6.4

EPA Contract No. 68-W9-0036
EPA Work Assignment No. 19-1N51

EPA Project Officer: Nancy Barmakian
EPA Remedial Project Manager: Bob Cianciarulo

VOLUME 4

SOLVENT EXTRACTION TREATABILITY STUDY REPORT

NORWOOD PCB SUPERFUND SITE
NORWOOD, MASSACHUSETTS

January, 1993

Prepared by:

Metcalf & Eddy, Inc.
Wakefield, MA

M&E
Metcalf & Eddy

Site: Norwood
Break: 6.4
Other: 456939

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LIST OF ACRONYMS AND ABBREVIATIONS

BDAT	Best Demonstrated Available Technology
B.E.S.T.	Basic Extractive Sludge Treatment, a trademark of Resources Conservation Company
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
cPAH	Carcinogenic Polynuclear Aromatic Hydrocarbon
CRHT	Contract Required Holding Time
CRQL	Contract Required Quantitation Limit
CRR	Contract Required Recovery Range
cy	Cubic Yard
DRE	Destruction and Removal Efficiency
EPA	Environmental Protection Agency (United States)
GC	Gas Chromatograph
gpm	Gallons Per Minute
HpCDD	Heptachlorodibenzo-p-dioxin
HpCDF	Heptachlorodibenzofuran
HPLC	High Performance Liquid Chromatography
HxCDD	Hexachlorodibenzo-p-dioxin
HxCDF	Hexachlorodibenzofuran
LEEP	Low Energy Extraction Process
mg/kg	Milligram Per Kilogram
mg/l	Milligram Per Liter
MS/MSD	Matrix Spike/Matrix Spike Duplicate
OCDD	Octachlorodibenzo-p-dioxin
OCDF	Octachlorodibenzofuran
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PeCDD	Pentachlorodibenzo-p-dioxin
PeCDF	Pentachlorodibenzofuran
POHC	Principal Organic Hazardous Constituent
POTW	Publicly-Owned Treatment Works
ppb	Parts Per Billion
ppm	Parts Per Million
QA/QC	Quality Assurance/Quality Control
QAP	Quality Assurance Plan
RAS	Routine Analytical Services
RCC	Resources Conservation Company
RCRA	Resources Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RFP	Request for Proposals

LIST OF ACRONYMS AND ABBREVIATIONS (Cont'd)

RPD	Relative Percent Difference
RPM	Remedial Project Manager
SAS	Special Analytical Services
SITE	Superfund Innovative Technology Evaluation
SMO	Sample Management Office
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzofuran
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TEA	Triethylamine
TEF	Toxicity Equivalence Factor
TOC	Total Organic Carbon
tpd	Tons Per Day
TSCA	Toxic Substances Control Act
TSD	Treatment Storage and/or Disposal
μg/kg	Microgram Per Kilogram
VOC	Volatile Organic Compound

Section One

SECTION 1.0
INTRODUCTION

Metcalf & Eddy (M&E), under EPA contract number 68-W9-0036, Work Assignment No. 19-1N51, conducted bench-scale treatability studies of two solvent extraction technologies for remediation of soils at the Norwood PCB Superfund Site. The treatability studies were performed as part of the Remedial Design/Remedial Action (RD/RA) work being carried out by M&E for EPA.

Two vendors of solvent extraction technologies were procured by M&E to carry out bench-scale studies of their respective technologies. The vendors and technologies were:

- CF Systems Corporation - Liquefied Propane Extraction
- Resources Conservation Company - Triethylamine Extraction (B.E.S.T. Process)

This report summarizes the results of those studies and their implications for the ongoing RD/RA effort. The remainder of this section is devoted to brief descriptions of the overall site, the samples which were tested, and the technologies being evaluated. Subsequent sections describe the general approach taken in performing the studies, the results of each study, and the overall conclusions which can be drawn from the studies in terms of the overall RD/RA effort.

1.1 SITE SUMMARY

The Norwood PCB Superfund Site is located approximately 14 miles southwest of the city of Boston. The 26 acre site consists of several parcels of land including industrial/commercial properties, associated parking areas, and adjacent fields. The Site is bordered to the north by Meadow Brook, to the east by the heavily commercial U.S. Route 1 and the Dean Street access road, to the south by Dean Street, and to the west by the residential Pellana Road.

The sources of contamination at the Site are surficial and subsurface soils, dredge piles of sediments taken from Meadow Brook, sediments in Meadow Brook and sediments in the drainage system of the building operated by Grant Gear. The highest levels of soil contamination are located in an area directly west of the Grant Gear building.

The target contaminants at the Site are PCBs, primarily in the form of Aroclor-1254, and carcinogenic PAHs (cPAHs). The average and maximum concentrations of PCBs and PAHs detected in surficial and subsurface soils are presented in Table 1-1. The approximate volume of soils and sediments which is expected to require treatment is 30,000 cubic yards. This volume was used by the treatability study subcontractors when estimating costs for remediation by solvent extraction.

A limited number of samples from the Site have been collected and analyzed for dioxins/dibenzofurans. These included four stream sediment samples, three surficial soil samples, and two subsurface soil samples. One of the subsurface soil samples showed a total 2,3,7,8 TCDD Toxicity Equivalence of 1.60 ppb, which is above the action level of 1.0 ppb (Ebasco Services, July 1990 report, *Norwood Dioxin and PCB Sampling*).

Surficial soils at the Site include both undisturbed native soil and imported fill material. The native soil is a fine sandy loam. The fill material varies in thickness from 0 to 9.5 feet and consists of silt, fine to coarse sand, gravel, and various types of rubble including wood, metal scrap, brick, and electrical components.

The total organic carbon (TOC) content of the soils is relatively low, varying from a geometric mean value of 2.31 percent for surficial soils to a geometric mean value of 0.32 percent for subsurface soils.

TABLE 1-1. PCB AND PAH CONCENTRATIONS IN SURFICIAL AND SUBSURFACE SOILS FROM THE NORWOOD PCB SUPERFUND SITE

	Concentrations in Surficial Soils (μg/kg)		Concentrations in Subsurface Soils (μg/kg)	
Compound	Average	Maximum	Average	Maximum
PCBs (Aroclor-1254)	886,000	26,000,000	283,000	13,400,000
PCBs (Aroclor-1260)	ND	ND	48,000	230,000
PAHs				
Naphthalene	150	150	ND	ND
2-Methylnaphthalene	78	88	100	100
Acenaphthylene	200	270	ND	ND
Acenaphthene	123	180	78	78
Dibenzofuran	120	200	ND	ND
Flourene	61	100	ND	ND
Phenanthrene	530	2,800	190	380
Anthracene	303	880	ND	ND
Flouranthene	651	2,800	310	850
Pyrene	568	3,500	340	740
Benzo(a)anthracene*	580	2,000	390	1,400
Chrysene*	552	2,100	640	1,700
Benzo(b)flouranthene*	1,370	5,300	870	3,500
Benzo(k)flouranthene*	1,130	5,300	350	350
Benzo(a)pyrene*	670	2,700	1,100	3,800
Indeno(1,2,3-cd)pyrene*	424	1,900	740	2,400
Dibenz(a,h)anthracene*	331	800	570	570
Benzo(g,h,i)perylene	466	1,700	600	1,800
Total PAHs	>5,000	27,771	1,220	17,160

Source: Ebasco Services Inc., 1989. Final Remedial Investigation Report, Norwood PCB Site, Town of Norwood, Norfolk County, Massachusetts. Prepared for U.S. EPA.

Notes: * = carcinogenic PAH (cPAH)
ND = Not Detected

1.2 SAMPLE DESCRIPTION

Two composite soil samples were collected for solvent extraction treatability testing. Both samples were made up of grab samples collected from a trench excavated in an area approximately 100 feet west of the Grant Gear building. One composite sample was made up of grab samples collected from areas of the trench believed to be highly contaminated. The second composite sample was made up of grab samples collected from areas believed to contain PCB concentrations which were more representative of average Site PCB concentrations. Sample collection is described in more detail in Section 2.5. The average concentrations of PCBs, cPAHs and dioxins/dibenzofurans (expressed as 2,3,7,8-TCDD toxicity equivalences) detected in the composite samples are presented in Table 1-2. The cPAH data which were rejected (flagged R) were rejected due to holding time exceedances by the laboratory. However, these rejections are not believed to significantly impact this study, since some samples were analyzed within holding times, and those samples did not contain detectable concentrations of cPAHs.

The concentrations of individual dioxin/dibenzofuran isomers for the same samples are presented in Table 1-3. These concentrations are the results of analyses of duplicate samples submitted to CLP laboratories by both CF Systems Corporation and Resources Conservation Company. Data summary tables for each independent analysis are presented in Appendix A (the report by CF Systems Corporation) and Appendix B (the report by Resources Conservation Company).

For those unfamiliar with the concept, it is noted that the 2,3,7,8-TCDD toxicity equivalence is a standardized way of expressing the toxicity of a sample containing a complex mixture of dioxin/dibenzofuran isomers. Weighting factors called Toxicity Equivalence Factors (TEF values) have been assigned to each dioxin/dibenzofuran isomer based on its relative toxicity as compared to the most toxic dioxin/dibenzofuran isomer; i.e., 2,3,7,8-TCDD. The CLP laboratories which perform dioxin/dibenzofuran analyses use the TEF values specified in the

TABLE 1 - 2. CONCENTRATIONS OF PCBs, cPAHs, AND TOTAL TOXICITY EQUIVALENCE IN COMPOSITE SOIL SAMPLES COLLECTED FOR TREATABILITY TESTING: NORWOOD PCB SUPERFUND SITE

		HIGH PCB CONCENTRATION COMPOSITE SOIL SAMPLE					LOW PCB CONCENTRATION COMPOSITE SOIL SAMPLE				
EPA SAMPLE NUMBER (PCBs):		7018A-301	7018A-302	7018A-601	7018A-602		7018A-303	7018A-304	7018A-603	7018A-604	
EPA SAMPLE NUMBER (cPAHs):		7018A-201	7018A-202	7018A-601	7018A-602		7018A-203	7018A-204	7018A-603	7018A-604	
EPA SAMPLE NUMBER (dioxins/furans):		7018A-401	7018A-402	7018A-801	7018A-802		7018A-403	7018A-404	7018A-803	7018A-804	
COMPOUND	CRQL (mg/kg)					AVERAGE CONC'N					AVERAGE CONC'N
PCBs (mg/kg):											
Toxaphene	50	5000 U	5000 U	5000 U	5000 U		5000 U	5000 U	5000 U	5000 U	
Aroclor-1016	10	1000 U	1000 U	1000 U	1000 U		1000 U	1000 U	1000 U	1000 U	
Aroclor-1221	10	1000 U	1000 U	1000 U	1000 U		1000 U	1000 U	1000 U	1000 U	
Aroclor-1232	10	1000 U	1000 U	1000 U	1000 U		1000 U	1000 U	1000 U	1000 U	
Aroclor-1242	10	1000 U	1000 U	1000 U	1000 U		1000 U	1000 U	1000 U	1000 U	
Aroclor-1248	10	1000 U	1000 U	1000 U	1000 U		1000 U	1000 U	1000 U	1000 U	
Aroclor-1254	10	9930	8300	8740	8390	8840	789 J	796 J	737 J	766 J	772 J
Aroclor-1260	10	1000 U	1000 U	1000 U	1000 U		1000 U	1000 U	1000 U	1000 U	
Carcinogenic PAHs (mg/kg):											
Benzo(a)anthracene	10	R	R	21 U	21 U		R	R	21 U	21 U	
Chrysene	10	R	R	21 U	21 U		R	R	21 U	21 U	
Benzo(b)fluoranthene	10	R	R	21 U	21 U		R	R	21 U	21 U	
Benzo(k)fluoranthene	10	R	R	21 U	21 U		R	R	21 U	21 U	
Benzo(a)pyrene	10	R	R	21 U	21 U		R	R	21 U	21 U	
Indeno(1,2,3-c,d)pyrene	10	R	R	21 U	21 U		R	R	21 U	21 U	
Dibenz(a,h)anthracene	10	R	R	21 U	21 U		R	R	21 U	21 U	
Dioxins/Dibenzofurans (ug/kg):											
Total 2,3,7,8-TCDD Toxicity Equivalence		7.068 J	3.55 J	7.845 J	4.1645 J	5.66 J	0.3093 J	0.3262 J	0.366 J	0.3164 J	0.329 J

Footnotes:

CRQL - Contract Required Quantitation Limit
J - Quantitation is approximate due to limitations identified in the quality control review.
U - Value is the sample detection limit.
UJ - Sample detection limit is approximate due to limitations identified in the quality control review.
R - Data rejected due to limitations identified in the quality control review.

TABLE 1 - 3. CONCENTRATIONS OF DIOXIN/DIBENZOFURAN ISOMERS IN COMPOSITE SOIL SAMPLES COLLECTED FOR TREATABILITY TESTING: NORWOOD PCB SUPERFUND SITE

	HIGH PCB CONCENTRATION COMPOSITE SOIL SAMPLE				LOW PCB CONCENTRATION COMPOSITE SOIL SAMPLE			
EPA SAMPLE NUMBER: COMPOUND	7018A-401	7018A-402	7018A-801	7018A-802	7018A-403	7018A-404	7018A-803	7018A-804
TCDD/TCDF Concentration (ug/kg)								
2,3,7,8-TCDD	0.007 UJ	0.15 UJ	0.060 * UJ	0.014 * UJ	0.004 U	0.006 U	0.004 U	0.005 U
1,2,3,7,8-PeCDD	0.05 J	0.35 UJ	0.006 U	0.007 U	0.009 U	0.014 U	0.032 U	0.008 U
1,2,3,4,7,8-HxCDD	0.10 J	0.57 UJ	0.038 U	0.028 U	0.021 U	0.027 U	0.025 U	0.020 U
1,2,3,6,7,8-HxCDD	0.27 * UJ	0.48 UJ	0.034 U	0.025 U	0.019 U	0.025 U	0.022 U	0.018 U
1,2,3,7,8,9-HxCDD	0.22 J	0.54 UJ	0.034 U	0.025 UJ	0.019 UJ	0.025 UJ	0.022 UJ	0.018 UJ
1,2,3,4,6,7,8-HpCDD	2.1 J	0.79 UJ	0.058	0.074	0.016 U	0.022 U	0.010 UJ	0.016 UJ
OCDD	0.28 J	0.99 J	0.033 J	0.046 J	0.161 J	0.050 * J	0.312 J	0.113 J
2,3,7,8-TCDF	6.5 J	3.49 J	11.998 * UJ	5.224	0.202 J	0.128	0.234 U	0.161
1,2,3,7,8-PeCDF	1.7 J	0.80 J	1.597 * UJ	0.003 U	0.051 J	0.037	0.005 U	0.006 U
2,3,4,7,8-PeCDF	5.2 J	2.87 J	4.703	0.002 U	0.006 U	0.181	0.180	0.172
1,2,3,4,7,8-HxCDF	24.0 J	12.30 J	29.076	26.40	1.971 J	1.552	1.843	1.551
1,2,3,6,7,8-HxCDF	8.7 J	4.39 J	9.598	8.576	0.697 J	0.532	0.622	0.524
2,3,4,6,7,8-HxCDF	1.8 * UJ	0.64 * UJ	1.521	0.026 U	0.076 J	0.050	0.018 U	0.020 U
1,2,3,7,8,9-HxCDF	0.009 U	0.44 UJ	0.029 U	0.031 U	0.039 J	0.025	0.021 U	0.024 U
1,2,3,4,6,7,8-HpCDF	10.9 J	2.86 J	7.706	6.977	0.452 J	0.304	0.380 J	0.361 J
1,2,3,4,7,8,9-HpCDF	6.8 J	2.23 J	5.668	5.913	0.340 J	0.177	0.233	0.263
OCDF	0.80 * UJ	2.87 J	0.454 J	0.588	0.328 J	0.184	0.183 * UJ	0.264
TOTAL TCDD **	0.15	2.891 * UJ	44.678 U	28.608 U	1.982 * UJ	1.973 U	17.066 * UJ	17.299 * UJ
TOTAL PeCDD **	0.20	211.15 * UJ	0.09	0.05	0.641 * UJ	8.217 U	465.21 * UJ	1380.05 * UJ
TOTAL HxCDD **	1.9	0.567 UJ	0.465 U	0.467 U	0.032 * UJ	0.031 U	0.161 * UJ	0.020 * U
TOTAL HpCDD **	3.4	2.090 * UJ	0.10	0.07	0.016 * UJ	0.022 U	0.010 U	0.016 * U
TOTAL TCDF **	17.1	5.65	8.98	8.21	0.904 * UJ	0.620 U	0.10	0.29
TOTAL PeCDF **	25.5	11.52	40.52	43.35	2.351 * UJ	1.50	2.56	2.34
TOTAL HxCDF **	56.5	23.96	81.87	71.97	5.29	4.17	5.45	4.59
TOTAL HpCDF **	25.3	7.86	20.21	19.59	1.285 * UJ	0.72	0.87	0.91
TOTAL 2,3,7,8-TCDD TOXICITY EQUIVALENCE (ug/kg)	7.068 J	3.55 J	7.845 J	4.1645 J	0.3093 J	0.3262 J	0.366 J	0.3164 J

Footnotes:

* - Quantity is an EMPC (Estimated Maximum Possible Concentration) rather than a detection limit, because the ion abundance ratio was outside QC limits. The EMPC is a worst case estimate and is not included in TEF calculations.

** - Total includes isomers which are formed by addition of chlorine atoms to 2,3,7,8-TCDD (i.e., those for which individual concentrations have also been reported) as well as any other isomers detected. Therefore, these totals may not match the totals of the individual concentrations reported here.

J - Quantitation is approximate due to limitations identified in the quality control review.

U - Value is the sample detection limit (or EPMC if *).

UJ - Value is the sample detection limit (or EPMC if *); value is approximate due to limitations identified in the quality control review.

Statement of Work for Analysis of Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans, Multi-Media/Multi-Concentration, October 1990 (Document DFLM01.0) to calculate a total toxicity equivalence for each sample they analyze. The concentration of each isomer in a particular sample is multiplied by the corresponding TEF value for that isomer, and the resulting weighted concentrations are summed to yield a total toxicity equivalence for the sample. The laboratories report both the individual isomer concentration and the toxicity equivalences according to a standard format specified in the above-referenced statement of work. The concept of toxicity equivalence is useful because it provides a basis for comparison of samples which contain different distributions of dioxin/dibenzofuran isomers.

1.3 TECHNOLOGY DESCRIPTIONS

Solvent extraction methods involve the contacting of contaminated soil with a solvent into which the contaminants will preferentially dissolve, resulting in transfer of contaminants from the soil phase to the solvent phase. The solvent is subsequently treated to recover the solvent for reuse and to recover or destroy the contaminants.

The method of solvent recovery depends on the technology being used, but it may involve distillation, decompression with a solvent phase change from liquid to gas (e.g., liquefied propane extraction), or extraction with a second solvent.

Two different solvent extraction technologies were tested on site soils: liquefied propane extraction and triethylamine extraction (the B.E.S.T. process). These technologies are described below.

1.3.1 CF Systems Corporation - Liquefied Propane Extraction. This process uses liquefied propane as a solvent for the extraction of oils and tars from soils and sludges. The physical properties of liquefied propane, such as its low viscosity and high diffusivity, enhance the rate of extraction. The propane is easily recovered by using a simple vapor recompression cycle.

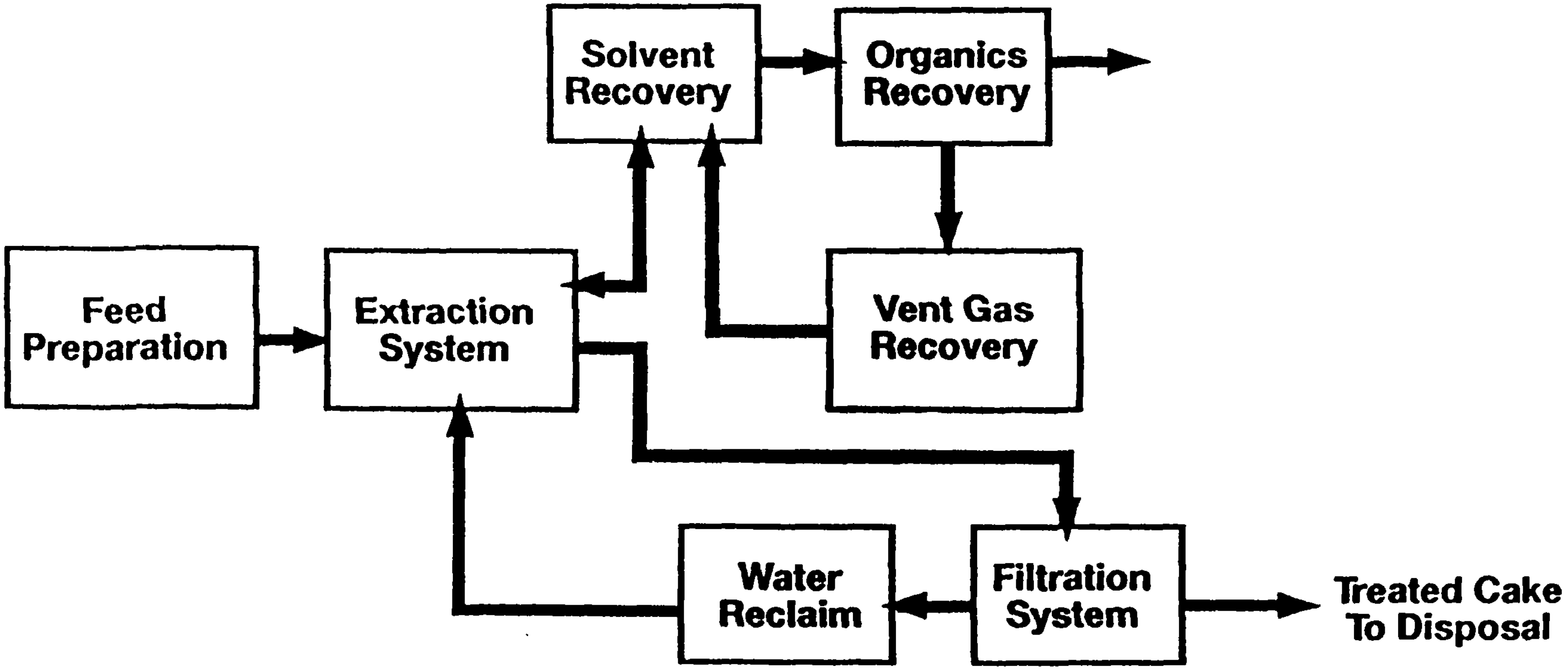
CF Systems Corporation markets liquefied propane extraction units which operate in a series of steps covering extraction, phase separation, and propane recovery (Figure 1-1). Contaminated soil which has been screened to one inch maximum dimension is initially fed to a stirred-tank extractor. Gaseous propane is compressed, condensed, and fed into the extractor and the contents are well-mixed to allow extraction to occur. After extraction, the contents of the extractor flow to a decanter where the water/solids fraction and the propane/organic fraction are separated by gravity. The treated water and solids are collected from the bottom of the decanter. The propane/organic stream leaves the top of the decanter and flows to a solvent recovery still where propane is vaporized and concentrated organics are withdrawn. The vaporized propane is combined with make-up gas and recycled through the compressor as fresh solvent.

The residuals generated by this process include the treated soils and the extracted organics in the form of an oil. The oil is generally disposed of by off-site incineration. The treated soils are suitable for backfilling on site. The treated soils do not contain any residual solvent because the solvent (propane) is a gas under ambient conditions.

1.3.2 Resources Conversation Company - B.E.S.T. Process. Resources Conservation Company has developed a patented process known as the B.E.S.T. process, in which triethylamine (TEA) is used as the primary solvent for the extraction of organic contaminants from soils and sludges. One advantage of TEA as a solvent is that it is inversely miscible with water. At temperatures less than 20 degrees C, TEA and water are completely miscible, but at higher temperatures the two become immiscible. This property allows the B.E.S.T. process to separate a waste stream into water, solids, and concentrated organic phases with minimal energy input. Another advantage of TEA is that is readily biodegradable, so the presence of residual levels of TEA in treated solids and water do not present a hazard.

CF SYSTEMS
A MORRISON KNUDSEN COMPANY

CF Systems Solvent Extraction Remediation Process



Feed Preparation

Extraction System

Solvent Recovery

Organics Recovery

Vent Gas Recovery

Filtration System

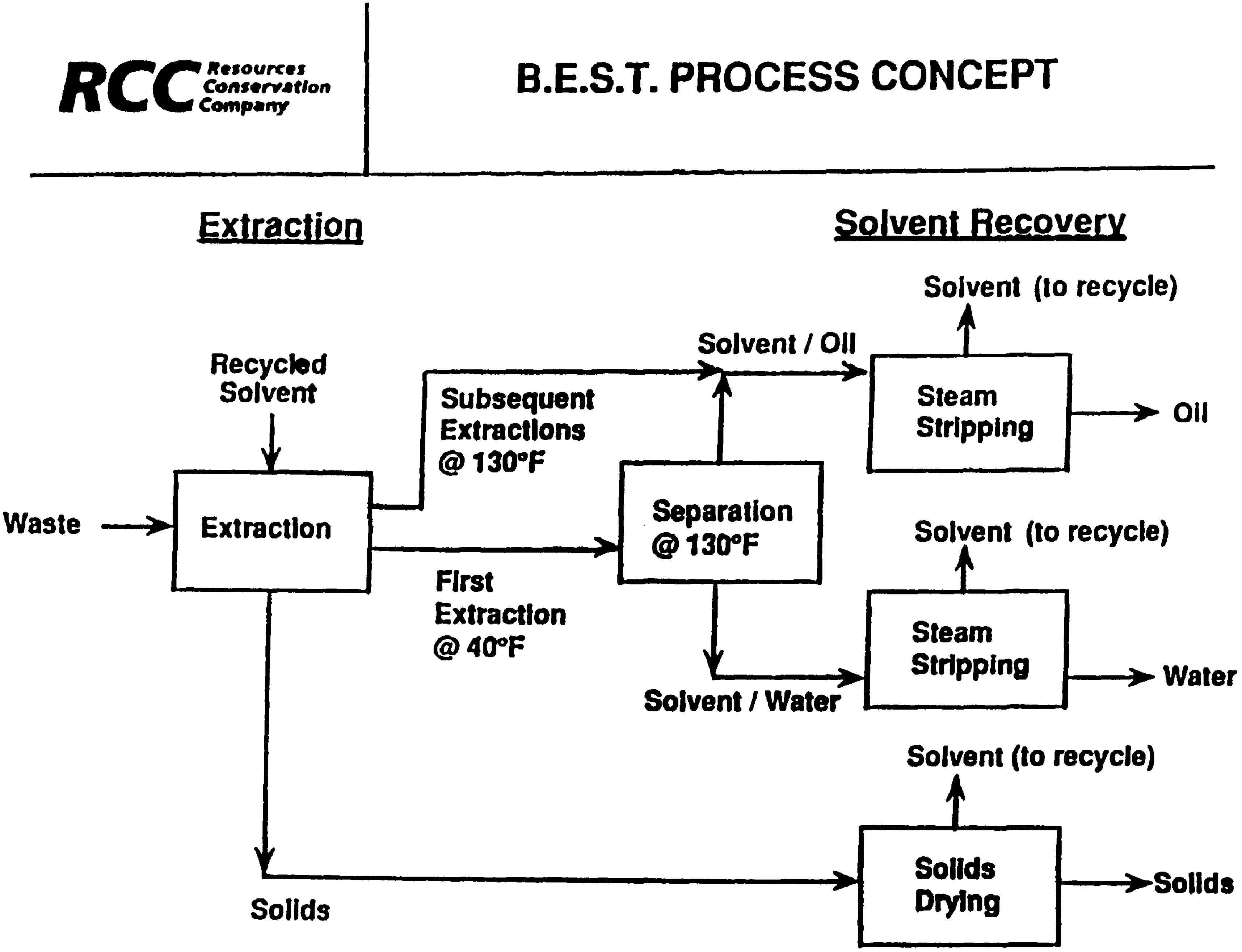
Water Reclaim

Treated Cake To Disposal

FIGURE 1-1.

The B.E.S.T. process consists of extraction, separation, and TEA recovery stages (Figure 1-2). Waste materials which have been screened to one inch maximum dimension are loaded into an extraction vessel and contacted with cold TEA. The solid and liquid phases are allowed to separate by gravity. Treated solids settle out and are dried to remove residual TEA. The liquid phase, consisting of TEA, water, and extracted organics, is drawn off and heated. The heating causes the liquid phase to separate into water and TEA/organic phases. The water is typically discharged to a Publicly-Owned Treatment Works (POTW) or to an industrial-type wastewater treatment plant, depending on the contaminants present. The TEA/organic phase is heated further to evaporate the TEA and recover the concentrated organics as a liquid. The evaporated TEA is then condensed and cooled for reuse in the extraction vessel. The concentrated organics are generally disposed of by off-site incineration.

FIGURE 1-2.



RCC Resources Conservation Company

B.E.S.T. PROCESS CONCEPT

Section Two

SECTION 2.0
OBJECTIVES AND APPROACH

2.1 OBJECTIVES

The objectives of the solvent extraction treatability studies performed under the pre-design phase were to:

- Evaluate two solvent extraction technologies and their applicability in the treatment of Site soils and sediments to a target level no greater than 10 mg/kg total PCBs and 6 mg/kg total carcinogenic polynuclear aromatic hydrocarbons (cPAHs)
- Determine operating conditions such as number of extractions needed and pretreatment requirements for effective treatment
- Estimate treatment costs
- Estimate quantities of residuals (e.g., extracted oil and water) which would need treatment or disposal
- Determine dioxin/dibenzofuran and PCB concentrations in the extracted oil, to determine disposal options
- Evaluate implementability of solvent extraction technologies at the Site

2.2 TREATABILITY SUBCONTRACTOR PROCUREMENT

Two vendors of solvent extraction treatment technologies were procured by M&E to carry out bench-scale treatability studies. Sources used to identify potential subcontractors included a list of EPA SITE program participants and previous experience of M&E with various subcontractors.

Subcontractors were selected after evaluation of their responses to a request for proposals (RFP) issued by M&E. The RFP was prepared by M&E and reviewed by EPA. EPA's comments were incorporated into the RFP before it was sent to potential subcontractors. The RFP was sent to six vendors of solvent extraction technologies:

- CF Systems Corporation - Critical fluid extraction with liquefied propane
- ART International - Low energy extraction process (LEEP)
- Dehydro-Tech Corporation - Carver-Greenfield process
- Harmon Environmental Services - Soil washing with a patented solvent blend
- Resources Conservation Company - B.E.S.T. process (triethylamine extraction)
- Sanivan Group - Extraksol process

Each of the six vendors employs a different solvent or solvent blend for the extraction of contaminants from soils. It would not have been possible to use the results of a treatability study performed by one vendor to predict the results that would be obtained by another vendor who employs a different solvent. Therefore, it was decided that two vendors, each employing a different technology, would be selected to carry out treatability studies. M&E and EPA established the following criteria for evaluation of proposals in order to select two vendors:

- Experience with pilot and full-scale treatment of PCB-contaminated wastes
- Test facility and equipment
- Quality Assurance Plan (QAP) and laboratory capabilities acceptable to EPA Region I
- Work plan and approach to testing
- Price

Out of six vendors who received RFPs, four declined to submit proposals. Proposals were received from CF Systems Corporation and Resources Conservation Company. These proposals were reviewed by M&E according to the above criteria and both were found to be technically worthy. After negotiation of the price and scope of each proposal with the respective vendors, and consultation with the EPA Remedial Project Manager, it was decided to award contracts to both vendors. Details of M&E's price analysis and negotiations were provided as part of M&E's request for EPA contracting officer consent.

2.3 ANALYTICAL APPROACH

The analytical approach used in support of the treatability studies included analyses performed under the EPA Contract Laboratory Program (CLP), and analyses performed by the treatability subcontractors or their designated laboratories.

2.3.1 Analyses by CLP Laboratories

The laboratories which performed the EPA-CLP analyses were obtained by M&E through the EPA Region I Sample Management Office (SMO). Analyses were performed by CLP laboratories both to minimize the number of laboratories being used for the treatability studies, and to ensure that the data generated from the studies would be comparable.

The samples submitted to CLP laboratories were analyzed under the Special Analytical Services (SAS) program in order to obtain 14-day turnaround times for Routine Analytical Services (RAS) methods. Samples analyzed by SAS require the preparation and submittal of SAS client request forms to initiate the analytical scheme. The analytes for which SAS requests were prepared included:

- Target Compound List (TCL) organic compounds in soil and oil samples, high concentration, 14-day turnaround (for analysis of pesticides/PCBs and SVOCs in untreated soils and extracted oils)

- Pesticides/PCBs in soil, low level, 14-day turnaround (for analysis of treated soils)
- Semivolatile organics in soil, low level, 14-day turnaround (for analysis of treated soils)
- Volatile organics in soil, low level, 14-day turnaround (for analysis of untreated and treated soils)
- Target Analyte List (TAL) metals in soil, low level, 14-day turnaround (for analysis of untreated and treated soils)
- Dioxins/dibenzofurans in soil and oil samples (for analysis of untreated soils, treated soils, and extracted oils)

2.3.2 Analyses by Subcontractors

Certain analyses were performed by the subcontractors themselves or by their designated laboratories instead of by CLP laboratories. These determinations included the analysis of untreated soils for oil and grease, moisture content and particle size distribution; the analysis of soils from intermediate stages of extraction for PCBs; and the analysis of treated soils for residual solvent. It was necessary to allow the subcontractors to perform these analyses internally, rather than through the CLP system, both to minimize the consumption of sample volume and to allow for immediate feedback so that the subcontractors could select appropriate operating conditions for their tests. The nature of these analyses was discussed in each subcontractor's Quality Assurance Plan (QAP). The QAPs were reviewed by M&E and EPA prior to performance of the treatability tests.

2.4 DATA MANAGEMENT

The samples generated during the treatability studies were analyzed and the data validated by a number of QA/QC protocols. The details of these analyses and validation issues are addressed in this section.

The initial composite soil samples were tested using a PCB field test kit. The purpose of these tests was to serve as a screening process to ensure that the PCB concentrations of the samples submitted for treatability testing were sufficiently high (at least 100 mg/kg for the average sample and at least 5,000 mg/kg for the highly contaminated sample). The data was not validated due to the nature of the analysis.

Samples generated by the subcontractors were comprised of those requiring analysis by CLP laboratories designated by the EPA Region I SMO, and those analyzed by the subcontractors or their designated laboratories, as described in Section 2.3. The samples analyzed through the CLP system were analyzed according to the Statement of work for Inorganics Analysis, Multi-Media/Multi-Concentration, July 1988; the Statement of Work for Organics Analysis, Multi-Media/Multi-Concentration, March 1990; the Statement of Work for Organics Analysis Multi-Media/High Concentration, March 1990; and a Special Analytical Services (SAS) request employing the Statement of Work for Analysis of Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans, Multi-Media/Multi-Concentration (October 1990) protocols for dioxins/dibenzofurans. The methods used for subcontractor-performed analyses are described in their individual reports and QAPs.

Metcalf & Eddy validated all data acquired through the CLP system from analyses of untreated soil, treated soil, and extracted oil samples, with the exception of data from dioxin/dibenzofuran analyses, which was validated by EPA Region I personnel who are specially schooled in dioxin/dibenzofuran validation. Data from analyses performed by the subcontractors or their designated laboratories was reviewed by the subcontractors and M&E but was not validated by M&E.

M&E performed Level III validation on all organic and inorganic data packages (with the exception of dioxins/dibenzofurans) using criteria based on the "Region I Laboratory Data Validation Functional Guidelines for Evaluating Organics Analysis" (February 1988) and the "Region I Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses" (June 1988). The evaluation criteria used by M&E for Level III validation are outlined in Table 2-1. All laboratory data summaries and quality control (QC) summaries were reviewed to determine their effect on the quality of the associated data, but only a limited effort was made to review the raw data and verify the accuracy of the laboratories' calculations, because review of the raw data is not a part of Level III validation.

The data review package produced by the data validators consisted of validation worksheets, a summary page of the validation flagging criteria, and a tabulation of flagged data both on paper and diskette (LOTUS 1-2-3). The treatability study subcontractors were sent hard-copy and diskette versions of the tabulated and flagged data for all samples which they submitted to CLP laboratories. These data were used by the subcontractors when preparing their reports, along with the data generated by their own laboratories.

The dioxin/dibenzofuran data were not required to be included in the subcontractors' reports because the data were not available at the time they prepared their draft reports. However, the data became available prior to finalization of their reports, and they agreed to incorporate it into their final reports. The data are also discussed in this report in Section 3.0 for the liquefied propane extraction study, and in Section 4.0 for the triethylamine extraction study.

2.5 SAMPLE COLLECTION

The two solvent extraction technologies were tested on two composite samples collected at the Site. One composite sample was made up of grab samples collected from areas believed to be highly contaminated, where "highly contaminated" was defined as greater than 5,000 mg/kg total PCBs. A second composite sample was made up of grab samples collected from areas believed to be more representative of average Site concentrations. This second composite was expected to contain at least 100 mg/kg total PCBs.

All grab samples were collected from a trench excavated in a heavily contaminated area approximately 100 feet west of the Grant Gear building. The location of this trench is shown

TABLE 2-1. M&E LEVEL III DATA EVALUATION CRITERIA

I. HOLDING TIMES

- Qualify all compounds in the applicable sample

Action Level: Contract Required Holding Times (CRHT)

	<CRHT	SLIGHTLY >CRHT	GROSSLY >CRHT
Hit or Positive Result	No qualifier	Approximate	Approximate
Non-Detected Result	No qualifier	Approximate	Reject

II. BLANKS (Method, Equipment)

- Qualify detected compounds in the applicable analytical batch that have also been found in the blanks
- Compare action level concentrations for the blank contaminants with the corresponding sample concentrations

Action Level (Concentration)

	Report CRQL	Report Conc'n Found and Qualify as Non detected	No Qualifier
Sample Hits of Acetone, 2-Butanone, Phthalates, Toluene or Methylene Chloride	<CRQL	CRQL to 10X	>10X
Sample Hits of any Other Organics or Metals	<CRQL	CRQL to 5X	>5X

Where: x = blank contaminant concentration

TABLE 2-1 (CONTINUED). M&E LEVEL III DATA EVALUATION CRITERIA

III. SURROGATE RECOVERIES

- Qualify all compounds in the applicable sample fraction (i.e., Volatiles, Base/Neutral Extractables, Acid Extractables, etc.)

- Sample fraction qualified if:

  1 or more Volatile surrogate recovery not met
  2 or more Base/Neutral extractable surrogate recoveries not met
  2 or more Acid Extractable surrogate recoveries not met

- Sample fraction is not qualified if:

  1 or fewer Base/Neutral extractable surrogate recovery is not met
  1 or fewer Acid Extractable surrogate recovery is not met

	Action Level	(Percent Recovery)	
	<10%	10%-Lower CRR	>Higher CRR
Hit or Positive Result	Approximate	Approximate	Approximate
Non-Detected Result	Reject	Approximate	No qualifier

Where: CRR is the Contract Required Recovery Range

IV. MATRIX SPIKE/MATRIX SPIKE DUPLICATES

- If both sets of spike results (MS/MSD) are not within the contract required recovery range (CRR), qualify only the compound(s) which is out of range in the applicable sample.

	Action Level	(Percent Recovery)	
Organics	<10%	10%-Lower CRR	>Higher CRR
Metals	<30%	30%-Lower CRR	>Higher CRR
Hit or Positive Result	Approximate	Approximate	Approximate
Non-Detected Result	Reject	Approximate	No qualifier

TABLE 2-1 (CONTINUED). M&E LEVEL III DATA EVALUATION CRITERIA

V. LABORATORY CONTROL STANDARDS

- Qualify all corresponding metals in the applicable sample fraction for all samples within the applicable analytical batch.

Action Level (Percent Recovery)

	<30%	30-80%	80-120%	>120%
Hit or Positive Result	Approximate	Approximate	No Qualifier	Approximate
Non-Detected Result	Reject	No Qualifier	No Qualifier	No Qualifier

VI. REPLICATE SAMPLES

- Qualify detected compounds based on the relative percent difference between the sample and corresponding replicate.

Action Level (Relative Percent Difference)

	Aqueous Sample		**Soil Sample**	
Volatiles*	<15%	>15%	<25%	>25%
Base/Neutral Extractables*	<25%	>25%	<32%	>32%
Acid Extractables	<45%	>45%	<43%	>43%
Metals	<20%	>20%	<35%	>35%
Hit or Positive Result	No Qualifier	Approx.	No Qualifier	Approx.

* In the case of organic analysis these criteria refer to the RPD between the recovery results of the matrix spike/matrix spike duplicate analyses.

in Figure 2-1. The concentration ranges of PCBs and cPAHs in the trench area were estimated to be 1,000 - 10,000 mg/kg and 0.01 - 10 mg/kg, respectively.

A trench 2 feet wide x 15 feet long x 7 feet deep was excavated using a backhoe. Soil grab samples were collected from various areas of the trench (both aerial and with depth) to a total of approximately 100 pounds. The soil was sieved through a ½-inch mesh screen into a polyethylene-lined 55 gallon 17H drum. Soil compositing was performed approximately 10 feet east of the trench by sealing the drum, turning the drum on its side, and rolling the drum for several minutes. The drum was then opened and the contents visually inspected to see if the material was thoroughly mixed. This operation was performed in Level C personal protective equipment.

Two composite samples were collected by the procedures outlined above in order to create a highly contaminated sample (>5,000 mg/kg total PCBs) and a sample containing a moderate level of contamination (no less than 100 mg/kg total PCBs). A PCB field test kit was used to screen both composite samples to determine whether the samples contained sufficiently high total PCB concentrations. The test kit yielded measurements of greater than 10,000 mg/kg total PCB for the highly contaminated sample, and approximately 1,700 mg/kg total PCB for the moderately contaminated sample.

Once the composited soil samples were collected, the samples were apportioned into one-gallon glass jars and packed into drums for shipment to the treatability study subcontractors. Each subcontractor was shipped two gallons (approximately 10 to 15 kg) of each soil sample. The samples were manifested and the shipments were carried out by registered hazardous waste transporters as specified under the Toxic Substances Control Act (TSCA) PCB manifesting rules (40 CFR 761.207-209).

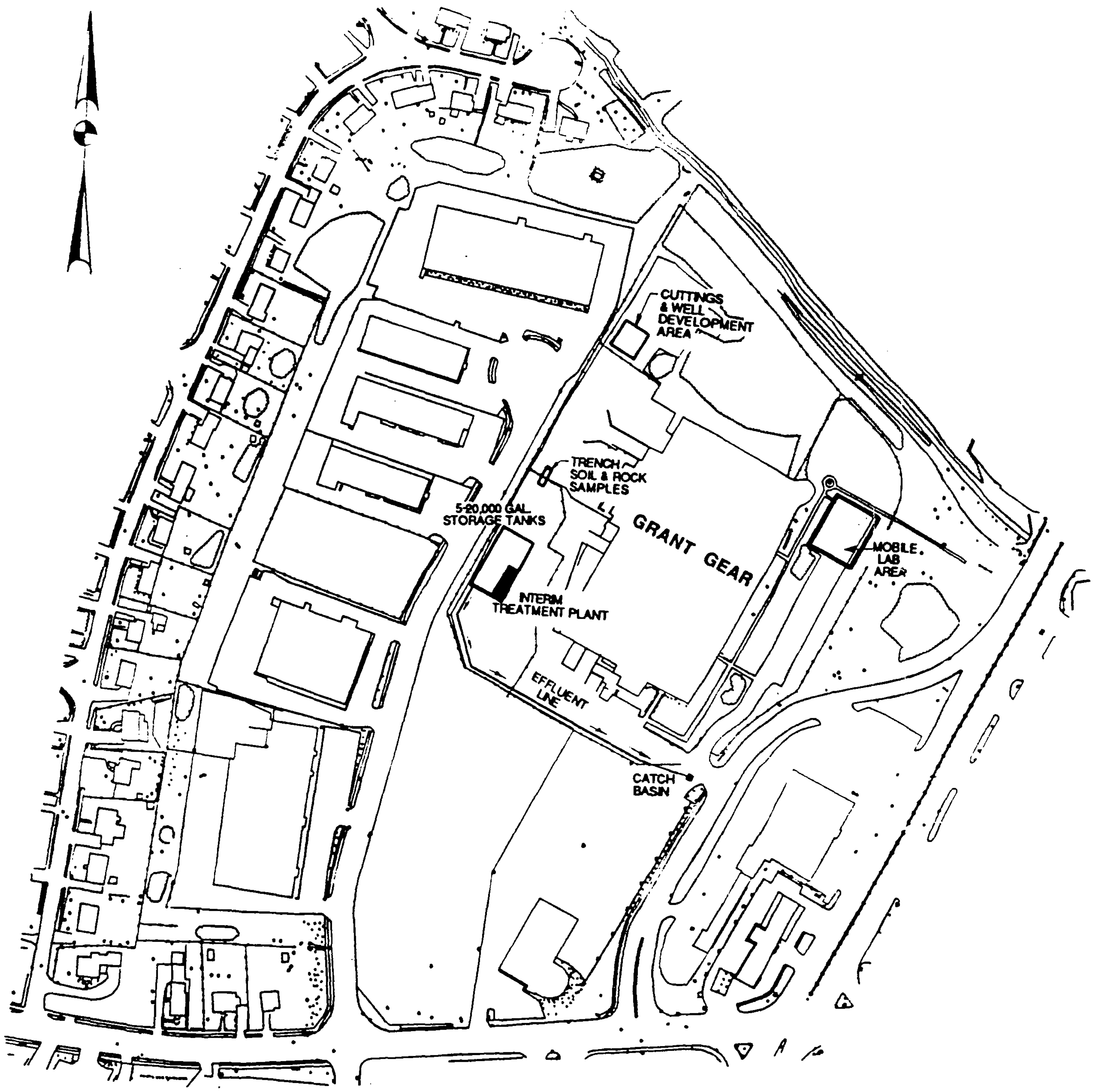


FIGURE 2-1. SOIL SAMPLE COLLECTION LOCATION

PLAN
SCALE: 1" = 200'-0"

METCALF & EDDY

NORWOOD PCB SITE

DRAWN BY
DATE
CHECKED BY
DATE
APPROVED BY
DATE
FILE NO.
2-

Section Three

SECTION 3.0

LIQUEFIED PROPANE EXTRACTION STUDY

This section summarizes the bench-scale treatability study of the liquefied propane extraction process performed by CF Systems Corporation on two composite soil samples collected from the Norwood PCB Site. Further details are presented in CF Systems' report which is included as Appendix A of this document.

3.1 PROCEDURES AND APPARATUS

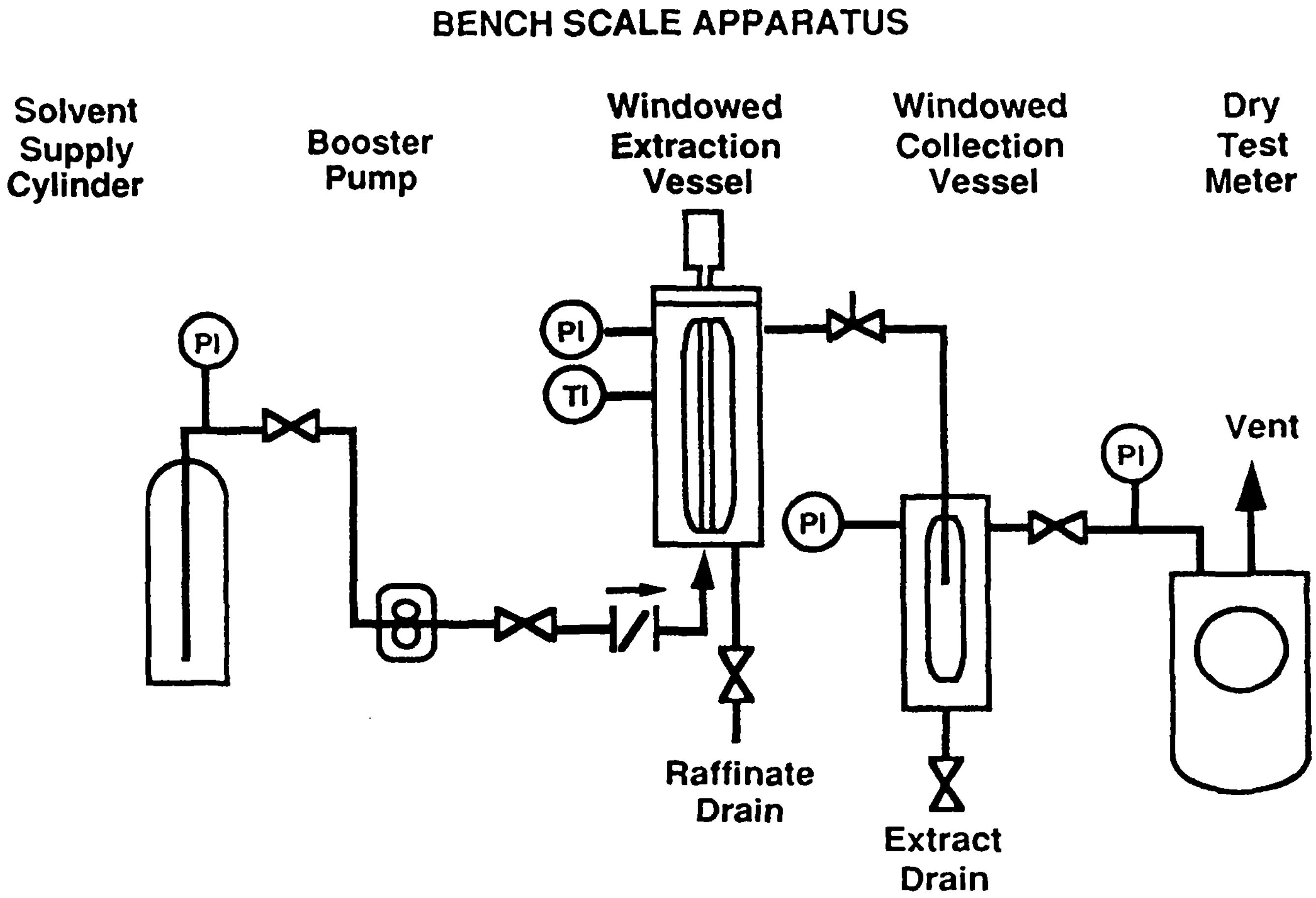
The liquefied propane extraction study was performed in the bench-scale apparatus shown schematically in Figure 3-1. Each of the soil samples was extracted in the apparatus, following the performance of routine mixing tests needed to determine the appropriate mixing speed, settling time, and solvent-to-soil ratio for each sample.

The extractions were performed in a walk-in hood according to the procedure outlined below and described in CF Systems' report (Appendix A).

The bench-scale testing procedure was as follows:

1. 2 kg of untreated soil was charged to a windowed high pressure extraction vessel equipped with a high torque mixer.
2. The vessel was sealed, and liquefied propane was introduced until the pressure reached approximately 200 psi.
3. The soil/solvent mixture was stirred, and then allowed to settle into two distinct phases: an organics rich solvent phase (extract) and a soil/water residue phase.
4. Liquid extract (solvent + organics) was then drained from the extractor by gravity to a collection vessel until all of the organic-contaminated solvent had been removed from the extractor.

FIGURE 3-1. BENCH-SCALE LIQUEFIED PROPANE EXTRACTION APPARATUS



SOURCE: CF SYSTEMS CORPORATION

5. The extraction vessel was depressurized and a 50 gram aliquot of treated soil (intermediate sample) was removed for PCB analysis by CF Systems' subcontract laboratory.

6. In the collection vessel, solvent (propane) was vaporized and sent to a dry test meter in order to quantify the amount of solvent used during the course of each extraction stage.

7. Steps 2 through 6 were repeated until the desired number of extraction stages (i.e., 6 stages) were achieved.

8. Following six stages of extraction, the organics remaining in the collection vessel and the treated soil/water residue remaining in the extractor were collected, weighed, labelled and refrigerated in appropriate sample containers prior to shipment to CLP laboratories and CF Systems' subcontract laboratory.

CF Systems decided to use six extraction stages for each sample based on the need to attain the 10 mg/kg total PCB cleanup level, and on the estimates of initial PCB concentrations which M&E provided to CF Systems. CF Systems did not await the results of PCB analyses on the intermediate soil samples before proceeding to the next extraction stage. For a given set of operating conditions, CF Systems' bench-scale testing procedure provides a direct measure of extraction efficiency for targeted contaminants. During this study, both of the samples were extracted with six equivalent stages of extraction in order to determine the number of stages needed to attain cleanup levels. Data collected by CF Systems during each test included the following:

- Feed (untreated soil) weight
- Solvent weight
- Extract (organics) weight
- Residue (treated soil) weight
- Temperature in the extractor
- Pressure in the extractor
- Mixing time
- Mixing speed
- Settling time

3.2 SAMPLING AND ANALYSIS

The liquefied propane extraction tests yielded two phases for each soil tested: an extracted (treated) soil phase and a recovered oil phase. Soils were analyzed both before treatment and after six stages of extraction for pesticides/PCBs, SVOCs, VOCs, dioxins/dibenzofurans, and metals. Extracted oils were analyzed for dioxins/dibenzofurans, SVOCs, and pesticides/PCBs. These analyses were all carried out by CLP laboratories according to the appropriate RAS or SAS methods.

CF Systems and its designated laboratory, GP Laboratories, also performed soil analyses. The untreated soils were analyzed for PCBs, oil and grease, and moisture content by GP Laboratories. CF Systems determined the particle size distributions of the untreated soils. Aliquots of soil removed from the extractor after each intermediate stage of extraction were analyzed for PCBs by GP Laboratories. These intermediate analyses enabled CF Systems to generate a plot of PCB concentration versus number of extraction stages, so that the number of extraction stages needed to reach the target cleanup level of 10 mg/kg total PCBs could be determined. The treated soils were not analyzed for residual solvent because the solvent (propane) is a gas under ambient conditions. Table 3-1 summarizes the analyses performed as part of the liquefied propane extraction study.

3.3 RESULTS AND DISCUSSION

This section summarizes the results of the liquified propane extraction study. The results are described in detail in CF Systems' final report, which is reproduced as Appendix A.

3.3.1 Extraction of Aroclor - 1254

Figure 3-2 illustrates the reduction in Aroclor-1254 concentration as a function of extraction stage for the soil samples which underwent treatment in CF Systems' bench-scale extraction apparatus. (Note that the Aroclor-1254 concentration is plotted on a logarithmic scale).

TABLE 3-1. SUMMARY OF ANALYSES FOR THE LIQUEFIED PROPANE EXTRACTION STUDY

Analysis	Number of Samples	Duplicates	Total Number of Samples
SOILS BEFORE EXTRACTION			
TCL Volatile Organics (RAS)[a]	2	2	4
TCL Semivolatile Organics (SAS)[a]	2	2	4
Pesticides/PCBs (SAS)[a]	2	2	4
Dioxins/Dibenzofurans (SAS)[a]	2	2	4
TAL Metals (RAS)[a]	2	2	4
Particle Size Distribution[c]	2	0	2
PCBs[b]	2	0	2
Oil and Grease[b]	2	0	2
Moisture Content[b]	2	0	2
SOILS FROM INTERMEDIATE STAGES			
PCBs[b,d]	6 stages x 2 soils	0	12
SOILS AFTER LAST STAGE OF EXTRACTION			
TCL Volatile Organics (RAS)[a]	2	0	2
TCL Semivolatile Organics (SAS)[a]	2	0	2
Pesticides/PCBs (SAS)[a]	2	0	2
Dioxins/Dibenzofurans (SAS)[a]	2	0	2
TAL Metals (RAS)[a]	2	0	2
Oil and Grease[b]	2	2	4
Moisture Content[b]	2	0	2
EXTRACTED OILS			
Dioxins/dibenzofurans (SAS)[a]	2	0	2
High Concentration Organics (SAS)[a,c]	2	0	2

Notes to Table 3-5:

a. Samples were shipped by CF Systems to CLP Laboratories designated by the EPA Region I SMO, under M&E's direction.
b. Analysis was performed by CF Systems' designated laboratory (GP Laboratories).
c. The High Concentration Organics procedure determined SVOC and pesticide/PCB concentrations in concentrated oily extracts.
d. The number of extraction stages needed to reach the target PCB cleanup level was expected to be 6 stages.
e. Determinations were performed by CF Systems.

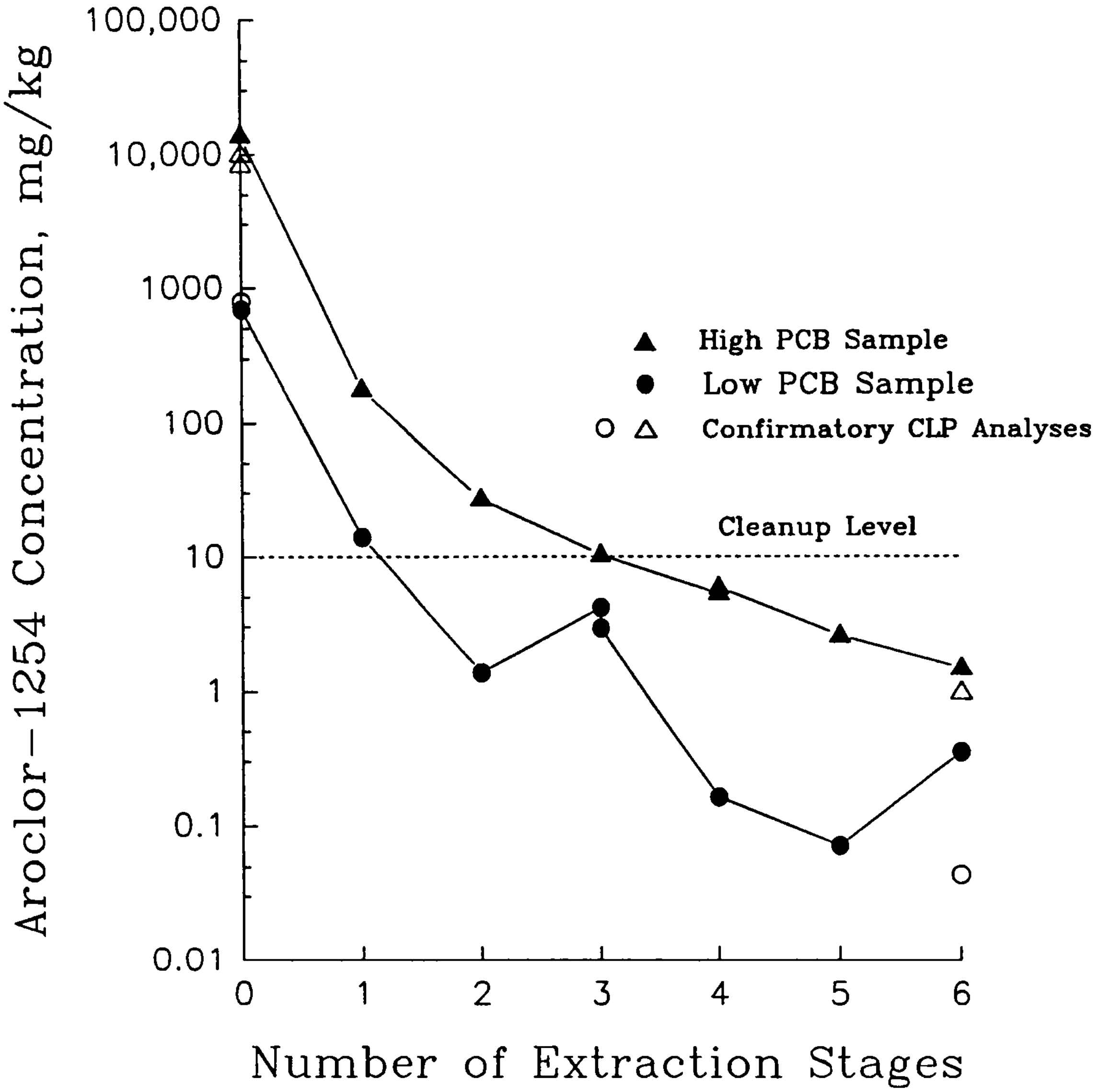


Figure 3−2. Aroclor−1254 Concentration in Extracted Soils as a function of extraction stage: Treatability Study by CF Systems Corp.

Both the high PCB and the low PCB composite samples were effectively treated to concentrations well below the established cleanup level of 10 mg/kg total PCBs. Two stages of extraction were sufficient to meet the cleanup level for the low PCB sample, while it appears that three or more stages will be needed for soils as contaminated as the high PCB sample. The actual number of stages which would be needed for full-scale remediation of the Site will depend on the proportion of the Site which is contaminated at the levels represented by the high PCB sample. In practice, a two or three-stage full-scale system could be used at the Site, and when the "hot spot" area is excavated, the highly contaminated soils could be processed through the system twice, if necessary.

The Aroclor-1254 concentrations shown by solid symbols on Figure 3-2 are the analytical results obtained by CF Systems' laboratory (GP Laboratories). The open symbols represent the results obtained by independent EPA-CLP laboratories for splits of the feed and sixth-stage soil samples. The results for the feed samples compare quite well, as do the results for the sixth-stage high PCB sample. The CLP result for the sixth-stage low PCB sample was a factor of eight lower than that obtained by GP Laboratories. However, at the low concentrations reported for these samples (0.355 mg/kg and 0.044 mg/kg), this magnitude of variation is not unexpected. To be conservative, the higher PCB concentration has been used in calculations of extraction efficiency and cumulative percent extracted. The results of these calculations are presented in Table 3-2. The values for extraction efficiency per stage and cumulative percent extracted illustrate that the bulk of the Aroclor-1254 is extracted in the first stage. Subsequent stages generally show progressively less extraction. In fact, for the low PCB sample there appears to have been an increase in Aroclor-1254 concentration after the third stage. This anomalous result has been attributed to analytical and sampling variability, since there is no mechanism by which the extraction process could actually "create" PCBs.

For the high PCB sample, the first two stages yielded extraction efficiencies of 99 and 85 percent, while the efficiencies of Stages 3 through 6 were in the range of 40 to 60 percent. It appears from these values that for the Norwood soils, the extraction efficiency decreases

TABLE 3-2. CONCENTRATIONS OF AROCLOR-1254 IN SOILS AS A FUNCTION OF EXTRACTION STAGE: LIQUEFIED PROPANE EXTRACTION TREATABILITY STUDY

Composite Sample Containing "Low" PCB Concentration

Extraction Stage	Aroclor-1254 Concentration (mg/kg) CF Systems' data (1)	CLP data (1)	Cumulative Percent Extracted (2)	Extraction Efficiency Per Stage
0 (Feed Analysis)	697	789/796	--	--
1	14	NA	97.99	98
2	1.38	NA	99.80	90
3	4.16/2.95	NA	99.49	NC
4	0.164	NA	99.98	NC
5	0.0724	NA	99.99	56
6	0.355	0.044	99.95	NC

Composite Sample containing "High" PCB concentration

Extraction Stage	Aroclor-1254 Concentration (mg/kg) CF Systems' data (1)	CLP data (1)	Cumulative Percent Extracted (2)	Extraction Efficiency Per Stage
0 (Feed Analysis)	13800	9930/8300	--	--
1	178	NA	98.71	99
2	26.8	NA	99.81	85
3	10.3	NA	99.93	62
4	5.33/5.90	NA	99.96	45
5	2.59	NA	99.98	54
6	1.49	0.98	99.99	42

Cumulative Percent Extracted for Stage N = (Conc'n in Feed - Conc'n at Stage N)/Conc'n in Feed x 100

Extraction Efficiency for Stage N = (Conc'n at Stage N-1 - Conc'n at Stage N)/Conc'n at Stage N-1 x 100

(1) When two values are listed separated by a slash (/), the values are the results of duplicate analyses.

(2) Calculations are based on the concentrations reported by CF Systems.

NA Not analyzed. Only untreated soil samples and final treated soil samples were submitted to CLP laboratories for confirmatory analysis.

NC Not calculated due to anomalous result (i.e., an apparent increase in concentration due to extraction).

with decreasing concentration up to a certain point, at which point the efficiency remains fairly constant at about 40 to 60 percent. This behavior is typical of extraction processes. Large reductions in contaminant concentrations occur in the first stage because most of the easily extractable material is removed in this stage. Also, the driving force for mass transfer (i.e., the concentration gradient) between the soil and solvent phases is largest during the first stage. During subsequent stages the fraction of the remaining contamination which is strongly adsorbed to the soil increases, while at the same time the concentration gradient between the soil and solvent phases is decreasing. As a result, it becomes more and more difficult to extract the remaining contaminants from the soil. However, the PCB cleanup level is attained before a significant drop in extraction efficiency occurs. Therefore, this drop in extraction efficiency does not adversely affect the economics of the liquefied propane process for use at the Norwood PCB Site.

3.3.2 Extraction of Dioxins/Dibenzofurans

Table 3-3 presents the dioxin/dibenzofuran concentrations observed in the feed soil samples and in the treated soil samples after six stages of extraction. The concentrations are expressed in terms of total 2, 3, 7, 8-TCDD toxicity equivalences to simplify this discussion; the individual isomer concentrations for each sample are presented in Appendix C of CF Systems' report (Appendix A). The analyses were performed by a CLP laboratory and were validated by EPA Region I personnel.

The data in Table 3-3 shows that dioxins/dibenzofurans were effectively extracted from the Norwood soils by liquefied propane, with extraction efficiencies on the order of 98 percent.

3.3.3 Extraction of VOCs and SVOCs

The high and low PCB soil samples were also analyzed for volatile and semivolatile organic compounds both before and after treatment. The untreated soil samples did not contain

TABLE 3-3. DIOXIN/DIBENZOFURAN TOXICITY EQUIVALENCES IN FEED AND TREATED SOILS: LIQUEFIED PROPANE EXTRACTION TREATABILITY STUDY

	Total 2, 3, 7, 8-TCDD Toxicity Equivalence, μg/kg	
	Low PCB Sample	High PCB Sample
Feed Soil	0.32	5.31
Soil after Six Stages of Extraction	0.00777	0.0924
Percent Extracted	97.57	98.26

detectable concentrations of VOCs and SVOCs, with the exception of 1, 2, 4-trichlorobenzene. This compound was detected in the high PCB feed sample at an average concentration of 9.5 mg/kg. Given the fact that VOCs and SVOCs were virtually non-detected in the feed soil samples, it was expected that the treated soil samples would also contain no detectable VOCs and SVOCs. However, the treated samples contained significant concentrations of VOCs, according to the results obtained from an independent CLP laboratory (Table 3-4). Because the liquefied propane extraction process does not involve chemical reactions of any sort, it is not considered possible that the VOCs in the treated soils could have been produced during treatment. CF Systems' engineers and M&E chemists have concluded that the most likely source of the VOCs is contaminated propane.

If the propane solvent used for extraction were contaminated with VOCs, it could potentially have contaminated the soil in the bench-scale extractor. This phenomenon has never been observed before by CF Systems, nor have they ever encountered contaminated propane. CF Systems made a cursory attempt to look for contamination in their propane by bubbling some of the propane into methanol and then analyzing the methanol by High Performance Liquid Chromatography (HPLC). No peaks were detected by HPLC. However, this does not rule out the possibility that contaminants were present in the propane that either did not transfer into the methanol solution, or were not detectable by HPLC. CF Systems contacted their propane vendor, who claimed that their propane could not have been contaminated by

TABLE 3-4. VOLATILE AND SEMIVOLATILE ORGANIC COMPOUNDS DETECTED IN UNTREATED AND TREATED SOIL SAMPLES: LIQUEFIED PROPANE EXTRACTION TREATABILITY STUDY

Compound	Low PCB Sample		High PCB Sample	
	Untreated (ug/kg)	Treated (ug/kg)	Untreated (ug/kg)	Treated (ug/kg)
2-Butanone	10 U	4100	10 U	4400
Trichloroethene	10 U	1300	10 U	250
Benzene	10 U	410	10 U	1900
Toluene	10 U	3200	10 U	6600
Ethylbenzene	10 U	1500	10 U	1600
Total Xylenes	10 U	9200	10 U	9300
Chlorobenzene	10 U	1300	10 U	190
1,2,4-Trichlorobenzene	R	390 U	9.5	0.047

NOTES:

U - Value is the sample detection limit.
R - Value was rejected due to quality control problems.

the VOCs detected. This issue remains unresolved. Further analytical work on the batch of propane used for the Norwood tests is not possible because it was used up during later tests.

3.3.4 Analysis of Extracted Oil

As discussed in previous sections, Aroclor-1254 and dioxins/dibenzofurans were effectively extracted from both the low PCB and the high PCB soil samples, as demonstrated by analyses of the feed and treated soils. The oily extracts which were generated by the bench-scale extraction of both samples were also collected and submitted for analysis. This section presents the results of those analyses. This information is important because it is needed both to evaluate disposal options for the oil, and to calculate mass balances for the contaminants of concern. Mass balance calculations will be presented in Section 3.3.6.

Table 3-5 presents the results of the PCB and dioxin/dibenzofuran analyses of the oil extracted from the high PCB sample. The results for the oil extracted from the low PCB sample have not been presented here because the oil was diluted with hexane by CF Systems prior to its shipment to the CLP laboratories. This was done because so little oil was extracted from the low PCB sample that it could only be removed from the walls of the extraction vessel by rinsing that vessel with hexane. Because the actual mass of oil extracted from the low PCB sample is not known, the analytical results cannot be corrected for dilution by hexane. The results are therefore not useful for evaluating disposal options.

3.3.5 Disposal of Extracted Oil

The Aroclor-1254 concentration in the oil was 212,000 mg/kg, or 21.2 percent by weight. The Toxic Substances Control Act (TSCA) requires that liquid PCB wastes containing greater than 500 ppm PCBs be disposed of in an incinerator or by an alternate method that achieves a level of performance equivalent to incineration (EPA, 1990d). The incinerator must comply with the requirements set forth in 40 CFR 761.70. Requirements for the alternative

TABLE 3-5. ANALYSIS OF OIL EXTRACTED FROM HIGH PCB SOIL SAMPLE FOR DIOXINS/DIBENZOFURANS AND AROCLOR-1254: LIQUEFIED PROPANE EXTRACTION TREATABILITY STUDY

Compound	Extract from High PCB Soil Sample	
<u>TCDD/TCDF Concentration, ug/kg</u>		
2,3,7,8-TCDD	0.99 *	UJ
1,2,3,7,8-PeCDD	1.4	U
1,2,3,4,7,8-HxCDD	2.0	UJ
1,2,3,6,7,8-HxCDD	3.1 *	UJ
1,2,3,7,8,9-HxCDD	1.7	UJ
1,2,3,4,6,7,8-HpCDD	2.4	UJ
OCDD	0.25	J
2,3,7,8-TCDF	166	
1,2,3,7,8-PeCDF	1.3	U
2,3,4,7,8-PeCDF	150	
1,2,3,4,7,8-HxCDF	894	J
1,2,3,6,7,8-HxCDF	195	J
2,3,4,6,7,8-HxCDF	131	J
1,2,3,7,8,9-HxCDF	14.3	J
1,2,3,4,6,7,8-HpCDF	201	J
1,2,3,4,7,8,9-HpCDF	149	J
OCDF	3.2	J
TOTAL TCDD **	88.0 *	UJ
TOTAL PeCDD **	3400 *	UJ
TOTAL HxCDD **	5.4	
TOTAL HpCDD **	2.1	
TOTAL TCDF **	468	
TOTAL PeCDF **	935	
TOTAL HxCDF **	1980	
TOTAL HpCDF **	537	
TOTAL 2,3,7,8-TCDD TOXICITY EQUIVALENCE (ug/kg)	219.8	J
<u>PCB Concentration, mg/kg</u>		
AROCLOR-1254	212000	

NOTES:

* - Quantity is an EMPC (Estimated Maximum Possible Concentration) rather than a detection limit, because the ion abundance ratio was outside QC limits. The EMPC is a worst case estimate and is not included in TEF calculations.

** - Total includes isomers which are formed by addition of chlorine atoms to 2,3,7,8-TCDD (i.e., those for which individual concentrations have also been reported) as well as any other isomers detected. Therefore, these totals may not match the totals of the individual concentrations reported here.

J - Quantitation is approximate due to limitations identified in the quality control review.

U - Value is the sample detection limit (or EPMC if *).

UJ - Value is the sample detection limit (or EPMC if *); value is approximate due to limitations identified in the quality control review.

disposal method are presented in 40 CFR 761.60(e). The requirements have been interpreted to imply that treatment residuals must contain less than 2 ppm PCBs (EPA, 1990d).

The oil also contains low concentrations of dioxins/dibenzofurans which may limit the availability of TSCA incinerators which will accept the oil. There were three dibenzofuran isomers detected in the oil which are toxic constituents under RCRA, as listed in Appendix VIII of 40 CFR Part 261:

- Tetrachlorodibenzofurans (TCDFs)
- Pentachlorodibenzofurans (PeCDFs)
- Hexachlorodibenzofurans (HxCDFs)

The presence of these isomers in the oil does not, in and of itself, classify the oil as a RCRA- listed hazardous waste. There are seven RCRA-listed hazardous wastes which are listed because of the possible presence of dioxins/dibenzofurans; these listed wastes are waste codes F020, F021, F022, F023, F026, F027, and F028. The oil to be generated by solvent extraction would not fall under any of these waste codes, however, because the source of contamination at the Site is not believed to be due to any of the processes defined in these waste codes. These waste codes and their definitions as presented in 40 CFR 261.13 are reproduced in Table 3-6.

TABLE 3-6. RCRA-LISTED HAZARDOUS WASTES WHICH MAY CONTAIN DIOXINS/DIBENZOFURANS

Industry and EPA Hazardous Waste No.	Hazardous Waste	Hazard Code
F020	Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tri- or tetrachlorophenol, or of intermediates used to produce their pesticide derivatives. (This listing does not include wastes from the production of Hexachlorophene from highly purified 2,4,5-trichlorophenol.)	(H)
F021	Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of pentachlorophenol, or of intermediates used to produce its derivatives.	(H)

TABLE 3-6 (Continued). RCRA-LISTED HAZARDOUS WASTES WHICH MAY CONTAIN DIOXINS/DIBENZOFURANS

Industry and EPA Hazardous Waste No.	Hazardous Waste	Hazard Code
F022	Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tetra-, penta-, or hexachlorobenzenes under alkaline conditions.	(H)
F023	Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production of materials on equipment previously used for the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tri- and tetrachlorophenols. (This listing does not include wastes from equipment used only for the production or use of Hexachlorophene from highly purified 2,3,5-trichlorophenol).	(H)
F026	Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production of materials on equipment previously used for the manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tetra-, penta-, or hexachlorobenzene under alkaline conditions.	(H)
F027	Discarded unused formulations containing tri-, tetra-, or pentachlorophenol or discarded unused formulations containing compounds derived from these chlorophenols. (This listing does not include formulations containing Hexachlorophene synthesized from prepurified 2,4,5-trichlorophenol as the sole component.).	(H)
F028	Residues resulting from the incineration or thermal treatment of soil contaminated with EPA Hazardous Waste Nos. F020, F021, F022, F023, F026, and F027.	(T)

Although the oil is not considered to be a RCRA-listed waste, it is possible that the oil could be classified as a RCRA characteristic waste due to the characteristic of toxicity. To determine whether the oil is in fact a RCRA characteristic waste, the Toxicity Characteristic Leaching Procedure (TCLP) would have to be performed on the oil.

The implication of the TSCA regulations cited previously for off-site disposal of the oil is that it must be incinerated in an incinerator which is TSCA-permitted to burn liquid PCB wastes containing greater than 500 ppm PCBs. Because the oil is not considered to be a listed RCRA hazardous waste under waste codes F020, F021, F022, F023, F026, F027, or F028, the incinerator would not require a RCRA permit allowing the incineration of wastes with these waste codes. The incinerator may require some form of RCRA permit, however, depending on the outcome of TCLP tests on the oil to determine whether it is a RCRA characteristic waste due to the toxicity characteristic.

M&E has contacted a number of TSCA- and RCRA-permitted disposal facilities to determine availability and to estimate the cost of oil disposal. With the permission of the RPM, M&E provided the facilities with the results of the PCB and dioxin/dibenzofuran analyses on the oil. Several of the facilities expressed concern over the dioxin/dibenzofuran content of the oil, since the presence of these compounds indicated to them that the oil may be a RCRA-listed waste with one of the F waste codes, which they were not permitted to accept. These facilities stated that if EPA were to draft a letter stating that the oil was not an F-listed RCRA waste, they would consider accepting the oil pending the results of their own analyses of it.

One facility (Aptus, Coffeyville, Kansas) indicated that it could potentially accept the oil even if it were an F-listed RCRA waste. Aptus is currently permitted to incinerate TSCA and RCRA wastes containing PCBs and dioxins/dibenzofurans. However, they do not yet have a permit to dispose of the slag generated by their incinerator. They expect to obtain this permit within the next 6 to 12 months. The cost for incineration of the oil is expected to be $5 to $6 per pound, according to Aptus.

Documentation concerning M&E's contacts with potential oil disposal facilities is presented in Appendix C.

3.3.6 Mass Balances

An overall mass balance and mass balances for Aroclor-1254 and dioxins/dibenzofurans have been performed from the data obtained by CF Systems and the CLP laboratories. The information provided by mass balances is important for a number of reasons:

- It allows estimation of the quantity of oil which would be generated during full-scale remediation. This is needed to estimate disposal costs for the oil.
- It provides a check on the quality of the bench-scale test protocol and the chemical analyses performed. Since solvent extraction does not destroy contaminants, there should be no net losses or gains in mass for the contaminants of concern. Poor closure of mass balances can result from inaccuracies in weighing, inaccurate analytical results, unquantified losses from the test system (such as leaks), poor recovery of contaminants from the solvent, or poor recovery of materials from the test system (such as failure to drain all oil from the extraction vessel).

The mass balances for the liquefied propane extraction study are shown in Table 3-7. The calculations are presented in Appendix D. There was good closure of the overall mass balance for the high PCB composite sample. The two percent of the mass that was not recovered could most likely be accounted for by the small amounts of soil withdrawn after each extraction stage for PCB analysis. The weights of these intermediate samples have been included in the mass balance; however, the withdrawal of these samples increased the chances for losses of material and errors in weighing by a factor of six.

For the low PCB composite sample, CF Systems was not able to weigh the extracted oil since it could not be withdrawn from the extraction vessel. The oil had coated the sides of the vessel and was recovered by rinsing the vessel with 25 ml of hexane. The resulting oil/hexane solution was then sent to CLP laboratories for analysis for PCBs and dioxins/dibenzofurans. Therefore, the mass of oil extracted from the low PCB sample remains unknown.

The recoveries of Aroclor-1254 are considered to be adequate, given the sensitivity of the mass balance calculations to the mass of oil generated and to the concentration of Aroclor-1254 in the oil.

The dioxin/dibenzofuran mass balances were performed using the 2,3,7,8-TCDD toxicity equivalences rather than performing balances on the individual isomers. The recoveries were within reasonable limits.

3.3.7 Oil Volume Estimates

The volume of oil which would be generated during full-scale remediation of the Norwood PCB Site using liquefied propane extraction can be estimated from the overall mass balance data in Table 3-7. The calculations are presented in Appendix D. For the high PCB sample, 26.1 grams of oil were extracted from 919.9 grams of feed. Assuming a soil density of 1.3 tons per cubic yard and an oil density of 8 pounds per gallon, this translates to an estimated oil yield of 9.22 gallons per cubic yard of high PCB soil treated.

A direct estimate of oil volume cannot be made for the low PCB sample since the mass of oil generated from the bench-scale test was not measured. However, CF Systems performed oil and grease analyses on both the high and low PCB soil samples from which they were able to estimate an oil volume for the low PCB sample. The calculations are presented in Appendix D. The estimate arrived at using CF Systems' oil and grease data was 0.262 gallons of oil per cubic yard of soil, which is roughly forty times less than that for the high PCB soil sample.

Due to the large differences in oil yield between the high PCB and low PCB samples, an estimate of oil volume for full-scale remediation is extremely sensitive to the assumptions one makes concerning the levels of contamination on site. The total volume of contaminated soil on site is on the order of 39,785 cubic yards. If it is assumed that the low PCB sample is representative of the entire 39,785 cubic yards, then the estimated volume of oil to be

TABLE 3-7. MASS BALANCES FOR LIQUEFIED PROPANE EXTRACTION TREATABILITY STUDY

Overall Mass Balance (1)

Sample	Untreated Soil (grams)	Treated Soil (grams)	Extracted Oil (grams)	Percent Recovery
Low PCB Composite	900.4	830.7	NA	> 92.3
High PCB Composite	919.9	877.9	26.1	98.3

Aroclor-1254 Balance (2)

Sample	Untreated Soil (mg)	Treated Soil (mg)	Extracted Oil (mg)	Percent Recovery
Low PCB Composite	714	0.037	320	44.8
High PCB Composite	8389	0.86	5533	66.0

Dioxin/Dibenzofuran (Total 2,3,7,8-TCDD Toxicity Equivalence) Balance (2)

Sample	Untreated Soil (ug)	Treated Soil (ug)	Extracted Oil (ug)	Percent Recovery
Low PCB Composite	0.286	0.00645	0.259	92.8
High PCB Composite	4.884	0.0811	5.737	119

NOTES: Percent Recovery = (Treated Soil Mass + Extracted Oil Mass)/Untreated Soil Mass x 100

NA Not available. CF Systems did not weigh extracted oil for the Low PCB sample; it had to be rinsed from the extraction vessel with 25 ml of hexane due to the small quantity generated. Mass balance calculations assumed that the density of the Low PCB extracted oil sample was the same as that of hexane.

(1) Weights are those measured by CF Systems.

(2) Balances calculated from analyses done by CLP laboratories and weights measured by CF Systems.

generated during remediation is 0.262 x 39,785 = 10,400 gallons. If 90 percent of the soil to be remediated is represented by the low PCB sample, with the remaining 10 percent represented by the high PCB sample, the estimated oil volume increases to 46,100 gallons. To obtain a more accurate estimate of oil volume, further sampling to determine the extent of the "hot spot" area (which the high PCB sample was intended to represent) would be necessary.

It is noted that CF Systems made certain measurements or assumptions as to the weight per cubic yard of material to be processed which may not be identical to those used above. However, M&E has elected to use uniform weights per ton and amounts of soil to be treated so as to better compare the two solvent extraction processes. This comparison and M&E's basis for the comparison are presented in Section 5.0.

3.3.8 Full-Scale Operations

CF Systems proposes to use a 240 ton per day (tpd) treatment unit at the Norwood PCB Site. Based on past experience, they estimate that the unit will have an operating factor of no less than 83 percent, thereby yielding an actual throughput of 200 tons per day. Assuming that there is 40,000 tons of material to be treated, CF Systems estimated that they could complete the remediation in approximately 10 months, including mobilization/demobilization. This 10-month time frame begins with the mobilization of the unit on the site, includes the treatment of 40,000 tons of soil, and ends with demobilization of the unit. It does not include site preparation or restoration. In addition, CF Systems requires a period of ten months after contract closing to construct the unit. Therefore, the time frame from contract closing to demobilization would be on the order of 20 months.

The footprint of the treatment unit is approximately 200 feet by 100 feet, including feed and treated soil storage bins. The unit requires 480 volt, three-phase electricity with a 300 to 400 amp draw, and cooling water at 100 gallons per minute (gpm). Net water consumption can be reduced to 10 gpm, if necessary, through an optional cooling tower or refrigeration system. CF Systems supplies the propane solvent, nitrogen, and compressed air.

The cost for remediation of the Norwood PCB Site using liquefied propane extraction was estimated to be $200 per ton. CF Systems based this estimate on the results of the bench-scale study, a target cleanup level of 10 mg/kg total PCBs, and a remediation volume of 30,000 cubic yards (40,000 tons). The estimate includes mobilization/demobilization, labor, utilities, capital depreciation and profit. It does not include excavation and delivery of soil to the treatment unit, backfilling of treated soil, or oil disposal costs. The marginal increase in remediation volume from the 30,000 cubic yards assumed by CF Systems to 39,785 cubic yards would not be expected to change their unit cost quote.

Section Four

SECTION 4.0

TRIETHYLAMINE EXTRACTION STUDY

This section summarizes the bench-scale treatability study of triethylamine (TEA) extraction performed by Resources Conservation Company (RCC) on two composite soil samples collected from the Norwood PCB Site. Further details are presented in RCC's report which is included in Appendix B of this document.

4.1 PROCEDURES AND APPARATUS

The bench-scale study of the TEA extraction process (the B.E.S.T. process) involved four tasks: sample preparation, characterization of the two feed soils, preliminary testing of the feed soils, and performance of a bench-scale simulation of the B.E.S.T. process on each feed soil. These tasks are outlined briefly below and described in more detail in RCC's report (Appendix B).

Sample Preparation. The two soil samples were screened by RCC to remove debris and homogenize the samples. For bench-scale testing material larger than 1/4-inch must be removed, although at full-scale the B.E.S.T. process can accept material up to one inch in diameter. Approximately 20 percent of the low PCB sample mass and 16 percent of the high PCB sample mass was larger than 1/4 inch and was removed. It is noted that the samples were screened to 1/2 inch at the Site by M&E personnel prior to shipment to RCC. The material screened out by RCC therefore represents the size fraction between 1/2 inch and 1/4 inch.

Feed Characterization. Each feed soil sample was analyzed by RCC to determine its oil, water and solids content. Oil was determined by methylene chloride extraction followed by GC analysis, water by Karl Fisher titration, and solids by drying at 105°C. Each soil was also analyzed for pesticides/PCBs, SVOCs, VOCs, total metals, and dioxins/dibenzofurans by CLP RAS or SAS methods.

RCC also chose to supplement the CLP analyses to provide data for their own internal use at no cost to EPA. These additional analyses included the analysis of each soil for PCBs and PAHs.

Preliminary Testing. RCC tested each soil to determine its compatibility with TEA and its pH adjustment requirements. The compatibility test was necessary because TEA has the potential to react with some rare types of samples. The pH adjustment test was performed to determine the amount of caustic soda needed to establish the alkaline pH required by the B.E.S.T. process. Alkaline conditions are needed to ensure that the TEA does not become ionized, rendering it nonvolatile. Nonvolatile TEA will not be efficiently recovered from the process product streams, leaving residual TEA in the treated soils.

Bench-Scale Simulation. The bench-scale simulations were carried out in standard laboratory glassware such as beakers and separatory funnels. Each simulation consisted of three stages: 1) extraction of the soil with TEA; 2) decantation to separate the TEA/oil and TEA/water phases; and 3) distillation to separate TEA, oil, and water, when possible. The stages are briefly described below. A detailed description is presented in RCC's report included in full in Appendix B.

1. Extraction - The soil was placed in a glass beaker, chilled to 40°F, and pH-adjusted by addition of caustic soda at the dosage indicated by the preliminary pH adjustment test. Chilled TEA was added to the beaker and the extraction was performed with mixing provided by an air-driven prop mixer. The TEA/soil mixture was then centrifuged to remove solids. The centrate was set aside for later processing. Additional extractions were performed on the solids under conditions identical to those used for the first extraction, with two exceptions: no more caustic was used, and the temperature was raised to 140°F. After the final extraction the solids were processed by drying and by washing with water to remove residual TEA.

2. Decantation - When possible, the centrates generated in the extraction stage were heated to 140°F and separated into TEA/oil and TEA/water phases in a separatory funnel. This method of separation is generally used only after the first stage of extraction. For subsequent stages, the TEA/oil and TEA/water phases are separated by distillation as described below.

3. Distillation - Liquid (TEA/oil and TEA/water) phases were separated into oil, water, and TEA phases by distillation. Residual TEA was removed from the oil phase by steam stripping. The oil was further distilled without steam at 120°C to remove excess water. The water phase was of such small volume that it was not practical to perform chemical analyses on it. Very little water was produced because the moisture contents of the feed soils were so low (on the order of 4 to 6 percent). For feed soils this dry, any water generated during full-scale remediation is added back to the treated solids for dust control purposes. Therefore, the small volumes of water generated by the bench-scale tests were also added back to the treated solids before they were analyzed.

4.2 SAMPLING AND ANALYSIS

The B.E.S.T. process bench-scale tests yielded two product phases for each soil tested: a treated soil phase and an extracted oil phase. As described previously, a product water phase is also usually generated by the B.E.S.T. process. However, a separate product water stream was not generated from treatment of either of the Norwood Site composite samples because the samples contained relatively little moisture. Therefore, no analyses of product water were performed.

Soils were analyzed both before and after treatment for pesticides/PCBs, SVOCs, VOCs, dioxins/dibenzofurans, and TAL metals. The analyses were carried out by CLP laboratories designated by the EPA Region I SMO, according to the appropriate RAS or SAS methods.

RCC also performed soil analyses. Untreated soils were analyzed for PCBs, metals, oil and grease, and moisture content; and also underwent the preliminary testing described in Section 4.1. After each intermediate stage of extraction, RCC withdrew a portion of the extracted soil for PCB analysis before proceeding with the next stage. These intermediate PCB analyses were done to generate a plot of PCB concentration versus number of extraction stages, so that RCC could determine how many stages would be necessary to achieve the target cleanup level of 10 mg/kg total PCBs. RCC also analyzed treated soils for residual solvent (i.e., triethylamine, the solvent used in the B.E.S.T. process) and metals, in addition to performing TCLP metals extractions on the treated materials.

A summary of all analyses performed as part of the B.E.S.T. process treatability study is presented in Table 4-1.

4.3 RESULTS AND DISCUSSION

This section summarizes the results of the triethylamine extraction study. The results are described in detail in RCC's final report, which is reproduced as Appendix B.

4.3.1 Extraction of Aroclor-1254

Figure 4-1 illustrates the reduction in Aroclor-1254 concentration as a function of extraction stage for the soil samples which underwent bench-scale simulations of the B.E.S.T. process. (Note that the Aroclor-1254 concentrations are plotted on a logarithmic scale.)

The low PCB soil sample was apparently treated to the 10 mg/kg cleanup level after two stages of extraction. The addition of a third stage did not appear to reduce the concentration further. However, it is believed that the third stage result is questionable since by the fourth stage, the Aroclor-1254 concentration was well below the 10 mg/kg cleanup level. The conservative assumption is that four stages of extraction will be needed to treat Site soils having Aroclor-1254 concentrations approximated by the low PCB sample.

For the high PCB sample, the Aroclor-1254 concentration appeared to reach a plateau near the 10 mg/kg cleanup level. The cleanup level appeared to be attained after seven stages. However, according to RCC's analytical results, the addition of an eighth stage did not reduce the Aroclor-1254 concentration any further. The confirmatory analysis of the eighth-stage soil performed by a CLP laboratory did indicate a reduction in Aroclor-1254 concentration to approximately 5 mg/kg in the eighth stage. It is concluded that, for Site

TABLE 4-1. SUMMARY OF ANALYSES FOR THE B.E.S.T. PROCESS TREATABILITY STUDY

Analysis	Number of Samples	Duplicates	Total Number of Samples
SOILS BEFORE EXTRACTION			
TCL Volatile Organics (RAS)[a]	2	2	4
TCL Semivolatile Organics (SAS)[a]	2	2	4
Pesticides/PCBs (SAS)[a]	2	2	4
Dioxins/Dibenzofurans (SAS)[a]	2	2	4
TAL Metals (RAS)[a]	2	2	4
PCBs[b]	2	0	2
Oil and Grease[b]	2	0	2
Moisture Content[b]	2	0	2
Triethylamine Compatibility Test[b]	2	0	2
pH Adjustment Test	2	0	2
SOILS FROM INTERMEDIATE STAGES			
PCBs[b,d]	N stages x 2 soils	0	14
SOILS AFTER LAST STAGE OF EXTRACTION			
TCL Volatile Organics (RAS)[a]	2	0	2
TCL Semivolatile Organics (SAS)[a]	2	0	2
Pesticides/PCBs (SAS)[a]	2	0	2
Dioxins/Dibenzofurans (SAS)[a]	2	0	2
TAL Metals (RAS)[a]	2	0	2
Oil and Grease[b]	2	0	2
Moisture Content[b]	2	0	2
Triethylamine[b]	2	0	2
TCLP Metals[b]	2	0	2

TABLE 4-1 (Continued). SUMMARY OF ANALYSES FOR THE B.E.S.T. PROCESS TREATABILITY STUDY

Analysis	Number of Samples	Duplicates	Total Number of Samples
EXTRACTED OILS			
Dioxins/dibenzofurans (SAS)[a]	2	0	2
High Concentration Organics (SAS)[a,c]	2	0	2

a. Samples were shipped by RCC to CLP Laboratories designated by the EPA Region I SMO, under M&E's direction.
b. Analysis performed by RCC.
c. The High Concentration Organics RAS procedure determined SVOC and Pesticide/PCB concentrations in concentrated oily extracts.
d. The number of extraction stages needed to reach the target PCB cleanup level was expected to be in the range of 6 to 10 stages. RCC used six stages for the low PCB sample and eight stages for the high PCB sample.

soils as contaminated as the high PCB sample, it will be possible to attain the 10 mg/kg cleanup level, although at least eight stages will be needed to do so. In practice, a four-stage full-scale unit would probably be used at the Site, since the majority of the soil to be remediated is believed to be represented by the low PCB sample. When the heavily contaminated "hot spot" area of the site is excavated, these soils could be set aside and processed through the four-stage unit twice to ensure attainment of the 10 mg/kg cleanup level.

The Aroclor-1254 concentrations shown by solid symbols on Figure 4-1 are the results obtained by RCC. The open symbols are the results obtained by independent CLP laboratories for splits of the feed and final stage soil samples. The results from RCC's laboratory and the CLP laboratories compare fairly well, with RCC's results generally being slightly higher. To be conservative, RCC's results have been used in calculations of extraction efficiency and cumulative percent extracted. The results of these calculations are

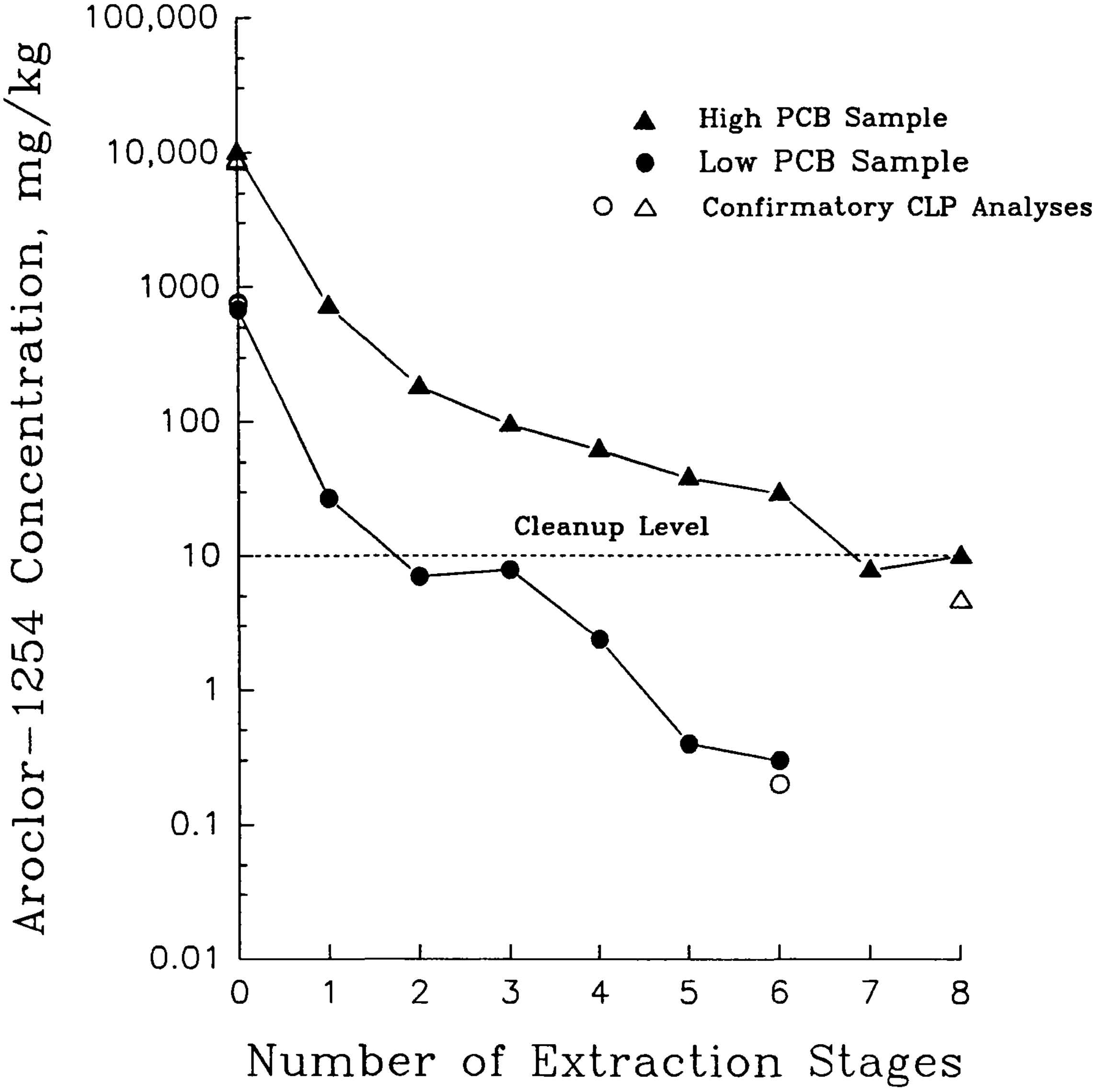


Figure 4−1. Aroclor−1254 Concentration in Extracted Soils as a function of extraction stage: Treatability Study by Resources Conservation Co.

shown in Table 4-2. The values for cumulative percent extracted and extraction efficiency per stage show that the bulk of the Aroclor-1254 was extracted from the soils in the first stage. The extraction efficiency generally decreases with each subsequent stage of extraction. This behavior is similar to that observed for the liquefied propane extraction studies (Section 3.3.1), and is typical of extraction processes for the reasons described in that section. It becomes progressively more difficult to remove contaminants from the soil as the number of stages increases. However, this phenomenon does not affect the viability of the B.E.S.T. process for use at the Norwood PCB Site, since the cleanup level of 10 mg/kg is attained before the extraction efficiency is effectively reduced to zero.

4.3.2 Extraction of Dioxins/Dibenzofurans

Table 4-3 presents the dioxin/dibenzofuran toxicity equivalences observed in feed soil samples and in treated soil samples after the final stage of extraction. The concentrations are expressed in terms of total 2,3,7,8-TCDD toxicity equivalences to simplify this discussion; the individual isomer concentrations for each sample are presented in the appendix of RCC's final report (Appendix B). The analyses were performed by a CLP laboratory and were validated by EPA Region I personnel.

The data in Table 4-3 show that dioxins/dibenzofurans were effectively extracted from the Norwood Site soils by triethylamine, with extraction efficiencies on the order of 99 percent.

4.3.3 Extraction of VOCs and SVOCs

The high and low PCB soil samples were analyzed for volatile and semivolatile organic compounds both before and after treatment. The concentrations of VOCs and SVOCs detected in treated and untreated samples are shown in Table 4-4.

TABLE 4-2. CONCENTRATIONS OF AROCLOR-1254 IN SOILS AS A FUNCTION OF EXTRACTION STAGE: TRIETHYLAMINE EXTRACTION TREATABILITY STUDY

Composite Sample containing "Low" PCB concentration

	Aroclor-1254 Concentration (mg/kg)			
Extraction Stage	RCC's data	CLP data (1)	Cumulative Percent Extracted (2)	Extraction Efficiency Per Stage
0 (Feed Analysis)	680	737/766	--	--
1	27	NA	96.03	96
2	7.0	NA	98.97	74
3	7.9	NA	98.84	NC
4	2.4	NA	99.65	66
5	0.4	NA	99.94	83
6	0.3	0.2	99.96	25

Composite Sample containing "High" PCB concentration

	Aroclor-1254 Concentration (mg/kg)			
Extraction Stage	RCC's data	CLP data (1)	Cumulative Percent Extracted (2)	Extraction Efficiency Per Stage
0 (Feed Analysis)	10,000	8740/8390	--	--
1	720	NA	92.80	93
2	180	NA	98.20	75
3	94	NA	99.06	48
4	61	NA	99.39	35
5	38	NA	99.62	38
6	29	NA	99.71	24
7	7.7	NA	99.92	73
8	9.9	4.6	99.90	NC

Cumulative Percent Extracted for Stage N = (Conc'n in Feed - Conc'n at Stage N)/Conc'n in Feed x 100

Extraction Efficiency for Stage N = (Conc'n at Stage N-1 - Conc'n at Stage N)/Conc'n at Stage N-1 x 100

(1) When two values are listed separated by a slash (/), the values are the results of duplicate analyses.

(2) Calculations are based on the concentrations reported by Resources Conservation Company.

NA Not Analyzed. Only untreated soil samples and final treated soil samples were submitted to CLP laboratories for confirmatory analysis.

NC Not calculated due to anomalous result (i.e., an apparent increase in concentration due to extraction).

TABLE 4-3. DIOXIN/DIBENZOFURAN TOXICITY EQUIVALENCES IN FEED AND TREATED SOILS: TRIETHYLAMINE EXTRACTION TREATABILITY STUDY

	Total 2,3,7,8-TCDD Toxicity Equivalence, μg/kg	
	Low PCB Sample	High PCB Sample
Feed Soil	0.34	6.0
Soil after Final Stage of Extraction	0.000075	0.063
Percent Extracted	99.98	98.95

No VOCs or SVOCs were detected in the untreated low PCB sample. Very low concentrations of two SVOCs, naphthalene and butylbenzylphthalate, were detected in the treated low PCB sample. These detections are not believed to be of concern since they are very low, and are not for compounds identified as contaminants of concern at the Site (i.e., PCBs or cPAHs).

In the untreated High PCB sample two SVOCs, bis(2-ethylhexyl)phthalate and 1,2,4-trichlorobenzene, were detected at levels in the ppm range. Both compounds were effectively extracted, with extraction efficiencies of 98.3 percent for 1,2,4-trichlorobenzene and >95.8 percent for bis(2-ethylhexyl)phthalate.

4.3.4 TCLP Metals Testing of Treated Soils

As part of its bench-scale B.E.S.T. process simulations, RCC routinely performs TCLP testing for metals on the treated soils following the final stage of extraction. TCLP analyses were not required by M&E's contracts with RCC or CF Systems because metals are not contaminants of concern at the Norwood PCB Site. However, RCC's results are presented in Table 4-5 since RCC performed the analyses and made the data available to M&E. The treated soils readily passed the TCLP test for metals.

TABLE 4-4. VOLATILE AND SEMIVOLATILE ORGANIC COMPOUNDS DETECTED IN UNTREATED AND TREATED SOIL SAMPLES: TRIETHYLAMINE EXTRACTION TREATABILITY STUDY

Compound	Low PCB Sample		High PCB Sample	
	Untreated (ug/kg)	Treated (ug/kg)	Untreated (ug/kg)	Treated (ug/kg)
Trichloroethene	10 U	10 U	2 J	10 U
1,2,4-Trichlorobenzene	21000 U	170 U	18000 J	300 J
Naphthalene	21000 U	9 J	21000 U	170 U
N-nitrosodiphenylamine	21000 U	170 U	21000 U	25 J
Butylbenzylphthalate	21000 U	11 J	21000 U	170 U
Bis(2-ethylhexyl)phthalate	21000 U	170 U	4000 J	170 U

NOTES: U - Value is the sample detection limit.
J - Value is approximate due to limitations identified in the quality control review.

TABLE 4-5. TCLP METALS ANALYSIS OF HIGH AND LOW PCB SOIL SAMPLES AFTER FINAL STAGE OF EXTRACTION: TRIETHYLAMINE EXTRACTION TREATABILITY STUDY

	TCLP Metals Leachate Analysis, mg/l (1)		
Analyte	High PCB Final Treated Soil	Low PCB Final Treated Soil	Regulatory Concentration, mg/l
Arsenic	< 1.0	< 1.0	5
Barium	0.57	0.3	100
Cadmium	< 0.05	< 0.05	1
Chromium	< 0.1	< 0.1	5
Lead	0.8	< 0.3	5
Mercury	0.006	0.016	0.2
Selenium	< 0.5	< 0.5	1
Silver	< 0.05	<0.05	5

NOTE: (1) TCLP extractions and leachate analyses performed by Resources Conservation Company.

4.3.5 Analysis and Disposal of Extracted Oils

As discussed in previous sections, Aroclor-1254 and dioxins/dibenzofurans were effectively extracted from both the low PCB and the high PCB soil samples, as demonstrated by analyses of the feed and treated soils. The oily extracts which were generated by the B.E.S.T. process extraction of both samples were also collected and submitted for analysis of PCBs and dioxins/dibenzofurans. These analyses are important because they are needed both to evaluate disposal options for the oil, and to calculate mass balances for the contaminants of concern. Mass balance calculations will be presented in Section 4.3.6.

Table 4-6 presents the results of the PCB and dioxin/dibenzofuran analyses of the oils extracted from the low and high PCB samples. As expected, the two oils did not differ greatly in composition. The Aroclor-1254 concentration in the high PCB oil was 299,000 mg/kg (29.9 percent) and its total toxicity equivalence was 181 μg/kg. For the low PCB oil the Aroclor-1254 concentration was 206,000 mg/kg (20.6 percent) and the total toxicity equivalence was 117 μg/kg.

Since the oils contained greater than 500 ppm PCBs, they are subject to TSCA regulations governing the disposal of liquid PCB wastes containing greater than 500 ppm PCBs. Such wastes must be incinerated in an incinerator which complies with the requirements in 40 CFR 761.70, or they must be destroyed by an alternate method that achieves an equivalent level of performance, as described in 40 CFR 761.60(e). The oils also contained low concentrations of dioxins/dibenzofurans which could limit the availability of TSCA incinerators which would accept them. The oils are not believed to be RCRA-listed hazardous wastes. However, several facilities contacted about disposal of the oil expressed concern about accepting it unless EPA were to state, in writing, that it is not a RCRA-listed waste due to dioxin/dibenzofuran constituents. Such wastes include RCRA waste codes F020, F021, F022, F023, F026, F027, and F028.

TABLE 4-6. ANALYSIS OF OILS EXTRACTED FROM HIGH AND LOW PCB SOIL SAMPLES FOR DIOXINS/DIBENZOFURANS AND AROCLOR-1254: TRIETHYLAMINE EXTRACTION TREATABILITY STUDY

Compound	Extract from High PCB Soil Sample (1)		Extract from Low PCB Soil Sample (1)	
TCDD/TCDF Concentration, ug/kg				
2,3,7,8-TCDD	0.20	U	0.87	U
1,2,3,7,8-PeCDD	7.86 *	UJ	0.74	U
1,2,3,4,7,8-HxCDD	2.49	U	10.1	U
1,2,3,6,7,8-HxCDD	2.21	U	8.92	U
1,2,3,7,8,9-HxCDD	2.19	U	8.89	U
1,2,3,4,6,7,8-HpCDD	1.95 *	UJ	2.37	J
OCDD	17.80	J	28.82	J
2,3,7,8-TCDF	309.52	J	56.69	J
1,2,3,7,8-PeCDF	139.11	J	6.70 *	UJ
2,3,4,7,8-PeCDF	0.43	U	72.94	J
1,2,3,4,7,8-HxCDF	979.92	J	541.03	J
1,2,3,6,7,8-HxCDF	285.62	J	158.8	J
2,3,4,6,7,8-HxCDF	45.16	J	17.4	J
1,2,3,7,8,9-HxCDF	31.46	J	1.6	U
1,2,3,4,6,7,8-HpCDF	218.30	J	135.5	J
1,2,3,4,7,8,9-HpCDF	221.76	J	130.2	J
OCDF	216.46	J	101.7	J
TOTAL TCDD **	2942.4 *	UJ	2655.40 *	UJ
TOTAL PeCDD **	21670 *	UJ	51627.9 *	UJ
TOTAL HxCDD **	13.6 *	UJ	16.9	U
TOTAL HpCDD **	3.57 *	UJ	2.4	
TOTAL TCDF **	511.9		56.7	
TOTAL PeCDF **	1576.8		967.6	
TOTAL HxCDF **	2501.3		1467	
TOTAL HpCDF **	738.9		408.9	
TOTAL 2,3,7,8-TCDD TOXICITY EQUIVALENCE (ug/kg)	181.1		117.0	J
PCB Concentration, mg/kg				
AROCLOR-1254	299000		206000	

NOTES:

* - Quantity is an EMPC (Estimated Maximum Possible Concentration) rather than a detection limit, because the ion abundance ratio was outside QC limits. The EMPC is a worst case estimate and is not included in TEF calculations.

** - Total includes isomers which are formed by addition of chlorine atoms to 2,3,7,8-TCDD (i.e., those for which individual concentrations have also been reported) as well as any other isomers detected. Therefore, these totals may not match the totals of the individual concentrations reported here.

J - Quantitation is approximate due to limitations identified in the quality control review.

U - Value is the sample detection limit (or EPMC if *).

UJ - Value is the sample detection limit (or EPMC if *); value is approximate due to limitations identified in the quality control review.

(1) - Values have been corrected for dilution of the oil by the solvent (triethylamine), and as such they reflect the composition of the oil which will be produced by a full-scale system (where triethylamine is recovered before oil is disposed of).

In addition to formally stating that the oil is not a RCRA-listed waste, it is also necessary to have the oil tested by the Toxicity Characteristic Leaching Procedure (TCLP) to determine whether it is a RCRA characteristic waste. Depending on the outcome of the TCLP test, the incinerator which accepts the oil may or may not require a RCRA permit in addition to a TSCA permit.

It is worthy of note that the Aroclor-1254 concentrations and toxicity equivalences of these oils were not greatly different from those measured in the oil obtained during the liquefied propane extraction test (Section 3.3.4). The high PCB oil from the liquefied propane extraction test contained 212,000 mg/kg (21.2 percent) Aroclor-1254 and had a total toxicity equivalence of 220 μg/kg. The discussion of disposal options for this oil presented in Section 3.3.5 therefore also applies to the disposal of oil which would be generated by the B.E.S.T. process.

4.3.6 Mass Balances

An overall mass balance and mass balances for Aroclor-1254 and dioxins/dibenzofurans have been performed using the weights obtained by RCC and the concentrations reported by the CLP laboratories. The mass balances are shown in Table 4-7 and the calculations are presented in Appendix D. The overall mass balances showed good closure and indicate that the weights measured by RCC are accurate. The recoveries for Aroclor-1254 and toxicity equivalence are considered to be adequate, given the sensitivity of the mass balance calculations both to the masses of oil generated, and to the concentrations reported for the oils.

4.3.7 Oil Volume Estimates

The volume of oil which would be generated during full-scale remediation of the Norwood PCB Site using the B.E.S.T. process can be estimated from the overall mass balance data in Table 4-7. The calculations are presented in Appendix D. For the high PCB sample,

TABLE 4-7. MASS BALANCES FOR TRIETHYLAMINE EXTRACTION TREATABILITY STUDY

Overall Mass Balance (1)

Sample	Untreated Soil (grams)	Treated Soil (grams)	Extracted Oil (grams)	Percent Recovery
Low PCB Composite	869	869	1.1	100.1
High PCB Composite	835	837	16.0	102.2

Aroclor-1254 Balance (2)

Sample	Untreated Soil (mg)	Treated Soil (mg)	Extracted Oil (mg)	Percent Recovery
Low PCB Composite	653	0.15	227	34.8
High PCB Composite	7152	3.85	4779	66.9

Dioxin/Dibenzofuran (Total 2,3,7,8-TCDD Toxicity Equivalence) Balance (2)

Sample	Untreated Soil (ug)	Treated Soil (ug)	Extracted Oil (ug)	Percent Recovery
Low PCB Composite	0.2965	0.00006	0.1287	43.4
High PCB Composite	5.014	0.05297	2.896	58.8

NOTES: Percent Recovery = (Treated Soil Mass + Extracted Oil Mass)/Untreated Soil Mass x 100

(1) Weights are those measured by Resources Conservation Company.

(2) Balances calculated from analyses done by CLP laboratories and weights measured by Resources Conservation Company.

16.0 grams of oil were extracted from 835 grams of soil. Extraction of 835 grams of low PCB soil yielded 1.1 grams of oil. Assuming a soil density of 1.3 tons per cubic yard and an oil density of 8 pounds per gallon, the mass balance data translates to an estimated oil yield of 6.23 gallons per cubic yard of high PCB soil. The oil yield from the low PCB soil was estimated to be 0.44 gallons per cubic yard of soil, assuming a soil density of 1.4 tons per cubic yard and an oil density of 8 pounds per gallon.

Due to the large difference in oil yield between the high PCB and low PCB soil samples, an estimate of oil volume for full-scale remediation is extremely sensitive to the assumptions one makes concerning the levels of contamination on site. The total volume of contaminated soil on Site is on the order of 39,785 cubic yards. If it is assumed that the low PCB sample is representative of the entire 39,785 cubic yards, then the estimated volume of oil to be generated during remediation is 0.44 x 39,785 = 17,500 gallons. If 90 percent of the soil to be remediated is represented by the low PCB sample, with the remaining 10 percent represented by the high PCB sample, then the estimated oil volume increases to 40,500 gallons. To obtain a more accurate estimate of oil volume, further sampling to determine the extent of the "hot spot" area (which the high PCB sample was intended to represent) would be necessary.

4.3.8 Full-Scale Operations

RCC proposes to use a B.E.S.T. Model 415 unit to treat the soils at the Norwood PCB Site. A flow schematic of this unit is presented in Figure 2 of RCC's final report (Appendix B). The unit consists of four extractor/dryer vessels and has an estimated processing capacity of 120 to 150 tons per day. Based on an assumed soil remediation volume of 30,000 cubic yards, RCC estimated that treatment of the soils could be completed in 10 to 12 months, including time for on-site mobilization and demobilization. This time estimate must be extended since the estimated soil treatment volume is now 39,785 cubic yards. The Model 415 unit is a mobile unit which can be available approximately 10 months after it is ordered.

Therefore, the total time needed for RCC to carry out the remediation, from the time of their selection through demobilization from the Site, is on the order of two years.

The foot print of the Model 415 unit is approximately 75 feet by 125 feet, exclusive of storage areas for feed and treated soils. The standard site plan for this unit is shown in Figure 4 of RCC's final report (Appendix B).

Based on the treatability test results, RCC estimated costs for the treatment of both the high PCB soil and the low PCB soil. The total unit cost for treating the high PCB soil was estimated to be $258 per ton, which includes $202 per ton for operating charges, $17 per ton for mobilization/demobilization, and $39 per ton for capital recovery. For the low PCB soil sample the total unit cost was estimated to be $208 per ton, which includes $162 per ton for operating charges, $16 per ton for mobilization/demobilization, and $30 per ton for capital recovery.

To formulate these estimates, RCC assumed a density of 1.3 tons per cubic yard for the high PCB soil and 1.4 tons per cubic yard for the low PCB soil. The costs do not include site preparation, soil excavation, pre-screening of the feed soil, backfilling of treated soil or oil disposal.

Section Five

SECTION 5.0
SUMMARY AND CONCLUSIONS

This section summarizes and compares the results of the bench-scale tests of liquefied propane extraction and triethylamine extraction for remediation of soils at the Norwood PCB Site. The treatability study subcontractors used 30,000 cubic yards of contaminated soil as a basis for their estimates, with no estimate as to the relative amounts of highly contaminated soil (over 1,000 mg/kg PCBs) and less contaminated soil (less than 1,000 mg/kg PCBs). This section presents revised estimates and compares the two systems using an assumed total volume of contaminated soil of 39,785 cubic yards, 10 percent of which is assumed to be highly contaminated. The total volume of 39,785 cubic yards is from the Site Investigation Report (Volume 1, Section 1). It is further assumed that the density of the highly contaminated soil is 1.3 tons per cubic yard and that of the less contaminated soil is 1.4 tons per cubic yards. Table 5-1 presents the basic parameters used for comparison of the two solvent extraction systems.

Table 5-2 present a comparison between the two systems with respect to the following criteria which are considered important to full-scale remediation.

- Existing Operational Systems
- Proposed System and Capacity
- Number of Extraction Stages Needed to Reach the 10 mg/kg PCB Cleanup Level
- Types of Residuals Generated
- Oil Yields
- Vent Gas and Treatment
- Post Treatment of Soil
- Area Requirements

TABLE 5-1
BASIC PARAMETERS FOR COMPARISON OF SYSTEMS

1. Volume of Soil to be Treated - 39,785 Cubic Yards
   Taken from Site Investigation report and includes all soil in excess of 10 ppm PCB in unpaved areas and in excess of 25 ppm PCB in paved areas.*

2. Contamination - high contamination assumed over 1000 ppm PCB.
   Low contamination assumed under 1000 ppm PCB.

3. Volume of highly contaminated soil assumed to be 10% of total = 4000 cy.

4. Weight of Soil
   High contamination = 1.3 ton/cy = 5,200 tons
   Low contamination = 1.4 ton/cy = 50,099 tons

   Total weight = 55,299 tons

* Note: Soils with 1 to 10 ppm PCB in residential or Meadow Brook area will be replaced, not treated.

TABLE 5-2. COMPARISON OF SYSTEMS

Item	Liquefied Propane CF Systems	Triethylamine (B.E.S.T Process) Resources Conservation Co.
1. Existing Operational Systems	25 ton/day presently operational 200 ton/day under construction	120-150 ton/day presently operational
2. Proposed System and Capacity	240 ton/day (assume 83% operational therefore - 200 ton/day nominal capacity)	Model 415 (4 trains each 30 - 40 tons/day) Total = 120-150 ton/day
3. Number of Extraction Stages needed to reach the 10 mg/kg PCB Cleanup Level	Low PCB Soil - 2 extractions High PCB Soil - 3-4 extractions	Low PCB Soil - 2 to 4 extractions High PCB Soil - Minimum of 8 extractions
4. Types of Residuals Generated	Treated wet soils, extracted oil	Treated wet soils, extracted oil
5. Oil Yield	Gallons per cy of soil Total Gal Low PCB soil - 0.262 gal 9,381 High PCB soil - 9.22 gal 36,682 46,063	Gallons per cy of soil Total Gal Low PCB soil - 0.44 gal 15,755 High PCB soil - 6.23 gal 24,786 40,541
6. Vent Gas and Treatment	None	One vent to provide pressure equalization. The air stream is condensed and treated with a water scrubber system to reduce TEA emissions.
7. Post Treatment of Soil	None	Recommended inoculation with soil bacteria
8. Area Requirements - assume 100'x200' for preparation & storage	200' x 200'	300' x 430' (includes a 50' buffer zone around unit)
9. Effectiveness on PAH-Contaminated Soils	Demonstrated effectiveness at full scale with sludges; demonstrated bench-scale effectiveness with soil and sediment	Demonstrated effectiveness for soils at bench and pilot scales

TABLE 5-2 (Continued). COMPARISON OF SYSTEMS

Item	Liquefied Propane CF Systems	Triethylamine (B.E.S.T Process) Resources Conservation Co.
10. Estimated Costs		
a. Pretreatment including excavation and backfill (no housing costs included)	Screening to separate 1" and larger stone. Crushing to under 1" all stones 1" to 2" for solvent extraction. Over 2" stone returned as backfill. $20/cy x 39,785 cy = $795,700	Screening to separate 1" and larger stone. Crushing to under 1" all stones 1" to 2" for solvent extraction. Over 2" stone returned as backfill. $20/cy x 39,785 cy = $795,700
b. Unit and total costs for solvent extraction	$200/ton x 55,299 tons = $11,059,800	Low PCB Soil = $206/ton $206 x 50,099 tons = $10,320,394 High PCB Soil = $258/ton $258 x 5,200 tons = $1,341,600 Total = $11,661,994
c. Utilities not included in solvent extraction costs	Cooling tower capital cost $20,000 Operational cost $20/day 5,200 $25,200	None
d. Oil disposal costs	46,063 gal @ 50 gal/drum = 921 drums $1,000 x 921 drums = $921,000	40,541 gal @ 50 gal/drum = 811 drums $1,000 x 811 drums = $811,000
TOTAL COST	$12,000,000	$12,500,000
11. Remediation Time Estimates		
a. Contract signing to completion of mobilization	10 Months	10 Months
b. Solvent extraction processing	276 Days = 9.1 Months	377 Days = 12.4 Months
c. Demobilization	1 Month	1 Month

- Effectiveness on PAH-Contaminated Soils
- Estimated Costs
- Remediation Time Estimates
  - Contract signing to completion of mobilization
  - Solvent extraction processing
  - Demobilization

5.1 EXISTING OPERATIONAL SYSTEMS

Both CF Systems and RCC have full-scale solvent extraction units in operation, but no full-scale cleanups of sites as large as the Norwood Site have been completed by either firm to date. In terms of the technology of solvent extraction, however, CF systems and RCC are the most experienced firms.

5.1.1 CF Systems' Experience

CF Systems currently has two full-scale units in operation. One unit was built at a Texas refinery for the treatment of heavy petroleum sludges containing PAH compounds. This unit operates at 25 tons per day and routinely achieves extraction efficiencies in excess of 99 percent for PAH compounds. A second unit is in operation at a waste treatment facility in Baltimore, Maryland, where it treats industrial wastewaters containing organic compounds.

Neither of CF Systems' full-scale units was designed specifically for soil remediation. It is expected that extraction of soils will pose materials handling problems which have not arisen in CF Systems' full-scale units, which handle sludges and wastewaters. However, CF Systems is scheduled to install a 200 ton-per-day batch soil treatment unit at the United Creosoting Superfund Site in Conroe, Texas, during the third quarter of 1993. The unit is being designed to attain extraction efficiencies for PAHs, dioxins/dibenzofurans, and pentachlorophenol of up to 99 percent. Experience gained during the design and operation of this unit should be applicable to the Norwood Site.

5.1.2 RCC's Experience

RCC has completed pilot-scale testing at a site in New York State for the remediation of PCB-contaminated soils, sludges and sediments. The total quantity of material to be treated is approximately 130,000 tons, making this remediation three times larger than the Norwood site remediation.

RCC is also experienced in Superfund work. RCC used a full-scale unit with a nominal capacity of 70 tons per day to treat 3,700 cubic yards of oily sludges and soils at the General Refining Superfund Site near Savannah, Georgia. The process separated the oily soils and sludges into product water, oil, and treated solids fractions. The oil was suitable for recycle as fuel oil. PCBs in the feed were concentrated into the oil, resulting in residual PCB concentrations in the treated solids of less than 0.1 mg/kg. No PCBs were detected in the product water. The water was transported to a nearby industrial wastewater treatment plant and discharged.

5.1.3 Comparison of Experience

Neither CF Systems nor RCC is currently operating a full-scale soil remediation system with a throughput as high as that planned for the Norwood Site (i.e., 150 to 200 tons per day). However, both firms are currently designing and/or piloting such systems at other sites. Both firms should have systems in operation before remedial actions are ready to begin at Norwood.

5.2 PROPOSED SYSTEM AND CAPACITY

CF Systems and RCC have proposed systems with nominal throughputs of 200 tons per day and 120 to 150 tons per day, respectively. It is not certain whether throughputs this large can be consistently maintained when treating soils due to the potential for materials handling problems. However, both firms expect to be operating systems of this size for soils treatment prior to the commencement of remedial work at Norwood. Experience with these systems should help to minimize problems in attaining the proposed throughputs at Norwood.

5.3 NUMBER OF EXTRACTION STAGES

The bench-scale test results indicated that liquefied propane extraction would attain the 10 mg/kg PCB cleanup level in as few as two extraction stages, for soils containing Aroclor-1254 concentrations similar to that found in the low PCB sample (i.e., approximately 1000 mg/kg). For soils containing concentrations as high as the high PCB sample (i.e., approximately 10,000 mg/kg), it appears that a minimum of three to four stages would be necessary.

The bench-scale test results for triethylamine extraction (the B.E.S.T. process) indicated that at least two and perhaps as many as four stages would be needed to attain the 10 mg/kg cleanup level for soils represented by the low PCB sample, while a minimum of eight stages would be needed for soils as contaminated as the high PCB sample.

These results indicate that the liquefied propane extraction process is somewhat more efficient in extracting PCBs from the Norwood soils, since fewer extraction stages were required to attain the 10 mg/kg cleanup level. However, the need for more extraction stages when using the B.E.S.T. process does not necessarily mean that the process would be less cost-efficient for remediation of the Norwood PCB Site. Costs are considered in Section 5.10.

5.4 RESIDUALS GENERATED

The liquefied propane extraction process and the B.E.S.T. process both generated a concentrated oily residual which contained the bulk of the Aroclor-1254 and dioxin/dibenzofuran contamination originally present in the soil fed to the processes. When treating the soil samples from the Norwood PCB Site, both processes also generated a treated soil residual which contained moisture at approximately the same percentage as the feed soil. The liquefied propane extraction process always generates a wet treated soil residual, since the propane solvent is not soluble in water and does not extract water from the feed soil. Any water originally present in the feed soil remains with the soil phase throughout treatment. In contrast, the B.E.S.T. process may generate a dry treated soil residual and a product water stream instead of a combined treated soil/water residual. The form which the residuals take (either wet soil, or dry soil + water) depends on the initial water content of the feed soil. The triethylamine (TEA) solvent used in the B.E.S.T. process does extract water from the feed soil, since water is soluble in TEA at the temperatures used for the first extraction stage. The first extraction stage yields a TEA/oil phase, a TEA/water phase, and a treated soil phase. A product water residual is generated when the TEA/water phase is distilled to recover the TEA. If a significant volume of product water is produced, it is discharged separately from the treated soils, generally to a POTW or an on-site water treatment plant. However, if volume of product water generated is low, it is mixed back with the treated soils for dust control purposes. In the latter case, there is no separate product water residual requiring treatment. Because the Norwood soil samples used for treatability testing were low in moisture content (containing only 4 to 6 percent water), no product water was collected from the B.E.S.T. process bench-scale tests. Assuming that this low moisture content prevails throughout the Site, the B.E.S.T. process would not generate a separate product water stream during full-scale remediation. Under such circumstances, the residuals generated by the liquefied propane extraction process and the B.E.S.T. process would be virtually identical.

5.5 OIL YIELDS

The oil yields obtained during the bench-scale tests of both processes are listed in Table 5-2. These yields are not considered to be significantly different. Therefore, the quantity of oil requiring disposal during full-scale remediation would not be expected to differ significantly between the two processes.

The analytical results for the oils generated by both processes were very similar. As would be expected, the oils contained high levels of Aroclor-1254, on the order of 20 weight percent. Liquid wastes containing PCBs at concentrations this high must be disposed of in a TSCA-permitted incinerator which complies with 40 CFR 761.70, or by an alternate method which achieves the same level of performance. If the oils are determined to be RCRA characteristic wastes the incinerator will also require a RCRA permit.

Since the analytical results for the oils generated from the liquefied propane extraction tests and the B.E.S.T. process tests were similar in terms of Aroclor-1254 and dibenzofuran concentrations, the regulations governing off-site oil disposal would likely be the same for either process. Neither process offers an advantage over the other in terms of oil disposal costs, or the implementability of off-site oil disposal. For either process, the availability of an off-site incinerator which is TSCA- and RCRA-permitted to accept the oil may be a potential problem. M&E's discussions with TSD facilities indicate that there are facilities which may accept the oil, provided EPA states in writing that the oil is not a RCRA F-listed waste. Aptus, which owns a TSCA- and RCRA-permitted incinerator, expects to obtain a permit for ash disposal within the next six to twelve months, after which they can begin to accept both TSCA and RCRA F-listed wastes for incineration. It is not possible to provide a more definitive statement concerning the availability of off-site disposal facilities at this time.

5.6 VENT GAS AND TREATMENT

CF Systems' liquefied propane extraction process does not vent any propane solvent. Low pressure propane vapor from oil storage tanks is recovered with a low pressure compressor. The compressed recovered propane is recycled for use in extraction.

RCC's B.E.S.T. process uses one vent to the atmosphere to provide pressure equalization and to purge noncondensable gases from process condensers. A refrigerated condenser and water scrubber are used to reduce TEA emissions from the vent.

5.7 POST TREATMENT OF SOIL

Both vendors were asked to provide information concerning post-treatment requirements for soil before it is backfilled, and specifically whether addition of supplemental organic material and/or microorganisms would be necessary. RCC stated that inoculation of treated soils with bacteria may be advisable because treated soils from the B.E.S.T. process are essentially sterile. Sterility occurs because treated soils are heated to drive off residual TEA. Inoculation of treated soils is not difficult; it can be accomplished by simply mixing in some untreated clean soil.

CF Systems stated that the treated soils would contain most of the naturally-occurring organic material that was originally present, and would therefore not require addition of supplemental organic material. CF Systems also did not anticipate a need to add microorganisms, because they assumed that soil bacteria from the surrounding untreated soils would readily influx to the backfill area. If this assumption is valid then it would apply equally well to the B.E.S.T. process. Therefore, M&E does not believe that the post-treatment requirements for treated soils prior to backfilling would actually be different for the liquefied propane process vs. the B.E.S.T. process. In any case, post-treatment requirements (if any) would have a minimal impact on the overall cost of the remediation.

5.8 AREA REQUIREMENTS

Area requirements for the two systems are given in Table 5-2. Both vendors have stated that the area requirements are somewhat flexible, in that their systems could be designed to fit into a longer and narrower area should site space restrictions require it.

5.9 EFFECTIVENESS ON PAH-CONTAMINATED SOILS

CF Systems has effectively treated refinery sludges contaminated with PAHs at full scale in a 25 ton-per-day unit. This unit routinely attains extraction efficiencies for PAHs of 99 percent. Treated sludges meet RCRA Best Demonstrated Available Technology (BDAT) standards for PAHs.

The liquefied propane extraction process was also demonstrated to be effective at the bench scale for extraction of PAHs from soils from the Pine Street Canal Superfund Site (M&E, 1992). Data from these tests are presented in Appendix E, Table E-1.

RCC has performed pilot testing of the B.E.S.T. process on PAH-contaminated soils as part of EPA's Soils and Debris BDAT Development program. The soils were from the Bayou Bonfouca and Jennison Wright Superfund sites. On these soils the B.E.S.T. process achieved extraction efficiencies for PAHs of greater than 99 percent. RCC has also performed bench-scale testing of their process on PAH-contaminated soils and sediments from the Pine Street Canal Superfund Site (M&E, 1992). Data from these tests are presented in Appendix E, Table E-2.

Based on the available information, it is concluded that both the liquefied propane extraction process and the B.E.S.T. process would be able to effectively extract PAHs from Norwood Site soils. Data for PAH extraction efficiencies are not available for the Norwood soils, however, since the untreated soil samples sent to CF systems and RCC did not contain detectable concentrations of PAHs.

5.10 ESTIMATED COSTS

The cost estimates provided by CF Systems and RCC, and revised by M&E to reflect the assumptions in Table 5-1, are listed in Table 5-2. The costs are not greatly different, as was expected considering that the liquefied propane extraction process and the B.E.S.T. process are competing aggressively for the same markets.

5.11 REMEDIATION TIME

The remediation time estimates listed in Table 5-2 are also very similar. Both CF Systems and RCC would require an approximately 10-month lead time to construct a treatment unit for the Norwood PCB Site, and an additional 10 to 13 months to mobilize, treat Site soils, and demobilize.

Section Six

SECTION 6.0
REFERENCES

Ebasco Services, 1990. *Norwood Dioxin and PCB Sampling.*

Ebasco Services, 1989. *Final Remedial Investigation Report,* Norwood PCB Site, Town of Norwood, Norfolk County, Massachusetts. Prepared for U.S. EPA.

EPA, 1988. *Statement of Work for Inorganics Analysis, Multi-Media/Multi-Concentration,* July 1988.

EPA, 1990a. *Statement of Work for Organics Analysis, Multi-Media/Multi-Concentration,* March 1990.

EPA, 1990b. *Statement of Work for Organics Analysis, Multi-Media/High Concentration,* March 1990.

EPA, 1990c. *Statement of Work for Analysis of Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans, Multi-Media/Multi-Concentration,* October 1990, Document DFLM01.0.

EPA, 1990d. *Guidance on Remedial Actions for Superfund Sites with PCB Contamination.* EPA/540/G-90/007.

M&E, 1992. *Treatability Study Final Report, Pine Street Canal Site, Burlington, VT.* Prepared for EPA, Contract No. 68-W9-0036, Work Assignment No. 13-1L19.

M&E, 1992. *Site Investigation Report, Volume 1, Section 1, Norwood PCB Site, Norwood, Massachusetts.* Prepared for EPA, Contract No. 68-W9-0036, Work Assignment No. 19-1N51.

Section Seven

SECTION 7.0

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Appendix A

APPENDIX A

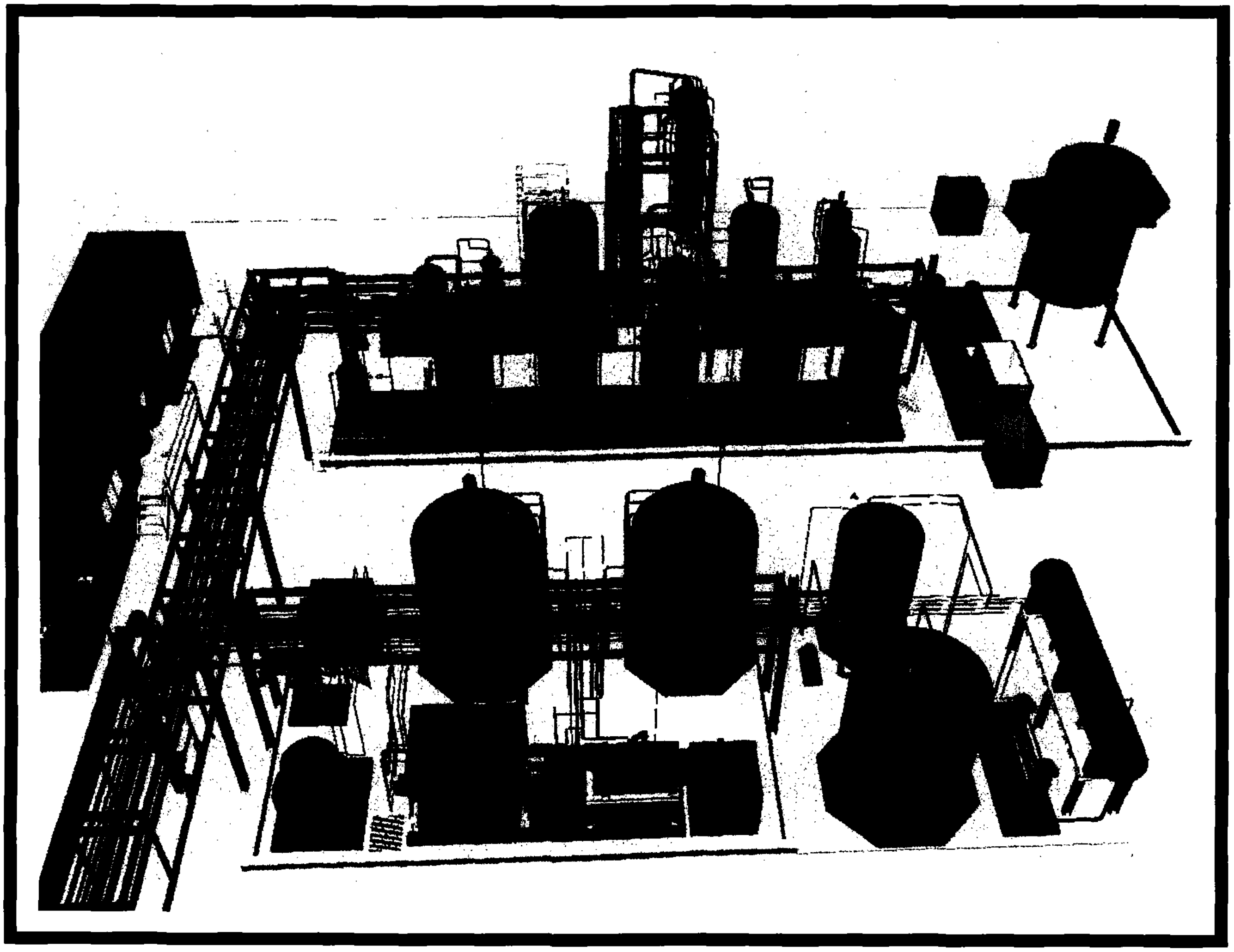
TREATABILITY STUDY FINAL REPORT

PREPARED BY

CF SYSTEMS CORPORATION

Final Report to Metcalf & Eddy

Bench Scale Treatability Study for the Norwood Superfund Site



June 23, 1992

CF SYSTEMS

A MORRISON KNUDSEN COMPANY

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APPENDICES

1.0 INTRODUCTION

During the months of January and February, 1992, CF Systems conducted a bench scale treatability study to determine the feasibility of using condensed gas solvent extraction to treat contaminated soil samples from the Norwood PCB Superfund site, located in Norwood, Massachusetts. PCB contamination originated from disposal practices at the site, and it is estimated that approximately 30,000 cubic yards of contaminated soil contains greater than 10 ppm PCBs and will require on-site remediation.

During three weeks of testing, two soil samples collected from the Norwood PCB site were extracted in a bench scale apparatus using liquid propane as the extractive solvent. One of the samples was used to represent the bulk of site contamination (i.e. composite sample), while the second sample was collected so as to represent an area of high PCB contamination (i.e. hot spot sample), and a worst case scenario for full scale remediation. Each of the two samples were subjected to six stages of extraction in order to simulate a level of organics removal that could be economically achieved during commercial remediation.

Following bench scale extraction, results from comprehensive analyses of treated soil samples were compared to analyses of the raw waste in order to determine the percent reduction for each of the organic contaminants of interest, including PCBs, dioxins, volatiles, and semi-volatiles. Treated soil samples were also compared to the target treatment level of 10 ppm for PCBs, and 6 ppm for cPAHs, which was used as a guideline for this study. Treated soil samples were analyzed for metals to determine what effect, if any, solvent extraction has on the concentration of metals in the waste. Extracted oil samples were analyzed for PCBs and dioxins in order to perform a PCB-component mass balance calculation for each extraction, and to determine the equivalent toxicity of the extract material. In addition, samples of treated soil were analyzed for PCBs after each stage of extraction in order to correlate the percent removal of PCBs to the number of extraction stages.

Based on the results of this bench scale treatabilty study, this report contains cost and engineering data associated with the use of CF Systems' solvent extraction process for full scale remediation at the Norwood PCB Superfund site, including an analysis of the treatment residues generated by the process.

2.0 BACKGROUND

Metcalf & Eddy is providing technical services to the U. S. Environmental Protection Agency, (EPA), in support of remedial response activities at uncontrolled hazardous disposal sites in EPA Region I. Treatability studies are being subcontracted by Metcalf & Eddy to firms capable of providing solvent extraction feasibility studies on soil samples collected at the Norwood PCB Superfund site.

CF Systems is a technology-based company in the hazardous waste treatment and resource recovery business, offering services and equipment based on a proprietary solvent extraction technology. Waste treatment units built by CF Systems extract organics from soils, sludges, and wastewaters, resulting in the minimization of waste volumes and a reduction of treatment and disposal costs.

Founded in 1980 as a subsidiary of Arthur D. Little, Inc., CF Systems was acquired in August, 1990, by Morrison Knudsen Corporation (MK), a $2 billion a year diversified services company with primary focus in the fields of engineering, construction, and environmental services. MK ownership of CF Systems guarantees that a full range of engineering and technical support services will be available, and that each remediation project will meet its expected goals.

2.1 Commercial Scale Activity

On March 15, 1992, CF Systems successfully completed a two year commercial-scale remediation project at the Texaco refinery in Port Arthur, Texas. The 25 ton per day solvent extraction unit used for this project was operated continuously, 24 hours a day, 7 days per week, and had an on-line availability exceeding 90% for the second full year of operation. CF Systems' treatment unit processed waste sludges and solids generated from on-going refinery operations, and consistently exceeded the EPA's treatment standards for refinery wastes by greater than an order of magnitude. Extraction efficiencies of greater than 99% were achieved for both PAHs and BTX compounds, and the ability of the process to adapt to feed fluctuations for both solids and organic content was a major factor in the successful completion of this project. Appendix A contains full scale treatment data for the extraction of phenanthrene, and correlates the percent reduction of this PAH-compound in the treated solids to the number of extraction stages.

CF Systems has made delivery on a second full-scale solvent extraction unit to a centralized waste treatment facility located in Baltimore, Maryland. This solvent extraction unit, which began operating in September, 1991, was designed specifically for the treatment of organic bearing wastewaters, and is currently treating a variety of industrial waste streams to meet regulatory requirements for wastewater discharge. CF Systems' commercial-scale wastewater treatment units are designed for maximum flexibility, and may be used to treat a wide range of waste streams with organic loadings as high as 30 wt%.

In a Record of Decision dated September, 1989, CF Systems' critical fluid solvent extraction technology was selected by EPA Region VI and the Texas Water Commission for full-scale remediation of the United Creosoting Superfund site in Conroe, Texas. The remediation of 80,000 cubic yards of contaminated soil and sediment at this former wood treating site is scheduled to begin during the third quarter of 1993, at which time CF Systems will install and begin operating a soil treatment unit with a nominal throughput of 200 tons per day. The design requirements for this soil treatment unit specify removal efficiencies up to 99% for PAHs, Dioxins, Furans, and Pentachlorophenols (PCPs).

3.0 PROCESS DESCRIPTION

The CF Systems' solvent extraction process for the remediation of organic-contaminated soils, (Fig. 1, Appendix B), comprises the following systems:

- A Feed Delivery System
- An Extraction/Gravity Settling System
- A Treated Solids Filtration System
- A Solvent Recovery System
- A Vent Gas Recovery System

3.1 Feed Delivery

Soil delivered to the process battery limits is screened to less than 1 inch to remove oversized material. Oversize materials are segregated and in many cases reprocessed to an acceptable size through the use of mechanical size reduction equipment. The screened soil is sent to the extractor(s) via an enclosed conveyor screw auger system. In most cases, this solvent extraction process does not require other forms of soil pretreatment, such as dewatering or the addition of reagents.

3.2 Extraction System

The extraction system is comprised of one or more agitated extraction vessels where contaminated soil is contacted with a liquefied gas solvent, such as liquid propane. The number of extraction vessels and the size of the vessels determine the rate of throughput and the degree of organics removal.

Contaminated soil is fed to the extractors where it is contacted with liquid solvent pumped from the solvent recovery system. After each stage of extraction, the agitators are stopped, and gravity separation of the soil and solvent is allowed to occur. Gravity separation of soil and solvent occurs rapidly in the extraction vessel due to the enhanced physical properties of the solvents. Following gravity separation, the solvent/organics phase is drained to the solvent recovery system, where the propane is recovered in a vapor recompression cycle.

The extraction-settling-draining process is repeated in the extraction vessel until the extraction is complete. The final step involves injecting warm water into the extraction vessel in order to displace residual liquid propane, which is insoluble in water, and floats out from the top of the extractor. This final water displacement step in the extractor vessel forms a treated soil/water slurry that is gravity fed to a filter press operation.

3.3 Filtration System

This system includes the soil/water slurry day tank, filter press, and all required drums and pumps for routine filter press operation. Treated filter cake from the filter press has high compressive strength, and is suitable for land disposal. Treated filter cake also has the appropriate moisture content (i.e., 40-60%), for the addition of solidification/stabilization reagents for the fixation of metals, if required.

3.4 Solvent Recovery System

This system contains surge vessels, a main solvent recovery still and compressor, a solvent condenser, and a recycle pump. The solvent/organics mixture (extract) flows from the extractor to the main solvent recovery still, where the liquid propane is vaporized using the heat of condensation from the main compressor. Energy requirements for solvent recovery in a vapor recompression cycle are typically 40% to 60% of the energy requirements for solvent recovery in a distillation operation.

Solvent vapor from the still is condensed against cooling water and flows to the solvent storage drum. The solvent recycle pump takes a gravity suction from this drum and pumps liquid solvent, on demand, to the extraction system.

In the main still reboiler section (i.e., bottom), oil-rich extract flows to a low pressure organics recovery tank where residual solvent is removed from the extracted oil and sent to the vent gas recovery system. Recovered oil is sent to product oil storage.

3.5 Vent Gas Recovery System

A low pressure compressor recovers low pressure solvent vapor from the organics recovery tank and the oil product storage. The compressed recovered solvent is returned to the main still for recycling.

4.0 EXECUTIVE SUMMARY

Results from this bench scale treatability study showed that full-scale remediation at the Norwood PCB site using CF Systems' solvent extraction process is feasible, and that the level of PCBs in the soil can be reduced to below the target treatment level using two to three stages of extraction for the bulk of material at the site. PCB concentrations were reduced to below the 10 ppm target treatment level in the second and fourth stages respectively for the composite and hot spot sample, and analyses of the hot spot extract sample indicated a 23-fold increase in the concentration of PCBs compared to the feed sample. The percent reductions of PCBs per extraction stage were similar for the two samples, and indicated that the process is not significantly affected by feed concentration.

The composite and hot spot samples did not contain detectable levels of cPAHs in either the treated soil or the extract samples, and indicate that carcinogenic PAHs are not present at the site in significant concentrations, and therefore, will not pose a problem for full scale remediation. Analysis of the hot spot treated soil sample indicated a total semivolatile concentration of 1.76 ppm, whereas the analysis of the composite treated soil sample indicated a total semivolatile concentration of 2.83 ppm. With the exception of Trichlorobenzene, which was reduced by 99.51%, analyses of semivolatiles in the feed samples were rejected due to long holding times at the analytical lab, and percent reductions could, therefore, not be calculated.

Dioxin toxicity equivalents were reported for the feed samples and the treated soil samples, and showed a percent reduction of 98.3% and 97.6% respectively for the hot spot and composite samples. These reductions are slightly less than the reductions observed for PCBs, and are probably due to the very low dioxin concentrations, (ie. <8 ppb), in the two feed samples. Analyses of extract samples showed that the extract material generated from full scale operations may contain as much as 200 to 400 ppb dioxin toxicity equivalents, and may require ultimate destruction by means other than incineration. Depending upon the regulatory limitations for dioxin content in the PCB-oil sent off-site for incineration, on-site batch dechlorination of dioxins may be required. Previous correspondence with the EPA has indicated that the capital costs for a 500 gallon batch-dechlorination system to treat liquid chlorinated waste is estimated to be $250,000, and does not include the associated labor, utilities and reagents required for operation.

Analyses of the two treated soil samples for volatiles was inconsistent with the analyses of the two feed samples, and indicated that the concentration of volatiles increased as a result of solvent extraction. This phenomenon has not been observed in numerous treatability studies previously conducted at CF Systems, and does not agree with the results from the treatment of volatiles during two years of full scale operations. During full scale treatment, total volatiles were typically reduced to well below 1 ppm, resulting in extraction efficiencies of greater than 99%.

The only plausible explanation for these results is that the propane solvent used for bench scale experimentation was contaminated with gasoline and/or other refinery products, and a study is currently planned to determine the purity of the propane supplied to CF Systems. CF Systems has been using its current propane supplier, (ie. Colony-Airco), for the past nine months, and in recent conversations they have indicated that they are not the source of contamination. It should be noted that the propane used for bench scale testing is drawn as a liquid from the supply tank, and that contamination from dissolved organics is theoretically possible. It should also be noted, however, that purchasing clean propane for full scale treatment will not be a problem, and that non-contaminated propane is the rule, rather than the exception.

As expected, the concentration of metals in the soil did not change significantly as a result of solvent extraction, and metals such as iron and magnesium, which were at high levels in the feed, were also present at high concentrations in the treated soils. Although outside the scope of this solvent extraction treatability study, the fixation/stabilization of metals in the treated soil is a service offered by CF Systems through its parent company, Morrison Knudsen Corporation. The incremental cost of metals treatment is not included in the cost estimate presented in this report.

Mass balance closures were reported at 92.3% for the composite sample and 98.3% for the hot spot sample. Although these values are within acceptable limits for bench scale testing, the relatively low composite sample value, (ie. 92.3%), is probably due to the fact that soil samples were removed from the extractor after each stage, thereby increasing the chances for inaccurate weighing and/or spillage by a factor of six. The amount of extractable organics in the composite sample could not be quantified due to the small amount of oil extracted from the sample, which had to be rinsed from the collection vessel with 25 ml. hexane.

PCB mass balance calculations for the two samples yielded values of 66.0% and 44.9% respectively for the hot spot sample and composite sample respectively, and indicated some difficulty in collecting all of the extracted oil from the extract collection vessel. In particular, the oil extracted from the composite sample was so small in quantity that it had to be rinsed from the collection vessel with 25 ml. hexane, which in retrospect was not sufficient to rinse the entire interior surface of the vessel. The PCB mass balance for the hot spot sample was more accurate due to the larger quantity of extractable organics collected.

A particle size classification was performed on both the Composite and Hot Spot samples, and results are shown in Appendix D. Results are shown in both tabular and bar graph formats, and show that a majority of the site material has a particle size in the range of 0.02 to 0.1 inch.

4.1 Full Scale Operations

The design throughput of the full scale treatment unit used by CF Systems at the Norwood Superfund site will be 240 tons/day, with a nominal throughput of 200 tons/day based on an 83% operating factor. For comparison, the on-line factor of CF Systems' Port Arthur, Texas, commercial unit was greater than 90% during the second full year of operation. Assuming 40,000 tons of material to be treated at the Norwood site, this equates to 200 days of operation, or about ten months including mobilization/demobilization.

The footprint of CF Systems' processing area will be approximately 200' by 100', including the feed and product storage bins and/or tanks. Utility requirements include 480 V, 3 phase electricity, with a 300 to 400 amp draw, and cooling water at 100 GPM. As an option, cooling water can be recirculated either through a cooling tower or refrigeration system so as to reduce net water consumption to approximately 10 GPM. All propane solvent make-up, reagents, compressed air and nitrogen will be supplied by CF Systems.

The two streams that will be generated from CF Systems' treatment process during full scale operations are: (1) a treated filter cake containing 60% solids and 40% moisture, and: (2) a concentrated liquid extract stream containing approximately 10% water and 90% organics. The treated cake will contain less than 10 ppm

PCBs, (ie. dry basis), and less than 6 ppm cPAHs. The extract stream will contain approximately 10% moisture, PCBs at a concentration as high as 50 wt% and dioxins up to 400 ppb toxicity equivalents. The balance of the extract stream will be made up of non-PCB and non-dioxin organics.

The treated filter cake generated from the process will be suitable for backfilling, and will contain most, if not all, of the naturally occuring organic material that was initially present prior to treatment. Naturally occurring organic material, (eg. humic acids), that are normally found in healthy soil are typically large molecular weight, complex organics, that are not readily soluble in liquid propane, and are therefore not extracted during full scale treatment. With a sufficient quantity of organic material and nutrients still present in the treated soil, it is anticipated that the soil bacteria from the surrounding area will influx to the backfill area, and that soil bacteria seeding will not be neccessary.

The total weight of the extract stream generated during full scale operations can be estimated from the results of Oil & Grease determinations, (ie. soxhlet extraction), and from the quantity of extracted oil collected during bench scale extraction. Oil & Grease analyses of the hot spot and composite feed samples showed that the quantity of hexane extractable organics to be 1.67 wt% and 0.05 wt% respectively. It should be noted, however, that hexane soxhlet extractions often result in lower Oil and Grease values, (ie. wt% extractable organics), than are typically observed during bench scale extraction using propane at elevated temperatures, (ie. 140°F). For example, the quantity of oil extracted from the hot spot sample during bench scale extraction with propane was 2.8 wt%, whereas the quantity of oil & grease removed from the hot spot sample during the soxhlet extraction with hexane was 1.67 wt%. A comparison of these two values, (1.67 vs 2.8), indicates that the actual quantity of oil extracted at full scale may be 50% higher than predicted by soxhlet extraction.

From oil & grease analyses and extract collection data, it can be reasonably assumed that the quantity of oil extracted from any single feed batch of soil during full scale operations will range between 0.05 wt% and 2.8 wt% of the feed weight. If it is further assumed that the composite sample, (ie. 0.05 wt% organics), represents 90% of the soil at the site, and that the hot spot sample, (ie. 1.67 wt% organics), represents only 10% of the soil on the site, then the average concentration of extractable organics for the entire site is estimated by soxhlet extraction to be 0.21

wt%. If this value is increased by 50% to account for the difference between soxhlet extraction with hexane and full scale extraction with propane, then the overall average quantity of oil extracted during full scale operations is estimated to be 0.31 wt%. The total quantity of PCB-oil extracted from 40,000 tons of soil at the Norwood site will be approximately 124 tons, or about 33,067 gallons. There will be no separate wastewater streams generated from the process other than washwater used during decontamination procedures.

The treatment of saturated sediments with CF Systems' solvent extraction process is feasible, and feeds containing as much as 80% moisture have been successfully treated at commercial scale. However, the presence of excess moisture may reduce extraction efficiency for some materials by simply introducing a physical barrier between the solvent and the organic constituents, which are typically associated with the soil/sediment particles. Bench scale testing is usually required to quantify the reduction in extraction efficiency for a specific waste matrix.

If the total quantity of saturated sediments is relatively high, (eg. >5,000 tons), and if the moisture content of the sediments is greater than 70%, it is generally more cost effective to incorporate a dewatering unit operation on-site in order to reduce the tonnage of material requiring solvent extraction. A gross estimate of full scale dewatering costs using a standard belt filter press operation is in the range of $20 to $40/ton of wet feed, and this type of filtering operation is capable of reducing the moisture content of the saturated sediments down to 40 or 50 wt%. It is worth noting that CF Systems typically incorporates a belt filter press operation as part of its overall treatment process, (sec. 3.3), and this filter press could potentially be utilized for pretreatment of sediments prior to solvent extraction.

Based on data generated during the course of this bench scale study, the estimated cost for remediating 40,000 tons of PCB-contaminated soil at the Norwood site to achieve the 10 ppm treatment level is $200/ton. This estimate includes mobilization/ demobilization of equipment, labor, utilities, capital depreciation and profit. Operating expenses alone account for 40% of the total charge, or about $80/ton. This estimate does not include the costs associated with excavating the material and delivery to CF Systems' battery limits, or the the costs associated with the disposition of the extract and backfilling of the treated soil.

CF Systems' full scale treatment process is a closed loop system and does not contain process vents that would lead to potentially toxic air emmisions. Previous studies from full scale operations have calculated that fugitive emissions from leaking flanges and valves may account for up to six tons of propane vapor per year of operation. It should be noted, however, that propane has been classified as a "Generally Regarded as Safe", (ie. GRAS), compound by the EPA, and a CF Systems' treatment unit would typically not require special air permits.

CF Systems' will require ten months after contract closing to construct and mobilize a full scale unit to the Norwood Superfund site. An additional six weeks will be required to install and start-up the treatment unit prior to actually beginning commercial scale operations.

5.0 Test Conditions

Appendix E contains a schematic of the bench scale apparatus that was used during the course of this treatability study, and the test conditions for the two samples are listed below:

Parameter	Composite Sample	Hot Spot Sample
Feed Weight	900.4 gm.	919.9 gm.
Temperature, (ave)	133 (F)	139 (F)
Mixing	30 min.	30 min.
Settling	30 min.	30 min.

The bench scale extraction procedure consists of mixing the contaminated soil with liquid propane in a sealed vessel for 30 minutes, and then allowing the inorganic phase, (ie. solids/moisture) to settle for an additional 30 minutes. The top phase liquid, (ie. solvent/organics) is drained from the extractor to a collection vessel, where the propane is vaporized and the organics are collected for analysis. These steps are repeated until the desired number of extraction stages, (ie. 6 stages), are achieved.

For this treatability study, the extractor vessel was opened after each stage, and an aliquot of soil was removed for analysis. These interstage samples were used to correlate removal efficiency to the number of extraction stages.

5.0 ANALYTICAL RESULTS

Results from the bench scale extraction of the composite sample and the hot spot sample are presented in Table 1, and show the concentration of aroclor 1254 after each stage of extraction. In addition, Table 1 correlates the cumulative percent reduction of PCBs to the number of extraction stages, and indicates overall percent reductions of 99.96% and 99.99% for the two samples. It should be noted that these analyses were performed at General Physics Environmental Services Laboratory, (ie. GP Labs), and differ somewhat from the analyses performed at the CLP laboratory contracted by Metcalf & Eddy, which are presented in Table 2.

The percent reductions in Table 1 were calculated using the following equation:

$$\textbf{\% Reduction} = ((\textbf{Feed} - \textbf{Residue})/\textbf{Feed})$$

Despite the difference in feed PCB concentrations for the two samples, data presented in Table 1 indicates that the cumulative percent reductions per extraction stage are similar. For example, the composite and hot spot samples both showed a cumulative percent reduction of 99.8% after two stages of extraction. Due to the higher concentration of the hot spot sample, however, two additional extraction stages, (ie. four), were required to meet the target treatment level of 10 ppm PCBs.

Figures 1 & 2 graphically illustrate the extraction of the composite and hot spot samples, and indicates that the efficiency of extraction begins to decrease significantly after the first stage of extraction. High extraction efficiency during the first stage indicates that a large percentage of the PCBs exist as "free oil", and are not strongly absorbed to the solid matrix. High removal efficiency during the first extraction stage of the hot spot sample also indicates a high solubility for PCBs in the solvent (ie. liquid propane), phase.

Figure 1. Solvent Extraction Curve

M&E Norwood - Composite Sample

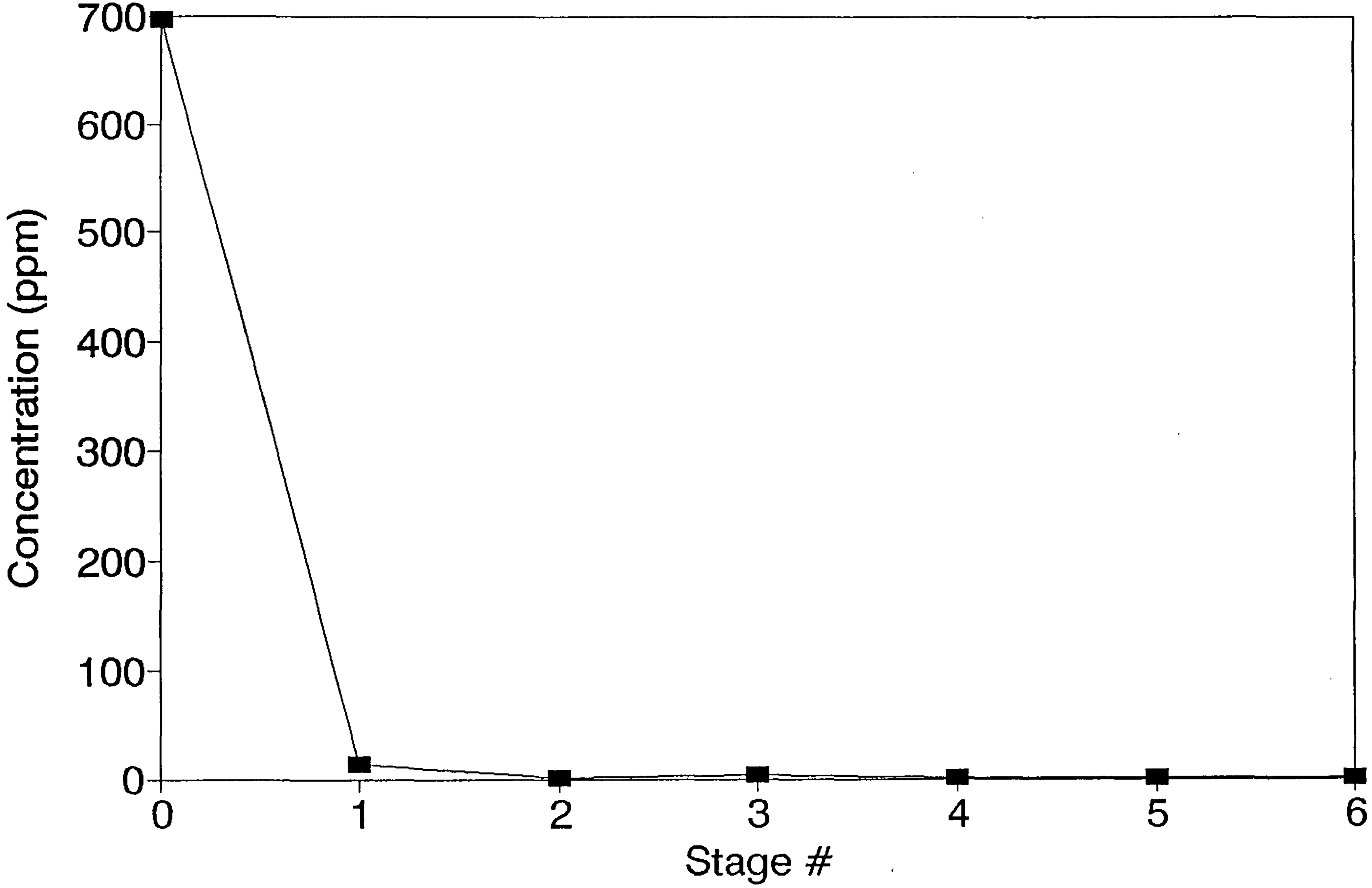


Figure 2. Solvent Extraction Curve

M&E Norwood - "Hot Spot" Sample

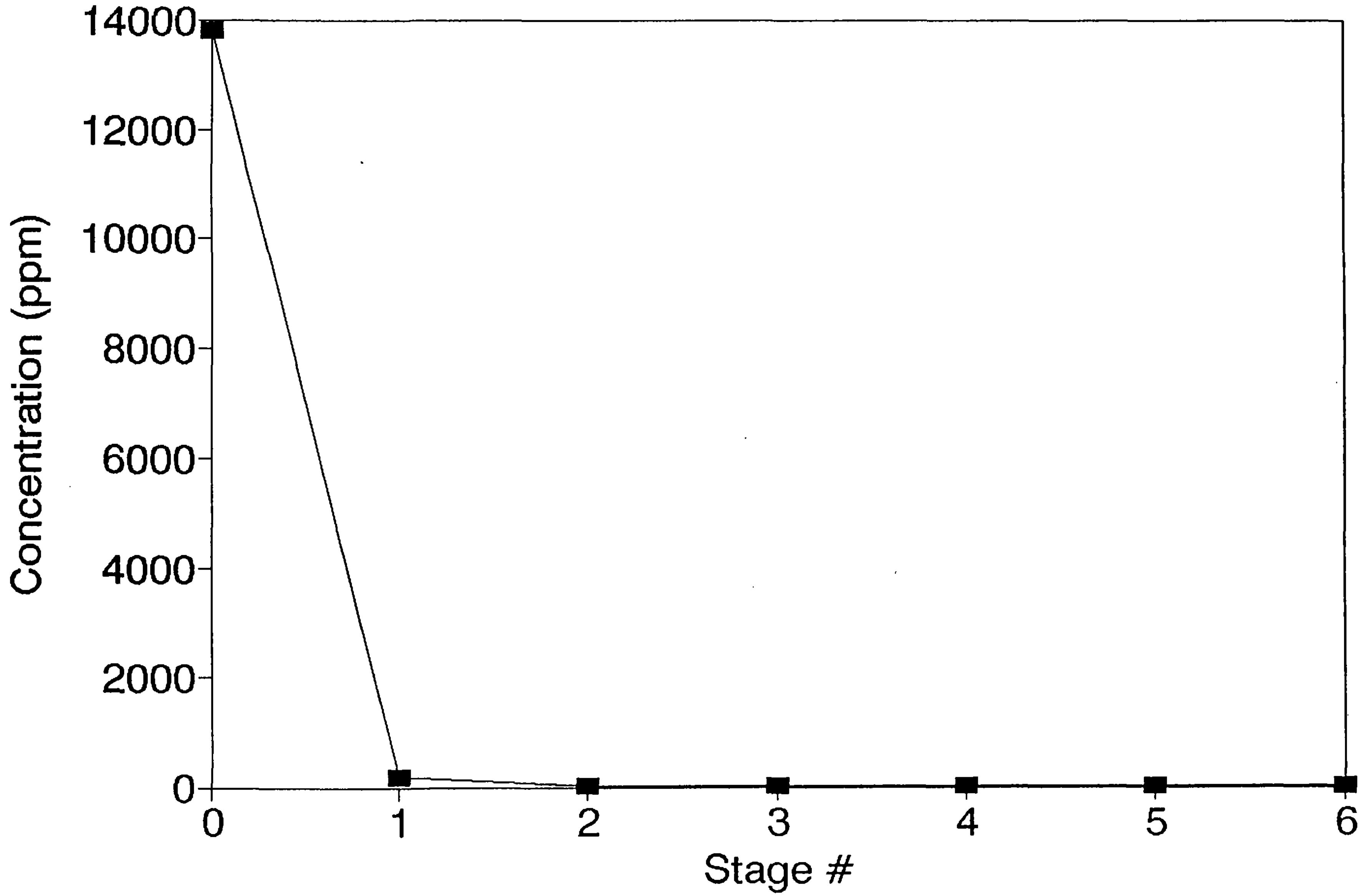


TABLE 1
SOLVENT EXTRACTION RESULTS NORWOOD PCB SUPERFUND SITE

SAMPLE	COMPOSITE SAMPLE (ppm)	CUMULATIVE EXTRACTION (%)	HOT SPOT SAMPLE (ppm)	CUMULATIVE EXTRACTION (%)
FEED	697.0	-	13800.0	-
STAGE #1	14.0	97.99	178.0	98.71
STAGE #2	1.4	99.80	26.8	99.81
STAGE #3	2.9	99.58	10.3	99.93
STAGE #4	0.2	99.97	5.3	99.96
STAGE #5	0.1	99.99	2.6	99.98
STAGE #6	0.3	99.96	1.4	99.99

* General Physics Laboratories Data

Results of PCB analyses performed by the CLP laboratory contracted by Metcalf & Eddy on "before" and "after" soil samples are presented in Table 2, and indicate high percent reductions, (ie. 99.99%), for both samples after six stages of extraction. These percent reductions are similar to the values presented in Table 1, although the actual concentrations of PCBs in the feed and final raffinate samples differ by as much as 28%.

Table 2 also contains PCB analyses of the extracted oil phase, and indicates a 23-fold increase in PCB concentration from the hot spot feed to the hot spot extract.

TABLE 2
SOLVENT EXTRACTION RESULTS FOR PCBs NORWOOD PCB SUPERFUND SITE

SAMPLE	COMPOSITE SAMPLE (ppm)	CUMULATIVE EXTRACTION (%)	HOT SPOT SAMPLE (ppm)	CUMULATIVE EXTRACTION (%)
FEED	789.0	-	9930.0	-
FEED DUPLICATE	796.0	-	8300.0	-
TREATED SAMPLE; 6 STAGES	0.044	99.99	0.98	99.99
EXTRACT	19400		212000	

* CLP Data

Note: Results in Table 2 are for extract sample diluted with 25 ml. hexane

Table 3 shows the concentration of dioxin toxicity equivalents for the two feed samples, the treated soil samples and the extract samples. The percent reduction of dioxins in the two samples is also shown, and was calculated to be 98.3% for the hot spot sample and 97.6% for the composite sample. Although the overall percent reductions for dioxins are slightly lower than for the PCBs, (ie. >99.9%), the reductions are comparable to the reductions for PCBs once the concentration of PCBs are reduced to less than 1 ppm. Analyses of the extract samples shows a 41-fold increase in the concentration of dioxin equivalents for the hot spot sample, and a 49-fold increase in the concentration for the composite sample.

TABLE 3
SOLVENT EXTRACTION RESULTS FOR DIOXINS NORWOOD PCB SUPERFUND SITE

SAMPLE	COMPOSITE SAMPLE (toxicity equiv.)	CUMULATIVE EXTRACTION (%)	HOT SPOT SAMPLE (toxicity equiv.)	CUMULATIVE EXTRACTION (%)
FEED	0.3093	-	7.068	-
FEED DUPLICATE	0.3262	-	3.550	-
TREATED SAMPLE	0.00777	97.55	0.0924	98.26
EXTRACT	15.72		219.8	

* CLP Data

Note: Results in Table 3 are for extract diluted with 25 ml. hexane

With the exception of trichlorobenzene in the hot spot feed sample, analyses of the two feed samples for semivolatiles was rejected during data validation due to longer than acceptable holding times. Trichlorobenzene was detected at an average of 9.5 ppm in the hot spot feed, and was reduced to 0.047 ppm in the treated solids. Analysis of the hot spot treated soil sample indicated a total semivolatile concentration of 1.76 ppm, whereas the analysis of the composite sample treated soil indicated a total semivolatile concentration of 2.44 ppm. Because the semivolatile analyses of the feed samples were rejected during data validation, it is not possible to calculate the percent reductions for semivolatiles due to extraction.

TABLE 4
VOLATILE AND SEMI-VOLATILE ANALYSES NORWOOD PCB SUPERFUND SITE

	COMPOSITE TREATED SAMPLE (ppm)	HOT SPOT FEED SAMPLE (ppm)	COMPOSITE FEED SAMPLE (ppm)	HOT SPOT TREATED SAMPLE (ppm)
VOLATILES				
2-Butanone	4100	U	U	4400
Trichloroethene	1300	U	U	250
Benzene	410	U	U	1900
Toluene	3200	U	U	6600
Ethylbenzene	1500	U	U	1600
Total Xylenes	9200	U	U	9300
Chlorobenzene	1300	U	U	190
SEMI-VOLATILES				
1,2,4-Trichlorobenzene	U	9.5 (ave)	R	0.047 99.51% RED

* CLP Data

* U = Undetected

Results from volatile analyses of the "before" and "after" soil samples showed that the concentration of volatiles increased following extraction, which is not possible under normal circumstances, and has not been seen before in previous studies. It is possible, however, that the propane used for extraction was contaminated with gasoline products, which in turn contaminated the soil in the bench scale extractor. The final step in bench scale extraction is to vent residual liquid "clean" propane from the extractor to reduce pressure prior to opening the vessel. If the clean propane is in fact contaminated with gasoline products, these contaminants will re-deposit on the treated soil, and will result in the analyses seen in Table 4. This phenomenon has not been seen in previous bench scale studies where treated soil samples were analyzed for volatiles, and will result in a study to determine the purity of the propane currently being supplied to CF Systems. It should be noted that commercial grade propane is not typically contaminated with volatiles, and that this particular occurrence is highly unusual. Results from CF Systems' propane purity study will be made available to Metcalf & Eddy as soon as they are available. It should also be noted that propane is inert, and that chemical reactions to form the volatiles seen in Table 4 is not a plausible explanation.

TABLE 5
MASS BALANCE CLOSURE

SAMPLE	FEED (grams)	RAFFINATE (grams)	EXTRACT (grams)	% CLOSURE
COMPOSITE	900.40	830.70	-	>92.3
HOT SPOT	919.90	877.90	26.10	98.3

TABLE 6
PCB MASS BALANCES

SAMPLE	FEED (mg PCB's)	RAFFINATE (mg PCB's)	EXTRACT (mg PCB's)	% CLOSURE
HOT SPOT	8384.89	NIL	5533.20	65.99
COMPOSITE	713.57	NIL	320.25	44.88

TABLE 7
Dioxin Mass Balances

SAMPLE	FEED (ug PCBs)	RAFFINATE (ug PCBs)	EXTRACT (ug PCBs)	% CLOSURE
HOT SPOT	4.88	0.08	5.74	119 %
COMPOSITE	0.29	0.01	0.26	92.8 %

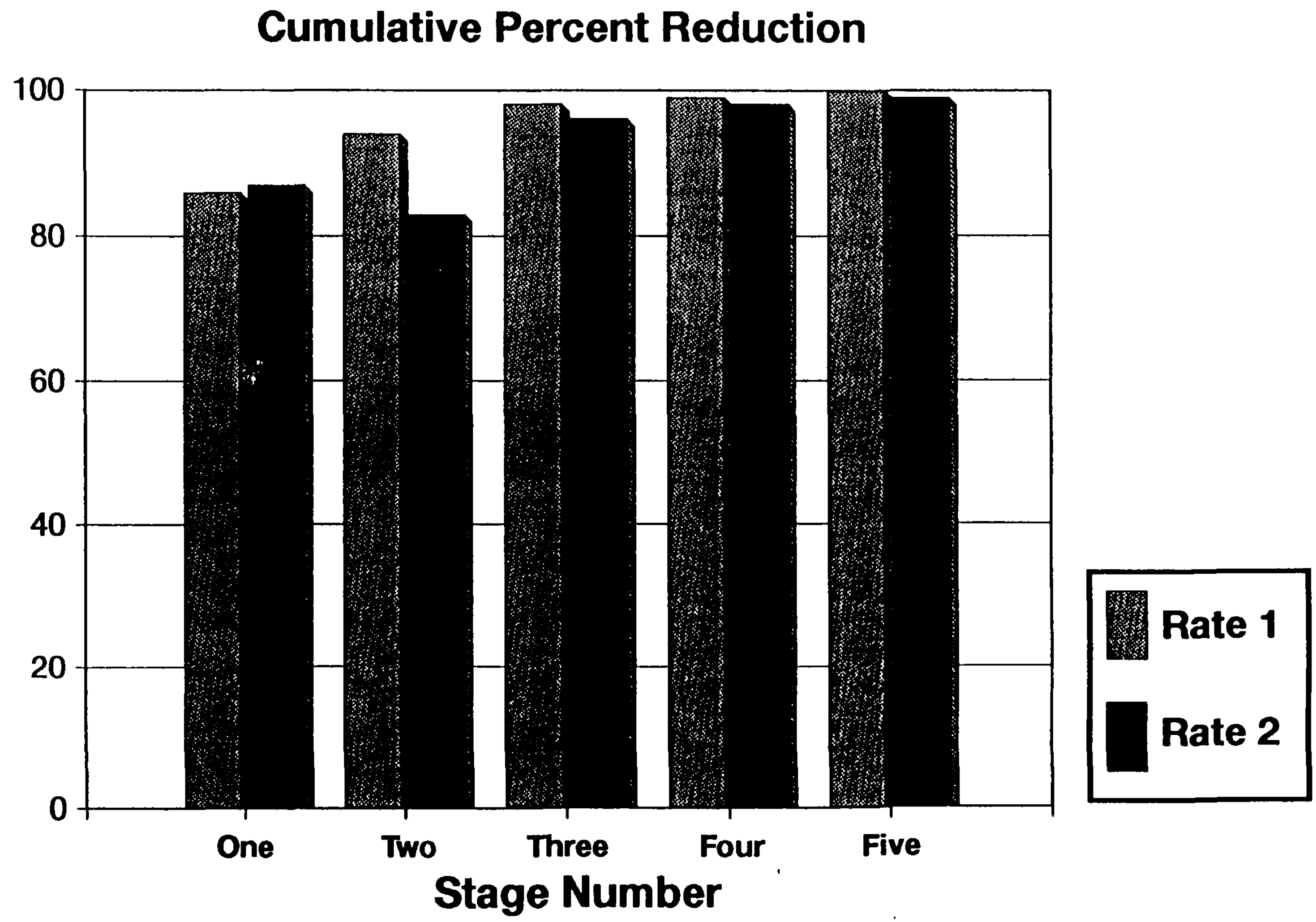
TABLE 8
OIL AND GREASE ANALYSES

	Composite Sample	Hot Spot Sample
Untreated	0.05	1.67
Treated	0.04	0.30

APPENDIX A

Phenanthrene Reduction

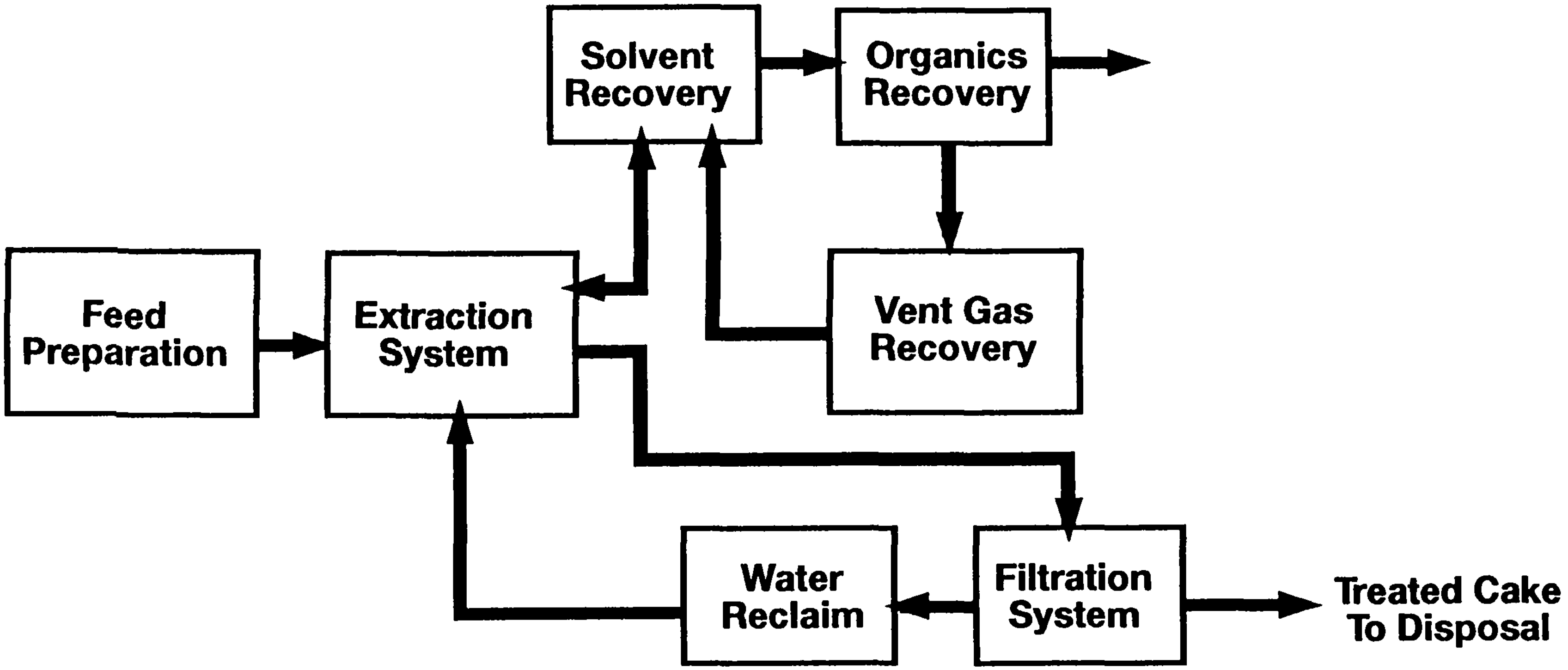
Port Arthur Facility 8/91



APPENDIX B

CF SYSTEMS
A MORRISON KNUDSEN COMPANY

CF Systems Solvent Extraction Remediation Process



Solvent Recovery

Organics Recovery

Feed Preparation

Extraction System

Vent Gas Recovery

Water Reclaim

Filtration System

Treated Cake To Disposal

APPENDIX C

GP Work Order # 92-01-117

SAMPLE ANALYSIS REPORT

Prepared For:

CF Systems
3D Gill Street
Woburn, MA 01801

M & E NORWOOD

Prepared By:

GP Environmental Services
202 Perry Parkway
Gaithersburg, Maryland 20877

February 10, 1992

Paul Ioannides, Laboratory Director

CASE NARRATIVE

92-01-117

Sample "NORWOOD HIGH-EXTRACT RINSE E1" leaked slightly during transportation to the laboratory. When sample bottles were opened, it was discovered that the 40 ml vial was not properly sealed.

Only a small amount must have leaked, because the tape around the sample vial was wet. The remainder of the sample was measured and it was determined to be 23.5 ml.

The PCB concentration in the "High Feed" sample was expected to be above 10,000 ppm, and it was actually 13,800 ppm. However, the "low Feed" sample was expected to contain above 2,000 ppm of PCBs, but it only had 697 ppm.

The high concentration series of samples exhibited a steady reduction of PCBs after each stage of treatment. The duplicate sample (stage 4) results showed only a 11% RPD, which indicates a good reproducibility of sample creation as well as analytical technique.

Thee low concentration series of samples exhibited a similar pattern in PCB concentration reduction, with the exception of stage three (3). There were no calculational errors, and in addition, the stage 3 sample was analyzed in duplicate, with the results showing a 33% RPD. The high RPD possibly indicates a matrix problem.

The MS/MSD results on a blank sample showed excellent recoveries. The MS/MSD results are included in this submission.

02/10/92

GP ENVIRONMENTAL SERVICES
ANALYTICAL RESULTS

Work order: 9201117
Work ID: M & E NORWOOD
Date Received: 01/30/92

CF Systems
3D Gill Street
Woburn, MA 01801
Atten: Mr. Bill McGovern

GP ENVIRONMENTAL SERVICES
202 Perry Parkway
Gaithersburg, MD 20877

Atten: Client Services
Phone: (800) 926-6802

Certified by:

SAMPLE IDENTIFICATION

GP ID	Client ID
9201117-01A	NORWOOD LOW-FEED
9201117-02A	NORWOOD LOW-1ST STAGE
9201117-03A	NORWOOD LOW-2ND STAGE
9201117-04A	NORWOOD LOW-3RD STAGE
9201117-05A	NORWOOD LOW-3RD STAGE DUP
9201117-06A	NORWOOD LOW-4TH STAGE
9201117-07A	NORWOOD LOW-5TH STAGE
9201117-08A	NORWOOD LOW-6TH STAGE
9201117-09A	NORWOOD HIGH-FEED
9201117-10A	NORWOOD HIGH-1ST STAGE
9201117-11A	NORWOOD HIGH-2ND STAGE
9201117-12A	NORWOOD HIGH-3RD STAGE
9201117-13A	NORWOOD HIGH-4TH STAGE
9201117-14A	NORWOOD HIGH-4TH STAGE DUP
9201117-15A	NORWOOD HIGH-5TH STAGE
9201117-16A	NORWOOD HIGH-6TH STAGE
9201117-17A	* NORWOOD HIGH-EXTRACT RINSE

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-01A	Matrix: SOIL	Analyst: DJS
Client ID: NORWOOD LOW-FEED	Method: SW846 8080	Analyzed: 02/03/92
Collected: 01/29/92	Units: ug/Kg	Extracted: 02/03/92
Dilution: 5000		

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	100000	
Aroclor-1221	BQL	100000	
Aroclor-1232	BQL	100000	
Aroclor-1242	BQL	130000	
Aroclor-1248	BQL	200000	
Aroclor-1254	697000	200000	
Aroclor-1260	BQL	200000	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-02A
Client ID: NORWOOD LOW-1ST STAGE
Collected: 01/29/92
Dilution: 50

Matrix: SOIL
Method: SW846 8080
Units: ug/Kg

Analyst: DJS
Analyzed: 02/04/92
Extracted: 02/03/92

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	1900	
Aroclor-1221	BQL	1900	
Aroclor-1232	BQL	1900	
Aroclor-1242	BQL	2400	
Aroclor-1248	BQL	3700	
Aroclor-1254	14000	3700	
Aroclor-1260	BQL	3700	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-03A	Matrix: SOIL	Analyst: DJS
Client ID: NORWOOD LOW-2ND STAGE	Method: SW846 8080	Analyzed: 02/04/92
Collected: 01/29/92	Units: ug/Kg	Extracted: 02/03/92
Dilution: 1		

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	52	
Aroclor-1221	BQL	52	
Aroclor-1232	BQL	52	
Aroclor-1242	BQL	68	
Aroclor-1248	BQL	100	
Aroclor-1254	1380	100	
Aroclor-1260	BQL	100	

Notes and definitions for this report:

BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-04A
Client ID: NORWOOD LOW-3RD STAGE
Collected: 01/29/92
Dilution: 5

Matrix: SOIL
Method: SW846 8080
Units: ug/Kg

Analyst: DJS
Analyzed: 02/04/92
Extracted: 02/03/92

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	250	
Aroclor-1221	BQL	250	
Aroclor-1232	BQL	250	
Aroclor-1242	BQL	330	
Aroclor-1248	BQL	500	
Aroclor-1254	4160	500	
Aroclor-1260	BQL	500	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-05A	Matrix: SOIL	Analyst: DJS
Client ID: NORWOOD LOW-3RD STAGE DUP	Method: SW846 8080	Analyzed: 02/05/92
Collected:	Units: ug/Kg	Extracted: 02/03/92
Dilution: 5		

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	290	
Aroclor-1221	BQL	290	
Aroclor-1232	BQL	290	
Aroclor-1242	BQL	380	
Aroclor-1248	BQL	580	
Aroclor-1254	2950	580	
Aroclor-1260	BQL	580	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-06A
Client ID: NORWOOD LOW-4TH STAGE
Collected: 01/29/92
Dilution: 1

Matrix: SOIL
Method: SW846 8080
Units: ug/Kg

Analyst: DJS
Analyzed: 02/04/92
Extracted: 02/03/92

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	26	
Aroclor-1221	BQL	26	
Aroclor-1232	BQL	26	
Aroclor-1242	BQL	34	
Aroclor-1248	BQL	52	
Aroclor-1254	164	52	
Aroclor-1260	BQL	52	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-07A
Client ID: NORWOOD LOW-5TH STAGE
Collected: 01/29/92
Dilution: 1

Matrix: SOIL
Method: SW846 8080
Units: ug/Kg

Analyst: DJS
Analyzed: 02/05/92
Extracted: 02/03/92

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	34	
Aroclor-1221	BQL	34	
Aroclor-1232	BQL	34	
Aroclor-1242	BQL	44	
Aroclor-1248	BQL	68	
Aroclor-1254	72.4	68	
Aroclor-1260	BQL	68	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-08A	Matrix: SOIL	Analyst: DJS
Client ID: NORWOOD LOW-6TH STAGE	Method: SW846 8080	Analyzed: 02/05/92
Collected:	Units: ug/Kg	Extracted: 02/03/92
Dilution: 1		

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	25	
Aroclor-1221	BQL	25	
Aroclor-1232	BQL	25	
Aroclor-1242	BQL	32	
Aroclor-1248	BQL	50	
Aroclor-1254	355	50	
Aroclor-1260	BQL	50	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-09A
Client ID: NORWOOD HIGH-FEED
Collected: 01/29/92
Dilution: 25000

Matrix: SOIL
Method: SW846 8080
Units: ug/Kg

Analyst: DJS
Analyzed: 02/04/92
Extracted: 02/03/92

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	570000	
Aroclor-1221	BQL	570000	
Aroclor-1232	BQL	570000	
Aroclor-1242	BQL	740000	
Aroclor-1248	BQL	1100000	
Aroclor-1254	13800~~000~~	1100000	
Aroclor-1260	BQL	1100000	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-10A
Client ID: NORWOOD HIGH-1ST STAGE
Collected: 01/29/92
Dilution: 500

Matrix: SOIL
Method: SW846 8080
Units: ug/Kg

Analyst: DJS
Analyzed: 02/04/92
Extracted: 02/03/92

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	10000	
Aroclor-1221	BQL	10000	
Aroclor-1232	BQL	10000	
Aroclor-1242	BQL	13000	
Aroclor-1248	BQL	20000	
Aroclor-1254	178000	20000	
Aroclor-1260	BQL	20000	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-11A	Matrix: SOIL	Analyst: DJS
Client ID: NORWOOD HIGH-2ND STAGE	Method: SW846 8080	Analyzed: 02/04/92
Collected: 01/29/92	Units: ug/Kg	Extracted: 02/03/92
Dilution: 100		

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	3700	
Aroclor-1221	BQL	3700	
Aroclor-1232	BQL	3700	
Aroclor-1242	BQL	4800	
Aroclor-1248	BQL	7400	
Aroclor-1254	26800	7400	
Aroclor-1260	BQL	7400	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-12A	Matrix: SOIL	Analyst: DJS
Client ID: NORWOOD HIGH-3RD STAGE	Method: SW846 8080	Analyzed: 02/04/92
Collected: 01/29/92	Units: ug/Kg	Extracted: 02/03/92
Dilution: 33		

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	550	
Aroclor-1221	BQL	550	
Aroclor-1232	BQL	550	
Aroclor-1242	BQL	710	
Aroclor-1248	BQL	1100	
Aroclor-1254	10300	1100	
Aroclor-1260	BQL	1100	

Notes and definitions for this report:

BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-13A
Client ID: NORWOOD HIGH-4TH STAGE
Collected: 01/29/92
Dilution: 5

Matrix: SOIL
Method: SW846 8080
Units: ug/Kg

Analyst: DJS
Analyzed: 02/05/92
Extracted: 02/03/92

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	300	
Aroclor-1221	BQL	300	
Aroclor-1232	BQL	300	
Aroclor-1242	BQL	390	
Aroclor-1248	BQL	600	
Aroclor-1254	5330	600	
Aroclor-1260	BQL	600	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-14A	Matrix: SOIL	Analyst: DJS
Client ID: NORWOOD HIGH-4TH STAGE DUP	Method: SW846 8080	Analyzed: 02/05/92
Collected: 01/29/92	Units: ug/Kg	Extracted: 02/03/92
Dilution: 5		

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	280	
Aroclor-1221	BQL	280	
Aroclor-1232	BQL	280	
Aroclor-1242	BQL	360	
Aroclor-1248	BQL	560	
Aroclor-1254	5900	560	
Aroclor-1260	BQL	560	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-15A	Matrix: SOIL	Analyst: DJS
Client ID: NORWOOD HIGH-5TH STAGE	Method: SW846 8080	Analyzed: 02/05/92
Collected: 01/29/92	Units: ug/Kg	Extracted: 02/03/92
Dilution: 5		

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	140	
Aroclor-1221	BQL	140	
Aroclor-1232	BQL	140	
Aroclor-1242	BQL	190	
Aroclor-1248	BQL	290	
Aroclor-1254	2590	290	
Aroclor-1260	BQL	290	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-16A
Client ID: NORWOOD HIGH-6TH STAGE
Collected: 01/29/92
Dilution: 5

Matrix: SOIL
Method: SW846 8080
Units: ug/Kg

Analyst: DJS
Analyzed: 02/05/92
Extracted: 02/03/92

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	130	
Aroclor-1221	BQL	130	
Aroclor-1232	BQL	130	
Aroclor-1242	BQL	170	
Aroclor-1248	BQL	260	
Aroclor-1254	1490	260	
Aroclor-1260	BQL	260	

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
ORGANIC ANALYSIS RESULTS

GP ID: 9201117-17A	Matrix: LIQUID	Analyst: DJS
Client ID: NORWOOD HIGH-EXTRACT RINSE	Method: SW846 8080	Analyzed: 02/05/92
Collected: 01/29/92	Units: ug/L	Extracted: 02/03/92
Dilution: 20000		

GC TARGET COMPOUNDS

Parameter	Result	Det.Lim.	Qualifier
Aroclor-1016	BQL	1000000	
Aroclor-1221	BQL	1000000	
Aroclor-1232	BQL	1000000	
Aroclor-1242	BQL	1300000	
Aroclor-1248	BQL	2000000	
Aroclor-1254	15100000	2000000	
Aroclor-1260	15100	2000000	J

Notes and definitions for this report:

BQL = Below Quantitation Limit

J = An estimated value, below method detection limit

GP ENVIRONMENTAL SERVICES
WET CHEMISTRY ANALYSIS RESULTS

GP ID: 9201117-01A
Client ID: NORWOOD LOW-FEED
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	97.4		%		CS 02/03/92 17:00:00

GP ID: 9201117-02A
Client ID: NORWOOD LOW-1ST STAGE
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.0		%		CS 02/03/92 17:00:00

GP ID: 9201117-03A
Client ID: NORWOOD LOW-2ND STAGE
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.4		%		CS 02/03/92 17:00:00

GP ID: 9201117-04A
Client ID: NORWOOD LOW-3RD STAGE
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.6		%		CS 02/03/92 17:00:00

GP ID: 9201117-05A
Client ID: NORWOOD LOW-3RD STAGE DUP
Collected:
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.8		%		CS 02/03/92 17:00:00

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
WET CHEMISTRY ANALYSIS RESULTS

GP ID: 9201117-06A
Client ID: NORWOOD LOW-4TH STAGE
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.8		%		CS 02/03/92 17:00:00

GP ID: 9201117-07A
Client ID: NORWOOD LOW-5TH STAGE
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.8		%		CS 02/03/92 17:00:00

GP ID: 9201117-08A
Client ID: NORWOOD LOW-6TH STAGE
Collected:
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.8		%		CS 02/03/92 17:00:00

GP ID: 9201117-09A
Client ID: NORWOOD HIGH-FEED
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	95.3		%		CS 02/03/92 17:00:00

GP ID: 9201117-10A
Client ID: NORWOOD HIGH-1ST STAGE
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	98.9		%		CS 02/03/92 17:00:00

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
WET CHEMISTRY ANALYSIS RESULTS

GP ID: 9201117-11A
Client ID: NORWOOD HIGH-2ND STAGE
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	98.5		%		CS 02/03/92 17:00:00

GP ID: 9201117-12A
Client ID: NORWOOD HIGH-3RD STAGE
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.4		%		CS 02/03/92 17:00:00

GP ID: 9201117-13A
Client ID: NORWOOD HIGH-4TH STAGE
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.7		%		CS 02/03/92 17:00:00

GP ID: 9201117-14A
Client ID: NORWOOD HIGH-4TH STAGE DUP
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.7		%		CS 02/03/92 17:00:00

GP ID: 9201117-15A
Client ID: NORWOOD HIGH-5TH STAGE
Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.6		%		CS 02/03/92 17:00:00

Notes and definitions for this report:
BQL = Below Quantitation Limit

GP ENVIRONMENTAL SERVICES
WET CHEMISTRY ANALYSIS RESULTS

GP ID: 9201117-16A
Client ID: NORWOOD HIGH-6TH STAGE

Collected: 01/29/92
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Dil.	Analyzed by
Percent Solids	MCAWW 160.3	99.8		%		CS 02/03/92 17:00:00

Notes and definitions for this report:
BQL = Below Quantitation Limit

G. P. ENVIRONMENTAL

PCB MS/MSD Analysis Data Sheet

Client: CF_SYSTEMS

Work Order No.: 92-01-117

Dash No.: P02035BmS

Sample I.D.: PBLK-59

Analysis Date(s): 02/03/92

02/03/92

Dilution Factor(s): 1

Parameter: ________

Units: ug/L
(ug/L or ug/Kg)

Matrix: ________

MATRIX SPIKE COMPOUNDS FOUND:

Compound	Conc. added	Sample Conc.	Concentration Found		% Recovery		%RPD
			MS	MSD	MS	MSD	
AR1016	5.0	0.0	4.91	4.90	98	98	0.20
AR1260	10.0	0.0	9.38	9.80	94	98	4.5

*-- outside of advisory quality control limits.

Number of percent recoveries outside of criteria 0

Number of relative percent recoveries outside of criteria 0

Analyst: ________

Reviewed By: ________

Comments:

[illegible]

92 Perry Parkway
aithersburg, Maryland 20877
(301) 926-6802

Samplers Signature:

Client: CF SYSTEMS

Project: M+E NORWOOD

Client Sample ID	Collection Date	Collection Time	Collected By (Initials)	Matrix	Total No. of Containers	Bottle Type and Preservative: GLASS NONE Analyses Requested: PESTICIDES/PCBs METHOD 8080									Comments
NORWOOD LOW - FEED L0	1-19-92	0900	SJL	S	1	✓									ORANGE LABELS
NORWOOD LOW - 1ST STAGE L1	"	"	"	S	1	✓									↓
NORWOOD LOW - 2ND STAGE L2	"	"	"	S	1	✓									
NORWOOD LOW - 3RD STAGE L3	"	"	"	S	2	✓									
Total															

Relinquished by:	Company:	Date:	Time:	Received by:	Company:	Date:	Time:
					CPES	1/20/92	10:30

G90-421

Sheet ___ of ___

2 Perry Parkway
ithersburg, Maryland 20877
(301) 926-6802

Samplers Signature:

Client: CF SYSTEMS

Project: M+E NORWOOD

Client Sample ID	Collection Date	Collection Time	Collected By (Initials)	Matrix	Total No. of Containers	Bottle Type and Preservative: GLASS NONE Analyses Requested: PESTICIDES/PCBs METHOD 8080									Comments
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]											
NORWOOD LOW - 4TH STAGE L4	"	"	"	S	1	✓									ORANGE LABELS
NORWOOD LOW - 5TH STAGE L5	"	"	"	S	1	✓									↓
NORWOOD LOW - 6TH STAGE L6	"	"	"	S	1	✓									↓
Total															

Relinquished by:	Company:	Date:	Time:	Received by:	Company:	Date:	Time:
					GPES	1/30/92	10:30

G90-421

[illegible]
Gaithersburg, Maryland 20877
(301) 926-6802

Samplers Signature:

Client: CF SYSTEMS

Project: M+E NORWOOD

Client Sample ID	Collection Date	Collection Time	Collected By (Initials)	Matrix	Total No. of Containers	PESTICIDES/PCB METHOD 8080 GLASS NONE								Comments
NORWOOD HIGH-FEED HO	1-29-92	0900	SJL	S	1	✓								GREEN LABELS
NORWOOD HIGH-1ST STAGE H1	"	"	"	S	1	✓								↓
NORWOOD HIGH-2ND STAGE H2	"	"	"	S	1	✓								
NORWOOD HIGH-3RD STAGE H3	"	"	"	S	1	✓								
Total														

Bottle Type and Preservative

Analyses Requested

Relinquished by:	Company:	Date:	Time:	Received by:	Company:	Date:	Time:
					CIES	1/30/92	10:20

[illegible] CHAIN OF CUSTODY FORM Sheet [illegible] of [illegible]

2 Perry Parkway
Gaithersburg, Maryland 20877
(301) 926-6802

Samplers Signature:

Client: CF Systems

Project: M+E Norwood

Client Sample ID	Collection Date	Collection Time	Collected By (Initials)	Matrix	Total No. of Containers	Pesticides/PCB Method 8080									Comments
Bottle Type and Preservative						Glass None									
Norwood High - 4th stage H4	"	"	"	S	2	✓									Green Labels
Norwood High - 5th stage H5	"	"	"	S	1	✓									↓
Norwood High - 6th stage H6	"	"	"	S	1	✓									↓
Total															

Relinquished by:	Company:	Date:	Time:	Received by:	Company:	Date:	Time:
					GPES	1/30/92	10:30

G90-421

Sheet of

2 Perry Parkway
ithersburg, Maryland 20877
(301) 926-6802

Samplers Signature:

Client: CF SYSTEMS

Project: MHE NORWOOD

Client Sample ID	Collection Date	Collection Time	Collected By (Initials)	Matrix	Total No. of Containers	PESTICIDES/PCB METHOD 8080									Comments
Bottle Type and Preservative						GLASS NONE									
NORWOOD HIGH - EXTRACT RINSE E1	1-29 92	1100	SJL	L	1	✓									SAMPLE IS HEXANE RINSE OF VESSEL THEN CONCENTRATED (RED LABEL)
Total															

Relinquished by:	Company:	Date:	Time:	Received by:	Company:	Date:	Time:
					GPES	1/30/92	10:30

G90-421

TABLE 3

SITE: Norwood PCB - Norwood, MA

CASE/SAS NO: 7018A / 7018A-401

SUBCONTRACTOR: CF SYSTEMS CORPORATION

TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

	UNTREATED SOIL, HIGH PCB		UNTREATED SOIL, HIGH PCB, DUPLICATE		TREATED SOIL, HIGH PCB	
Sample No	7018A-401DL		7018A-402DL		7018A-406	
Matrix	SOIL		SOIL		SOIL	
TCDD/TCDF Conc	ug/kg	DL/EMPC*	ug/kg	DL/EMPC*	ug/kg	DL/EMPC*
2,3,7,8-TCDD	UJ	0.007	UJ	0.15	U	0.003
1,2,3,7,8-PeCDD	0.05 J		UJ	0.35	UJ	0.041 *
1,2,3,4,7,8-HxCDD	0.10 J		UJ	0.57	U	0.023
1,2,3,6,7,8-HxCDD	UJ	0.27 *	UJ	0.48	U	0.021
1,2,3,7,8,9-HxCDD	0.22 J		UJ	0.54	UJ	0.021
1,2,3,4,6,7,8-HpCDD	2.1 J		UJ	0.79	U	0.008
OCDD	0.28 J		0.99 J		0.102 J	
2,3,7,8-TCDF	6.5 J		3.49 J		0.201	
1,2,3,7,8-PeCDF	1.7 J		0.80 J		U	0.008
2,3,4,7,8-PeCDF	5.2 J		2.87 J		UJ	0.042 *
1,2,3,4,7,8-HxCDF	24.0 J		12.30 J		0.190	
1,2,3,6,7,8-HxCDF	8.7 J		4.39 J		0.072	
2,3,4,6,7,8-HxCDF	UJ	1.8 *	UJ	0.64 *	UJ	0.016 *
1,2,3,7,8,9-HxCDF	U	0.009	UJ	0.44	U	0.008
1,2,3,4,6,7,8-HpCDF	10.9 J		2.86 J		0.192	
1,2,3,4,7,8,9-HpCDF	6.8 J		2.23 J		0.072	
OCDF	UJ	0.80 *	2.87 J		0.279	
TOTAL TCDD	0.15	4.8 *	UJ	2.891 *	UJ	1.868 *
TOTAL PeCDD	0.20	236 *	UJ	211.15 *	UJ	0.041 *
TOTAL HxCDD	1.9	3.8 *	UJ	0.567	U	0.023
TOTAL HpCDD	3.4		UJ	2.090 *	U	0.008
TOTAL TCDF	17.1	22.7 *	5.65	9.825 *	0.38	0.566
TOTAL PeCDF	25.5	25.7 *	11.52	11.908 *	0.08	0.126
TOTAL HxCDF	56.5	56.5 *	23.96	25.18 *	0.38	0.448
TOTAL HpCDF	25.3	25.4 *	7.86	8.396 *	0.33	
TOXICITY EQUIVALENCY	7.068 J		3.55 J		0.0924. J	
DILUTION FACTOR	10		50		1.0	
DATE OF RECEIPT	1/29/92		1/29/92		1/29/92	
SAMPLE EXTRACTION DATE	1/31/92		1/31/92		1/31/92	
ANALYSIS DATE	2/7/92		2/26/92		2/5/92	
GC/MS I.D.	E005637		E005603		E005608	

SITE: Norwood PCB - Norwood, MA

CASE/SAS NO: 7018A / 7018A-401

SUBCONTRACTOR: CF SYSTEMS CORPORATION

TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

	UNTREATED SOIL, LOW PCB		UNTREATED SOIL, LOW PCB, DUPLICATE		TREATED SOIL, LOW PCB	
Sample No	7018A-403		7018A-404		7018A-405	
Matrix	SOIL		SOIL		SOIL	
TCDD/TCDF Conc	ug/kg	DL/EMPC*	ug/kg	DL/EMPC*	ug/kg	DL/EMPC*
2,3,7,8-TCDD	U	0.004	U	0.006	U	0.004
1,2,3,7,8-PeCDD	U	0.009	U	0.014	U	0.024
1,2,3,4,7,8-HxCDD	U	0.021	U	0.027	U	0.037
1,2,3,6,7,8-HxCDD	U	0.019	U	0.025	U	0.034
1,2,3,7,8,9-HxCDD	UJ	0.019	UJ	0.025	UJ	0.034
1,2,3,4,6,7,8-HpCDD	U	0.016	U	0.022	U	0.019
OCDD	0.161 J		J	0.050 *	U	0.213
2,3,7,8-TCDF	0.202 J		0.128		0.006	
1,2,3,7,8-PeCDF	0.051 J		0.037		U	0.011
2,3,4,7,8-PeCDF	U	0.006	0.181		U	0.010
1,2,3,4,7,8-HxCDF	1.971 J		1.552		0.050	
1,2,3,6,7,8-HxCDF	0.697 J		0.532		0.018	
2,3,4,6,7,8-HxCDF	0.076 J		0.050		U	0.013
1,2,3,7,8,9-HxCDF	0.039 J		0.025		U	0.016
1,2,3,4,6,7,8-HpCDF	0.452 J		0.304		0.036	
1,2,3,4,7,8,9-HpCDF	0.340 J		0.177		U	0.024
OCDF	0.328 J		0.184		U	0.212
TOTAL TCDD	UJ	1.982 *	U	1.973	U	2.184
TOTAL PeCDD	UJ	0.641 *	U	8.217	U	0.024
TOTAL HxCDD	UJ	0.032 *	U	0.031	U	0.037
TOTAL HpCDD	UJ	0.016 *	U	0.022	U	0.019
TOTAL TCDF	UJ	0.904 *	U	0.620	0.02	0.061
TOTAL PeCDF	UJ	2.351 *	1.50		U	0.032
TOTAL HxCDF	5.29		4.17	4.203	0.10	
TOTAL HpCDF	UJ	1.285 *	0.72	0.708	0.04	
TOXICITY EQUIVALENCY	0.3093 J		0.3262 J		0.00777	
DILUTION FACTOR	1.0		1.0		1.0	
DATE OF RECEIPT	1/29/92		1/29/92		1/29/92	
SAMPLE EXTRACTION DATE	1/31/92		1/31/92		1/31/92	
ANALYSIS DATE	2/5/92		2/5/92		2/5/92	
GC/MS I.D.	E005604		E005605		E005607	

SITE: Norwood PCB - Norwood, MA

CASE/SAS NO: 7018A / 7018A-401

SUBCONTRACTOR: CF SYSTEMS CORPORATION

TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

	EXTRACT FROM HIGH PCB SOIL		EXTRACT FROM LOW PCB SOIL	
Sample No	7018A-410		7018A-409	
Matrix	OIL		OIL	
TCDD/TCDF Conc	ug/kg	DL/EMPC*	ug/kg	DL/EMPC*
2,3,7,8-TCDD	UJ	0.99 *	UJ	0.23 *
1,2,3,7,8-PeCDD	U	1.4	U	0.70
1,2,3,4,7,8-HxCDD	UJ	2.0	U	0.60
1,2,3,6,7,8-HxCDD	UJ	3.1 *	U	0.60
1,2,3,7,8,9-HxCDD	UJ	1.7	UJ	0.60
1,2,3,4,6,7,8-HpCDD	UJ	2.4	1.0 J	
OCDD	0.25 J		3.1 J	
2,3,7,8-TCDF	166		7.4	
1,2,3,7,8-PeCDF	U	1.3	2.6	
2,3,4,7,8-PeCDF	150		10.5	
1,2,3,4,7,8-HxCDF	894 J		64.2	
1,2,3,6,7,8-HxCDF	195 J		22.0	
2,3,4,6,7,8-HxCDF	131 J		3.3	
1,2,3,7,8,9-HxCDF	14.3 J		U	0.4
1,2,3,4,6,7,8-HpCDF	201 J		23.8	
1,2,3,4,7,8,9-HpCDF	149 J		15.9	
OCDF	3.2 J		17.8	
TOTAL TCDD	UJ	88.0 *	U	41.5
TOTAL PeCDD	UJ	3400 *	0.18	32.5
TOTAL HxCDD	5.4	19.3 *	0.20	4.3
TOTAL HpCDD	2.1	45.9 *	1.60	
TOTAL TCDF	468	708 *	25.3	46.4
TOTAL PeCDF	935	951 *	85.3	89.7
TOTAL HxCDF	1980	1980 *	175	175
TOTAL HpCDF	537	541 *	58.1	58.6
TOXICITY EQUIVALENCY	219.8 J		15.72 J	
DILUTION FACTOR	1.0		1.0	
DATE OF RECEIPT	1/29/92		1/29/92	
SAMPLE EXTRACTION DATE	2/3/92		2/3/92	
ANALYSIS DATE	2/7/92		2/7/92	
GC/MS I.D.	E005638		E005639	

Summary of Liquefied Propane Extraction Results

[redacted]

SITE: NORWOOD PCB SITE
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION
SUBCONTRACTOR: CF SYSTEMS

SAMPLE DESIGNATION	Untreated High	Untreated High Duplicate	Treated High	Percent Reduction
VOLATILES				
2-Butanone	10 U	10 U	4400 U	
Trichloroethene	10 U	10 U	250 J	
Benzene	10 U	10 U	1900	
Toluene	10 U	10 U	6600	
Ethylbenzene	10 U	10 U	1600	
Total Xylenes	10 U	10 U	9300	
Chlorobenzene	10 U	10 U	190 J	
SEMIVOLATILES				
Phenol	R	R	0.180 U	
2-Methylphenol	R	R	0.180 U	
4-Methylphenol	R	R	0.230	
2,4-Dimethylphenol	R	R	0.180 U	
1,2,4-Trichlorobenzene	9 J	10 J	0.047 J	99.51
Naphthalene	R	R	0.420	
2-Methylnaphthalene	R	R	0.460	
Fluorene	R	R	0.180 U	
Phenanthrene	R	R	0.038 J	
Di-n-butylphthalate	R	R	0.560	
PCBS				
Aroclor 1254	9930	8300	0.98	99.99

Volatiles concentrations are in ug/Kg.
Semivolatiles and PCB concentrations
are in mg/Kg.

Summary of Liquefied Propane Extraction Results

Low Concentration PCB Sample

SITE: NORWOOD PCB SITE
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION
SUBCONTRACTOR: CF SYSTEMS

SAMPLE DESIGNATION	Untreated Low	Untreated Low Duplicate	Treated Low	Percent Reduction
VOLATILES				
2-Butanone	10 U	10 U	4100	
Trichloroethene	10 U	10 U	1300	
Benzene	10 U	10 U	410	
Toluene	10 U	10 U	3200	
Ethylbenzene	10 U	10 U	1500	
Total Xylenes	10 U	10 U	9200	
Chlorobenzene	10 U	10 U	1300	
SEMIVOLATILES				
Phenol	R	R	0.350	
2-Methylphenol	R	R	0.190 J	
4-Methylphenol	R	R	0.400	
2,4-Dimethylphenol	R	R	0.094 J	
1,2,4-Trichlorobenzene	R	R	0.390	
Naphthalene	R	R	0.180 J	
2-Methylnaphthalene	R	R	0.400	
Fluorene	R	R	0.037 J	
Phenanthrene	R	R	0.079 J	
Di-n-butylphthalate	R	R	0.710	
PCBS				
Aroclor 1254	789 J	796 J	0.044 J	99.99

Volatiles concentrations are in ug/Kg.
Semivolatiles and PCB concentrations
are in mg/Kg.

Untreated High and Low Soil and Extracted Oil PCB Analysis
mg/Kg

SITE: NORWOOD PCB SITE
SDG NO.: 7018A-301, 901
SUBCONTRACTOR: CF SYSTEMS CORPORATION
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

		UNTREATED SOIL SAMPLES				EXTRACTED OIL SAMPLES	
		HIGH PCB CONCENTRATION		LOW PCB CONCENTRATION		HIGH PCB CONCENTRATION	LOW PCB CONCENTRATION
CF SYSTEMS' SAMPLE ID:		Norwood site high	Norwood site high-duplicate	Norwood site low	Norwood site low-duplicate	Norwood site high-extracted oil	Norwood site low-extracted oil
EPA SAMPLE NUMBER:		7018A-301	7018A-302	7018A-303	7018A-304	7018A-902	7018A-901
COMPOUND	CRQL						
Toxaphene	50	5000 U	5000 U	5000 U	5000 U	50000 U	50000 U
Aroclor-1016	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
Aroclor-1221	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
Aroclor-1232	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
Aroclor-1242	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
Aroclor-1248	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
Aroclor-1254	10	9930	8300	789 J	796 J	212000	19400
Aroclor-1260	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
DILUTION FACTOR:		100	100	100	100	1000	1000
DATE SAMPLED:		1-15-92	1-15-92	1-15-92	1-15-92	1-28-92	1-28-92
DATE EXTRACTED:		3-10-92	3-10-92	3-10-92	3-10-92	2-03-92	2-03-92
DATE ANALYZED:		3-13-92	3-13-92	3-13-92	3-13-92	3-06-92	3-06-92
REMARKS:			Dupe of -301		Dupe of -303		

Footnotes:

CRQL -	Quantitation Limit.
J -	Quantitation is approximate due to limitations identified in the quality control review.
U -	Value is the sample detection limit.
R -	Value is rejected.
UJ -	Sample detection limit is approximate due to limitations identified in the quality control review.

SEMIVOLATILE ORGANIC ANALYSIS
(mg/Kg)

SITE: NORWOOD PCB SITE
SDG NO.: 7018A-201
SUBCONTRACTOR: CF SYSTEMS CORPORATION
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

		UNTREATED SOIL SAMPLES			
		HIGH PCB CONCENTRATION		LOW PCB CONCENTRATION	
CF SYSTEMS' SAMPLE ID:		Norwood site high	Norwood site high-duplicate	Norwood site low	Norwood site low-duplicate
EPA SAMPLE NUMBER:		7018A-201	7018A-202	7018A-203	7018A-204
COMPOUND	CRQL				
Phenol	10	R	R	R	R
bis(2-Chloroethyl) ether	10	R	R	R	R
2-Chlorophenol	10	R	R	R	R
1,3-Dichlorobenzene	10	R	R	R	R
1,4-Dichlorobenzene	10	R	R	R	R
Benzyl Alcohol	50	R	R	R	R
1,2-Dichlorobenzene	10	R	R	R	R
2-Methylphenol	10	R	R	R	R
2,2'-oxybis(1-Chloropropane)	10	R	R	R	R
4-Methylphenol	10	R	R	R	R
N-Nitroso-di-n-propylamine	10	R	R	R	R
Hexachloroethane	10	R	R	R	R
Nitrobenzene	10	R	R	R	R
Isophorone	10	R	R	R	R
2-Nitrophenol	10	R	R	R	R
2,4-Dimethylphenol	10	R	R	R	R
Benzoic Acid	50	R	R	R	R
bis(2-Chloroethoxy)methane	10	R	R	R	R
2,4-Dichlorophenol	10	R	R	R	R
1,2,4-Trichlorobenzene	10	8 J	10 J	R	R
Naphthalene	10	R	R	R	R
4-Chloroaniline	10	R	R	R	R
Hexachlorobutadiene	10	R	R	R	R
4-Chloro-3-Methylphenol	10	R	R	R	R
2-Methylnaphthalene	10	R	R	R	R
Hexachlorocyclopentadiene	10	R	R	R	R
2,4,6-Trichlorophenol	10	R	R	R	R
2,4,5-Trichlorophenol	25	R	R	R	R
2-Chloronaphthalene	10	R	R	R	R
2-Nitroaniline	25	R	R	R	R
Dimethylphthalate	10	R	R	R	R
Acenaphthylene	10	R	R	R	R
2,6-Dinitrotoluene	10	R	R	R	R
3-Nitroaniline	25	R	R	R	R
Acenaphthene	10	R	R	R	R
2,4-Dinitrophenol	25	R	R	R	R
4-Nitrophenol	25	R	R	R	R
Dibenzofuran	10	R	R	R	R
2,4-Dinitrotoluene	10	R	R	R	R
Diethylphthalate	10	R	R	R	R
4-Chlorophenyl-Phenylether	10	R	R	R	R
Fluorene	10	R	R	R	R
4-Nitroaniline	25	R	R	R	R
4,6-Dinitro-2-Methylphenol	25	R	R	R	R
N-nitrosodiphenylamine	10	R	R	R	R

Footnotes:

CRQL -	Contract Required Quantitation Limit	U -	Value reported is the sample detection limit.
J -	Quantitation is approximate due to limitations identified in the quality control review.	R -	Value is rejected.
		UJ -	Sample detection limit is approximate due to limitations identified in the quality control review.

SEMIVOLATILE ORGANIC ANALYSIS
(mg/Kg)

SITE: NORWOOD PCB SITE
SDG NO.: 7018A-201
SUBCONTRACTOR: CF SYSTEMS CORPORATION
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

		UNTREATED SOIL SAMPLES			
		HIGH PCB CONCENTRATION		LOW PCB CONCENTRATION	
CF SYSTEMS' SAMPLE ID:		Norwood site high	Norwood site high-duplicate	Norwood site low	Norwood site low-duplicate
EPA SAMPLE NUMBER:		7018A-201	7018A-202	7018A-203	7018A-204
COMPOUND	CRQL				
4-Bromophenyl-Phenylether	10	R	R	R	R
Hexachlorobenzene	10	R	R	R	R
Pentachlorophenol	25	R	R	R	R
Phenanthrene	10	R	R	R	R
Anthracene	10	R	R	R	R
Di-n-butylphthalate	10	R	R	R	R
Fluoranthene	10	R	R	R	R
Pyrene	10	R	R	R	R
Butylbenzylphthalate	10	R	R	R	R
3,3'-Dichlorobenzidine	20	R	R	R	R
Benzo(a)anthracene	10	R	R	R	R
Chrysene	10	R	R	R	R
Bis(2-ethylhexyl)phthalate	10	R	R	R	R
Di-n-octylphthalate	10	R	R	R	R
Benzo(b)fluoranthene	10	R	R	R	R
Benzo(k)fluoranthene	10	R	R	R	R
Benzo(a)pyrene	10	R	R	R	R
Indeno(1,2,3-cd)pyrene	10	R	R	R	R
Dibenz(a,h)anthracene	10	R	R	R	R
Benzo(g,h,i)perylene	10	R	R	R	R
DILUTION FACTOR:		1	1	1	1
DATE SAMPLED:		1-15-92	1-15-92	1-15-92	1-15-92
DATE EXTRACTED:		3-10-92	3-10-92	3-10-92	3-10-92
DATE ANALYZED:		3-12-92	3-12-92	3-12-92	3-12-92

Footnotes:

CRQL - Contract Required Quantitation Limit
J - Quantitation is approximate due to limitations identified in the quality control review.
U - Value reported is the sample detection limit.
R - Value is rejected.
UJ - Sample detection limit is approximate due to limitations identified in the quality control review.

VOLATILE ORGANIC COMPOUNDS IN SOIL
ug/kg
(OLM01.0 SOW)

SITE: NORWOOD PCB SITE
SDG NO.: 7018A-101
SUBCONTRACTOR: CF SYSTEMS CORPORATION
TECHNOLOGY: BENCH-SCALE TESTS OF LIQUEFIED PROPANE EXTRACTION

		UNTREATED SOIL SAMPLES				
		HIGH PCB CONCENTRATION		LOW PCB CONCENTRATION		
CF SYSTEMS' SAMPLE ID:		Norwood site high	Norwood site high-duplicate	Norwood site low	Norwood site low-duplicate	TR-CF-01
EPA SAMPLE NUMBER:		7018A-101	7018A-102	7018A-103	7018A-104	7018A-105
QC DESIGNATION:		—FIELD DUPLICATE PAIR—		—FIELD DUPLICATE PAIR—		TRIP BLANK
COMPOUND	CRQL *					
Chloromethane	10	10 U	10 U	10 U	10 U	10 U
Bromomethane	10	10 U	10 U	10 U	10 U	10 U
Vinyl Chloride	5	5 U	5 U	5 U	5 U	5 U
Chloroethane	10	10 U	11 U	10 U	10 U	10 U
Methylene Chloride	10	10 U	10 U	10 U	10 U	18
Acetone	10	10 U	10 U	39 U	37 U	20
Carbon Disulfide	10	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethene	10	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane	10	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene(total)	10	10 U	10 U	10 U	10 U	10 U
Chloroform	10	10 U	10 U	10 U	10 U	17
1,2-Dichloroethane	10	10 U	10 U	10 U	10 U	10 U
2-Butanone	10	10 U	10 U	10 U	10 U	10 U
1,1,1-Trichloroethane	10	10 U	10 U	10 U	10 U	10 U
Carbon Tetrachloride	10	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	10	10 U	10 U	10 U	10 U	10 U
1,2-Dichloropropane	10	10 U	10 U	10 U	10 U	10 U
cis-1,3-Dichloropropene	10	10 U	10 U	10 U	10 U	10 U
Trichloroethene	10	10 U	10 U	10 U	10 U	10 U
Dibromochloromethane	10	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	10	10 U	10 U	10 U	10 U	10 U
Benzene	10	10 U	10 U	10 U	10 U	10 U
trans-1,3-Dichloropropene	10	10 U	10 U	10 U	10 U	10 U
Bromoform	10	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone	10	10 U	10 U	10 U	10 U	10 U
2-Hexanone	10	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene	10	10 U	10 U	10 U	10 U	10 U
Toluene	10	10 U	10 U	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane	10	10 U	10 U	10 U	10 U	10 U
Chlorobenzene	10	10 U	10 U	10 U	10 U	10 U
Ethylbenzene	10	10 U	10 U	10 U	10 U	10 U
Styrene	10	10 U	10 U	10 U	10 U	10 U
Total Xylenes	10	10 U	10 U	10 U	10 U	10 U
PERCENT SOLIDS:		95.6	95.9	98.0	98.0	AQ
DILUTION FACTOR:		1	1	1	1	1
SAMPLE WEIGHT (g):		5.0	5.0	5.0	5.0	5.0
PERCENT MOISTURE:		4.4	4.1	2.0	2.0	100
LEVEL:		LOW	LOW	LOW	LOW	LOW
DATE SAMPLED:		01/15/92	01/15/92	01/15/92	01/15/92	01/15/92
DATE ANALYZED:		01/22/92	01/22/92	01/22/92	01/22/92	01/22/92

Footnotes:

* - Medium soils are 120 times the value shown.
CRQL - Contract Required Quantitation Limit.
J - Quantitation is approximate due to limitations identified in the quality control review.
U - Value is the sample detection limit.
R - Value is rejected.
UJ - Sample detection limit is approximate due to limitations identified in the quality control review.

INORGANIC SOIL RESULTS

(mg/kg)

SITE: NORWOOD PCB SITE
SDG NO: 7018A-101
NTRACTOR: CF SYSTEMS CORPORATION
ECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

				UNTREATED SOIL SAMPLES			
				HIGH PCB CONCENTRATION		LOW PCB CONCENTRATION	
		CF SYSTEMS' SAMPLE ID:		Norwood site high	Norwood site high-duplicate	Norwood site low	Norwood site low-duplicate
		EPA SAMPLE NUMBER:		7018A-101	7018A-102	7018A-103	7018A-104
ANALYTES		CRDL (ug/L)**	IDL (ug/L)				
Aluminum	P	200	10	3860	3710	5620	5060
Antimony	P	60	38	— UJ	— UJ	4.8 J	— UJ
Arsenic	F	10	1.0	2.1 J	2.5 J	1.1 J	0.82 J
Barium	P	200	12	24.2	22.7	12.7	11.0
Beryllium	P	5	1.0	0.46	0.52	0.24	0.23
Cadmium	P	5	4.0	1.5	1.6	1.3	1.2
Calcium	P	5000	38	4310	5440	1030	865
Chromium	P	10	4.0	13.8 J	9.8 J	11.0 J	8.3 J
Cobalt	P	50	8.0	3.4	2.9	5.1	5.1
Copper	P	25	3.0	153 J	165 J	23.6 J	20.8 J
Iron	P	100	6.0	8820	9390	8680	8160
Lead	F	3	1.0	92.8 J	64.3 J	4.8 J	5.5 J
Magnesium	P	5000	49	1480	1370	3170	2820
Manganese	P	15	2.0	314 J	329 J	217 J	183 J
Mercury	C	0.2	0.2	—	—	—	—
Nickel	P	40	9.0	6.9	7.0	9.8	8.3
Potassium	P	5000	360	551	607	352	307
Selenium	F	5	1.0	— UJ	— UJ	— UJ	— UJ
Silver	P	10	7.0	2.0 J	1.8 J	1.2 J	0.77 J
Sodium	P	5000	241	56 U	61 U	83 U	75 U
Thallium	F	10	2.0	—	—	—	—
Vanadium	P	50	3.0	7.4	7.6	14.3	12.5
Zinc	P	20	3.0	90.9 J	97.4 J	41.2 J	37.8 J
% SOLIDS				95.6	95.9	97.9	97.5
ICP SAMPLE WT. (g)				1.25	1.14	1.12	1.20
FURN. SAMPLE WT. (g)				1.14	1.23	1.05	1.16
HG SAMPLE WT. (g)				0.20	0.21	0.24	0.29

Footnotes:

F – Furnace
P – ICP/Flame AE
CV – Cold Vapor
IDL – Instrument Detection Limit
CRDL – Contract Required Detection Limit

J – Quantitation is approximate due to limitations identified in the quality control review.
UJ – Quantitation limit is approximate due to limitations identified in the quality control review.
** – Specific sample detection limits are listed on the accompanying table.
U – The element was not detected. The reported result is a modified quantitation limit.

	Untreated Soil Sample Detection Limits mg/Kg			
ANALYTE	7018A-101 NORWOOD-HIGH	7018A-102 NORWOOD-HIGH DUPLICATE	7018A-103 NORWOOD-LOW	7018A-104 NORWOOD-LOW DUPLICATE
Aluminum	0.84	0.92	0.91	0.86
Antimony	3.2	3.5	3.5	3.2
Arsenic	0.09	0.08	0.09	0.09
Barium	1.0	1.1	1.1	1
Beryllium	0.08	0.09	0.09	0.09
Cadmium	0.34	0.37	0.36	0.34
Calcium	3.2	3.5	3.5	3.2
Chromium	0.34	0.37	0.36	0.34
Cobalt	0.67	0.73	0.73	0.68
Copper	0.75	0.27	0.27	0.26
Iron	0.50	0.55	0.55	0.51
Lead	0.09	0.08	0.09	0.09
Magnesium	4.1	4.5	4.5	4.2
nganese	0.17	0.18	0.18	0.17
Mercury	0.10	0.10	0.09	0.07
Nickel	0.75	0.82	0.82	0.77
Potassium	30	33	33	31
Selenium	0.09	0.08	0.10	0.09
Silver	0.59	0.64	0.64	0.6
Sodium	20	22	22	21
Thallium	0.28	0.25	0.29	0.26
Vanadium	0.75	0.27	0.27	0.26
Zinc	0.75	0.27	0.27	0.26

Pesticide/PCB Soil Analysis
ug/kg

SITE: NORWOOD PCB SITE
SDG NO.: 7018A-305
SUBCONTRACTOR: CF SYSTEMS CORPORATION
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

		TREATED SOIL SAMPLES	
		LOW PCB	HIGH PCB
CF SYSTEMS' SAMPLE ID:		Norwood site low-treated soil	Norwood site high-treated soil
EPA SAMPLE NUMBER:		7018A-305	7018A-306
COMPOUND	CRQL		
alpha-BHC	1.7	1.60 U	3.4 U
beta-BHC	1.7	0.78 J	3.4 U
delta-BHC	1.7	1.60 U	3.4 U
gamma-BHC(Lindane)	1.7	1.60 U	3.4 U
Heptachlor	1.7	1.60 U	3.4 U
Aldrin	1.7	1.60 U	3.4 U
Heptachlor Epoxide	1.7	1.60 U	3.4 U
Endosulfan I	1.7	1.60 U	3.4 U
Dieldrin	3.3	3.20 U	15.0 J
4,4'-DDE	3.3	3.20 U	6.6 U
Endrin	3.3	3.20 U	6.6 U
Endosulfan II	3.3	3.20 U	6.6 U
4,4'-DDD	3.3	3.20 U	6.6 U
Endosulfan Sulfate	3.3	3.20 U	6.6 U
4,4'-DDT	3.3	3.20 U	6.6 U
Methoxychlor	17.0	16.00 U	34.0 J
Endrin Ketone	3.3	3.20 U	6.6 U
Endrin Aldehyde	3.3	3.20 U	6.6 U
alpha-Chlordane	1.7	0.86 J	23.0 U
gamma-Chlordane	1.7	1.60 U	3.4 U
Toxaphene	170.0	160.00 U	340.0 U
Aroclor-1016	33.0	32.00 U	66.0 U
Aroclor-1221	67.0	64.00 U	130.0 U
Aroclor-1232	33.0	32.00 U	66.0 U
Aroclor-1242	33.0	32.00 U	66.0 U
Aroclor-1248	33.0	32.00 U	66.0 U
Aroclor-1254	33.0	44.00 J	980.0 J
Aroclor-1260	33.0	32.00 U	66.0 U
DILUTION FACTOR:		1	1
SAMPLE WEIGHT (g):		31.2	30
% MOISTURE:		*0*	0
LEVEL:		LOW	LOW
DATE SAMPLED:		1-22-92	1-28-92
DATE EXTRACTED:		1-29-92	1-31-92
DATE ANALYZED:		2-5-92	2-12-92

CRQL - Contract Required Quantitation Limit
J - Quantitation is approximate due to limitations identified in the quality control review.
U - Value is the sample detection limit.
R - Value is rejected.
UJ - Sample detection limit is approximate due to limitations identified in the quality control review.
D - The reported value is from the diluted analysis.

Semivolatile Soil Analysis

ug/kg

SITE: NORWOOD PCB SITE
SDG NO.: 7018A-205
SUBCONTRACTOR: CF SYSTEMS CORPORATION
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

		TREATED SOIL SAMPLES	
CF SYSTEMS' SAMPLE ID:		LOW PCB Norwood site low-treated soil	HIGH PCB Norwood site high-treated soil
EPA SAMPLE ID:		7018A-205	7018A-206
COMPOUND	CRQL *		
Phenol	330	350 J	180 U
bis(2-Chloroethyl) ether	330	390 U	180 U
2-Chlorophenol	330	390 U	180 U
1,3-Dichlorobenzene	330	390 U	180 U
1,4-Dichlorobenzene	330	390 U	180 U
1,2-Dichlorobenzene	330	390 U	180 U
2-Methylphenol	330	190 J	180 U
2,2'-oxybis(1-Chloropropane)	330	390 U	180 U
4-Methylphenol	330	400	230
N-Nitroso-di-n-propylamine	330	390 U	180 U
Hexachloroethane	330	390 U	180 U
Nitrobenzene	330	390 U	180 U
Isophorone	330	390 U	180 U
2-Nitrophenol	330	390 U	180 U
2,4-Dimethylphenol	330	94 J	180 U
bis(2-Chloroethoxy)methane	330	390 U	180 U
2,4-Dichlorophenol	330	390 U	180 U
1,2,4-Trichlorobenzene	330	390 U	47 J
Naphthalene	330	180 J	420
4-Chloroaniline	330	390 U	180 U
Hexachlorobutadiene	330	390 U	180 U
4-Chloro-3-Methylphenol	330	390 U	180 U
2-Methylnaphthalene	330	400	460
Hexachlorocyclopentadiene	330	390 U	180 U
2,4,6-Trichlorophenol	330	390 U	180 U
2,4,5-Trichlorophenol	800	980 U	440 U
2-Chloronaphthalene	330	390 U	180 U
2-Nitroaniline	800	980 U	440 U
Dimethylphthalate	330	390 U	180 U
Acenaphthylene	330	390 U	180 U
2,6-Dinitrotoluene	330	390 U	180 U
3-Nitroaniline	800	980 UJ	440 UJ
Acenaphthene	330	390 U	180 U
2,4-Dinitrophenol	800	980 U	440 U
4-Nitrophenol	800	980 U	440 U
Dibenzofuran	330	390 U	180 U
2,4-Dinitrotoluene	330	390 U	180 U
Diethylphthalate	330	390 U	180 U
4-Chlorophenyl-Phenylether	330	390 U	180 U
Fluorene	330	37 J	180 U
4-Nitroaniline	800	980 U	440 U
4,6-Dinitro-2-Methylphenol	800	980 U	440 U

Semivolatile Soil Analysis

ug/kg

SITE: NORWOOD PCB SITE
SDG NO.: 7018A-205
SUBCONTRACTOR: CF SYSTEMS CORPORATION
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

		TREATED SOIL SAMPLES	
CF SYSTEMS' SAMPLE ID:		LOW PCB Norwood site low-treated soil	HIGH PCB Norwood site high-treated soil
EPA SAMPLE ID:		7018A-205	7018A-206
COMPOUND	CRQL *		
N-nitrosodiphenylamine	330	390 U	180 U
4-Bromophenyl-Phenylether	330	390 U	180 U
Hexachlorobenzene	330	390 U	180 U
Pentachlorophenol	800	980 U	440 U
Phenanthrene	330	79 J	38 J
Anthracene	330	390 U	180 U
Carbazole	330	390 U	180 U
Di-n-butylphthalate	330	710	560
Fluoranthene	330	390 U	180 U
Pyrene	330	390 U	180 U
Butylbenzylphthalate	330	390 U	180 U
3,3'-Dichlorobenzidine	330	390 U	180 U
Benzo(a)anthracene	330	390 U	180 U
Chrysene	330	390 U	180 U
Bis(2-ethylhexyl)phthalate	330	390 U	180 U
Di-n-octylphthalate	330	390 U	180 U
Benzo(b)fluoranthene	330	390 U	180 U
Benzo(k)fluoranthene	330	390 U	180 U
Benzo(a)pyrene	330	390 U	180 U
Indeno(1,2,3-cd)pyrene	330	390 U	180 U
Dibenz(a,h)anthracene	330	390 U	180 U
Benzo(g,h,i)perylene	330	390 U	180 U
DILUTION FACTOR:		1	1
SAMPLE WEIGHT (g):		30	30
% MOISTURE:		15	5
LEVEL:		LOW	LOW
DATE SAMPLED:		1/22/92	1/28/92
DATE EXTRACTED:		1/27/92	2/03/92
DATE ANALYZED:		2/09/92	2/09/92

Footnotes:

CRQL - Contract Required Quantitation Limit
J - Quantitation is approximate due to limitations identified in the quality control review.
U - Value is the sample detection limit.
UJ - Sample detection limit is approximate due to limitations identified in the quality control review.

VOLATILE ORGANIC COMPOUNDS IN SOIL

(ug/kg)

SITE: NORWOOD PCB SITE
SDG NO.: 7018A-106
SUBCONTRACTOR: CF SYSTEMS CORPORATION
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

		TREATED SOIL SAMPLES			
		LOW PCB CONCENTRATION		HIGH PCB CONCENTRATION	
CF SYSTEMS' SAMPLE ID:		Norwood site low-treated soil	Trip Blank	Norwood site high-treated soil	Trip Blank
EPA SAMPLE NUMBER:		7018A-106	7018A-107	7018A-108	7018A-109
COMPOUND	CRQL *				
Chloromethane	10	10 U	10 U	1300 U	10 U
Bromomethane	10	10 U	10 U	1300 U	10 U
Vinyl Chloride	5	5 U	5 U	630 U	5 U
Chloroethane	10	10 U	10 U	1300 U	10 U
Methylene Chloride	10	10 U	20	1300 U	17
Acetone	10	1200	32 J	1900 U	8 J
Carbon Disulfide	10	10 U	10 U	1300 U	10 U
1,1-Dichloroethene	10	10 U	10 U	1300 U	10 U
1,1-Dichloroethane	10	10 U	10 U	1300 U	10 U
1,2-Dichloroethene(total)	10	10 U	10 U	1300 U	10 U
Chloroform	10	10 U	19	1300 U	14
1,2-Dichloroethane	10	10 U	10 U	1300 U	10 U
2-Butanone	10	55 U	6 J	4400 U	10 U
1,1,1-Trichloroethane	10	10 U	10 U	1300 U	10 U
Carbon Tetrachloride	10	10 U	10 U	1300 U	10 U
Bromodichloromethane	10	10 U	2 J	1300 U	1 J
1,2-Dichloropropane	10	10 U	10 U	1300 U	10 U
cis-1,3-Dichloropropene	10	10 U	10 U	1300 U	10 U
Trichloroethene	10	10 U	10 U	250 J	10 U
Dibromochloromethane	10	10 U	10 U	1300 U	10 U
1,1,2-Trichloroethane	10	10 U	10 U	1300 U	10 U
Benzene	10	410 J	10 U	1900	10 U
trans-1,3-Dichloropropene	10	10 U	10 U	1300 U	10 U
Bromoform	10	10 U	10 U	1300 U	10 U
4-Methyl-2-pentanone	10	10 U	10 U	1300 U	10 U
2-Hexanone	10	10 U	10 U	1300 U	10 U
Tetrachloroethene	10	10 U	10 U	1300 U	10 U
Toluene	10	3200	10 U	6600	10 U
1,1,2,2-Tetrachloroethane	10	10 U	10 U	1300 U	10 U
Chlorobenzene	10	10 U	10 U	190 J	10 U
Ethylbenzene	10	1500	10 U	1600	10 U
Styrene	10	10 U	10 U	1300 U	10 U
Total Xylenes	10	9200	10 U	9300	10 U
% SOLIDS		98.8	AQ	98.2	AQ
DILUTION FACTOR:		1	1		1
SAMPLE WEIGHT (g):		4		4	5
% MOISTURE:		0.2	100	1.80%	100
LEVEL:		MEDIUM/LOW	LOW	MEDIUM	LOW
DATE SAMPLED:		1/22/92	1/22/92	1/28/92	1/28/92
DATE ANALYZED:		1/24/92	1/23/92	1/30/92	1/29/92

Footnotes:

* -	Medium soils are 120 times the value shown.	U -	Value is the sample detection limit.
CRQL -	Contract Required Quantitation Limit.	R -	Value is rejected.
J -	Quantitation is approximate due to limitations identified in the quality control review.	UJ -	Sample detection limit is approximate due to limitations identified in the quality control review.

INORGANIC SOIL ANALYSIS
mg/kg

SITE: NORWOOD PCB SITE
SAS NO.: 7018A
UBCONTRACTOR: CF SYSTEMS CORPORATION
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

				TREATED SOILS	
				LOW PCB	HIGH PCB
		SAMPLE DESCRIPTION:		Norwood site low-treated soil	Norwood site high-treated soil
		EPA SAMPLE NUMBER:		7018A-106	7018A-108
ANALYTES		CRDL (ug/L) **	IDL (ug/L)		
Aluminum	P	200	—	6470 J	8970 J
Antimony	P	60	—	3.1 J	— UJ
Arsenic	F	10	—	1.5	2.7 J
Barium	P	200	—	22.1	54.3
Beryllium	P	5	—	0.31	0.77 J
Cadmium	P	5	—	1.9	2.1
Calcium	P	5000	—	1580 J	7870 J
Chromium	P	10	—	59.7 J	191 J
Cobalt	P	50	—	6.7	6.9 U
Copper	P	25	—	24.7 J	337 J
Iron	P	100	—	11300 J	13700 J
Lead	F	3	—	8.1 J	86.9 J
Magnesium	P	5000	—	3600 J	2260 J
Manganese	P	15	—	238	486
Mercury	CV	0.2	—	—	0.16
Nickel	P	40	—	41.9	129
Potassium	P	5000	—	752	1890
Selenium	F	5	—	—	— UJ
Silver	P	10	—	— UJ	0.97 J
Sodium	P	5000	—	209 U	305
Thallium	F	10	—	—	—
Vanadium	P	50	—	18.7	11.1
Zinc	P	20	—	43.7 J	159 J
% Solids				99.8%	99.8%

Footnotes:

F -	Furnace	U -	Value reported is the sample detection limit.
P -	ICP/Flame AE	J -	Quantitation is approximate due to limitations identified in the quality con
CV -	Cold Vapor	UJ -	Sample detection limit is approximate due to limitations identified in the quality control review.
C -	Colorimetric		
R -	Value is rejected.	IDL -	Instrument Detection Limit
		CRDL -	Contract Required Detection Limit
		** -	Specific sample detection limits are listed on the accompanying table.

Treated Soil Sample Detection Limits mg/Kg		
ANALYTE	7018A-106 Low Treated	7018A-108 High Treated
Aluminum	0.8	1.8
Antimony	3.1	3.4
Arsenic	0.2	0.2
Barium	1.0	1.4
Beryllium	0.1	0.2
Cadmium	0.3	0.3
Calcium	3.1	6.8
Chromium	0.3	0.7
Cobalt	0.7	0.8
Copper	0.2	0.3
Iron	0.5	0.8
Lead	0.1	0.1
Magnesium	4.0	2.2
Manganese	0.2	0.3
Mercury	0.1	0.1
Nickel	0.7	1.9
Potassium	29.5	35.0
Selenium	0.1	0.1
Silver	0.6	0.3
Sodium	19.8	13.7
Thallium	0.3	0.1
Vanadium	0.2	0.6
Zinc	0.2	0.5

Oil Semivolatile Organics Analysis
mg/Kg

SITE: NORWOOD PCB SITE
SDG NO.: 7018A-901
SUBCONTRACTOR: CF SYSTEMS CORPORATION
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

		EXTRACTED OIL SAMPLES			
		LOW PCB		HIGH PCB	
CF SYSTEMS' SAMPLE ID:		Oil Extracted from Low Soil		Oil Extracted from High Soil	
EPA SAMPLE ID:		7018A-901		7018A-902	
COMPOUND	CRQL				
Phenol	20	110		370	J
bis(2-Chloroethyl) ether	20	100	U	100	UJ
2-Chlorophenol	20	100	U	100	UJ
1,3-Dichlorobenzene	20	100	U	100	UJ
1,4-Dichlorobenzene	20	100	U	100	UJ
Benzyl Alcohol	20	100	U	100	UJ
1,2-Dichlorobenzene	20	100	U	100	UJ
2-Methylphenol	20	100	U	100	UJ
bis (2-Chloroisopropyl)ether	20	100	U	100	UJ
4-Methylphenol	20	100	U	200	J
N-Nitroso-di-n-propylamine	20	100	U	100	UJ
Hexachloroethane	20	100	U	100	UJ
Nitrobenzene	20	100	U	100	UJ
Isophorone	20	100	U	100	UJ
2-Nitrophenol	20	100	U	100	UJ
2,4-Dimethylphenol	20	100	U	100	UJ
Benzoic Acid	100	500	U	500	UJ
bis(2-Chloroethoxy)methane	20	100	U	100	UJ
2,4-Dichlorophenol	20	100	U	100	UJ
1,2,4-Trichlorobenzene	20	100	U	560	J
Naphthalene	20	310		1500	J
4-Chloroaniline	20	100	U	100	UJ
Hexachlorobutadiene	20	100	U	100	UJ
4-Chloro-3-Methylphenol	20	100	U	100	UJ
2-Methylnaphthalene	20	450		1500	J
Hexachlorocyclopentadiene	20	100	U	100	UJ
2,4,6-Trichlorophenol	20	100	U	100	UJ
2,4,5-Trichlorophenol	100	500	U	500	UJ
2-Chloronaphthalene	20	100	U	100	UJ
2-Nitroaniline	100	500	U	500	UJ
Dimethylphthalate	20	100	U	100	UJ
Acenaphthylene	20	100	U	100	UJ
2,6-Dinitrotoluene	20	100	U	100	UJ
3-Nitroaniline	20	500	U	500	UJ
Acenaphthene	20	15	J	100	UJ
2,4-Dinitrophenol	100	500	U	500	UJ
4-Nitrophenol	100	500	U	500	UJ
Dibenzofuran	20	100	U	100	UJ
2,4-Dinitrotoluene	20	100	U	100	UJ
Diethylphthalate	20	100	U	100	UJ

Oil Semivolatile Organics Analysis
mg/Kg

SITE: NORWOOD PCB SITE
SDG NO.: 7018A-901
SUBCONTRACTOR: CF SYSTEMS CORPORATION
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION

		EXTRACTED OIL SAMPLES	
		LOW PCB	HIGH PCB
CF SYSTEMS' SAMPLE ID:		Oil Extracted from Low Soil	Oil Extracted from High Soil
EPA SAMPLE ID:		7018A-901	7018A-902
COMPOUND	CRQL		
4-Chlorophenyl-Phenylether	20	100 U	100 UJ
Fluorene	20	23 J	52 J
4-Nitroaniline	100	500 U	500 UJ
4,6-Dinitro-2-Methylphenol	100	500 U	500 UJ
N-nitrosodiphenylamine	20	100 U	100 UJ
4-Bromophenyl-Phenylether	20	100 U	100 UJ
Hexachlorobenzene	20	100 U	100 UJ
Pentachlorophenol	100	500 U	500 UJ
Phenanthrene	20	67 J	100 J
Anthracene	20	14 J	100 UJ
Di-n-butylphthalate	20	100 U	100 UJ
Fluoranthene	20	100 U	100 UJ
Pyrene	20	15 J	100 UJ
Butylbenzylphthalate	20	100 U	100 UJ
Benzo(a)anthracene	20	100 U	100 UJ
Chrysene	20	100 U	100 UJ
3,3'-Dichlorobenzidine	20	100 U	100 UJ
Bis(2-ethylhexyl)phthalate	20	100 U	100 UJ
Di-n-octylphthalate	20	100 U	100 UJ
Benzo(b)fluoranthene	20	100 U	100 UJ
Benzo(k)fluoranthene	20	100 U	100 UJ
Benzo(a)pyrene	20	100 U	100 UJ
Indeno(1,2,3-cd)pyrene	20	100 U	100 UJ
Dibenz(a,h)anthracene	20	100 U	100 UJ
Benzo(g,h,i)perylene	20	100 U	100 UJ
DILUTION FACTOR:		5	5
DATE SAMPLED:		1-28-92	1-28-92
DATE EXTRACTED:		1-31-92	1-31-92
DATE ANALYZED:		2-04-92	2-04-92

Footnotes:

CRQL – Contract Required Quantitation Limit

J – Quantitation is approximate due to limitations identified in the quality control review.

U – Value reported is the sample detection limit.

R – Value is rejected.

UJ – Sample detection limit is approximate due to limitations identified in the quality control review.

D – The reported value is from the diluted analysis.

Summary of Liquefied Propane Extraction Results

Low Concentration PCB Sample

SITE: NORWOOD PCB SITE
TECHNOLOGY: LIQUEFIED PROPANE EXTRACTION
SUBCONTRACTOR: CF SYSTEMS

SAMPLE DESIGNATION	Untreated Low	Untreated Low Duplicate	Treated Low	Percent Reduction
VOLATILES				
2-Butanone	10 U	10 U	4100	
Trichloroethene	10 U	10 U	1300	
Benzene	10 U	10 U	410	
Toluene	10 U	10 U	3200	
Ethylbenzene	10 U	10 U	1500	
Total Xylenes	10 U	10 U	9200	
Chlorobenzene	10 U	10 U	1300	
SEMIVOLATILES				
Phenol	R	R	0.350	
2-Methylphenol	R	R	0.190 J	
4-Methylphenol	R	R	0.400	
2,4-Dimethylphenol	R	R	0.094 J	
1,2,4-Trichlorobenzene	R	R	0.390 U	
Naphthalene	R	R	0.180 J	
2-Methylnaphthalene	R	R	0.400	
Fluorene	R	R	0.037 J	
Phenanthrene	R	R	0.079 J	
Di-n-butylphthalate	R	R	0.710	
PCBS				
Aroclor 1254	789 J	796 J	0.044 J	99.99

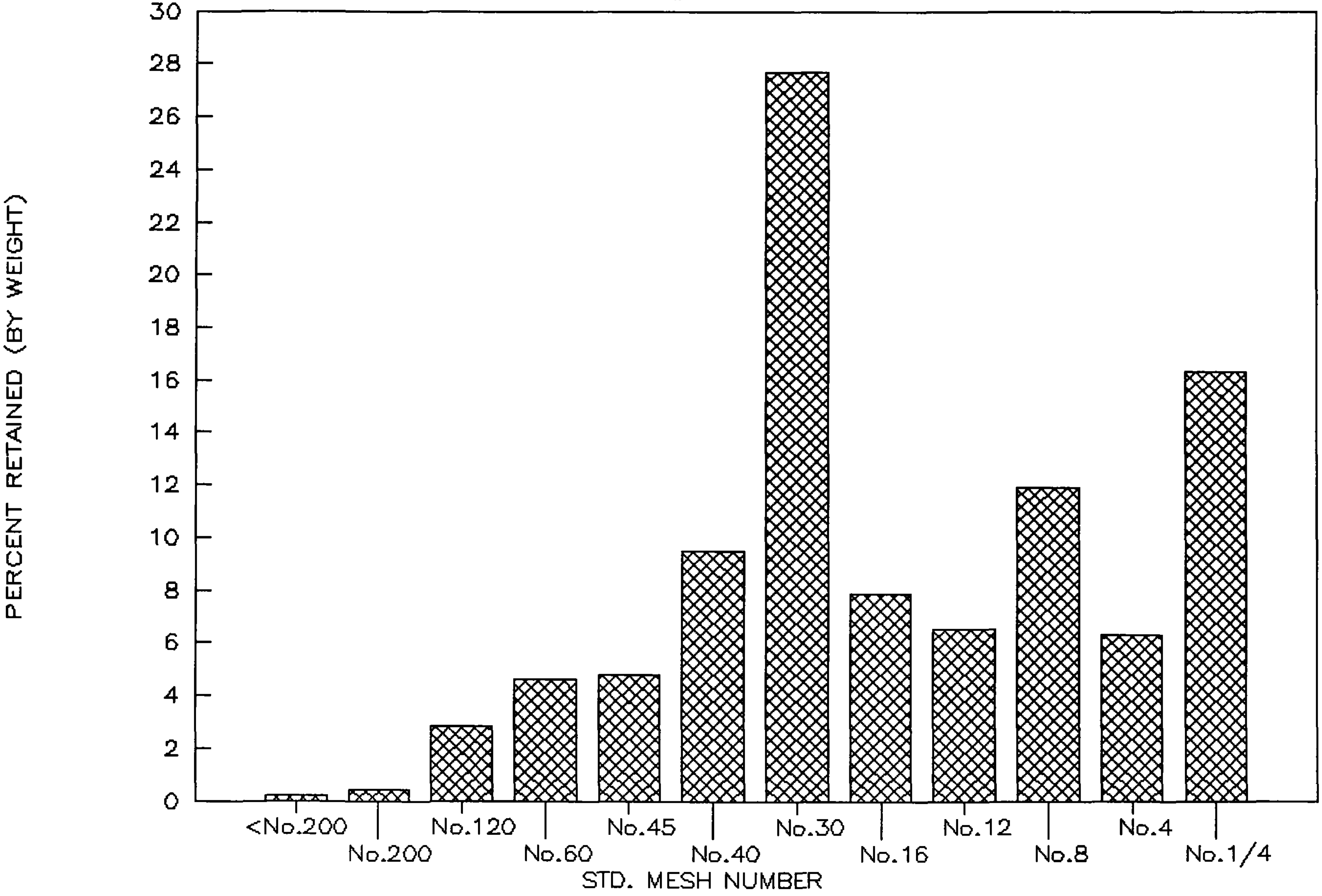
Volatiles concentrations are in ug/Kg.

Semivolatiles and PCB concentrations are in mg/Kg.

APPENDIX D

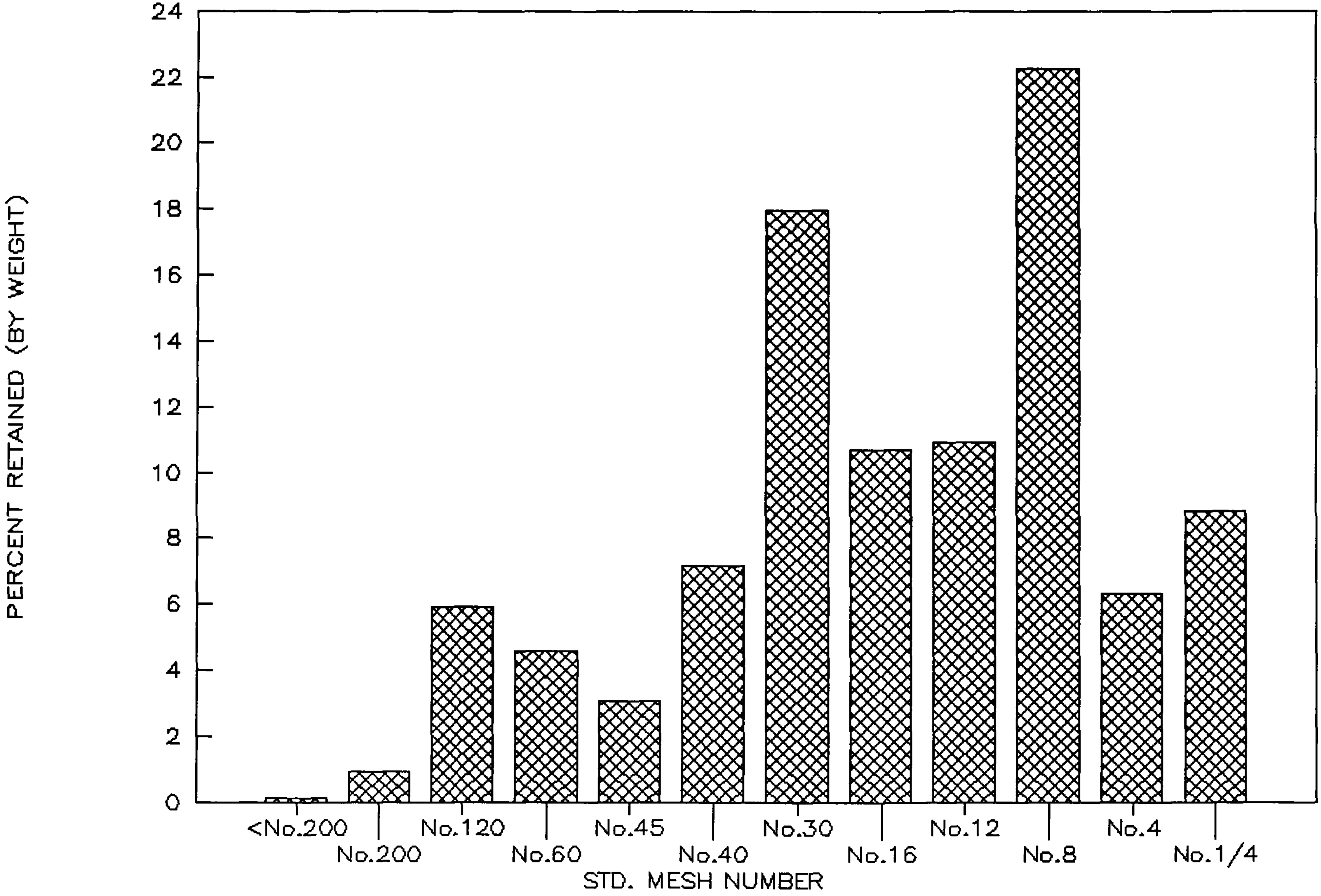
SIZE DISTRIBUTION NORWOOD-LOW

SCF# 574 LOT# 0110101C FIG.1



SIZE DISTRIBUTION NORWOOD-HI

SCF# 574 LOT# 0110101C FIG.2



CF SYSTEMS BENCH SCALE EXTRACTION REPORT

DATE: 01-28-92

CLIENT: Metcalf & Eddy, Inc
LOCATION: Woburn, MA

CFS SAMPLE NO: SCF# 574
SAMPLE NAME: NORWOOD-LOW LOT# 0110101C

SIZE CLASSIFICATION

MESH (#)	SIEVE OPENING (mm)	SIEVE OPENING (inch)	WEIGHT RETAINED (gm)	PERCENT RETAINED (%)
<No.200	0.0000	0.0000	4.2300	0.2021
No.200	0.0750	0.0029	9.1400	0.4367
No.120	0.1250	0.0049	59.1700	2.8273
No.60	0.2500	0.0098	96.8800	4.6292
No.45	0.3550	0.0139	100.8000	4.8165
No.40	0.4250	0.0165	198.9700	9.5073
No.30	0.6000	0.0234	578.9300	27.6628
No.16	1.1800	0.0469	164.4700	7.8588
No.12	1.7000	0.0661	136.1800	6.5070
No.8	2.3600	0.0937	248.5900	11.8783
No.4	4.7500	0.1870	131.2300	6.2705
No.1/4	6.3000	0.2500	342.0300	16.3431

TOTAL SAMPLE RETAINED 2070.62 98.93970

TOTAL SAMPLE USED 2092.81

NOTE:

1.1 % of the original sample was lost during sieving.

CF SYSTEMS BENCH SCALE EXTRACTION REPORT DATE: 01-29-92

CLIENT:	Metcalf & Eddy, Inc	
LOCATION:	Woburn, MA	
CFS SAMPLE NO:	SCF# 574	
SAMPLE NAME:	NORWOOD-HI	LOT# 0331501C

SIZE CLASSIFICATION

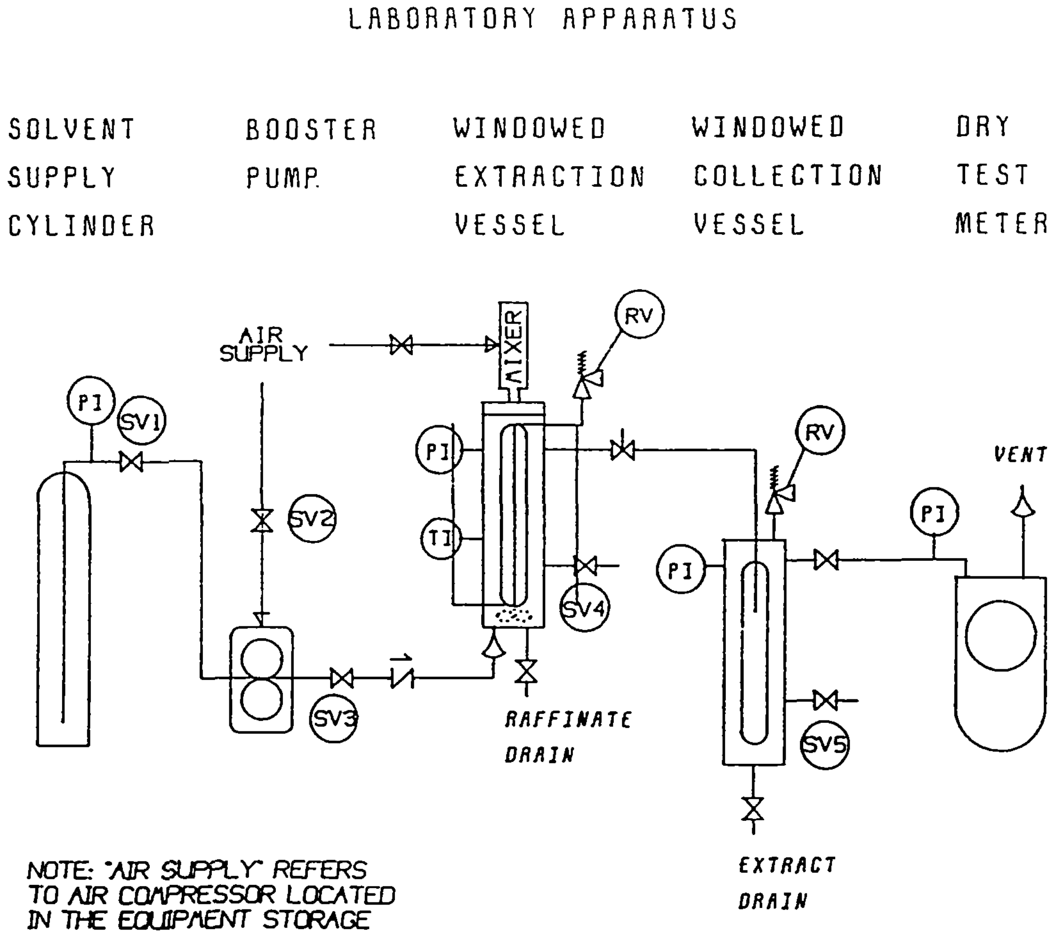
MESH (#)	SIEVE OPENING (mm)	SIEVE OPENING (inch)	WEIGHT RETAINED (gm)	PERCENT RETAINED (%)
<No.200	0.0000	0.0000	2.3400	0.1251
No.200	0.0750	0.0029	16.9400	0.9057
No.120	0.1250	0.0049	111.0500	5.9374
No.60	0.2500	0.0098	86.0700	4.6018
No.45	0.3550	0.0139	56.9500	3.0449
No.40	0.4250	0.0165	134.0000	7.1645
No.30	0.6000	0.0234	335.6000	17.9433
No.16	1.1800	0.0469	200.1000	10.6986
No.12	1.7000	0.0661	203.8300	10.8980
No.8	2.3600	0.0937	416.0700	22.2457
No.4	4.7500	0.1870	118.4200	6.3315
No.1/4	6.3000	0.2500	164.9300	8.8182

TOTAL SAMPLE RETAINED	1846.3	98.7147
TOTAL SAMPLE USED	1870.34	

NOTE:

1.3 % of the original sample was lost during sieving.

APPENDIX E



NOTE: "AIR SUPPLY" REFERS TO AIR COMPRESSOR LOCATED IN THE EQUIPMENT STORAGE ROOM. COMPRESSOR SHUTOFF SWITCH IS LOCATED ON WALL NEXT TO COMPRESSOR.

LEGEND

PI - PRESSURE INDICATOR
TI - TEMPERATURE INDICATOR
RV - RELIEF VALVE
SV - SAFETY VALVE
⋈ - BALL VALVE
↗ - CHECK VALVE

BENCH-SCALE
TEST APPARATUS

SIMPLIFIED PROCESS
FLOW DIAGRAM

CF SYSTEMS
A MORRISON KNUDSEN CORP.
BOSTON TECHNOLOGY CENTER

DRAWN BY	DATE		REV.
[illegible]	[illegible]		1

The On-Site Remediation Solution

For more information contact us at one of the following office locations:

3D Gill Street
Woburn, Massachusetts 01801
Telephone: 617/937-0800
FAX: 617/937-5610

Morrison Knudsen Plaza
P.O. Box 73
Boise, Idaho 83729
Telephone: 208/386-5469
FAX: 208/386-6871

7100 E. Belleview, Suite 300
Englewood, Colorado 80111
Telephone: 303/793-5002
FAX: 303/290-0238

MK-Ferguson Plaza
1500 West 3rd Street
Cleveland, Ohio 44113-1406
Telephone: 216/523-5286
FAX: 216/523-5201

180 Howard Street
San Francisco, California
Telephone: 415/442-7390
FAX: 415/442-7673

MORRISON KNUDSEN CORPORATION

serving private- and public-sector clients worldwide in the management of hazardous and radioactive wastes, municipal solid wastes, and environmental programs, building on its tradition of engineering and construction since 1912.

- Site/facility investigations and feasibility studies
- Engineering or facility modifications or retrofitting
- Remedial design
- Implementation of corrective measures and remedial actions
- Turnkey development and operation of waste facilities

Appendix B

APPENDIX B

TREATABILITY STUDY FINAL REPORT

PREPARED BY

RESOURCES CONSERVATION COMPANY

B.E.S.T.® BENCH-SCALE TREATABILITY FINAL REPORT

NORWOOD SITE

Norwood, MA

for

METCALF & EDDY
Wakefield, MA

Project # 92-004609-052

August, 1992

Prepared by
RESOURCES CONSERVATION COMPANY
3006 Northup Way
Bellevue, WA 98004-1407

® Registered in the U.S. Patent Office

RCC Resources Conservation Company

3006 Northup Way
Bellevue, Washington
98004-1407

Phone: 206 828-2400
Telex: 350166 RCC SEA
Fax: 206 828-0526

Ms. Barbara Weir
Metcalf & Eddy
30 Harvard Mill Square
Wakefield, MA 01880

August 4, 1992

Subject: B.E.S.T.® Process Bench-Scale Treatability Test Final Report
Norwood PCB Contaminated Site, Project Number 92-004609-052

Dear Ms. Weir:

Bench-scale treatability test results clearly demonstrate that Resources Conservation Company's (RCC) B.E.S.T.® solvent extraction process can successfully treat PCB contaminated soils from the Norwood Site. The final report describing the results of the B.E.S.T. process bench-scale treatability test on two samples from the site is enclosed. The final report incorporates your comments to the draft report sent to RCC on June 8, 1992.

The high PCB sample contained 10,000 mg/kg PCBs. After treatment, the PCB concentration was 9.9 mg/kg, (4.6 mg/kg CLP result). The low PCB sample contained 680 mg/kg PCBs. After treatment, the PCB concentration was 0.3 mg/kg, (0.2 mg/kg CLP result). The PCB removal efficiency from both samples was greater than 99.9% using either RCC or CLP lab data. The treated solids from both samples readily passed the TCLP test for metals. The concentration of carcinogenic polynuclear aromatic hydrocarbons (cPAHs) in both the treated and both the untreated samples were below RCC quantitation limits.

Based on these test results, RCC estimates that 30,000 cubic yards of high PCB concentration soil found at this site can be treated with the B.E.S.T. solvent extraction process at a cost of $258 per ton. The same volume of low PCB concentration soil can be treated at a cost of $208 per ton. Operating, mob/demob and capital expenses, processing capacity, and the estimated number of days on site, are as follows:

	High PCB Soil	Low PCB Soil
Operating charges	= $202/ton	= $162/ton
Mob/Demob	= $ 17/ton	= $ 16/ton
Capital Recovery	= $ 39/ton	= $ 30/ton
TOTAL	$258/ton	$208/ton
Processing Capacity	120 tons/day	150 tons/day
Days On Site	355	310

The material bulk densities used in formulating these cost estimates are 1.3 tons/cubic yard for the high PCB material and 1.4 tons/cubic yard for the low PCB material. These cost estimates are based on the bench-scale treatability test results and assume that 30,000 cubic yards will be treated with the B.E.S.T. process. These cost estimates are on a "hopper-to-hopper" basis. The treatment cost does not include site excavation, civil work, applicable taxes, pre-screening of feed, or overall site management. The cost for dechlorination/destruction of the recovered oil is also not included in the treatment cost. An allowance for mobilization/demobilization is included in the treatment cost. The cost estimate assumes the use of a mobile B.E.S.T. Model 415 unit. This unit could be available in the Fall of 1993 if ordered by January 4, 1993.

RCC estimates that the cost to dispose of the oil produced from treating 30,000 cubic yards of the Low PCB sample to be $46,000 or $1 per ton of sample. The estimated cost to dispose of the oil produced from processing 30,000 cubic yards of the High PCB sample is $595,000 or $15 per ton of sample. This is based on a unit processing cost of $3.50 per gallon of oil for on-site dechlorination followed by off-site incineration via cement kiln. The product oil is expected to be readily dechlorinated by commercial processes such as KPEG since this oil will be low in water and solids content.

If you have any questions, please call me at (301) 596-6066 or Jim Nowak at (206) 828-2400.

Sincerely,

RESOURCES CONSERVATION COMPANY

James C. Nowak for

Lanny D. Weimer
Manager, Business Development

Attachment

SS/Norwood

B.E.S.T.® BENCH-SCALE TREATABILITY TEST
FINAL REPORT

Norwood Site

TABLE OF CONTENTS

TABLE OF CONTENTS

(continued)

B.E.S.T.® BENCH-SCALE TREATABILITY TEST
FINAL REPORT

Metcalf & Eddy
Norwood Site

I. INTRODUCTION

SUMMARY

A bench-scale treatability test of the B.E.S.T. solvent extraction process was conducted on two polychlorinated biphenyl (PCB) contaminated soil samples from the Norwood site. A summary of the bench-scale treatability test results follows:

BENCH-SCALE TREATABILITY TEST RESULTS

Sample	Feed PCB Content, mg/kg (dry basis)		Product Solids PCB Content, mg/kg (dry basis)	
	RCC Lab	CLP Lab	RCC Lab	CLP Lab
Low PCB	680	750	0.3	0.2
High PCB	10,000	8,600	9.9	4.6

As can be seen from the data above, the PCB residual of the treated solids (Product Solids) was below the target level of 10 mg/kg, yielding a PCB removal efficiency of 99.9% for both the Low and High PCB samples using either RCC or CLP lab data.

The total concentration of the seven carcinogenic polynuclear aromatic hydrocarbon compounds (cPAHs) was below quantitation limits in both the treated and untreated samples. Therefore, the cPAH removal efficiency cannot be calculated. The treated solids readily passed the TCLP Toxicity Test for the leaching of metals.

Treating 30,000 cubic yards of the Low PCB sample would produce an estimated 13,000 gallons of product oil. Treating 30,000 cubic yards of the High PCB sample would produce an estimated 170,000 gallons of product oil.

RESOURCES CONSERVATION COMPANY (RCC) BACKGROUND

Resources Conservation Company (RCC), established in 1971, is a multi-discipline engineering services company that specializes in the design of hazardous waste and wastewater treatment systems. RCC is a wholly owned subsidiary of the Halliburton Company whose headquarters are in Dallas, Texas. RCC's main office is located in Bellevue, Washington. RCC's treatability laboratory is located near the main office.

THE B.E.S.T. SOLVENT EXTRACTION PROCESS

The B.E.S.T. process is a patented solvent extraction technology using triethylamine as the solvent. Triethylamine is an aliphatic amine that is produced by reacting ethyl alcohol and ammonia.

Triethylamine is an excellent solvent for treating hazardous wastes because it exhibits several characteristics that enhance its use in the solvent extraction system. These characteristics include:

- A high vapor pressure; therefore, the solvent can be easily recovered from the extract solution (oil, water, and solvent) via steam stripping.

- Formation of a low boiling temperature azeotrope with water, allowing the solvent to be recovered from the oil to very low residual levels (typically less than 100 ppm).

- A low heat of vaporization (1/7 of water), allowing solvent to be recovered from the treated solids with very low energy input.

- The ability to treat materials with a wide variety of water content, including high water content sediments, without loss of process performance or throughput. Triethylamine is completely miscible with water below 40 degrees F and is an excellent dewatering agent.

- Triethylamine is alkaline (pH=10); therefore, some heavy metals are converted to the hydroxide form, precipitate and exit the system with the treated solids.

- Triethylamine readily biodegrades. Data available in EPA document EPA Data ORD USEPA Washington, D.C. 20460, Feb. 1983 (reprint) Manual, Volume 1 600/2-82001a, shows that a level of 200 ppm triethylamine in water was degraded completely within 11 hours by the common soil bacteria *aerobacter*.

A block diagram of the B.E.S.T. process is presented in Figure 1. The first extraction of the contaminated feed is conducted at low temperatures (about 40 degrees F). At this temperature, triethylamine is soluble with water. Therefore, the extract solution contains most of the water in the feed sample. If the first extract solution contains sufficient water to allow a phase separation of the solvent and water, the extract is heated to a temperature above the miscibility limit (130 degrees F). At this temperature, the extract solution separates into two distinct phases, a solvent/oil phase and a water phase. The two phases are separated by gravity and decanted. The extract solution from the subsequent stages is combined with the decanted solvent/oil phase from the first extraction stage. The solvent is recovered by steam stripping and evaporation.

RCC Resources Conservation Company

B.E.S.T. PROCESS CONCEPT

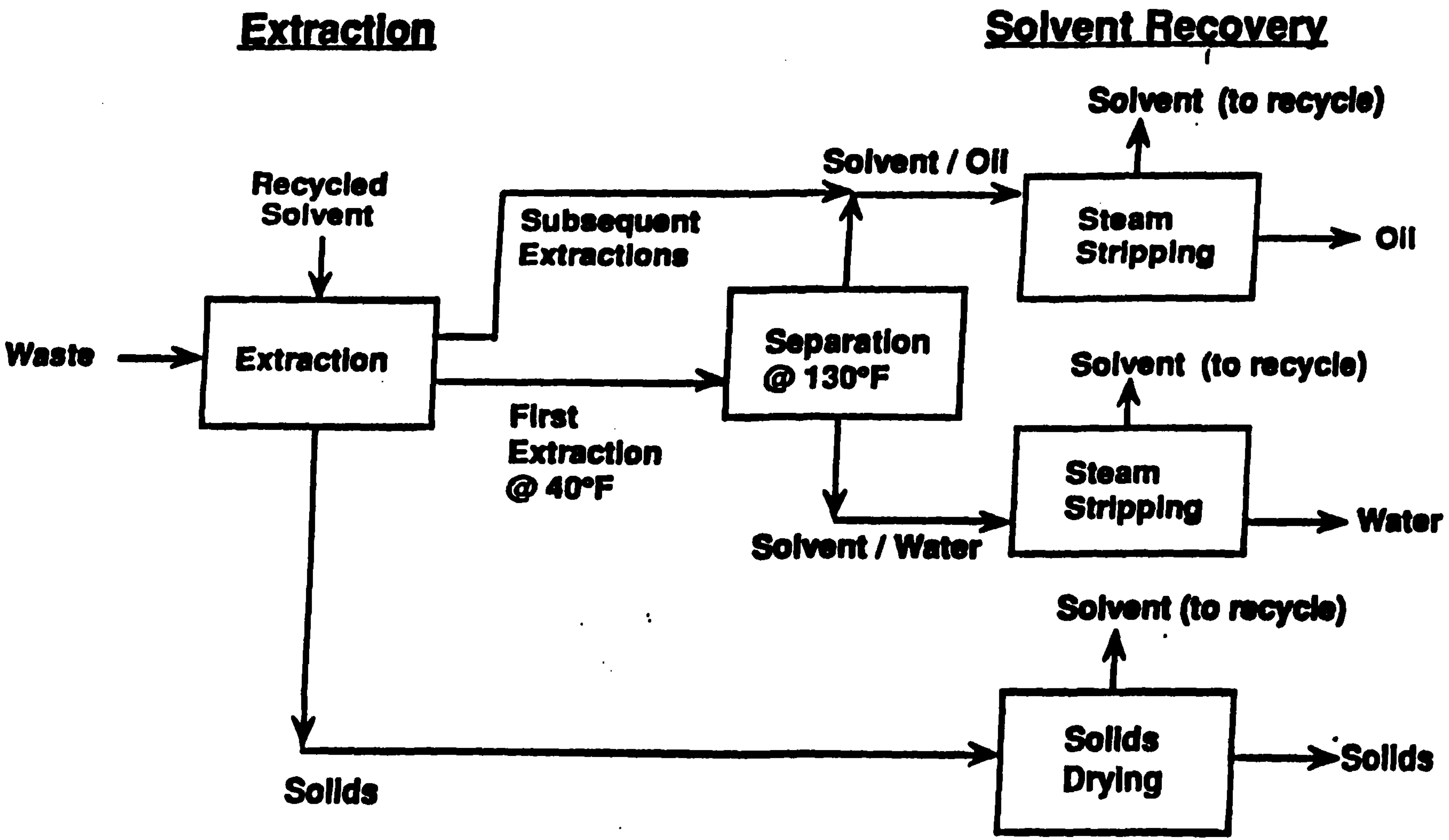


Figure 1

Triethylamine is removed from the treated solids by indirect steam heating. A small amount of steam may be added directly to the dryer vessel to provide the water required to form the low boiling temperature azeotrope. Residual solvent biodegrades readily, allowing the treated solids to be used as backfill at the site in some cases. However, the treated solids will be sterile as they exit the B.E.S.T. process. Therefore, for triethylamine biodegradation to occur, the treated solids would have to be inoculated with soil bacteria by mixing in untreated clean soil.

The B.E.S.T. process operates near ambient pressure and temperature and at an alkaline pH. Temperatures of the liquid streams within the unit vary from about 40 to 170 degrees F, and elevated pressures are not required. This gives the B.E.S.T. process the advantage that it can use standard off-the-shelf processing equipment.

EQUIPMENT DESCRIPTION

RCC proposes using a B.E.S.T. Model 415 unit to treat the PCB contaminated material at this site. A flow schematic for the B.E.S.T. Model 415 is presented in Figure 2.

The B.E.S.T. Model 415 uses four extractor/dryer vessels to extract and dry the PCB contaminated materials. The extractor/dryer is a horizontal, steam-jacketed vessel that allows for solvent contacting, mixing, solids/solvent separation, solids drying, and solids conditioning in one vessel. The extractor/dryer vessel is an off-the-shelf assembly that has a long history of reliable performance in a wide range of process industry applications.

Contaminated materials are excavated from the site and screened to one inch maximum dimension. The screened material is then loaded into top-loading, bottom discharge hoppers. An overhead crane facilitates the positioning and lowering of the loaded hopper onto the loading port of the extractor/dryer unit. The flow of material through the extractor/dryer system is shown in Figure 3. Treated solids are discharged into hoppers and transported to a holding area.

Figure 4 provides the standard Site Plan for RCC's B.E.S.T. Model 415.

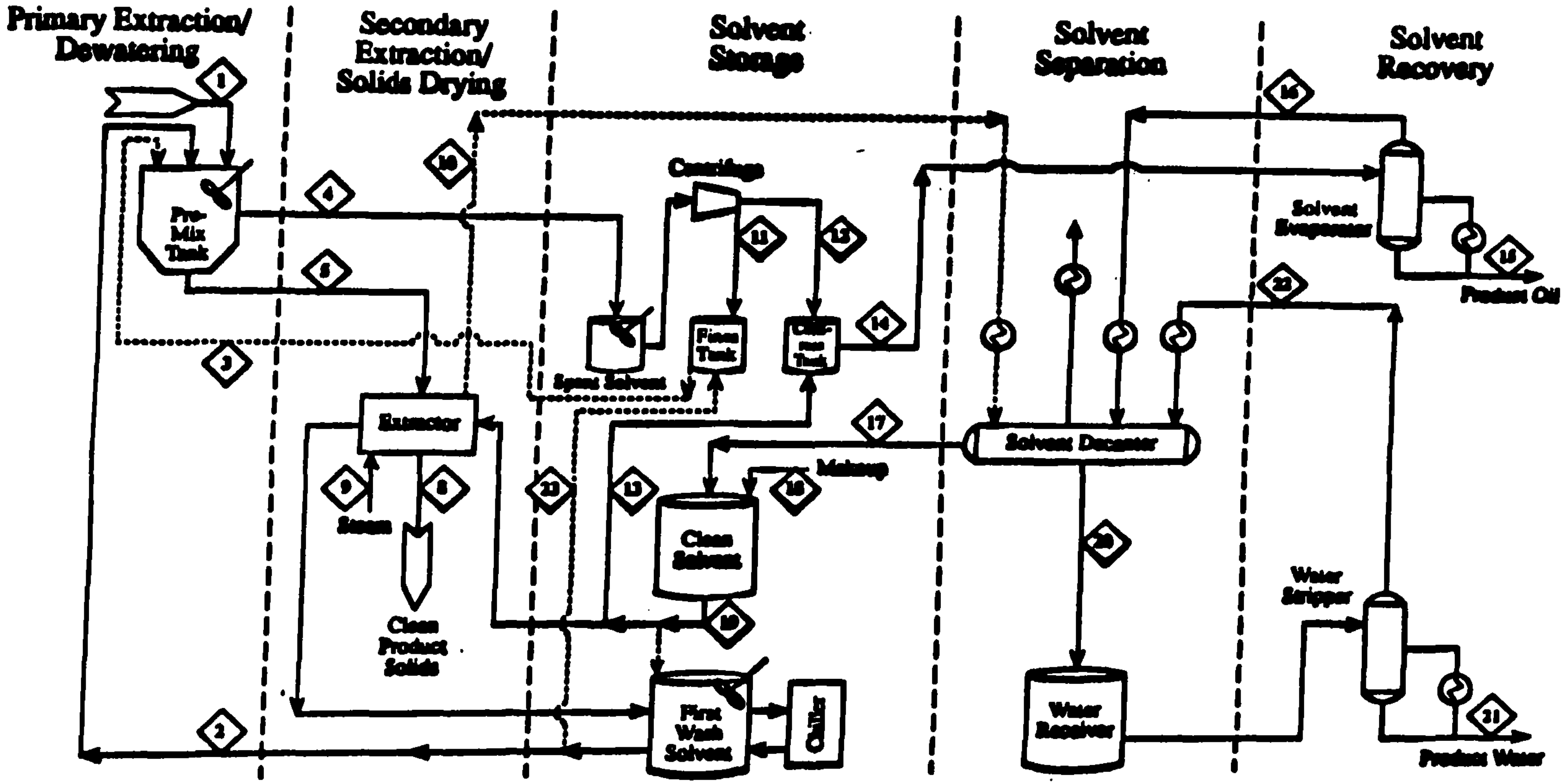
AIR EMISSIONS AND ABATEMENT

The B.E.S.T. process uses one vent to the atmosphere. The vent provides pressure equalization for the nitrogen blanketing system and a purge for noncondensible gases from process condensers. RCC uses a refrigerated condenser and an auxiliary water scrubber system to reduce solvent emissions from the vent.

During a performance test in February 1987 at the General Refining Superfund Site cleanup, a third party reported the following emissions from the B.E.S.T. process vent at a time when the auxiliary water scrubber was not in operation:

	Emission Rate, lb/hr
Benzene	0.00114
Mercury	< 0.000000043
Toluene	0.000614
Triethylamine	0.0954
Xylene	0.000884

RCC expects air emissions from future operations to be lower than these results. The use of the auxiliary water scrubber will lower the triethylamine release rate even further. RCC now utilizes activated carbon filters on the single vent line to achieve zero emissions of triethylamine.



Resources Conservation Company

PROCESS FLOW SCHEMATIC

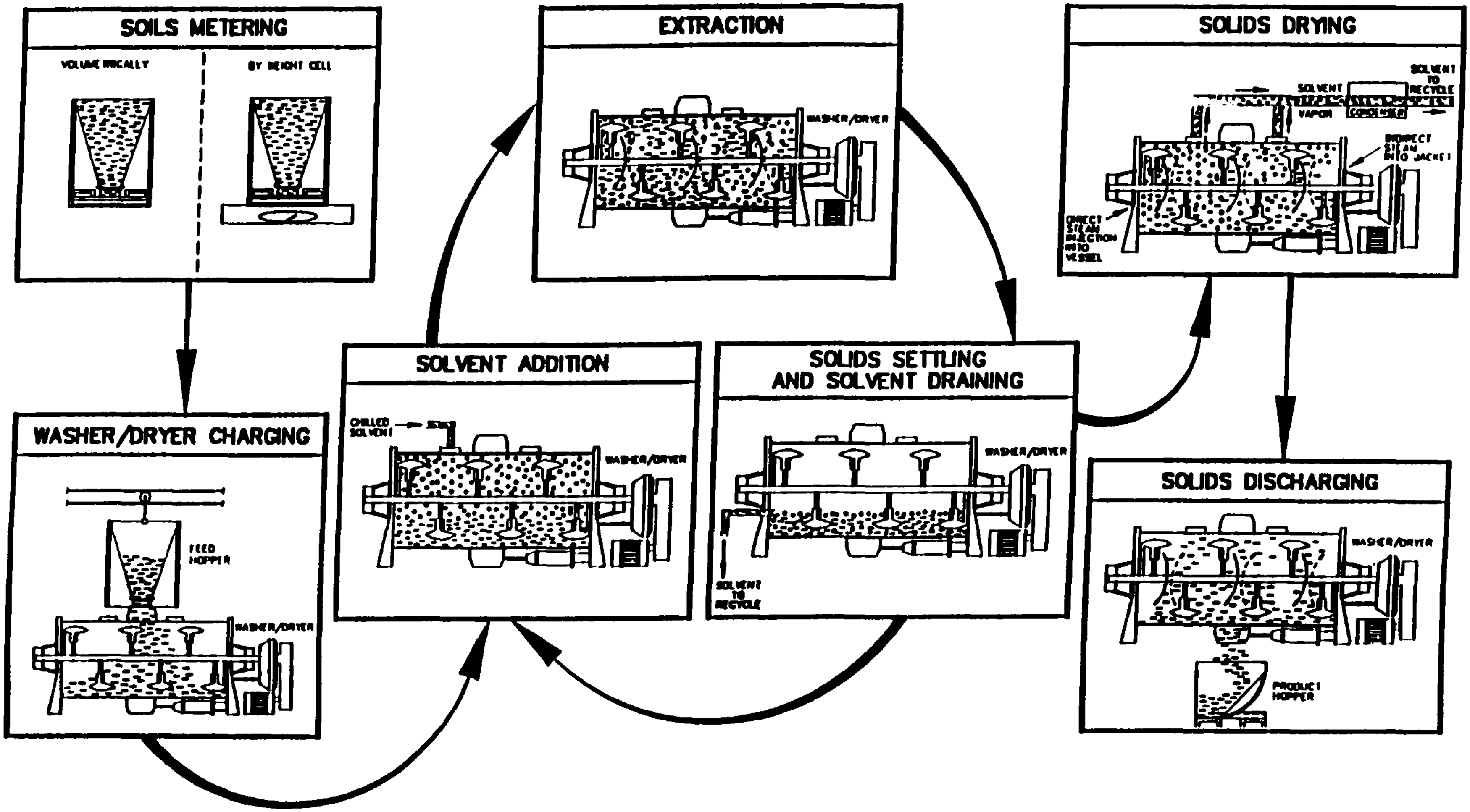
B.E.S.T. MODEL 415

SOILS TREATMENT UNIT

Figure 2

RCC Resources Conservation Company

B.E.S.T.® PROCESS STEPS
BATTERY LIMITS OPERATION



SOILS METERING

WASHER/DRYER CHARGING

SOLVENT ADDITION

EXTRACTION

SOLIDS SETTLING AND SOLVENT DRAINING

SOLIDS DRYING

SOLIDS DISCHARGING

Figure 3

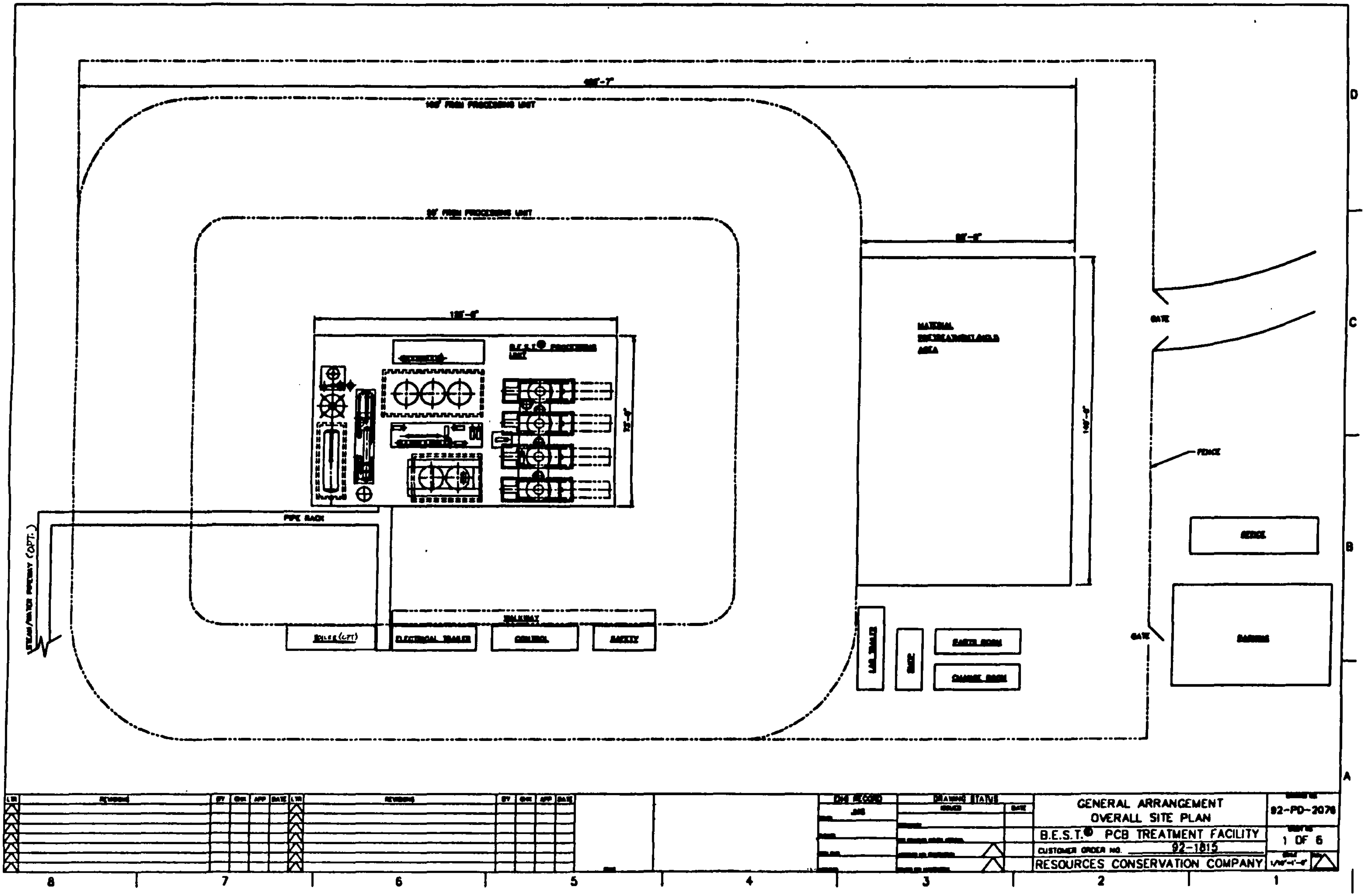

FROM PROCESSING UNIT
FROM PROCESSING UNIT
B.E.S.T.® PROCESSING UNIT
PIPE RACK
STEAM/WATER PIPEWAY (OPT.)
WALKWAY
BOILER (OPT)
ELECTRICAL TRAILER
CONTROL
SAFETY
MATERIAL PRETREATMENT/HOLD AREA
LAB TRAILER
PARTS ROOM
CHANGE ROOM
GATE
FENCE
GATE
PARKING
D
C
B
A
8
7
6
5
4
3
2
1
GENERAL ARRANGEMENT
OVERALL SITE PLAN
B.E.S.T.® PCB TREATMENT FACILITY
CUSTOMER ORDER NO. 92-1815
RESOURCES CONSERVATION COMPANY
92-PD-2078
1 OF 6

Figure 4

BENCH-SCALE TREATABILITY TEST DATA CORRELATION TO FULL-SCALE PERFORMANCE

In order to evaluate each potential application for the B.E.S.T. process, RCC has developed a low cost bench-scale treatability test protocol that provides data that closely simulates full-scale system performance. The bench-scale treatability test data allows RCC to evaluate the feasibility of the process on a particular sample and to estimate treatment costs.

The reliability of the bench-scale treatability tests to predict full-scale performance has been verified by the USEPA report Evaluation of the B.E.S.T. Solvent Extraction Sludge Treatment Technology - Twenty-Four Hour Test, by Enviresponse, Inc., under EPA Contract 68-03-3255. A quote from this report evaluating the B.E.S.T. process states:

> "Resources Conservation Company has conducted many laboratory tests and developed correlations to which data from full-scale operations, such as the General Refining site, can be compared."

Figures 5 and 6 present data from two separate bench-scale treatability tests and full-scale operating performance data at the General Refining, Inc., Superfund site, as collected by an EPA contractor. This data demonstrates a close correlation between bench-scale treatability test data and full-scale operating data.

Bench-scale treatability testing provides valuable information about the use of the B.E.S.T. process at full-scale including:

- The PCB removal efficiency from the sample.
- Solids separation requirements for full-scale operation.
- The separation efficiency of water from the water/solvent/oil solution by decantation.
- General information on the partitioning of metals and organic compounds in the oil, water, and solids products.
- Full-scale operating parameters to develop treatment costs.

RCC Resources Conservation Company

GENERAL REFINING SITE
PCB CONCENTRATIONS IN RAW SLUDGE & PRODUCT FRACTIONS (ppm)

	LAB SCALE TESTING (1986) TEST "A"	 TEST "B"	FULL SCALE PROCESSING FEB. 26-27, 1987
RAW SLUDGE (DRY BASIS) mg/kg	14.	12.	13.5
PRODUCT SOLIDS mg/kg	0.02	0.14	<0.13
PRODUCT WATER mg/L	<0.01	<0.01	<0.005
%EXTRACTION EFFICIENCY	99.9	98.8	>99.0

Figure 5

RCC Resources Conservation Company

COMPARISON OF BENCH SCALE TO FULL SCALE PHASE SEPARATION PERFORMANCE FOR GENERAL REFINING SITE SLUDGE

	Bench Scale				Full Scale			
	Raw Sludge	Separated Phase Fractions			Raw Sludge	Separated Phase Fractions		
		Oil	Water	Solids		Oil	Water	Solids
Oil %	36	>97.	.017	5.7	27	99.	0.0033	0.81
Water %	56	*	N/A	<1.0	66	0.88	>99.	<0.5
Solids %	8	*	N/A	>94.	7	*	0.81	>98.

N/A Not Available
* BS&W = 2.8%

PL/C/AG4

Figure 6

II. BENCH-SCALE TREATABILITY TESTING

OBJECTIVES

Resources Conservation Company (RCC) has conducted a bench-scale treatability test on two PCB contaminated soil samples from the Norwood PCB Superfund Site. The primary objective of this test was to determine the feasibility and cost effectiveness of the B.E.S.T. solvent extraction process for treating the raw waste, specifically:

- Determine effectiveness of the B.E.S.T. process for treating PCB contaminated soils from the site, including the PCB removal efficiency.
- Determine material handling and other equipment needs for each waste tested.
- Develop data to project process operating conditions for full-scale treatment, as well as estimate full-scale treatment costs.

BENCH-SCALE TREATABILITY TEST DOCUMENTATION

The documentation of the testing can be separated into three distinct categories. The following summarizes the procedures used for each step of the treatability process:

1. When the sample was received in the laboratory, the shipment was checked for correctness of accompanying paperwork, including Chain of Custody. The information was recorded both in a hardbound sample logbook and on a computer system that has been specifically designed by RCC for use in tracking samples. The sample was issued a discrete laboratory sample number, and a test request form was completed. The sample was kept in a refrigerator under controlled and documented temperature prior to any lab analysis or the treatability study. Chain of Custody records and other information received with the sample are kept as part of the project file.

2. The bench-scale treatability testing was conducted in accordance with the test plan, and all records and observations taken during the simulation of the process were recorded in laboratory notebooks. The laboratory notebooks are the property of RCC, and each analyst and engineer has been issued a notebook. The notebooks are retained by RCC as permanent record of raw data collection.

3. Samples that were collected during the bench-scale test, including samples internal to the process, were submitted to the RCC analytical chemistry laboratory for further analysis. Each sample collected was issued a discrete laboratory number. An analysis request form was completed. The samples were analyzed in accordance with the Norwood treatability testing Quality Assurance Project Plan (QAPP) and reviewed for correctness prior to issuance. A file is maintained to permanently store the accumulated test results from completion of the analytical testing.

SAMPLE PREPARATION

The PCB contaminated samples from the Norwood Site arrived at RCC's laboratory in January, 1992. Both samples were a moist sand/gravel mixture. The High PCB sample was a somewhat darker color than the Low PCB sample.

The feed was screened using standard Tyler sieves to remove debris and to homogenize the sample. Results of the screen analysis were as follows:

Soil Sample Screening

Sample	> 1/4 inch	> 1 inch
Low PCB	20%	none
High PCB	16%	none

Bench-scale testing requires material greater than 1/4 inch be removed. Full-scale processing requires that the feeds be screened to remove only material greater than 1 inch in diameter.

FEED COMPOSITIONAL ANALYSIS

The feed was analyzed by RCC for percent oil, water, solids, PCBs, cPAHs and metals per the following methods:

- The oil & grease content was determined as per Standard Methods for the Examination of Water and Wastewater, 16th Edition, Method 503D, with two exceptions: the extraction time was extended from 4 to 16 hours, and methylene chloride ($MeCl_2$) was substituted for Freon based on RCC experience that $MeCl_2$ is a better solvent for oils and greases.

- The water content was determined by weight loss at 105 degrees C.

- The PCB concentration was determined per EPA Publication SW846 Test Methods for Evaluating Solid Waste, Method 8080. The sample extraction method was by Soxhlet extraction with 1:1 acetone:hexane for 16 hours. The PCBs were quantitated as Aroclor 1254.

- The Polynuclear Aromatic Hydrocarbon concentrations were determined per EPA Publication SW846, Method 8100, after Soxhlet extraction with 1:1 acetone:hexane.

- The metals composition (except for Mercury) was determined by nitric acid digestion after ashing at 550 degrees C, followed by ICP analysis (EPA SW846, Method 6010).

- Mercury concentration was determined by the Cold Vapor Technique, Method 303F, of Standard Methods for the Examination of Water and Wastewater.

The untreated soil samples were also analyzed by an EPA CLP laboratory for pesticides/PCBs, semi-volatile organics (including cPAHs), volatile organics, metals and dioxins/furans. The results of these analyses, provided by Metcalf & Eddy, are presented in the attachment.

Water, solids and PCB results by RCC, alongside those of the CLP laboratory, were as follows (duplicate assays, when available, have been averaged):

Feed Compositional Analysis

(wet basis unless noted)

Analyte	RCC Results		CLP Results	
	Low PCB	High PCB	Low PCB	High PCB
Oil & Grease (by $MeCl_2$), %	< 0.2	1.6	--	--
Water, %	4	5.7	5.8	5.6
Solids, %	96	92.7	94.2	94.5
PCBs mg/kg, dry basis	680	10,000	750	8,600

The carcinogenic polynuclear aromatic hydrocarbon analyses results are presented and discussed later under SAMPLE EXTRACTION/PRODUCT SOLIDS.

The heavy metals composition of each feed was as follows:

Feed Metals Composition, mg/kg

(as received basis)

Analyte	RCC Results		CLP Results	
	Low PCB	High PCB	Low PCB	High PCB
Arsenic	< 95	< 90	1.1	2.4
Barium	29	39	15	22
Cadmium	5.0	< 5.0	1.4	2.3
Chromium	14	12	8.2	15
Copper	19	160	77	203
Lead	< 29	100	7.1	80
Mercury	< 0.1	< 0.1	--	--
Nickel	11	8.0	6.3	9.3
Selenium	< 95	< 90	--	--
Silver	< 5.0	< 5.0	0.83	1.0
Zinc	45	110	53	108

TRIETHYLAMINE COMPATIBILITY TEST

Triethylamine is a compound with a unique chemical structure. The geometry of the structure is tetrahedral, meaning that the nitrogen atom is at the center of a three-sided pyramid. The four points of the pyramid structure are occupied by three ethyl functional groups and one electron cloud. This structure gives triethylamine dual polarity characteristics. The ethyl groups are essentially nonpolar; the electron cloud is polar. Although triethylamine is a very stable solvent, there is a remote possibility that the electron pair can react with certain types of materials. In order to determine if this will occur with a sample, a compatibility test is performed. This involves mixing of the sample with triethylamine and making observations as to the heat of solution and any other visual signs of reaction.

When each feed sample was mixed with cold triethylamine, visible sign of adverse reaction was not observed, and the heat of solution was in a normal range. The triethylamine was observed to darken upon mixing, indicating that extraction of the organic compounds was occurring.

Based on the favorable results of this preliminary test, it was decided that the B.E.S.T. bench-scale treatability test should proceed.

FEED pH ADJUSTMENT

Triethylamine can be ionized at low pH to triethylammonium salts that cannot be removed from the products. The alkaline nature of triethylamine will buffer the pH of the sample to a pH of around 9. The solvent spent in the pH buffering will be lost. In order to efficiently recover the triethylamine from the separated phase fraction products, the pH of the sample is adjusted to about 11 with caustic soda.

A 5-gram portion of each feed sample was slurried with deionized water. The pH of this mixture indicated that caustic would need to be added to each sample. Incremental portions of caustic soda (NaOH) were added to bring the pH to 11. The amount of caustic that was required to perform this pH adjustment and the original sample pH is summarized below:

Sample pH and Caustic Dose

Sample	pH	Caustic Dose (mls 50% NaOH per kg)
Low PCB	4.6	2.0
High PCB	8.3	1.8

SAMPLE EXTRACTION/PRODUCT SOLIDS

For the first extraction stage, a portion of soil was prechilled by placing it in a resin kettle, immersed in a temperature controlled water bath set at 0.5 degrees C. The sample pH was adjusted by adding caustic soda at the same time that chilled triethylamine was added. Mixing was performed by an air-driven propeller mixer in the same resin kettle immersed in the cooling bath. As expected, the solvent became colored indicating extraction of organic compounds was occurring. The mixing was stopped and settling characteristics were observed. For the High PCB sample, the liquid in the mixture was decanted off and then separated from any remaining solids by centrifuging at 2100 rpm for 10 minutes. The decant solution from the Low PCB material was free of solids and was not centrifuged. Each solvent/oil/water mixture was temporarily set aside after centrifugation for testing as discussed later under SOLVENT EVAPORATION/PRODUCT OIL.

No additional caustic was added for the additional extraction stages. The decanted TEA/Oil from the additional extraction stages on the High PCB material was not centrifuged. The improved settling characteristics observed during subsequent extractions on both samples resulted in a TEA/Oil mixture which was free of suspended solids. A total of six extraction stages were performed on the Low PCB sample and eight extractions were performed on the High PCB sample. A sample of the solids remaining in the kettle after each extraction was taken for PCB analysis. The final extraction solids are hereafter referred to as Product Solids.

Product Solids were analyzed by RCC per the following methods:

- The oil & grease (O&G) content was determined as per Standard Methods for the Examination of Water and Wastewater, 16th Edition, Method 503D, with two exceptions: the extraction time was extended from 4 to 16 hours, and methylene chloride ($MeCl_2$) was substituted for Freon based on RCC experience that $MeCl_2$ is a better solvent for oils and greases. The O & G content was also determined using the Freon protocol.

- The PCB concentration was determined per EPA Publication SW846 Test Methods for Evaluating Solid Waste, Method 8080. The sample extraction method was by Soxhlet extraction with 1:1 acetone:hexane for 16 hours. The PCBs were quantitated as Aroclor 1254.

- The Polynuclear Aromatic Hydrocarbon concentrations were determined per EPA Publication SW846, Method 8100, after Soxhlet extraction with 1:1 acetone:hexane.

- The metals composition (except for mercury) was determined by aqua regia digestion, followed by ICP analysis (EPA SW846, Method 6010).

- Mercury concentration was determined by the Cold Vapor Technique, Method 303F, of Standard Methods for the Examination of Waste and Wastewater.

- The triethylamine content was determined by shaker bath water extraction and packed column gas chromatography with a flame ionization detector.

- The pH was determined by measuring the pH of a slurry of 5 grams of sample and 50 mls of deionized water. The slurry was tested by pH probe after mixing.

- The water content was determined by weight loss at 105 degrees C.
- Loss on ignition was determined by heating a sample to 550 degrees C.

PCB analytical results from RCC, as well as the EPA CLP laboratory, of the solids samples were as follows:

PCB Analysis Summary, mg/kg
(all data dry basis)

Sample Point	**Results**			
	RCC Low PCB	**CLP Low PCB**	**RCC High PCB**	**CLP High PCB**
Feed	680	750 (average)	10,000	8,600 (average)
1st Extraction	27	--	720	--
2nd Extraction	7.0	--	180	--
3rd Extraction	7.9	--	94	--
4th Extraction	2.4	--	61	--
5th Extraction	0.4	--	38	--
6th Extraction	0.3	0.2	29	--
7th Extraction	--	--	7.7	--
8th Extraction	--	--	9.9*	4.6*

* Product Solids

PCB reduction versus extraction stage using RCC lab results are presented graphically (semilog) in Figures 7 and 8.

PCB removal efficiency is determined by comparing the amount of PCBs in the feed to the amount remaining in the environment after treatment. The fraction of PCBs remaining in the environment is calculated by dividing the PCB content of the product solids by the PCB content of the feed, on a dry basis. The calculation of the Low PCB sample using RCC lab analytical results follows:

PCB Removal Efficiency Calculation

. . . .

$$\text{Fraction of PCBs remaining in environment} = \frac{\text{Product solids PCB Content (dry basis)}}{\text{Feed PCB Content (dry basis)}}$$

$$= \frac{0.30 \text{ mg/kg}}{680 \text{ mg/kg}} = 0.0004$$

. . . .

$$\text{\% Removal from environment} = 100 \bullet (1 - \text{fraction of PCBs remaining in environment})$$

$$= 100 \bullet (1 - 0.0004)$$

$$= 99.9\ \%$$

The reduction in the PCB content and the corresponding removal efficiency of PCBs from the environment for both samples using RCC lab data is summarized below.

Total PCB Removal Summary

	PCBs in Feed, mg/kg (dry basis)	PCBs in Product Solids, mg/kg (dry basis)	Removal Efficiency, %
Low	680	0.3	99.9
High	10,000	9.9	99.9

The total concentration of the seven carcinogenic PAHs (cPAHs) were below detection limits in both feed samples. The detection limit for the total cPAH concentrations in the feeds was 7 mg/kg by the RCC Lab and 0.15 mg/kg by the EPA CLP laboratory. The RCC cPAH analyses results of the feed, product solids and product oil are presented in Figure 9. The EPA CLP laboratory analyses results are attached. The cPAH removal efficiency cannot be calculated since the cPAH concentrations were below detection limits.

Product solids were also analyzed by an EPA CLP laboratory for pesticides/PCBs, semi-volatile organics (including cPAHs), volatile organics, metals and dioxins/furans. The results are attached.

Additional product solids analysis by RCC follows:

Product Solids Analysis

Analyte	RCC Results		CLP Results	
	Low PCB	High PCB	Low PCB	High PCB
Oil & Grease (by $MeCl_2$), %	< 0.2	< 0.2	--	--
Oil & Grease (Freon), %	< 0.2	< 0.2	--	--
Triethylamine, mg/kg	12	16	--	--
pH	10.6	10.7	--	--
Water, %	2.0	3.0	2	4
Loss on ignition, %	0.8	0.6	--	--

* Product water added to the product solids for dust control.

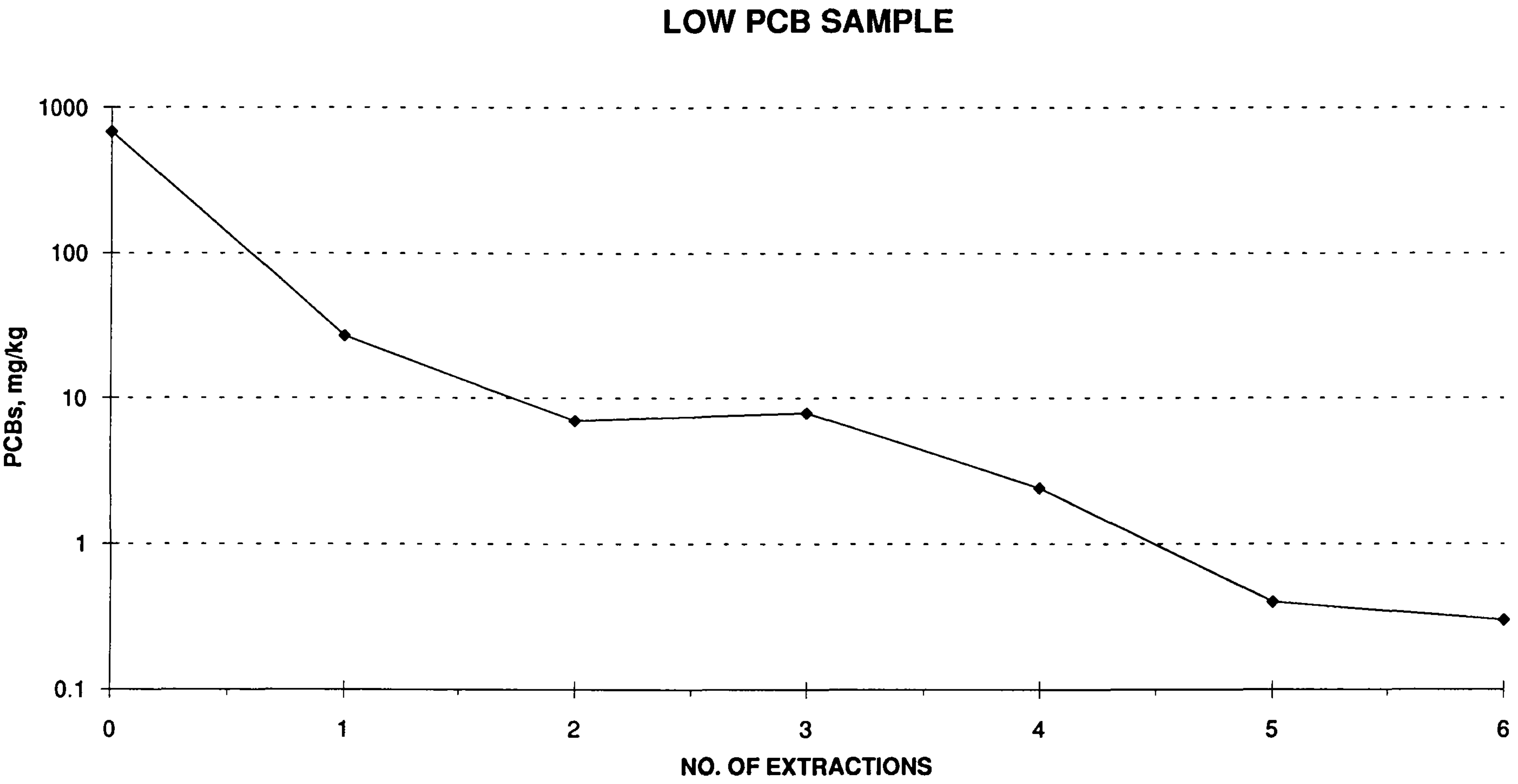

LOW PCB SAMPLE
1000
100
10
1
0.1
PCBs, mg/kg
0
1
2
3
4
5
6
NO. OF EXTRACTIONS

FIGURE 7

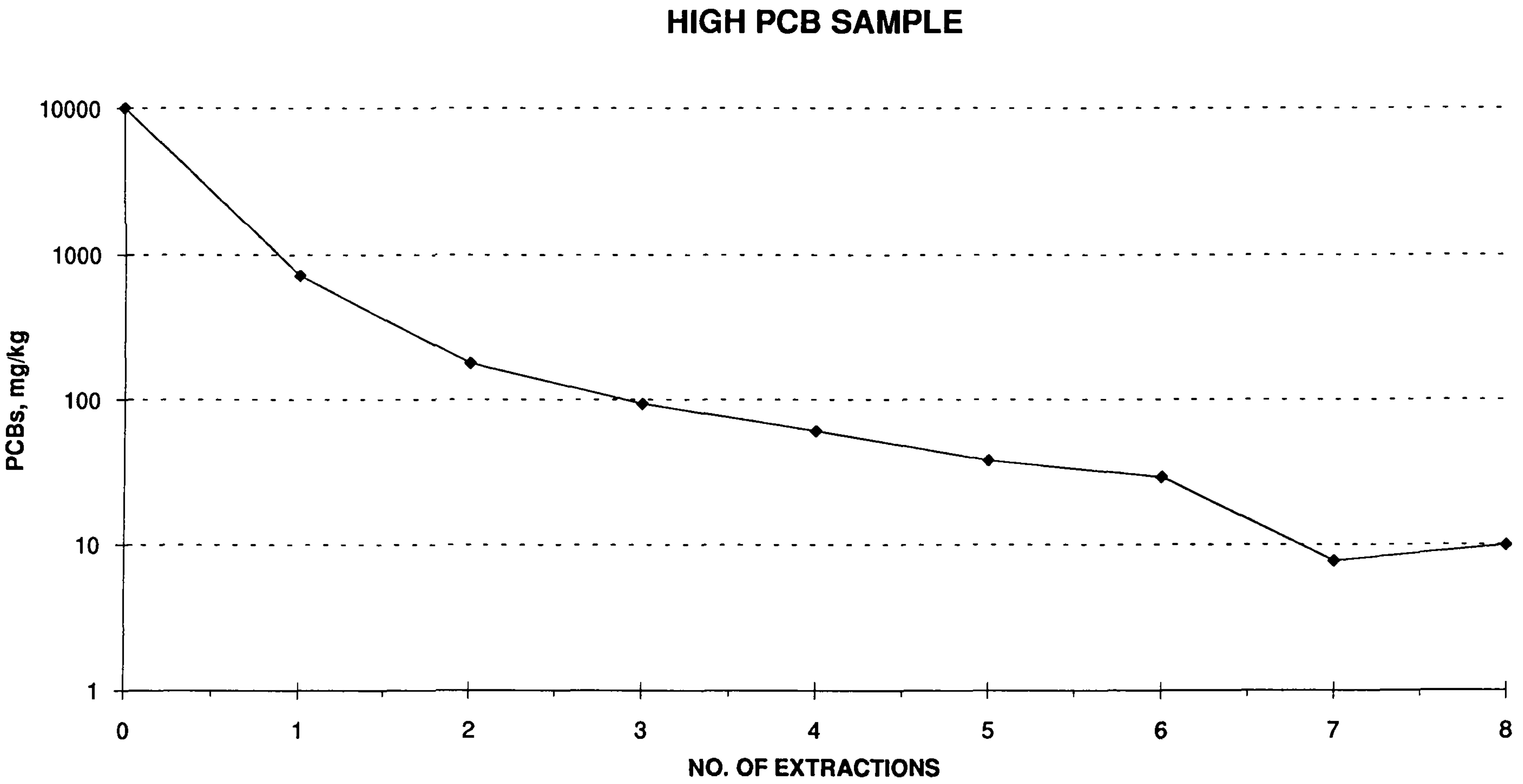

HIGH PCB SAMPLE
PCBs, mg/kg
10000
1000
100
10
1
0
1
2
3
4
5
6
7
8
NO. OF EXTRACTIONS

FIGURE 8

Figure 9

RCC cPAH SUMMARY

PAH	FEED (dry basis)	PRODUCT OIL	PRODUCT SOLIDS
	conc.	conc.	conc.
	mg/kg	mg/kg	mg/kg
LOW PCB SAMPLE			
Benzo(a)anthracene	< 0.5	< 1.0	< 0.2
Crysene	< 2.0	< 1.0	< 0.2
Benzo(b)fluoranthene	< 0.2	< 1.0	< 0.2
Benzo(k)fluoranthene	< 0.2	< 1.0	< 0.2
Benzo(a)pyrene	< 2.0	< 10	< 2.0
Indeno(1,2,3-cd)pyrene	< 1.0	< 5.0	< 1.0
Dibenz(a,h)anthracene	< 1.0	< 5.0	< 1.0
HIGH PCB SAMPLE			
Benzo(a)anthracene	< 0.5	< 1.2	< 0.2
Crysene	< 2.0	< 2.2	< 0.2
Benzo(b)fluoranthene	< 0.3	< 1.2	< 0.2
Benzo(k)fluoranthene	< 0.2	< 1.0	< 0.2
Benzo(a)pyrene	< 2.0	< 10	< 2.0
Indeno(1,2,3-cd)pyrene	< 1.0	< 5.0	< 1.0
Dibenz(a,h)anthracene	< 1.0	< 5.0	< 1.0

Total heavy metal analysis of the product solids was as follows:

Product Solids
Total Metals Analysis, (mg/kg)
(dry basis)

Analyte	RCC Results		CLP Results	
	Low PCB	High PCB	Low PCB	High PCB
Arsenic	< 100	< 100	1.3	1.8
Barium	30	33	12.3	20.7
Cadmium	< 5.0	< 5.0	1.1	1.2
Chromium	27	25	8.6	9.1
Copper	23	190	18.9	164
Lead	< 30	79	--	--
Mercury	< 0.1	0.13	--	0.14
Nickel	18	15	8.3	4.1
Selenium	< 100	< 100	0.12	--
Silver	< 5.0	< 5.0	0.79	1.2
Zinc	44	120	35.4	73.5

TOXICITY CHARACTERISTIC LEACHING PROCEDURE ANALYSIS ON PRODUCT SOLIDS

The product solids from each sample were extracted using the Toxicity Characteristic Leaching Procedure (TCLP) in accordance with Federal Register, March 29, 1990. Each TCLP leachate was analyzed for metals content. The results from this analysis were as follows:

Product Solids
TCLP Leachate Analysis, mg/l

Analyte	Sample Results		Regulatory Level, mg/l
	Low PCB	High PCB	
Arsenic	< 1.0	< 1.0	5
Barium	0.3	0.57	100
Cadmium	< 0.05	< 0.05	1
Chromium	< 0.1	< 0.1	5
Lead	< 0.3	0.8	5
Mercury	0.016	0.006	0.2
Selenium	< 0.5	< 0.5	1
Silver	< 0.05	< 0.05	5

As can be seen from the above data, the product solids readily passed the TCLP test for metals.

SOLVENT EVAPORATION/PRODUCT OIL

Recovery of product oil (the organic compound in the feed) was accomplished by distilling off the triethylamine. This was done by boiling the triethylamine/oil/water extract in a rotary evaporator apparatus. The oil remained in the boiling flask of the evaporator while the triethylamine was condensed as it evaporated and was collected separately. Triethylamine was deliberately left in the oil because of the extremely low oil content in both feed samples. In this fashion, the oil could be transferred from the evaporator flask and the oil would still be homogenous which is very important for the integrity of the PCB mass balance. (The PCB mass balance is discussed on page 29.) Normally the oil is further treated to remove residual solvent.

The analysis of each product oil was performed as follows:

- The ash content is calculated by weight loss at 550 degrees C.
- The PCB concentration was determined by dilution of the oil in hexane, followed by EPA SW846 (Test Methods for Evaluating Solid Waste), Method 3620, Florisil column cleanup and/or sulfuric acid digest. Then the prepared sample was analyzed by EPA SW846, Method 8080.
- The Polynuclear Aromatic Hydrocarbon concentrations were determined per EPA document SW846, Method 8100, after Soxhlet extraction with 1:1 acetone:hexane.

The product oil analysis results reported, after the triethylamine diluent remaining in the oil is factored out, were as follows:

Product Oil Analysis
(Triethylamine-free basis)

Analyte	RCC Results		CLP Results	
	Low	High	Low	High
PCBs, mg/kg	380,000	410,000	210,000	299,000
Ash, %	< 1.1	4.5	--	--

The Product Oil was not analyzed for triethylamine since the Product Oil was left in solution with triethylamine due to the low oil content of the feed. This makes an analysis of triethylamine residual meaningless.

The carcinogenic polynuclear aromatic hydrocarbon concentrations, also on a triethylamine-free basis, are shown in Figure 9.

Product oil ('Extracts') analyses were also conducted by an EPA CLP laboratory and the results are attached. These analyses have not been corrected to a triethylamine-free basis. The correction factors to do this are provided at the end of the attachment. The toxicity equivalency factor (TEF) of the product oil corrected to a triethylamine-free basis which would be produced from full-scale processing of the Low PCB sample will be 120. The TEF of product oil from full-scale processing of the High PCB sample will be 180. The TEF of the product oil from the High PCB sample is entirely due to furans as opposed to dioxins. Only 0.002% of the TEF of the product oil from the Low PCB sample is due to dioxins. (The TEFs have been calculated according to the EPA October, 1990, Statement of Work.)

The distilled and condensed solvent carried with it water in the form of an azeotrope. The solvent/water mixture was further processed as per the next section, DECANTATION OF SOLVENT FROM WATER.

DECANTATION OF SOLVENT FROM WATER

The solvent recovered from each extraction stage was separated into its aqueous (water), oil and solvent components. Only the extract from the first extraction stage had a significant amount of water in solution, so only the water in the first stage extract is recovered.

The water was separated from the feed by evaporation. When the triethylamine/oil/water first stage extract was evaporated, as described in section SOLVENT EVAPORATION/PRODUCT OIL, the water formed an azeotrope with the distilled triethylamine, leaving the oil behind. The water was then separated from the triethylamine of the condensed triethylamine/water azeotrope by decantation. The triethylamine/water recovered from the Solvent Evaporation/Product Oil step was heated to 140 degrees F, then poured into a 4-liter separatory funnel. Separation occurred immediately, so no temperature control system was required. This separation was highly effective as expected because there was virtually no oil or solids in the condensed triethylamine/water that could hinder the separation of triethylamine from water by decantation.

PRODUCT WATER

Removal of residual triethylamine from each decant water was accomplished by heating the water on a hot plate while maintaining an elevated pH. The elevated pH is necessary to ensure that the majority of the triethylamine remains in the volatile molecular form. Triethylamine/water azeotrope boils at about 170 degrees F. When the triethylamine is removed, the water temperature increases to 212 degrees F. The product water produced was combined with the product solids in order to simulate the quality of solids produced in both the pilot and full scale processing equipment.

Treated (product) solids produced during full-scale processing will typically be deliberately left with approximately 10% moisture using water native in the feed so that these solids are not dusty. Both the Low and High PCB untreated samples have less than 10% moisture. Therefore, there would be no product stream during full-scale processing of these samples since all of this water would be used to wet the treated solids. To simulate this, the small amount of water recovered during bench testing, 23-30 mls, was mixed into the product solids prior to analysis of the product solids. Although there was an insufficient quantity of product water to analyze, it can be assumed that the quality of this water was high since it was recovered by evaporation (distillation).

III. MASS BALANCES

The data gathered during the bench-scale treatability test provides the data required to calculate mass balances. The mass balances have been segregated into four groups: solids, oil, water, and PCBs. A cPAH mass balance was not possible due to the very low cPAH concentrations in both untreated samples as previously discussed.

SOLIDS MASS BALANCE

The mass balance for solids is a comparison of the solids input during the test to the solids recovered after the test. The mass of solids input during the test includes the solids portion of the feed extracted and the solids portion of caustic soda added. The solids portion of the feed extracted was calculated by multiplying the weight of feed extracted by the solids content as determined by analysis. The solids portion of the caustic soda added was calculated by multiplying the weight of the 50 percent NaOH solution added by 0.50.

The mass of the solids recovered from the test is equivalent to the sum of the product solids and samples taken for stage-by-stage assays. A summary of this data follows:

Solids Mass Balance

	Low PCB Sample	High PCB Sample
Total Feed Extracted, Wet Basis	905 g	901 g
Solids Portion of Feed	869 g	835 g
Solids Portion of Caustic	+ 1.4 g	+ 1.1 g
Total Calculated Solids Input	= 870 g	= 836 g
Weight of Product Solids Recovered	796 g	687 g
Weight of Solids Samples Recovered	+ 73 g	+ 150 g
Total Solids Recovered	= 869 g	= 837 g
Recovery, %	100	100

OIL MASS BALANCE

The oil mass balance was computed via the same method used in calculating the solids mass balance. The oil & grease content of each feed was determined by extracting a sample of the feed with methylene chloride. This oil & grease content (by $MeCl_2$) was multiplied by the weight of the feed input to determine the amount of oil input. The mass of oil recovered from the test was equivalent to the product oil recovered. The residual oil in the product solids was negligible when calculating an oil mass balance.

The oil mass balance (based on methylene chloride) follows:

Oil Mass Balance

	Calculated Oil Input	Triethylamine-free Equivalent Product Oil Recovered	% Recovery
Low PCB Sample	< 1.8 g	1.1 g	*
High PCB Sample	14.4 g	16.0 g	111

* Oil balance not possible due to low oil & grease content of feed (< 0.2%).

Virtually all of the PCBs from the sample now reside in the product oil. For the bench-scale tests, the weight of PCB contaminated material can be reduced from 900 grams to approximately 1.1 grams for the Low PCB sample and 16 grams for the High PCB sample. This corresponds to an 820-fold reduction for the Low PCB sample and a 56-fold reduction in mass for the High PCB sample.

Treating 30,000 cubic yards of the Low PCB sample would generate 13,000 gallons of product oil. Treating 30,000 cubic yards of the High PCB sample would generate 170,000 gallons of product oil. The feed material bulk densities used in formulating these volumes are 1.4 tons/cubic yard for the Low PCB material and 1.3 tons/cubic yard for the High PCB material. A density of 8 #/gallon for both product oils was assumed.

WATER MASS BALANCE

The water mass balance was computed similarly to the method used for solids. The mass of water input came from the water in the feed, plus the water introduced with the caustic. The water portion of each feed was calculated by multiplying the weight of the feed by the water content as determined by analysis. The water portion of the caustic input was calculated by multiplying the weight of the 50 percent NaOH solution by 0.50.

The mass of water recovered was equivalent to the sum of the decant water and the residual water in the decant triethylamine/oil. A summary of this data follows:

Water Mass Balance

	Low PCB Sample	High PCB Sample
Water Portion of Feed	36.2 g	51.4 g
Water Portion of Caustic	+ 1.4 g	+ 1.1 g
Total Calculated Water Input	= 37.6 g	= 52.5 g
Water recovered as decant water	23.8 g	30.4 g
Total Water Recovered	= 23.8 g	= 30.4 g
Recovery, %	63	58

The recovery of water was low as is typical for bench tests. The temperature tends to increase above the triethylamine/water miscibility limit when the treated solids are centrifuged. At these conditions, some water may have exited the centrifuge with the solids. This water was lost when the solids were dried. In addition, a portion of the water in the feed was left behind in the resin kettle after decantation of the first extraction since it is not possible to decant all the solvent from the solids. This water was lost when the solids were dried. This portion of the water lost in the dryer is not accounted for in the water mass balance. In RCC's Pilot Unit, and Full-Scale Unit, all such water is recovered from the dryer.

PCB MASS BALANCE

The PCB mass balance was computed similarly to the method used for oil. The mass of PCBs input was calculated by multiplying the weight of each feed by the PCB concentration as determined by analysis. The PCBs recovered from the test reside in the product oil. The PCBs in the product solids and recovered triethylamine were negligible when calculating a PCB mass balance. The mass of PCBs recovered in the oil was calculated by multiplying the weight of oil recovered by the PCB concentration as determined by analysis. The PCB mass balance using RCC lab analytical results was as follows:

PCB Balance

	Calculated PCBs Input	Calculated PCBs Recovered	Total PCB % Recovery
Low PCB Sample	591 mg	421 mg	71 %
High PCB Sample	9010 mg	6890 mg	76 %

SUMMARY OF MASS BALANCE CALCULATIONS

The following table summarizes the mass balance calculations for each of the constituents considered. The mass balances were based on the amount of the fraction recovered from the simulation divided by the calculated input amount to the simulation.

Mass Balance Summary, %

	Solids	Oil	Water	PCBs
Low PCB Sample	100	--	63	71
High PCB Sample	100	111	58	76

IV. CONCLUSIONS

Both PCB contaminated soil samples from the Norwood Site are suitable for treatment with the B.E.S.T. solvent extraction process. Problems were not observed during testing of the sample. Consequently, no significant changes to the existing B.E.S.T. Model 415 plans are anticipated.

1. Both samples were chemically compatible with triethylamine.

2. The total PCB concentration in the Low PCB sample was 680 mg/kg. After treatment of the Low PCB sample, the PCB residual concentration was 0.3 mg/kg, which yields a PCB removal efficiency of 99.9%.

3. The total PCB concentration in the High PCB sample was 10,000 mg/kg. After treatment of the High PCB sample, the PCB residual concentration was 9.9 mg/kg, which yields a PCB removal efficiency of 99.9%.

4. The total concentration of the seven carcinogenic polynuclear aromatic hydrocarbon compounds (cPAHs) in both feed samples were below detection limits and, therefore, the cPAH removal efficiency cannot be calculated.

5. The treated solids from both samples readily passed the TCLP Toxicity Test for leaching of metals. The triethylamine residual in the treated solids was relatively low, namely, 12 and 16 mg/kg in the treated solids from the Low and High PCB sample, respectively. If triethylamine biodegradation of the treated solids is desired, untreated clean soil would have to be mixed into the treated solids to inoculate the treated solids with soil bacteria. This is because the treated solids are sterile as they exit the B.E.S.T. process.

6. Virtually all of the PCBs from the sample have been concentrated into the product oil. The weight of PCB contaminated material can be reduced 820-fold for the Low PCB sample and 56-fold for the High PCB sample.

7. Treating 30,000 cubic yards of the Low PCB sample would produce an estimated 13,000 gallons of product oil. Treating 30,000 cubic yards of the High PCB sample would produce an estimated 170,000 gallons of (triethylamine-free) product oil. CLP analytical data shows that the toxicity equivalency factor (TEF) of the product oil from full-scale processing of the Low PCB sample will be 120. The TEF of product oil from the High PCB sample will be 180.

* * * * *

B.E.S.T. BENCH-SCALE TREATABILITY TEST
FINAL REPORT

Norwood Site

for

METCALF & EDDY

ATTACHMENT

EPA CLP LABORATORY DATA

M&E Metcalf & Eddy
An Air & Water Technologies Company

004609-0019-011-006-004

April 28, 1992

Mr. Steve O'Loughlin
Resources Conservation Company
Analytical Laboratory
11113 NE 33rd Place
Bellevue, WA 98004

Subject: EPA-CLP Data from Treatability Study Samples
Norwood PCB Site

Dear Steve:

Enclosed are the data tables which present the analytical results for the samples which you sent to EPA-CLP laboratories as part of the Norwood PCB site treatability study. As stated in the contract, your draft report on the treatability study should make use of these data. For example, a comparison of the CLP data for PCBs with the PCB analyses performed by RCC should be presented in the report. Please consult Exhibit A of the contract for more details on what should be included in the report.

The data tables are also on the enclosed disk as Lotus Version 2.2 spreadsheets. The Lotus filenames and the data in each file are summarized in the attached table.

The data were evaluated by M&E chemists according to Level III data validation guidelines established by M&E, based on EPA Region I functional guidelines for Level IV data validation.

Please note that the data for the extracted oil samples have not been corrected for dilution by the solvent (hexane). You must do this before using the data to determine mass balances.

SEE END of ATTACHMNT

Data from the dioxin/dibenzofuran analyses are currently being validated by EPA, and will be made available to you when the validation is completed. You can prepare the treatability study report without this data. M&E is planning to prepare a separate letter report to EPA concerning the dioxin/dibenzofuran data once it is available.

30 Harvard Mill Square, Wakefield, MA 01880
Mailing Address: PO Box 4043, Woburn, MA 01888-4043
617-246-5200 FAX 617-245-6293

Please feel free to call me if you have any questions. I look forward to receiving your draft report.

Very truly yours,

METCALF & EDDY, INC.

Barbara Weir

Barbara Weir
Treatability Study Coordinator

cc L. Weimer, RCC (letter only)
J. Levengood (letter only)
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WA #19 file (letter w/attachment)

Summary of Triethylamine Extraction Results

SITE: NORWOOD PCB SITE
TECHNOLOGY: TRIETHYLAMINE EXTRACTION
SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY

SAMPLE DESIGNATION	Untreated High	Untreated High Duplicate	Treated High	Percent Reduction
VOLATILES				
Trichloroethene	2 J	2 J	10 U	
SEMIVOLATILES				
1,2,4-Trichlorobenzene	19 J	16 J	0.30 J	98.29
Naphthalene	21 U	21 U	0.170 U	
PCBS				
Aroclor 1254	8740	8390	4.60	99.95

SAMPLE DESIGNATION	Untreated Low	Untreated Low Duplicate	Treated Low	Percent Reduction
VOLATILES				
Trichloroethene	10 U	11 U	10 U	
SEMIVOLATILES				
1,2,4-Trichlorobenzene	21 U	21 U	0.170 U	
Naphthalene	21 U	21 U	0.009 J	
PCBS				
Aroclor 1254	737 J	766 J	0.170	99.98

Volatiles concentrations are in ug/Kg.
Semivolatile and PCB concentrations
are in mg/Kg.

UNTREATED HIGH AND LOW SOIL AND EXTRACTED OIL PCB ANALYSIS
MG/KG

SITE: NORWOOD
SDG NO.: 7018A-601, 920
SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

		UNTREATED SOIL SAMPLES				EXTRACTED OIL SAMPLES △1	
		HIGH PCB		LOW PCB		LOW PCB	HIGH PCB
SAMPLE DESCRIPTION:		Norwood site high-untreated soil	Norwood site high-untreated soil-dupl.	Norwood site low-untreated soil	Norwood site low-untreated soil dupl.	Extracted oil from low soil	Extracted oil from high soil
EPA SAMPLE NUMBER:		7018A-601	7018A-602	7018A-603	7018A-604	7018A-921	7018A-920
RCC SAMPLE ID:		20112-02	20112-02	20111-02	20111-02	20111-20	20112-20
COMPOUND	CRQL						
Toxaphene	50	5000 U	5000 U	5000 U	5000 U	50000 U	50000 U
Aroclor-1016	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
Aroclor-1221	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
Aroclor-1232	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
Aroclor-1242	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
Aroclor-1248	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
Aroclor-1254	10	8740	8390	737 J	766 J	11400	29000
Aroclor-1260	10	1000 U	1000 U	1000 U	1000 U	10000 U	10000 U
DILUTION FACTOR:		100	100	100	100	1000	1000
DATE SAMPLED:		1-23-92	1-23-92	1-23-92	1-23-92	2-17-92	2-17-92
DATE EXTRACTED:		2-03-92	2-03-92	2-03-92	2-03-92	2-20-92	2-20-92
DATE ANALYZED:		3-05-92	3-06-92	3-08-92	3-08-92	3-06-92	3-06-92
REMARKS:			Dupe of -601		Dupe of -603		

Footnotes:

CRQL – Contract Required Quantitation Limit
J – Quantitation is approximate due to limitations identified in the quality control review.
U – Value is the sample detection limit.
R – Value is rejected.
UJ – Sample detection limit is approximate due to limitations identified in the quality control review.

△1 EXTRACTED OILS DILUTED IN SOLVENT. SEE END of this ATTACHMENT FOR DILUTION.

PESTICIDE/PCB SOIL ANALYSIS
UG/KG

SITE: NORWOOD
SDG NO.: 7018A-305
UBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

		TREATED SOILS			
SAMPLE DESCRIPTION:		HIGH PCB Norwood site high-treated soil		LOW PCB Norwood site low-treated soil	
EPA SAMPLE NUMBER:		7018A-705		7018A-706	
RCC SAMPLE NUMBER:		20112-18		20111-18	
COMPOUND	CRQL				
alpha-BHC	1.7		R	1.7	U
beta-BHC	1.7		R	1.7	U
delta-BHC	1.7		R	1.7	U
gamma-BHC(Lindane)	1.7		R	1.7	U
Heptachlor	1.7		R	1.7	U
Aldrin	1.7		R	1.7	U
Heptachlor Epoxide	1.7		R	1.7	U
Endosulfan I	1.7		R	1.7	U
Dieldrin	3.3	43.0	J	2.5	J
4,4'-DDE	3.3		R	3.3	U
Endrin	3.3		R	3.3	U
Endosulfan II	3.3		R	3.3	U
4,4'-DDD	3.3		R	3.3	U
Endosulfan Sulfate	3.3		R	3.3	U
4,4'-DDT	3.3		R	3.3	U
Methoxychlor	17.0		R	17.0	U
Endrin Ketone	3.3		R	3.3	U
Endrin Aldehyde	3.3		R	3.3	U
alpha-Chlordane	1.7	81.0	J	3.8	J
gamma-Chlordane	1.7		R	1.7	U
Toxaphene	170.0		R	170.0	U
Aroclor-1016	33.0		R	33.0	U
Aroclor-1221	67.0		R	67.0	U
Aroclor-1232	33.0		R	33.0	U
Aroclor-1242	33.0		R	33.0	U
Aroclor-1248	33.0		R	33.0	U
Aroclor-1254	33.0	4600.0	D	170.0	J
Aroclor-1260	33.0		R	33.0	U
DILUTION FACTOR:		50		1	
SAMPLE WEIGHT (g):		20.5		30.7	
% MOISTURE:		4		2	
LEVEL:		LOW		LOW	
DATE SAMPLED:		2-12-92		2-12-92	
DATE EXTRACTED:		2-14-92		2-14-92	
DATE ANALYZED:		2-26-92		2-26-92	

Footnotes:

CRQL -	Contract Required Quantitation Limit	R -	Value is rejected.
J -	Quantitation is approximate due to limitations identified in the quality control review.	UJ -	Sample detection limit is approximate due to limitations identified in the quality control review
U -	Value is the sample detection limit.	D -	The reported value is from the diluted analysis.

HIGH CONCENTRATION SEMIVOLATILE SOIL ANALYSIS
(mg/Kg)

SITE: NORWOOD
SDG NO.: 7018A-601
UBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

		UNTREATED SOIL SAMPLES			
		HIGH PCB CONCENTRATION		LOW PCB CONCENTRATION	
SAMPLE DESCRIPTION:		Norwood site high untreated soil	Norwood site high untreated soil dupl.	Norwood site low untreated soil	Norwood site low untreated soil dupl.
EPA SAMPLE NUMBER:		7018A-601	7018A-602	7018A-603	7018A-604
RCC SAMPLE ID:		20112-02	20112-02	20111-02	20111-02
COMPOUND	CRQL				
Phenol	10	21 U	21 U	21 U	21 U
bis(2-Chloroethyl) ether	10	21 U	21 U	21 U	21 U
2-Chlorophenol	10	21 U	21 U	21 U	21 U
1,3-Dichlorobenzene	10	21 U	21 U	21 U	21 U
1,4-Dichlorobenzene	10	21 U	21 U	21 U	21 U
1,2-Dichlorobenzene	10	21 U	21 U	21 U	21 U
2-Methylphenol	10	21 U	21 U	21 U	21 U
2,2'-oxybis(1-Chloropropane)	10	21 U	21 U	21 U	21 U
4-Methylphenol	10	21 U	21 U	21 U	21 U
N-Nitroso-di-n-propylamine	10	21 U	21 U	21 U	21 U
Hexachloroethane	10	21 U	21 U	21 U	21 U
Nitrobenzene	10	21 U	21 U	21 U	21 U
Isophorone	10	21 U	21 U	21 U	21 U
2-Nitrophenol	10	21 U	21 U	21 U	21 U
2,4-Dimethylphenol	10	21 U	21 U	21 U	21 U
Benzoic Acid	50	110 U	110 U	100 U	100 U
bis(2-Chloroethoxy)methane	10	21 U	21 U	21 U	21 U
2,4-Dichlorophenol	10	21 U	21 U	21 U	21 U
1,2,4-Trichlorobenzene	10	19 J	16 J	21 U	21 U
Naphthalene	10	21 U	21 U	21 U	21 U
4-Chloroaniline	10	21 U	21 U	21 U	21 U
Hexachlorobutadiene	10	21 U	21 U	21 U	21 U
4-Chloro-3-Methylphenol	10	21 U	21 U	21 U	21 U
2-Methylnaphthalene	10	21 U	21 U	21 U	21 U
Hexachlorocyclopentadiene	10	21 U	21 U	21 U	21 U
2,4,6-Trichlorophenol	10	21 U	21 U	21 U	21 U
2,4,5-Trichlorophenol	25	110 U	110 U	100 U	100 U
2-Chloronaphthalene	10	21 U	21 U	21 U	21 U
2-Nitroaniline	25	110 U	110 U	100 U	100 U
Dimethylphthalate	10	21 U	21 U	21 U	21 U
Acenaphthylene	10	21 U	21 U	21 U	21 U
2,6-Dinitrotoluene	10	21 U	21 U	21 U	21 U
3-Nitroaniline	25	110 U	110 U	100 U	100 U
Acenaphthene	10	21 U	21 U	21 U	21 U
2,4-Dinitrophenol	25	110 U	110 U	100 U	100 U
4-Nitrophenol	25	110 U	110 U	100 U	100 U
Dibenzofuran	10	21 U	21 U	21 U	21 U

HIGH CONCENTRATION SEMIVOLATILE SOIL ANALYSIS
(mg/Kg)

SITE: NORWOOD
SDG NO.: 7018A-601
UBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

		UNTREATED SOIL SAMPLES			
		HIGH PCB CONCENTRATION		LOW PCB CONCENTRATION	
SAMPLE DESCRIPTION:		Norwood site high-untreated soil	Norwood site high-untreated soil dupl.	Norwood site low-untreated soil	Norwood site low-untreated soil dupl.
EPA SAMPLE NUMBER:		7018A-601	7018A-602	7018A-603	7018A-604
RCC SAMPLE ID:		20112-02	20112-02	20111-02	20111-02
COMPOUND	CRQL				
2,4-Dinitrotoluene	10	21 U	21 U	21 U	21 U
Diethylphthalate	10	21 U	21 U	21 U	21 U
4-Chlorophenyl-Phenylether	10	21 U	21 U	21 U	21 U
Fluorene	10	21 U	21 U	21 U	21 U
4-Nitroaniline	25	110 U	110 U	100 U	100 U
4,6-Dinitro-2-Methylphenol	25	110 U	110 U	100 U	100 U
N-nitrosodiphenylamine	10	21 U	21 U	21 U	21 U
4-Bromophenyl-Phenylether	10	21 U	21 U	21 U	21 U
Hexachlorobenzene	10	21 U	21 U	21 U	21 U
Pentachlorophenol	25	110 U	110 U	100 U	100 U
Phenanthrene	10	21 U	21 U	21 U	21 U
Anthracene	10	21 U	21 U	21 U	21 U
Carbazole	10	21 U	21 U	21 U	21 U
Di-n-butylphthalate	10	21 U	21 U	21 U	21 U
Fluoranthene	10	21 U	21 U	21 U	21 U
Pyrene	10	21 U	21 U	21 U	21 U
Butylbenzylphthalate	10	21 U	21 U	21 U	21 U
3,3'-Dichlorobenzidine	20	42 U	42 U	42 U	42 U
Benzo(a)anthracene	10	21 U	21 U	21 U	21 U
Chrysene	10	21 U	21 U	21 U	21 U
Bis(2-ethylhexyl)phthalate	10	4 J	4 J	21 U	21 U
Di-n-octylphthalate	10	21 U	21 U	21 U	21 U
Benzo(b)fluoranthene	10	21 U	21 U	21 U	21 U
Benzo(k)fluoranthene	10	21 U	21 U	21 U	21 U
Benzo(a)pyrene	10	21 U	21 U	21 U	21 U
Indeno(1,2,3-cd)pyrene	10	21 U	21 U	21 U	21 U
Dibenz(a,h)anthracene	10	21 U	21 U	21 U	21 U
Benzo(g,h,i)perylene	10	21 U	21 U	21 U	21 U
DILUTION FACTOR:		1	1	1	1
DATE SAMPLED:		1-23-92	1-23-92	1-23-92	1-23-92
DATE EXTRACTED:		1-31-92	1-31-92	1-31-92	1-31-92
DATE ANALYZED:		2-04-92	2-04-92	2-04-92	2-04-92

Footnotes:

CRQL -	Contract Required Quantitation Limit
J -	Quantitation is approximate due to limitations identified in the quality control review.
U -	Value reported is the sample detection limit.
R -	Value is rejected.
UJ -	Sample detection limit is approximate due to limitations identified in the quality control review.

Semivolatile Soil Analysis
ug/kg

SITE: NORWOOD
SDG NO.: 7018A-206
SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

		TREATED SOILS			
		HIGH PCB		LOW PCB	
SAMPLE DESCRIPTION:		Norwood site high-treated soil		Norwood site low-treated soil	
EPA SAMPLE NUMBER:		7018A-605		7018A-606	
RCC SAMPLE ID:		20112-18		20111-18	
COMPOUND	CRQL *				
Phenol	330	170	U	170	U
bis(2-Chloroethyl) ether	330	170	U	170	U
2-Chlorophenol	330	170	U	170	U
1,3-Dichlorobenzene	330	170	U	170	U
1,4-Dichlorobenzene	330	170	U	170	U
1,2-Dichlorobenzene	330	170	U	170	U
2-Methylphenol	330	170	U	170	U
2,2'-oxybis(1-Chloropropane)	330	170	U	170	U
4-Methylphenol	330	170	U	170	U
N-Nitroso-di-n-propylamine	330	170	U	170	U
Hexachloroethane	330	170	U	170	U
Nitrobenzene	330	170	U	170	U
Isophorone	330	170	U	170	U
2-Nitrophenol	330	170	U	170	U
2,4-Dimethylphenol	330	170	U	170	U
bis(2-Chloroethoxy)methane	330	170	U	170	U
2,4-Dichlorophenol	330	170	U	170	U
1,2,4-Trichlorobenzene	330	300	J	170	U
Naphthalene	330	170	U	9	J
4-Chloroaniline	330	170	U	170	U
Hexachlorobutadiene	330	170	U	170	U
4-Chloro-3-Methylphenol	330	170	U	170	U
2-Methylnaphthalene	330	170	U	170	U
Hexachlorocyclopentadiene	330	170	U	170	U
2,4,6-Trichlorophenol	330	170	U	170	U
2,4,5-Trichlorophenol	800	430	U	430	U
2-Chloronaphthalene	330	170	U	170	U
2-Nitroaniline	800	430	U	430	U
Dimethylphthalate	330	170	U	170	U
Acenaphthylene	330	170	U	170	U
2,6-Dinitrotoluene	330	170	U	170	U
3-Nitroaniline	800	430	U	430	U
Acenaphthene	330	170	U	170	U
2,4-Dinitrophenol	800	430	U	430	U
4-Nitrophenol	800	430	U	430	U
Dibenzofuran	330	170	U	170	U
2,4-Dinitrotoluene	330	170	U	170	U
Diethylphthalate	330	170	U	170	U
4-Chlorophenyl-Phenylether	330	170	U	170	U
Fluorene	330	170	U	170	U

Semivolatile Soil Analysis
ug/kg

SITE: NORWOOD
SDG NO.: 7018A-205
SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

		TREATED SOILS	
		HIGH PCB	LOW PCB
SAMPLE DESCRIPTION:		Norwood site high-treated soil	Norwood site low-treated soil
EPA SAMPLE NUMBER:		7018A-605	7018A-606
RCC SAMPLE ID:		20112-18	20111-18
COMPOUND	CRQL *		
4-Nitroaniline	800	430 U	430 U
4,6-Dinitro-2-Methylphenol	800	430 U	430 U
N-nitrosodiphenylamine	330	25 J	170 U
4-Bromophenyl-Phenylether	330	170 U	170 U
Hexachlorobenzene	330	170 U	170 U
Pentachlorophenol	800	430 U	430 U
Phenanthrene	330	170 U	170 U
Anthracene	330	170 U	170 U
Carbazole	330	170 U	170 U
Di-n-butylphthalate	330	170 U	170 U
Fluoranthene	330	170 U	170 U
Pyrene	330	170 U	170 U
Butylbenzylphthalate	330	170 U	11 J
3,3'-Dichlorobenzidine	330	170 U	170 U
Benzo(a)anthracene	330	170 U	170 U
Chrysene	330	170 U	170 U
Bis(2-ethylhexyl)phthalate	330	170 U	170 U
Di-n-octylphthalate	330	170 U	170 U
Benzo(b)fluoranthene	330	170 U	170 U
Benzo(k)fluoranthene	330	170 U	170 U
Benzo(a)pyrene	330	170 U	170 U
Indeno(1,2,3-cd)pyrene	330	170 U	170 U
Dibenz(a,h)anthracene	330	170 U	170 U
Benzo(g,h,i)perylene	330	170 U	170 U
DILUTION FACTOR:		1	1
SAMPLE WEIGHT (g):		30	30
% MOISTURE:		4	2
LEVEL:		LOW	LOW
DATE SAMPLED:		2/12/92	2/12/92
DATE EXTRACTED:		2/18/92	2/18/92
DATE ANALYZED:		2/24/92	2/24/92

Footnotes:

CRQL - Contract Required Quantitation Limit
J - Quantitation is approximate due to limitations identified in the quality control review.
U - Value is the sample detection limit.
UJ - Sample detection limit is approximate due to limitations identified in the quality control review.

VOLATILE ORGANICS IN SOIL
(ug/kg)

SITE: NORWOOD
SDG NO.: 7018A-501
SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

		UNTREATED SOIL SAMPLES				
		HIGH PCB CONCENTRATION		LOW PCB CONCENTRATION		
SAMPLE DESCRIPTION:		Norwood site high-untreated soil	Norwood site high-untreated soil dupl.	Norwood site low-untreated soil	Norwood site-low untreated soil dupl.	Trip Blank
EPA SAMPLE NUMBER:		7018A-501	7018A-502	7018A-503	7018A-504	7018A-505
RCC SAMPLE ID:		20112-02	20112-02	20111-02	20111-02	
COMPOUND	CRQL *					
Chloromethane	10	11 U	11 U	10 U	11 U	10 U
Bromomethane	10	11 U	11 U	10 U	11 U	10 U
Vinyl Chloride	5	5 U	5 U	5 U	5 U	5 U
Chloroethane	10	11 U	11 U	10 U	11 U	10 U
Methylene Chloride	10	10 U	11 U	10 U	11 U	8 J
Acetone	10	10 U	11 U	10 U	11 U	4 J
Carbon Disulfide	10	11 U	11 U	10 U	11 U	10 U
1,1-Dichloroethene	10	11 U	11 U	10 U	11 U	10 U
1,1-Dichloroethane	10	11 U	11 U	10 U	11 U	10 U
1,2-Dichloroethene(total)	10	11 U	11 U	10 U	11 U	10 U
Chloroform	10	11 U	11 U	10 U	11 U	10 U
1,2-Dichloroethane	10	11 U	11 U	10 U	11 U	10 U
2-Butanone	10	11 U	10 U	10 U	11 U	3 J
1,1,1-Trichloroethane	10	11 U	11 U	10 U	11 U	10 U
Carbon Tetrachloride	10	11 U	11 U	10 U	11 U	10 U
Bromodichloromethane	10	11 U	11 U	10 U	11 U	10 U
1,2-Dichloropropane	10	11 U	11 U	10 U	11 U	10 U
cis-1,3-Dichloropropene	10	11 U	11 U	10 U	11 U	10 U
Trichloroethene	10	2 J	2 J	10 U	11 U	10 U
Dibromochloromethane	10	11 U	11 U	10 U	11 U	10 U
1,1,2-Trichloroethane	10	11 U	11 U	10 U	11 U	10 U
Benzene	10	11 U	11 U	10 U	11 U	10 U
trans-1,3-Dichloropropene	10	11 U	11 U	10 U	11 U	10 U
Bromoform	10	11 U	11 U	10 U	11 U	10 U
4-Methyl-2-pentanone	10	11 U	11 U	10 U	11 U	10 U
2-Hexanone	10	11 U	11 U	10 U	11 U	10 U
Tetrachloroethene	10	11 U	11 U	10 U	11 U	10 U
Toluene	10	11 U	11 U	10 U	11 U	10 U
1,1,2,2-Tetrachloroethane	10	11 U	11 U	10 U	11 U	10 U
Chlorobenzene	10	11 U	11 U	10 U	11 U	10 U
Ethylbenzene	10	11 U	11 U	10 U	11 U	10 U
Styrene	10	11 U	11 U	10 U	11 U	10 U
Total Xylenes	10	11 U	11 U	10 U	11 U	10 U
% SOLIDS		94.7	94.2	95.8	92.6	AQ
DILUTION FACTOR:		1	1	1	1	1
SAMPLE WEIGHT (g):		5	5	5	5	5
% MOISTURE:		5.3	5.8	4.2	7.4	100
LEVEL:		LOW	LOW	LOW	LOW	LOW
DATE SAMPLED:		1/24/92	1/24/92	1/24/92	1/24/92	1/24/92
DATE ANALYZED:		1/29/92	1/29/92	1/28/92	1/29/92	1/28/92

* -	Medium soils are 120 times the value shown.
CRQL -	Contract Required Quantitation Limit
J -	Quantitation is approximate due to limitations identified in the quality control review.
U -	Value is the sample detection limit.
R -	Value is rejected.
UJ -	Sample detection limit is approximate due to limitations identified in the quality control review.

Soil Volatile Organics Analysis
(ug/kg)

SITE: NORWOOD PCB SITE
SDG NO.: 7018A-506
SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

		TREATED SOILS		
		HIGH PCB	LOW PCB	
SAMPLE DESCRIPTION:		Norwood site high-treated soil	Norwood site low-treated soil	Trip Blank
EPA SAMPLE NUMBER:		7018A-506RE	7018A-507	7018A-508
RCC SAMPLE ID:		20112-18	20111-18	20111-26
COMPOUND	CRQL			
Chloromethane	10	10 U	10 U	10 U
Bromomethane	10	10 U	10 U	10 U
Vinyl Chloride	5	5 U	5 U	5 U
Chloroethane	10	10 U	10 U	10 U
Methylene Chloride	10	10 U	10 UJ	9 J
Acetone	10	63 U	20 U	31 J
Carbon Disulfide	10	10 U	10 U	10 U
1,1-Dichloroethene	10	10 U	10 U	10 U
1,1-Dichloroethane	10	10 U	10 U	10 U
1,2-Dichloroethene(total)	10	10 UJ	10 UJ	10 UJ
Chloroform	10	10 U	10 U	10 U
1,2-Dichloroethane	10	10 U	10 U	10 U
2-Butanone	10	24 U	10 U	6 J
1,1,1-Trichloroethane	10	10 U	10 U	10 U
Carbon Tetrachloride	10	10 U	10 U	10 U
Bromodichloromethane	10	10 U	10 U	10 U
1,2-Dichloropropane	10	10 U	10 U	10 U
cis-1,3-Dichloropropene	10	10 U	10 U	10 U
Trichloroethene	10	10 U	10 U	10 U
Dibromochloromethane	10	10 U	10 U	10 U
1,1,2-Trichloroethane	10	10 U	10 U	10 U
Benzene	10	10 U	10 U	10 U
trans-1,3-Dichloropropene	10	10 U	10 U	10 U
Bromoform	10	10 U	10 U	10 U
4-Methyl-2-pentanone	10	10 U	10 U	10 U
2-Hexanone	10	10 U	10 U	10 U
Tetrachloroethene	10	10 U	10 U	10 U
Toluene	10	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane	10	10 U	10 U	10 U
Chlorobenzene	10	10 U	10 U	10 U
Ethylbenzene	10	10 U	10 U	10 U
Styrene	10	10 U	10 U	10 U
Total Xylenes	10	10 U	10 U	10 U
DILUTION FACTOR:		1	1	1
LEVEL:		LOW	LOW	LOW
DATE SAMPLED:		2-12-92	2-12-92	2-12-92
DATE ANALYZED:		2-18-92	2-14-92	2-14-92

Footnotes:

CRQL - Contract Required Quantitation Limit
J - Quantitation is approximate due to limitatio identified in the quality control review.
U - Value is the sample detection limit.
R - Value is rejected.
UJ - Sample value is approximate due to limitations identified in the quality control review.
D - The reported value is from the diluted analysis.

INORGANIC SOIL ANALYSIS
(mg/kg)

SITE: NORWOOD PCB SITE
SAS NO.: 7018A
CONTRACTOR: RESOURCES CONSERVATION COMPANY
ECHNOLOGY: TRIETHYLAMINE EXTRACTION

				UNTREATED SOILS			
				HIGH PCB		LOW PCB	
SAMPLE DESCRIPTION:				Norwood site high–untreated soil	Norwood site–high untreated soil dupl.	Norwood site low–untreated soil	Norwood site–low untreated soil dupl.
EPA SAMPLE NUMBER:				7018A-501	7018A-502	7018A-503	7018A-504
RCC SAMPLE ID:				20112-02	20112-02	20111-02	20111-02
QC DESIGNATION:				FIELD DUPL		FIELD DUPL	
ANALYTES		CRDL (ug/L) **	IDL (ug/L)				
Aluminum	P	200	—	7130 J	3960 J	5450 J	3580 J
Antimony	P	60	—	— UJ	5.4 J	5.4 J	— UJ
Arsenic	F	10	—	2.4	2.3	1.0	1.2
Barium	P	200	—	13.7	30.5	11.0	19.8
Beryllium	P	5	—	0.33	0.63	0.25	0.47
Cadmium	P	5	—	1.7	2.9	1.5	1.3
Calcium	P	5000	—	1320 J	4980 J	976 J	5740 J
Chromium	P	10	—	13.4 J	16.2 J	10.2 J	6.2 J
Cobalt	P	50	—	6.9	3.6	4.8	2.7
Copper	P	25	—	26.1 J	380 J	18.0 J	136 J
Iron	P	100	—	10700 J	18100 J	10000 J	10300 J
Lead	F	3	—	64.2 J	95.3 J	6.8 J	7.3 J
Magnesium	P	5000	—	3880 J	1520 J	3040 J	1240 J
Manganese	P	15	—	249	289	231	259
Mercury	CV	0.2	—	—	—	—	—
Nickel	P	40	—	11.7	6.8	9.3	3.3
Potassium	P	5000	—	318 U	492 J	263 U	546 J
Selenium	F	5	—	— UJ	— UJ	— UJ	— UJ
Silver	P	10	—	— UJ	1.0 J	— UJ	0.83 UJ
Sodium	P	5000	—	102 U	73.2 U	71.6 U	68.8 U
Thallium	F	10	—	— UJ	—	—	—
Vanadium	P	50	—	17.6 J	9.5 J	13.3 J	7.4 J
Zinc	P	20	—	49.2 J	166 J	36.4 J	69.6 J
% Solids				94.7%	94.2%	95.8%	92.6%

Footnotes:

F – Furnace
P – ICP/Flame AE
CV – Cold Vapor
C – Colorimetric
R – Value is rejected.

J – Quantitation is approximate due to limitations identified in the quality control review.
UJ – Sample detection limit is approximate due to limitations identified in the quality control review.
IDL – Instrument Detection Limit
CRDL – Contract Required Detection Limit
** – Specific sample detection limits are listed on the accompanying table.
U – Value reported is the sample detection limit.

INORGANIC SOIL ANALYSIS
(mg/kg)

SITE: NORWOOD PCB SITE
SAS NO.: 7018A
SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

				TREATED SOILS	
				HIGH PCB	LOW PCB
SAMPLE DESCRIPTION:				Norwood site high–treated soil	Norwood site low–treated soil
EPA SAMPLE NUMBER:				7018A–506	7018A–507
RCC SAMPLE ID:				20112–18	20111–18
ANALYTES		CRDL (ug/L) **	IDL (ug/L)		
Aluminum	P	200	—	2640 J	3960 J
Antimony	P	60	—	— R	— R
Arsenic	F	10	—	1.8	1.3
Barium	P	200	—	20.7	12.3
Beryllium	P	5	—	0.49	0.2
Cadmium	P	5	—	1.2	1.1
Calcium	P	5000	—	3680 J	1020 J
Chromium	P	10	—	9.1 J	8.6 J
Cobalt	P	50	—	2.9 U	4.2 U
Copper	P	25	—	164 J	18.9 J
Iron	P	100	—	6630 J	5990 J
Lead	F	3	—	— R	— R
Magnesium	P	5000	—	950 J	2100 J
Manganese	P	15	—	255	208
Mercury	CV	0.2	—	0.14 J	—
Nickel	P	40	—	4.1 U	8.3 U
Potassium	P	5000	—	565	362
Selenium	F	5	—	0.12	—
Silver	P	10	—	1.2 J	0.79 J
Sodium	P	5000	—	1330	1280
Thallium	F	10	—	—	—
Vanadium	P	50	—	6.1	11.0
Zinc	P	20	—	73.5 J	35.4 J
% Solids				96.7%	97.8%

Footnotes:

F – Furnace
P – ICP/Flame AE
CV – Cold Vapor
C – Colorimetric
R – Value is rejected.

U – Value reported is the sample detection limit.
J – Quantitation is approximate due to limitations identified in the quality control review.
UJ – Sample detection limit is approximate due to limitations identified in the quality control review.
IDL – Instrument Detection Limit
CRDL – Contract Required Detection Limit
** – Specific sample detection limits are listed on the accompanying table.

Untreated Soil Sample Detection Limits mg/Kg				
ANALYTE	7018A -501 20112-2	7018A -502 20112-02	7018A -503 20111-02	7018A -504 20111-02
	-------- FIELD DUPL --------		-------- FIELD DUPL --------	
Aluminum	1.0	0.9	0.8	0.9
Antimony	3.9	3.4	3.1	3.2
Arsenic	0.2	0.2	0.2	0.2
Barium	1.2	1.1	1.0	1.0
Beryllium	0.1	0.1	0.1	0.1
Cadmium	0.4	0.4	0.3	0.3
Calcium	3.9	3.4	3.1	3.2
Chromium	0.4	0.4	0.3	0.3
Cobalt	0.8	0.7	0.6	0.7
Copper	0.3	0.3	0.2	0.3
IronLead	0.6	0.5	0.5	0.5
Lead	0.1	0.1	0.1	0.1
Magnesium	5.0	4.4	4.0	4.2
Manganese	0.2	0.2	0.2	0.2
Mercury	0.1	0.1	0.1	0.1
Nickel	0.9	0.8	0.7	0.8
Potassium	36.7	32.0	29.2	30.6
Selenium	0.1	0.1	0.1	0.1
Silver	0.7	0.6	0.6	0.6
Sodium	24.6	21.4	19.5	20.5
Thallium	0.3	0.3	0.3	0.3
Vanadium	0.3	0.3	0.2	0.3
Zinc	0.3	0.3	0.2	0.3

Treated Soil Sample Detection Limits mg/Kg		
ANALYTE	7018A -506 20112-18	7018A -507 20111-18
Aluminum	1.0	1.0
Antimony	3.7	3.8
Arsenic	0.1	0.2
Barium	1.2	1.2
Beryllium	0.1	0.1
Cadmium	0.4	0.4
Calcium	3.7	3.8
Chromium	0.4	0.4
Cobalt	0.8	0.8
Copper	0.3	0.3
Iron	0.6	0.6
Lead	0.1	0.1
Magnesium	4.8	4.9
Manganese	0.2	0.2
Mercury	0.1	0.1
Nickel	0.9	0.9
Potassium	35.3	36.0
Selenium	0.1	0.1
Silver	0.7	0.7
Sodium	23.6	24.1
Thallium	0.2	0.2
Vanadium	0.3	0.3
Zinc	0.3	0.3

OIL SEMIVOLATILE ORGANICS ANALYSIS
MG/KG

SITE: NORWOOD PCB SITE
SDG. NO.: 7018A-920
SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

OILS DILUTED IN SOLVENT. SEE END OF THIS ATTACHMENT FOR DILUTION.

		EXTRACTED OILS			
		HIGH PCB		LOW PCB	
SAMPLE DESCRIPTION:		Oil extracted from high PCB soil		Oil extracted from low PCB soil	
EPA SAMPLE NUMBER:		7018A-920		7018A-921	
RCC SAMPLE ID:		20112-20		20111-20	
COMPOUND	CRQL				
Phenol	20	20	U	20	U
bis(2-Chloroethyl) ether	20	20	U	20	U
2-Chlorophenol	20	20	U	20	U
1,3-Dichlorobenzene	20	20	U	20	U
1,4-Dichlorobenzene	20	20	U	20	U
Benzyl Alcohol	20	20	U	20	U
1,2-Dichlorobenzene	20	20	U	20	U
2-Methylphenol	20	20	U	20	U
bis (2-Chloroisopropyl)ether	20	20	U	20	UJ
4-Methylphenol	20	20	U	20	U
N-Nitroso-di-n-propylamine	20	20	U	20	U
Hexachloroethane	20	20	U	20	U
Nitrobenzene	20	20	U	20	U
Isophorone	20	20	U	20	U
2-Nitrophenol	20	20	U	20	U
2,4-Dimethylphenol	20	20	U	20	U
Benzoic Acid	100	35	J	20	U
bis(2-Chloroethoxy)methane	20	20	U	20	U
2,4-Dichlorophenol	20	20	U	20	U
1,2,4-Trichlorobenzene	20	34	J	3	J
Naphthalene	20	20	U	3	J
4-Chloroaniline	20	20	U	20	U
Hexachlorobutadiene	20	20	U	20	U
4-Chloro-3-Methylphenol	20	20	U	20	U
2-Methylnaphthalene	20	20	U	20	U
Hexachlorocyclopentadiene	20	20	U	20	U
2,4,6-Trichlorophenol	20	20	U	20	U
2,4,5-Trichlorophenol	100	100	U	100	U
2-Chloronaphthalene	20	20	U	20	U
2-Nitroaniline	100	100	U	100	U
Dimethylphthalate	20	20	U	20	U
Acenaphthylene	20	20	U	20	U
2,6-Dinitrotoluene	20	20	U	20	U
3-Nitroaniline	20	100	U	100	U
Acenaphthene	20	20	U	20	U
2,4-Dinitrophenol	100	100	U	100	U
4-Nitrophenol	100	100	U	100	U
Dibenzofuran	20	20	U	20	U

OIL SEMIVOLATILE ORGANIC ANALYSIS
MG/KG

SITE: NORWOOD PCB SITE
SDG. NO.: 7018A-920
SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

OILS DILUTED IN SOLVENT,
SEE END OF THIS ATTACHMENT
FOR DILUTION.

		EXTRACTED OILS			
		HIGH PCB		LOW PCB	
SAMPLE DESCRIPTION:		Oil extracted from high PCB soil		Oil extracted from low PCB soil	
EPA SAMPLE NUMBER:		7018A-920		7018A-921	
RCC SAMPLE ID:		20112-20		20111-20	
COMPOUND	CRQL				
2,4-Dinitrotoluene	20	20	U	20	U
Diethylphthalate	20	20	U	20	U
4-Chlorophenyl-Phenylether	20	20	U	20	U
Fluorene	20	20	U	20	J
4-Nitroaniline	100	100	U	100	U
4,6-Dinitro-2-Methylphenol	100	100	U	100	U
N-nitrosodiphenylamine	20	20	U	20	U
4-Bromophenyl-Phenylether	20	20	U	20	U
Hexachlorobenzene	20	20	U	20	U
Pentachlorophenol	100	100	U	100	U
Phenanthrene	20	20	U	20	J
Anthracene	20	20	U	20	U
Di-n-butylphthalate	20	20	U	20	U
Fluoranthene	20	20	U	20	U
Pyrene	20	20	U	20	U
Butylbenzylphthalate	20	20	U	20	U
Benzo(a)anthracene	20	20	U	20	U
Chrysene	20	20	U	20	U
3,3'-Dichlorobenzidine	40	40	U	40	U
Bis(2-ethylhexyl)phthalate	20	17	J	15	J
Di-n-octylphthalate	20	20	U	3	J
Benzo(b)fluoranthene	20	4	J	20	U
Benzo(k)fluoranthene	20	4	J	20	U
Benzo(a)pyrene	20	20	U	20	U
Indeno(1,2,3-cd)pyrene	20	20	U	20	U
Dibenz(a,h)anthracene	20	20	U	20	U
Benzo(g,h,i)perylene	20	20	U	20	U
DILUTION FACTOR:		1		1	
DATE SAMPLED:		2-17-92		2-17-92	
DATE EXTRACTED:		2-20-92		2-20-92	
DATE ANALYZED:		2-24-92		2-25-92	

Footnotes:

CRQL - Contract Required Quantitation Limit
J - Quantitation is approximate due to limitations identified in the quality control review.

U - Value reported is the sample detection limit.
R - Value is rejected.
UJ - Sample detection limit is approximate due to lim identified in the quality control review.
D - The reported value is from the diluted analysis.

M&E Metcalf & Eddy
An Air & Water Technologies Company

004609-0019-011-006-004

May 18, 1992

Mr. Steve O'Laughlin
Resources Conservation Company
Analytical Laboratory
11113 NE 33rd Place
Bellevue, WA 98004

Subject: EPA-CLP Dioxin Data from Treatability Study Samples
Norwood PCB Site

Dear Steve:

Enclosed are the data tables which present the analytical results for the samples which you sent to an EPA-CLP laboratory for dioxin/dibenzofuran analysis, as part of the Norwood PCB Site treatability study.

The data were validated by EPA chemists and include analyses of untreated soils (in duplicate), treated soils, and extracted oils.

Please note that the reported concentrations in the extracted oil samples have not been corrected for dilution by the solvent (hexane). Please provide us with this information so that the concentrations in the undiluted oils can be calculated.

SEE END OF ATTACHMENT

We have received your draft report and will be providing you with comments within the next two weeks. Please feel free to call me if you have any questions or comments on the dioxin data.

Very truly yours,

METCALF & EDDY, INC.

Barbara Weir

Barbara Weir
Treatability Study Coordinator

cc J. Levengood (letter only)
D. Carpenter (letter only)
WA #19 file (letter w/attachment)

30 Harvard Mill Square, Wakefield, MA 01880
Mailing Address: PO Box 4043, Woburn, MA 01888-4043
617-246-5200 FAX 617-245-6293
AWT

SITE: Norwood PCB - Norwood, MA

CASE/SAS NO: 7018A / 7018A-401

SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY

TECHNOLOGY: TRIETHYLAMINE EXTRACTION

	20112-02 UNTREATED SOIL, HIGH PCB		20112-02 UNTREATED SOIL, HIGH PCB, DUPLICATE		20112-08 TREATED SOIL, HIGH PCB	
Sample No	7018A-801		7018A-802		7018A-807	
Matrix	SOIL		SOIL		SOIL	
TCDD/TCDF Conc	ug/kg	DL/EMPC*	ug/kg	DL/EMPC*	ug/kg	DL/EMPC*
2,3,7,8-TCDD	UJ	0.060 *	UJ	0.014 *	U	0.004
1,2,3,7,8-PeCDD	U	0.006	U	0.007	U	0.011
1,2,3,4,7,8-HxCDD	U	0.038	U	0.028	U	0.014
1,2,3,6,7,8-HxCDD	U	0.034	U	0.025	U	0.013
1,2,3,7,8,9-HxCDD	U	0.034	UJ	0.025	UJ	0.013
1,2,3,4,6,7,8-HpCDD	0.058		0.074		U	0.007
OCDD	0.033 J		0.046 J		0.062 J	
2,3,7,8-TCDF	UJ	11.998 *	5.224		0.392	
1,2,3,7,8-PeCDF	UJ	1.597 *	U	0.003	0.034	
2,3,4,7,8-PeCDF	4.703		U	0.002	UJ	0.031 *
1,2,3,4,7,8-HxCDF	29.076		26.40		UJ	0.054 *
1,2,3,6,7,8-HxCDF	9.598		8.576		0.015	
2,3,4,6,7,8-HxCDF	1.521			0.026	U	0.015
1,2,3,7,8,9-HxCDF	U	0.029		0.031	U	0.018
1,2,3,4,6,7,8-HpCDF	7.706		6.977		0.017 J	
1,2,3,4,7,8,9-HpCDF	5.668		5.913		U	0.013
OCDF	0.454 J		0.588		0.023	
TOTAL TCDD	U	44.678	U	28.608	UJ	2.056 *
TOTAL PeCDD	0.09	461.809	0.05	417.048	UJ	76.67 *
TOTAL HxCDD	U	0.465	U	0.467	U	0.014
TOTAL HpCDD	0.10		0.07	0.176	U	0.007
TOTAL TCDF	8.98	30.665	8.21	25.704	1.07	1.157
TOTAL PeCDF	40.52	51.315	43.35	47.438	0.16	0.191
TOTAL HxCDF	81.87	82.309	71.97	72.217	0.02	0.087
TOTAL HpCDF	20.21	20.217	19.59		0.02	
TOXICITY EQUIVALENCY	7.845 J		4.1645 J		0.06329 J	
DILUTION FACTOR	1.0		1.0		1.0	
DATE OF RECEIPT	2/13/92		2/13/92		2/13/92	
SAMPLE EXTRACTION DATE	2/24/92		2/24/92		2/24/92	
ANALYSIS DATE	2/27/92		2/27/92		2/27/92	
GC/MS I.D.	E005921		E005922		E005927	

SITE: Norwood PCB - Norwood, MA

CASE/SAS NO: 7018A / 7018A-401

SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY

TECHNOLOGY: TRIETHYLAMINE EXTRACTION

	20111-02 UNTREATED SOIL, LOW PCB		20111-02 UNTREATED SOIL, LOW PCB, DUPLICATE		20111-08 TREATED SOIL, LOW PCB	
Sample No	7018A-803		7018A-804		7018A-808	
Matrix	SOIL		SOIL		SOIL	
TCDD/TCDF Conc	ug/kg	DL/EMPC*	ug/kg	DL/EMPC*	ug/kg	DL/EMPC*
2,3,7,8-TCDD	U	0.004	U	0.005	U	0.003
1,2,3,7,8-PeCDD	U	0.032	U	0.008	U	0.006
1,2,3,4,7,8-HxCDD	U	0.025	U	0.020	U	0.017
1,2,3,6,7,8-HxCDD	U	0.022	U	0.018	U	0.016
1,2,3,7,8,9-HxCDD	UJ	0.022	UJ	0.018	UJ	0.015
1,2,3,4,6,7,8-HpCDD	UJ	0.010	UJ	0.016	U	0.005
OCDD	J	0.312	0.113 J		0.072 J	
2,3,7,8-TCDF	U	0.234	0.161		U	0.003
1,2,3,7,8-PeCDF	U	0.005	U	0.006	U	0.006
2,3,4,7,8-PeCDF	0.180		0.172		U	0.006
1,2,3,4,7,8-HxCDF	1.843		1.551		U	0.015
1,2,3,6,7,8-HxCDF	0.622		0.524		U	0.014
2,3,4,6,7,8-HxCDF	U	0.018	U	0.020	U	0.015
1,2,3,7,8,9-HxCDF	U	0.021	U	0.024	U	0.018
1,2,3,4,6,7,8-HpCDF	0.380 J		0.361 J		U	0.009
1,2,3,4,7,8,9-HpCDF	0.233		0.263		U	0.011
OCDF	UJ	0.183 *	0.264		U	0.021
TOTAL TCDD	UJ	17.066 *	UJ	17.299 *	UJ	1.875 *
TOTAL PeCDD	UJ	465.21 *	UJ	1380.05 *	UJ	0.131 *
TOTAL HxCDD	UJ	0.161 *	U	0.020 *	U	0.017
TOTAL HpCDD	U	0.010	U	0.016 *	U	0.005
TOTAL TCDF	0.10	3.897 *	0.29	3.995 *	UJ	0.032 *
TOTAL PeCDF	2.56	4.453 *	2.34	3.915 *	UJ	0.043 *
TOTAL HxCDF	5.45	5.484 *	4.59	4.642 *	U	0.018
TOTAL HpCDF	0.87	0.953 *	0.91	0.963 *	U	0.011
TOXICITY EQUIVALENCY	0.366 J		0.3164 J		0.000075 J	
DILUTION FACTOR	1.0		1.0		1.0	
DATE OF RECEIPT	2/13/92		2/13/92		2/13/92	
SAMPLE EXTRACTION DATE	2/24/92		2/14/92		2/24/92	
ANALYSIS DATE	2/27/92		2/27/92		2/27/92	
GC/MS I.D.	E005923		E005924		E005928	

SITE: Norwood PCB - Norwood, MA

CASE/SAS NO: 7018A / 7018A-401

SUBCONTRACTOR: RESOURCES CONSERVATION COMPANY
TECHNOLOGY: TRIETHYLAMINE EXTRACTION

	20112-20 EXTRACT FROM HIGH PCB SOIL		20111-20 EXTRACT FROM LOW PCB SOIL	
Sample No	7018A-809		7018A-810	
Matrix	OIL		OIL	
TCDD/TCDF Conc	ug/kg	DL/EMPC*	ug/kg	DL/EMPC*
2,3,7,8-TCDD	U	0.019	U	0.048
1,2,3,7,8-PeCDD	UJ	0.763 *	U	0.041
1,2,3,4,7,8-HxCDD	U	0.242	U	0.558
1,2,3,6,7,8-HxCDD	U	0.215	U	0.493
1,2,3,7,8,9-HxCDD	U	0.213	U	0.491
1,2,3,4,6,7,8-HpCDD	UJ	0.189 *	0.131 J	
OCDD	1.728 J		1.592 J	
2,3,7,8-TCDF	30.050 J		3.132 J	
1,2,3,7,8-PeCDF	13.506 J		UJ	0.370 *
2,3,4,7,8-PeCDF	U	0.042	4.030 J	
1,2,3,4,7,8-HxCDF	95.138 J		29.891 J	
1,2,3,6,7,8-HxCDF	27.730 J		8.771 J	
2,3,4,6,7,8-HxCDF	4.384 J		0.962 J	
1,2,3,7,8,9-HxCDF	3.054 J		U	0.090
1,2,3,4,6,7,8-HpCDF	21.194 J		7.484 J	
1,2,3,4,7,8,9-HpCDF	21.530 J		7.194 J	
OCDF	21.016 J		5.617 J	
TOTAL TCDD	UJ	285.67 *	UJ	146.707 *
TOTAL PeCDD	UJ	2103.9 *	UJ	2852.37 *
TOTAL HxCDD	UJ	1.32 *	U	0.931
TOTAL HpCDD	UJ	0.347 *	0.13	
TOTAL TCDF	49.70	76.896 *	3.13	39.424
TOTAL PeCDF	153.09	176.4 *	53.46	57.86
TOTAL HxCDF	242.84	243.89 *	81.03	
TOTAL HpCDF	71.74		22.59	
TOXICITY EQUIVALENCY	17.58 J		6.464 J	
DILUTION FACTOR	1.0		1.0	
DATE OF RECEIPT	2/19/92		2/19/92	
SAMPLE EXTRACTION DATE	3/2/92		3/2/92	
ANALYSIS DATE	3/3/92		3/3/92	
GC/MS I.D.	E005972		E005973	

Data Summary Key

A - Acceptable data.

J - The associated numerical value is an estimated quantity.

R - Reject data due to quality control criteria. The data are unusable (compound may or may not be present). Resampling and reanalysis is necessary for verification.

U - The compound was analyzed for, but was not detected. The associated numerical value is the sample quantitation limit.

UJ - The compound was analyzed for, but was not detected. The sample quantitation limit is an estimated quantity.

-- - The compound was analyzed for, but was not detected. The sample quantitation limit is the same as the CRQL presented.

Conversion Factors

for

CLP Oil ('Extract') Analyses

The product oils ('extracts') from the treatability tests were deliberately left in triethylamine solvent. (This was due to the low oil content, and therefore low quantity of oil produced from the treatability tests.) The triethylamine diluent was exchanged into hexane prior to sending the extracts to the CLP lab to facilitate analysis by the CLP lab. The attached sheet gives the conversion factors for both extracts to convert the CLP oil-in-hexane results to a hexane-free basis such that the results reflect product oil that would be produced by full-scale processing.

C.M

RCC LAB MANAGER

6/17/92

CONVERSION FACTORS FOR NORWOOD OIL SAMPLES

LOW PCB SAMPLE

CONCENTRATION FACTOR		OIL CONTENT FACTOR		HEXANE CORRECTION		CONVERSION FACTOR
(1/10)	X	(1/.005)	X	(0.66/0.73)	=	18.1

HIGH PCB SAMPLE

CONCENTRATION FACTOR		OIL CONTENT FACTOR		HEXANE CORRECTION		CONVERSION FACTOR
(1/1)	X	(1/.088)	X	(0.66/0.73)	=	10.3

NOTE: The conversion factors can be used as a multiplier to convert oil analysis results from a hexane/oil basis to an oil basis. For example, for the low PCB sample PCB concentration conversion is as follows:

Initial CLP lab result		Conversion factor		PCB concentration on an oil basis
11400 mg/kg	x	18.1	=	210000 mg/kg

Appendix C

APPENDIX C

OIL DISPOSAL EVALUATION INFORMATION

APPENDIX C-1

LETTER TO RPM
CONCERNING OIL DISPOSAL

M&E Metcalf & Eddy
An Air & Water Technologies Company

004609-0019-011-006-004

August 21, 1992

Ms. Pamela Shields
Remedial Project Manager
USEPA Region I (HRS)
JFK Federal Building
Boston, Massachusetts 02203-2211

Subject: **Contract No. 68-W9-0036**
Work Assignment No. 19-1N51
Norwood PCB (RD)

Dear Ms. Shield:

Metcalf & Eddy (M&E) is providing engineering services to EPA in support of the Remedial Design/Remedial Action (RD/RA) being carried out at the Norwood PCB Superfund Site in Norwood, Massachusetts. The Record of Decision for this site has identified solvent extraction as the selected remedy for the remediation of site soils contaminated with PCBs, specifically Aroclor-1254. The solvent extraction studies are described further below in terms of the samples which were extracted, and the data obtained on extracted oils.

The solvent extraction treatability studies involved the bench-scale extraction of two soil samples: 1) a composite sample, identified herein as the "average" sample, which is representative of the average PCB concentration expected during full-scale remediation; and 2) a "hot spot" sample collected from the most highly contaminated area of the site, which represents the worst-case situation for treatment. The PCBs present at the site are quantified as Aroclor-1254. No other Aroclors were detected in the samples. Dioxins/dibenzofurans were also detected in each soil.

As a result of the presence of dioxins/dibenzofurans, M&E conducted an evaluation of possible disposal options for the PCB/dioxin oily waste. M&E contacted the following vendors, selected from the Directory of Commercial Hazardous Waste Management (Hazardous Waste Consultant, 1991) based on the fact they could handle PCB wastes with concentrations greater than 500 ppm.

30 Harvard Mill Square Wakefield, MA 01880
Mailing Address: PO Box 4043 Woburn, MA 01888-4043
617-246-5200 FAX 617-245-6293

COMPANY	STATE
1. East Coast Environmental Service Co.	Connecticut
2. Chemwaste Management	New Jersey
3. Cecos, Inc.	Connecticut
4. Aptus\Westinghouse	Kansas
5. GSX\Laidlaw	Arkansas
6. Rollins Environmental Services	New Jersey

Each vendor was asked to provide transportation and disposal costs for the oily waste. Many of the vendors, however, needed analytical data to determine whether they could handle the material, and subsequently provide costs for handling and disposing the material. Upon approval from EPA, M&E sent analytical information, obtained during the Solvent Extraction treatability study, to the selected vendors, and requested the following:

1. Cost estimate (disposal, transportation, taxes) assuming that approximately 300 drums of oil would require transportation from the Norwood site (Norwood, Massachusetts) to the facility.

2. Capacity of the facility in 1995 (i.e., if all the oil cannot be accepted, could the vendor accept a portion of it, and how much?)

3. RCRA and TSCA permit status

4. If it is not possible to make a decision concerning disposal of the oil at this time, please outline what additional information the vendor would need to make a decision

5. If the facility declined to accept the oil under any conditions, explain why.

M&E received the following responses from the vendors. East Coast Environmental and Chemwaste Management are not able to handle the waste due to the presence of dioxin. Rollins Environmental Services informed M&E that they could not handle the waste due to the elevated levels of dioxin. They have a facility in Texas that will accept dioxin with a Dioxin Toxicity Equivalency (DTE) of 20 or less. The DTE of the waste generated at the Norwood Superfund site is 181.

GSX\Laidlaw notified M&E they were not sure if they could handle waste containing Dioxin. Currently, their price for PCB disposal is $1500 - $1600 per drum. They were quick to point out the cost is continually changing and if they were able to accept the dioxin contaminated waste, the cost per drum would be different.

Cecos, Inc. expressed the same general response that at the current time they could not accept the dioxin contaminated PCB oil. In the past they have exported the waste to Finland. Currently, this disposal method is on hold, but they hope to reestablish exporting practices in the near future. Cecos did express concern over the combination of PCB and dioxin and believed there may be problems shipping the waste overseas. Before exportation of the material was terminated, shipping\disposal costs were $2500 - $4000 per drum.

The last company contacted was APTUS. Currently they have a permit to incinerate dioxin contaminated waste, and have done so in the recent past. However, they do not have a permit to dispose the slag material generated by their incineration process. They believe this permit may be attainable within 6-12 months. Cost for the incineration is expected to be $5 - $6 per pound of material.

Currently, there doesn't seem to be a company that is able to handle the dioxin contaminated waste. Many of the vendors contacted seem to think that by 1995 they will be able to process the waste. Based on the initial costs quoted by the vendors it seems as though transportation and disposal costs, for the 300 drums of PCB oil generated at the Norwood Superfund site, will run in excess of 1 million dollars.

If you have any questions or comments, please do not hesitate to call.

Very truly yours,

METCALF & EDDY, INC.

Dave Carpenter

David F. Carpenter
Project Manager

cc: N. Barmakian
C. Hagger
J. Levengood
B. Weir
WA#19-1L51
Contract File

APPENDIX C-2

INFORMATION ON OIL PROVIDED TO TSD FACILITIES

File: Norwood PCB Superfund Site, Solvent Extraction Treatability Study, Job No. 004609-0019-011-006-004

Subject: Evaluation of Options for Disposal of Extracted Oil: Information to be provided to TSDFs

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Metcalf & Eddy (M&E) is providing engineering services to EPA in support of the Remedial Design/Remedial Action (RD/RA) being carried out at the Norwood PCB Superfund Site in Norwood, Massachusetts. The Record of Decision for this site has identified solvent extraction as the selected remedy for the remediation of site soils contaminated with PCBs, specifically Aroclor-1254. During the pre-design phase of the RD/RA, M&E procured two solvent extraction technology vendors to carry out bench-scale treatability studies of their respective processes. The objectives of the treatability studies were to:

- Determine the effectiveness of solvent extraction for attaining a cleanup level of < 10 mg/kg total PCBs in site soils
- Obtain an estimate of the quantity of PCB-laden oil which would be generated by the remediation of site soils using solvent extraction
- Obtain analytical data for PCBs and dioxins/dibenzofurans in the oil to allow for an evaluation of disposal options
- Obtain data needed to design a full-scale solvent extraction process

The studies are described further below in terms of the samples which were extracted, the test procedures, and the analytical data obtained on extracted oils.

Soil Samples: The solvent extraction treatability studies involved the bench-scale extraction of two soil samples: 1) a composite sample, identified herein as the "average" sample, which is representative of the average PCB concentration expected during full-scale remediation; and 2) a "hot spot" sample collected from the most highly contaminated area of the site, which represents the worst-case situation for treatment. The PCBs present at the site are quantified as Aroclor-1254. No other Aroclors were detected in the samples. Dioxins/dibenzofurans were also detected in each soil. The Aroclor-1254 concentrations and toxicity equivalencies for the samples (average values) were:

	Aroclor-1254 Concentration (mg/kg)	Toxicity Equivalency (ug/kg)
"Average" Soil	772	0.3295
"Hot Spot" Soil	8840	5.6569

Solvent Extraction Processes: Two vendors of solvent extraction processes were selected to carry out the treatability studies, CF Systems Corporation and Resources Conservation Company (RCC). The process marketed by CF Systems uses liquefied gases (usually propane or a propane/butane mixture) as the solvent; propane was used for the Norwood treatability studies. The process marketed by RCC is known as the B.E.S.T. process and uses aliphatic amines (usually triethylamine) as solvents. Triethylamine was used by RCC for the Norwood treatability studies.

Test Procedure: Approximately 1 kg of each of these samples was extracted six times in the bench-scale solvent extraction units used by CF Systems and RCC to simulate their respective processes. All solvent extraction processes work on the basis of differential solubility. As the soil is contacted with the solvent, Aroclor-1254, dioxins/dibenzofurans, and other organic compounds are transferred from the soil matrix into the solvent, in which they are more soluble. The solvent, which now contains the bulk of the organic compounds originally present in the soil, is removed from the extraction apparatus and processed to recover the solvent, leaving behind the organic compounds in the form of an oil (also called an "extract"). Because metals tend to remain with the soil rather than being extracted into the solvent, the oil generated by solvent extraction processes does not contain significant concentrations of metals.

Oil Analyses: The oils (extracts) generated from the extraction of both the "average" soil sample and the "hot spot" soil sample were submitted to EPA-CLP laboratories for analyses of PCBs, dioxins/dibenzofurans, and semivolatile organic compounds. Attachment 1 presents the isomer breakdown from dioxin/dibenzofuran analyses, and the Aroclor-1254 concentration, for two representative oil samples generated during the treatability studies. Aroclor-1254 was the only Aroclor detected in any of the oils analyzed. Note that 2,3,7,8-TCDD was not detected in the samples.

Attachment 2 presents the analytical results for semivolatile organic compounds. Trace concentrations of a few semivolatiles were detected in the oils. These concentrations are insignificant in comparison to the Aroclor-1254 concentrations in the oils.

The oils which will be generated during full-scale remediation are expected to be of similar composition to these oils, and are expected to contain no more than ten percent water. The total quantity of oil to be generated is estimated to be on the order of 300 drums over a ten-month remediation period. The remediation is expected to occur in 1995.

Information requested: Please provide the following information concerning the possibility of disposal of this oil at your facility:

1. Cost estimate (disposal, transportation, taxes) assuming that approximately 300 drums of oil will require transportation from the Norwood site (Norwood, Massachusetts) and incineration at your facility

2. Capacity of your facility in 1995 (i.e., if all the oil cannot be accepted, could you accept a portion of it, and how much?)

3. RCRA and TSCA permit status

4. If it is not possible to make a decision concerning disposal of the oil at this time, please outline what additional information you may need to make a decision

5. If your facility would decline to accept the oil under any conditions, please state why.

Please contact Barbara Weir at Metcalf & Eddy with any questions concerning this request. The phone number is 617-246-5200, extension 4608.

ATTACHMENT 1

SOLVENT EXTRACTION TREATABILITY STUDY RESULTS

Compound	Extracted Oils	
	Extract from "Hot Spot" Soil Sample	Extract from "Average" Soil Sample
TCDD/TCDF Concentration	(ug/kg)	(ug/kg)
2,3,7,8-TCDD	U	U
1,2,3,7,8-PeCDD	UJ	U
1,2,3,4,7,8-HxCDD	U	U
1,2,3,6,7,8-HxCDD	U	U
1,2,3,7,8,9-HxCDD	U	U
1,2,3,4,6,7,8-HxCDD	UJ	2.371 J
OCDD	17.798 J	28.815 J
2,3,7,8-TCDF	309.515 J	56.689 J
1,2,3,7,8-PeCDF	139.112 J	UJ
2,3,4,7,8-PeCDF	U	72.943 J
1,2,3,4,7,8-HxCDF	979.921 J	541.027 J
1,2,3,6,7,8-HxCDF	285.619 J	158.755 J
2,3,4,6,7,8-HxCDF	45.155 J	17.412 J
1,2,3,7,8,9-HxCDF	31.456 J	U
1,2,3,4,6,7,8-HpCDF	218.298 J	135.460 J
1,2,3,4,7,8,9-HpCDF	221.759 J	130.211 J
OCDF	216.465 J	101.668 J
TOTAL TCDD	UJ	UJ
TOTAL PeCDD	UJ	UJ
TOTAL HxCDD	UJ	U
TOTAL HpCDD	UJ	2.353 J
TOTAL TCDF	511.91 J	56.653 J
TOTAL PeCDF	1576.827 J	967.626 J
TOTAL HxCDF	2501.252 J	1466.643 J
TOTAL HpCDF	738.922 J	408.879 J
TOXICITY EQUIVALENCY	181.074 J	116.998 J
	(mg/kg)	(mg/kg)
AROCLOR-1254	298700 J	206340 J

ATTACHMENT 2

SOLVENT EXTRACTION TREATABILITY STUDY RESULTS

OIL SEMIVOLATILE ORGANICS ANALYSIS
MG/KG

		EXTRACTED OILS	
COMPOUND	CRQL	Extract from "Hot Spot" Soil Sample	Extract from "Average" Soil Sample
Phenol	20	U	U
bis(2-Chloroethyl) ether	20	U	U
2-Chlorophenol	20	U	U
1,3-Dichlorobenzene	20	U	U
1,4-Dichlorobenzene	20	U	U
Benzyl Alcohol	20	U	U
1,2-Dichlorobenzene	20	U	U
2-Methylphenol	20	U	U
bis (2-Chloroisopropyl)ether	20	U	UJ
4-Methylphenol	20	U	U
N-Nitroso-di-n-propylamine	20	U	U
Hexachloroethane	20	U	U
Nitrobenzene	20	U	U
Isophorone	20	U	U
2-Nitrophenol	20	U	U
2,4-Dimethylphenol	20	U	U
Benzoic Acid	100	360.5 J	U
bis(2-Chloroethoxy)methane	20	U	U
2,4-Dichlorophenol	20	U	U
1,2,4-Trichlorobenzene	20	350 J	54 J
Naphthalene	20	U	54 J
4-Chloroaniline	20	U	U
Hexachlorobutadiene	20	U	U
4-Chloro-3-Methylphenol	20	U	U
2-Methylnaphthalene	20	U	U
Hexachlorocyclopentadiene	20	U	U
2,4,6-Trichlorophenol	20	U	U
2,4,5-Trichlorophenol	100	U	U
2-Chloronaphthalene	20	U	U
2-Nitroaniline	100	U	U
Dimethylphthalate	20	U	U
Acenaphthylene	20	U	U
2,6-Dinitrotoluene	20	U	U
3-Nitroaniline	20	U	U
Acenaphthene	20	U	U
2,4-Dinitrophenol	100	U	U
4-Nitrophenol	100	U	U
Dibenzofuran	20	U	U

SOLVENT EXTRACTION TREATABILITY STUDY RESULTS

OIL SEMIVOLATILE ORGANIC ANALYSIS
MG/KG

		EXTRACTED OILS	
COMPOUND	CRQL	Extract from "Hot Spot" Soil Sample	Extract from "Average" Soil Sample
2,4-Dinitrotoluene	20	U	U
Diethylphthalate	20	U	U
4-Chlorophenyl-Phenylether	20	U	U
Fluorene	20	U	362 J
4-Nitroaniline	100	U	U
4,6-Dinitro-2-Methylphenol	100	U	U
N-nitrosodiphenylamine	20	U	U
4-Bromophenyl-Phenylether	20	U	U
Hexachlorobenzene	20	U	U
Pentachlorophenol	100	U	U
Phenanthrene	20	U	362 J
Anthracene	20	U	U
Di-n-butylphthalate	20	U	U
Fluoranthene	20	U	U
Pyrene	20	U	U
Butylbenzylphthalate	20	U	U
Benzo(a)anthracene	20	U	U
Chrysene	20	U	U
3,3'-Dichlorobenzidine	40	U	U
Bis(2-ethylhexyl)phthalate	20	179 J	272 J
Di-n-octylphthalate	20	U	54 J
Benzo(b)fluoranthene	20	42 J	U
Benzo(k)fluoranthene	20	42 J	U
Benzo(a)pyrene	20	U	U
Indeno(1,2,3-cd)pyrene	20	U	U
Dibenz(a,h)anthracene	20	U	U
Benzo(g,h,i)perylene	20	U	U

Footnotes:

CRQL - Contract Required Quantitation Limit
J - Quantitation is approximate due to limitations identified in the quality control review.
U - Value reported is the sample detection limit.
R - Value is rejected.
UJ - Sample detection limit is approximate due to limitatio identified in the quality control review.
D - The reported value is from the diluted analysis.

APPENDIX C-3

TELEPHONE LOGS
CONCERNING OIL DISPOSAL

M&E
METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 4609-19-11-6-4

DATE: 12/1/92

SUBJECT: Norwood PCB + Dioxin Disposal

M&E ENGINEER: K. Campbell

OUTSIDE PARTY: Debbie Strother
GSX (Laidlaw)
800-356-8570

MADE CALL ( )

REC'D CALL ( )

COMMENTS

SUMMARY OF CONVERSATION:

Answering machine, left message

12/3 - It is Debbie's understanding that the change in F-listing will not impact Laidlaw's ability to take the material. As far as Debbie knows, there are no facilities in the U.S. which can treat Dioxin-containing materials except one government facility which only accepts government wastes (Isn't this a government waste?)

JL →

Debbie will verify that her facility won't take it and call me back.

12/7/92 Called Deb back. She asked me to fax her the chemical info and any communication we had from EPA regarding delisting.

12/9/92 Rec'd FAX. Laidlaw cannot take mat'l. They suggest CWM. (I'll follow up with another call to CWM.)

CC: J. Weir
J. Levengood

M&E FORM NO. 196 (9/78)

FROM :LAIDLAW SALES/MARKETING TO : 617 245 6293 1992,12-09 12:52PM #688 P.01/01

LAIDLAW ENVIRONMENTAL SERVICES INC.

FAX Transmission

To: [redacted]

Fax #: 617 245-6293

Company: Metcalf & Eddy, Inc

Department:

From: Debbie Strother

Page 1 Of 1

Time:

Date:

Comments: Reference - 12-7-92 fax regarding analytical for job # 9659
The PCB content is >50 ppm.
Laidlaw cannot landfill nor incinerate PCB's >50 ppm.
Thank you for your inquiry - we suggest you try ICWM-Emelle.

If you do not receive the pages as specified, please call as soon as possible:

803.798.2993 Ext: __________

FAX Reply To:

Corporate 803.798.3660
Finance/Controller 803.731.0271
Human Resources 803.772.2118
Purchasing 803.750.1195
Compliance/Engineering 803.731.0549
Accounting 803.731.2009
Sales & Marketing 803.750.1552

HOUSEHOLD HAZARDOUS WASTE

RESOURCE RECOVERY

SITE REMEDIATION

LAB PACK SERVICES

LABORATORY SERVICES

TRANSPORTATION

INCINERATION

WASTEWATER TREATMENT

SECURE LANDFILLS

BIOLOGICAL TREATMENT

GOVERNMENT SERVICES

20 Outlet Pointe Boulevard (29210), P.O. Box 210799 (29221), Columbia, South Carolina 1.800.845.1019 1.803.798.2993

DEC 9 '92 11:42 803-750-1552 9 0 PAGE.001

METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 4609-19-11-6-4

DATE: 12/1/92

SUBJECT: Norwood PCB + Dioxin Disposal

M&E ENGINEER: K. Campbell

OUTSIDE PARTY: Shawnee Cook / Bill Magee
Chem Waste Mgmt
609-243-7968

MADE CALL (✓)
REC'D CALL ( )

COMMENTS	SUMMARY OF CONVERSATION:
	Shawnee Cook no longer works at Chem. Waste Mgmt. Bill is on road but will call me.
12/2	Bill called back. I reviewed the new circumstances with him with respect to F-listing. He was not sure if Chem Waste could handle sample. He will check with his staff and call back.
	12/9/92

cc:
J. Greenwood
B. Wei

M&E FORM NO. 196 (9/78)

METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 4609-19-11-6-4

DATE: 12/1/92

SUBJECT: Norwood PCB + Dioxin Disposal

M&E ENGINEER: K. Campbell

OUTSIDE PARTY: Alyssa Serianni
CECOS Inc.
(Clean Harbors) 203 583-8917

MADE CALL ( )

REC'D CALL ( )

COMMENTS	SUMMARY OF CONVERSATION:
-027. off-site disposal manager.	Explained case to Alyssa. She did not think that a change in listing would make a difference. She agreed to check and then get back to me.

CC:
B. Weir
J. Levengood.

M&E FORM NO. 196 (9/78)

M&E
METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 4609-19-11-6-4

DATE: 12/1/92

SUBJECT: Norwood PCB + Dioxin Disposal

M&E ENGINEER: K. Campbell

MADE CALL (✓)

REC'D CALL ( )

OUTSIDE PARTY: Kathy Moreno
Rollins
609-467-3105

COMMENTS

SUMMARY OF CONVERSATION:

Explained case to Kathy. She fowarded me to John Ambrosini to answer question.

John not at line. Left message. John called back and left message:

Rollins can take waste if de-listed however not if dioxins exceed 20ppb. He suggested calling Maxine Wellman for details on Wednesday.

CC:
B. Weil
J. Levengood.

M&E FORM NO. 196 (9/78)

M&E
METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 4609-19-11-6-4

DATE: 12/1/92

SUBJECT: Norwood PCB + Dioxin Disposal

M&E ENGINEER: K Campbell

OUTSIDE PARTY: Leo Tancreti, Jr.
East Coast Environmental
(203) 469-2376

MADE CALL (✓)

REC'D CALL ( )

COMMENTS

SUMMARY OF CONVERSATION:

Leo (Jr.) is out this week. According to the receptionist there is no one else who can help me. Left name & number in case Leo Jr. called back.

CC: B. Weir
J. Levengood

M&E FORM NO. 196 (9/78)

METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 4609-19-11-6-4

DATE: 12/1/92

SUBJECT: Norwood PCB Disposal

M&E ENGINEER: K. Campbell

MADE CALL (✓)

REC'D CALL ( )

OUTSIDE PARTY: Celia Witwer
APTUS
800-248-0442

COMMENTS

'Waste Acceptance Procedure.

→ Sample to Completed profile

→ letter declaring in light of its process has been delisted.

[illegible]'t give cost 'til they receive sample

SUMMARY OF CONVERSATION:

Still haven't obtained permit to handle slag material from Dioxin incinerated material and probably will not have for another 1+ years. I mentioned dropping of F listing. She directed me to Giles Pennick

Giles said that if F-listing was dropped, they could handle the waste. In order to tell us how much things cost, they need to initiate ~~do~~ the waste acceptance procedure which includes analysis of a sample. They would also need a letter from EPA stating that the waste has been delisted.

CC: B. Weir
J. Levengood

M&E FORM NO. 196 (9/78)

M&E
METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 024609-1911-6-4

DATE: 6/12/92

SUBJECT: Norwood

M&E ENGINEER: J. Levergood

OUTSIDE PARTY: Jane Downing

MADE CALL (X)

REC'D CALL ( )

COMMENTS

SUMMARY OF CONVERSATION:

- Gave Jane rundown of solvent extraction results — based on average sample — looks like 200-300 drums of oil will be generated. We have been calling disposal companies to see if anyone will take the oil — most companies will not give us an answer without analytical data — J[illegible] is OK to send analytical data on oil to these companies

- Jane definitely wants us to look into dechlor option

- Jane is getting a new job which will start fairly soon
  Does not know who the new RPM will be for Norwood
  Wants sampling to happen ASAP but must wait until new RPM → probably within 1 month

CC: Carpenter

[illegible]

[illegible]

M&E FORM NO. 196 (9/78)

METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 704609-19-11-6-4 ✓

DATE: 6/23/92

SUBJECT: Norwood

M&E ENGINEER: J. Livingood

OUTSIDE PARTY: Jane Downing

MADE CALL (X)

REC'D CALL ( )

COMMENTS

SUMMARY OF CONVERSATION:

Called to ask about 1) summary of oil contamination to send to disposal companies & 2) RCC + CF's report

1) She had discussed w/ Mark Mekus? at EPA in Cincinatti (solv. ext. expert) he had no knowledge of where to take it + said we were doing the right thing - on right track → also said TEF not important - they'll want to know about 2,3,7,8-TCDD + TCDF

Jane's comments on this fax are as follows:

→ In cover letter, refer to breakdown of dioxin in the attachment

→ Add that waste will be disposed in 1995 to see if company has capacity

→ Add note that vendors say metals will remain w/ soil + we don't expect much metals in the oil.

→ Ask if RCRA + TSCA permitted

→ In Test Procedure, say that oil is generated from treatability tests done by RCC who uses TEA + CF who uses propane as solvent

→ Add Intro ¶ that says what we're doing - treat studies conducted + oil generated. Trying to develop info to determine appropriate disposal options

→ Add directions to respond → would appreciate response by certain deadline

Do not have to resubmit to Jane - can send out.

Dechlor - she has discussed w/ Cincinnati → seems there is a big uncertainty with dioxin - technology is too non-demonstrated - probably should not pursue much further.

- Jane can't get to RCC + CF's report - instructed us to go ahead + send in with draft report.

CC:
Carpenter
[illegible]
File

M&E FORM NO. 196 (9/78)

METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 004609-0019-011-006-004 ✓✓

DATE: 7/9/91

SUBJECT: PCB/DIOXIN DISPOSAL

M&E ENGINEER: B Daly

OUTSIDE PARTY: John Ambrosini

Rollins Environmental

(609) 467-3105 x 233

MADE CALL ( )

REC'D CALL (✓)

COMMENTS

SUMMARY OF CONVERSATION:

I spoke w/ John and he informed me his Company would not be able to handle the waste. Evidently their facility is located in Texas. Texas can only handle a Dioxin Toxicity Equivalency of 20 and our waste is 181.07d. Thus no ~~[illegible]~~ cost estimates were developed.

CC:

D. Weir

[illegible]

M&E FORM NO. 196 (9/78)

METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 004609 – [illegible]

DATE: 7/17/92

SUBJECT: NORWOOD PCB

M&E ENGINEER: B. Daly

OUTSIDE PARTY: Bill Magee
Chemwaste Management
1-609-243-7968

MADE CALL ( )

REC'D CALL (✓)

COMMENTS

SUMMARY OF CONVERSATION:

BILL informed me, due to the fact DIOXIN was present, they would not be able to handle the waste.

CC:
B. Weir

M&E FORM NO. 196 (9/78)

M&E
METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 504609-0010-041-002 VV

DATE: 7/20/92

SUBJECT: NORWOOD PCB

M&E ENGINEER: B. Daly

OUTSIDE PARTY: East Coast Environmental
LEO TANGRETI
1-203-469-2376

MADE CALL ( )
REC'D CALL ( )

COMMENTS

SUMMARY OF CONVERSATION:

Spoke w/ Leo and he informed me they could do nothing w/ the waste due to the fact that DIOXIN was PRESENT

CC:
B. Weir
T. [illegible]

M&E FORM NO. 196 (9/78)

M&E
METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 004609-0019-011-006-004

DATE: 7/20/92

SUBJECT: Norwood PCB

M&E ENGINEER: B. Daly

OUTSIDE PARTY: Vince Testa
APTUS
1-203-294-1223

MADE CALL (✓)

REC'D CALL ( )

COMMENTS

SUMMARY OF CONVERSATION:

Spoke w/ Vin. He informed me that currently they are permitted to Burn Dioxin/PCBs. The problem lies with the fact that they are not permitted to dispose of the slag produced from the process. He will call back w/ more info

also possible cost \$5-6/lb

CC:
B. Wait
J. Havengood

M&E FORM NO. 196 (9/78)

M&E
METCALF & EDDY, INC.

TELECON MEMORANDUM

JOB NO. 004609-0019-011-006-004

DATE: 7/30/92

SUBJECT: Norwood – Oil Disposal Quote

M&E ENGINEER: B. Weir

OUTSIDE PARTY: Jim Maloney
Laidlaw
508-683-1002

MADE CALL (✓)
REC'D CALL (✓)

COMMENTS

SUMMARY OF CONVERSATION:

Jim: Prices for disposal of PCB oils change monthly + fluctuate widely. He can't give a quote that will have any meaning 3 yrs. from now. Current price is $1500 to $1600 per drum. Price has been as low as $300/drum at times.

I asked about how dioxins affect price. He didn't have the table which we sent showing the dioxin isomer breakdown (either lost it or maybe never got it – he will check their files + call back). Still – he doesn't see how they can give a quote given how quickly prices change, even if they can accept oil.

CC:
J. Levergood
D. Carpenter

&E FORM NO. 196 (9/78)

Appendix D

APPENDIX D

MASS BALANCE CALCULATIONS

Project Norwood PCB	Acct. No. 4609-19-11-6-4	Page 1	of 2
Subject Aroclor-1254 Mass Balance	Comptd. By B. Weir	Date 9/2/92	
Detail CF Systems' Treat. Study	Ck'd. By J. Levenquist	Date 12/15/92	

Aroclor-1254 Concentrations (as determined by CLP labs. Average of 2 analyses for untreated soils)

	Low PCB Sample	High PCB Sample
Untreated Soils: Average Value, mg/kg	793	9120
Treated Soils, mg/Kg	0.044	0.98
Extracted Oil, mg/Kg	19,400 *	212,000

* This sample was diluted with 25 mL of hexane (used to wash the oil from the extraction vessel). The concentration reported therefore does not represent the actual concentration in the oil.

Masses of Each Material (as determined by CF Systems)

	Low PCB Sample	High PCB Sample
Untreated Soils, g dry wt.	900.4	919.9
Treated Soils (Raffinate), g dry wt.	830.7	877.9
Extracted Oil, g	Not Measured	26.1

Mass PCB in Low PCB Extracted Oil:

$$\frac{19{,}400 \text{ mg PCB}}{\text{kg sample}} \Bigg| \frac{1 \text{ kg}}{1000 \text{ g}} \Bigg| \frac{0.659 \text{ g hexane}}{1 \text{ mL hexane}} \Bigg| \frac{25 \text{ mL hexane}}{}$$

$$= 320 \text{ mg PCB} \checkmark$$

Mass PCB in Low PCB Untreated Soil:

$$\frac{793 \text{ mg PCB}}{\text{kg soil}} \Bigg| \frac{1 \text{ kg}}{1000 \text{ g}} \Bigg| \frac{900.4 \text{ g soil}}{} = 714 \text{ mg PCB} \checkmark$$

Mass PCB in Low PCB Treated Soil:

$$\frac{0.044 \text{ mg PCB}}{\text{kg soil}} \Bigg| \frac{1 \text{ kg}}{1000 \text{ g}} \Bigg| \frac{830.7 \text{ g soil}}{} = 0.037 \text{ mg PCB} \checkmark$$

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METCALF & EDDY, ENGINEERS

Project	Norwood PCB	Acct. No.	4609-19-11-6-4	Page	2 of 2
Subject	Aroclor-1254 Mass Balance	Comptd. By	B. Weir	Date	9/2/92
Detail	CF Systems' Treat. Study	Ck'd. By	J. Levergood	Date	12/15/92

Mass PCB in High PCB Extracted Oil:

$$\frac{212{,}000 \text{ mg PCB}}{\text{kg oil}} \left| \frac{1 \text{ kg}}{1000 \text{ g}} \right| 26.1 \text{ g oil} = 5533 \text{ mg PCB}$$ ✓

Mass PCB in High PCB Untreated Soil:

$$\frac{9120 \text{ mg PCB}}{\text{kg soil}} \left| \frac{1 \text{ kg}}{1000 \text{ g}} \right| 919.9 \text{ g soil} = 8389 \text{ mg PCB}$$ ✓

Mass PCB in High PCB Treated Soil:

$$\frac{0.98 \text{ mg PCB}}{\text{kg soil}} \left| \frac{1 \text{ kg}}{1000 \text{ g}} \right| 877.9 \text{ g soil} = 0.86 \text{ mg PCB}$$ ✓

Summary Table

	Low PCB Sample	High PCB Sample
Untreated Soil (Feed)	714 mg	8389 mg
Treated Soil Extracted Oil	0.037 mg 320 mg	0.86 mg 5533 mg
Treated Soil + Ex. Oil	320.037 mg ✓	5533.86 mg ✓
% Recovery	44.8 ✓	66.0 ✓

$$\% \text{ Recovery} = \frac{\text{Mass in Treated Soil + Ex. Oil}}{\text{Mass in Untreated Soil}} \times 100$$

Project Norwood PCB Acct. No. 4609-19-11-6-4 Page 1 of 2
Subject Dioxin Mass Balance for Comptd. By B. Weir Date 6/9/92
Detail CF Systems' Treat. Study Ck'd. By Jclevengood Date 12/5/92

Toxicity Equivalencies (as determined by CLP Lab)

	Low PCB Sample (Composite)	High PCB Sample (Hot Spot)
Untreated Soils: Average Value, μg/kg	0.3178	5.309
Treated Soils, μg/kg	0.00777	0.0924
Extracted Oil, μg/kg	15.72 *	219.8

* This concentration has not been corrected for dilution of the sample by CF Systems to 25 mL with hexane.

Masses of Each Material (as determined by CF Systems)

	Low PCB Sample (Composite)	High PCB Sample (Hot Spot)
Untreated Soils, g dry wt.	900.4	919.9
Treated Soils (Raffinate), g dry wt.	830.7	877.9
Extracted Oil, g	?	26.1

? → This weight was not determined by CF Systems; the oil was collected by rinsing it from their apparatus with 25 mL of hexane; this material was sent to CLP labs for analysis without "blowing off" the hexane.

Mass dioxin in Low PCB extracted oil:

$$\frac{15.72\ \mu g\ T.E.}{kg\ sample}\left|\frac{1\ kg}{1000\ g}\right|\frac{0.659\ g\ hexane}{1\ mL\ hexane}\left|\frac{25\ mL\ hexane}{}\right.$$

$$= 0.259\ \mu g\ T.E.$$ ✓

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METCALF & EDDY, ENGINEERS

Project	Norwood PCB	Acct. No.	4609-19-11-6-4	Page	2 of 2
Subject	Dioxin Mass Balance for	Comptd. By	B. Weir	Date	6/9/92
Detail	CF Systems' Treat. Study	Ck'd. By	J. Levangood	Date	12/15/92

Mass Dioxin in Low PCB Untreated Soil:

$$\frac{0.3178\ \mu g\ T.E.}{kg\ soil}\left|\frac{1\ kg}{1000\ g}\right| 900.4\ g\ soil = 0.286\ \mu g\ T.E.$$ ✓

Mass Dioxin in Low PCB Raffinate (Treated Soil):

$$\frac{0.00777\ \mu g\ T.E.}{kg\ soil}\left|\frac{1\ kg}{1000\ g}\right| 830.7\ g\ soil = 0.00645\ \mu g\ T.E.$$ ✓

Mass Dioxin in High PCB extracted oil:

$$\frac{219.8\ \mu g\ T.E.}{kg\ oil}\left|\frac{1\ kg}{1000\ g}\right| 26.1\ g = 5.737\ \mu g\ T.E.$$ ✓

Mass Dioxin in High PCB Untreated Soil:

$$\frac{5.309\ \mu g\ T.E.}{kg\ soil}\left|\frac{1\ kg}{1000\ g}\right| 919.9\ g\ soil = 4.884\ \mu g\ T.E.$$ ✓

Mass Dioxin in High PCB Treated Soil (Raffinate):

$$\frac{0.0924\ \mu g\ T.E.}{kg\ soil}\left|\frac{1\ kg}{1000\ g}\right| 877.9\ g\ soil = 0.0811\ \mu g\ T.E.$$ ✓

Summary Table

	Low PCB (Composite) Sample	High PCB (Hot Spot) Sample
Toxicity Equivalencies:		
Untreated Soil (Feed)	0.286 μg	4.884 μg
Treated Soil (Raffinate)	0.00645 μg	0.0811 μg
Extracted Oil	0.259 μg	5.737 μg
Treated Soil + Ex. Oil	0.26545 μg ✓	5.8181 μg ✓
% Recovery	92.8 ✓	119 ✓

$$\%\ Recovery = \frac{Mass\ in\ Treated\ Soil + Ex.\ Oil}{Mass\ in\ Untreated\ Soil} \times 100$$

Project	Norwood PCB	Acct. No.	4609-19-11-6-4
Subject	CF Systems' Oil Volume	Comptd. By	B. Weir
Detail	Estimate	Ck'd. By	J. Lewyord

Page 1 of 2

Date 12/15/92

Date 12/15/92

From results of bench-scale tests performed by CF Systems:

Sample	Mass Feed Soil (g)	Mass Oil Collected (g)
High PCB Composite	919.9	26.1
Low PCB Composite	900.4	not measured

Assumptions: Density of Soil = 1.3 tons/cy
Density of Oil = 8 lb/gal

For High PCB Sample, Oil Volume

$$= \frac{26.1 \text{ ton oil}}{919.9 \text{ ton soil}} \Big| \frac{1.3 \text{ tons soil}}{1 \text{ cy soil}} \Big| \frac{2000 \text{ lb oil}}{1 \text{ ton oil}} \Big| \frac{1 \text{ gallon oil}}{8 \text{ lb oil}}$$

= 9.22 gallons oil / cy of soil ✓

For Low PCB Sample, the mass of oil was not measured. However, CF Systems make measurements of oil + grease concentrations on the feed soil samples from which they were able to estimate an oil volume from the Low PCB soil:

Sample	Oil + grease, Wt. %
Low PCB feed Soil	0.05
High PCB feed soil	1.67

CF Systems correlated the mass of oil generated from the High PCB sample with the oil + grease content:

$$\text{Wt. \% oil (from bench test)} = \frac{26.1}{919.9} \times 100 = 2.8 \text{ wt.\%},$$

Whereas oil and grease was 1.67 wt. %, or roughly 50% less. CF Systems says that it is typical for oil + grease measurements to underestimate actual oil extracted. They used a 50% factor to correct the oil and grease measurements

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Project Norwood PCB **Acct. No.** 4609-19-11-6-4 **Page** 2 **of** 2

Subject CF Systems' Oil Volume **Comptd. By** B. Weir **Date** 12/15/92

Detail Estimate **Ck'd. By** J. Clevenger **Date** 12/15/92

for the Low PCB sample, in order to estimate oil volume: [Assume density of low PCB soil is 1.4 ton/cy].

Oil generation from Low PCB sample then becomes 0.05 wt. % × 1.5 = 0.075 wt. %

$$\frac{0.075 \text{ tons oil}}{100 \text{ tons soil}} \bigg| \frac{1.4 \text{ tons soil}}{1 \text{ cy soil}} \bigg| \frac{2000 \text{ lb oil}}{1 \text{ ton oil}} \bigg| \frac{1 \text{ gallon oil}}{8 \text{ lb oil}}$$

$$= 0.262 \text{ gallons oil / cy soil}$$ ✓

If the site is, on the average, represented by the Low PCB sample, and if 39,785 cy of soil are to be remediated,

Oil Volume Estimate =

$$\frac{0.262 \text{ gal}}{\text{cy}} \bigg| 39{,}785 \text{ cy} \bigg| \frac{1 \text{ drum}}{55 \text{ gal}} = \boxed{\begin{array}{c}190 \text{ drums} \\ \text{or } 10{,}424 \text{ gallons}\end{array}}$$ ✓

If 10% of the 39,785 cy of soil is like the High PCB sample, with the remaining volume like the Low PCB sample,

Oil Volume Estimate =

$$\frac{0.262 \text{ gal}}{\text{cy}} \bigg| 39{,}785 \text{ cy} \bigg| 0.9 \bigg| \frac{1 \text{ drum}}{55 \text{ gal}} + \frac{9.22 \text{ gal}}{\text{cy}} \bigg| 39{,}785 \bigg| 0.1 \bigg| \frac{1}{55}$$

170.57

$$= 838 \text{ drums}$$

or $\boxed{46{,}063 \text{ gallons}}$ ✓

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Project	Norwood PCB	Acct. No.	4609-19-11-6-4	Page	1 of 2
Subject	Aroclor-1254 Mass Balance	Comptd. By	B. Weir	Date	6/9/92
Detail	RCC's Treatability Study	Ck'd. By	J. Levergood	Date	12/15/92

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Aroclor-1254 Concentrations (as determined by CLP Labs)

	Low PCB Sample	High PCB Sample
Untreated Soils: Average Value, mg/kg	752	8565
Treated Soils, mg/kg	0.17	4.6
Extracted Oil, mg/kg*	11,400	29,000

* Extracted oil concentrations have not been corrected for dilution by RCC's solvent (triethylamine, or TEA).

Correction of Extracted oil concentrations (based on conversion factors calculated by Steve O'Laughlin of RCC):

Low PCB Oil: Aroclor-1254 conc'n = 18.1 × 11,400
= 206,340 mg/kg ✓

High PCB Oil: Aroclor-1254 conc'n = 10.3 × 29,000
= 298,700 mg/kg ✓

Masses of Each Material (as determined by RCC)

	Low PCB Sample	High PCB Sample
Untreated Soils, g dry wt.	869	835
Treated Soils, g dry wt.	869	837
Extracted Oil, g	1.1	16.0

Masses of Aroclor-1254 in Each Material:

Untreated Soil, Low PCB Sample:

$$\frac{752 \text{ mg PCB}}{\text{kg soil}} \left| \frac{1 \text{ kg}}{1000 \text{ g}} \right| \frac{869 \text{ g soil}}{} = 653 \text{ mg PCB} \checkmark$$

Project	Norwood PCB	Acct. No.	4609-19-11-6-4	Page	2 of 2
Subject	Aroclor-1254 Mass Balance	Comptd. By	B. Weir	Date	9/2/92
Detail	RCC's Treatability Study	Ck'd. By	J. Levengood	Date	12/15/92

Treated Soil, Low PCB Sample:

$$\frac{0.17\text{ mg PCB}}{\text{kg soil}}\left|\frac{1\text{ kg}}{1000\text{ g}}\right|\frac{869\text{ g soil}}{} = 0.15\text{ mg PCB}$$ ✓

Extracted Oil, Low PCB Sample:

$$\frac{206{,}340\text{ mg PCB}}{\text{kg oil}}\left|\frac{1\text{ kg}}{1000\text{ g}}\right|\frac{1.1\text{ g oil}}{} = 227\text{ mg PCB}$$ ✓

Untreated Soil, High PCB Sample:

$$\frac{8565\text{ mg PCB}}{\text{kg soil}}\left|\frac{1\text{ kg}}{1000\text{ g}}\right|\frac{835\text{ g soil}}{} = 7152\text{ mg PCB}$$ ✓

Treated Soil, High PCB Sample:

$$\frac{4.6\text{ mg PCB}}{\text{kg soil}}\left|\frac{1\text{ kg}}{1000\text{ g}}\right|\frac{837\text{ g soil}}{} = 3.85\text{ mg PCB}$$ ✓

Extracted Oil, High PCB Sample:

$$\frac{298{,}700\text{ mg PCB}}{\text{kg oil}}\left|\frac{1\text{ kg}}{1000\text{ g}}\right|\frac{16.0\text{ g oil}}{} = 4779\text{ mg PCB}$$ ✓

Summary Table

	Low PCB Sample	High PCB Sample
Untreated Soil, mg	653	7152
Treated Soil, mg	0.15	3.85
Extr. Oil, mg	227	4779
Treated Soil + Ex. Oil, mg	227.15 ✓	4782.85 ✓
% Recovery	34.8 ✓	66.9 ✓

Project Norwood PCB	Acct. No. 4609-19-11-6-4	Page 1 of 2	
Subject Dioxin Mass Balance	Comptd. By B. Weir	Date 6/5/92	
Detail RCC's Treatability Study	Ck'd. By B. Daly	Date 6/8/92	

Toxicity Equivalencies (as determined by CLP Lab)

	Low PCB Sample	High PCB Sample
Untreated Soils: Average Value, µg/kg	0.3412	6.0048
Treated Soils, µg/kg	0.000075	0.06329
Extracted Oil, µg/kg *	6.464	17.58

* Extracted Oil concentrations have not been corrected for dilution by RCC's solvent (triethylamine, or TEA).

Correction of Extracted Oil concentrations (based on conversion factors calculated by Steve O'Laughlin of RCC):

Low PCB Oil: Toxicity Equivalency = 18.1 × 6.464
$= \boxed{117\ \mu g/kg}$ ✓

High PCB Oil: Toxicity Equivalency = 10.3 × 17.58
$= \boxed{181\ \mu g/kg}$ ✓

Masses of Each Material (as determined by RCC)

	Low PCB Sample	High PCB Sample
Untreated Soils, g dry wt.	869	835
Product Solids + Samples (Treated Soils), g dry wt.	869	837
Extracted Oil, g	1.1	16.0

Mass of Dioxin (i.e., Toxicity Equivalency) in each material:

Untreated Soil, Low PCB Sample:

$$\frac{869\text{ g soil}}{}\bigg|\frac{1\text{ kg}}{1000\text{ g}}\bigg|\frac{0.3412\ \mu\text{g T.E.}}{1\text{ kg}} = 0.2965\ \mu\text{g T.E.}$$ ✓

Project	Norwood PCB	Acct. No.	4609-19-11-6-4	Page	2 of 2
Subject	Dioxin Mass Balance	Comptd. By	B. Weir	Date	6/5/92
Detail	RCC's Treatability Study	Ck'd. By		Date	12/15/92

Untreated Soil, High PCB Sample:

$$\frac{835\text{ g soil}}{}\Bigg|\frac{1\text{ kg}}{1000\text{ g}}\Bigg|\frac{6.0048\ \mu g\text{ T.E.}}{\text{kg}} = 5.014\ \mu g\text{ T.E.}\ \checkmark$$

Treated Soil, Low PCB Sample:

$$\frac{869\text{ g soil}}{}\Bigg|\frac{1\text{ kg}}{1000\text{ g}}\Bigg|\frac{0.000075\ \mu g\text{ T.E.}}{\text{kg}} = 0.0000652\ \mu g\text{ T.E.}\ \checkmark$$

Treated Soil, High PCB Sample:

$$\frac{837\text{ g soil}}{}\Bigg|\frac{0.06329\ \mu g\text{ T.E.}}{\text{kg}}\Bigg|\frac{1\text{ kg}}{1000\text{ g}} = 0.05297\ \mu g\text{ T.E.}\ \checkmark$$

Extracted Oil, Low PCB Sample:

$$\frac{1.1\text{ g oil}}{}\Bigg|\frac{1\text{ kg}}{1000\text{ g}}\Bigg|\frac{117\ \mu g\text{ T.E.}}{\text{kg}} = 0.1287\ \mu g\text{ T.E.}\ \checkmark$$

Extracted Oil, High PCB Sample:

$$\frac{16.0\text{ g oil}}{}\Bigg|\frac{1\text{ kg}}{1000\text{ g}}\Bigg|\frac{181\ \mu g\text{ T.E.}}{\text{kg}} = 2.896\ \mu g\text{ T.E.}\ \checkmark$$

Summary Table

	Low PCB Sample	High PCB Sample
Toxicity Equivalencies:		
Untreated Soil	0.2965 µg	5.014 µg
Treated Soil	0.0000652 µg	0.05297 µg
Extracted Oil	0.1287 µg	2.896 µg
Treated Soil + Ex. Oil	0.1287652 µg	2.94897 µg
% Recovery	43 ✓	59 ✓

$$\%\text{ Recovery} = \frac{\text{Mass in Treated Soil + Ex. Oil}}{\text{Mass in Untreated Soil}} \times 100$$

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Project Norwood PCB	**Acct. No.** 4609-19-11-6-4	**Page** 1	**of** 1
Subject RCC's Oil Volume	**Comptd. By** B. Weir	**Date** 12/15/92	
Detail Estimate	**Ck'd. By** J. Levangood	**Date** 12/15/92	

From results of bench-scale tests performed by RCC:

Sample	Mass Feed Soil (g)	Mass Oil Extracted (g)
High PCB Composite	835	16.0
Low PCB Composite	869	1.1

Assumptions:
Density of soil = 1.3 tons/cy (High PCB soil)
Density of oil = 8 lb/gal
Density of soil = 1.4 tons/cy (Low PCB soil)

For High PCB Sample, Oil Volume =

$$\frac{16.0 \text{ ton oil}}{835 \text{ ton soil}} \bigg| \frac{1.3 \text{ tons soil}}{1 \text{ cy soil}} \bigg| \frac{2000 \text{ lb}}{1 \text{ ton}} \bigg| \frac{1 \text{ gal}}{8 \text{ lb}}$$

= 6.23 gallons oil/cy soil ✓

For Low PCB Sample, Oil Volume =

$$\frac{1.1 \text{ ton oil}}{869 \text{ ton soil}} \bigg| \frac{1.4 \text{ tons soil}}{1 \text{ cy soil}} \bigg| \frac{2000 \text{ lb}}{1 \text{ ton}} \bigg| \frac{1 \text{ gal}}{8 \text{ lb}}$$

= 0.44 gallons oil/cy soil ✓

Assume 39,785 cy of soil to be remediated, and that Low PCB sample is representative of all 39,785 cy.

Then Oil Volume = $\frac{0.44 \text{ gal}}{\text{cy}} \bigg| 39{,}785 \text{ cy}$ = $\boxed{\begin{array}{l} 17{,}505 \text{ gal} \\ = 318 \text{ drums} \end{array}}$ ✓

Assume 39,785 cy soil total; 10% represented by High PCB sample and 90% represented by Low PCB sample.

Then Oil Volume = $0.44(39{,}785)(0.9) + 6.23(39{,}785)(0.1)$

$= \boxed{\begin{array}{l} 40{,}541 \text{ gal} \\ = 737 \text{ drums} \end{array}}$ ✓

Appendix E

APPENDIX E

TREATABILITY STUDY DATA FROM
PINE STREET CANAL
SUPERFUND SITE

TABLE E-1. COMPOUNDS DETECTED IN PEAT, FILL AND SEDIMENT SAMPLES BEFORE AND AFTER SIX STAGES OF EXTRACTION WITH LIQUEFIED PROPANE: BENCH-SCALE TEST RESULTS BY CF SYSTEMS CORPORATION. SAMPLES WERE FROM THE PINE STREET CANAL SUPERFUND SITE, BURLINGTON, VERMONT.

WASTE TYPE	PEAT		FILL		SEDIMENT		PERCENT EXTRACTED		
COMPOUND	BEFORE (ug/kg)	AFTER (ug/kg)	BEFORE (ug/kg)	AFTER (ug/kg)	BEFORE (ug/kg)	AFTER (ug/kg)	PEAT	FILL	SEDIMENT
Naphthalene	803000 J	7400 J	48500 J	1400 J	1600 UJ	350 J	99.1	97.1	NC
2-Methylnaphthalene	360000 J	14000	30000 J	1700	1600 UJ	430 J	96.1	94.3	NC
1-Methylnaphthalene	200000 J	10000	16000 J	810	1600 UJ	460 J	95.0	94.9	NC
Acenaphthylene	108000 J	12000 J	14400 J	970 J	1600 UJ	410 J	88.9	93.3	NC
Acenaphthene	101000 J	13000 J	4480 J	260 J	420 J	90 J	87.1	94.2	78.6
Fluorene	109000 J	12000	10500 J	510 J	350 J	230 J	89.0	95.1	34.3
Phenanthrene	131000 J	7200 J	15300 J	1400	706 J	790 J	94.5	90.8	NL
Anthracene	47600 J	14000	5200 J	540	330 J	270 J	70.6	89.6	18.2
Fluoranthene	210000 J	23000	10000 J	1400	2200	850 J	89.0	86.0	61.4
Pyrene	522000 J	41000	65000 J	1700	2089 J	990 J	92.1	97.4	52.6
Benzo(a)anthracene *	37900 J	16000	3900 J	910	277 J	610 J	57.8	76.7	NL
Chrysene *	98900 J	16000	6960 J	990	494 J	910 J	83.8	85.8	NL
Benzo(b)fluoranthene *	12500 J	8500	1680 J	940	334 J	840 J	32.0	44.0	NL
Benzo(k)fluoranthene *	16300 J	3800	2080 J	470	319 J	420 J	76.7	77.4	NL
Benzo(a)pyrene *	23100 J	9000	2320 J	780	770 J	1600	61.0	66.4	NL
Indeno(1,2,3-c,d)pyrene *	1400 J	7800 J	2200 J	550 J	328 J	1400 J	NL	75.0	NL
Dibenzo(a,h)anthracene *	15400 UJ	550 J	2560 UJ	200 UJ	2560 UJ	470 J	NC	NC	NC
Benzo(g,h,i)perylene	12000 J	6700 J	1980 J	460 J	730 J	860 J	44.2	76.8	NL
Total PAH Detected	2793700 J	221400 J	240500 J	15790 J	9347 J	11980 J	92.1	93.4	NL
Total cPAH Detected	190100 J	61650 J	19140 J	4640 J	2522 J	6250 J	67.6	75.8	NL
VOLATILE ORGANICS:									
Methylene Chloride	54000 J	350 J	22000 U	25 U	2300 UJ	58	99.4	NC	NC
Benzene	140000 J	600 J	55000	9 J	6700 U	7 J	99.6	100.0	NC
Toluene	1200000 J	1800	540000	68	2000 J	54 J	99.9	100.0	97.3
Ethylbenzene	350000 J	510 J	115000	12	1300 J	9 J	99.9	100.0	99.3
Styrene	110000 UJ	820 J	87000	22	6700 U	3 J	NC	100.0	NC
Xylene (total)	2150000 J	2600	780000	82	8200 J	51	99.9	100.0	99.4
Total VOCs Detected	3894000 J	6680 J	1577000	193 J	11500 J	182 J	99.8	100.0	98.4

DEFINITIONS AND QUALIFIERS:	
*	Carcinogenic PAH (cPAH)
J	Estimated concentration
U	Compound not detected
UJ	Estimated detection limit
NC	Not calculable
NL	Not listed because value is outside of reasonable limits (0 to 100 per cent)

TABLE E-2. COMPOUNDS DETECTED IN PEAT, FILL, AND SEDIMENT SAMPLES BEFORE AND AFTER SIX STAGES OF EXTRACTION WITH TRIETHYLAMINE: BENCH-SCALE TEST RESULTS BY RESOURCES CONSERVATION COMPANY. SAMPLES FROM THE PINE STREET CANAL SUPERFUND SITE, BURLINGTON, VERMONT.

WASTE TYPE	PEAT		FILL		SEDIMENT		PERCENT EXTRACTED		
COMPOUND	BEFORE (ug/kg)	AFTER (ug/kg)	BEFORE (ug/kg)	AFTER (ug/kg)	BEFORE (ug/kg)	AFTER (ug/kg)	PEAT	FILL	SEDIMENT
Naphthalene	803000 J	830 J	48500 J	670 J	1600 UJ	4000 U	99.9	98.6	NC
2-Methylnaphthalene	360000 J	460 J	30000 J	420 J	1600 UJ	88 J	99.9	98.6	NC
1-Methylnaphthalene	200000 J	230 J	16000 J	230 J	1600 UJ	NA	99.9	98.6	NC
Acenaphthylene	108000 J	1000 UJ	14400 J	1000 UJ	1600 UJ	4000 U	NC	NC	NC
Acenaphthene	101000 J	1000 UJ	4480 J	1000 UJ	420 J	4000 U	NC	NC	NC
Fluorene	109000 J	1000 UJ	10500 J	1000 UJ	350 J	53 J	NC	NC	84.9
Phenanthrene	131000 J	590 J	15300 J	720 J	706 J	430	99.5	95.3	39.1
Anthracene	476000 J	580 J	5200 J	230 J	330 J	450	99.9	95.6	NL
Fluoranthene	210000 J	260 J	10000 J	390 J	2200	250	99.9	96.1	88.6
Pyrene	522000 J	260 J	65000 J	480 J	2089 J	570	100.0	99.3	72.7
Benzo(a)anthracene *	37900 J	130 J	3900 J	230 J	277 J	59	99.7	94.1	78.7
Chrysene *	98900 J	1000 UJ	6960 J	230 J	494 J	41	NC	96.7	91.7
Benzo(b)fluoranthene *	12500 J	69 J	1680 J	370 J	334 J	34 J	99.4	78.0	89.8
Benzo(k)fluoranthene *	16300 J	200 U	2080 J	110 J	319 J	17 J	98.8	94.7	94.7
Benzo(a)pyrene *	23100 J	99 J	2320 J	220	770 J	29 J	99.6	90.5	96.2
Indeno(1,2,3-c,d)pyrene *	1400 J	1000 UJ	2200 J	260 J	328 J	110	NC	88.2	66.5
Dibenzo(a,h)anthracene *	15400 UJ	1000 UJ	2560 UJ	1000 UJ	2560 UJ	130 U	NC	NC	NC
Benzo(g,h,i)perylene	12000 J	800 U	1980 J	380 J	730 J	44	NC	80.8	94.0
Total PAH Detected	3222100 J	3508 J	240500 J	4940 J	9347 J	2305 J	99.9	97.9	75.3
Total cPAH Detected	190100 J	298 J	19140 J	1420 J	2522 J	290 J	99.8	92.6	88.5
VOLATILE ORGANICS:									
Benzene	16000 J	20000 U	50000 J	2400 U	120 UJ	1300 U	NC	NC	NC
Toluene	170000 J	20000 U	510000 J	570 J	120 U	1300 U	NC	99.9	NC
Ethylbenzene	33000 U	20000 U	110000 J	2400 U	120 U	1300 U	NC	NC	NC
Styrene	33000 U	20000 U	100000 J	2400 U	120 U	1300 U	NC	NC	NC
Xylene (total)	1000000	20000 U	800000	540 J	220 J	1300 U	NC	99.9	NC
Total VOCs Detected	1186000 J	ND	1570000 J	1110 J	220 J	ND	NC	99.9	NC

DEFINITIONS AND QUALIFIERS:
* - Carcinogenic PAH
J - Estimated concentration
U - Compound not detected
UJ - Estimated detection limit
NC - Not calculable
NA - Not analyzed
NL - Not listed because value is outside of reasonable limits (0 to 100 per cent)
ND - None detected