APPENDIX NOT INCLUDED

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LOG # 12-16-91-86

DRAFT
PRELIMINARY PUBLIC HEALTH EVALUATION AND ENDANGERMENT ASSESSMENT

Combustion, Inc. Site
Denham Springs, Louisiana

Angela M. Levert

December 13, 1991

W.O. #85-17

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Combustion, Inc. is a former waste oil reclamation facility located in Livingston Parish, Louisiana approximately three miles northeast of the city of Denham Springs. The site is located adjacent to a rural residential area of approximately 200 residents. The site consists of two separate source areas: the Process Area and the Pond Area. Oily feedstock was received, stored, and processed at the Process Area. Wastewater and storm water run-off from the Process Area was then pumped to the Pond Area for oil-water separation and natural biological treatment. Treated wastewater was then discharged through a permitted outfall into an adjacent creek.

The Remedial Investigation revealed the presence of volatile and semi-volatile organic compounds, metals, cyanide, pesticides, and polychlorinated biphenyls (PCBs) in various media within the source areas. Affected media within the Process Area are soil and ground water. Affected media within the Pond Area are soil, pond surface water, pond oil, pond solids, and ground water.

A human health and ecological risk assessment was performed for the site according to current USEPA guidance as presented in Risk Assessment Guidance for Superfund (December 1989). Risk to human health was evaluated by estimating risk on the basis of current and future reasonable maximum exposure (RME) scenarios. The current land use scenario estimated exposure and risk for a child intermittently trespassing on both source areas. This scenario assumes that the site has been abandoned and is unfenced and accessible; under current conditions the site is fenced and inaccessible. In this scenario, exposure occurred to all affected media in the Pond Area and Process Area, except ground water. The future land use scenario estimated exposure and risk for a residence located on or immediately adjacent to each of the source areas. In this scenario, daily exposure by children and adults is assumed for soil. Affected pond media (oil, solids, and surface water) are assumed to have been removed prior to construction activities for the residence.

In the current land use scenario, the highest cancer risk estimated is for exposure to pond oil (10^{-5}). Removal of pond oil as proposed by the Participating Parties in March 1990 reduces the total cancer risk by approximately one order of magnitude (see table below). In the future land use scenario, cancer risks are estimated in the 10^{-5} range. Noncarcinogenic hazard indices do not exceed 1.0 for either exposure scenario. The table on the following page summarizes human health risks for each exposure scenario.

Ecological risk was evaluated on the basis of site observations and of comparison of off-site analytical data to relevant protective criteria. No significant ecological risk was determined.

SUMMARY TABLE OF RISK

Combustion, Inc.
Denham, Louisiana

	CURRENT LAND USE		FUTURE LAND USE	
	Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Process Area				
Adult	--	--	0.3	6E-05
Child	0.2	9E-06	0.7	4E-05
Pond Area				
Adult	--	--	0.2	6E-06
Child	0.2	2E-05	0.4	5E-06
Pond Area (pond oil removed)				
Adult	--	--	--	--
Child	0.1	3E-06	--	--

-- Not applicable

DRAFT

PRELIMINARY PUBLIC HEALTH EVALUATION AND
ENDANGERMENT ASSESSMENT

COMBUSTION, INC. SITE
LIVINGSTON PARISH, LOUISIANA

1 - INTRODUCTION

1.1 Purpose and Format of the Preliminary Public Health Evaluation and Endangerment Assessment

This report establishes baseline data for evaluation of the effects of potential remedial actions on public health and the environment, and constitutes the baseline Public Health Evaluation and Endangerment Assessment for the Combustion, Inc. site under current site conditions. The methods and approach are consistent with the procedures set forth in Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual (EPA/540/1-89-002, December 1989). Additional guidance is obtained from the following USEPA documents:

Superfund Exposure Assessment Manual (EPA540/1-88/001, April 1988)

IRIS Database -- EPA's Integrated Risk Information System (On-line toxicity database)

Health Effects Assessment Summary Tables (January 1991)

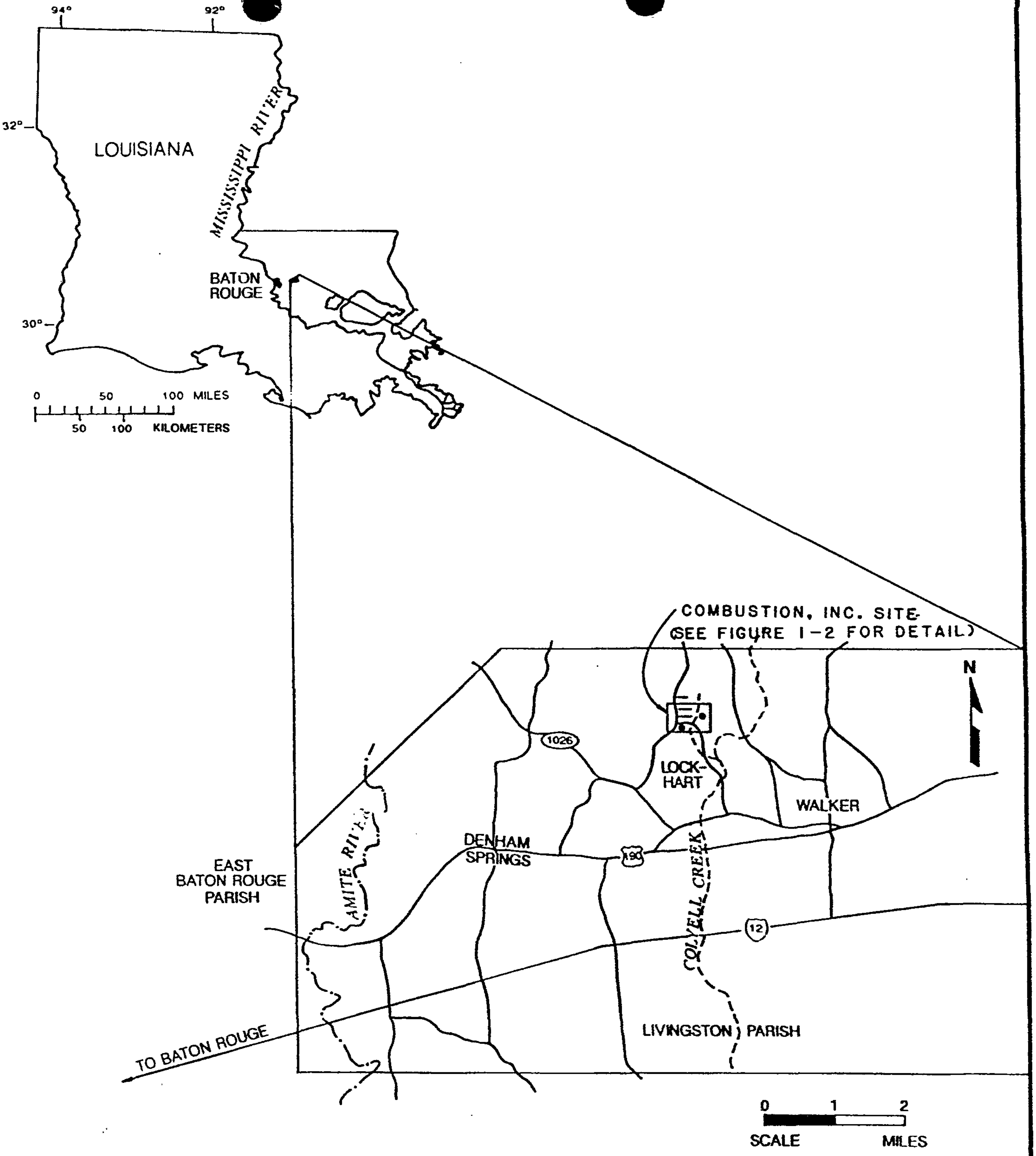
Agency for Toxic Substances and Disease Registry, Toxicological Profiles

This assessment follows standard procedures for performance of risk assessments. These procedures include:

- identification of chemical sources, exposure pathways (environmental transport media), target receptors and routes of exposure for both the Pond Area and Process Area;
- documentation of constituent concentrations and their distribution throughout the Pond and Process Areas;
- toxicity assessment of the constituents of concern;
- calculation of chemical intakes for reasonable maximum exposure involving a residential and a trespass scenario; and
- characterization of carcinogenic and noncarcinogenic risk.

1.2 Site Location and Layout

The Combustion, Inc. site is located in Livingston Parish, Louisiana, approximately three miles northeast of the city of Denham Springs (Figure 1-1). The site can be located on a United States Geological Survey (USGS) Watson 7.5-minute quadrangle at



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NEW ORLEANS, LOUISIANA HOUSTON, TEXAS

DATE	5/22/89	W.O.NO.	8508A008

R315

FIGURE 1-1
GENERAL LOCATION
COMBUSTION, INC. SITE
Livingston Parish,
Denham Springs, Louisiana

approximately longitude W90° 53'30", latitude N30° 30'30". The site includes a processing plant and a separate area approximately one-half mile away that consists of a series of fourteen shallow ponds (site vicinity and layout shown in Figure 1-2). These two areas are referred to as the Process Area and the Pond Area, respectively. A pipeline connects the two areas.

1.3 History of Site Operations

Dubose Oil Products Company and subsequently Combustion, Inc. operated primarily as a waste oil reclamation facility. The mode of oil reclamation processing varied during the years. Generally, oily feed-stock was stored in some tanks and in some of the ponds shown in Figure 1-3 and was processed in the tankage shown in Figure 1-4. Spent materials and storm water from the processing operation were also stored and treated in the ponds. According to the former site caretaker, the reclamation process operated by Combustion, Inc. in 1978-1982 was as follows:

1. Oily fluids, typically with 20 percent basic sediments and water (BS&W), were received in Tank 1 near the entrance of the plant site (Figure 1-3). Some material was also received in what is now called Pond C in the Pond Area.

2. The material was pumped into the three "cookers" (Tanks 5, 7 and 8) along with other fluids with varying percentages of BS&W to create a mixture of at least 50% BS&W.

3. Salt was then added and the material was heated to 190°F.

4. Following mixing, the material was allowed to separate and the recoverable oil was transferred to one of two "sale" tanks (Tanks 2 and 3).

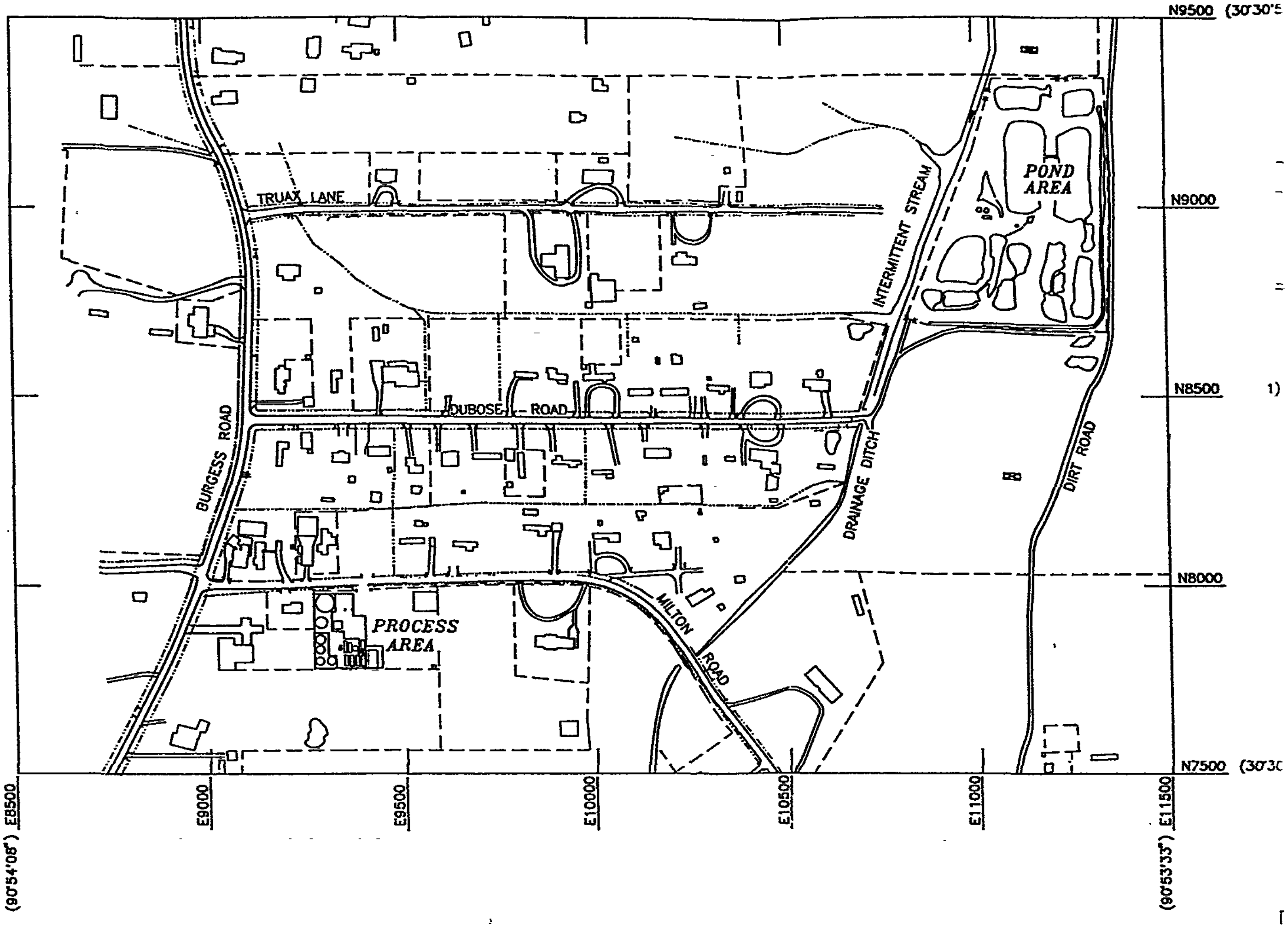
5. The excess water layer, along with plant storm water runoff, was ultimately pumped to Pond C.

The wastewater and storm water runoff from the Process Area was pumped to a series of shallow ponds (i.e., the Pond Area) for oil-water separation and natural biological treatment. The treated wastewater was then discharged through a permitted outfall to the unnamed tributary of the Beaver Branch of West Colyell Creek.

1.4 Site Investigations

Besides routine inspections by various regulatory personnel while the site was in operation, the following investigations were conducted to identify potential releases from the site:

- A suspected spill area east of the Process Area was sampled by DEQ in October 1984.



AERIAL PHOTO BASE BY GULF COAST AERIAL MAPPING CO. INC., SITE PHOTOGRAPHY ON DECEMBER 2, 1988

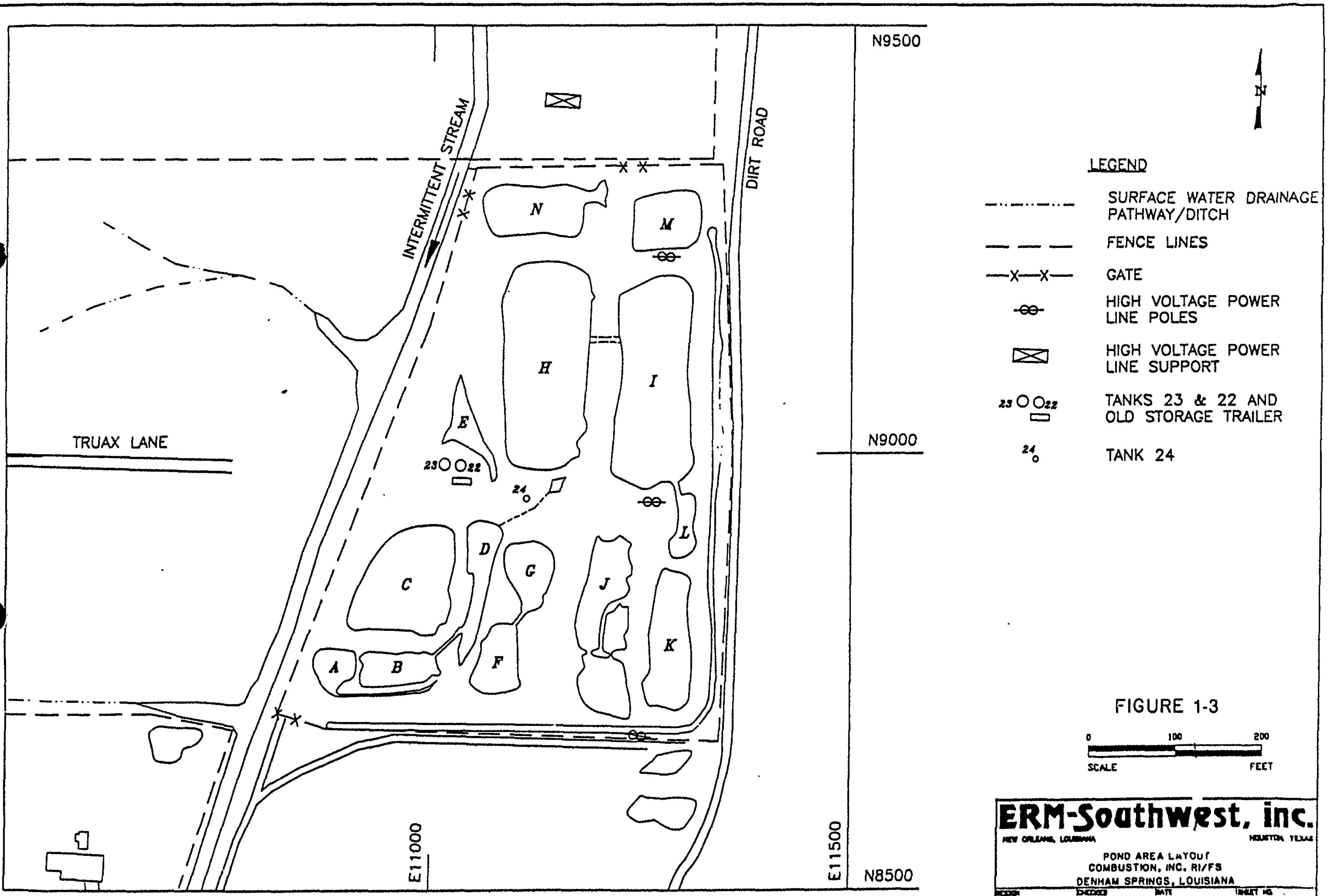


FIGURE 1-3

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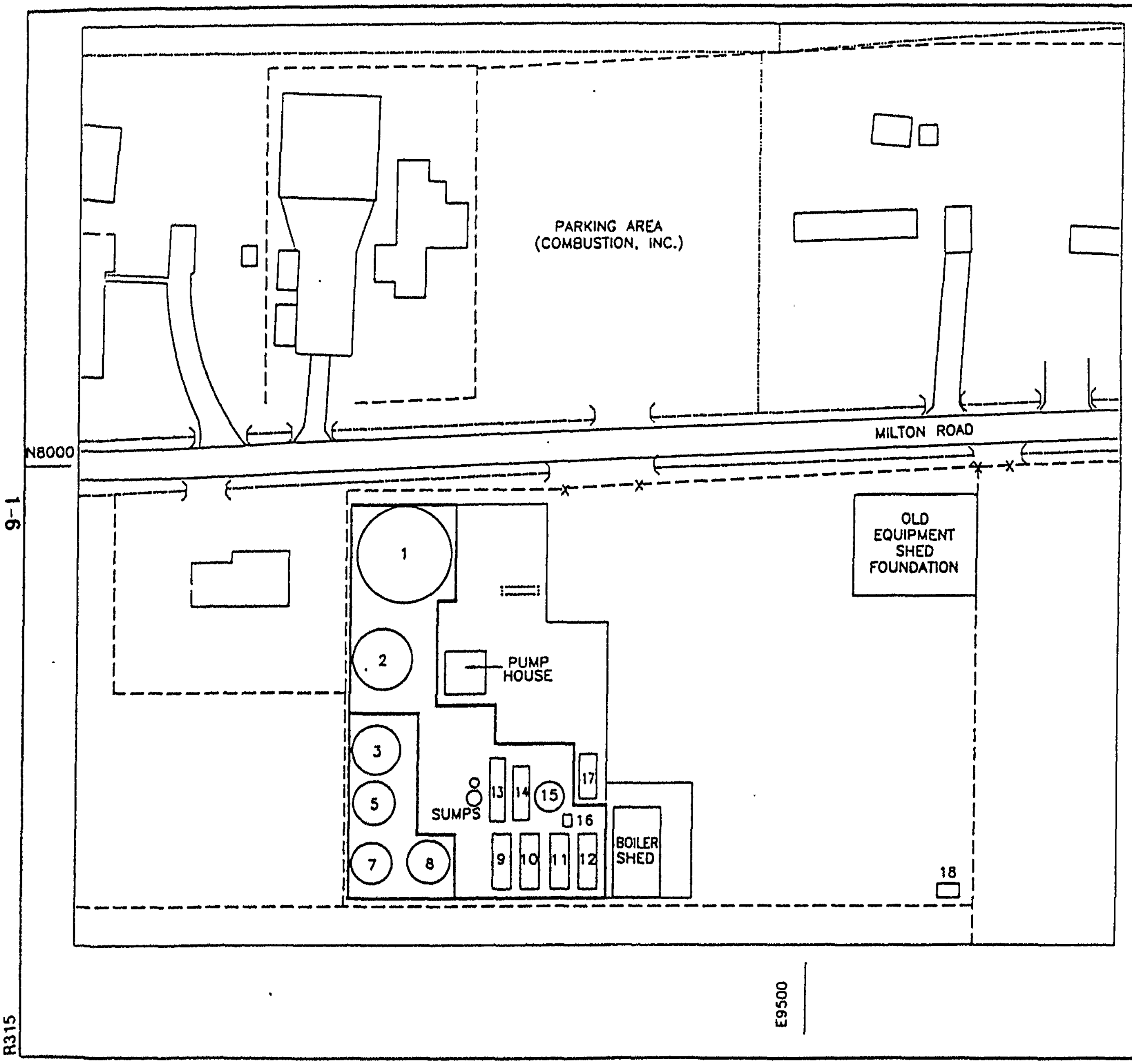
POND AREA LAYOUT
COMBUSTION, INC. RI/FS
DENHAM SPRINGS, LOUISIANA

DESIGN	CHECKED	DATE	SHEET NO.
DRAWN	SCALE AS SHOWN	DWG. NO. 85-08	



LEGEND

- SURFACE WATER DRAINAGE PATHWAY/DITCH
- FENCE LINE
- GATE
- HOUSE/BUILDING
- PROCESS AREA STORAGE TANKS
- GAS/DIESEL PUMP ISLAND (W/O PUMPS)
- CINDER BLOCK WALL

FIGURE 1-4

0 50 100
SCALE FEET

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NEW ORLEANS, LOUISIANA HOUSTON, TEXAS

PROCESS AREA LAYOUT
COMBUSTION, INC. RI/FS
DENHAM SPRINGS, LOUISIANA

DRAWN	CHECKED	DATE	SHEET NO.
[illegible]	SCALE	W.O. NO. 8508	

R315

TABLE 1-1

Constituents – Pond Water

Combustion, Inc.
Denham Springs, Louisiana

Constituent	Maximum Detected Value (mg/L)
Volatiles	
Acetone	0.13
Benzene	0.005
Methylene chloride	0.017
Total xylenes	0.014
Trichlorethene	0.01
Semivolatiles	
Anthracene	0.011
Naphthalene	0.021
N–nitrosodiphenylamine	0.015
Phenol	0.036
2–Methylphenol	0.017
4–Methylphenol	0.035
2,4–Dimethylphenol	0.023
Metals	
Antimony	0.56
Arsenic	0.014
Barium	2.2
Chromium	0.35
Cobalt	0.13
Lead	9

TABLE 1–2

Constituents – Pond Oil

Combustion, Inc.
Denham Springs, Louisiana

Constituent	Maximum Detected Value (mg/L)
Volatiles	
Acetone	5.4
Ethylbenzene	1.4
Toluene	2.7
Total xylenes	5
Metals	
Arsenic	0.25
Cadmium	0.3
Chromium	6.2
Lead	106
Pesticides/PCBs	
PCBs	69

TABLE 1-3

Constituents – Pond Solids

Combustion, Inc.
Denham Springs, Louisiana

Constituent	Maximum Detected Value (mg/kg)
Volatiles	
1,2-Dichloroethane	3.5
2-Hexanone	12
Acetone	0.016
Benzene	340
Chlorobenzene	4.3
Ethylbenzene	270
Methylene chloride	0.025
Styrene	110
Tetrachloroethene	57
Toluene	990
Total xylenes	560
Trichlorethene	53
Semivolatiles	
1,2-Dichlorobenzene	37
1,4-Dichlorobenzene	26
2-Methylnaphthalene	170
Acenaphthene	70
Acenaphthylene	45
Anthracene	76
Benzo(a)anthracene	38
Benzo(b)fluoranthene	40
bis(2-Ethylhexyl)phthalate	160
Butylbenzylphthalate	330
Chyrsene	66
Dibenzofuran	22
Di-n-butylphthalate	18
Di-n-octylphthalate	0.77
Fluoranthene	160
Fluorene	110
Naphthalene	280
N-nitrosodiphenylamine	0.84
N-nitroso-di-n-propylamine	0.84
Phenanthrene	400
Phenol	40
Pyrene	160
Metals	
Antimony	16
Barium	930
Cadmium	6.5
Chromium	120
Lead	1100
Pesticides/PCBs	
4,4-DDE	0.65
PCB	8.5

TABLE 1-4

Constituents – Pond Area Soil

Combustion, Inc.
Denham Springs, Louisiana

Constituent	Maximum Detected Value (mg/kg)
Volatiles	
Acetone	2.4
Benzene	6.1
Ethylbenzene	21
Tetrachloroethene	4.4
Tetrachloroethene	4.4
Toluene	34
Total xylenes	35
1,2-Dichloroethene	3.8
Semivolatiles	
Anthracene	11
Fluoranthene	13
Fluorene	12
Naphthalene	13
Phenanthrene	36
Pyrene	11
2-Methylnaphthalene	19
Metals	
Arsenic	2.4
Barium	223
Calcium	3280
Chromium	13
Copper	15
Iron	13300
Lead	178
Magnesium	156
Manganese	156
Mercury	0.21
Potassium	2130
Vanadium	19
Zinc	549
Pesticides/PCBs	
Heptachlor	0.13

TABLE 1-5

Constituents - Process Area Soil

Combustion, Inc.
Denham Springs, Louisiana

Constituent	Maximum Detected Value (mg/kg)
Volatiles	
Acetone	2
Ethylbenzene	0.039
Methylene chloride	0.029
Styrene	0.024
Toluene	980
Total xylenes	0.1
Semivolatiles	
Naphthalene	38
Phenanthrene	4.5
2-Methylnaphthalene	6.1
2,4-Dinitrotoluene	37
Metals	
Aluminum	11000
Arsenic	4.3
Barium	332
Calcium	3280
Chromium	14
Cobalt	14
Copper	7.6
Cyanide	1.7
Iron	13900
Lead	402
Magnesium	1770
Manganese	1090
Nickel	30
Potassium	2130
Vanadium	28
Zinc	81
Pesticides/PCBs	
PCB	0.384
4,4-DDT	0.96

TABLE 1-6

Population Trends In Denham Springs and Livingston Parish

Combustion, Inc.
Denham Springs, Louisiana

	Denham City Population	% Increase	Livingston Parish Population	% Increase
1970	6,752		36,511	
1980	8,412	24.6	58,806	61.1
1990	8,381	-0.4	70,526	19.9

Source: Denham Springs Chamber of Commerce, November 1991

TABLE 1-7

Housing Starts - Denham Springs

Combustion Inc.
Denham Springs, Louisiana

1985	24
1986	29
1987	23
1988	10
1989	14
1990	5
1991	4

Source: Planning and Zoning Office, Metairie, Louisiana, November 1991

TABLE 1-8

Temperature (°F) as Recorded at Ryan Airport
Baton Rouge, Louisiana
(1959 - 1987)

Combustion, Inc.
Denham Springs, Louisiana

Month	Mean Daily Maximum	Mean Daily Minimum	Mean Monthly
January	62.2	41.9	52.1
February	64.1	43.5	53.8
March	71.9	50.5	61.2
April	76.1	57.3	66.7
May	83.2	64.1	73.7
June	90.4	70.3	80.4
July	91.4	72.5	82.0
August	91.5	72.1	81.8
September	88.4	67.9	78.2
October	80.9	57.2	69.1
November	69.6	47.1	58.3
December	62.6	42.6	52.6
Annual	77.7	57.3	67.5

Source: National Oceanic and Atmospheric Administration, 1987

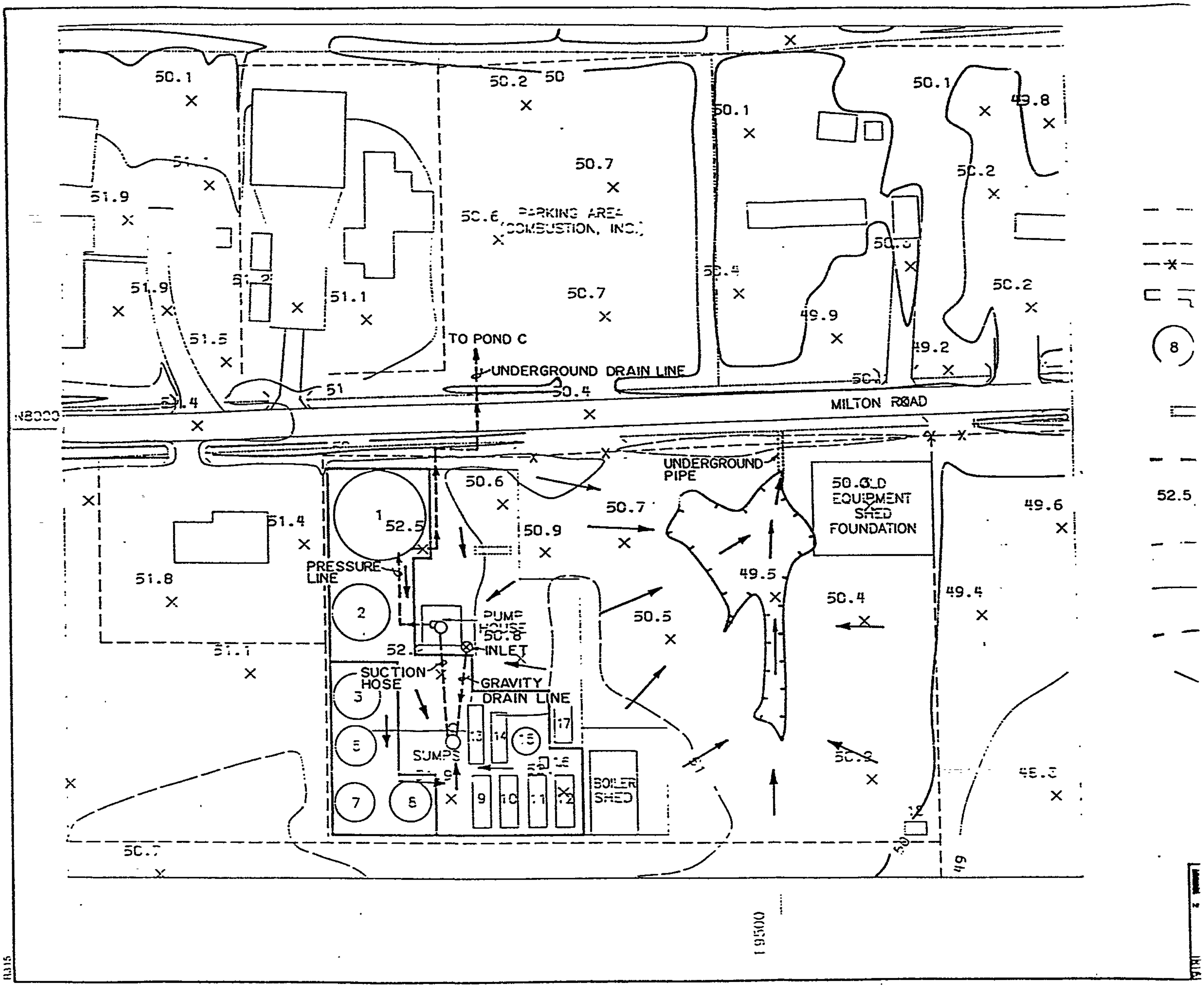
TABLE 1-9

Average Precipitation (inches) as Recorded at Ryan Airport
Baton Rouge, Louisiana
(1958 - 1987)

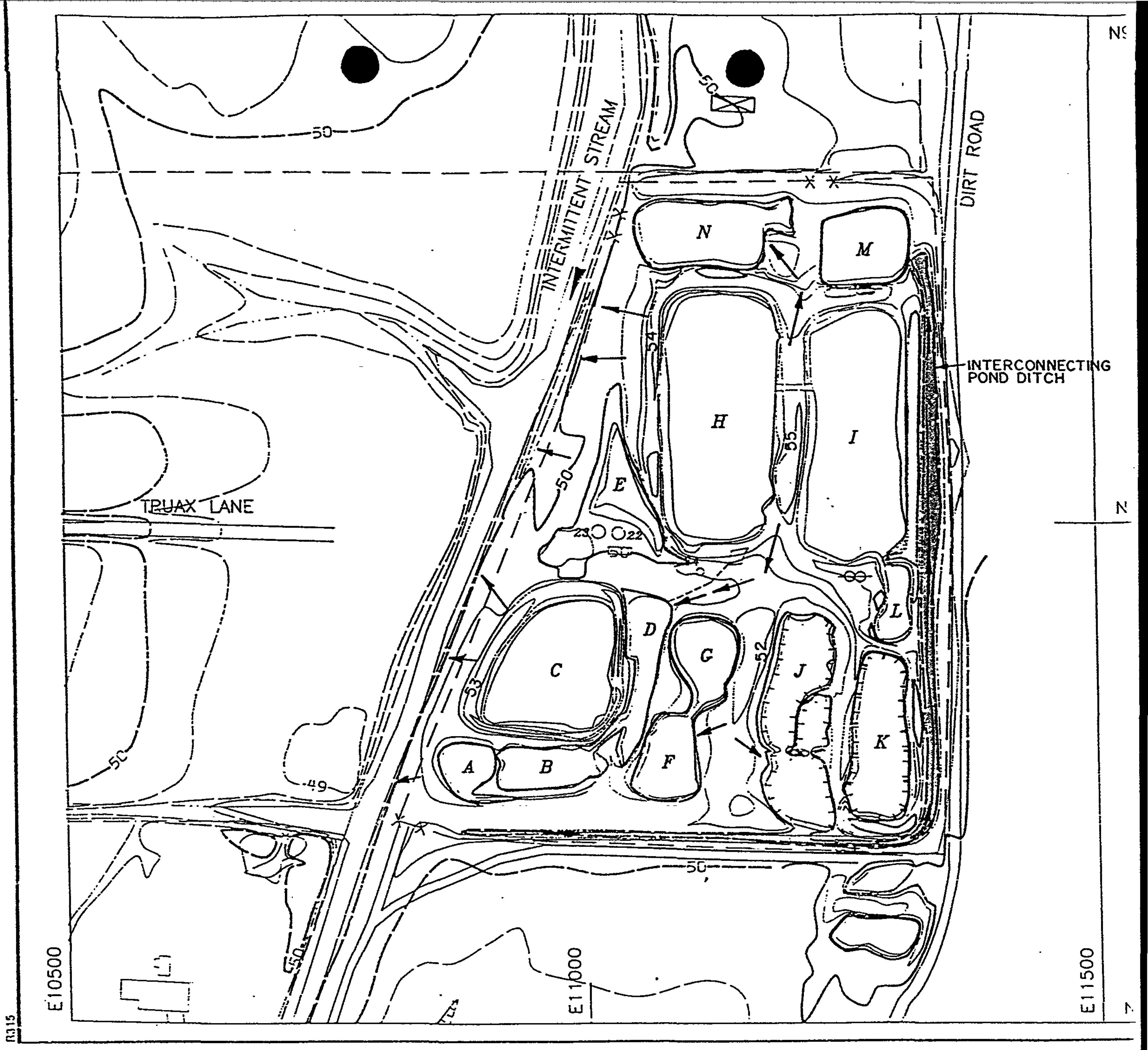
Combustion, Inc.
Denham Springs, Louisiana

Month	Precipitation
January	4.88
February	4.75
March	4.95
April	4.86
May	4.90
June	4.30
July	6.51
August	5.52
September	4.20
October	3.15
November	3.85
December	5.25
Annual	57.12

Source: National Oceanic and Atmospheric Administration, 1987



PARKING AREA (COMBUSTION, INC.)
TO POND C
UNDERGROUND DRAIN LINE
MILTON ROAD
N8000
UNDERGROUND PIPE
OLD EQUIPMENT SHED FOUNDATION
PRESSURE LINE
PUMP HOUSE
INLET
SUCTION HOSE
GRAVITY DRAIN LINE
SUMPS
BOILER SHED
1
2
3
5
7
8
9
10
11
12
13
14
15
17
18
50.1
50.2
50
50.7
50.6
51.9
51.1
51.5
51.4
51
50.4
49.8
49.9
49.2
50.2
51.8
52.5
50.9
50.8
49.5
49.4
49.6
50.5
52.5
50.7
50
49
8
19500
8315



INTERMITTENT STREAM
DIRT ROAD
INTERCONNECTING POND DITCH
TRUAX LANE
A
B
C
D
E
F
G
H
I
J
K
L
M
N
23
22
50
49
52
53
54
55
E10500
E11000
E11500
8315

Runoff in the Process Area that is not collected by the tank sump system is discharged to a drainage ditch along Milton Road at a point between the gate and the northeast corner of the site. Part of the runoff flows to the east to the unnamed tributary, and the remainder remains in the ditch. Runoff immediately south of the Process Area flows to a low area south of the southeast corner of the site. Runoff from within the diked areas is collected and pumped to the Pond Area, via a pipeline, for treatment. The treated wastewater from the Pond Area is continuously discharged (except during extended dry periods) via the discharge pipe from Pond N into the unnamed tributary of the Beaver Branch of West Colyell Creek.

Most of the runoff in the Pond Area is contained within the pond-ditch drainage system. The perimeter ditch captures runoff before it leaves the site along the east and south sides, and ponds M and N collect runoff before it leaves the north side. Runoff from a narrow section of the west side drains directly to the unnamed tributary to the west. Rainfall is rapidly captured within the ponds and ditches, and the only standing water that remains after storm events is in Pond E. Based on the Flood Insurance Rate Map by the Federal Emergency Management Agency, effective September 30, 1988, neither the Pond Area nor Process Area is within the 100-year flood zone.

1.9 Ecological Assessment of Site

1.9.1 Background

On January 12, 1989, ERM-Southwest, Inc. personnel performed a visual, qualitative ecological assessment of the Combustion, Inc. site and the immediate area around it. The site survey was performed by walking throughout the facilities of the Combustion, Inc. site itself (Pond and Process Areas) and along Burgess Road and throughout the woodlands surrounding the site. The creek bed that lies to the west of the Pond Area was followed from its headwaters, which begin just to the north of the Pond Area, to approximately 600 feet south of Dubose road and east of the residential area. The creek was examined by both walking along the banks and by walking in the stream bed itself.

1.9.2 General Physical Description

The site is located in Livingston Parish in the Coastal Plain of Louisiana. It is situated within a pine-hardwood woodland that is interspersed with open areas that contain residential development and power lines.

A woodland stands directly south of the Process Area. West, east and north of the Process Area, the woodland is interrupted by houses and roadways. South of the Process Area, the woodland stretches west across Burgess Road and east across an unnamed tributary of the Beaver Branch of West Colyell Creek.

Immediately north of the Process Area is a residential area of houses and mobile homes. Other permanent residences are located east, west and south of the Process Area.

The Pond Area is situated in a wide easement for two high power electrical transmission lines. The cleared grassy area of the easement extends directly north and south of the Pond Area. The unnamed tributary of Beaver Branch lies along the western edge of the Pond Area. The residential area that is located to the north of the Process Area lies west of the stream bed. Another large stand of pine-hardwood woodlands lies east of the Pond Area.

1.9.3 Site Ecology: Woodlands

1.9.3.1 Vegetation

The general ecology of the region surrounding the Combustion, Inc. site is characteristic of a pine and hardwood creek bottom. The woodlands throughout the area are predominantly short leaf and loblolly pines interspersed with live oak, water oak and willow oak. The woodlands appear to be fairly mature (up to 15-20 years old) due to the size of the trees and the lack of an extensive understory. Throughout the riparian woodland to the north of the Dubose Lane residential area and along the west bank of the creek there are extensive stands of dwarf palmetto, which are representative of low-lying, saturated woodland soils.

1.9.3.2 Animal Life

The most conspicuous animal life at the time of the year that the ecological assessment was carried out was the avifauna. The bird species included both resident and migratory species characteristic of a forested or semi-forested region. Species observed included eastern phoebe, Carolina chickadee, red-tailed hawk, crow, house sparrow, northern cardinal and ruby-crowned kinglet. The passerine species indicate the presence of grain and insects as food sources; the buteo hawk indicates the presence of rodent and lagomorph species as food sources. The Natural Heritage Program of the Louisiana Department of Wildlife and Fisheries has indicated that no rare, threatened or endangered species are found in the site area (see Appendix A).

1.9.4 Site Ecology: Creek

1.9.4.1 Watershed and Drainage

The unnamed tributary of the Beaver Branch of West Colyell Creek begins several hundred feet north of the Pond Area as a low-lying swampy area with an ill-defined creek bed. The area is covered with vegetation and young tree growth, indicating that standing water has not long been present in substantial quantities. As the creek bed moves farther south, it becomes more defined. At the northern edge of the Pond Area, the banks are five to eight feet wide and the stream bed is one to three feet deep in the vicinity of the site.

North of the Pond Area, the creek receives natural drainage from two sloughs from the west and one from the east. The slough from the east side runs near and parallel to the northern edge of the Pond Area. Due to the berms surrounding the ponds, there is no surface water connection between the ponds and the creek. The only existing connection between the creek and the Pond Area is the discharge pipe from Pond N.

1.9.4.2 Aquatic Life

Apart from aquatic insects and an occasional amphibian vertebrate, aquatic life was scant within the stream bed above and below the site. The lack of established aquatic life is due to the intermittent presence of water in the creek. A few small minnow-like fish were observed, primarily in the portion of creek adjacent to the Pond Area and at the Pond N discharge points. Fish of recreational size or fish of value as food sources were not observed within the creek above or below the discharge pipe from Pond N.

1.9.4.3 Water Quality

Eutrophication, as demonstrated by heavy algae growth on the water's surface, was observed at two locations in the creek. One location was at the junction of the creek with the drainage ditch that passes through the residential area along Dubose Road west of the creek. The other area of eutrophication is approximately three hundred feet south of Dubose Road where three PVC pipes were observed to come out of the west bank of the creek and drain into the creek.

Apparently the drainage ditch and the PVC pipes provide sewage outfall into the creek, as evidenced by the algae bloom and malodorous condition. Other septic outflows into bar ditches were observed throughout the residential area.

The only water discharge from the site into the creek is from Pond N, located in the northwest corner of the Pond Area and east of the creek. Visual and olfactory inspection revealed clear outflow with a slight greenish tinge and a faint odor. No evidence of stressed vegetation or aquatic life mortality was observed in the vicinity of the outfall or in the adjacent streambed during the site visit.

Furthermore, daily visual inspections of the outfall and the stream by the site authorities have shown no evidence of adverse impact since the inspections were begun in January 1988.

Surface water sampling was performed both upstream and downstream of the outfall during the Remedial Investigation. Downstream of the Pond N discharge point, small increases in biochemical oxygen demand, total organic carbon, total dissolved solids, and oil and grease were observed. No metals were observed above detection limits downstream (Table 1-10).

TABLE 1-10

Summary of Analytical Results (a)
Surface Water Samples

Combustion, Inc.
Denham Springs, Louisiana

LOCATION REFERENCE	Pond Area Upstream	Pond Area Downstream	Pond Area Downstream (b)
Sample Number	SC401	SC403	SC405
Sample Date	05/05/89	05/05/89	05/05/89
All units in mg/l except where noted			
Biochemical Oxygen Demand	5.0	7.0	7.0
pH (SU)	5.5	6.8	6.1
Total Organic Carbon	14	25	25
Total Dissolved Solids	130	150	200
Total Suspended solids	6	14	17
Chemical Oxygen Demand	58	56	56
Oil and Grease	1.7	4.6	2.8
Total Metals			
Antimony	ND (0.2)	ND (0.2)	ND (0.2)
Arsenic	ND (0.005)	ND (0.005)	ND (0.005)
Barium	ND (0.11)	ND (0.11)	ND (0.11)
Chromium	ND (0.05)	ND (0.05)	ND (0.05)
Cobalt	ND (0.05)	ND (0.05)	ND (0.05)
Lead	ND (0.05)	ND (0.05)	ND (0.05)

Abbreviations

ND = Not detected at detection limit shown in parentheses.

Footnotes

(a) Table is from ERM-Southwest Preliminary Remedial Investigation Report, November 7, 1991.
(b) Duplicate sample of SC403.

1.9.5 Site Ecology: Process/Pond Areas

1.9.5.1 Process Area

Apart from the oil-stained area that contains the tanks, boilers and concrete aprons, most of the surficial area of the Process Area does not show evidence of significant alteration by site constituents. The open surficial area of the Process Area is primarily vegetated with low-lying herbaceous tracheophytes (grasses) interspersed with patches of bryophytes (mosses). This relatively small area is not suitable for animal life, due to the lack of sufficient vegetative cover to provide food and shelter.

1.9.5.2 Pond Area

Within the perimeter of the Pond Area and between the individual ponds lies a growth of mid-successional vegetation interspersed with thin woody plants three to four feet tall. The immediate inside edges of most of the ponds show evidence of saturation by pond constituents; the pond edges lack vegetation.

Along the east and south perimeter and inside the fence lies a drainage ditch that contains dark green water with a slight sheen on top. No aquatic life was observed in this water. Standing water along the dirt road that lies outside the fence to the east of the Pond Area showed no obvious evidence of hydrocarbon or septic constituents, as determined by visual and olfactory inspection.

Fish, turtles, frogs and aquatic insects have been observed occasionally in Ponds E, I, J, M and N. Rabbits, raccoons, field mice and snakes have been observed inside the fence, but the Pond Area is unlikely to be their primary habitat. No observable off-site impacts in the form of affected vegetation or terrestrial or aquatic life mortality were observed in the vicinity of either the Process Area or the Pond Area at the time of this study.

1.9.6 Off-Site Impacts

Sampling of the outfall discharge from Pond N was carried out monthly from January to December 1988. Lead, PCBs, Base/Neutral organics and acid extractable organics were not detected above detection limits at any time. The volatile organics were detected above detection limits in only two sampling events (Table 1-11). Table 1-12 presents a comparison of ambient water quality criteria and outfall discharge concentrations. It can be seen that the outfall concentrations are much lower than the protective criteria. If the dilution of the outfall were to be taken into account, the ambient concentrations resulting from the outfall would be even lower. The Louisiana DEQ eventually allowed the sampling to be stopped since the concentrations of site constituents were insignificant.

TABLE 1-11

Pond Area Discharge Monitoring

Combustion, Inc.
Denham Springs, Louisiana

1988 Pond N Discharge

January - June

Sample Date:	January 12	February 13	March 17	April 14	May	June
PARAMETER						
Total Organic Carbon, mg/L	75	67	98	62	No Flow	No Flow
Oil & Grease, mg/L	3.0	3.8	0.4	1.5		
pH	6.0	6.1	5.6	5.8		
PCBs, mg/L	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)		
Lead, mg/L	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)		
Biochemical Oxygen Demand (mg/L 02)	14	26	110	36		
PRIORITY POLLUTANTS:						
Volatile Organic Compounds	Below Detection Limits For All Compounds		Below Detection Limits For All Compounds	Below Detection Limits For All Compounds		
- Benzene, mg/L		0.025				
- Chlorobenzene, mg/L		0.032				
- Toluene, mg/L		0.067				
- Trichloroethene, mg/L		0.038				
- Methylene Chloride, mg/L		ND (0.010)				
- Total Xylenes, mg/L		ND (0.010)				
		Below Detection Limits For All Other Compounds				
Base/Neutral Organic Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds		
Acid Extractable Organic Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds		

TABLE 1-11 (Cont'd)

Pond Area Discharge Monitoring

Combustion, Inc.
Denham Springs, Louisiana

1988 Pond N Discharge

January - June

Sample Date:	July 28	August 30	September 30	October	November	December 28
PARAMETER						
Total Organic Carbon, mg/L	70	80	66	No Flow	No Flow	64
Oil & Grease, mg/L	1.4	1.6	2.6			[illegible]
pH	6.0	6.0	5.6			5.5
PCBs, mg/L	ND(0.001)	ND(0.001)	ND(0.001)			ND(0.001)
Lead, mg/L	ND(0.1)	ND(0.1)	ND(0.1)			ND(0.1)
Biochemical Oxygen Demand (mg/L 02)	14	29	17			22
PRIORITY POLLUTANTS:						
Volatile Organic Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds			
- Benzene, mg/L						0.029
- Chlorobenzene, mg/L						ND(0.001)
- Toluene, mg/L						[illegible]38
- Trichloroethene, mg/L						[illegible]031
- Methylene Chloride, mg/L						0.010
- Total Xylenes, mg/L						0.031
						Below Detection Limits For All Other Compounds
Base/Neutral Organic Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds			Below Detection Limits For All Compounds
Acid Extractable Organic Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds	Below Detection Limits For All Compounds			Below Detection Limits For All Compounds

TABLE 1-12

Comparison of Outfall Concentrations To Water Quality Criteria

Combustion, Inc.
Denham Springs, Louisiana

	Acute Ambient Water Quality Criteria for Protection of Fresh Water Aquatic Life (mg/L)	Concentration in Outfall from Pond N (mg/L)
Benzene	5.3	0.025 (a) 0.029 (b)
Chlorobenzene	NA	0.032 (a) ND (0.001) (b)
Toluene	17.5	0.067 (a) 0.038 (b)
Trichloroethylene	45 21.9 (c)	0.038 (a) 0.031 (b)
Methylene Chloride	NA	ND (0.010) (a) 0.010 (b)
Total Xylenes	NA	ND (0.010) (a) 0.031 (b)

NOTES:

(a) Sample taken February 13, 1988
(b) Sample taken December 28, 1988
(c) Chronic

1.10 Site Geology

The Combustion, Inc. site, located in west central Livingston Parish, is situated within the Gulf Coastal Plain of Louisiana. The shallow subsurface geology is generally characterized by interbedded sands and clays. Surficial sediments are Holocene to alluvial and Pleistocene age terrace deposits (Meyers and Turcan, 1955). The Louisiana Geologic Survey (LGS) regional geologic map indicates that surficial loess (wind blown silts) deposits are also common in the area (LGS, 1984).

The only major structural feature in the shallow subsurface near the Combustion, Inc. site is the Baton Rouge Fault Zone. Faults of this system are typical growth faults associated with gradual large scale slumping and contemporaneous deposition of coastal and deltaic sediments. These faults are oriented nearly parallel to the Gulf Coast and dip toward the coast. Because of the unconsolidated and sandy nature of the regional sediments, growth faults in general should have no major influence on the shallow hydrogeology of the site.

1.11 Site Hydrogeology

The interbedded sands and clays present in the Livingston Parish and surrounding areas compose a complex system of fresh water aquifers that extend to depths down to -3200 feet mean sea level (MSL). Generally defined as the Southern Hills Regional Aquifer System by Buono (1983), the sands and clays have been locally subdivided into as many as thirteen aquifer units. Many of the sands are, however, interfingering and are probably functioning on a regional basis as a lesser number of aquifer units.

Ground water recharge occurs principally by precipitation on the Citronelle Formation where it crops out in southern Mississippi (north of Livingston Parish). Figure 1-7 illustrates the regional ground water flow pattern southward through the Citronelle Formation into the laterally correlatable Shallow Aquifer Unit and down dip into the lower aquifer units.

According to Morgan (1963), in the northeastern Livingston Parish area the hydraulic gradient in the lower aquifer units may reverse from a down dip and lateral direction to an upward direction into the Shallow Quaternary Aquifer. The regional flow patterns have been affected by the heavy use of ground water in the Baton Rouge area.

The upward gradient is evidenced by numerous flowing wells completed in the lower sands north-northeast of the site. The Shallow Aquifer Unit is confined but generally not characterized by flowing wells. In northwestern Livingston Parish, the upward hydraulic gradient is reduced due to large withdrawal rates associated with municipal and industrial usage in the Baton Rouge area (Tomaszewski

1988). Tomaszewski (1988) reports that yearly decreases in water levels in the lower aquifer units from 0.2 feet to six feet are common.

The base of fresh water in the Livingston Parish area ranges from about -2500 feet MSL in the northeast to -3200 feet MSL in the southeast. In the south part of the parish, the occurrence of salt water at depths of approximately -1200 feet MSL is directly associated with the presence of the Baton Rouge Fault Zone (Figure 1-8). This indicates that the faulting serves as a barrier to lateral flow.

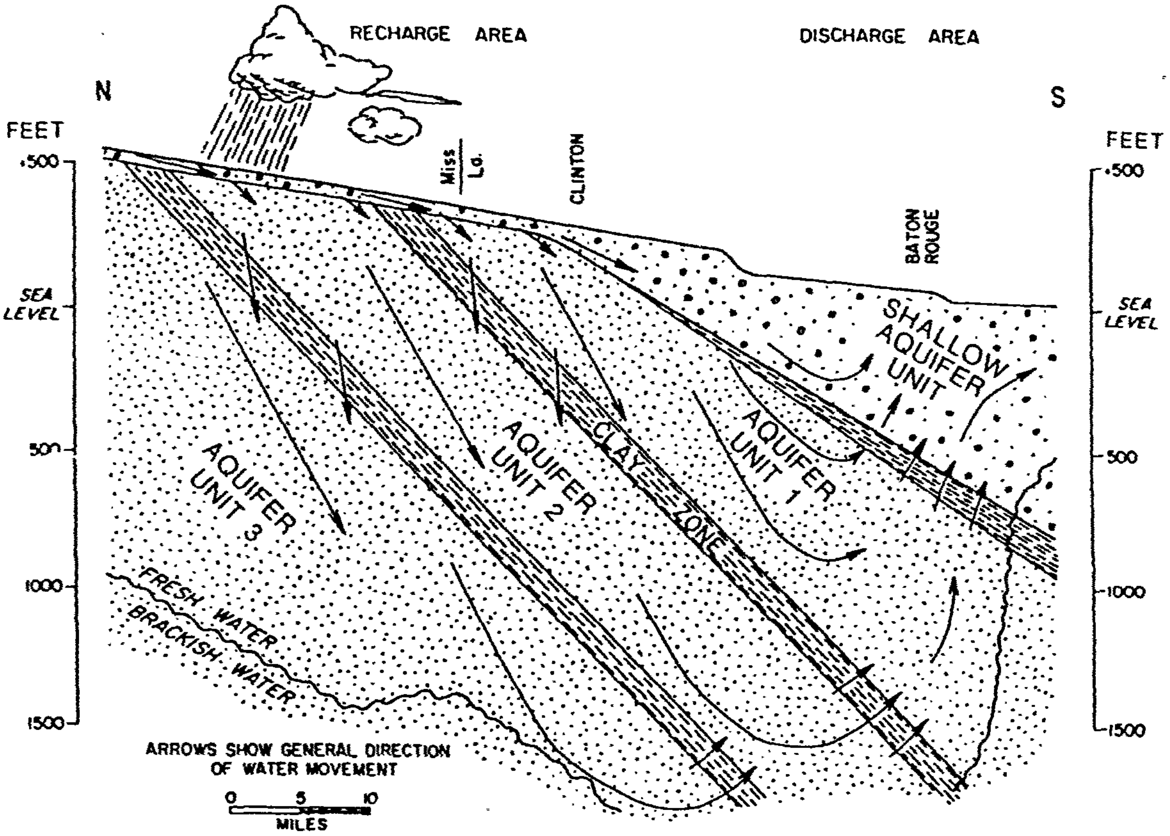
1.12 Ground Water Usage

Ground water is used for municipal, industrial, irrigation and domestic purposes in the Livingston Parish area. A water well listing by the Louisiana Department of Transportation and Development (DOTD) was used to locate all registered wells within a two-mile radius of the Combustion, Inc. site. The wells of primary concern within a two-mile radius of the Combustion, Inc. site are those located to the south of the site. Wells north of the site are not of concern because the regional gradient is to the south and these wells are upgradient of the site. Also, any wells screened in the lower aquifer units are not of concern because of the regional upward gradient.

In the immediate vicinity of the Combustion, Inc. site, the ground water flow direction in the Shallow Aquifer Unit and the shallow sands above it are primarily toward the south. Based on these flow patterns, Figure 1-9 indicates that there are no municipal or public supply wells screened in these zones that would be impacted by the Combustion, Inc. site. Figure 1-10 shows the location of wells within the two mile radius.

Based on a review of the resident surveys conducted by Louisiana State University, two shallow domestic wells were identified in the near vicinity of the Combustion, Inc. site. Neither of these wells are currently being used and apparently have not been used since public water supply lines (Ward 2 Water) were installed. Based on the locations of these wells and the apparent shallow ground water flow direction, neither of these wells should be impacted by the Combustion, Inc. site.

The DEQ sampled six drinking water wells in August 1986, including the Ward 2 Water District and the Town of Walker water supply wells. No detectable levels of volatile organics, pesticides, PCBs, phenols, cyanides, and fecal coliform were found. The only semivolatile organic compounds detected were trace amounts of a phthalate, a common contaminant of plastic piping and laboratory tubing. Concentrations of metals in unfiltered well samples were below detection limits or below the primary and/or secondary drinking water standards.



Modified from Morgan, 1963.

NOTE:

1) AQUIFER DESIGNATIONS CORRESPOND TO DEFINITIONS AS GIVEN BY TOMAZEWSKI (1988) FOR LIVINGSTON PARISH.

2) CROSS-SECTION LOOKS EASTWARD, TOWARD LIVINGSTON PARISH.

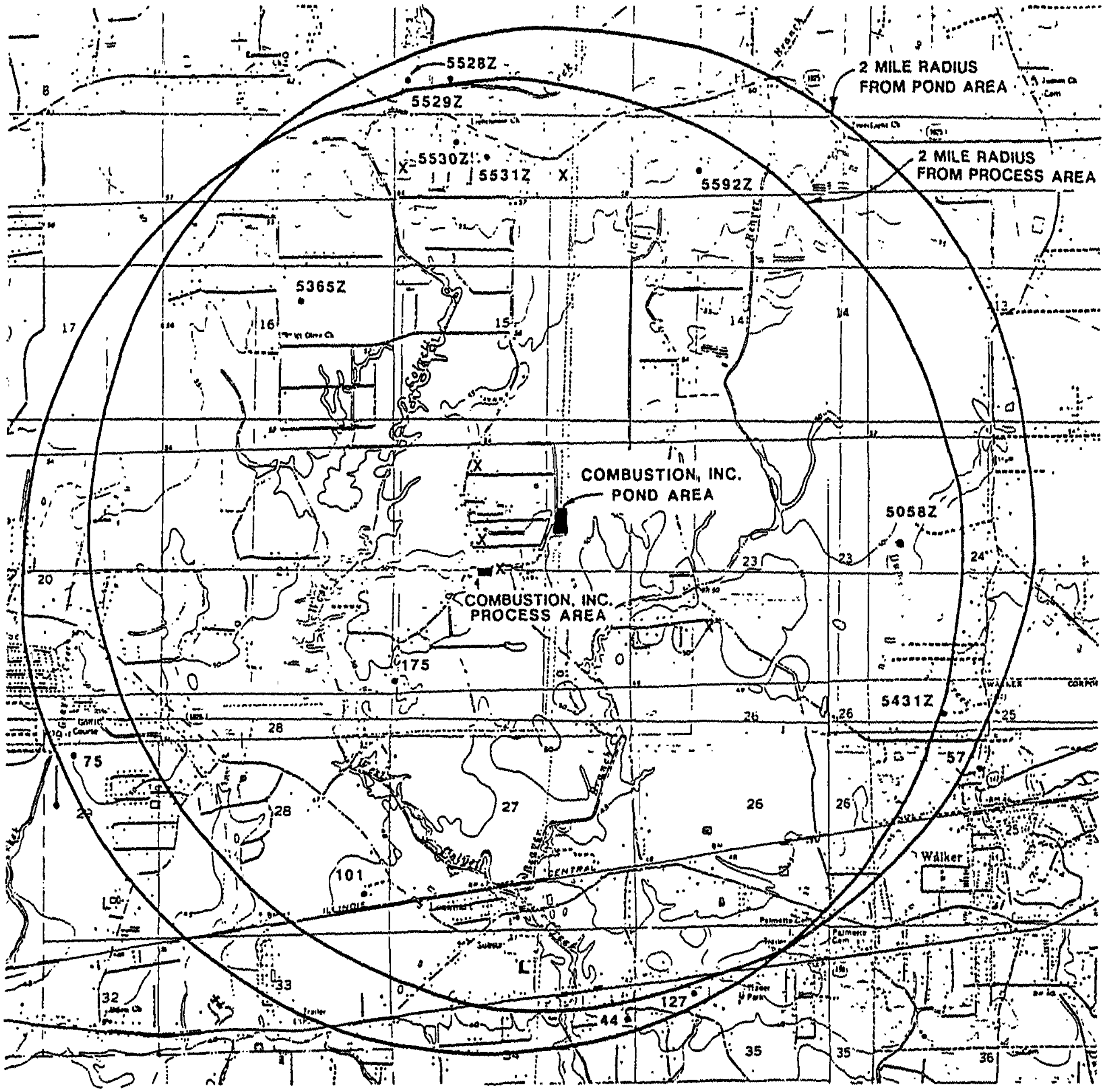
ERM-Southwest, inc.
NEW ORLEANS, LOUISIANA HOUSTON, TEXAS

DATE 6/21/89

W.O.NO. 8508A012

FIGURE 1-8
SCHEMATIC CROSS-SECTION
REGIONAL GROUND WATER FLOW
Southeastern Louisana
Combustion Inc. RI/FS

R315



N

LEGEND

5531Z ● LOCATION AND WELL NO. OF REGISTERED WELLS, PRODUCTION DEPTHS PROVIDED IN TABLE 2-1

(Source. Water Resources Section of the Louisiana Department of Transportation and Development

X APPROXIMATE LOCATION OF UNREGISTERED WELLS IDEN[illegible]ED IN THE RESIDENT SURVEY [illegible]S REPORTED IN THE AUGUST 21, 1986 LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY DOMESTIC WELL SAMPLING EVENT

Base from Watson, Satsuma, Walker and Denham Springs, Louisiana USGS 7.5' Quadrangle Maps.

SCALE 1:24 000

CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

ERM-Southwest, inc.

NEW ORLEANS, LOUISIANA HOUSTON, TEXAS

DATE 6/27/89 W.O.NO. 8508A017

FIGURE 1-10
WATER WELLS WITHIN A TWO MILE RADIUS OF THE COMBUSTION, INC. SITE
Combustion, Inc. RI/FS
Denham Springs, Louisiana

2 - SELECTION OF CONSTITUENTS OF CONCERN

2.1 Division of the Site into Source Areas

The Combustion, Inc. site is divided into two source areas: the Pond Area and the Process Area. The Pond Area consists of a series of interconnected shallow ponds that contain affected surface water, oil (in five of the ponds), solids (sediment at the bottom), and soil. The Process Area is characterized by affected soil. Affected ground water is also present near each source area. Since each affected medium in each source area represents a potential exposure point, constituents of concern were selected for each medium in the Pond Area and Process Area.

2.2 Constituent Screening Process

All analytical results which passed the Quality Assurance/Quality Control (QA/QC) review performed by ERM-Southwest were considered for each source area in every medium. A three phase screening process was used to identify constituents of potentially significant estimated risk for further evaluation.

The initial screening phase considered the quantitative reliability of the data. After the data was reviewed for reliability, the mean chemical concentration and the 95th percent upper confidence limit of the arithmetic mean were determined. To calculate the mean constituent concentration and the confidence limits, one half the sample quantitation limits for the ND results were used in the event that the source area had at least one positive detection of the constituent. This assumes that the constituent is truly in the area, but may be at a level below the quantitation limit.

The second phase of the screening consisted of the concentration-toxicity screening procedure outlined in RAGS. This phase consists of deriving a risk factor (R_j) for an individual constituent as the product of the constituent's concentration in a given medium and an appropriate EPA reviewed toxicity value:

$$R_j = \text{Concentration} \times 1/\text{RfD} \quad \text{or}$$
$$R_j = \text{Concentration} \times \text{CSF}$$

where:

RfD = Reference Dose (mg/kg/day)
CSF = Cancer Slope Factor $(\text{mg/kg/day})^{-1}$

Risk factors for all potential constituents of concern are then summed for carcinogenic and noncarcinogenic effects separately (Total R). A ratio of risk factor to total risk factor (Rj/Total R) is than determined for each individual carcinogenic or noncarcinogenic constituent. Chemicals comprising 99 percent of the total are chosen as indicators representing the majority of the estimated site risk for each source area.

The third phase of the screening considered detected constituents for which an EPA reviewed RfD or CSF was not available. Lead was selected as an indicator constituent in every medium in which it occurred although no agency-approved toxicity value is available.

2.3 List of Constituents of Concern for Source Areas

The final indicator chemicals for each source area are listed below.

Pond Area Soils

Arsenic
Barium
Benzene
Copper
1,2-Dichloroethene
Ethylbenzene
Fluoranthene
Fluorene
Heptachlor
Lead
Manganese
Mercury
Naphthalene
Pyrene
Tetrachloroethylene
Vanadium
Zinc

Pond Solids

Acenaphthene
Antimony
Barium
bis(2-Ethylhexyl)phthalate
Benzene
Benzo(a)anthracene
Benzo(b)fluoranthene
Butylbenzylphthalate
Cadmium
Chrysene
Ethylbenzene
Fluoranthene
Fluorene
2-Hexanone
Lead
Naphthalene
n-Nitrosopropylamine
PCB
Pyrene
Styrene
Tetrachloroethylene
Toluene
Trichloroethylene

Pond Water

Antimony
Arsenic
Barium
Benzene
Lead
Methylene chloride

Pond Oil

Arsenic
Acetone
Cadmium
Chromium
Ethylbenzene
Lead
PCB
Toluene

Process Area Soils

Arsenic
Barium
DDT
2,4-Dinitrotoluene
Lead
Manganese
Naphthalene
Nickel
PCB
Toluene
Vanadium

3.1 Characterization of Exposure Setting

The site is located in Livingston Parish in the Coastal Plain of Louisiana. It is situated within a pine-hardwood woodland that is interspersed with open areas that contain residential development and power lines.

A woodland stands directly south of the Process Area. West, east and north of the Process Area, the woodland is interrupted by houses and roadways. South of the Process Area, the woodland stretches west across Burgess Road and east across an unnamed tributary of the Beaver Branch of West Colyell Creek.

Immediately north of the Process Area is a residential area of houses and mobile homes. Other permanent residences are located east, west and south of the Process Area.

The Pond Area is situated in a wide easement for two high power electrical transmission lines. The cleared grassy area of the easement extends directly north and south of the Pond Area. The unnamed tributary of Beaver Branch lies along the western edge of the Pond Area. The residential area that is located to the north of the Process Area lies west of the stream bed. Another large stand of pine-hardwood woodlands lies east of the Pond Area.

For a more complete description of the site ecology, demographics, hydrogeology and land use, see Section 1.9.

3.2 Identification of Exposure Pathways

The major components of an exposure assessment are:

1. An evaluation of the environmental fate and transport processes of the indicator compounds;
2. The formulation of one or more exposure scenarios, each of which consists of the following four elements. These four elements constitute an exposure pathway; a pathway is not complete if any one of them is not present:
    a) a source and mechanism of chemical release to the environment,
    b) an environmental transport medium (air, water, soil),
    c) a point of potential contact with the affected environmental medium (exposure point), and
    d) a route of exposure (e.g., ingestion of drinking water, dermal contact with soil).
3. The determination of the populations that could be exposed to the site constituents; and

4. The calculation of chemical intakes for each indicator.

3.2.1 Source Areas

At the Combustion, Inc. site the contents of the Pond Area lagoon system and the Process Area are the source areas for site constituents. At the Pond Area, source materials may be subdivided into pond water, pond oil, pond solids (the semisolid material at the bottom of each pond), as well as Pond Area soils. In addition to affected soils at the Process Area, there are also tanks and other process equipment that were used during site operations. Some of the tanks contain residual hydrocarbon materials.

3.2.2 Release and Transport from Source Areas

Release and transport of the site constituents may take place by several potential means, namely: volatilization of volatile organics, fugitive dust emission, storm water runoff, Pond Area overflow, discharge from Pond N into the intermittent stream, transport of soluble constituents by ground water, and direct contact with affected media. These mechanisms are evaluated below for their relevance to the Combustion, Inc. site.

Volatilization: Subsequent to the RI field work, the site was placed on the NPL on the basis of an air release in 1985. However, the site air monitoring and industrial hygiene survey that was conducted by Eagle Environmental Health in January 1989 indicated no volatile releases of total hydrocarbons above detection limits. These negative results were obtained in spite of the fact that personnel air samples were taken at both the Pond Area and Process Area during sampling and trenching activities, when release of constituents would be expected to be the highest (ERM-Southwest, 1989; see Appendix B). Volatilization of hydrocarbons is therefore not considered a relevant release and transport mechanism for the site.

Fugitive Dust Emission: The industrial hygiene investigation cited above indicated that suspended particulate matter was present in ambient air at concentrations ranging up to 6.4 $\mu g/m^3$. Samples were taken upwind and downwind of trenching operations. Although these detected levels are low compared to the national ambient air quality standard of 150 $\mu g/m^3$, fugitive dust emission is considered a relevant release and transport mechanism since dust may be generated from affected soil during residential or construction activities.

Storm Water Runoff: Storm water runoff of constituents from the Process Area and Pond Area was evaluated in the Remedial Investigation. The storm water runoff samples from both areas were generally similar to the background runoff samples. The total suspended solids and chemical oxygen demand measured in the Pond Area were slightly higher than the background sample. There does not appear to be significant runoff from the Process Area on the basis of these data. Surface water samples from south of the Process Area do not indicate any movement of constituents in that direction. Process Area drainage runs primarily toward the northeast. Storm water runoff subsequent to physical entrainment of affected materials is not considered a significant release and transport mechanism for the site.

Pond Area Overflow: The Pond Area is characterized by an average of 2.1 feet of freeboard, as determined by weekly observations performed during the Remedial Investigation. Even after a heavy rainfall, there is a minimum of eight to ten inches of freeboard in all of the ponds. Should heavy flooding occur, either the berms around each pond or the on-site perimeter ditch would prevent off-site release and transport of pond materials. Pond Area overflow therefore is not considered a relevant release and transport mechanism for the site.

Pond N Discharge to Stream: An outfall pipe carries overflow from Pond N, the last pond in the interconnected lagoon system, into the intermittent stream that runs to the west of the Pond Area. The surface water of the stream was sampled upstream and downstream of the outfall pipe. Although immediate downstream parameters were slightly elevated relative to upstream, surface water quality does not appear to be seriously affected because of Pond Area discharge (downstream sample taken 15 feet south of the Pond N discharge). No metals, for example, were detected above detection limits (Table 1-11). Farther downstream, however, water quality is degraded by the sewage outfall from the overflow of residential septic systems. This degradation is evident from the extensive eutrophication, the presence of PVC discharge pipes from the residences, and from the malodorous condition of the surface water. Pond N discharge therefore is not considered a significant mechanism of release and transport for the site.

Transport in Ground Water: Ground water data indicate that several site constituents are present in the shallow aquifer near the source areas. Many of the inorganic constituents are naturally occurring, however. Dissolution from soil and aquifer transport is considered a potential mechanism of release and transport of constituents from the site. Due to the widely observed septic overflow in the neighborhood,, it is highly unlikely that ground water would be used as a domestic water source in the immediate vicinity of the source areas. Ground water is therefore not used as an exposure pathway.

Direct Contact: Direct contact with affected materials, such as soil, surface water, or pond oil may occur in a future or current land use scenario. This contact represents a means of release of site constituents, and it is therefore considered relevant to the site.

Release from Tanks: The tanks at the process area contain residual hydrocarbon materials. In the event of a leak due to tank deterioration, the material will flow into the on-site sump and will eventually drain into the Pond Area. Any direct exposure to leaking material by a trespasser would be very unlikely. Evaluation of direct contact is considered in the Pond Area. Therefore, a separate exposure assessment for leaking tank materials is not required.

3.2.3 Exposure Points

The following exposure points are identified for the site:

Pond Area:	soil, surface water, oil, solids
Process Area:	soil

These exposure points represent the various affected media at the site.

3.2.4 Exposure Routes

The following exposure routes are identified for the site:

Pond and Process Area Soil:	ingestion, dermal contact, inhalation of fugitive dust
Pond Oil:	ingestion, dermal contact
Pond Solids:	ingestion, dermal contact
Pond Surface Water:	ingestion, dermal contact

The complete exposure pathways are summarized in Table 3-1.

3.3 Quantification of Exposure

Following identification of the various exposure pathways that are applicable to the Combustion, Inc. site, the next step in exposure assessment is the quantification of exposure. This step provides a quantitative estimate of chemical intake by the exposed population. A threefold approach, described below, comprises this step: development of exposure scenarios, estimation of exposure point concentrations, and calculation of chemical intakes. This overall estimate of exposure provides the mathematical basis for the characterization of risk.

3.3.1 Development of Exposure Scenarios

An exposure scenario integrates the site-specific information on exposure pathways with the most appropriate land use patterns. In accordance with RAGS, two scenarios were used: current land use and future land use.

Current Land Use - With Access: This scenario estimates chemical intake on the basis of exposure to the unremediated site, with the

TABLE 3-1

Summary of Exposure Pathway Analysis

Combustion, Inc.
Denham Springs, Louisiana

SOURCE	POTENTIAL RELEASE MECHANISM	SITE-SPECIFIC PATHWAY INFORMATION	RECEPTOR & ROUTE
Pond Area Soil	o Volatilization	o Site air monitoring and industrial hygiene survey indicated no volatile releases of total hydrocarbons above detection limits; exposure to volatilized constituents is not considered a complete pathway.	Current: Child (O, D, I) Future: Adult Child (O, D, I)
	o Fugitive Dust	o Site air monitoring indicated suspended particulate matter was present up to 6.4 $\mu g/m^3$ during trenching activities; exposure to dust is considered a complete pathway.	
	o Transport in Runoff Water	o Although transport in runoff water is a relevant release mechanism and potentially a complete exposure pathway, site samples from the process and pond areas were generally similar to background samples. Off-site release and transport of constituents through runoff is judged insignificant.	
	o Direct Contact	o Direct contact is a relevant and complete exposure pathway for current and future land use scenarios.	
	o Release to Ground Water	o Release to ground water is a relevant release mechanism for both land use scenarios, but no complete pathway exists under the future exposure scenarios.	

TABLE 3-1 (Cont'd)

Summary of Exposure Pathway Analysis

Combustion, Inc.
Denham Springs, Louisiana

SOURCE	POTENTIAL RELEASE MECHANISM	SITE-SPECIFIC PATHWAY INFORMATION	RECEPTOR & ROUTE
Pond Water	o Volatilization	o Site air monitoring and industrial hygiene survey indicated no volatile releases of total hydrocarbons above detection limits; exposure to volatilized constituents not considered a complete pathway.	Current: Child (O, D)
	o Pond Area Overflow	o Sufficient freeboard in ponds (including after heavy rain) indicates berms around ponds are of sufficient height to prevent overflow. Perimeter ditches also prevent off-site release and transport in the unlikely event of overflow. Pond area overflow does not constitute a complete exposure pathway.	
	o Pond N Discharge to Stream	o Although Pond N discharge to stream water is a relevant release mechanism and potentially complete exposure pathway, site effect on surface water quality is considered insignificant based upon stream sampling data.	
	o Direct Contact	o Direct contact is a relevant and complete exposure pathway only for the current land use scenario since the material would be removed for construction of residences as considered in the future land use scenario.	
Pond Oil	o Volatilization o Pond Area Overflow o Pond N Discharge to Stream o Direct Contact	Same as pond water	Current: Child (O, D)

TABLE 3-1 (Cont'd)

Summary of Exposure Pathway Analysis

Combustion, Inc.
Denham Springs, Louisiana

SOURCE	POTENTIAL RELEASE MECHANISM	SITE-SPECIFIC PATHWAY INFORMATION	RECEPTOR & ROUTE
Pond Solids	o Pond Area Overflow o Pond N Discharge to Stream o Direct Contact	Same as pond water	Current: Child (O, D)
Process Area Soil	o Volatilization o Fugitive Dust o Transport in Runoff Water o Direct Contact o Release to Ground Water	Same as pond area soil	Current: Child (O, D, I) Future: Adult Child (O, D, I)

Routes of Exposure:

O = Oral (ingestion)
D = Dermal
I = Inhalation

assumption that it has been abandoned and is now accessible. Since the site currently is fenced and inaccessible to the public, exposure cannot occur under actual site conditions. A trespass scenario, involving intermittent exposure by a teen-aged child, is assumed here. Since a residential area is nearby, it is reasonable to assume that children will occasionally trespass and wander around and play in the source areas (Pond Area and Process Area). Adults are not considered in this scenario since they are less likely to trespass routinely. It is not reasonable to assume that this intruder-type visitation would occur daily or even weekly, since the areas are not especially attractive because of the open lagoons and equipment. As a conservative measure, however, each visitation is assumed to involve exposure to all affected media. For pond oil, water, and solids, exposure is assumed to occur three times a year. Pond soil exposure is assumed to be 108 times a year (twice a week during the nine month school year and three times a week during the three month summer vacation). Regular soil exposure is more probable than exposure to the pond contents (oil, water, solids) because of the unappealing nature of the latter. The pond contents are not attractive for swimming or fishing or other recreational purposes. In addition, the depths of the ponds render most of them unusable as wading areas. Only two ponds are less than three feet deep. Ponds with no oil range from 1.3 to 7.2 feet deep; ponds containing oil range from 4.7 to 9.2 feet in depth. These considerable depths would make it unlikely that any routine wading exposure would occur. Ground water exposure is not evaluated in this scenario. Complete exposure parameters for this scenario are presented in Table 3-2.

Future Land Use: This scenario estimates chemical exposure to the site on the basis of hypothetical future land use. To be in accordance with RAGS, this scenario was developed as a residential scenario that is intended to provide an estimate of reasonable maximum exposure (RME). The scenario involves both a child and an adult with daily exposure to affected soil. This scenario assumes that a house has been constructed on or immediately adjacent to the Pond Area or the Process Area. Exposure to pond contents (oil, water, and solids) is not evaluated since those materials would have to be removed before any residential construction activities would occur. Pond soil, however, could be left in place after bulldozing and excavation activities were done to prepare the site for construction. The shallow aquifer near the site is not likely to be used as a domestic water source. It is probably contaminated by septic overflow that has been observed throughout the area. To assume aquifer use goes beyond the concept of a reasonable maximum exposure. Complete exposure parameters for this scenario are presented in Table 3-3.

3.3.2 Determination of Exposure Concentrations

In accordance with RAGS, exposure point concentrations were considered to be 95th per cent upper confidence limit (95th UCL) of the analytical data set for a given chemical within a medium. In certain cases, where the variance of the data set was sufficiently

TABLE 3-2

Summary of Exposure Parameters

Combustion, Inc.
Denham Springs, Louisiana

Current Land Use–Trespasser Scenario:	Exposure Parameters	Comments/References
Receptor	Child (8-14)	
Body Weight	37 kg	National average, EFH
Body Surface Exposed	4550 sq cm	hands + 1/2 arms + 1/2 legs + feet, EFH
Ingestion Rate (soil)	100 mg/day	RAGS, 1989
Ingestion Rate (pond water)	0.05 L/day	RAGS, 1989
Ingestion Rate (pond oil)	0.0175 L/day	Ratio of ponds with oil x 50 ml
Inhalation Rate	0.83 cu m/hour	National average, RAGS
Exposure Time (soil)	4 hours	Conservative Assumption
Exposure Time (water/oil/solids)	0.5 hour	Conservative Assumption
Exposure Frequency (soil)	108 days/year	3 days/wk summer + 2 days/wk 9 months
Exposure Frequency (water/oil/solids)	3 days/year	Conservative Assumption
Exposure Duration	7 years	
Soil Adherence Factor	1.45 mg/sq cm	RAGS, 1989
Air Concentration of Dust	0.0064 mg/cu m	Site specific air monitoring
Respirable Fraction of Air Dust	0.5	Paustenbach, 1989
Noncancer Averaging Time	2555 days	Exposure duration x 365 days/yr
Cancer Averaging Time	25550 days	70 years x 365 days/yr

SOURCES:

EFH = EPA, Exposure Factors Handbook, 1989
RAGS = EPA, Risk Assessment Gudance For Superfund, Human Health Evaluation Manual, Part A, 1989
Paustenbach, D.J., The Risk Assessment of Environmental and Human Health Hazards: A Textbook of Case Studies, Wiley & Sons, New York, 1989

TABLE 3-3

Summary of Exposure Parameters

Combustion, Inc.
Denham Springs, Louisiana

	EXPOSURE PARAMETERS	COMMENTS/REFERENCES
Future Land Use – Residential Scenario:		
Receptor	Adult	
Body Weight	70 kg	National average, EFH
Body Surface Exposed (soil)	3940 sq cm	Hands + forearms + lowerlegs, EFH
Ingestion Rate (soil)	100 mg/day	RAGS, 1989
Inhalation Rate	0.83 cu m/hour	National average, RAGS
Exposure Time (soil)	24 hrs/day	RAGS, 1989
Exposure Frequency (soil)	350 days/year	RAGS, 1989
Exposure Duration	30 years	90th percentile, RAGS, 1989
Soil Adherence Factor	1.45 mg/sq cm	RAGS, 1989
Air Concentration of Dust	0.0064 mg/cu m	Site specific air monitoring
Respirable Fraction of Air Dust	0.5	Paustenbach, 1989
Noncancer Averaging Time	10950 days	Exposure duration x 365 days/yr
Cancer Averaging Time	25550 days	70 years x 365 days/yr
Receptor	Child (0–5)	
Body Weight	16 kg	National average, RAGS
Body Surface Exposed (soil)	1730 sq cm	Hands + 1/2 arms + 1/2 legs, EFH
Ingestion Rate (soil)	200 mg/day	RAGS, 1989
Inhalation Rate	0.6 cu m/hour	National average, RAGS
Exposure Time (soil)	24 hrs/day	RAGS, 1989
Exposure Frequency (soil)	350 days/year	RAGS, 1989
Exposure Duration	5 years	
Soil Adherence Factor	1.45 mg/sq cm	RAGS, 1989
Air Concentration of Dust	0.0064 mg/cu m	Site specific air monitoring
Respirable Fraction of Air Dust	0.5	Paustenbach, 1989
Noncancer Averaging Time	1825 days	Exposure duration x 365 days/yr
Cancer Averaging Time	25550 days	70 years x 365 days/yr

SOURCES:

EFH = EPA, Exposure Factors Handbook, 1989
RAGS = EPA, Risk Assessment Gudance For Superfund, Human Health Evaluation Manual, Part A, 1989
Paustenbach, D.J., The Risk Assessment of Environmental and Human Health Hazards: A Textbook of Case Studies, Wiley & Sons, New York, 1989

high, the 95th UCL exceeded the maximum detected concentration. In these cases the maximum value was used as the exposure point concentration.

The data from the Pond B water sample that was taken November 17, 1986 were omitted from the risk assessment because the water was later shown to contain a significant amount of solids stirred up from the bottom of the pond. These suspended solids resulted in unrepresentatively high values of constituents in the water column. The pond was later resampled for lead only.

Exposure concentrations for pond oil are expressed in mg/L. The analytical data were originally reported as mg/kg ; these units were converted to mg/L by assuming a density of 0.85 g/ml (i.e., lighter than water and similar to xylene and toluene). The mg/kg concentrations were multiplied by 0.85 to obtain the mg/L concentration.

3.3 3 General Intake Equations

Oral and dermal chemical intakes were calculated according to Chapter 6 in the U.S. EPA Risk Assessment Guidance for Superfund, 1989 (RAGS). Inhalation of constituents associated with soil entrained in air was estimated according to RAGS as well.

Oral

Oral intake of constituents was calculated as follows for the residential soil ingestion and for the trespasser incidental ingestion of soil, pond water, and oil. The result is the daily constituent intake calculated as an administered dose. For incidental ingestion of pond oil, an additional 5/14 factor was included for fraction of medium affected (five of the fourteen of ponds contain discrete oil layers).

Intake (mg/kg/day) = (C*IR*EF*ED)/(BW*AT)

where:

C = concentration (mg/L liquid or mg/kg soil)
IR = ingestion rate (L/day liquid or mg/day soil x 10^{-6} kg/mg)
EF = exposure frequency (days/yr)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days) = 365 days/yr * ED for noncarcinogens or 365 days/yr * 70 years for carcinogens

Dermal

Intake of constituents through dermal exposure to liquids for the trespasser was calculated for all indicator constituents (except PCBs in oil) using the following equation (U.S. EPA, RAGS, 1989). The result is the daily constituent intake expressed as an absorbed dose.

Intake (mg/kg/day) = (C*SA*PC*T*EF*ED*1L/1000 cm^3)/(BW*AT) where:

C = chemical concentration in liquid (mg/L)
SA = skin surface area immersed (cm^2)
PD = dermal permeability constant for chemical (cm/hr)
T = duration of exposure event (hrs/day)
EF = exposure frequency (days/year)
ED = exposure duration (yrs)
AT = averaging time (days) = 365 days/yr * ED for noncarcinogens or
365 days/yr * 70 yrs for carcinogens
BW = body weight (kg)

The term 1L/1000 cm^3 is a volumetric conversion constant for water.

In absence of chemical-specific dermal permeability factors for some of the inorganics, it is assumed that chemicals are carried through the skin as a solute in absorbed water (rather than being preferentially absorbed independently of the water). The permeation rate of water across the skin boundary is assumed to be the factor controlling the absorption rate for most of the inorganic constituents in the above equation.

The dermal permeability constants for the constituents of concern are listed in Table 3-4.

The dermal intake of PCBs contained in pond oils was derived using a slight modification of the equation used to determine intake via dermal contact with water or other constituents in oil. A recent study by Wester et al. (1990) measured the dermal uptake of PCBs in monkeys using mineral oil as the oil vehicle. An hourly dermal absorption rate constant was modeled from the results of this study by assuming absorption (as is true in almost all cases) was a first order reaction process (Ritschel, 1977). The film thickness of the oil adhering to the skin of a trespasser wading in it was conservatively assumed to be 1 mm, or some 20 times that of water (Versar, 1987). This conservative assumption means the child is covered with about one half a quart of oil per exposure event. Because the Wester et al. (1990) study measured dermal absorption using skin on the abdomen, a correction factor was applied to the amount dermally absorbed to account for the lower absorption rate found in skin of the limbs, hands and feet (Guy and Maibach, 1984). The equation and equation variables for dermal absorption of PCBs in oil is:

$$\text{Absorbed Dose} = \frac{PCB_{oil} \times SA \times FT \times D_{abs} \times CF \times ET \times EF \times ED}{BW \times AT}$$

where:

PCB_{oil} = PCB concentration the oil (mg/L)
SA = surface area of skin exposed (cm^2)
FT = film thickness of the oil (cm)
D_{abs} = dermal absorption factor for PCBs from oil (per hr 1/hr)
CF = correction Factor for lower dermal absorption limbs (unitless)

TABLE 3–4

Dermal Absorption and Permeability Factors

Combustion, Inc.
Denham Springs, Louisiana

Constituent	Dermal Absorption Factor (unitless)	Reference	Dermal Permeability Constant (cm/hour)	Reference
Acenaphthene	0.05	A	3.16E–01	J
Acetone	–		1.00E–03	J
Antimony	0.005	B	1.50E–03	K
Arsenic	0.001	C	1.50E–03	K
Barium	0.005	B	1.50E–03	K
Benzene	0.01	D	1.11E–01	J
bis(2–Ethylhexyl)phthalate	0.1	E	5.70E–06	J
Benzo(b)fluoranthene	0.01	F	3.16E–02	J
Benzo(a)anthracene	0.01	F	3.16E–02	J
Butylbenzylphthalate	0.1	E	5.76E–06	L
Cadmium	0.005	B	1.50E–03	K
Chromium	–		2.10E–03	J
Chrysene	0.01	F	3.16E–02	J
Copper	0.005	B	1.50E–03	K
DDT	0.01	G	3.16E–02	J
1,2–Dichloroethane	0.1	E	1.95E–02	J
1,2–Dichloroethene	0.1	E	–	J
2,4–Dinitrotoluene	0.05	A	1.10E–04	J
Ethylbenzene	0.1	E	1.37E+00	J
Fluoranthene	0.05	A	3.16E–02	J
Fluorene	0.05	A	3.16E–02	J
Heptachlor	0.1	E	3.16E–02	J
2–Hexanone	0.1	E	1.50E–03	K
Lead	0.003	H	1.50E–03	K
Manganese	0.005	B	1.50E–03	K
Mercury	0.005	B	1.50E–03	K
Methylene chloride	–		5.62E–03	J
Naphthalene	0.05	A	3.16E–01	J
Nickel	0.005	B	1.50E–03	K
N–Nitrosopropylamine	0.1	E	–	
PCB	0.01	I	9.80E–03 (a)	J
Pyrene	0.05	A	3.16E–02	J
Styrene	0.1	E	2.82E–01	J
Tetrachloroethylene	0.1	E	7.94E–03	J
Toluene	0.1	E	1.01E+00	J
Trichloroethene	0.1	E	8.32E–02	J
Vanadium	0.005	B	1.50E–03	K
Zinc	0.005	B	1.50E–03	J

NOTE:

– Value was not determined (not needed in the risk assessment)

(a) The PCB dermal permeability is 0.98% per hour as calculated from a study using mineral oil applications to monkeys (Wester, et al., 1990). A first order process for absorption was used.

TABLE 3–4 (Cont'd)

Dermal Absorption and Permeability Factors

Combustion, Inc.
Denham Springs, Louisiana

References

A. Calculated based on PAHs.

B. Risk Assessment Guidance for Super fund, Volume I: Human Health Evaluation Manual, Appendix A, 1989. EPA/540/1–89/002.

C. EPA, Special Report on Ingested Inorganic Arsenic, July 1988, EPA/625/3–87/013.

D. Maibach, H.I. and D.M. Anjo, 1981 Percutaneous Penetration of Benzene and Benzene Contained in Solvents Used in the Rubber Industry, Archives of Environmental Health, Vol. 36, No. 5, pp. 256–260.

E. Default value, based on Bartek, M.J., J.A. LaBudda, and H.I. Maibach, (1972) Skin Permeability In Vivo: Comparison in Rat, Rabbit, Pig, and Man, The Journal of Investigative Dermatology.

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I. Wester, R.C., H.I. Maibach, D.A.W. Bucks, J. McMasters, and M. Mobayer, 1990, Percutaneous Absorption and Skin Decontamination of PCBs: In Vitro Studies with Human Skin and In Vivo Studies in Rhesus Monkey, Journal of Toxicology and Environmental Health, 31:235–246.

J. EPA Interim Guidance for Dermal Exposure Assessment, March 1991, EPA/600/8–91/011A.

K. Water Default Value.

L. Analogy to bis(2–ethylhexyl)phthalate.

ET = exposure time (hrs/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging Time (a lifetime or 365 days/yr for 70 years)

For PCBs the equation variables not already defined in Table 3-2 become:

PCB_{oil} = 59×10^{-6} g/cm^3 of oil
FT = 1 mm or 0.1 cm
D_{abs} = 0.98 %/hr (0.0098 hr^{-1})
CF = 0.33

Intake of constituents through dermal exposure to affected soil and pond solids was calculated using the following equation (U.S. EPA, RAGS, 1989). The resulting intake is expressed as an absorbed dose.

Intake (mg/kg/day) = (C*CF*SA*AF*ABS*EF*ED)/(BW*AT)

where:

C = chemical concentration in soil (mg/kg)
CF = conversion factor (10^{-6} kg/mg)
SA = skin surface area available for contact (cm^2)
AF = soil to skin adherence factor (mg/cm^2)
ABS = absorption factor (unitless)
EF = exposure frequency (events/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

Chemical specific dermal absorption factors are listed in Table 3-4.

Inhalation

Intake of constituents through inhalation of affected soil was calculated using the following equation (U.S. EPA, RAGS, 1989). Intake is expressed as an administered dose.

Intake (mg/kg/day) = (C*CF*AD*IR*ET*EF*ED)/(BW*AT)

where:

C = constituent concentration in soil (mg/kg)
CF = conversion factor (10^{-6} kg/mg)
AD = air concentration of dust (mg/m^3)
IR = inhalation rate (m^3/hour)
ET = exposure time (hrs/day)
EF = exposure frequency (days/yr)
ED = exposure duration (yrs)
BW = body weight (kg)
AT = averaging time (days)

4 - TOXICITY ASSESSMENT AND ENVIRONMENTAL FATE AND TRANSPORT PROCESSES

4.1 Introduction

This section presents information on the environmental fate and transport, environmental and human toxicology, carcinogenicity, and chemical and physical properties of the Combustion, Inc. site constituents of concern. These constituents include volatile and semivolatile organics, pestidices, polychlorinated biphenyls (PCBs) and metals. The regulatory assumption for assessment of carcinogenic toxicity is that no threshold of exposure exists for carcinogenic chemicals; any exposure, no matter how small, is assumed to exert a carcinogenic effect, even though that effect may not be measurable or significant. This assumption has no generally accepted scientific basis, but is utilized for regulatory purposes because it is inherently conservative.

For non-carcinogenic effects, thresholds of exposure are considered to exist. The underlying assumption for the assessment of non-carcinogenic toxicity is that exposure to a chemical can occur with no adverse noncarcinogenic health effects, as long as exposure is below the threshold. Noncarcinogenic effects include those health effects that do not involve tumor growth or neoplasias. Compounds considered to be carcinogenic may also have noncarcinogenic effects.

4.2 Acetone

There is limited information as to the fate and transport of acetone, although ketones in general are not very persistent in the environment. Within both water and soil, acetone volatilizes readily, but its high water solubility limits volatilization. Adsorption is not a major environmental factor due to its low octanol/water partition coefficient (0.24). Acetone frequently occurs in analytical data sets as a laboratory contaminant.

Exposure to high concentrations of acetone fumes can be narcotic, with the potential for coma and death. Chronic exposure to lower concentrations in air has been associated with central nervous system perturbation, although these effects are controversial.

Chemical Formula: CH_3COCH_3
Form: clear colorless liquid, fragrant mint-like odor
Chemical Class: ketone
Molecular Weight: 58.08
Boiling Point: 56.2°C
Melting Point: -95°C
Specific Gravity: 0.791 at 20°C
Solubility in Water: 1.00×10^6 mg/L
Solubility in Organics: alcohol, benzene, chloroform and ether
Organic Carbon Partition Coefficient: 2.2 ml/g

Log Octanol/Water
Partition Coefficient: 0.24
Vapor Pressure: 270 mm at 30°C
Vapor Density: 2.00
Henry's Law Constant: 2.06×10^{-5} - atm-m^3/mole

4.3 Antimony

Bioaccumulation appears to be only a minor fate process for antimony. Airborne transport of antimony in the form of particulates can also occur.

No definite data concerning the toxicity of antimony to wildlife or domestic animals are available.

Chemical Formula: Sb
Chemical Class: Metal
Molecular Weight: 121.75
Boiling Point: 1750°C
Melting Point: 630.74°C
Specific Gravity: 6.684 at 25°C
Solubility in Water: insoluble; some compounds are soluble
Solubility in Organics: soluble in hot, conc. H_2SO_4

4.4 Arsenic

The major environmental fate processes of arsenic are sorption, bioaccumulation, and biodegradation/biotransformation. The cycling of arsenic through the environment is dominated by its sorption and desorption on soils and sediments. Some arsenic compounds tend to bioaccumulate in lower levels of the food chain and to a certain extent, in fish. Arsenic is readily biotransformed in aquatic environments to less toxic methylated forms. Based upon the limited quantitative data available for arsenic, photolysis, oxidation, volatilization, and hydrolysis are considered to be environmentally insignificant fate processes.

Arsenic has a high acute as well as chronic toxicity. Systemic chronic poisoning is primarily characterized by skin lesions such as dermatoses, which may include eruption, pigmentation or hyperkeratosis, that may ultimately lead to the development of skin cancer. Effects on the nervous system (e.g. peripheral nervous disturbance) as well as on the heart and circulatory system have also been reported following chronic exposure to arsenic. Hematological changes, following arsenic exposure, are characterized by anemia and leukopenia.

In man, various forms of arsenic-induced skin cancer have been detected in populations chronically exposed to arsenic via drinking water, drugs, etc. The risk of lung cancer is also increased in certain populations occupationally exposed to high levels of airborne arsenic. In the latter case, the carcinogenic action is strongly enhanced by smoking and possibly also by other environmental factors.

Chemical Formula: As
Chemical Class: metal
Molecular Weight: 74.92
Boiling Point: 61.3°C
Melting Point: 818°C at 36 atm
Specific Gravity: 5.727 at 25/4°C
Solubility in Water: insoluble, some salts are soluble
Solubility in Organics: Not attacked by cold H_2SO_4 or HCl; converted by HNO_3 or hot H_2SO_4 into arsenous or arsenic acid
Bioconcentration Factor: 44 (L/kg in fish; accumulates in fish tissue to a concentration 44 times greater than the ambient water concentration)

4.5 Barium

Barium is a member of the alkaline earth group which occurs in nature chiefly as barite ($BaSO_4$) and witherite ($BaCO_3$), both of which are highly insoluble salts. Barium is stable in dry air, but readily oxidized in humid air or in water. The predominant environmental fate process for barium is hydrolysis, while the major environmental transport process for barium appears to be fugitive dust emission and/or dry fallout from the atmosphere. Minor environmental significance is placed upon the importance of volatilization, biodegradation, hydrolysis, photolysis, oxidation, bioaccumulation, and sorption of barium due to the limited information available.

The basic mechanisms of barium toxicity appear to involve counteracting potassium, the latter, of course, being an essential element in cellular osmotic balance and therefore central in many homeostatic functions.

It should be noted that barium is a prevalent contaminant of the average human diet (Schroeder et al, 1972).

Chemical Formula: Ba
Chemical Class: metal
Molecular Weight: 137.33
Boiling Point: approximately 1600°C
Melting Point: approximately 710°C
Specific Gravity: 3.6
Solubility in Water: decomposes, $BaSO_4$ has a solubility of 1.6 mg/l at 20°C
Solubility in Organics: alcohol

4.6 Benzene

Benzene is a monocyclic aromatic ring of six unsaturated carbons that is ubiquitous in nature. Benzene's low chemical reactivity is related to the stability of the aromatic ring. It is produced biologically in many anabolic and catabolic processes and is amenable to biological degradation. Its metabolites are the toxic intermediaries, rather than benzene itself. Benzene is very short-lived in any environment which is biologically active. Benzene rises to the water's surface when present in excess of its water solubility. Benzene volatilizes easily from surface waters or surficial soils and is moderately soluble in ground water.

The major environmental fate process is volatilization of benzene from both soil and water to the atmosphere. The overall half-life of benzene in water is estimated at one to six days. Benzene can be considered moderately mobile in soils. Studies indicated that microorganisms in soil and water are capable of slowly biodegrading benzene. Data are scarce regarding the bioaccumulation of benzene in aquatic organisms; benzene's octanol/water partition coefficient suggests its overall level of bioaccumulation is low. In summary, the major environmental transport process for benzene is volatilization from soil and water to the atmosphere (Callahan, et al., 1979).

The acute toxicity of benzene is low (LC50, 7 hours inhal., for the rat 10,000 ppm; LD50, oral for the rat 6 g/kg). Depression of the central nervous system is the main symptom of exposure to high levels of benzene in both animals and man.

Chronic intoxication in man may give rise to severe bone marrow toxicity. Apparently, benzene - or more probably hydroquinone, a metabolite of benzene - inhibits maturation of early blood cell precursors in the bone marrow. Long-term exposure of man and experimental animals to high concentrations of benzene, may result in severe damage to the hematopoietic system including anemia, reduced number of circulating white blood cells and platelets. Epidemiologic studies have shown that chronic exposure of workers to sufficient levels of benzene may be associated with increased risk of aplastic anemia and of certain specific forms of leukemia (IARC, 1987; Infante, 1978; Infante and White, 1983; Decoufle et al., 1983; Aksoy, 1985; Infante and White, 1985; Rinsky et al., 1987).

Benzene may be absorbed by inhalation or ingestion as well as upon skin contact. However, experimental investigations have shown dermal absorption to be slow, and in most situations inhalation is by far the most important route of absorption. Benzene is rapidly distributed throughout the organism and, as with other lipophilic solvents, preferentially concentrated in fatty tissues.

Chemical Formula: C_6H_6
Form: clear colorless liquid
Chemical Class: monocyclic aromatic
Molecular Weight: 78.11
Boiling Point: 80.01°C
Melting Point: 5.5°C
Specific Gravity: 0.8786 at 20°C
Solubility in Water: 1,750 mg/l
Solubility in Organics: miscible with alcohol, ether, acetic acid, acetone, chloroform, glacial acetic acid, oils and carbon tetrachloride

Organic Carbon Partition Coefficient: 83 ml/g
Log Octanol/Water Partition Coefficient: 2.13 at 20°C
Vapor Pressure: 76 mm at 20°C
Vapor Density: 2.77
Henry's Law Constant: 5.59×10^{-3} atm-m^3/mole
Bioconcentration Factor: 3.5 L/kg (eel)

4.7 Bis(2-ethylhexyl)phthalate

Bis(2-ethylhexyl)phthalate will biodegrade, adsorb to sediments and bioconcentrate in aquatic organisms in water. In the soil bis(2-ethylhexyl)phthalate will not evaporate or leach but may biodegrade under aerobic conditions following acclimation.

Bis(2-ethylhexyl)phthalate is absorbed in the gastrointestinal tract following oral exposure; the liver is the major repository organ. It is an essential ingredient in the plastics industry; it frequently occurs as a laboratory contaminant in analytical data sets.

Chemical Formula: $C_{12}H_{14}O_4$
Form: Colorless liquid
Chemical Class: Dicarboxylic Acid derivative
Molecular Weight: 222.26
Boiling Point: 295°C
Melting Point: -40.5°C
Solubility in Water: 1080 mg/l at 25°C
Log Octanol/Water Partition Coefficient: 2.47
Vapor Pressure: 1.65×10^{-3} mm Hg at 25°C
Henry's Law Constant: 4.8×10^{-7} atm-m^3/mole (calculated)

4.8 Butylbenzylphthalate

Biodegradation is the primary fate mechanism for butylbenzylphthalate. In soil, butylbenzylphthalate will sorb to the soil and will not leach appreciably to the ground water. In water, butylbenzylphthalate will adsorb to sediments and biota but will not volatilize significantly.

Chemical Formula: C_4H_6
Form: Clear oily liquid
Chemical Class: Dicarboxylic Acid derivative
Molecular Weight: 54.09
Boiling Point: -4.5°C at 760 mm Hg
Melting Point: -108.91°C
Specific Gravity: 1.1 at 25/25°C
Solubility in Water: 735 mg/l at 25°C
Log Octanol/Water Partition Coefficient: 1.99
Vapor Pressure: 856 mm Hg at -1.5°C
Henry's Law Constant: 2.57 atm-m^3/mole

4.9 Cadmium

The major environmental fate processes of cadmium are sorption, bioaccumulation and biodegradation/biotransformation. The majority of movement of cadmium is through sorption and desorption of soil and sediments. Sorption processes account for removal of dissolved cadmium from water to sediments, and increases as pH increases. Dust fall from air emissions contributes to soil and water contamination. Food sources such as rice and wheat are able to bioconcentrate cadmium in considerable quantities. Cadmium is toxic at relatively low concentrations and exhibits bioaccumulation in lower levels of the food chain. Compared to other heavy metals, it is relatively mobile in aquatic environments. Based upon the limited, quantitative data available for cadmium, photolysis, oxidation, volatilization and hydrolysis are considered to be environmentally insignificant fate processes.

Since cadmium is naturally present in the earth's crust - usually associated with zinc - the metal is found in the environment at varying concentrations. Cadmium is also present in tobacco, with a metal content in the range 1-2 μg/cigarette.

Cadmium and cadmium compounds possess a moderate acute toxicity by ingestion or inhalation. The primary target organ upon ingestion of low levels of cadmium is the kidney. In addition to kidney disease, emphysema of the lungs may develop after inhalation of dust and fumes containing cadmium over prolonged periods of time. There is some epidemiological evidence for induction of lung cancer in heavily exposed workers.

Chemical Formula:	Cd
Chemical Class:	metal
Molecular Weight:	112.41
Boiling Point:	765°C
Melting Point:	321°C
Specific Gravity:	8.65 at 25°C
Solubility in Water:	insoluble
Solubility in Organics:	variable, depends on compound
Vapor Pressure:	1 mm at 394°C
Bioconcentration Factor:	81 (Fish L/kg)

4.10 Chromium

The major environmental fate processes of chromium are sorption and bioaccumulation. Most of the trivalent chromium in the aquatic environment is hydrolyzed and precipitates as $Cr(OH)_3$. Sorption processes and bioaccumulation will remove the remaining Cr(III) from solution. Under certain natural water conditions chromium can exist in hexavalent form. Chromium (VI) exists as an oxyanion in aqueous solution and is quite soluble. Chromium is an essential nutrient, and it is accumulated in aquatic and marine biota to levels much higher than in ambient water. Photolysis, oxidation, volatilization, and hydrolysis are considered to be environmentally insignificant processes based upon the limited quantitative data available for chromium.

Chromium compounds are poorly absorbed from the human gastro-intestinal tract, but appreciable intake may occur via inhalation. Hexavalent chromium is, in general, considerably more toxic than the metal in its trivalent state. Occupational inhalation exposure to slightly soluble hexavalent chromium compounds has been associated with an increased incident of lung cancer. Studies in animals as well as human experience indicate that chromium compounds have a relatively low toxicity upon chronic oral exposure, and no carcinogenic effects have been demonstrated via this route of administration. Chromium is an essential element for the normal functioning of the organism.

Chemical Formula: Cr
Chemical Class: metal
Atomic Weight: 52
Boiling Point: 2642°C
Melting Point: 1900°C
Specific Gravity: 7.14
Solubility in Water: Insoluble; some compounds are soluble

4.11 Copper

Copper is usually concentrated in sediments of well-oxygenated water, where it is sorbed by clays, organic material, and iron and manganese oxides. Copper transported in the water column is usually associated with dissolved or suspended solids. Most copper in soils remains in the top few centimeters, sorbed to organic matter, clays, and iron and manganese oxides. The potential for migration of copper to ground waters is small. Literature indicates that photolysis, volatilization, and degradation are considered insignificant in determining the fate of copper. Copper is an essential nutrient.

Chronic exposure to excessive doses of copper generally results in accumulation of copper in the liver followed by hepatocellular damage both in animals and humans (NRC 1977).

There is little evidence in the literature to suggest that copper has a carcinogenic effect in either animals or humans.

Chemical Formula: Cu
Chemical Class: Metal
Molecular Weight: 63.55
Boiling Point: 2595°C
Melting Point: 1083°C
Specific Gravity: 8.94
Solubility in Water: Most copper salts are insoluble except copper sulfate, copper nitrate and cupric chloride
Vapor Pressure: 1 mm at 1,628°C

4.12 DDT

DDT will leach from the soil into the ground water at an extremely slow rate. In the atmosphere DDT is probably removed by rainfall, fallout or photochemical degradation.

DDT absorption in humans follows the same pattern as the absorption of dietary fat, which is a slow process.

Chemical Formula: $C_{14}H_9Cl_5$
Form: white, odorless crystalline solid
Chemical Class: chlorinated ethane derivative pesticide
Molecular Weight: 354.5
Solubility in Water: 1.2 - 25 mg/l at 25°C for P,P'-DDT
Log Octanol/Water Partition Coefficient: 3.98-6.19
Vapor Pressure: 1.57×10^{-7} mm Hg for P,P'-DDT
5.5×10^{-6} mm Hg for O,P'-DDT
Bioconcentration factor: $10^3 - 10^6$ L/kg

4.13 1,2-Dichloroethane

Most of the 1,2-dichloroethane released into the atmosphere will be volatilized. Photooxidation is the primary fate process, hydrolysis and biodegradation do not appear to be important. Upon release of 1,2-dichloroethane to surface water, it will readily evaporate.

Exposure to 1,2-dichloroethane at high concentrations can cause adverse effects on the central nervous system, gastrointestinal tract and respiratory tract. The primary target organs are lungs, liver and kidneys.

1,2-Dichloroethane is rapidly absorbed through the lungs following inhalation exposure. Ingested 1,2-dichloroethane is rapidly absorbed into the systemic circulation of humans.

Chemical Formula: $C_2H_4Cl_2$
Form: colorless heavy liquid
Chemical Class: chlorinated hydrocarbon
Molecular Weight: 98.96
Boiling Point: 83-84°C
Melting Point: -35.3°C
Specific Gravity: 1.25 at 20°C
Solubility in Water: 0.869 g/100 ml at 20°C
Organic Carbon Partition Coefficient: 1.14 ml/g
Log Octanol/Water Partition Coefficient: 1.48
Vapor Pressure: 61 mm Hg at 20°C
Henry's Law Constant: 4.5×10^{-2} at 25°C atm-m^3-mole

4.14 1,2-Dichloroethene

Volatilization appears to be the major transport process for trans-1,2-dichloroethene in surface water and soils. The volatilization half-life in surface water is reported to be 22 minutes. Oxidation and hydrolysis processes are important in the atmosphere but do not appear to be significant in the aquatic environment. Based on its K_{oc}, trans-1,2-dichloroethene probably does not sorb to soils and sediments. Based on its octanol/water partition coefficient (K_{ow}), this compound would seem to biodegrade poorly, yet dechlorination to vinyl chloride has been reported under anaerobic conditions.

Animal studies have demonstrated that trans-1,2-dichloroethene causes acute liver, kidney, and lung damage, especially when inhaled. Only one study has been reported detailing the toxic effects associated with chronic exposure to this compound. In humans, 1,2-dichloroethene has produced adverse central nervous system effects.

Chemical Formula:	$C_2H_2Cl_2$
Form:	liquid
Chemical Class:	halogenated aliphatic hydrocarbon
Molecular Weight:	96.94
Boiling Point:	47.5°C
Melting Point:	-50°C
Specific Gravity:	1.2565 at 20°C
Solubility in Water:	600 mg/l at 20°C
Solubility in Organics:	benzene, chloroform, alcohol, ether, acetone
Organic Carbon Partition Coefficient:	59 ml/g
Log Octanol/Water Partition Coefficient:	1.48 (calculated)
Vapor Pressure:	200 mm Hg at 14°C
Vapor Density:	3.34
Henry's Law Constant:	0.067 atm-m^3/mole
Bioconcentration Factor:	48 L/kg (microbial)

4.15 2,4-Dinitrotoluene

2,4-Dinitrotoluene is slightly mobile in soil. In water 2,4-dinitrotoluene will have a slight tendency to sorb to sediment, suspended solids and biota. Photolysis is the most significant pathway for removal from water.

Inhalation and dermal exposure are considered the major pathways in industrial exposure. Oral ingestion is considered a secondary route for occupationally-exposed humans. There is some evidence that exposure to 2,4-dinitrotoluene can affect the nervous system and blood of exposed workers.

Chemical Formula:	$CH_3C_6H_3(NO_2)_2$
Form:	yellow solid
Chemical Class:	substituted benzene

Molecular Weight: 182.14
Boiling Point: 300°C
Melting Point: 71°C
Solubility in Water: 270 mg/l at 22°C
Solubility in Organics: alcohol, ether, acetone, benzene
Organic Carbon Partition Coefficient: 2.0 ml/g
Log Octanol/Water Partition Coefficient: 1.65
Vapor Pressure: 5.1×10^{-3} at 20°C
Henry's Law Constant: 4.5×10^{-6} atm-m^3/mole

4.16 Ethylbenzene

The major transport mechanism for ethylbenzene is volatilization from soils and waters. Once in the atmosphere, ethylbenzene undergoes rapid photochemical reactions. This process dominates all other fate processes. Little information is available regarding oxidation, hydrolysis, biodegradation, and bioaccumulation of ethylbenzene in aquatic systems; thus, these are not considered significant fate processes.

Ethylbenzene is irritating to the eyes, skin and mucous membranes, and at high concentrations, is narcotic (Merck, 1983).

Ethylbenzene is metabolized by pathways which are separate from those of benzene, toluene and xylene. Ethylbenzene is not leukemogenic or carcinogenic.

Chemical Formula: C_8H_{10}
Form: colorless liquid, aromatic odor
Chemical Class: monocyclic aromatic
Molecular Weight: 106.17
Boiling Point: 136.2°C
Melting Point: -94.97°C
Specific Gravity: 0.687 at 20/4°C
Solubility in Water: 152 mg/L at 20°C, 206 mg/L at 25°C
Solubility in Organics: alcohol, ether
Organic Carbon Partition Coefficient: 1100 ml/g
Log Octanol/Water Partition Coefficient: 3.15
Vapor Pressure: 7 mm at 20°C, 12 mm at 30°C
Vapor Density: 3.66
Henry's Law Constant: 6.43×10^{-3} atm-m^3/mole
Bioconcentration Factor: 37.5 L/kg

4.17 Heptachlor

Heptachlor will volatilize from the surface of soils. In moist soils hydrolysis of heptachlor is significant. Heptachlor will hydrolyze and volatilize from surface water. Some biodegradation will occur in soil and surface water, but is slow compared to hydrolysis.

Heptachlor is readily absorbed from the gastrointestinal tract and may be absorbed through the skin. Long-term exposure to heptachlor may affect the liver. Oral exposure to heptachlor may also be associated with infertility and improper development of offspring (Dynamac Corporation, 1989).

Chemical Formula: $C_{10}H_5Cl_7$
Form: light tan crystalline solid
Chemical Class: Chlorinated cyclodiene insecticide
Molecular Weight: 373.35
Boiling Point: 145°C at 1.5 mm Hg
Melting Point: 95-96°C
Specific Gravity: 1.57-1.59
Solubility in Water: 56 mg/l at 25-29°C
Log Octanol/Water Partition Coefficient: 5.27
Vapor Pressure: 4×10^{-4} mm Hg at 25°C
Henry's Law Constant: 1.48×10^{-3} atm-m^3/mole

4.18 2-Hexanone

Acute oral toxicity is low as is topical damage to skin and eyes. However, transient eye irritation may occur. Percutaneous absorption coupled with inhalation exposure may increase the toxicity of 2-hexanone. Acute exposure to high vapor concentrations may result in irritation to the eyes and lungs followed by CNS depression and narcosis. Chronic inhalation exposures at low concentrations produce neurologic and hematologic changes whereas high doses produce germinal cell damage. The primary hazard from 2-hexanone is repeated inhalation and skin absorption from industrial use.

Chemical Formula: $C_6H_{12}O$
Form: clear liquid
Chemical Class: ketone
Molecular Weight: 100.18
Boiling Point: 128°C
Melting Point: -57°C
Specific Gravity: 0.830 at 0/4°C
Solubility in Water: 35,000 at 20°C
Solubility in Organics: alcohol, ether
Log Octanol/Water Partition Coefficient: 1.38
Vapor Pressure: 2 mm Hg at 20°C
Vapor Density: 3.45

4.19 Lead

The major environmental fate processes of lead are sorption, bioaccumulation, and biotransformation. The movement of lead through the environment is dominated by sorption and desorption of soils and sediments.

The transport of lead in the aquatic environment is influenced by the speciation of the ion. The available information indicated that bioaccumulation of lead in fish is not significant.

Lead may enter the aquatic environment from affected sediments. Based upon the limited quantitative data available for lead, photolysis, volatilization and hydrolysis are considered to be insignificant environmental fate processes for the inorganic lead compounds.

Evidence of high toxicity of lead and its compounds has accumulated since the time of the Roman Empire. Although the biological effects of lead are well known, data concerning the dose-response curve are less precise for a number of toxic end-points. The major toxic effects are confined to four organ systems: the hematopoietic, nervous, gastrointestinal and renal systems.

Lead toxicity to aquatic biota depends on the local conditions of the water body, including: pH, hardness, alkalinity, dissolved oxygen, dissolved solids, and the presence of other metals. A negative correlation has been identified between lead toxicity and water hardness.

The majority of information pertaining to lead in wildlife focuses on waterfowl, since lead poisoning has seldom been observed in other species in the field. Lead toxicosis in waterfowl arising from the ingestion of spent lead shot is well documented in the literature (Bellrose 1959).

With sufficient exposure to large quantities, acute lead intoxication may give rise to gastrointestinal colic, reversible kidney damage, as well as brain damage. Symptoms of chronic intoxication are anemia, damages to the central as well as the peripheral nervous systems and progressive damage to the kidneys.

The is no epidemiological or occupational evidence that lead or lead compounds are human carcinogens in spite of extensive exposure of large human subpopulations. Chronic lead intoxication is usually observed in occupationally exposed workers or children exhibiting abnormal eating behavior (pica). The anemia that characterizes chronic lead intoxication results from inhibition of hemoglobin biosynthesis and a shortening of the lifespan of circulating erythrocytes.

Chemical Formula: Pb
Chemical Class: metal
Molecular Weight: 207.2
Boiling Point: 1740°C
Melting Point: 327.4°C
Specific Gravity: 11.34 at 4°C, 10.65 at melting point
Solubility in Water: Insoluble; some organic compounds are soluble
Vapor Pressure: 1.77 mm at 1000°C
Bioconcentration Factor: 49 L/kg (fish)

4.20 Manganese

Sorption, complexation, oxidation and bioaccumulation are important fate processes for manganese in the environment. In soil systems, concentrations and mobility of manganese are controlled by soil chemistry (e.g., pH, cation exchange capacity, organic matter content etc.). The solubility and bioavailability of manganese in soils is strongly enhanced by low pH, reducing conditions and high concentrations of ligands. Sorption in aquatic systems is heavily influenced by pH, dissolved oxygen, and availability of complexing agents. Manganese can easily be released from sediments under reducing conditions. Manganese dusts and fumes may also undergo atmospheric transport.

Although manganese does not occur naturally as a free metal, it is ubiquitous in the environment, where it is cycled between the atmosphere, land surface, aquatic systems and oceans. Manganese is an essential micro-nutrient for plants and animals.

Manganese and its compounds are poorly absorbed from the gastrointestinal tract of man and of other mammals, and the oral toxicity is in general low. There is no evidence of carcinogenicity, either from animal experiments or from epidemiological studies.

Chemical Formula: Mn
Chemical Class: metal
Molecular Weight: 54.94
Boiling Point: 2095°C
Melting Point: 1244°C
Specific Gravity: 7.21 at 20°C
Solubility in Water: Mn and oxides insoluble; halides, sulfates and permanganates are soluble
Bioconcentration Factor: 12,000 l/kg (marine shellfish)

4.21 Mercury

The major factors controlling the environmental fate of mercury include volatilization, photolysis, complexation, sorption, biotransformation and bioaccumulation.

Metallic mercury and dimethylmercury may be released to the atmosphere from soils and surface water before being deposited and sorbed by soil or sediment particulates. The mobility of mercury will thus depend on the form of the compound. However, sorption processes appear to control the transport and partitioning of mercury. Very little inorganic mercury is desorbed from sediments, and the leaching of mercury from soils is insignificant.

Two critical transformation processes in surface waters and soils are biotransformation and bioaccumulation. Almost any forms of mercury entering surface waters or soils can be converted to methylmercury or elemental mercury via microbial action. These compounds can in turn be transformed into volatile compounds by other microbial or abiotic processes.

Elemental mercury vaporizes at room temperature. Hence, most human exposure to elemental mercury is via inhalation. Inhaled mercury vapor is corrosive and, if intense enough, first yields bronchitis and pneumonitis and eventually CNS effects, such as tremor and excitability. Cardinal signs in addition to tremor are thyroid enlargement as well as increased iodine uptake, labile pulse, tachycardia, dermographism, gingivitis and hematologic changes.

Chemical Formula: Hg
Chemical Class: metal
Molecular Weight: 200.59
Boiling Point: 356.72°C
Melting Point: -38.87°C
Specific Gravity: 13.534 at 25°C
Solubility in Water: 0.08 mg/l at 30°C; some salts and organic compounds are soluble
Solubility in Organics: Varies; dependent on chemical species
Vapor Pressure: 0.0012 mm at 20°C

4.22 Methylene Chloride

The major transport process for methylene chloride in the environment is volatilization from surface waters and soils. In aquatic systems, photolysis and hydrolysis do not appear to be important fate processes with reported half-lives of 250 hours and 704 years, respectively. Based on its small K_{oc}, sorption does not seem to be an important fate process. Based on its octanol/water partition coefficient, methylene chloride is not highly lipophilic and probably would not tend to bioaccumulate. It frequently occurs as a laboratory contaminant in analytical data sets.

In spite of many reports of toxic effects on the liver and kidney tubuli in experimental animals exposed to high concentrations of methylene chloride, there is no clear evidence of liver or kidney damage in man. The increased levels of carboxyhemoglobin--formed by metabolic conversion of this solvent to carbon monoxide--may have clinical significance in occupationally exposed individuals with heart disease.

Methylene chloride has been shown to induce an increased incidence of lung and liver tumors in mice as well as of benign mammary tumors and sarcomas in rats.

Chemical Formula: CH_2Cl_2
Form: colorless liquid
Chemical Class: halogenated volatile hydrocarbon
Molecular Weight: 84.93
Boiling Point: 40 to 42°C
Melting Point: -97°C
Specific Gravity: 1335 at 15/4°C
Solubility in Water: 20,000 mg/l at 20°C, 16,700 mg/l at 25°C
Solubility in Organics: miscible with alcohol and ether

Organic Carbon Partition Coefficient: 8.8 ml/g
Log Octanol/Water Partition Coefficient: 1.3
Vapor Pressure: 349 mm at 20°C, 500 mm at 30°C
Vapor Density: 2.93
Henry's Law Constant: 2.03 x 10^{-3} atm-m^3/mole
Bioconcentration Factor: 5 L/kg

4.23 Nickel

The major environmental fate process of nickel appears to be sorption. However, nickel is a highly mobile metal (depending on chemical species) and thus is sorbed only to a small extent. The partitioning of nickel into dissolved and particulate fractions is related to the abundance of suspended material, competition with organic material, and concentrations of iron and manganese. In general, nickel is not accumulated in significant amounts by aquatic organisms. Based upon the limited quantitative data available for nickel, photolysis, volatilization, bioaccumulation, biodegradation, and hydrolysis are considered to be environmentally insignificant fate processes.

Nickel carbonyl has been shown to be a carcinogen for organs of the respiratory tract in workers who are exposed to refinery dust. Nickel exposure may induce allergic reactions, predominantly contact dermatitis. (Sunderman, 1981; Anke et al, 1983).

Nickel is absorbed poorly from the GI tract. In general, in the U.S., normal dietary intake of nickel is 300-600 μg/day (Schroeder et al, 1962).

Chemical Formula: Ni
Chemical Class: metal
Molecular Weight: 58.69
Boiling Point: 2837°C
Melting Point: 1555°C
Specific Gravity: 8.9
Solubility in Water: insoluble; some salts are soluble
Solubility in Organics: varies, depends on properties of specific salt
Vapor Pressure: 1 mm at 1,810°C
Bioconcentration Factor: 47 (Fish L/kg)

4.24 N-nitrosopropylamine

N-nitrosopropylamine is not a persistent environmental constituent. N-nitrosopropylamine is readily degraded by direct photolysis in the atmosphere and in water. In the soil, n-nitrosopropylamine is subject to rapid removal by photolysis and volatilization, and in the subsurface by biodegradation under anaerobic and aerobic conditions.

N-nitrosopropylamine's effects have not been studied in humans. Animal evidence indicates that exposure to n-nitrosopropylamine by ingestion could cause liver disease and cancer in humans, but this is inconclusive.

Chemical Formula: $C_6H_{14}N_2O$
Form: yellow liquid
Chemical Class: organic amine
Molecular Weight: 130.19
Boiling Point: 206°C
Melting Point: 6.6°C (estimated)
Specific Gravity: 0.9163 at 20/4°C
Solubility in Water: 9894 mg/l at 23-25°C
Solubility in Organics: alcohol, ether and other organic solvents
Organic Carbon Partition Coefficient: 2.11 mg/l (estimated)
Log Octanol/Water Partition Coefficient: 1.36
Vapor Pressure: 0.086 mm Hg at 20°C (estimated)

4.25 Noncarcinogenic Polynuclear Aromatic Hydrocarbons

Polynuclear aromatic hydrocarbons (PNAs) are a class of compounds that contain two or more aromatic rings. The indicator group includes acenaphthene, fluoranthene, fluorene, naphthalene, and pyrene. These compounds are similar in chemical, physical and toxicological properties. In general, these compounds have low solubilities, low vapor pressures, adsorb strongly to soil and undergo slow biodegradation. They therefore are considered fairly immobile in soil. In general, when sufficient exposure conditions exist, the noncarcinogenic PNAs can cause dermal or ocular irritation when direct contact occurs. When ingested in sufficient quantities, the noncarcinogenic PNAs can cause abdominal cramping, gastritis and nausea (Sax, 1979). Information on the individual compounds in the indicator group is provided below.

4.25.1 Acenaphthene

Acenaphthene exists in its pure form as orthorhombic bipyramidal white needles. It is soluble in alcohol, methanol, propanol, chloroform, benzene, toluene and glacial acetic acid. Acenaphthene is insoluble in water. Acenaphthene has the following physical properties:

Molecular Weight: 154.21
Boiling Point: 96.2°C
Melting Point: 95°C
Organic Carbon Partition Coefficient: 4.6×10^3 ml/g
Octanol/Water Partition Coefficient: 9.6×10^3
Vapor Pressure: 4.47×10^{-3} mm Hg

4.25.2 Anthracene

Anthracene exists in pure form as colorless crystals with violet fluorescence (Hawley, 1977). It is soluble in alcohols, chloroform, carbon disulfide; slightly soluble in ether and toluene and virtually insoluble in water. Anthracene is believed to be photosensitizing (Encyclopedia of Health and Safety, 1983). It has the following physical properties (Merck Index, 1983):

Molecular Weight: 178.22
Boiling Point: 342°C
Melting Point: 218°C
Specific Gravity: 1.283
Vapor Pressure: 1 mm Hg at 145°C

4.25.3 Fluoranthene

Fluoranthene exists in pure form as pale yellow needle crystals (National Research Council, 1982). It is soluble in alcohol, ether, benzene and acetic acid and is virtually insoluble in water. It is presently used as a research chemical and, as a constituent of coal tar, was once used in the treatment of acute and chronic dermatoses (NIOSH, 1977). Fluoranthene has the following physical properties (Weast, 1986; Sax, 1984):

Molecular Weight: 202.26
Boiling Point: 375°C
Melting Point: 111°C
Specific Gravity: 1.252
Vapor Pressure: 0.01 mm Hg at 20°C
Organic Carbon Partition Coefficient: 3.8×10^4 ml/g
Log Octanol/Water Partition Coefficient: 4.90
Henry's Law Constant: 6.5×10^{-6} atm-m^3/mole

4.25.4 Fluorene

Fluorene exists as white leaflets or flakes when recrystallized from ethanol. It is soluble in acetic acid, acetone, benzene, carbon disulphide, carbon tetrachloride, diethylether, ethanol, pyrimidine and toluene. Fluorene is almost insoluble in water (1.68-1.98 mg/l). Fluorene has the following physical properties:

Molecular Weight: 166.2
Boiling Point: 205°C
Melting Point: 116-117°C
Organic Carbon Partition Coefficient: 7.3×10^3 ml/g
Octanol/Water Partition Coefficient: 1.5×10^4
Vapor Pressure: 10 mm at 146°C

4.25.5 Naphthalene

Naphthalene exists in pure form as a colorless to brown solid with the characteristic odor of mothballs. Naphthalene is used as an insecticide and moth repellant, as a fumigant and is found in the manufacture of chemical intermediates in the production of pharmaceuticals, resins, dyes, plasticisers, solvents, coatings, pigments, rubber chemicals, tanning agents, waxes and rodenticides (Grisham, 1986). Naphthalene has been shown to be cataractogenic and hemolytic. It has the following physical properties (Grisham, 1986):

Molecular Weight: 128.2
Boiling Point: 218°C
Melting Point: 80.1°C
Specific Gravity: 1.41-1.152
Vapor Pressure: 1 mm Hg at 52.6°C

4.25.6 Pyrene

Pyrene in its pure form is a colorless solid which is sparingly soluble in water and soluble in carbon disulfide, toluene, alcohol, ether, benzene and petroleum ether (Weast, 1986). Pyrene has the following physical properties (Grisham, 1986; Merck Index, 1983):

Molecular Weight: 202.26
Boiling Point: 393°C
Melting Point: 156°C
Specific Gravity: 1.271
Vapor Pressure: 6.82×10^{-7} mm Hg
Organic Carbon Partition Coefficient: 3.8×10^{4} ml/g
Log Octanol/Water Partition Coefficient: 4.88
Henry's Law Constant: 5.1×10^{-6} atm-m^3/mole

4.26 Carcinogenic Polynuclear Aromatic Hydrocarbons

The second class of PNAs is the carcinogens. The indicator group includes benzo(a)anthracene, benzo(b)fluoranthene and chrysene. These compounds are similar in chemical, physical and toxicological properties. In general, these compounds have low solubilities, low vapor pressures, adsorb strongly to the soil and undergo slow biodegradation. Reports have shown that individuals exposed to breathing or skin contact for long periods of time to mixtures of other compounds and PNAs may develop cancer. Information on the individual compounds in this indicator group is provided below.

4.26.1 Benzo(b)fluoranthene

Benzo(b)fluoranthene exists as colorless needles in its pure state. It is slightly soluble in benzene and acetone. Benzo(b)fluoranthene is virtually insoluble in water. Benzo(b)fluoranthene is a carcinogen through the dermal route. It has the following physical properties:

Molecular Weight: 252.3
Melting Point: 168.3°C
Organic Carbon Partition Coefficient: 5.5 x 10^5 ml/g
Octanol/Water Partition Coefficient: 1.1 x 10^6
Vapor Pressure: 10^{-11} ->10^{-6} torr at 20°C
Henry's Law Constant: 1.22 x 10^{-5} atm-m^3/mole

4.26.2 Benzo(a)anthracene

Benzo(a)anthracene exists as plates with a yellow-blue fluorescence when it has been recrystallized from glacial acetic acid or ethane. It is slightly soluble in acetic acid and hot ethanol. It is soluble in acetone and diethylether and is very soluble in benzene. Benzo(a)anthracene is a potential carcinogen through the oral route and the dermal route. Benzo(a)anthracene has the following physical properties:

Molecular Weight: 228.29
Boiling Point: 400°C
Melting Point: 158-159°C
Organic Carbon Partition Coefficient: 2 x 10^5 ml/g
Octanol/Water Partition Coefficient: 4.1 x 10^5
Vapor Pressure: 2.2 x 10^{-8} torr at 20°C
Henry's Law Constant: 1 x 10^{-6} atm-m^3/mole

4.26.3 Chrysene

Chrysene exists as colorless orthorhombic bipyramidal plates with a blue fluorescence when recrystallized from benzene. It is slightly soluble in acetone, carbon disulphide, diethylether, ethanol, glacial acetic acid and hot xylene. It is soluble in benzene. Chrysene is virtually insoluble in water. Chrysene is a carcinogen through the dermal route. Chrysene has the following physical properties:

Molecular Weight: 228.3
Boiling Point: 448°C
Melting Point: 255-256°C
Organic Carbon Partition Coefficient: 2 x 10^5 mg/l
Octanol/Water Partition Coefficient: 4.1 x 10^5
Vapor Pressure: 6.3 x 10^{-9} mm Hg at 25°C
Henry's Law Constant: 1.05 x 10^{-6} atm-m^3/mole

4.27 Polychlorinated Biphenyls

PCBs in commercial products are liquids characterized by a very high thermal stability, resistance to oxidation, resistance to acids, bases and other chemical agents, and excellent dielectric (insulating) properties. PCBs have low vapor pressures and a very low solubility in water (0.007-5.9 mg/L for the more commonly used PCB isomers) (Hutzinger et al., 1974), but are readily soluble in oils and various organic solvents.

Sorption and bioaccumulation are important fate processes. Biotransformation and biodegradation are important fate processes for the mono-, di-, and tri-chlorinated biphenyls; are of intermediate importance for tetrachlorinated biphenyls; and are of no importance for penta- and higher chlorinated biphenyls. PCBs strongly sorb to sediments and/or suspended particles resulting in long half-lives ($t_{1/2}$ = 52.5 days). PCBs strongly bioaccumulate in the food chain through desorption from sediments and direct uptake by plants and aquatic animals. PCBs are degraded by a number of photolytic reactions in sunlight and under a number of laboratory conditions. PCBs have a very low acute toxicity. Although various toxic effects have been described in laboratory animals, the only acute health effects observed in humans have been relatively minor. Subacute exposures to mammals are characterized by hepatic effects, including enlargement, fatty infiltration and necrosis at higher doses. At low exposure levels these effects have been shown to be reversible (Fishbein, 1974).

Upon chronic administration to mammals, toxic effects on the liver constitute the main pathological finding. Chronic occupational exposure is characterized by the development of chloracne, a slowly healing acne-like dermatitis. The available toxicological and epidemiological evidence concerning PCBs does not establish this group of compounds as a human carcinogen or as even a serious health hazard. No other significant chronic effects have been associated with human exposure to PCBs (Kimbrough, 1987). PCBs have been shown to be nonmutagenic and animal bioassays show only limited, often inconclusive evidence of animal carcinogenicity (Michael et al., 1987; Harbison et al., 1987).

Chemical Formula: $C_{12}H_xCl_{10-x}$, where x = 1 - 9 (ave. 7)
Form: light yellow soft sticky resin
Chemical Class: polychlorinated biphenyl
Molecular Weight: 375.7
Specific Gravity: 1.566
Solubility in Water: 2.70×10^{-3} mg/L at 25°C
Solubility in Organics: benzene, trichlorobenzene
Organic Carbon Partition Coefficient: 1.40×10^{-7}
Log Octanol/Water Partition Coefficient: 7.15
Vapor Pressure: 4.05×10^{5} mm Hg
Henry's Law Constant: 0.74
Bioconcentration Factor: 1.70×10^{-5} L/kg (microplankton)

Solubility in Water: 150 mg/l at 25°C
Log Octanol/Water Partition Coefficient: 2.88
Vapor Pressure: 14 mm Hg at 20°
Henry's Law Constant: 1.49×10^{-2} atm-m^3/mole

4.30 Toluene

Upon release to the soil, toluene will be lost by evaporation from near surface soil and microbial degradation. Toluene may leach to the ground water where slow biodegradation may occur. In surface water, toluene will be lost by volatilization and biodegradation. In the air, toluene will exist predominantly in the vapor phase. Toluene is not subject to direct photolyses.

Toluene exposure affects the nervous system. Short-term exposure can cause fatigue, confusion, general weakness, drunken actions, memory loss, nausea and loss of appetite. Long-term exposure can affect the kidneys. Inhalation of toluene can irritate the respiratory tract. Toluene is readily absorbed from the respiratory and gastrointestinal tracts and to a lesser extent through the skin.

Chemical Formula: $C_6H_5CH_3$
Form: colorless liquid
Chemical Class: substituted benzene
Molecular Weight: 92.15
Boiling Point: 110.6°C
Melting Point: -95°C
Solubility in Water: 515 mg/l at 20°C
Organic Carbon Partition Coefficient: 2.47 ml/g
Log Octanol/Water Partition Coefficient: 2.79
Vapor Pressure: 22 mm Hg at 20°C
Henry's Law Constant: 6.66×10^{-3} atm-m^3/mole

4.31 Trichloroethene

Trichloroethene (or trichloroethylene) when released to the atmosphere will remain in the vapor phase due to its relatively high vapor pressure. Trichloroethene biodegrades very slowly and it is not hydrolyzed by water. Trichloroethene does not absorb light readily so it will not photodegrade quickly. Adsorption to sediment and bioconcentration in aquatic organisms are not important processes.

Exposure to high concentrations of trichloroethene in air will affect the central nervous system, causing dizziness, headache, slowed reaction times, sleepiness and facial numbness. Trichloroethene can also cause eye, nose and throat irritation.

Trichloroethene is metabolized in humans to trichloroethanol, trichloroethane, glucuronide and trichloroacetic acid.

Chemical Formula: C_2HCl_3
Form: clear, colorless liquid
Chemical Class: chlorinated alkene
Molecular Weight: 131.40
Boiling Point: 86.7°C
Melting Point: -87.1°C
Specific Gravity: 1.465 at 20/4°C
Solubility in Water: 1.366 g/l at 25°C
Log Octanol/Water Partition Coefficient: 2.42
Vapor Pressure: 59 mm at 20°C
Henry's Law Constant: 0.02 at 20°C

4.32 Vanadium

Sorption, complexation, and volatilization processes contribute to the fate of vanadium in the environment. Transport in aqueous systems is dependent on chemical speciation, organic matter content and other parameters such as pH and ligand concentration. Atmospheric transport can occur through volatilization from surface waters.

Vanadium salts are poorly absorbed from the human gastrointestinal tract, but soluble vanadium compounds are taken up to a considerable extent after inhalation. Soluble pentavalent vanadium compounds, like the pentoxide, have a rather high acute as well as chronic toxicity. The activity of lower valency state compounds seems to be less. Exposure may elicit local as well as systemic effects involving several organs and tissues. In man, long-term exposure to vanadium-containing dust may cause bronchitis, pneumonia, or emphysema.

Chemical Formula: V
Form: light gray or white lustrous powder; fused hard lumps or body-centered cubic crystals
Chemical Class: metal
Molecular Weight: 50.94
Boiling Point: 3,380°C
Melting Point: 1,917°C
Specific Gravity: 6.11 at 18.7°C
Solubility in Water: insoluble

4.33 Zinc

The major environmental transport processes for zinc are sorption on to soils, sediments and/or suspended particles and bioaccumulation in organisms. Bioconcentration factors ranging from 10^2 to 10^5 have been reported for zinc. No evidence of biodegradation of zinc in the environment is noted in the literature. Minor environmental significance is placed upon the role of volatilization, biodegradation, hydrolysis, photolysis and oxidation of zinc.

Zinc is an essential nutrient for the biosynthesis of numerous enzymes. Zinc is an essential element in humans. In man the average daily intake of zinc is about 10-15 mg/day. By the oral route or by inhalation, the acute as well as chronic toxicity of inorganic zinc are extremely low.

Chemical Formula: Zn
Form: bluish-white, lustrous metal; distorted hexagonal close-packed structure
Chemical Class: metal
Molecular Weight: 65.38
Boiling Point: 908°C
Melting Point: 419.5°C
Specific Gravity: 7.14 at 25°C
Solubility in Water: insoluble; some salts are soluble
Solubility in Organics: acetic acid and alkali
Vapor Pressure: 1 mm at 487°C

The toxicity and exposure assessments are integrated into quantitative and qualitative expressions of potential risk in this section. Methodologies for estimating risks are described and results are presented for all exposure scenarios. An interpretation of these conditional risk estimates qualifies the results and puts them into a meaningful perspective.

Carcinogens and noncarcinogens are characterized separately because the methodology differs for these two modes of chemical toxicity. To characterize noncarcinogenic effects, estimated intakes of constituents are compared to EPA-approved toxicity values. To characterize potential carcinogenic effects, probabilities that cancer will develop within an exposed population over a lifetime of exposure are estimated from intakes of constituents and chemical-specific dose-response information.

5.1 Toxicity Values

The noncarcinogenic reference dose (RfD) values and the cancer slope factors for the constituents of concern in this assessment were obtained from EPA's IRIS database (October 1991) or from the Health Effects Assessment Summary Tables (EPA, January 1991). Chronic reference doses were used in the assessment of exposures with a duration of seven years or more. Subchronic reference doses were used in the assessment of exposures with a duration less than seven years (i.e., the child residential exposure with a five year duration). Route-specific reference doses and slope factors were used for the oral and inhalation routes of exposure; inhalation values were not extrapolated from oral values. Because no dermal toxicity values are available, oral values were extrapolated to the dermal route using an "absorption adjustment".

5.1.1 Absorption Adjustment

In accordance with agency guidance (RAGS), oral and inhalation daily chemical intakes were calculated as administered doses while dermal intake was calculated as an absorbed dose. Estimated intakes expressed as absorbed doses may be compared to reference doses or slope factors only if the reference doses or slope factors are likewise based on an absorbed dose. An absorption adjustment to oral RfDs and oral slope factors which are based on administered dose was necessary to extrapolate to the dermal route. The absorption adjustment factor is chemical-specific and is the fraction of oral dose absorbed in the test species on which the RfD or slope factor is based. Species absorption factors used in this assessment were obtained from the scientific literature. No absorption adjustment was made to oral or inhalation RfDs or slope factors.

Most reference doses and slope factors are based on administered dose; frequently the basis is not specified. If administered versus absorbed dose was not specified, the basis was assumed to be

TABLE 5-1

Subchronic Reference Doses

Combustion, Inc.
Denham Springs, Louisiana

CONSTITUENT	FRACTION OF ORAL DOSE ABSORBED IN TEST SPECIES	Reference	SUBCHRONIC REFERENCE DOSE (mg/kg/day) (a)		
			Oral RfD	Derm RfD (b)	Inhal RfD
Acenaphthene	0.7	A	0.6	0.42	–
Acetone	1	B	1	1	–
Antimony	0.04	C	0.0004	0.000016	–
Arsenic	0.9	D	0.001	0.0009	–
Barium	0.07	E	0.05	0.0035	0.001
Benzene	1	F	–	–	–
bis (2–Ethylhexyl) phthalate	0.9	G	0.02	0.018	–
Benzo(b)fluoranthene	0.7	H	–	–	–
Benzo(a)anthracene	0.7	I	–	–	–
Butylbenzylphthalate	0.9	J	2	1.8	–
Cadmium	0.05	K	–	–	–
Chromium	0.11	L	0.02	0.0022	5.71E–06
Chrysene	0.7	M	–	–	–
Copper	0.57	N	0.037	0.02109	–
DDT	0.8	O	0.0005	0.0004	–
1,2–Dichloroethane	1	P	–	–	–
1,2–Dichloroethene	1	B	0.1	0.1	–
2–4–Dinitrotoluene	0.72	Q	–	–	–
Ethylbenzene	1	R	1	1	0.29
Fluoranthene	0.7	H	0.4	0.28	–
Fluorene	0.7	H	0.4	0.28	–
Heptachlor	1	S	0.0005	0.0005	–
2–Hexanone	1	T	–	–	–
Lead	0.1	U	–	–	–
Manganese	0.04	V	0.1	0.004	0.000114
Mercury	0.15	W	0.0003	0.000045	0.00009
Methylene chloride	1	X	0.06	0.06	0.86
Naphthalene	0.85	Y	0.04	0.034	–
Nickel	0.05	Z	0.02	0.001	–
N–Nitrosopropylamine	1	B	–	–	–
PCB	1 (liquid), 0.9 (soil)	AA	–	–	–
Pyrene	0.7	H	0.3	0.21	–
Styrene	1	BB	2	2	–
Tetrachloroethylene	1	CC	0.1	0.1	–
Toluene	1	DD	2	2	0.57
Trichloroethene	1	EE	–	–	–
Vanadium	0.03	FF	0.007	0.00021	–
Zinc	0.25	GG	0.2	0.05	–

NOTES:

– Data not available

(a) Sources: EPA's IRIS online database, October 1991, and Health Effects Assessment Summary Tables, January 1991

(b) Dermal RfDs are calculated as follows: Oral RfD x Fraction of Oral Dose Absorbed in Test Species

TABLE 5-1 (Cont'd)

Subchronic Reference Doses

Combustion, Inc.
Denham Springs, Louisiana

References

A. Analogy to PCB's
B. Default
C. Toxicological Profile for Antimony, Agency for Toxic Substances and Disease Registry (ATSDR)), 10/90, p. 32
D. Toxicological Profile for Arsenic, ATSDR, 11/87, p. 38
E. Toxicological Profile for Barium, ATSDR, 10/90, p. 31
F. Toxicological Profile for Benzene, ATSDR, 12/87, p. 37
G. Toxicological Profile for bis(2-Ethylhexyl)phthalate, ATSDR, 12/87, p. 32
H. Based on Analogy to PAH's
I. Toxicological Profile for Benzo(a)anthracene, ATSDR, 10/89, p. 48
J. Based on Analogy to phthalates
K. Toxicological Profile for Cadmium, ATSDR, 11/87, p. 34
L. Toxicological Profile for Chromium, ATSDR, 7/89, p. 47
M. Toxicological Profile for Chrysene, ATSDR, 10/89, pp. 48-49
N. Toxicological Profile for Copper, ATSDR, 12/90, p. 33
O. Toxicological Profile for DDT, ATSDR, 12/88, p. 51
P. Toxicological Profile for 1,2- Dichloroethane, ATSDR, 12/88, p. 49
Q. Toxicological Profile for 2,4- Dinitrotoluene, ATSDR, 12/89, p. 51
R. Toxicological Profile for Ethylbenzene, ATSDR, 12/90, p. 34
S. Toxicological Profile for Heptachlor, ATSDR, 4/89, p. 34
T. Toxicological Profile for 2- Hexanone, ATSDR, 10/90, p. 29
U. Toxicological Profile for Lead, ATSDR, 6/90, p. 52
V. Toxicological Profile for Manganese, ATSDR, 10/90, p. 32
W. Toxicological Profile for Mercury, ATSDR, 12/88, p. 69
X. Toxicological Profile for Methylene Chloride, ATSDR, 12/87, p. 34
Y. Toxicological Profile for Naphthalene, ATSDR, 12/87, p. 40
Z. Toxicological Profile for Nickel, ATSDR, 12/88, p. 39
AA. Toxicological Profile for PCB's, ATSDR, 6/89, pp. 45-46
BB. Toxicological Profile for Styrene, ATSDR, 10/90, p. 43
CC. Toxological Profile for Tetrachloroethylene, ATSDR, 12/87, p. 33
DD. Based on Analogy to Other Alkylbenzenes
EE. Toxicological Profile for Trichloroethene, ATSDR, 1/88, pp. 37-38
FF. Toxicological Profile for Vanadium, ATSDR, 10/90, p. 21
GG. Toxicological Profile for Zinc, ATSDR, 12/88, p. 37

TABLE 5-2

Chronic Reference Doses

Combustion, Inc.
Denham Springs, Louisiana

CONSTITUENT	FRACTION OF ORAL DOSE ABSORBED IN TEST SPECIES (a)	CHRONIC REFERENCE DOSE (mg/kg/day) (b)		
		Oral RfD	Derm RfD (c)	Inhal RfD
Acenaphthene	0.7	0.06	0.042	–
Acetone	1	0.1	0.1	–
Antimony	0.04	0.0004	0.00002	–
Arsenic	0.9	0.001	0.0009	–
Barium	0.07	0.05	0.0035	0.0001
Benzene	1	–	–	–
bis(2-Ethylhexyl)phthalate	0.9	0.02	0.018	–
Benzo(b)fluoranthene	0.7	–	–	–
Benzo(a)anthracene	0.7	–	–	–
Butylbenzylphthalate	0.9	0.2	0.18	–
Cadmium	0.05	0.0005	0.00003	–
Chromium	0.11	0.005	0.0005	5.71E-07
Chrysene	0.7	–	–	–
Copper	0.57	0.037	0.0210	–
DDT	0.8	0.0005	0.0004	–
1,2- Dichloroethane	1	–	–	–
1,2- Dichloroethene	1	0.01	0.01	–
2,4- Dinitrotoluene	0.72	–	–	–
Ethylbenzene	1	0.1	0.1	0.29
Fluoranthene	0.7	0.04	0.028	–
Fluorene	0.7	0.04	0.028	–
Heptachlor	1	0.0005	0.0005	–
2- Hexanone	1	–	–	–
Lead	0.1	–	–	–
Manganese	0.04	0.1	0.004	0.00011
Mercury	0.15	0.0003	0.00005	0.00009
Methylene chloride	1	0.06	0.06	0.86
Naphthalene	0.85	0.004	0.0034	–
Nickel	0.05	0.02	0.001	–
N-Nitrosopropylamine	1	–	–	–
PCB	1 (liquid), 0.9 (soil)	–	–	–
Pyrene	0.7	0.03	0.021	–
Styrene	1	0.2	0.2	–
Tetrachloroethylene	1	0.01	0.01	–
Toluene	1	0.2	0.2	0.57
Trichloroethene	1	–	–	–
Vanadium	0.03	0.007	0.0002	–
Zinc	0.25	0.2	0.05	–

NOTES:

– Data not available.
(a) For Fraction Oral Dose Absorbed References See Table 5-1
(b) Sources: EPA's IRIS online database, October 1991, and Health Effects Assessment Summary Tables, January 1991.
(c) Dermal RfDs are calculated as follows: Oral RfD x Fraction of Oral Dose Absorbed in Test Species

and outdoors through soil/dust ingestion, water ingestion, inhalation, intake through the diet, and transfer of lead from mother to fetus. A blood lead level of 10 µg lead per deciliter of blood or less in a child is considered by EPA to be not associated with demonstrable clinical symptoms. Use of the model was only appropriate for the residential child scenario; estimates of risk for the residential adult and trespasser child scenarios were not quantified.

5.2 Quantitative Estimates of Risk

5.2.1 Estimation of Noncarcinogenic Hazard Indices

The estimation of noncarcinogenic risk is expressed by the ratio (known as the Hazard Quotient, HQ) of estimated actual intake of a constituent to a determined intake level that is not expected to produce adverse health effects (RfD). This ratio is expressed by the following equation:

$$HQ = Intake\,(mg/kg/day) \times \frac{1}{RfD}\,(mg/kg/day)^{-1}$$

A HQ of less than 1 indicates a level of intake below the estimated acceptable level, thus adverse health effects would not be expected. A HQ greater than 1 indicates a chemical intake greater than the estimated acceptable level, suggesting the potential for adverse health effects.

For each exposure scenario for every environmental medium, chemical-specific HQs were calculated per route for the noncarcinogens selected as constituents of concern. The exposure assumptions presented in Section 3 were used, and the toxicity values presented in Tables 5-1 and 5-2 were used. Oral, dermal, and inhalation HQs were summed for each chemical. Assuming that simultaneous subthreshold exposures to several constituents could result in an adverse health effect, constituent specific HQs were then summed to give one Hazard Index (HI) for a medium encompassing all constituents and relevant exposure routes (HI = the sum of HQs). It is important to note that the Hazard Index is not a probability of developing a health effect. It is an index of potential for effect.

5.2.2 Estimation of Carcinogenic Risk

Carcinogenic risks are expressed as unitless probabilities; they reflect an upper-bound estimate of the probability of cancer developing within a population as a result of assumed exposure to a potential carcinogen. Carcinogenic risks are calculated by the following equation under the assumption of a linear relationship at low-dose between intake and carcinogenic response:

TABLE 5-4

Pond Area Soil – Trespasser

Combustion, Inc.
Denham Springs, Louisiana

Receptor	Child (age 8 – 14)
Body Weight	37 kg
Exposure Duration	7 yrs
Body Surface	4550 sq cm/day
Exposure Frequency	108 days/yr
Inhalation Rate	0.83 cu m/hr
Exposure Time	4 hrs/day
Soil Ingestion	100 mg/day
Soil Adherence	1.45 mg/sq cm
Respirable Fraction	0.5
Air Conc. Dust	0.0064 mg/cu m
Averaging Time	2555 days
Cancer Averaging Time	25550 days

		Chronic Hazard Indices				Lifetime Cancer Risks			
Constituent	Concentration (mg/kg)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)
Arsenic	2.4 b	1.92E-03	1.41E-04	--	2.06E-03	3.36E-07	2.46E-08	1.02E-09	3.62E-07
Barium	223 b	3.57E-03	1.68E-02	1.89E-04	2.06E-02	--	--	--	--
Benzene	5.4 a	--	--	--	--	1.25E-08	8.26E-09	1.33E-12	2.08E-08
Copper	15 b	3.24E-04	1.88E-04	--	5.12E-04	--	--	--	--
Dichloroethene(1,2)	3.8 b	3.04E-04	2.00E-03	--	2.31E-03	--	--	--	--
Ethylbenzene	18.9 a	1.51E-04	9.97E-04	5.54E-09	1.15E-03	--	--	--	--
Fluoranthene	11 b	2.20E-04	1.04E-03	--	1.26E-03	--	--	--	--
Fluorene	12 b	2.40E-04	1.13E-03	--	1.37E-03	--	--	--	--
Heptachlor	0.13 b	2.08E-04	1.37E-03	--	1.58E-03	4.68E-08	3.09E-07	4.97E-12	3.55E-07
Lead	178 b	--	--	--	--	--	--	--	--
Manganese	156 b	1.25E-03	1.03E-02	1.16E-04	1.17E-02	--	--	--	--
Mercury	0.21 b	5.60E-04	1.23E-03	1.98E-07	1.79E-03	--	--	--	--
Naphthalene	19 b	3.80E-03	1.47E-02	--	1.85E-02	--	--	--	--
Pyrene	11 b	2.93E-04	1.38E-03	--	1.68E-03	--	--	--	--
Tetrachloroethylene	4.4 b	3.52E-04	2.32E-03	--	2.67E-03	1.79E-08	1.18E-07	6.73E-14	1.36E-07
Vanadium	19 b	2.17E-03	2.39E-02	--	2.60E-02	--	--	--	--
Zinc	549 a	2.20E-03	2.90E-03	--	5.09E-03	--	--	--	--
				Total =	9.83E-02			Total =	8.74E-07

NOTES:

-- Agency-verified toxicity value unavailable for quantitative assessment.
a Upper 95 percent confidence limit on the arithmetic mean was used.
b Maximum detected value was used.

TABLE 5-5

Process Area Soil – Trespasser

Combustion, Inc.
Denham Springs, Louisiana

Receptor	Child (age 8 – 14)
Body Weight	37 kg
Exposure Duration	7 yrs
Body Surface	4550 sq cm/day
Exposure Frequency	108 days/yr
Inhalation Rate	0.83 cu m/hr
Exposure Time	4 hrs/day
Soil Ingestion	100 mg/day
Soil Adherence	1.45 mg/sq cm
Respirable Fraction	0.5
Air Conc. Dust	0.0064 mg/cu m
Averaging Time	2555 days
Cancer Averaging Time	25550 days

		Chronic Hazard Indices				Lifetime Cancer Risks			
Constituent	Concentration (mg/kg)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)
Arsenic	4.3 b	3.44E–03	2.52E–04	– –	3.69E–03	6.02E–07	4.41E–08	1.83E–09	6.48E–07
Barium	302 a	4.83E–03	2.28E–02	2.57E–04	2.78E–02	– –	– –	– –	– –
DDT	0.96 b	1.54E–03	1.27E–03	– –	2.80E–03	2.61E–08	2.15E–08	2.77E–12	4.76E–08
Dinitrotoluene(2,4)	27.8 a	– –	– –	– –	– –	1.51E–06	6.93E–06	– –	8.44E–06
Lead	264 a	– –	– –	– –	– –	– –	– –	– –	– –
Manganese	768 a	6.14E–03	5.07E–02	5.72E–04	5.74E–02	– –	– –	– –	– –
Naphthalene	20.2 a	4.04E–03	1.57E–02	– –	1.97E–02	– –	– –	– –	– –
Nickel	20.7 a	8.28E–04	5.46E–03	– –	6.29E–03	– –	– –	1.48E–10	1.48E–10
PCB	0.384 b	– –	– –	– –	– –	1.02E–07	1.73E–07	– –	2.75E–07
Toluene	586 a	2.34E–03	1.55E–02	8.73E–08	1.78E–02	– –	– –	– –	– –
Vanadium	25.9 a	2.96E–03	3.25E–02	– –	3.55E–02	– –	– –	– –	– –
				Total =	1.71E–01			Total =	9.41E–06

NOTES:

– – Agency–verified toxicity value unavailable for quantitative assessment.
a Upper 95 percent confidence limit on the arithmetic mean was used.
b Maximum detected value was used.

TABLE 5-6

Pond Water – Trespasser

Combustion, Inc.
Denham Springs, Louisiana

Receptor	Child (age 8–14)
Body Weight	37 kg
Exposure Duration	7 yrs
Body Surface Exposed	4550 sq cm/day
Water Ingestion	0.05 liters/day
Exposure Frequency	3 days/yr
Duration of Event	0.5 hr/day
Averaging Time	2555 days
Cancer Averaging Time	25550 days

		Chronic Hazard Index			Lifetime Cancer Risk		
Constituent	Concentration (mg/L)	Ingestion (unitless)	Dermal (unitless)	Sum (unitless)	Ingestion (unitless)	Dermal (unitless)	Sum (unitless)
Antimony	0.34 a	4.72E–03	1.61E–02	2.08E–02	– –	– –	– –
Arsenic	0.01 a	5.55E–05	8.42E–06	6.40E–05	9.72E–09	1.47E–09	1.47E–09
Barium	1.32 a	1.47E–04	2.86E–04	4.33E–04	– –	– –	– –
Benzene	0.005 b	– –	– –	– –	8.05E–11	8.13E–10	8.13E–10
Lead	4.98 a	– –	– –	– –	– –	– –	– –
Methylene chloride	0.017 b	1.57E–06	8.05E–07	2.38E–06	7.08E–11	3.62E–11	3.62E–11
			Total =	2.13E–02		Total =	2.32E–09

NOTES:

– – Agency–verified toxicity value unavailable for quantitative assessment.
a Upper 95 percent confidence limit on the arithmetic mean was used.
b Maximum detected value was used.

TABLE 5-7

Pond Oil – Trespasser

Combustion, Inc.
Denham Springs, Louisiana

Receptor	Child (age 8-14)
Body Weight	37 kg
Exposure Duration	7 yrs
Body Surface Exposed	4550 sq cm/day
Oil Ingestion	0.005 liters/day
Exposure Frequency	3 days/yr
Duration of Event	0.5 hr/day
Averaging Time	2555 days
Cancer Averaging Time	25550 days

		Chronic Hazard Index			Lifetime Cancer Risk		
Constituent	Concentration (mg/L)	Ingestion (unitless)	Dermal (unitless)	Sum (unitless)	Ingestion (unitless)	Dermal (unitless)	Sum (unitless)
Arsenic	0.213 b	4.22E-05	6.41E-05	1.06E-04	7.39E-09	1.12E-08	1.86E-08
Acetone	4.191 a	8.31E-06	7.56E-06	1.59E-05	--	--	--
Cadmium	0.255 b	1.01E-04	2.76E-03	2.86E-03	--	--	--
Chromium	5.27 b	2.09E-04	3.63E-03	3.84E-03	--	--	--
Ethylbenzene	1.165 a	2.31E-06	2.88E-03	2.88E-03	--	--	--
Lead	90.1 b	--	--	--	--	--	--
PCB	58.65 b	--	--	--	8.96E-06	5.27E-06	1.42E-05
Toluene	2.108 a	2.09E-06	1.92E-03	1.92E-03	--	--	--
			Total =	1.16E-02		Total =	1.42E-05

NOTES:

Concentrations detected in oil were reported by the laboratory in mg/kg and were converted to the mg/L values shown assuming 0.85 g/ml density (i.e., lighter than water and similar to compounds such as xylene and toluene).

A 5/14 factor was used in the intake equation to account for the fraction of the medium affected. Five of 14 ponds contained discreet oil layers which were sampled in the 1/89 RI sampling event.

Calculations for dermal absorption of PCB in oil were slightly different than for the other constituents due to the availability of specific information concerning absorption of PCBs from oil in laboratory experiments (see text).
-- Agency-verified toxicity value unaivalable for quantitative assessment.
a Upper 95 percent confidence limit on the arithmetic mean was used.
b Maximum detected value was used.

TABLE 5-8

Pond Area Solids – Trespasser

Combustion, Inc.
Denham Springs, Louisiana

Receptor	Child (age 8-14)
Body Weight	37 kg
Exposure Duration	7 yrs
Body Surface	4550 sq cm/day
Exposure Frequency	3 days/yr
Soil Ingestion	100 mg/day
Soil Adherence	1.45 mg/sq cm
Averaging Time	2555 days
Cancer Averaging Time	25550 days

		Chronic Hazard Indices			Lifetime Cancer Risks		
Constituent	Concentration (mg/kg)	Ingestion (unitless)	Dermal (unitless)	Sum (unitless)	Ingestion (unitless)	Dermal (unitless)	Sum (unitless)
Acenaphthene	46 b	1.70E-05	8.03E-05	9.73E-05	--	--	--
Antimony	14.5 a	8.05E-04	6.64E-03	7.45E-03	--	--	--
Barium	886 a	3.94E-04	1.85E-03	2.25E-03	--	--	--
Bis(2-ethylhexyl)phthalate	102 a	1.13E-04	8.30E-04	9.44E-04	3.17E-09	2.33E-08	2.64E-08
Benzene	257 a	--	--	--	1.66E-08	1.09E-08	2.75E-08
Benzo(b)fluoranthene	28.7 a	--	--	--	1.03E-07	9.67E-08	1.99E-07
Benzo(a)anthracene	29 a	--	--	--	1.08E-07	1.01E-07	2.09E-07
Butylbenzylphthalate	210 a	2.33E-05	1.71E-04	1.94E-04	--	--	--
Cadmium	5.15 a	2.29E-04	1.51E-03	1.74E-03	--	--	--
Chrysene	44.9 a	--	--	--	5.05E-09	4.76E-09	9.80E-09
Ethylbenzene	233 a	5.18E-05	3.41E-04	3.93E-04	--	--	--
Fluoranthene	122 a	6.78E-05	3.19E-04	3.87E-04	--	--	--
Fluorene	110 b	6.11E-05	2.88E-04	3.49E-04	--	--	
Hexanone(2-)	64.1 a	--	--	--	--	--	--
Lead	1050 a	--	--	--	--	--	--
N-Nitrosopropylamine	15.7 a	--	--	--	2.44E-07	1.61E-06	1.85E-06
Naphthalene	210 b	1.17E-03	4.53E-03	5.69E-03	--	--	--
PCB	8.5 b	--	--	--	6.25E-08	1.07E-07	1.69E-07
Pyrene	125 a	9.26E-05	4.36E-04	5.29E-04	--	--	--
Styrene	74.7 a	8.30E-06	5.47E-05	6.30E-05	4.98E-09	3.28E-08	3.78E-08
Tetrachloroethylene	41.4 a	9.20E-05	6.07E-04	6.99E-04	4.69E-09	3.09E-08	3.56E-08
Toluene	605 a	6.72E-05	4.43E-04	5.11E-04	--	--	--
Trichloroethene	47.5 a	--	--	--	1.16E-09	7.66E-09	8.82E-09
			Total =	2.13E-02		Total =	2.58E-06

NOTES:

-- Agency-verified toxicity value unavailable for quantitative assessment.
a Upper 95 percent confidence limit on the arithmetic mean was used.
b Maximum detected value was used.

TABLE 5-9

Pond Area Soil – Residential

Combustion, Inc.
Denham Springs, Louisiana

Receptor	Adult
Body Weight	70 kg
Exposure Duration	30 yrs
Body Surface	3940 sq cm/day
Exposure Frequency	350 days/yr
Inhalation Rate	0.83 cu m/hr
Exposure Time	24 hrs/day
Soil Ingestion	100 mg/day
Soil Adherence	1.45 mg/sq cm
Respirable Fraction	0.5
Air Conc. Dust	0.0064 mg/cu m
Averaging Time	10950 days
Cancer Averaging Time	25550 days

		Chronic Hazard Indices				Lifetime Cancer Risks			
Constituent	Concentration (mg/kg)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)
Arsenic	2.4 b	3.29E-03	2.09E-04	--	3.50E-03	2.47E-06	1.57E-07	4.49E-08	2.67E-06
Barium	223 b	6.11E-03	2.49E-02	1.95E-03	3.30E-02	--	--	--	--
Benzene	5.4 a	--	--	--	--	9.19E-08	5.25E-08	5.86E-11	1.45E-07
Copper	15 b	5.55E-04	2.78E-04	--	8.34E-04	--	--	--	--
Dichloroethene(1,2)	3.8 b	5.21E-04	2.97E-03	--	3.49E-03	--	--	--	--
Ethylbenzene	18.9 a	2.59E-04	1.48E-03	5.69E-08	1.74E-03	--	--	--	--
Fluoranthene	11 b	3.77E-04	1.54E-03	--	1.91E-03	--	--	--	--
Fluorene	12 b	4.11E-04	1.68E-03	--	2.09E-03	--	--	--	--
Heptachlor	0.13 b	3.56E-04	2.03E-03	--	2.39E-03	3.43E-07	1.96E-06	2.19E-10	2.31E-06
Lead	178 b	--	--	--	--	--	--	--	--
Manganese	156 b	2.14E-03	1.53E-02	1.19E-03	1.86E-02	--	--	--	--
Mercury	0.21 b	9.59E-04	1.83E-03	2.04E-06	2.79E-03	--	--	--	--
Naphthalene	19 b	6.51E-03	2.19E-02	--	2.84E-02	--	--	--	--
Pyrene	11 b	5.02E-04	2.05E-03	--	2.55E-03	--	--	--	--
Tetrachloroethylene	4.4 b	6.03E-04	3.44E-03	--	4.05E-03	1.32E-07	7.53E-07	2.96E-12	8.84E-07
Vanadium	19 b	3.72E-03	3.54E-02	--	3.91E-02	--	--	--	--
Zinc	549 a	3.76E-03	4.30E-03	--	8.06E-03	--	--	--	--
				Total =	1.52E-01			Total =	6.00E-06

NOTES:

-- Agency-verified toxicity value unavailable for quantitative assessment.
a Upper 95 percent confidence limit on the arithmetic mean was used.
b Maximum detected value was used.

TABLE 5-10

Pond Area Soil – Residential

Combustion, Inc.
Denham Springs, Louisiana

Receptor	Child (age 0 – 6)
Body Weight	16 kgs
Exposure Duration	5 yrs
Body Surface	1730 sq cm/day
Exposure Frequency	350 days/yr
Inhalation Rate	0.6 cu m/hr
Exposure Time	24 hrs/day
Soil Ingestion	200 mg/day
Soil Adherence	1.45 mg/sq cm
Respirable Fraction	0.5
Air Conc. Dust	0.0064 mg/cu m
Averaging Time	1825 days
Cancer Averaging Time	25550 days

		Subchronic Hazard Indices				Lifetime Cancer Risks			
Constituent	Concentration (mg/kg)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)
Arsenic	2.4 b	2.88E-02	4.01E-04	--	2.92E-02	3.60E-06	5.01E-08	2.37E-08	3.67E-06
Barium	223 b	5.35E-02	4.79E-02	6.16E-04	1.02E-01	--	--	--	--
Benzene	5.4 a	--	--	--	--	1.34E-07	1.68E-08	3.09E-11	1.51E-07
Copper	15 b	4.86E-03	5.35E-04	--	5.39E-03	--	--	--	--
Dichloroethene(1,2)	3.8 b	4.55E-04	5.71E-04	--	1.03E-03	--	--	--	--
Ethylbenzene	18.9 a	2.27E-04	2.84E-04	1.80E-07	5.11E-04	--	--	--	--
Fluoranthene	11 b	3.30E-04	2.95E-04	--	6.25E-04	--	--	--	--
Fluorene	12 b	3.60E-04	3.22E-04	--	6.82E-04	--	--	--	--
Heptachlor	0.13 b	3.12E-03	3.91E-03	--	7.03E-03	5.01E-07	6.28E-07	1.15E-10	1.13E-06
Lead	178 b	--	--	--	--	--	--	--	--
Manganese	156 b	1.87E-02	2.93E-02	3.78E-03	5.18E-02	--	--	--	--
Mercury	0.21 b	8.39E-03	3.51E-03	6.44E-06	1.19E-02	--	--	--	--
Naphthalene	19 b	5.69E-03	4.20E-03	--	9.89E-03	--	--	--	--
Pyrene	11 b	4.39E-04	3.94E-04	--	8.33E-04	--	--	--	--
Tetrachloroethylene	4.4 b	5.27E-04	6.61E-04	--	1.19E-03	1.92E-07	2.41E-07	1.56E-12	4.33E-07
Vanadium	19 b	3.25E-02	6.80E-02	--	1.01E-01	--	--	--	--
Zinc	549 a	3.29E-02	8.25E-03	--	4.12E-02	--	--	--	--
				Total =	3.64E-01			Total =	5.38E-06

NOTES:

-- Agency-verified toxicity value unavailable for quantitative assessment.
a Upper 95 percent confidence limit on the arithmetic mean was used.
b Maximum detected value was used.

TABLE 5-11

Process Area Soil – Residential

Combustion, Inc.
Denham Springs, Louisiana

Receptor	Adult
Body Weight	70 kg
Exposure Duration	30 yrs
Body Surface	3940 sq cm/day
Exposure Frequency	350 days/yr
Inhalation Rate	0.83 cu m/hr
Exposure Time	24 hrs/day
Soil Ingestion	100 mg/day
Soil Adherence	1.45 mg/sq cm
Respirable Fraction	0.5
Air Conc. Dust	0.0064 mg/cu m
Averaging Time	10950 days
Cancer Averaging Time	25550 days

		Chronic Hazard Indices				Lifetime Cancer Risks			
Constituent	Concentration (mg/kg)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)
Arsenic	4.3 b	5.89E-03	3.74E-04	--	6.26E-03	4.42E-06	2.80E-07	8.05E-08	4.78E-06
Barium	302 a	8.27E-03	3.38E-02	2.64E-03	4.47E-02	--	--	--	--
DDT	0.96 b	2.63E-03	1.88E-03	--	4.51E-03	1.92E-07	1.37E-07	1.22E-10	3.29E-07
Dinitrotoluene(2,4)	27.8 a	--	--	--	--	1.11E-05	4.40E-05	--	5.51E-05
Lead	264 a	--	--	--	--	--	--	--	--
Manganese	768 a	1.05E-02	7.51E-02	5.88E-03	9.15E-02	--	--	--	--
Naphthalene	20.2 a	6.92E-03	2.32E-02	--	3.02E-02	--	--	--	--
Nickel	20.7 a	1.42E-03	8.10E-03	--	9.52E-03	--	--	6.51E-09	6.51E-09
PCB	0.384 b	--	--	--	--	7.46E-07	1.10E-06	--	1.85E-06
Toluene	586 a	4.01E-03	2.29E-02	8.98E-07	2.69E-02	--	--	--	--
Vanadium	25.9 a	5.07E-03	4.83E-02	--	5.33E-02	--	--	--	--
				Total =	2.67E-01			Total =	6.21E-05

NOTES:

-- Agency-verified toxicity value unavailable for quantitative assessment.
a Upper 95 percent confidence limit on the arithmetic mean was used.
b Maximum detected value was used.

TABLE 5-12

Process Area Soil – Residential

Combustion, Inc.
Denham Springs, Louisiana

Receptor	Child (age 0 – 6)
Body Weight	16 kg
Exposure Duration	5 yrs
Body Surface	1730 sq cm/day
Exposure Frequency	350 days/yr
Inhalation Rate	0.6 cu m/hr
Exposure Time	24 hrs/day
Soil Ingestion	200 mg/day
Soil Adherence	1.45 mg/sq cm
Respirable Fraction	0.5
Air Conc. Dust	0.0064 mg/cu m
Averaging Time	1825 days
Cancer Averaging Time	25550 days

		Subchronic Hazard Indices				Lifetime Cancer Risks			
Constituent	Concentration (mg/kg)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)	Ingestion (unitless)	Dermal (unitless)	Inhalation (unitless)	Sum (unitless)
Arsenic	4.3 b	5.15E–02	7.18E–04	––	5.23E–02	6.44E–06	8.98E–08	4.24E–08	6.57E–06
Barium	302 a	7.24E–02	6.49E–02	8.34E–04	1.38E–01	––	––	––	––
DDT	0.96 b	2.30E–02	3.61E–03	––	2.66E–02	2.79E–07	4.38E–08	6.44E–11	3.23E–07
Dinitrotoluene(2,4)	27.8 a	––	––	––	0.00E+00	1.62E–05	1.41E–05	––	3.03E–05
Lead	264 a	––	––	––	0.00E+00	––	––	––	––
Manganese	768 a	9.21E–02	1.44E–01	1.86E–02	2.55E–01	––	––	––	––
Naphthalene	20.2 a	6.05E–03	4.47E–03	––	1.05E–02	––	––	––	––
Nickel	20.7 a	1.24E–02	1.56E–02	––	2.80E–02	––	––	3.43E–09	3.43E–09
PCB	0.384 b	––	––	––	0.00E+00	1.09E–06	3.53E–07	––	1.44E–06
Toluene	586 a	3.51E–03	4.40E–03	2.84E–06	7.92E–03	––	––	––	––
Vanadium	25.9 a	4.43E–02	9.27E–02	––	1.37E–01	––	––	––	––
				Total =	6.55E–01			Total =	3.86E–05

NOTES:

––	Agency–verified toxicity value unavailable for quantitative assessment.
a	Upper 95 percent confidence limit on the arithmetic mean was used.
b	Maximum detected value was used.

TABLE 5–13

Summary Table
Current Land Use Scenario

Combustion, Inc.
Denham Springs, Louisiana

Reasonable Maximum Exposure

ENVIRONMENTAL MEDIUM	RECEPTOR	EXPOSURE SCENARIO	SUMMED HAZARD INDEX, ALL ROUTES	SUMMED CANCER RISK, ALL ROUTES
Pond Area Soil	Child (8–14)	Trespasser	0.10	9E–07
Process Area Soil	Child (8–14)	Trespasser	0.17	9E–06
Pond Water	Child (8–14)	Trespasser	0.02	2E–09
Pond Oil	Child (8–14)	Trespasser	0.01	1E–05
Pond Solids	Child (8–14)	Trespasser	0.02	3E–06

Total Risk: (a)

Pond Soil + Pond Water + Pond Oil + Pond Solids				
	Child (8–14)	Trespasser	0.2	2E–05

NOTE:

(a) Indices and risks are combined for the soil, liquid, and solid media in the pond area since these are reasonable pathway combinations for the trespasser scenario.

TABLE 5-14

Summary Table
Future Land Use Scenario

Combustion, Inc.
Denham Springs, Louisiana

Reasonable Maximum Exposure

ENVIRONMENTAL MEDIUM	RECEPTOR	EXPOSURE SCENARIO	SUMMED HAZARD INDEX, ALL ROUTES	SUMMED CANCER RISK, ALL ROUTES
Pond Area Soil	Adult	Residential	0.15	6E-06
	Child (0-6)		0.36	5E-06
Process Area Soil	Adult	Residential	0.27	6E-05
	Child (0-6)		0.66	4E-05

TABLE 5-15

Pond Area Soil
Lead Biokinetic Model Output (Modified)

Combustion, Inc,
Denham Springs, Louisiana

ABSORPTION METHODOLOGY: Non-Linear Active-Passive

AIR Concentration: 0.001 µg Pb/m3
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: MODEL DEFAULT (see Table 5-1[illegible]

DRINKING WATER Concentration: 0.00 µg Pb/L

SOIL & DUST:
Soil: constant conc.
Dust: Multiple Source Analysis
(indoor soil/dust + outdoor air contribution)

Age	Soil (µg Pb/g)	House Dust (µg Pb/g)
0-1	178.0	49.9
1-2	178.0	49.9
2-3	178.0	49.9
3-4	178.0	49.9
4-5	178.0	49.9
5-6	178.0	49.9
6-7	178.0	49.9

Additional Dust Sources: None (DEFAULT)
Soil contribution conversion factor: 0.28
Air contribution conversion factor: 100.0

PAINT Intake: 0.00 µg Pb/day (DEFAULT)

MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 7.50 µg Pb/dL

TABLE 5-15 (Cont'd)

Pond Area Soil
Lead Biokinetic Model Output (Modified)

Combustion, Inc,
Denham Springs, Louisiana

CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (µg/dL)	Total Uptake (µg/day)	Soil+Dust Uptake (µg/day)
0.5-1:	2.38	6.17	3.23
1-2:	1.95	6.19	3.23
2-3:	1.88	6.62	3.23
3-4:	1.90	6.51	3.23
4-5:	1.94	6.41	3.23
5-6:	1.94	6.60	3.23
6-7:	1.98	6.97	3.23

YEAR	Diet Uptake (µg/day)	Water Uptake (µg/day)	Paint Uptake (µg/day)	Air Uptake (µg/day)
0.5-1:	2.94	0.00	0.00	0.00
1-2:	2.96	0.00	0.00	0.00
2-3:	3.40	0.00	0.00	0.00
3-4:	3.29	0.00	0.00	0.00
4-5:	3.18	0.00	0.00	0.00
5-6:	3.38	0.00	0.00	0.00
6-7:	3.74	0.00	0.00	0.00

TABLE 5-16

Process Area Soil
Lead Biokinetic Model Output (Modified)

Combustion, Inc,
Denham Springs, Louisiana

ABSORPTION METHODOLOGY: Non-Linear Active-Passive

AIR Concentration: 0.002 μg Pb/m3
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: MODEL DEFAULT (see Table 5-17)

DRINKING WATER Concentration: 0.00 μg Pb/L
WATER Consumption: MODEL DEFAULT (see Table 5-17)

SOIL & DUST:
Soil: constant conc.
Dust: Multiple Source Analysis
(indoor soil/dust + outdoor air contribution)

Age	Soil (μg Pb/g)	House Dust (μg Pb/g)
0-1	264.0	74.1
1-2	264.0	74.1
2-3	264.0	74.1
3-4	264.0	74.1
4-5	264.0	74.1
5-6	264.0	74.1
6-7	264.0	74.1

Additional Dust Sources: None (DEFAULT)
Soil contribution conversion factor: 0.28
Air contribution conversion factor: 100.0

PAINT Intake: 0.00 μg Pb/day (DEFAULT)

MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 7.50 μg Pb/dL

TABLE 5-16 (Cont'd)

Process Area Soil
Lead Biokinetic Model Output (Modified)

Combustion, Inc,
Denham Springs, Louisiana

CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (µg/dL)	Total Uptake (µg/day)	Soil+Dust Uptake (µg/day)
0.5-1:	2.82	7.73	4.79
1-2:	2.41	7.75	4.79
2-3:	2.32	8.18	4.79
3-4:	2.35	8.07	4.79
4-5:	2.40	7.97	4.79
5-6:	2.41	8.16	4.79
6-7:	2.44	8.53	4.79

YEAR	Diet Uptake (µg/day)	Water Uptake (µg/day)	Paint Uptake (µg/day)	Air Uptake (µg/day)
0.5-1:	2.94	0.00	0.00	0.00
1-2:	2.96	0.00	0.00	0.00
2-3:	3.40	0.00	0.00	0.00
3-4:	3.29	0.00	0.00	0.00
4-5:	3.18	0.00	0.00	0.00
5-6:	3.38	0.00	0.00	0.00
6-7:	3.74	0.00	0.00	0.00

TABLE 5-17

Summary of Blood-Lead Levels from the Lead Biokinetic Model

Combustion, Inc,
Denham Springs, Louisiana

POND AREA - RESIDENTIAL:

YEAR	Total Uptake (μg/day)	Blood Level (μg/dL)
0.5-1:	6.17	2.38
1-2:	6.19	1.95
2-3:	6.62	1.88
3-4:	6.51	1.90
4-5:	6.41	1.94
5-6:	6.60	1.94
6-7:	6.97	1.98

PROCESS AREA - RESIDENTIAL:

YEAR	Total Uptake (μg/day)	Blood Level (μg/dL)
0.5-1:	7.73	2.82
1-2:	7.75	2.41
2-3:	8.18	2.32
3-4:	8.07	2.35
4-5:	7.97	2.40
5-6:	8.16	2.41
6-7:	8.53	2.44

NOTE: Blood lead levels were estimated for children ages 0-7.

Total HI values for the future residential land use scenario are below 1.0. Cancer risks are in the 10^{-5} to 10^{-6} range (see summary Table 5-14).

To put these risk numbers into perspective, it is recognized that uncertainty in numerical results for risk assessment are generally in the range of at least one order of magnitude or more (RAGS). The direction of potential bias in this assessment is probably high, which overestimates site related risk. The source of the bias direction is the use of conservative factors in nearly every facet of the assessment in an attempt to include behaviors of all populations, including sensitive subpopulations.

The risk estimates presented in this characterization are conditional risk estimates; e.g., if a residential development is built on the site immediately after the pond liquids and semi-solids are removed, then the residential exposure scenario is relevant. The scenario has no relevance if the assumed land use does not occur and, as shown in Section 1, population growth and housing starts are in decline in the Denham Springs area. The same is true for the trespasser scenario; if visitation at the assumed frequency does not occur, risk estimates are not relevant. Therefore a large degree of the uncertainty in this risk analysis is a result of the necessity of making assumptions concerning exposures and population behavior.

Interpretation of these results includes recognition of the assumption of dose-additivity for carcinogens and noncarcinogens. The summation of chemical-specific Hazard Quotients and cancer risks relies on the assumption that additive toxicity will occur among materials with different toxic effects, or which affect different organ systems (cardiovascular, hepatic, etc.). A limitation of this approach is that hazard quotients and risks are combined for substances with RfDs or slope factors derived from critical effects of varying significance and data sets. As a result, application of this approach to more than only a few compounds often results in a substantial over-estimation of the potential for adverse effects.

It is notable that pond oil represents the highest risk in the current land use scenario (10^{-5} versus 10^{-6} or less). The risk value for oil is driven by PCB risk values.

5.3.1 Risks Associated With Pond Oil

The pond oil which is represented by the calculated exposure point concentration (59 mg/L) occurs in only some of the ponds. The oil which was sampled was an observed discreet layer of oil present in five of the 14 ponds. Exposure to the Pond Area in general does not necessarily include exposure to oil and to the risk driver, PCBs. The calculated risk values should be considered very conservative.

Given the unattractive nature of the oily material (bad tasting, physically messy), it is likely that the frequency of child trespass exposure would decrease over the assumed seven year exposure duration. It is unlikely that the same child would revisit and wade in the ponds containing an oil layer three times a year for seven years. In addition, an incidental ingestion of 5 ml is highly conservative for such an aesthetically unattractive medium. The 10^{-5} risk value is not representative of a probable scenario, but identifies a localized high risk area that may be encountered on a less frequent basis and that would most likely include lower intake than assumed in the dermal and oral exposure scenarios used in this assessment.

Additional conservatism is used in the estimation of risk due to PCB exposure; all PCBs present are assumed to be carcinogens having potency equal to that of Aroclor 1260 (the congener used in the test on which the slope factor is based). Only the highly chlorinated PCB forms show strong evidence for carcinogenicity in laboratory animals and some PCBs may in fact be noncarcinogenic. In addition, Arochlor 1260 accounted for only approximately 12% of PCB sales during the commercial life of this product. Yet the assumption is made that the PCBs present at the site, in reality probably a complex mixture of isomers of greatly varying potency, are all equivalent to Arochlor 1260. Furthermore, the cancer slope factor of 7.7 was derived from experimental data using only the female Sprague Dawley Rat. Recent studies indicate reduced cancer risk and likelihood of EPA lowering the risk. When data from other strains of rat showing similar biological responses, such as the Sherman and Wistar strains, the calculated cancer slope factor is 1.9 (Institute for Evaluating Health Risks, July, 1991). Therefore, exposure estimates to environmental PCB mixtures probably overestimate cancer risk by several orders of magnitude. It is very conservative to assume all PCBs in the oil at the site have equal and maximum carcinogenicity.

Because the oil is a discreet medium, this localized potential high risk exposure point can be removed relatively easily. Removal of the oil from the ponds would reduce by several orders of magnitude the calculated potential risk of the Pond Area. Such a removal was proposed by the Combustion, Inc. Participating Parties. (See Work Plan for Removal Action, Phase I, GDC Engineering, May 1990).

5.3.2 Risks Associated With Lead

Lead levels in the blood which were estimated for children by a biokinetic model are shown in Tables 5-15, 5-16, and 5-17. The model output and input parameters for the Pond and Process Areas are shown in Tables 5-16 and 5-17, respectively. Blood lead levels are summarized for both exposure areas in Table 5-17. Table 5-18 lists default model parameters used. Levels ranging from 1.9 to 2.8 μg/dL are well below the recommended maximum level of 10 μg/dL for the age group (0 to 7 years). Lead levels could not be estimated for the 8-14 year old child in the trespasser scenario or for the adult. However, it is assumed that levels protective of

TABLE 5–18

Values of Default Parameters For the Lead Biokinetic Model

Combustion, Inc.
Denham Springs, Louisiana

Air Data:

Lung Absorption: 32.0%
Vary Air Conc by Year: No
Ventilation Rate:

Age	Ventilation Rate
0–1	2.0 m^3/day
1–2	3.0 m^3/day
2–3	5.0 m^3/day
3–4	5.0 m^3/day
4–5	5.0 m^3/day
5–6	7.0 m^3/day
6–7	7.0 m^3/day

Diet Data:

Diet intake:

Age	Diet intake
0–1	5.88 μg Pb/day
1–2	5.92 μg Pb/day
2–3	6.79 μg Pb/day
3–4	6.57 μg Pb/day
4–5	6.36 μg Pb/day
5–6	6.75 μg Pb/day
6–7	7.48 μg Pb/day

Soil and Dust Data:

Percent of Soil+Dust that is Soil: 45%
Amount Ingested Daily:

Age	Amount Ingested Daily
0–1	0.10 g/day
1–2	0.10 g/day
2–3	0.10 g/day
3–4	0.10 g/day
4–5	0.10 g/day
5–6	0.10 g/day
6–7	0.10 g/day

Multiple Source Analysis:

Soil Contribution to House Lead Dust (conversion factor): 0.28
Air Contribution to House Lead Dust (conversion factor): 100
Use Alternate Dust Sources: No

Paint Data:

Amount Ingested Daily: 0.0 μg Pb/day (all ages)

Maternal Data:

Infant Model:
Mother's Blood Lead Concentration at Child's Birth: 7.50 μg Pb/l

the most sensitive subpopulation are also protective of other receptors.

It is notable that lead is a naturally occurring element found in soil, and part of the lead contribution is from the background lead level in soil.

5.4 Assumptions and Uncertainties in the Risk Assessment

The objective of this risk assessment is to estimate the relative magnitude of the potential risk posed to human health and the environment by the constituents detected in the various media at the site. As in all environmental risk assessments, it is known that uncertainty about the numerical results is generally large (one order of magnitude or more) (U.S. EPA, RAGS, 1989). The categories of uncertainty associated with site risks include selection of substances for quantitative assessment, uncertainty inherent in toxicity values, uncertainties inherent in the assumptions of the exposure scenarios, and uncertainties incorporated by summing multiple exposure pathways and risks for multiple constituents. The potential bias associated with this assessment most likely overestimates site-related risk.

5.4.1 Overestimation of Risk

One of the site-related assumptions which contributes to the uncertainty of this risk assessment is the likelihood of the residential future land use actually occurring. The residential scenario has no relevance if the assumed residential land use does not occur. As part of the residential land use scenario, assumptions concerning use of the shallow aquifer as a sole water source are conservative and represent an unlikely scenario (as discussed in section 5.3). In addition, conservative assumptions related to this scenario include one hundred percent absorption of constituents by humans in the gastrointestinal tract and daily consumption of the same quality of drinking water at a constant chemical concentration. Natural attenuation, soil adsorption, dilution of constituents by rainwater percolation and recharge and eventual removal of constituents over time were not taken into account. These processes will lower the actual constituent concentrations and subsequent exposure and risk. It is highly conservative to assume such consistent exposure over a long period of time (30 years for an adult) to the same concentration of a constituent, where the exposure concentration is very near the maximum detected value.

Assumptions used in the trespass scenario which are particularly conservative include: three times a year contact and ingestion of the pond oil for seven years, and weekly visits (2-3 times per week) to areas of affected soil on the site for seven years.

An important uncertainty inherent in the exposure assessment is that dermal and gastrointestinal absorption rates are subject to great variation. They depend on constituent class, temperature, particulate sorption effect, age of the person exposed, length of exposure, and concentration in the medium. It is reasonable to expect that in reality, these factors would vary with each exposure, thus significantly affecting the actual amount of chemical taken in by the individual each time.

A measure of conservatism in development of slope factors for carcinogens adds particular uncertainty to the toxicity assessment of carcinogens. The linear multi-stage model used by EPA for establishing dose-response relationships for carcinogenic compounds is considered likely to overestimate human risk. The carcinogenic potency factor that is derived from the dose-response experimental data is the statistical upper confidence limit (95 percent confidence limit) for the lifetime cancer risk produced by a lifetime exposure to a carcinogen. In addition, toxicity values are often derived from data for the most sensitive exposed test species and sex. Use of this data results in overestimation of human risk because it is assumed that humans are at least as sensitive as an animal perhaps hundreds of times more sensitive than any other species tested.

These conservative assumptions, which tend to overestimate exposure and risk, are made for three basic reasons: 1) to compensate for deficiencies in technical knowledge or data, 2) to compensate for the uncertainties inherent in the assessment process, and 3) to attempt to include the behaviors of all the population, including sensitive subpopulations. The risks conservatively estimated in this assessment may not represent the risk for all individuals.

5.4.2 Underestimation of Risk

There are factors which may operate to underestimate rather than overestimate risk as well. Sources for underestimation of risk in this assessment include the following:

- some chemicals are more toxic to humans than to small mammal test species
- there are deficits in knowledge about toxicity (e.g., synergistic effects of toxic compounds may exist, toxicity values were not available for several chemicals)
- persistence and environmental fate of constituents is highly uncertain

In summary, there are substantial gaps in our knowledge concerning the human and environmental health effects of chemicals and their environmental fate. To compensate for these deficiencies and uncertainties, conservative assumptions were made during the formulation of the risk assessment.

5.4.3 Potential Bias

Estimates of risk presented in this assessment are most likely biased high. The use of conservative assumptions for nearly every facet of the evaluation may cause a magnifying effect that no longer represents a reasonable maximum exposure, but an unreasonable maximum. The resulting risk estimates may be an extreme estimate rather than a best estimate of conditional risk (particularly for the residential scenario). The magnitude of the bias is conservatively estimated at one order of magnitude, given the inherent range of variability in quantitative risk assessment (U.S. EPA, RAGS, 1989).

5.5 Conclusions

Two conclusions can be drawn from the foregoing analysis: 1) there is no significant ecological impact from the site, and 2) no significant human health impacts can be expected from most probable exposure patterns. The risk estimates provided in this risk assessment, for both current and future land use scenarios, are based on reasonable maximum exposure. This level of exposure employs not the average but upper-bound exposure parameters for a given scenario. The result is that exposure and risk are estimated for the less probable exposure scenario. Average risk, or the more probable risk, would therefore be expected to be significantly less than the risk presented under the reasonable maximum scenario.

Under actual current site conditions, site risk is non-existent since there is no public access. Under the assumed conditions of site access for current land use - with access, the highest risk (10^{-5}) is the carcinogenic risk presented by exposure to pond oil. The inherent uncertainties in PCB risk evaluation have been discussed; the conclusion can be made, however, that PCB risk evaluation most probably overestimates risk by several orders of magnitude. This overestimation stems not only from the mathematical compounding of conservative assumptions but also from the equivocal nature of the carcinogenicity of the polychlorinated biphenyls. If pond oil is removed from the current -with access exposure scenario, the cancer risk drops an order of magnitude (from 2.0×10^{-5} to 3.0×10^{-5}.

If pond contents (oil, water and solids) are removed from the exposure assessment, the pond area risk becomes 9.0×10^{-7}. As noted earlier, the ponds, because of their depth and unattractive nature, make them unlikely to be a source of regular exposure.

Since the conservative approach to risk evaluation taken in this assessment overestimates risk by one or more orders of magnitude, actual site risk can be considered to fall well within the range of EPA's acceptable levels of 10^{-4} to 10^{-7}. Therefore, the Combustion, Inc. site most probably does not present a significant risk to either human health or the environment.

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APPENDIX A

Letter from Louisiana Department of Wildlife and Fisheries

APPENDIX B

Industrial Hygiene Survey During the Trenching and Pond Sampling Operations

January 9 - 31, 1989

(Report Appendices Not Included)

INDUSTRIAL HYGIENE SURVEY
DURING THE TRENCHING AND
POND SAMPLING OPERATIONS

Combustion, Inc. RI/FS
Livingston Parish, Louisiana
January 9-31, 1989

September 12, 1989

W.O. #85-05

(9.1)

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INDUSTRIAL HYGIENE SURVEY
DURING THE TRENCHING AND
POND SAMPLING OPERATIONS

Combustion, Inc. RI/FS
Livingston Parish, Louisiana
January 8-31, 1989

1 - EXECUTIVE SUMMARY

This air monitoring and industrial hygiene survey was conducted by ERM-Southwest, Inc during trenching and pond sampling activities at the Combustion, Inc. site from January 6, 1989 through January 31, 1989. A total of 40 samples representing area exposures and personal exposures were collected to characterize airborne contaminant concentrations during these activities. Monitoring was performed during trenching and pond sampling because the activities were considered to be "worst case" with regard to potential releases and/or exposures during the remedial investigation. Samples were collected and analyzed for the following constituents: total suspended particulates (area samples), total particulates, arsenic, lead, zinc, total hydrocarbons, polychlorinated biphenyls, and polynuclear aromatic hydrocarbons.

All personal samples were found to be below the analytical level of quantitation for total dust, arsenic, lead, zinc, polynuclear aromatic hydrocarbons and polychlorinated biphenyls. All the samples analyzed for total hydrocarbons were below the analytical level of quantitation, except one field blank. A trace amount of methylene chloride, a common laboratory contaminant, was detected on that one field blank.

The area-wide samples, collected using high volume air samplers, showed little difference between the upwind and the downwind samples for total suspended particulates (TSP). These results indicate that significant dust generation did not occur during trenching.

The boiler house, and the boiler in the house were inspected to determine if asbestos containing materials were present. Three bulk samples were collected from the boiler house and boiler, and analyzed for asbestos. The wall tile on the south wall of the boiler house contains a small percentage of asbestos. Because the tile is non-friable, it is not a hazard unless broken and dust is released. The insulation on the boiler was not identified as containing asbestos.

2 - PURPOSE AND BACKGROUND

Air sampling was conducted by Deanna M. Pursley and R. Glenn Nix during the trenching and pond sampling operations at the Combustion, Inc. site on January 9, 10, 11, 12, 13, 16, 17, and 31, 1989 to characterize potential airborne exposures during these operations. In addition, building material from a building and boiler were sampled by Glenn Nix on January 6, 1989 to identify building materials containing asbestos.

Trenching in alleged burial areas and sampling of the ponds were considered to be "worst case" activities in terms of potential worker exposures to airborne materials during the Combustion, Inc. RI/FS. In preparation for the industrial hygiene survey, previous ERM-Southwest reports regarding the Combustion, Inc. site were reviewed. The "Remedial Investigation and Feasibility Study Work Plan", Combustion, Inc. Site, Livingston Parish, Louisiana, July 28, 1988, presents results of the analysis of the oil/sludge of the ponds and some information on the suspected buried materials. In addition, the "Site Inspection Follow-up Report for the Combustion, Inc. Site, Denham Springs, Louisiana", by The Earth Technology Corporation, March, 1985 was also reviewed. Based on the analytical results presented in these reports, a sampling strategy was designed to monitor for specific materials present at the site using NIOSH and EPA protocols. Sampling was conducted for:

Total Suspended Particulates (40 CFR 50.6)
Total Particulates (NIOSH 500)
Arsenic (NIOSH 7900)
Lead (NIOSH 7082)
Zinc (NIOSH 7030)
Total Hydrocarbon (NIOSH 1500)

Polynuclear Aromatic Hydrocarbons (NIOSH 5506)
Polychlorinated Biphenyls (NIOSH 5503)

Potential asbestos-containing materials from the boiler house were also sampled to determine if asbestos was present.

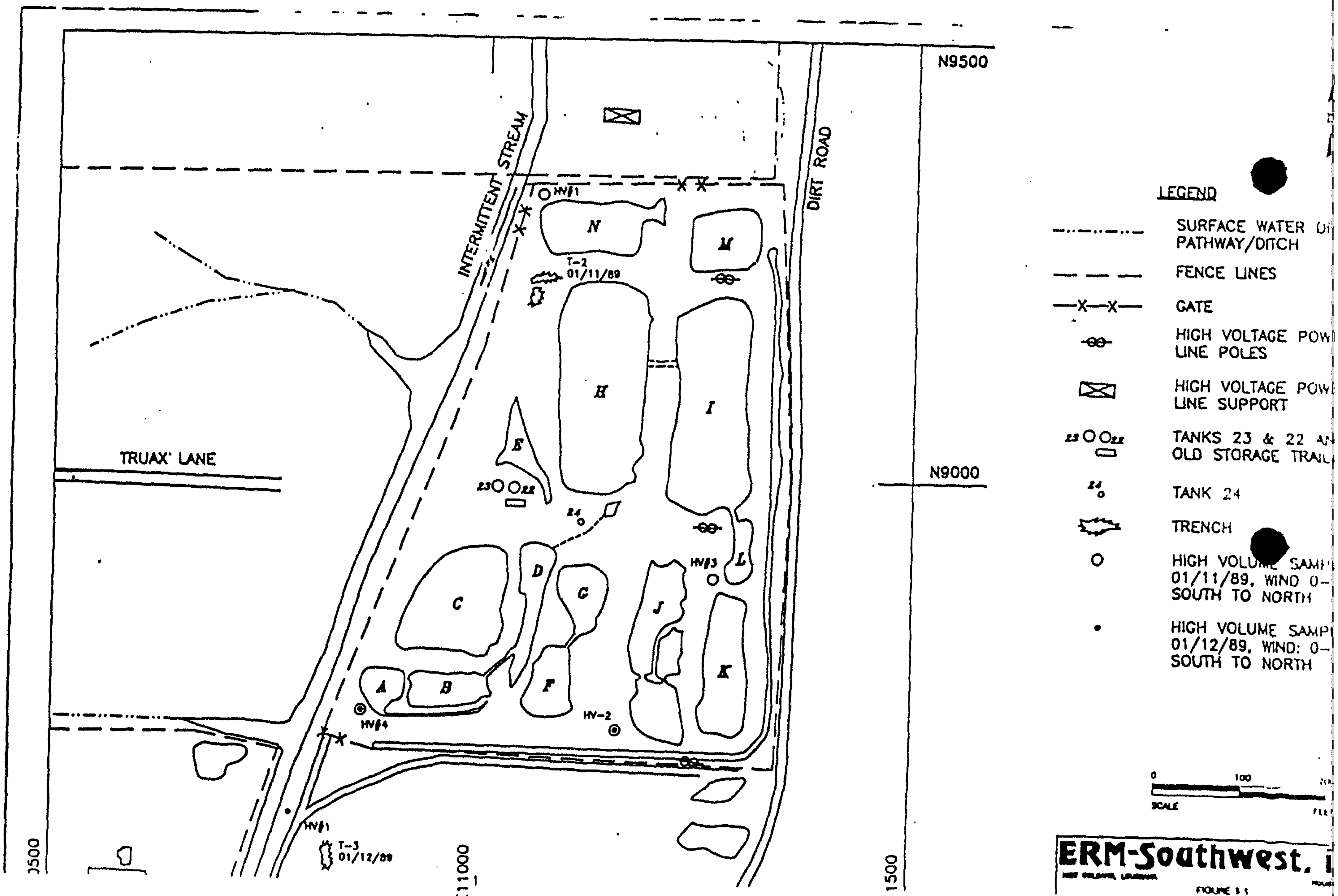
3.1 Area Monitoring

Area sampling for total suspended particulates (TSP) was performed using four GMWT 2200 High Volume Air Samplers fitted with preweighed glass binder filters. Four high volume air samples and one field blank, were collected over approximately eight hours on each of four days during the trenching operations. In total, eight samples were collected in the Process Area and eight in the Pond Area during the four-day period. Each day one high volume air sampler was positioned upwind, and three samplers were positioned downwind, of the area where trenching took place. The positions of the high volume air sampler are shown in Figures 3-1 and 3-2.

The high volume pumps were calibrated on-site before and after use. Operation and calibration instructions can be found in Appendix B. Wind speed and direction was monitored continuously during each day of sampling using the Qualimetrics, Inc. Dual Channel Wind Recording System, Model 3260 and 2132. Appendix C presents the operation and calibration instructions for this wind monitoring system. Wind speed and direction data was recorded continuously for the days on which sampling occurred and is provided in Appendix F.

3.2 Personal Monitoring

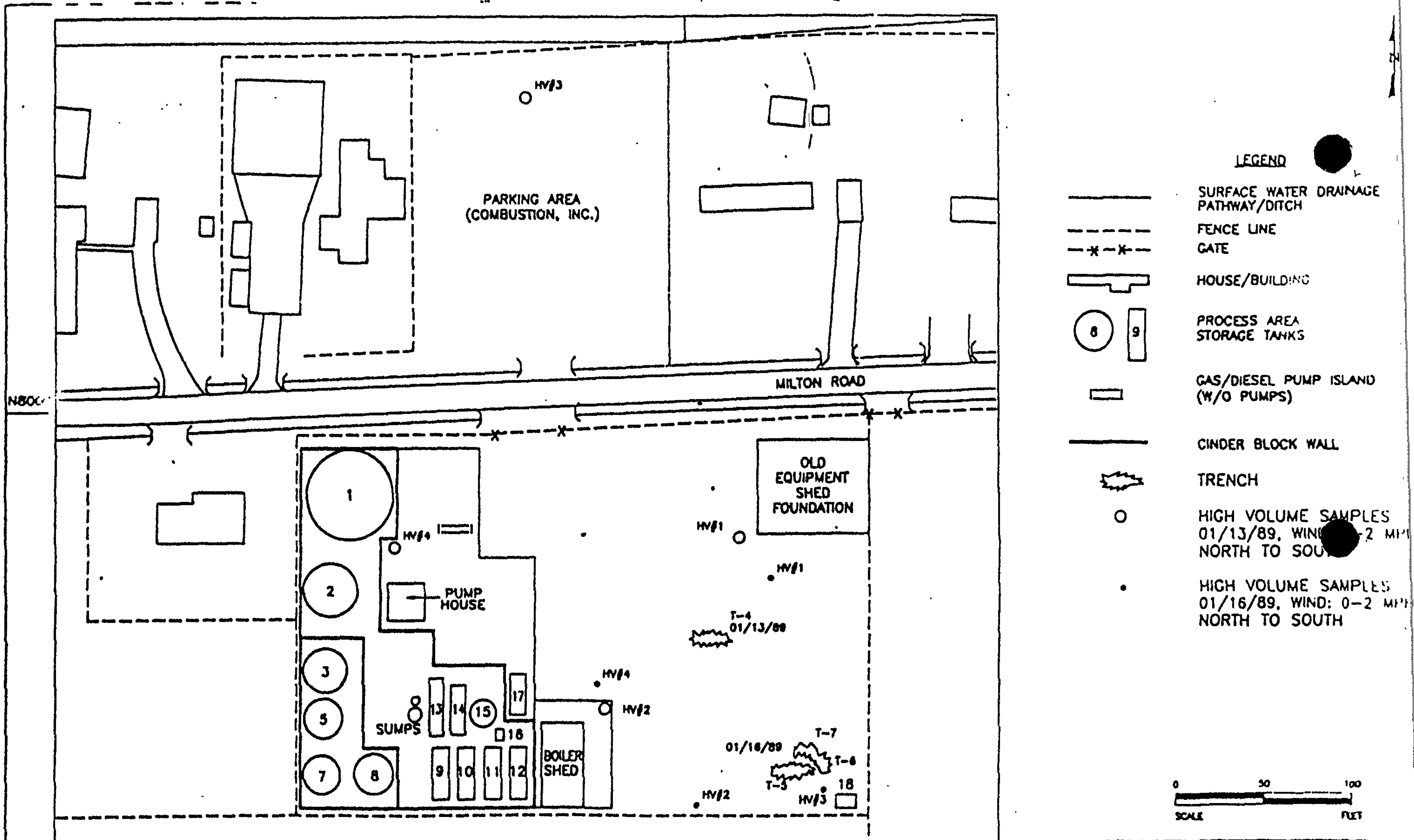
Personal monitoring was conducted during a variety of sampling activities for total dust, lead, zinc, arsenic, polynuclear aromatic hydrocarbons, and polychlorinated biphenyls. Monitoring for these parameters was performed using Gilian AC513 personal pumps. The pumps were calibrated before and after each eight-hour



ERM-Southwest, I

NEW ORLEANS, LOUISIANA

FIGURE 3.1



ERM-Southwest, inc

NEW ORLEANS, LOUISIANA

HOUSTON,

FIGURE 3-1
PROCESS AREA
HIGH VOLUME AIR SAMPLE LOCATIONS
Combustion, Inc

sample was collected. The operation and calibration procedures and calibration results are provided in Appendix D. The sample collection media and analytical procedures are summarized in Table 3-1. The sampling times and conditions for each individual sample are provided in Appendix A. In addition to the Gilian pumps, 3M 3500 Organic Vapor Monitors (passive badge) were used to sample for total hydrocarbons. The badges were worn by workers for approximately 8 hours. The exact exposure time was recorded for each badge. The badges were analyzed for total hydrocarbons, using NIOSH method 1500. Two field blanks were also analyzed.

Following the sample collection, each sample media was sealed and labeled for laboratory identification. Each sample media (except for PNA media) was stored at room temperature in a filing cabinet in the site trailer prior to shipping. The PNA filters were transferred to glass culture tubes, wrapped in aluminum foil and immediately shipped to the laboratory at 0°C.

After all the personal samples were collected, they were packed and sent by Federal Express to Lancaster Laboratories, Lancaster, Pennsylvania. The high-volume air sample filters were sent to NUS Laboratory, Clear Lake, Texas for analysis. Standard chain-of-custody procedures were utilized for all sample shipments.

3.3 Asbestos Survey

An asbestos inspection of a building and boiler on the Combustion, Inc. site was also conducted. Bulk samples of boiler insulation, and floor tile located on the south wall of the building were collected using needle-nosed pliers and a knife. The condition,

TABLE 3-1

Sampling Method Used in Industrial Hygiene Survey During the Trenching and Pond Sampling Operations

Analyte (number of blanks)	Method	Collection Media	Lot Number
Total suspended particulates (4)	EPA 40 CFR 50.6	Glass binder filter	G810
Total particulates (4)	NIOSH 500	37mm-5um MCE membrane filter, tared	LLI
Arsenic (particulate) (4)	NIOSH 7900	37mm-5um MCE membrane filter, tared	LLI
Lead (particulate) (4)	NIOSH 7082	37mm-5um MCE membrane filter, tared	LLI
Zinc (particulate) (4)	NIOSH 7030	37mm-5um MCE membrane filter, tared	LLI
Total Hydrocarbon (Scan) (2)	NIOSH 1500	3M OVM	8258 008
Polynuclear Aromatic Hydrocarbons (2)	NIOSH 5506	37mm-2um, PTFE Teflon, filter	SKC 421310
Polychlorinated Biphenyls (2)	NIOSH 5503	13mm, glass fiber filter, and 100mg/50mg Florisil tube	SKC-H8E85076 SKC 486

NOTE:

LLI = Supplied by Lancaster Laboratories, Inc.

quantity and friability of the building materials sampled were recorded in the Industrial Hygiene field notebook.

The analyses were performed using a Polarized Light Microscope with dispersion staining methods as described in EPA's "Interim Method for the Determination of Asbestos in Bulk Insulation Samples".

The bulk building material and insulation samples were doubled bagged in plastic, labeled and forwarded under chain-of-custody procedures to Accumin Analysis Laboratory, Houston, Texas.

4 - ANALYTICAL RESULTS

During the RI/FS trenching and pond sampling operations, weather conditions varied from clear to intermittent misting to raining. Because rain conditions reduce the concentrations of particulates, and possibly organic compounds in the air, air sampling was discontinued while it was raining. Intermittent misting did not interfere with site work activities, therefore, air sampling continued during these conditions.

4.1 Total Suspended Particulates

Total suspended particulates (TSP) samples were collected upwind and downwind of the trenching to determine if the trenching operations generated significant dust. The results of this study reflect samples collected for 8-10 hours. The amount of particulate matter collected ranged from 0.6 - 6.4 micrograms per cubic meter. As a point of reference, the level of the national primary and secondary 24-hour ambient air quality standards for particulate matter is 150 micrograms per cubic meter, 24-hour average concentration.

Complete results from sampling and analysis of total suspended particulates (including field blanks) are shown in Table 4-1. The data indicate the dust generated by trenching was negligible.

Appendix E presents the analytical laboratory data for total suspended particulates.

4.2 Total Particulates and Metals (Arsenic, Lead and Zinc)

Results from analyses of samples collected and analyzed for total particulates, inorganic arsenic, inorganic lead and zinc indicate

Table 4-1

Total Suspended Particulates Analyses Results (approximately 8 hour samples)

Date	Sample ID	Area/Sample Position	Total Suspended Particulates (ug/m^3)[b]
1/11/89	HV-2	pond/upwind	3.0
1/11/89	HV-3	pond/downwind	3.5
1/11/89	HV-1	pond/downwind	2.6
1/11/89	HV-4	pond/upwind[a]	6.4
1/12/89	HV-3	pond/upwind	4.2
1/12/89	HV-2	pond/downwind	2.5
1/12/89	HV-1	pond/downwind	2.8
1/12/89	HV-4	pond/downwind	4.5
1/13/89	HV-3	process/upwind	1.4
1/13/89	HV-4	process/downwind	1.6
1/13/89	HV-2	process/downwind	0.8
1/13/89	HV-1	process/upwind[a]	0.6
1/16/89	HV-1	process/upwind	2.2
1/16/89	HV-4	process/downwind	2.9
1/16/89	HV-2	process/downwind	2.4
1/16/89	HV-3	process/downwind	2.1

[a] Wind shifted after station selection, therefore this became an upwind sample.

[b] The level of the national primary and secondary 24-hour ambient air quality standards for particulate matter is 150 ug/m^3, 24-hour concentration.

these constituents to be less than the analytical limit of quantitation and therefore also below the OSHA Permissible Exposure Limits (PELs) and the ACGIH Threshold Limit Values (TLVs) shown in Table 4-2. Appendix G contains the laboratory results. Blanks were utilized and are shown as samples #9, 12, 19 and 20.

4.3 Total Hydrocarbons

Twelve samples were collected on passive dosimeters to be analyzed for total hydrocarbons. Of these 12 samples, 2 were field blanks (Samples #3 and #24). All the dosimeters were worn by field personnel during regular field activities. Table 4-3 presents the laboratory quantitation limits, OSHA exposure limits, and ACGIH exposure limits for all hydrocarbons included in this analysis.

The data indicate that all analyses are below the level of quantitation except in one sample. Sample #3 showed methylene chloride at a concentration slightly above the limit of quantitation. Because this sample was a field blank, this result is attributed to a random event in analytical procedures. Appendix G presents the analytical results.

4.4 Polynuclear Aromatic Hydrocarbons (Naphthalene, Phenanthrene, Pyrene)

Four personal samples were collected and analyzed for the following polynuclear aromatic hydrocarbons: naphthalene, phenanthrene and pyrene. All four samples were collected on personnel working one day during trenching in the Process Area.
The analysis of these samples did not detect these polynuclear aromatic hydrocarbons to be above the level of quantitation. Table 4-4 shows the laboratory quantitation limits, OSHA exposure limits,

TABLE 4-2

Analytical Results and Exposure Limits for Total Particulates, Lead, Zinc, and Arsenic

Compound	Analytical Result (mg/m3)	Laboratory Quantitation Limit (mg/m3) [a]	OSHA-PEL (mg/m3)	ACGIH-TLV (mg/m3)
Total Particulates	<0.5	0.5	15	10
Lead (particulate)	<0.002	0.002	0.05	0.15
Zinc (particulate)	<0.009	0.009	5	10
Arsenic (particulate)	<0.00008	0.00008	0.010	0.2

NOTE:

OSHA-PEL	OSHA Permissible Exposure Limit - 8-hour time weighted average
ACGIH-TLV	ACGIH Threshold Limit Value - 8-hour time weighted average

[a] Highest Laboratory Quantitation Limit reported shown here.

Table 4-3

Analytical Results and Exposure Limits for Hydrocarbons

Compound	Analytical Result (ppm)	Laboratory Quantitation Limit (ppm) [a]	OSHA-PEL (ppm)	ACGIH-TLV (ppm)
n-pentane	<2.7	2.7	600.	600
n-hexane	<2.4	2.4	50	50
n-heptane	<2.2	2.2	400	400
n-octane	<2.1	2.1	300	300
iso-octane	<2.1	2.1	---	---
benzene	<0.3	0.3	1	10
toluene	<2.3	2.3	100	100
ethyl benzene	<2.4	2.4	100	100
xylenes	<2.2	2.2	100	100
styrene	<2.3	2.3	50	50
chlorobenzene	<2.1	2.1	75	75
ethanol	<5.4	5.4	1000	1000
n-propanol	<3.1	3.1	200	200
iso-propanol	<3.1	3.1	400	400
n-butanol	<2.8	2.8	100	50
iso-butanol	<3.	3.	100	50
acetone	<3.4	3.4	750	750
methyl ethyl ketone	<2.7	2.7	200	200
methyl isobutyl ketone	<2.2	2.2	50	50
cyclohexanone	<2.5	2.5	50	25
methyl cellosolve	<3.4	3.4	25 *	5
ethyl cellosolve	<3.1	3.1	200 *	5
butyl cellosolve	<2.4	2.4	25	25
cellosolve acetate	<1.9	1.9	100 *	5
ethyl acetate	<2.	2.	400	400
propyl acetate	<2.	2.	200	200
iso-propyl acetate	<2.	2.	250	250
n-butyl acetate	<1.8	1.8	150	150
carbon tetrachloride	<1.	1.	2	5
chloroform	<1.8	1.8	2	10
methylene chloride	<2.4	2.4	500 *	100
1, 1-dichloroethane	<2.1	2.1	100	200
1, 2-dichloroethylene	<2.1	2.1	200	10
1, 1, 1-trichloroethane	<1.7	1.7	50	350
1, 1, 2-trichloroethane	<1.7	1.7	10	10
trichloroethylene	<1.7	1.7	50	50
tetrachloroethylene	<1.	1.	25	50
freon 113	<1.9	1.9	1000 (ceiling)	1000 (ceiling)

NOTE:

OSHA-PEL	OSHA Permissible Exposure Limit - 8-hour time weighted average
ACGIH-TLV	ACGIH Threshold Limit Value - 8-hour time weighted average
	*in the process of rule-making

[a] Highest Laboratory Quantitation Limit reported shown here.

TABLE 4-4

Analytical Results and Exposure Limits for Polynuclear Aromatic Hydrocarbons

Compound	Analytical Result (mg/m3)	Laboratory Quantitation Limit (mg/m3) [a]	OSHA-PEL (mg/m3)	ACGIH-TLV (mg/m3)
Naphthalene	<0.00006	0.00006	50	50
Pyrene	<0.000008	0.000008	Not Listed	Not Listed
Phenanthrene	<0.00001	0.00001	Not Listed	Not Listed

NOTE:

OSHA-PEL	OSHA Permissible Exposure Limit - 8-hour time weighted average
ACGIH-TLV	ACGIH Threshold Limit Value - 8-hour time weighted average

[a] Highest Laboratory Quantitation Limit reported shown here.

and ACGIH exposure limits for PNA's. Appendix G contains the laboratory results.

4.5 Polychlorinated Biphenyls

Four personal samples were collected and analyzed for polychlorinated biphenyls. All four samples were collected on field personnel one day during the sampling of Ponds H, G, and F in the Pond Area. The analysis of these samples did not detect any PCB's to be above the level of quantitation. Table 4-5 shows the laboratory quantitation limits, OSHA exposure limits and ACGIH exposure limits for PCB's. Appendix G contains the laboratory results.

4.6 Asbestos

Three samples of bulk building material and insulation were collected from the building and boiler on the site. The location of this building is shown in Figure 3-2. Table 4-6 shows the sample location, description and analytical results of the polarized light microscopy analyses of the samples. Appendix H contains the laboratory results.

Asbestos was found in the wall tile which covers the south wall of the building. The presence of asbestos does not present a hazard because the material is non-friable and fibers would not be released unless the tiles were mechanically broken down.

Table 4-6

Bulk Samples Analyzed for Asbestos

Sample #1	Location	Description	% Asbestos
1	Boiler House	pipe, top of boiler	0
2	Boiler House	pipe, top of boiler	0
3	Boiler House	wall tile on south wall	1-2 chrysotile

5 - CONCLUSIONS

The industrial hygiene survey at the Combustion, Inc. site during trenching and pond sampling activities produced the following conclusions:

1. Dust generation during trenching and pond sampling activities was negligible. Although there are not sufficient data to do a rigorous statistical evaluation comparing upwind and downwind values, review of the data show the upwind and downwind values to be essentially the same during this period. The scatter in the data is typical of data sets of ambient particulate values.

   The absence of even modest increases in downwind particulate values during this "worst case" exposure scenario indicates that the studied events did not result in off-site migration of particulate materials.

2. During the study period there was no measurable worker exposure to the following constituents:
   - Total dust
   - Arsenic
   - Lead
   - Zinc
   - Total hydrocarbons
   - Polychlorinated biphenyls
   - Polynuclear aromatics hydrocarbons

   Because the trenching and sampling by personnel represent the "worst case" exposure scenario, it is concluded that these constituents are not being transmitted by air to off-site locations.

3. The boiler house does not present an asbestos hazard as long as the wall tile on the south wall remains intact and non-friable.