Creek sediments. Although Aroclors 1242, 1248, and 1254 were detected in Pool C and Connecting Channel sediments, SQC only exist for Aroclor 1254. Risks will be characterized by comparing Aroclor 1254 concentrations with the site-specific SQC and by comparing total PCB concentrations with the ER-L and ER-M values (Table 1-6). Because the SQC are calculated to be protective of chronic effects (EPA 1988), the geometric mean concentrations will be used in the comparisons. The maximum concentrations will be discussed in the characterization of the pattern of contamination. The vast majority of sampling took place at tidal Edmonds Creek and, to a lesser extent, at Pool C and the Connecting Channel. Characterization of the other areas is based on a maximum of five samples per area.

Table 4-2. Comparisons of geometric mean and maximum sediment concentrations with guidance values for chemicals of potential concern

A. Comparisons with EPA SQC in Site Area (mg/kg)

	A		B		C		D		E		F		G		H	
	Mean,* Max.	SQC	Mean, Max	SQC	Mean, Max.	SQC	Mean, Max	SQC	Mean, Max.	SQC	Mean, Max.	SQC	Mean, Max.	SQC	Mean, Max.	SQC
PAHs:																
Phenanthrene	0.386, 14.000	1.40	0.251, 5.900	1.00	NC, 0.019	0.26	0.215, 0.330	0.60	0.910, 1.200	0.86	0.128, 0.450	0.12	0.128, 0.170	0.50	0.150, 0.380	0.62
Pyrene	0.969, 25.000	15.64	0.382, 4.900	11.13	0.036, 0.049	2.96	0.626, 0.980	6.62	1.223, 3.600	9.54	0.283, 0.790	1.32	0.377,0 430	5.56	0.220, 0.740	6.09
PCBs:																
Aroclor 1254	0.531, 130.000	0.23	0.264, 37.000	0.16	--	--	NC, 0.200	0.097	--	--	0.085, 0.096	0.019	NC, 0.140	0.080	0.240, 0.870	0.100

B. Comparison with ER-L and ER-M Values (mg/kg)

	ER-L, ER-M	A	B	C	D	E	F	G	H
		Mean, Max	Mean, Max	Mean, Max	Mean, Max	Mean, Max	Mean, Max	Mean, Max	Mean, Max
Total PAHs:	4, 35	6.748, 54.000	0.884, 15.970	0.087, 0.088	3.012, 4.421	4.253, 14.794	1.353, 4.018	1.750, 1.957	.800 5.220
Total PCBs:	0.05, 0.400	30.621, 730.00	0.423, 300.000	--	0.450, 0.700	--	0.085, 0.096	0.250, 3.300	.320 2.97
Antimony	2, 25	5.26, 13.10	5.89, 25.25	--	--	NC 4.00	--	--	--
Arsenic	33, 85	20.92, 174.00	42.12, 257.00	NC, 2.70	--	21.79, 23.50	--	--	22.99, 125.00
Cadmium	5, 9	1.08, 2.80	1.13, 3.30	--	--	1.62, 29.40	--	--	1.02, 2.50
Chromium	80, 145	58.93, 110.00	57.46, 116.00	37.65, 44.30	24.48, 31.70	50.95, 62.80	30.66, 39.20	NC, 41.10	43.14, 117.00
Copper	70, 390	133.51, 242.00	98.21, 441.00	43.02, 53.70	74.81, 77.20	63.58, 126.00	47.64, 57.00	NC, 35.40	58.36, 297.00
Lead	35, 110	115.81, 258.00	78.34, 372.00	19.53, 22.20	51.27, 60.30	77.73, 227.00	80.90, 163.00	NC, 49.10	25.38, 172.00
Mercury	0.15, 1.3	0.63, 1.50	0.49, 3.30	--	0.06, 0.07	0.18, 0.69	NC, 0.07	NC, 0.18	0.39, 3.40
Nickel	30, 50	34.34, 85.80	43.47, 176.00	28.73, 39.50	18.39, 21.00	23.41, 25.80	27.27, 35.30	NC, 29.10	23.65, 57.40
Silver	1, 2.2	1.02, 4.10	0.94, 4.70	--	NC, 061	0.88, 2.20	0.44, 0.77	NC, 0.98	1.43, 7.50
Zinc	120, 270	238.77, 526.00	190.68, 662.00	NC, 63.70	--	218.83 292.00	--	--	110.82, 293.00

Values are geometric mean and maximum for each site area

NC	= Mean not calculated
A	= Pool C and Channel
B	= Tidal Edmonds Creek
C	= Non-tidal Edmonds Creek
D	= Low Lying Area
E	= Martins Creek
F	= Mill Brook
G	= Raritan River
H	= Unnamed Ditch

Geometric mean Aroclor 1254 concentrations exceeded site-specific SQC at Pool C and the Connecting Channel, tidal Edmonds Creek, and Mill Brook. ER-L and ER-M values for total PCBs were exceeded at these areas, the Low Lying Area, and the Raritan River. The major areas of concern are the Pool C and the Connecting Channel (geometric means (mg/kg): Aroclor 1254 = 0.531, total PCBs = 30.621) and tidal Edmonds Creek (geometric means (mg/kg): Aroclor 1254 = 0.264, total PCBs = 0.423). Highly elevated locations in these areas exist; maximum total PCB concentrations were 730.00 mg/kg at Pool C and 300.000 mg/kg at tidal Edmonds. PCB contamination was widespread in both areas, since the frequency of detection was 100 percent in Pool C and the Connecting Channel and 80 percent in tidal Edmonds. With the exception of the Unnamed Ditch and Low Lying Area, frequency of detection was less than 50 percent in all other areas. Except for a single sample from the Raritan River at 3.300 mg/kg and an Unnamed Ditch sample at 2.970 mg/kg, all of the samples had total PCB levels of 0.900 mg/kg or less.

In the Pool C and Connecting Channel area, geometric mean Aroclor 1254 exceeded the SQC by a factor of 2.3. Mean total PCB concentrations exceeded the ER-L by 612 and the ER-M by 76. In tidal Edmonds Creek, geometric mean Aroclor 1254 concentrations exceeded the SQC by a factor of 1.6. Mean total PCBs exceeded the ER-L by a factor of 8 and slightly exceeded the ER-M. In the Unnamed Ditch area, mean Aroclor 1254 concentrations exceeded the SQC by a factor of 2.4; mean total PCBs were 6.4 times the ER-L. In the Low Lying Area, mean total PCBs exceeded the ER-L by a factor of 9 and slightly exceeded the ER-M. Occasional samples from other areas had detectable PCBs, but pervasive contamination was not indicated.

PAHs

Several site areas had high maximum concentrations of total PAHs: Pool C and Connecting Channel--54.000 mg/kg, tidal Edmonds Creek--15.970 mg/kg, and Martins Creek -- 14.794 mg/kg. All other areas had maximum total PAH concentrations of less than 6 mg/kg. Comparisons of the mean total PAH concentrations to the ER-L value of 4 mg/kg indicated that this guidance value was exceeded at the following locations: Pool C and Connecting Channel -- 5.746 mg/kg; Martins Creek--4.253 mg/kg. At tidal Edmonds, the mean total PAHs concentration was 0.864 mg/kg.

For the individual PAHs, only phenanthrene was detected at mean concentrations exceeding the SQC. At Martins Creek, the mean value of 0.951 mg/kg exceeded the SQC of 0.86 mg/kg. At Mill Brook, the mean value of 0.128 mg/kg exceeded the SQC of 0.120 mg/kg.

Analysis of the patterns of PAH concentration does not clearly indicate that contamination is site-related. Although several elevated concentrations were found at the source area, there is no overall concentration gradient. The geometric mean concentration in tidal Edmonds is about one-fifth of the ER-L and about one-half of the geometric mean concentration in the sediments from the Raritan River at the mouths of Edmonds Creek and Martins Creek (although few samples were collected from the area). Whereas total PAH concentrations in Martins Creek approach the ER-L value, these levels may be attributable to multiple sources including inputs from the Raritan River.

Metals

For many of the metals, mean concentrations were equal to or greater than the ER-L or ER-M guidance values. However, in order to evaluate the likelihood that site activities rather than natural sources or regional anthropogenic activities are responsible, comparisons were made to the background area. Thus, site areas were cosidered to have metal concentrations of concern if: (1) at least one sample was greater than twice the maximum measured in the background areas and (2) the geometric mean concentrations were greater than the ER-L guidance value for sediment toxicity (see Section 1.3.4). For antimony, no data were available from the background areas so all site areas with mean concentrations exceeding ER-L values were selected. As shown in Tables 1-4 and 4-2, the site areas with elevated metals concentrations are tidal Edmonds Creek (where antimony, arsenic, copper, lead, mercury, nickel, and zinc are contaminants of concern), Pool C and the Connecting Channel (for antimony, arsenic, and nickel), the Unnamed Ditch area (for arsenic, mercury, and silver), and Martins Creek (for antimony and cadmium).

The primary area of concern for ecological impacts from metal contaminants is tidal Edmonds Creek. A small number of samples have maximum concentrations greatly exceeding ER-M concentrations. It is likely that these samples would be toxic to benthic organisms due to the effects of multiple metals and PCB contamination. For example, the maximum concentration of arsenic in tidal Edmonds Creek was 257 mg/kg which exceeds the ER-M of 85 by a factor of three. Maximum concentrations of copper (440 mg/kg; ER-M--390 mg/kg), lead (372.00 mg/kg; ER-M--110 mg/kg), mercury (3.30 mg/kg; ER-M--1.3 mg/kg), nickel (176.00 mg/kg; ER-M--50 mg/kg), and zinc (662.00 mg/kg; ER-M--270 mg/kg) are of concern in tidal Edmonds Creek.

Maximum levels of several of these metals in Pool C and the Connecting Channel are also high: arsenic--174.00 mg/kg; lead--258.00 mg/kg; nickel--85.80 mg/kg, and zinc--526.00 mg/kg. Although a strict concentration gradient from Pool C and the Connecting Channel as a source area to the other site areas is not evident, it appears likely that these concentrations contribute to the elevated levels in Edmonds Creek.

Although mean concentrations of the metals of concern at tidal Edmonds Creek exceed the ER-L value, none of the mean values exceed the ER-M. The only site area where a mean value exceeded an ER-M was the Pool C and Connecting Channel area. where the mean lead concentration (115.51 mg/kg) exceeded the ER-M of 110 mg/kg.

These comparisons indicate that the primary area for concern from metal contamination is tidal Edmonds Creek where seven metals (antimony, arsenic, copper, lead, mercury, nickel, and zinc were found to be both elevated relative to the background areas and at mean levels exceeding ER-Ls. Of these metals, antimony may be of lesser concern since it was detected in only 2 of 59 tidal Edmonds Creek samples. Lesser concern for metal contamination is warranted at the Unnamed Ditch where arsenic, mercury, and silver were elevated and at mean levels exceeding the ER-L and at Martins Creek where antimony and cadmium were of concern. Any benthic species that may be present in Pool C and the Connecting Channel may be at risk from concentrations of antimony, arsenic, and nickel. It is conservative to assume that metal toxicity in sediments is additive: areas where a large number of metals exceed guidance values are more likely to exhibit sediment toxicity than areas where only one or two metals slightly exceed guidance values. The limitations and uncertainties in using the ER-L and ER-M values are discussed in Section 1.8.

Conclusions

Benthic species appear to be at risk from contaminants in sediments in three areas: Pool C and the Connecting Channel, tidal Edmonds Creek, and the Low Lying Area. The greatest concern for adverse ecological effects is at the tidal Edmonds Creek area since it is the largest area of the site and it is where ecological receptors have been identified (although the benthic community has not been characterized). The presence of ecological receptors at the other two areas is not known. Benthic species presumed to inhabit tidal Edmonds Creek appear to be at risk primarily from the presence of PCBs, where the geometric mean concentration is slightly greater than the ER-M and a number of samples had concentrations greater than 10 mg/kg or 25 times the ER-M. Additional risks may be attributable to the presence of six metals (arsenic, copper, lead, mercury, nickel, and zinc) at mean concentrations exceeding ER-L values.

4.1.3 Body Burden Data

Risks to aquatic life from exposure to contaminants in surface water, sediments, and diet were analyzed by comparing body burdens with levels associated with toxic effects. In order to place body burdens in perspective, concentrations will be compared with data from national or localized surveys of contaminant tissue residues.

Polychlorinated biphenyls

Geometric mean and maximum total PCB concentrations in mummichogs (*Fundulus heteroclitus*) (whole fish samples) collected from tidal Edmonds Creek were 2.97 and 4.10 mg/kg, respectively (Table 1-7). These levels were compared with concentrations measured in whole freshwater fish samples in the National Contaminant Biomonitoring Program in 1984 (the most recent available data; Schmitt et al. 1990). The national geometric mean and maximum total PCBs concentrations were 0.39 and 6.7 mg/kg, respectively. Thus, fish sampled at Kin-Buc have average PCB concentrations 7.6 times the national average and maximum concentrations about 60 percent of the national maximum.

PCB body burdens in both fiddler crabs and mummichogs are likely to be attributable to sediment contamination in tidal Edmonds Creek. Both species are known to be stationary (Krebs and Valiella 1978; Abraham 1985) and are therefore good indicators of localized contamination. Bioaccumulation of PCBs from contaminated sediments has been reported for fiddler crabs (Clark et al. 1986) and fish (Rubinstein et al. 1984). The patterns in tissue concentrations at the site areas are similar to the patterns in PCB concentrations in sediments. PCBs were only detected in one out of seven samples in the Martins Creek/Mill Brook system. Mean and maximum PCB concentrations in fish from these areas were about 1.0 mg/kg and may be attributable to regional sources. Concentrations in tidal Edmonds Creek fish were about three times higher and appear to reflect the higher sediment concentrations. Since fiddler crabs were only collected at tidal Edmonds Creek, it is not possible to characterize patterns in PCB levels.

Although no studies were found relating PCB concentrations in mummichogs with adverse effects, data are available for other fish species (summarized in Table 1-12). These studies can be used as guidance to indicate a range of concentrations that have been associated with toxic effects although there may be great differences between species. Several of the studies are field surveys in which fish contained other contaminants as well as PCBs. Comparisons between studies are complicated by the measurement of specific organs rather than whole body residues.

With these caveats in mind, it is apparent that toxic effects have been reported in fish with tissue concentrations in specific organs that are less than the 3.0 mg/kg mean Kin-Buc level. A study with rainbow trout (*Oncorhynchus mykiss*) found that the presence of PCB concentrations of 2.7 mg/kg in eggs, resulted in a 75 percent mortality rate by day 25 after hatching (Hogan and Braughn 1975). Seventy percent of the survivors had deformities. Von Westernhagen et al. (1981) collected ripe Balthic flounder (*Platichthys flesus*) from the Balthic sea, mixed eggs and milt, and monitored both egg viability and PCB concentrations in ovaries and liver. The authors found that when ovarian PCB concentrations were greater than 0.120 mg/kg, viable hatch rate was significantly reduced. At concentrations of 0.250 mg/kg there was less than 15 percent viable hatch. Concentrations in gonads appear to be similar to levels measured in muscle or whole fish with excised gonads (Von Westernhagen et al. 1981; Bengtsson 1980).

Von Westernhagen et al. (1981) reviewed other studies linking PCB tissue residues with adverse effects. In a study by Johansson et al. (1970), there was 60 percent mortality in Atlantic salmon eggs containing 17.0 mg/kg total PCBs. Bengtsson (1980) fed the minnow (*Phoxinus phoxinus*) a PCB (Clophen A50) for 40 days and monitored tissue residues and reproduction for an additional 260 days. Premature hatching which resulted in fry mortality occurred in the progeny of fish which contained whole body residues greater than or equal to 15 mg/kg. No effects were observed at a concentration of 1.6 mg/kg.

PCB concentrations in fiddler crabs (*Uca minax*) were lower than in mummichogs; geometric mean and maximum levels in individuals from tidal Edmonds Creek were 0.830 mg/kg and 2.09 mg/kg, respectively (Table 1-7). Crabs were not collected from the other site areas. In the only study found linking concentrations and effects with this species, mortality was not increased in fiddler crabs that obtained concentrations of 0.30 mg/kg after 42 day exposure to contaminated sediments (Clark et al. 1986). Clark et al. (1986) measured whole body residues; no data were found linking concentrations in carapace-free tissues with toxic effects. In a 36-day bioaccumulation study with *Uca pugnax*, there were no reported effects in animals that accumulated body burdens of 4-6 mg/kg by day 10 and maintained these concentrations until the end of the study (Marinucci and Bartha 1982). No studies were found that examined PCB effects on growth or reproduction in fiddler crabs and also measured tissue concentrations.

There may be great differences between fish in their sensitivity to PCB tissue residues. No studies that linked residues and effects in mummichogs were found. A conservative conclusion is that mummichogs appear to be at risk from reproductive effects from the mean and maximum tissue residues measured at Kin Buc. There are insufficient data to make inferences on the effects of the PCB body burdens measured at the site on fiddler crabs.

Cadmium

Cadmium was not detected in fish tissues at tidal Edmonds Creek or Martins Creek (Table 1-7). It was found in a single sample (0.180 mg/kg) at Mill Brook. The national geometric mean and maximum concentrations for cadmium in freshwater fish were 0.03 and 0.22 mg/kg, respectively (Schmitt and Brumbaugh 1990).

Eisler (1985) stated that whole body cadmium concentrations of 5.0 mg/kg may be life threatening to fish and that levels exceeding 2.0 mg/kg should be viewed as evidence of contamination. In view of the lack of detection of cadmium in tidal Edmonds Creek and its detection in only a single sample at a fraction of these levels of concern, cadmium concentrations in fish do not appear to warrant concern for ecological effects.

Cadmium concentrations in fiddler crabs were somewhat higher (mean: 0.300 mg/kg, maximum: 0.360 mg/kg). There are no national surveys for contaminants in fiddler crabs. Winger et al. (1990) measured cadmium concentrations in fiddler crabs (Uca pugilator) at the Savannah National Wildlife Refuge and the lower Savannah River. At all five locations where crabs were sampled, average crab concentrations were substantially greater than average fish concentrations. The authors stated that evidence of cadmium contamination was found at a station in the Savannah River where fiddler crabs contained 1.57 mg/kg. Three other stations in the River contained concentrations of 0.15 to 0.36 mg/kg. In the sample collected in the Wildlife Refuge, the average cadmium concentration was 0.20 mg/kg.

No studies were available linking tissue levels and effects in fiddler crabs.

Based on the available data, cadmium concentrations do not appear to pose risks to mummichogs at the site. Although no data were found linking tissue levels and effects in fiddler crabs, the concentrations observed do not appear to indicate site-related contamination.

Chromium

Chromium was detected in mummichogs at mean and maximum concentration of 0.970 and 2.300 mg/kg at tidal Edmonds Creek, 0.500 and 0.950 mg/kg at Martins Creek, and 0.490 and 0.740 mg/kg at Mill Brook (Table 1-7). In fiddler crabs at tidal Edmonds Creek, mean and maximum concentrations were 0.840 and 1.300 mg/kg, respectively.

No national survey data were available for fish or fiddler crabs. Winger et al. (1990) reported chromium levels of 0.71 to 2.03 mg/kg in longnose gar (*Lepisosteus osseus*) in the Savannah National Wildlife Refuge and 0.87 to 1.34 in the Savannah River. They stated that these concentrations were elevated relative to concentrations reported by Giesy and Wiener (1977) in fish from a South Carolina reservoir (0.02-0.06 mg/kg). Winger et al. (1990) measured concentrations of 0.90 to 2.06 mg/kg in fiddler crabs from four stations in the Savannah River and 1.17 mg/kg in a station in the Wildlife Refuge. No information on other areas where chromium was measured in fiddler crabs were provided in this paper.

Eisler (1986b) stated that tissue concentrations greater than 0.8 mg/kg should be viewed as presumptive evidence of contamination, however, no studies supporting this concentration were cited. No other reports relating concentrations with adverse effects were found in the literature.

The relationship between concentrations of chromium in sediments and aquatic biota has not been demonstrated to the same extent as for PCBs. Accumulation from sediments was demonstrated in mussels (*Mytilus edulis*) and softshell clams (*Mya arenaria*) (Cappuzzo and Sasner 1977, as cited in Eisler 1986b). Bioavailability of sediment-bound chromium is suggested by the study of Doughtie et al. (1983). These authors reported chromium concentrations of greater than 100 mg/kg in the New York Bight and found that lobsters, crabs, and shrimp in the area had a high incidence of cuticular lesions. These same lesions were induced in grass shrimp (*Palaemonetes pugio*) by exposure to 0.5 mg/l hexavalent chromium in water for 28 days.

The pattern of chromium sediment concentration at Kin-Buc shows similar levels at tidal Edmonds Creek and Martins Creek. However, chromium concentrations in mummichogs are about twice as high at tidal Edmonds Creek. It is clear that, in addition to concentration, factors such as particle size, organic content, sulfides, salinity, and oxidation-reduction potential (Jennett et al. 1980) are of major importance in determining the bioavailability of chromium.

There are insufficient evidence to suggest that the tissue concentrations of chromium measured in mummichogs and fiddler crabs provide evidence of toxic exposure.

Lead

Lead was not detected in fish tissues at tidal Edmonds Creek. It was found in single samples at Martins Creek and Mill Brook, at the same concentration (0.580 mg/kg). Mean and maximum concentrations in fiddler crabs at tidal Edmonds Creek were 1.510 and 1.800 mg/kg, respectively (Table 1-7).

The national geometric mean and maximum concentrations for lead in freshwater fish were 0.11 and 4.88 mg/kg, respectively (Schmitt and Brumbaugh 1990). While no national survey data were available for fiddler crabs, concentrations were 0.2 to 1.3 mg/kg in four Savannah River stations and 0.5 mg/kg in the Savannah River Wildlife Refuge station (Winger et al. 1990). Based on the presence of several fish samples at concentrations greater than 2 mg/kg, Winger et al. (1990) stated that there appears to be a lead contamination problem in the refuge and suggested that traffic from a nearby highway was a possible source.

Although lead is bioaccumulated to some extent (Eisler 1988a), the relationship between sediment and biota concentrations is complex and dependent on the same factors as described for chromium. Whereas data are available which link blood lead levels with adverse effects. no studies were found linking whole body residues and effects.

The lack of detectable lead concentrations at tidal Edmonds Creek and the infrequent detection at Martins Creek/Mill Brook indicate that lead contamination of fish tissues is not a concern at the site. The significance of the concentrations detected in fiddler crabs is not known.

4.2 Risks to Wetland Species

Risks were assessed by comparing surface water concentrations to WDAC developed by the Wisconsin Department of Natural Resources (1989; see Section 3.2.1), by evaluating exposure in birds (Section 4.2.1), and by comparing tissue concentrations with literature for mammals (Section 4.2.2).

Comparisons with WDAC are only possible for the three chemicals for which criteria exist: mercury, DDT, and PCBs. None of the these chemicals were detected in surface waters of tidal or non-tidal Edmonds Creek, which is the largest habitat for wildlife at the site. No samples were collected at the other major system (Martins Creek/Mill Brook). In the only sample measured in the Low Lying Area, the mercury concentration of 0.1 µg/l exceeded the WDAC of 0.002 µg/l. In the Pool C and Connecting Channel area, DDT and Aroclor 1254 were each detected in one of three samples at concentrations of 0.2 and 0.3 µg/l, respectively. These concentrations exceed the WDAC of 0.00015 µg/l for DDT and metabolites and 0.003 µg/l for Aroclor 1254. While the presence of these concentrations is cause for concern, it is not known whether there are wildlife residing or feeding in these areas.

4.2.1 Risks to Birds

Risks to birds were assessed by comparing average and maximum estimated dosages (Table 2-4) with TRVs (Table 3-2). As shown in Table 4-3, for all chemicals, neither the average nor the maximum estimated dosage exceeds the TRV.

For the heron, the estimated average dosage of PCBs were calculated using both whole fiddler crabs (Wehran 1990) data and carapace-free fiddler crabe data of Adams et al. (1990). Using the whole fiddler crab data, the estimated average dosage is 0.082 mg/kg/day which is 22 percent of the TRV (0.375 mg/kg/day). The estimated maximum dosage is 0.155 mg/kg/day or 31 percent of the TRV. Using the carapace-free fiddler crab data, the average and maximum estimated dosages are 0.121 mg/kg/day (32% of TRV) and 0.202 mg/kg/day (54% of TRV). The estimated average chromium dosage at tidal Edmonds Creek is 30 percent of the TRV while the maximum is 70 percent of the TRV. Estimated doses of PCBs and chromium were several times

Table 4-3. Risks to birds from exposure to PCBs. cadmium, chromium, and lead at Kin-Buc.

	Estimated Dosage (mg/kg/day)						**TRV (mg/kg/day)**	**Estimated Dosage (mg/kg/day)**		**TRV (mg/kg/day)**
	A. Great Blue Heron							**B. Red-Tailed Hawk**		
Chemical	**Tidal Edmonds**		**Martins Creek**		**Mill Brook**			**Tidal Edmonds**		
	Average	Maximum	Average	Maximum	Average	Maximum		Average	Maximum	
PCBs(a)	8.20E^{-2}	1.55E^{-1}	3.10E^{-2}	4.76E^{-2}	4.10E^{-2}	5.51E^{-2}	3.75E^{-1}	1.30E^{-2}	2.08E^{-2}	3.75E^{-1}
PCB(b)	1.21E^{-1}	2.02E^{-1}	0	0	0	0	3.75E^{-1}	2.02E^{-1}	0	3.75E^{-1}
Cadmium	0	0	0	0	5.36E^{-3}	7.14E^{-3}	5.0E^{-2}	5.64E^{-3}	6.20E^{-3}	5.0E^{-2}
Chromium	2.87E^{-2}	8.75E^{-2}	1.49E^{-2}	3.77E^{-2}	1.46E^{-2}	2.94E^{-2}	1.25E^{-1}	1.94E^{-2}	1.96E^{-2}	1.25E^{-1}
Lead	4.31E^{-5}	1.56E^{-4}	1.73E^{-2}	2.30E^{-2}	1.72E^{-2}	2.30E^{-2}	3.12E^{-1}	8.54E^{-2}	1.13E^{-1}	3.12E^{-1}

(a) = Based on Wehran (1990) fiddler crab data.
(b) = Using Adams et al (1990) fiddler crab data (without carapace).

lower at Martins Creek or Mill Brook compared to tidal Edmonds Creek. At tidal Edmonds Creek and at Martins Creek, the estimated exposure to cadmium was zero because it was not detected in surface water or biota. Estimated average and maximum cadmium dosages at Mill Brook were 11 percent and 14 percent of the TRV, respectively. Lead, which was found only in surface water at tidal Edmonds Creek, posed minimal risks at all locations.

For the hawk, the estimated average and maximum PCB dosages were 4 percent and 6 percent of the TRV, respectively. The greatest potential risks were attributable to lead where the average estimated dosage was 27.3 percent of the TRV and the maximum estimated dosage was 36.9 percent of the TRV. Average and maximum dosages of cadmium and chromium were between 10 and 20 percent of their TRVs.

Fish-eating birds (e.g., herons) are likely to be exposed to higher levels of PCBs and chromium than are rodent-eating birds (e.g., red-tailed hawk). However, exposure to lead may be greater in the rodent-eating than fish-eating birds. Since the rodent body burdens are based on kidney rather than whole body residues, there are substantial uncertainties associated with these estimates.

The greatest concern for ecological impact is from exposure of the heron to PCBs and chromium and exposure of the hawk to lead. Estimated dosages of these chemicals do not pose substantial risks. However, because the estimated dosages were about one-fifth to one-half of the TRVs, and in view of the considerable uncertainties in both the estimates of exposure and of risk (see Section 5.0), the possibility that adverse impacts may occur cannot be ruled out.

4.2.2 Risks to Mammals

Risks to mammals were evaluated by comparing tissue residue data (Table 1-7) with concentrations reported to be associated with toxic effects.

Polychlorinated biphenyls

PCBs were sampled in livers of muskrats, rats, mice from the tidal Edmonds Creek area by Wehran (1990). Only Aroclor 1254 was detected in muskrat livers whereas only Aroclor 1260 was detected in mouse and rat livers. Geometric mean and maximum concentrations were 0.06 and 0.20 mg/kg in the muskrat and 0.230 and 0.370 mg/kg in the rat. In the single mouse sample a concentration of 0.067 mg/kg was measured.

Charters et al. (1991) also analyzed PCBs in the livers from 61 muskrats collected from tidal Edmonds Creek and 16 samples from a reference area. PCBs were not detected in any of the samples.

The concentrations detected in mammals are compared with the concentrations in adipose tissue associated with reproductive effects (Hornshaw et al. 1983). To make the comparison, it was necessary to estimate adipose tissue concentrations in Kin-Buc mammals. Felt et al. (1979) found that the concentration of a pentachlorobiphenyl isomer in fat of laboratory rats (average of abdominal and subcutaneous) was 16 times the concentration in the liver. This factor will be used to compare the tissue levels measured in mammals at Kin-Buc with the levels associated with toxic effects in mink. There are considerable uncertainties in using this factor for a specific PCB with field data for commercial mixtures and in using laboratory rat data to estimate distributions in wild mammals.

Multiplying the mean and maximum concentrations in Kin-Buc liver samples by 16 yields estimated adipose concentrations of 0.96 and 3.20 mg/kg for the muskrat and 3.68 and 5.92 mg/kg for the rat. The estimated concentration in the single mouse sample was 1.07 mg/kg.

A comparison of the adipose concentrations reported by Hornshaw et al. (1983) with the estimated concentrations indicates that tissue concentrations are unlikely to be associated with risks to Kin-Buc mammals. The maximum concentration estimated for a rat sample at Kin-Buc (5.92 mg/kg) is less than the 6.0 mg/kg level which was not associated with adverse reproductive effects in the mink. Since the mink appears to be more sensitive than the rat (Eisler 1986a), the estimated levels in adipose tissues at the site are unlikely to be associated with toxic effects.

Cadmium

Cadmium was measured in the kidneys of muskrats and rats from tidal Edmonds Creek. Geometric mean and maximum concentrations were 0.280 and 1.800 mg/kg in the muskrat and 0.100 and 0.110 mg/kg in the rat. In muskrats from Martins Creek, geometric mean and maximum concentrations were 0.620 and 2.300 mg/kg, respectively.

These concentrations are considerably lower than the 100 mg/kg level identified as a critical levels for adverse effects on the kidney. Although liver effects can also occur in laboratory animals exposed to cadmium (Tohyama et al. 1987), it is unlikely that these effects would be present at the concentrations observed in mammals at Kin-Buc.

Chromium

In samples collected at tidal Edmonds Creek, geometric mean and maximum concentrations were 0.280 and 0.450 mg/kg in the muskrat kidney and 0.28 and 0.34 mg/kg in the rat kidney. In samples collected from Martins Creek, geometric mean and maximum concentrations in the muskrat kidney were 0.240 and 0.440 mg/kg, respectively.

Eisler (1986b) stated that organs and tissues of wildlife containing residues of greater than 0.8 mg/kg should be viewed as possibly contaminated. No studies linking tissue concentrations with effects were cited in this review or were found in the literature.

The significance of the tissue residues of chromium in mammals at the site is not known. No data were found associating these concentrations with adverse health effects in mammals.

Lead

In samples collected at tidal Edmonds Creek, geometric mean and maximum concentrations were 1.500 and 2.000 mg/kg in the rat kidney (Wehran, 1990). Lead was not detected in muskrat kidney tissues. At Martins Creek, lead was detected in one of three muskrat kidney samples at a concentration of 0.500 mg/kg. Charters et al. (1991) detected lead at mean concentrations of 0.32-0.50 mg/kg in livers of muskrats collected from tidal Edmonds Creek. Mean concentration in livers of animals from the reference area were approximately 8.20 mg/kg.

Young et al. (1986) found similar concentrations of lead in the liver and kidneys of woodchucks. Therefore, it is possible to compare the concentrations in Kin-Buc kidney samples with those in liver or kidney from studies with wild mammals.

The study of Diters and Nielsen (1978) indicates that liver concentrations above 5 mg/kg may be associated with toxic effects in mammals. Since the maximum concentration found at Kin-Buc was 2.0 mg/kg in the rat kidney and because the mean levels of lead in muskrats were about about an order of magnitude less than 5 mg/kg, it is unlikely that lead toxicity in mammals is an ecological concern at the site.

4.2.3 Risks to Plants

Risks to plants were evaluated by comparing geometric mean sediment concentrations in the wetland areas (tidal Edmonds Creek, Martins Creek, and Mill Brook) (Table 1-5) with TRVs (Table 3-2). As shown in Table 4-4, plants do not appear to be at risk from exposure to PCBs in sediments. However, several metals were reported at mean concentrations exceeding TRVs.

Table 4-4 **Risks to plants from exposure to chemicals in sediments at Kin-Buc II.**

Geometric mean sediment concentrations (mg/kg)				**TRV (mg/kg)**
	Tidal Edmonds	**Martins Creek**	**Mill Brook**	
PCBs	0.423	ND	0.085	26
Antimony	5.89	4.00*	ND	5
Arsenic	42.12	21.79*	ND	15
Cadmium	1.13	1.62	ND	2.5
Chromium	57.46	50.95	30.66	64
Copper	98.21	63.58	47.64	60
Lead	76.34	77.73	80.90	46
Mercury	0.49	0.18	0.07*	8
Nickel	43.47	23.41	27.27	100
Silver	0.94	0.88	0.44	2
Zinc	190.68	218.83	ND	260

ND = Not detected.
* = Maximum value listed because mean was not calculated.

At tidal Edmonds, the geometric mean concentration of arsenic exceeded the TRV by a factor of 2.8. The geometric mean lead concentration (76.34 mg/kg) is 1.6 times the TRV of 46 mg/kg, while the mean copper concentration of 98.21 mg/kg is 1.6 times the TRV of 60 mg/kg. At Martins Creek, mean concentrations of lead exceeded the TRV by a factor of 1.7, while mean concentrations of arsenic and copper slightly exceeded the TRVs. At Mill Brook, the mean concentration of lead exceeded the TRV by a factor of 1.8.

As discussed in Section 5.0, there are considerable uncertainties associated with the use of the plant TRVs. The greatest uncertainty is the use of these soil concentrations to represent levels in sediment. Bioavailability and effects of metals in sediments vs. soils is likely to differ substantially due to factors such as redox potential, sulfide content, salinity, and pH.

Marsh plants may be at risk from exposure to metals such as arsenic, copper, and lead in tidal Edmonds Creek sediments. Lead and copper concentrations in the Martins Creek/Mill Brook system may also pose risks to marsh plants. However, as described in the following section, there are considerable uncertainties associated with these estimates.

5.0 UNCERTAINTIES IN THE ECOLOGICAL ASSESSMENT

The primary sources of uncertainty are the small number of samples collected for surface water and biota, the lack of sampling of the benthic community, the assumptions used to model exposure, and the derivation and use of guidance values to evaluate risks.

A major source of uncertainty is the small number of samples collected in some locations of the site. No more than five surface water samples were collected in any site area and there were no samples collected at Martins Creek or Mill Brook. Sample analyses for several metals were rejected due to laboratory contamination. These data gaps limit the ability to perform a comprehensive assessment of surface water risks. Sediment analyses of several other Raritan River samples would have been useful in comparing site contaminant levels with levels from other local areas. Samples of fish and mammals never exceeded six organisms per site area.

The fish community at the site has not been well characterized. The only sampling gear used--minnow traps--is selective for small fish. Although the mummichog is an excellent fish for hazard assessment (because of its stationary nature), it is possible that unsampled species may have greater PCB body burdens and greater risks. Thus, the characterization of risk to fish using only the mummichog data contains considerable uncertainty.

It is unknown whether ecological receptors exist in Pool C and the Connecting Channel and the Low Lying Area. These data would be useful in characterizing environmental risks in these areas. Benthic data would be especially useful at Pool C and the Connecting Channel which has the highest concentrations of PCBs in sediments.

It must be assumed that a benthic community exists in the tidal marsh since many other ecological receptors were found. Data on benthic community abundance and diversity would be useful in assessing possible sediment impacts.

Considerable uncertainties arise in the estimation of exposure for birds. Limited data were available on the movements and feeding habits of great blue heron and red-tailed hawks in the Raritan River system. Estimates of prey concentrations were based on a small number of samples. Concentrations of PCBs in fiddler crabs were considerably higher in a single sample analyzed with the carapace removed. Further analyses of carapace-free crabs would be needed as confirmation. For hawks, estimates of dietary concentrations were based on rat liver and kidney since whole body concentrations were not available. These organ concentrations may be greater or lower than whole body concentrations.

Comparisons of body burdens in fish and mammal samples at Kin-Buc II with levels associated with toxicity in literature studies are also subject to uncertainty. In most cases comparisons are between different species and involve tissue concentrations in different organs. Animals from field studies frequently have measurable concentrations of other contaminants.

Aquatic toxicity data. which are the basis for ambient water quality criteria, have inherent variability. Sprague (1985) reported that LC_{50} tests, performed by the same investigators using the same dilution water over a period of years, varied by factors of 1.3-5.5. Ambient water quality criteria based on these studies are, therefore, also subject to uncertainty.

There are greater uncertainties in the guidance values for sediment toxicity. The EPA (1988) interim sediment quality criteria are based on partitioning theory which uses parameters such as distribution coefficients (K_{oc}) to estimate interstitial water concentrations to evaluate toxicity. A further source of uncertainty is the adjustment of these values by the total organic carbon content for the site area (which are based on few measurements and can greatly affect the SQC). The ER-L and ER-M guidance values are statistical estimates based on a variety of studies. The vast majority of these studies are tests with field-collected sediments which contain many compounds in addition to the one under investigation. Thus, these values may be strongly influenced by sediment characteristics such as the presence of other contaminants, organic carbon content, acid volatile sulfides, redox potential, and particle size.

Plant toxicity values are based on studies which may not accurately model realistic exposures. Hansen and Chaney (1987) reviewed the phytotoxicity database. One major error in phytotoxicity tests is the application of soluble metal salts to soils since metals in solution are more bioavailable and toxic than metals incorporated in a soil matrix. Other sources of error are the use of small pots which confines roots and overestimates uptake. Soil pH is a major factor affecting uptake. Often pH is not controlled or measured in these tests. Use of these soil-derived data for sediments also adds considerable uncertainty since contaminant mobility will be very different.

6.0 SUMMARY AND CONCLUSIONS

Potential risks to ecological receptors have been evaluated based on site monitoring data, a review of the toxicity of the chemicals of concern, and exposure estimates. The assumptions used in estimating exposures and deriving toxicity reference values have been described in this assessment. The results of the environmental assessment are summarized below.

Exposure of aquatic life to chemicals measured in surface water were assessed by comparing concentrations with ambient water quality criteria and other guidance values. Organic chemicals were infrequently detected in surface waters. PCBs and DDT were detected in only one of three samples in the primary source area for contaminants (Pool C and the Connecting Channel). The DDT concentration of 0.20 µg/l slightly exceeded the acute AWQC of 0.12 µg/l and exceeded the chronic AWQC of 0.001 µg/l. The PCB concentration of 0.3 µg/l did not exceed the acute AWQC of 2.0 µg/l but exceeded the chronic AWQC of 0.014 µg/l. Neither compound was detected in the major receiving system (tidal Edmonds Creek), where ecological receptors were sampled. Aquatic life at the site does not appear to be at risk from exposure to organic chemicals in surface waters.

A number of inorganic chemicals were found at concentrations exceeding AWQC. Aquatic life in tidal Edmonds Creek may be at risk from the levels of aluminum, copper, iron, nickel, and zinc. However, aluminum and zinc concentrations were higher in tidal Edmonds than in Pool C and the Connecting Channel. Concentrations of copper in the site areas cannot be compared because Pool C and Connecting Channel samples were rejected during data validation. Iron appears to be elevated regionally and the pattern of contamination does not implicate Pool C and the Connecting Channel as a source. Similarly, nickel concentrations were higher in the non-tidal Edmonds Creek samples than in the source area. Thus, although aquatic life may be at risk from exposure to several metals in site surface waters, regional inputs and natural sources appear to be more important than site-related contamination.

The major site-related risk to aquatic life is from exposure to PCBs in sediments at tidal Edmonds Creek (including the mosquito channel area). A concentration gradient was evident with total PCB levels as high as 730 mg/kg measured in the source area and a maximum concentration of 300 mg/kg measured in tidal Edmonds Creek. Geometric mean Aroclor 1254 concentrations exceeded the site-specific sediment quality criteria at Pool C and the Connecting Channel, tidal Edmonds Creek, the Unnamed Ditch, and Mill Brook. Mean total PCB concentrations also exceeded both the ER-L and ER-M concentrations used as guidance for sediment toxicity at Pool C and the Connecting Channel, tidal Edmonds Creek, and the Low Lying Area.

Several PAH compounds and total PAHs were found at levels exceeding toxicity guidance values. Although several samples at Pool C and the Connecting Channel contained individual PAHs at the highest levels reported onsite (greater than 10 mg/kg), there is not clear pattern of contamination implicating Pool C and the Connecting Channel as the primary source of PAHs.

Seven metals (antimony, arsenic, copper, lead, mercury, nickel, and zinc) appear to be at elevated levels in tidal Edmonds Creek sediments relative to sediments from nearby background areas. These seven metals were found at mean concentrations exceeding their ER-L guidance values; thus sediments from tidal Edmonds Creek may be toxic due to metals contamination as well as PCB contamination. Of these metals, antimony is of lesser concern since it was only detected in 2 of 59 samples from the area. Although there is no strict concentration gradient from Pool C and the Connecting Channel to the receiving streams in all cases, the areas with the highest sediment metal concentrations were usually Pool C and the Connecting Channel and tidal Edmonds Creek. Thus site-related metals cannot be ruled out as a contributor to the observed metal concentrations in site.

It is conservative to assume that metal toxicity in sediments is additive; sediments with a large number of metals exceeding guidance values are more likely to be toxic than sediments with few metals exceeding guidance values. Thus, the greatest concern for metal toxicity is at tidal Edmonds Creek. Other areas where sediment metals appear to be elevated relative to background samples at levels of concern are Pool C and the Connecting Channel (for antimony, arsenic, and nickel), the Unnamed Ditch (for arsenic, mercury, and silver) and Martins Creek (for antimony and cadmium).

Sediments can serve as a source for PCBs and metals contamination to fish and macrocrustaceans such as the fiddler crab. PCB concentrations in mummichogs at tidal Edmonds Creek (geometric mean: 2.97 mg/kg; maximum: 4.10 mg/kg) were about three times the concentrations measured in the Martins Creek/Mill Brook system and reflect the higher sediment concentrations. Although no literature was found linking tissue concentrations with effects in mummichogs, data for other species indicates the potential adverse effects of the body burdens in the tidal Edmonds Creek fish. Data are inadequate to evaluate the possible effects of the body burdens measured in fiddler crabs at tidal Edmonds Creek, which was the only site area sampled. Concentrations of cadmium, chromium, and lead measured in fish and fiddler crabs do not appear to pose risks and cannot be strongly attributed to site contamination.

Exposure of predatory birds to contaminants in their prey and drinking water have been estimated using the great blue heron as an example of a bird that consumes fish and crabs and the red-tailed hawk as a rodent-eating bird. Estimated dosages were compared with toxicity reference values (TRVs; estimated no adverse effect concentrations). Estimated dosages do not appear to pose substantial risk in that, in all cases, dosages were less than the TRVs. The greatest concern is from exposure of the heron to PCBs and chromium and exposure of the hawk to lead. Because estimated dosages were about one-fifth to one-half of the TRVs, and in view of the uncertainties in both the estimates of exposure and risk, the possibility that adverse impacts on these receptors may occur cannot be ruled out.

Based on body burden analysis, mammals do not appear to be at risk from exposure to PCBs, cadmium, chromium, and lead. PCB body burdens were highest in the rat samples. Estimated adipose tissue concentrations in rats are equivalent to levels that were not associated with reproductive effects in mink which is the most PCB-sensitive mammal tested to date. Tissue concentrations of cadmium in mammalian kidneys at the site are about 50 times less than the critical level associated with renal toxicity. No data were found linking chromium kidney concentrations with toxic effects. The maximum lead concentrations measured in rat kidney are several times lower than levels associated with toxic effects.

Marsh plants at tidal Edmonds Creek and Martins Creek may be at risk from exposure to arsenic, copper, and lead. Geometric mean concentrations exceeded the toxicity reference values for all three metals. However, there are considerable uncertainties in the toxicity reference values which were derived for soil rather than sediment exposures.

Threatened and endangered bird species have been observed at or adjacent to Kin-Buc as part of the RI investigation. Exposure pathways were explicitly assessed for the great blue heron (New Jersey threatened). Pathways evaluated for the red-tailed hawk are relevant for evaluating risks to other threatened or endangered predatory birds. Based on the exposure and toxicity assessment, these species do not appear to be at substantial risk from site-related contamination.

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APPENDIX

CAUTIONS AND RESTRICTIONS ON NATURAL HERITAGE DATA

CAUTIONS AND RESTRICTIONS ON NATURAL HERITAGE DATA

The quantity and quality of data collected by the Natural Heritage Program is dependent on the research and observations of many individuals and organizations. Not all of this information is the result of comprehensive or site-specific field surveys. Some natural areas in New Jersey have never been thoroughly surveyed. As a result, new locations for plant and animal species are continuously added to the data base. Since data acquisition is a dynamic, ongoing process, this Office cannot provide a definitive statement on the presence, absence, or condition of biological elements in any part of New Jersey. Information supplied by the Natural Heritage Program summarizes existing data known to the program at the time of the request regarding the biological elements or location in question. The information should never be regarded as final statements on the elements or areas being considered, nor should they be substituted for on-site surveys required for environmental assessments. The attached data is provided as one source of information to assist others in the preservation of natural diversity.

This office cannot provide a letter of interpretation or a statement addressing the classification of wetlands as defined by the Freshwater Wetlands Act. Requests for such determination should be sent to DEP Division of Coastal Resources, Bureau of Freshwater Wetlands, CN 402, Trenton, NJ 08625.

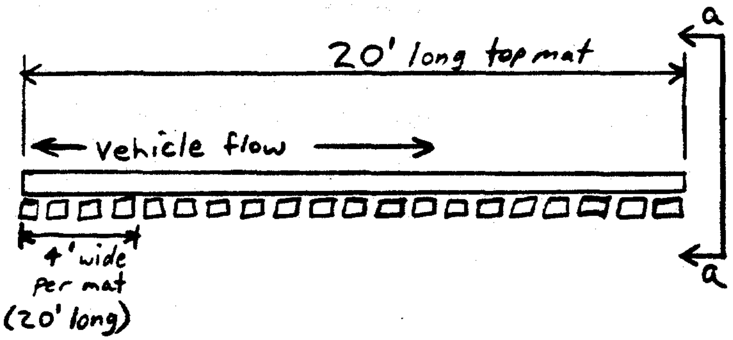
Information provided by this database may not be published without first obtaining the written permission of the Office of Natural Lands Management. In addition, the Natural Heritage Program must be credited as an information source in any publication of data.

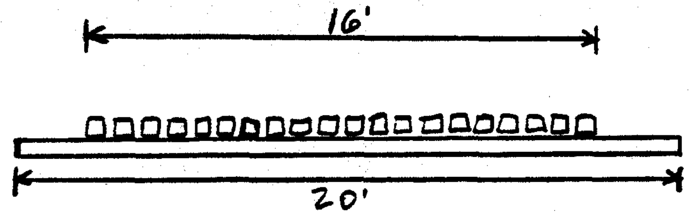
APPENDIX B
CALCULATION OF MARSH GROUND PRESSURES

By MID Date 5-13-92 **WehranEnviroTech** Job No. 09406 F5
Chkd. by ______ Date ______ Sheet No. 1 of 3
Subject KIN-BUC, OU2 FEASIBILITY STUDY

TIMBER MAT LOADING ON MARSH

The use of heavy equipment on the marsh areas would not be possible without the use of timber mats to spread the equipment weight over a larger area. The maximum allowable loading applied to the surface of the marsh was determined to be 2 psi. To sufficiently spread the load, the mats shall be stacked in two layers such that the timbers of the upper mats run perpendicular to the timbers of the lower mats and parallel to the direction of vehicle flow as shown below:





Section a-a

By MID Date 5-13-92 **Wehran EnviroTech** Job No. 04406-F5
Chkd. by ________ Date ________ Sheet No. 2 of 3
Subject KIN-BUC, OU2 FEASIBILITY STUDY

The upper portion of the timber-mat roadway shall be 4 mats wide giving a sufficient surface to operate equipment on.

In addition to the equipment, the timber mats also contribute to loading on the marsh.

weight of 5 lower mats $= 20 \frac{CF}{Timber} \times 4 \frac{timbers}{mat} \times 5 \text{ mats} \times 60 \frac{lb}{CF}$

$= \underline{24{,}000 \text{ lbs.}}$

weight of 4 upper mats $= 20 \frac{CF}{Timber} \times 4 \frac{timbers}{mat} \times 4 \text{ mats} \times 60 \frac{lb}{CF}$

$= \underline{19{,}200 \text{ lbs.}}$

Surface area of lower mats $= 20 \frac{ft^2}{timber} \times 4 \frac{timbers}{mat} \times 5 \text{ mats} =$

$= \underline{400 \text{ ft}^2}$

Loading due to timber mats $= \frac{(24{,}000 \text{ lb} + 19{,}200 \text{ lb})}{400 \text{ ft}^2} \times \frac{ft^2}{144 \text{ in}^2}$

$= \boxed{0.75 \text{ psi}}$

Additional loading allowed due to equipment $= 1.25 \text{ psi}$

Allowable weight allowed due to equipment $= (1.25 \text{ psi}) \times (400 \text{ ft}^2) \times (144 \frac{\text{in}^2}{\text{ft}^2})$

$= \boxed{72{,}000 \text{ lbs.}}$

By MID Date 6-4-92 **Wehran EnviroTech** Job No. 09400-F5
Chkd. by ____ Date ____ Sheet No. 3 of 3
Subject KIN-BUC, OU2 Feasibility STUDY

As stated in Section 2.0 equipment is readily available at a weight of less than 72,000 pounds (including payload).

APPENDIX C
DESCRIPTION AND COST OF GROUNDWATER MONITORING PROGRAM

APPENDIX C
DESCRIPTION AND COST OF GROUNDWATER MONITORING PROGRAM

I. MONITORING PROGRAM DESCRIPTION

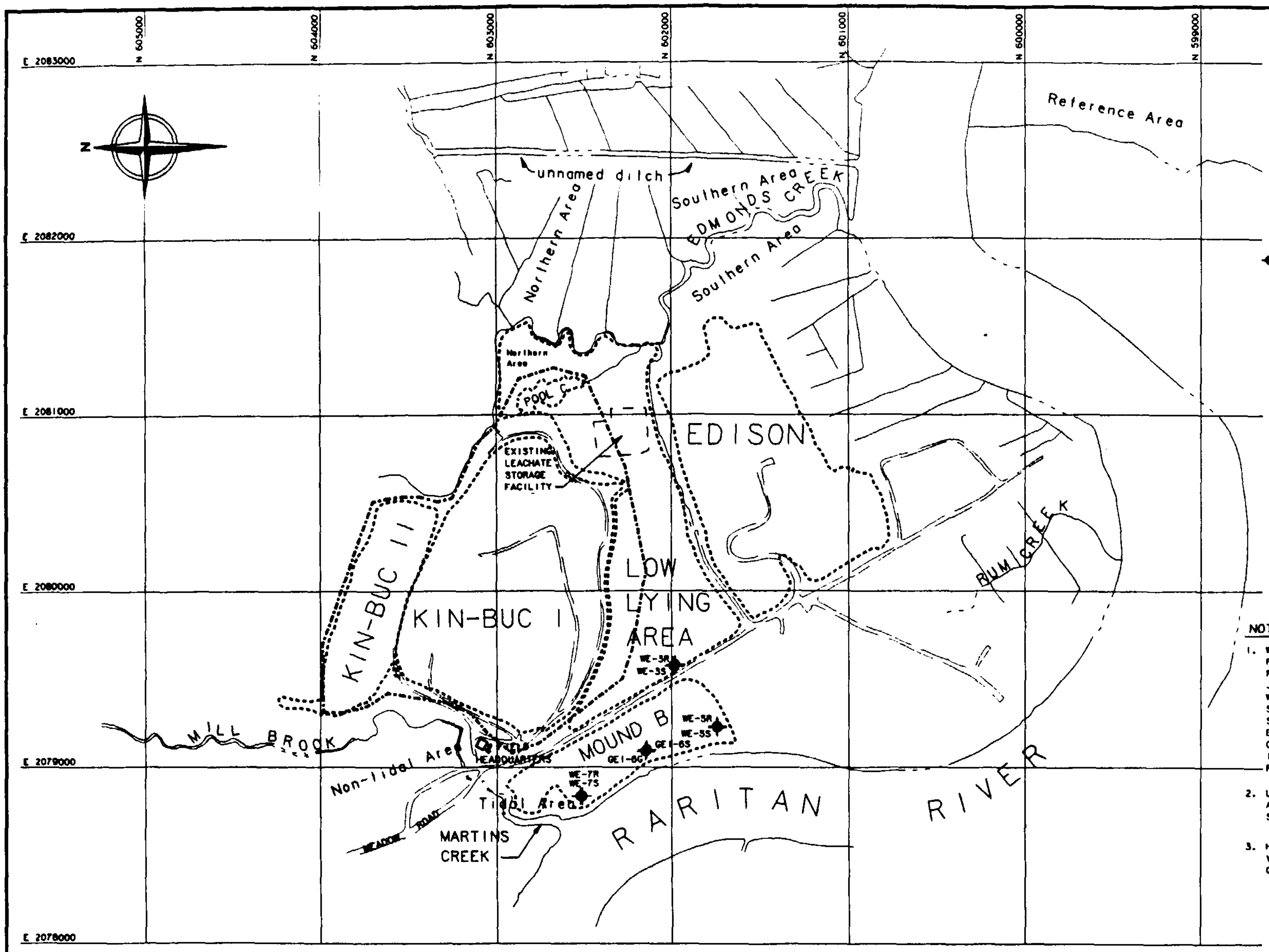
Groundwater in the Mound B and Low-Lying Areas of OU2 would be monitored to determine the efficacy of no further action. A total of nine sand and gravel and bedrock well couplets would be sampled annually. Every 5 years, the no further action remedy would be reviewed. Based on the 5-year reviews of the groundwater data, the sampling schedule could be modified or maintained for a period of up to 30 years. The couplet locations are shown in Figures C-1 and C-2. The samples would be analyzed for Target Compound List parameters and the following indicator parameters: nitrate, ammonia, total organic carbon, total kjeldahl nitrogen, total suspended solids, and total dissolved solids.

II. MONITORING PROGRAM COST ESTIMATE

The annual estimated cost for sampling and analysis of the nine couplets would be approximately:

18 samples/yr x $2,450/sample = $44,100/yr

The present value cost over a period of 30 years (at 5 percent discount rate before taxes and after inflation) would be $677,900. However, monitoring for 30 years may not be required after the 5-year reviews of the monitoring data.



LEGEND

-·-·-·-·-·	PROPOSED O.U.I. SLURRY WALL ALIGNMENT BASED ON PRE-FINAL O.U.I. RD/RA CLUSURE DESIGN DOCUMENTS. APRIL 1992
············	LIMITS OF REMEDIAL STUDY AREAS

✦ MONITORING WELL LOCATION:

GEI-SERIES	EXISTING WELLS INSTALLED BY GEOENGINEERING
WE-SERIES	NEW WELLS INSTALLED BY WEHRAN AT EXISTING LOCATIONS

NOTES:

1. WEHRAN ENVIROTECH HAS UTILIZED SURVEY INFORMATION TAKEN FROM SITE PLAN (FIG NO.2) FROM THE REMEDIAL INVESTIGATION REPORT PREPARED BY GEOENGINEERING, INC. OF DENVILLE, NEW JERSEY, ENTITLED "GENERAL SITE PLAN AND NEW MONITORING WELL LOCATIONS" DATED MAY 18, 1984 TO DEVELOP GENERALIZED SITE SKETCH AND ASSUMES NO ACCURACY FOR SAME. ALL SURFACE FEATURES AND BOUNDARIES TAKEN FROM THE GEO-ENGINEERING SITE PLAN WERE ORIGINALLY PREPARED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY TAKEN NOV. 7, 1980 BY AERIAL DATA REDUCTION ASSOCIATES, INC., OF PENNSAUKEN, NEW JERSEY.
2. LOCATION AND ELEVATION OF MONITORING WELLS, PIEZOMETERS AND SURFACE WATER GAUGES WERE SURVEYED BY WEHRAN FIELD SURVEY CREW IN FEBRUARY AND APRIL, 1990.
3. HORIZONTAL CONTROL IS BASED ON NAD 1927 VERTICAL CONTROL IS BASED ON NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.

500 0 500
SCALE IN FEET
(APPROXIMATE)

KIN-BUC OPERABLE UNIT 2
FEASIBILITY STUDY

MOUND B
PROPOSED GROUNDWATER MONITORING

DATE: JULY 1992	FIGURE: C-1

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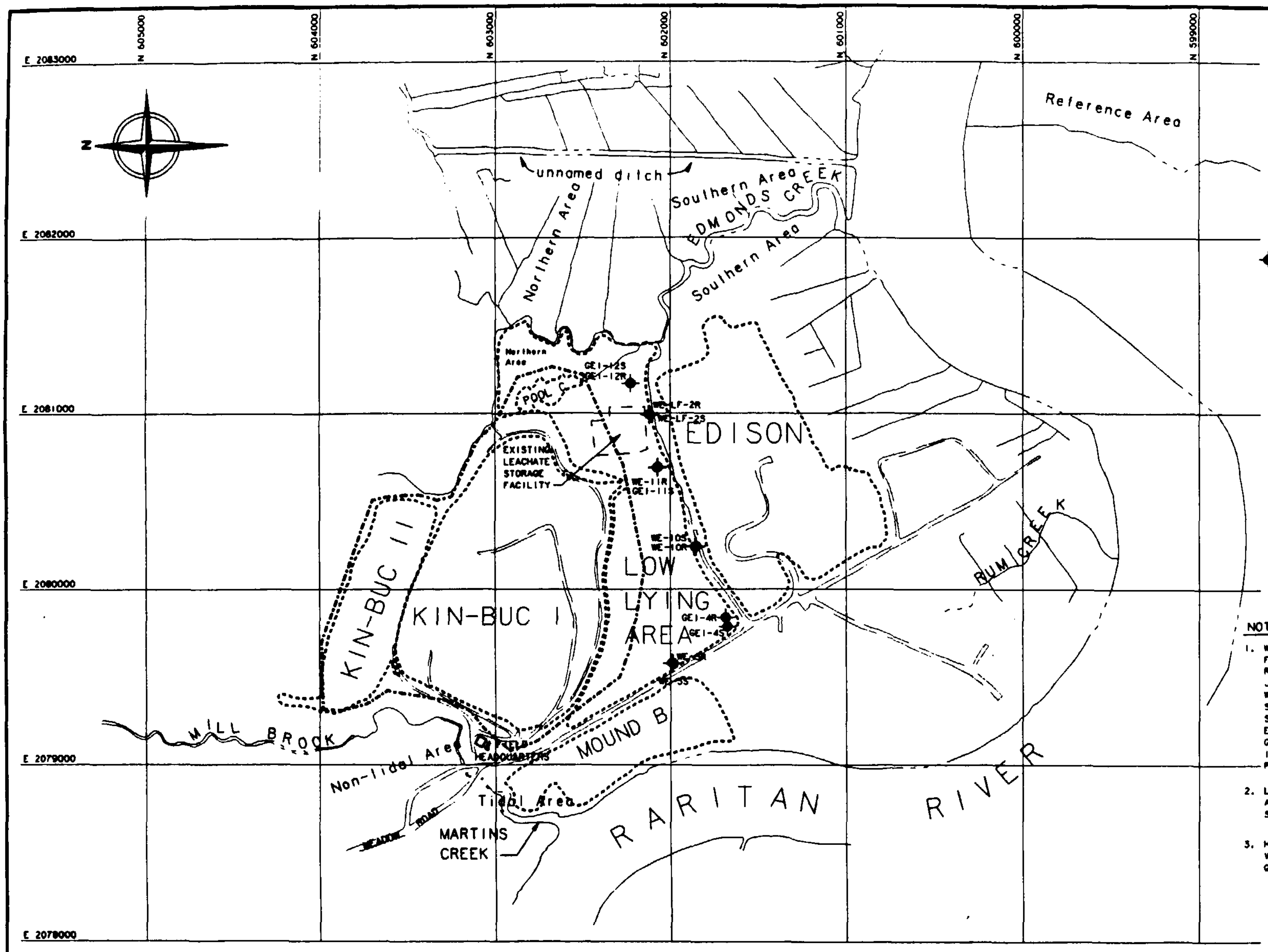


LEGEND

-·-·-·-·-·-	PROPOSED O.U.I. SLURRY WALL ALIGNMENT BASED ON PRE-FINAL O.U.I. RD/RA CLOSURE DESIGN DOCUMENTS, APRIL 1992
············	LIMITS OF REMEDIAL STUDY AREAS

◆ MONITORING WELL LOCATION:

GEI-SERIES	EXISTING WELLS INSTALLED BY GEOENGINEERING
WE-SERIES	NEW WELLS INSTALLED BY WEHRAN AT EXISTING LOCATIONS

NOTES:

1. WEHRAN ENVIROTECH HAS UTILIZED SURVEY INFORMATION TAKEN FROM SITE PLAN (FIG NO.2) FROM THE REMEDIAL INVESTIGATION REPORT PREPARED BY GEOENGINEERING, INC. OF DENVILLE, NEW JERSEY, ENTITLED "GENERAL SITE PLAN AND NEW MONITORING WELL LOCATIONS" DATED MAY 18, 1984 TO DEVELOP GENERALIZED SITE SKETCH AND ASSUMES NO ACCURACY FOR SAME. ALL SURFACE FEATURES AND BOUNDARIES TAKEN FROM THE GEO-ENGINEERING SITE PLAN WERE ORIGINALLY PREPARED BY PHOTO-GRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY TAKEN NOV. 7, 1980 BY AERIAL DATA REDUCTION ASSOCIATES, INC., OF PENNSAUKEN, NEW JERSEY.

2. LOCATION AND ELEVATION OF MONITORING WELLS, PIEZOMETERS AND SURFACE WATER GAUGES WERE SURVEYED BY WEHRAN FIELD SURVEY CREW IN FEBRUARY AND APRIL, 1990.

3. HORIZONTAL CONTROL IS BASED ON NAD 1927 VERTICAL CONTROL IS BASED ON NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.

500 0 500
SCALE IN FEET
(APPROXIMATE)

WehranEnviroTech
Wehran Engineering Corporation

KIN-BUC OPERABLE UNIT 2
FEASIBILITY STUDY

LOW LYING AREA
PROPOSED GROUNDWATER MONITORING

DATE: JULY 1992	FIGURE: C-2

APPENDIX D
RARITAN RIVER DATA AND MONITORING PROGRAM COST ESTIMATE

APPENDIX D
RARITAN RIVER DATA AND MONITORING PROGRAM COST ESTIMATE

I. RARITAN RIVER DATA

Data were obtained for the Raritan River as part of the effort to develop effluent discharge limits for the OU1 leachate/groundwater treatment plant. Tables D-1 to D-8 show the Raritan River surface water data obtained. (This data also appears in Appendix A of the June 1992 Addendum to Background Information for Development of Effluent Limits.) The data were obtained over an eight-week period over different tidal cycles. Figure D-1 shows the sampling location at the proposed effluent outfall location (denoted in Figure D-1 as outfall (submerged)). This location is approximately 60 feet from the shoreline. Samples were obtained at a depth of 3 feet above the river bottom at the sampling location.

The data do not indicate any elevated levels of contaminants in the Raritan River close to the shoreline in the vicinity of Mound B.

II. MONITORING PROGRAM COST ESTIMATE

In order to monitor potential impacts to the Raritan River, a monitoring program would be instituted. This would consist of a gauging station in the Raritan River, monitoring in the Raritan River (as described in Section 3.0), and automatic water level gauging of a monitoring well in Mound B and the Low-Lying Area. The automatic water level gauging of the monitoring wells would be done in addition to the monitoring well sampling described in Appendix C.

The estimated cost for these activities is as follows:

Capital

• River gauging station/monitoring well water level recording stations	<u>$30,000</u>
Subtotal Capital	$30,000

O&M

• Raritan River water quality sampling, analysis/reporting	$20,000/yr
• River and monitoring well water level data compilation/analysis/reporting	<u>$50,000/yr</u>
Subtotal O&M	$70,000/yr

The present value cost of these efforts over 30 years at a 5 percent discount rate would be $1.1 million. However, 30 years of monitoring may not be required based on the 5-year reviews of the data.

Table D-1

KINBUC / RARITAN RIVER SURFACE WATER QUALITY RESULTS

OCTOBER 10, 1991

Sample Date	10/10/91	10/10/91	10/10/91
Time	1:10PM	4:45PM	8:00PM
Tide Cycle	ME	SBF	MF
Metals (ug/l)			
Aluminum	1730	1450	1450
Antimony	<60	<60	<60
Arsenic	<10	<10	<10
Barium	<200	<200	<200
Beryllium	<5	<5	<5
Cadmium	<10	<10	<10
Calcium	83500	49800	93500
Chromium	<10	<10	<10
Cobalt	<50	<50	<50
Copper	55	<25	<25
Iron	1560	1030	2850
Lead	7.7	4.5	11.3
Magnesium	208000	90000	246000
Manganese	170	159	160
Mercury	<0.2	<0.2	<0.2
Nickel	<40	<40	<40
Potassium	65600	28000	77800
Selenium	<5	<5	<5
Silver	<10	<10	<10
Sodium	1680000	691000	2040000
Thallium	<10	<10	<10
Vanadium	<50	<50	<50
Zinc	52.2	24.5	39.2
Indicator Parameters (mg/l)			
Ammonia-Nitrogen	0.3	0.2	0.31
Biochemical Oxygen Demand	<2	<2	<2
Chemical Oxygen Demand	109	122	217
Cyanide	<0.01	<0.01	<0.01
Total Dissolved Solids	5510	2630	7410
Total Kjeldahl Nitrogen	0.95	1.41	0.96
Total Suspended Solids	37	25	78
Volatile Organics (µg/l)			
Acetone	12	<10	<10
Xylene (total)	0.9J	<5	<5
Semi Volatile Organics (µg/l)			
Di-n-butylphthalate	<10	<10	1J
Pyrene	0.6J	<10	<10
Bis (2-Ethylhexyl) phthalate	0.3J	0.7JB	<10
Benzo (b) fluoranthene	0.6J	<10	<10
Pesticides/PCBs (µg/l)			
beta-BHC	<0.05	0.02J	<0.05
Aldrin	0.06	0.04J	0.06

Table D-1
KINBUC / RARITAN RIVER
SURFACE WATER QUALITY RESULTS
OCTOBER 10, 1991
Continued

Field Measurements			
Temperature (C)	17.1	16.8	NA
pH (S.U.)	NA	NA	NA
eH (mV)	NA	NA	NA
Conductivity (umhos)	NA	NA	NA
Dissolved Oxygen (ppm)	NA	NA	NA
Salinity (ppt)	3.4	1.88	NA

< - Indicates compound was below detection limit (value shown is detection limit)
J - Indicates compound was present in the sample at an estimated value, greater then zero, but less then the minimum detection limit.
NA - Measurement not recorded
ME - Maximum ebb tide
MF - Maximum flood tide
SL - Slack tide
SBF -

Table D-2

KINBUC / RARITAN RIVER
SURFACE WATER QUALITY RESULTS

OCTOBER 17, 1991

Sample Date	10/17/91	10/17/91	10/17/91
Time	7:50AM	10:45AM	1:30PM
Tide Cycle	ME	SL	MF
Metals (ug/l)			
Aluminum	368	<200	271
Antimony	<60	<60	<60
Arsenic	<10	<10	<10
Barium	<200	<200	<200
Beryllium	<5	<5	<5
Cadmium	<10	<10	<10
Calcium	123000	114000	127000
Chromium	<10	<10	<10
Cobalt	<50	<50	<50
Copper	<25	<25	<25
Iron	424	404	532
Lead	<3	<3	<3
Magnesium	365000	333000	387000
Manganese	90.1	91.1	89.1
Mercury	<0.2	<0.2	<0.2
Nickel	<40	<40	<40
Potassium	122000	111000	132000
Selenium	<10	<5	<10
Silver	<10	<10	<10
Sodium	3230000	2860000	3360000
Thallium	<10	<10	<10
Vanadium	<50	<50	<50
Zinc	<20	<20	<20
Indicator Parameters (mg/l)			
Ammonia-Nitrogen	<0.04	0.24	0.18
Biochemical Oxygen Demand	NA	NA	NA
Chemical Oxygen Demand	244	199	177
Cyanide	<0.01	<0.01	<0.01
Total Dissolved Solids	11000	10200	11700
Total Kjeldahl Nitrogen	1.05	1	1.17
Total Suspended Solids	17	17	17
Volatile Organics (µg/l)			
Acetone	<10	4JB	<10
Field Measurements			
Temperature (C)	NA	NA	NA
pH (S.U.)	NA	NA	NA
eH (mV)	NA	NA	NA
Conductivity (umhos)	NA	NA	NA
Dissolved Oxygen (ppm)	NA	NA	NA
Salinity (ppt)	NA	NA	NA

NA - Compound not analyzed for or measurement not recorded.

Table D-3

KINBUC / RARITAN RIVER
SURFACE WATER QUALITY RESULTS
OCTOBER 25, 1991

Sample Date	10/25/91	10/25/91	10/25/91
Time	1:32PM	4:47PM	6:43PM
Tide Cycle	ME	SBF	MF
Metals (ug/l)			
Aluminum	696	453	1830
Antimony	<60	<60	<60
Arsenic	<10	<10	<10
Barium	<200	<200	<200
Beryllium	<5	<5	<5
Cadmium	<10	<10	<10
Calcium	67200	40200	55400
Chromium	<10	<10	<10
Cobalt	<50	<50	<50
Copper	<25	<25	<25
Iron	1290	902	3470
Lead	4.7	3.7	12
Magnesium	161000	67100	121000
Manganese	105	98.8	125
Mercury	<0.2	<0.2	<0.2
Nickel	<40	<40	<40
Potassium	46900	20800	36700
Selenium	<5	<5	<5
Silver	<10	<10	<10
Sodium	1310000	511000	964000
Thallium	<10	<10	<10
Vanadium	<50	<50	<50
Zinc	<20	<20	24.4
Indicator Parameters (mg/l)			
Ammonia-Nitrogen	0.25	0.18	0.16
Biochemical Oxygen Demand	8	12	7
Chemical Oxygen Demand	120	50.1	86.1
Cyanide	<0.01	<0.01	<0.011
Total Dissolved Solids	4880	1970	3600
Total Kjeldahl Nitrogen	1.01	1.58	1.09
Total Suspended Solids	14	10	75
Volatile Organics (µg/l)			
Acetone	<10	<10	6JB
Field Measurements			
Temperature (C)	15	14.8	14.2
pH (S.U.)	NA	NA	NA
eH (mV)	NA	NA	NA
Conductivity (umhos)	7000	2500	6000
Dissolved Oxygen (ppm)	7.2	6.4	7.2
Salinity (ppt)	4.8	1.8	4.2

NA - Measurement not recorded.

Table D-4
KINBUC / RARITAN RIVER
SURFACE WATER QUALITY RESULTS
OCTOBER 30, 1991

Sample Date	10/30/91	10/30/91	10/30/91
Time	10:24AM	2:20PM	5:27PM
Tide Cycle	MF	SBE	ME
Metals (ug/l)			
Aluminum	1410	1020	2350
Antimony	<60	81	71.9
Arsenic	<10	<10	<10
Barium	<200	<200	<200
Beryllium	<5	<5	<5
Cadmium	<10	<10	<10
Calcium	103000	176000	150000
Chromium	<10	<10	<10
Cobalt	<50	<50	<50
Copper	57.5	72.7	92.8
Iron	2370	1790	3900
Lead	13.2	9.5	15.6
Magnesium	294000	555000	464000
Manganese	97.7	81.5	105
Mercury	<0.2	<0.2	<0.2
Nickel	<40	<40	<40
Potassium	86900	168000	139000
Selenium	<10	<10	<10
Silver	<10	<10	<10
Sodium	2940000	5770000	3720000
Thallium	<10	<10	<10
Vanadium	<50	<50	<50
Zinc	63.6	43.3	117
Indicator Parameters (mg/l)			
Ammonia-Nitrogen	0.28	0.31	0.27
Biochemical Oxygen Demand	6	23	9
Chemical Oxygen Demand	258	731	287
Cyanide	<0.011	<0.01	<0.01
Total Dissolved Solids	9310	18600	14200
Total Kjeldahl Nitrogen	0.48	0.97	0.49
Total Suspended Solids	32	57	195
Semi Volatile Organics (μg/l)			
Diethylphthalate	0.6J	<10	<10
Bis (2-Ethylhexyl) phthalate	1.2JB	2.8JB	1.7JB
Field Measurements			
Temperature (C)	13.1	13.2	13.2
pH (S.U.)	7.24	7.24	7.45
eH (mV)	31.1	-54.6	-64.65
Conductivity (umhos)	12510	21650	14000
Dissolved Oxygen (ppm)	7.9	7.7	7.5
Salinity (ppt)	9.4	17.4	11

Table D-5

KINBUC / RARITAN RIVER
SURFACE WATER QUALITY RESULTS

NOVEMBER 7, 1991

Sample Date	11/07/91	11/07/91	11/07/91
Time	11:40AM	3:06PM	5:06PM
Tide Cycle	ME	SBF	MF
Metals (ug/l)			
Aluminum	693	507	535
Antimony	<60	<60	<60
Arsenic	<10	<10	<10
Barium	<200	<200	<200
Beryllium	<5	<5	<5
Cadmium	<10	<10	<10
Calcium	91600	71800	82200
Chromium	<10	<10	<10
Cobalt	<50	<50	<50
Copper	55.1	64.4	75.6
Iron	1410	972	1120
Lead	6.4	9.3	8.4
Magnesium	229000	157000	193000
Manganese	113	111	113
Mercury	<0.2	<0.2	<0.2
Nickel	<40	<40	<40
Potassium	60800	43600	54000
Selenium	<5	<5	<5
Silver	<10	<10	<10
Sodium	1900000	1200000	1380000
Thallium	<10	<10	<10
Vanadium	<50	<50	<50
Zinc	80.6	80.4	87.1
Indicator Parameters (mg/l)			
Ammonia-Nitrogen	0.25	0.24	0.21
Biochemical Oxygen Demand	3	2	<2
Chemical Oxygen Demand	161	149	138
Cyanide	<0.01	<0.01	0.012
Total Dissolved Solids	6550	4190	5270
Total Kjeldahl Nitrogen	1.1	1.3	0.83
Total Suspended Solids	40	<5	22
Volatile Organics (μg/l)			
Methylene Chloride	2JB	<5	<5
Acetone	4JB	5JB	4JB
Carbon Disulfide	1J	<5	<5
1,2-Dichloroethene (total)	1JB	<5	<5
1,1,1 Trichloroethane	1J	<5	<5
Xylene (total)	1JB	<5	<5
Semivolatile Organics (μg/l)			
Bis (2-Ethylhexyl) phthalate	0.7JB	0.6JB	0.9JB

Table D-5

KINBUC / RARITAN RIVER
SURFACE WATER QUALITY RESULTS

NOVEMBER 7, 1991

continued

Field Measurements			
Temperature (C)	10.1	10	9.2
pH (S.U.)	7.16	7.28	7.4
eH (mV)	-59.75	-60.5	-67
Conductivity (umhos)	7900	4375	6050
Dissolved Oxygen (ppm)	7.6	4	8
Salinity (ppt)	5.4	3.9	5

Table D-6
KINBUC / RARITAN RIVER
SURFACE WATER QUALITY RESULTS
NOVEMBER 14, 1991

Sample Date	11/14/91	11/14/91	11/14/91
Time	10:02AM	2:54PM	5:08PM
Tide Cycle	MF	SBE	ME
Metals (ug/l)			
Aluminum	522	<200	220
Antimony	65.4	85.7	<60
Arsenic	<10	<10	<10
Barium	<200	<200	<200
Beryllium	<5	<5	<5
Cadmium	<10	<10	<10
Calcium	133000	138000	73600
Chromium	<10	<10	<10
Cobalt	<50	<50	<50
Copper	51.6	56.8	28.7
Iron	1100	466	504
Lead	<3	<3	3
Magnesium	375000	394000	166000
Manganese	76.8	73.4	73.6
Mercury	<0.2	<0.2	<0.2
Nickel	<40	<40	<40
Potassium	101000	105000	45200
Selenium	<6.5	<6.5	<5
Silver	<10	<10	<10
Sodium	3580000	3650000	1670000
Thallium	<10	<10	<10
Vanadium	<50	<50	<50
Zinc	63.1	44.6	42.9
Indicator Parameters (mg/l)			
Ammonia-Nitrogen	0.25	0.26	0.1
Biochemical Oxygen Demand	<2	<2	<2
Chemical Oxygen Demand	503	639	179
Cyanide	<0.01	<0.01	<0.01
Total Dissolved Solids	9960	2680	4890
Total Kjeldahl Nitrogen	0.75	0.71	0.62
Total Suspended Solids	23	26	11
Semivolatile Organics (µg/l)			
Bis (2-ethylhexyl) phthalate	5J	0.7J	0.9J
Field Measurements			
Temperature (C)	8.5	8.5	8
pH (S.U.)	6.24	7.49	7.43
eH (mV)	-16.8	-77.7	-74.7
Conductivity (umhos)	7500	13900	8200
Dissolved Oxygen (ppm)	7.5	NA	NA
Salinity (ppt)	7	12	7.1

NA - Measurement not recorded.

Table D-7

KINBUC / RARITAN RIVER
SURFACE WATER QUALITY RESULTS
NOVEMBER 21,1991

Sample Date	11/21/91	11/21/91	11/21/91
Time	10:30AM	2:00PM	4:00PM
Tide Cycle	ME	SBF	MF
Metals (ug/l)			
Aluminum	324	320	712
Antimony	67.7	<60	78.8
Arsenic	<10	<10	<10
Barium	<200	<200	<200
Beryllium	<5	<5	<5
Cadmium	<10	<10	<10
Calcium	95800	64300	92600
Chromium	<10	<10	<10
Cobalt	<50	<50	<50
Copper	77.7	30.5	<25
Iron	825	637	1540
Lead	3.8	3.3	6
Magnesium	253000	141000	248000
Manganese	96.9	88.1	101
Mercury	<0.2	0.21	<0.2
Nickel	<40	<40	<40
Potassium	70200	42800	72700
Selenium	<10	<5	<10
Silver	<10	<10	<10
Sodium	1870000	1080000	2010000
Thallium	<10	<10	<10
Vanadium	<50	<50	<50
Zinc	41	95.8	31.2
Indicator Parameters (mg/l)			
Ammonia-Nitrogen	0.22	0.17	0.16
Biochemical Oxygen Demand	3	<2	<2
Chemical Oxygen Demand	132	147	203
Cyanide	<0.01	0.011	<0.01
Total Dissolved Solids	7070	3840	7120
Total Kjeldahl Nitrogen	1.12	0.75	0.82
Total Suspended Solids	24	26	37
Volatile Organics (µg/l)			
Methylene Chloride	3JB	3JB	2JB
Acetone	88B	31B	8JB
Toluene	<5	1J	<5
Semivolatile Organics (µg/l)			
Bis (2-Ethylhexyl) phthalate	<10	0.9J	3J

Table D-7
KINBUC / RARITAN RIVER
SURFACE WATER QUALITY RESULTS
NOVEMBER 21,1991
continued

Field Measurements			
Temperature (C)	9	10	9.5
pH (S.U.)	6.68	7.35	7.25
eH (mV)	-35.5	-72.3	-66.5
Conductivity (umhos)	9040	5130	9050
Dissolved Oxygen (ppm)	12	9.5	10
Salinity (ppt)	5.04	2.05	5.23

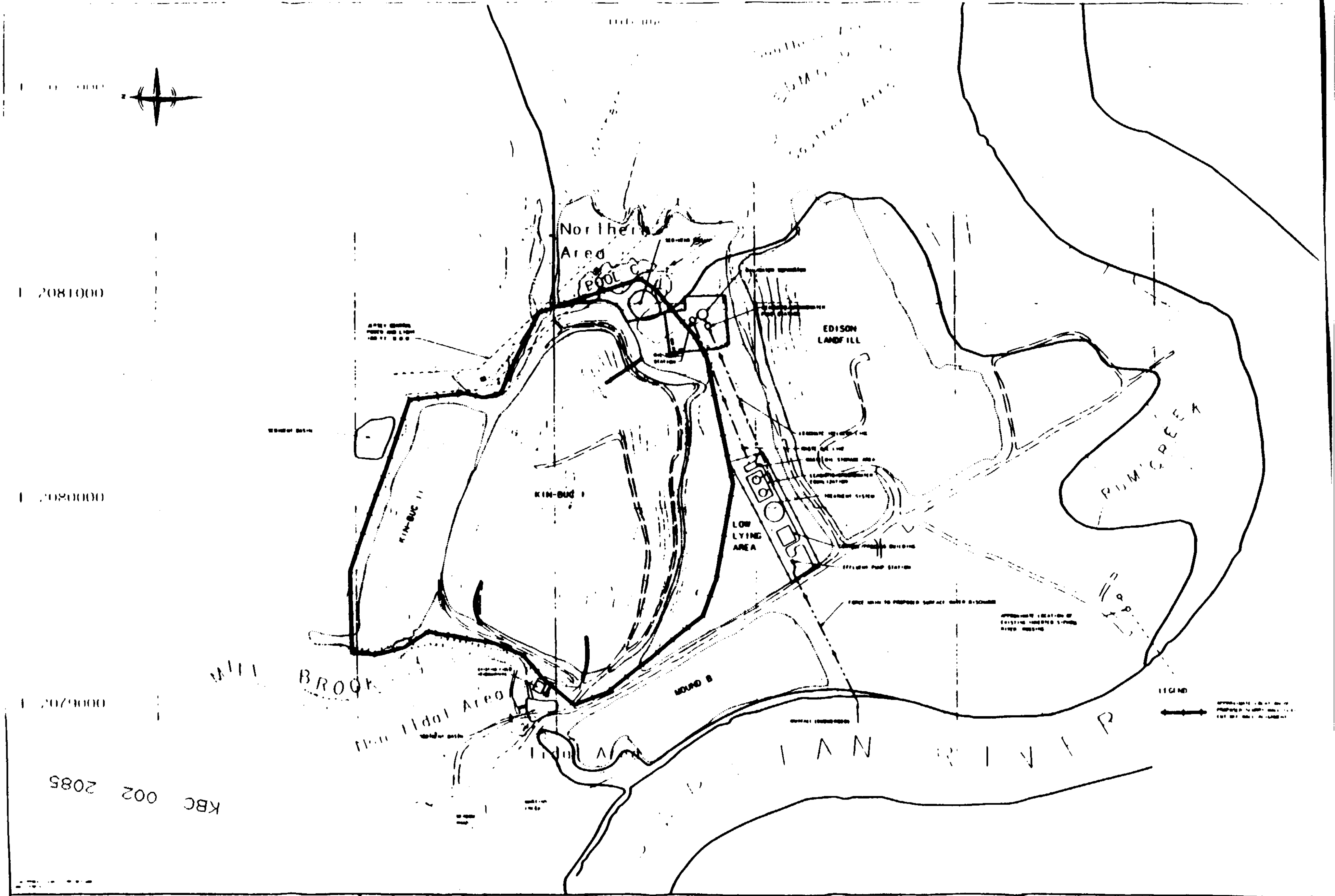
Table D-8
KINBUC / RARITAN RIVER
SURFACE WATER QUALITY RESULTS
NOVEMBER 26, 1991

Sample Date	11/26/91	11/26/91	11/26/91
Time	7:45AM	12:45PM	2:40PM
Tide Cycle	MF	SL	ME
Metals (ug/l)			
Aluminum	1340	695	559
Antimony	<60	<60	<60
Arsenic	<10	<10	<10
Barium	<200	<200	<200
Beryllium	<5	<5	<5
Cadmium	<10	<10	<10
Calcium	23800	47100	30800
Chromium	<10	<10	<10
Cobalt	<50	<50	<50
Copper	<25	<25	<25
Iron	2340	1480	1100
Lead	8.1	5.2	4.1
Magnesium	24700	108000	50500
Manganese	102	105	92.3
Mercury	<0.2	<0.2	<0.2
Nickel	<40	<40	<40
Potassium	9920	34600	18000
Selenium	<5	<5	<5
Silver	<10	<10	<10
Sodium	170000	833000	391000
Thallium	<10	<10	<10
Vanadium	<50	<50	<50
Zinc	42.5	51.5	50.5
Indicator Parameters (mg/l)			
Ammonia-Nitrogen	0.212	0.21	0.155
Biochemical Oxygen Demand	4	2	<2
Chemical Oxygen Demand	23	92.4	46
Cyanide	<0.01	<0.01	<0.01
Total Dissolved Solids	432	2970	1260
Total Kjeldahl Nitrogen	0.764	1.06	0.79
Total Suspended Solids	69	53	35
Volatile Organics (µg/l)			
Methylene Chloride	0.9JB	0.8JB	1JB
Acetone	6JB	<10	14B
Carbon Disulfide	0.3J	<5	<5
1,1,1 Trichloroethane	<5	<5	1J
Xylene (total)	0.5J	<5	<5

Table D-8
KINBUC / RARITAN RIVER
SURFACE WATER QUALITY RESULTS
NOVEMBER 26, 1991
continued

Semivolatile Organics (µg/l)			
4-Chloro-3-Methylphenol	1J	0.8J	<10
Diethylphthalate	<10	<10	0.7J
Di-n-butylphthalate	<10	<10	2J
Bis (2-Ethylhexyl) phthalate	1JB	0.9JB	2JB
Field Measurements			
Temperature (C)	7.5	8.5	8
pH (S.U.)	NA	NA	NA
eH (mV)	NA	NA	NA
Conductivity (umhos)	1025	3900	1700
Dissolved Oxygen (ppm)	7.5	7.5	7.5
Salinity (ppt)	0.9	3.25	1.5

NA - Measurement not recorded.



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KIN BUC LANDFILL
RD/RA PROJECT OVERVIEW

Figure D-1

EFFLUENT OUTFALL LOCATION