250
9/24/77
T.S.
(2) 492 R-2250
Dr. 2324

DOE/RA-7137

STRATEGIC PETROLEUM RESERVE
WEST HACKBERRY OIL STORAGE CAVERN
FIRE AND SPILL
OF SEPTEMBER 21, 1978

MASTER

AN ENVIRONMENTAL ASSESSMENT

U. S. DEPARTMENT OF ENERGY
FEBRUARY, 1980

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

"NOTICE"

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the Department of Energy, nor any of their employees, nor any of their contractors, subcontractors or their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

The views, opinions and conclusions contained in this report are those of the contractors and do not necessarily represent those of the United States Government or the United States Department of Energy.

STRATEGIC PETROLEUM RESERVE
WEST HACKBERRY OIL STORAGE CAVERN FIRE AND SPILL
OF
SEPTEMBER 21, 1978

AN ENVIRONMENTAL ASSESSMENT

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION	1-1
2.0 ASSESSMENT ORGANIZATION	2-1
3.0 DESCRIPTION OF THE WEST HACKBERRY SITE	3-1
4.0 DESCRIPTION OF THE INCIDENT	4-1
5.0 OBJECTIVES OF THE ENVIRONMENTAL ASSESSMENT	5-1
5.1 CHEMICAL FACTORS	5-1
5.2 PREVIOUS SPILLS IN THE AREA	5-4
5.3 BIOLOGICAL FACTORS	5-4
5.3.1 Microbial Degradation	5-4
5.3.2 Health Hazards	5-5
5.4 FORMULATION OF THE ENVIRONMENTAL ASSESSMENT PLAN	5-8
6.0 LITERATURE REVIEW	6-1
6.1 BIOLOGICAL	6-1
6.2 CHEMICAL	6-16
7.0 METHODS AND MATERIALS	7-1
7.1 SAMPLING APPROACH	7-1
7.2 FIELD TECHNIQUES	7-2
7.2.1 Biological	7-2
7.2.2 Chemical	7-5
7.2.2.1 Trace Metals	7-5
7.2.2.2 Hydrocarbon Samples	7-5
7.2.3 Physical	7-6

TABLE OF CONTENTS (Cont.)

		Page
7.3	LABORATORY TECHNIQUES	7-11
7.3.1	Biological	7-11
7.3.2	Chemical	7-14
7.3.2.1	Chemical Extraction and Workup	7-14
7.3.2.2	Analytical Instruments and Calibration	7-18
7.3.2.3	Infrared Spectrometry	7-21
7.3.2.4	Capillary Gas Chromatography	7-22
7.3.2.5	Gas Chromatography/Mass Spectrometry	7-26
7.3.2.6	Trace Metal Analytical Techniques	7-29
7.3.3	Physical	7-33
7.4	DATA ANALYTICAL TECHNIQUES	7-35
7.4.1	Biological	7-35
7.4.2	Chemical	7-35
7.4.3	Physical	7-49
8.0	RESULTS	8-1
8.1	BIOLOGICAL	8-1
8.1.1	Black Lake Benthos	8-1
8.1.2	Marsh Benthos	8-18
8.1.3	Marsh Vegetation	8-32
8.1.4	Nekton	8-50
8.1.5	Biochemical Analyses	8-60
8.1.6	Birds	8-60
8.2	CHEMICAL	8-66
8.2.1	Quantitative Analysis by Infrared Spectroscopy	8-66
8.2.2	Qualitative Analysis by Capillary Gas Chromatography and Capillary Gas Chromatography/Mass Spectrometry	8-72
8.2.3	Quantitative Analysis by Glass Capillary Gas Chromatography	8-123
8.2.4	Trace Metal Analysis	8-145
8.2.4.1	Introduction	8-145
8.2.4.2	Analysis of Oil from Known Sources	8-145
8.2.4.3	Soils and Sediments	8-145
8.2.4.4	Analysis of Trace Metals on Vegetation	8-148
8.2.4.5	Total Fallout Estimates Based on Foliar Vanadium Analysis	8-151

TABLE OF CONTENTS (Cont.)

		Page
8.2.5	Pyrogenic Hydrocarbons	8-154
8.2.6	Comparison of Trace Metal and Chemical Analyses	8-176
8.3	PHYSICAL	8-180
8.3.1	Grain Size Analysis	8-180
8.3.2	Meteorology	8-180
8.3.3	Air Quality	8-198
8.3.4	Hydrology	8-201
8.4	REMOTE SENSING	8-211
8.4.1	Introduction and Objectives	8-211
8.4.2	Data Acquisition	8-214
8.4.3	Data Analysis	8-217
8.4.4	Results	8-218
9.0	DISCUSSION AND CONCLUSIONS	9-1
9.1	BIOLOGICAL	9-1
9.2	CHEMICAL	9-5
9.2.1	Factors that Affect Assessment	9-5
9.2.1.1	Chemical Factors	9-5
9.2.1.2	Physical Factors	9-7
9.2.2	Conclusions	9-8
9.3	PHYSICAL	9-11
10.0	CONJUNCTIVE BIOLOGICAL/CHEMICAL/PHYSICAL CONCLUSIONS	10-1
	LITERATURE CITED	
	APPENDICES	
A.	STATIONS SAMPLED	A-1
B.	BIOLOGY	B-1
B.1	Lake Fauna Densities	B-2
B.2	Marsh Fauna Densities	B-16
B.3	Computer Programs Developed for This Assessment	B-35
B.4	Variance Ratios (F) for Two-Level Analyses of Variance	B-56
B.5	Marsh Vegetation Data	B-61

TABLE OF CONTENTS (Cont.)

		Page
C.	CHEMISTRY	C-1
	C.1 Representative Gas Chromatographic Data	C-2
	C.2 Representative Mass Spectral Data	C-43
	C.3 Discriminant Analysis Results	C-51
	C.4 Plume Models	C-100
	C.5 Trace Metal Data	C-110
	C.6 Quantitative Data - Petroleum Hydrocarbon Contamination and Pyrogenic Products	C-122
D.	WIND FREQUENCY DISTRIBUTIONS	D-1
E.	QUALITY ASSURANCE	E-1
F.	ASSESSMENT TEAM MEMBERS	F-1

LIST OF TABLES

Table	Title	Page
5.3-1	Cancer Potential for Some Polycyclic Aromatic Hydrocarbons	5-6
6.1-1	Toxicity Tests of Water Soluble Fractions of Various Oils	6-3
7.4-1	Standardized Discriminant Function Coefficients	7-47
8.1-1	Animal Species Found in Benthic Samples	8-2
8.1-2	Mean Densities (per 0.25 m^2) ± One Standard Error of Selected Taxa in Black Lake Benthic Samples	8-5
8.1-3	Three-Level Nested Analysis of Variance for Black Lake Polychaeta	8-12
8.1-4	Three-Level Nested Analysis of Variance for Black Lake Bivalves	8-13
8.1-5	Three-Level Nested Analysis of Variance for Black Lake Tanaidacea	8-14
8.1-6	Three-Level Nested Analysis of Variance for Black Lake Amphipoda	8-15
8.1-7	Three-Level Nested Analysis of Variance for Black Lake Total Animals	8-16
8.1-8	Sensitivity of Lake Sediment Faunal Analysis to Changes in Average Density of the Total Fauna	8-17
8.1-9	Mean Densities (per 0.25 m^2) ± One Standard Error of Selected Taxa in Marsh Samples	8-21
8.1-10	Three-Level Nested Analysis of Variance for Marsh Tanaidacea	8-28
8.1-11	Three-Level Nested Analysis of Variance for Marsh Amphipoda	8-29
8.1-12	Three-Level Nested Analysis of Variance for Marsh Total Animals	8-30
8.1-13	Sensitivity of Marsh Faunal Analysis to Changes in Average Density of the Total Fauna	8-31

LIST OF TABLES (Cont.)

Table	Title	Page
8.1-14	Dominant Species List, Vegetative Communities, West Hackberry, Louisiana	8-38
8.1-15	Mean ± One Standard Error of Total Dry Weights of 0.25 m^2 Vegetation Biomass Samples	8-46
8.1-16	Significance Test (t-distribution) for Total Biomass of Vegetation Samples	8-48
8.1-17	Productivity and Maximum Standing Biomass for Juncus roemerianus	8-49
8.1-18	Phase I Gill Net Sampling Times in Black Lake	8-51
8.1-19	Phase II Gill Net Sampling Times in Black Lake	8-52
8.1-20	Phase III Gill Net Sampling Times in Black Lake	8-53
8.1-21	Phase IV Gill Net Sampling Times in Black Lake	8-54
8.1-22	Total Phase I Gill Net Catch in Black Lake	8-55
8.1-23	Total Phase II Gill Net Catch in Black Lake	8-56
8.1-24	Total Phase III Gill Net Catch in Black Lake	8-57
8.1-25	Total Phase IV Gill Net Catch in Black Lake	8-58
8.1-26	Louisiana Wild Life and Fisheries Commission Otter Trawl Survey of Black Lake, 1968-1969	8-59
8.1-27	Results of Biochemical Analyses of Water Samples Taken From Black Lake Adjacent to Affected and West Control Marshes on September 30, 1978	8-61
8.1-28	Bird List for Phases I and III	8-63
8.2-1	Quantification of Oil Contamination, DOE Hackberry Sediment Samples	8-67
8.2-2	Quantification of Oil Contamination, DOE Hackberry Water, Soil and Mussel Samples	8-70
8.2-3	Pristane/Phytane Ratios in Sediment Samples	8-84

LIST OF TABLES (Cont.)

Table	Title	Page
8.2-4	Pristane/Phytane Ratios in Soil, Water and Oil Samples	8-85
8.2-5	Persistence of Cavern 6 Oil in the West Hackberry Environment As Indicated By Its Presence or Absence at Various Stations Analyzed by Gas Chromatography	8-87
8.2-6	Alkylated Phenanthrene/Alkylated DBT Ratio, DOE Hackberry Sediment Samples	8-95
8.2-7	Alkylated Phenanthrene/Alkylated DBT Ratio, DOE Hackberry Soil Samples	8-99
8.2-8	Alkylated Phenanthrene/Alkylated DBT Ratio, DOE Hackberry Foliage Samples	8-101
8.2-9	Alkylated Phenanthrene/Alkylated DBT Ratio, Cavern 6 Crude Oil and Tissue Samples	8-103
8.2-10	Compounds Detected in Air Samples Taken at Site 1, Phase I, SPR Site, Hackberry, Louisiana	8-125
8.2-11	Quantification of Oil Contamination, Hackberry Sediment Samples	8-129
8.2-12	Quantification of Oil Contamination, Hackberry Soil Samples	8-133
8.2-13	Quantification of Oil Contamination, Hackberry Foliage Samples	8-134
8.2-14	Quantification of Oil Contamination, Black Lake Mussel Tissue Samples	8-135
8.2-15	Quantification of Oil Contamination in West Hackberry Soil and Sediment Samples	8-136
8.2-16	Persistence of Cavern 6 Crude Oil in the West Hackberry Environment	8-140
8.2-17	Differences in Oil Concentration (in ppm) in Soil and Sediment Samples	8-143
8.2-18	Trace Metal Concentrations in Oil Samples (in ppm)	8-146
8.2-19	Trace Metal Analyses of Phase II Soils	8-147

LIST OF TABLES (Cont.)

Table	Title	Page
8.2-20	Trace Metal Analyses of Phase II Sediments.....	8-149
8.2-21	Trace Metal Concentrations in Vegetation (Phases I and II).....	8-150
8.2-22	Vegetational Vanadium-Aluminum Comparisons for Phases I and IV.....	8-152
8.2-23	Comparison of Trace Metal and Chemical Analyses, Phase I - Vegetation.....	8-178
8.3-1	Temperature During the West Hackberry Cavern 6 Oil Spill and Fire.....	8-184
8.3-2	Raw Frequency Distribution of Winds During the West Hackberry Fire, Lake Charles Data, September 21-27, 1978.....	8-185
8.3-3	Relative Frequency Distribution of Winds During the West Hackberry Fire, Lake Charles Data, September 21-27, 1978.....	8-186
8.3-4	Raw Frequency Distribution of Winds, West Hackberry Site, Station 1, September 29 - December 27, 1978.....	8-192
8.3-5	Relative Frequency Distribution of Winds, West Hackberry Site, Station 1, September 29 - December 27, 1978.....	8-193
8.3-6	Raw Frequency Distribution of Winds, West Hackberry Site, Station 2, September 29 - December 27, 1978.....	8-194
8.3-7	Relative Frequency Distribution of Winds, West Hackberry Site, Station 2, September 29 - December 27, 1978.....	8-195
8.3-8	Raw Frequency Distribution of Winds, West Hackberry Site, Station 3, September 29 - December 27, 1978.....	8-196
8.3-9	Relative Frequency Distribution of Winds, West Hackberry Site, Station 3, September 29 - December 27, 1978.....	8-197
8.3-10	Onsite Air Quality Data During the West Hackberry Fire, September 25-26, 1978.....	8-200
8.3-11	Hourly Air Quality Data, West Orange, Texas, September 15, 1978 - October 4, 1978.....	8-202

LIST OF TABLES (Cont.)

Table	Title	Page
8.3-12	Hourly Air Quality Data, Nederland, Texas, September 15, 1978 - October 4, 1978.....	8-203
8.4-1	Standard Multispectral Photography.....	8-215
8.4-2	Multispectral Scanner.....	8-216

LIST OF FIGURES

Figure	Title	Page
2.0-1	Environmental Assessment Team Organization.....	2-2
4.0-1	Detail of Area in Immediate Vicinity of Cavern 6 Indicating the Permanent Levee, Oil Containment Boom Placement and the Containment of Oil by the Booms.....	4-4
5.4-1	Flow Chart of the Environmental Assessment Plan.....	5-9
6.2-1	Examples of Selected Hydrocarbon Distributions in Nine Crude Oils.....	6-17
7.2-1	Locations of Biology Sampling Sites in Black Lake.....	7-4
7.2-2	Meteorological Stations at the West Hackberry Site, September - December, 1978.....	7-8
7.2-3	Air Quality Monitoring Stations at West Hackberry Site, September 25-26, 1978.....	7-9
7.3-1	Benthic Sample Subsampling and Sorting Procedure.....	7-13
7.3-2	Mass Chromatograms of the Phenanthrene and Dibenzothiophene Families of Hydrocarbons in Cavern 6 Oil.....	7-28
7.4-1	Gas Chromatogram of Cavern 6 Crude Oil.....	7-37
7.4-2	Gas Chromatogram of Cavern 6 Artificially Weathered Crude Oil.....	7-38
7.4-3	Gas Chromatogram of Louisiana Sweet Crude Oil.....	7-39
7.4-4	Gas Chromatogram of Artificially Weathered Louisiana Sweet Crude Oil.....	7-40
7.4-5	Mass Chromatograms of the Dibenzothiophene Family in Cavern 6 and Louisiana Sweet Crude Oils.....	7-42
7.4-6	Mass Chromatograms of the Phenanthrene Family in Cavern 6 and Louisiana Sweet Crude Oils.....	7-43
7.4-7	Mass Chromatograms of the Naphthalene Family in Cavern 6 and Louisiana Sweet Crude Oils.....	7-44
8.1-1	Differences in Black Lake Benthic Faunal Densities Between Sites During Phase I.....	8-7

LIST OF FIGURES (CONT.)

Figure	Title	Page
8.1-2	Differences in Black Lake Benthic Faunal Densities Between Sites During Phase II	8-8
8.1-3	Differences in Black Lake Benthic Faunal Densities Between Sites During Phase III	8-9
8.1-4	Differences in Black Lake Benthic Faunal Densities Between Sites During Phase IV	8-10
8.1-5	Temporal Changes in Relative Abundances of Selected Taxa in Black Lake Sediments	8-19
8.1-6	Differences in Marsh Faunal Densities Between Sites During Phase I	8-23
8.1-7	Differences in Marsh Faunal Densities Between Sites During Phase II	8-24
8.1-8	Differences in Marsh Faunal Densities Between Sites During Phase III	8-25
8.1-9	Differences in Marsh Faunal Densities Between Sites During Phase IV	8-26
8.1-10	Temporal Changes in Relative Abundances of Selected Taxa in Marsh Sediments	8-33
8.1-11	Size-Frequency Distributions of Mussels (*Geukensia demissa*) from the Sites	8-35
8.1-12	Map of Vegetative Communities in Vicinity of the West Hackberry Site	8-37
8.2-1	Expanded Gas Chromatogram of Cavern 6 Crude Oil	8-74
8.2-2	Expanded Gas Chromatogram of Louisiana Sweet Crude Oil	8-75
8.2-3	Gas Chromatogram of Slick 6.4 km West of DOE Site	8-76
8.2-4	Gas Chromatogram of Amoco Oil	8-77
8.2-5	Gas Chromatogram of Surface Water at Station 9-9-C in Phase I	8-78
8.2-6	Gas Chromatogram of Surface Water at Station 9-5-C in Phase I	8-79

LIST OF FIGURES (CONT.)

Figure	Title	Page
8.2-7	Gas Chromatogram of Sediment Sample No. 26.....	8-81
8.2-8	Sample Gas Chromatogram Demonstrating Interference on the Pristane Peak.....	8-82
8.2-9	Expanded Sample Gas Chromatogram Demonstrating the Resolution of a Pristane Peak.....	8-83
8.2-10	Sample Gas Chromatogram of a Heavily Weathered Oil.....	8-86
8.2-11	Gas Chromatogram of the Aliphatic Components of Sediment Sample No. 597.....	8-90
8.2-12	Expanded Gas Chromatogram of the Aliphatic Components of Sediment Sample No. 597.....	8-91
8.2-13	Gas Chromatogram of the Aliphatic Components of Sediment Sample No. 963.....	8-92
8.2-14	Gas Chromatogram of the Aliphatic Components of Sediment Sample No. 1116.....	8-93
8.2-15	Ratio of C_1 Phenanthrene to C_1 Dibenzothiophene in Phase I Sediment Samples.....	8-104
8.2-16	Ratio of C_2 Phenanthrene to C_2 Dibenzothiophene in Phase I Sediment Samples.....	8-105
8.2-17	Ratio of C_3 Phenanthrene to C_3 Dibenzothiophene in Phase I Sediment Samples.....	8-106
8.2-18	Ratio of C_1 Phenanthrene to C_1 Dibenzothiophene in Phase II Sediment Samples.....	8-107
8.2-19	Ratio of C_2 Phenanthrene to C_2 Dibenzothiophene in Phase II Sediment Samples.....	8-108
8.2-20	Ratio of C_3 Phenanthrene to C_3 Dibenzothiophene in Phase II Sediment Samples.....	8-109
8.2-21	Ratio of C_1 Phenanthrene to C_1 Dibenzothiophene in Phase III Sediment Samples.....	8-110
8.2-22	Ratio of C_2 Phenanthrene to C_2 Dibenzothiophene in Phase III Sediment Samples.....	8-111

LIST OF FIGURES (CONT.)

Figure	Title	Page
8.2-23	Ratio of C_3 Phenanthrene to C_3 Dibenzothiophene in Phase III Sediment Samples	8-112
8.2-24	Ratio of C_1 Phenanthrene to C_1 Dibenzothiophene in Phase IV Sediment Samples	8-113
8.2-25	Ratio of C_2 Phenanthrene to C_2 Dibenzothiophene in Phase IV Sediment Samples	8-114
8.2-26	Ratio of C_3 Phenanthrene to C_3 Dibenzothiophene in Phase IV Sediment Samples	8-115
8.2-27	Distribution of Oils as Indicated by Discriminant Functions Analysis	8-116
8.2-28	Gas Chromatogram of the Aliphatic Components of Sediment Sample No. 16	8-119
8.2-29	Gas Chromatogram of the Aliphatic Components of Sediment Sample No. 940	8-120
8.2-30	Gas Chromatogram of the Aliphatic Components of Sediment Sample No. 1253	8-121
8.2-31	Gas Chromatogram of the Aliphatic Components of Sediment Sample No. 1551	8-122
8.2-32	Air Samples - Site 1 (Phase I)	8-124
8.2-33	Cavern 6 Crude Oil Volatiles, Tag No. 4	8-126
8.2-34	Louisiana Sweet Crude Oil Volatiles, Tag No. 208	8-127
8.2-35	Regression of Foliage Vanadium Concentration on Distance from Cavern 6	8-153
8.2-36	Pyrogenic Products in Phase I Foliage	8-155
8.2-37	Pyrogenic Products in Phase I Sediments in a Non-Impact Area (Canal)	8-157
8.2-38	Pyrogenic Products in Phase I Sediments in a Non-Impact Area (Lake)	8-158
8.2-39	Pyrogenic Products in Phase I Sediments in the Impact Area	8-159

LIST OF FIGURES (CONT.)

Figure	Title	Page
8.2-40	Pyrogenic Products in Phase II Foliage.....	8-162
8.2-41	Pyrogenic Products in Phase II Soils.....	8-163
8.2-42	Pyrogenic Products in Phase II Sediments in a Non-Impact Area (Lake).....	8-164
8.2-43	Pyrogenic Products in Phase II Sediments in the Impact Area.....	8-165
8.2-44	Pyrogenic Products in Phase III Foliage.....	8-167
8.2-45	Pyrogenic Products in Phase III Soils.....	8-168
8.2-46	Pyrogenic Products in Phase III Sediments in a Non-Impact Area (Lake and Wildlife Refuge).....	8-170
8.2-47	Pyrogenic Products in Phase III Sediments in the Impact Area.....	8-172
8.2-48	Pyrogenic Products in Phase IV Soils.....	8-174
8.2-49	Pyrogenic Products in Phase IV Sediments in a Non-Impact Area (Lake).....	8-175
8.2-50	Pyrogenic Products in Phase IV Sediments in the Impact Area.....	8-177
8.3-1	Cumulative Percent Grain Size Distributions for Black Lake Sediments.....	8-181
8.3-2	Cumulative Percent Grain Size Distributions for Marsh Sediments.....	8-182
8.3-3	Comparison of Wind Rose Data, Lake Charles, Louisiana...	8-187
8.3-4	Wind Speed and Direction During the West Hackberry Cavern 6 Spill and Fire.....	8-188
8.3-5	Drogue Trajectories for Black Lake, West Hackberry Site, December 7, 1978.....	8-205
8.3-6	Wind Speed and Direction During Drogue Studies, Black Lake, December 7, 1978.....	8-206

LIST OF FIGURES (CONT.)

Figure	Title	Page
8.3-7	Comparison of Surface Current and Wind on Black Lake, December 7, 1978.....	8-207
8.3-8	Oil Distribution and Containment in Black Lake at West Hackberry Site, September 22, 1978 (0130 CST).....	8-209
8.3-9	Oil Distribution and Containment in Black Lake at West Hackberry Site, September 23, 1978 (1800 CST).....	8-210

LIST OF PLATES

Plate	Title	Page
4.0-1	The Fire at Wellpad 6 2-1/2 Hours After It Began.....	4-2
4.0-2	Wellpad 6 Showing Booms and Weir Pits.....	4-3
4.0-3	Looking East Over Black Lake, September 25, 1978.....	4-5
8.1-1	Examples of Oiled Vegetation in the Affected Area, Phase I.....	8-44
8.3-1	Plume Rise From the Fire, September 23, 1978.....	8-199
8.4-1	Black-and-White and Enhanced Color Infrared Images.....	8-219
8.4-2	Enhanced Color Infrared Thematic Map from 3,200 m on October 1, 1978.....	8-221
8.4-3	Black-and-White Images Showing the Extent of the Plume from the Site of the Fire to the Gulf Coast. Taken at 3,200 m on September 24, 1978.....	8-223
8.4-4	Black-and-White Images (September 1978) and Comparable Enhanced Color Infrared Image (July 1979).....	8-224
8.4-5	Enhanced Color Infrared Thematic Maps, October 1978 (Left) Showing Stressed Vegetation and July 1979 (Right) With No Stressed Vegetation.....	8-225
8.4-6	Black-and-White (October 1978) and Enhanced Color Infrared Images (July 1979).....	8-226
8.4-7	Enhanced Color Infrared Thematic Map (July 1979) Showing No Evidence of Continued Vegetation Stress.....	8-227
8.4-8	Enhanced Color Infrared Mosaic (July 1979).....	8-229
8.4-9	Black-and-White and Enhanced Color Infrared Images (July 1979).....	8-230
8.4-10	Black-and-White and Enhanced Color Infrared Images (July 1979).....	8-231

ACKNOWLEDGEMENTS

We wish to acknowledge and thank the following entities, without whose expert and consistent effort this document would not have been possible.

1) Department of Energy
Strategic Petroleum Reserve Office
900 Commerce Road
New Orleans, Louisiana 70823

2) Louisiana Stream Control Commission
Lake Charles, Louisiana

3) U.S. Fish and Wildlife Service
Sabine National Wildlife Refuge

4) DOE Personnel and Contractors
Stategic Petroleum Reserve Site
West Hackberry, Louisiana

5) Regional Response Team, Region VI
Dallas, Texas

EXECUTIVE SUMMARY

This report completes extensive efforts to provide an environmental assessment of the fire and oil spill which occurred at the Strategic Petroleum Reserve (SPR) site at West Hackberry, Louisiana. The fire and subsequent spill started at 1600 Central Daylight Savings Time (CDT) on September 21, 1978. An oil well workover rig was in the process of removing brine piping from Well 6 in Cavern 6 of the West Hackberry Strategic Petroleum Reserve site when the accident occurred. The 5-1/2 inch brine pipe was being removed from the well when a packer inexplicably slipped up the piping and allowed oil to flow to the surface. Vapors from this oil immediately ignited, resulting in the death of one rig crew member and serious injury of another. The rig and surrounding equipment were subsequently destroyed or damaged in the fire.

An estimated 72,000 barrels of oil spilled to the surface as the cavern depressurized. A packer was set to stem the flow on September 26, 1978. The fire was then extinguished and all response actions were directed toward oil spill cleanup. Of the total quantity spilled, 52,000 barrels (including 32,000 barrels spilled into Black Lake) were eventually recovered. The remainder (20,000 barrels) burned or was irrecoverably attached to the soil and debris, which has been removed from the well pad area for further treatment and disposal. The recovered oil was reinjected into caverns, as test results confirmed that the quality was acceptable for SPR use.

The U.S. Coast Guard declared the spill a major pollution incident because of the spill volume and the potential for damage to the adjoining Black Lake. Because of this declaration, many state officials and the federal Regional Response Team members came onscene to assist in the response action and/or to carry out regulatory responsibilities, as required by the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 1510). The Department of Energy quickly established

an onsite Command Center from which response actions were directed and coordinated. Hundreds of personnel from area fire departments, oil spill cleanup companies, well fire consulting firms and their support contractors, regulatory agencies, and news media were onscene within hours.

Cleanup of the approximately 32,000 barrels of oil that spilled on Black Lake began on September 24, 1978, even before the fire was extinguished. Most of this oil was recovered from Black Lake within 3 days. During this period, oil was recovered at a peak rate of eight barrels per minute and was trucked to nearby barges and storage tanks. Final shoreline cleanup was completed on October 11, 1978, and the cleanup action was approved for termination by the Regional Response Team on that date. Fast and effective spill containment along with favorable weather conditions contributed to an unusually rapid and effective cleanup operation.

The final estimated cost for the entire fire and spill response, equipment and oil losses, and liabilities was between 14 and 20 million dollars. The cost for oil spill containment and recovery alone was approximately 350,000 dollars, or 25 cents per gallon.

The need for assessment and documentation of any environmental damage which could result from the oil spill and fire was recognized immediately by the Department of Energy as an important element of the response action. Further, under the documentation and cost recovery phase of a federal response action (National Contingency Plan, Section 1510.45, Phase V), the collection of scientific and technical information may be of value to the scientific community. Such information would serve as a basis for research and development activities and for the enhancement of the understanding of the environment. The Regional Response Team environmental agency representatives and their scientific contractors were interested in pursuing this initiative upon arrival at

West Hackberry. Concurrently, the Department of Energy recognized early that the collection of samples and necessary data should be coordinated through a unified interdisciplinary effort.

On September 26, all onsite environmental scientists convened to establish a plan and scope for the damage assessment. State agency representatives chose not to serve as official members of the multi-institution team but offered other assistance.

A comprehensive environmental assessment program was established and implemented by a team of personnel from several federal agencies, universities, and government contractors within days of the accident. Within 2 weeks, over 500 biological, chemical, and meteorological samples were taken from the lake, marsh and land for analysis. Followup samples were collected over the next 12 months. Maps of all the sampling stations are found in Appendix A, Figures A.1-2 and A.1-3. The team's initial assessment after the first sample collection period was that the impact to the environment was minimal and that quick reaction by site personnel and extremely favorable weather conditions significantly averted more severe environmental damage.

A 1-year assessment of selected environmental impacts of the oil spill and fire was completed in four phases. Preliminary subjective identification of contaminated habitats was supported by a more rigorous classification of samples utilizing discriminant analysis of several oil characteristics. This analysis resulted in the identification of 14 stations containing spilled oil from Cavern 6, and 19 stations lacking this oil. The contaminated stations were distributed along the shore of Black Lake just north and west of Wellpad 6, encompassing an area of approximately 9 hectares.

Seasonal variation in the structures of marsh and lake bottom communities in this contaminated area were not generally distinguishable from that of similar communities in uncontaminated areas along the

southern and southeastern shores of Black Lake. Analyses of the faunal differences between these sites were sufficiently sensitive to detect a 20 to 45 percent change in density of animals at the 95 percent confidence level. Thus, the possibility of not detecting an impact of greater magnitude is unlikely.

The major impact of spilled oil on the marsh vegetation was to accelerate the natural marsh deterioration. This deterioration will eventually impact animals which depend on marsh vegetation for habitat structure. Adaptation of the existing biota to 40 years of oil production in Black Lake is probably the reason for the lack of a more significant detectable impact.

Vanadium, a predominate trace metal in the oil, as well as pyrogenic products due to the fire were found at the most distant sampling site (5 km) from Cavern 6 during Phase I. However, these compounds were not detected downwind of the fire in concentrations greater than background levels in later phases of the assessment. Remote sensing evaluation of stress in vegetation under the plume path also indicated that stress existed immediately after the fire, but had disappeared by the end of the 1-year survey.

1.0 INTRODUCTION

On September 21, 1978, a mechanical failure occurred during removal of well piping from Well 6 in Cavern 6 at the Strategic Petroleum Reserve Complex at West Hackberry, Louisiana. The incident resulted in the blowout of a well, a fire which claimed one life, and an oil spill of approximately 72,000 barrels (DOE, 1978a). The Department of Energy (DOE) immediately assembled an environmental assessment team composed of environmental representatives of state and federal regulatory agencies, DOE contractors, and universities.

This report summarizes the analytical findings of a 1-year field sampling program following the accident. The sampling program was conducted to assess the environmental impacts of the oil spill and fire. The results of chemical, physical and biological analyses are presented in Chapter 8. Discussion and conclusions are offered in Chapter 9. Conjunctive conclusions are presented in Chapter 10. The nontechnical reader is directed to the discussion and conclusions in Chapters 9 and 10 and to the Executive Summary. Appropriate technical support is provided in the methods and results sections (Chapters 7 and 8) and in the appendices.

2.0 ASSESSMENT ORGANIZATION

A multidisciplinary environmental assessment team was assembled to carry out physical, biological and chemical investigations. A schematic diagram (Figure 2.0-1) identifies participating member agencies, contractors and universities. Appendix F lists the names of the team members who participated in the assessment.

The environmental assessment team was divided into three functional working groups coordinated by Dames & Moore. The chemistry team was composed of personnel from the University of New Orleans and the University of Rhode Island. The biology team was directed by Dames & Moore, and the meteorology and hydrology team was directed by Parsons-Gilbane. The Las Vegas Division of EG&G provided remote imagery for the assessment.

The Environmental Control Division of Parsons-Gilbane was responsible for various physical aspects of the damage assessment. In addition to meteorological and hydrological studies, Parsons-Gilbane provided air quality monitoring, cartographic services and general logistical support to the Environmental Assessment Team during the course of the investigation. Dames & Moore was responsible for the identification of biological impacts from the spill, project coordination, statistical analyses used in distinguishing oil types, and report production. The University of New Orleans was responsible for the differentiation and quantification of oil by gas chromatography/mass spectroscopy and for measurement of pyrogenic hydrocarbons from the fire. The University of Rhode Island was responsible for quantification of spilled oil using infrared techniques, for differentiation of oils using hydrocarbon and trace metal tracers, and for tracking fallout from the plume using trace metal tracers.

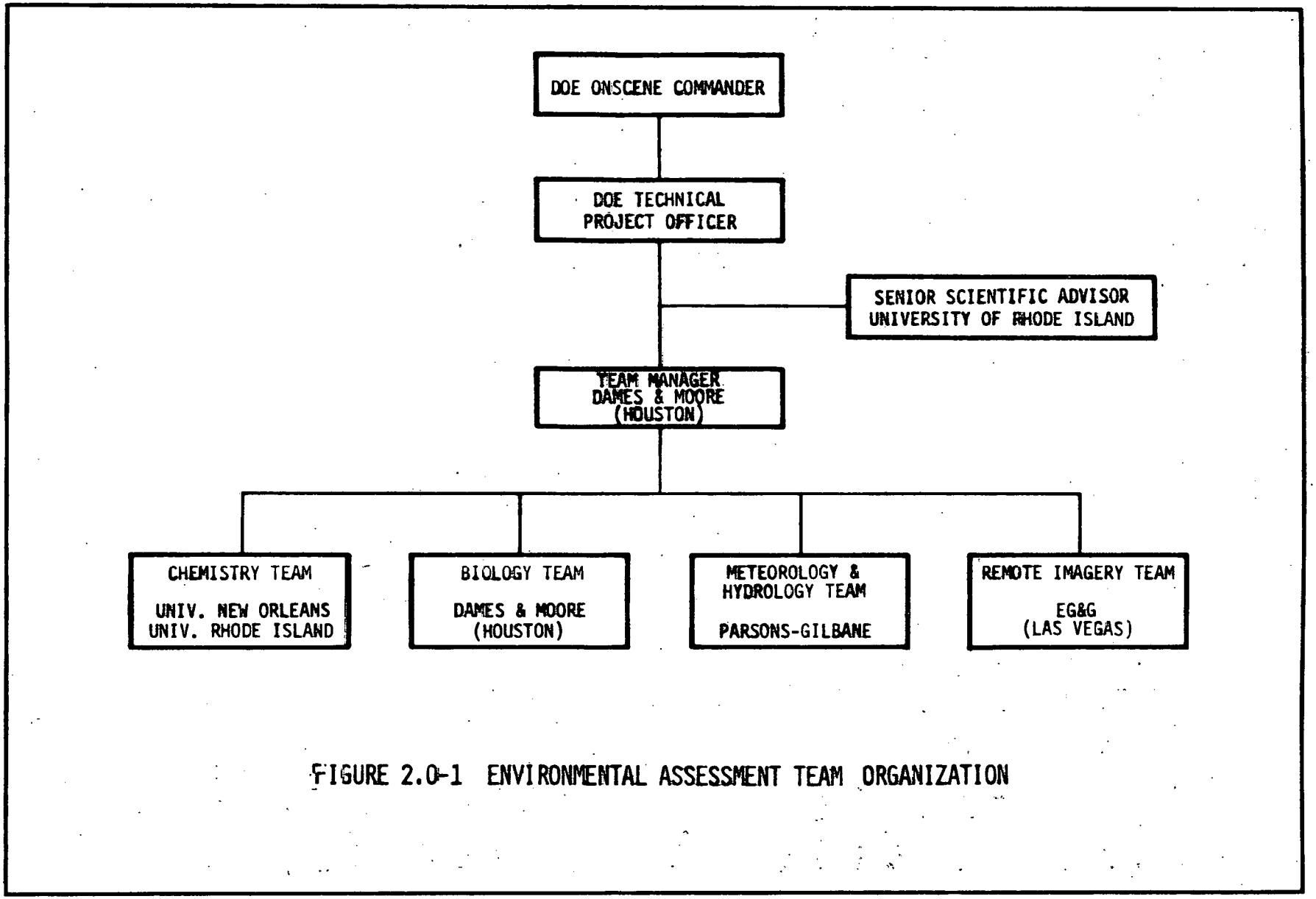


FIGURE 2.0-1 ENVIRONMENTAL ASSESSMENT TEAM ORGANIZATION

3.0 DESCRIPTION OF THE WEST HACKBERRY SITE

The West Hackberry storage site is located at the southern edge of Black Lake, approximately 8 km west of Hackberry, Louisiana. The area has undergone many topographic changes in recent years caused by manmade levees and dredge spoils. The area has been impacted by a number of oil spills throughout its 40-year history of oil and gas production. The observation of two offsite spills in the production area within the 10-day sampling period following the incident supports this hypothesis. The presence of this oil, coupled with the oil that has been introduced into the environment over a period of years, complicated the assessment of the impact of the Department of Energy oil spill and fire.

The West Hackberry site is located on the coastal Chenier Plain characterized as marshland. The site has intricately convoluted bayous, streams, rivers, bays, and several large lakes with oceanic connections. Together these comprise a complex hydrological system of fresh, estuarine, and marine waters. Topographically the site is a series of ridges (cheniers) extending in a generally east-west direction across flat, open, marshy land. Less than 10 percent of the area is dry land. No substantially wooded areas are present, and the predominant vegetation is coastal shrubs, grasses, and sedges.

Aquatic communities range from freshwater to estuarine, because of the complex hydrology and the influence of the Gulf of Mexico. Vertebrate and invertebrate animal populations are temperate to subtropical in nature, and include both indigenous and migratory populations.

The water of Black Lake is predominantly brackish, with onsite salinity measurements taken between December 1, 1977 and February 28, 1979 indicating a salinity range from 2 to 16 parts per thousand (ppt). Sediments consist primarily of clays which are nearly impervious to water and oil.

The climate of the West Hackberry site is strongly influenced by the proximity of the Gulf of Mexico (U.S. Dept. of Commerce, 1964). The site is located in southwestern Louisiana approximately 27 km north of the Gulf Coast at approximately 30° north latitude. As a result, a subtropical maritime climate prevails with warm summers, mild winters, and abundant rainfall throughout the year. The wind pattern of the area is primarily controlled by airflow around the western portion of the Atlantic high pressure cell known as the Bermuda high. The presence of this system results in prevailing southerly winds during the warmer months when the high pressure cell is most intense. During the colder months, the high pressure cell is somewhat suppressed, and intense migratory midlatitude weather systems are occasionally able to penetrate southward to influence the climate of the site. Such intrusions consist of brief outbreaks of cold continental air, northerly winds and occasional rain and storm activity.

Normal monthly temperatures range from 26.7-29.4°C during the summer to 10-12.8°C in the winter. Extreme high temperatures in summer are moderated somewhat by sea breezes from the Gulf of Mexico. Normal monthly precipitation ranges from 15 to 18 cm during the summer months to less than 13 cm for all other seasons, with the lowest monthly precipitation occurring in March and October.

Variations in seasonal precipitation have a direct effect on the water levels in Black Lake and the brackish marsh which bound the West Hackberry site on the north side. Tidal influences are small, although detailed hydrologic data are unavailable for the immediate vicinity (FEA, 1977). Local wind stress is primarily responsible for major changes in water level.

The Department of Energy began construction for an oil storage site at West Hackberry in the summer of 1977. Since that time, intensive construction activity associated with building well pads, storage tanks,

brine ponds and connecting pipelines have altered the site. The entire site has been graded repeatedly and little natural vegetation remains. Reseeding was initiated over much of the site following completion of construction.

The wells entering Cavern 6 are located at the northern edge of the site and the southern edge of Black Lake. This well pad is isolated from the lake by a 1.5 m dike.

4.0 DESCRIPTION OF THE INCIDENT

The incident began on Thursday, September 21, 1978. Approximately 2,219 m of 5-1/2 inch pipe was being removed from Well 6 in Cavern 6 when an inflatable packer inexplicably failed. Subsequent depressurization allowed oil to flow to the surface. Vapors from the oil ignited almost immediately, resulting in a fire that lasted nearly 6 days. The fire resulted in the fatal burning of the tool pusher, the severe burning of the derrickman, and in the destruction of the rig and nearby equipment. Eyewitnesses stated that the fire was visible nearly 25 miles from the site. An estimated 72,000 barrels of oil were released during the incident, of which 52,000 barrels were recovered (DOE, 1978b). At its peak, flames were reported to reach a height of approximately 300 feet, and the resulting plume reached a height of approximately 1,500 feet (Cox, 1980) and drifted southwestward. Oil containment booms were installed around the area and pits dug to collect the oil from the lake. Dikes were bulldozed near the waterfront in an effort to contain the oil onshore. These cleanup efforts began shortly after the incident occurred. At times the fire spread to the diked area, resulting in a broad based flame (Plate 4.0-1). The extent of the dike and location of the oil pits and containment booms are shown in Figure 4.0-1 and Plate 4.0-2. DOE began pumping oil from the pits at 1800 CDT on September 23. Because of the predominantly northeast wind that prevailed throughout the incident, the early deployment of booms, the construction of dikes, and prompt cleanup operations, the oil was confined to the south shore of Black Lake near the site. Very little oil appears to have escaped the boomed area, which is shown in Plate 4.0-3. The Strategic Petroleum Reserve Program project office estimated that 32,000 barrels of oil were recovered from Black Lake within the boomed area (DOE, 1978b). Most of the oil contained in Black Lake was recovered within 3 days. The remaining oil was removed by October 11, 1978.

PLATE 4.0-1. THE FIRE AT WELLPAD 6, 2-1/2 HOURS AFTER IT BEGAN

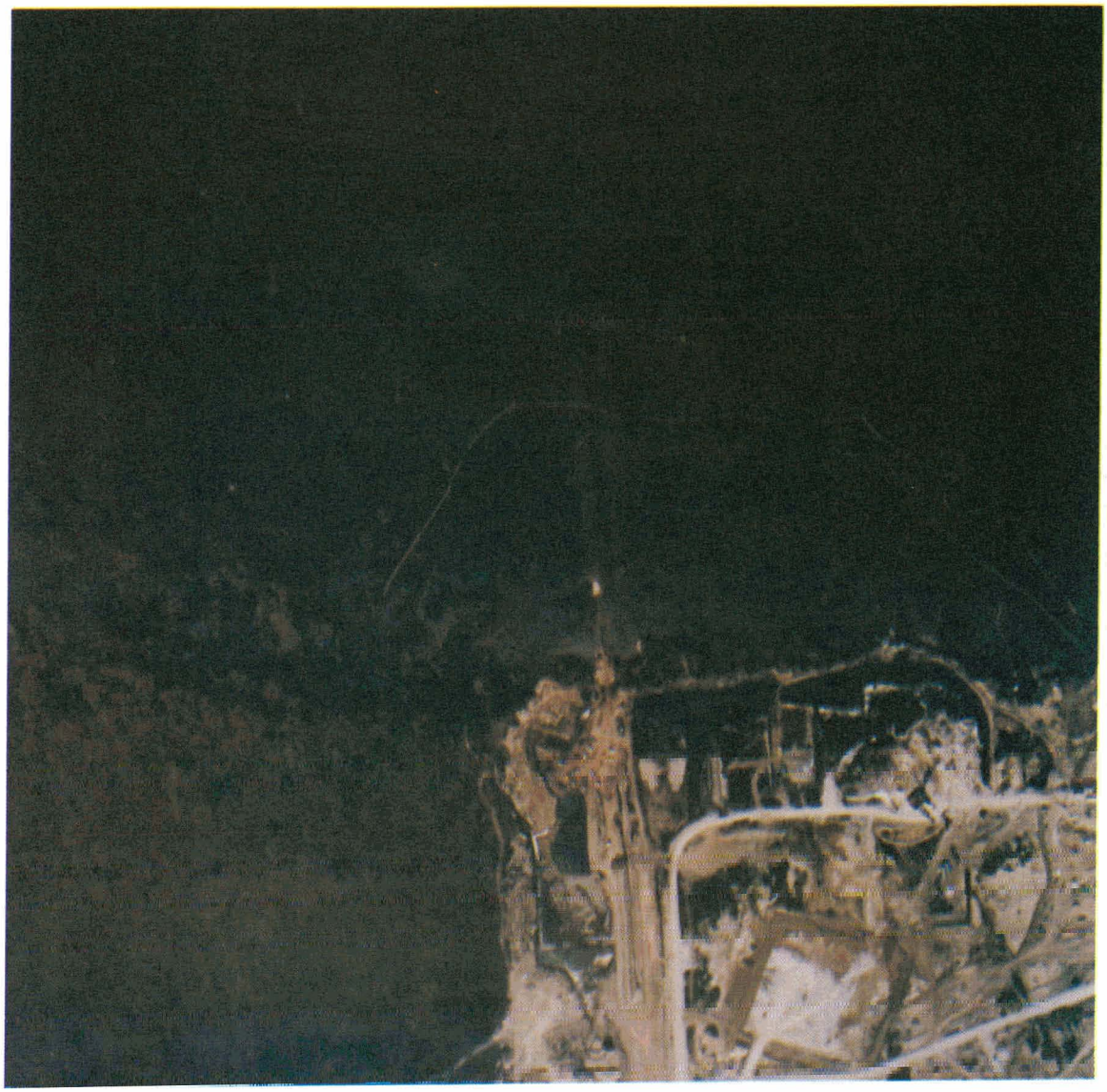


PLATE 4.0-2. WELLPAD 6 SHOWING BOOMS AND WEIR PITS

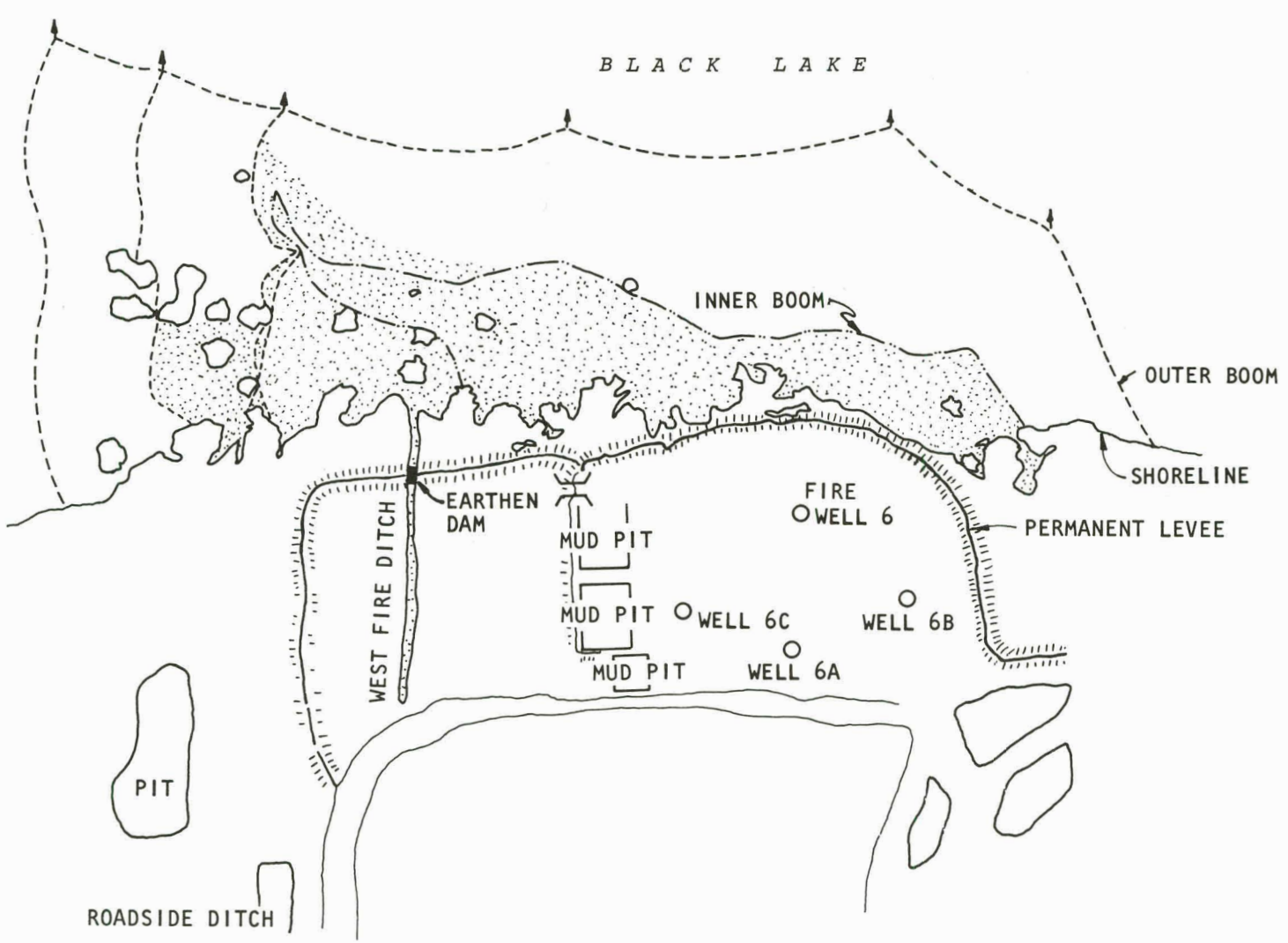


FIGURE 4.0-1. DETAIL OF AREA IN IMMEDIATE VICINITY OF CAVERN 6 INDICATING THE PERMANENT LEVEE, OIL CONTAINMENT BOOM PLACEMENT AND THE CONTAINMENT OF OIL BY THE BOOMS (Redrawn from DOE-OSC **After Action Report,** November, 1978)

PLATE 4.0-3. LOOKING EAST OVER BLACK LAKE, SEPTEMBER 25, 1978

5.0 OBJECTIVES OF THE ENVIRONMENTAL ASSESSMENT

The primary objectives of the Environmental Assessment Plan were: 1) to identify parameters which might be used to distinguish Cavern 6 crude oil and pyrogenic products of the fire from hydrocarbons already in the West Hackberry environment; 2) to apply these discriminant techniques to determine the spatial and temporal distribution of hydrocarbons from the incident; 3) to estimate the quantity of hydrocarbons from the oil spill and fire which persisted in contaminated habitats; and 4) to estimate the type and magnitude of the responses of biological systems in the contaminated habitats due to the presence of hydrocarbons deposited during the incident.

Secondary objectives of the assessment were: 1) to document meteorological conditions during the accident; 2) to collect and analyze air quality data measured during the fire; and 3) to study surface currents in the spill area in order to ascertain possible oil transport at the time of the incident. This information was used in conjunction with the chemical and biological data to estimate impacts on the environment from the spill and fire.

In deriving these objectives and consequently the assessment plan to achieve these objectives, numerous physical, chemical, and biological factors were considered. Physical transport mechanisms were generally responsible for the distribution of oil to the environment. Chemical and biological factors and their relevance to the development of the assessment plan are covered in the following paragraphs.

5.1 CHEMICAL FACTORS

An accurate environmental assessment of this oil spill and fire was dependent upon two considerations. First, it was necessary to be able to distinguish between Cavern 6 crude oil and background levels

of Louisiana Sweet Crude in environmental samples and to quantify the level of oil contamination in these samples. Second, the composition of pyrogenic by-products from the fire had to be differentiated from the normal background levels of these compounds in the West Hackberry environment. The ability to distinguish Cavern 6 crude oil and its pyrogenic products from normal background levels of hydrocarbons, however, was complicated by the fact that no information was available on composition and quantities of these substances at the storage site and in the surrounding area prior to the incident.

Crude oils are complex mixtures of many classes of compounds and thousands of individual components. In general, oils from different geographic locations contain the same types of compounds, but the quantitative distribution of these substances is determined by conditions prevalent during the formation of the various crudes. Therefore, the quantitative distribution of certain groups of organic compounds contained in crude oil can be used as passive tags to identify oil from a specific source. The quantitative distribution of the components, however, is altered by various physical and chemical processes, collectively referred to as weathering, which act on the oil in the environment. The distributions which prove most useful for passive tagging are those which are least affected by these weathering processes.

Weathering includes a combination of processes, such as evaporation, dissolution, emulsification, absorption on suspended sedimentary material, and photochemical and microbial degradation. Environmental conditions at the time of the incident, as well as the chemical composition of the spilled oils, determined which of these weathering processes predominated. In general, all weathering processes act in unison to alter the chemical composition of spilled oil. Thus, the chemical composition of environmentally exposed oil is significantly different from that of fresh crudes.

Another factor which must be considered when analyzing environmental samples for petroleum-based compounds is the presence of numerous biogenic hydrocarbons in these samples. Virtually all analytical schemes which require extraction of hydrocarbons also extract these ubiquitous biogenic substances. These biogenic compounds can often interfere with the ability to distinguish sources of petroleum contamination in environmental samples.

Certain classes of compounds do not originate from biological sources but are present in crude oils to a greater or lesser extent, depending on the source of the crudes. Many of these petroleum-based substances are also not readily affected by various weathering processes. Examples of these compounds include the alkyl homologs of phenanthrene and the sulfur-containing dibenzothiophenes. The quantitative distribution of these and other substances offers reliable information that can be used to trace oil found in the environment.

Combustion of petroleum results in the formation of hydrocarbon compounds which are generally not found in the original oil in large quantities. These pyrogenic compounds, called polycyclic aromatic hydrocarbons (PAH), have very little alkyl substitution (C_nH_{2n+1}) and molecular weights up to approximately 300. Combustion of various fuel types produces the same polycyclic aromatic hydrocarbons, but the relative quantitative distribution of these compounds is dependent primarily on the combustion temperature. Elevated levels of environmental contamination from PAH compounds are generally associated with various anthropogenic activities such as power production or transportation activities. The distribution of PAH can generally be traced to certain of these specific activities. For instance, the fire at Cavern 6 produced large quantities of two PAH compounds, fluoranthene and pyrene, relative to the quantities of other PAH produced by the fire. The background of PAH in the West Hackberry area did not contain relative elevated levels of fluoranthene and pyrene. Therefore,

unusually high levels of fluoranthene and pyrene relative to the other PAH in environmental samples indicate contamination of pyrogenic products from the fire.

Many polycyclic aromatic hydrocarbons have been identified as being carcinogenic. Thus, combustion processes, such as the fire at Well Pad 6, may present a health hazard. More information concerning the relationship between PAH and human health is given in Section 5.3.2.

5.2 PREVIOUS SPILLS IN THE AREA

Oil and gas production has existed in the Black Lake area since the 1930's, and a number of oil spills of varying degrees have occurred in that period. The distribution of the hydrocarbons in the crude from the wells in the production area is very similar to the oil in Cavern 6. The distinguishing characteristics between these two oils will be discussed in more detail in later sections. Evaluation of the possibility that the resident organisms in the area existed under a significant degree of environmental stress from hydrocarbon contamination previous to the incident required that the stress on the environment caused by the incident at the DOE site be differentiated from the stress in the area caused by previous spills. Thus, it was necessary to distinguish the difference in the amount of Cavern 6 crude oil from Louisiana Sweet Crude in the environment.

5.3 BIOLOGICAL FACTORS

5.3.1 Microbial Degradation

Microbial degradation is generally considered a much slower process than the other weathering mechanisms. Microbes, known as hydrocarbon-utilizing microbes, can selectively use portions of the oil as carbon

sources (Floodgate, 1972). For instance, microbes will degrade normal hydrocarbons more rapidly than they degrade branched, cyclic and aromatic hydrocarbons. These degradation processes are oxidative and therefore the availability of oxygen, as well as the carbon source and the availability of inorganic nutrients, is essential for microbial degradation. Also, hydrocarbons dissolved in the water column are degraded at a much faster rate than those compounds entrapped in sediments. Oil entrapped in anoxic sediments can remain for a period of years without significant degradation. The nature of the sediments as well as the mixing energy in a given environment determine how significantly microbes alter the distribution of petroleum compounds in oils. At later stages in the degradation process, it is nearly impossible to relate the source of petroleum hydrocarbons or degradation products to specific oil sources.

5.3.2 Health Hazards

The carcinogenesis related to PAH compounds is one of the most important occupational and environmental health impacts of the current and projected national energy base (Guerin, 1978). Sediment, soil, and foliage contaminated by the recent oil spill and fire at West Hackberry are potential sources of PAH with varying carcinogen, mutagen, and co-carcinogen risk potentials. Table 5.3-1 summarizes the currently known cancer-related health impacts of these compounds. Since accurate assays of comparative carcinogenic strengths are difficult, due to factors such as dose, species, mode of administration and sex differences, the significant results are indicated simply as an (X). However, there is general agreement regarding the high carcinogenic activity of a few of the compounds listed (Gelboin and Ts'o, 1978). Benzo(a)pyrene is one of the most extensively studied of all carcinogens. Direct testing has established benzo(a)pyrene as a general, strong carcinogen for numerous species including monkeys (Rinkus and Legator, 1979). Furthermore, some of its metabolically activated oxidation products are among the most powerful carcinogens known to date. Mutagenicity testing,

TABLE 5.3-1

CANCER POTENTIAL FOR SOME POLYCYCLIC AROMATIC HYDROCARBONS[a]

	COMPOUND	MOLECULAR WEIGHT	CARCINOGENICITY[b]	MUTAGENICITY[b]	CO-CARCINOGENICITY[c]
A	Naphthalene	128			
B	Phenanthrene	178			X
C	Dibenzothiophene	184			
D	Fluoranthene	202			X
E	Pyrene	202			X
F	Triphenylene	228			
G	Chrysene	228	X	X	
H	Benzo(a)anthracene	228	X	X	X
I	Benzo(c)phenanthrene	228	X[c]		
J	Benzo(b)fluoranthene	252	X		
K	Benzo(j)fluoranthene	252	X		
L	Benzo(a)pyrene	252	X	X	
M	Benzo(e)pyrene	252	X	X	X
N	Perylene	252			
O	Benzo(e)ocephenanthrylene	252			

a) The notation X indicates simply a positive result, with no assessment of strength

b) Rinkus and Legator, 1979 and references therein to:

IARC, 1971-1977
EPA, 1976
McCann et al., 1975

c) Hoffman et al., 1978

although not definitive proof of carcinogenicity, is often a good indicator of carcinogenic potential and is given here for that purpose (Rinkus and Legator, 1979). Co-carcinogenicity is a particularly insidious health hazard, since the compounds possessing this characteristic can either increase or inhibit carcinogenic effects without necessarily being carcinogens themselves. For example, Hoffman et al. (1978) have reported that the tumor-imitating agents in the particulate phase of tobacco smoke exhibited considerably enhanced activity when combined with a mixture of PAH co-carcinogens.

The high incidence of human cancer found in urban and industrialized areas has led to extensive research on sources, mode of exposure and ambient levels of PAH compounds. Benzo(a)pyrene level, often used as a rough index of all PAH exposure, reaches about 100 ng/m^3 in heavily polluted air and 23 ng/l in drinking water (Baum, 1978). Detailed listings of PAH found in the atmosphere from fossil-fuel related processes, steel manufacture and other industrial sources, reveal the presence of many of the PAH compounds discussed in this report. For example, among the PAH compounds whose concentrations have been monitored in the air over Los Angeles and Birmingham (Baum, 1978) are the compounds D, E, G, H, J, K, L, M, and N shown in Table 5.3-1. Therefore, the epidemiological studies pertaining to automobile exhausts, coal processing, etc., may have a direct bearing on the cancer risk to the human population.

Another factor, which various studies indicate to be important in judging the carcinogenic potential of emissions, is the particle size, distribution, and nature of the airborne particles. The PAH compounds tend to be concentrated on the smaller, more readily inhaled airborne particles and, therefore, their health hazard may be greater than indicated by measurements of total PAH concentration (Baum, 1978). This fact may be important, since a certain amount of the PAH compounds in the Hackberry area doubtless found their way into the environment from a combustion process and were therefore airborne.

A further consideration is the widespread human consumption of seafood in the Hackberry area. These organisms have a relatively slow rate of PAH metabolism and may serve as bioaccumulation banks for PAH compounds that find their way into the aquatic environment (Varanasi and Malins, 1977). This bioaccumulation process can increase the health impact on humans to levels higher than would be indicated by total PAH concentrations in foliage, soil and sediment samples.

5.4 FORMULATION OF THE ENVIRONMENTAL ASSESSMENT PLAN

Based on the various chemical, biological and physical factors discussed above, an environmental assessment plan was developed to evaluate the impacts of the oil spill and fire on the aquatic and terrestrial habitats surrounding the West Hackberry site. The preliminary Environmental Assessment Plan is presented in the "OSC-After Action Report" (DOE, 1978b). This plan is outlined in Figure 5.4-1.

A set of parameters was selected to differentiate, either singly or collectively, samples containing different crude oils. These parameters included concentrations and ratios of various hydrocarbon components of oil. Concentrations and identification of the source of oil from contaminated and control habitats were estimated either directly or extrapolated from measured concentrations of trace metal components of the oil. Samples of water, soil, sediment and foliage were collected over a 1-year period. Comparisons of concentrations of oil between sampling phases were used to estimate persistence of oil in the environment.

Since no recent baseline data were available, biological responses to the spill were estimated by comparison to biological systems in adjacent uncontaminated habitats of the same type (control sites). The assessment plan included direct evaluations of both short- and long-term effects. The assessment covered 1 year, with sampling periods at 1, 16, 29, and 53 weeks after the incident.

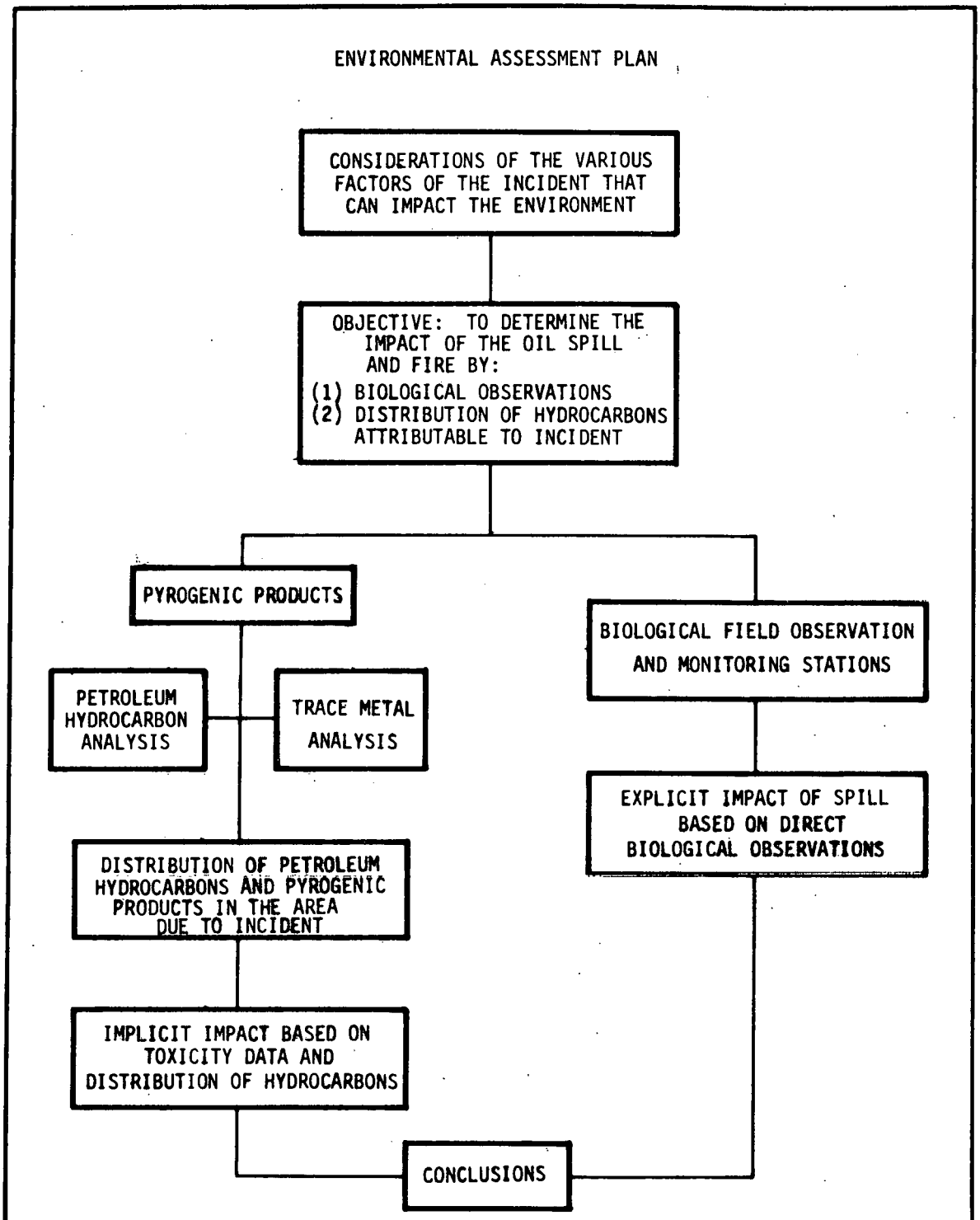


FIGURE 5.4-1 FLOW CHART OF THE ENVIRONMENTAL ASSESSMENT PLAN

Blank

6.0 LITERATURE REVIEW

6.1 BIOLOGICAL

Effects of oil spills vary, due to differences in environmental and geographic conditions at the spill site and to differences in the type of oil spilled. Water soluble fractions (WSF) are the most important element in assessing effects of oil spills on biota of marine and estuarine waters. Investigators disagree as to which components of WSF are toxic. Anderson et al. (1974) suggested that dicyclic and tricyclic aromatics were the toxic agents; whereas Byrne and Calder (1977) indicated that the, "more polar, NSO-type molecules," were the toxic substances. In general, increased concentrations of aromatics in WSF indicates an increase in toxicity. The relative boiling points of the aromatics are also important. Low boiling point aromatics, the most soluble, can have an acute toxic effect, but are a short-lived (12 to 24 hours) component of WSF due to their volatility. Medium and high boiling point aromatics are the most persistent toxic components of WSF. The medium boiling point aromatics are more soluble than the higher boiling point aromatics and remain a component of WSF over periods of days. The higher boiling point aromatics are not considered a significant toxic component of an oil spill due to their low concentration in most oils and relative insolubily (Moore and Dwyer, 1974).

Stability of the various aromatic components in oil is enhanced by contact with sediments. This is probably due to sediment-hydrocarbon attraction being greater than dissolution forces, thus slowing degradation and increasing residence time. Thus, contaminated substrates may be toxic or uninhabitable for several years after an incident (Moore and Dwyer, 1974).

Direct oiling or coating may be lethal to some forms of life. Sea birds are the only group of marine organisms known to have been affected

by oil pollution to the extent that local populations have been jeopardized (FAO, 1977). Other groups which may be affected by coating are intertidal sessile species, plankton, and marine mammals (Moore and Dwyer, 1974). Plankton should only suffer short-term effects due to their high reproductive rates (FAO, 1977). Though little substantiated data are available, the FAO suggests that mammals, if coated with oil, would suffer the same consequences as birds. However, LeBoeuf (1971), in a study of oil-coated marine mammals in California, reported no significant health effects to the animals as a result of exposure to crude oil.

Intertidal organisms may suffer the effects of direct oiling, as well as exposure to WSF contained in the water column. Benthic organisms, exclusive of those in the intertidal zone, would normally be exposed only to WSF, unless the oil had weathered considerably or become attached to sediment. In either case, the oil becomes denser than the surrounding water medium.

Estimated effects of previous spills, including Torrey Canyon (Smith, 1970), Santa Barbara (Straughan, 1971), West Falmouth (Blumer et al., 1970) and numerous small spills (Mackin, 1973), have ranged from minimal to substantial. Substantial species-specific differences occur in the patterns of hydrocarbon uptake, retention, and release (depuration). The effects may be lethal or sublethal (Atema, 1976), and may occur at the organism or population level.

A summary of toxicity tests utilizing the WSF of various oils on a broad range of test animals is presented in Table 6.1-1. The tests presented are on species observed in the West Hackberry area, closely related species, or on animals that may potentially occur in the area. Lethal limits are expressed as the concentration of oil hydrocarbons required for a 50 percent mortality at the given exposure times. Not all test results expressed in the table indicate mortality. In Table 6.1-1,

TABLE 6.1-1

TOXICITY TESTS OF WATER SOLUBLE FRACTIONS OF VARIOUS OILS

Test Animal	Oil	Concentration (ppm)	Exposure Time (hrs)	Source
INVERTEBRATES				
POLYCHAETES:				
Neanthes arenaceodentata				
4 segment	No. 2 Fuel Oil	>[a] 8.7	24	Rossi & Anderson, 1976
4 "	"	> 8.7	48	"
4 "	"	8.4	96	"
18 "	"	> 8.7	24	"
18 "	"	> 8.7	48	"
18 "	"	5.7	96	"
32 "	"	> 8.7	24	"
32 "	"	7.8	48	"
32 "	"	5.4	96	"
40 "	"	> 8.7	24	"
40 "	"	6.2	48	"
40 "	"	4.0	96	"
4 "	South La. Crude	>19.8	24	"
4 "	"	>19.8	48	"
4 "	"	>19.8	96	"
18 "	"	>19.8	24	"
18 "	"	>19.8	48	"
18 "	"	>19.8	96	"
32 "	"	>19.8	24	"
32 "	"	>19.8	48	"
32 "	"	17.8	96	"
40 "	"	>19.8	24	"
40 "	"	17.0	48	"
40 "	"	15.2	96	"
Immature Adult - 48 seg.	No. 2 Fuel Oil	> 8.7	24	"
"	"	3.2	48	"
"	"	2.7	96	"

a) > = greater than

TABLE 6.1-1 (Cont.)

Test Animal	Oil	Concentration (ppm)	Exposure Time (hrs)	Source
Neanthes arenaceodentata (cont.)				
Mature Males - 54 seg.	No. 2 Fuel Oil	> 8.7	24	Rossi & Anderson, 1976
"	"	3.0	48	"
"	"	2.6	96	"
Gravid Females - 54 seg.	"	> 8.7	24	"
"	"	5.6	48	"
"	"	4.2	96	"
Immature Adults	South La. Crude	18.0	24	"
"	"	13.9	48	"
"	"	12.5	96	"
Mature Males	"	18.1	24	"
"	"	13.6	48	"
"	"	12.0	96	"
Gravid females	"	>19.8	24	"
"	"	18.0	48	"
"	"	17.6	96	"
Spiochaetopterus costarum oculatus	Bunker "C"	4.92	48	Bender et al., 1974
Nereis succinea	Bunker "C"	5.53	>48	Bender et al., 1974
Polychaete larvae (mixed)	No. 2 Fuel Oil	9.25	>70	Lee and Nicol, 1977
"	"	7.4	>70	"
"	"	5.55	>70	"
"	"	3.7	>70	"
"	"	1.85	>70	"
"	"	0.185	>70	"

TABLE 6.1-1 (Cont.)

Test Animal	Oil	Concentration (ppm)	Exposure Time (hrs)	Source
MOLLUSCS:				
Gastropods:				
Nassarius obsoletus	Bunker "C"	5.53	>48	Bender et al., 1974
Bivalves:				
Modiolus demissus	Bunker "C"	5.53	>48	Bender et al., 1974
Mercenaria sp.				
Embryos & Larvae	Kuwait Crude	>10.0	144	Byrne and Calder, 1977
"	"	2.0	240	"
"	South La. Crude	2.0	240	"
"	Fla. Jay Crude	< 1.0	48	"
"	"	0.2	240	"
"	No. 2 Fuel Oil	1-2	48	"
"	Bunker "C"	1-2	48	"
"	Used Crankcase Oil	< 0.1	48	"
ARTHROPODS:				
Crustaceans:				
Copepods (including mixed populations of zooplankton):				
Coastal Zooplankton (mixed)	No. 2 Fuel Oil	9.25	45	Lee and Nicol, 1977
"	"	3.7	>50	"
"	"	1.85	>50	"
"	"	0.925	>50	"
"	"	0.185	>50	"

TABLE 6.1-1 (Cont.)

Test Animal	Oil	Concentration (ppm)	Exposure Time (hrs)	Source
Oceanic Zooplankton (mixed)	No. 2 Fuel Oil	9.25	< 9	Lee and Nicol, 1977
"	"	7.4	<12	"
"	"	5.55	<23	"
"	"	3.7	<23	"
"	"	1.85	>70	"
"	"	0.185	>70	"
Cyclopoid Copepods (mixed)	No. 2 Fuel Oil	9.25	<13	Lee and Nicol, 1977
"	"	7.4	<35	"
"	"	5.55	<38	"
"	"	3.7	50	"
"	"	1.85	>70	"
"	"	0.185	>70	"
Calanoid Copepods (mixed)	No. 2 Fuel Oil	9.25	<10	Lee and Nicol, 1977
"	"	7.4	<10	"
"	"	5.55	<10	"
"	"	3.7	<10	"
"	"	1.85	<32	"
Coastal Copepods (mixed)	No. 2 Fuel Oil	9.25	<15	Lee and Nicol, 1977
Mysids:				
Mysidopsis almyra	South La. Crude	11.7	24	Anderson et al., 1974
"	"	8.7	48	"
"	Kuwait Crude	8.2	24	"
"	"	6.6	48	"
"	No. 2 Fuel Oil	2.6	24	"
"	"	0.9	48	"
"	Bunker "C" Residual	6.3	24	"
"	"	0.9	48	"

TABLE 6.1-1 (Cont.)

Test Animal	Oil	Concentration (ppm)	Exposure Time (hrs)	Source
Amphipods:				
Amphithoe valida (adults)	No. 2 Fuel Oil	10.0	<24	Lee et al., 1977
"	"	4.0	<96	"
"	"	2.0	<216	"
"	South La. Crude	12.0	<48	"
"	"	4.8	<192	"
"	"	2.4	<192	"
"	"	0.96	>720	"
Gammarus mucronatus (adults)	No. 2 Fuel Oil	10.0	24	Lee et al., 1977
"	"	4.0	48	"
"	"	2.0	156	"
"	"	0.8	228	"
"	"	0.4	336	"
"	South La. Crude	12.0	60	"
"	"	4.8	120	"
"	"	2.4	168	"
"	"	0.96	>336	"
"	"	0.48	>336	"
Gammarus mucronatus	Bunker "C"	0.42	48	Bender et al., 1974
Isopods:				
Edotea triloba	Bunker "C"	5.53	>48	Bender et al., 1974
Shrimp:				
Palaemonetes pugio	South La. Crude	>16.8	24	Anderson et al., 1974
"	"	>16.8	48	"
"	"	>16.8	96	"

TABLE 6.1-1 (Cont.)

Test Animal	Oil	Concentration (ppm)	Exposure Time (hrs)	Source
Palaemonetes pugio (cont.)	Kuwait Crude	>10.2	24	Anderson et al., 1974
"	"	>10.2	48	"
"	"	>10.2	96	"
"	No. 2 Fuel Oil	4.4	24	"
"	"	4.1	48	"
"	"	3.5	96	"
"	Bunker "C"	3.2	24	"
"	"	2.8	48	"
"	"	2.6	96	"
Penaeus aztecus (post-larvae)	South La. Crude	>19.8	24	Anderson et al., 1974
"	"	>19.8	48	"
"	"	>19.8	96	"
"	No. 2 Fuel Oil	5.0	24	"
"	"	5.0	48	"
"	"	4.9	96	"
"	Bunker "C"	3.8	24	"
"	"	3.5	48	"
"	"	1.9	96	"
Crabs:				
Rhithropanopeus harrisii (zoea)	No. 2 Fuel Oil	0.16	>360	Laughlin et al., 1978
"	"	0.31	>430	"
"	"	0.63	>648	"
"	"	0.94	<216	"
"	"	1.26	<120	"
Neopanope texana (zoea)	Light Venezuelan Crude	4.0	96	Katz, 1973
Pagurus longicarpus	Bunker "C"	0.62	48	Bender et al., 1974

TABLE 6.1-1 (Cont.)

Test Animal	Oil	Concentration (ppm)	Exposure Time (hrs)	Source
VERTEBRATES				
FISH:				
Cyprinodon variegatus	South La. Crude	>19.8	24	Anderson et al., 1974
"	"	>19.8	48	"
"	"	>19.8	96	"
"	No. 2 Fuel Oil	6.9	24	"
"	"	6.9	48	"
"	"	6.3	96	"
"	Bunker "C"	4.7	24	"
"	"	4.4	48	"
"	"	3.1	96	"
Menidia beryllina	South La. Crude	9.7	24	Anderson et al., 1974
"	"	8.7	48	"
"	"	5.5	96	"
"	Kuwait Crude	6.6	24	"
"	"	6.6	48	"
"	"	6.6	96	"
"	No. 2 Fuel Oil	5.7	24	"
"	"	5.2	48	"
"	"	3.9	96	"
"	Bunker "C"	3.6	24	"
"	"	2.7	48	"
"	"	1.9	96	"
Fundulus similus	South La. Crude	16.8	24	Anderson et al., 1974
"	"	16.8	48	"
"	"	16.8	96	"

TABLE 6.1-1 (Cont.)

Test Animal	Oil	Concentration (ppm)	Exposure Time (hrs)	Source
Fundulus similus (cont.)	Kuwait Crude	>10.4	24	Anderson et al., 1974
"	"	>10.4	48	"
"	"	>10.4	96	"
"	No. 2 Fuel Oil	5.6	24	"
"	"	4.7	48	"
"	"	3.9	96	"
"	Bunker "C"	3.8	24	"
"	"	2.27	48	"
"	"	1.69	96	"

mortality resulting from concentrations for a given exposure time is summarized by the columns "Concentration, ppm" and "Exposure Time (hrs)." The symbol > (greater than) shown next to a concentration amount indicates that greater concentration of oil would have been required to cause 51 percent mortality. The symbol > shown next to hours indicates that more time would have been required to cause 51 percent mortality.

In addition to testing the lethal qualities of various oils on different animals, many investigators have explored sublethal effects. The following paragraphs summarize these results.

Single Cell Organisms:

Lower organisms, such as bacteria (Hodson et al., 1977) and phytoplankton (Atkinson et al., 1976), can be affected sublethally by reduction or inhibition of population growth rates.

Polychaete Worms:

Rossi and Anderson (1976) found that the juvenile stages of a polychaete worm (Neanthes arenaceodentata) were more resistant to the effects of oil than were adults, indicating that the timing of an oil spill may be a critical factor when predicting impacts. Sublethal effects in a subsequent study (Rossi and Anderson, 1978) were a suppression of fecundity, reduced hatching success, and inhibition of growth. Bender et al. (1974) found one polychaete (Nereis succinea) to be resistant to the effects of Bunker "C" oil and another polychaete (Spiochaetopterus costarum oculatus) to be sensitive. Field studies following a spill supported these laboratory tests (Bender et al., 1974). Lee and Nicol (1977) found that coastal polychaete larvae (meroplanktonic) were particularly resistant to the toxicity of No. 2 Fuel Oil, having zero mortality in 208 cases.

Molluscs:

Exposure to oil hydrocarbons can lead to alteration of enzyme activity in the oyster (Crassostrea virginica), possibly a detoxification response (Heitz et al., 1974). Oysters and a scallop (Aequipecten irradians) were found to assimilate and store, but not readily depurate, oil hydrocarbons in the lipid pools (Blumer et al., 1970). The soft shell clam (Mya arenaria) may experience altered respiration (Stainken, 1978), and reduced feeding and growth rates (Keck et al., 1978; Gilfillan and Vandermuelen, 1978) after exposure to oil hydrocarbons.

The mussel, Geukensia (=Modiolus) demissus, is somewhat resistant to oil contamination (Bender et al., 1974). However, Gilfillan (1975) found that crude oil does reduce the amount of carbon available for growth and reproduction, and that this reduction can be severe enough to fall below maintenance levels. This also was found for another mussel, Mytilus edulis, which underwent rapid uptake and discharge, but did not metabolize, hydrocarbons (Lee et al., 1972).

Byrne and Calder (1977) found that at normal oil hydrocarbon spill concentrations ($\leq$ 2 ppm), embryonic and larval clams (Mercenaria sp.) would probably be heavily impacted. High concentrations of WSF (about 11.5 ppm) killed all test embryos within 3 hours. Any significant decrease in larval survival always resulted in decreased growth of the survivors, which may indicate sublethal long-term effects in that these larvae may not continue to survive and/or reproduce.

Atema (1976) found that the mud snail (Nassarius obsoletus) had altered feeding responses upon sublethal exposure to petroleum hydrocarbons. Alterations in feeding behavior ranged from attraction to repulsion to inhibition. The observed changes were sufficiently general to affect a large number of marine invertebrates in a similar manner (Atema, 1976).

Copepods and Barnacles:

Venezia and Fossato (1977) found that the effects of a Kuwait oil suspension on 1) adult harpacticoid copepods (Tisbe bulbisetosa), 2) the number of eggs produced, 3) the number of nauplii produced, and, 4) the hatching success for third and fourth generation females subject to continuous exposure were negligible. The suspensions used in these experiments were 200 times higher than those determined for a highly polluted lagoon area. The preparation process used for the suspensions removed some low boiling point hydrocarbons, mimicking natural weathering (Venezia and Fossato, 1977).

Lee and Nicol (1977) examined the effects of WSF from No. 2 Fuel Oil on Texas coastal and oceanic zooplankton and determined that meroplankton (organisms which spend part of their life cycle in plankton) was more resistant to toxicity than holoplankton (organisms which spend all of their life cycle in plankton) and that an inshore assemblage was more resistant than an offshore population. Barnacle nauplii were particularly resistant to the toxicity of No. 2 Fuel Oil.

Amphipods:

Lee, et al. (1977) determined that 0.8 ppm No. 2 Fuel Oil and 2.4 ppm South Louisiana Crude were toxic to adults of the amphipods Gammarus mucronatus and Amphithoe valida and to their reproductive capabilities. High mortality rates and reduced fecundity of the survivors indicated that population levels could be severely depressed as a result of a spill.

Decapod crustaceans:

Krebs and Burns (1977) found that the salt marsh fiddler crab, Uca pugnax, was sensitive to contamination from No. 2 Fuel Oil. Effects

included reduced populations, reduced ratio of females to males, reduced juvenile settlement, and heavy overwinter mortality. Metabolic uptake and behavioral disorders were directly related to high oil content in sediment. Recovery from these effects correlated with the disappearance of the napthalene fraction of the aromatics, a process requiring in excess of 7 years in an original contamination of up to 6,000 mg oil/g (6,000 ppm) of wet mud. Surface sediment concentrations greater than 1,000 ppm (with greater than 20 percent aromatics) were directly toxic to adults; concentrations greater than 100 to 200 ppm were toxic to juveniles; and concentrations less than 100 ppm allowed population recovery (Krebs and Burns, 1977).

Young larvae (zoea) of the mud crab (Rithropanopeus harrisii) were more sensitive to exposure to No. 2 Fuel Oil toxicity than were the older larvae (megalopa) or adult stages (Laughlin et al., 1978). The crabs had considerable ability to recover from chronic sublethal exposure and the main effect of WSF of No. 2 Fuel Oil on a population may be due to its impact on larval recruitment.

Katz (1973) found a similar pattern in a study of the effect of light Venezuelan crude on larvae of the crab Neopanope texana. Chronic exposure of the first zoeal stage clearly demonstrated high toxicity. Successive molt stages were increasingly resistant to toxicity.

Atema (1976) found similarities between the lobster (Homarus americanus) and the mud snail (Nassarius obsoletus) in that altered feeding responses were similar upon sublethal exposure to petroleum hydrocarbons.

Exposure of the shrimp Crangon crangon to sublethal concentrations of oil hydrocarbons resulted in a variety of responses, including decreased respiration attributed to the possible narcotic effect of the toxicant, reduced growth, and hypersensitivity to disturbance (Edwards, 1978). The latter may increase chances of attack by predators.

Fishes:

Acute exposure of the striped mullet, Mugil cephalus, to 1 ppm Arabian crude oil or Empire Mix altered the metabolic capacity and increased liver size by 50 percent (Yarbrough and Chambers, 1977). Upon sublethal exposure to Empire Mix crude, Heitz et al. (1974) found a decrease in the activity of a mitochondrial enzyme (B-GLU) in muscle tissue and an increase in activity in brain tissues.

Exposure of the Baltic herring, Clupea harengus membras, to petroleum hydrocarbons demonstrated that early development can be affected by alterations in embryonic activity, decreased heart rates, changes in hatching times, and malformed or dead larvae (Linden, 1978).

Payne et al. (1978a) exposed cunner (Tautogolabrus adspersus) for 6 months to chronic doses of Venezuelan crude oil in a flow-through system. Survival was greater than 95 percent. Through a series of physical and pathological parameters, the only detectable biological response was a change in eye lens size.

Anderson et al. (1974) studied the toxic effect of four oils (South Louisiana Crude, Kuwait crude, No. 2 Fuel Oil, and Bunker D residual oil) on three fish and three crustaceans. The crudes were less toxic than refined oils, and the fish were less sensitive than the crustaceans. The order of increasing sensitivity was as follows:

Fish:

Sheepshead minnow	Cyprinodon variegatus
Tidewater silverside	Menidia beryllina
Longnose killifish	Fundulus similis

Crustacea:

Brown Shrimp	Penaeus aztecus post larvae
Grass Shrimp	Palaemonetes pugio
Mysid	Mysidopsis almyra

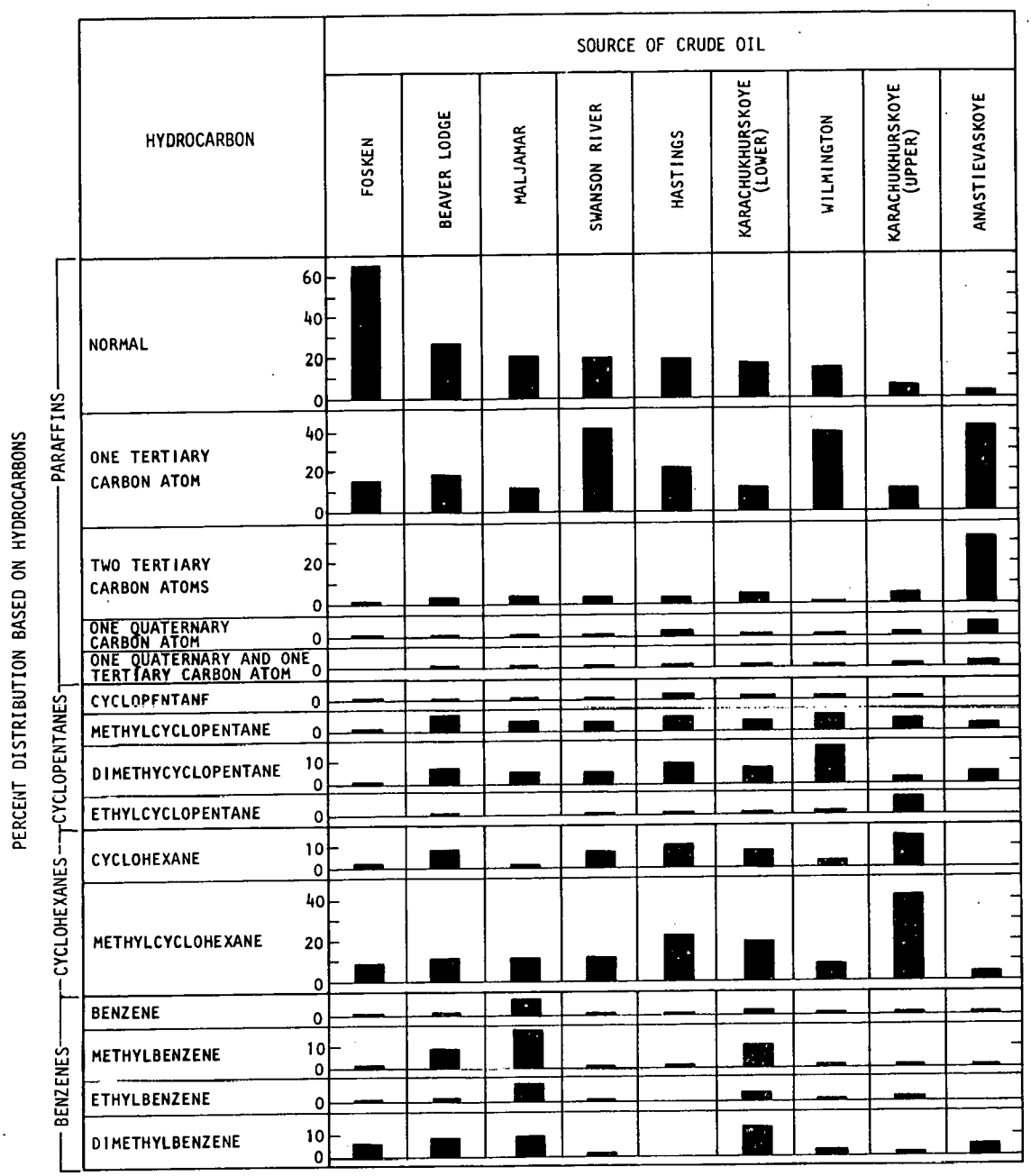
Vegetation:

A recent United Nations report (FAO, 1977) reviewed the published literature on the responses of marsh grasses to oiling. Severity of response was in general related to season of spill, quantity and type of product spilled, and frequency of spill (that is, a single spill is much less detrimental than sequential oiling in the same place). An offloading spill of No. 6 oil from the tanker, Aries, impacted a strip of Spartina alterniflora and Juncus roemerianus marsh along the Cooper River in Charleston, South Carolina. Parts of the marsh were cut, and both the cut and uncut portions appeared to be fully recovered 6 months after the spill (Anon., 1979). Oil-related death of grasses seems to result from direct foliage contact and coating of stomata, cell membrane damage, blocking of intercellular spaces, increased respiration, inhibition of translocation, and possible oil penetration of the vascular system (Baker, 1970). This is particularly a problem in heavy marsh soils with low sand content. However, some marsh grasses have apparently been stimulated by application of oil to soils, specifically Pucinnella maritima and Festuca rubra (Baker, 1970), both of which are found on sandy substrates.

6.2 CHEMICAL

A major problem in the documentation of the chemical fate of an oil spill or fire is the fact that crude oil is such a complex mixture of many classes of compounds. In addition, the quantitative distribution of these compounds can vary quite dramatically depending on the origin of the oil. Considering, for example, only some selected hydrocarbons, the range of their relative distributions is illustrated in Figure 6.2-1 (Smith, 1968).

A further complication is that once the crude oil is exposed to the environment, various physical and chemical processes ensue, collectively

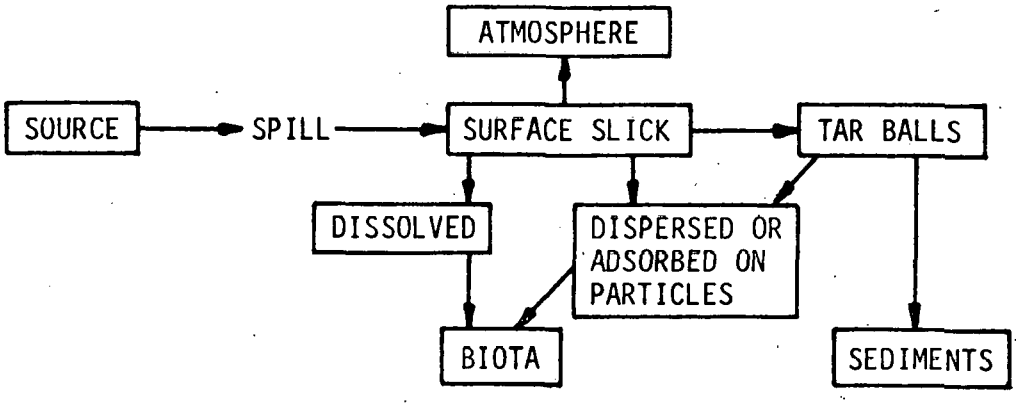


[a] ADAPTED FROM H.M. SMITH, 1968.

FIGURE 6.2-1 EXAMPLES OF SELECTED HYDROCARBON DISTRIBUTIONS IN NINE CRUDE OILS[a]

known as weathering, which qualitatively and quantitatively proceed to alter the composition of the original crude oil. Here, the importance of passive tagging distributions which are least affected by these weathering processes come into play, as discussed in Section 5.1. Depending on individual factors such as the type of oil spilled, environmental conditions at the time of the spill, etc., the time required for observing a general decrease in the amounts of oil and a change in its composition can vary anywhere from weeks to years (Goldberg, 1979). Regrettably, the visual disappearance of an oil slick, though desirable from the point of view of gross acute toxic effects such as wildfowl kills, is hardly the end of its impact from a chemical standpoint (Goldberg, 1979; Larson et al., 1977). Rather, as the parent compounds "disappear" from the site of the accident, their chemical conversion route is just beginning. This chemical conversion, in some cases, may lead to new compounds differing in toxicity and chronic health effects as compared to the parent components in the crude oil (Goldberg, 1979; Larson et al., 1977; Gibson et al., 1978; Gelboin and Ts'o, 1978).

The general hydrocarbon transport after an oil spill can be represented by a simple box model such as the one shown below (Goldberg, 1979).



Because of the multicomponent nature of the crude oils and their quantitative differences and environmental variations in individual spills, it

is very difficult to accurately predict the presence or chemical fate of specific oil components in any of the reservoirs (boxes) outlined in the above model. For example, the evaporation, solution, dispersion and adsorption of the more volatile hydrocarbons has been studied in some detail (American Petroleum Institute, 1977). For these volatile hydrocarbons, evaporation and solution are simultaneous and competitive processes, since each hydrocarbon will evaporate and also go into solution at rates depending on its vapor pressure (American Petroleum Institute, 1977). However, as has been pointed out in the report of the Argo Merchant oil spill (Department of Commerce, 1977), the phenomenon of "skinning" or formation of a high-molecular-weight compound skin at the air-water interface can greatly alter the normal process of volatile hydrocarbon evaporation into the atmosphere. Similarly, under actual spill conditions, making a distinction between truly dissolved hydrocarbons and colloidal dispersions is quite difficult (American Petroleum Institute, 1977; Department of Commerce, 1977). Nevertheless, on the basis of experience with previous oil spills and simulated spill experiments, some generalizations have been made regarding the roles of sedimentation, emulsification, dispersion, evaporation and dissolution processes (American Petroleum Institute, 1977; Department of Commerce, 1977).

The role of pyrolysis and the pyrogenesis of various polycyclic aromatic hydrocarbons, as well as their health implications, have already been discussed in Section 5.3.2.

From the point of view of actual chemical conversion, oxidation is probably the single most significant process that must be considered in oil weathering. Included under oxidation are the processes of photo-oxidation, autooxidation and microbial oxidation. Microbial oxidation has already been discussed in Section 5.3.1. It is to be noted that in the case of the aromatic hydrocarbons, bacteria mediated processes effect ring cleavage after hydroxylation with eventual degradation of the

aromatic hydrocarbons to carbon dioxide (Goldberg, 1979; Burwood and Speers, 1974). Enzymatic oxidation converts hydrocarbons into more soluble alcohols, organic acids, CO_2 and water. However, for aromatic hydrocarbons, the integrity of the aromatic ring is preserved during the hydroxylation and subsequent conjugation reactions.

One aspect of the enzymatic metabolism of aromatic hydrocarbons is the formation of highly reactive arene oxides as intermediates. In certain cases, these arene oxides, in addition to isomerization to phenols, may also react with nucleophiles such as DNA, RNA and protein. Thus, they become so-called bioactivated intermediates binding aromatic compounds to the biopolymers within a cell (Jerina and Daly, 1974). Good correlations have been obtained for toxic, carcinogenic, and mutagenic effects of certain polynuclear aromatic hydrocarbons with the extent of this binding, thus pointing to their arene oxides as the agents producing these effects (Jerina and Daly, 1974).

Photooxidation processes include direct as well as sensitized photooxidation, photo-induced autooxidation and possibly singlet oxygen oxidation. The photooxidation of crude oils as well as the photooxidation of individual components of crude oils has drawn considerable attention recently (Larson et al., 1977; Burwood and Speers, 1974; Patel et al., 1978; Patel et al, 1979; Lacaze and Villedon de Naide, 1976; Calder et al., 1978; Overton et al., 1979). The oxidation would be expected to occur at sites of unsaturation or at heteroatoms yielding products with polar functional groups, thus enhancing water solubility (Patel et al., 1979). Simulated environmental ultraviolet irradiations of crude oils have been shown to yield various classes of oxygenated products such as alcohols, phenols, carboxylic acids, diacids, ketones, aldehydes, esters, peroxides and sulfoxides (Larson, et al., 1977; Burwood and Speers, 1974). For example, initial irradiation of a crude oil sample produced considerable amounts of peroxides presumably arising from a number of aromatic systems including fluorene and its alkyl isomers (Larson et al., 1977).

A significantly enhanced toxicity to baker's yeast was observed after irradiation of a crude oil sample (Larson et al., 1977). Baker's yeast was chosen by these investigators because of its similarity in cellular organization to higher aquatic life forms. Whereas the toxicity may be ascribed largely to the formation of peroxides and acids, it was noteworthy that significant toxicity was retained even after the addition of a mild reducing agent. Therefore, toxicity from other oxygenated products is also strongly implied. One of these, fluorenone, exhibited a high level of toxicity to the yeast cultures (Larson et al., 1977). In general, enhanced toxicity following photooxidation of crude oil or selected components, has been observed (Larson et al., 1977; Lacaze and Villedon de Naide, 1976; Scheir and Gominger, 1976). Even more noteworthy in terms of chronic rather than acute toxic effects of the oxygenated products are recent reports of enhanced mutagenicity after irradiation. Irradiated crankcase oil showed increased mutagenic properties when compared to nonirradiated oil (Payne et al., 1978b). Similarly, irradiated mixtures of polycyclic aromatic hydrocarbons were found to be mutagenic to bacteria cultures (Gibson et al., 1978). Mutagenicity, whereas not definitive proof of carcinogenicity, has often been used as a good indicator for carcinogenic potential (Rinkus and Legator, 1979).

A number of investigations have focused on the photooxidation of individual compounds known to be present in crude oils. Thus, when fluorene, tetralin and acenapthene were irradiated (under simulated environmental conditions), the corresponding ketones were formed (Larson et al., 1977). Of these, fluorenone is of particular interest, not only because of its significant yeast toxicity but also because it is a known sensitizer for singlet oxygen production. This finding implies the existence of another possible mode of oxidation; i.e., the singlet oxygen reaction, affecting for example, double bonds, aromatic nucleii and heterocyclic rings (Larson et al., 1977). Along the lines of this approach, a singlet oxygen reaction was shown to generate a host of

oxygenated products from the common oil constitutent phenanthrene (Patel et al., 1978). Among the numerous oxidation products formed were arene oxides, phenols, dihydrols, acids, aldehydes and an epoxy-dihydrol, 9,10-epoxy-9, 10-dihydrophenanthrene. The finding of this latter compound is significant since it is representative of the class of compounds initially formed in the enzymatic metabolism of aromatic hydrocarbons in many life forms (Patel et al., 1978). In some cases, such as the well studied example of benzo(a)pyrene, some of these hydroxylated epoxides have been shown to be powerful carcinogens.

Some indications point to the preferential oxidation of sulphur-containing compounds during oil weathering, based on observations from the Arrow oil spill. It was noted that the original cargo contained 2.28 percent sulphur and that after 20 months of weathering, this percentage had dropped to 1.45 percent (Bentancourt and McLean, 1973). Heterocyclic sulfides in general and dibenzothiophenes in particular have received recent attention in the studies of oil photooxidation. The presence of thiocyclanes was observed to affect the degree of photooxidation of other aromatic hydrocarbons, presumably due to the facile oxidation to the corresponding thiacyclane oxides (Larson et al., 1977; Burwood and Speers, 1974; Patel et al., 1979). Oil samples from the recent Amoco Cadiz oil spill showed dibenzothiophene and its C_1, C_2, and C_3 alkyl isomers to be abundantly present and for both direct environmental sampling as well as simulated laboratory conditions, established the photooxidative formation of their corresponding oxides (Patel et al., 1979; Overton et al., 1979). Some evidence exists that these sulfoxides are more mutagenic than their parent sulfides (Goldberg, 1979; Patel et al., 1979). It would appear from these photooxidation studies of both crude oil and selected individual components that photooxidation in an oil slick or in the atmosphere may be a significant part of the oil weathering process. However, much remains to be studied regarding the nature, rate of production, accumulation and biological properties of the oxidation products.

7.0 METHODS AND MATERIALS

7.1 SAMPLING APPROACH

Over-sampling of the area was deliberately undertaken to provide sufficient samples, should more data be needed at a later date. Samples were taken in the area suspected of being affected and in areas beyond the boundries of the suspected area. Station locations were identified by local surveyors utilizing the Louisiana Lambert coordinate system. A chain-of-custody tag (supplied by the U.S. Environmental Protection Agency) was attached to each sample, denoting the sample type, date and time of collection, collector, witness, station number, preservative used, and the type of analysis intended. The samples were logged into a central control station and preserved for temporary storage by freezing or the addition of a chemical preservative. This procedure ensured accurate definition of all samples taken. Subsequent sample handling for delivery to the analytical laboratories was tracked through changes in custody marked on the sample tag and through the sample logs.

7.2 FIELD TECHNIQUES

7.2.1 Biological

The objective of the biological sampling was to estimate spill-induced changes in density of organisms and faunal composition of those habitat types having the greatest probability of experiencing a major faunal change (greater than 51 percent) as a result of the oil spill. These habitat types are those located at or just below the waterline. Thus, sampling was concentrated in these areas. Whenever possible, identical habitat types were sampled at each site to minimize the effects of small scale spatial variation inherent in most habitat mosaics.

Teams of biologists collected a variety of samples from several different habitat types. The nektonic fauna of Black Lake was sampled with 19.2 m gill nets. These nets were composed of 8 panels (1.2 m x 2.4 m), forming two sequences of the four stretched mesh sizes: 1.9, 2.5, 5.1, and 7.6 cm. Gill nets were deployed perpendicular to channels or other suspected migratory pathways. Catches of nektonic animals were counted and identified in the field and discarded, except when a reference specimen was kept to confirm its species identification or for chemical analyses.

Benthic organims in Black Lake were sampled with a 23 x 23 cm (0.053 m^2) Ponar grab sampler dropped from a small boat. These samples were washed through a No. 18 (1.00 mm) or No. 20 (0.85 mm) sieve aboard the boat or onshore near the field office to separate the organisms from the sediment. Portions of additional samples were kept intact for grain size analyses. Portions of the washed samples retained by the sieve were placed in a plastic bag or bucket and fixed with a 10 percent solution of formalin.

Sets of samples were taken at each of three locations in Black Lake. The first location, designated the "Affected Area," was established

approximately 600 m northwest of the Well 6, between the well and the peninsula to the west of it (Figure 7.2-1). The second location, designated the "West Control Area," was established approximately 800 m southwest of this peninsula and nearly the same distance from shore as the first site (approximately 150 m). The third site was designated the "East Control Area" and was established in a channel approximately 500 m east of the Well 6.

Samples of the marsh flora and fauna were collected at three sites corresponding to and directly onshore of the three lake sites (Figure 7.2-1). A fourth location, designated the "North Control Area," was established in a small tidal pond approximately 800 m northeast of the East Control Area during the Phase II sampling effort. To ensure uniformity of habitat type these samples were collected in stands of the black rush (Juncus roemerianus), which grow along the edges of the shore and numerous small islands adjacent to the shore. At each site, 8 to 36 replicate 0.25 m^2 samples (stations) were located without prejudice by tossing a short stick over a shoulder into the habitat. In some cases, a shortage of uniform habitat left little choice of sample location. A 0.5 m x 0.5 m frame was then placed on the site identified by the stick. Vegetation was then clipped as near to the ground as practical without destroying bottom dwelling animals (usually approximately 3 cm) and placed in a plastic bag, which was then sealed and tagged. A smaller (0.25 m x 0.25 m) frame was placed approximately in the center of the larger frame. The soil within the smaller frame was excavated to a depth of approximately 10 cm, placed in a plastic bag or bucket and fixed with a 10 percent formalin solution.

Birds were surveyed daily during the Phases I and III field surveys by an experienced biologist. Water samples for biochemical analyses were collected in prepared jars from a small boat at sites adjacent to the affected and west control marshes on September 30, 1978.

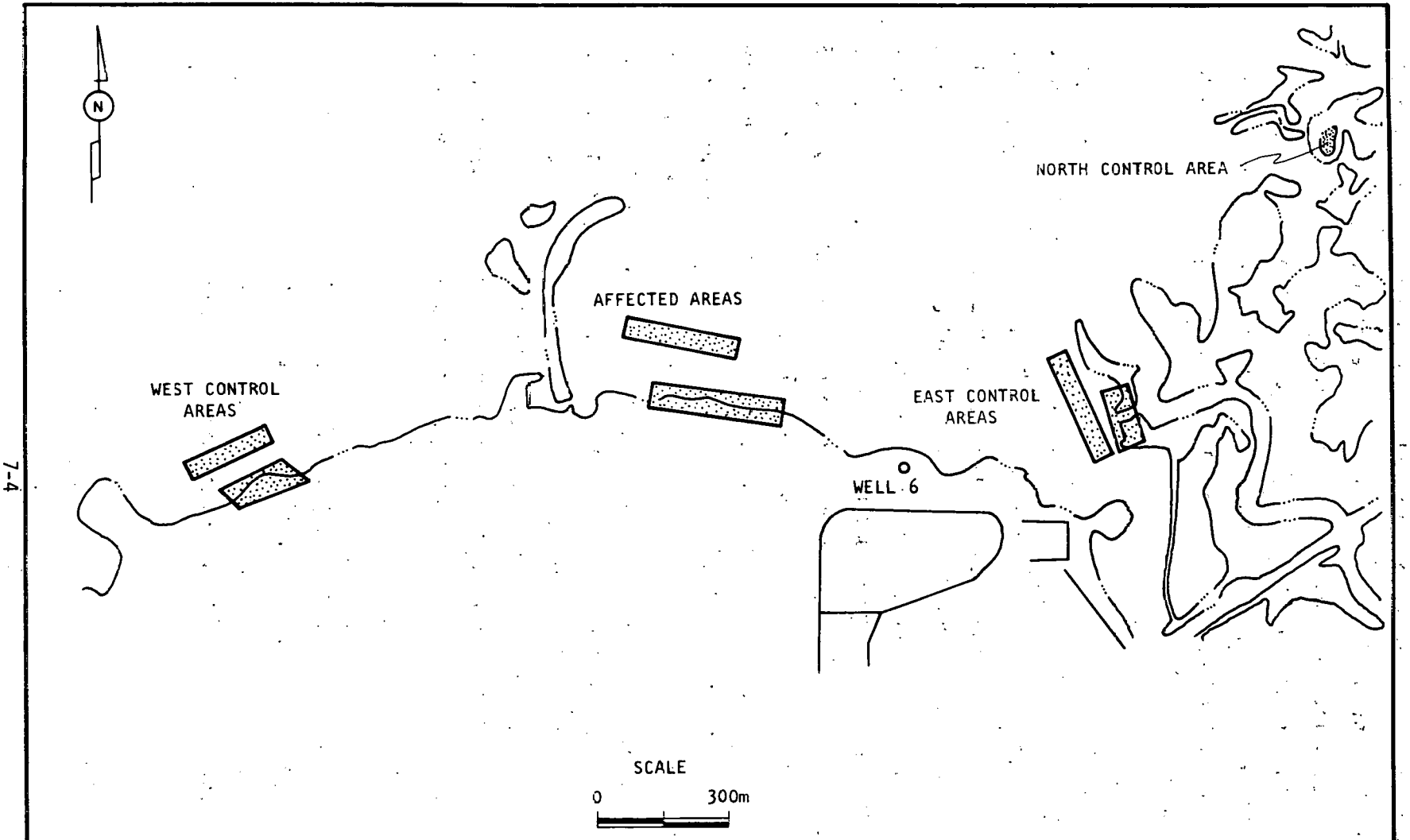


FIGURE 7.2-1. LOCATIONS OF BIOLOGY SAMPLING SITES IN BLACK LAKE

7.2.2 Chemical

7.2.2.1 Trace Metals

Soil samples were obtained by taking three 2 cm x 2 cm square samples of soil 1 to 2 cm deep which were relatively free of any roots and/or other plant growth. These soil samples were placed in an acid leached plastic bag, sealed, and tagged with a chain-of-custody tag.

Vegetation samples were obtained from Chinese tallow trees that were exposed to the plume. Three branches about 1.5 to 1.8 m off the ground were selected from the side of the tree facing the fire. The branches were then stripped of their outermost leaves and these leaves placed in a plastic bag, sealed and labelled. The samples were placed in a cool area and frozen at the end of the day's collections.

Samples were collected at selected distances from the fire to permit mapping of the distribution of vanadium as a function of downwind distance. Since no prefire samples were obtainable, samples collected 1 year after the fire (Phase IV) were used to estimate the background levels of vanadium. Phase IV vegetation samples from deciduous plants consisted of new leaves which were not directly exposed to the plume; however, they may have been exposed to soot from other fires in the area, e.g., field burnoff, chemical plant flaring, etc.

7.2.2.2 Hydrocarbon Samples

Several types of samples were collected for the analysis of organic components (hydrocarbons). These included air, sediment, soil (terrestrial), foliage, water, oil slick, and animal tissue samples. Emphasis was placed on collection of sediment, soil, and foliage samples, since these types of samples provided information that most accurately reflected conditions in the environment. All samples for hydrocarbon

analysis were collected in a manner designed to minimize contamination. Sediment and soil samples were collected by either a clam shell grab or shovel and stored in the frozen state in acid washed, Teflon-capped bottles. Foliage samples were wrapped in aluminum foil and frozen for storage.

A Nutech Model 221-1A gas sampler was used to collect air samples. Cartridges were packed with approximately 1 gram of Tenax which had been conditioned at 300°C for several hours with a helium flow of approximately 15 ml/minute. The packing material was held in place in the cartridges with plugs of silylated glass wool.

Air samples were collected utilizing a 4 l/minute sampling rate for a duration of 15 minutes. Cartridges were stored and transported in pyrex glass tubes with Teflon-lined screw caps which had been acid washed and heated prior to use. Samples were stored and transported at room temperature.

Sampling sites were chosen to reflect the areas of impact in Black Lake and the area downwind from the fire. Areas unaffected by the oil spill were chosen as control sites. Sampling was done in a modified grid network. The areas sampled included Black Lake (east, west and north of Well 6); the southwest quadrant on land (from Well 6) as far as was accessible by vehicle; and portions of the Sabine Wildlife Refuge.

7.2.3 Physical

To investigate the spatial variations of the wind field in the shoreline complex where the spill occurred, three portable meteorological stations were installed at West Hackberry on September 29, 1978. The meteorological stations were established onshore, southwest of Well 6; in the marsh along the south shore of Black Lake; and offshore on a

narrow peninsula (Figure 7.2-2). Three MRI Mechanical Weather Stations were selected for this application, based on their durability under similar, adverse monitoring conditions.

Meteorological Stations 1, 2, and 3 were each equipped with MRI Model 1076 Mechanical Weather Stations. These models continuously monitor wind speed, wind direction, temperature and relative humidity, although the system at Station 3 did not contain a relative humidity element. Up to 65 days of data can be recorded in rectilinear form on a strip chart recorder which is standard on these systems. The temperature sensor is a shielded spiral coiled bimetallic element with a system range of -34.4°C to 48.8°C. Wind speed (or more accurately wind run) is measured by an aluminum, 3-cup anemometer with a specified starting threshold of less than 1.2 km/hr and an overall accuracy of ±2 percent. Wind direction is measured by a ball bearing-mounted single blade aluminum vane with nose damping. The vane has a specified delay distance of 2.44 m and an overall accuracy of ±1 percent full scale. The relative humidity sensor utilizes a xerex sensing element capable of producing system accuracies of ±3 percent.

Air quality monitoring was initiated at the West Hackberry site during the fire at 1910 CST, September 25, 1978. Sampling locations were established at a site upwind from the fire and at two downwind locations directly beneath the plume centerline at the time monitoring began (Figure 7.2-3). A high volume sampler and a bubbler unit were installed at each site. Air Quality Stations 1 and 3 were powered by portable generators placed downwind of the sampling units. Air Quality Station 2 received its electrical power from a nearby guard house. After Well 6 was plugged, air quality sampling was terminated at 0730 CST, September 26, 1978.

Hydrological sampling of surface currents in Black Lake were scheduled in late October, 1978, following restoration of the shoreline

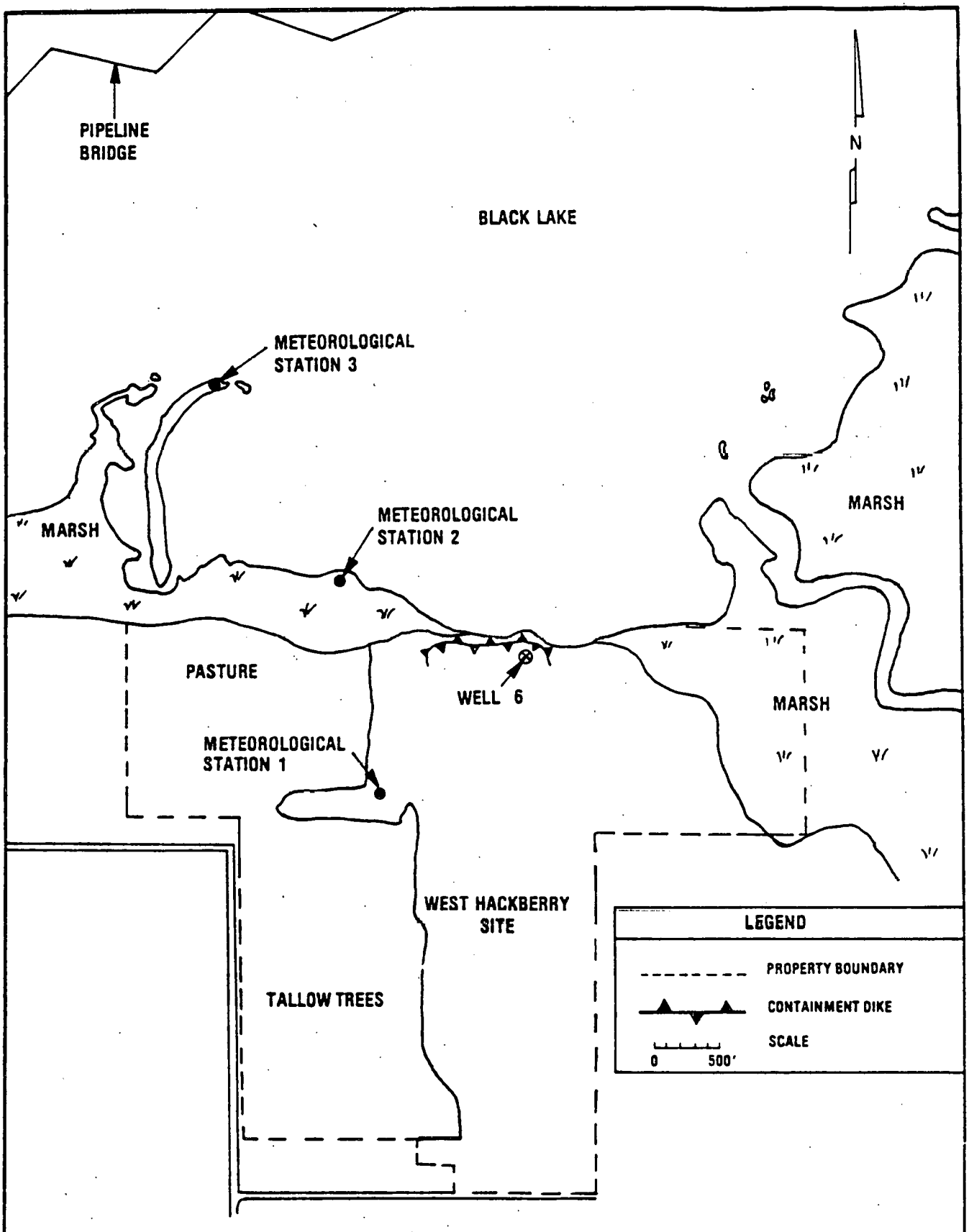


FIGURE 7.2-2
METEOROLOGICAL STATIONS AT THE WEST HACKBERRY SITE
SEPTEMBER - DECEMBER 1978

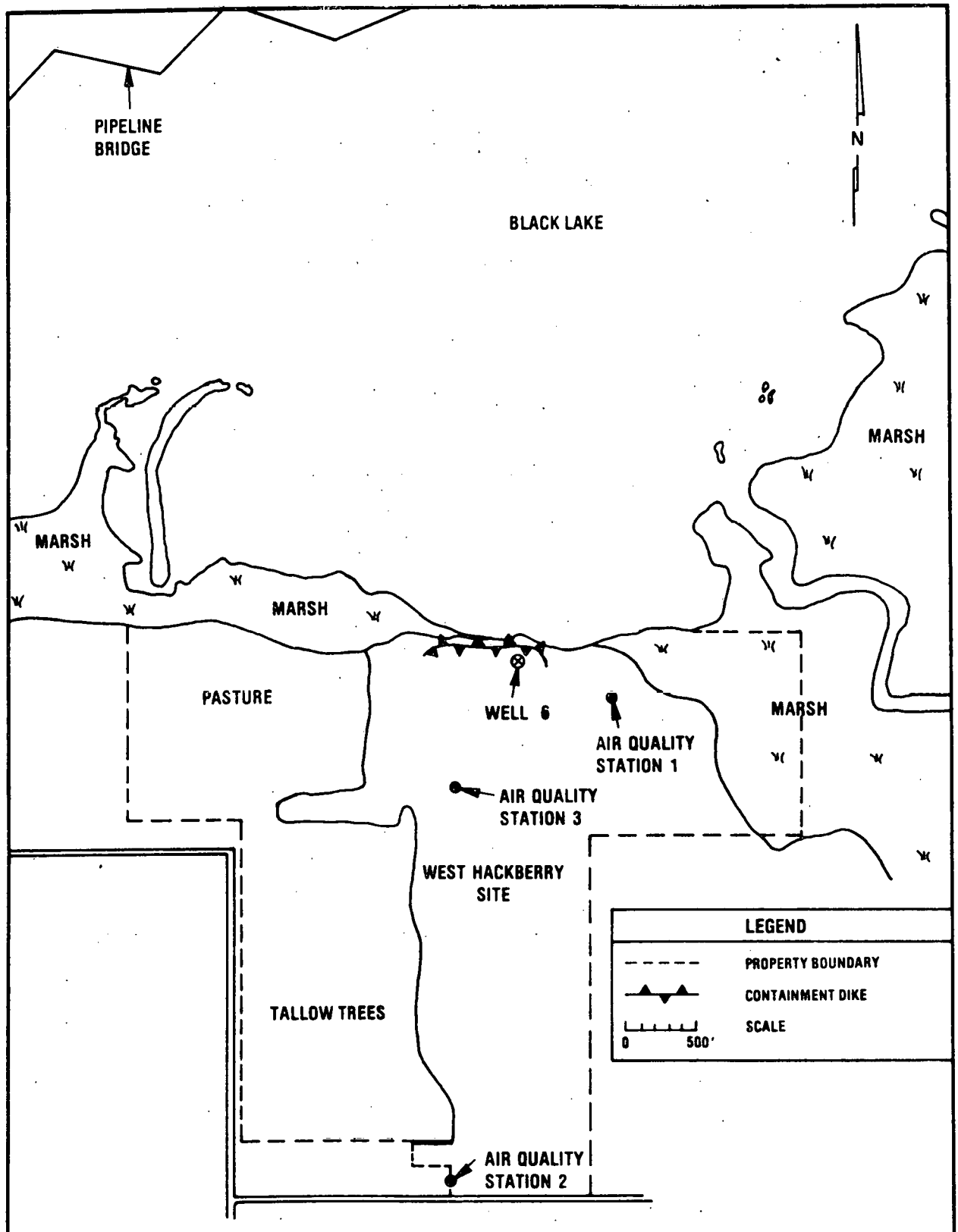


FIGURE 7.2-3
AIR QUALITY MONITORING STATIONS AT WEST HACKBERRY SITE
SEPTEMBER 25-26, 1978

in the area of the spill. Ideally, all oil containment booms should have been removed for these tests, but a permament boom remained deployed as a precautionary measure during restoration of the wellpad surrounding Cavern 6. Lack of precipitation during the autumn months seriously reduced water levels in Black Lake and the surrounding marsh. Water depths of only a few inches in the marsh and portions of the lake hampered transportation by boat until December.

On December 7, 1978, drogue studies were conducted in the general area of the spill. A total of seven weighted, styrofoam drogues were released and accurately tracked with a theodolite and range finder at intervals ranging from about 15 minutes to 1 hour. The drogues were designed to achieve buoyant equilibrium just below the water surface to preclude direct influence of winds at the air-water interface. Their 6.35 cm depth made them suitable tracers of near surface currents which transported spilled oil.

This inexpensive procedure of current measurement proved to be relatively problem-free. It provided good spatial continuity over relatively large areas. Drogue tracking was particularly advantageous in that it reflected an accurate measure of small mean velocities since it yielded a time integral of velocity along a trajectory. On the other hand, the drogue method of current measurement was associated with poor time continuity, since data was obtained only for the few hours that drogues were in the water. In addition, the marsh environment at West Hackberry prevented the transport of drogues through marsh vegetation.

The limitations of drogue tracking in the marsh environment were somewhat mitigated by the delineation of liquid tracers. Although Cavern 6 oil and LSC oil were not readily distinguishable in the field, an excellent trace of the areal extent of the spill in the marsh was determined from the presence of fresh oil-stained marsh vegetation and occasional spill-related oil sheens. This tracing method was enhanced

as water levels in Black Lake receded due to northerly winds and the lack of precipitation in late September and early October 1978. The high water level was clearly indicated by oil stains on vegetation in the marsh west of the main spill area, and occasional oil sheens were also observed. On September 23, 1978, the general area of this sporadic but visibly impacted area was delineated on field copies of aerial photographs of the site.

7.3 LABORATORY TECHNIQUES

7.3.1 Biological

Vegetation samples were stored dry in the laboratory until processing. Each clip was broken apart, washed with water over a U.S.A. Standard Testing Sieve No. 18 (1.00 mm) to remove any soil, and dried with towel papers. Stems (cut into sections if needed) were then placed in paper bags and weighed on a Series E2000 Mettler balance to the nearest 0.1 gram (wet weight). Samples were then dried in laboratory ovens at 100°C for 72 hours and then reweighed (dry weight). Representative samples from each site were sorted by species prior to drying and weighing to determine floral composition of the habitats sampled.

Black Lake benthic (Ponar grab) samples were washed in the laboratory through a U.S.A. Standard Testing Sieve No. 18 (1.00 mm) to remove any remaining sand or silt and to standardize all samples. (Samples had been washed with both No. 18 and No. 20 sieves in the field.) In one study, Reish (1959) found this size sieve to retain approximately 85 percent of the species in the sample and greater than 90 percent of the biomass. Many nematodes, copepods, and ostracods were probably lost, but almost all larger crustaceans and molluscs were retained.

Samples were stained with a 1:1 mixture of Eosin B and Biebrich Scarlet (Matheson, Coleman and Bell Biological Stains) at the ratio of 1

to 3 parts stain to 1,000 parts sample and left for 24 hours. The samples were then back-washed prior to sorting to get rid of excess stain. This staining method, based on Williams (1974), reduces sorting time per sample and improves the accuracy of the sorting process.

All samples were sorted with the aid of a stereoscope. The entire sample was scanned at a 7X magnification in a flat grid tray. All organisms were identified to species when practical and placed in labeled vials. Unidentified specimens were placed in separate vials and set aside for later identification. All organisms from the samples were maintained in the laboratory for the duration of the project.

Faunal analysis of sediment samples from marsh habitats required a two-stage sorting scheme, as illustrated in Figure 7.3-1. Large animals (mussels, mud crabs, etc.) were removed when the plant stems and roots were broken apart and cleaned. The slurry in the sieve was stained and back-washed as described above, then split into 24 equivalent parts, using a specially designed plexiglas splitter. Each resultant replicate subsample was sorted as a unit. After four subsamples were analyzed, the need for additional analyses from that sample was determined based on the testing requirements (sensitivity, confidence). Sensitivity to a 51 percent change in faunal abundance at the 95 percent confidence level was required for a Type II error. A Type II error would occur if it were concluded that no change had occurred when in fact one had.

Grain size analyses were performed using the ASTM standard methods for dry preparation of soil samples for particle size analysis, determination of soil constants and for sieve analysis of mineral filler (D 421-58 and D 546-72, ASTM, 1975). These procedures yielded a cumulative percentage grain size distribution by weight for the sand and silt fractions.

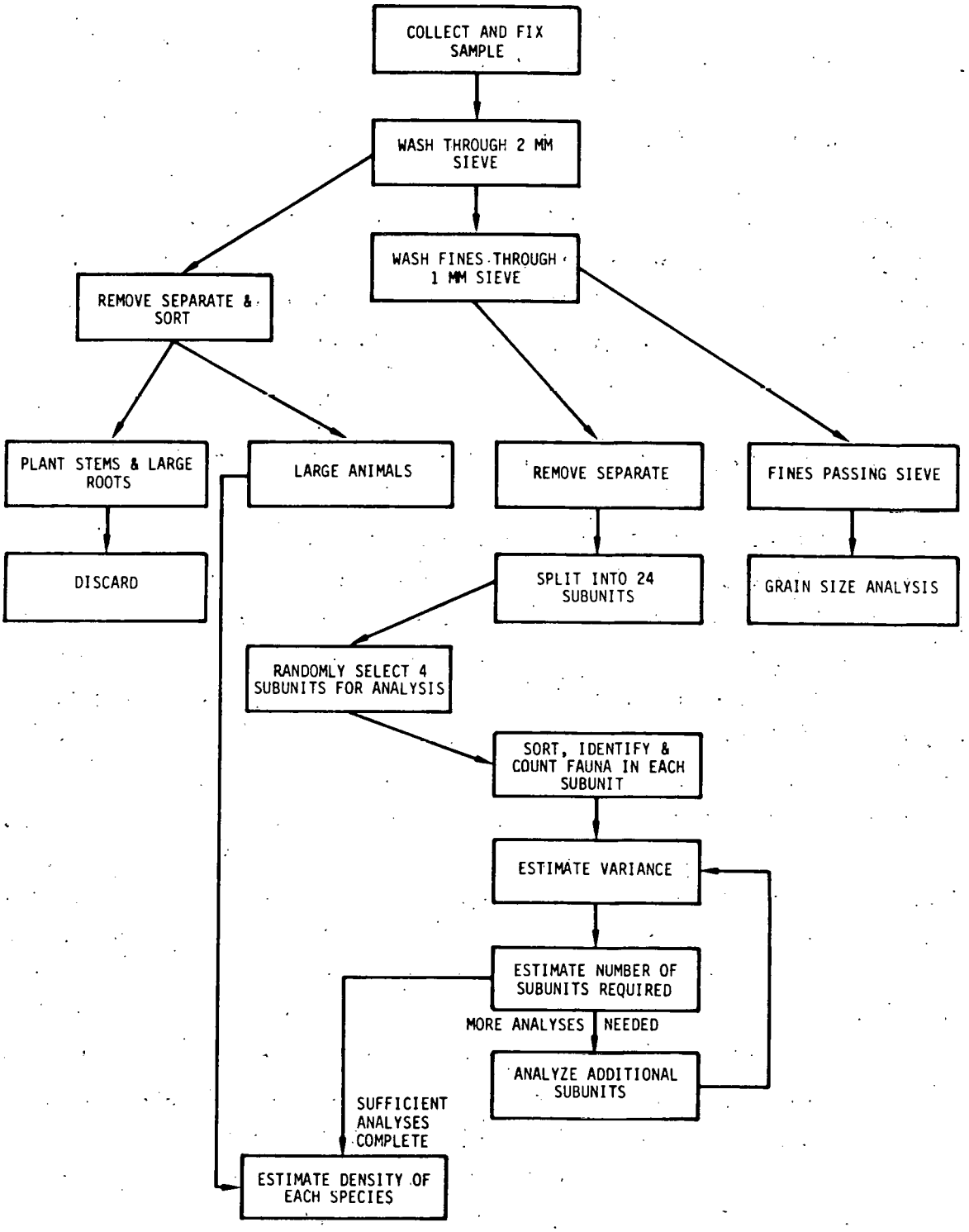


FIGURE 7.3-1 BENTHIC SAMPLE SUBSAMPLING AND SORTING PROCEDURE

7.3.2 Chemical

7.3.2.1 Chemical Extraction and Workup

A. University of New Orleans (UNO) Procedures

Solvents used in the analyses of environmental assessment samples were glass distilled and were purchased from Burdick-Jackson (Muskegon, Michigan). Deionized water was used in all procedures. Glassware was washed with Alconox detergent, soaked in chromic acid and rinsed with deionized water prior to use.

Chemical analysis of the environmental samples consisted of three steps: extraction; isolation; and instrumental analysis. There are numerous methods which can be used to remove petroleum hydrocarbons from environmental samples. The method chosen was based on the extraction procedure for sediments developed at the NOAA National Marine Fisheries Service laboratory in Seattle (MacLeod's method) and involved shaking the sediment, soil or mussel tissue sample with solvent (methanol, methanol/methylene chloride and methylene chloride), then backextracting the liquid extract with organic solvents. The sample was first homogenized and a 50 gram aliquot was removed for analysis (for heavily oiled samples, smaller quantities were used). Then 50 ml methanol and 12 µg of recovery standard (dodecylcyclohexane in hexane) were added. The sample and methanol were shaken together for 20 minutes and the solvent decanted. The sample was then shaken once for 10 minutes with 50 ml of methanol, twice for 10 minutes, each time with 50 ml of methylene chloride to methanol (2:1), and once for 10 minutes with 50 ml of methylene chloride. All liquid extracts were combined, and 100 ml of deionized water was added to the extract. This solution was extracted twice with 25 ml of methylene chloride. The organic extract was combined with an additional 100 ml of deionized water and again extracted twice with 25 ml of methylene chloride. The extract was then dried with sodium sulphate and stored in a freezer for later processing.

The surface of foliage samples was extracted by shaking the sample material with 50 ml of methylene chloride for 20 minutes. The organic extracts were decanted, filtered, dried with sodium sulphate and stored in a freezer for later processing.

Methods for extracting hydrocarbons also may extract numerous biogenic-type compounds that are present in soil, sediment and biota samples. The petroleum-derived hydrocarbons must be isolated out of this complex mixture. The conventional method is fractionation of the sample on a column of activated silica gel. This procedure separates the components of the extraction mixture into three fractions: saturate (f_1); aromatic (f_2); and polar (f_3). Much of the biogenic material in the samples was either retained by the silica gel or eluted in the polar fraction. However, foliage samples were an exception since a significant amount of biogenic material also eluted in the aromatic fraction.

The organic extracts were reduced in volume using rotary evaporators and the solvent displaced with hexane. The organic extracts were transferred to silica gel columns which had been prepared in the following manner. A piece of filter paper was placed in the bottom of a 1 x 30 cm glass liquid chromatographic column. One centimeter of sand was placed in the liquid chromatographic column. A slurry of hexane and silica gel (activated overnight at 150°C) was added to the column. The fractions were eluted using 60 ml of the following solvents: hexane (saturate); 30 percent methylene chloride in hexane (aromatic) and methanol (polar). Each fraction was reduced in volume by rotary evaporators, transferred to 5 ml vials and stored in a freezer for gas chromatographic analyses. Procedural blanks were processed with each batch of samples in order to check the procedure and solvents and avoid contamination.

B. University of Rhode Island (URI) Procedures

All solvents used in the analyses were of reagent grade quality and were purchased from Matheson Coleman & Bell. Immediately prior to use, all solvents were distilled in stopcock grease-free glass to remove any contaminants. Freshly deionized-distilled water was used. Glassware was prepared by cleaning with Alconox detergent, followed by cleansing in a glassware washer and rinsing with distilled water. Immediately prior to use, all glassware was rinsed with the solvent to be used in that portion of the analysis.

Water Samples

Approximately one liter of each water sample was extracted with two successive 15 ml aliquots of carbon disulfide. The aliquots were then combined for subsequent chemical analysis.

Sediment Extraction

A sediment sample was wet sieved through 1.0 mm chromel screen using distilled water. A 5.0 g sample was dried in an oven at 105°C for two hours and its percent dry weight determined. A wet sediment sample that was calculated to be 50 g dry weight was put into a 500 ml round bottom flask. A liquid volume equal to five times the amount of sample was added so that the resulting solution was 70 percent 0.5 N KOH/MgOH and 30 percent benzene. A sufficient amount of distilled water was added to make the final composition of the solution 15 percent water. Fifty µg of an internal standard, n-C_{20} in methanol, was added, and the mixture was refluxed for 2 hours.

After cooling, the mixture was vacuum filtered through a Whatman GF/C glass fiber filter and washed with methanol and hexane. The filtrate was placed in a 500 ml separatory funnel, and sufficient water was

added such that the resulting solution had an aqueous layer which was 1:1, water to methanol. The layers were separated, the benzene layer was saved, and the aqueous layer washed with hexane. The benzene and hexane soluble portions were combined and the sample was condensed to 1 ml using a rotary evaporator.

A chromatographic column was prepared by plugging the end of a Pasteur pipet with glass wool which had been previously washed with hydrochloric acid. The column bed was prepared with 0.3 g copper powder (activated by elution with 1.0 ml of Normal hydrochloric acid) and alumina (previously deactivated with 5 percent water). A plug of glass wool was inserted above the alumina. After preparing the column by eluting with two bed volumes of 95:5 hexane to benzene, the sample was charged to the column followed by elution with 5 bed volumes of hexane and benzene mixture. The eluent was collected in a 100 ml round-bottom flask, and the solvent completely removed by evaporation under nitrogen.

The residue was dissolved in carbon disulfide for quantitative and qualitative analysis by infrared spectroscopy. Following the infrared analysis, the sample was further separated using thin layer chromatography. Plates coated with 0.25 mm silica gel 60F-254 from E. M. Labs, Inc., were predeveloped with hexane. The sample was concentrated to 0.5 ml and spotted on the plate along with a phenanthrene reference. After development with hexane and viewing under ultraviolet light, the plate was divided at the phenanthrene standard into upper and lower portions. The separate portions were scraped into a round-bottom flask and carbon disulfide added to dissolve the sample. Each portion was filtered through a sintered glass funnel under vacuum and condensed for gas chromatograph and gas chromatograph/mass spectrometer analyses.

7.3.2.2 Analytical Instruments and Calibration

A. University of New Orleans (UNO) Procedures

Calibration of the gas chromatographs and gas chromatograph/mass spectrometer was monitored by running a series of standards prior to each batch analysis.

The following analytical instruments were used in this investigation:

1. A Hewlett-Packard 3354A laboratory data system based around a HP 2100A computer with a 32K word memory was used for data acquisition of chromatographic data, data storage, data manipulation and subsequent data display. This system was interfaced to an HP 7905A high density disk with 5 megawords of online storage. Offline storage was via a 9-track IBM compatible magnetic tape drive which stored 1600 characters per inch. The data system was interfaced to 15 gas chromatographs with HP 18652A A/D converters via 2 data loops.

   Graphics were supplied by a Tektronix 4051 intelligent terminal with a 32K word memory and a Tektronix 4662 digital plotter. These instruments were interfaced to the 3354A laboratory data system and data graphically displayed using software developed in-house (Steele, 1978). All data were retained on magnetic tape or magnetic disk.

2. Hewlett-Packard 5710A gas chromatographs equipped with an HP 18740A glass capillary inlet system were used for all chromatographic analyses except air samples. Air samples were analyzed on a Hewlett-Packard 5710 gas chromatograph equipped with a modified injection part which would accept the

cartridges containing the air samples. All gas chromatographs were interfaced to the HP3354A laboratory data system.

3. A Hewlett-Packard 5840A gas chromatograph equipped with a glass capillary column and interfaced to a Hewlett-Packard 5985 quadrupole mass spectrometer was used to quantify pyrogenic products and to qualify the type of oil present in the samples. This instrument was equipped with an HP 7920 disk drive, HP 7970B digital tape unit, HP 21MX E-series computer with a 2.5M word memory, a Tektronix 4012 display terminal and a Tektronix 4631 hard copy unit. All data were retained on magnetic tape.

4. A Varian 311A high resolution mass spectrometer interfaced to a Varian Spectrosystem 100 data system was also used for gas chromatograph/mass spectrometer analyses. This unit was coupled to a Varian 2700 gas chromatograph. All gas chromatograph/mass spectrometer data were stored on magnetic disk.

5. A DuPont 21-491 mass spectrometer interfaced to a Hewlett-Packard 5710A gas chromatograph which was equipped with a modified injection part (able to accept Tenax air sample cartridges) was used in the analysis of air samples. Spectral data was processed by a PDP-12 LDP computer.

B. University of Rhode Island (URI) Procedures

Calibrations of the infrared spectrophotometer, gas chromatographs, and gas chromatograph/mass spectrometer were maintained by running a series of blanks and standards prior to each batch of analysis. The

Mettler balance used by this laboratory was calibrated by a factory serviceman prior to the start of this project.

Analytical Instruments

The following analytical instruments were used in this investigation:

1. Nova 3/12 minicomputer with a 10 megabyte cartridge disk drive, a dual 0.3 megabyte "floppy" diskette drive, a 64K word memory, 16 channel ADC, 16 channel digital I/O, 2 channel D/A, a teletype (TTY), a graphic CRT, and a digital plotter.

2. Micro Nova microcomputer with a dual 0.3 megabyte floppy diskette drive, a 28K word memory, 16 channel ADC, and terminal.

   These two computer systems were used for data acquisition from the infrared spectrophotometer, gas chromatographs, and gas chromatographs/mass spectrometer data storage, data manipulation, and subsequent data display.

3. Beckman 4260 infrared spectrophotometer interfaced to the Nova 3/12. This instrument was used for quantitative and qualitative analysis on oil and water extracts.

4. Hewlett-Packard 5710A gas chromatograph with a capillary column, interfaced to the Micro Nova 3/12. This instrument was used for qualitative analysis of oil, water extracts, and sediment extracts. It was also used for quantitative analysis on sediment extracts.

5. Perkin-Elmer Sigma II gas chromatograph with a capillary column, interfaced to the Micro Nova. This instrument was used for the same analysis as the H-P 5710A gas chromatograph.

6. Gas chromatograph/mass spectrometer was interfaced to the Nova 3/12 with the HP-5710A gas chromatograph. This instrument was used to differentiate those samples which could not be positively identified by infrared spectrophotometer and gas chromatograph methods.

After the extraction and isolation (fractionation) of the petroleum hydrocarbons, the different fractions were analyzed by glass capillary gas chromatography and gas chromatography/mass spectrometry.

7.3.2.3 Infrared Spectrometry

Infrared spectrometry was used primarily to determine the concentration of extractable organics from a sample. The organic material was extracted from the sample by using a suitable solvent (carbon tetrachloride or carbon disulfide). The amount of extractable hydrocarbons was measured by the amount of infrared absorbence at a frequency of 2,930 cm^{-1}. This corresponded to the carbon-hydrogen stretching band of the molecule. The concentrations in the sample were determined by comparing the amount of absorbence in this band to a standard.

The disadvantage of this method is that it cannot differentiate quantitatively between petroleum hydrocarbons and biogenic hydrocarbons. This method was used in this work in conjunction with column chromatography to differentiate between total extractable organics and total extractable hydrocarbons. Other methods such as capillary gas chromatography must be used to separate petroleum hydrocarbons and biogenic hydrocarbons.

Quantitative Analysis

The concentrations of extractable organics including oxidized hydrocarbons in water and sediment samples were determined by measuring the infrared absorption in the carbon-hydrogen stretching region at 2930 cm^{-1}. The measured absorbences were converted to concentrations by using a predetermined graph obtained for standard mixtures of Cavern 6 crude oil and carbon disulfide.

For unknown solutions of marine extracts in carbon disulfide, the total volume was adjusted to 25 ml. Approximately 0.5 ml of the solution was placed in an infrared cell with a 6 mm pathlength; pure carbon disulfide in an identical cell was used for compensation. The infrared spectrum of the sample was measured from 3,200 to 2,800 cm^{-1}. To determine the absorbence, the percent transmission at 3,200 cm^{-1} (no absorption) was used as I_0 and the percent transmission at 2,930 cm^{-1} as I. All spectra were measured on a Beckman 4260 infrared spectrometer.

Qualitative Analysis

The carbon disulfide solutions used above were concentrated to 1 ml and the complete infrared spectrum from 4,000 to 600 cm^{-1} was measured using the same 6 mm pathlength cells and the same instrument. In the case of concentrated oil samples, infrared spectra of the fresh samples were measured from 4,000 to 500 cm^{-1}.

7.3.2.4 Capillary Gas Chromatography

Capillary gas chromatography is capable of resolving hundreds of components in the complex chemical mixture of oil and providing passive tags of the oil. Calculations of such parameters as odd-even n-alkane ratios, n-alkane-isoprenoid ratios, and pristane/phytane ratios have traditionally been used to indicate the types of hydrocarbons

present in samples. More recently, integration of the entire chromatogram has been used to quantify the amount of petroleum hydrocarbons in samples (Lawler et al., 1978a and Lawler et al., 1978b). Capillary columns which exhibit low absorption characteristics for aromatic type hydrocarbons are extremely useful in the analysis of these types of compounds. Many of these aromatic hydrocarbons such as the alkylated benzenes, naphthalenes, dibenzothiophenes, and phenanthrenes are excellent markers for determining the sources of petroleum contamination in environmental samples. Other aromatic hydrocarbons, known as polycyclic aromatic hydrocarbons or PAH, which are produced in combustion processes such as the fire can also be analyzed using glass capillary gas chromatography.

One difficulty encountered in the use of gas chromatography to quantify oil in samples is the presence of an unresolved complex mixture which is evident in samples containing weathered petroleum. The unresolved complex mixture constantly alters the chromatographic baseline and therefore interferes with the use of standard chromatographic integration methods. To overcome this limitation, special software has been developed which accounts for the changing baseline and allows proper integration of peak areas (Overton et al., 1978).

A. Capillary Gas Chromatography Analysis (UNO)

1. Qualitative Analysis by Capillary Gas Chromatography

All fractions for gas chromatographic analysis were spiked with an internal standard containing 20 µg each of hexamethylbenzene and 3-methyltricosane. The aromatic fraction of the foliage samples was spiked with 20 µg each of hexaethylbenzene and 3-methyltricosane. The fractions generally were reduced to a final volume of 100 to 200 µl under a stream of purified nitrogen. One microliter volumes were injected.

All samples (except air samples) were run on HP 5710A gas chromatographs equipped with SE-52 coated glass capillary columns (about 0.3 mm

x 28 m) and flame ionization detection. The chromatographic ovens were programmed from 50°C to 240°C at 4C° per minute. For the air samples, cartridges packed with Tenax were inserted directly into a modified injection port of a Hewlett-Packard 5710 series gas chromatograph. A 152 m x 0.508 m ID stainless steel capillary column coated with SF-96 and Igepal Co 880 was used for analysis. The chromatographic column was programmed from -20°C to 170°C during the course of analysis. Identification of compounds from chromatographic data (internal standards, recovery standard, pristane, phytane, normal hydrocarbons) was based on retention times comparisons after periodically running a series of standards containing the compounds of interest. All qualitative identifications were confirmed by gas chromatograph/mass spectrograph analysis.

2. Quantitative Analysis by Capillary Chromatography

There are several ways to determine the quantity of petroleum hydrocarbons in environmental samples. The method chosen for analyses in this study allowed quantification of the resolvable and identifiable petroleum components in samples but did not quantify the total hydrocarbon content of the samples. This method was chosen because the hydrocarbons that were quantified could also be identified as either Cavern 6 crude oil or Louisiana Sweet Crude oil and the resolvable aromatic components are those substances known to be toxic for marine organisms. Also, total hydrocarbon content reflects those substances that originate not only from petroleum contamination but from biological sources.

The resolvable components were quantified as follows: A relatively noncontaminated sediment sample from Black Lake was homogenized and divided into aliquots. The aliquots were spiked with Cavern 6 crude oil at the 0, 1, 10, 50, and 100 ppm levels and with a recovery standard (dodecylcyclohexane). The samples were then chromatographically analyzed for the following parameters: total hydrocarbon content; total

resolvable hydrocarbon content; pristane concentration; phytane concentration; and the n-C_{18} to n-C_{23} total hydrocarbon content. All parameters were corrected for recovery. A calibration curve was constructed which displayed the quantity of each parameter as a function of its concentration from 0 to 100 ppm. Using these calibration curves, the quantity of Cavern 6 crude oil in environmental samples was estimated for each parameter.

The concentration values were manually interpreted to select those parameters which gave the best estimate of oil contamination based on the amount of fresh oil present in the samples. For example, the total hydrocarbon parameter reflected both the resolved components and the unresolved complex mixture in a given sample. The unresolved complex mixture becomes predominant in heavily weathered samples and is not a good indicator of fresh petroleum levels. Therefore, the total hydrocarbon parameter cannot be used to estimate contamination in the samples. Also, pristane is not a good parameter to quantify oil contamination, since pristane can come from biological sources and thus may give an abnormally high concentration reading. On the other hand, phytane is a component of Cavern 6 crude oil and is generally absent in organisms in appreciable concentrations. This parameter should accurately reflect Cavern 6 crude oil contamination levels. By examination of the data obtained from numerous Phase I and Phase II samples, it was determined that the C_{18} to C_{23} normal hydrocarbon quantities and the phytane concentration were the most accurate parameters for determining the quantity of oil contamination. An average of these two parameters was used to quantify the extent of oil contamination in the samples. Over 1,200 glass capillary gas chromatograms were run to provide data for the environmental assessment of the oil spill and fire at the West Hackberry storage facility.

B. Capillary Column Gas Chromatography (URI)

Gas chromatography of oil and marine samples were measured on a Hewlett-Packard Model 5710A gas chromatograph and on a Perkin-Elmer Sigma 2 gas chromatograph, using glass capillary columns (Supelco SP-2100, 60 m) and flame ionization detection. The column ovens were temperature programmed from 90° to 270°C at 4C° per minute. Prior to measurement of the gas chromatograms, all solvent was removed from the samples, and the samples were dissolved in hexane to remove any asphalts. The hexane solutions were then injected into the gas chromatographs. The gas chromatograph columns were calibrated with a standard mixture of n-C_{20}, n-C_{21}, n-C_{22}, and n-C_{23}, i.e., the retention times of these four components were used to determine the retention times of unknown components. The pristane and phytane retention times were identified by spiking samples of Cavern 6 crude oil and Louisana Sweet Crude oil with a standard mixture of pristane and phytane and measurement of the gas chromatograms.

All of the gas chromatograms were stored digitally on disks via a NOVA 3/12 computer and a Micro Nova computer and displayed on a digital plotter. The chromatograms were stored on both hard, 5 Megabyte disk and on floppy 0.3 Megabyte diskettes, as backup.

7.3.2.5 Gas Chromatography/Mass Spectrometry

Gas chromatography/mass spectrometry is the most widely accepted technique for the qualitative analysis of extractable organic components in environmental samples. Useful quantitative information also can be obtained if the instrument is operated at rapid (1 sec) scan and cycle times. The principal advantage of using gas chromatography/mass spectrometry techniques to analyze environmental samples is that it can function as a selective detector for a large number of components. For instance, in a given analysis, the technique can readily distinguish

between the alkylated phenanthrenes and alkylated dibenzothiophenes. This is particularly advantageous since these components are difficult to separate chromatographically but are useful indicators of the source of crude oil contamination. The ability to distinguish between substances is based not only on physical characteristics of the substances, such as polarity, but also on the molecular weight of individual molecules and fragments of molecules. Figure 7.3-2 displays an example of the mass chromatograms (extracted ion current profiles) of the phenanthrene and dibenzothiophene families of hydrocarbons from Cavern 6 oil.

A. Glass Capillary Gas Chromatography/Mass Spectrometry Analysis-Qualitative and Quantitative (UNO)

The method of analysis for gas chromatography/mass spectrometry closely parallels that of gas chromatography analysis, except that a mass spectrometer was used as the chromatographic detector instead of a flame ionization detector.

For most analyses, the mass range was scanned from 110 to 275 atomic mass units every 1.0 second. Each scan was stored on a disk for subsequent processing and display. At the end of each run, a total ion plot was generated and mass searches were conducted for the C_1 to C_3 alkylated phenanthrenes (192, 206, 220) and C_1 to C_3 alkylated dibenzothiophenes (198, 212, 226). The ratios of the alkylated phenanthrenes to the correspondingly alkylated dibenzothiophenes were used to determine the type of oil present in the samples. Mass searches were also conducted for dibenzothiophene (184), phenanthrene (178) and pyrogenic compounds such as fluoranthene (202), pyrene (202), the chrysene family (228) and the benzopyrene family (252). The quantities of each of these substances were determined using the internal standard method from integrated mass chromatograms.

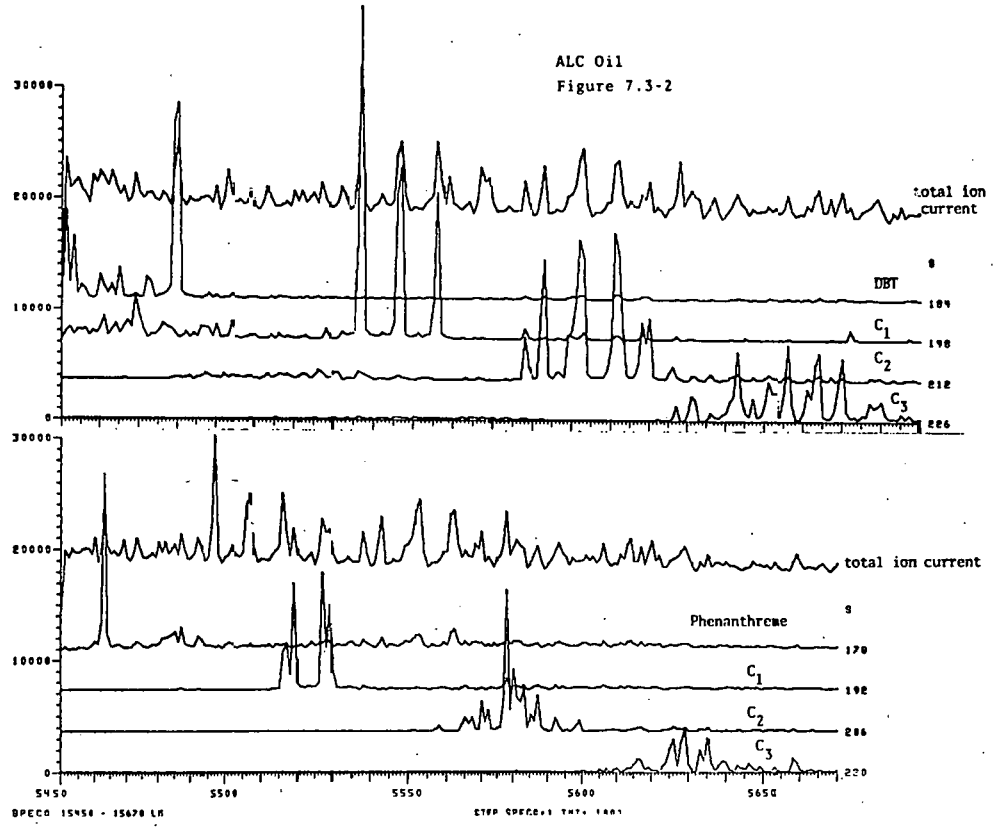


FIGURE 7.3-2 MASS CHROMATOGRAMS OF THE PHENANTHRENE AND DIBENZOTHIOPHENE FAMILIES OF HYDROCARBONS IN CAVERN 6 OIL

Over 200 gas chromatograph/mass spectrograph analyses were made to provide qualitative and quantitative data for the enviromental assessment of the West Hackberry oil spill and fire.

B. Gas Chromatography/Mass Spectrometry (URI)

The method of analysis for gas chromatography/mass spectrometry closely parallels that of gas chromatography analysis, except that a quadrapole mass spectrometer was used as the detector instead of a flame ionization detector.

The mass range was scanned from 50 to 400 atomic mass units every 0.3 seconds. Each scan was stored on disk for subsequent processing and display. At the end of each run, a total ion plot was generated and searches were conducted for aromatic compounds of specific masses at specific retention times.

7.3.2.6 Trace Metal Analytical Techniques

A. Instrumental Neutron Activation Analysis

Triplicate aliquots of Cavern 6 crude oil and API certified South Louisiana Crude oil were sealed in polyethylene vials which were pre-cleaned by leaching in 8 m nitric acid for 2 days, followed by three 2-day soaks in distilled, deionized water. Calibration standards for vanadium, aluminum, calcium, sodium, magnesium and manganese were prepared from commercial (Fisher) 1,000 mg/liter atomic absorption stock solutions. Chloride standards were made from solutions prepared from reagent-grade potassium salts. All vials were sealed in individual polyethylene bags for irradiation (double containment required).

Samples were irradiated individually along with aluminum foil flux monitors for 5 minutes in a pneumatic tube facility. Reported flux was 4×10^{12} neutrons/cm^2 sec.

Each sample was counted in fixed geometry for 800 seconds clock time, beginning 7 minutes after the beginning of irradiation; monitors were counted for 100 seconds beginning at 22 minutes after the beginning of irradiation. The counting system consisted of a 23 percent Ge(Li) detector, FWHM: 3.0 keV @ 1332 keV, coupled to a Canberra 8100 multichannel analyzer with 9-track computer tape readout capability. Counting data was automatically transferred to the tape at the end of each count.

Triplicate aliquots representing 7.7 cm^2 of exposed surface (both faces) were cut from individual leaves selected randomly from each sample bag. Standards for the same eleven elements as screened for in the oils were prepared by evaporating aliquots of the same standard solution onto circles of Whatman 41 filter paper the same size as the leaf aliquots. Irradiations occurred for 1 minute, and samples were counted for 200 seconds, 3 minutes after the beginning of irradiation. Monitors were counted for 100 seconds at 12 minutes after the beginning of irradiation. Conditions were otherwise identical to those described for the oil analysis.

Areas under most photopeaks were calculated by the GAMANAL portion of the computer program PIDAQ (Fashing et al., 1977). The standard comparison portion of that program was implemented manually with a Texas Instrument SR-52 programmable calculator to reduce interfacing problems. Corrections for detector dead time were made with the aid of an external pulser peak (60 cps) included in each gamma-ray spectrum.

The amount of any elements of interest (i.e., AL, V) in a sample was calculated based on the ratio of photopeak area to that of the same element in a known reference standard. Since all samples and standards of a given type were counted under identical conditions, no corrections for radioactive decay or differential detector efficiencies were necessary.

Soils were analyzed in a similar manner. The soils were dried to a constant weight and sieved to pass an 80 mesh screen. Next, 0.1 g of soil was placed into a clean vial and irradiated for 10 seconds. Triplicate analyses were performed on each sample, and concentrations determined as above.

To determine how much, if any, of the vanadium in the soils was bound to readily extractable organic matter, the soils were extracted with a benzene/methanol mixture and the extract analyzed for vanadium.

The following extraction procedure was utilized for extracting organic vanadium:

1. Ten g of soil (sieved to pass an 0.80 mesh screen) was placed in a beaker containing 50 ml of a 1/2 mixture of methanol/benzene. The soil was stirred and heated at 50°C for 12 hours.

2. The liquid was decanted and centrifuged to remove any suspended soil particles. The resulting liquid was concentrated down to 3 ml by allowing the solvent to evaporate.

3. One ml of the resulting concentrate was placed in a 5/8-dram polyethylene vial and the methanol/benzene mixture removed by a three step process.

    a. The vials were placed under a sun lamp on a laminar air clean bench and allowed to dry for 12 hours.

    b. The vials were then placed in a vacuum and heated to 40°C for 2 hours to remove any entrained solvents.

    c. The vials were then placed on a clean bench for 48 hours to allow all the solvents which may have diffused into the walls to escape.

4. The vial was then sealed shut by welding the edge of the lid to the rim of the vial. This vial was then sealed in a plastic bag and the bag placed in a larger vial and irradiated.

B. Atomic Absorption Analysis

While instrumental neutron activation analysis is the preferred analytical technique for some elements (such as vanadium), it is inappropriate for nickel (a metal present in crude oils in trace amounts). Unfavorable nuclear properties of this element prevent its determination at trace levels by instrumental neutron activation analyses. Atomic absorption analysis is the method of choice due to its specificity and relatively low detection limit for nickel compared to other available techniques. Preparation of samples for atomic absorption analysis is, however, somewhat more involved than for instrumental neutron activation analysis.

The procedure used to digest vegetation samples was as follows:

1. Freeze-dry aliquots.
2. Weigh.
3. Ash in radio frequency oxygen discharge furnace (low temperature asher).
4. Transfer ash to Teflon acid digestion bomb.
5. Add concentrated nitric acid, heat to digest, then cool.
6. Repeat Item 5 twice.
7. Add hydrogen peroxide to solubilize manganese dioxide formed.
8. Heat gently exposed to the atmosphere to destroy residual peroxides, then cool.
9. Dilute to minimum volume (25 ml).

Determination of nickel was by flameless atomic absorption analysis, using a Perkin-Elmer 603 atomic absorption spectrophotometer equipped

with a D_2-arc background suppression system and a Perkin-Elmer HGA-2100 heated graphite atomizer. All determinations were made by standard additions in order to minimize unavoidable interference inherent in nickel determinations.

7.3.3 Physical

Meteorological data recordings from the onsite stations shown in Figure 7.2-2 were removed at approximately 30-day intervals during the monitoring period, September 29, 1978 to December 27, 1978. Data from the pressure-sensitive strip charts were then reduced to hourly values averaged from one-half hour before to one-half hour after the hour. Wind data were reduced to 15 minute averages for the period concurrent with drogue tracking in Black Lake.

At the completion of the meteorological program, each wind instrument was calibrated in the manufacturer's (Meteorological Research, Inc.) wind tunnel whose accuracies are traceable to the National Bureau of Standards. Although starting thresholds of the anemometers were slightly high (3.1 to 4.0 km/hr), the performance of the systems was considered adequate for hydrological applications. Wind data from Meteorological Stations 1 and 3 (which have higher starting thresholds than Station 2) should have a slightly greater tendency toward calm conditions than Station 2 would measure under similar wind conditions.

Air quality samples and parameters measured during the fire at West Hackberry on September 25-26, 1978, were transported for laboratory analysis immediately following the fire (Henry, 1978). The samples were prepared for analysis of nitrogen oxides, suspended particulates, sulphur dioxide, ammonia, chlorine and fluoride, which were all common parameters measured by the monitoring system utilized.

Hydrological data in the form of azimuth, range, and positioning times for drogues deployed in Black Lake were plotted on planimetric maps compiled from a recent aerial survey of the area impacted by the oil spill and fire.

7.4 DATA ANALYTICAL TECHNIQUES

7.4.1 Biological

Since the subsampling technique applied to sample sorting typically resulted in the analysis of a variable number of subsamples per sample and since differences in within-site variability made it efficient to vary the number of samples examined per site, statistical techniques applicable to unequal sample sizes were used. The major statistical tools applied to the results were two-level and three-level nested analyses of variance, as described in Sokal and Rohlf (1969). Satterthwaite's approximation was used to generate an appropriate variance ratio (F value) between among-sites and within-sites variance components by synthesizing a within-sites mean square and its corresponding degrees of freedom (df). This approximation was also used to synthesize an among-sites mean square for the three-level analyses of variance. Nonparametric statistical tests used are described in Tate and Clelland (1957).

Estimates of the number of samples (or subsamples) required were determined from the relationship $n \geq (2t^2s^2)/d^2$ (Steel and Torrie, 1960), where t is the t-value associated with a Type II error, s^2 is the variance estimate, and d is the difference to be detected (= 0.51 x mean). Application of this procedure to environmental assessments is described by the U.S. Environmental Protection Agency (EPA, 1978b).

7.4.2 Chemical

A. Distinguishing Cavern 6 Crude from Louisiana Sweet Crude

The initial task of this investigation was to determine the feasibility of distinguishing the crude oil stored in Cavern 6 from background levels of the Louisiana Sweet Crude already in the West Hackberry environment.

Gas chromatograms of the fresh Cavern 6 crude oil and fresh Louisiana Sweet Crude were examined to determine if there were any differences in the quantitative distribution of petroleum components in these two oils. These distributions, which enable the scientist to distinguish one crude oil from another, are also known as passive tags.

Gas chromatograms of the Cavern 6 crude oil and the same oil artificially weathered at West Hackberry on October 1, 1978 are shown in Figures 7.4-1 and 7.4-2. For artificial weathering, a small amount of oil was placed into a beaker of Black Lake water and exposed to the atmosphere for the length of the workday. The gas chromatograms of the fresh and weathered samples of Louisiana Sweet Crude oil obtained from the Amoco storage area are shown in Figures 7.4-3 and 7.4-4. After weathering, the lower boiling point components of both oils disappear and the oils consist primarily of hydrocarbons with molecular weights between those of n-C_{12} and n-C_{24}.

The major differences in the chromatographic profile of the two weathered oils appear between n-C_{17} and n-C_{20}. These differences can be exemplified in the ratio of pristane/phytane. In the Cavern 6 crude oil, this ratio is approximately 1:1, whereas it is approximately 2.5:1 in the Louisiana Sweet Crude. Other differences in the quantitative profiles of the Cavern 6 and Louisiana Sweet Crude chromatograms can also be used to identify specific oil sources. These passive tags, however, are acceptable indicators for only relatively fresh oil slicks and are not generally applicable for identification of weathered oils or contamination in sediment samples.

As oil in environmental samples is weathered by various physical and chemical processes, the characteristics which distinguish one oil from another become less discernable. More detailed and sophisticated analytical techniques were used to identify sources of petroleum in these weathered samples. These techniques included separation of the extractable hydrocarbons into saturate and aromatic fractions and

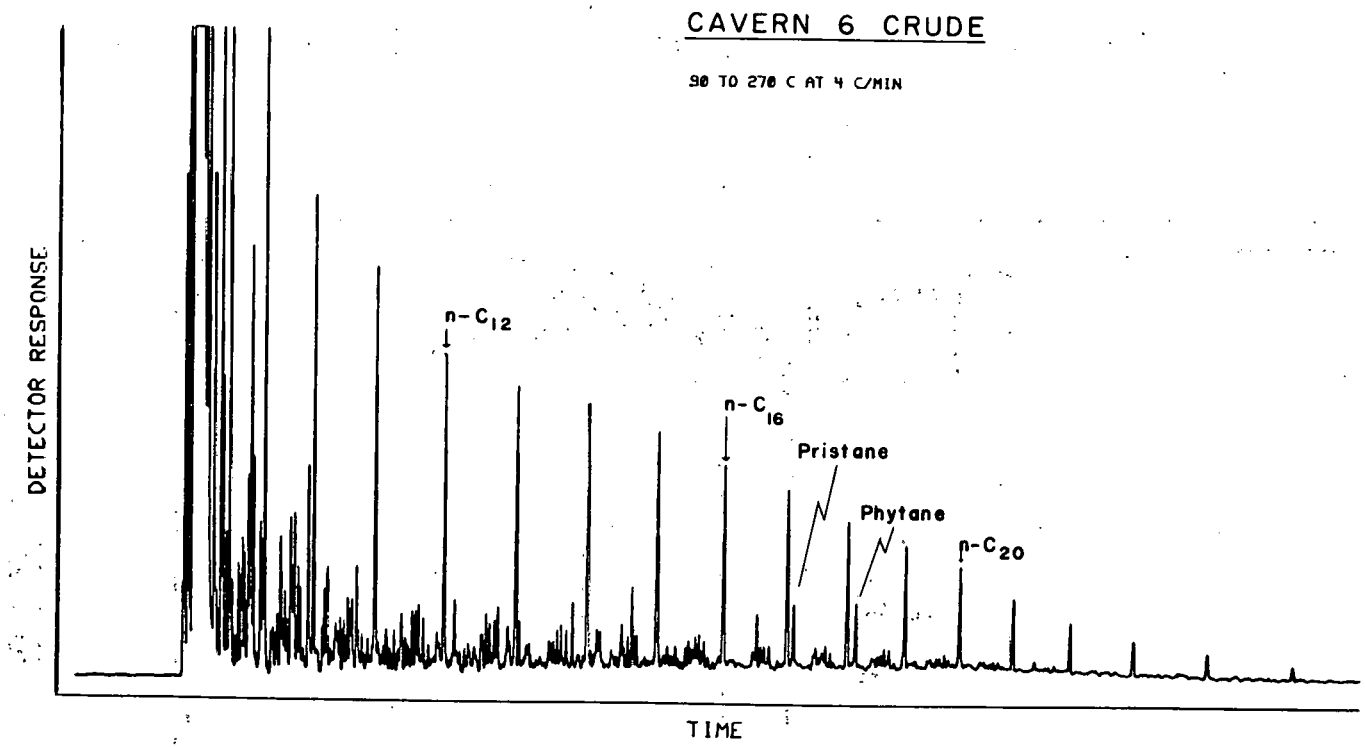


FIGURE 7.4-1 GAS CHRCMATOGRAM OF CAVERN 6 CRUDE OIL

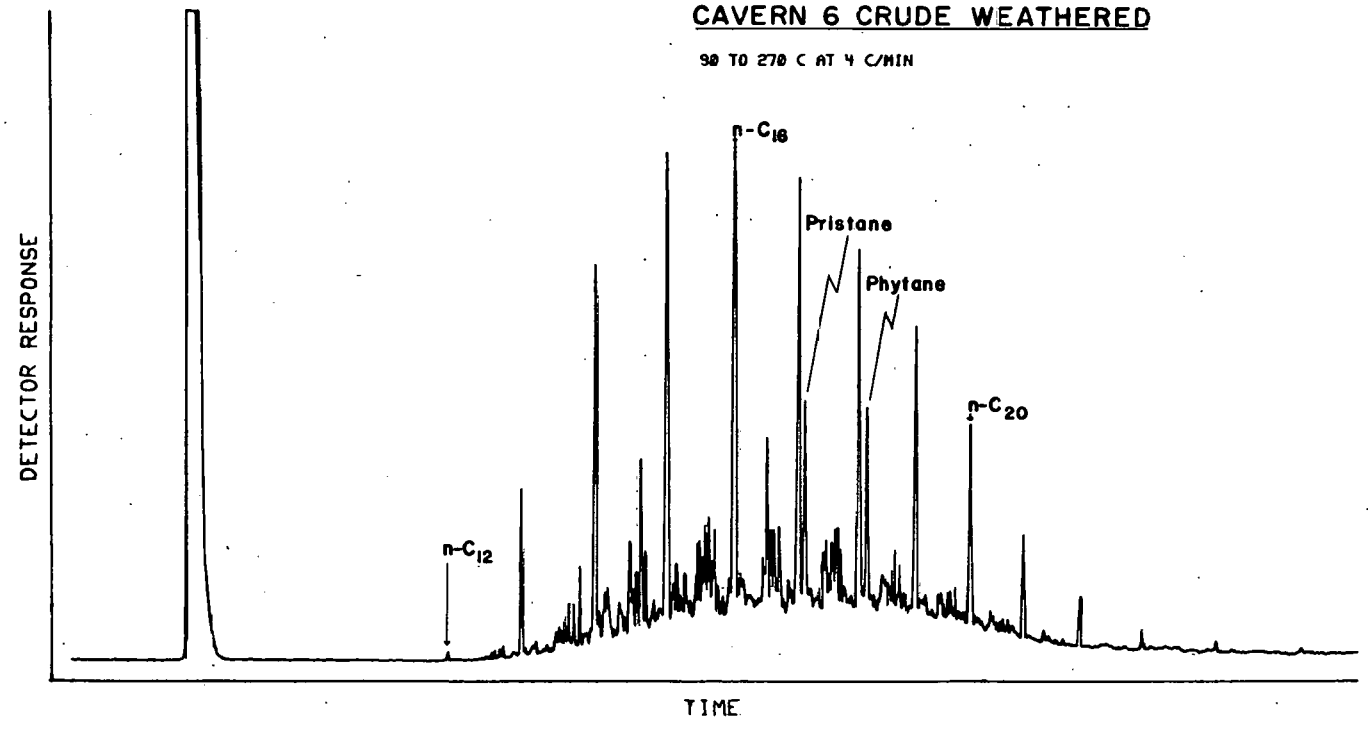


FIGURE 7.4-2 GAS CHROMATOGRAM OF CAVERN 6 ARTIFICIALLY WEATHERED CRUDE OIL

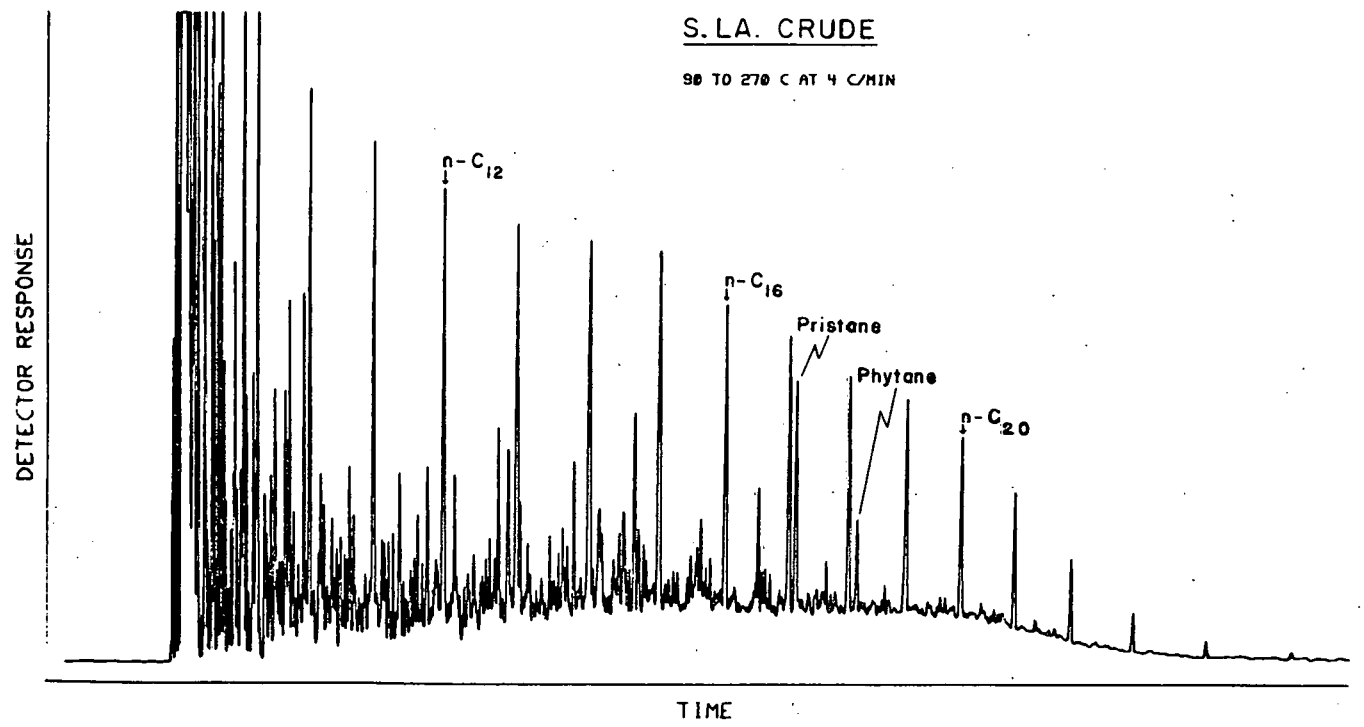


FIGURE 7.4-3 GAS CHROMATOGRAM OF LOUISIANA SWEET CRUDE OIL

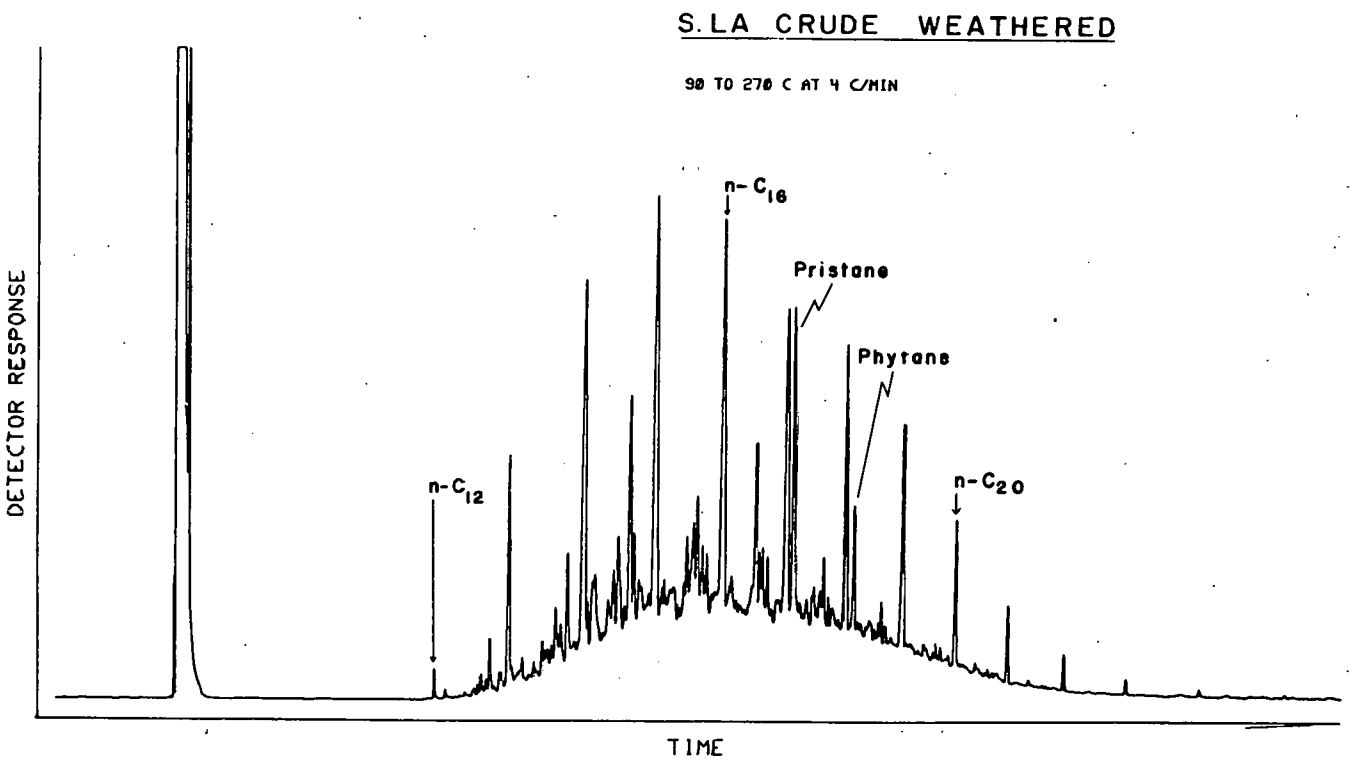


FIGURE 7.4-4 GAS CHROMATOGRAM OF ARTIFICIALLY WEATHERED LOUISIANA SWEET CRUDE OIL

analysis of the aromatic fraction with combined gas chromatographic/mass spectrometric/computer methods.

In the aromatic fraction, it was determined by combined gas chromatography/mass spectrometry that the two oils differ significantly in the quantity of naphthalenes, phenanthrenes, and dibenzothiophenes that are present. The mass chromatograms in Figures 7.4-5 through 7.4-7 indicate that Cavern 6 oil has more dibenzothiophenes than phenanthrenes than naphthalenes while Louisiana Sweet Crude oil exhibits an opposite trend. Mass chromatographic profiles of the naphthalenes, phenanthrenes, and dibenzothiophenes are also very characteristic for these two crude oil types.

In order to determine if members of the naphthalene, phenanthrene, and/or dibenzothiophene families were indicators that could be used to distinguish between the two oils in environmentally impacted samples, numerous Phase I and II samples (both impact and nonimpact areas of Black Lake) were analyzed in addition to the two oils. From these analyses, it was determined that the ratios of the alkylated phenanthrenes (C_1, C_2, and C_3) to the correspondingly alkylated dibenzothiophenes (C_1, C_2, and C_3) were good criteria that could be used to distinguish between the two oils in environmental samples. These ratios were found to be two to three times larger for Louisiana Sweet Crude impacted samples than in samples impacted by Cavern 6 crude oil.

B. Pyrogenic Products

Quantities of selected PAH compounds were chosen for use as a chemical tag for the impact of the Cavern 6 fire. This class of compounds is analytically most useful. The PAH compounds are relatively easy to isolate from environmental samples. Also, the high molecular weight PAH compounds produced during a petroleum fire were generally not among the PAH components of the original petroleum, although they might be present in trace amounts. This virtually eliminated the possibility

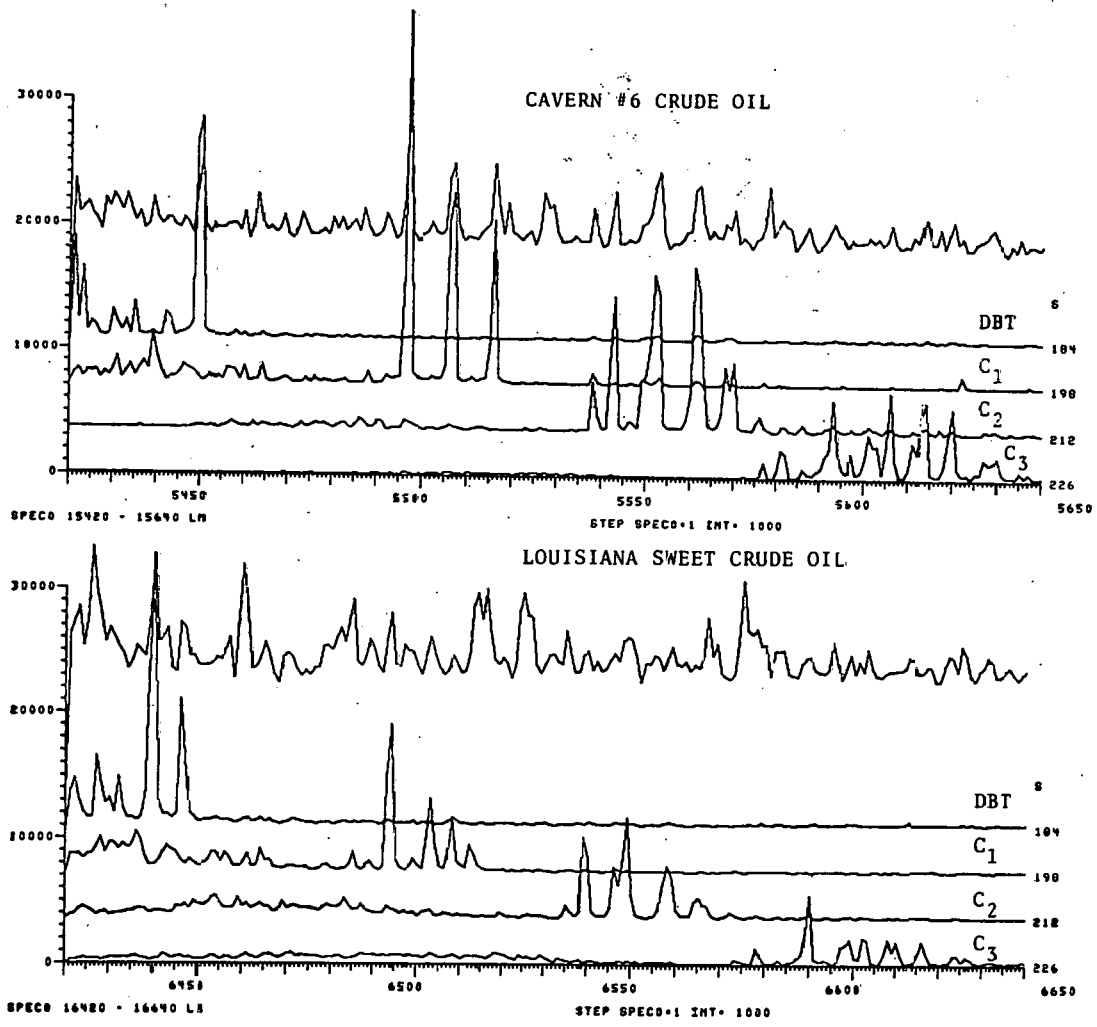


FIGURE 7.4-5 MASS CHROMATOGRAM OF THE DIBENZOTHIOPHENE FAMILY IN CAVERN 6 AND LOUISIANA SWEET CRUDE OIL

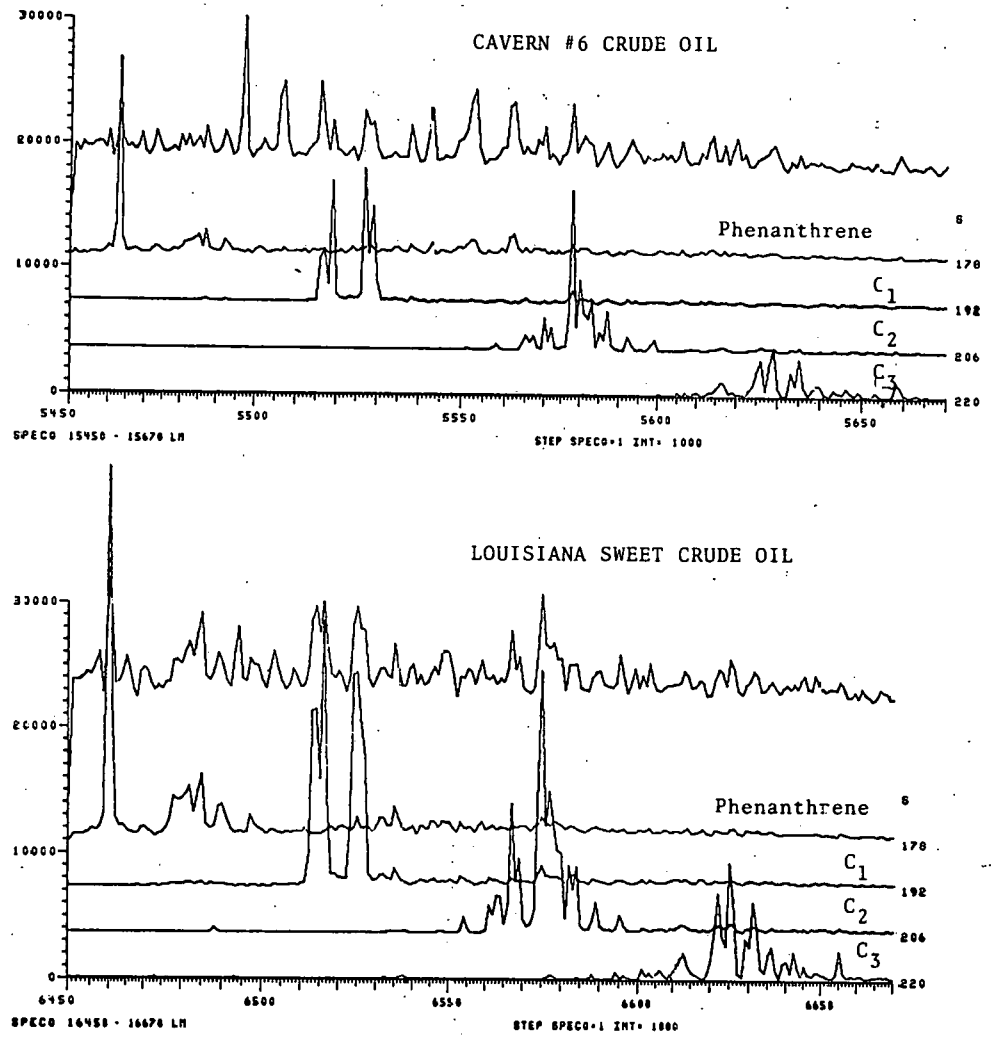


FIGURE 7.4-6 MASS CHROMATOGRAM OF THE PHENANTHRENE FAMILY IN CAVERN 6 AND LOUISIANA SWEET CRUDE OIL

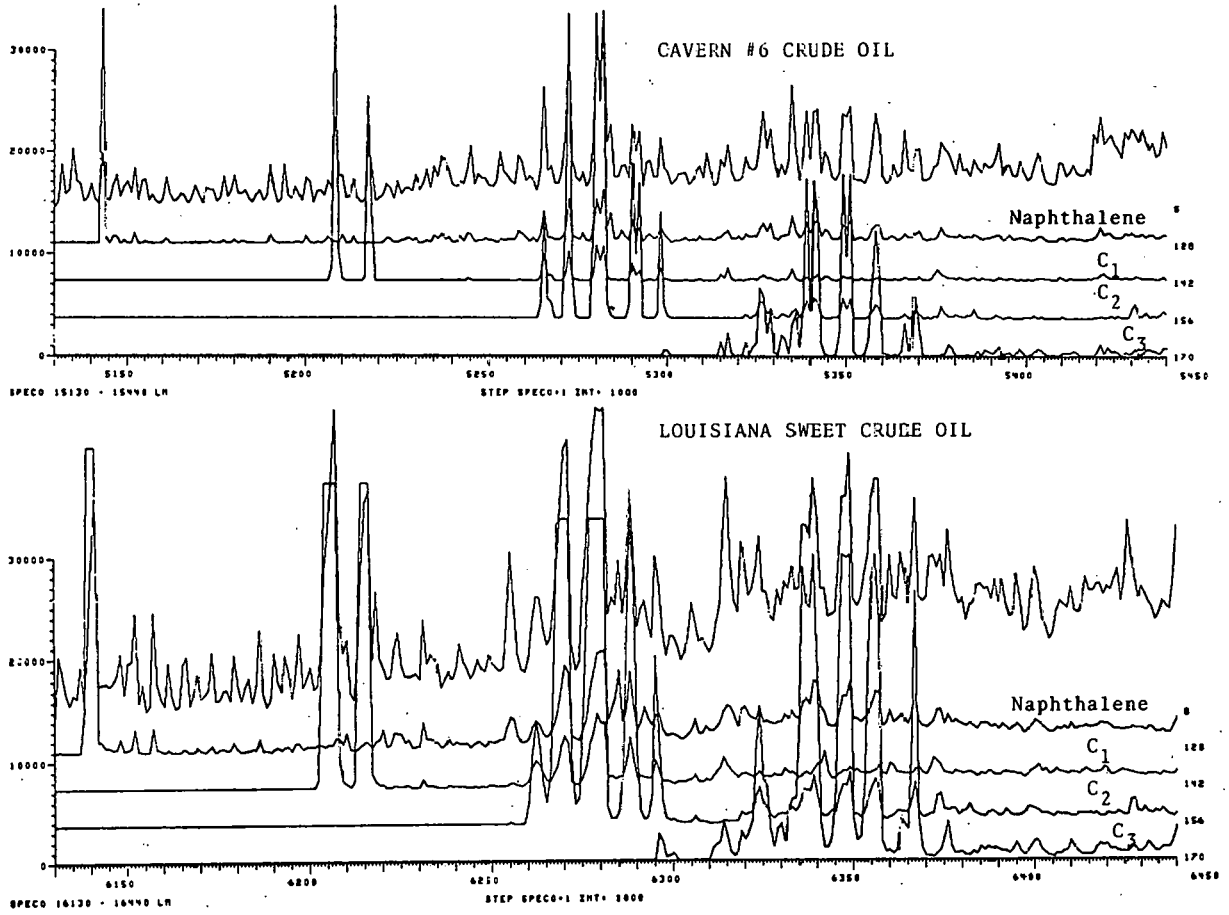


FIGURE 7.4-7 MASS CHROMATOGRAM OF THE NAPHTHALENE FAMILY IN CAVERN 6 AND LOUISIANA SWEET CRUDE OIL

of confusion between petroleum contamination from the spill (indigenous or Cavern 6) and contamination resulting from the fire.

The PAH compounds tended to persist in the environment due to their chemical stability and resistance to biological attack. This persistence makes PAH extremely useful as chemical tracers in the environment long after other chemical traces of the fire have vanished.

The PAH compounds were useful fingerprints of combustion sources because of the unique distribution of these compounds produced in the fire. The PAH compounds identified as products of the Hackberry fire were pyrene, fluoranthene, the isomers of chrysene which have a molecular weight of 228 (the chrysene family), and the isomers of benzopyrene with molecular weights of 252 (the benzopyrene family).

Gas chromatography/mass spectrometry was used as an extremely sensitive and selective method for the quantification of PAH in environmental samples. The chemical stability of PAH prevented extensive fragmentation of these compounds under electron bombardment encountered in the mass spectrometer. Thus, PAH ions in the gas chromatographic/mass spectrometric system tended to retain their original PAH molecular weight. This greatly simplified the identification and quantification of PAH by gas chromatography/mass spectrometry. During gas chromatographic/mass spectrometric runs, data was collected over a wide molecular weight range. Selective quantification was obtained from the extracted ion current profiles (mass chromatograms) at any desired molecular weight from the gas chromatographic/mass spectrometric data. For the examination of pyrogenic products, extracted ion current profiles were produced for molecular weights 202 (fluoranthene, pyrene), 228 (chrysene family) and 252 (benzopyrene family).

C. Discriminant Function Analysis

Discriminant analysis was used to develop a multivariate procedure for distinguishing between sediment samples containing Louisiana Sweet

Crude oil and those containing Cavern 6 crude oil. Several parameters believed to be useful in this procedure on the basis of the analyses described above were analyzed with a documented commercial computer program (Nie et al., 1975). These parameters were: 1) total resolvable hydrocarbon concentration; 2) ratio of pristane to phytane; 3) number of weeks after the incident; 4) ratio of C_1 phenanthrene to C_1 dibenzothiophene (designated C_1 ratio below); 5) ratio of C_2 phenanthrene to C_2 dibenzothiophene (C_2 ratio); and, 6) ratio of C_3 phenanthrene to C_3 dibenzothiophene (C_3 ratio).

The relative contributions of these parameters to the separation of the samples by oil type are indicated by the absolute values of their standardized discriminant function coefficients (Table 7.4-1). Since the first two parameters listed in Table 7.4-1 made greater contributions than the last four parameters, the discriminant analysis was repeated using only the first two parameters in order to develop a discriminant function based on a manageably small number of parameters.

The discriminant function generated by this analysis was efficient at differentiating between sediment samples containing different oil types (canonical correlation = 0.712). This function, F = -2.581 + 0.918 C_1 ratio + 0.714 C_3 ratio, was used to produce a score (F) for each sample. This score was used to classify the sample by oil type. Samples containing Cavern 6 crude oil had a mean score of -1.568; those lacking Cavern 6 crude oil had a mean score of 0.613. A sample having a score higher than -0.456 would be classified as lacking Cavern 6 crude oil; a sample with a score lower than -0.456 and near the mean -1.568 would be classified as containing predominantly Cavern 6 crude oil.

Discriminant analysis was also applied to the identification of soil and sediment samples containing pyrogenic products from Cavern 6 crude oil in Phase I. The parameters used in this analysis were: 1) ratio of fluoranthene to pyrene; 2) ratio of chrysene to pyrene; and 3) ratio of benzopyrene to pyrene. The standardized discriminant function

TABLE 7.4-1

STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS

	Parameter	Coefficient
Case 1 (all parameters)	C_3 ratio	-0.705
	C_1 ratio	-0.695
	Hydrocarbon concentration	0.654
	Time (weeks)	-0.438
	Pristane/Phytane	-0.350
	C_2 ratio	0.155
Case 2 (two highest parameters in Case 1)	C_1 ratio	0.897
	C_3 ratio	0.617

coefficients for these parameters were 2.134, -0.753, and -0.414, respectively.

The discriminant function, F = -2.451 + 5.215 fluoranthene to pyrene - 4.081 chrysene to pyrene - 1.037 benzopyrene to pyrene, was also efficient at differentiating sample types (cannonical correlation = 0.922). Samples containing Cavern 6 fire products had a mean score (F) of 3.517; those lacking Cavern 6 fire products had a mean score of -1.319. A sample having a score lower than 1.063 would be classified as lacking Cavern 6 fire products; a sample with a score higher than 1.063 and near the mean 3.517 would be classified as containing pyrogenic products from predominately the fire at Cavern 6

D. Trace Metals

The trace element composition of the oil was used as both a measure of the amount of oil contamination in the area and as a method of assigning a source for the oil contamination.

The oils native to the area and oil from the Department of Energy storage system were analyzed by neutron activation and the trace metal composition determined. Similar analyses were performed on the soils, sediments and vegetation of the area. Seven elements were routinely determined: sodium, magnesium, aluminum, manganese, calcium, chlorine and vanadium. The resulting patterns and levels of the trace metals were used to determine the geographical extent and intensity of oil related contamination. The ratio of vanadium to aluminum in the soils of the area was compared with the vanadium to aluminum ratio of the vegetation, to determine how much of the vanadium in the vegetation was due to the presence of soil on the leaves. The vanadium concentrations found on vegetation were regressed against the distance of the vegetation from the fire in an effort to determine the extent and intensity of oil fire related contamination. This regression equation was used to estimate the total amount of vanadium deposited over the entire downwind land area.

The vanadium concentrations measured during Phase I were compared with the vanadium concentrations measured 1 year later (Phase IV) in order to assess the persistence of the vanadium in the environment. This comparison permitted the estimation of a prefire baseline level of vanadium in vegetation which was used to determine whether a Phase I sample was impacted or not.

The meteorological data measured at Lake Charles, combined with a Gaussian Plume Model, were used in the estimation of the distribution of fire-related vanadium deposition downwind of the fire. The estimation was used to corroborate the observed distribution pattern and to predict the extent and intensity of contamination in areas that were not sampled.

7.4.3 Physical

Meteorological data from the National Weather Service in Lake Charles and three onsite meteorological stations were analyzed to determine statistical trends during the West Hackberry accident. Temperature means and extremes and wind frequency distributions were developed to aid interpretation of the data.

Air quality samples collected at the site during the fire were analyzed for oxides of nitrogen, sulphur dioxide, suspended particulates, ammonia, chlorine and fluoride (Henry, 1978). Oxides of nitrogen samples were contaminated and lost during analysis. Sulphur dioxide and suspended particulates were analyzed respectively using the pararosaniline and high volume method described in Appendices A and B of 40 CFR 50 (EPA, 1977). Ammonia was analyzed using the dilute acid absorption and Nesslerization method (API, 1957). Chlorine concentrations were obtained by collection in distilled water and developing color with orthotolidine; fluoride was collected in a sodium hydroxide solution and determined with specific ion electrode (APHA, 1971).

Hydrological data obtained during drogue tracking exercises on Black Lake were analyzed to determine mean current direction and speeds and their relationship to concurrently measured wind data. Oil-stained vegetation and visible oil sheens observed in the marsh during the fire were delineated to identify areas impacted by the spill.

8.0 RESULTS

8.1 BIOLOGICAL

8.1.1 Black Lake Benthos

Animal species identified in benthic samples from Black Lake and marsh habitats are listed in Table 8.1-1. The taxonomy and phylogenetic scheme used in this list were derived from Richardson (1905), Johannsen (1937), Shoemaker (1947), Hartman (1951), Usinger (1956), Williams (1965), Harper (1968), Barnes (1968), Gosner (1971), Chanley and Andrews (1971), Bousfield (1973), Andrews (1977), and Fauchild (1977). Species identifications were not possible for several of these organisms for lack of intact specimens, adult specimens, or relevant taxonomic literature for this region. Table 8.1-2 sets forth mean densities of the predominant taxa in the Black Lake benthic samples for each of the three sampling locations. The West Control Area was conspicuously barren compared with the other two areas. This was determined by performing analyses of variance on the densities of all animals and on densities of five predominant taxa: Polychaeta, Oligochaeta, Gastropoda, Tanaidacea, and Amphipoda.

The results of these analyses, tested at the 95 percent confidence level, are summarized in Figures 8.1-1 through 8.1-4. Each of the 18 triangles in each of these figures represents a 2-level analysis of variance between the 2 sites denoted at the outer corners of the triangle. In Phase I, the West Control Area had significantly fewer benthic animals than either of the other two areas. The sediment grain size distribution (Figure 8.3-1) and poor penetration by the grab sampler (apparently due to contact with compacted clay outcrops) suggested that this site was anomalous. Consequently, the East Control Area was designated as the primary control site and subsequent sampling in the West Control Area was reduced. During Phase II, we detected

TABLE 8.1-1

ANIMAL SPECIES FOUND IN BENTHIC SAMPLES

Phylum Coelenterata	
Class Anthozoa	
Actinaria	sea anemone
Phylum Platyhelminthes	
Turbellaria	
Phylum Rhynchocoela	ribbon worms
Nemertinea	
Phylum Nematoda	nematodes
Nematoda	
Phylum Annelida	segmented worms
Annelid	
Class Polychaeta	
Family Spionidae	
Polydora sp.	
Polydora ligni	
Polydora websteri	
Streblospio sp.	
Streblospio benedicti	
Family Pilargiidae	
Parandalia americana	
Family Capitellidae	
Capitellid sp.	
Capitella capitata	
Mediomastus californiensis	
Family Neridae	
Nereid	
Laeonereis sp.	
Neanthes succinea	
Neanthes sp.	
Nereis sp.	
Namalycastis abiuma	
Family Phyllodocidae	
Eteone heteropoda	
Family Ampharetidae	
Ampharetid	
Class Oligochaeta	
Oligochaeta	
Phylum Mollusca	
Class Gastropoda	snails
Family Littorinidae	
Littoridinops sp.	
Texadina sphinctosomata	

Family Neritidae	
Neritina reclivata	
Nerita fulverans	
Family Truncatellidae	
Probythinella louisianae	
Class Pelecypoda	clams and mussels
Pelecypoda	
Family Mactidae	
Mulinia lateralis	
Rangia sp.	
Family Mytilidae	
Brachidontes exustus	
Amygdalum papyria	
Geukensia demissa granosissima	
Family Tellinidae	
Macoma mitchilli	
Family Ungulinidae	
Diplodonta sp.	
Family Corbiculidae	
Polymesoda caroliniana	
Phylum Arthropoda	
Class Arachnida	
Acari	mites
Class Crustacea	
Subclass Copepoda	copepods
Order Calanoida	
Oithona sp.	
Order Cyclopoida	
Order Harpacticoida	
Subclass Cirripedia	barnacles
Subclass Malacostraca	
Order Mysidacea	mysids
Order Cumacea	
Order Tanaidacea	
Leptochelia dubia	
Leptochelia filum	
Leptochelia rapax	
Leptochelia savignyi	
Order Amphipoda	
Erichthonius sp.	
Corophium sp.	
Corophium louisianum	
Gammarus mucronatus	
Orchestia sp.	

Order Isopoda	
Cassidinidea lunifrons	
Edotea montosa	
Isopoda (probably *Sphaeroma* sp.)	
Order Decapoda	
Family Palaemonidae	
Palaemonetes pugio	
Family Portunidae	
Callinectes sapidus	blue crab
Family Xanthidae	rock and mud crabs
Xanthid	
Neopanope texana texana	
Rhithropanopeus harrisii	
Class Insecta	
Order Coleoptera	beetles
Family Hydrophilidae	
Order Collembola	
Order Diptera	
Family Chironomidae	midges
Family Dolichopodidae	
Diptera	
Order Hemiptera	true bugs
Family Bellastomidae	
Phylum Tardigarda	water bears
Tardigrade	
Phylum Ectoprocta	bryozoans
Bryozoa	
Phylum Chordata	
Class Osteichthyes	
Gobiasoma bosci	goby

TABLE 8.1-2

MEAN DENSITIES (PER 0.25m^2) ± ONE STANDARD ERROR
OF SELECTED TAXA IN BLACK LAKE BENTHIC SAMPLES

Taxon	WEST CONTROL AREA				AFFECTED AREA			
	Phase I	Phase II	Phase III	Phase IV	Phase I	Phase II	Phase III	Phase IV
All species	17 ± 4	201 ± 66	77 ± 27	111 ± 54	190 ± 44	1205 ± 373	1177 ± 230	179 ± 47
Nematoda	0	17 ± 13	1 ± 1	1 ± 1	9 ± 5	105 ± 59	125 ± 49	13 ± 6
Polychaeta	7 ± 2	81 ± 39	60 ± 22	69 ± 33	34 ± 9	271 ± 127	237 ± 62	67 ± 19
Capitella capitata	0	0	0	0	---	3 ± 3	0	< 1
Nereidae	0	0	0	0	< 1	0	0	0
Oligochaeta	< 1	6 ± 5	4 ± 2	2 ± 1	14 ± 8	24 ± 18	50 ± 21	17 ± 6
Gastropoda	2 ± 1	4 ± 3	5 ± 5	7 ± 6	3 ± 1	6 ± 2	1 ± 1	1 ± 1
Texadina sphinctosomata	2 ± 1	4 ± 3	5 ± 5	---	0	6 ± 2	< 1	0
Pelecypoda	3 ± 1	12 ± 4	4 ± 2	12 ± 7	< 1	34 ± 11	18 ± 6	19 ± 5
Tanaidecea	0	12 ± 9	0	2 ± 1	78 ± 20	574 ± 214	235 ± 44	14 ± 6
Amphipoda	< 1	38 ± 11	2 ± 2	2 ± 1	15 ± 7	121 ± 39	436 ± 99	12 ± 6
Corophium louisianum	0	24 ± 10	0	---	6 ± 3	98 ± 35	367 ± 104	---
Isopoda	3 ± 1	2 ± 2	0	1 ± 1	12 ± 3	5 ± 2	27 ± 7	9 ± 5

TABLE 8.1-2 (Cont.)

Taxon	EAST CONTROL AREA			
	Phase I	Phase II	Phase III	Phase IV
All species	344 ± 93	13242 ± 3497	4494 ± 1103	531 ± 171
Nematoda	52 ± 52	1445 ± 432	652 ± 208	35 ± 24
Polychaeta	13 ± 6	328 ± 119	214 ± 53	37 ± 12
Capitella capitata	0	< 1	2 ± 1	0
Nereidae	< 1	< 1	0	< 1
Oligochaeta	3 ± 3	132 ± 111	88 ± 26	33 ± 23
Gastropoda	9 ± 3	4 ± 3	8 ± 7	< 1
Texadina sphinctosomata	5 ± 2	< 1	7 ± 7	0
Pelecypoda	< 1	14 ± 5	28 ± 8	20 ± 5
Tanaidecea	112 ± 30	5382 ± 1184	1229 ± 328	68 ± 50
Amphipoda	103 ± 59	5384 ± 1988	2150 ± 606	219 ± 77
Corophium louisianum	85 ± 53	5051 ± 1921	1740 ± 579	116 ± 55
Isopoda	10 ± 3	104 ± 22	32 ± 8	83 ± 26

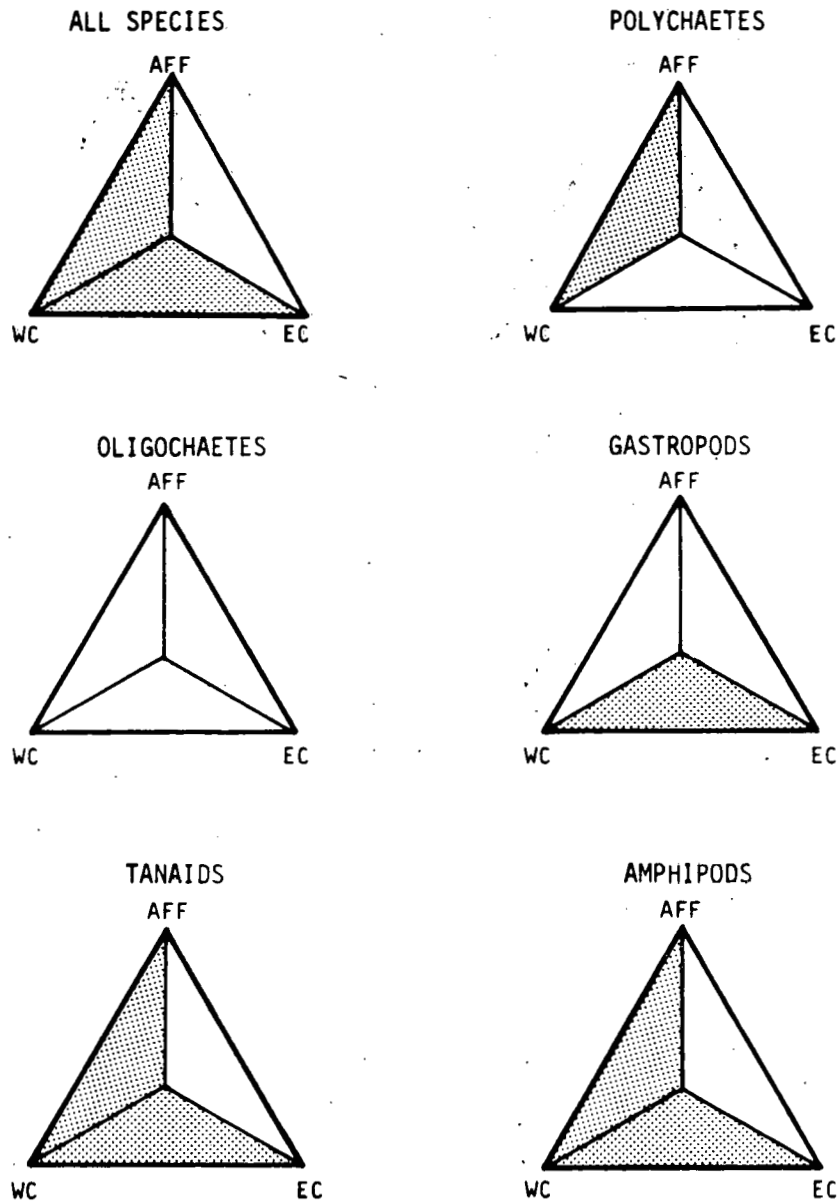


FIGURE 8.1-1 DIFFERENCES IN BLACK LAKE BENTHIC FAUNAL DENSITIES BETWEEN SITES DURING PHASE I

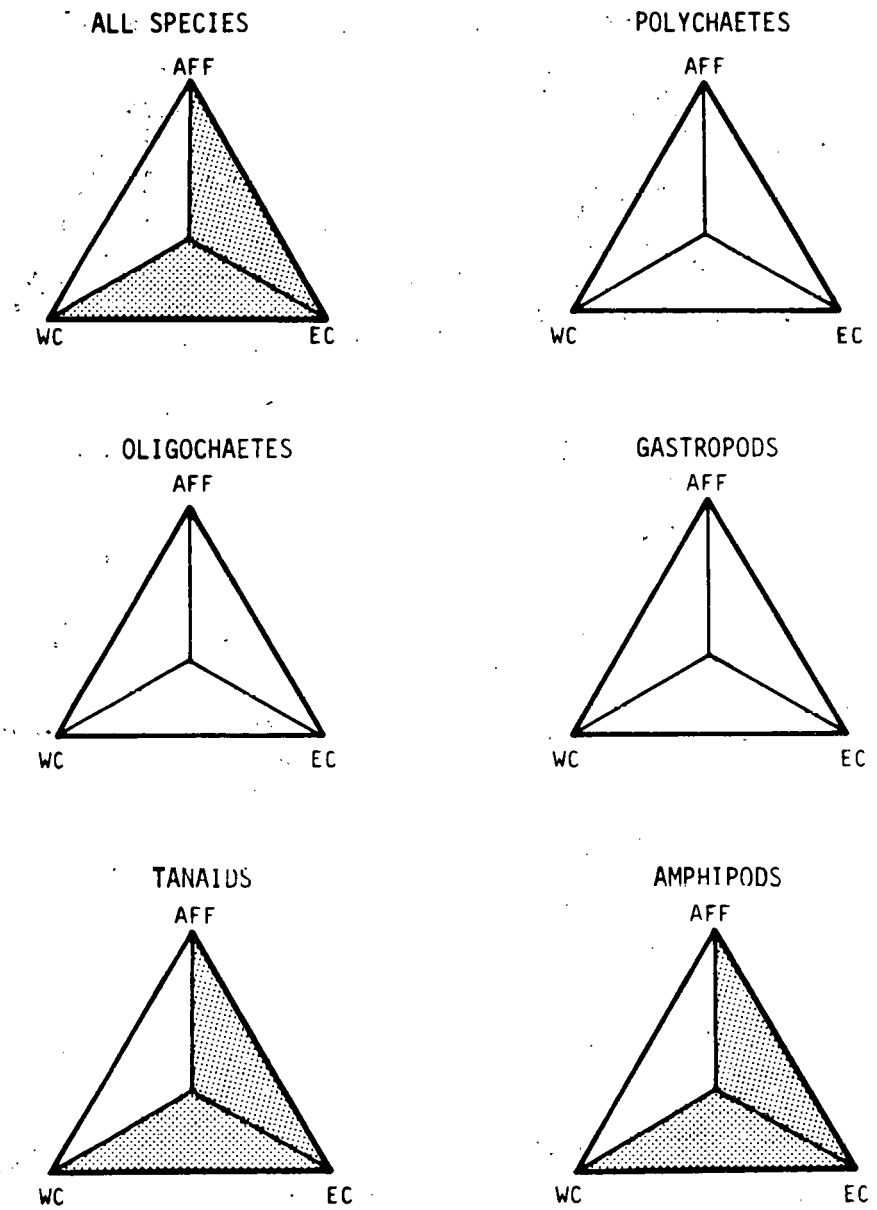


FIGURE 8.1-2 DIFFERENCES IN BLACK LAKE BENTHIC FAUNAL DENSITIES BETWEEN SITES DURING PHASE II

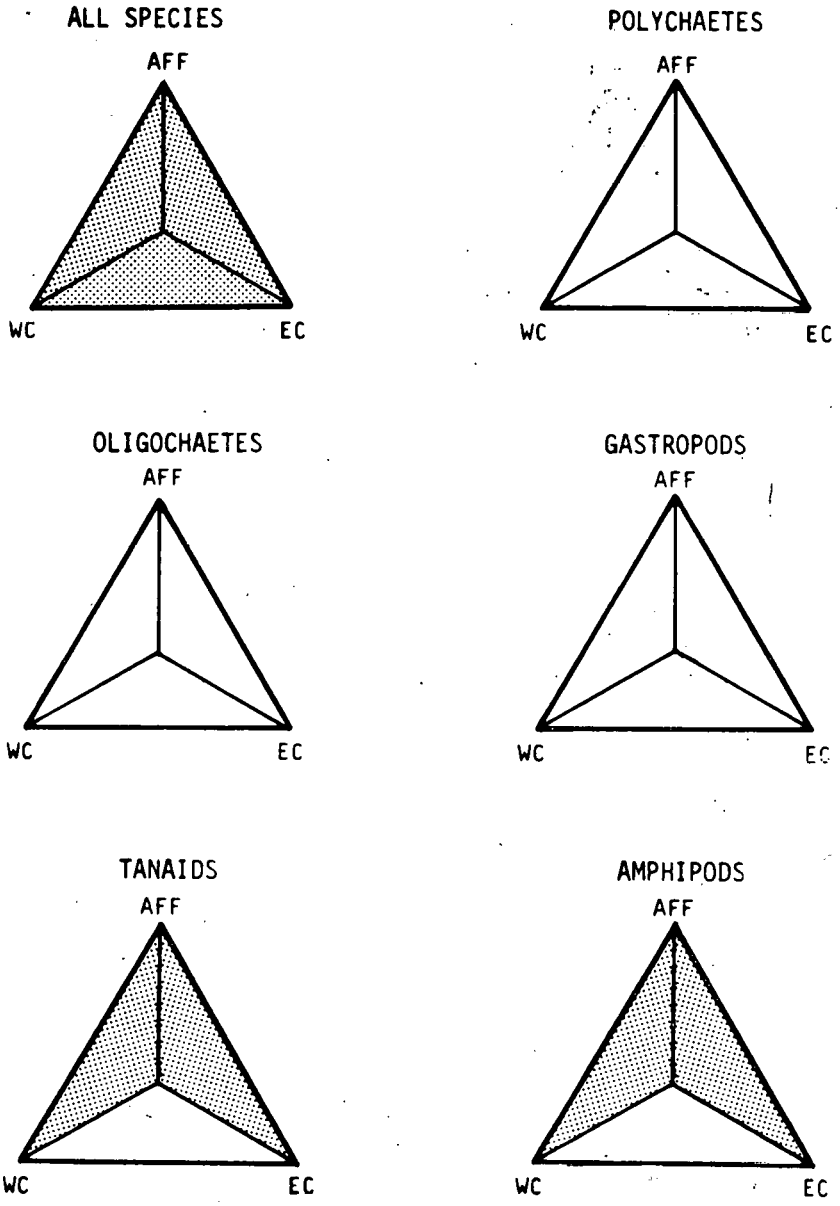


FIGURE 8.1-3 DIFFERENCES IN BLACK LAKE BENTHIC FAUNAL DENSITIES BETWEEN SITES DURING PHASE III

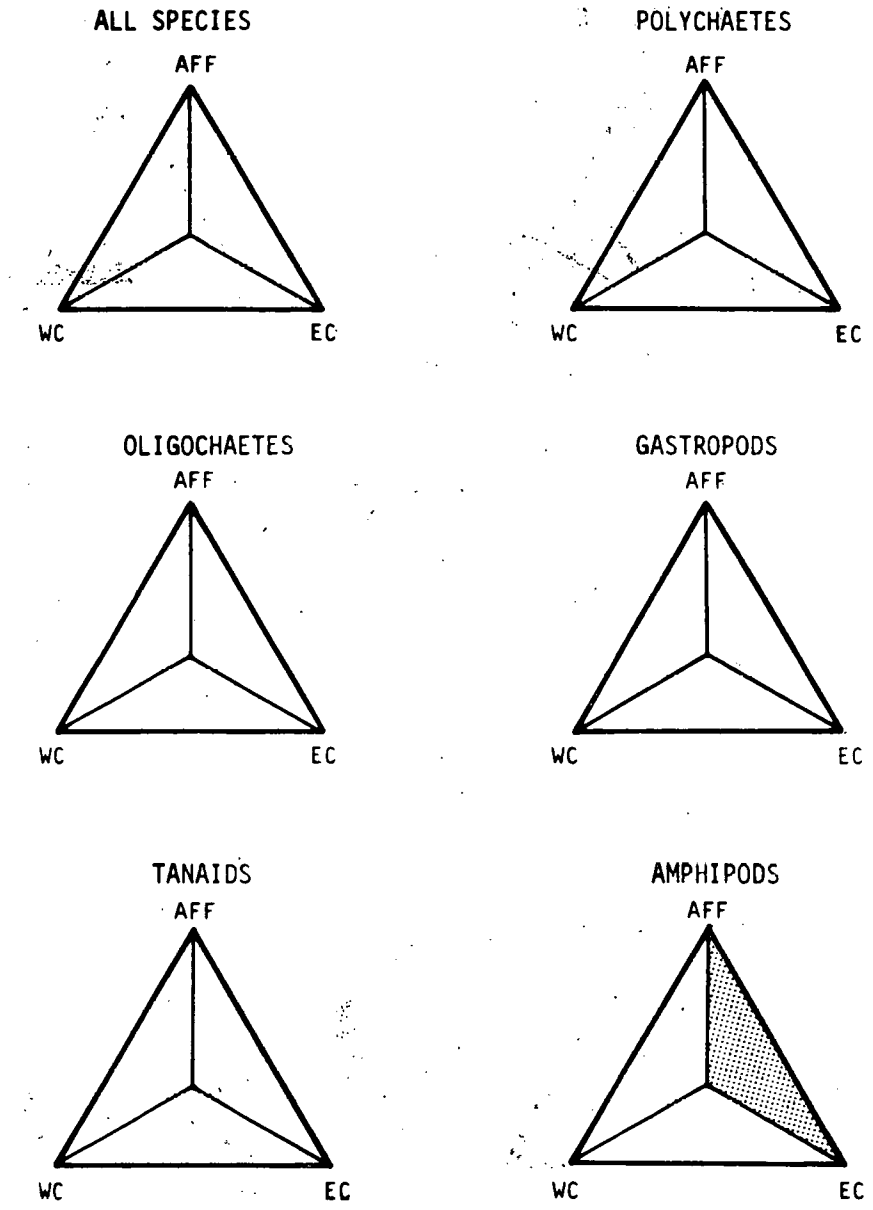


FIGURE 8.1-4 DIFFERENCES IN BLACK LAKE BENTHIC FAUNAL DENSITIES BETWEEN SITES DURING PHASE IV

increased populations in all three areas. This increase was greatest in the East Control Area, resulting in a significant difference in faunal density between this area and the Affected Area. This difference was caused primarily by increases in tanaid and amphipod populations.

In Phase III, the faunal density in both control areas declined relative to the Affected Area. The total faunal density in each area was significantly different from that of the others, again due primarily to changes in tanaid and amphipod populations.

In Phase IV, the East Control Area had significantly more amphipods than the Affected Area, but no other differences were detected. A significant increase in total density was detected in the Affected Area between Phases I and II ($F = 29.71$, $df = 1, 22$, $p < 0.001$). However, no significant difference was detected at this site between Phases I and IV ($F = 3.58$, $df = 1, 24$, $p > 0.05$), and the significant increase between Phases I and II was also detected at the East Control site ($F = 24.09$, $df = 1, 17$, $p < 0.001$).

Results of three-level analyses of variance (Tables 8.1-3 through 8.1-7) indicated that there was no significant change in faunal density among phases for total animals, tanaids, and amphipods. However, significant changes in polychaete and bivalve densities among phases were detected. Bivalves were generally rare in Phase I at all sites and more abundant in subsequent phases. Polychaetes displayed a similar pattern, and also showed a decline in Phase IV to densities only slightly above those observed in Phase I.

The sensitivity of these analyses is indicated in Table 8.1-8. The initial goal of being sensitive to a 51 percent change in faunal density at the 95 percent confidence level was achieved for all phases in the Affected and primary (East) control areas, and in the West Control Area for Phases I and II. In the former two areas, this sensitivity was on the order of 20 to 30 percent.

TABLE 8.1-3

THREE-LEVEL NESTED ANALYSIS OF VARIANCE FOR BLACK LAKE POLYCHAETA

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F Ratio	Probability
Among Phases	3	5,984,159	1,994,720	11.16	< 0.005
Among Sites Within Phases	10	1,033,047	103,305	1.51	> 0.25
Among Stations Within Sites	107	8,281,240	77,395	2.77	< 0.001
Within Stations	573	16,003,889	27,930		
TOTAL	693	31,302,335			

TABLE 8.1-4

THREE-LEVEL NESTED ANALYSIS OF VARIANCE FOR BLACK LAKE BIVALVES

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F Ratio	Probability
Among Phases	3	54,784	18,261	27.79	< 0.001
Among Sites Within Phases	10	6,570	657	0.39	> 0.25
Among Stations Within Sites	107	167,972	1,570	0.73	> 0.25
Within Stations	573	1,228,412	2,144		
TOTAL	693	1,457,738			

TABLE 8.1-5

THREE-LEVEL NESTED ANALYSIS OF VARIANCE FOR BLACK LAKE TANAIDACEA

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F Ratio	Probability
Among Phases	3	546,161,683	182,053,894	1.98	> 0.10
Among Sites Within Phases	10	458,603,627	45,860,363	15.62	< 0.001
Among Stations Within Sites	107	383,557,128	3,584,646	113.82	< 0.001
Within Stations	573	18,045,582	31,493		
TOTAL	693	1,406,368,020			

TABLE 8.1-6

THREE-LEVEL NESTED ANALYSIS OF VARIANCE FOR BLACK LAKE AMPHIPODA

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F Ratio	Probability
Among Phases	3	580,851,287	193,617,096	1.38	> 0.25
Among Sites Within Phases	10	696,266,205	69,626,620	8.27	< 0.001
Among Stations Within Sites	107	1,108,376,693	10,358,661		
TOTAL	693	2,385,494,185			

TABLE 8.1-7

THREE-LEVEL NESTED ANALYSIS OF VARIANCE FOR BLACK LAKE TOTAL ANIMALS

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F Ratio	Probability
Among Phases	3	3,280,060,361	1,093,353,454	1.79	> 0.25
Among Sites Within Phases	10	3,035,021,573	303,502,157	11.17	< 0.001
Among Stations Within Sites	107	3,547,676,314	33,155,853	109.30	< 0.001
Within Stations	573	173,817,352	303,346		
TOTAL	693	10,036,575,600			

TABLE 8.1-8

SENSITIVITY OF LAKE SEDIMENT FAUNAL ANALYSIS TO CHANGES IN AVERAGE DENSITY OF THE TOTAL FAUNA

	Number of Samples Analyzed	Confidence Level at which a 51 Percent Change[a] is Detectable (percent)	Percent Change[a] Detectable at the 95 Percent Confidence Level
AFFECTED AREA			
Phase I	13	99.9	20
Phase II	11	99	29
Phase III	8	99	23
Phase IV	13	99.9	23
EAST CONTROL AREA			
Phase I	11	99	26
Phase II	8	99	31
Phase III	12	99.9	22
Phase IV	13	99	28
WEST CONTROL AREA			
Phase I	18	99.9	18
Phase II	6	95	49
Phase III	4	80	80
Phase IV	4	60	109

[a]Magnitude of change expressed as a percent of the mean density.

Changes in relative abundance of the dominant taxa are illustrated in Figure 8.1-5. The Affected Area was characterized by a relative increase in the dominance of amphipods in Phase III (at the expense of the tanaids) and a relative increase in the dominance of polychaetes and miscellaneous taxa between Phases III and IV. These changes were not evident in the East Control Area, which experienced a marked increase in isopod dominance in Phase IV and a decrease in tanaid dominance from Phase II to Phase IV. The West Control Area, which had relatively low faunal densities, was dominated by polychaetes throughout the study.

8.1.2 Marsh Benthos

Table 8.1-9 shows mean densities of the predominant taxa in the marsh benthos for each of the four sampling locations. Nematodes and copepods were excluded from the densities of total animals in this table and in the analyses described below. Nematodes are so small that they were marginally retained by the 1.00 mm sieve used to wash the samples. Thus, density for nematodes was probably greatly underestimated and the variation density was probably overestimated. Moreover, some parasitic nematode species, which cannot readily be distinguished from free-living species, inhabited the stems and roots of marsh grasses. Many of these parasitic nematodes probably left their hosts and entered the sample upon contact with the preservative. Similarly, copepods were marginally retained by the sieve and are transients of the habitat sampled. In addition, a pronounced bloom of encysted copepods occurred in Phase II, which may have masked other faunal changes more directly related to the incident. Two-level analyses of variance were performed on the densities of all animals and on densities of five predominant taxa (Polychaeta, Oligochaeta, Gastropoda, Tanaidacea, and Amphipoda) to test the hypothesis that no differences existed between sites.

The results of these analyses, tested at the 95 percent confidence level, are summarized in Figures 8.1-6 through 8.1-9. Each of the

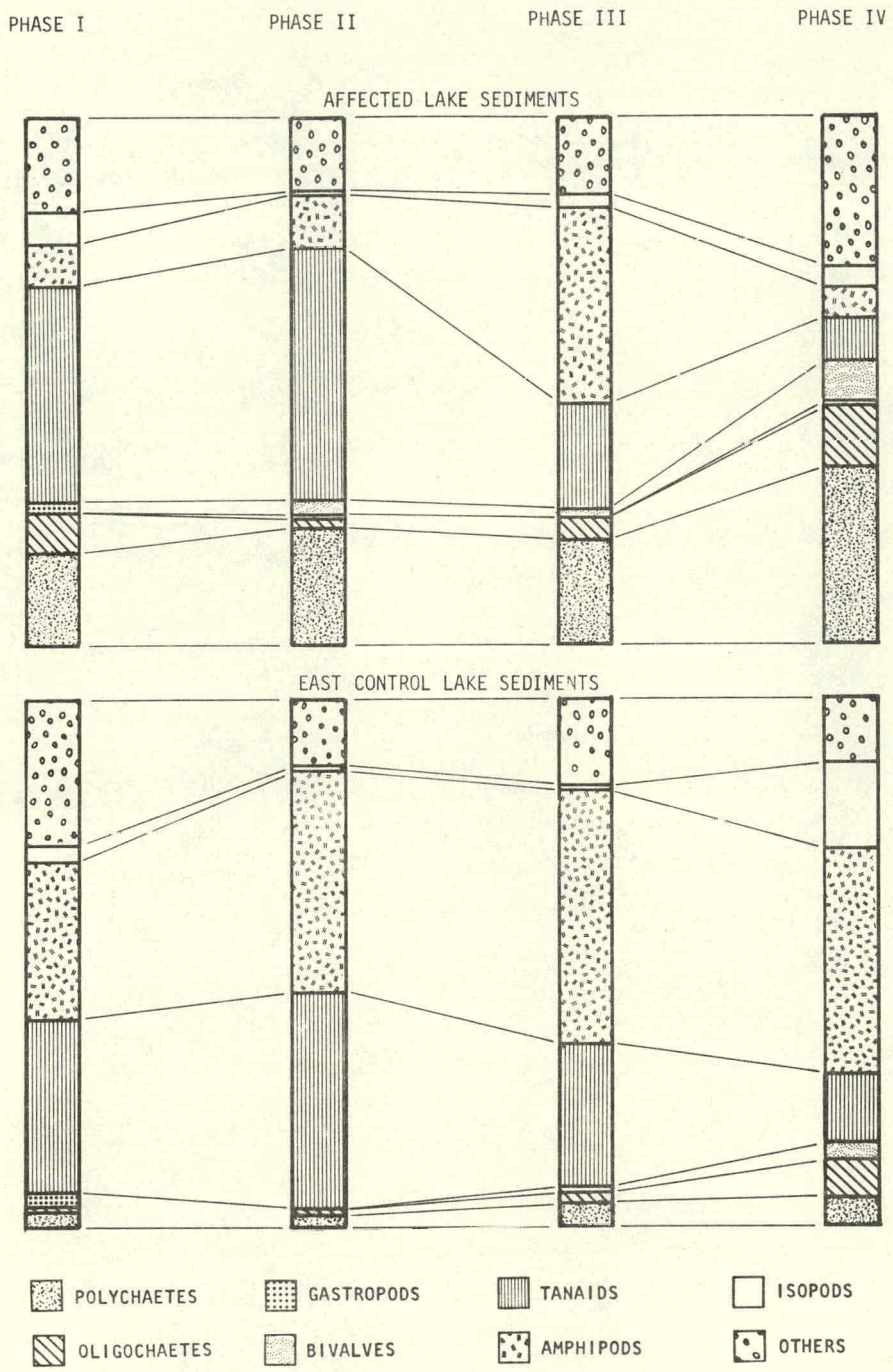


FIGURE 8.1-5
TEMPORAL CHANGES IN RELATIVE ABUNDANCES
OF SELECTED TAXA IN BLACK LAKE SEDIMENTS.

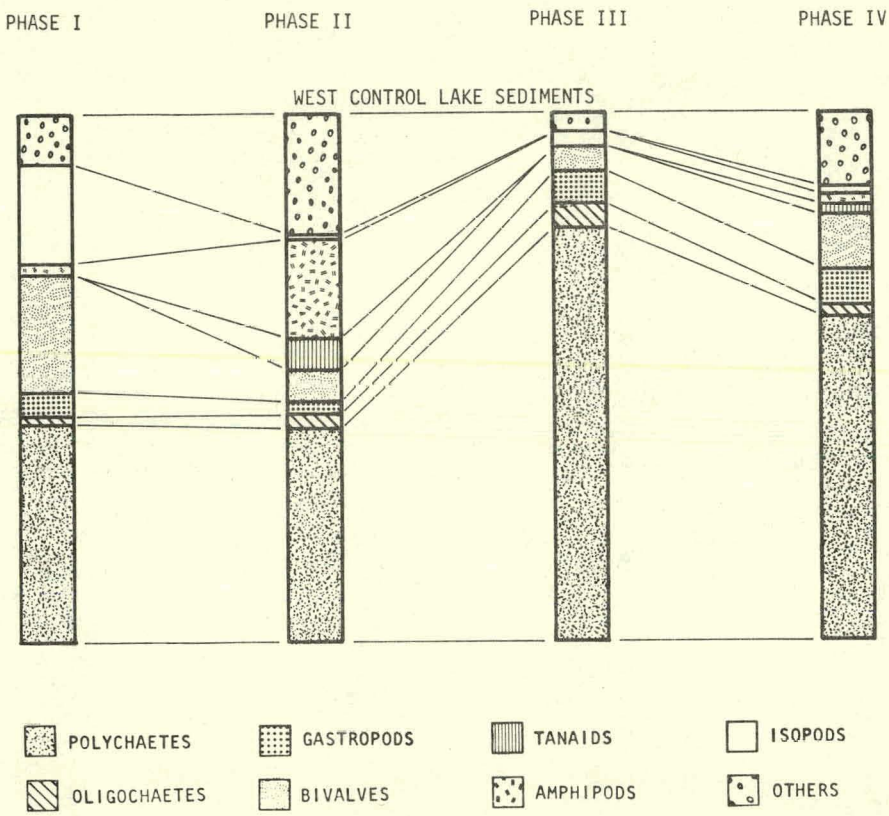


FIGURE 8.1-5 (CONT.)

TABLE 8.1-9

MEAN DENSITIES (PER $0.25m^2$) ± ONE STANDARD ERROR
OF SELECTED TAXA IN MARSH SAMPLES

Taxon	WEST CONTROL AREA				AFFECTED AREA			
	Phase I	Phase II	Phase III	Phase IV	Phase I	Phase II	Phase III	Phase IV
All species[a]	745 ± 250	3151 ± 1015	1678 ± 377	6309 ± 2839	709 ± 294	8082 ± 2627	3256 ± 788	3821 ± 1073
Nematoda	1213 ± 480	2250 ± 1163	821 ± 229	5132 ± 3076	291 ± 134	6123 ± 2461	4200 ± 3234	1317 ± 315
Polychaeta	49 ± 20	199 ± 72	72 ± 25	805 ± 131	9 ± 4	416 ± 184	170 ± 66	671 ± 157
Capitella capitata	0	0	0	0	0	0	0	0
Oligochaeta	285 ± 145	474 ± 159	373 ± 140	867 ± 246	72 ± 46	697 ± 414	262 ± 97	594 ± 158
Gastropoda	3 ± 1	6 ± 4	0	3 ± 2	15 ± 8	1 ± 1	10 ± 6	1 ± 1
Pelecypoda	34 ± 15	41 ± 12	50 ± 37	464 ± 182	62 ± 29	123 ± 25	48 ± 9	195 ± 100
Tanaidecea	41 ± 21	990 ± 364	388 ± 85	198 ± 78	382 ± 173	4629 ± 1552	1050 ± 258	425 ± 102
Amphipoda	257 ± 115	1277 ± 525	602 ± 233	3247 ± 1868	105 ± 59	1863 ± 841	1591 ± 361	1674 ± 598
Isopoda	2 ± 1	69 ± 24	36 ± 9	404 ± 225	3 ± 1	176 ± 72	31 ± 11	105 ± 23

[a]except nematodes and copepods.

TABLE 8.1-9 (Cont.)

Taxon	EAST CONTROL AREA			NORTH CONTROL AREA		
	Phase I	Phase II	Phase III	Phase II	Phase III	Phase IV
All species[a]	22 ± 6	10913 ± 2469	9405 ± 6179	320 ± 93	864 ± 329	4569 ± 1992
Nematoda	0	10992 ± 3026	6396 ± 4105	288 ± 113	324 ± 155	1056 ± 476
Polychaeta	3 ± 2	105 ± 35	129 ± 37	20 ± 12	99 ± 22	578 ± 292
Capitella capitata	0	0	0	0	0	0
Oligochaeta	7 ± 6	290 ± 138	3171 ± 2888	52 ± 26	202 ± 88	541 ± 197
Gastropoda	2 ± 2	14 ± 5	90 ± 90	< 1	0	19 ± 18
Pelecypoda	0	204 ± 121	239 ± 167	130 ± 28	35 ± 17	317 ± 98
Tanaidecea	4 ± 3	6414 ± 1999	3789 ± 1747	8 ± 5	49 ± 21	27 ± 17
Amphipoda	2 ± 1	3525 ± 1170	1863 ± 1253	70 ± 34	384 ± 287	2663 ± 1301
Isopoda	< 1	49 ± 10	42 ± 28	0	0	64 ± 51

[a]except nematodes and copepods.

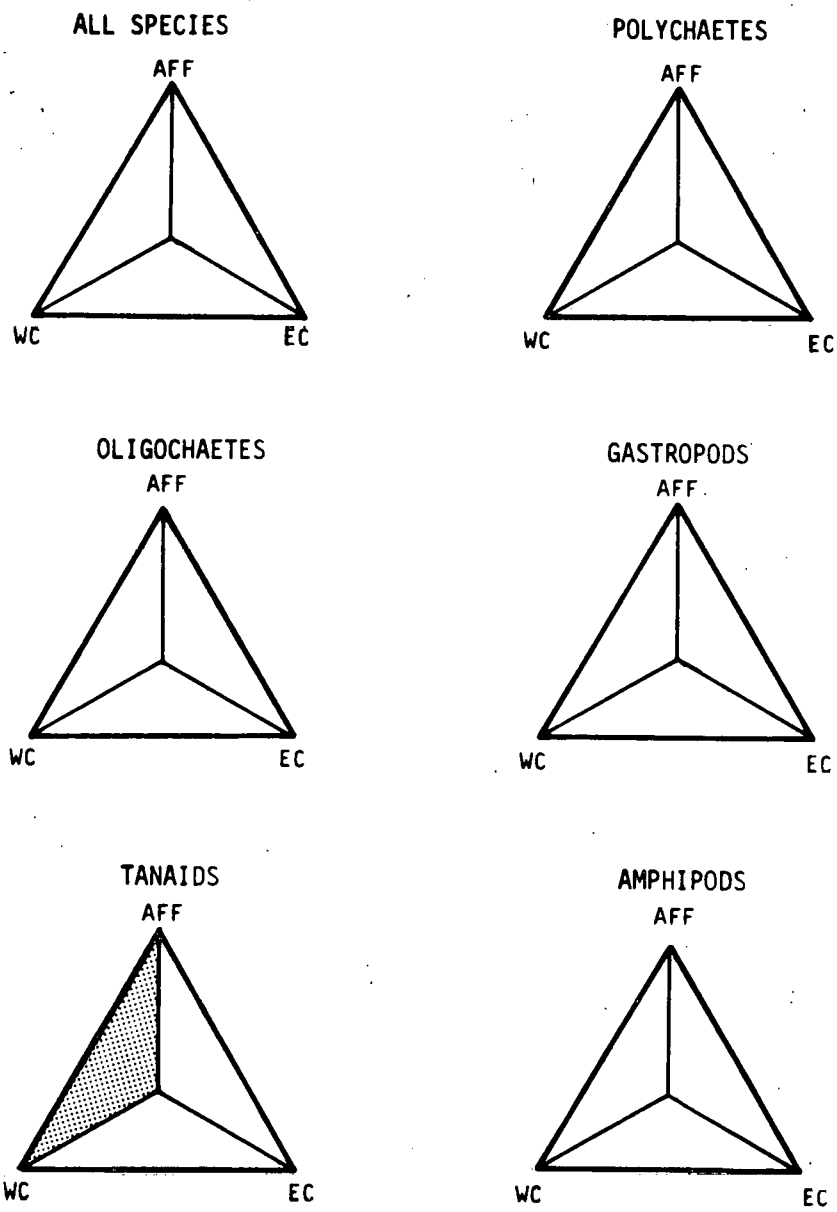


FIGURE 8.1-6 DIFFERENCES IN MARSH FAUNAL DENSITIES BETWEEN SITES DURING PHASE I

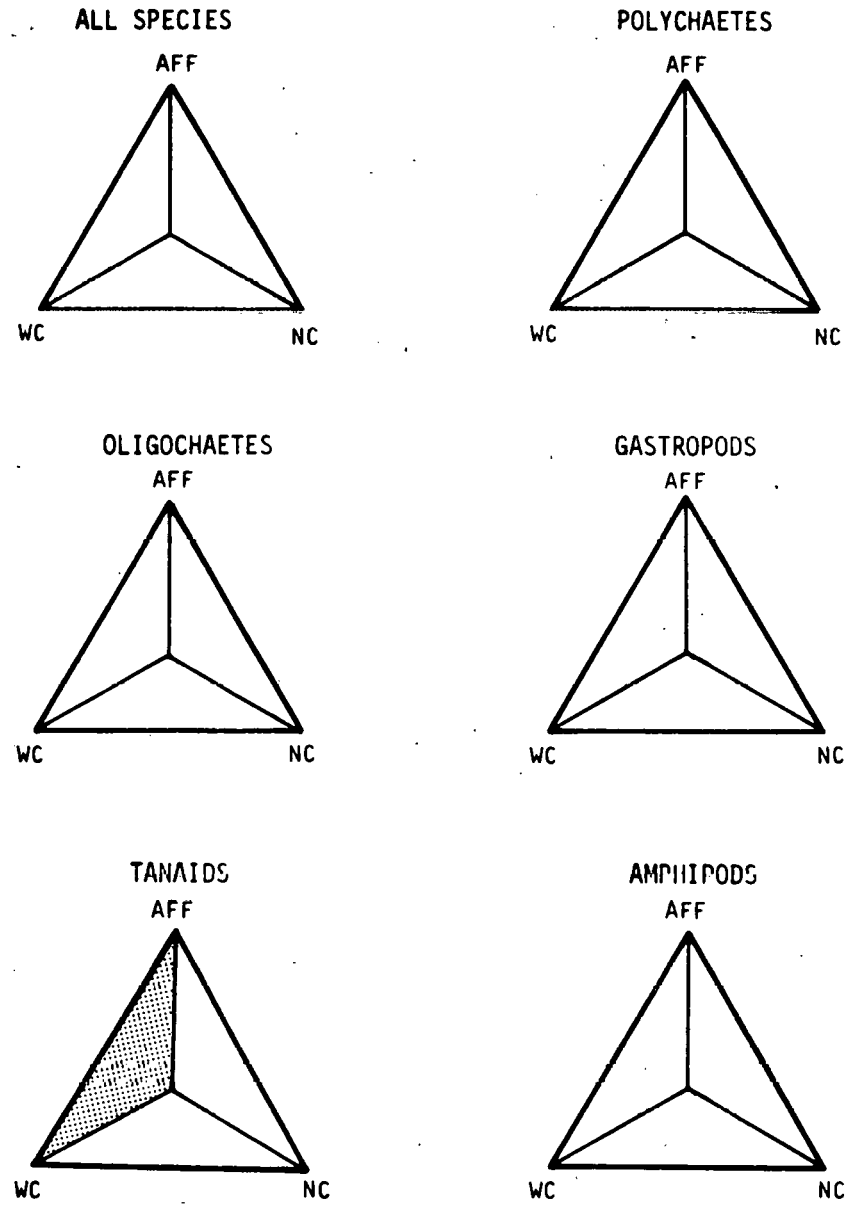


FIGURE 8.1-7 DIFFERENCES IN MARSH FAUNAL DENSITIES BETWEEN SITES DURING PHASE II

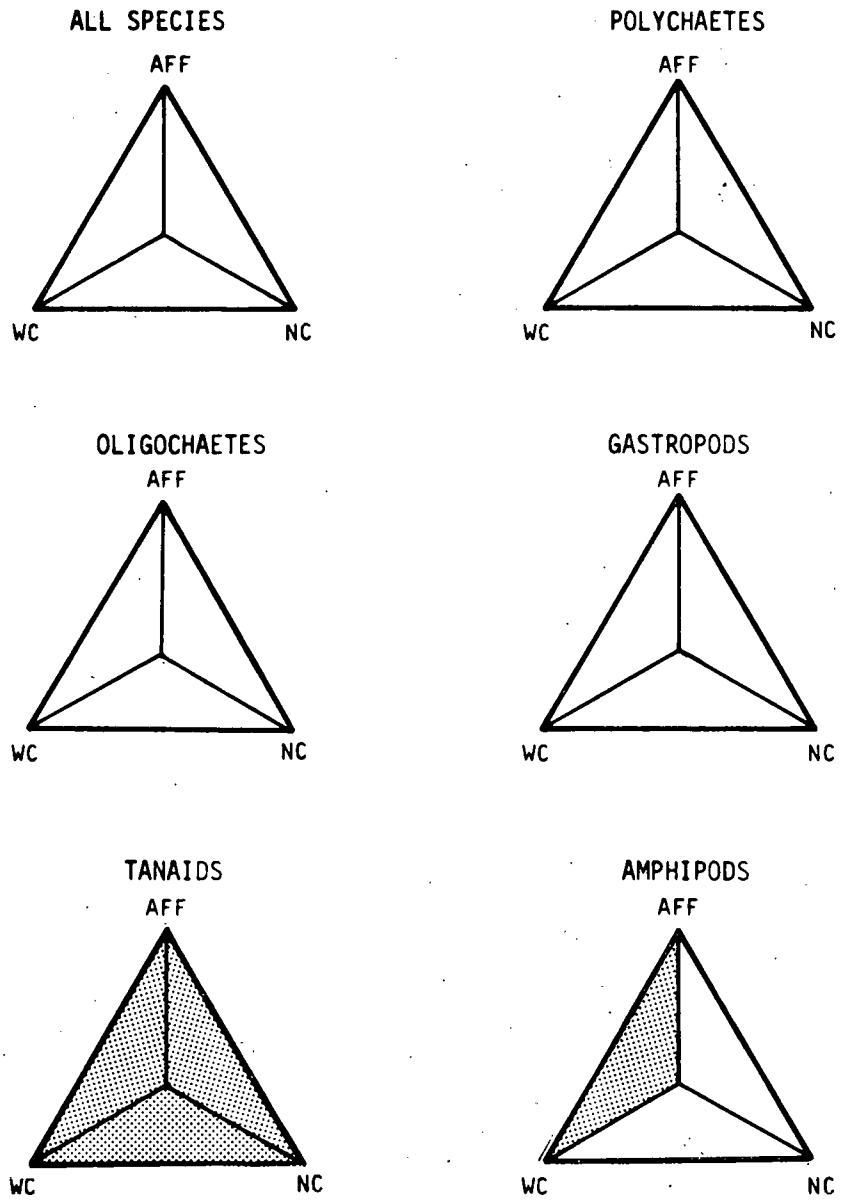


FIGURE 8.1-8 DIFFERENCES IN MARSH FAUNAL DENSITIES BETWEEN SITES DURING PHASE III

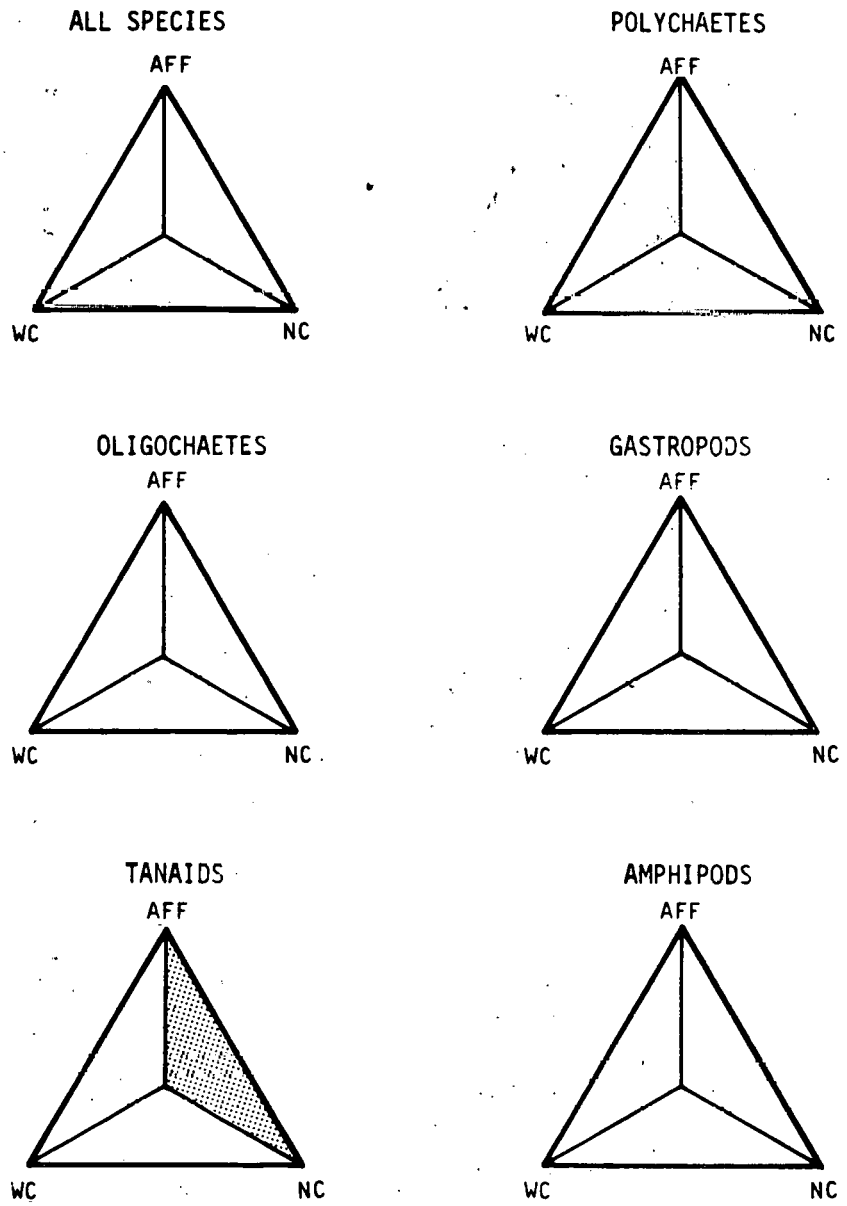


FIGURE 8.1-9 DIFFERENCES IN MARSH FAUNAL DENSITIES BETWEEN SITES DURING PHASE IV

18 triangles in each of these figures represents a 2-level analysis of variance between the 2 sites denoted at the outer corners of the triangle.

Tanaid densities were significantly higher in the Affected Area than in the West Control Area in Phases I through III. No other significant differences were detected in Phase I and II. In Phase III, the amphipod density was also significantly higher in the Affected Area than in the West Control. These differences had disappeared by Phase IV.

In Phases II through IV, a North Control Area was substituted for the East Control Area in these analysis. This was done because the East Control Area was not characterized by the Juncus marsh sampled in the other areas and because this area was rapidly eroding, adversely affecting sampling reproducibility between phases. The North Control Area had significantly fewer tanaids than the Affected Area in Phases III and IV.

Significant increases in total density were detected in the Affected Area between Phases I and II ($t = 3.84$, $df = 18$, $p < 0.01$) and between Phases I and IV ($t = 2.71$, $df = 25$, $p < 0.02$). However, similar increases were observed in the West Control Area between Phases I and IV ($t = 2.24$, $df = 28$, $p < 0.05$). Results of three-level analyses of variance (Tables 8.1-10 through 8.1-12) indicated that there were no significant changes in faunal density among phases for total animals, tanaids, and amphipods.

The sensitivity of these analyses is indicated in Table 8.1-13. The initial goal of being sensitive to a 51 percent change in faunal density at the 95 percent confidence level was achieved for all phases in the Affected and primary (West) control areas, and in the East Control Area for Phase II. In the first two areas, the sensitivity was on the order of 25 to 45 percent.

TABLE 8.1-10

THREE-LEVEL NESTED ANALYSIS OF VARIANCE FOR MARSH TANAIDACEA

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F Ratio	Probability
Among Phases	3	1,420,327,844	473,442,615	1.65	> 0.10
Among Sites Within Phases	11	972,095,316	88,372,301	20.51	< 0.001
Among Stations Within Sites	88	1,703,827,861	19,361,680	28.89	< 0.001
Within Stations	833	558,244,233	670,161		
TOTAL	935	4,654,495,254			

TABLE 8.1-11

THREE-LEVEL NESTED ANALYSIS OF VARIANCE FOR MARSH AMPHIPODA

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F Ratio	Probability
Among Phases	3	755,927,388	251,975,796	4.50	> 0.10
Among Sites Within Phases	11	615,369,630	55,942,694	3.57	< 0.025
Among Stations Within Sites	88	6,676,635,936	75,870,863	69.15	< 0.001
Within Stations	833	913,942,930	1,097,170		
TOTAL	935	8,961,875,884			

TABLE 8.1-12

THREE-LEVEL NESTED ANALYSIS OF VARIANCE FOR MARSH TOTAL ANIMALS

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F Ratio	Probability
Among Phases	3	4,602,222,053	1,534,074,018	4.75	> 0.10
Among Sites Within Phases	11	3,554,298,786	323,118,072	5.68	< 0.001
Among Stations Within Sites	84	19,746,470,024	224,391,705	38.42	< 0.001
Within Stations	778	4,865,443,946	5,840,869		
TOTAL	876	32,768,434,809			

TABLE 8.1-13

SENSITIVITY OF MARSH FAUNAL ANALYSIS TO CHANGES IN AVERAGE DENSITY OF THE TOTAL FAUNA

	Number of Samples Analyzed	Confidence Level at which a 51 Percent Change[a] is Detectable (percent)	Percent Change[a] Detectable at the 95 Percent Confidence Level
AFFECTED AREA			
Phase I	13	99	35
Phase II	7	95	42
Phase III	10	99	24
Phase IV	12	99.9	23
WEST CONTROL AREA			
Phase I	17	99.9	24
Phase II	8	98	38
Phase III	9	99	24
Phase IV	11	98	38
EAST CONTROL AREA			
Phase I	4	90	66
Phase II	4	95	50
Phase III	4	60	147
NORTH CONTROL AREA			
Phase II	4	90	65
Phase III	4	80	85
Phase IV	4	80	98

[a]Magnitude of change expressed as a percent of the mean density.

Changes in relative abundance of the dominant taxa are illustrated in Figure 8.1-10. The Affected Area was characterized by relative increases in the dominance of amphipods and polychaetes between Phases I and IV, and by a decrease in tanaid dominance between Phases II and IV. A similar pattern was weakly developed in the West Control Area. The North Control Area was also characterized by increased dominance of amphipods and polychaetes between Phases II and IV, and a decrease of the bivalves and miscellaneous taxa.

The polychaete annelid, Capitella capitata, was found in marsh samples. This species is apparently an oil tolerant opportunist whose populations increase dramatically as a result of oil spills (Reish, 1971). No dramatic increase was observed in Black Lake marshes. A slight increase was observed in both the Affected and West Control marshes during Phases II and III, but no Capitella individuals were found at any site in Phase IV. Capitella densities did not exceed nine individuals per 0.25 m^2 at any site during the study.

Size-frequency distributions were determined for mussel populations at each site (Figure 8.1-11) to evaluate potential impacts of the oil spill on population structure. This species was selected for this analysis because it was believed to be the most long-lived sessile resident animal species in the Affected Area, and thus offered the greatest probability that individuals sampled near the end of the study were present during the incident. Mussel growth, as indicated by shifts in modes of these distributions, occurred at all sites, and no detectable difference in the rate of growth was detected between sites.

8.1.3 Marsh Vegetation

The major vegetative communities in the vicinity of the study area were mapped (Figure 8.1-12). The dominant species and their distribution are listed in Table 8.1-14. Brackish marsh areas are

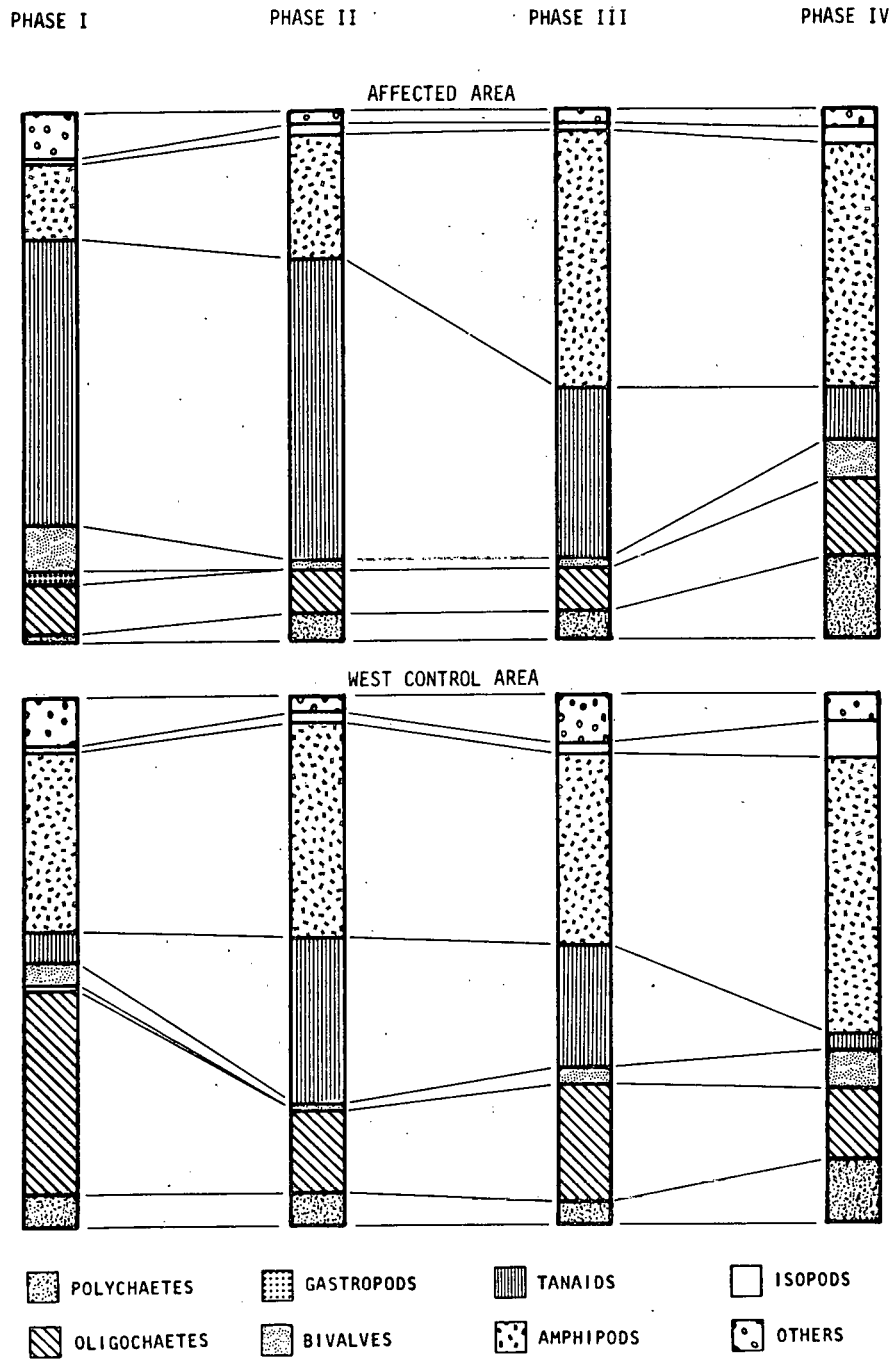


FIGURE 8.1-10 TEMPORAL CHANGES IN RELATIVE ABUNDANCES OF SELECTED TAXA IN MARSH SEDIMENTS

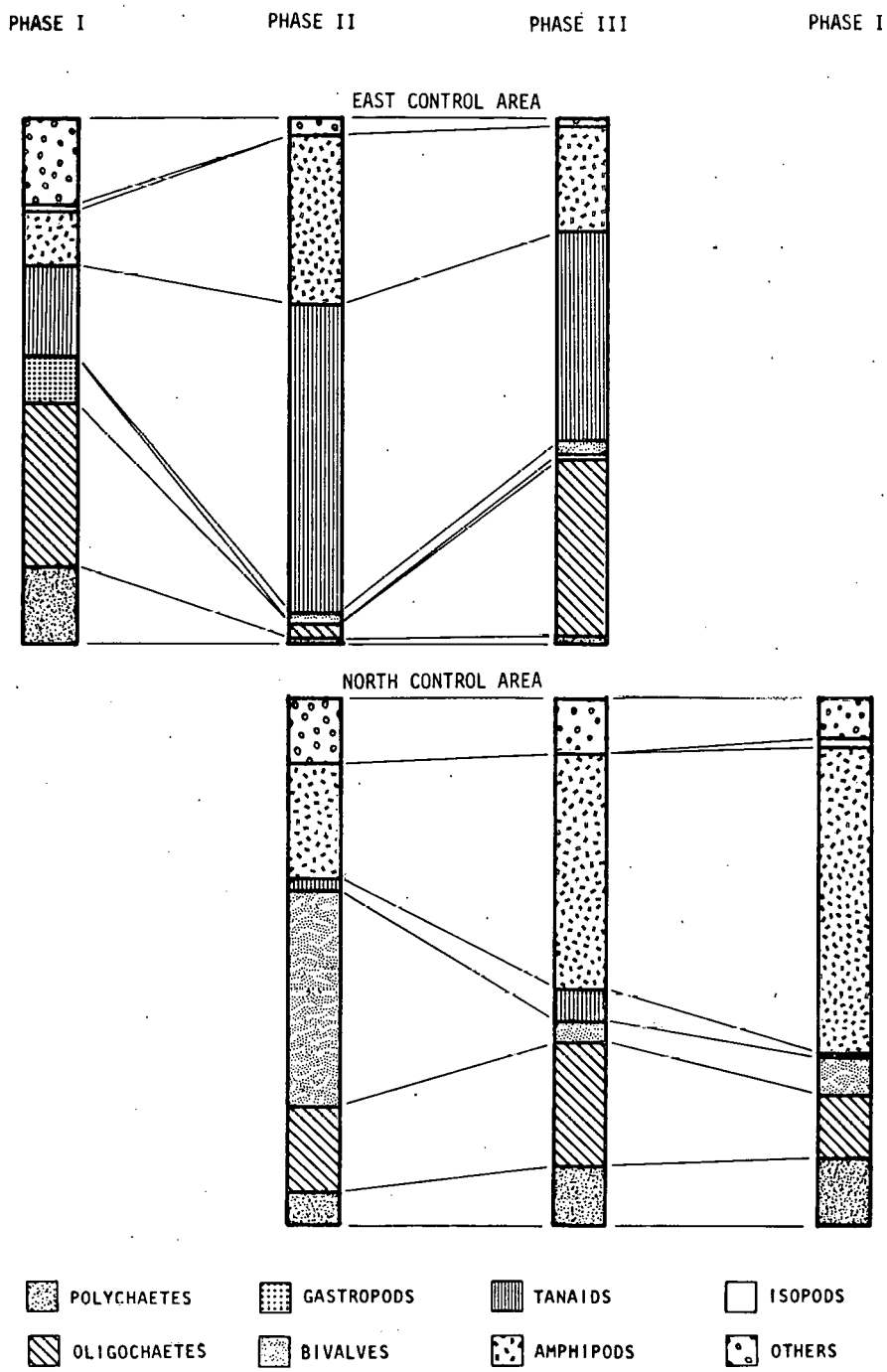


FIGURE 8.1-10 (CONTINUED) TEMPORAL CHANGES IN RELATIVE ABUNDANCES OF SELECTED TAXA IN MARSH SEDIMENTS

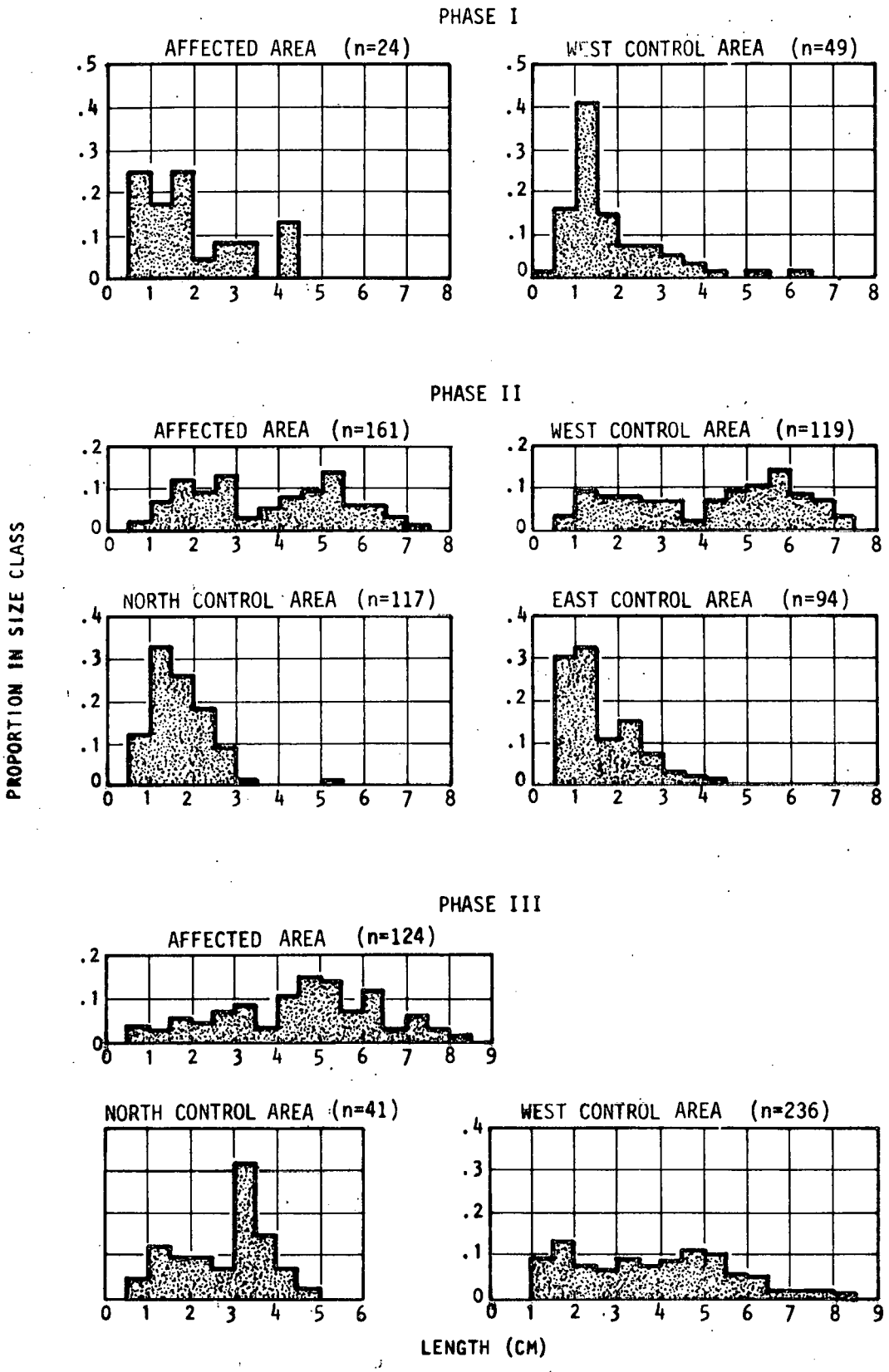


FIGURE 8.1-11 SIZE CLASS HISTOGRAMS OF WEST HACKBERRY MUSSELS (GEUKENSIA DEMISSA).

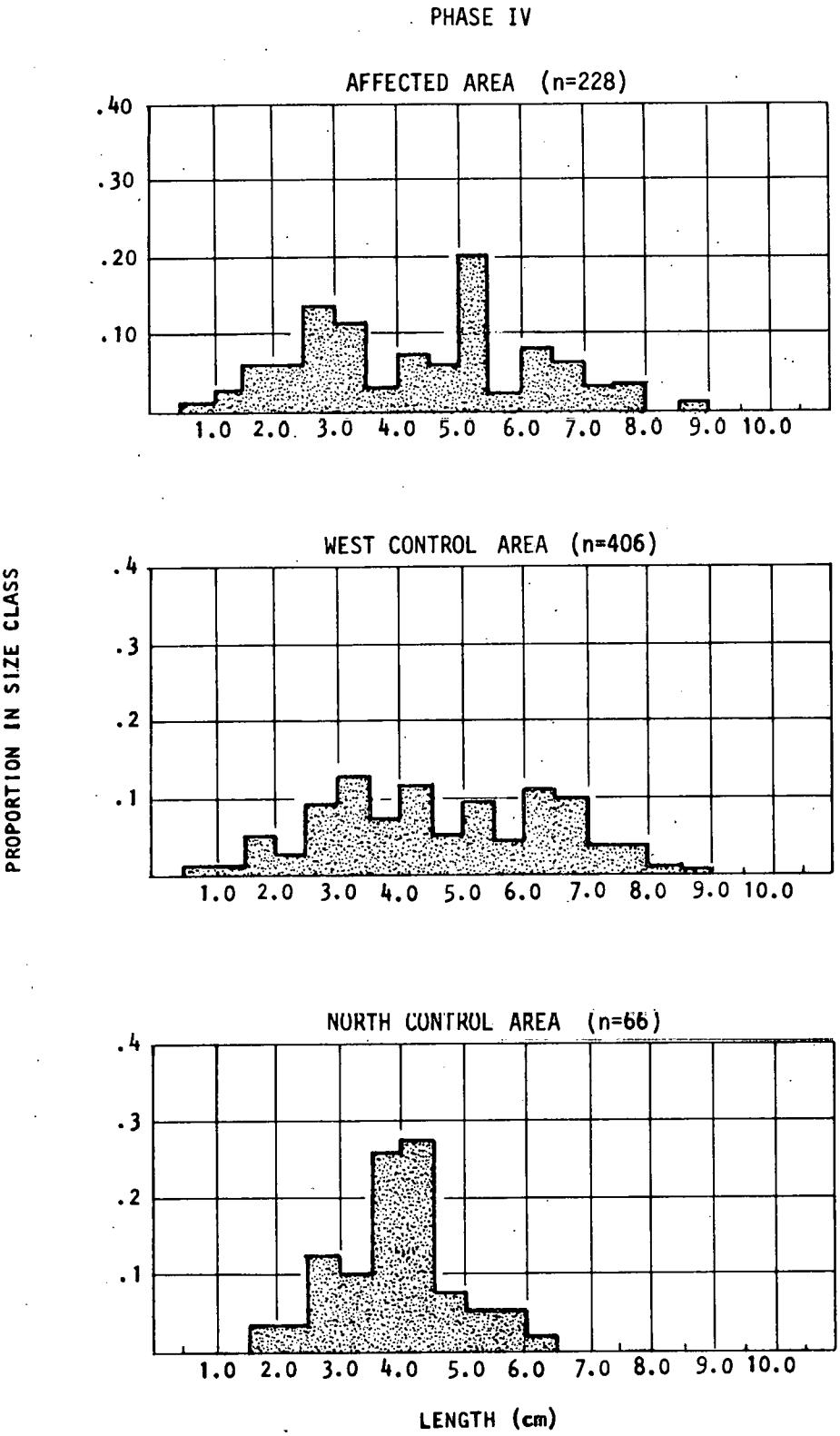


FIGURE 8.1-11 (CONTINUED) SIZE CLASS HISTOGRAMS OF WEST HACKBERRY MUSSELS (GEUKENSIA DEMISSA)

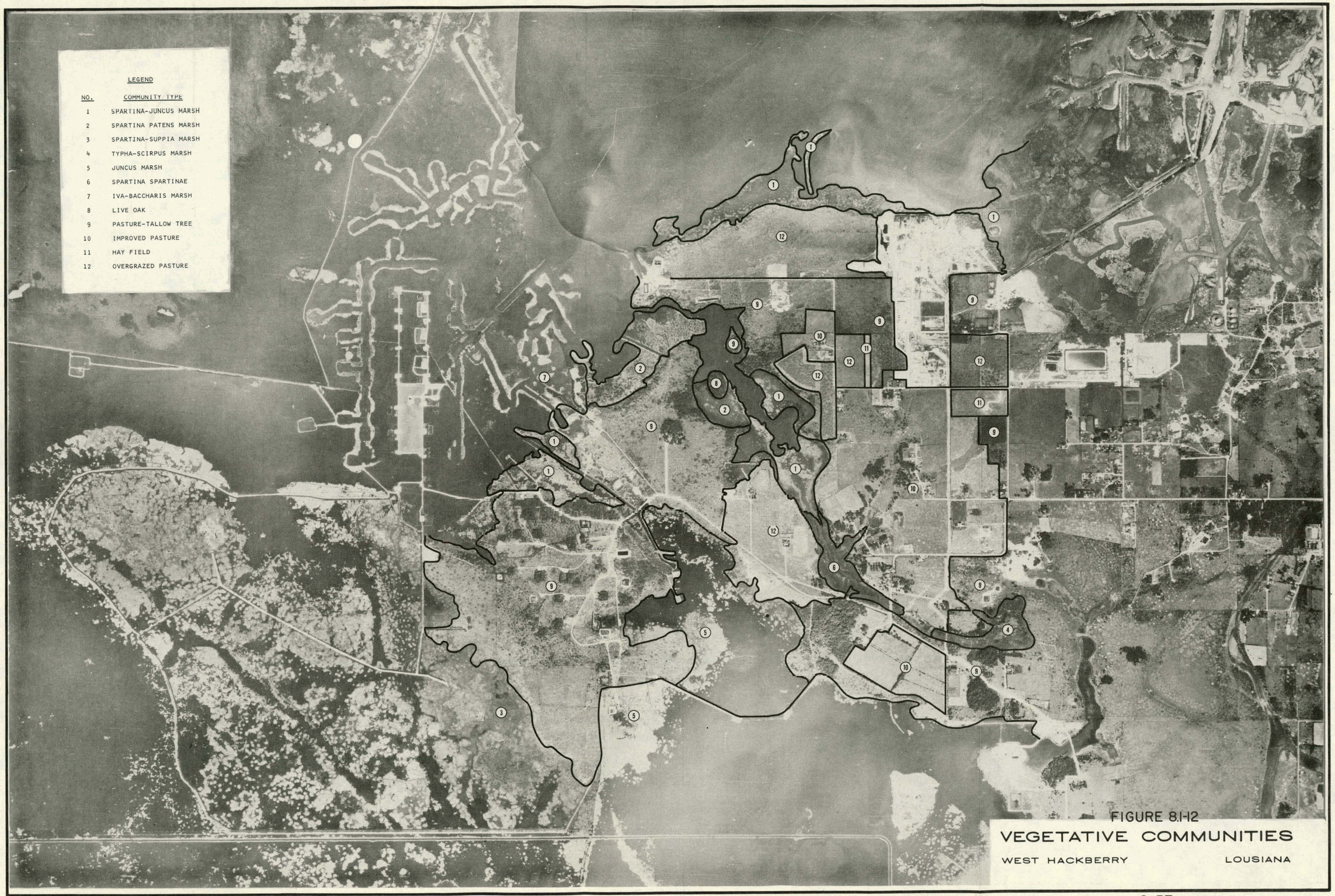


FIGURE 8.1-12

VEGETATIVE COMMUNITIES

WEST HACKBERRY LOUSIANA

TABLE 8.1-14

DOMINANT SPECIES LIST,
VEGETATIVE COMMUNITIES,
WEST HACKBERRY, LOUISIANA

Family[a] Scientific Name Common Name	Community Type[b]	Remarks
Typhaceae		Limited distribution
Typha domingensis Tule	4	
Typha angustifolia Narrow-leaved cat-tail	6	Large stand south of site
Ruppiaceae		
Ruppia maritima Widgeon-grass	3	Limited distribution
Gramineae		Limited to levee of Starks Canal south of site
Arundo donax Giant reed		
Phragmites communis Rouseau cane	7, 14	
Paspalum plicatulum Brownseed paspalum	9, 10, 11, 12	Common
Paspalum urvillei Vasey grass	10, 12	Common
Paspalum dilatatum Dallis grass	9, 12	Common
Paspalum vaginatum Seashore paspalum	5	Limited patch west of site
Schizachyrium scoparium Little bluestem	9	Limited distribution in pasture west of site adjacent to Black Lake

TABLE 8.1-14 (Cont.)

Family[a] Scientific Name Common Name	Community Type[b]	Remarks
Sporobolus virginicus Coastal dropseed	4, 6	Occurs only in small patches
Sporobolus indicus Smutgrass	9, 12	Common
Spartina spartinae Gulf cordgrass	6	Limited distribution
Spartina alterniflora Smooth cordgrass	1	Occurs in small area northeast of site
Spartina patens Saltmeadow cordgrass	1, 2, 3, 5, 7	Common
Distichlis spicata Saltgrass	2	Limited distribution
Cyperaceae		
Eleocharis parvula Spikerush	1, 4, 5	Locally abundant on shallow mud flats
Eleocharis sp. Spikerush	1, 4, 5	Common in ditches, fresh marsh borders
Scirpus californicus Bulrush	4, 6	Limited distribution
Scirpus maritimus Salt marsh bulrush	2	Limited distribution
Fimbristylis castanea	1	Scattered occurrence along edge of Black Lake
Cyperus articulatus Jointed sedge	6	Limited distribution

TABLE 8.1-14 (Cont.)

Family[a] Scientific Name Common Name	Community Type[b]	Remarks
Cyperus odorata Flatsedge		Limited distribution, not common
Juncaceae Juncus roemerianus Black rush	1, 5	Common
Fagaceae Quercus virginiana Live oak	8	
Quercus nigra Water oak	8	Common on undisturbed higher ground (inland)
Leguminosae Sesbania drummondii Rattlebush	7, 9, 12	Common
Euphorbiaceae Sapium sebiferum Chinese tallow tree	7, 9	Heavy infestations in pastures
Croton capitatus Woolly croton	9, 12	Common
Compositae Baccharis halimifolia Sea-myrtle	7	Heavy infestation on spoil banks, occurs on some hummocks in Juncus marsh along lake
Eupatorium capillifolium Dog-fennel	12	Heavy infestations in overgrazed pastures
Helenium amarulum Bitter sneezeweed	1, 6, 12	Common in overgrazed areas, marsh inland borders

TABLE 8.1-14 (Cont.)

Family[a] Scientific Name Common Name	Community Type[b]	Remarks
Iva fructescens Marsh elder	7, 9, 12	Very common on all high lands, pastures
Alismataceae *Sagittaria falcata* Bull tongue		Limited distribution shallow creeks, ditches south of site
Amaranthaceae *Alternanthera philoxeroides* Alligator weed		Limited distribution, shallow creeks, ditches south of site
Malvaceae *Kosteletzkya virginica* Salt marsh-mallow	7	Common on higher spots in all marsh types
Rosaceae *Rosa bracteata* Macartney rose	7, 9, 10, 12	Very common along road sides and high spots in all marsh types

[a]Nomenclature follows Correll and Johnston, 1970

[b]See Legend Figure 8.1-12

prevalent along all shores of Black Lake. These marshes grade into freshwater marshes in the bayous and impounded ponds. Most of the upland areas immediately south of the well pads are pasture or hayfields. Chinese tallow trees have invaded and are dominant in many of the abandoned hayfields and pasturelands in the area.

The highly dissected south shoreline of Black Lake has been colonized by salt-tolerant grasses, rushes and sedges. In general, the shoreline in all areas of the site was in poor condition; i.e., the marshlands adjacent to the southern shores of Black Lake have been considerably eroded since 1955 (USGS, 1955), presumably due to a combination of hydrologic, meteorologic and geologic factors. These include: 1) subsidence (approximately 0.6 cm per year) (U.S. Corps of Engineers, 1973); 2) probable increased (though somewhat indirect) water flow via the Alkali Ditch, Calcasieu Ship Channel, Black Lake Bayou, and associated canals; 3) wind-driven wave action (up to 1 m) during winter cold fronts; and 4) diking and drainage operations, which disrupt sediment and freshwater input.

The remaining marshlands consist of small island patches of saltmeadow cordgrass (Spartina patens), black rush (Juncus roemerianus) and, occasionally, smooth cordgrass (Spartina alterniflora). Smooth cordgrass is adapted to the deep water (up to 1 m) and occasional high wave action which is characteristic of the south shore of Black Lake. Saltmeadow cordgrass stands are extensively matted as a result of wind and water action. Additional evidence of wind-driven water action is the presence of drift materials that had been deposited on the marsh vegetation.

Black rush is present as a border around higher areas (spoil banks and hummocks) and, more extensively, in the protected areas of the shallow marsh immediately north and west of the well pad. Both the saltmeadow cordgrass and black rush areas exhibit high levels of insect

parasitism and litter accumulation. (Ratios of live to dead biomass were always less than 1, in some cases as low as 0.3.)

The stresses imposed on these marshlands by the physical setting made evaluation of any additional oil-related stress difficult. Furthermore, it was difficult to specifically relate vegetative response to the October spill and fire, since the area had been subjected to chronic oil contamination as a result of other oil production activity in Black Lake. Observations indicated that all control areas had been oiled at least once since the beginning of the study. The Affected Area did not appear to have sustained any noticeable long-term spill-related damage within the study year, even though at least two and often three distinct bands of oil were observed on stands of black rush. Plate 8.1-1 shows oil-stained vegetation in the Affected Area during the Phase I sampling period. The oiled stems from sampled plots were dying, but recruitment rates and growth rates of new stems were high enough that the overall aspect of the marsh appeared relatively healthy. The remaining, more protected areas near the "uplands," which were heavily colonized by seashore paspalum (Paspalum vaginatum), were quite healthy. Furthermore, submerged populations of spike rush (Eleocharis sp.) did not show evidence of being diseased or yellowed, even though a definite slick was present in the Affected Area at the time of site visits subsequent to the spill and fire.

Sample sites in three control areas and the Affected Area were established for this study (Figure 7.2-1). The East Control Area consisted of saltmeadow cordgrass hummocks bordered by black rush. Saltgrass (Distichlis spicata) was common here, but did not constitute a major portion of the plant biomass. At least one species of Cyperus was noted, and an occasional small marsh elder (Iva fructescens) was also present on these hummocks. A fairly large stand of smooth cordgrass fringed the spoil banks just south of the East Control area near the confluence of Black Lake and Black Lake Bayou.

PLATE 8.1-1. EXAMPLES OF OILED VEGETATION IN THE AFFECTED AREA, PHASE I

The West Control Area vegetation was dominated by saltmeadow cordgrass, with black rush occurring in isolated clumps on the northern margin of the site, along the fringes of spoil banks and on the outer side of the "real" shoreline about 300 feet south of the "foreshore" mapped in Figure 7.2-1. Sampling in this area concentrated on black rush stands to maximize comparisons with Affected Area vegetation. The West Control Area represented an area of moderate erosional stress.

A North Control Area was added for sampling in Phases II through IV. This area was selected for a control sampling station because it represented an environment with minimum erosional stress and was dominated by black rush. It differed from the other areas in that the sample region was on the inside of a naturally enclosed pond. There was evidence that the pond had been oiled in the past year.

A major portion of the area originally designated for sampling within the Affected Area had been disturbed by construction activities related to reclamation of temporary oil storage pits excavated for the spill. A special sampling area established for production plots just west of the well pad was destroyed except for one control station further west in a protected area of the marsh. As a result, no comparative production data were available. Seashore paspalum was codominant in this area with black rush. A spike rush, Eleocharis sp., was dominant on shallow mudflats, while saltmeadow cordgrass was restricted to a narrow zone around the base of high areas. These spoil banks and hummocks were dominated by marsh elder and chinese tallow trees (Sapium sebiferum). Sea-myrtle (Baccharis halimifolia) occured as a subdominant in these areas, along with saltmarsh mallow (Kosteletzkya virginica), McCartney rose (Rosa bracteata) and rattlebox (Sesbania drummondii).

Results of the standing crop vegetation sampling efforts for Phases I through IV are shown in Table 8.1-15. A number of habitat types were sampled in Phase I in order to characterize the area. These

TABLE 8.1-15

MEAN ± ONE STANDARD ERROR OF TOTAL DRY WEIGHTS
OF 0.25 m^2 VEGETATION BIOMASS SAMPLES

	Phase I		Phase II		Phase III		Phase IV	
	n	Dry Weight (g)	n	Dry weight (g)	n	Dry weight (g)	n	Dry weight (g)
Affected Area	12	194.8 ± 21.0	36	214.9 ± 19.0	18	450.8 ± 31.5	20	242.7 ± 18.9
West Control Area	36	265.3 ± 24.0	11	598.1 ± 96.1	18	611.2 ± 41.2	20	359.9 ± 25.6
East Control Area	36	331.0 ± 30.0	16	292.2 ± 27.2	2	407.6 ± 24.2	--	--
North Control Area	0	--	17	766.2 ± 57.8	10	829.6 ± 67.2	12	404.3 ± 46.5
Terrestrial Transect	22	58.5 ± 6.5	0	--	0	--	--	--

included a terrestrial area and a control area dominated by saltmeadow cordgrass. These two areas were subsequently dropped from the study because differences in floral composition made statistical comparisons between them and the Affected Area invalid. A number of parameters directly related to both the measurement of standing biomass and the calculation of productivity are determined by floral composition. These include plant size, growth rates, and rate of decomposition of plant parts, all of which are directly related to turnover rates within the biomass. Because these variables are species-specific, biomass estimates of different plant populations cannot be readily compared.

The West Control and North Control Areas were comparable to the Affected Area in species composition. These data were analyzed using a two-tailed t-test for uneven sample sizes. There was no significant difference in mean dry weight (g per 0.25 m^2) found between the Affected Area and the West Control Area for Phase I samples. Subsequent samples in Phases II, III and IV, however, showed highly significant differences in standing biomass between the Affected Area and both West and North Control Areas (Table 8.1-16). The Affected Area samples yielded lower average dry-weight biomass for all Phase samples. Moreover, comparison of data from a subset of samples (which were sorted by species) from each of these areas indicated the Affected Area populations had consistently lower stem weights, lower densities, and shorter heights than in the control populations. Affected Area samples also had a higher percentage of parasitized stems than samples from either control area (Appendix B.5). Within any Phase samples, there were no significant differences between North and West Control Areas.

Total standing biomass for both control areas and Affected Area samples compared favorably with published estimates for other coastal black rush marshes (Table 8.1-17). The Affected Area fell within the low end of published values, while the controls, especially the north control, met or exceeded published values. However, published values in Table 8.1-17 are for maximum live standing biomass rather than total

TABLE 8.1-16

SIGNIFICANCE TEST (t-distribution) FOR TOTAL BIOMASS OF VEGETATION SAMPLES

	West Control Versus Affected Area t-value	df	Probability	North Control Versus Affected Area t-value	df	Probability	North Control Versus West Control t-value	df	Probability
Phase I	1.623	45	> 0.10	--	--	--	--	--	--
Phase II	6.157	46	< 0.001	11.462	52	< 0.001	1.597	27	> 0.10
Phase III	3.091	35	< 0.005	5.813	27	< 0.001	2.932	34	< 0.005
Phase IV	3.640	38	< 0.002	4.472	30	< 0.001	1.450	30	> 0.10

TABLE 8.1-17

PRODUCTIVITY AND MAXIMUM STANDING BIOMASS FOR JUNCUS ROEMERIANUS

Maximum Biomass (g/m^2)	Net Above Ground Primary Productivity (g/m^2 per year)	State	Reference
Juncus roemerianus			
650	--	VA	Wass and Wright, 1969
1173	796	NC	Stroud and Cooper, 1969
786	1360	"	Waits, 1967
697	--	"	Cooper and Waits, 1973
340	850	"	Williams and Murdoch, 1969
--	750	"	Williams and Murdoch, 1969
--	654	"	Stroud and Cooper, 1969
--	560	"	Foster, 1968
913	1003	GA	Gallagher, 1972
1500	2156 (ave)	"	Gallagher, et al., 1976
"	2810+	"	"
"	2507+	"	"
"	2502+	"	"
"	1503+	"	"
"	1351+	"	"
675	390	MS	Gabriel and de la Cruz, 1974
--	1697	"	de la Cruz, 1974
--	232	FL	Heald, 1959
--	849	FL	Heald, 1959

biomass as reported for this study. It should be noted also that samples for this study were collected from pure stands of black rush, but no conversion to average coverage was made; the data consequently represented maximum estimates of expected standing biomass for the marsh. This is not the case with much of the published literature (Table 8.1-17) where marsh averages, inclusive of open areas and mixed stands, are of primary interest. Unlike many other types of marshes on the Gulf Coast such as Spartina alterniflora and Spartina patens marshes, the study area did not reach maximum total biomass at the end of the growing season (late September for the Gulf Coast). Data were insufficient to determine time of maximum live biomass.

8.1.4 Nekton

Tables 8.1-18 through 8.1-21 present sampling time and duration for gill nets deployed at each site. Catches of macroinvertebrates and fish, expressed as catch per unit effort, are shown for each site in Tables 8.1-22 through 8.1-25. Because these species are migratory and cover very large ranges, differences in these data are not indicative of impacts from the spill or fire. However, these differences illustrate that the fauna utilizing the Affected Area might have been affected by a loss of habitat. The sampling effort was biased in favor of this area.

Table 8.1-26 provides some supplementary data for fishes and macroinvertebrates. These data are the results of a 1968-69 otter trawl survey conducted in Black Lake by the Louisiana Wildlife and Fisheries Commission. Differences in faunal composition between the present study and the 1968-69 study probably were due to differences in collecting methods. Otter trawls collect demersal (bottom associated) fauna, whereas gill nets are more efficient at collecting pelagic (swimming) forms.

American alligators (Alligator mississipiensis) were observed on the site and in the Affected Area marsh during the Phase I field

TABLE 8.1-18

PHASE I GILL NET SAMPLING TIMES IN BLACK LAKE

Location	Date	Time	Duration (Hours)
Affected Area	Sept. 30	0840 - 1350	5.2
	Sept. 30	1412 - 1645	2.5
	Sept. 30 - Oct. 1	1653 - 0800	15.1
	Oct. 1	0840 - 1550	7.2
	Oct. 1 - Oct. 2	1608 - 1000	17.9
	Oct. 2	1020 - 1630	6.2
	Oct. 2 - Oct. 3	1645 - 0730	14.8
Total			68.9
West Control Area	Oct. 3	0945 - 1845	9.0
	Oct. 3 - Oct. 4	1900 - 0730	12.5
	Oct. 4	0800 - 1755	9.9
Total			31.4
East Control Area	Oct. 4 - Oct. 5	1805 - 1045	16.7
	Oct. 5	1100 - 1700	6.0
Total			22.7

TABLE 8.1-19

PHASE II GILL NET SAMPLING TIMES IN BLACK LAKE

Location	Date	Time	Duration (Hours)
Affected Area	Jan. 15	1000 - 1530	5.5
West Control Area	Jan. 16 - Jan. 17	1400 - 1107	21.1
East Control Area	Jan. 15	1110 - 1650	5.6

TABLE 8.1-20

PHASE III GILL NET SAMPLING TIMES IN BLACK LAKE

Location	Date	Time	Duration (Hours)
Affected Area	Apr. 17	0900 - 1600	7.0
	Apr. 17 - Apr. 18	1600 - 0915	17.25
Total			24.25
West Control Area	Apr. 18	0930 - 1720	7.8
East Control Area	Apr. 17 - Apr. 18	1700 - 0915	16.25
	Apr. 18	0915 - 1700	7.45
Total			23.70

TABLE 8.1-21

PHASE IV GILL NET SAMPLING TIMES IN BLACK LAKE

Location	Date	Time	Duration (Hours)
Affected Area	Oct. 11	1145 - 1655	5.2
	Oct. 11 - Oct. 12	1655 - 1020	18.4
Total			23.6
East Control Area	Oct. 11	1130 - 1645	5.25
	Oct. 11 - Oct. 12	1645 - 1110	18.45
Total			23.70

TABLE 8.1-22

TOTAL PHASE I GILL NET CATCH IN BLACK LAKE

Scientific Name	Common Name	Total Catch	Catch/Hr.
AFFECTED AREA:			
Penaeus setiferus	White shrimp	16	0.232
Callinectes sapidus	Blue crab	24	0.348
Lepisosteus spatula	Alligator gar	2	0.029
Elops saurus	Ladyfish	1	0.015
Brevoortia patronus	Gulf menhaden	5	0.073
Dorosoma petenense	Threadfin shad	1	0.015
Arius felis	Sea catfish	3	0.044
Strongylura marina	Atlantic needlefish	2	0.029
Lagodon rhomboides	Pinfish	2	0.029
Micropogon undulatus	Atlantic croaker	2	0.029
Leiostomus xanthurus	Spot	3	0.044
Mugil cephalus	Striped mullet	5	0.073
Paralichthys lethostigma	Southern flounder	1	0.015
Unknown		6	0.087
Total		73	1.062
WEST CONTROL AREA:			
Callinectes sapidus	Blue crab	7	0.223
Brevoortia patronus	Gulf menhaden	1	0.032
Dorosoma petenense	Threadfish shad	1	0.032
Arius felis	Sea Catfish	2	0.064
Pogonias cromis	Black drum	2	0.064
Micropogon undulatus	Atlantic croaker	1	0.032
Leiostomus xanthurus	Spot	1	0.032
Total		15	0.479
EAST CONTROL AREA:			
Lepisosteus oculatus	Spotted gar	1	0.044
Arius felis	Sea catfish	3	0.132
Pogonias cromis	Black drum	1	0.044
Cynoscion nebulosus	Spotted seatrout	1	0.044
Leiostomus xanthurus	Spot	4	0.076
Mugil cephalus	Striped mullet	1	0.044
Paralichthys lethostigma	Southern flounder	1	0.044
Total		12	0.428

TABLE 8.1-23

TOTAL PHASE II GILL NET CATCH IN BLACK LAKE

Scientific Name	Common Name	Total Catch	Catch/Hr.
AFFECTED AREA:			
---	---	None	0
WEST CONTROL AREA:			
Mugil cephalus	Mullet	2	0.093
Lepisosteus spatula	Alligator gar	1	0.047
Total		3	0.140
EAST CONTROL AREA:			
---	---	None	0

TABLE 8.1-24

TOTAL PHASE III GILL NET CATCH IN BLACK LAKE

Scientific Name	Common Name	Total Catch	Catch/Hr.
AFFECTED AREA:			
Callinectes sapidus	Blue crab	21	0.866
Arius felis	Sea catfish	5	0.206
Leiostomus xanthurus	Spot	2	0.082
Cynoscion arenarius	Sand seatrout	1	0.041
Total		29	1.195
WEST CONTROL AREA:			
Callinectes sapidus	Blue crab	12	1.538
Arius felis	Sea catfish	2	0.256
Cynoscion arenarius	Sand seatrout	2	0.256
Total		16	2.050
EAST CONTROL AREA:			
Callinectes sapidus	Blue crab	20	0.844
Arius felis	Sea catfish	6	0.253
Leiostomus xanthurus	Spot	2	0.084
Total		28	1.181

TABLE 8.1-25

TOTAL PHASE IV GILL NET CATCH IN BLACK LAKE

Scientific Name	Common Name	Total Catch	Catch/Hr.
AFFECTED AREA:			
Callinectes sapidus	Blue crab	9	0.381
Micropogan undulatus	Atlantic croaker	4	0.169
Leiostomus xanthurus	Spot	2	0.085
Total		15	0.635
EAST CONTROL AREA:			
Penaeus setiferus	White shrimp	1	0.042
Callinectes sapidus	Blue crab	8	0.338
Micropogan undulatus	Atlantic croaker	4	0.169
Mugil cephalus	Mullet	2	0.084
Leiostomus xanthurus	Spot	5	0.211
Lepisosteus spatula	Alligator gar	1	0.042
Chloroscombrus chrysurus	Atlantic bumper	1	0.042
Total		22	0.928

TABLE 8.1-26

LOUISIANA WILD LIFE AND FISHERIES COMMISSION OTTER TRAWL SURVEY OF BLACK LAKE, 1968 - 1969 (ANON., 1969)

Common Name	1968: May	Jun	Jul	Sep	Oct	1969: Jan	Feb	Apr	May
Spot	X*	X	X	X	X			X	X
Bay Anchovy	X	X	X	X	X	X	X	X	X
Large Scale Menhaden	X	X	X	X	X			X	X
Atlantic Croaker	X	X	X	X	X	X	X	X	X
Brown Shrimp	X	X	X	X	X	X		X	X
Eight Threadfin Herring	X	X							
Sharptail Goby		X		X	X				
Blue Crab		X		X	X	X	X	X	X
White Trout				X	X				
Spade Fish				X	X				
White Shrimp				X	X		X		X
River Shrimp									X
Star Drum					X				
Naked Goby					X				
Southern Puffer					X				
Lyre Goby					X		X		
Sand Sea Trout					X				X
Rainwater Killifish					X	X			X
Net Clinger					X				
Tidewater Silversides					X	X	X		
Southern Pipefish					X				
Striped Mullet						X	X		
Threadfin Shad						X			
Grass Shrimp						X		X	
Black Drum						X			
Cutlass Fish							X		
Varigated Minnow							X		
Atlantic Menhaden							X		
Bay Whif								X	
Southern Flounder							X		X
Shad							X		

*X - Designates presence at time of sampling

survey. This species currently is not listed as threatened or endangered in Cameron Parish, Louisiana. Alligators are sufficiently mobile to avoid localized contamination.

8.1.5 Biochemical Analyses

On September 30, 1978, water samples were collected at three stations on the periphery of the Affected and West Control Areas for determination of pH, biochemical oxygen demand, chemical oxygen demand, and counts of coliform bacteria. These results are presented in Table 8.1-27. Chloride concentrations, determined as a by-product of the chemical oxygen demand analyses, are also presented. Each of these parameters was measured in two replicate samples from each station. Statistically significant differences were observed between these two areas in biochemical oxygen demand ($t = 3.73$, $p<0.01$) and chlorides ($t = 14.12$, $p<0.001$).

8.1.6 Birds

Birds were observed and recorded during Phases I and III. Incidental observations of birds during the other sampling phases were recorded but are not included in these results. Table 8.1-28 lists all birds identified during Phases I and III.

The area around Hackberry, Louisiana is one of the richest waterfowl wintering grounds in the United States. Numerous species of ducks and geese, numbering in the hundreds of thousands, come to the Louisiana marshes south of Hackberry. The Sabine Wildlife Refuge is the principal wintering ground. However, the immediate area of the Hackberry Storage Site has been drastically disturbed and drained, and does not support a significant population of either permanent or wintering waterfowl. Gulls and terns in the area tend to be transient, arriving to feed off the lake, rarely in large numbers. Waterfowl, except for the mottled

TABLE 8.1-27

RESULTS OF BIOCHEMICAL ANALYSES OF WATER SAMPLES
TAKEN FROM BLACK LAKE ADJACENT TO AFFECTED AND WEST CONTROL MARSHES
ON SEPTEMBER 30, 1978

Station No.	Sample No.	pH	BOD mg/l	Chlorides mg/l	COD mg/l	Total Coliform No./100ml
West Control Marsh						
7-30-B	269-B	8.0	4.6	7048		
	215-B	8.0	4.7	7098		
	287-B				73.1	
	266-B				81.3	
	267-B					540
	211-B					540
8-30-B	285-B	7.7	4.4	7098		
	213-B	7.7	4.8	7148		
	283-B				73.5	
	281-B				79.7	
	263-B					≥2400
	270-B					1600
9-30-B	273-B	7.5	4.1	7148		
	265-B	7.5	3.8	7148		
	286-B				81.3	
	282-B				161.1	
	260-B					350
	288-B					540
Affected Marsh						
10-9-B	276-B	7.7	5.1	7448		
	279-B	7.7	5.0	7448		
	272-B				90.7	
	268-B				77.1	
	262-B					≥2400
	261-B					≥2400
2-9-C	271-B	7.4	6.6	7448		
	278-B	7.4	6.0	7498		
	274-B				112.6	
	277-B				107.9	
	216-B					≥2400
	212-B					≥2400

TABLE 8.1-27 (Continued)

Station No.	Sample No.	pH	BOD mg/l	Chlorides mg/l	COD mg/l	Total Coliform No./100ml
5-9-C	275-B	7.4	8.1	7548		
	214-B	7.4	6.9	7498		
	280-B				106.7	
	259-B				98.5	
	284-B					≥2400
	264-B					≥2400

TABLE 8.1-28

BIRD LIST FOR PHASES I AND III

SCIENTIFIC NAME	COMMON NAME	PHASE I	PHASE III
Phalacrocorax auritas	Double-crested cormorant	X	X
Phalacrocorax olivaceus	Olivaceous cormorant		X
Branta canadensis	Canada goose	X	
Anas fulvigula	Mottled duck	X	X
Anas discors	Blue-winged teal	X	X
Cathartes aura	Turkey vulture	X	
Elanoides forficatus	Swallow-tailed kite		X
Circus cyaneus	Marsh hawk		X
Buteo swainsoni	Swainson's hawk	X	
Pandion haliaetus	Osprey	X	
Falco sparverius	American kestrel	X	
Colinus virginianus	Bobwhite	X	X
Casmerodius albus	Great egret	X	X
Egretta thula	Snowy egret	X	X
Bubulcus ibis	Cattle egret	X	X
Ardea herodias	Great blue heron	X	X
Hydranassa tricolor	Louisiana heron	X	X
Florida caerulea	Little blue heron		X
Butorides vorescens	Green heron		X
Nyctanassa violacea	Yellow-crowned night heron	X	
Botaurus lentiginosus	American bittern		X
Ixobrychus exilix	Least bittern		X
Plegadis chihi	White faced ibis	X	X
Grus candensis	Sandhill crane	X	
Rallus elegans	King rail		X
Chradrius vociferus	Killdeer	X	X
Actitis macularia	Spotted sandpiper	X	
Catoptrophorus semipalmatus	Willet	X	X
Tringa flavipes	Lesser yellowlegs		X

TABLE 8.1-28 (Cont.)

SCIENTIFIC NAME	COMMON NAME	PHASE I	PHASE III
Capella gallinango	Common snipe		X
Larus atricilla	Laughing gull		X
Sterna forsteri	Forster's tern		X
Thalasseus maxima	Royal tern		X
Hydroprogne caspia	Caspian tern		X
Zenaida macroura	Mourning dove		X
Archilochus colubris	Ruby-throated hummingbird		X
Megaceryle alcyon	Belted kingfisher	X	
Tyrannus tyrannus	Eastern kingbird		X
Hirundo rustica	Barn swallow		X
Tridoprocne bicolor	Tree swallow		X
Progne subis	Purple martin		X
Cyanocitta cristata	Blue jay	X	X
Corvus brachyrhynches	Common crow	X	X
Cistothorus platensis	Short-billed marsh wren		X
Mimus plygottus	Mockingbird	X	X
Lanius ludovicianus	Loggerhead shrike		X
Sturnis vulgaris	Starling	X	X
Vermivora peregrina	Tennessee warbler		X
Geothylypis trichas	Yellowthroat		X
Passer domesticus	House sparrow	X	X
Sturnella magna	Eastern meadowlark	X	X
Agelaius phoeniceus	Red-winged blackbird	X	X
Cassidix mexicanus	Boat-tailed grackle	X	X
Molothrus ater	Brown-headed cowbird		X
Icturus spurius	Orchard oriole		X
Cardinalis cardinalis	Cardinal		X
Passerina cyanea	Indigo bunting		X
Melospiza georgiana	Swamp sparrow		X

duck (Anas fulvigula), normally fly over the area or use it intermittently.

During Phase I, 29 species of birds were observed. Nineteen of these species were permanent residents of the area. Only nine species were recorded that are not directly associated with water. Of the migrants and winter residents recorded, only the osprey (Pandion haliaetus) was of more than usual interest since this bird has declined in numbers on the Gulf Coast in recent years. However, in Louisiana this bird is both a migrant, passing through only during its fall and spring migrations, and a very local winter resident (Robbins, 1966).

During Phase III, 49 species of birds were recorded. Of these, 31 species were permanent residents of the area. In this survey, 23 species were recorded which are not directly dependent on lakes, estuaries or marshes. The only unusual siting during this phase was the swallow-tailed kite (Elanoides forficatus), a winter resident of Louisiana marshes but one which has become somewhat more infrequent in recent years (Robbins, 1966).

The wide difference in the number of species seen between the two phases can be attributed to both observation technique and time of the year. In Phase I, bird observations were made during the vegetation sampling program by one observer. During Phase III, one observer was present primarily for the purpose of recording birds. Observations also were tabulated by two additional observers. Phase III field sampling was conducted near the peak spring migration when the overlap of wintering birds, migrating birds and arriving summer residents would be expected to result in more species seen per day.

In all four phases of the work, no difference in the avifauna of the region was noted. No birds are known to have been killed as a result of the oil spill, and there is no evidence to suggest that any indirect losses occurred as a result of the spill.

8.2 CHEMICAL

8.2.1 Quantitative Analysis by Infrared Spectroscopy

Concentrations of total extractable hydrocarbons are given in Tables 8.2-1 and 8.2-2. These quantitative values are indicative of the amount of total hydrocarbon (oil) concentration in the sample. Since the sediment extracts were separated by column chromatography prior to their analysis, the values given are concentrations of hydrocarbons rather than extractable organics. These include the resolved and unresolved components. The resolved components would include normal paraffins (such as waxes), which are relatively nontoxic. The unresolved components would include polycyclic aromatic compounds (PAH), some of which are extremely toxic. Total extractable hydrocarbon values can be related to toxicity (bioassay) studies in which water soluble hydrocarbon fractions are tested.

Since none of the sediment samples analyzed by infrared spectroscopy was homogenized, duplicate aliquots of two samples (26 and 121) were extracted and analyzed to estimate sample heterogeneity. The average coefficient of variation for these two samples was 64 percent. Also, two replicate samples (156 and 169) from the same station were analyzed, yielding a coefficient of variation of 33 percent. Thus, considerable spatial heterogeneity was detected on two different scales in Black Lake.

Each Phase I sample which contained Cavern 6 crude oil showed hydrocarbon concentrations greater than 1,200 ppm. Two samples (72 and 73) from the Starks Canal also showed high concentrations, possibly due to the presence of biological material and/or heavily weathered oil. Hydrocarbon concentrations in all the sediment samples were high relative to samples analyzed from over 30 East Coast tidal areas, including sites subject to recent oil spills (API Report-URI; not yet released), possibly

TABLE 8.2-1

QUANTIFICATION OF OIL CONTAMINATION
DOE HACKBERRY SEDIMENT SAMPLES

TAG	SITE	QUANTITY OF OIL[a] (µg/g dry weight)
PHASE I		
Samples Containing Cavern 6 Crude Oil		
26	9-6-C	1247-2849
Mean		2048
Samples Not Containing Cavern 6 Crude Oil		
16	9-3-C	27
68	SNR 6	499
73	SNR 8	1150-1357
121	9-1-C	119-365
151	LaBouve Fishing Camp	833
156	30-14-C	674
169	30-14-C	1091
194	30-4-C	245
Mean		608
Standard Error		154
Sensitivity[b]		85%
PHASE II		
Samples Containing Cavern 6 Crude Oil		
606	7-9-B	335
607	2-C	10
943	203-30-C	126
955	6-C	74
Mean		136
Standard Error		70
Sensitivity[b]		232%

[a]Total extractable hydrocarbons

[b]Change in hydrocarbon concentration detectable at the 95 percent confidence level

TABLE 8.2-1 (Cont.)

TAG	SITE	QUANTITY OF OIL[a] (µg/g dry weight)
PHASE II (Cont.)		
Samples Not Containing Cavern 6 Crude Oil		
587	15-3-B	234
595	26-2-B	287
596	8-2-B	407
603	17-3-B	299
618	30-4-C	90
619	30-4-C	398
620	30-4-C	394
624	30-12-C	59
626	2-C	38
628	30-4-C	290
630	Back of Gill Net	112
937	16-1-B	134
941	9-3-C	1026
951	30-7-C	817
952	30-14-C	53
Mean		309
Standard Error		73
Sensitivity[b]		72%
Samples of Uncertain Hydrocarbon Origin		
598	9-2-B	418
649	UNO 2	90
932	LaBouve Fishing Camp	383
944	30-13-C	192
PHASE III (No Samples Contained Cavern 6 Crude Oil)		
Samples Not Containing Cavern 6 Crude Oil		
1115	30-3-C	103
1117	30-7-C	66
1252	9-2-C	660
1546	2-C	297
Mean		281
Standard Error		136
Sensitivity[b]		218%
Samples of Uncertain Hydrocarbon Origin		
1176	9-11-C	15
1191	LaBouve Fishing Camp	112
1248	9-7-C	256

TABLE 8.2-1 (Cont.)

TAG	SITE	QUANTITY OF OIL[a] (µg/g dry weight)
PHASE IV (No Samples Contained Cavern 6 Crude Oil)		
Samples Not Containing Cavern 6 Crude Oil		
1603	UNO 1	46
1606	UNO 2	95
1609	RC 103	336
1616	Texaco Rollers	208
1622	RC 104	173
1625	RC 107	40
1626	No. 8 Barge	94
1670	30-14-C	1281
1687	Levee N.W. of Lake	1247
1689	West of S. Dike	315
Mean		384
Standard Error		150
Sensitivity[b]		125%
Samples of Uncertain Hydrocarbon Origin		
1552	9-3-C	>10,000
1669	30-13-C	228

TABLE 8.2-2

QUANTIFICATION OF OIL CONTAMINATION
DOE HACKBERRY WATER, SOIL, AND MUSSEL SAMPLES

TAG	SITE	QUANTITY OF OIL[a]
PHASE I (WATER SAMPLES, ppb)		
Samples Containing Cavern 6 Crude Oil		
86	9-2-C	4954
117	9-5-C	1859
123	9-9-C	Oil
124	9-1-C	1792
Mean		2868
Standard Error		1043
Sensitivity[b]		221%
Samples Not Containing Cavern 6 Crude Oil		
56	SNR 2	848
70	SNR 6	667
72	SNR 9	1434
198	30-4-C	210
251	Drilling Field	Oil
314	9-12-C	682
Mean		768
Standard Error		197
Sensitivity[b]		101%
Samples of Uncertain Hydrocarbon Origin		
250	Outside Boom	Oil
PHASE II (WATER SAMPLES, ppb) - No Samples Contained Cavern 6 Crude Oil		
Samples Not Containing Cavern 6 Crude Oil		
600	16-3-B	116

[a] Total extractable hydrocarbons

[b] Change in hydrocarbon concentration detectable at the 95 percent confidence level

TABLE 8.2-2 (Cont.)

TAG	SITE	QUANTITY OF OIL[a]
PHASE II (SOIL SAMPLES, µg/g dry weight) - No Samples Contained Cavern 6 Crude Oil		
Samples of Uncertain Hydrocarbon Origin		
639	UNO 3	218
PHASE III (SOIL SAMPLES, µg/g dry weight) - No Samples Contained Cavern 6 Crude Oil		
Samples Not Containing Cavern 6 Oil		
1537	UNO 7	1090
1592	UNO 11	43
PHASE III (MUSSEL SAMPLES, µg/g wet weight) - No Samples Contained Cavern 6 Crude Oil		
1430	W. Marsh	>10,000

indicating chronic contamination of the Black Lake area from indigenous sources.

A significant difference was detected between the mean hydrocarbon concentration in Phase I water samples containing Cavern 6 crude oil and that in Phase I water samples without Cavern 6 crude oil ($t = 2.61$, $df = 6$, $p < 0.05$). Only one water sample was analyzed subsequent to Phase I. Only one Phase I sediment sample containing Cavern 6 crude oil was analyzed. Thus, a similar test was not possible for Phase I sediments. In Phase II, no significant differences were detected between sediment samples containing Cavern 6 crude oil and those without this oil ($t = 1.17$, $df = 17$, $p > 0.20$). No sediment samples containing Cavern 6 crude oil were analyzed subsequent to Phase II.

A significant finding of this particular investigation is that, with the exception of Phase I results, there were no gross differences between the concentration of oil found in the stations contaminated by Cavern 6 crude oil than in those stations contaminated by other oils.

8.2.2 Qualitative Analysis by Capillary Gas Chromatography and Capillary Gas Chromatography/Mass Spectrometry

During the course of this study, there were differences in scientific opinion concerning the best method for chemically tagging the oil. Therefore, two procedures were used to qualitatively tag each oil. Procedure A used pristane-phytane ratios and Procedure B used alkylated phenanthrene (C_1, C_2, C_3) - alkylated dibenzothiophene (C_1, C_2, C_3) ratios.

Procedure A; Pristane/Phytane Method

The gas chromatograms of Cavern 6 crude oil and Louisiana Sweet Crude from the Amoco Oil Company are shown in Figures 7.4-1 and 7.4-3,

respectively. To visualize better the similarities and differences between these gas chromatographic tags, the gas chromatograms were replotted from the computer on an expanded time/temperature scale (Figures 8.2-1 and 8.2-2). Examination of specific peaks showed that the pristane/phytane ratio was different in the two oils. This ratio was approximately 1:1 in the Cavern 6 crude oil and 2:1 in the Louisiana Sweet Crude.

Pristane and phytane are branched isoprenoids and are less susceptible to microbial degradation than the normal paraffin compounds which are preferentially degraded by microorganisms (DOE Report-URI; not yet released). However, they are eventually degraded, and how long they can be used as chemical markers is not known.

To determine whether these differences could be used for weathered oil samples, samples of Cavern 6 crude oil and Louisiana Sweet Crude were artificially weathered for 10 hours at the Hackberry site on October 1, 1978. Their gas chromatograms are shown in Figures 7.4-2 and 7.4-4. The pristane/phytane ratios and peak patterns in the n-C_{17} and n-C_{20} range were consistent with those determined for the unweathered oils. Therefore, the sources of unknown oil weathered for short periods (10 hours, primarily by evaporation) may be identified in samples using the peak pattern in the n-C_{17} and n-C_{20} region and the pristane/phytane ratio.

The gas chromatograms of an oil slick collected 4 miles west of the DOE site are shown in Figure 8.2-3, and that of an oil collected near an Amoco well in the Black Lake is shown in Figure 8.2-4. Interpretation of the gas chromatographic patterns identified these oils as Louisiana Sweet Crudes. On the other hand, the gas chromatographic data of surface water samples collected in the immediately impacted area (Sites 9-9-C and 9-5-C) identified these samples as containing Cavern 6 crude oil (Figures 8.2-5 and 8.2-6).

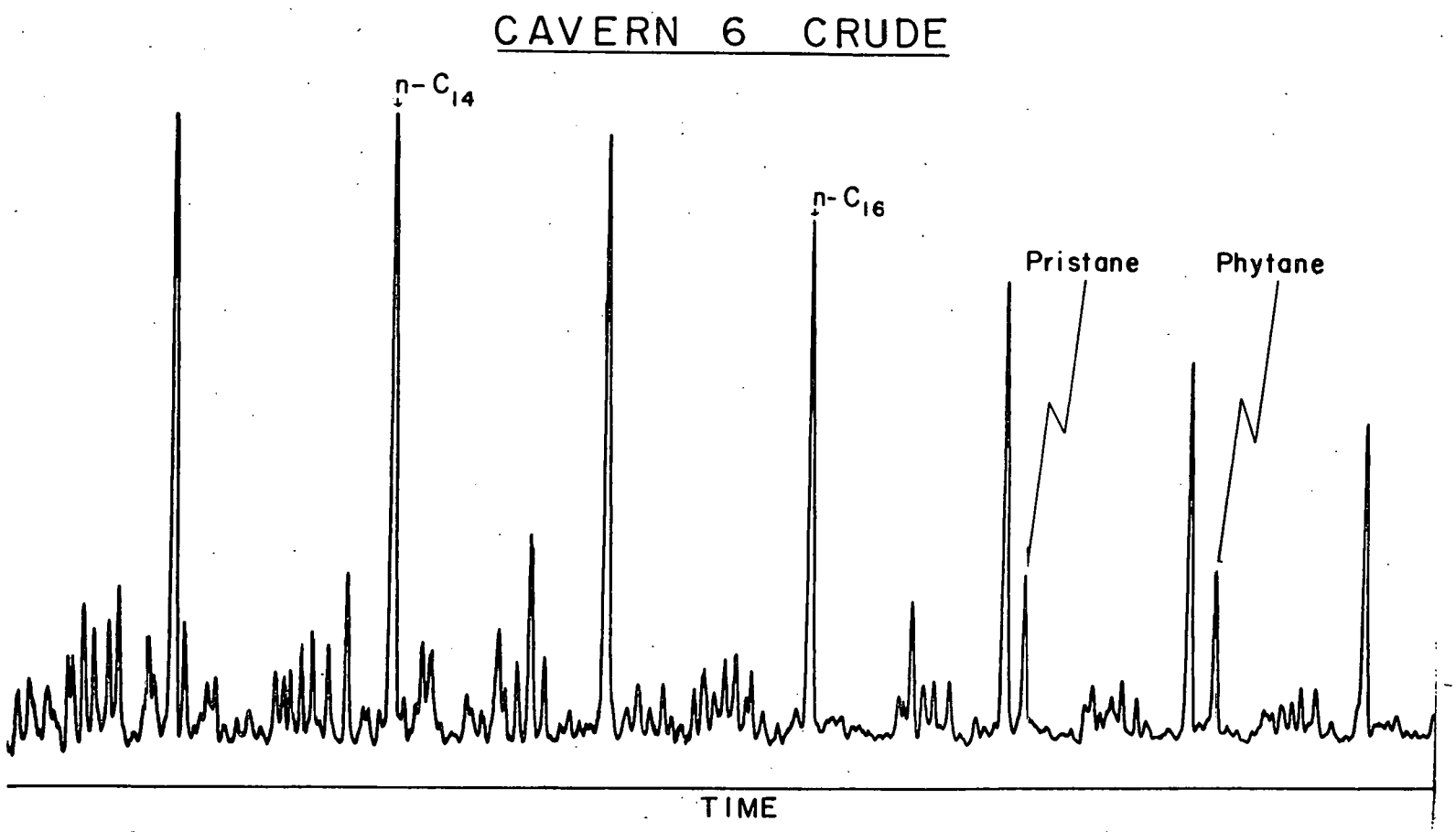


FIGURE 8.2-1 EXPANDED GAS CHROMATOGRAM OF CAVERN 6 CRUDE OIL

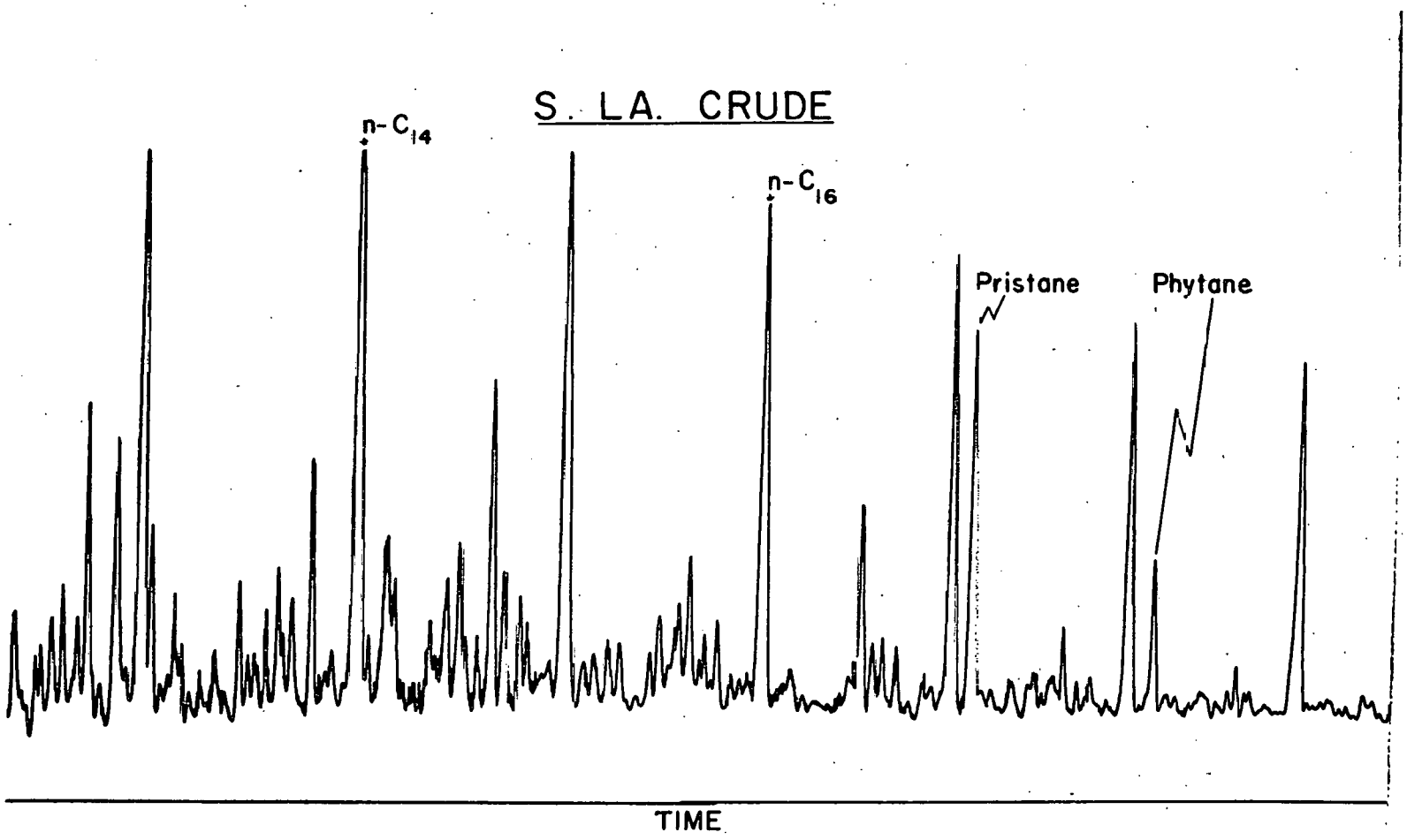


FIGURE 8.2-2 EXPANDED GAS CHROMATOGRAM OF LOUISIANA SWEET CRUDE OIL

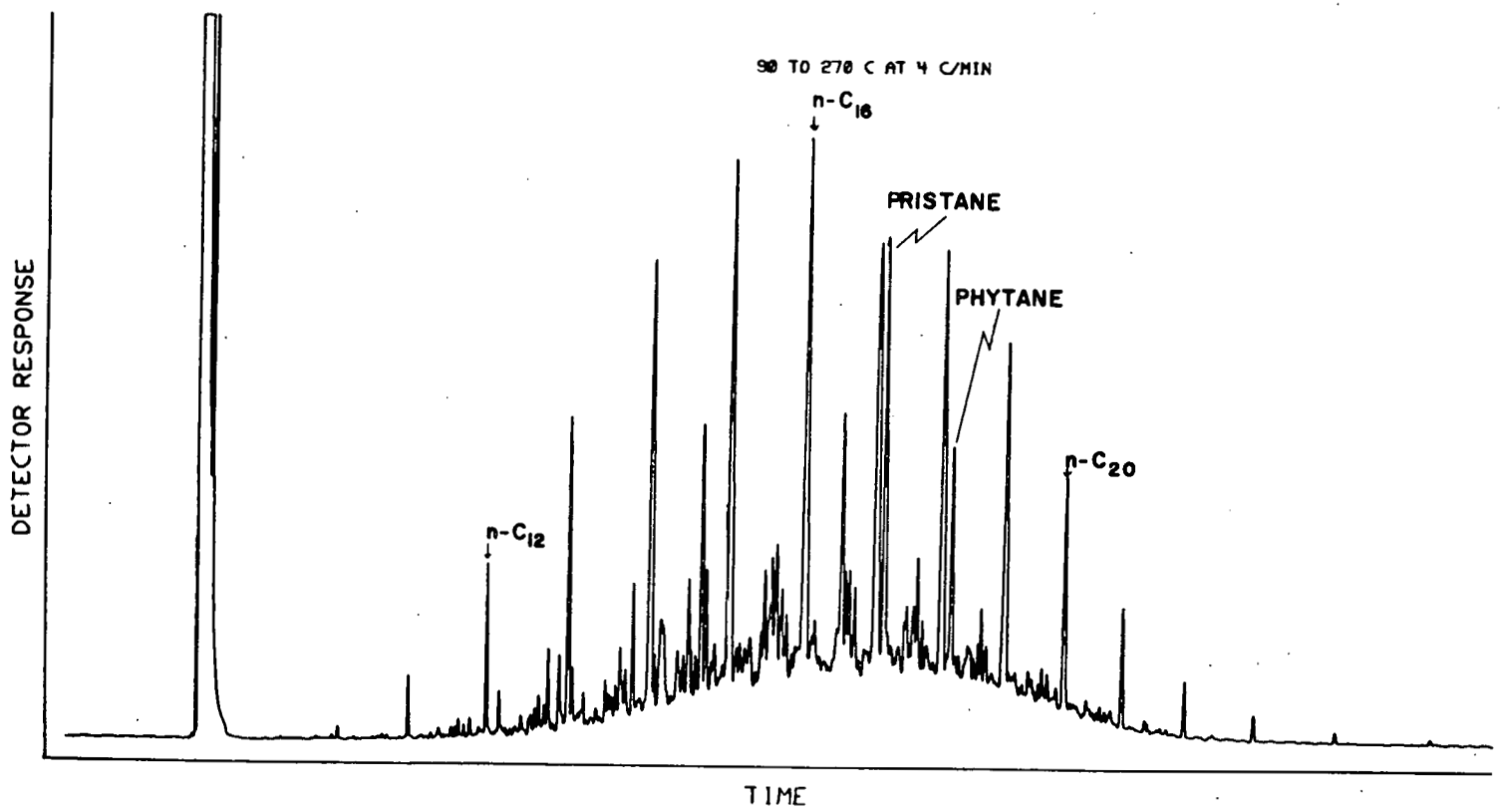


FIGURE 8.2-3 GAS CHROMATOGRAM OF SLICK 6.4 KM WEST OF DOE SITE

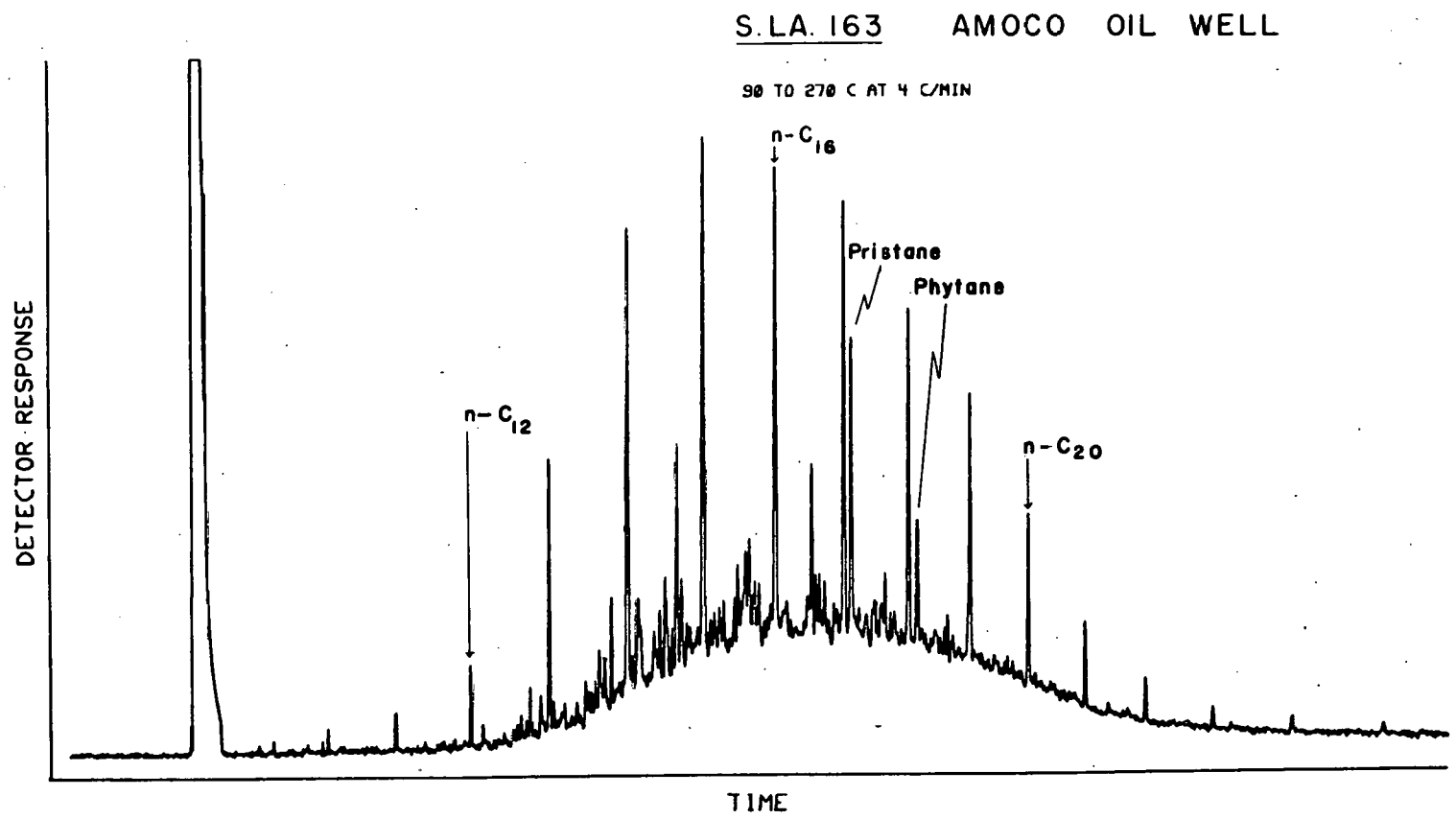


FIGURE 8.2-4 GAS CHROMATOGRAM OF AMOCO OIL

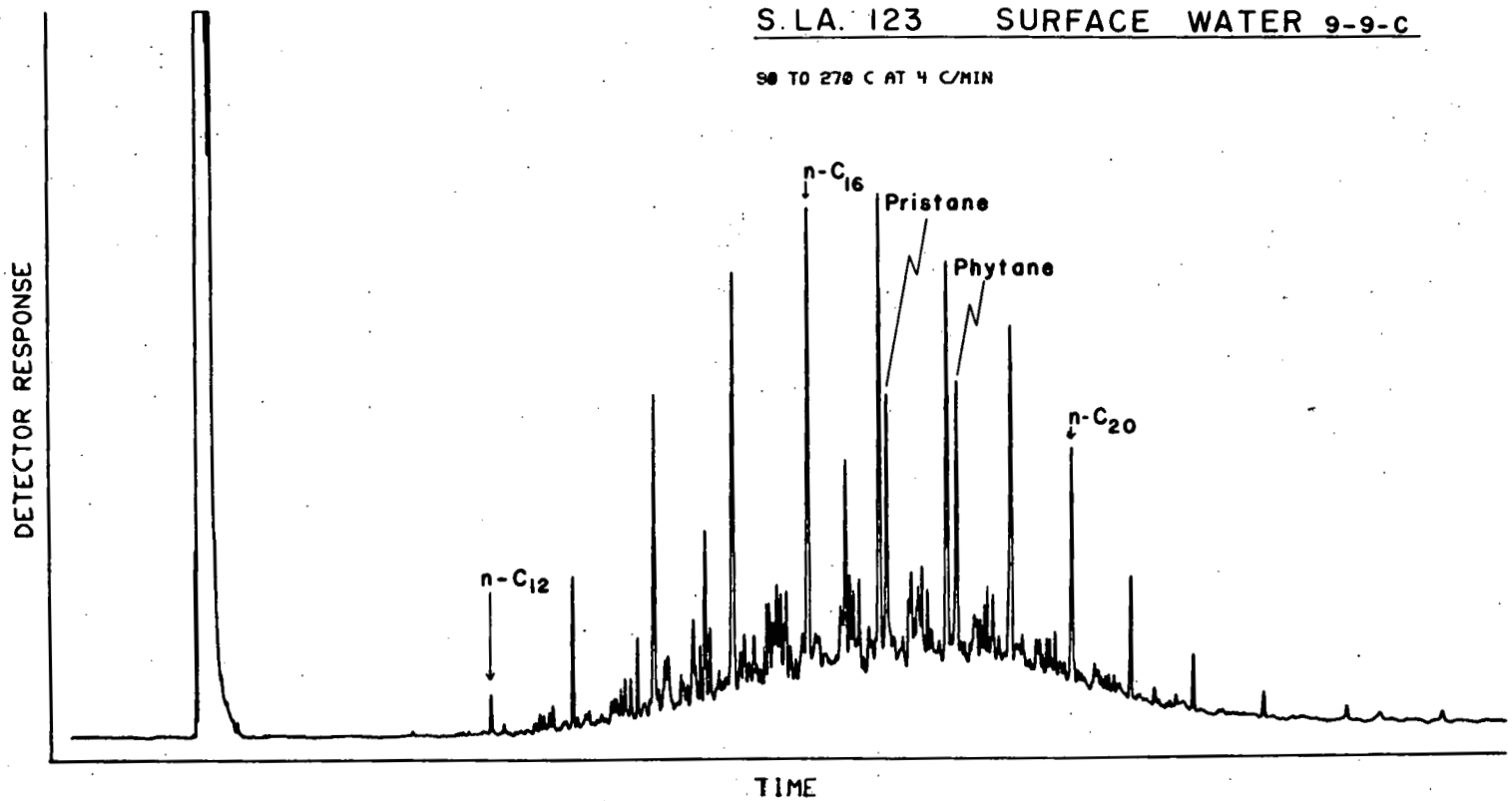


FIGURE 8.2-5 GAS CHROMATOGRAM OF SURFACE WATER AT STATION 9-9-C IN PHASE I

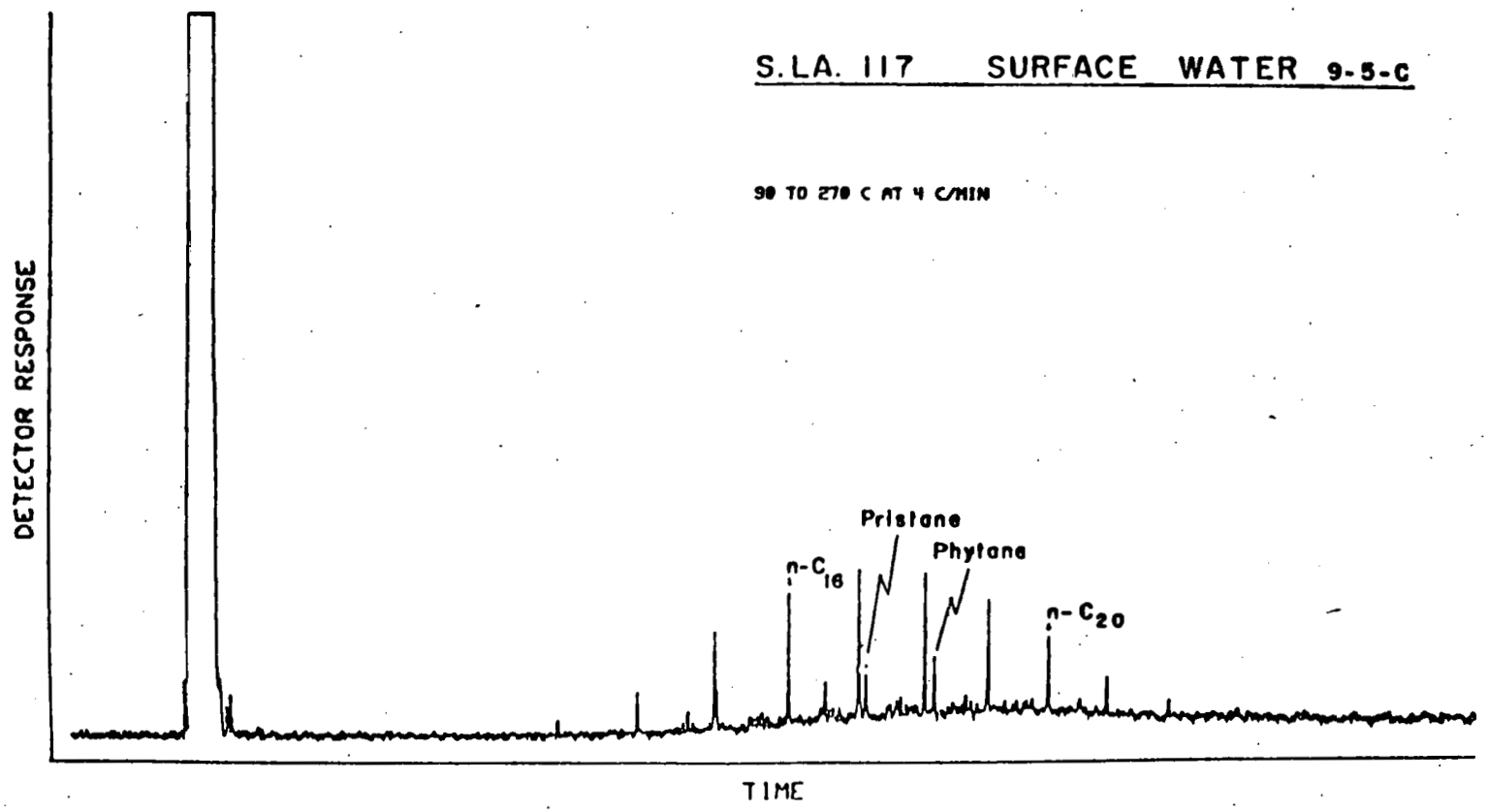


FIGURE 8.2-6 GAS CHROMATOGRAM OF SURFACE WATER AT STATION 9-5-C IN PHASE I

The gas chromatogram of a representative sediment sample is shown in Figure 8.2-7 (note that 50 µg of a n-C_{20} hydrocarbon were added as an internal standard to all sediment samples). The pristane/phytane ratio was 1:1 and indicated that the source of oil was from Cavern 6. The most intense peak in the gas chromatogram was due to n-C_{17}, a plant wax compound which was extracted along with the oil components. Also in this region, an additional interference (possibly an olefin) may be present and may cause problems in the identification and quantification of pristane, but by optimizing the gas chromatographic separation for these compounds, i.e., using the computer to expand the display, and carefully identifying the appropriate peak, it was still possible to differentiate between Cavern 6 crude oil and Louisiana Sweet Crude in all but the extremely weathered samples (where normal paraffin distribution was severely distorted).

An example showing these interferences is shown in Figure 8.2-8 and on an expanded scale in Figure 8.2-9. The pristane/phytane ratio can still be estimated and used to differentiate between Cavern 6 crude oil and Louisiana Sweet Crude. Pristane/phytane ratios of the samples analyzed are shown in Tables 8.2-3 and 8.2-4.

An example of a heavily weathered oil is shown in Figure 8.2-10. The distinguishing characteristics in the gas chromatograms are totally obliterated. However, because this sample was collected during Phase I, it could not possibly be a weathered Cavern 6 crude oil (in such a short time of exposure) and, therefore, must be another oil.

Table 8.2-5 is a list of each station analyzed using this procedure. A "yes" means Cavern 6 crude oil was identified in the sample. A "no" means Cavern 6 crude oil was not in the sample. A question mark indicates uncertainty over the results, and "mixture" means there was probably both Cavern 6 crude oil and Louisiana Sweet Crude in the sample.

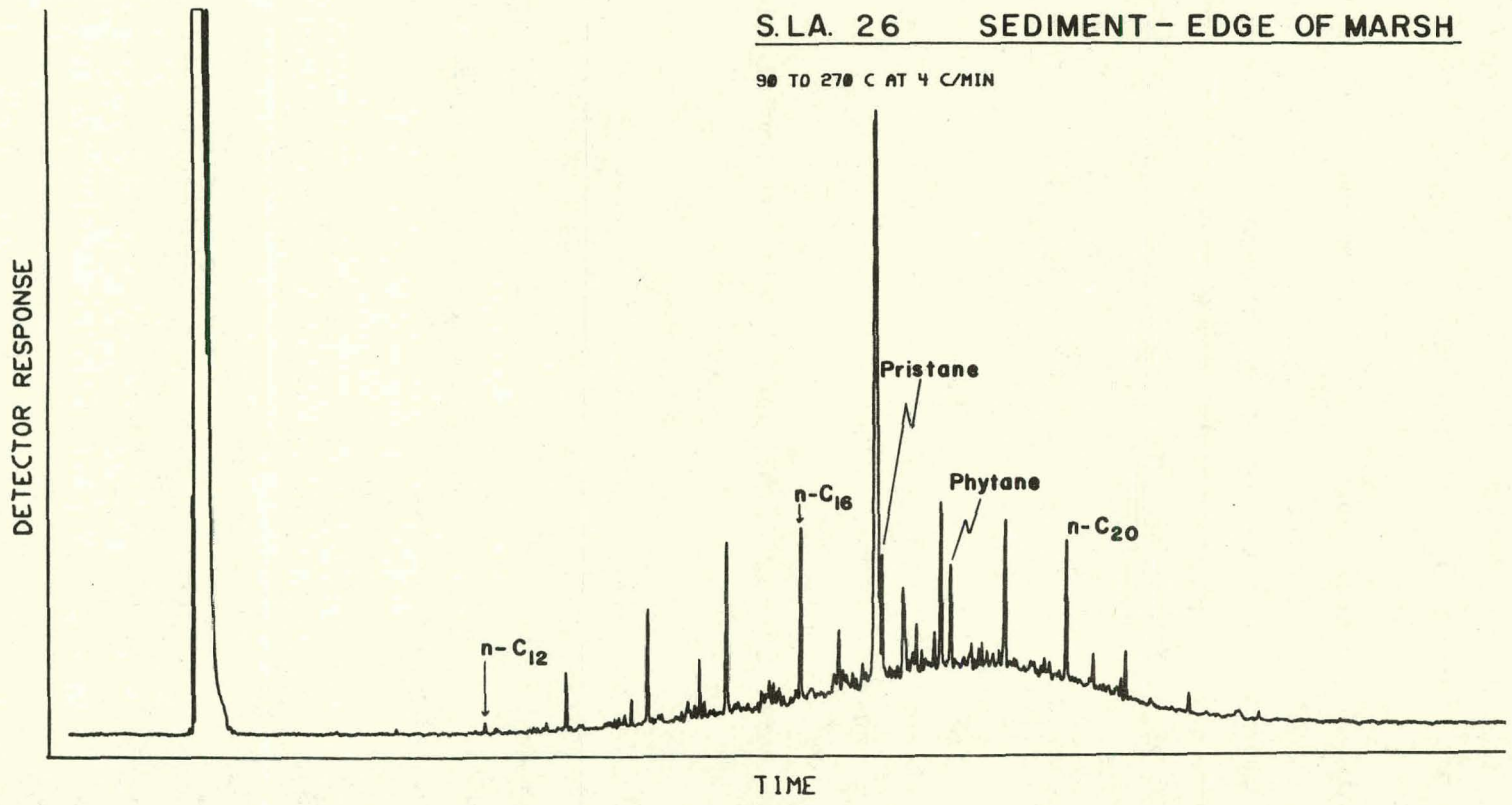


FIGURE 8.2-7 GAS CHROMATOGRAM OF SEDIMENT SAMPLE NO. 26

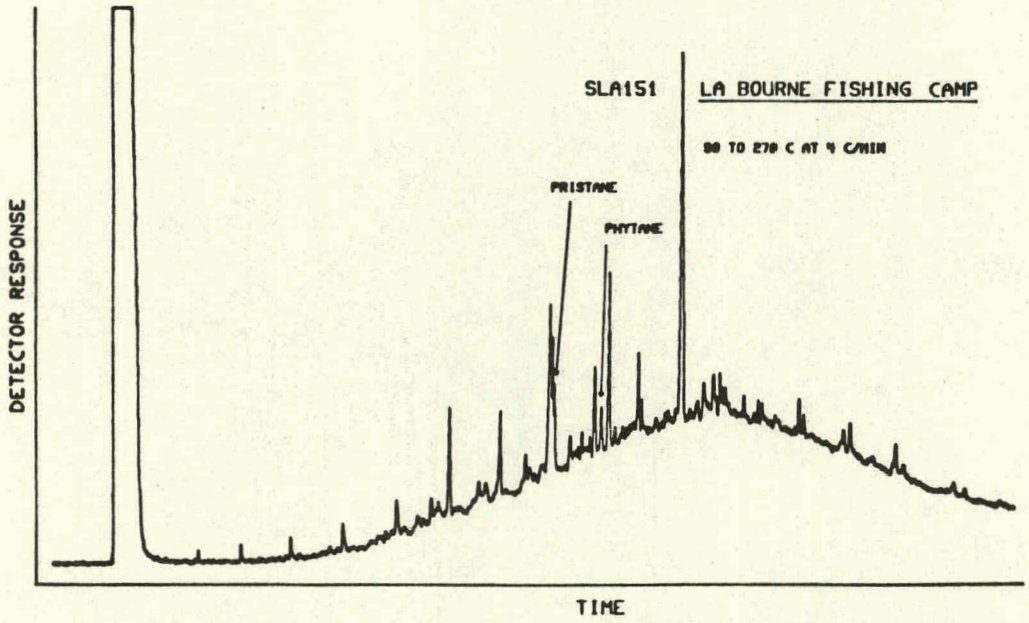


FIGURE 8.2-8 SAMPLE GAS CHROMATOGRAM DEMONSTRATING INTERFERENCE ON THE PRISTANE PEAK

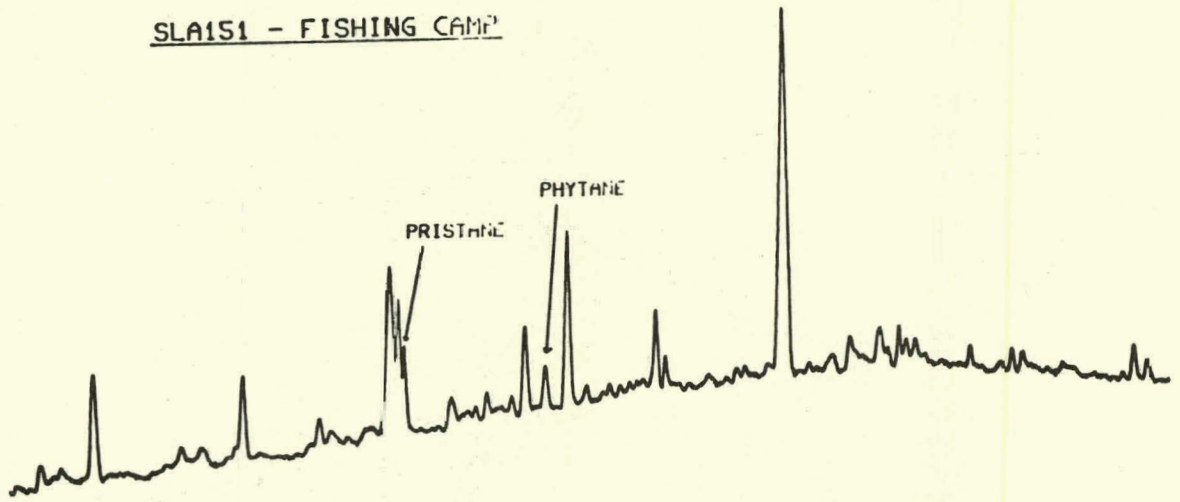


FIGURE 8.2-9 EXPANDED SAMPLE GAS CHROMATOGRAM DEMONSTRATING THE RESOLUTION OF A PRISTANE PEAK

TABLE 8.2-3

PRISTANE/PHYTANE RATIOS IN SEDIMENT SAMPLES[a]

TAG	SITE	PRISTANE/PHYTANE (GC)
PHASE I		
26	9-6-C	1.1
151	LaBouve Fishing Camp	≥2.0
191	30-4-C	2.0[b]
PHASE II		
587	15-3-B	5.0[b]
595	26-2-B	6.6[b]
596	8-2-B	6.6[b]
603	17-3-B	3.75[b]
618	30-4-C	3.0[b]
619	30-4-C	3.0[b]
624	30-12-C	0.71[b]
628	30-4-C	3.75[b]
630	Back of Gill Net	1.75[b]
639	UNO No. 3	1.0
932	LaBouve Fishing Camp	1.38
937	16-1-B	13.3[b]
939	245-1-C	0.90
943	203-30-C	0.83
952	30-14-C	2.5
952	6-C	1.7

[a]Ratios determined by gas chromatography

[b]Interference

TABLE 8.2-4

PRISTANE/PHYTANE RATIOS IN SOIL, WATER AND OIL SAMPLES[a]

TAG	SITE	PRISTANE/PHYTANE
SOIL SAMPLES (PHASE II)		
639	UNO No. 3	1.0
WATER SAMPLES (PHASE I)		
86	9-2-C	1.0
117	9-5-C	1.0
123	9-9-C	1.0
124	9-1-C	0.94
WATER SAMPLES (PHASE II)		
933	LaBouve Fishing Camp	5.0
OIL SAMPLES (PHASE I)		
4	Cavern 6	1.0
163	Bayou S. of Amoco Plant	2.4
250	Outside Last Boom	1.6
251	Drilling Field (2-2-C)	1.7
312	Cavern 6, Well 1A	1.0

[a]Ratios determined by gas chromatography

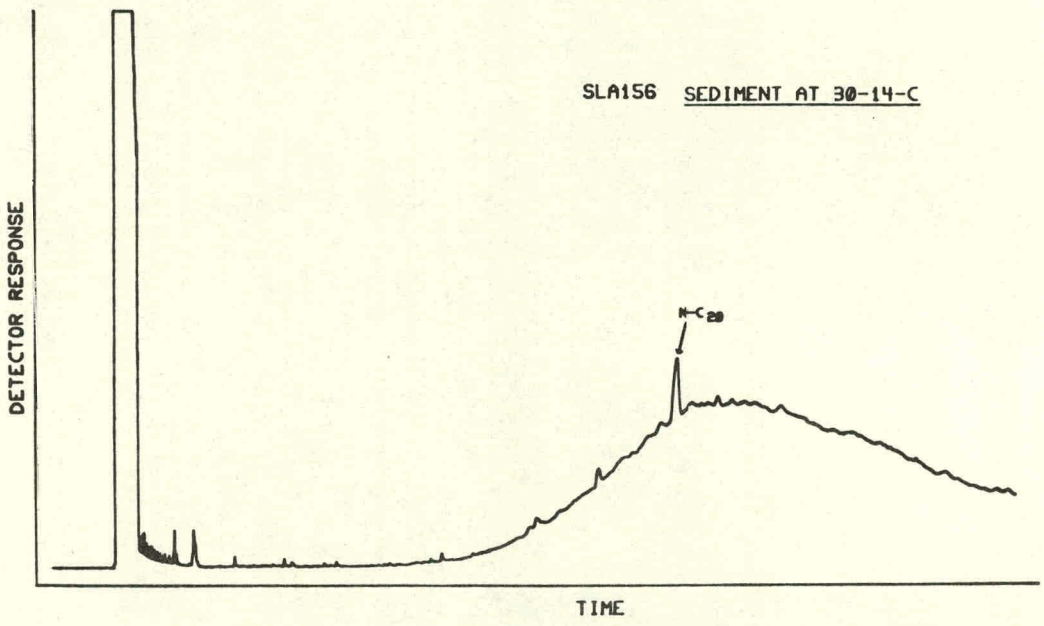


FIGURE 8.2-10 SAMPLE GAS CHROMATOGRAM OF A HEAVILY WESTHERED OIL

TABLE 8.2-5

PERSISTENCE OF CAVERN 6 CRUDE OIL IN THE HACKBERRY ENVIRONMENT AS INDICATED BY ITS PRESENCE OR ABSENCE AT VARIOUS STATIONS ANALYZED BY GAS CHROMATOGRAPHY

SITE	PHASE I	PHASE II	PHASE III	PHASE IV
2-C		No[a], Yes[a]	No[a]	
6-C		Yes[a]		
7-C				
7-9-B		Yes[a]		
8-2-B		No[a]		
9-1-C	No[a], Yes[b]			
9-2-B		?[a]		
9-2-C	Yes[b]		No[a]	
9-3-C	No[a]	No[a]		?[a]
9-5-C	Yes[b]			
9-6-C	Yes[a]			
9-7-C			?[a]	
9-9-C	Yes[b]			
9-11-C			?[a]	
9-12-C	No[b]			
15-3-R		No[a]		
16-1-B		No[a]		
16-3-B		No[a]		
17-3-B		No[a]		
26-2-B		No[a]		
30-3-C			No[a]	
30-4-C	No[a], No[b]	No[a]		
30-7-C		No[a]	No[a]	

[a] sediment samples
[b] water samples
[c] soil samples

TABLE 8.2-5 (Cont.)

SITE	PHASE I	PHASE II	PHASE III	PHASE IV
30-12-C		?[a]		
30-13-C		?[a]		?[a]
30-14-C	No[a]	No[a]		No[a]
203-30-C		Yes[a]		
RC 103				No[a]
RC 104				No[a]
RC 107				No[a]
SNR 2	No[a], No[b]			
SNR 6W	No[b]			
SNR 8	No[a]			
SNR 9W	No[b]			
UNO 1				No[a]
UNO 2		?[a]		No[a]
UNO 3		?[c]		
UNO 7			No[c]	
UNO 11			No[c]	
Back of Gill Net		No[a]		
LaBouve Fishing Camp	No[a]	Mixture(?)[a]	Mixture(?)[a]	
#8 Barge				No[a]
Texaco Rolls				No[a]
Levee N.W. of Lake				No[a]
West of S. Dike				No[a]
Drilling Fields	No[b]			
W. Marsh (mussels)			No	
Outside Boom	Mixture(?)[b]			

The results of this investigation showed the presence of Cavern 6 crude oil only in the immediately impacted area of the Strategic Petroleum Reserve site and that Cavern 6 crude oil was not detected in other areas of Black Lake or in the Starks Canal. The only other area to be affected was LaBouve Fishing Camp, where mixtures of Cavern 6 crude oil and Louisiana Sweet Crude were found in the sediment.

Gas chromatograms of other representative samples analyzed by this method are shown in Appendix C.1.

Procedure B; Alkylated Phenanthrene (C_1, C_2, C_3) - Alkylated Dibenzothiophene (C_1, C_2, C_3)

Examination of numerous samples from Phases I and II indicated that the pristane/phytane ratio was a limited indicator of the source of petroleum hydrocarbons. Pristane can come from biological sources and thus may give an abnormally high pristane/phytane ratio. Moreover, the presence of another peak (possibly an olefin) eluting between n-C_{17} and pristane did not permit the proper integration of the pristane peak area and this would result in inaccurate pristane/phytane ratios. This peak appeared in over half of the sediment samples analyzed. This can be observed in Figure 8.2-11 and on an expanded scale in Figure 8.2-12 for sample 597. Weathering of oil interferes with the ability to accurately determine the pristane/phytane ratio in an oil-impacted sample. Approximately 38 percent of the sediment samples analyzed from Phases II, III and IV had undergone substantial weathering and another 15 percent of the sediment samples had been slightly weathered. Several heavily weathered sediment samples (No. 963 and No. 1116), which can be seen in Figures 8.2-13 and 8.2-14, indicate that it was not possible to determine accurately the pristane/phytane ratio from these samples. Therefore, after Phase I, the pristane/phytane ratio cannot be used reliably to identify the source of oil contamination in the West Hackberry environment.

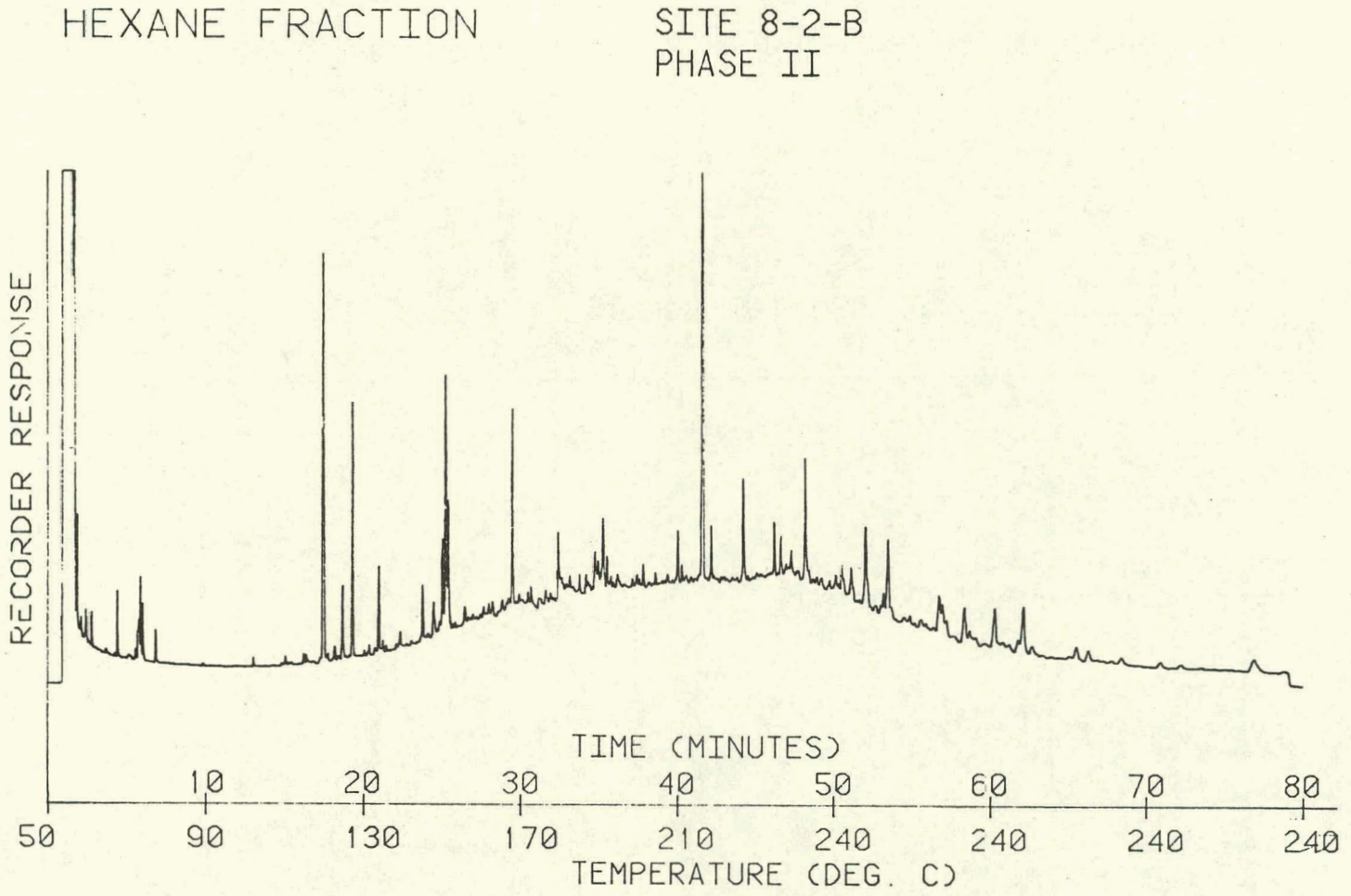


FIGURE 8.2-11 GAS CHROMATOGRAM OF THE ALIPHATIC COMPONENTS OF SEDIMENT SAMPLE NO. 597

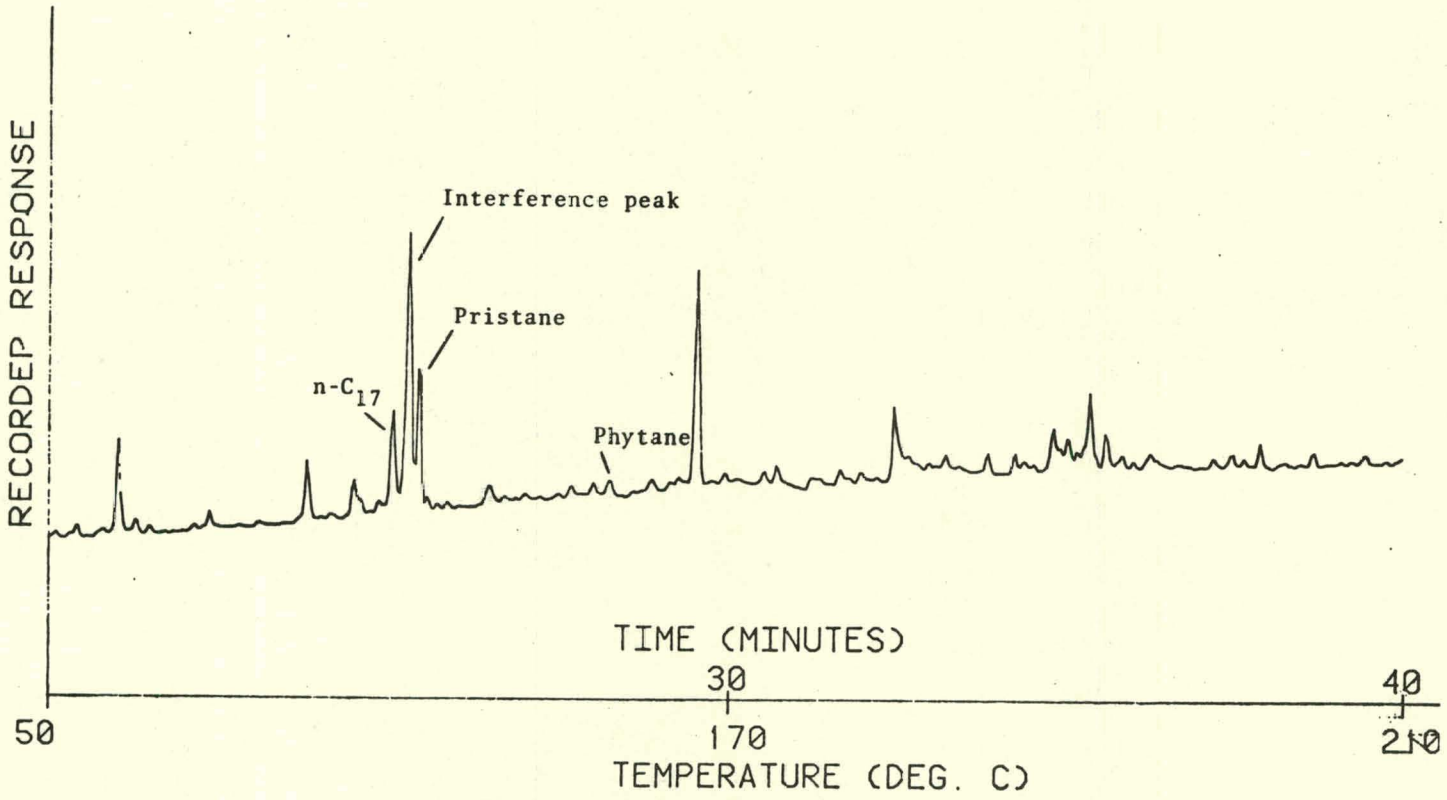


FIGURE 8.2-12 EXPANDED GAS CHROMATOGRAM OF THE ALIPHATIC COMPONENTS OF SEDIMENT SAMPLE NO. 597

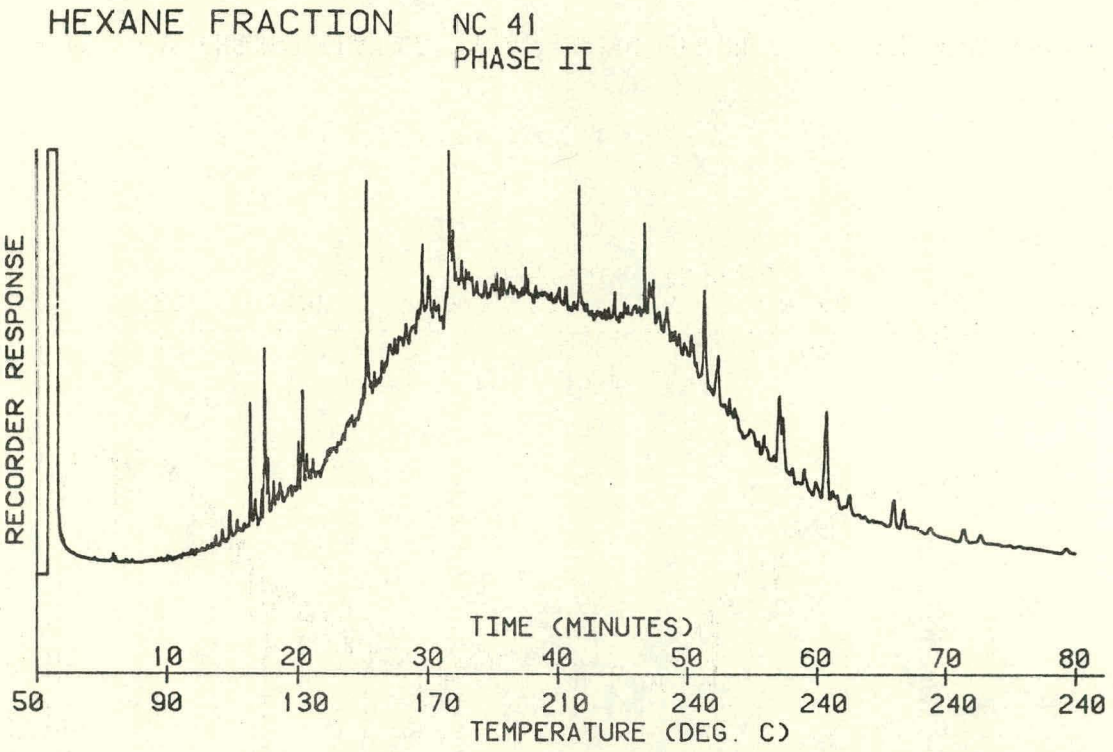


FIGURE 8.2-13 GAS CHROMATOGRAM OF THE ALIPHATIC COMPONENTS OF SEDIMENT SAMPLE NO. 963

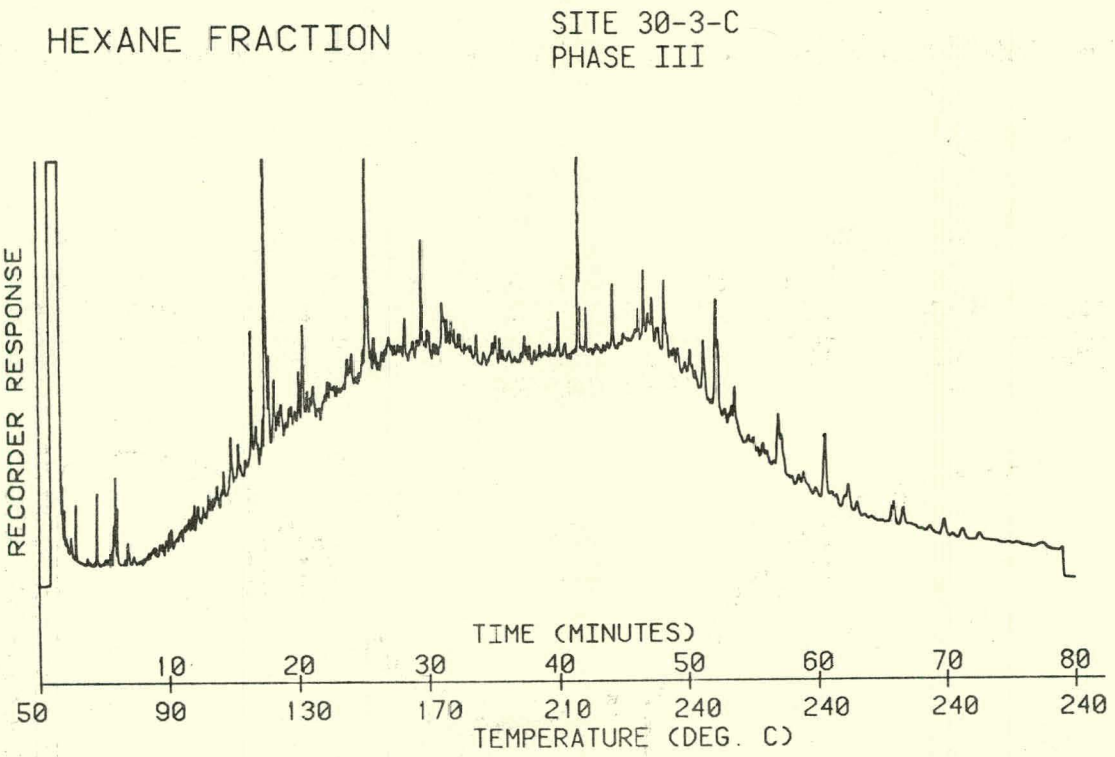


FIGURE 8.2-14 GAS CHROMATOGRAM OF THE ALIPHATIC COMPONENTS OF SEDIMENT SAMPLE NO. 1116

In this procedure, the alkylated phenanthrene (C_1, C_2, C_3) to alkylated dibenzothiophene (C_1, C_2, C_3) ratios are judged to be the primary parameters than can be used to distinguish between the two oils in environmentally impacted samples since these particular components of oil are not readily degraded in the environment and since the two oils do differ significantly in the quantitative distribution of these components. This is consistent with the results of the discriminant analysis (Section 7.4.2) performed on the samples. Tables 8.2-6 through 8.2-9 give the alkylated phenanthrene to alkylated dibenzothiophene ratios for samples analyzed from all four phases, and Figures 8.2-15 through 8.2-26 are bar graphs of these ratios for all sediment samples analyzed. In the bar graph, the error bars bracket the high and lower "worst case" values for the ratios (see Appendix C.2 for further explanation).

The discriminant functions analysis identified 16 stations as containing primarily Cavern 6 crude oil in their sediments and 22 stations as containing primarily Louisiana Sweet Crude oil in their sediments. The distribution of these stations is shown in Figure 8.2-27. Two stations changed categories between phases. Station 201/202-30-C apparently did not contain Cavern 6 crude oil in Phase II but did contain this oil in Phase IV. Station 30-12-C did not contain Cavern 6 crude oil in Phase I but did contain this oil in Phases II and IV.

After examining the data acquired for both the Cavern 6 crude oil and the Louisiana Sweet Crude (Amoco production well) and numerous Phase I and II samples from both the impact and nonimpact areas of Black Lake, it has been determined that whenever the C_1 and C_3 phenanthrene to C_1 and C_3 dibenzothiophene ratios are less than 1 and the C_2 phenanthrene to C_2 dibenzothiophene ratio is less than 2, the sample probably contains Cavern 6 crude oil.

Interpretation of the data in Table 8.2-6 for Phase I sediments indicates that Samples 13 (Site 9-7-C), 15 (Site 9-4-C), 19 (Site

TABLE 8.2-6

ALKYLATED PHENANTHRENE/ALKYLATED DBT[a] RATIO[b]
DOE HACKBERRY SEDIMENT SAMPLES

TAG	SITE	$\frac{C_1 \text{ PHENANTHRENE}}{C_1 \text{ DBT}}$	$\frac{C_2 \text{ PHENANTHRENE}}{C_2 \text{ DBT}}$	$\frac{C_3 \text{ PHENANTHRENE}}{C_3 \text{ DBT}}$
PHASE I				
Samples Containing Cavern 6 Crude Oil[c]				
13	9-7-C	0.7	0.9	0.8
15	9-4-C	0.4	0.7	0.4
19	9-13-C	0.6	1.7	0.8
85	9-2-C	0.9	1.2	0.4
122	9-5-C	0.4	0.7	0.4
128	9-9-C	0.6	0.5	0.8
229	30-7-C	1.0	1.3	1.2
Samples Not Containing Cavern 6 Crude Oil[c]				
16	9-3-C	1.2	1.0	1.9
18	9-11-C	2.7	3.8	3.7
20	9-12-C	d	2.9	d
21	9-14-C	d,e	d	d,e
54	SNR-2	7.2	3.0	d
61	SNR-4	d,e	d,e	d,e
65	SNR-5	d	d	d
153	30-16-C	13.6	6.1	d
154	30-17-C	d,e	d,e	d,e
193	30-3-C	2.2	2.4	1.3
197	30-6-C	3.1	5.8	2.5
226	30-17-C	1.0	2.4	1.6
234	30-12-C	1.8	2.2	1.3

[a]Dibenzothiophene
[b]Ratios determined by gas chromatography/mass spectrometry
[c]Based on interpretation of discriminant analysis using C_1 and C_3 ratios
[d]No alkylated DBT's detected
[e]No alkylated phenanthrenes detected

TABLE 8.2-6 (Cont.)

TAG	SITE	$\frac{C_1 \text{ PHENANTHRENE}}{C_1 \text{ DBT}}$	$\frac{C_2 \text{ PHENANTHRENE}}{C_2 \text{ DBT}}$	$\frac{C_3 \text{ PHENANTHRENE}}{C_3 \text{ DBT}}$
PHASE II				
Samples Containing Cavern 6 Crude Oil[c]				
623	30-12-C	1.4	1.4	0.9
627	2-C	0.6	0.6	0.6
938	245-1-C	0.2	0.4	0.3
945	7-C	0.4	0.6	0.4
948	2-C	1.2	2.2	0.7
954	6-C	0.7	0.7	0.4
957	16-1-B	1.1	1.5	d
Samples Not Containing Cavern 6 Crude Oil[c]				
586	15-3-B	1.9	3.3	1.9
594	E6-2-B	1.9	3.2	1.8
597	8-2-B	1.9	2.1	1.7
599	9-2-B	2.3	2.6	1.5
601	16-3-B	3.9	3.8	1.5
604	17-3-B	2.0	2.3	1.2
609	7-9-B	d	e	1.6
631	WC GILL NET	1.7	2.3	1.7
929	30-3-C	1.9	2.2	1.3
940	9-3-C	2.1	1.6	2.1
942	201/202-30-C	2.9	2.4	1.6
946	5-C	d,e	2.0	2.5
949	2-C	d	d	d
963	NC 41	d,e	1.3	2.4
964	NC 42	d,e	d,e	d,e
990	30-13-C	d,e	d,e	d,e
1498	SNR-1	d	d	d
1499	SNR-2	3.8	3.6	4.9
1500	30-5-C	1.8	1.6	1.4

TABLE 8.2-6 (Cont.)

TAG	SITE	$\frac{C_1 \text{ PHENANTHRENE}}{C_1 \text{ DBT}}$	$\frac{C_2 \text{ PHENANTHRENE}}{C_2 \text{ DBT}}$	$\frac{C_3 \text{ PHENANTHRENE}}{C_3 \text{ DBT}}$
PHASE III				
Samples Containing Cavern 6 Crude Oil[c]				
1181	203-30-C	0.1	0.3	0.2
1182	203-30-C	0.2	0.4	0.3
1247	9-7-C	0.3	1.5	0.7
1251	9-2-C	0.4	1.6	1.3
1253	9-3-C	0.8	2.4	1.0
1254	9-3-C	0.8	1.5	0.6
Samples Not Containing Cavern 6 Crude Oil[c]				
1040	SNR-6	3.4	d	d
1083	RC 107	3.1	2.9	2.0
1084	RC 107	d	4.3	d
1098	30-4-C	d,e	d,e	d
1116	30-3-C	1.3	1.0	2.7
1118	30-7-C	d	1.9	2.8
1177	9-11-C	d,e	d	d
1187	S of 30-19-C	d,e	d,e	d,e
1188	S of 30-19-C	2.1	2.1	1.4
1193	9-2-B	d,e	d,e	d,e
1194	8-2-B	d,e	d	1.2
1282	2-C	d,e	d,e	d,e
1290	RS 109	d,e	d,e	d,e
1292	RS 109	d,e	d,e	d,e
1296	RS 111	d,e	d,e	d,e
1297	RS 111	d,e	d,e	d,e
1465	North site/ west of dike	4.2	4.4	2.1
1466	Post 234	2.6	3.1	2.2

TABLE 8.2-6 (Cont.)

TAG	SITE	$\frac{C_1 \text{ PHENANTHRENE}}{C_1 \text{ DBT}}$	$\frac{C_2 \text{ PHENANTHRENE}}{C_2 \text{ DBT}}$	$\frac{C_3 \text{ PHENANTHRENE}}{C_3 \text{ DBT}}$
PHASE IV				
Samples Containing Cavern 6 Crude Oil[c]				
1545	203-30-C	0.3	0.5	0.5
1551	9-3-C	0.2	0.7	0.4
1555	2-C	d,e	1.8	0.5
1563	9-7-C	0.1	0.6	0.4
1567	201/202-30-C	0.3	0.7	0.4
1568	9-1-C	0.9	2.7	1.4
1573	9-2-C	0.6	1.5	0.8
1679	30-12-C	0.4	1.0	0.4
Samples Not Containing Cavern 6 Crude Oil[c]				
1533	30-3-C	1.3	2.3	1.4
1657	8-2-B	1.0	2.9	1.6
1665	30-7-C	1.3	1.4	1.5
1683	30-4-C	d	5.9	1.8
1735	30-5-C	d	d	1.3

TABLE 8.2-7

ALKYLATED PHENANTHRENE/ALKYLATED DBT[a] RATIO[b]
DOE HACKBERRY SOIL SAMPLES
(NO CAVERN 6 CRUDE OIL DETECTED[c])

TAG	SITE	$\frac{C_1 \text{ PHENANTHRENE}}{C_1 \text{ DBT}}$	$\frac{C_2 \text{ PHENANTHRENE}}{C_2 \text{ DBT}}$	$\frac{C_3 \text{ PHENANTHRENE}}{C_3 \text{ DBT}}$
PHASE II				
640	UNO #1	d	d	d
641	UNO #1	d	d	d,e
642	UNO #1	d	d	d
654	UNO #4	d	4.2	d
690	UNO #6	d,e	d,e	d,e
702	UNO #7	d	d	d,e
703	UNO #7	d	d	d
934	UNO #2	d,e	d,e	d,e
PHASE III				
1238	UNO #7	d	d	d
1239	UNO #7	d	d	d
1240	UNO #7	d,e	d,e	d,e
1424	URI #18	d,e	d,e	d,e
1425	URI #18	d,e	d,e	d,e
1427	URI #19	d,e	d,e	d,e
1428	URI #19	d,e	d,e	d,e

[a]Dibenzothiophene
[b]Ratios determined by gas chromatography/mass spectrometry
[c]Cavern 6 oil when C_1 and C_3 ratios < 1 and C_2 ratio < 2
[d]No alkylated DBT's detected
[e]No alkylated phenanthrenes detected

TABLE 8.2-7 (Cont.)

TAG	SITE	$\frac{C_1 \text{ PHENANTHRENE}}{C_1 \text{ DBT}}$	$\frac{C_2 \text{ PHENANTHRENE}}{C_2 \text{ DBT}}$	$\frac{C_3 \text{ PHENANTHRENE}}{C_3 \text{ DBT}}$
PHASE IV				
1502	UNO #3	d	d	d
1503	UNO #4	d,e	d,e	d,e
1505	UNO #5	d,e	d,e	d,e
1507	UNO #6	d,e	d	d,e
1509	UNO #12	d,e	d,e	d,e
1511	UNO #11	d,e	d,e	d,e
1516	UNO #14	d	d	d,e
1519	UNO #7	d	d	d,e
1527	URI #18	d,e	d,e	d,e
1529	URI #19	d,e	d,e	d,e

TABLE 8.2-8

ALKYLATED PHENANTHRENE/ALKYLATED DBT[a] RATIO[b]
DOE HACKBERRY FOLIAGE SAMPLES
(ONLY SITE A2 CONTAINED CAVERN 6 CRUDE OIL[c])

TAG	SITE	$\frac{C_1 \text{ PHENANTHRENE}}{C_1 \text{ DBT}}$	$\frac{C_2 \text{ PHENANTHRENE}}{C_2 \text{ DBT}}$	$\frac{C_3 \text{ PHENANTHRENE}}{C_3 \text{ DBT}}$
PHASE I				
3	A2	0.3	0.7	0.4
41	UNO #2	d,e	d,e	d,e
43	UNO #3	d,e	d,e	d,e
47	UNO #4	d,e	d,e	d,e
48	UNO #5	d,e	d,e	d,e
53	SNR-1	d,e	d,e	d,e
57	SNR-2	d,e	d,e	d,e
60	SNR-3	d,e	d,e	d,e
63	SNR-4	d,e	d,e	d,e
67	SNR-5	d,e	d,e	d,e
69	SNR-6	d,e	d,e	d,e
87	UNO #7	1.4	5.1	1.3
88	UNO #7	1.5	3.4	1.2

[a]Dibenzothiophene
[b]Ratios determined by gas chromatography/mass spectrometry
[c]Cavern 6 oil when C_1 and C_3 ratios < 1 and C_2 ratio < 2
[d]No alkylated DBT's detected
[e]No alkylated phenanthrenes detected

TABLE 8.2-8 (Cont.)

TAG	SITE	$\frac{C_1 \text{ PHENANTHRENE}}{C_1 \text{ DBT}}$	$\frac{C_2 \text{ PHENANTHRENE}}{C_2 \text{ DBT}}$	$\frac{C_3 \text{ PHENANTHRENE}}{C_3 \text{ DBT}}$
PHASE II				
644	UNO #1	d	d,e	d,e
645	UNO #1	2.8	5.3	2.3
650	UNO #1	d	d	d
653	UNO #4	d	d	d
691	UNO #6	d,e	d,e	d,e
700	UNO #7	d,e	d,e	d,e
701	UNO #7	d	2.9	d
704	UNO #7	d,e	d,e	d,e
PHASE III				
1067	RS 111	d,e	d,e	d,e
1365	UNO #7	d,e	d,e	d,e
1366	UNO #7	d,e	d,e	d,e
1367	UNO #7	d,e	d,e	d,e
1426	URI #18	d,e	d,e	d,e
1424	URI #19	d,e	d,e	d,e

TABLE 8.2-9

ALKYLATED PHENANTHRENE/ALKYLATED DBT[a] RATIO[b]
CAVERN 6 CRUDE OIL AND TISSUE SAMPLES

TAG	SITE	SAMPLE TYPE	$\frac{C_1 \text{ PHENANTHRENE}}{C_1 \text{ DBT}}$	$\frac{C_2 \text{ PHENANTHRENE}}{C_2 \text{ DBT}}$	$\frac{C_3 \text{ PHENANTHRENE}}{C_3 \text{ DBT}}$	CAVERN 6 OIL[c]
OIL SAMPLES (PHASE I)						
4	CAVERN #6	CAVERN 6 CRUDE	0.3	0.7	0.3	YES
208		LOUISIANA SWEET CRUDE	1.5	2.9	1.5	NO
MUSSEL TISSUE (PHASE II)						
846	9-10-B	MUSSELS	d	7.6	2.5	NO
MUSSEL TISSUE (PHASE III)						
1430	WEST CONTROL	MUSSELS	d	d	d	NO

[a]Dibenzothiophene
[b]Ratios determined by gas chromatography/mass spectrometry
[c]Cavern 6 Crude oil when C_1 and C_3 ratios < 1 and C_2 ratio < 2
[d]No alkylated DBT's detected

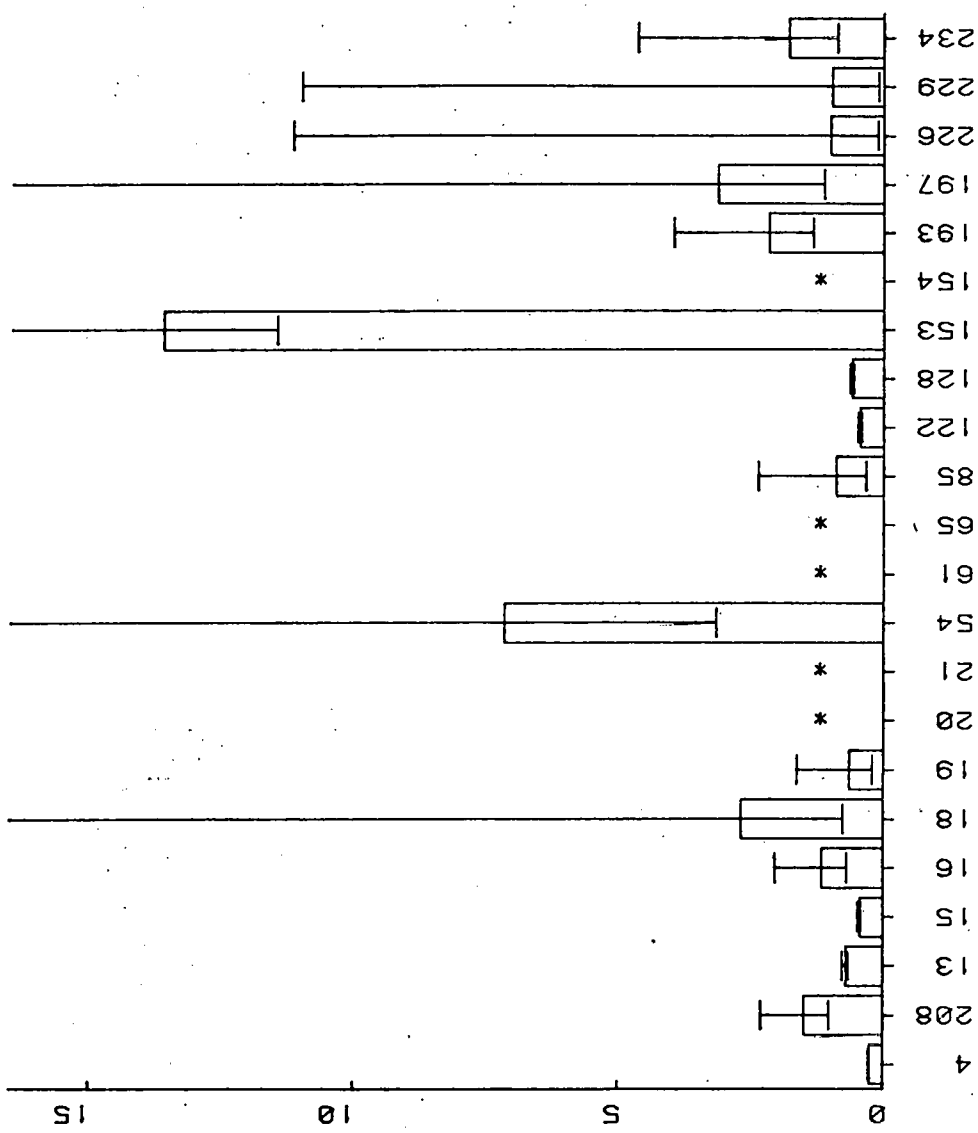


FIGURE 8.2-15 RATIO OF C_1 PHENANTHRENE TO C_1 DIBENZOTHIOPHENE IN PHASE I SEDIMENT SAMPLES

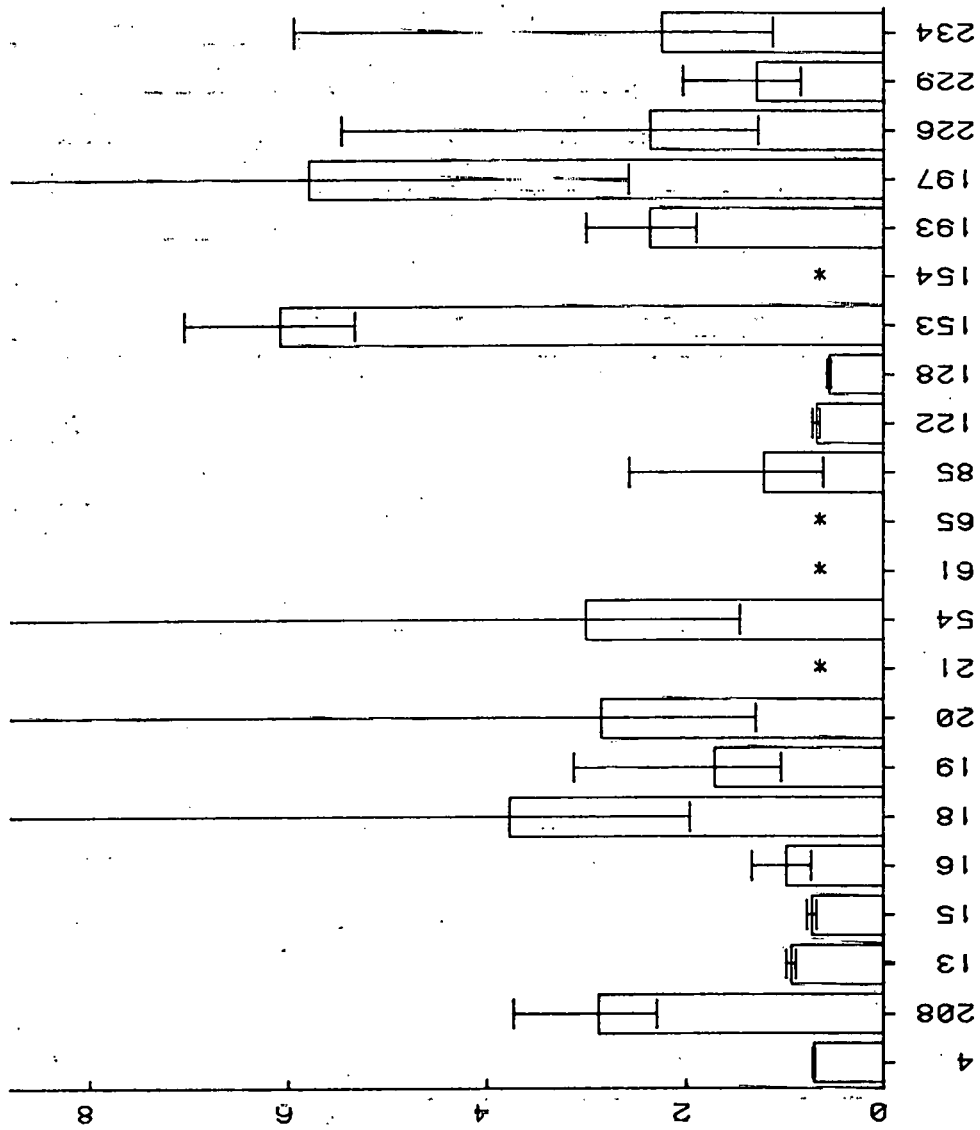


FIGURE 8.2-16 RATIO OF C_2 PHENANTHRENE TO C_2 DIBENZOTHIOPHENE IN PHASE I SEDIMENT SAMPLES

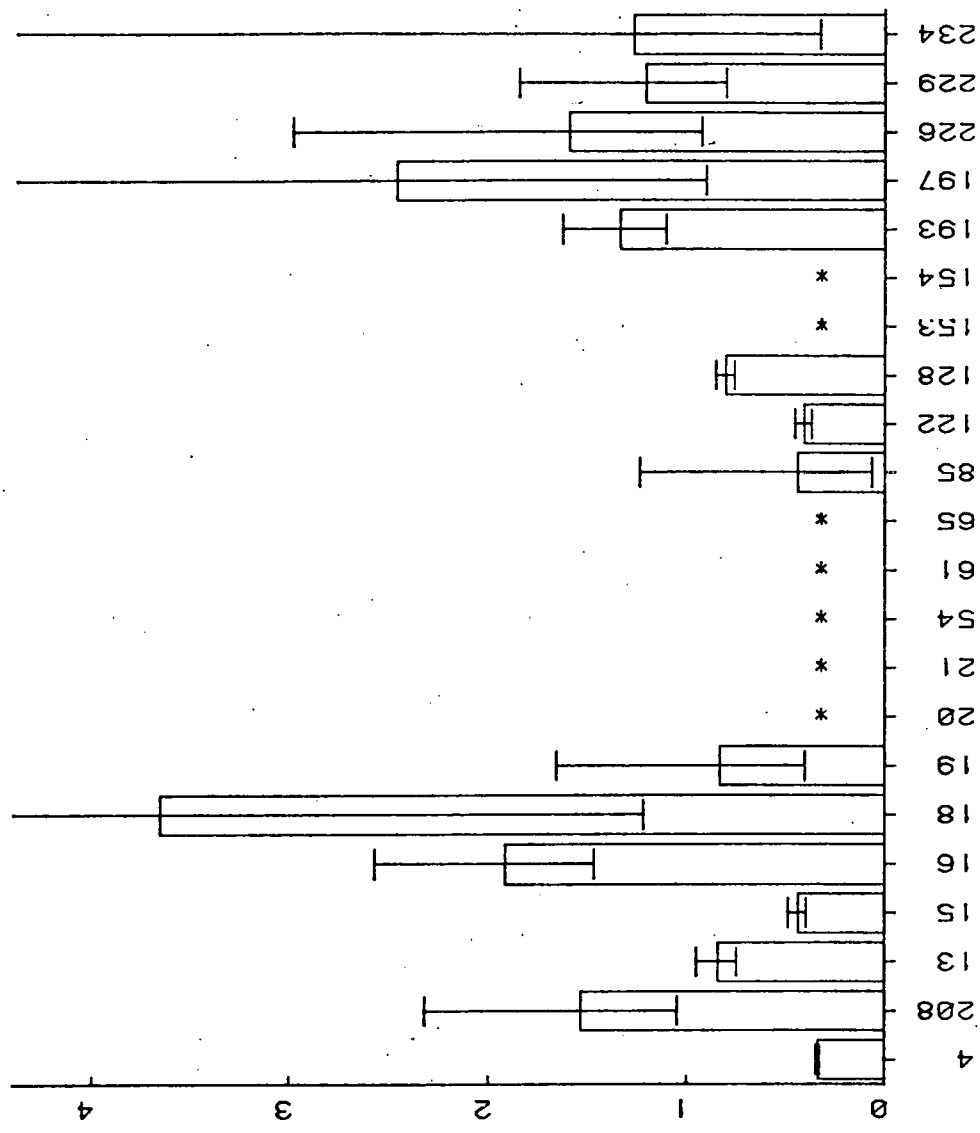


FIGURE 8.2-17 RATIO OF C_3 PHENANTHRENE TO C_3 DIBENZOTHIOPHENE IN PHASE I SEDIMENT SAMPLES

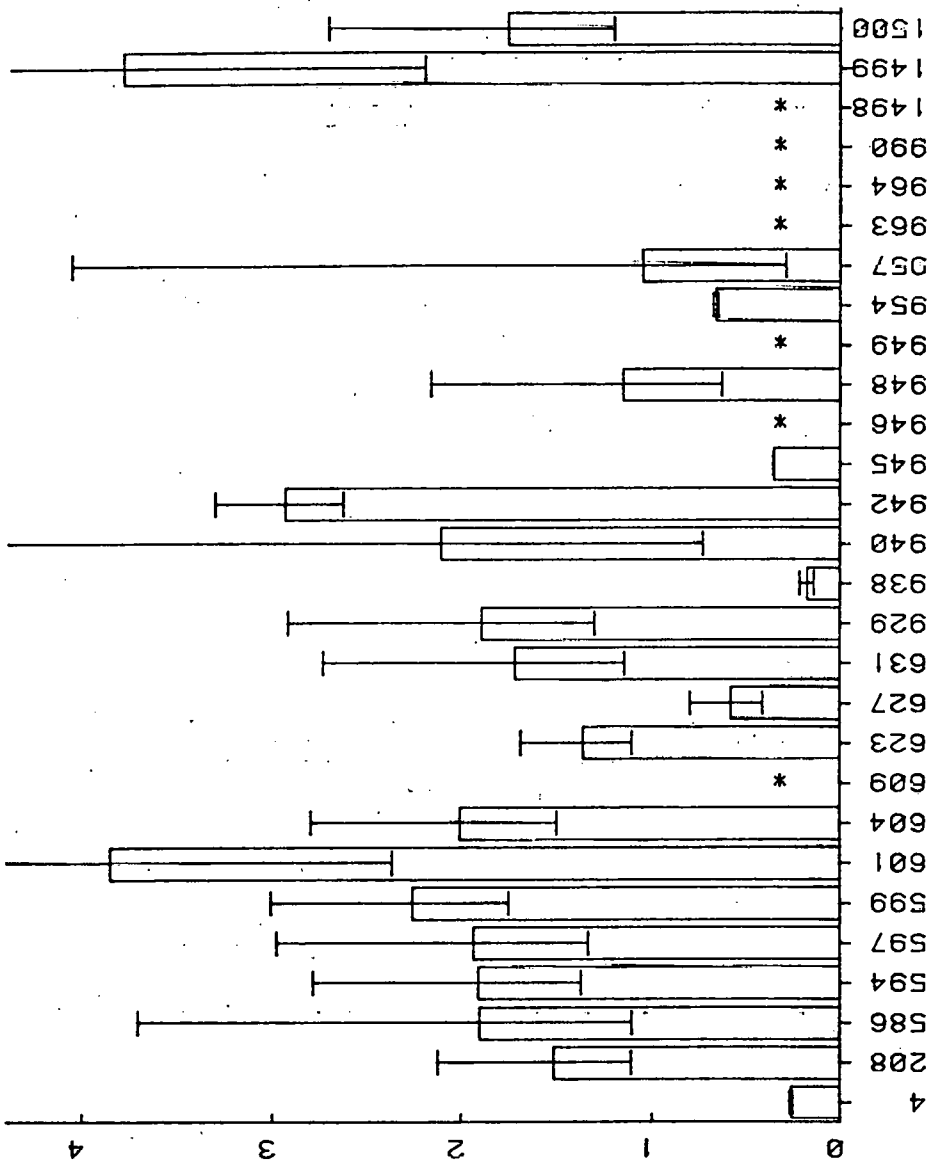


FIGURE 8.2-18 RATIO OF C_1 PHENANTHRENE TO C_1 DIBENZOTHIOPHENE IN PHASE II SEDIMENT SAMPLES

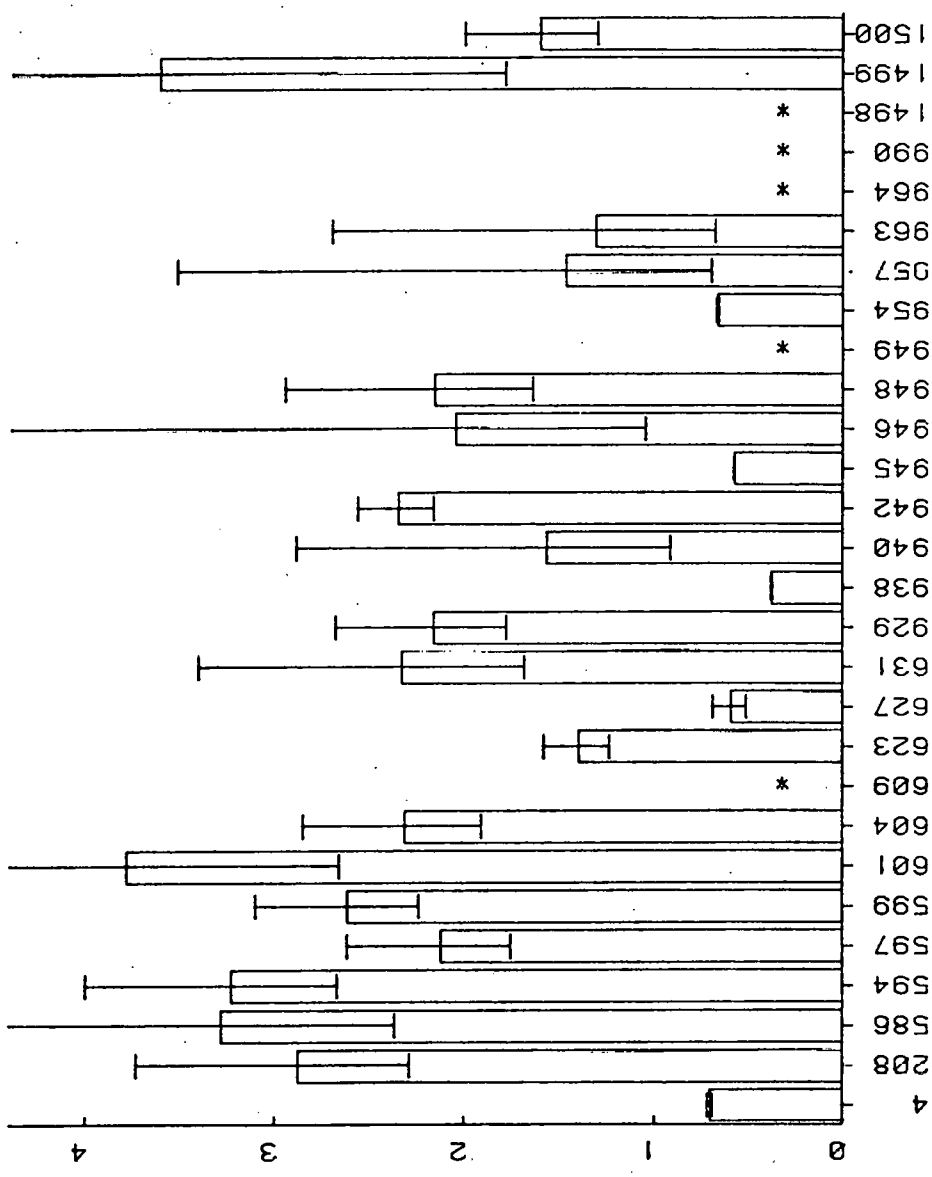


FIGURE 8.2-19 RATIO OF C_2 PHENANTHRENE TO C_2 DIBENZOTHIOPHENE IN PHASE II SEDIMENT SAMPLES

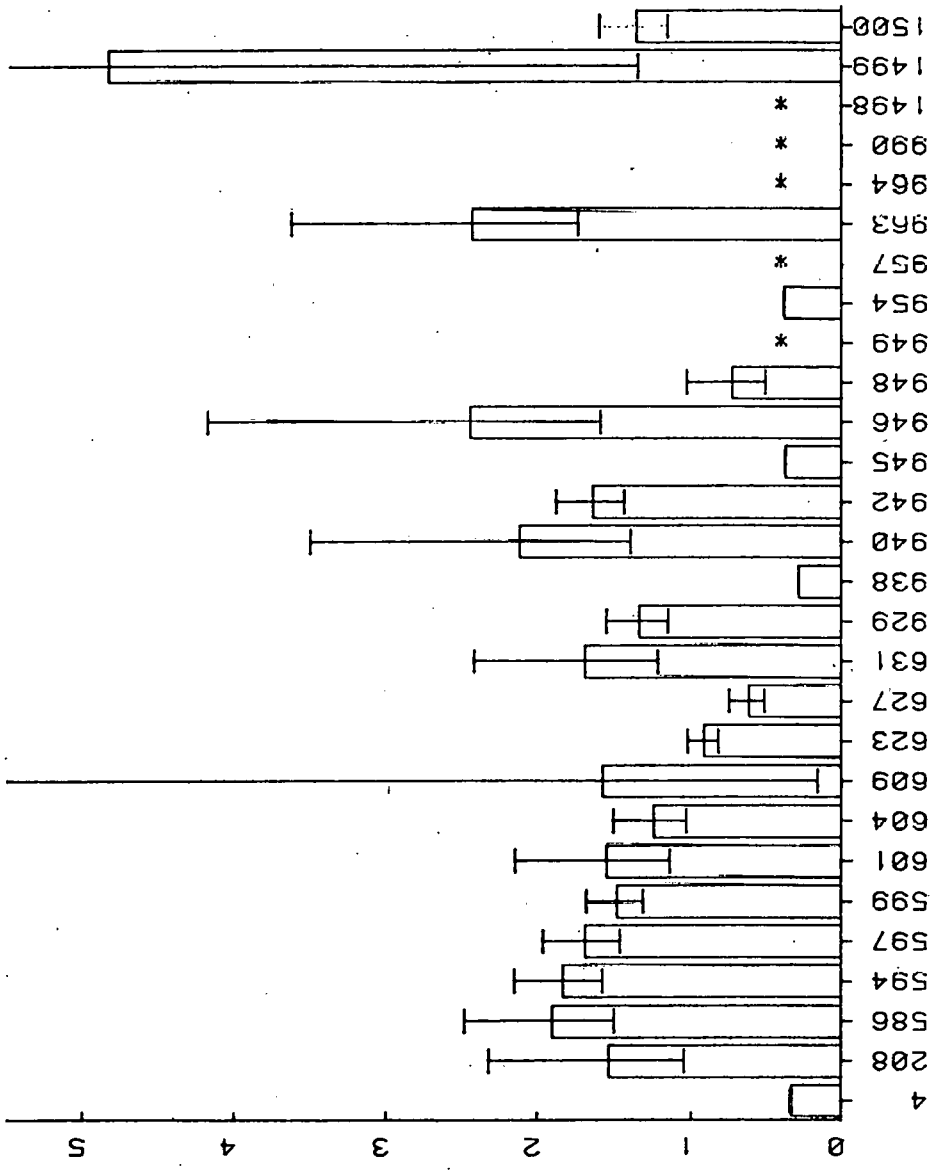


FIGURE 8.2-20 RATIO OF C_3 PHENANTHRENE TO C_3 DIBENZOTHIOPHENE IN PHASE II SEDIMENT SAMPLES

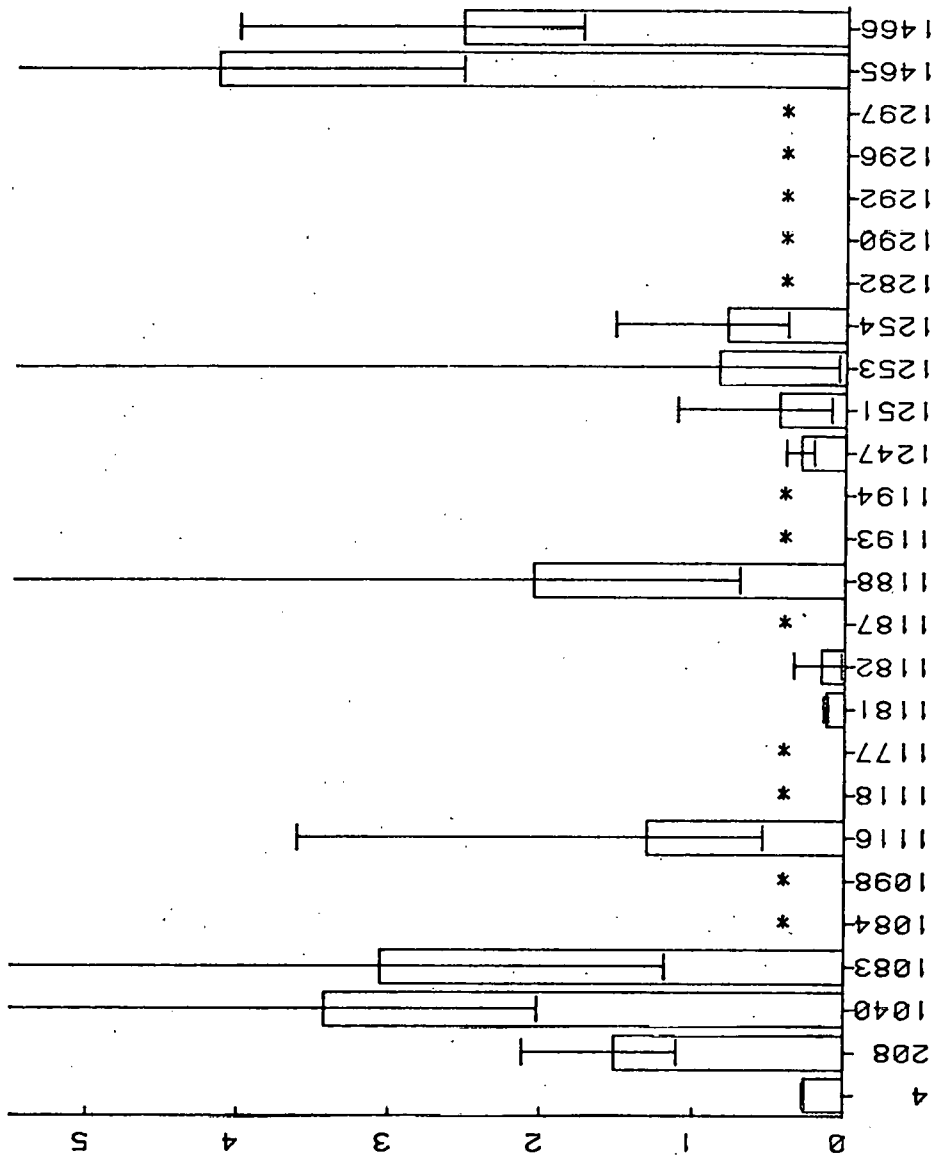


FIGURE 8.2-21 RATIO OF C_1 PHENANTHRENE TO C_1 DIBENZOTHIOPHENE IN PHASE III SEDIMENT SAMPLES

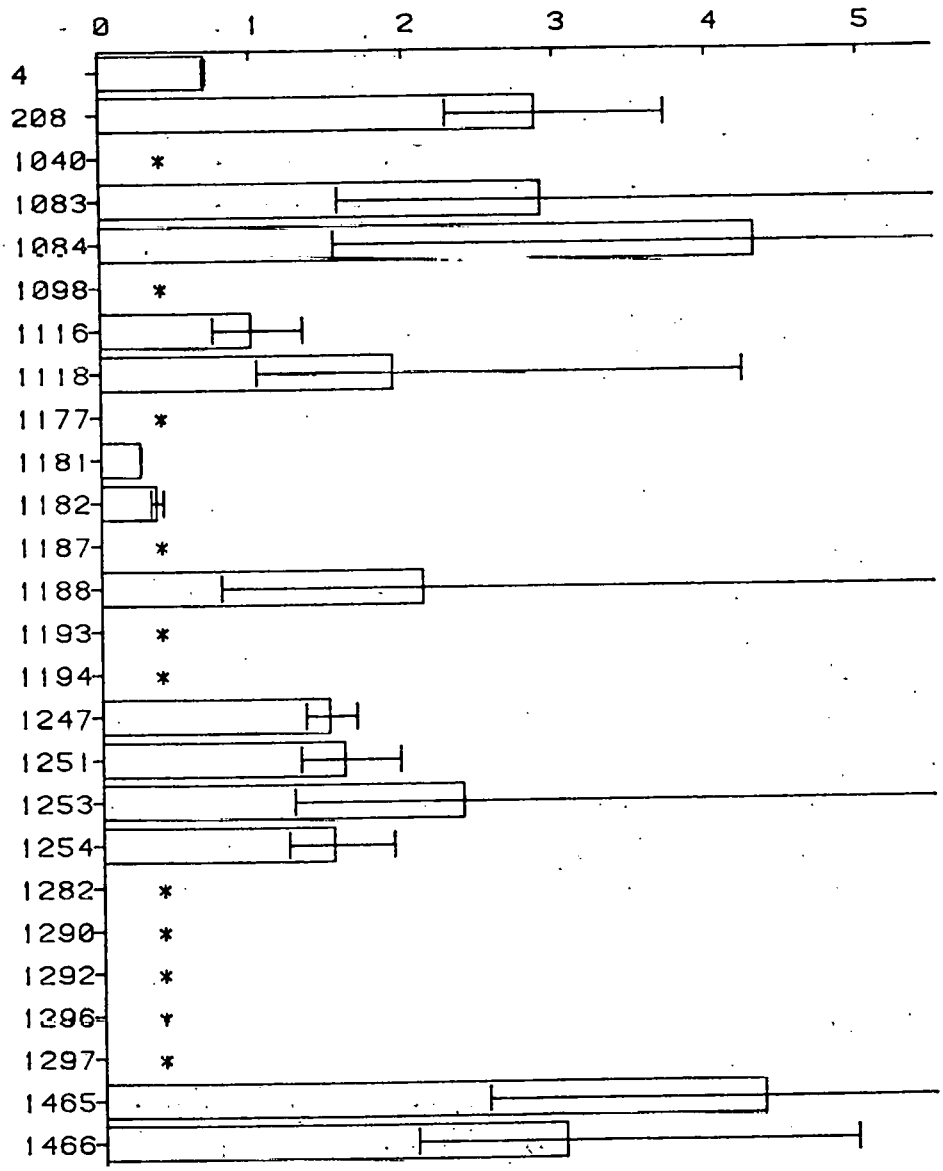


FIGURE 8.2-22 RATIO OF C_2 PHENANTHRENE TO C_2 DIBENZOTHIOPHENE IN PHASE III SEDIMENT SAMPLES

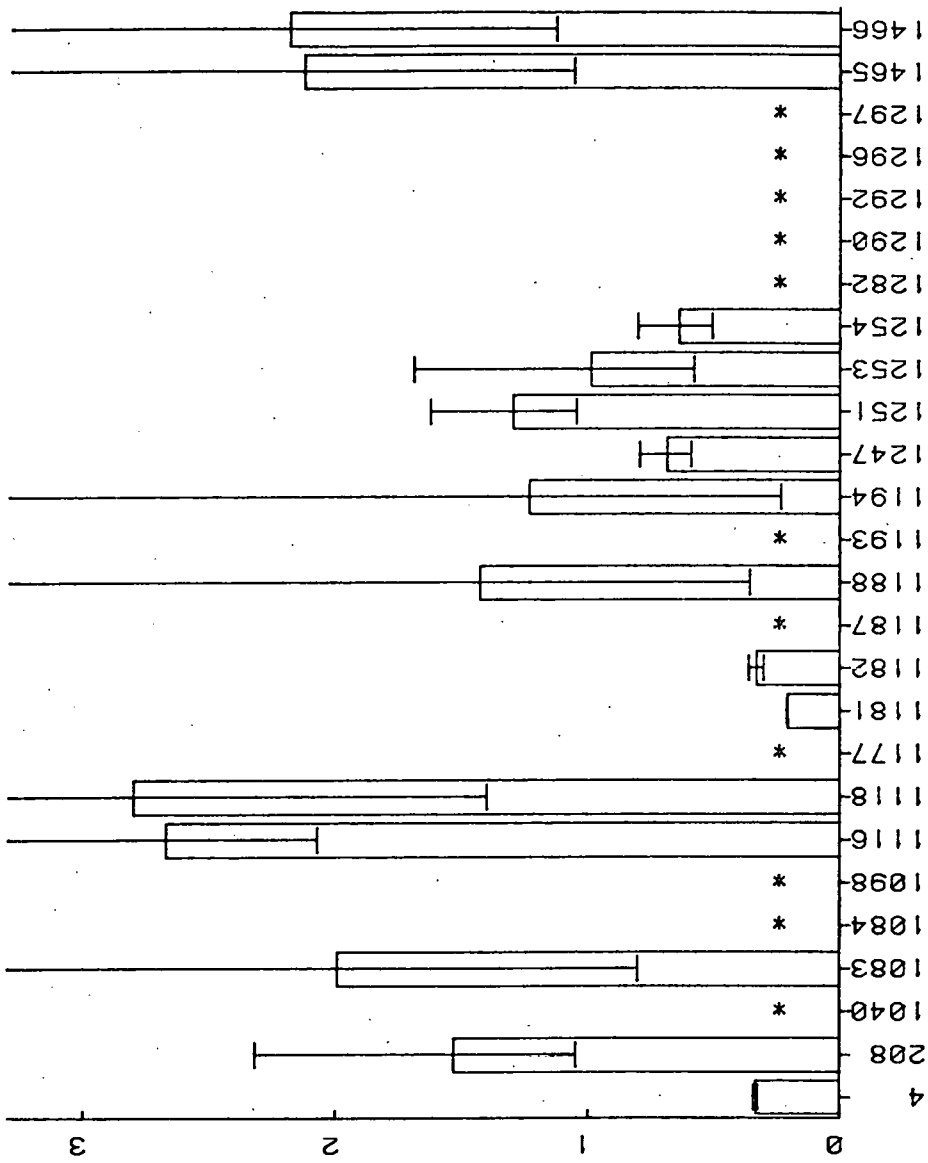


FIGURE 8.2-23 RATIO OF C_3 PHENANTHRENE TO C_3 DIBENZOTHIOPHENE IN PHASE III SEDIMENT SAMPLES

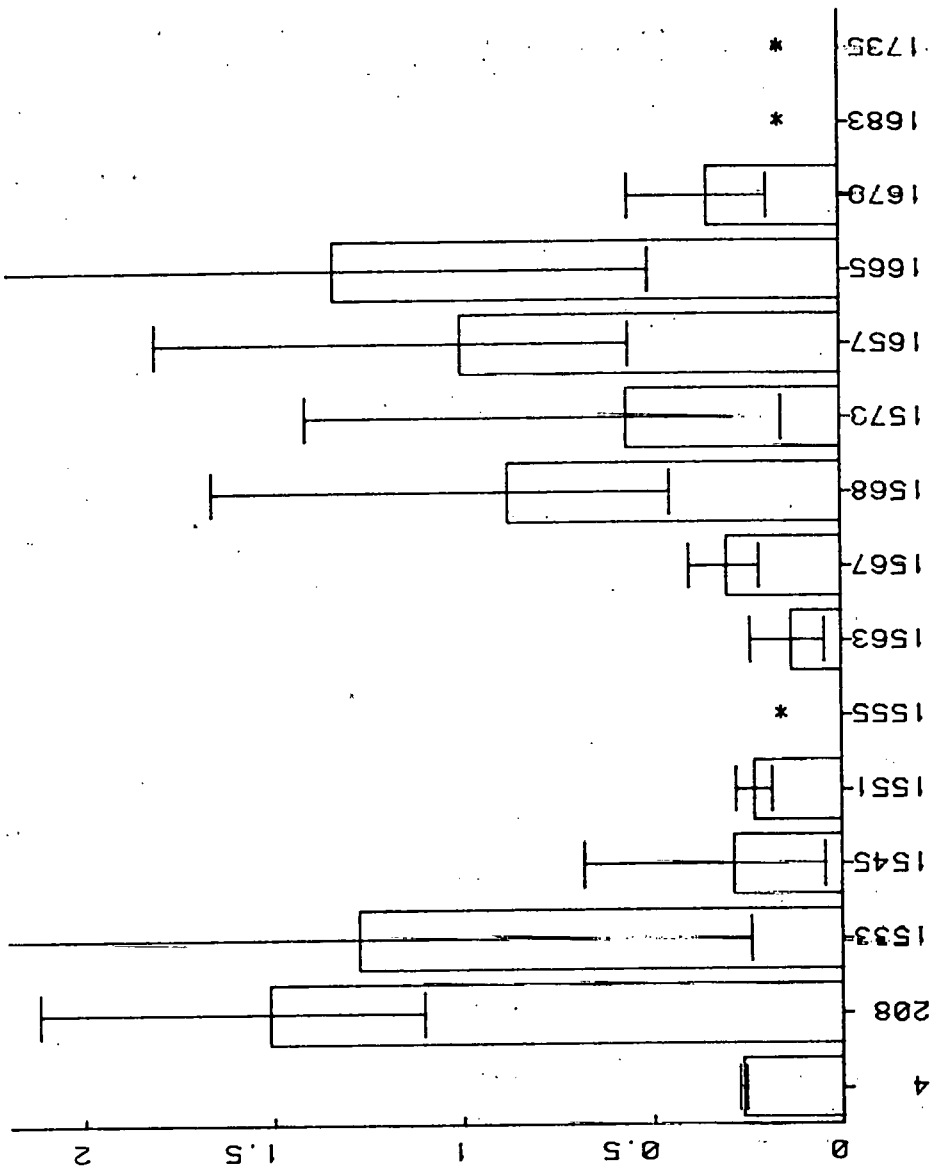


FIGURE 8.2-24 RATIO OF C_1 PHENANTHRENE TO C_1 DIBENZOTHIOPHENE IN PHASE IV SEDIMENT SAMPLES

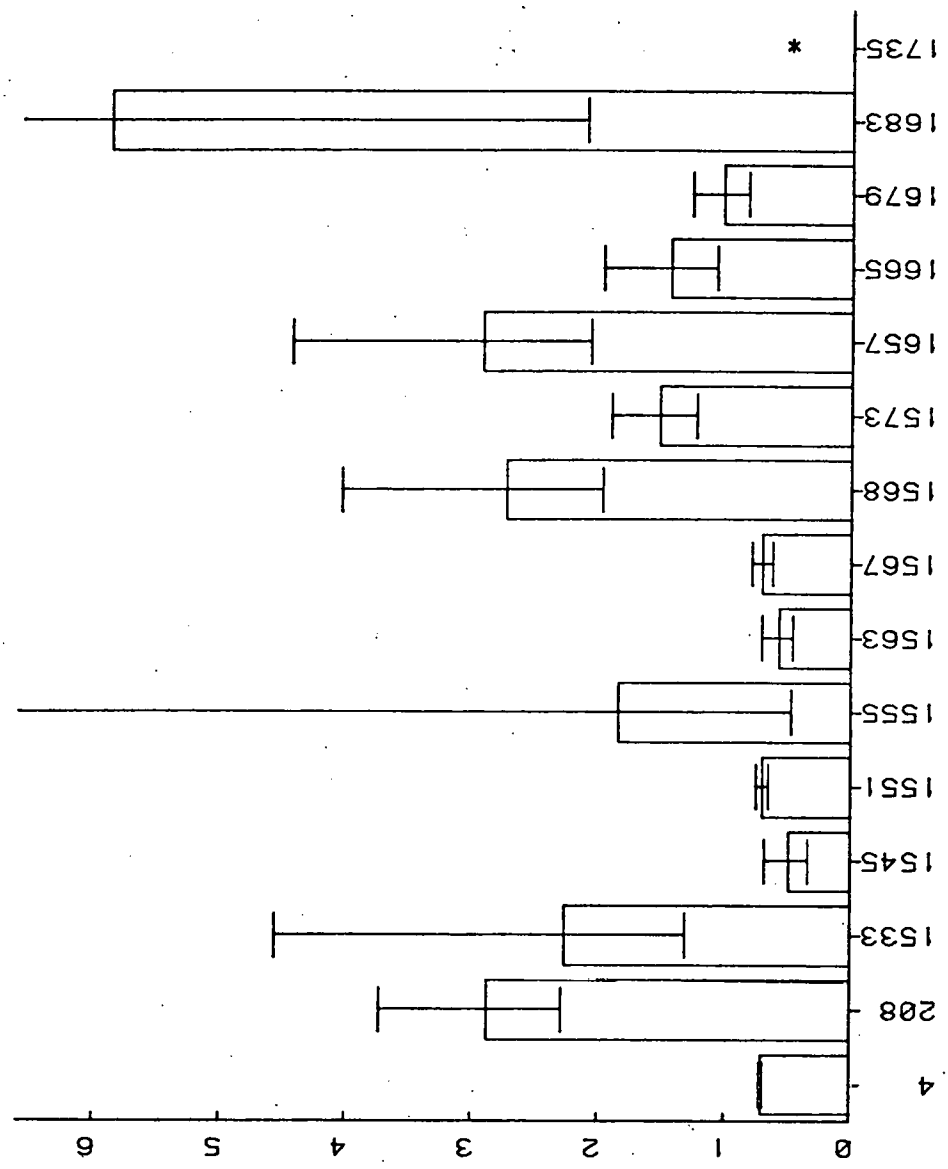


FIGURE 8.2-25 RATIO OF C_2 PHENANTHRENE TO C_2 DIBENZOTHIOPHENE IN PHASE IV SEDIMENT SAMPLES

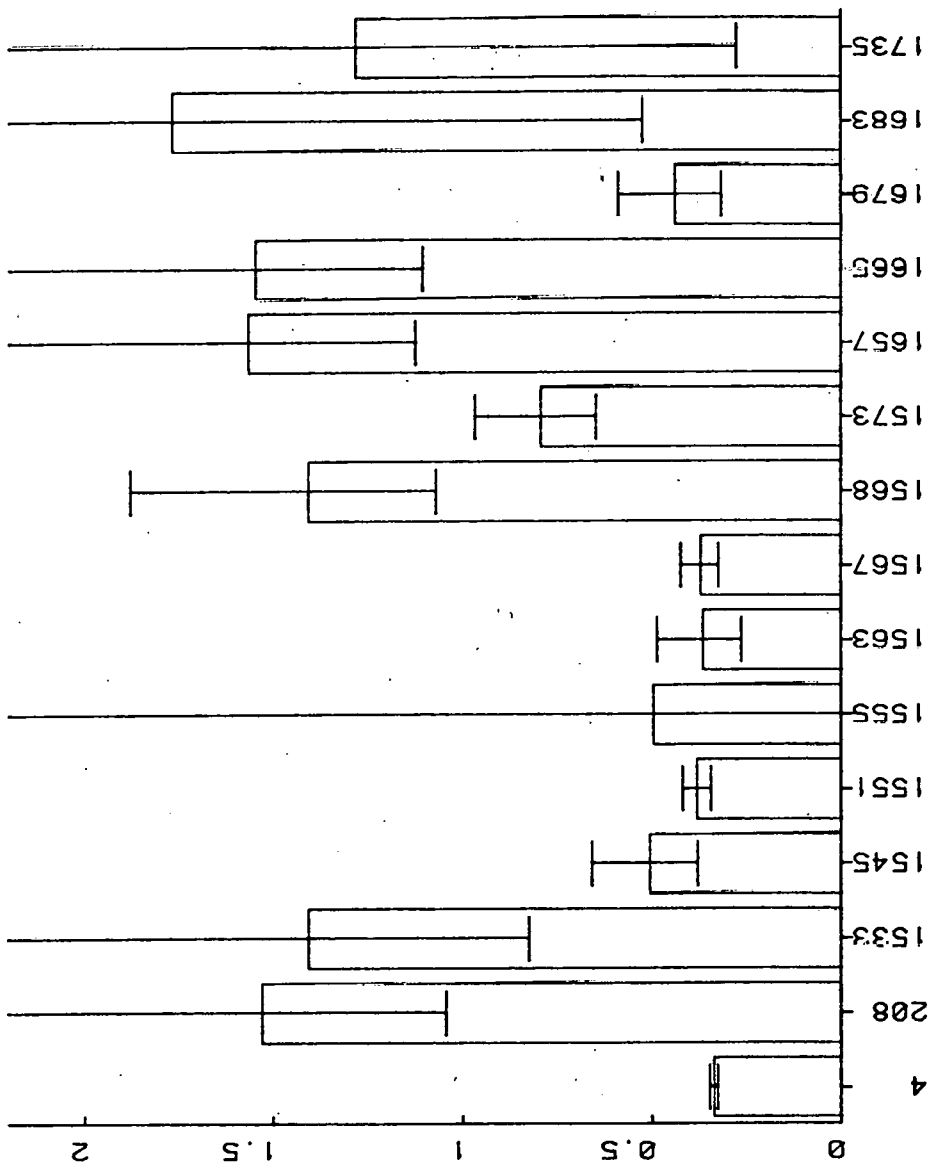


FIGURE 8.2-26 RATIO OF C_3 PHENANTHRENE TO C_3 DIBENZOTHIOPHENE IN PHASE IV SEDIMENT SAMPLES

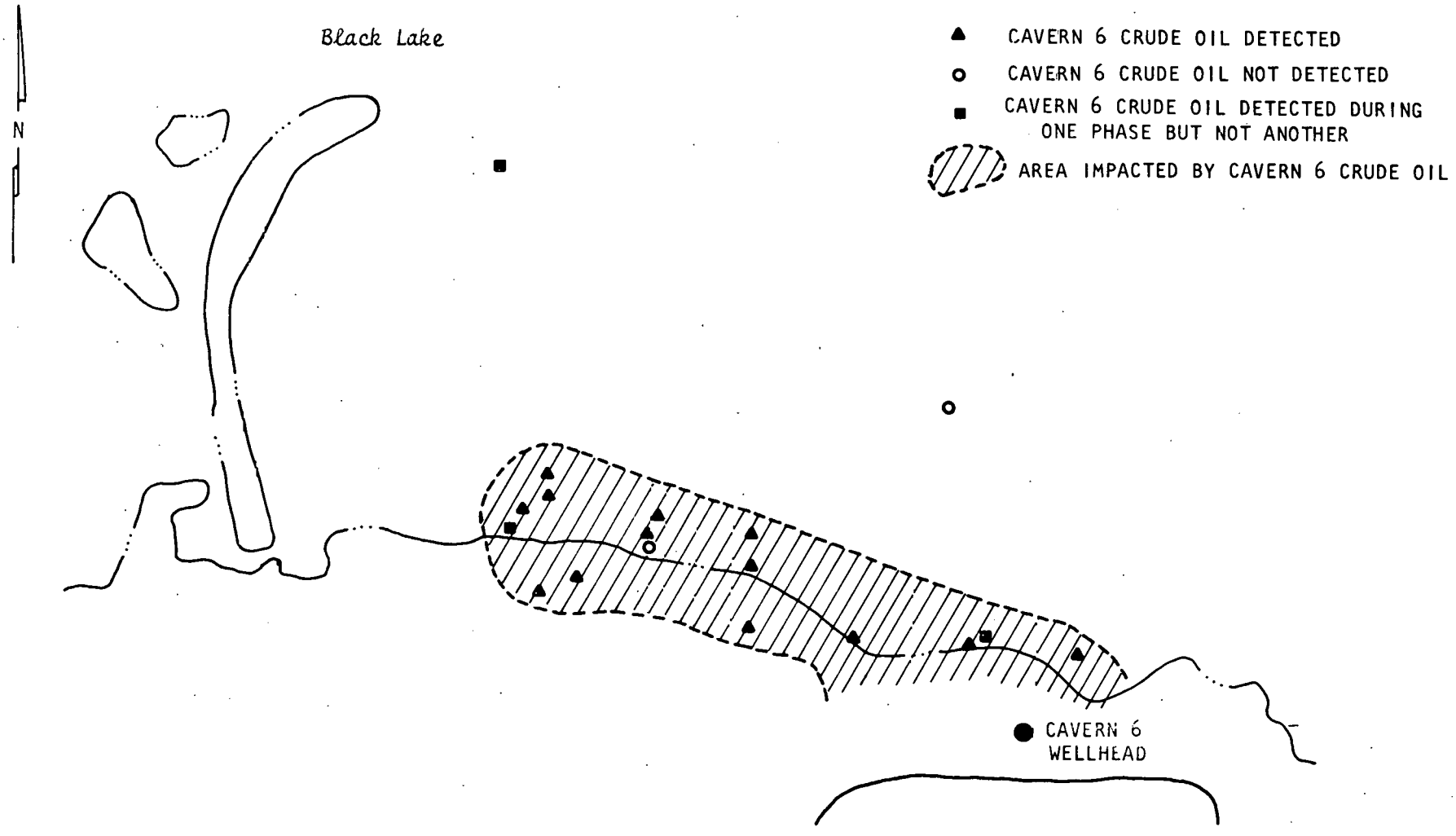


FIGURE 8.2-27 DISTRIBUTION OF OILS AS INDICATED BY DISCRIMINANT FUNCTIONS ANALYSIS

9-13-C), 85 (Site 9-2-C), 122 (Site 9-5-C), 128 (Site 9-9-C), and 229 (Site 30-7-C) probably contain Cavern 6 crude oil. All these samples with the exception of Sediment 229 were located in the impact area as determined by visual observation of an oil sheen on the water after the oil spill from Cavern 6. Sample 229 was located to the northwest of Cavern 6 and it is possible that a southeasterly wind may have deposited some Cavern 6 crude oil at this location. Subsequent analyses of samples at this location (30-12-C) from Phases III (Sample 1118) and IV (Sample 1665) do not indicate the presence of Cavern 6 crude oil.

Examination of the data for Phase II sediments revealed that Samples 627 (Site 2-C), 938 (Site 245-1-C), 945 (Site 7-C), 948 (Site 2-C), 954 (Site 6-C) and 957 (Site 16-1-B) which were all located in the probable impact area had alkylated phenanthrene to alkylated dibenzothiophene ratios, which indicate the presence of Cavern 6 crude oil. Sample 623 (Site 30-12-C) which was collected slightly north of the impact area also appears to contain Cavern 6 crude oil. Analysis of samples collected at this site during Phases I (Sample 234) and IV (Sample 1679) indicated the presence of Cavern 6 crude oil in Phase IV (Sample 1679) but not in Phase I (Sample 234).

Table 8.2-6 indicates that the Phase III sediment Samples 1181 and 1182 (Site 203-30-C), 1247 (Site 9-7-C), 1251 (Site 9-2-C) and 1253 and 1254 (Site 9-3-C), which were all located within the suspected impact area of the oil spill, most probably contain Cavern 6 crude oil.

The qualitative data for the Phase IV (Table 8.2-6) sediment samples indicated that all sediment samples located in the impact area and analyzed by UNO are contaminated with Cavern 6 oil. These are Samples 1545 (Site 203-30-C), 1551 (Site 9-3-C), 1555 (Site 2-C), 1563 (Site 9-7-C), 1567 (Site 201/202-30-C), 1568 (Site 9-1-C), and 1573 (Site 9-2-C). The data for sample 1679 (Site 30-12-C), which is outside the impact area, indicated that this sample contains Cavern 6 crude oil.

With the exception of one foliage sample collected at Site A2, no Cavern 6 crude oil was found in the soil, foliage or tissue samples analyzed (Tables 8.2-7 through 8.2-9).

An overall examination of the qualitative data obtained by combined gas chromatography/mass spectrometry from Phase I through IV samples indicated that the oil spilled from Cavern 6 was confined to the area designated as the impact area, with the exception of Site 30-7-C for Phase I (Sample 229) and Site 30-12-C for Phases II (Sample 623) and IV (Sample 1679). Analysis of samples collected at Site 30-7-C during Phase III (1118) and Phase IV (1665) did not indicate the presence of Cavern 6 crude oil.

A number of samples collected and analyzed from the suspected impact area were found not to contain Cavern 6 crude oil. These are Samples 16, 18, 20 and 21 (Phase I); 609, 940, 942, 946 and 949 (Phase II); and 1177 and 1282 (Phase III). Since not all samples collected and analyzed from the impact area contained Cavern 6 oil, the distribution of oil in this area is obviously patchy. This patchy distribution of Cavern 6 crude oil is further demonstrated by examining the samples collected from Site 9-3-C for Phases I (Sample 16), II (Sample 940), III (Samples 1253, 1254) and IV (Sample 1551). It is interesting to examine the chromatographic and qualitative data for Samples 16, 940, 1253 and 1551. Figures 8.2-28, 8.2-29, 8.2-30, and 8.2-31 represent gas chromatograms of the aliphatic components of Samples 16, 940, 1253, and 1551, respectively.

The large unresolved complex mixture (UCM) in Figure 8.2-28 indicated that Sample 16 probably contained a high background level of weathered oil before the fire at West Hackberry. Examination of the qualitative data (Table 8.2-6) and gas chromatogram (Figure 8.2-28) for this sample revealed that Sample 16 contained weathered Louisiana Sweet Crude oil.

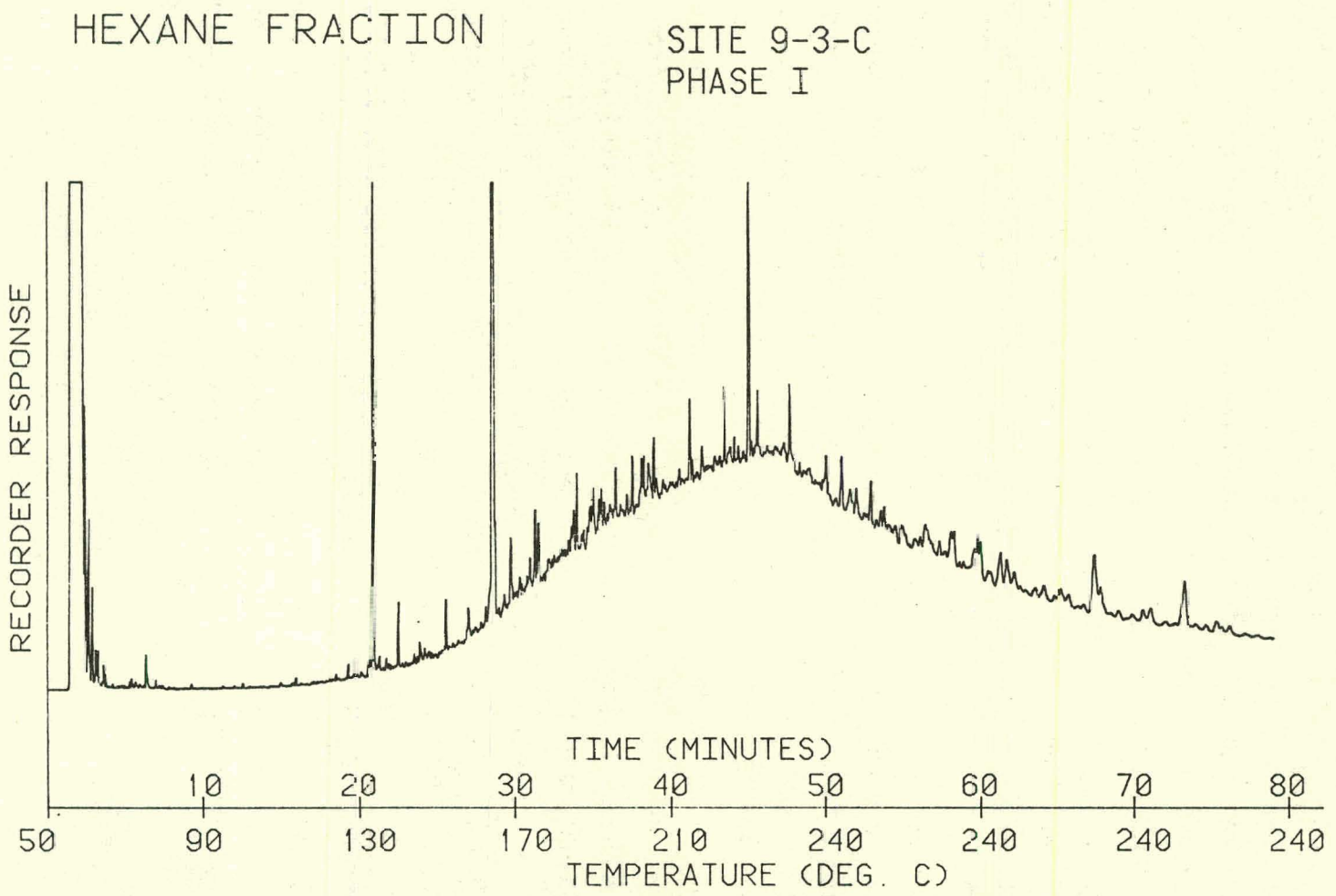


FIGURE 8.2-28 GAS CHROMATOGRAM OF THE ALIPHATIC COMPONENTS OF SEDIMENT SAMPLE 16

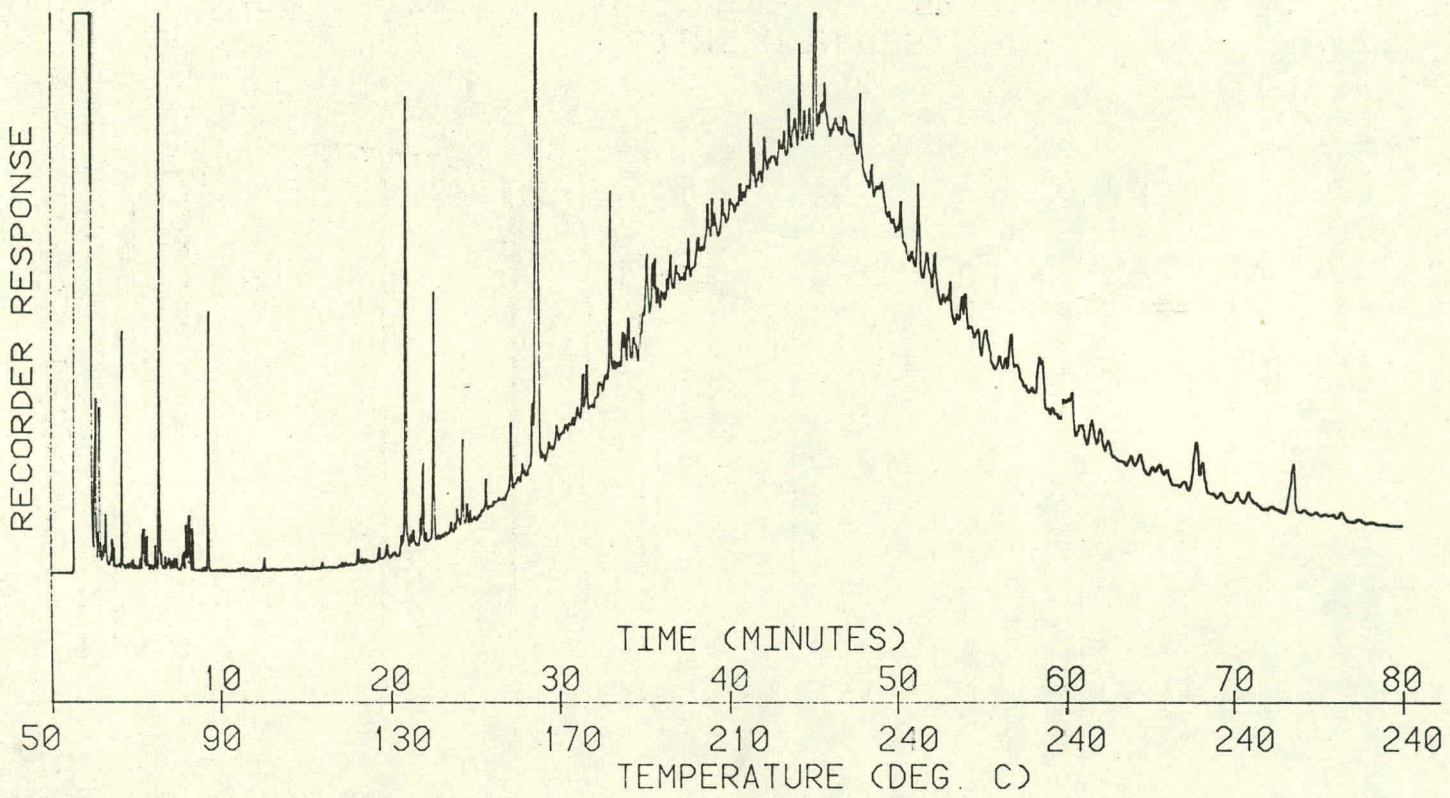


FIGURE 8.2-29 GAS CHROMATOGRAM OF THE ALIPHATIC COMPONENTS OF SEDIMENT SAMPLE 940

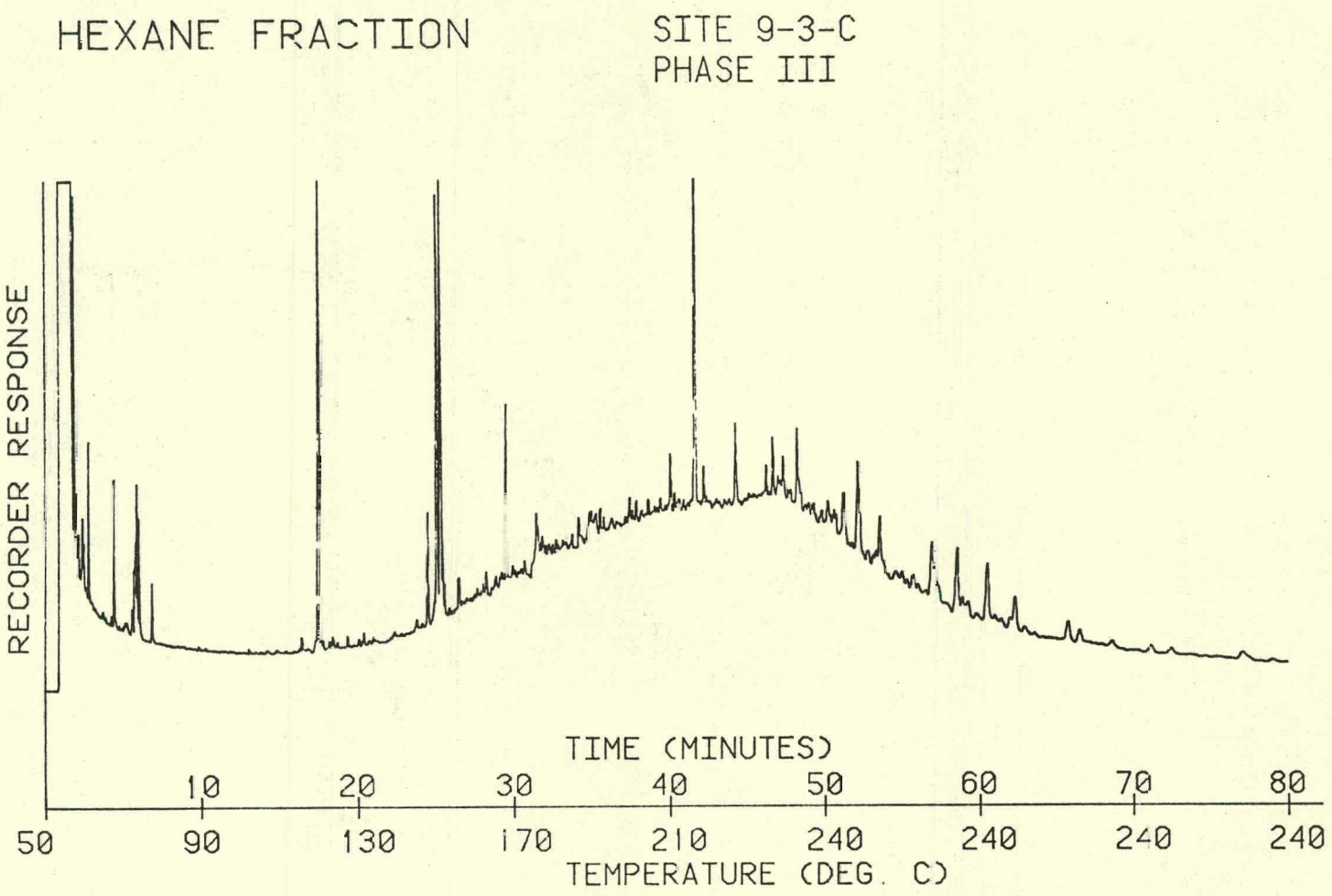


FIGURE 8.2-30 GAS CHROMATOGRAM OF THE ALIPHATIC COMPONENTS OF SEDIMENT SAMPLE 1253

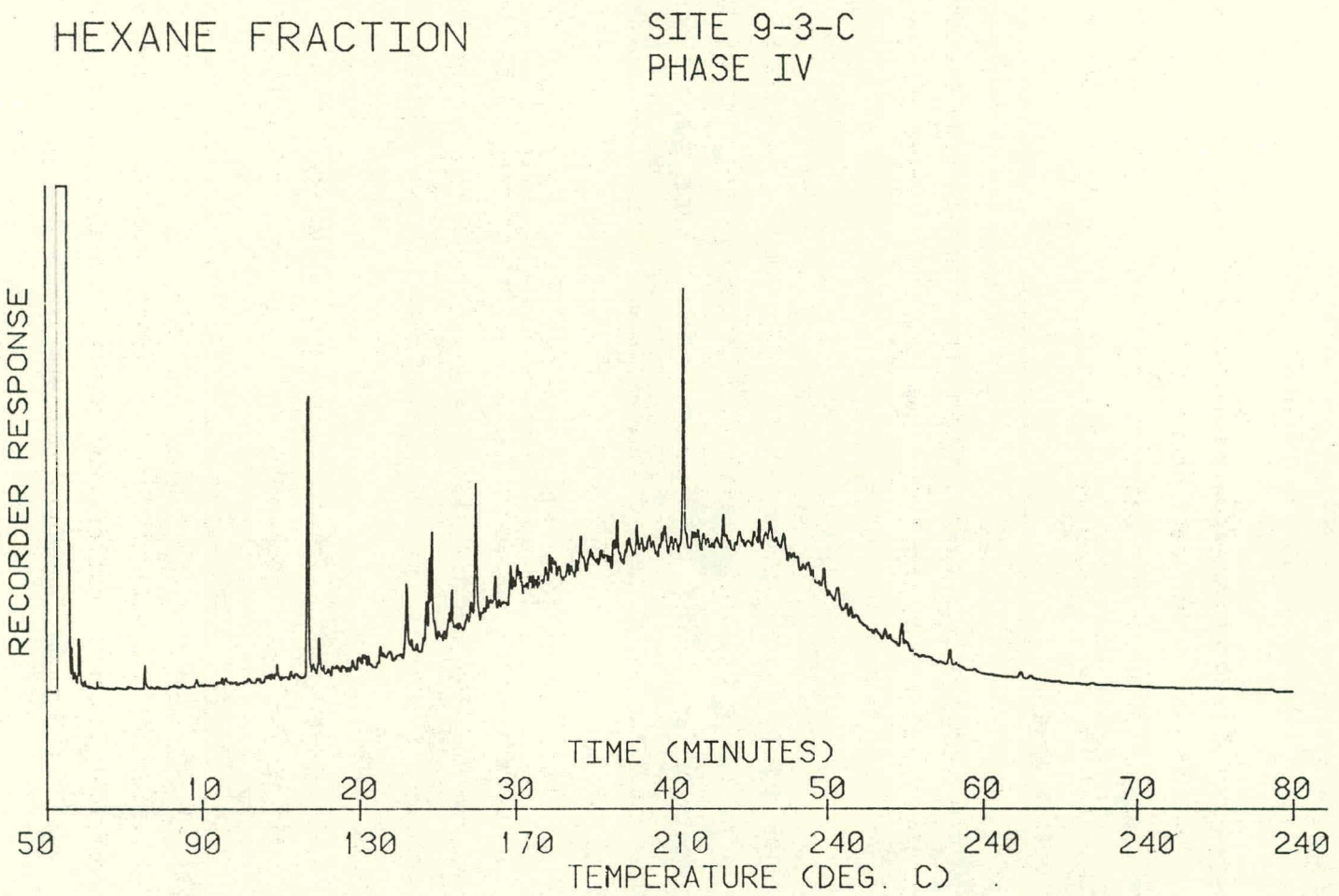


FIGURE 8.2-31 GAS CHROMATOGRAM OF THE ALIPHATIC COMPONENTS OF SEDIMENT SAMPLE 1551

The qualitative data (Table 8.2-6) for Sample 940 also indicated the presence of Louisiana Sweet Crude oil. The gas chromatogram (Figure 8.2-29) for this sediment sample showed increased weathering of the Louisiana Sweet Crude oil during the time period from October (Phase I) to January (Phase II).

On the other hand, Samples 1253 and 1551 presented a different perspective. The chromatographic data shown in Figures 8.2-30 and 8.2-31 indicated the presence of weathered petroleum in these samples. However, the qualitative (Table 8.2-6) data indicated the presence of Cavern 6 crude oil in both samples.

Other representative gas chromatograms of the aliphatic and aromatic components of the sediment, soil and foliage samples analyzed are shown in Appendix C.1.

In addition to sediment, soil and foliage samples, a number of air samples were collected and analyzed. The chromatograms of two air samples analyzed are given in Figure 8.2-32. These samples were collected from Site 1 during Phase I on two different days. Table 8.2-10 lists the types of organic compounds which were detected in several of the air samples. Volatile organics which can be purged and trapped from Cavern 6 crude oil and Louisiana Sweet Crude are illustrated in chromatograms in Figures 8.2-33 and 8.2-34. The procedures used to collect these samples do not duplicate the conditions used in the collection of the environmental samples.

8.2.3 Quantitative Analysis by Glass Capillary Gas Chromatography

The quantitative impact of oil on the samples was estimated from the results of sediment spiking experiments. These experiments involved analyzing a relatively contamination-free sample and then spiking that sample with several different concentrations of Cavern 6 crude oil. The

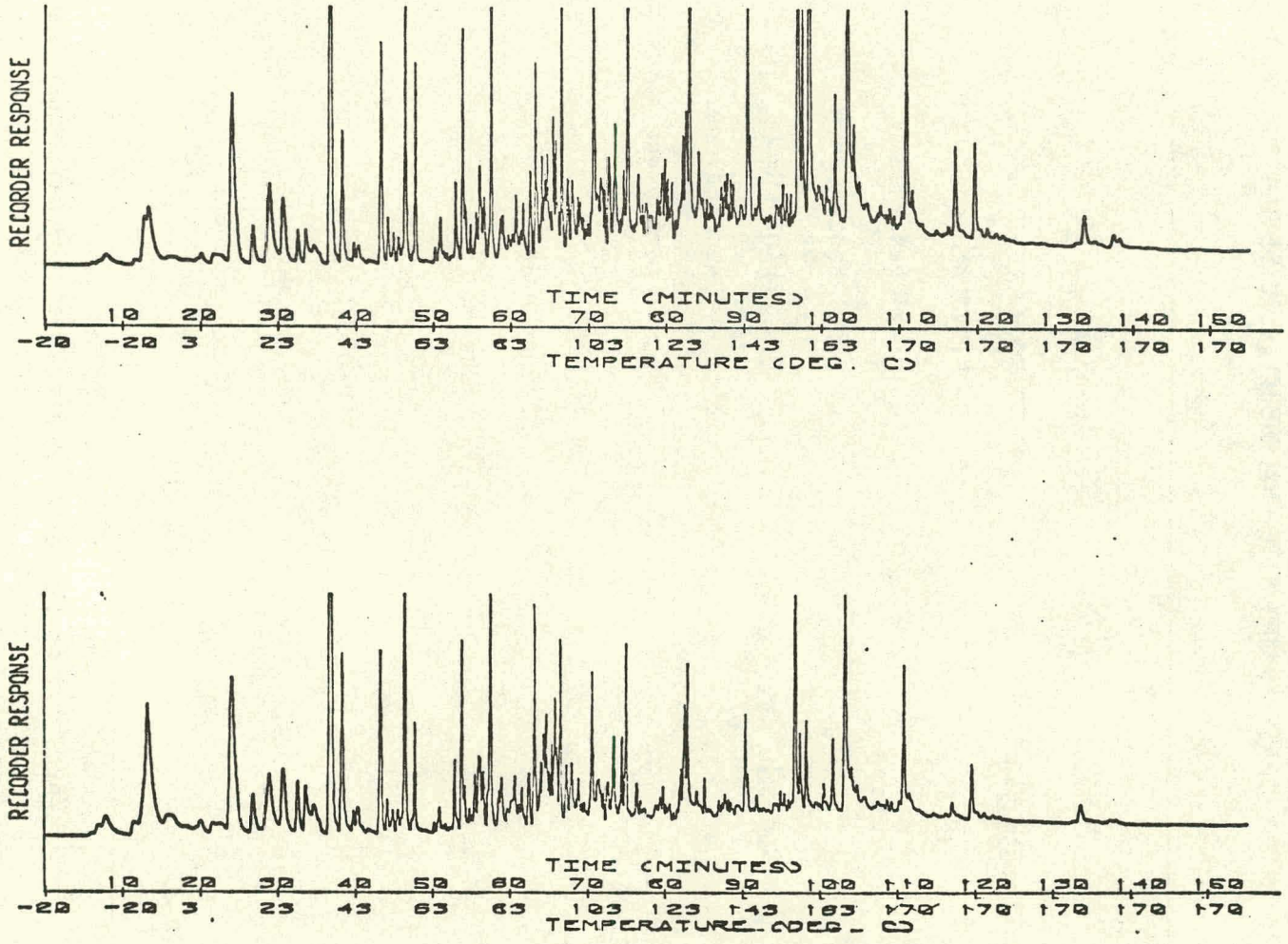


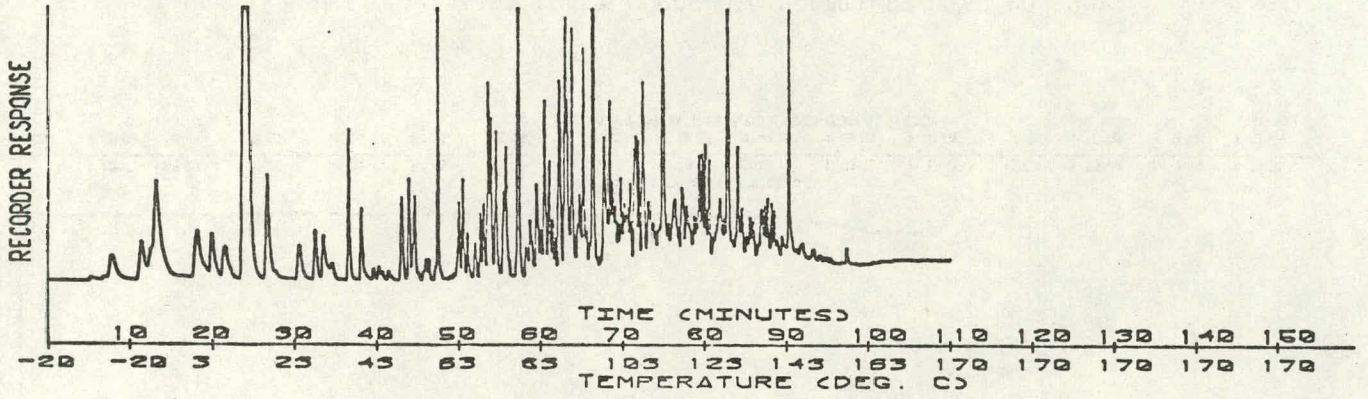
FIGURE 8.2-32 AIR SAMPLES - SITE 1 (PHASE I)

TABLE 8.2-10

COMPOUNDS DETECTED IN AIR SAMPLES TAKEN AT SITE 1, PHASE I, SPR SITE, HACKBERRY, LOUISIANA[a]

C_5H_{12}	benzene
n-C_6H_{14}	toluene
C_7H_{14}	C_2 alkyl benzenes
C_7H_{16}	C_3 alkyl benzenes
n-C_7H_{16}	C_4 alkyl benzenes
C_8H_{18}	methyl napthalene
n-$C_{10}H_{22}$	2 methyl naphthalene
$C_{11}H_{24}$	3 methyl napthalene
n-$C_{11}H_{24}$	benzophenone
n-$C_{12}H_{26}$	phenanthrene
n-$C_{13}H_{28}$	biphenyl
$C_{14}H_{30}$	none detected
$C_{15}H_{32}$	chloroform
branched-$C_{10}H_{22}$	dichloromethane
branched-$C_{11}H_{24}$	trichloroethane tetrachloroethylene

[a]Identification based on combined gas chromatography/mass spectrometry. The compounds are listed in order of elution from the gas chromatographic column.



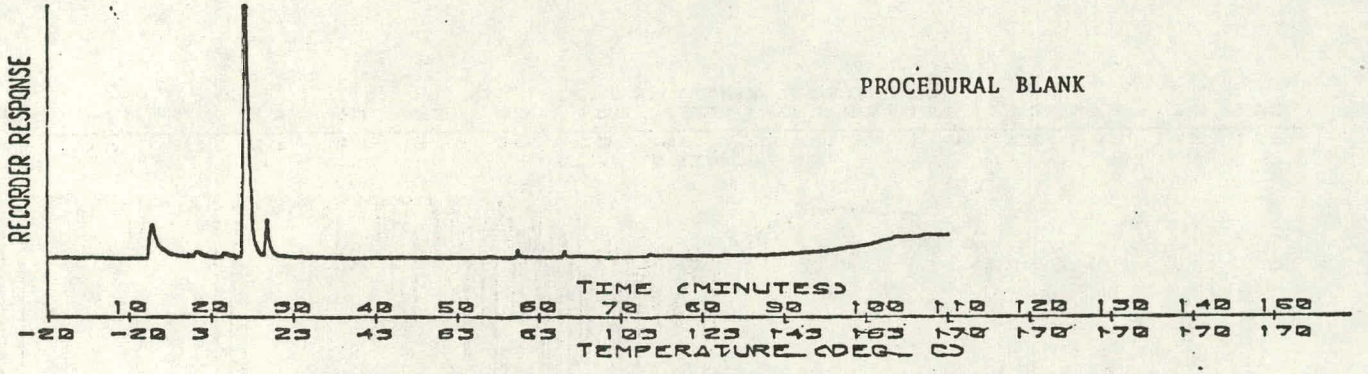
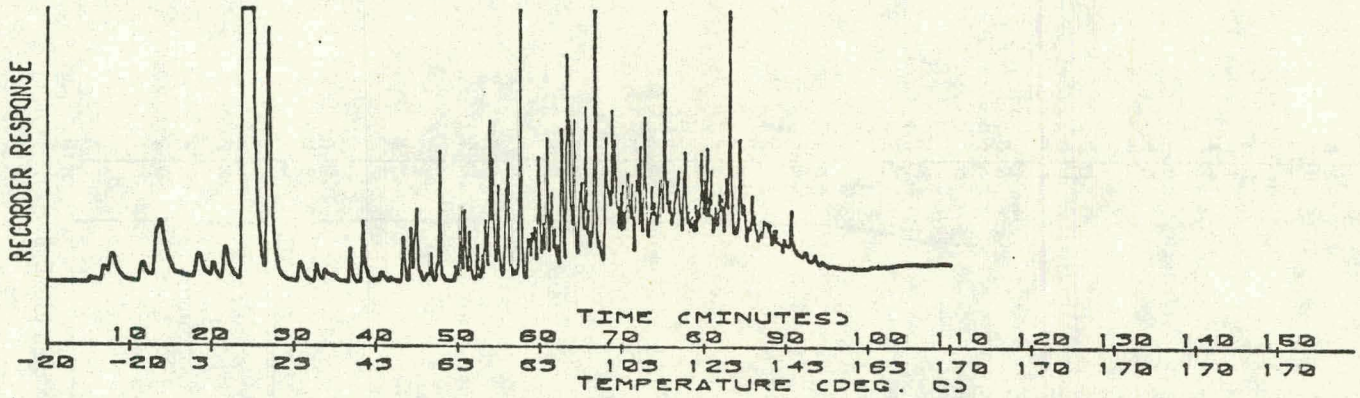


FIGURE 8.2-33 CAVERN 6 CRUDE OIL VOLATILES, TAG NO. 4



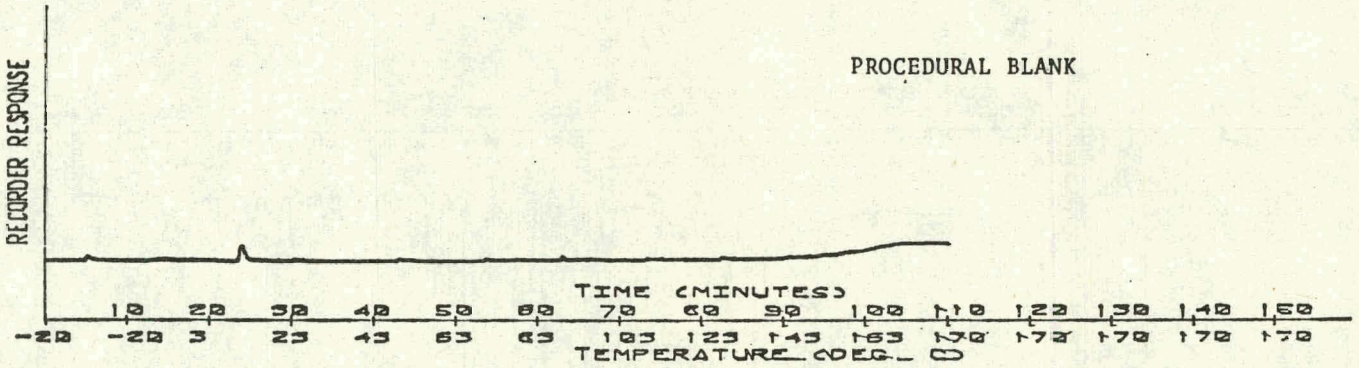


FIGURE 8.2-34 LOUISIANA SWEET CRUDE OIL VOLATILES, TAG NO. 208

spiked sediments were reanalyzed and several different parameters were used to tabulate the levels of spiked oil contamination. These parameters, along with the values obtained for each sample, are listed in Appendix C in Tables C.6-1 through C.6-4. Examination of the data obtained from numerous Phase I and II samples indicated that the C_{18} through C_{23} normal hydrocarbon quantities and the phytane concentration were the most accurate parameters for determination of the quantity of oil contamination. An average of these two parameters was used to quantify the extent of oil contamination in the samples. Tables 8.2-11 through 8.2-14 list the samples, along with station number, amount of contamination and whether or not Cavern 6 crude oil was found.

Those sediment samples which contained Cavern 6 crude oil had a greater concentration of petroleum type hydrocarbons than sediment samples which did not contain Cavern 6 crude oil. Samples containing Cavern 6 crude oil averaged 24, 4, 27 and 22 ppm of petroleum (excluding samples which had greater than 100 ppm of oil) for Phases I, II, III and IV, respectively. On the other hand, sediment samples not containing Cavern 6 crude oil averaged 10, 7, 4 and 7 ppm of oil for Phases I, II, III and IV, respectively (Table 8.2-11). The soil samples which were analyzed averaged 3, 2 and 4 ppm of petroleum hydrocarbons for Phases II, III and IV (see Table 8.2-12).

When sorted by geographical area, these sediment and soil samples indicate that Cavern 6 crude oil was randomly distributed (Table 8.2-15). The persistence of Cavern 6 crude oil at each sampling station is shown in Table 8.2-16. This persistence was tested by area using t-tests (Table 8.2-17). No significant differences in oil concentration were found in sediment samples between Phases I and IV in sediment samples nor in soil samples between Phases II and IV. Moreover, the concentration of oil in sediment samples was significantly greater among Cavern 6 contaminated samples than among other samples in all phases except Phase

TABLE 8.2-11

QUANTIFICATION OF OIL CONTAMINATION[a]
HACKBERRY SEDIMENT SAMPLES

TAG	SITE	QUANTITY OF OIL[b]
PHASE I		
Samples Containing Cavern 6 Crude Oil		
13	9-7-C	20
15	9-1-C	18
19	9-13-C	11
85	9-2-C	19
122	9-5-C	>100
128	9-9-C	64
229	30-7-C	11
Mean[c]		23.8
Standard error		8.2
Samples Not Containing Cavern 6 Crude Oil		
16	9-3-C	27
18	9-11-C	2
20	9-12-C	4
21	9-14-C	12
54	SNR-2	13
61	SNR-4	8
65	SNR-5	4
153	30-16-C	26
154	30-17-C	4
193	30-3-C	6
197	30-6-C	7
226	30-17-C	6
234	30-12-C	4
Mean		9.5
Standard error		2.3

[a]Based on spiked sediment experiments using the C_{18}-C_{23} normal hydrocarbon quantity and phytane concentration as parameters

[b]Expressed as ppm (µg/g wet weight)

[c]Excluding values >100, which are assumed to be anomalous

TABLE 8.2-11 (Cont.)

TAG	SITE	QUANTITY OF OIL[b]
PHASE II		
Samples Containing Cavern 6 Crude Oil		
623	30-12-C	4
627	2-C	4
938	245-1-C	>100
945	7-C	>100
948	2-C	3
954	6-C	>100
957	16-1-B	5
Mean[c]		4.0
Standard error		0.4
Samples Not Containing Cavern 6 Crude Oil		
586	15-3-B	4
594	E6-2-B	4
597	8-2-B	5
599	9-2-B	6
601	16-3-B	3
604	17-3-B	5
609	7-9-B	7
631	WC GILL NET	1
929	30-3-C	10
940	9-3-C	14
942	201/202-30-C	15
946	5-C	>100
949	2-C	2
963	NC 41	>100
964	NC 42	32
990	30-13-C	4
1498	SNR-1	1
1499	SNR-2	5
1500	30-5-C	5
Mean[c]		7.2
Standard error		1.8

TABLE 8.2-11 (Cont.)

TAG	SITE	QUANTITY OF OIL[b]
PHASE III		
Samples Containing Cavern 6 Crude Oil		
1181	203-30-C	>100
1182	203-30-C	>100
1247	9-7-C	36
1251	9-2-C	43
1253	9-3-C	10
1254	9-3-C	20
Mean[c]		27.3
Standard error		7.5
Samples Not Containing Cavern 6 Crude Oil		
1040	SNR-6	0
1083	RC 107	2
1084	RC 107	1
1098	30-4-C	12
1116	30-3-C	20
1118	30-7-C	13
1177	9-11-C	3
1187	S of 30-19-C	4
1188	S of 30-19-C	3
1193	9-2-B	1
1194	8-2-B	1
1282	2-C	0
1290	RS 109	1
1292	RS 109	4
1296	RS 111	1
1297	RS 111	1
1465	North site/ west of dike	4
1466	Post 234	7
Mean		4.3
Standard error		1.3

TABLE 8.2-11 (Cont.)

TAG	SITE	QUANTITY OF OIL[b]
PHASE IV		
Samples Containing Cavern 6 Crude Oil		
1545	203-30-C	50
1551	9-3-C	>100
1555	2-C	8
1563	9-7-C	>100
1567	201/202-30-C	41
1568	9-1-C	4
1573	9-2-C	24
1679	30-12-C	6
Mean[c]		22.2
Standard error		8.0
Samples Not Containing Cavern 6 Crude Oil		
1533	30-3-C	4
1657	8-2-B	12
1665	30-7-C	6
1683	30-4-C	8
1735	30-5-C	6
Mean		7.2
Standard error		1.4

TABLE 8.2-12

QUANTIFICATION OF OIL CONTAMINATION[a]
HACKBERRY SOIL SAMPLES
(NO CAVERN 6 CRUDE OIL DETECTED)

TAG	SITE	QUANTITY OF OIL[b]
PHASE I - No Sample Taken		
PHASE II		
640	UNO #1	1
641	UNO #1	2
642	UNO #1	2
654	UNO #4	9
690	UNO #6	1
702	UNO #7	5
703	UNO #7	1
934	UNO #2	2
Mean		2.9
Standard error		1.0
PHASE III		
1238	UNO #7	2
1239	UNO #7	4
1240	UNO #7	2
1424	URI #18	2
1425	URI #18	1
1427	URI #19	1
1428	URI #19	1
Mean		1.9
Standard error		0.4
PHASE IV		
1502	UNO #3	2
1503	UNO #4	1
1505	UNO #5	3
1507	UNO #6	2
1509	UNO #12	2
1511	UNO #11	1
1516	UNO #14	4
1519	UNO #7	20
1527	URI #18	2
1529	URI #19	2
Mean		3.9
Standard error		1.8

[a]Based on spiked sediment experiments using the C_{18}-C_{23} normal hydrocarbon quantity and phytane concentration as parameters

[b]Expressed as ppm (µg/g wet weight)

TABLE 8.2-13

QUANTIFICATION OF OIL CONTAMINATION[a]
HACKBERRY FOLIAGE SAMPLES
(CAVERN 6 CRUDE OIL DETECTED ONLY AT SITE A2)

TAG	SITE	QUANTITY OF OIL[b]
PHASE I		
3	A2	>100
41	UNO #2	0
43	UNO #3	0
47	UNO #4	0
48	UNO #5	0
53	SNR-1	0
57	SNR-?	0
60	SNR-3	0
63	SNR-4	0
67	SNR-5	0
69	SNR-6	0
87	UNO #7	>100
88	UNO #7	>100
PHASE II		
644	UNO #1	0
645	UNO #1	0
650	UNO #1	0
653	UNO #4	0
691	UNO #6	0
700	UNO #7	0
701	UNO #7	4
704	UNO #7	0
PHASE III		
1067	RS 111	0
1365	UNO #7	0
1366	UNO #7	0
1367	UNO #7	0
1426	URI #18	0
1429	URI #19	0

[a]Based on spiked sediment experiments using the C_{18}-C_{23} normal hydrocarbon quantity and phytane concentration as parameters.

[b]Expressed as ppm (µg/g wet weight)

TABLE 8.2-14

QUANTIFICATION OF OIL CONTAMINATION[a]
BLACK LAKE MUSSEL TISSUE SAMPLES
(NO CAVERN 6 CRUDE OIL DETECTED)

TAG	SITE	QUANTITY OF OIL[b]
PHASE II		
846	9-10-B	>100
1430	West Control	22

[a]Based on spiked sediment experiments using the C_{18}-C_{23} normal hydrocarbon quantity and phytane concentration as parameters

[b]Expressed as ppm (µg/g wet weight)

TABLE 8.2-15

QUANTIFICATION OF OIL CONTAMINATION
IN WEST HACKBERRY SOIL AND SEDIMENT SAMPLES

STATION	TAG NO.	PETROLEUM HYDROCARBON (ppm)[a]	CAVERN 6 CRUDE OIL[b]
PHASE I			
Impact Area			
9-2-C	85	19	YES
9-3-C	16	27	NO
9-4-C	15	18	YES
9-5-C	122	>100	YES
9-7-C	13	20	YES
9-9-C	128	64	YES
9-11-C	18	2	NO
9-12-C	20	4	NO
9-13-C	19	11	YES
9-14-C	21	12	NO
Non-Impact Area (Lake)			
30-3-C	193	6	NO
30-6-C	197	7	NO
30-7-C	229	11	YES
30-12-C	234	4	NO
30-16-C	153	26	NO
30-17-C	154	4	NO
30-17-C	226	6	NO
Non-Impact Area (Canal)			
SNR-2	54	13	NO
SNR-4	61	8	NO
SNR-5	65	4	NO

[a]Based on spiked sediment experiments using the C_{18}-C_{23} normal hydrocarbon quantity and phytane concentrations as parameters

[b]Determined by using C_1 and C_3 ratios as parameters

TABLE 8.2-15 (Cont.)

STATION	TAG NO.	PETROLEUM HYDROCARBON (ppm)[a]	CAVERN 6 CRUDE OIL[b]
PHASE II			
Impact Area			
2-C	627	4	YES
2-C	948	3	YES
2-C	949	2	NO
5-C	946	>100	NO
6-C	954	>100	YES
7-C	945	>100	YES
7-9-B	609	7	NO
9-3-C	940	14	NO
16-1-B	957	5	YES
201/202-30-C	942	15	NO
245-1-C	938	>100	YES
Non-Impact Area (Lake)			
8-2-B	597	5	NO
9-2-B	599	6	NO
15-3-B	586	4	NO
16-3-B	601	3	NO
17-3-B	604	5	NO
30-3-C	929	10	NO
30-5-C	1500	5	NO
30-12-C	623	4	YES
30-13-C	990	4	NO
E6-2-B	594	4	NO
NC 41	963	>100	NO
NC 42	964	32	NO
Dack of Gill Net	631	1	NO
Non-Impact Area (Land and Canal)			
UNO #1	640	1	NO
UNO #1	641	2	NO
UNO #1	642	2	NO
UNO #2	934	2	NO
UNO #4	654	9	NO
UNO #6	690	1	NO
UNO #7	702	5	NO
UNO #7	703	1	NO
SNR-1	1498	1	NO
SNR-2	1499	5	NO

TABLE 8.2-15 (Cont.)

STATION	TAG NO.	PETROLEUM HYDROCARBON (ppm)[a]	CAVERN 6 CRUDE OIL[b]
PHASE III			
Impact Area			
2-C	1282	0	NO
9-2-C	1251	43	YES
9-3-C	1253	10	YES
9-3-C	1254	20	YES
9-7-C	1247	36	YES
9-11-C	1177	3	NO
203-30-C	1181	>100	YES
203-30-C	1182	>100	YES
Non-Impact Area (Lake)			
8-2-B	1194	1	NO
9-2-B	1193	1	NO
30-3-C	1116	20	NO
30-4-C	1098	12	NO
30-7-C	1118	13	NO
S of 30-19-C	1187	4	NO
S of 30-19-C	1188	3	NO
Northsite/west of dike	1465	4	NO
Post 234	1466	7	NO
Non-Impact Area (Land and Canal)			
UNO #7	1238	2	NO
UNO #7	1239	4	NO
UNO #7	1240	2	NO
URI #18	1424	2	NO
URI #18	1425	1	NO
URI #19	1427	1	NO
URI #19	1428	1	NO
RC 107	1083	2	NO
RC 107	1084	1	NO
RS 109	1290	1	NO
RS 109	1292	4	NO
RS 111	1296	1	NO
RS 111	1297	1	NO
SNR 6	1040	0	NO

TABLE 8.2-15 (Cont.)

STATION	TAG NO.	PETROLEUM HYDROCARBON (ppm)[a]	CAVERN 6 CRUDE OIL[b]
PHASE IV			
Impact Area			
2-C	1555	8	YES
9-1-C	1568	4	YES
9-2-C	1573	24	YES
9-3-C	1551	>100	YES
9-7-C	1563	>100	YES
201/202-30-C	1567	41	YES
203-30-C	1545	50	YES
Non-Impact Area (Lake)			
8-2-B	1657	12	NO
30-3-C	1533	4	NO
30-4-C	1683	8	NO
30-5-C	1735	6	NO
30-7-C	1665	6	NO
30-12-C	1679	6	YES
Non-Impact Area (Land)			
UNO #3	1502	2	NO
UNO #4	1503	1	NO
UNO #5	1505	3	NO
UNO #6	1507	2	NO
UNO #7	1519	20	NO
UNO #11	1511	1	NO
UNO #12	1509	2	NO
UNO #14	1516	4	NO
URI #18	1527	2	NO
URI #19	1529	2	NO

TABLE 8.2-16

PERSISTENCE OF CAVERN 6 CRUDE OIL IN THE WEST HACKBERRY ENVIRONMENT

STATION	PHASE I	PHASE II	PHASE III	PHASE IV
Impact Area				
2-C		YES,YES,NO	NO	YES
5-C		NO		
6-C		YES		
7-C		YES		
7-9-B		NO		
9-1-C				YES
9-2-C	YES		YES	YES
9-3-C	NO	NO	YES,YES	YES
9-4-C	YES			
9-5-C	YES			
9-7-C	YES		YES	YES
9-9-C	YES			
16-1-B		YES		
201/202-30-C		NO		YES
203-30-C			YES,YES	YES
245-1-C		YES		
9-11-C	NO		NO	
9-12-C	NO			
9-13-C	YES			
9-14-C	NO			

TABLE 8.2-16 (Cont.)

SITE	PHASE I	PHASE II	PHASE III	PHASE IV
Non-Impacted Area (Lake)				
8-2-B		NO	NO	NO
9-2-B		NO	NO	
15-3-B		NO		
16-3-B		NO		
17-3-B		NO		
30-3-C	NO	NO	NO	NO
30-4-C			NO	NO
30-5-C		NO		NO
30-6-C	NO			
30-7-C	YES		NO	NO
30-12-C	NO	YES		YES
30-13-C		NO		
30-16-C	NO			
30-17-C	NO,NO			
NC 41		NO		
NC 42		NO		
L6-2-B		NO		
Back of Gill Net		NO		
S of 30-19-C			NO,NO	
North site/west of dike			NO	
Post 234			NO	

TABLE 8.2-16 (Cont.)

SITE	PHASE I	PHASE II	PHASE III	PHASE IV
Non-Impacted Area (Land and Canal)				
UNO #1		NO,NO,NO		
UNO #2		NO		
UNO #3				NO
UNO #4		NO		NO
UNO #5				NO
UNO #6		NO		NO
UNO #7		NO,NO	NO,NO,NO	NO
UNO #11				NO
UNO #12				NO
UNO #14				NO
URI #18			NO,NO	NO
URI #19			NO,NO	NO
SNR 1		NO		
SNR 2	NO	NO		
SNR 4	NO			
SNR 5	NO			
SNR 6			NO	
RC 107			NO,NO	
RS 109			NO,NO	
RS 111			NO,NO	

TABLE 8.2-17

DIFFERENCES IN OIL CONCENTRATION (in ppm)
IN SOIL AND SEDIMENT SAMPLES

SOIL SAMPLES (NO CAVERN 6 CRUDE OIL)

Phase	Concentration[a]	Phase	Concentration[a]	t	p
II	2.9 ± 1.0	IV	3.9 ± 1.8	0.45	>0.50

SEDIMENT SAMPLES

Oil Type	Phase	Concentration[a]	Phase	Concentration[a]	t	p
Cavern 6	I	23.8 ± 8.2	IV	22.2 ± 8.0	0.14	>0.50
Other	I	9.5 ± 2.3	IV	7.2 ± 1.4	0.59	>0.50

Phase	Cavern 6 Crude Oil Concentration[a]	Other Oil Concentration[a]	t	p
I	23.8 ± 8.2	9.5 ± 2.3	2.24	<0.05
II	4.0 ± 0.4	7.2 ± 1.8	0.84	>0.40
III	27.3 ± 7.5	4.3 ± 1.3	5.39	<0.001
IV	22.2 ± 8.0	7.2 ± 1.4	1.68	>0.10

[a]Mean ± one standard error

II (Table 8.2-17). The mean oil concentration in Phase II sediment samples contaminated with Cavern 6 crude oil was probably anomalous due to the exclusion of a large proportion of the samples with indeterminably high oil concentrations (Table 8.2-11) and due to poor overlap of stations analyzed with those in other phases.

8.2.4 Trace Metal Analysis

8.2.4.1 Introduction

The trace element composition of Cavern 6 crude oil was expected to be useful as a measure of the amount and determination of the source of oil contamination in the area. Identification of the source of any contamination was particularly important as the Hackberry site lies in an area of extensive petroleum production, refining and transport.

Trace metals were used primarily to delineate the area of impact during Phases I and II. During Phase I, it was assumed that for terrestrial areas the leaves of vegetation would be prime collectors of trace metal fallout from the fire plume and for water areas, the water column would collect trace metal fallout. By Phase II, it was assumed that the trace metals would be located in the soils at terrestrial sites and in the sediments at the lake sites. Phase IV foliage samples were assumed to have returned to the background levels present before the fire and spill occurred; therefore, Chinese tallow trees sampled during Phase I were resampled during Phase IV.

8.2.4.2 Analysis of Oil from Known Sources

Oils collected from known point sources were analyzed for the trace metals vanadium and nickel (Table 8.2-18). Cavern 6 crude oil and Louisiana Sweet Crude differ in their vanadium ($t = 28.6$, 4 df, $p < 0.001$) and nickel ($t = 8.28$, 2 df, $p < 0.05$) concentrations.

8.2.4.3 Soils and Sediments

Soil samples collected during Phase II were analyzed for vanadium and aluminum. Vanadium/aluminum ratios were regressed against distance from the fire (Table 8.2-19). The University of New Orleans (UNO) Sites

TABLE 8.2-18

TRACE METAL CONCENTRATIONS IN OIL SAMPLES (in ppm)

Replicate	Louisiana Sweet Crude	Cavern 6 Crude	South Louisiana Crude	Kuwait Crude	NBS Fuel Oil (1634)
A. Vanadium					
1	1.30	44.3	1.12	46.9	305.4
2	1.24	39.4	1.19	45.7	314.1
3	1.44	41.8	0.99	48.8	316.2
4					350.0
Mean	1.33	41.8	1.10	47.1	321.4[a]
Standard Deviation	0.10	2.5	0.10	1.6	19.6
Standard Error	0.06	1.4	0.06	0.9	9.8
95% Confidence Limits[b]	± 0.25	± 6.0	± 0.25	± 3.9	± 31.2
B. Nickel					
1	3.13	7.82			
2	1.96	8.51			
Mean	2.55	8.17			
Standard Deviation	0.83	0.49			
Standard Error	0.59	0.35			
95% Confidence Limits[b]	± 7.4	± 4.4			

[a]NBS certified value = 320 ± 15

[b]of the mean

TABLE 8.2-19

TRACE METAL ANALYSES OF PHASE II SOILS

Sample No.	Site	Distance from fire	% Al	SD^*_{Al}	ppmV	SD^*_V	V/Al Ratio ($\times 10^{-3}$)	Ratio ($\times 10^{-3}$)
652	UNO 1	0.75	2.42	0.23	43	4.1	1.8	0.24
647	UNO 2	0.53	1.79	0.19	33	3.1	1.8	0.26
637	UNO 3	0.63	2.51	0.18	41	3.3	1.6	0.18
656	UNO 4	1.4	2.33	0.21	35	4.2	1.5	0.23
658	UNO 5	1.2	2.30	0.47	35	4.3	1.5	0.36
688	UNO 6	1.7	2.14	0.14	34	1.3	1.6	0.12
708	UNO 7 SW	3.1	2.11	0.08	30	0.2	1.4	0.06
705	UNO 7 NE	3.1	2.27	0.20	31	3.4	1.4	0.19
717	UNO 8	2.6	3.04	0.30	42	7.0	1.4	0.27
722	UNO 9	2.8	2.18	0.12	33	1.3	1.5	0.11
698	UNO 10	3.4	2.14	0.06	29	1.6	1.4	0.09
712	UNO 11	2.6	2.84	0.18	47	3.4	1.7	0.16
727	UNO 12	2.0	1.96	0.28	25	2.7	1.3	0.23
695	UNO 14	4.1	2.17	0.06	31	1.3	1.4	0.07
			Mean % Al = 2.30		Mean ppmV = 35		Mean V/Al ratio = 1.5	
			SD^*_x = 0.33		SD^*_x = 6		SD^*_x = 0.15	
Correlation of distance from fire + parameter			r = +0.057		r = -0.35		r = -0.689, $p<0.01$	
			n = 14		n = 14		n = 14	

*SD = Standard Deviation

1 and 2 are statistically higher than the other, more remote sites, indicating the possibility of intense oil contamination in areas directly adjacent to the site of the fire (areas closer than 1 km in the downwind direction). Given the observed background levels of vanadium in the soils, the amount of vanadium that had to have been deposited at these sites in order to increase the vanadium/aluminum ratio from the mean of all the sites samples (1.5×10^{-3}) to the mean of Sites UNO 1 and 2 (1.8×10^{-3}) can be shown to be approximately 0.2 g/M^2. This corresponds to the amount of vanadium contained in approximately 5 kg of oil.

Because larger errors are possible when determining the difference between two large, almost equal numbers (i.e., grams vanadium per cubic meter in Sites 1 or 2 Soil minus grams vanadium per cubic meter in background levels equals added vanadium), these soil analyses are not considered as reliable as the vegetation analyses described later in determining the extent and intensity of fallout from the fire plume.

Table 8.2-20 summarizes the results of Phase II trace metal analysis of sediment samples. The average vanadium to aluminum ratio in the Black Lake sediments is 1.3×10^{-3}. This value is lower than the average vanadium to aluminum ratio of the land sites (1.5×10^{-3}) and is equal to the average vanadium to aluminum ratio found in the Sabine Wildlife Refuge during Phase III (Table C.5-3, Appendix C). These results indicated that there was no measurable increase in vanadium in these sediments with the possible exception of Stations 30-3-C, 30-16-C and 30-18-C, which appeared somewhat above average.

8.2.4.4 Analysis of Trace Metals on Vegetation

Analysis of Phase I vegetation was done in an effort to determine whether the vanadium to nickel ratio could be used to indicate the presence of Cavern 6 crude oil. These results (Table 8.2-21) indicate that it is the absolute value of the vanadium concentration that is

TABLE 8.2-20

TRACE METAL ANALYSES OF PHASE II SEDIMENTS

Sample No.	Site	% Al	SD* Al	ppmV	SD* V	V/Al Ratio (x 10^{-3})	Ratio (x 10^{-3})
652	Back of gill net	1.74	0.03	17.8	0.33	1.02	0.024
647	End of gill net	1.62	0.11	19.7	0.14	1.22	0.087
637	30-18-C	3.52	0.03	55.1	1.2	1.57	0.037
656	1-3-C, Top 1 cm	1.84	0.13	25.3	2.4	1.38	0.16
658	1-3-C, 1-2 cm	1.82	0.11	24.9	1.9	1.37	0.13
688	1-2-C	2.38	0.06	31.3	2.1	1.32	0.09
708	30-16-C	5.07	0.31	73.7	6.1	1.45	0.15
705	30-4-C	3.11	0.14	30.3	2.6	0.97	0.09
717	2-C	3.28	0.09	45.3	2.1	1.38	0.08
722	30-19-C	3.46	0.09	44.0	1.0	1.27	0.043
698	30-15-C	3.01	0.38	34.9	4.4	1.16	0.21
712	30-3-C	4.76	0.38	63.5	5.2	1.33	0.15
727	30-13-C, Top 2.5 cm	2.17	0.02	23.7	1.2	1.09	0.06
695	30-13-C, 2.5 - 4 cm	3.20	0.28	52.8	7.6	1.66	0.28

Mean % Al = 2.93 Mean ppmV = 38.7 Mean V/Al ratio = 1.30

SD^*_x = 1.08 SD^*_x = 17.3 SD^*_x = 0.20

	n	Mean	SD*
Phase II soils	14	1.52	0.16
Phase II sediments	14	1.30	0.20

t = 10.4, p<0.001

*SD = Standard Deviation

TABLE 8.2-21

TRACE METAL CONCENTRATIONS IN VEGETATION (PHASES I AND II)

SITE	TAG NO.	VANADIUM (ppm)	NICKEL (ppm)	VANADIUM/NICKEL
UNO 2	112	20.0	12.8	1.56
UNO 3	108	2.5	11.3	0.22
UNO 4	258	5.6	40.0	0.14
SNR 7	93	2.1	19.6	0.11
SNR 7	90	5.2	13.6	0.38
UNO 8	95	2.8	6.7	0.42
UNO 9	98	--	1.0	--
UNO 10	101	2.6	3.7	0.70
UNO 11	103	--	7.5	--
UNO 12	107	7.6	3.6	2.11
UNO 13	224	290.0	20.9	13.90
UNO 14	254	3.5	40.7	0.09
UNO 15	255	2.5	1.3	1.90
UNO 5	17[a]	9.3	1.3	7.15
UNO 6	24[a]	9.4	2.2	4.30
UNO 12	725[a,b]	4.3	1.3	3.30
UNO 5	657[a,b]	9.4	3.4	2.80

[a]Honeysuckle leaves; all others are Chinese tallow leaves

[b]Phase II samples; all others are Phase I

the indicator of oil, whereas the vanadium to nickel ratio is not as efficient an indicator.

Therefore, the trace metal analyses were directed towards examining the spatial and temporal distribution of vanadium.

In order to first assess the impact of soil contamination upon the amount of vanadium found in foliage, the vanadium to aluminum ratios of foliage collected during Phases I and IV were compared with the vanadium to aluminum ratios of soils in the area. The results are presented in Table 8.2-22. As indicated by this table, the average vanadium to aluminum ratio in Phase I is 23×10^{-3}, while it is 2×10^{-3} in Phase IV and 1.5×10^{-3} in the soils (Table 8.2-19). This indicates that the elevated levels of vanadium found during Phase I is nonsoil vanadium. Next, the vanadium concentrations found in Chinese tallow leaves at various stations in Phase I and IV were regressed (Figure 8.2-35).

The vertical distance between these two regression lines is the amount of vanadium (units = nanograms vanadium per square centimeter) in excess of background levels. The integral of the differences between these two lines is the total excess vanadium (units = nanograms vanadium) deposited between the upper and lower limits of the integration (i.e., between two given distances).

8.2.4.5 Total Fallout Estimates Based On Foliar Vanadium Analysis

Approximately 72,000 barrels of oil escaped from Cavern 6 and 52,000 barrels of that oil were recovered. Thus, approximately 20,000 barrels are unaccounted for, the majority of which is presumed to have been burned in the fire. Given an average vanadium concentration in the oil of 42 ppm, then there are 1.3×10^{5} g of vanadium in 20,000 barrels of oil.

TABLE 8.2-22

VEGETATIONAL VANADIUM - ALUMINUM COMPARISONS
FOR PHASES I AND IV
(µg/g - dry weight)

	PHASE I			PHASE IV		
Site	V	Al	V/Al Ratio ($\times 10^{-3}$)	V	Al	V/Al Ratio ($\times 10^{-3}$)
UNU 1				0.55	295	1.88
UNO 2	20.0	440	45.5			
UNO 3	2.5	81	30.9	0.39	86	2.10
UNO 4	5.61	280	20.0	0.87	458	1.90
UNO 5	9.29	660	14.2	0.67	388	1.73
UNO 6	9.41	451	20.9	ND	217	--
UNO 7 NE	2.08	110	18.9	0.28	129	2.17
UNO 7 SW	5.2	220	23.0			
UNO 8	2.8	140	20.0	0.35	139	2.52
UNO 9	--	56	--	0.24	118	2.03
UNO 10	2.6	155	16.8	0.35	192	1.82
UNO 11	--	136	--			
UNO 12	7.6	440	17.3	0.20	113	1.77
UNO 13	290.0	695	417.0			
UNO 14	3.5	140	25.0	ND	100	--
UNO 15	2.5	100	25.0	0.32	115	2.78
UNO 16						
UNO 17						
UNO 18				0.47	232	2.03
UNO 19				0.48	303	1.58
n	12	15	12	12	14	12
Mean	6.1	274	23.0	0.431	213	2.03
Standard Deviation	5.1	211	8.3	0.193	111	0.34
Coefficient of Variation	84%	77%	36%	45%	52%	17%

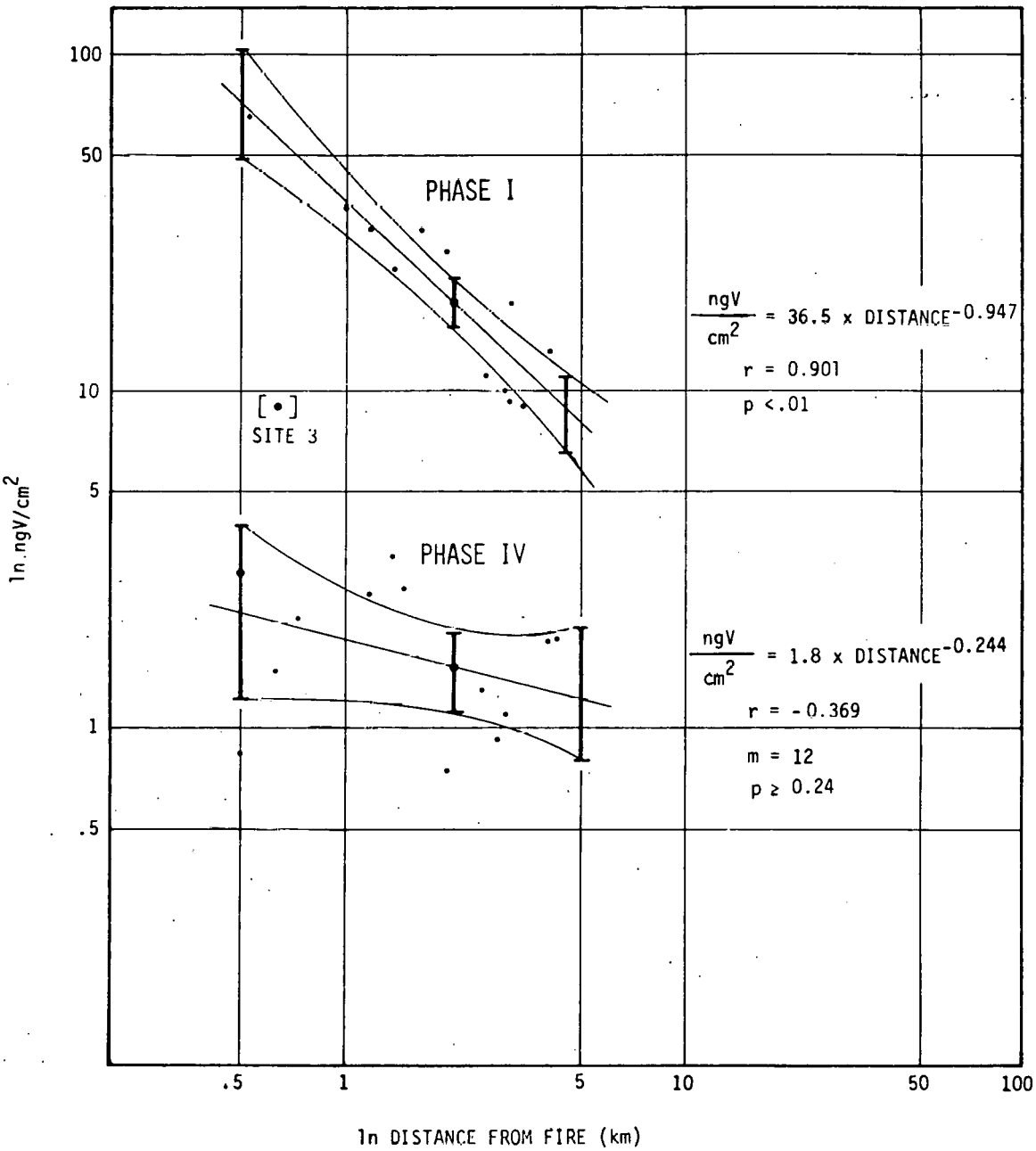


FIGURE 8.2-35 REGRESSION OF FOLIAR VANADIUM CONCENTRATION ON DISTANCE FROM CAVERN 6

If all of the vanadium fell out of the plume onto the vegetation in the study area, then the integral of excess vanadium over the area delineated by the land stations should be approximately 1.3×10^5 g vanadium.

We can express the observed total excess vanadium found between any two distances as a percent of the total amount of vanadium known to be emitted. This serves as a mass balance for vanadium; that is, it is a method of estimating how much vanadium is unaccounted for, i.e., deposited in a place which has not been sampled.

The most remote station sampled during Phase I was approximately 4 km from Cavern 6. The total excess vanadium accounted for by the elevated foliar levels depicted in Figure 8.2-35 within this distance is approximately 15 percent of all the vanadium known to have been lost. Had sampling been carried out to a distance of 10 km, then, based on these regressions, about 25 percent of all the vanadium could be accounted for. This indicates that most of the vanadium (and by inference, all other pollutants) were carried out of the immediate area by the prevailing winds.

8.2.5 Pyrogenic Hydrocarbons

PHASE I

Figures 8.2-36 through 8.2-39 show the distribution of fluoranthene (202), pyrene (202), the chrysene family (228) and the benzopyrene family (252) of polycyclic aromatic hydrocarbons (PAH) in various samples collected during the Phase I sampling period. The PAH profile in foliage Sample 3 (not shown in figures and collected near Cavern 6) indicated that the pyrogenic products produced by the fire were rich in fluoranthene and pyrene. The larger PAH compounds were produced in relatively small quantities when compared with the 202 family of compounds.

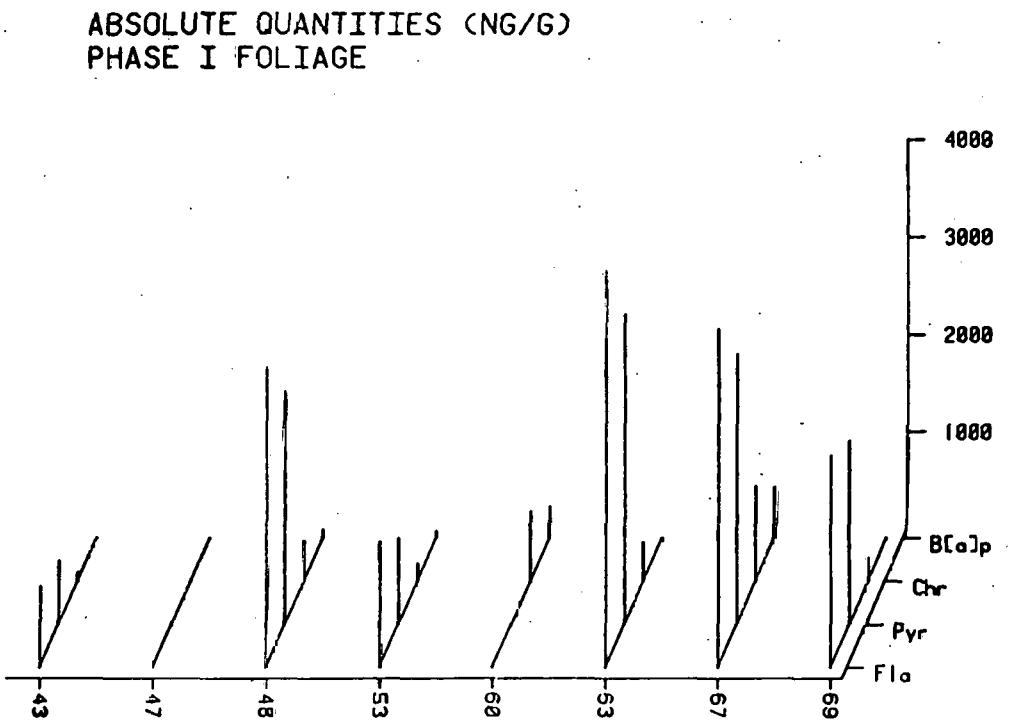


FIGURE 8.2-36 PYROGENIC PRODUCTS IN PHASE I FOLIAGE

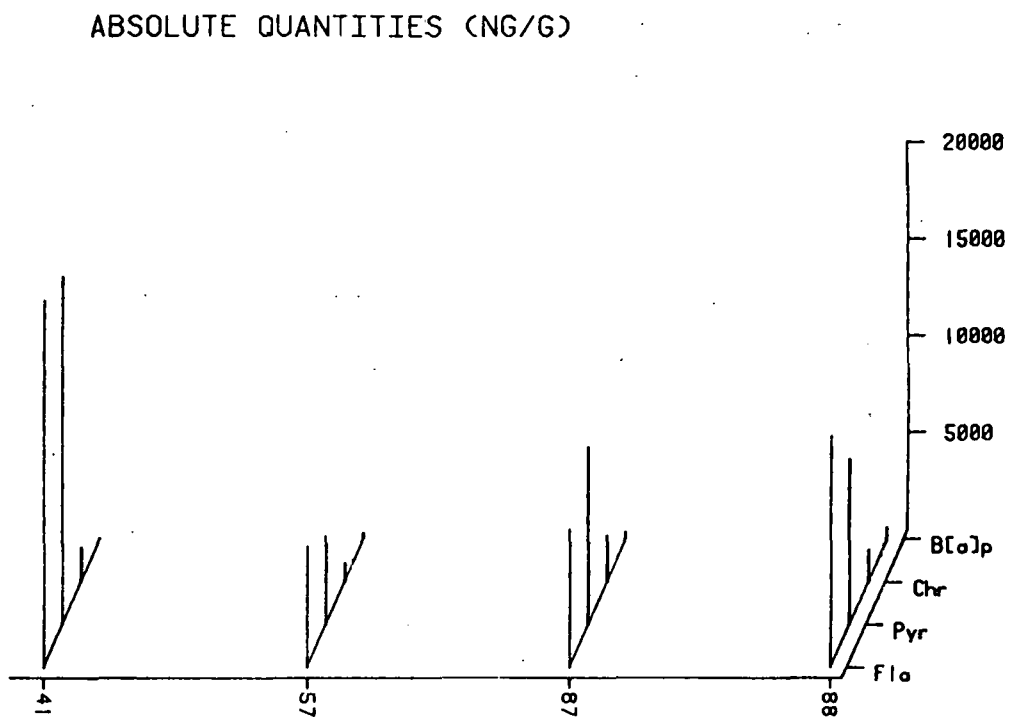


FIGURE 8.2-36 (CONTINUED) PYROGENIC PRODUCTS IN PHASE I FOLIAGE

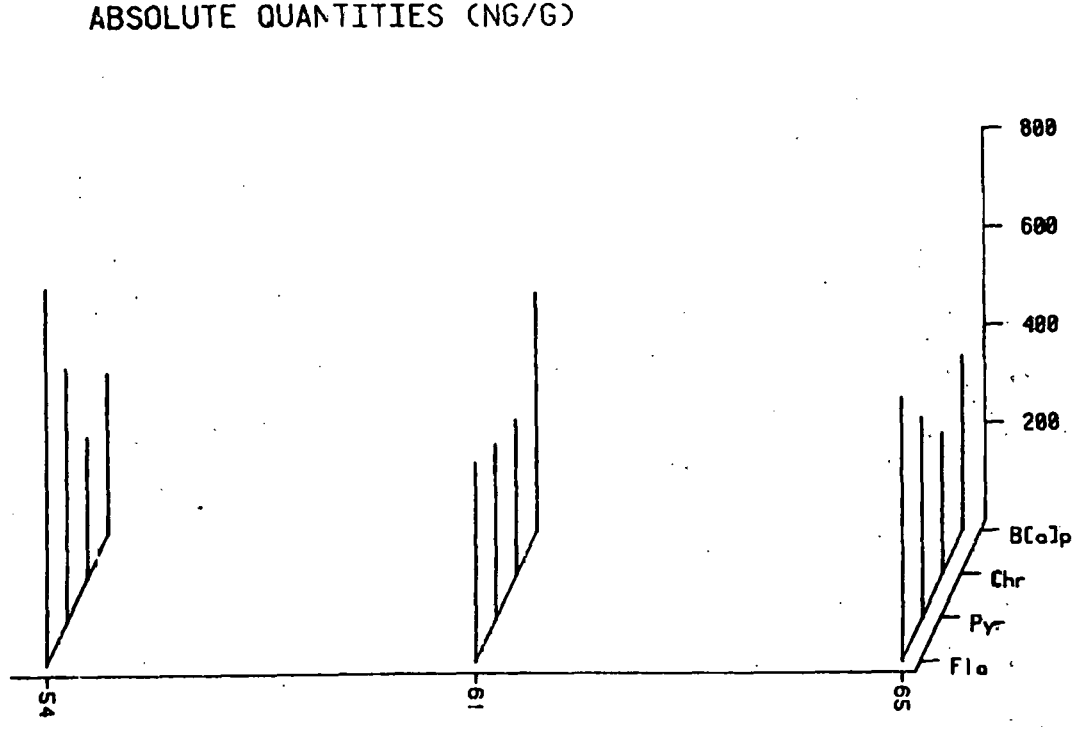


FIGURE 8.2-37 PYROGENIC PRODUCTS IN PHASE I SEDIMENTS IN A NON-IMPACT AREA (CANAL)

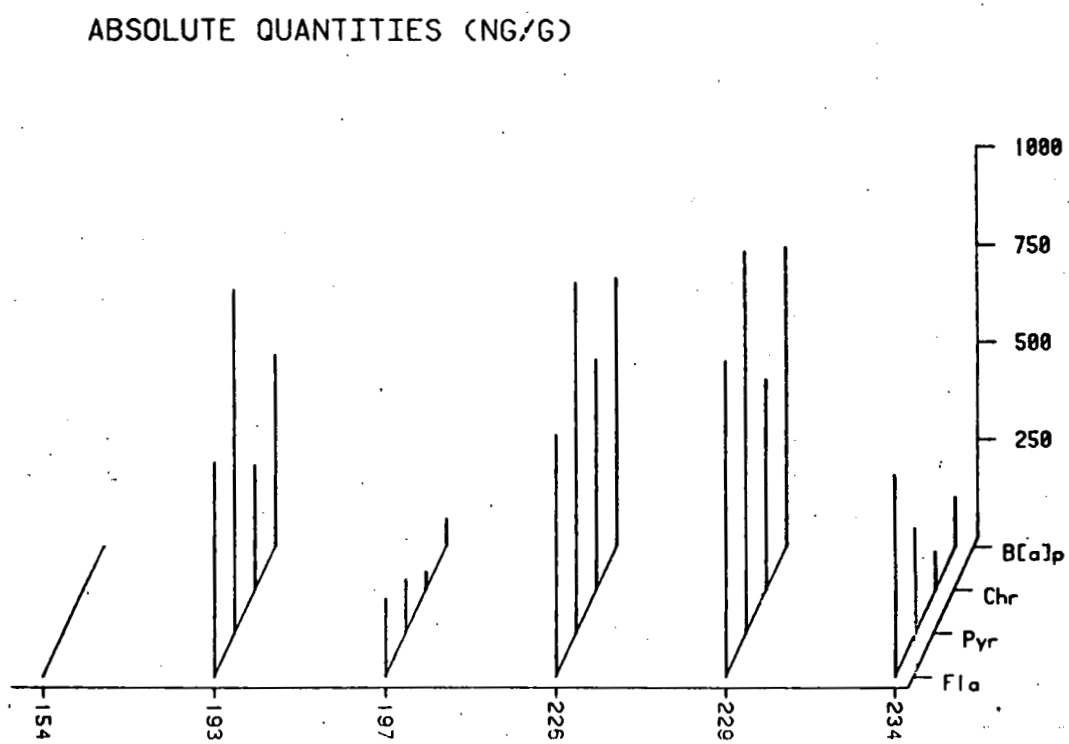


FIGURE 8.2-38 PYROGENIC PRODUCTS IN PHASE I SEDIMENTS IN A NON-IMPACT AREA (LAKE)

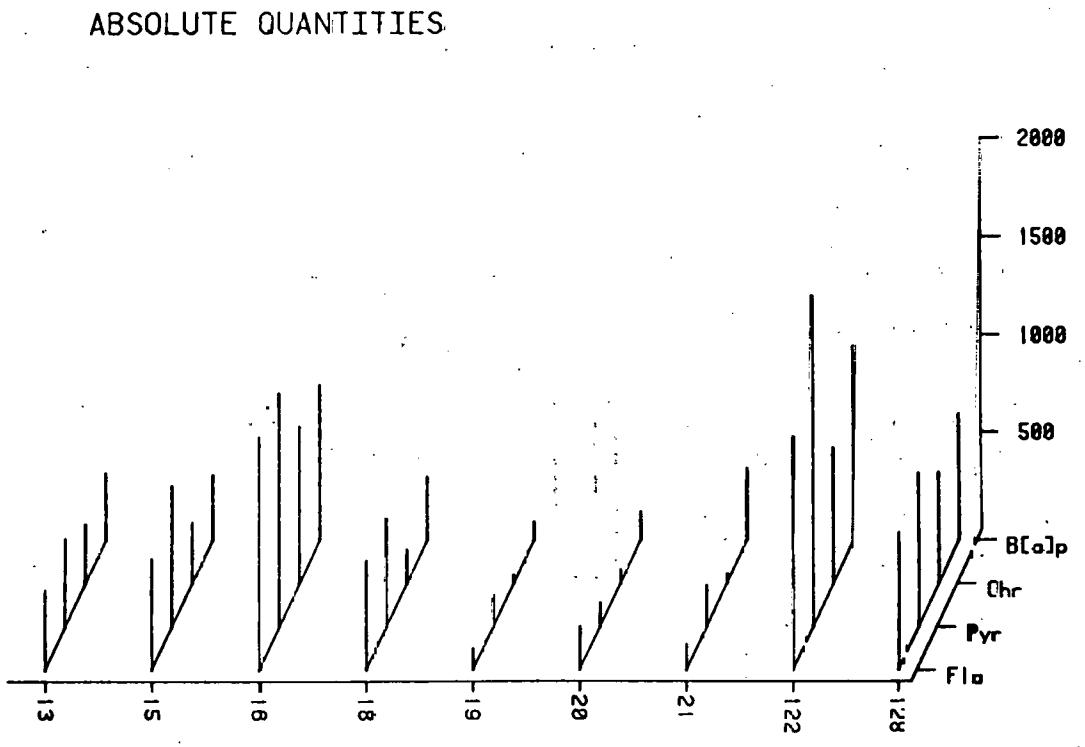


FIGURE 8.2-39 PYROGENIC PRODUCTS IN PHASE I SEDIMENTS IN THE IMPACT AREA

Profiles indicating contamination from the pyrogenic products of the fire were also found in Samples 41, 43, 48, 87 and 88, which were collected at UNO sites, and Samples 53, 57, 63, 67 and 69, which were collected along the north Stark Canal transect. Therefore, detectable fallout of PAH extended at least to the north boundary of the Sabine Wildlife Refuge.

Sediment Samples 54 and 65, collected along the Stark Canal transect, showed relatively elevated levels of fluoranthene and pyrene, indicating contamination from the fire. The sediment samples also contained higher relative levels of the larger PAH. This probably reflected background contamination of these compounds in the West Hackberry area.

Samples collected from Black Lake, but outside the area contaminated by the oil spill (Figure 8.2-38), contained PAH profiles indicative of background contamination in the area. In this profile, pyrene and members of the benzopyrene family were present in equal amounts but larger than those of fluoranthene and members of the chrysene family, which were also present in equal amounts. Sample 234 (Site 30-12-C) contained a PAH profile indicating contamination from the fire. The PAH distribution in samples collected from the area impacted by the oil spill (Figure 8.2-39) indicated relatively little contamination from pyrogenic products of the fire. However, Sample 85 (Site 9-2-C) had elevated levels of pyrogenic products and a PAH distribution indicative of contamination from the fire.

In summary, analysis of Phase I samples for polycyclic aromatic hydrocarbons showed PAH profiles that were characteristic of pyrogenic products from the fire and PAH profiles which indicated background contamination in the West Hackberry area. The pyrogenic contamination from the fire during Phase I extended at least to the north boundary of the Sabine Wildlife Refuge but generally not into the Black Lake area.

PHASE II

Examination of the PAH profiles in Figure 8.2-40 (foliage) showed contamination from the fire products on foliage samples at UNO Sites 1, 4 and 7. Similarly, the PAH profiles in Figure 8.2-41 indicated contamination of fire products in soils at UNO Sites 1, 2, 4 and 7.

Figure 8.2-42 shows the PAH profile for samples from Black Lake collected outside the area impacted by the oil spill. Samples 586, 594, 597, 599, 601, 604, 631, 929, 990 and 1500 had PAH distributions indicative of background contamination. Sample 623 (Site 30-12-C) had possible contamination from the fire. Samples 963 and 964 from the North Control Area had PAH distributions significantly different from the normal background profiles but not as a result of the fire at Cavern 6.

Figure 8.2-43 shows PAH distributions in samples collected in the area of Black Lake impacted by the oil spill. Samples 942, 948, and 949 appear to have been contaminated with products from the fire and Sample 942 had elevated levels of pyrogenic products. Samples 609, 627 and 954 had distributions of pyrogenic products which indicated background contamination. Samples 940, 945, 946 and 957 had PAH distributions different from those produced by the fire or from normal background contamination.

PHASE III

Figure 8.2-44 shows the PAH distribution on foliage samples collected during Phase III. These samples were new spring foliage and, as expected, were not contaminated with PAH on their surface. Figure 8.2-45 shows the PAH distribution in soil samples. Soil Samples 1238, 1239, and 1240 had PAH distributions indicative of contamination from the fire, and Samples 1238 and 1239 had elevated levels of PAH. Since the quantities of PAH in Samples 1424, 1425, 1427 and 1428 were very low, no information as to their sources could be obtained from these samples.

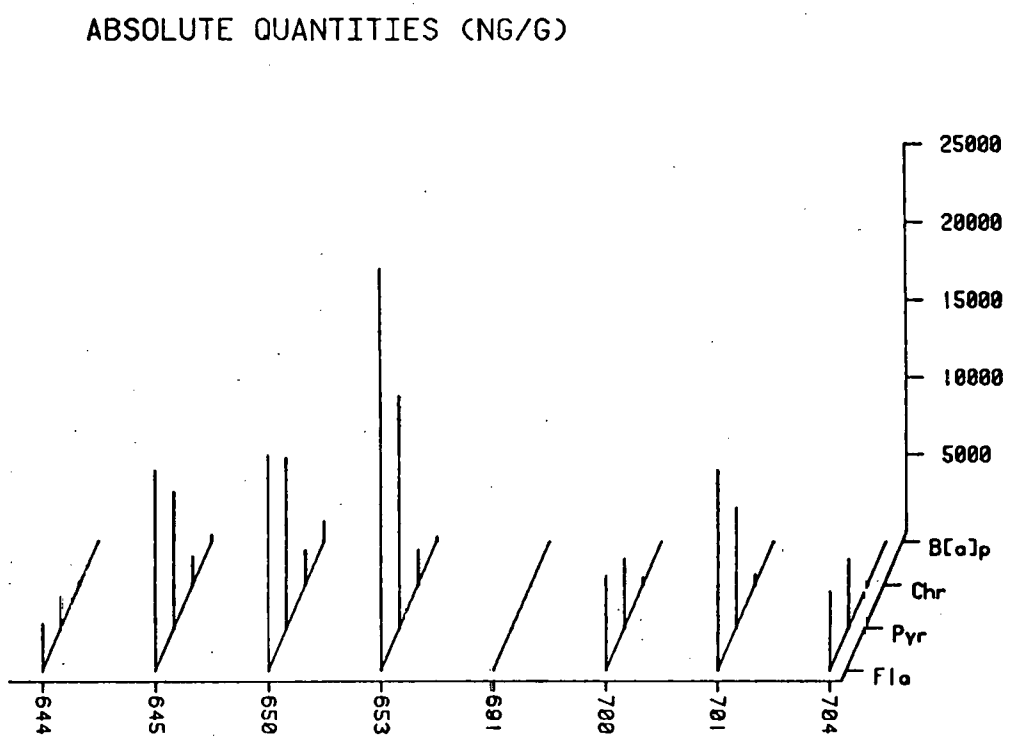


FIGURE 8.2-40 PYROGENIC PRODUCTS IN PHASE II FOLIAGE

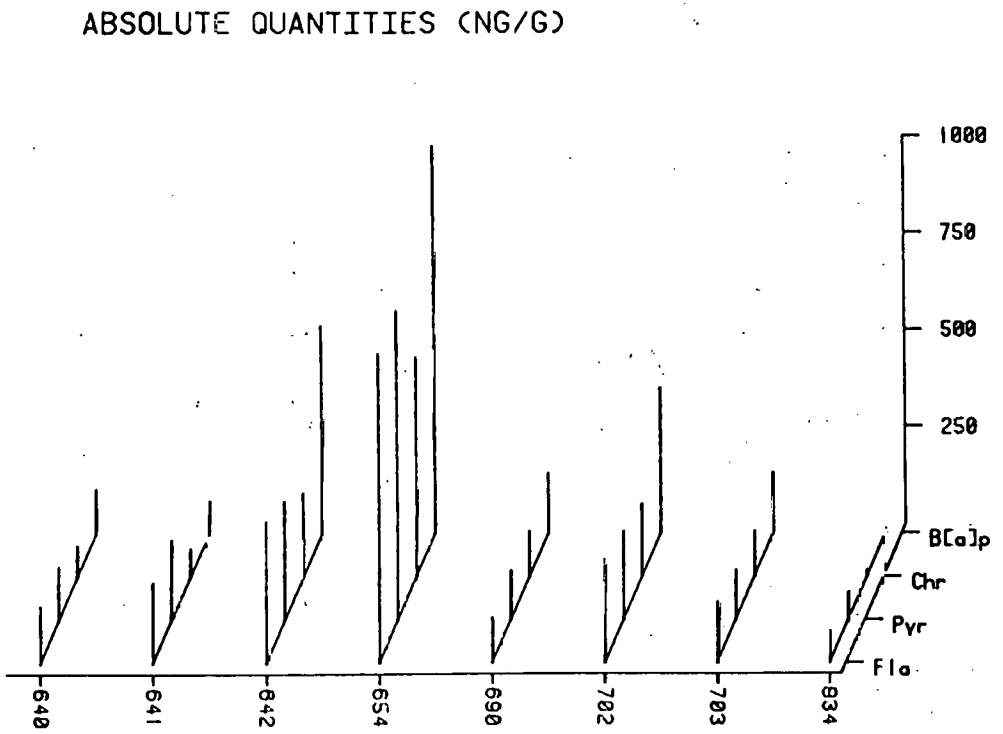


FIGURE 8.2-41 PYROGENIC PRODUCTS IN PHASE II SOILS

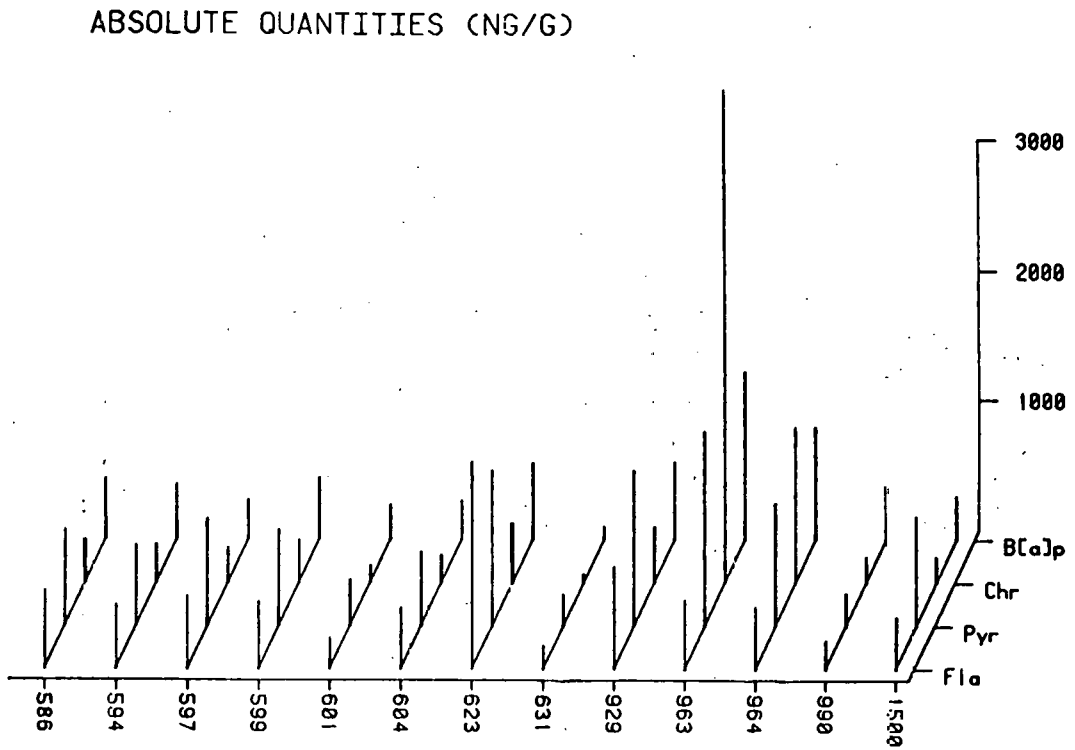


FIGURE 8.2-42 PYROGENIC PRODUCTS IN PHASE II SEDIMENTS IN A NON-IMPACT AREA (LAKE)

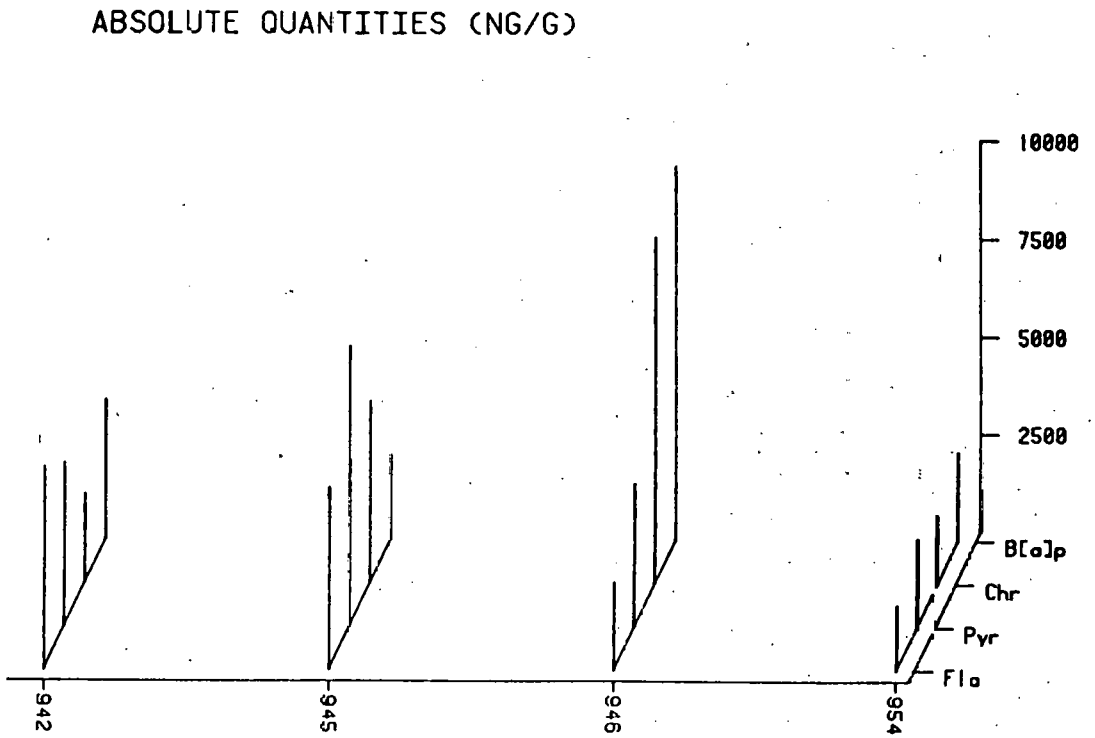


FIGURE 8.2-43 PYROGENIC PRODUCTS IN PHASE II SEDIMENTS IN THE IMPACT AREA

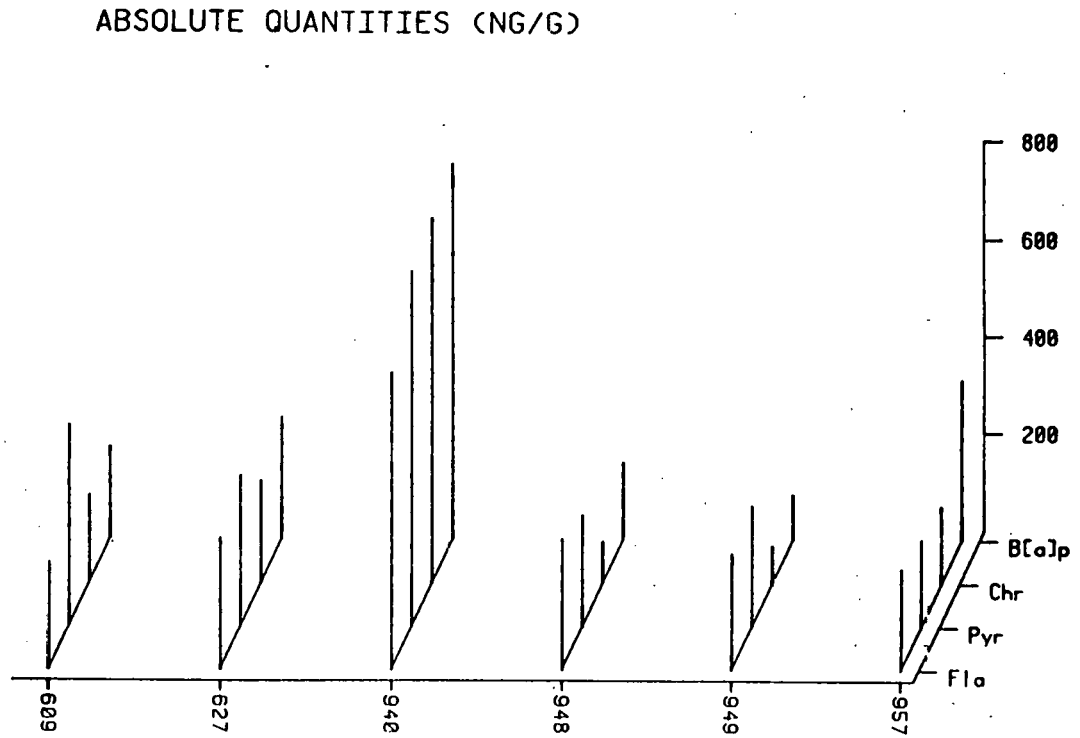


FIGURE 8.2-43 (CONTINUED) PYROGENIC PRODUCTS IN PHASE II SEDIMENTS IN THE IMPACT AREA

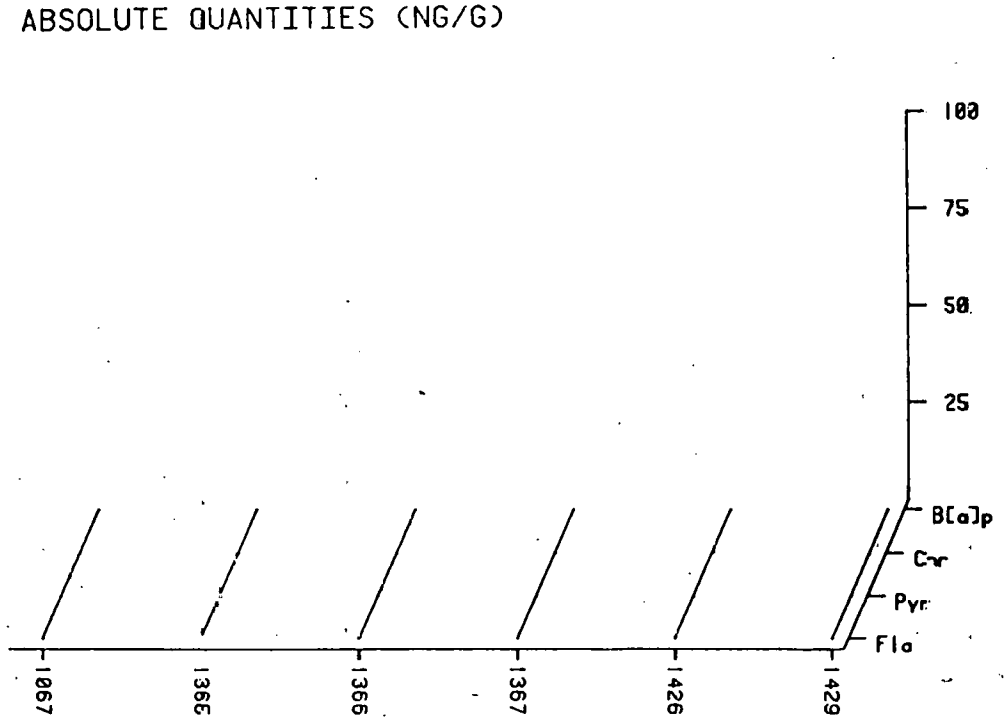


FIGURE 8.2-44 PYROGENIC PRODUCTS IN PHASE III FOLIAGE

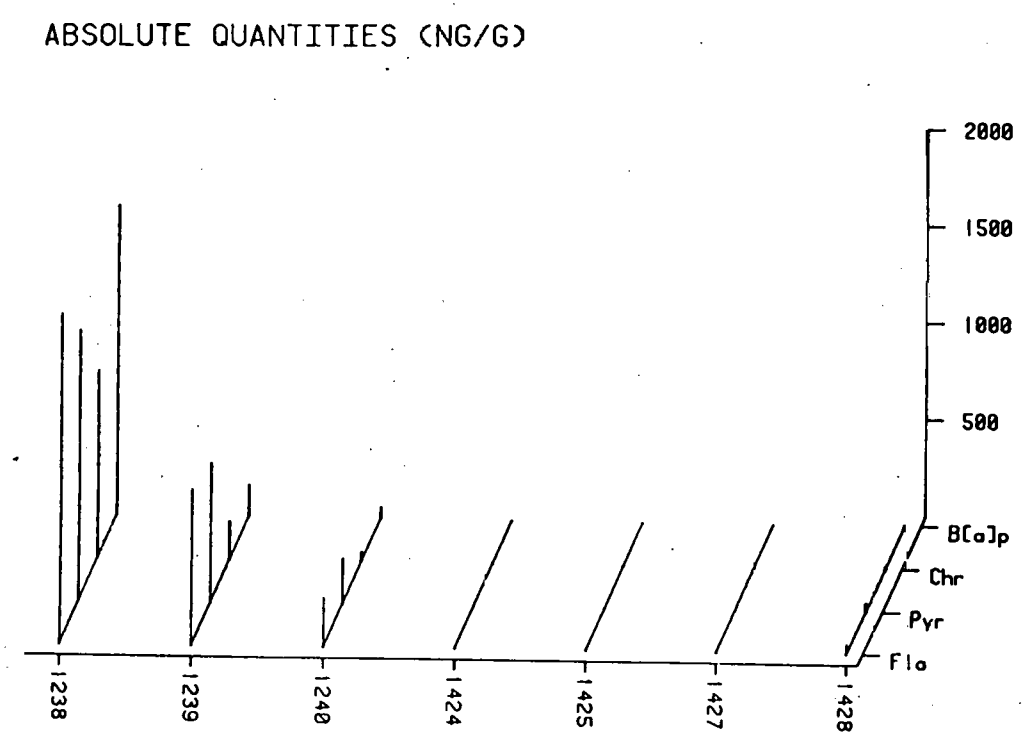


FIGURE 8.2-45 PYROGENIC PRODUCTS IN PHASE III SOILS

Figure 8.2-46 shows the PAH distribution in sediment samples from nonimpacted areas of Black Lake and the Wildlife Refuge. Generally, these samples exhibited PAH profiles indicative of PAH contamination from background sources. Samples 1465 and 1466, however, had relatively elevated levels of fluoranthene and may have been contaminated with particulates from the fire.

The PAH distributions in Figure 8.2-47 generally reflect contamination from background sources even though these samples were collected from areas of Black Lake impacted by the oil spill. Samples 1177, 1247, 1251 and 1254 exhibited profiles characteristic of contamination from the fire. Sample 1247 had elevated PAH levels.

PHASE IV

Figure 8.2-48 shows the PAH distribution in Phase IV soil samples. Generally, the quantities of PAH are very low and no definitive qualitative information can be obtained from these profiles. Sample 1519 (UNO Site 7), not shown in Figure 8.2-48, contained much higher levels of PAH than the surrounding area, and their distribution indicated the fire as their source.

The PAH distributions shown in Figure 8.2-49 from Black Lake samples collected in nonimpacted zones indicated Samples 1657, 1665, 1679 and 1683 were contaminated from the fire. Samples from these areas were not contaminated with PAH from the fire in previous sampling phases. These data may indicate particulate PAH contamination from the fire was spread by various physical processes into areas not contaminated at the time of the fire. The contamination from the fire found in Phase IV was, however, relatively low and difficult to distinguish from background contamination.

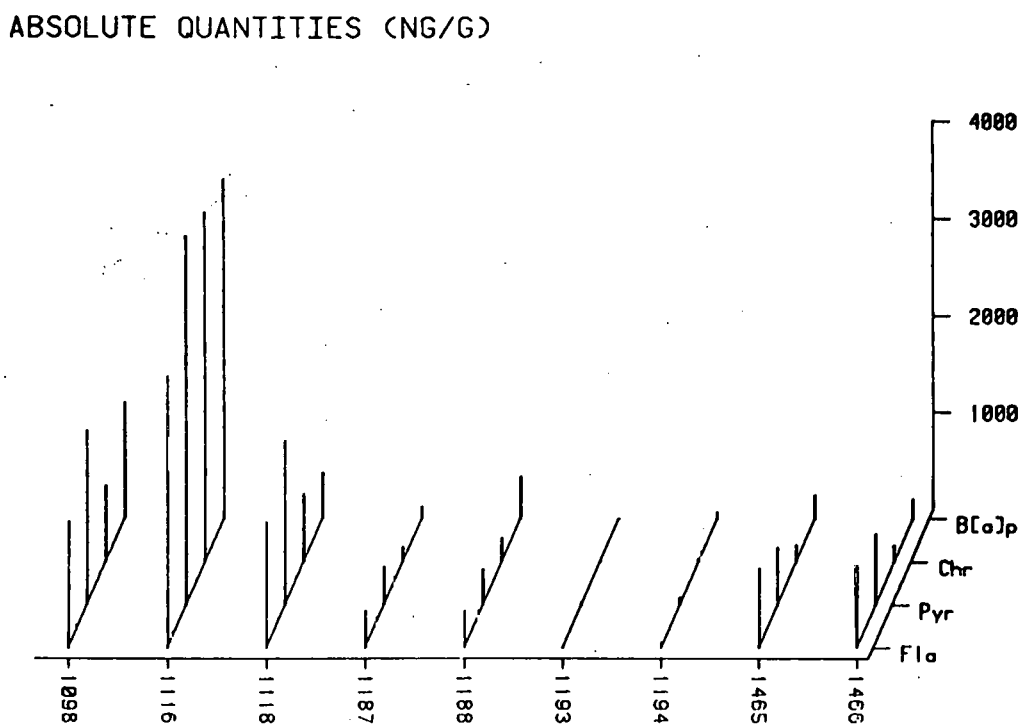


FIGURE 8.2-46 PYROGENIC PRODUCTS IN PHASE III SEDIMENTS IN A NON-IMPACT AREA (LAKE AND WILDLIFE REFUGE)

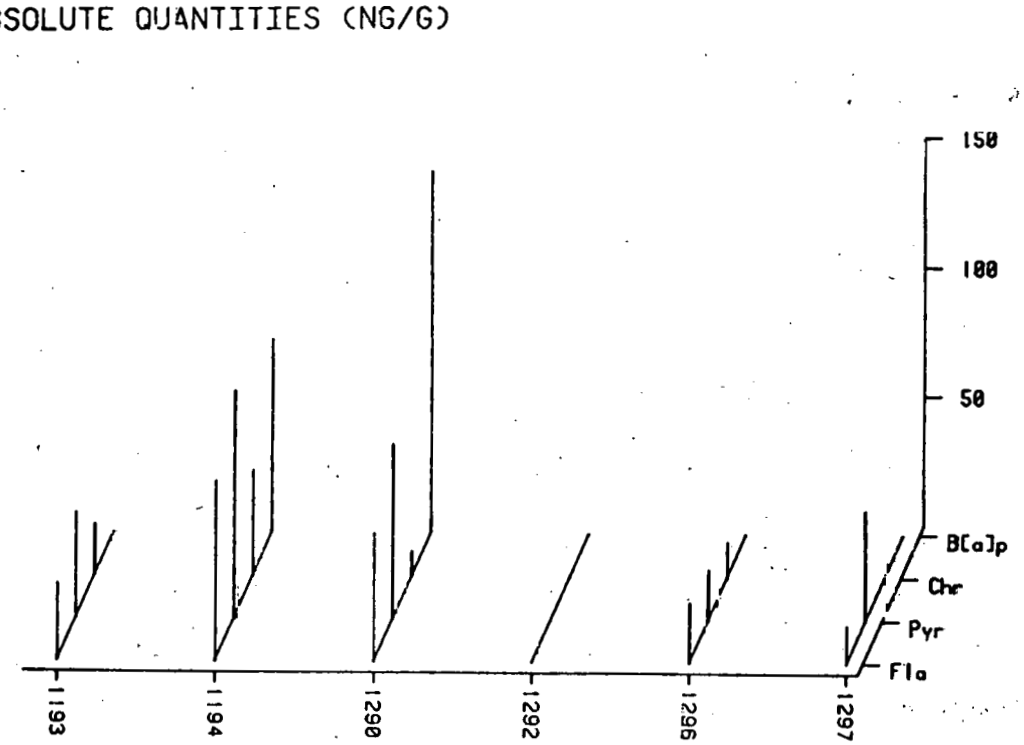


FIGURE 8.2-46 (CONTINUED) PYROGENIC PRODUCTS IN PHASE III SEDIMENTS IN A NON-IMPACT AREA (LAKE AND WILDLIFE REFUGE)

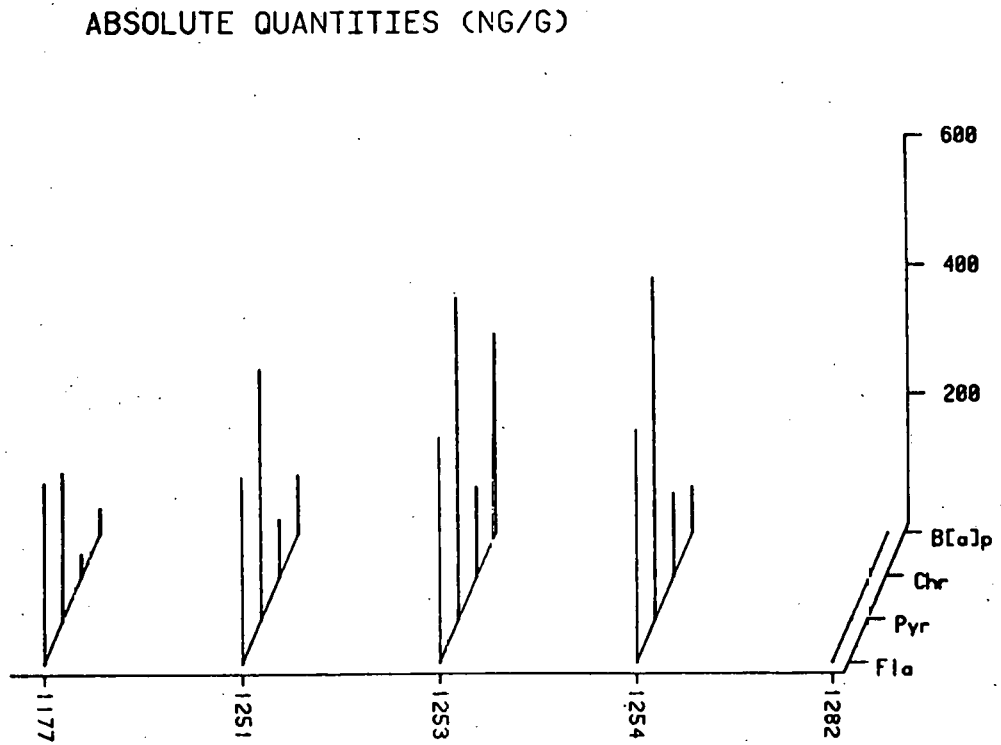


FIGURE 8.2-47 PYROGENIC PRODUCTS IN PHASE III SEDIMENTS IN THE IMPACT AREA

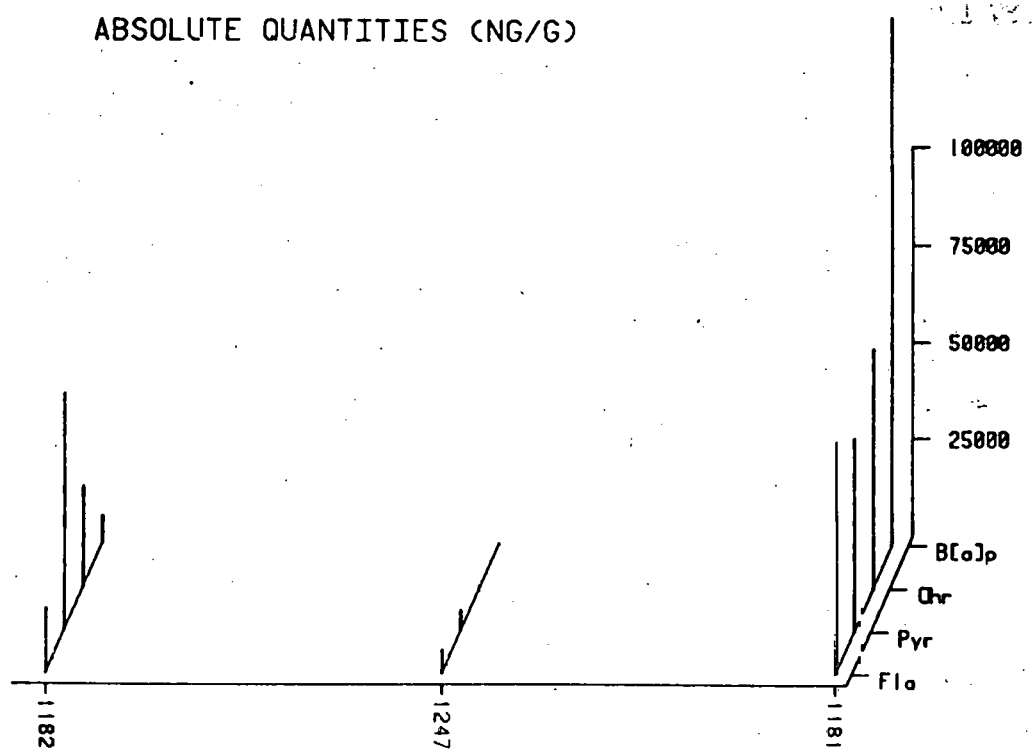


FIGURE 8.2-47 (CONTINUED) PYROGENIC PRODUCTS IN PHASE III SEDIMENTS IN THE IMPACT AREA

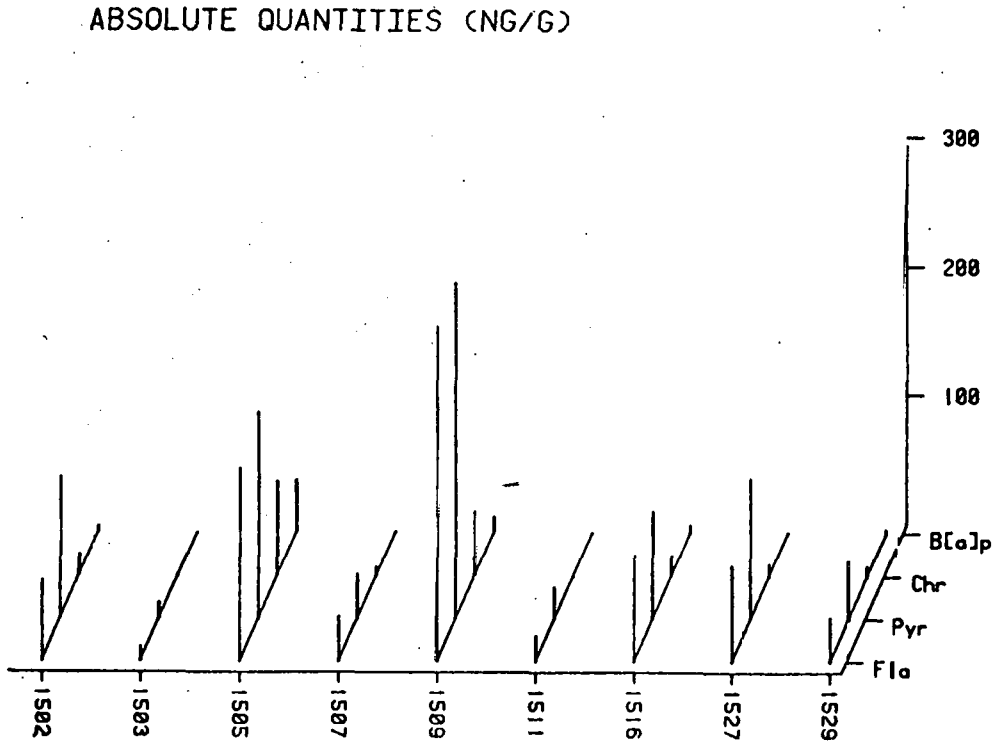


FIGURE 8.2-48 PYROGENIC PRODUCTS IN PHASE IV SOILS

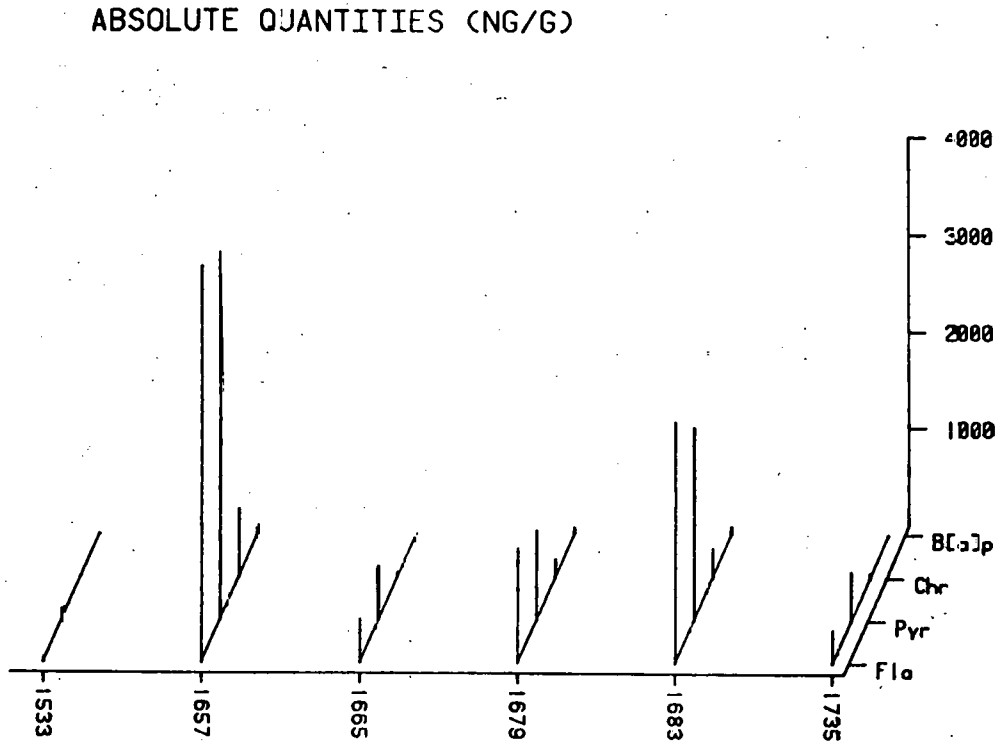


FIGURE 8.2-49 PYROGENIC PRODUCTS IN PHASE IV SEDIMENTS IN A NON-IMPACT AREA (LAKE)

Figure 8.2-50 shows the PAH distribution from the impacted area of Black Lake. Only background contamination was generally detected in these samples.

Tables C.6-5 through C.6-8 in Appendix C give the quantities of the individual pyrogenic products or the family of pyrogenic products for all samples analyzed by this laboratory. Table C.6-9, also in Appendix C, gives the average value for each pyrogenic product or family of pyrogenic products for each area.

8.2.6 Comparison of Trace Metal and Chemical Analyses

As a first approximation, it can be assumed that the pyrogenic compounds (i.e., fluoranthene) physically behaved in a manner similar to vanadium after the oil's combustion and were closely associated during the downwind travel of the resulting smoke particles. This implies that any changes in the fire temperature and/or changes in the fire air/fuel ratio affected the rates of formation of fluoranthene and the rate of mobilization or chemical change of vanadium to the same extent. It also is assumed that the vanadium and fluoranthene traveled downwind on the same type of particles and were deposited on vegetation at the same rate.

Given these assumptions, the concentrations of vanadium and fluoranthene on vegetation downwind from the fire can be compared. Table 8.2-23 shows the observed concentrations of vanadium and fluoranthene at the land stations where both were measured during Phase I, the distance from the fire, and the vanadium to fluoranthene ratio at each site. Both materials tended to vary together and decreased with increasing distance from the fire. The correlation between vanadium and fluoranthene was +0.752 ($p = 0.14$).

The regressions of both vanadium and fluoranthene on distance can be expressed in the form: $\text{concentration} = a \times \text{distance}^b$, where b had

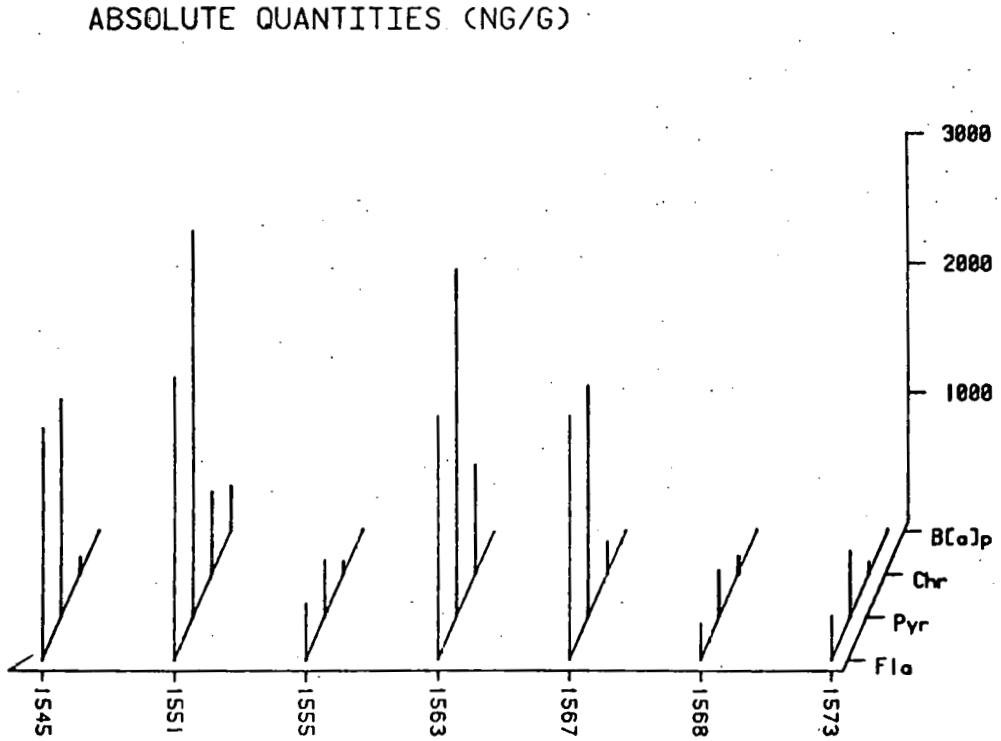


FIGURE 8.2-50 PYROGENIC PRODUCTS IN PHASE IV SEDIMENTS IN THE IMPACT AREA

TABLE 8.2-23

COMPARISON OF TRACE METAL AND CHEMICAL ANALYSES

PHASE I - VEGETATION

SITE	DISTANCE (km)	VANADIUM (ppm)	FLUORANTHENE (ppm)	V/F
2	0.53	20.0	19.0	1.05
3	0.64	2.5	0.84	3.0
5	1.2	7.8	3.1	2.5
7 NE	3.1	2.1	7.2	0.29
7 SW	3.1	5.1	12.0	0.43
14	4.1	3.5	N/A	--
SNR-4	5.2	N/A	4.1	--
SNR-5	5.3	N/A	3.5	--

Correlation of vanadium (ppm) with fluoranthene (ppm) = +0.752

$p = 0.14$

Regression of vanadium with distance: $V\ (ppm) = 10 \times Distance^{-.92}$

Regression of fluoranthene with distance: $F\ (ppm) = 9.3 \times Distance^{-.38}$

a negative value (-0.92 and -0.38, respectively). It was noted that fluoranthene did not fall out as fast as vanadium with increasing distance. This differential rate of decrease, however, was probably spurious; the limited sample locations varied in distance from the plume centerline, and deposition rates varied with meteorological conditions.

The association of elevated vanadium and pyrogenic aromatic compound levels supported the link between these contaminants and the Cavern 6 fire. Although elevated pyrogenic product levels in the environment can result from any fire, only a fire fed by petroleum containing relatively large amounts of vanadium (such as the Cavern 6 crude oil) would produce both elevated vanadium and pyrogenic product levels, as was observed.

8.3 PHYSICAL

8.3.1 Grain Size Analysis

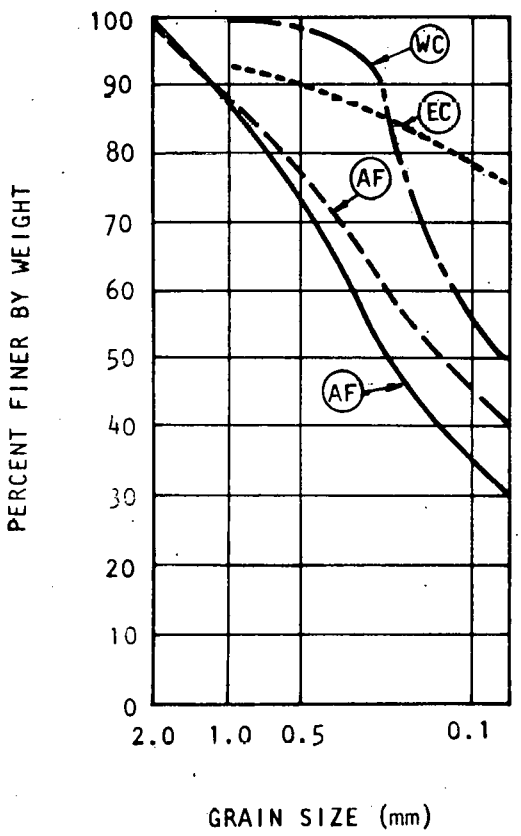
Cumulative percent grain size distributions are presented for the lake and marsh areas in Figures 8.3-1 and 8.3-2, respectively. Lake sediments in the West Control Area were considerably finer than those in the Affected Area. Approximately 5 percent of the West Control sediment was coarser than fine sand, whereas approximately 30 percent of the Affected Area sediment was that coarse. Clay outcrops occasionally prevented sample collection with the grab sampler at the West Control Area, and the depth of penetration of the sampler in this area was usually less than at the other two sites.

Marsh sediments were equally variable. The West Control Area marsh was composed predominantly of fine sand. The Affected Area marsh was characterized by roughly equal proportions of fine sand and silt. The East Control Area marsh had little fine or medium sand, and had sediments consisting of approximately 50 percent silt or clay and 20 percent coarse sand.

Several large pits were dug in an area west of Wellpad 6 for temporary storage of oil recovered from Black Lake. Permeability of clay strata in this area was very low. Oil penetration of the pit walls was less than 0.25 inch. The same clay strata were excavated just south of this area for use as dike material during construction of the site. Groundwater contamination from the temporary storage area was considered to be insignificant.

8.3.2 Meteorology

A large area of high pressure dominated the eastern half of the nation during the West Hackberry oil spill and fire. In southern

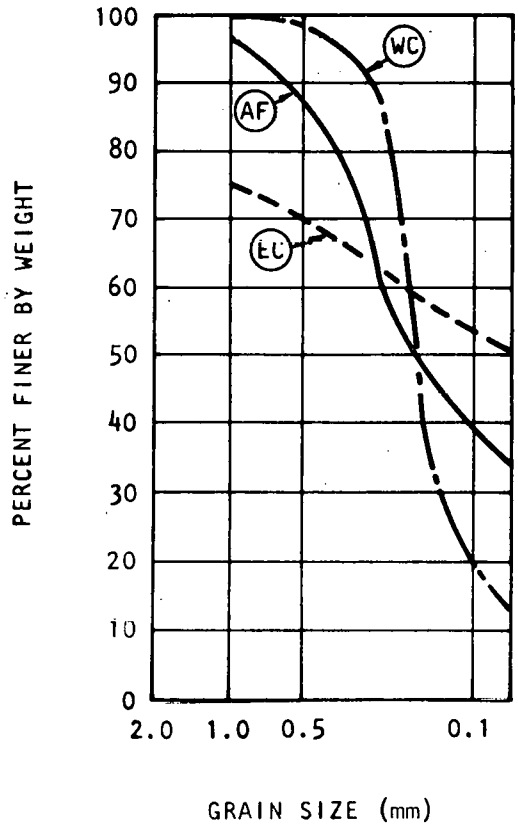


LEGEND:

AF - AFFECTED AREA
EC - EAST CONTROL
WC - WEST CONTROL

SAND		SILT OR CLAY
MEDIUM	FINE	

FIGURE 8.3-1 CUMULATIVE PERCENT GRAIN SIZE DISTRIBUTIONS FOR BLACK LAKE SEDIMENTS



LEGEND:

AF - AFFECTED AREA
EC - EAST CONTROL
WC - WEST CONTROL

FIGURE 8.3-2 CUMULATIVE PERCENT GRAIN SIZE DISTRIBUTIONS FOR MARSH SEDIMENTS

Louisiana, this airmass was characterized by persistent northeasterly winds that brought cooler temperatures to the area for about one week. Meteorological data concurrent with the oil spill and fire were obtained from the National Weather Service (Station 72240) at Lake Charles, Louisiana. Daily average and extreme temperatures are presented in Table 8.3-1. The wind data were analyzed to determine the frequency distribution of wind speed and direction during the fire. This information, in the form of both raw and relative frequencies, is presented in Tables 8.3-2 and 8.3-3. A graphical representation of this wind distribution is shown in the wind rose of Figure 8.3-3, with an annual wind rose for comparison. Upper level winds below the 850 millibar level at Lake Charles were directionally consistent with surface winds.

Figure 8.3-4 is an annotated plot of hourly wind speed and direction during the oil spill and fire compiled from measurements at Lake Charles and onsite Meteorological Station 2. The data indicated that winds were calm during the initial hours of the accident, but rapidly became more intense and persistent from the northeast until October 1, 1978. On this date, the effects of the high pressure area had diminished, temperatures had increased, and the sea breeze was re-established. The sea breeze can be observed in the diurnal variation of wind direction on October 1-2, 1978.

Wind frequency distributions also were compiled for the 3-month period from September 29, 1978, to December 27, 1978, for the three onsite meteorological stations shown in Figure 7.2-2. Both raw and relative frequency distributions for all three onsite meteorological stations are provided in Tables 8.3-4 through 8.3-9. More detailed wind distributions are found in Appendix D. Of particular interest in these distributions was the anomalous high frequency of calms measured at Meteorological Station 2. This condition may have resulted from the partially offsetting effects of the Gulf sea breeze and the lake

TABLE 8.3-1

TEMPERATURE DURING THE WEST HACKBERRY CAVERN 6 OIL SPILL AND FIRE [a] (°C)

Date	Maximum	Minimum	Average
21 Sep 78	31.1	22.2	26.7
22 Sep 78	30.6	21.1	25.8
23 Sep 78	28.9	20.0	24.4
24 Sep 78	28.3	19.4	23.9
25 Sep 78	28.9	17.2	23.1
26 Sep 78	29.4	19.2	24.4
27 Sep 78	27.2	20.6	23.9
28 Sep 78	23.9	21.1	22.5
29 Sep 78	27.2	19.4	23.3
30 Sep 78	31.1	20.0	25.6
1 Oct 78	33.9	21.7	27.8
2 Oct 78	32.2	21.7	26.9
Mean	29.4	20.3	24.9

(a) Temperature data were measured at Lake Charles, Louisiana, station 72240, for the period September 21, 1978, through 1200 CST, September 29, 1978. Subsequent temperature data were measured at Meteorological Station 2 at the West Hackberry site.

TABLE 8.3-2

RAW FREQUENCY DISTRIBUTION OF WINDS
DURING THE WEST HACKBERRY FIRE
LAKE CHARLES DATA, SEPTEMBER 21-27, 1978

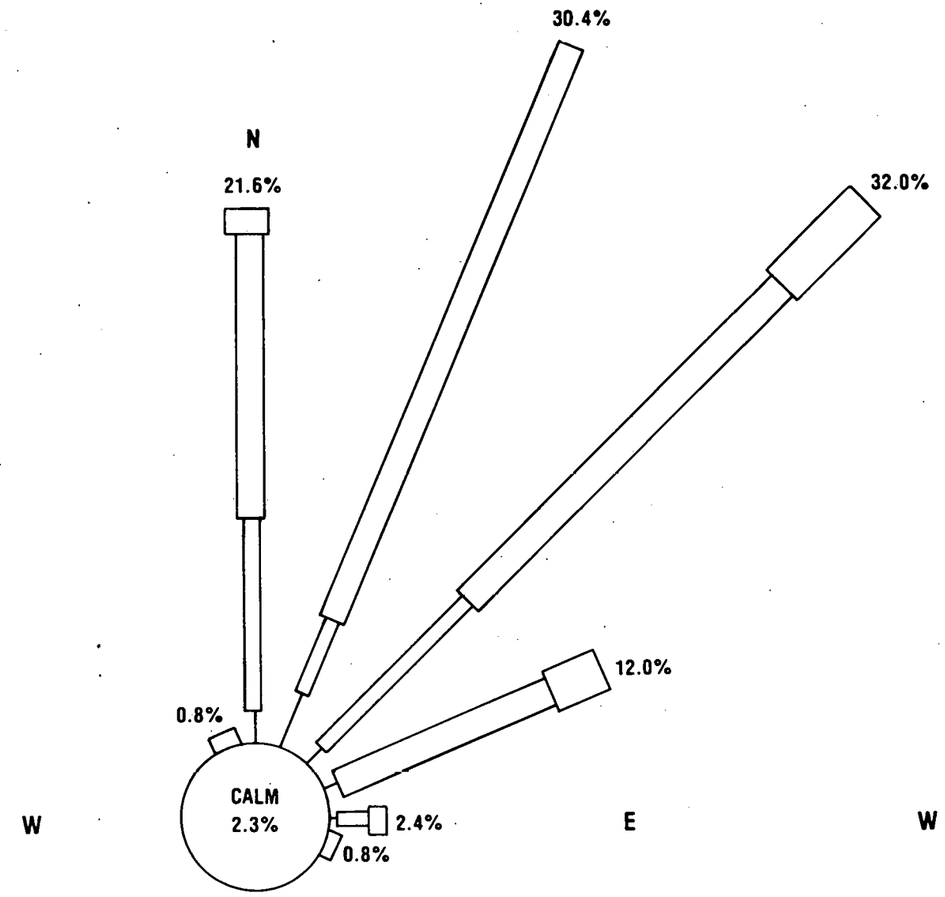
	Speed (kts)							
Direction	1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	1	10	15	1			27	7.1
NNE	2	4	32				38	7.8
NE		11	23	6			40	8.3
ENE			12	3			15	9.5
E		2	1				3	6.1
ESE			1				1	8.5
SE								
SSE								
S								
SSW								
SW								
WSW								
W								
WNW								
NW								
NNW		1					1	
Total	3	28	84	10			124	8.0
				Number of Hourly Observations of Calm			3	
				Total Number of Hourly Observations			127	

TABLE 8.3-3

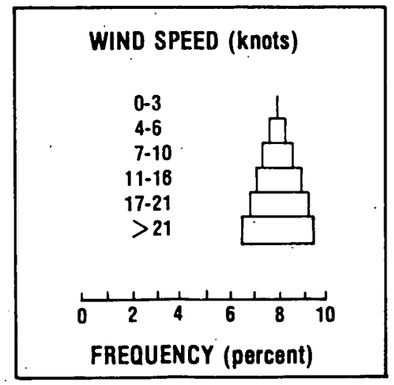
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
DURING THE WEST HACKBERRY FIRE
LAKE CHARLES DATA, SEPTEMBER 21-27, 1978

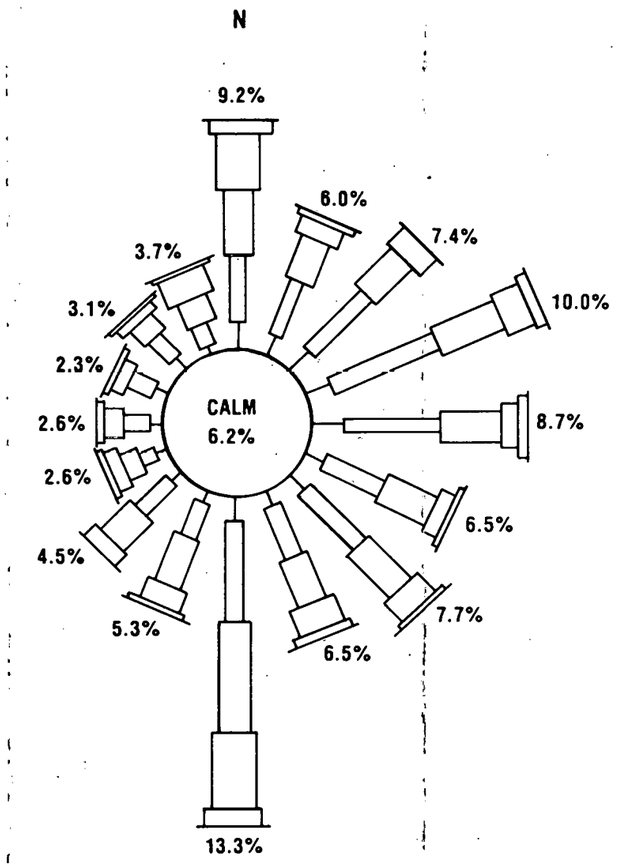
	Speed (kts)						
Direction	0-3	4-6	7-10	11-16	17-21	>21	Total
N	0.015625	0.078125	0.117188	0.007813			0.218751
NNE	0.031250	0.031250	0.250000				0.312500
NE		0.085938	0.179688	0.046875			0.312500
ENE			0.093750	0.023438			0.117188
E		0.015625	0.007813				0.023438
ESE			0.007813				0.007813
SE							
SSE							
S							
SSW							
SW							
WSW							
W							
WNW							
NW							
NNW		0.007813					0.007813
Total	0.046875	0.218751	0.656250	0.078126			1.00000
				Relative Frequency of Calms Distributed Above			0.002344

Blank



WIND ROSE
DURING WEST HACKBERRY FIRE
LAKE CHARLES
SEPTEMBER 21-27, 1978





ANNUAL WIND ROSE
LAKE CHARLES
1966-1970

FIGURE 8.3-3

COMPARISON OF WIND ROSE DATA
LAKE CHARLES, LOUISIANA

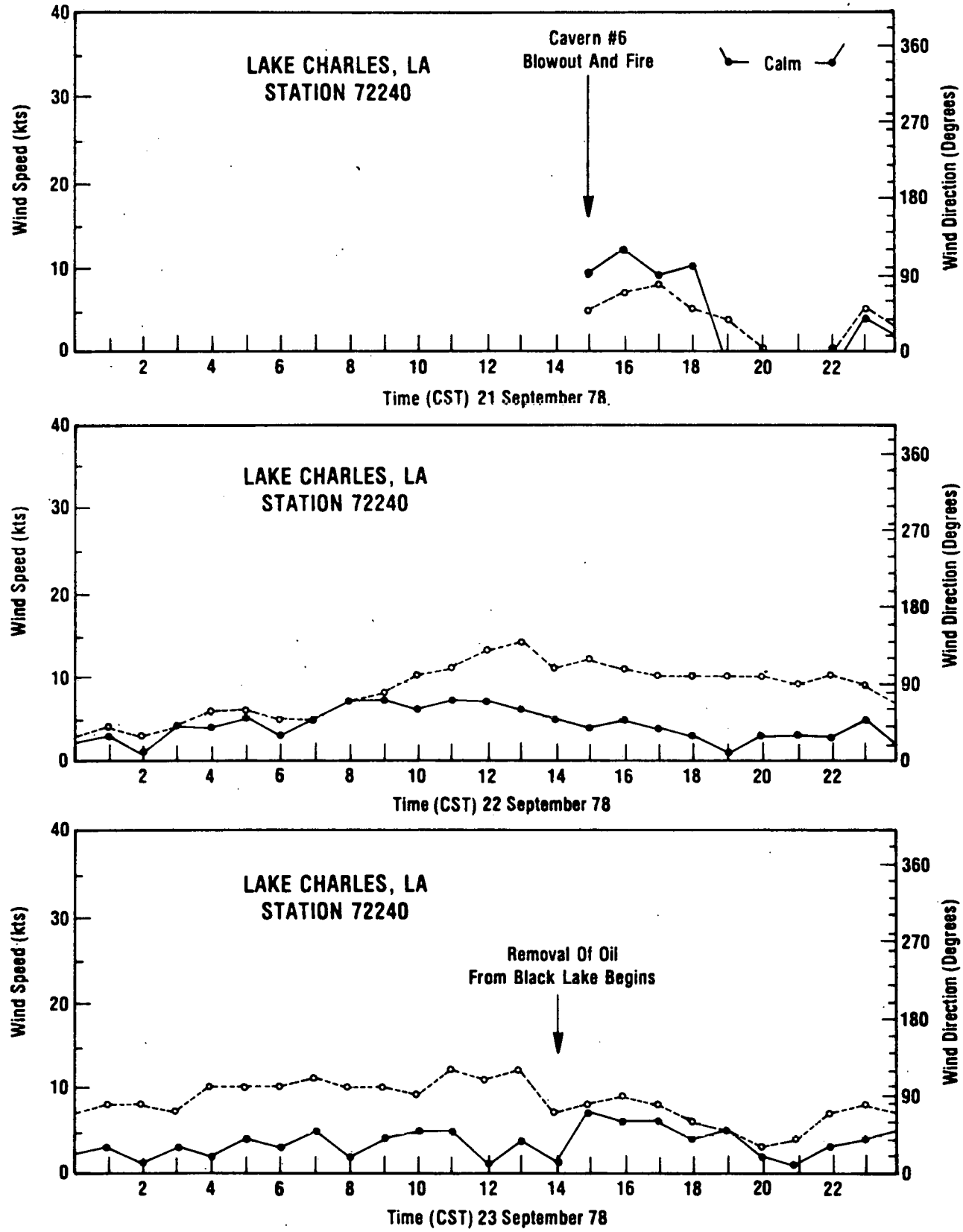


FIGURE 8.3-4
WIND SPEED (DASHED) AND DIRECTION (SOLID) DURING THE WEST HACKBERRY CAVERN 6 FIRE & SPILL

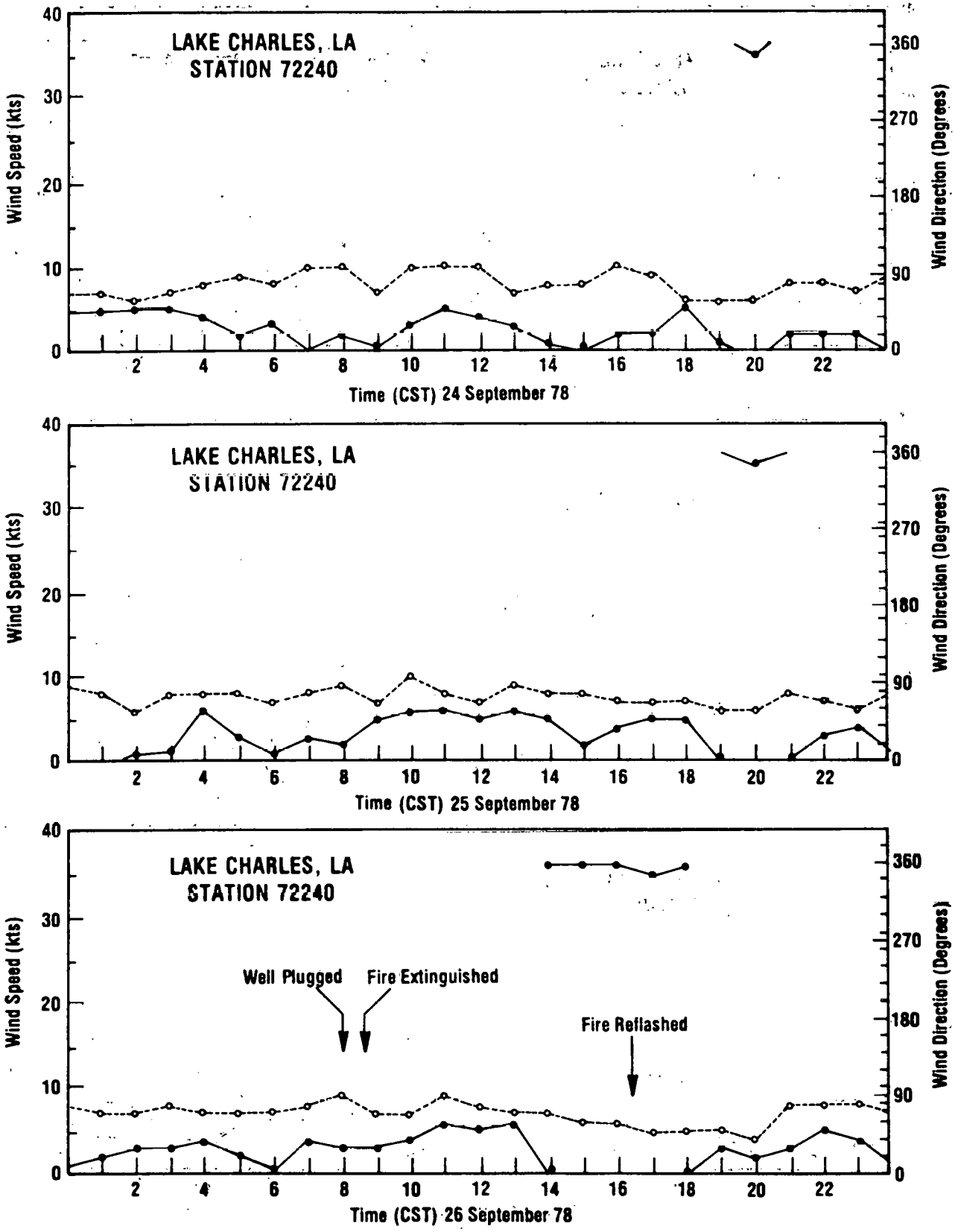


FIGURE 8.3-4 (CONT.)
WIND SPEED (DASHED) AND DIRECTION (SOLID) DURING
THE WEST HACKBERRY CAVERN 6 FIRE & SPILL

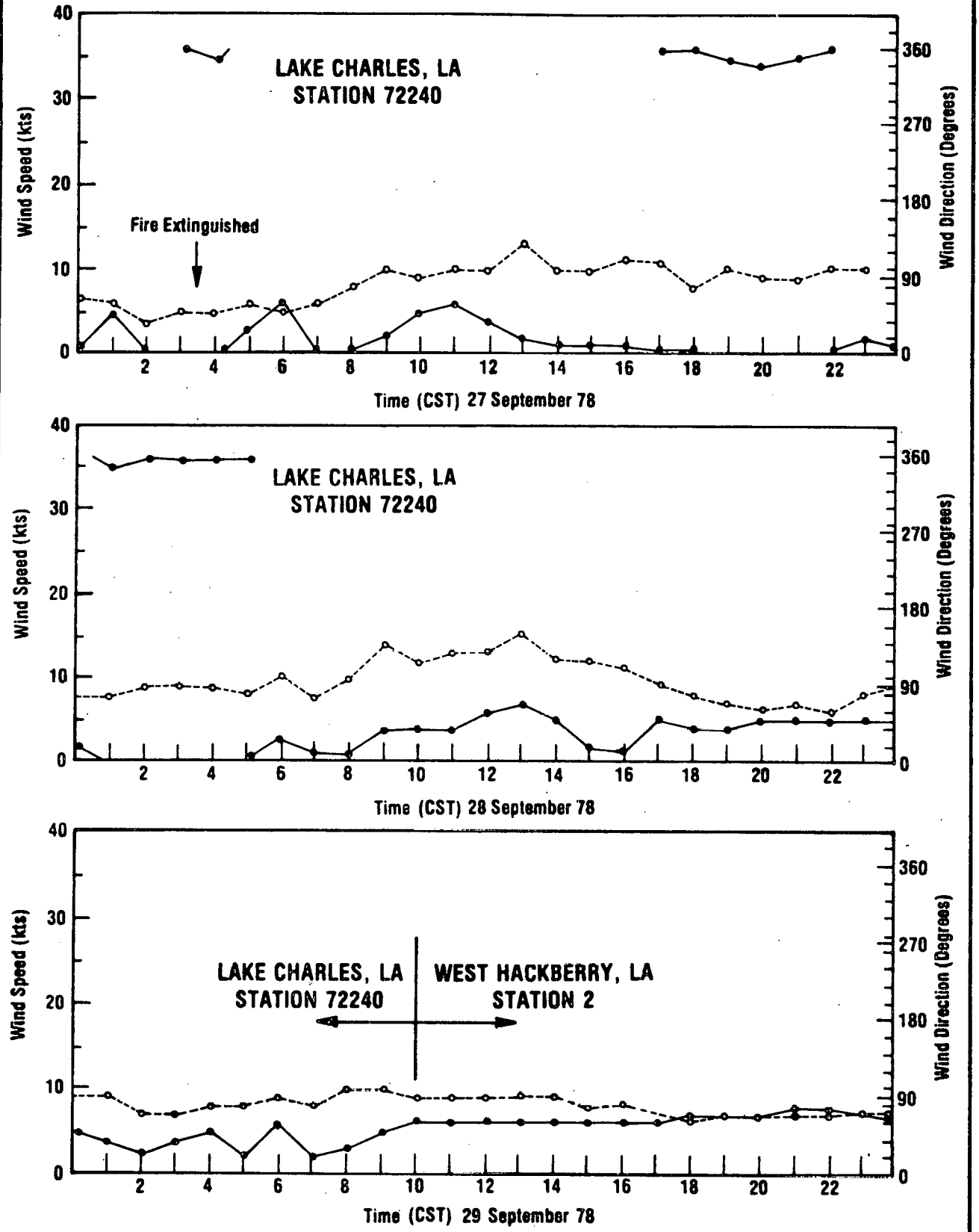


FIGURE 8.3-4 (CONT.)
WIND SPEED (DASHED) AND DIRECTION (SOLID) DURING
THE WEST HACKBERRY CAVERN 6 FIRE & SPILL

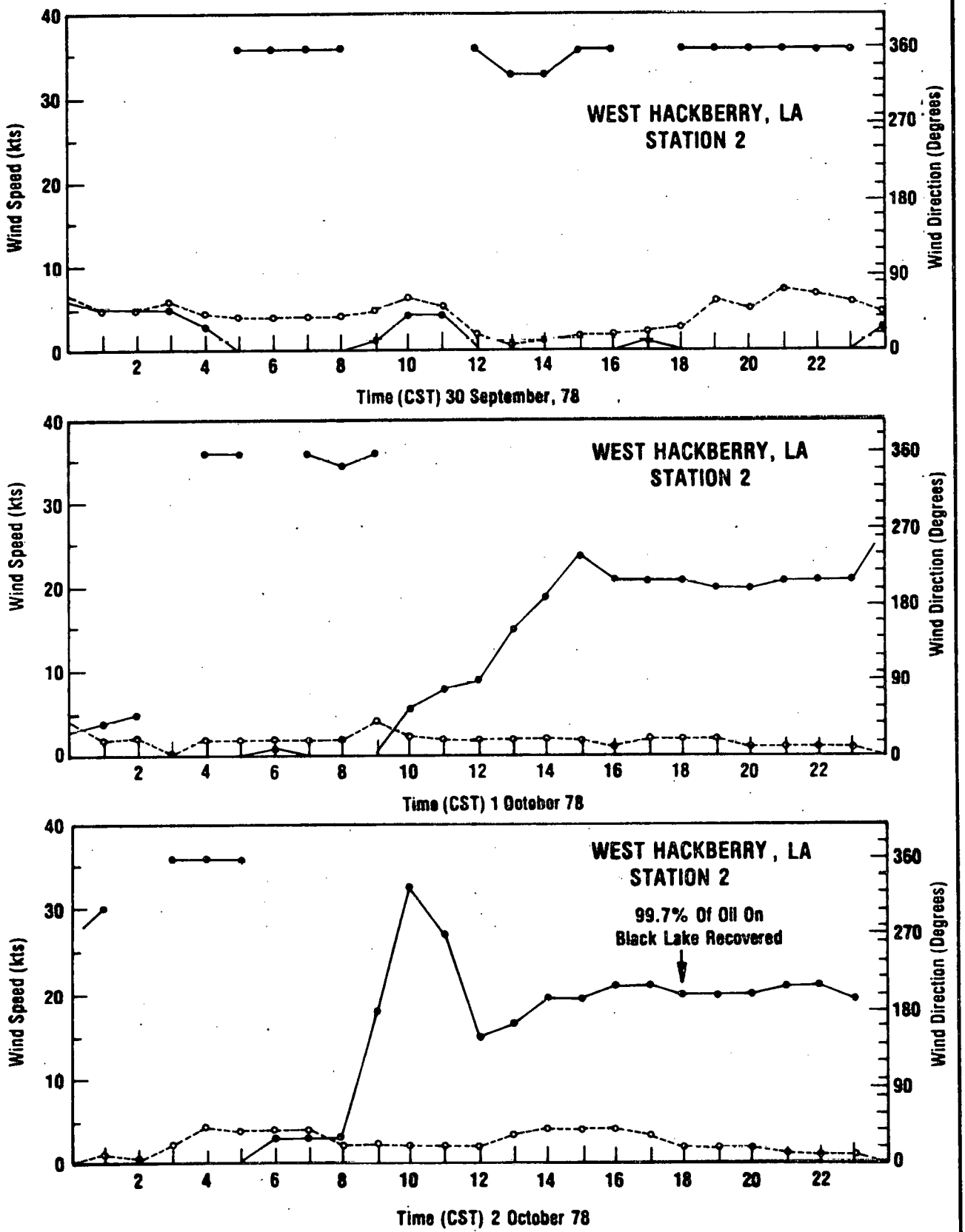


FIGURE 8.3-4 (CONT.)
WIND SPEED (DASHED) AND DIRECTION (SOLID) DURING THE WEST HACKBERRY CAVERN 6 FIRE & SPILL

TABLE 8.3-4

RAW FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 1
SEPTEMBER 29 - DECEMBER 27, 1978

	Speed (kts)							
Direction	1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	69	71	57	23	1		221	5.9
NNE	29	78	58	30	3		198	7.0
NE	31	53	72	22	3		181	5.5
ENE	50	75	43	9	1		178	4.8
E	70	65	13	2			150	4.0
ESE	52	87	36	8	3		186	5.4
SE	23	44	36	6	1		110	6.1
SSE	57	54	78	26	1		216	6.6
S	50	43	44	5			142	5.3
SSW	46	25	5	6	3		85	4.6
SW	15	5	1				21	3.0
WSW	14	8	1	1			24	3.7
W	18	10					28	3.0
WNW	5	10	2	2			19	5.5
NW	11	4	8	20	5		48	9.9
NNW	29	24	25	69	14		161	9.9
Total	569	656	479	229	35		1968	6.2
						Number of Hourly Observations of Calm	39	
						Total Number of Hourly Observations	2007	

TABLE 8.3-5

RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 1
SEPTEMBER 29 - DECEMBER 27, 1978

	Speed (kts)						
Direction	0-3	4-6	7-10	11-16	17-21	>21	Total
N	0.038864	0.035376	0.028401	0.011460	0.000498		0.114599
NNE	0.016442	0.038864	0.028899	0.014948	0.001495		0.100648
NE	0.015944	0.026408	0.035874	0.010962	0.001495		0.090683
ENE	0.025411	0.037369	0.021425	0.004484	0.000498		0.089188
E	0.034878	0.032387	0.006478	0.000997			0.074738
ESE	0.026906	0.043348	0.017937	0.003986	0.001495		0.093672
SE	0.011958	0.021923	0.017937	0.002990	0.000498		0.055306
SSE	0.028899	0.026906	0.038864	0.012955	0.000498		0.108122
S	0.025411	0.021425	0.021923	0.002491			0.071251
SSW	0.023418	0.012456	0.002491	0.002990	0.001495		0.042850
SW	0.007474	0.002491	0.000498				0.010463
WSW	0.007973	0.003986	0.000498	0.000498			0.012955
W	0.011460	0.004983					0.016443
WNW	0.003986	0.004983	0.000997	0.000997			0.010963
NW	0.007972	0.001993	0.003986	0.009965	0.002491		0.026407
NNW	0.015945	0.011958	0.012456	0.034380	0.006976		0.081715
Total	0.302941	0.326856	0.238665	0.114101	0.017439		1.00000
				Relative Frequency of Calms Distributed Above			0.019432

TABLE 8.3-6

RAW FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
SEPTEMBER 29 - DECEMBER 27, 1978

	Speed (kts)							
Direction	1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	47	99	55	17	4		222	6.1
NNE	30	56	41	19	7		153	7.0
NE	37	55	56	14	1		163	6.3
ENE	36	78	61	32	3		210	7.0
E	44	39	10	4			97	4.3
ESE	56	49	10				115	3.8
SE	48	50	22	1			121	4.5
SSE	42	37	28				107	4.7
S	40	38	12				90	4.1
SSW	71	19	5	1			96	3.7
SW	20	8	7	4			39	5.0
WSW	11	3	1	1			16	3.6
W	14	5	1				20	3.0
WNW	11	13	4	2			30	5.0
NW	7	3	1	11	2		24	9.3
NNW	15	10	23	31	3		82	9.2
Total	529	562	337	137	20		1585	5.7
						Number of Hourly Observations of Calm	140	
						Total Number of Hourly Observations	1725	

TABLE 8.3-7

RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
SEPTEMBER 29 - DECEMBER 27, 1978

	Speed (kts)						
Direction	0-3	4-6	7-10	11-16	17-21	>21	Total
N	0.031304	0.057391	0.031884	0.009855	0.002319		0.132754
NNE	0.020290	0.032464	0.023768	0.011014	0.004058		0.091594
NE	0.026088	0.031884	0.032464	0.008116	0.000580		0.099130
ENE	0.024348	0.045217	0.035362	0.018551	0.001739		0.125217
E	0.029565	0.022609	0.005798	0.002319			0.060290
ESE	0.038841	0.028406	0.005798				0.073043
SE	0.037101	0.028986	0.012754	0.000580			0.079420
SSE	0.038261	0.021449	0.016232				0.075942
S	0.033623	0.022029	0.006957				0.062609
SSW	0.048695	0.011014	0.002899	0.000580			0.063189
SW	0.013913	0.004638	0.004058	0.002319			0.024928
WSW	0.009276	0.001739	0.000580	0.000580			0.012174
W	0.010435	0.002899	0.000580				0.013913
WNW	0.008116	0.007536	0.002319	0.001160			0.019130
NW	0.006377	0.001739	0.000580	0.006377	0.001160		0.016232
NNW	0.011595	0.005798	0.013333	0.017971	0.001739		0.050435
Total	0.387826	0.325797	0.195362	0.079420	0.011594		1.00000
					Relative Frequency of Calms Distributed Above		0.081159

TABLE 8.3-8

RAW FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
SEPTEMBER 29 - DECEMBER 27, 1978

	Speed (kts)							
Direction	1-3	4-6	7-10	11-15	17-21	>21	Total	Avg. Speed
N	30	56	70	34	5		195	7.6
NNE	21	78	73	29	11	1	213	7.9
NE	12	44	57	29	7		149	8.4
ENE	36	67	55	16	1		175	6.3
E	39	61	13	3			116	4.6
ESE	47	74	48	13	2		184	5.4
SE	24	55	33	10	3		125	6.4
SSE	49	63	91	55	1		259	7.2
S	45	19	29	3	1		97	3.2
SSW	46	11	3	2			62	3.2
SW	9	3	4				16	4.2
WSW	33	5					38	2.5
W	20	3	1				24	2.6
WNW	16	10	3	7	1		37	5.3
NW	5	1	2	16	3	1	28	9.0
NNW	20	14	18	41	35	17	145	12.8
Total	452	564	500	258	70	19	1863	7.1
						Number of Hourly Observations of Calm	19	
						Total Number of Hourly Observations	1882	

TABLE 8.3-9

RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
SEPTEMBER 29 - DECEMBER 27, 1978

	Speed (kts)						
Direction	0-3	4-6	7-10	11-16	17-21	>21	Total
N	0.019659	0.029756	0.037194	0.018066	0.002557		0.107333
NNE	0.011689	0.041445	0.038788	0.015410	0.005845	0.000531	0.113709
NE	0.006376	0.023379	0.030287	0.015410	0.003720		0.079171
ENE	0.019660	0.035600	0.029224	0.008501	0.000531		0.093518
E	0.020727	0.032412	0.006901	0.001594			0.061637
ESE	0.026036	0.039320	0.025505	0.006908	0.001063		0.098831
SE	0.012752	0.029224	0.017535	0.005313	0.001594		0.066419
SSE	0.026567	0.033475	0.048353	0.029224	0.000531		0.138151
S	0.024442	0.010096	0.015410	0.001594	0.000531		0.052072
SSW	0.025505	0.005845	0.001594	0.001063			0.034006
SW	0.005313	0.001594	0.002125				0.009033
WSW	0.017535	0.002657					0.020191
W	0.010627	0.001594	0.000531				0.012752
WNW	0.009565	0.005313	0.001594	0.003719	0.000531		0.020723
NW	0.002657	0.000531	0.001063	0.008502	0.001594	0.000531	0.014878
NNW	0.011158	0.007439	0.009564	0.021785	0.018597	0.009033	0.077578
Total	0.250266	0.299681	0.265675	0.137088	0.037194	0.010096	1.00000
						Relative Frequency of Calms Distributed Above	0.010096

breezes of Black Lake. Such effects would be more appropriately investigated during warmer months.

8.3.3 Air Quality

Of the estimated 72,000 barrels of oil spilled, about 32,000 barrels were recovered from Black Lake, and an estimated 20,000 barrels were recovered from the wellpad area. The remaining 20,000 barrels were burned or lost during the 6-day fire (DOE, 1978b). Emissions from the fire were subjected to two types of release. The first, a high heat, point source release, originated at the wellhead where a 1.5 to 3 m fountain of oil was engulfed in flame. The plume rose from this source to about 450 m before bending in a southwesterly direction and reaching buoyant equilibrium (Plate 8.3-1). The second release point was an area source typified by the burning oil within the containment dikes on the west side of Wellpad 6. The plume from this emission source was frequently observed fuming to the ground behind the west containment dike. The entire southwest quadrant in the vicinity of Wellpad 6 is slightly higher in elevation than the emission sources. Consequently, this area was visibly blackened by combustion products from the fire, either by direct contact with the plume or as result of plume fallout.

In an attempt to quantify the impact of the fire on air quality, samples were collected at the site on September 25 and 26, 1978. Results from the testing for the pollutants are listed in Table 8.3-10. The results of these analyses from one upwind and two downwind sampling locations (Figure 7.2-3) indicate no significant air quality impacts at ground level. The increases in downwind concentrations (Stations 2 and 3) of particulate matter may be partially biased by fugitive dust emissions from heavy traffic on the site roads.

Immediately after Well 6 was plugged, cavern pressures increased to a degree that warranted bleeding off some of the oil into a pit east of

PLATE 8.3-1. PLUME RISE FROM THE FIRE, SEPTEMBER 23, 1978

TABLE 8.3-10

ONSITE AIR QUALITY DATA
DURING THE WEST HACKBERRY FIRE
SEPTEMBER 25-26, 1978

	Concentration ($\mu g/m^3$)		
Pollutant	Station 1	Station 2	Station 3
Particulates	82	152	130
SO_2	<26	<26	<26
NH_3	74	43	66
Cl_2	<2	<2	<2
F-	<0.05	<0.05	<0.05
Start Time	1910 CST	1940 CST	1955 CST
Start Date	9-25-78	9-25-78	9-25-78
End Time	0715 CST	0655 CST	0530 CST
End Date	9-26-78	9-26-78	9-26-78

the wellpad. Hydrogen sulfide measurements taken in the area indicated that concentrations varied from 12 ppm near the source of the oil discharge to 1 ppm along the access road to the wellpad (DOE, 1978b). Workmen in the area were notified and appropriate safety precautions were implemented.

The offsite air quality impact was addressed by surveying data from regional air quality monitoring stations. The Louisiana Air Control Commission and the Texas Air Control Board maintain air quality monitoring stations in the industrial areas of Lake Charles and West Lake, Louisiana, and West Orange and Nederland, Texas, respectively. There were no air quality monitoring stations downwind of the fire in Louisiana. Much of the impacted area to the southwest of the site is very sparsely populated due to the marsh environment.

The closest air quality station to the site is West Orange, located 22 miles west-northwest; Nederland is situated 35 miles west of the site. Air quality data from these stations for a period spanning the fire are presented in Tables 8.3-11 and 8.3-12. The maximum concentrations shown do not indicate significant changes in air quality for the period. Small increases in the hourly maximum concentrations for each day are more probably related to adjacent industrial sources and radiational inversion conditions. Due to the great distances of these monitoring stations from the West Hackberry site and the infrequency of easterly winds during the fire, it is highly unlikely that any measurable degradation of air quality at these locations resulted from the accident.

8.3.4 Hydrology

Occasional measurements of physical parameters in southern Black Lake were made between December 1, 1977, and October 12, 1979, in conjunction with the environmental monitoring program implemented during the

TABLE 8.3-11

HOURLY AIR QUALITY DATA
WEST ORANGE, TEXAS
SEPTEMBER 15, 1978 - OCTOBER 4, 1978

Date	Sulphur Dioxide (ppm)			Nitrogen Oxides (ppm)			Nonmethane Hydrocarbons (ppm)		
	Max	Mean	Wind Dir. (°)	Max	Mean	Wind Dir. (°)	Max	Mean	Wind Dir. (°)
15 Sep	0.00	0.00	-	0.05	0.02	076	0.6	0.1	061
16 Sep	0.00	0.00	-	0.05	0.01	323	0.6	0.1	323
17 Sep	0.00	0.00	-	0.11	0.02	162	0.2	0.0	143
18 Sep	0.00	0.00	-	0.06	0.02	125	0.3	0.0	132
19 Sep	0.00	0.00	-	0.05	0.02	188	0.6	0.1	076
20 Sep	0.00	0.00	-	0.04	0.02	063	0.7	0.3	063
21 Sep	0.00	0.00	-	0.06	0.02	324	1.4	0.4	324
22 Sep	0.00	0.00	-	0.05	0.01	050	0.6	0.1	047
23 Sep	0.00	0.00	-	0.03	0.01	035	0.3	0.0	032
24 Sep	0.00	0.00	-	0.02	0.00	349	0.1	0.0	190
25 Sep	0.00	0.00	012	0.01	0.00	054	0.1	0.0	020
26 Sep	0.00	0.00	-	0.01	0.00	070	1.1	0.5	028
27 Sep	0.03	0.00	-	0.01	0.00	129	1.4	1.3	018
28 Sep	0.00	0.00	-	0.01	0.00	026	-	-	-
29 Sep	0.00	0.00	-	0.03	0.01	045	-	-	-
30 Sep	0.00	0.00	-	0.02	0.01	030	-	-	-
1 Oct	-	-	-	-	-	-	-	-	-
2 Oct	0.00	0.00	-	0.03	0.01	269	-	-	-
3 Oct	0.00	0.00	-	0.05	0.02	197	-	-	-
4 Oct	0.00	0.00	-	0.43	0.03	046	-	-	-
Quarterly Values									
24 hr avg	0.00	0.00	-	0.06	0.02	-	-	-	-
6-9 a.m. avg	-	-	-	-	-	-	1.3	0.3	-

TABLE 8.3-12

HOURLY AIR QUALITY DATA
NEDERLAND, TEXAS
SEPTEMBER 15, 1978 - OCTOBER 4, 1978

Date	Sulphur Dioxide (ppm)			Nitrogen Oxides (ppm)			Nonmethane Hydrocarbons (ppm)		
	Max	Mean	Wind Dir. (°)	Max	Mean	Wind Dir. (°)	Max	Mean	Wind Dir. (°)
15 Sep	0.00	0.00	178	0.01	0.00	190	0.4	0.2	140
16 Sep	0.00	0.00	255	0.03	0.00	285	0.9	0.3	176
17 Sep	0.00	0.00	166	0.01	0.00	162	1.4	0.4	154
18 Sep	0.00	0.00	163	0.03	0.01	149	2.6	0.6	170
19 Sep	-	-	-	0.07	0.01	100	1.8	0.8	084
20 Sep	-	-	-	0.05	0.01	033	1.1	0.6	033
21 Sep	-	-	-	0.10	0.03	071	1.7	0.7	041
22 Sep	-	-	-	0.11	0.04	033	2.7	0.6	046
23 Sep	-	-	-	-	-	-	1.1	0.4	040
24 Sep	-	-	-	-	-	-	0.3	0.2	041
25 Sep	-	-	-	-	-	-	0.5	0.4	034
26 Sep	-	-	-	-	-	-	-	-	-
27 Sep	-	-	-	-	-	-	0.3	0.2	013
28 Sep	-	-	-	-	-	-	0.5	0.3	057
29 Sep	-	-	-	-	-	-	0.5	0.3	040
30 Sep	-	-	-	-	-	-	-	-	-
1 Oct	-	-	-	-	-	-	-	-	-
2 Oct	0.00	0.00	-	-	-	-	0.7	0.4	176
3 Oct	0.00	0.00	-	-	-	-	3.5	0.9	033
4 Oct	0.00	0.00	-	-	-	-	1.2	0.5	348
Quarterly Values									
24 hr avg	0.00	0.00	-	0.03	0.01	-	-	-	-
6-9 a.m. avg	-	-	-	-	-	-	1.4	0.6	-

construction phase of the project (DOE, 1977-1979). Temperatures ranged from 9°C in the winter to 32°C during the summer months. Dissolved oxygen values ranged from 3.3 to 10 ppm, and pH varied from 6.8 to 8.2. Salinity, which varied significantly with runoff and tidal influences, ranged between 2.0 and 17.0 ppt, while conductivity varied from 21 to 450 μmhos.

Hydrological data consisting of drogue position, time, and mean current speed along seven drogue trajectories are shown in Figure 8.3-5. These field studies were conducted on December 7, 1978, to provide insight into the general behavior of surface currents in the area of the spill. Wind speed and direction at Meteorological Station 2 were averaged over 15-minute intervals for the period of the studies and are shown in Figure 8.3-6. A direct comparison of surface currents and winds averaged over identical time intervals is shown in Figure 8.3-7.

The drogue studies indicated that surface currents are primarily influenced by meteorological forces. Drogue trajectories related well to wind direction measured during the study although some flow curvature is probably related to topographic influences of the peninsula west of the spill area, changes in fetch, and the presence of a permanent oil containment boom immediately south of the release points for Drogues 1, 2, and 3 (Figure 8.3-5). These physical impediments also resulted in variations in current speed manifested in areas of confluence and difluence. Such mechanisms offer a possible explanation for the anomalously high current speeds for Drogues 1, 2, and 3 between 1510 and 1549 CST. The speed of drogue movement in this time period was not readily explained by meteorological forcing alone, as indicated by the spurious values shown in Figure 8.3-7. Most of the data points, however, fall within a range of values expected from direct influence of the wind.

Knowledge of the spatial distribution of oil during the accident aided the understanding of transport processes affecting the spill. The

Blank

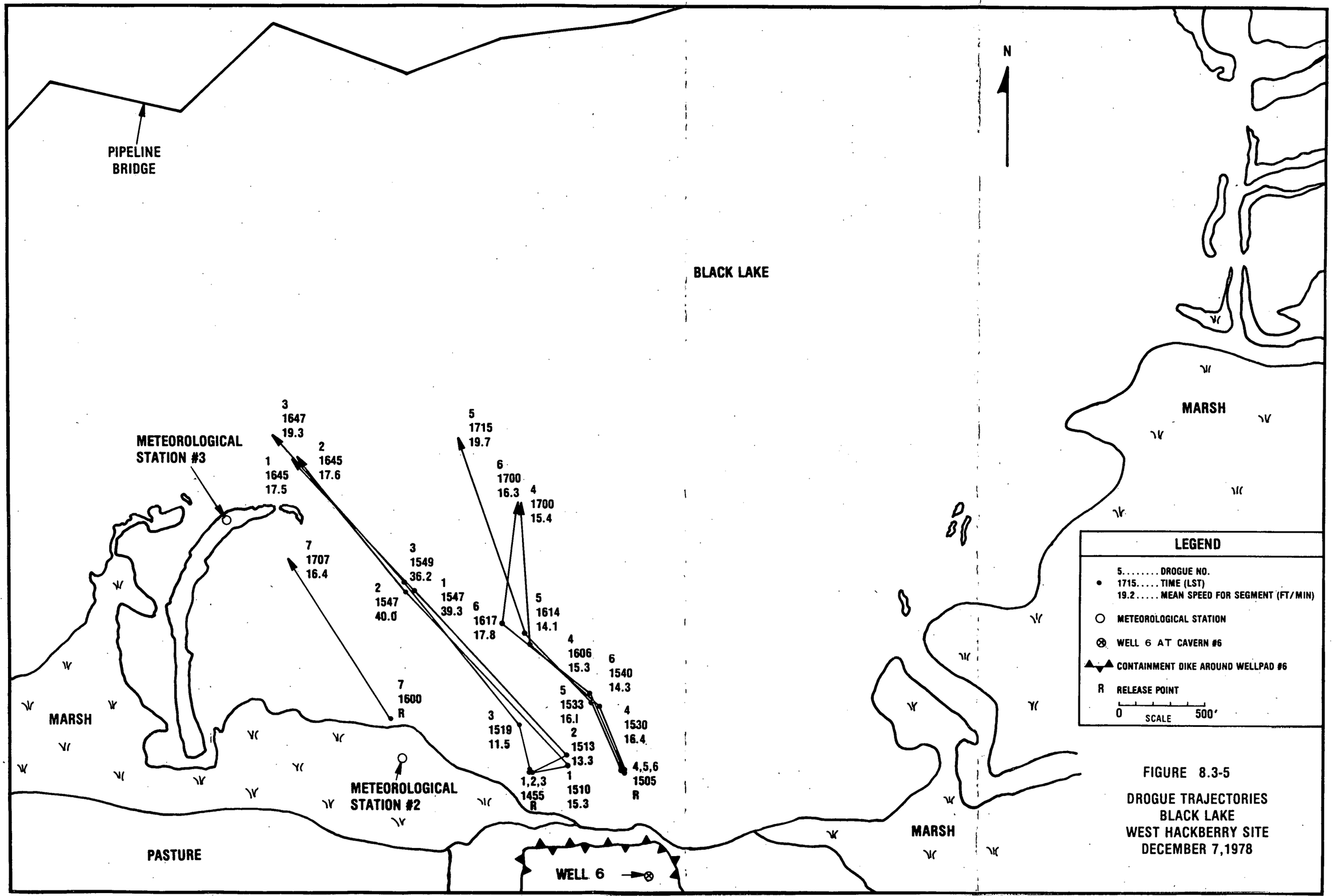
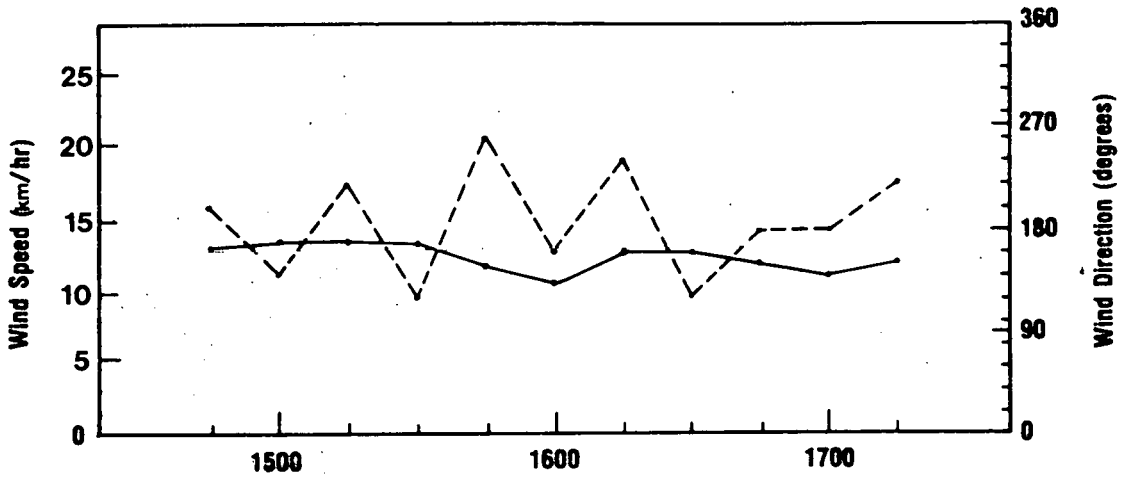


FIGURE 8.3-5

DROGUE TRAJECTORIES
BLACK LAKE
WEST HACKBERRY SITE
DECEMBER 7,1978



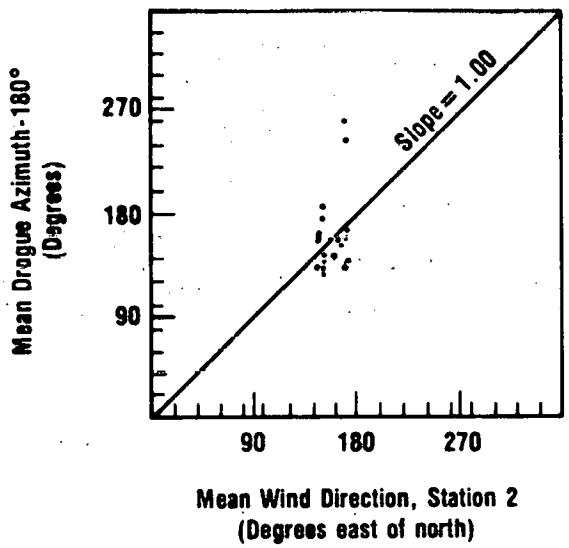
Time (CST)
Meteorological Station 2
December 7, 1978

Wind Speed - - - - -

Wind Direction ————

FIGURE 8.3-6

WIND SPEED AND DIRECTION DURING DROGUE STUDIES, BLACK LAKE, DECEMBER 7, 1978



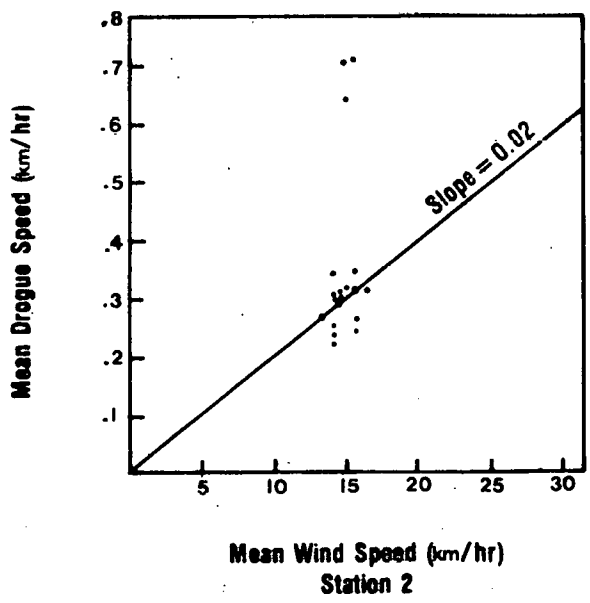


FIGURE 8.3-7

COMPARISON OF SURFACE CURRENT AND WIND ON BLACK LAKE, DECEMBER 7, 1978

distribution of the oil was delineated from personal accounts of individuals who deployed the oil containment boom (DOE, 1978b), from aerial photography taken during the course of the accident (Plate 4.0-3), and from a field map of oil-stained vegetation and sporadic oil sheens in the marsh area. Figure 8.3-8 depicts the distribution of oil after the first night of boom deployment. Under the influence of northeasterly winds, the oil began to build up against the western segments of the boom. Leakage of oil was apparent at a few boom connections and where the boom had run aground in the shallow marsh. Secondary and tertiary tiers of booms were deployed to catch the leakage.

By the next morning, September 22, 1978, northeasterly winds had become stronger and most of the estimated 4,000 barrels of oil on the lake had been transported closer to shore. Measured oil depth near the shore had reached 20 cm, and wind-induced set-up of oil against the southwestern containment booms was observed. Differences in fluid levels across the boom were estimated at 7 to 10 cm.

Figure 8.3-9 illustrates the distribution of oil on September 23, 1978. The bulk of the oil had been contained within the boom and a small inlet west of the oil recovery area. Isolated sheens, however, were observed as far west as the peninsula. As a precautionary measure, an additional containment boom was deployed across a canal immediately west of the peninsula to preclude northwesterly transport of oil through this opening. No visible observations of suspected Cavern 6 crude oil were made west of the peninsula. The diurnal wind patterns of early October (Figure 8.3-4), however, suggested that northerly transport of oil sheen from the uncontained marsh followed by westerly transport could be inferred.

Blank

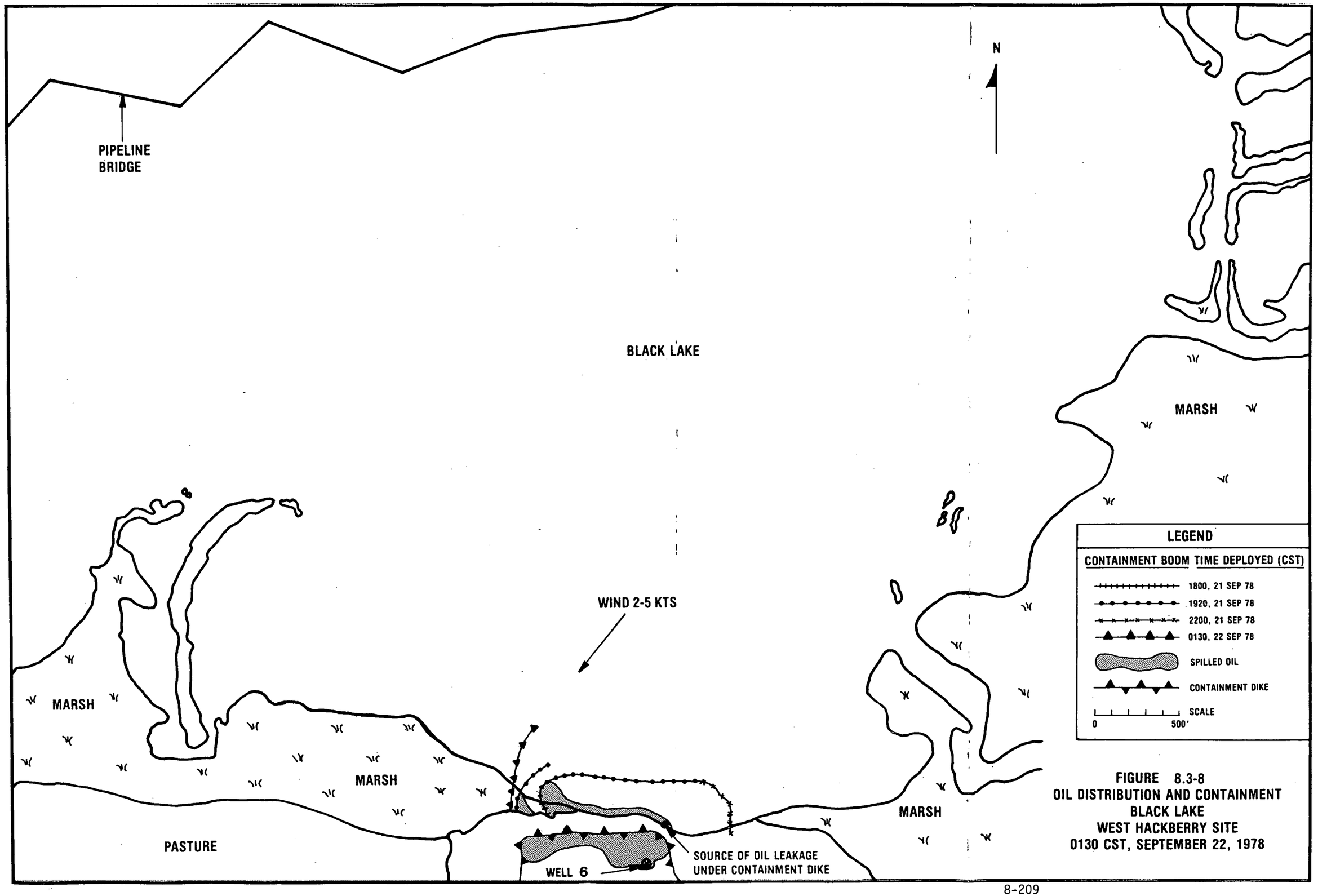


FIGURE 8.3-8
OIL DISTRIBUTION AND CONTAINMENT
BLACK LAKE
WEST HACKBERRY SITE
0130 CST, SEPTEMBER 22, 1978

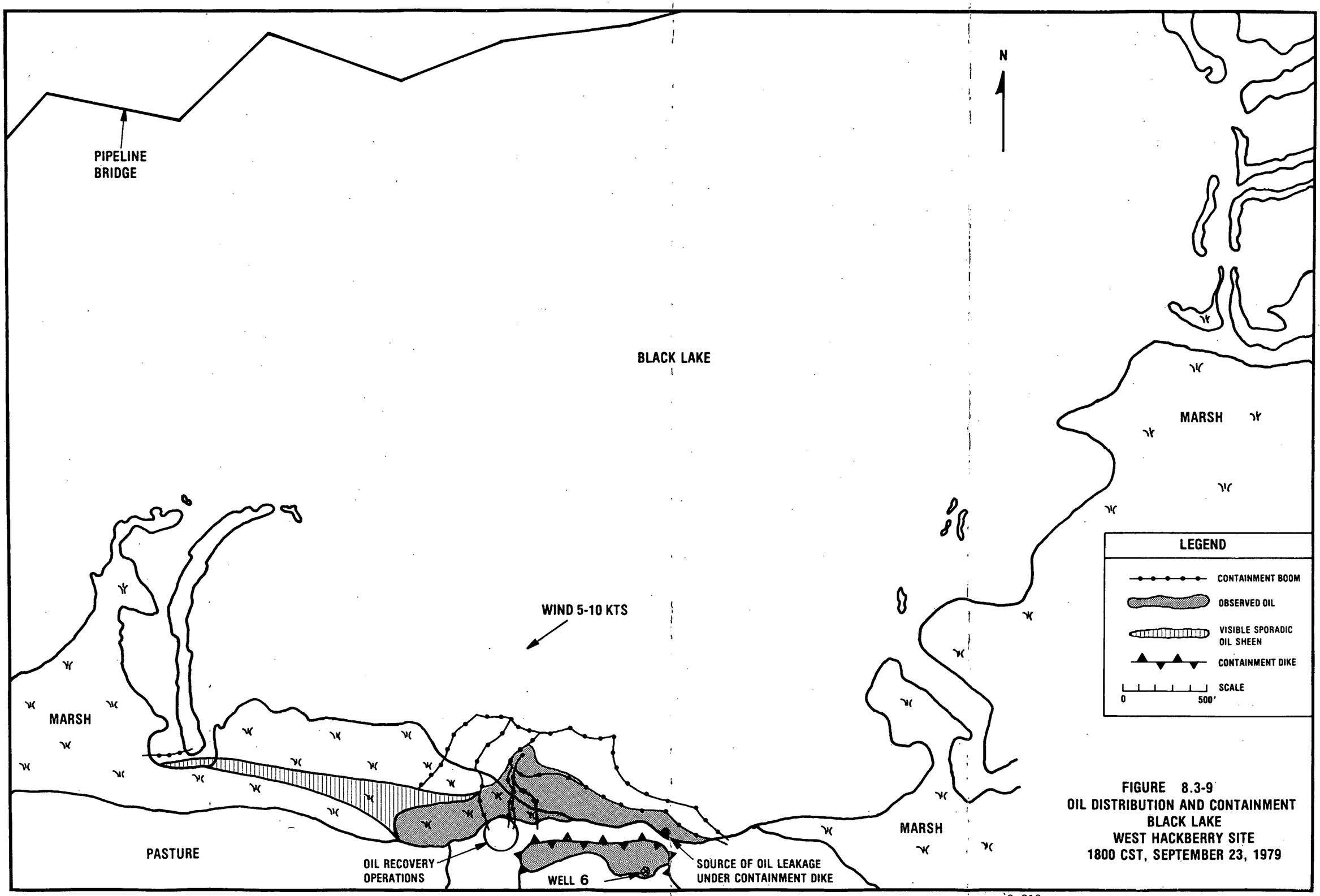


FIGURE 8.3-9
OIL DISTRIBUTION AND CONTAINMENT
BLACK LAKE
WEST HACKBERRY SITE
1800 CST, SEPTEMBER 23, 1979

8.4 REMOTE SENSING

8.4.1 Introduction and Objectives

Photographic systems (cameras and films) are still the most important of all remote sensors. They provide real-world images and, when flown in a stereoscopic mode, allow for three-dimensional viewing. The assortment of cameras and film types available today makes aerial photography the most adaptable of the remote sensing systems.

Conventional panchromatic black-and-white film emulsions have been the workhorse of aerial photomapping and reconnaissance missions for decades. Color, black-and-white-infrared, and color-infrared films are relatively new arrivals, however, and their characteristics and uses are elaborated below.

Color Film - Improvements in color emulsions have significantly upgraded their resolution capabilities. This additional resolution, together with the fact that it is visually easier to distinguish subtle differences within color tonalities than between shades of grey, make color films a new favorite with users of aerial photography. The addition of color provides the observer with another dimension of data from which to draw conclusions. Studies have shown that color photos can be interpreted with greater accuracy than can equivalent black-and-white images for such applications as vegetation and soil typing, geologic mapping, and surface water studies.

Black-and-White-Infrared Film - Black-and-white-infrared film contains an emulsion sensitive to radiant energy extending beyond the visual range, into the near-infrared portion of the electromagnetic spectrum. (Photography in this portion of the infrared band should not be confused with thermal-infrared sensing, which is a technique of recording heat radiation indirectly on film or other visual display.)

Black-and-white-infrared film is often used to record areas perpetually covered by haze, since infrared wavelengths penetrate haze and smoke quite well.

Color-Infrared Film - Color-infrared film is also known as "false color" because object colors recorded on this emulsion appear differently than in nature. This film type records healthy vegetation in exotic magentared tones. Cut vegetation rapidly loses its ability to reflect infrared radiation and is therefore recorded in pinkish to bluish tones. This film has been used by the earth-resources community for such applications as crop inspection, tree-growth inventory, and damage assessment (where diseased flora can often be previsually detected in time to permit corrective measures). Color infrared also enhances soil/vegetation boundaries and land/water interfaces.

For certain photo missions, aircraft are configured with two or more cameras, each loaded with a different film type and synchronized to simultaneously expose the same ground image. This technique, called multiband photography, can be performed using any combination of film emulsions - black-and-white and color-infrared, for example, or color and black-and-white-infrared, etc. In some systems, black-and-white films may be exposed through different band-pass filters to provide multiband results, with each frame responding to a selected portion of the spectrum.

Multispectral Scanners - The chief advantage of the multiband technique is that it provides a number of "different" recordings, and each filter band or film type complements the others to enhance those surface characteristics best recorded on that film.

Multispectral scanners are devices which provide data in a multiband mode similar to that obtained from multiband camera systems. The major

operational difference is that multispectral scanning devices are electro-optical instruments. Scanners are configured with single or arrayed detectors which sense the incoming image from a collector optic (scanning mirror). Scanners look at a single "spot" of ground at any given instant in time. The spot is scanned laterally to produce a line of imagery. The forward motion of the aircraft or spacecraft collects successive lines to produce a swath of the scene. (These are segmented during ground processing to create a frame of imagery.) The incoming optical signal image is converted to a modulated electrical signal which can be either recorded on tape for later reproduction or used to vary a point source of illumination to photographically record the image on film.

In the case of multiple-detector arrays, each detector (or group of detectors) is designed to provide an optimum response over a discrete portion of the electromagnetic spectrum. In this way, a single overflight with a multispectral scanner can provide a number of simultaneous "filtered" recordings, from which a number of different terrain characteristics may be detected.

The scanner technique is always applied to thermal-infrared sensing since no film emulsion is capable of direct thermal-infrared recording. Thermal surveys can be used to record either relative "heat contrasts" of surface objects or absolute thermal values (with ground-control calibration inputs).

The remote sensing objectives of this study were to detect and monitor any damage to the vegetation at the West Hackberry site caused by fallout from the smoke plume and fumigation from the nearby oil pits. Data for analysis was acquired in October 1978 immediately after the fire, and in July 1979.

8.4.2 Data Acquisition

Data consisted of aerial photographs, multispectral scanner imagery, and ground truth. Airborne data was acquired during the fire (September 1978), immediately after (October 1978), and approximately eight months later (July 1979). Multispectral scanning was performed on all the flights; aerial mapping photography with an RC-10 camera was taken only during the September 1978 flights. Multispectral photos were obtained on the latter two surveys.

The multiband photos were taken with an array of four Hasselblad cameras with essentially identical fields of view. As listed in Table 8.4-1, the cameras were equipped with 50mm lenses, filters, standard 70mm film of the aerocolor, false color infrared, black-and-white panchromatic and black-and-white infrared types.

Multispectral scanner data was acquired with a Daedalus DS-1260 scanner configured with a spectrometer and thermal infrared detector. Parameters for this particular configuration are given in Table 8.4-2. A liquid-nitrogen cooled Hg:Cd:Te detector was the thermal infrared detector. The spectrometer employed an array of 10 filtered silicone detectors sensitive to the spectral region from 0.38 μm to 1.1 μm.

The scanner is better than cameras for vegetation analysis because it is sensitive to longer wavelengths of the reflective infrared, 0.8 μm to 1.1 μm.

Multispectral scanner data was recorded on high density 10,000 bits-per-inch magnetic tape. At the laboratory, this data was transferred to computer-compatible tape. In this form, the data can be entered into the RSL computer system, which is dedicated to the analysis and display of imagery.

TABLE 8.4-1

STANDARD MULTISPECTRAL PHOTOGRAPHY

FILM TYPE	FILTER	SPECTRAL SENSITIVITY
Kodak Aerocolor Negative Film 2445	Wratten 2A (Haze)	0.4 - 0.7 μm
Kodak Aerocolor Infrared Film 2443	Wratten 12 (Yellow)	0.5 - 0.9 μm
Kodak Plus-X Aerographic Film 2402	Wratten 25	0.6 - 0.7 μm
Kodak Infrared Aerographic Film 2424	Wratten 89B	0.7 - 0.9 μm

TABLE 8.4-2

MULTISPECTRAL SCANNER

(Instantaneous Field of View = 2.5 milliradians)

SPECTROMETER

Channel	Spectral Sensitivity (μm)
1	0.38 - 0.42
2	0.42 - 0.45
3	0.45 - 0.50
4	0.50 - 0.55
5	0.55 - 0.60
6	0.60 - 0.65
7	0.65 - 0.69
8	0.70 - 0.79
9	0.80 - 0.89
10	0.90 - 1.10

THERMAL INFRARED

Spectral Sensitivity: 8.5 - 13.5 μm

Noise Equivalent Temperature Difference: <0.1K at 300K

During the September and October surveys, data was acquired at altitudes of 3,048 m and 1,676 m above ground level, with some additional coverage at 760 m and 610 m. The July data was obtained at 760 m only. Attempts had also been made in December 1978 and May 1979 to take remote sensing data. Unfortunately, weather conditions of heavy haze and broken, scattered clouds reduced the quality of that data. Although such data could still be useful, it was decided that the objectives of the surveys would be met by using only the October 1978 and July 1979 imagery. Ground truth was obtained by observation of the sites and from interpretation of the aerial photos taken during the scanner missions.

8.4.3 Data Analysis

For a number of reasons, computer analysis of the scanner was selected instead of photo interpretation. First, the scanner provides longer wavelengths in the reflective infrared; these are precisely the wavelengths in which stressed vegetation can be most accurately detected. Second, even in the visible part of the spectrum, the scanner had greater sensitivity. As a result, there was superior haze penetration and thus improved data quality. Third, spectral information is more easily and reliably extracted from the scanner than from photographs.

Experience led to the selection of three spectral channels for optimum accuracy and lowest cost. The selected channels were numbers 4, 6, and 10 spanning 0.50 to 0.55 μm, 0.60 to 0.65 μm, and 0.90 to 1.10 μm, respectively. It is in these channels that vegetation most quickly and accurately exhibits the evidence of stress. The addition of more channels to the analysis would yield slightly higher accuracies but at disproportionately greater expenditures of time and money.

Analysis consisted of unsupervised classification. Using as discriminants the similarities in reflected radiance in the three channels, the algorithms sorted objects on the ground into a number of

classes or categories. Nine classes were used for the October 1978 data; only six classes were needed for the July 1979 data. Based upon ground truth information, the classes were then identified and labeled. Each class was assigned its own color in the final output imagery. Areas in the Hackberry imagery were classified not only according to general terrain and vegetation but also degree of stress.

For those images where false color infrared photography is more desirable, false color infrared was simulated with the three scanner channels. Channels 4, 6, and 10 were used as the blue, green and red colors, respectively. The differences between the simulated and actual false color infrared photos are, however, substantial:

a) The three channels have been processed via a mapping of the values to enhance the color differences between healthy and stressed plants.

b) Additional changes in the mappings were used to enhance the image of oil slicks on the lake surface.

c) Use of channel 10 in the simulation resulted in information from the 0.9 to 1.10 μm region which is not present in photos.

The simulated false color infrared imagery provided enhancement of many features. Therefore, in what follows, it will be called "enhanced" rather than "simulated."

8.4.4 Results

Plate 8.4-1 is a composite of two flight lines taken at 3,200 m. The black-and-white portion was obtained at the time of the fire, September 24, 1978. It is channel 10 of the spectrometer. This channel is in the "reflective" infrared part of the spectrum where vigorous

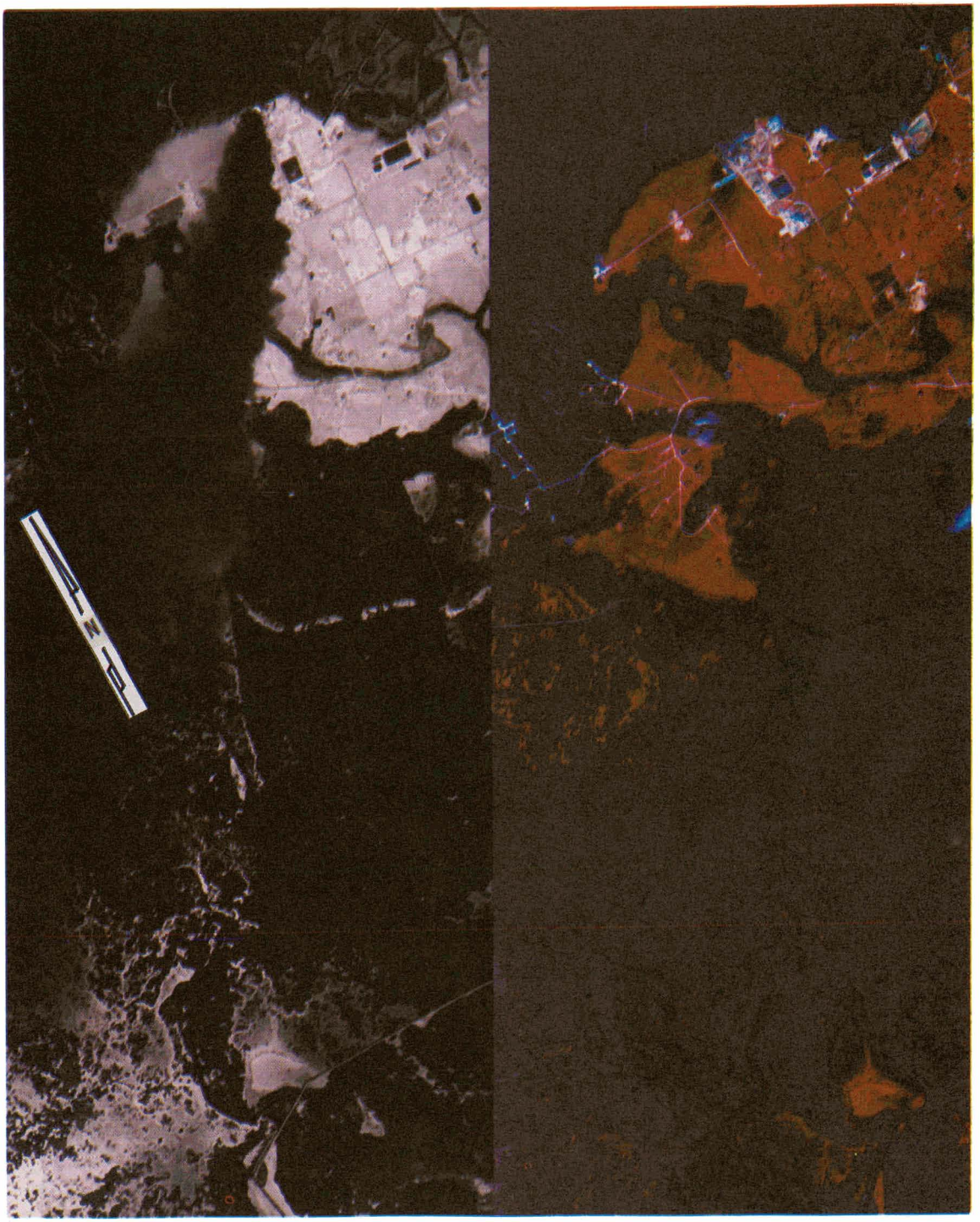


PLATE 8.4-1 BLACK AND WHITE AND ENHANCED COLOR INFRARED IMAGES FROM 3,200 METERS ON SEPTEMBER 24, 1978, AND OCTOBER 1, 1978, RESPECTIVELY

Blank

living plants have high reflectance. The colored half of the image was obtained October 1, 1978. It is produced by projecting channels 4, 6, and 10 of the spectrometer into blue, green, and red, respectively. Such a representation is similar to what is obtained with "false" color infrared film. We have referred to it as an enhanced color infrared image. Damaged or stressed vegetation appears as black or dark red in the imagery and contrasts with the neighboring bright reds of the healthy plants.

Further down the track of the plume to the southwest, there are dark areas. Similarly colored areas are also visible along the river banks and farther inland. Some of these areas are certainly not affected by the fire and smoke. But, in this image, it is impossible to discriminate the effects of the fire from other natural effects. To do this, one must use the more sophisticated computer analysis.

Plate 8.4-2 is the image produced by using the computer to perform statistical classification of the data from the three channels (4, 6, and 10), obtained at 3,200 m on October 1, 1978. They are the same channels used to produce the enhanced color infrared images. Each color in this thematic map represents a different class of terrain or surface cover condition:

COLOR	TERRAIN AND/OR VEGETATION TYPE
Black	Vegetation damage within plume
Red	Cottonwood, sycamore, willow tree zone
Light Green	Pasture with big bluestem, wild grass, grasses
Dark Green	Possible vegetation damage near plume, potential plant stress
Blue	Brackish water
Light Blue	Silt-laden water
Brown	Bare soil/scarified areas and clouds
Light Brown	Small trees/heavy brush zones (trees growing in brush form)
Beige	Marsh, brackish water/land interfaced with cordgrass, reed, and bullrush

PLATE 8.4-2 ENHANCED COLOR INFRARED THEMATIC MAP FROM 3,200 METERS ON OCTOBER 1, 1978

Note how obvious is the area of severe plant damage. The heavily stressed areas, colored dark green, are mainly confined to the plume area. Some stressed areas are present along the river bank. As a result of computer analysis, this image is more accurately and less ambiguously interpreted than is Plate 8.4-1.

Two flight lines at 3,200 m on September 24 were mosaiced using channel 10 to produce the black-and-white image shown on Plate 8.4-3. This image covers the area from the site of the fire to the Gulf Coast, showing the extent of the smoke plume. Somewhat better detail is present with this spectrometer channel than with a photo because the longer wavelength gives greater haze penetration.

The black-and-white image shown on Plate 8.4-4 is again channel 10 from the September 1978 flight. The color portion is the enhanced color infrared produced from channels 4, 6, and 10 taken at 760 m on July 28, 1979. To obtain comparable scaling, it was necessary to magnify and rotate the September data. Note that the black and dark red colors of stressed vegetation are not present in the July imagery. Confirmation of this interpretation was made using the classified image of Plate 8.4-5.

The July data was statistically classified to produce the thematic map shown on Plate 8.4-5. The colors have the same meaning as discussed above. For comparison, the classification image from the October data (scaled to match) is placed alongside within the plate. Note that stress in the vegetation has disappeared.

Plate 8.4-6 is a comparison of channel 10 (black-and-white) from the October 1978 flight and the enhanced color infrared image from the July 1979 data.

A mosaic of the classified data from three flightlines of July 1979 are shown on Plate 8.4-7. Almost all of the area over which

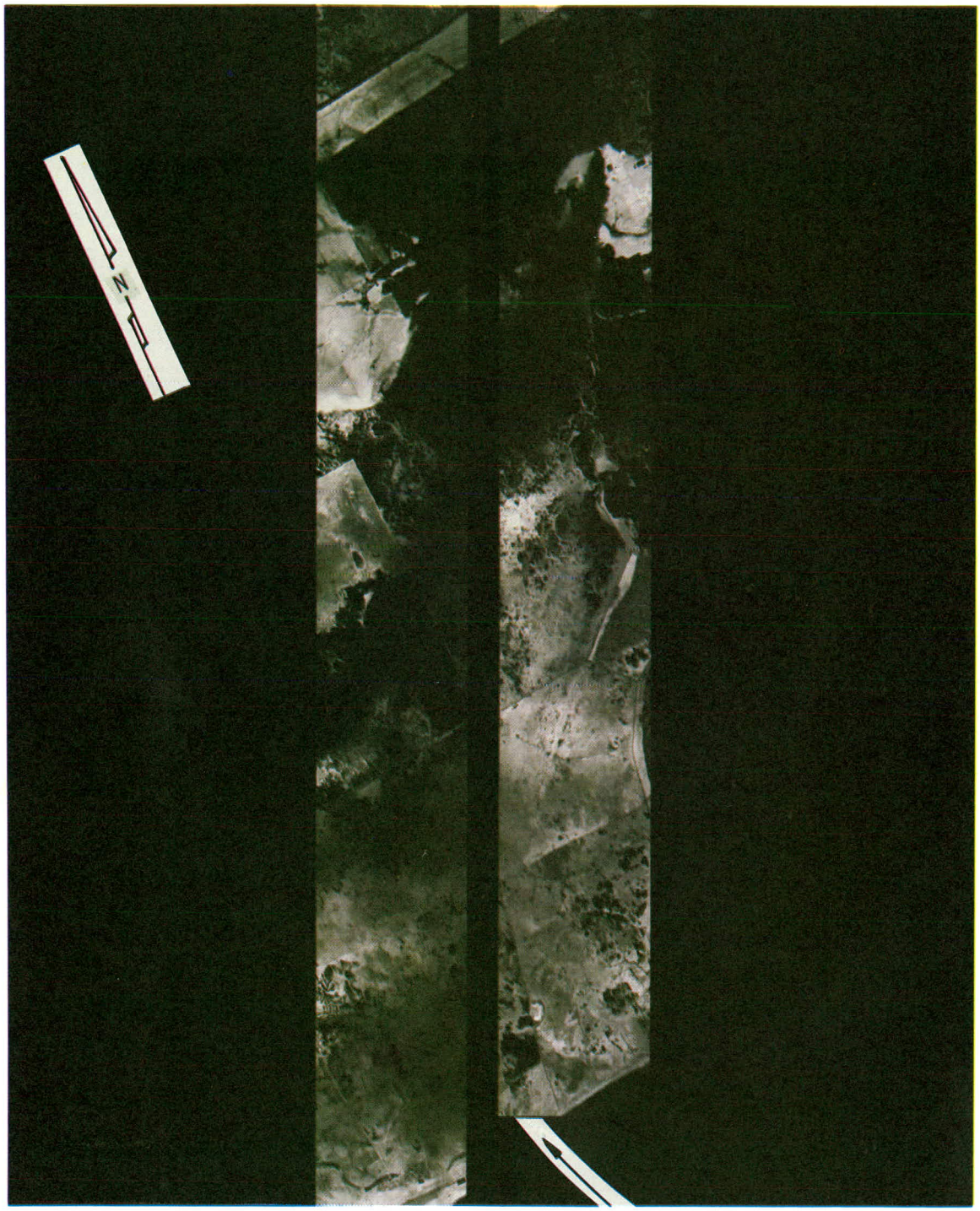


PLATE 8.4-3 BLACK AND WHITE IMAGES SHOWING THE EXTENT OF THE PLUME FROM THE SITE OF THE FIRE TO THE GULF COAST. TAKEN AT 3,200 METERS ON SEPTEMBER 24, 1978

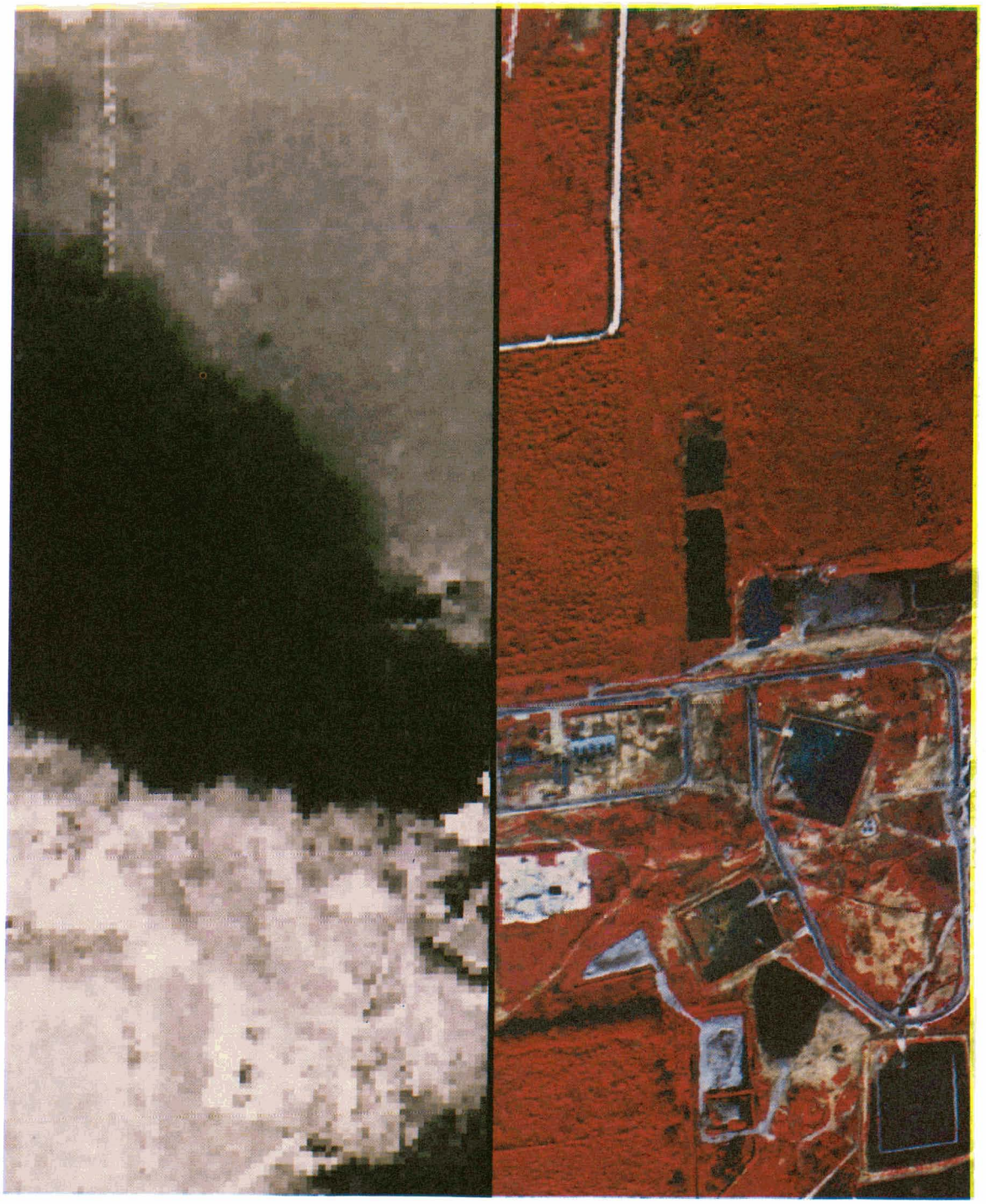


PLATE 8.4-4 BLACK AND WHITE IMAGE (SEPTEMBER, 1978) AND COMPRABLE ENHANCED INFRARED IMAGE (JULY 1979)

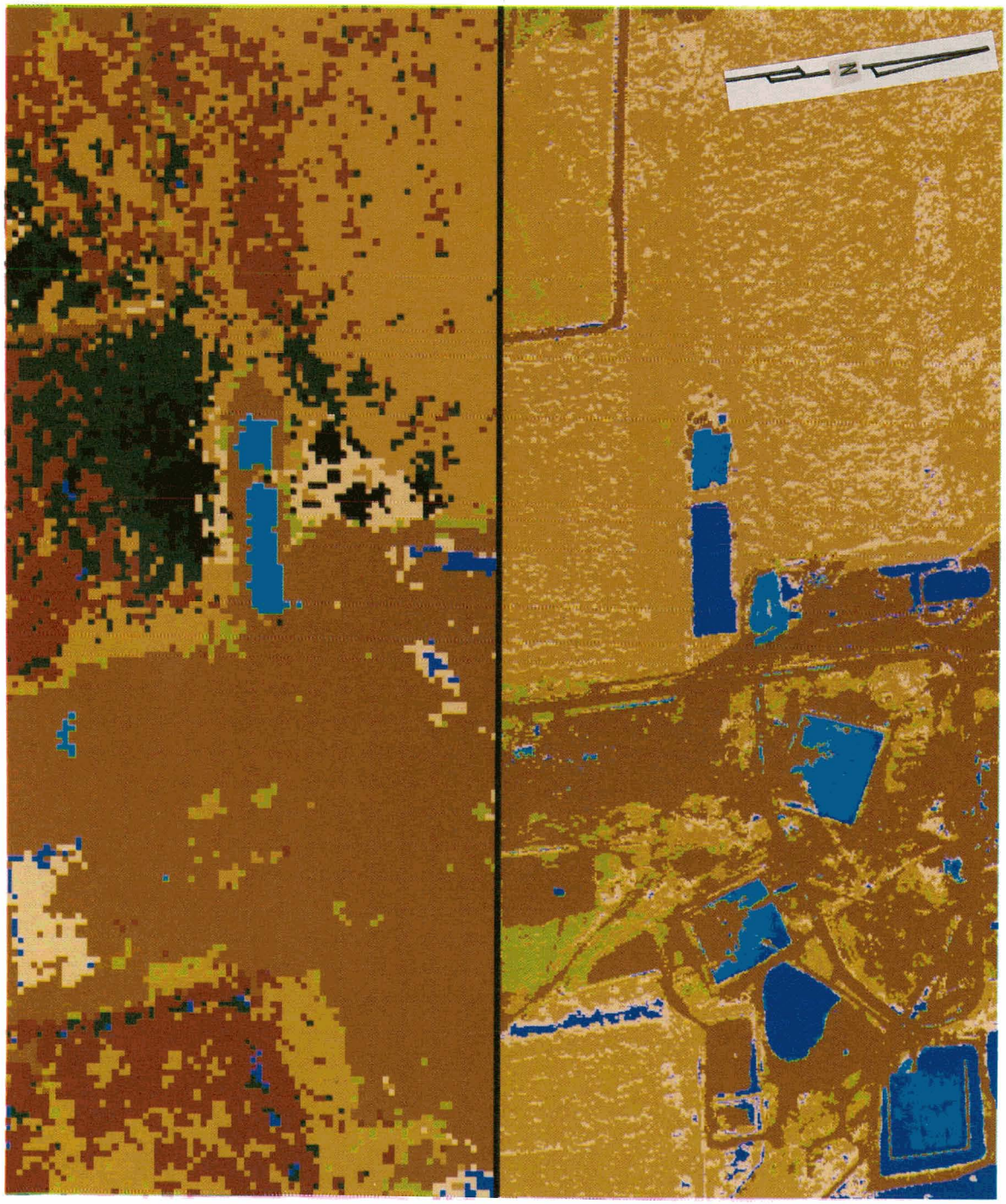


PLATE 8.4-5 ENHANCED COLOR INFRARED THEMATIC MAPS, OCTOBER, 1978 (LEFT), SHOWING STRESSED VEGETATION AND JULY, 1979 (RIGHT), WITH NO STRESSED VEGETATION

PLATE 8.4-6 BLACK AND WHITE (OCTOBER 1978) AND ENHANCED COLOR INFRARED IMAGES (JULY 1979)

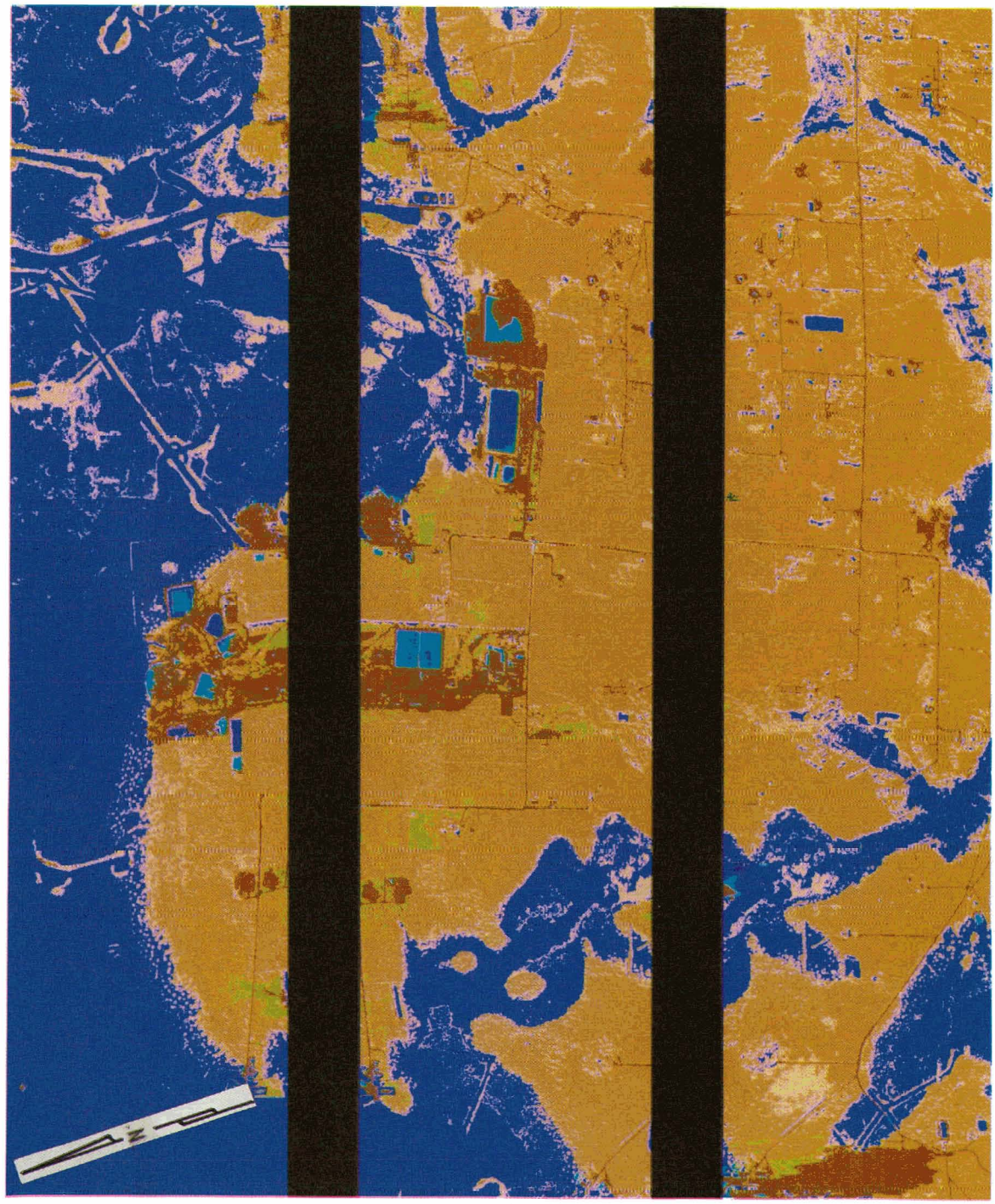


PLATE 8.4-7 ENHANCED COLOR INFRARED THEMATIC MAP (JULY 1979) SHOWING NO EVIDENCE OF CONTINUED VEGETATION STRESS

the plume passed is covered. No evidence of damage from the plume is visible.

The imagery shown on Plate 8.4-8 is an enhanced color infrared mosaic from the three flightlines of July 1979. Plate 8.4-9 and 8.4-10 are the data from July 1979. The black-and-white is channel 10 and the color is enhanced color infrared produced from channels 4, 6, and 10.

PLATE 8.4-8 ENHANCED COLOR INFRARED MOSAIC (JULY 1979)

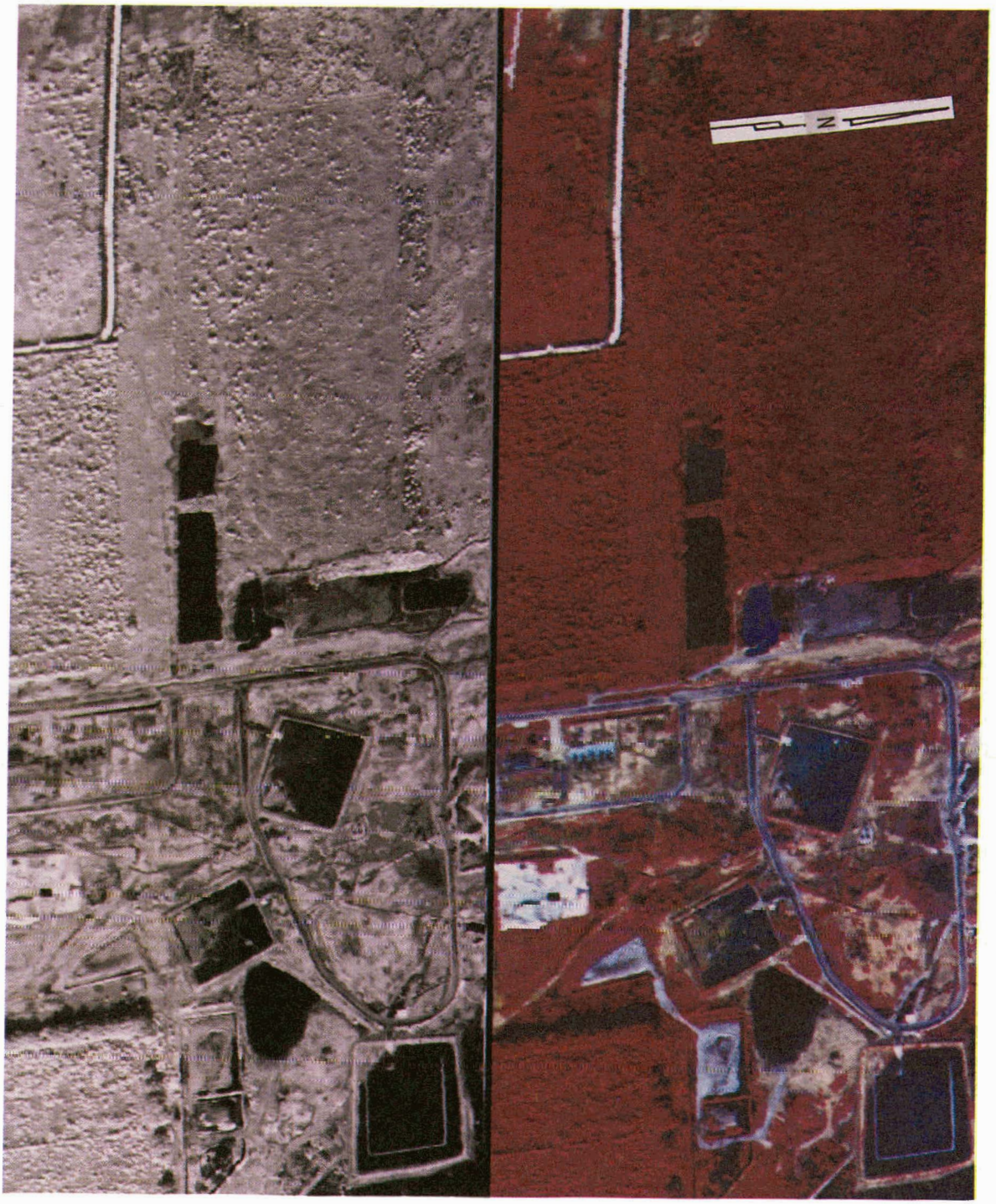


PLATE 8.4-9 BLACK AND WHITE AND ENHANCED COLOR, INFRARED IMAGES (JULY 1979)

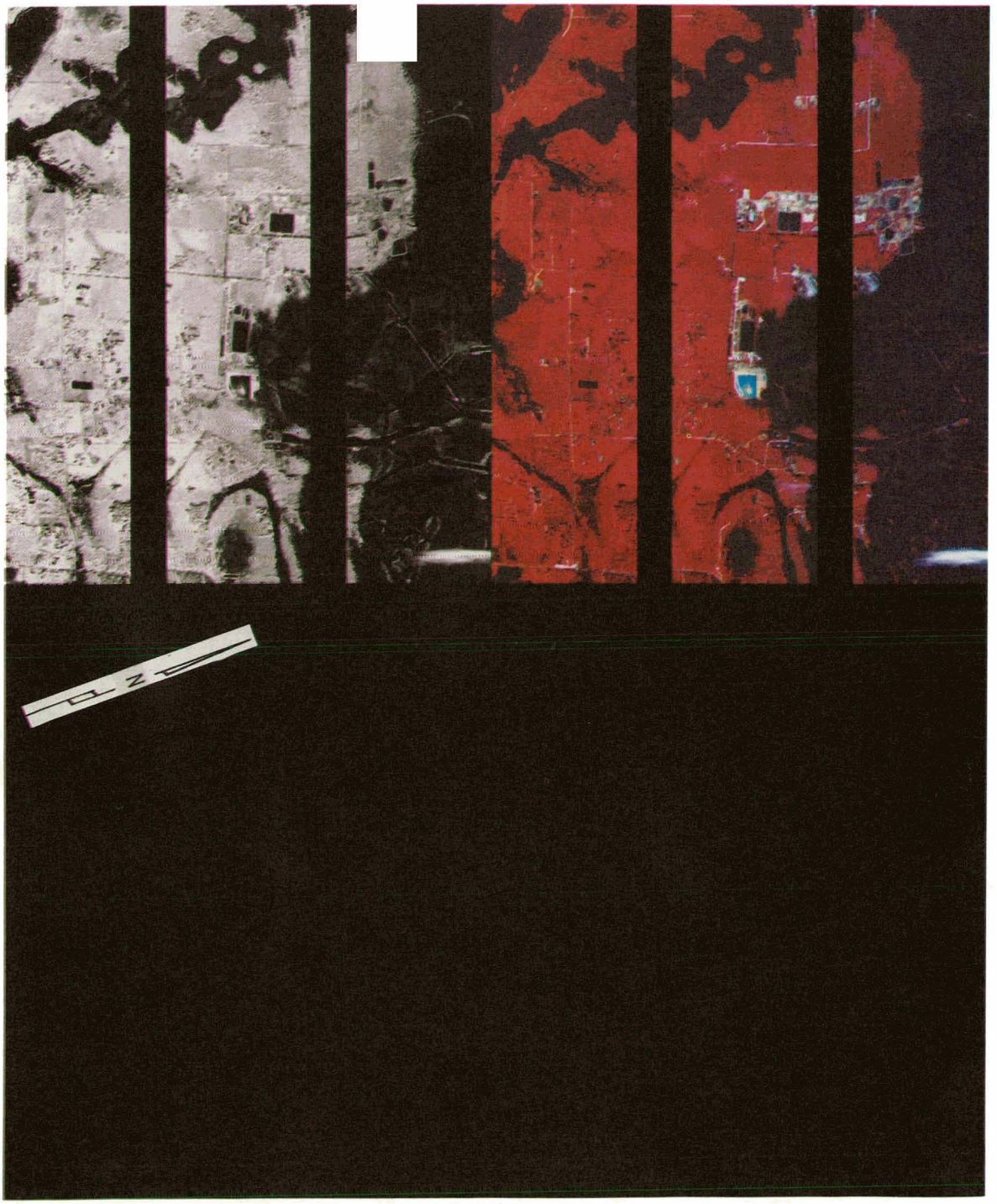


PLATE 8.4-10 BLACK AND WHITE AND ENHANCED COLOR INFRARED IMAGES (JULY 1979)

9.0 DISCUSSION AND CONCLUSIONS

9.1 BIOLOGICAL

In general, the area affected by the spill was as densely populated by aquatic organisms as either of the control areas selected. The West Control Area lake site had significantly fewer organisms in Phases I and III than its counterpart in the Affected Area. This faunal difference was probably due to a difference in substrate texture. A significant increase in density of animals between Phases I and II in the Affected Area was accompanied by a similar increase at the East Control Area. Thus, this increase was probably a seasonal change rather than a spill-induced effect. However, this change was greater in the East Control Area than in the Affected Area, resulting in a significant difference in total density between these sites in Phase II. This difference may have been related to the spill. No similar effects were observed in the marshes.

Although some of the faunal differences between the Affected Area and the control areas may have been induced by spilled oil, none of these differences have persisted. Analysis of total faunal densities indicated that a long-term (1-year) change in faunal density of greater than 30 percent of the lake benthos or greater than 45 percent of the marsh benthos did not occur.

Some of the distribution patterns of animals observed in the marsh habitats were interrelated. The absence of mussels (Geukensia) in Phase I East Control samples (Table 8.1-9) affected the distribution of amphipods, nematodes, and mud crabs, which utilize the mussel beds as a microhabitat. Other patterns are related to substrate. The predominance of medium to fine sands within the Affected Area of Black Lake probably accounted for the high densities of polychaete and oligochaete worms there, and the compacted fine sediments in the West Control Area of the lake were probably responsible for the low density of organisms.

The faunal, floral and substrate differences, which do not seem related to the spill, between the West Control lake area and the East Control marsh area and their counterparts in the Affected Area suggested that these former areas were poor control sites. Thus, they were sampled only minimally in Phases II through IV, and a North Control Area marsh was established to replace the East Control marsh.

Several of the species encountered in this survey are known to be sensitive to crude oil contamination. Juvenile mussels, Geukensia demissa, were common in the marshes at the time of the accident and during subsequent field surveys. The mud crab, Neopanope texana, was also commonly encountered in marsh samples. Survey results provided no evidence that these populations were reduced by the oil spill. The polychaete worm, Capitella capitata, rarely occurred in the samples. This worm is a cosmopolitan species often recognized as an opportunistic indicator of pollution (Reish, 1971; Grassle and Grassle, 1974). Its low abundance in Black Lake suggested that: 1) the contamination resulting from this spill was mild relative to that of other spills studied, 2) oil contamination is chronically high in Black Lake, enabling other oil-adapted species to replace Capitella, or 3) other environmental factors were unfavorable for Capitella.

Gill net catches provided no evidence that the Affected Area was being avoided by nektonic animals. In fact, the Phase I catch per unit effort was approximately twice as great in the Affected Area as in either control area. Commercial species (white shrimp, blue crab, menhaden, mullet, croaker) were commonly caught in the Affected Area.

There was no evidence of any direct impact on birds in or around Black Lake as a result of the fire and oil spill. Black Lake is not heavily used by waterfowl, and there was no evidence of either a qualitative or quantitative difference in use by birds.

The range of pH values determined during the Phase I field survey (7.4 to 8.0, Table 8.1-27) was within that observed at the site during construction (6.8 to 8.0, DOE, 1977-1979), and also within the Louisiana State Water Quality Criterion for Black Lake of 6.0 to 8.5. However, total coliform bacteria counts in the Affected Area exceeded the Louisiana State Water Quality Criterion for Black Lake of 1,000 per 100 milliliters. Only 1 of 25 measurements of dissolved oxygen during the construction was below the Louisiana State Water Quality Criterion of 4.0 ppm, and this condition was short-lived (DOE, 1977-1979). Biochemical oxygen demand values for the affected area (Table 8.1-24) were higher than those measured at numerous sites in La Fourche Parish (Russell, 1961) probably due in part to the high bacteria densities in these samples.

Because of the hydrologic, geologic and meteorologic processes and construction activities at the site, the difference in vegetative biomass between the Affected and Controlled Areas found in this study cannot be attributed solely to oiling. However, oiling(s) have had direct effects on individual stems in the population, given the observation that in addition to normal loss apparent in all plots, all oiled stems in the sorted samples were dying or dead. Populations in the Affected Area may have been experiencing higher mortality due to more frequent and/or severe oiling and possibly were forced to recruit vegetatively at a proportionally higher rate. It is possible that this additional stress made it difficult for the Affected Area population to sustain itself in an erosional environment as well as do the populations in the control areas (EPA, 1978a). The two factors may have been acting synergistically; i.e., increased mortality led to increased erosion which, in turn, increased mortality. The Affected Area may also be experiencing more erosional stress than either control area. This is certainly true for the North Control comparison. Based on field observations, the West Control seems to represent an intermediate erosional environment. According to the data collected in Phase IV (Appendix B.5), West Control

populations fell between North Control and Affected Area populations on almost all parameters measured. Since all sites surveyed in Phase IV showed evidence of oiling, erosional stress may be the differentiating factor.

9.2 CHEMICAL

9.2.1 Factors That Affect Assessment

Petroleum introduced into the environment is subject to various physical and chemical processes that produce changes in the character and disposition of the oil (weathering). These transformations create barriers to the recognition of the petroleum source with time after a spill. Source recognition requires that the chemical input from the incident be differentiated from those originating from indigeneous petroleum, biological sources, or other types of hydrocarbon sources and must take into account the effects of weathering in the distribution of these hydrocarbons. The sum of this information permits an evaluation of the chemical burden on the environment caused by the petroleum spill and fire. A discussion of the chemical and physical factors affecting this assessment follows.

9.2.1.1 Chemical Factors

Petroleum is a complex mixture of many thousands of different hydrocarbons, nonhydrocarbons (nitrogen, oxygen, sulfur-containing compounds) and trace metals (vanadium, nickel). Each type of petroleum has a characteristic distribution of these components peculiar to its source. Several of these chemical characteristics persist in an environmental sample and provide a means of establishing the source of the petroleum contamination. Specifically, the distributions of pristane, phytane, the alkylated dibenzothiophenes and phenanthrenes, and vanadium were used to indicate contamination by Cavern 6 crude oil. The distributions of various polycyclic aromatic hydrocarbons, such as fluoranthene and pyrene, were used to indicate contamination from the fire.

The oil from Cavern 6 was subjected to two primary types of chemical transformation: burning and weathering. An efficient fire would by

definition destroy the chemical identity of the burning material. However, large amounts of material were only partially oxidized in the fire at West Hackberry, possibly retaining some of the character of the original petroleum. The trace metal components of petroleum would not be destroyed by burning. Pyrolysis and pyrogenesis occur at the high temperatures in the fire. At temperatures greater than 500 to 700°C, many of the components of petroleum undergo pyrolysis (cracking), i.e., the breakdown of large molecules into smaller fragments. Pyrogenesis, the creation of compounds during burning, also occurred and was characterized by the generation of polynuclear aromatic hydrocarbons. The chemical processes of weathering include photo-oxidation and microbial degradation. Also, some petroleum compounds, when exposed to air, undergo auto-oxidation. It has been estimated that 0.2 tons of petroleum per square kilometer per day can be degraded by photo-oxidative processes (Garrett, 1969). These oxidative processes generally increase the water solubility of petroleum compounds and facilitate their decomposition in the environment. However, many of these oxidized petroleum compounds are more toxic and carcinogenic than their parent hydrocarbons.

Another chemical process of weathering is the degradation of petroleum by microorganisms. In a petroleum-producing area, a relatively large population of microbes exists which have petroleum-utilizing capability. Over a period of time, these microorganisms significantly alter the distribution of petroleum compounds and leave only residues and asphaltenes as indications that oil was spilled into the environment. During the advanced stages of the degradation process, it becomes impossible to distinguish the source of spilled oil or its degradation products. Recent studies show that there is a sequential bacterial growth that varies with time and composition of the crude (Pierce et al., 1975; Griffin, 1980). Some of these microbes are pathogenic and produce metabolites which are more soluble in water than the original hydrocarbons. It has not been shown that these metabolites are in sufficient concentrations to pose hazards in the marine environment, nor

has it been shown that the increase of pathogenic metabolite-utilizing bacteria are in sufficient quantities to cause significant environmental stresses. The studies conducted for this assessment did not evaluate microbial degradation.

9.2.1.2 Physical Factors

Petroleum is dispersed into the environment by numerous physical processes. Following the discharge of petroleum from any source, a surface film or "slick" usually forms. During weathering, additional physical effects acting on petroleum include evaporative loss of the volatile components, emulsification, dissolution of water-soluble components, adsorption by suspended organic material and sinking of nonbuoyant petroleum residues. Environmental conditions at the time of the oil spill, as well as the chemical composition of the spilled oil, determine which of the physical and/or chemical weathering processes predominate. The organic components of petroleum which prove most useful for identifying the oil source are those which are least affected by the various weathering processes.

Oil and gas production have existed in the Black Lake area over a period of years. A number of oil spills of varying degrees have occurred throughout its recent history. These spills have not been documented; however, it should be noted that during the 10-day sampling period following the incident, two minor spills occurred offsite in the production area. The supposition that the Black Lake area could not be considered a pristine site required that the stress on the environment caused by the incident at the Department of Energy site be differentiated from the stress in the area caused by previous spills. Thus, it was necessary to distinguish varying levels of Cavern 6 crude oil and Louisiana Sweet Crude in the environment. This goal was accomplished during the course of the assessment.

9.2.2 Conclusions

The two fresh crude oils can be easily differentiated by examining their characteristic passive tags (i.e., distribution of normal hydrocarbons, isoprenoid hydrocarbons and other branched hydrocarbons such as pristane and phytane). As oil in the environment is weathered by various physical (evaporation, dissolution, adsorption by suspended organic material) and chemical (photo-oxidation and microbial degradation) processes, those features which distinguish one oil from another become less clear in environmental samples. Furthermore, types of petroleum that are easily distinguishable while relatively unweathered may not be as easily distinguishable at the parts-per-million level in an environmental sample. Therefore, more detailed analytical techniques must be used to identify the source of petroleum hydrocarbons in weathered samples. These techniques involve separation of the extractable hydrocarbons into saturate and aromatic components and analysis of the aromatic fraction for compounds such as the alkylated phenanthrenes and alkylated dibenzothiophenes. These types of components are not readily affected by the various weathering processes occurring in the environment and therefore serve as excellent markers for determining the source of oil in environmental samples.

The results of this investigation indicated the presence of Cavern 6 crude oil in those areas of Black Lake immediately surrounding the Cavern 6 wellpad (Table 8.2-15 and Figure 8.2-27). Generally, all other areas of Black Lake appeared to be free from contamination with Cavern 6 crude oil. On three occasions, Cavern 6 crude oil was detected in locations outside the impact area. This occurred at Site 30-7-C (Phase I) and Site 30-12-C (Phases II and IV). Moreover, not all sediment samples analyzed from the impact area contained Cavern 6 crude oil. Some of these sediment samples were found to contain Louisiana Sweet Crude, which is indigenous to the area. Thus, the distribution of oil in this impact area was patchy, and efforts to make an accurate environmental

assessment of this oil spill and fire in an area that is not pristine is difficult. On the whole, the oil spill from Cavern 6 appeared to be confined to a small area.

The Cavern 6 oil in this area persisted over the 1-year period (Phase I through IV) of this study (Table 8.2-16). Those sediment samples containing Cavern 6 crude oil in all but Phase II had petroleum type hydrocarbons present in quantities two to four times greater than sediments (Black Lake and Wildlife Refuge) not impacted with Cavern 6 crude oil (Table 8.2-11). Sediments contaminated with Cavern 6 crude oil had 5 to 12 times more oil than soil samples analyzed during Phases III and IV (Tables 8.2-11 and 8.2-12). The relative amount of Cavern 6 crude oil in sediment and soil samples of the impact area remained fairly constant over the 1-year study (Tables 8.2-11 and 8.2-12).

By the analysis of the distribution of the pyrogenic polycyclic aromatic hydrocarbons in samples collected in the southwest quadrant from Well 6, fallout from the plume was detected as far south as the North Stark Canal during Phase I sampling. No samples were collected beyond this transect until Phases III and IV. Analysis of the Phase III samples collected from the Sabine Wildlife Refuge indicated that no pyrogenic products resulting from the fire were present.

Throughout the entire sampling period (Phases I through IV), a small number of samples collected from Black Lake (both impact and nonimpact areas) indicated the probable presence of pyrogenic products due to the fire. Only 8 percent of the soil and sediment samples had quantities of pyrogenic polycyclic aromatic hydrocarbons that were above the background levels for these compounds in this area and which might possibly be attributed to the fire. Other samples also contained elevated quantities of pyrogenic products but these elevations were not due to the fire at Well 6.

Of the pyrogenic products analyzed, those produced in largest quantity by the fire were the chemically stable fluoranthene and pyrene compounds. The more physiologically dangerous polycyclic aromatic hydrocarbons, such as the benzopyrenes, were not detected in concentrations greater than background contamination levels.

In summary, it appears that contamination in the West Hackberry environment was confined to a small area of Black Lake (called Affected Area, Figure 8.2-27) where the oil spill from Cavern 6 occurred.

The intensity and extent of contamination resulting from the fire plume was traced by sampling vegetation downwind of the fire and by measuring the amount of vanadium in excess of background levels as well as the excess levels of fluoranthene and pyrene. These analyses indicate that there were measurable depositions on the vegetation at least 4 km from Cavern 6, the most remote site sampled. The amount of vanadium deposited over this area is estimated to be about 15 percent of all the vanadium lost in the incident. Extrapolation of these distributions indicated that there was measurable deposition of vanadium to 15 km from Cavern 6, and that this additional area accounts for another 10 percent of all the vanadium estimated to be lost. These conclusions are in agreement with the predicted distributions obtained using a Gaussian Plume Model with no plume rise (Appendix C.4).

9.3 PHYSICAL

The effects of a large area of high pressure centered over the northeastern states dominated the entire eastern half of the nation during the last week of September, 1978. In southwest Louisiana, the wind patterns associated with this system had a beneficial impact on the control of the oil fire and spill at West Hackberry. Cooler temperatures associated with the air mass were sufficient to eliminate temporarily the local sea breeze which is characterized by southerly winds during the day and northerly winds at night.

Northeasterly winds prevailed for the duration of the fire and most of the spill (Figures 8.3-3 and 8.3-4). Approximately 96 percent of the winds were from the north to east-northeast sectors, while 66 percent of the wind speeds were observed between 7 and 10 kts. Upper level winds were directionally consistent with surface winds.

The northeasterly winds transported the dense plume over essentially uninhabited areas of marsh to the southwest of the site. The winds, while brisk, were generally insufficient to diminish the rise of the main plume and promote its fuming to ground levels. However, the plume emitted from burning oil within the western containment dike was frequently observed fuming to the ground. Consequently, the entire southwest quadrant in the vicinity of Wellpad 6 was blackened by combustion products from the plume. Otherwise, standard air quality measurements taken during the fire indicated no significant impact at ground level.

Investigations indicated that surface currents in southern Black Lake are dominated by meteorological forces with occasional variances imposed by topographic influences and changes in fetch. Current speeds are typically 2 percent of the wind speeds. Northeasterly winds during the spill forced oil against the south shore of Black Lake essentially

for the duration of cleanup operations. Westerly transport of the oil into the marsh was mitigated by three tiers of oil containment booms deployed the first night of the accident (Figure 8.3-8).

Northeasterly winds intensified on the second and third days of the spill, further concentrating the oil against the south shoreline. On September 22, 1978, the depth of oil near the shore was measured at 20 cm, and differences in fluid levels across the oil containment boom were estimated at 7 to 10 cm. Cleanup operations were greatly facilitated by this wind-induced concentration of the oil.

Nevertheless, some leakage of oil from the boom occurred when it drifted aground in the shallow marsh northwest of Wellpad 6 (Figure 8.3-9). Most of this oil was trapped in a small inlet of marsh immediately west of the oil recovery area, but some evidence of wind-driven oil sheens was observed as far west as the peninsula. The area of marsh impacted by these sheens remained uncontained on the north side for the duration of cleanup operations. Fortunately, about 99 percent of the oil had been recovered from Black Lake when southerly winds associated with the sea breeze were re-established on October 1, 1978 (Figure 8.3-4). Although northerly transport of these isolated sheens was not visibly observed, it is reasonable to assume that areas north of the impacted marsh may have been exposed to minor amounts of Cavern 6 crude oil in early October.

10.0 CONJUNCTIVE BIOLOGICAL/CHEMICAL/PHYSICAL CONCLUSIONS

Some of the oil spilled from Cavern 6 during the September 1978 incident (Cavern 6 crude oil) persisted in the marsh sediments west of the site throughout the 1-year survey and can be expected to persist for several years. The area represents approximately 8.8 hectares. No adverse impacts on animals in this marsh were detected. Adverse changes in marsh vegetation were detected, but the impacts of spilled oil could not be segregated from the impacts of site construction and from the long-term migration of the south shoreline of Black Lake. The major impact of spilled oil on the marsh vegetation was to accelerate the rate of deterioration of this marsh caused by other factors. This deterioration will eventually impact animals which depend on marsh vegetation for habitat structure.

Adaptation of the existing biota to 40 years of oil production in Black Lake probably is responsible for the lack of a more significant detectable impact. Continued oil production probably will continue to prevent development of any detectable sensitivity by aquatic communities to the Cavern 6 crude oil for as long as it persists in Black Lake.

Products of oil combustion (pyrogenic products) distributed by the fire plume consisted largely of chemically stable fluoranthene and pyrene compounds rather than more physiologically dangerous compounds, such as benzopyrenes. The latter compounds were not detected in concentrations greater than background levels in Phases III and IV within the path of the plume. Remote sensing evaluation of stress in vegetation under the plume indicated that such stress existed immediately after the fire, but had disappeared by the end of the 1-year survey.

Blank

LITERATURE CITED

Anonymous, 1969. Results of an otter trawl study in Black Lake, Louisiana. Louisiana Wildlife and Fisheries Commission. Unpublished manuscript.

_____. 1979. Oiled marsh grass recovers in Charleston. Oil Spill Intelligence Report, May 25, 1979, p. 4.

American Petroleum Institute. 1957. Determination of ammonia. Manual on disposal of refinery wastes. Number 736-754. API, New York.

_____. 1977. Oil spill studies: Strategies and techniques. API Publication No. 4286.

American Public Health Association. 1971. Standard methods for the examination of water and waste water, 13th edition. APHA, Washington, D.C.

American Society of Testing & Materials. 1975. Natural building stones; soil and rock; peats, mosses and humus. Part 19, ASTM, Philadelphia.

Anderson, J. W., J. M. Neff, B. A. Cox, H. E. Tatem, G. M. Hightower. 1974. Characteristics of dispersions and water soluble extracts of crude and refined oils and their toxicity to estuarine crustaceans and fish. Marine Biology 27:75-88.

Andrews, J. 1977. Shells and shores of Texas, 2nd edition. University of Texas Press, Austin, Texas.

Atema, J. 1976. Sublethal effects of petroleum fraction on the behavior of the lobster, Homarus americanus, and the mud snail, Nassarius obsoletus. In: Estuarine processes, vol. I, W. Wiley (ed.). Academic Press, New York, pp. 302-312.

Atkinson, L. D., W. M. Dunstan, and J. G. Natoli. 1977. The analysis and control of volatile hydrocarbon concentrations (e.g., Benzene) during oil bioassays. Water, Air, and Soil Pollution 8:235-242.

Baker, J. M. 1970. Oil pollution in salt marsh communities. Marine Pollution Bulletin 1:27-28.

Baum, E. J. 1978. Occurrence and surveillance of polycyclic aromatic hydrocarbons. In: Polycyclic hydrocarbons and cancer, vol. I, H. V. Gelboin and P. O. P. Ts'o (eds.). Academic Press, New York, pp. 45-70.

Barnes, R. D. 1968. Invertebrate zoology, 2nd edition. W. B. Saunders, Philadelphia.

Bender, M. E., J. L. Hyland, and T. K. Duncan. 1974. Effect of an oil spill on benthic animals in the Lower York River, Virginia. In: NBS Special Publications 409, marine pollution monitoring (petroleum), proceedings of a symposium and workshop held at NBS, Gaithersburg, Maryland, May 13-17, 1974.

Bentancourt, D. J., and A. Y. McLean. 1973. Changes in chemical composition and physical properties of a heavy residual oil weathering under natural conditions. Journal of the Institute of Petroleum 59:223-230.

Blumer, M., J. Sass, H. Sanders, J. Grassle, and G. Hampson. 1970. The West Falmouth oil spill. Unpublished report #70-44. Woods Hole Oceanographic Institute, Woods Hole, Massachusetts.

Bousfield, E. L. 1973. Shallow-water Gammaridean Amphipods of New England. Cornell University Press, Ithaca.

Burwood, R., and G. C. Speers. 1974. Photooxidation as a factor in the environmental disposal of crude oil. Estuarine and Coastal Marine Science 2:117-135.

Byrne, C. J., and J. A. Calder. 1977. Effect of the water-soluble fractions of crude, refined and waste oils on the embryonic and larval stages of the quahog clam, Mercenaria sp. Marine Biology 40:225-231.

Calder, J. A., J. Lake, and J. Laseter. 1978. Chemical composition of selected environmental and petroleum samples from the Amoco Cadiz oil spill. In: The Amoco Cadiz oil spill, W. N. Hess (ed.). NOAA/EPA Special Report, Washington, D.C., pp. 21-84.

Chanley, P., and J. Andrews. 1971. Aids for identification of bivalve larvae of Virginia. Malacologia 11(1):45-119.

Cooper, A. W., and E. D. Waits. 1973. Vegetation types in an irregularly flooded salt marsh in the North Carolina Outer Banks. Journal of the Elisha Mitchell Science Society 89:78-91.

Correll, D. S., and M. C. Johnston. 1970. Manual of the vascular plants of Texas. Texas Research Foundation, Renner, Texas.

Cox, Robert E., 1980. Personal communication.

Cruz, A. A. de la. 1974. Primary production of Mississippi coastal marshes. Bulletin of the Ecological Society of America 55(2):28.

Department of Commerce. 1964. Climatic summary of the United States, Louisiana Supplement Climatography of the United States No. 86-14. Washington, D.C.

_____. 1977. The Argo Merchant oil spill, a preliminary scientific report. NOAA Special Report.

Department of Energy. 1977-1979. Environmental reports. Strategic Petroleum Reserve Project Office. Unpublished manuscript. New Orleans, Louisiana.

_____. 1978a. Report on the explosion, fire and oil spill resulting in one fatality and injury on September 21, 1978; November, 1978 (DOE/EV-0032).

_____. 1978b. OSC After Action Report - West Hackberry Oil Storage Cavern Fire and Spill. Strategic Petroleum Reserve Project Office, New Orleans, Louisiana.

Edwards, R. R. C. 1978. Effects of water-soluble oil fractions on metabolism, growth and carbon budget of the shrimp, Crangon crangon. Marine Biology 46:259-265.

Environmental Protection Agency. 1976. An ordering of the NIOSH suspected carcinogen test based only on data contained in the test. Washington, D.C. NTIS PB-251851.

_____. 1977. Protection of the environment. Code of Federal Regulations, Title 40, Part 50, Chapter I. U.S. Government Printing Office, Washington, D.C.

_____. 1978a. Response of a salt marsh to oil spill and cleanup: Biotic and erosional effects in the Hackensack Meadows, New Jersey. Interagency Energy/Environment R&D Program Report No. EPA-600/7-78-109.

_____. 1978b. Procedures for quantitative ecological assessments in intertidal environments. EPA-600/3-78-087.

Fauchild, K. 1977. The Polychaete worms. Natural History Museum of Los Angeles, County, Science Series 28.

Floodgate, G. D. 1972. Microbial degradation of oil. Marine Pollution Bulletin 3:41-43.

Food & Agricultural Organization of the United Nations. 1977. Impact of oil in the marine environment: Reports and studies No. 6, Chapter 6, Effects on marine life forms. United Nations, New York.

Foster, W. A. 1968. Studies on the distribution and growth of Juncus roemerianus in southeastern Brunswick County, North Carolina. MS Thesis, North Carolina State University, Raleigh, North Carolina.

Gabriel, B. C., and A. A. de la Cruz. 1974. Species composition, standing stock and net primary productivity of a salt marsh community in Mississippi. Chesapeake Science 15(2):72-77.

Gallagher, J. L., et al. 1976. Aerial production, mortality and mineral accumulation dynamics in Spartina alterniflora and Juncus roemerianus in a Georgia salt marsh. Unpublished manuscript. Draft for the University of Georgia Marine Institute, Sarelo Island, Georgia.

Gallagher, J. L., R. J. Reinold and P. E. Thompson. 1972. Remote sensing and salt marsh production. American Society of Photogrammetry Annual Meeting, 1972.

Garrett, W. D. 1969. Confinement and control of oil pollution on water with monomolecular surface films. In: Proceedings, joint conference on prevention and control of oil spills. American Petroleum Institute, Washington, D.C., pp. 257-262.

Gelboin, H. V., and P. O. P. Ts'o (eds.). 1978. Polycyclic hydrocarbons and cancer, volume I. Academic Press, New York.

Gibson, T. L., V. B. Smart, and L. L. Smith. 1978. Non-enzymic activation of polynuclear aromatic hydrocarbons as mutagens. Mutation Research 49:153-161.

Gilfillan, E. S. 1975. Decrease of net carbon flux in two species of mussels caused by extracts of crude oil. Marine Biology 29(1): 53-58.

Gilfillan, E. S., and J. H. Vandermeulen. 1978. Alternations in growth and physiology of soft-shell clams, Mya arenaria, chronically oiled with Bunker C from Chedabucto Bay, Nova Scotia, 1970-1976. Journal of the Fisheries Research Board of Canada 35(5):630636.

Goldberg, E. D. (ed.). 1979. Proceedings of a workshop on scientific problems relating to ocean pollution. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Environmental Research Laboratories.

Gosner, K. L. 1971. Guide to identification of marine and estuarine invertebrates. Wiley-Interscience, New York.

Grassle, J. F., and J. P. Grassle. 1974. Opportunistic life histories and genetic systems in marine benthic polychaetes. J. Mar. Res. 32(2):253-284.

Griffin, D. J. 1980. Response of a natural population of marine heterotrophic bacteria to a crude oil and dispersant. MS Thesis, University of Rhode Island, Kingston, Rhode Island.

Guerin, M. R. 1978. Energy sources of polycyclic aromatic hydrocarbons. In: Polycyclic hydrocarbons and cancer, vol. I, H. V. Gelboin and P. O. P. Ts'o (eds.). Academic Press, New York, pp. 3-42.

Harper, D. E. 1968. Key to the polychaetous annelids of the northwestern Gulf of Mexico. Unpublished manuscript. Texas A&M Moody College of Marine Science, Galveston, Texas.

Hartman, O. 1951. Key to the polychaetous annelids of the Gulf of Mexico. Publication of the Institute of Marine Science, Port Aransas, Texas 2:7-124.

Heald, E. J. 1969. The production of organic detritus in a south Florida estuary. Ph.D. dissertation, University of Miami, Miami, Florida.

Heitz, J. R., L. Lewis, J. Chambers, and J. D. Yarbrough. 1974. The acute effects of empire mix crude oil on enzymes in oysters, shrimp and mullet. In: Pollution and physiology of marine organisms, F. Vernberg and W. Vernberg (eds). Academic Press, New York.

Henry, D. M. 1978. Ambient air survey for Parsons-Gilbane, Hackberry, Louisiana. Unpublished. Lake Charles, Louisiana.

Hodson, R. E., F. Azam, and R. F. Lee. 1977. Effects of four oils on marine bacterial populations: Controlled ecosystem pollution experiment. Bulletin of Marine Science 27(1):119-126.

Hoffman, D., I. Schmeltz, S. S. Hecht, and E. L. Wynder. 1978. Tobacco carcinogenesis. In: polycyclic hydrocarbons and cancer, vol. I, H. V. Gelboin and P. O. P. Ts'o (eds.). Academic Press, New York, pp. 85-117.

International Agency for Research on Cancer. IARC. 1971-1977. Monographs on the evaluation of carcinogenic risk of chemicals to man. Vol. 1 to 13. Lyon, France.

Jerina, D. M. and J. W. Daly. 1974. Arene oxides: A new aspect of drug metabolism. Science 185:573-582.

Johannsen, O. A. 1937. Aquatic Diptera. Cornell University Press, Ithaca.

Katz, L. M. 1973. The effects of water soluble fraction of crude oil on larvae of the decapod crustacea, Neopanope texana. Environmental Pollution 5:199-204.

Keck, R. T., R. C. Heess, J. Wehmiller, and D. Maurer. 1978. Sublethal effects of the water-soluble fraction of Nigerian crude oil on the juvenile hard clams, Mercenaria mercenaria (Linne). Environmental Pollution 15:109-119.

Krebs, C. T., and K. A. Burns. 1977. Long-term effects of an oil spill on populations of the salt marsh crab, Uca pugnax. Science 197: 4884-487.

Lacaze, J. C., and L. Villedon de Naide. 1976. Influence of illumination on phytotoxicity of crude oil. Marine Pollution Bulletin 7:73-76.

Larson, R. A., L. L. Hunt, and D. W. Blankenship. 1977. Formation of toxic products from a #2 fuel Oil by photooxidation. Environmental Science and Technology 11:492-496.

Laughlin, R. B., L. G. L. Young, and J. M. Neff. 1978. A long-term study of the effects of water-soluble fractions of No. 2 fuel oil on the survival, development rate, and growth of the mud crab, Rhithropnaopeus harrisii. Marine Biology 47:87-95.

Lawler, G. C., W. A. Loong, and J. L. Laseter. 1978a. The accumulation of saturated hydrocarbons in tissues of petroleum exposed mallard ducks (Anas platyrhynchos). Environmental Science and Technology 12:47-51.

_____. 1978b. The accumulation of aromatic hydrocarbons in tissues of petroleum exposed mallard ducks (Anas platyrhynchos). Environmental Science and Technology 12:51-54.

LeBoeuf, B. J. 1971. Oil contamination and elephant seal mortality: A "negative" finding. In: Biological and Oceanographical survey of the Santa Barbara Channel oil spill, 1969-1970, volume I, D. Straughan (Comp.). University of Southern California.

Lee, R. F., R. Sauerheber, and A. A. Benson. 1972. Petroleum hydrocarbons: Uptake and discharge by the marine mussel, Mytlus edulis. Science 177:344-346.

Lee, W. Y., and J. A. C. Nicol. 1977. The effects of the water soluble fractions of No. 2 fuel oil on the survival and behavior of coastal and oceanic zooplankton. Environmental Pollution 12:279-292.

Lee, W. Y., M. F. Welch, and J. A. C. Nicol. 1977. Survival of two species of amphipods in aqueous extracts of petroleum oils. Marine Pollution Bulletin 8(4).

Linden, O. 1978. Biological effects of oil on early development of the Baltic herring, Clupea harengus membras. Marine Biology 45: 273-283.

Mackin, J. G. 1973. A review of significant papers on effects of oil spills and oilfield brine discharge on marine biotic communities. TAMU Foundation Project Report 737, College Station, Texas.

McCann, J., E. Choi, E. Yamasaki, and E. N. Ames. 1975. Detection of carcinogens as mutagens in the Salmonella/microsome test: Assay of 300 chemicals. Proceedings of the National Academy of Science, USA, 72:5135-5139.

Moore, S. F., and R. L. Dwyer. 1974. Effects of oil on marine organisms. Water Research 8:819-822.

Nie, N. H., C. H. Hull, J. G. Jenkins, D. Steinbrenner, and D. H. Bent. 1975. Statistical package for the social sciences, 2nd edition. McGraw-Hill, New York.

Overton, E. B., J. R. Patel, and J. L. Laseter. 1979. Chemical characterization of mousse and selected environmental samples from the Amoco Cadiz oil spill. In: Proceedings 1979 oil spill conference, EPA, API, USCG, pp. 169-174.

Overton, E. B., C. F. Steele, and J. L. Laseter. 1978. Computer reconstruction of high resolution gas chromatograms. Journal of High Resolution Chromatography and Chromatography Communication 7:109-110.

Patel, J. R., E. B. Overton, and J. L. Laseter. 1979. Environmental photooxidation of dibenzothiophene following the Amoco Cadiz oil spill. Chemosphere 8:557-561.

Patel, J. R., I. R. Politzer, G. W. Griffin, and J. L. Laseter. 1978. Mass spectra of the oxygenated products generated from phenanthrene under simulated environmental conditions. Biomedical Mass Spectrometry 5:664-669.

Payne, J. F., J. W. Kiceniuk, W. R. Squires. 1978a. Pathological changes in a marine fish after a 6-month exposure to petroleum. Journal of the Fisheries Research Board of Canada 35:665-667.

Payne, J. F., I. Martina, and A. Rahimtula. 1978b. Crankcase oils: Are they a major mutagenic burden in the aquatic environment. Science 200:329-330.

Pierce, R. H., Jr., A. M. Cundell, and R. W. Traxler. 1975. Persistence and biodegradation of spilled residual fuel oil on an estuarine beach. Applied Microbiology 29:646-652.

Reish, D. J. 1959. A discussion of the importance of the screen size in washing quantitative marine bottom samples. Ecology 40(2): 307-309.

_____. 1971. Effect of petroleum abatement in Los Angeles harbor. Marine Pollution Bulletin 2:71-74.

Richardson, H. 1905. A monograph on the Isopods of North America. Bulletin of the U.S. National Museum 36:1-481.

Rinkus, S. J., and M. S. Legator. 1979. Chemical characterization of 465 known or suspected carcinogens and their correlation with mutagenic activity in the Salmonella typhimurium system. Cancer Research 39:3289-3318.

Robbins, C. 1966. Birds of North America. Western Publishing Co., New York.

Rossi, S. S., and J. W. Anderson. 1976. Toxicity of water-soluble fractions of No. 2 fuel oil and South Louisiana crude oil to selected stages in the life history of the polychaete, Neanthes arenaceodetata. Bulletin of Environmental Contamination and Toxicology 16(1):18-24.

_____. 1978. Effects of No. 2 fuel oil - water-soluble fractions on growth and reproduction in Neanthes arenaceodentata (Polychaeta: Annelida). Water, Air & Soil Pollution 9:155-170.

Russell, R. J. (ed.). 1961. Louisiana coastal marsh ecology. Technical Report No. 14, Coastal Studies Institute, Louisiana State University, Baton Rouge, Louisiana.

Scheir, A., and D. Gominger. 1976. A preliminary study of the toxic effects of irradiated versus nonirradiated water soluble fractions of #2 Fuel Oil. Bulletin of Environmental Contamination and Toxicology 16:595-603.

Shoemaker, C. R. 1947. Further notes on the amphipod genus, Corophium, from the east coast of America. Journal of the Washington Academy of Science 37(2):47-63.

Sokal, R. R., and F. J. Rohlf. 1969. Biometry. W. H. Freeman & Co., San Francisco.

Smith, H. M. 1968. Qualitative and quantitative aspects of crude oil composition. U.S. Department of Interior, Bulletin 642, Bureau of Mines.

Smith, J. E. 1970. "Torrey Canyon" pollution and marine life. Cambridge University Press, Cambridge, Massachusetts.

Stainken, D. M. 1978. Effects of uptake and discharge of petroleum hydrocarbons on the respiration of the soft-shell clam, Mya arenaria. Journal of the Fisheries Reserach Board of Canada 35: 637-642.

Steele, C. F. 1978. In preparation.

Straughan, D. (ed.). 1971. Biological and oceanographical survey of the Santa Barbara Channel oil spill, 1969-1970. Allan Hancock Foundation, University of Southern California, Los Angeles, California.

Stroud, L., and A. W. Cooper. 1969. Color infrared aerial photographic interpretation and net primary productivity of a regularly flooded North Carolina salt marsh. Report No. 14, Water Research Institute, University of North Carolina, Chappell Hill, North Carolina.

Tate, M. W., and R. C. Clelland. 1957. Nonparametric and shortcut statistics. Interstate Printers and Publishers, Inc., Danville, Illinois.

Turner, B. D. 1970. Workbook of atmospheric dispersion estimates. E.P.A, Office of Air Programs, Research Triangle Park, North Carolina.

U.S. Army Corps of Engineers. 1973. Inventory of basic environmental data - South Louisiana, Mermentau River Basin to Chandeleur Sound with special emphasis on the Atchofalaya Basin. New Orleans, Louisiana.

U.S. Geological Survey. 1955. Black Lake 7.5 minute series topographic map. Published by the U.S. Geological Survey in cooperation with the State of Louisiana Department of Public Works.

Usinger, R. L. 1956. Aquatic insects of California. University California Press, Berkeley.

Varanasi, U., and D. C. Malins. 1977. Metabolism of petroleum hydrocarbons: Accumulation and biotransformation in marine organisms. In: Effects of petroleum on arctic and subarctic marine environments and organisms, vol. II, D. C. Malins (ed.), pp. 175-270.

Venezia, L. D., and V. U. Fossato. 1977. Characteristics of suspensions of Kuwait oil and Corexit 7664 and their short- and long-term effects on Tisbe bulbisetosa (Copepoda: Harpacticoida). Marine Biology 42:233-237.

Waits, E. D. 1967. Net primary productivity of an irregularly flooded North Carolina salt marsh. Ph.D. dissertation, North Carolina State University, Raleigh, North Carolina.

Wass, W. L., and T. D. Wright. 1969. Special report, Virginia Institute of Marine Science, Applied Marine Science and Ocean Engineering, No. 10.

Williams, A. B. 1965. Marine decapod crustaceans of the Carolinas. Fisheries Bulletin 65(1):1-298.

Williams, B., and B. Murdoch. 1972. Compartmental analysis of the production of Juncus roemerianus in a North Carolina salt marsh. Chesapeake Science 13(2):69-79.

Williams, G. E., III. 1974. New technique to facilitate hand-picking macrobenthos. Transactions of the American Microscopy Society 93(2):220-226.

Yarbrough, J. D., and J. E. Chambers. 1977. Crude oil effects on microsomal mixed-function oxidase system components in the striped mullet (Mugil cephalus). Life Sciences 21:1095-1100.

APPENDICES

LIST OF TABLES

Table	Title	Page
A.1-1	Numbers and Types of Samples Collected at Designated Stations During Phases I-IV	A-2
A.1-2	Sample Coordinates - Chemical Stations	A-11
A.1-3	Sample Coordinates - Biological Stations	A-14
B.4-1	Variance Ratios (F) for Two-Level Comparisons Between Sites for Black Lake Benthos	B-57
B.4-2	Variance Ratios (F) for Two-Level Comparisons Between Sites for Marsh Benthos	B-59
B.5-1	Live Biomass Data Summary for Affected Area Samples	B-62
B.5-2	Live Biomass Data Summary for North Control Samples	B-65
B.5-3	Live Biomass Data Summary for West Control Samples	B-67
B.5-4	Total Biomass Data Summary for Affected Area Samples	B-70
B.5-5	Total Biomass Data Summary for North Control Samples	B-73
B.5-6	Total Biomass Data Summary for West Control Samples	B-75
C.4-1	Summary of Wind Conditions, Lake Charles, Louisiana, September 25-26, 1978	C-102
C.4-2	Comparison of Vanadium Deposition Calculated from Plume Model with Vanadium Found on the Tallow Leaves	C-107
C.5-1	Trace Element Analysis - Mean ng of Elements/cm^2 of Tallow Leaf - Phase I	C-111
C.5-2	Trace Metal Data for Soil Samples (ppm dry weight) - Phase II	C-113
C.5-3	Trace Metal Data for Sediment Samples (ppm dry weight) - Phase II	C-115
C.5-4	Trace Metal Data for Soil Samples - Phase III	C-117
C.5-5	Data for Vegetational Trace Metal Samples (ppm dry weight) - Phase IV	C-118

LIST OF TABLES (CONT.)

Table	Title	Page
C.5-6	Data for Soil Trace Metal Samples (ppm dry weight) - Phase IV.....	C-119
C.5-7	Weather Data for September 25-26, 1978.....	C-120
C.6-1	Multiparameter Quantification of Cavern 6 Crude Oil, DOE Hackberry Sediment Samples Analyzed by UNO.....	C-123
C.6-2	Multiparameter Quantification of Cavern 6 Crude Oil, DOE Hackberry Soil Samples Analyzed by UNO.....	C-126
C.6-3	Multiparameter Quantification of Cavern 6 Crude Oil, DOE Hackberry Foliage Samples Analyzed by UNO.....	C-127
C.6-4	Multiparameter Quantification of Cavern 6 Crude Oil, DOE Hackberry Tissue Samples Analyzed by UNO.....	C-128
C.6-5	Quantitation of Pyrogenic Products, DOE Hackberry Samples Analyzed by UNO, Phase I.....	C-129
C.6-6	Quantitation of Pyrogenic Products, DOE Hackberry Samples Analyzed by UNO, Phase II.....	C-131
C.6-7	Quantitation of Pyrogenic Products, DOE Hackberry Samples Analyzed by UNO, Phase III.....	C-133
C.6-8	Quantitation of Pyrogenic Products, DOE Hackberry Samples Analyzed by UNO, Phase IV.....	C-135
C.6-9	Quantitation of Pyrogenic Products by Area.....	C-136
D.1-1	Frequency Distribution of Winds, West Hackberry Site, Station 1, September 29-30, 1978.....	D-2
D.1-2	Relative Frequency Distribution of Winds, West Hackberry Site, Station 1, September 29-30, 1978.....	D-3
D.1-3	Frequency Distribution of Winds, West Hackberry Site, Station 1, October, 1978.....	D-4
D.1-4	Relative Frequency Distribution of Winds, West Hackberry Site, Station 1, October, 1978.....	D-5
D.1-5	Frequency Distribution of Winds, West Hackberry Site, Station 1, November, 1978.....	D-6

LIST OF TABLES (CONT.)

Table	Title	Page
D.1-6	Relative Frequency Distribution of Winds, West Hackberry Site, Station 1, November, 1978.....	D-7
D.1-7	Frequency Distribution of Winds, West Hackberry Site, Station 1, December, 1978.....	D-8
D.1-8	Relative Frequency Distribution of Winds, West Hackberry Site, Station 1, December, 1978.....	D-9
D.1-9	Frequency Distribution of Winds, West Hackberry Site, Station 1, September 29 to December 27, 1978.....	D-10
D.1-10	Relative Frequency of Winds, West Hackberry Site, Station 1, September 29 to December 27, 1978.....	D-11
D.1-11	Frequency Distribution of Winds, West Hackberry Site, Station 2, September 29-30, 1978.....	D-12
D.1-12	Relative Frequency Distribution of Winds, West Hackberry Site, Station 2, September 29-30, 1978.....	D-13
D.1-13	Frequency Distribution of Winds, West Hackberry Site, Station 2, October, 1978.....	D-14
D.1-14	Relative Frequency Distribution of Winds, West Hackberry Site, Station 2, October, 1978.....	D-15
D.1-15	Frequency Distribution of Winds, West Hackberry Site, Station 2, November, 1978.....	D-16
D.1-16	Relative Frequency Distribution of Winds, West Hackberry Site, Station 2, November, 1978.....	D-17
D.1-17	Frequency Distribution of Winds, West Hackberry Site, Station 2, December, 1978.....	D-18
D.1-18	Relative Frequency Distribution of Winds, West Hackberry Site, Station 2, December, 1978.....	D-19
D.1-19	Frequency Distribution of Winds, West Hackberry Site, Station 2, September 29 to December 27, 1978.....	D-20
D.1-20	Relative Frequency Distribution of Winds, West Hackberry Site, Station 2, September 29 to December 27, 1978.....	D-21

LIST OF TABLES (CONT.)

Table	Title	Page
D.1-21	Frequency Distribution of Winds, West Hackberry Site, Station 3, September 29-30, 1978	D-22
D.1-22	Relative Frequency Distribution of Winds, West Hackberry Site, Station 3, September 29-30, 1978	D-23
D.1-23	Frequency Distribution of Winds, West Hackberry Site, Station 3, October, 1978	D-24
D.1-24	Relative Frequency Distribution of Winds, West Hackberry Site, Station 3, October, 1978	D-25
D.1-25	Frequency Distribution of Winds, West Hackberry Site, Station 3, November, 1978	D-26
D.1-26	Relative Frequency Distribution of Winds, West Hackberry Site, Station 3, November, 1978	D-27
D.1-27	Frequency Distribution of Winds, West Hackberry Site, Station 3, December, 1978	D-28
D.1-28	Relative Frequency Distribution of Winds, West Hackberry Site, Station 3, December, 1978	D-29
D.1-29	Frequency Distribution of Winds, West Hackberry Site, Station 3, September 29 to December 27, 1978	D-30
D.1-30	Relative Frequency Distribution of Winds, West Hackberry Site, Station 3, September 29 to December 27, 1978	D-31

LIST OF FIGURES

Figure	Title	Page
A.1-1	Chemistry Stations in Sabine National Wildlife Refuge...	A-16
A.1-2	Sample Locations In and Around Well Pad 6 and Black Lake.....	A-17
C.1-1	Gas Chromatograms of a Foliage Sample Collected Near Wellpad 6 and Heavily Impacted with Cavern 6 Oil (Sample No. 3). A) Hexane Fractions; B) Aromatic Fractions.....	C-3
C.1-2	Gas Chromatograms of a Typical Foliage Sample (Sample No. 43). A) Hexane Fractions; B) Aromatic Fractions....	C-5
C.1-3	Gas Chromatograms of a Typical Soil Sample (Sample No. 640). A) Hexane Fractions; B) Aromatic Fractions.....	C-7
C.1-4	Gas Chromatograms of a Typical Sediment Sample (Phase II) in the Impact Area Lightly Contaminated with Cavern 6 Oil (Sample No. 627). A) Hexane Fractions; B) Aromatic Fractions.....	C-9
C.1-5	Gas Chromatograms of a Typical Sediment Sample (Phase I) in the Impact Area Moderately Contaminated with Cavern 6 Oil (Sample No. 13). A) Hexane Fractions; B) Aromatic Fractions.....	C-11
C.1-6	Gas Chromatograms of a Typical Sediment Sample (Phase III) in the Impact Area Moderately Contaminated with Cavern 6 Oil But Substantially Weathered (Sample No. 1254). A) Hexane Fractions; B) Aromatic Fractions.....	C-13
C.1-7	Gas Chromatograms of a Typical Sediment Sample (Phase I) in the Impact Area Heavily Contaminated with Cavern 6 Oil (Sample No. 122). A) Hexane Fractions; B) Aromatic Fractions.....	C-15
C.1-8	Gas Chromatograms of a Typical Sediment Sample (Phase III) in the Impact Area Relatively Uncontaminated (Sample No. 1282). A) Hexane Fractions; B) Aromatic Fractions.....	C-17
C.1-9	Gas Chromatograms of a Typical Sediment Sample (Phase II) in the Impact Area Moderately Contaminated with Indigenous Oil (Sample No. 942). A) Hexane Fractions; B) Aromatic Fractions.....	C-19

LIST OF FIGURES (CONT.)

Figure	Title	Page
C.1-10	Gas Chromatograms of a Typical Sediment Sample (Phase II) in the Impact Area with Substantially Weathered Indigenous Oil (Sample No. 946). A) Hexane Fractions; B) Aromatic Fractions.....	C-21
C.1-11	Gas Chromatograms of a Typical Sediment Sample (Phase II) in Eastern Black Lake with Little Indigenous Oil Contamination (Sample No. 604). A) Hexane Fractions; B) Aromatic Fractions.....	C-23
C.1-12	Gas Chromatograms of a Typical Sediment Sample (Phase III) in Eastern Black Lake with Heavily Weathered Indigenous Oil (Sample No. 1187). A) Hexane Fractions; B) Aromatic Fractions.....	C-25
C.1-13	Gas Chromatograms of a Typical Sediment Sample (Phase II) in Western Black Lake with Little Indigenous Oil Contamination (Sample No. 631). A) Hexane Fractions; B) Aromatic Fractions.....	C-27
C.1-14	Gas Chromatograms of a Typical Sediment Sample (Phase IV) in Western Black Lake with Heavily Weathered Indigenous Oil (Sample No. 1657). A) Hexane Fractions; B) Aromatic Fractions.....	C-29
C.1-15	Gas Chromatograms of a Typical Sediment Sample (Phase I) North of Cavern 6 with Little Indigenous Oil Contamination (Sample No. 234). A) Hexane Fractions; B) Aromatic Fractions.....	C-31
C.1-16	Gas Chromatograms of a Typical Sediment Sample (Phase IV) North of Cavern 6 with Substantially Weathered Indigenous Oil (Sample No. 1533). A) Hexane Fractions; B) Aromatic Fractions.....	C-33
C.1-17	Gas Chromatograms of a Typical Sediment Sample (Phase I) in the Far North Area of Black Lake with Little Indigenous Oil Contamination (Sample No. 197). A) Hexane Fractions; B) Aromatic Fractions.....	C-35
C.1-18	Gas Chromatograms of a Typical Sediment Sample (Phase II) in the Far North Area of Black Lake with Substantially Weathered Indigenous Oil (Sample No. 963). A) Hexane Fractions; B) Aromatic Fractions.....	C-37

LIST OF FIGURES (CONT.)

Figure	Title	Page
C.1-19	Gas Chromatograms of a Typical Sediment Sample (Phase I) Along the North Stark Canal (Sample No. 65). A) Hexane Fractions; B) Aromatic Fractions.....	C-39
C.1-20	Gas Chromatograms of a Typical Sediment Sample (Phase III) in the Sabine Wildlife Refuge (Sample No. 1083). A) Hexane Fractions; B) Aromatic Fractions.....	C-41
C.2-1	Total Ion Chromatogram (15-55 Minutes) for Sample No. 128.....	C-44
C.2-2	Total Ion Chromatogram (15-35 Minutes) and the Mass Chromatograms for the Quantitative Internal Standard Hexamethylbenzene (162), Dibenzothiophene (184), and Phenanthrene (178).....	C-47
C.2-3	Total Ion Chromatogram (29-48 Minutes) and the Mass Chromatograms for the C_1, C_2 and C_3 Alkylated Dibenzothiophenes (Ions 198, 212, and 226).....	C-48
C.2-4	Total Ion Chromatogram (30-50 Minutes) and the Mass Chromatograms for the C_1, C_2 and C_3 Alkylated Phenanthrenes (Ions 192, 206, and 220).....	C-49
C.2-5	Total Ion Chromatogram (34-54 Minutes) and the Mass Chromatograms for Fluoranthene (202), Pyrene (202), Members of the Chyrsene Family (228), and Members of the Benzopyrene Family (252).....	C-50
C.4-1	Isopleths of Average Micrograms of Vanadium Per Cubic Meter of Air for a 1500 Meter Release.....	C-104
C.4-2	Isopleths of Average Micrograms of Vanadium Per Cubic Meter of Air for a Ground Release.....	C-105
C.4-3	Comparison of Calculated Vanadium Concentration from a Ground Release with Excess Vanadium Found on the Vegetation.....	C-109

APPENDIX A

Stations Sampled

TABLE A.1-1

NUMBERS AND TYPES OF SAMPLES COLLECTED AT DESIGNATED STATIONS DURING PHASES I - IV

Station	PHASE I	II	III	IV
MARSH BENTHOS:				
E9-2-B	8			
E8-2-B	8			
F6-2-B	8			
E5-2-B	3			
7-9-B	6			
5-9-B	4			
2-9-B	4			
9-10-B	4			
9-1-B	8			
16-1-B	8			
3-2-B	4			
2-2-B	4			
1-2-B	4			
6-2-B	1			
4-2-B	4			
5-2-B	1			
7-2-B	4			
E4-2-B	4			
E7-2-B	4			
E3-2-B	4			
E2-2-B	4			
E1-2-B	4			
16-4-B	4			
Affected Marsh		36	20	20
East Control Marsh		16	6	
West Control Marsh		8	20	20
North Control Marsh		20	12	12
LAKE BENTHOS:				
1-30-B	1			
2-30-B	1			1
3-30-B	5			
4-30-B	6			
5-30-B	6			
6-30-B	5			1
10-30-B	4			

TABLE A.1-1 (Cont.)

Station	PHASE I	II	III	IV
LAKE BENTHOS (Cont.):				
16-3-B	4			
14-3-B	4			
10-3-B	4			
15-3-B	4			
12-3-B	3			
13-3-B	4			
17-3-B	4			
11-3-B	5			
Black Lake Affected Area		16	16	16
Black Lake East Control		16	16	16
Black Lake West Control		8	8	8
30-12-C			1	1
30-15-C			1	
9-11-C			1	1
9-1-C			2	1
6-2-B			2	
9-10-B				1
9-2-C				1
4-B				1
30-13-C				1
10-3-C				1
30-15-C				1
30-2-C				1
MARSH VEGETATION:				
3-2-B	4			
2-2-B	4			
1-2-B	4			
6-2-B	4			
4-2-B	4			
9-2-B	4			
8-2-B	4			
5-2-B	4			
7-2-B	4			
E&-2-B	4			
E5-2-B	4			
E4-2-B	4			
E7-2-B	7			
E8-2-B	4			

TABLE A.1-1 (Cont.)

Station	PHASE I	II	III	IV
MARSH VEGETATION (Cont.):				
E9-2-B	4			
E3-2-B	3			
E2-2-B	4			
E1-2-B	4			
16-4-B	5			
18-4-B	5			
1-5-B	1			
2-5-B	2			
4-5-B	1			
5-5-B	1			
6-5-B	1			
7-5-B	1			
8-5-B	1			
9-5-B	1			
10-5-B	1			
11-5-B	1			
12-5-B	1			
13-5-B	1			
14-5-B	1			
15-5-B	1			
16-5-B	1			
17-5-B	1			
18-5-B	1			
19-5-B	1			
20-5-B	1			
21-5-B	1			
22-5-B	1			
23-5-B	7			
24-5-B	3			
Affected Marsh		36	20	20
East Control Marsh		16	6	
West Control Marsh		8	20	20
North Control Marsh		20	12	12
SEDIMENT:				
244-1-C	1			
UNO-15	1			
UNO-16	1			
UNO-17	1			
UNO-18	1			

TABLE A.1-1 (Cont.)

Station	PHASE I	II	III	IV
SEDIMENT (Cont.):				
SNR-2	2		1	
SNR-3	1		1	
SNR-4	1		1	
SNR-5	1		1	
SNR-6	1		1	
SNR-8	1		1	
LaBouve Fish Camp	1	1	1	
5-1-C (9-Lake)	2			4
9-1-C	1		2	2
9-2-C	1		2	2
9-3-C	1	2	2	2
9-4-C	1			
9-6-C	1		2	
9-7-C	1		2	2
9-8-C	1			
9-9-C	1		2	
9-10-C	1			2
9-11-C	1		2	2
9-12-C	1		1	
9-13-C	1			2
9-14-C	1			
30-3-C	1	2	2	2
30-4-C	1	4	2	2
30-5-C	1		3	2
30-6-C	1			2
30-7-C	1	1	2	2
30-8-C	1			2
30-9-C	1	1	2	2
30-10-C	1			
30-11-C	1		2	2
30-12-C	1	2	3	2
30-13-C	1	4		2
30-14-C	2	1		2
30-15-C	1	3	2	
30-16-C	1	3	2	2
30-17-C	1	2	2	2
30-18-C	1	3	2	
9-10-B	1		2	
10-30-B	1			
13-3-B	1			
12-3-B	1			
11-3-B	1			

TABLE A.1-1 (Cont.)

Station	PHASE I	II	III	IV
SEDIMENT (Cont.):				
10-3-B	1			2
15-3-B		2		
14-3-B		2	2	2
E5-2-B		2		
E6-2-B		2		
8-2-B		2		2
9-2-B		2	2	
16-3-B		2		
17-3-B		2		
7-9-B		2		
2-C-		6	2	2
1-3-C (11-Canal)	1	4	2	2
1-2-C (10-Canal)		3	2	2
Back of Gill Net		4		
North Control		2	2	
245-1-C		4		3
7-C		2		
16-1-B		2	2	
6-C		2		
201/202-30-C		1	2	3
203-30-C		1	2	2
30-19-C		3	2	2
5-C		1		
30-2-C			3	2
2-30-R			2	
30-1-C			2	2
NW of Dike			3	
RS-111			3	
RS-109			6	
RC-102			3	2
SNR-1			1	
SNR-7			1	
SNR-9			1	
RN-101			1	3
RC-103				3
RC-107				3
Sunken Barge				1
Texaco Rollers				4
RC-104				2
Levy NW of Lake				2
S. Site/West of Dike				2
9-5-C				2

TABLE A.1-1 (Cont.)

Station	PHASE I	II	III	IV
SOIL:				
2-5-B	1			
4-5-B	1			
6-5-B	1			
8-5-B	1			
11-5-B	1			
12-5-B	1			
13-5-B	1			
16-5-B	1			
18-5-B	1			
20-5-B	1			
22-5-B	1			
23-5-B	6			
24-5-B	4			
UNO-3		2	4	1
UNO-2		3	4	
UNO-1		1	6	1
UNO-4		2	4	2
UNO-5		3	4	2
UNO-6		1	4	2
UNO-14		2	4	1
UNO-10		2	4	2
UNO-7		3	5	3
UNO-11		3	2	3
UNO-8		2	6	2
UNO-9		3	4	3
UNO-12		3	6	2
RC-103		2	2	
RC-104			2	
RC-105			2	
RS-111			2	
RS-109			2	
RC-106			2	
RC-107			2	
RS-108			2	
RS-110			2	
UNO-15			4	2
URI-16			2	2
URI-17			2	
URI-18			2	1
URI-19			2	2
RN-101			2	1

TABLE A.1-1 (Cont.)

Station	PHASE I	II	III	IV
SOIL (Cont.):				
SNR-1			1	
SNR-2			1	
SNR-3			1	
SNR-4			1	
SNR-5			1	
SNR-6			1	
SNR-7			1	
SNR-8			1	
SNR-9			1	
RC-102			1	
UNO-14				1
FOLIAGE:				
Site A	1			
244-1-C	1			
Site X	1			
UNO-1	2	4	4	2
UNO-2	4	2	2	
UNO-3	5	2	2	2
UNO-4	5	2	2	1
UNO-5	3	2	2	2
UNO-6	2		5	3
UNO-7	7	5	1	2
UNO-8	3	2	2	2
UNO-9	3	2	2	2
UNO-10	3	2	2	2
UNO-11	3	2	2	1
UNO-12	3	3	3	2
UNO-13	3			
UNO-14	3	2	4	2
UNO-15	3		2	2
SNR-2	2			
SNR-3	1			
SNR-4	1		1	
SNR-5	1			
SNR-6	1			
9-Lake	1			
10-Canal	1			
11-Canal	2			

TABLE A.1-1 (Cont.)

Station	PHASE I	II	III	IV
FOLIAGE (Cont.):				
1-3-C		2		
1-2-C		2		
RS-111			2	
RS-109			2	
RC-107			2	1
RC-102			1	
URI-16			1	1
URI-17			1	
URI-18			1	2
URI-19			1	2
RN-101			1	1
SNR-1			1	
SNR-7			1	
RC-103				1
RC-106				1
3 Mile Tower				1
Texaco Rollers				1
Sunken Barge				1
RC-104				1
WATER:				
201-30-C	1			
202-30-C	1			
203-30-C	1			
SNR-2	2			
SNR-3	1		2	
SNR-4	2			
SNR-5	1			
SNR-6	1		1	
SNR-8	1		1	
SNR-9	1		2	
LaBouve Fish Camp	1	1		
9-Lake	1			
10-Canal	1			
11-Canal	1			
1-4-C	1			
2-2-C	1			
9-1-C	2			
9-2-C	1			

TABLE A.1-1 (Cont.)

Station	PHASE I	II	III	IV
WATER (Cont.):				
9-4-C	2			
9-6-C	1			
9-8-C	2			
9-9-C	2			
9-10-C	2			
9-11-C	2			
9-12-C	2			
9-13-C	2			
9-14-C	3			
9-15-C	1			
30-1-C	1			
30-2-C	1		1	
30-4-C	1	2		
30-6-C	1			
30-7-C	1			
30-9-C	1			
30-10-C	1			
30-12-C	1	1	1	
30-13-C	1			
16-3-C		1		
Back of Gill Net		3		
2-C		1		
North Control		2		
30-15-C		2		
30-19-C		1		
30-16-C		1		
30-18-C		1		
30-3-C		1		
30-5-C			1	
RS-111			3	
RS-109			3	
RC-107			3	
RC-102			3	
SNR-1			1	

TABLE A.1-2

SAMPLE COORDINATES - CHEMICAL STATIONS
LOUISIANA LAMBERT COORDINATE SYSTEM

Station No.	North Coord.	East Coord.
9-1-C	493,245.86	1,343,510.30
9-2-C	493,163.50	1,343,421.57
9-3-C	493,045.16	1,343,360.59
9-4-C	493,082.50	1,343,888.47
9-5-C	493,022.28	1,343,840.38
9-6-C	492,651.16	1,344,968.77
9-7-C	492,922.77	1,344,194.54
9-8-C	492,853.98	1,344,188.90
9-10-C	494,434.29	1,343,067.65
9-11-C	493,458.52	1,344,893.07
9-12-C	492,482.96	1,345,690.06
9-13-C	492,614.31	1,345,331.74
9-14-C	492,544.04	1,345,230.26
30-1-C	492,923.85	1,345,008.70
30-2-C	493,252.12	1,344,772.56
30-3-C	494,815.37	1,344,393.00
30-4-C	497,271.46	1,343,181.12
30-6-C	506,982.11	1,341,407.64
30-7-C	494,853.78	1,341,395.42
30-8-C	494,037.97	1,340,964.72
30-9-C	495,370.23	1,340,099.41
30-10-C	497,189.40	1,338,165.84
30-11-C	493,874.08	1,339,975.53
30-12-C	494,300.49	1,343,345.21
30-13-C	493,768.00	1,343,839.43
30-14-C	493,721.13	1,345,705.01

TABLE A.1-2 (Cont.)

Station No.	North Coord.	East Coord.
30-15-C	495,671.11	1,346,365.13
30-16-C	498,095.90	1,347,233.52
30-17-C	492,746.20	1,346,550.39
30-18-C	499,292.50	1,346,897.88
30-19-C	495,809.88	1,348,125.27
1-1-C (9 Lake)	490,065.66	1,337,808.72
1-2-C (10 Canal)	489,379.71	1,339,062.88
1-3-C (11 Canal)	489,518.19	1,339,608.75
1-4-C		
2-C	493,155.36	1,343,424.97
5-C	492,986.57	1,343,852.36
6-C	492,903.45	1,343,579.79
7-C	492,705.51	1,344,193.89
201/202-30-C	492,671.37	1,344,999.15
203-30-C	492,652.11	1,344,967.77
244-1-C	25 yds W of 245-1-C	
245-1-C	492,662.50	1,344,570.17
2-30-B	493,431.40	1,343,750.78
7-9-B	492,970.68	1,344,158.01
8-2-B	492,360.94	1,339,891.81
9-2-B	492,390.56	1,339,821.66
9-10-B	493,176.65	1,343,118.67
14-3-B	492,585.45	1,346,643.91
15-3-B	492,856.22	1,346,435.07

TABLE A.1-2 (Cont.)

Station No.	North Coord.	East Coord.
16-1-B	492,857.81	1,343,349.63
16-3-B	493,092.72	1,346,455.16
17-3-B	493,371.99	1,346,203.46
E5-2-B	492,618.25	1,346,887.44
E6-2-B	492,579.58	1,346,779.24
Back of Gill Net	492,597.82	1,339,695.45
UNO 1 - Land	491,078.70	1,342,982.63
UNO 2 - Land	491,187.25	1,343,382.53
UNO 3 - Land	491,269.84	1,342,974.30
UNO 4 - Land	491,100.68	1,341,464.70
UNO 5 - Land	489,395.05	1,342,980.33
UNO 6 - Land	487,326.79	1,342,957.17
UNO 7 - Land	485,830.22	1,337,890.33
UNO 8 - Land	485,605.20	1,339,667.84
UNO 9 - Land	483,584.29	1,342,788.57
UNO 10 - Land	486,406.23	1,336,767.68
UNO 11 - Land	486,766.35	1,339,410.78
UNO 12 - Land	485,858.17	1,344,926.58
UNO 13 - Land	492,322.50	1,344,651.19
TR 15 - Water	494,556.38	1,344,984.72
TR 16 - Water	495,698.18	1,344,780.93
TR 19 - Water	497,228.81	1,343,854.76
Sabine Nat'l Wildlife Refuge (Starks North Canal)		
*SNR - 1		
*SNR - 2		
*SNR - 3		
*SNR - 4		
*SNR - 5		
*SNR - 6		

*Plotted on map

TABLE A.1-3

SAMPLE COORDINATES - BIOLOGICAL STATIONS
LOUISIANA LAMBERT COORDINATE SYSTEM

Station No.	North Coord.	East Coord.
E1-2-B	492,905.96	1,346,861.51
E2-2-B	493,030.35	1,346,701.13
E3-2-B	493,064.99	1,346,606.50
E4-2-B	492,630.82	1,347,098.61
E5-2-B	492,618.25	1,346,887.44
E6-2-B	492,579.58	1,346,779.24
E7-2-B	492,710.05	1,346,715.87
E8-2-B	492,800.67	1,346,640.08
E9-2-B	492,886.37	1,346,546.52
1-2-B	492,508.05	1,340,436.10
2-2-B	492,609.91	1,340,266.84
3-2-B	492,676.37	1,340,090.71
4-2-B	492,334.78	1,340,125.64
5-2-B	492,456.56	1,340,036.54
6-2-B	492,583.16	1,339,968.37
7-2-B	492,291.94	1,340,009.82
8-2-B	492,360.94	1,339,891.81
9-2-B	492,390.56	1,339,821.66
9-1-B	492,836.17	1,343,270.15
16-1-B	492,857.81	1,343,349.63
10-3-B	492,804.75	1,340,041.39
11-3-B	492,712.47	1,339,871.10
12-3-B	492,570.74	1,339,778.46
13-3-B	492,540.74	1,339,522.67
14-3-B	492,585.45	1,346,643.91

TABLE A.1-3 (Cont.)

Station No.	North Coord.	East Coord.
15-3-B	492,856.22	1,346,435.07
16-3-B	493,092.72	1,346,455.16
17-3-B	493,371.99	1,346,203.46
7-9-B	492,790.68	1,344,158.01
9-10-B	493,176.65	1,343,118.67
1-30-B	493,486.48	1,343,757.40
2-30-B	493,431.40	1,343,750.48
3-30-B	493,496.66	1,343,610.09
4-30-B	493,548.91	1,343,458.35
5-30-B	493,598.24	1,343,250.36
6-30-B	493,631.88	1,343,005.95

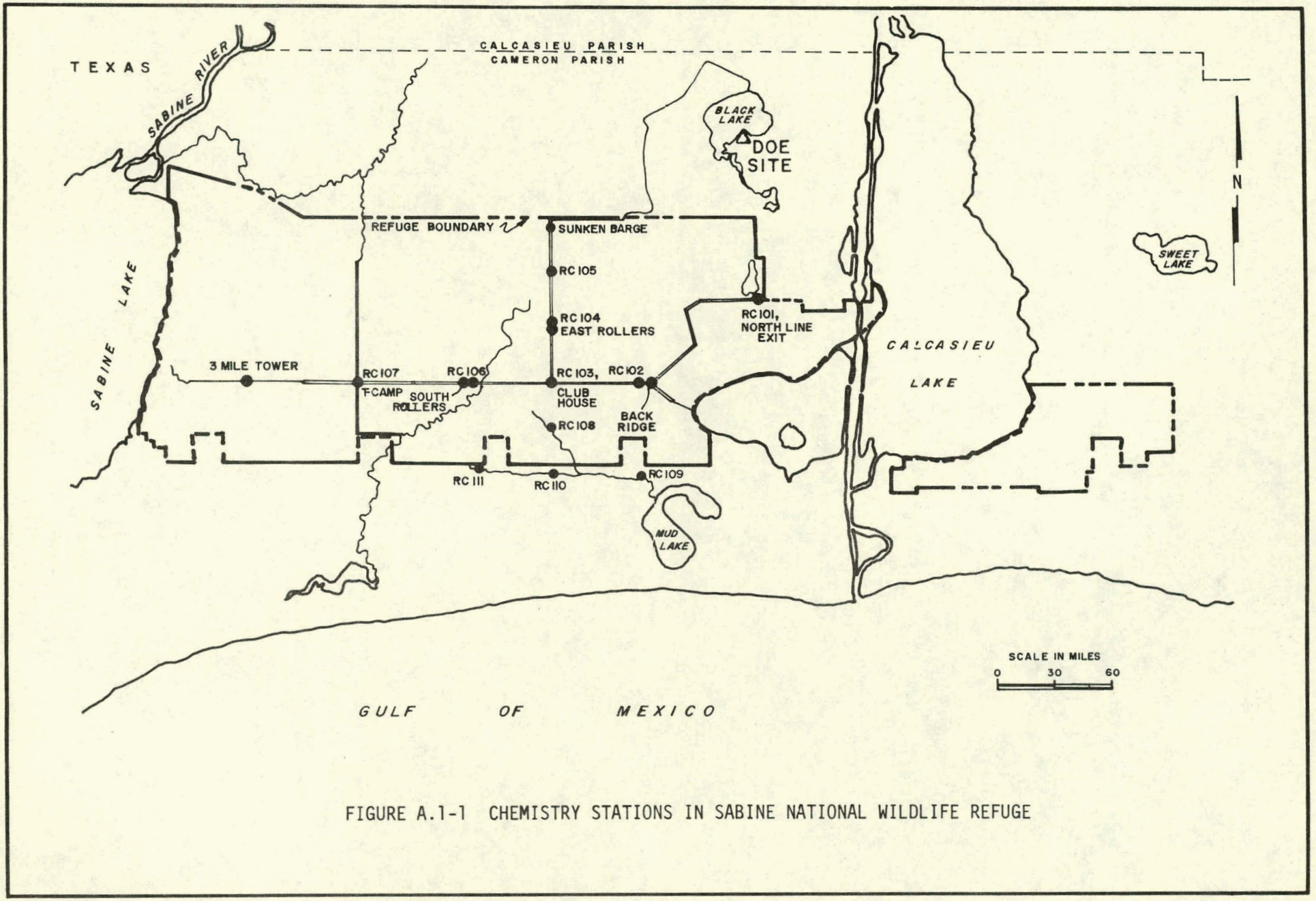


FIGURE A.1-1 CHEMISTRY STATIONS IN SABINE NATIONAL WILDLIFE REFUGE

APPENDIX B

Biology

APPENDIX B.1
Lake Fauna Densities

This appendix is a computer listing of the converted data (densities per 0.25 m^2) for the Black Lake sediment fauna in nine taxonomic categories and their sum. Multiple entries for the same phase, site, station, and sample number represent subsamples generated in the laboratory.

DENSITY (PER 0.25 SQUARE METER) OF BLACK LAKE BENTHIC FAUNA

PHASE	SITE	STATION/ SAMPLE	NEMATODA	OLIGOCHAETA	BIVALVIA	AMPHIPODA		MISC.		TOTAL
				POLYCHAETA	GASTROPODA	TANAIDACEA	ISOPODA			
1	AFFECTED AREA	2	0.00	42.53	4.73	0.00	0.00	47.26	0.00	14.18	0.00	108.70
1	AFFECTED AREA	3	0.00	14.18	0.00	0.00	0.00	51.99	9.45	18.90	0.00	94.52
1	AFFECTED AREA	4	0.00	18.90	0.00	0.00	4.73	99.25	0.00	4.73	23.63	151.23
1	AFFECTED AREA	5	0.00	4.73	0.00	0.00	0.00	28.36	0.00	18.90	14.18	66.16
1	AFFECTED AREA	6	0.00	255.20	9.45	0.00	0.00	160.68	70.89	47.26	66.16	609.65
1	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	6	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
1	AFFECTED AREA	6	113.42	0.00	0.00	0.00	0.00	226.85	0.00	0.00	0.00	340.27
1	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42	226.85
1	AFFECTED AREA	6	0.00	226.85	113.42	0.00	0.00	0.00	0.00	0.00	0.00	340.27
1	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	0.00	226.85
1	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	6	0.00	113.42	0.00	0.00	0.00	113.42	0.00	0.00	0.00	226.85
1	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	6	0.00	113.42	340.27	0.00	0.00	453.70	0.00	0.00	113.42	1020.82
1	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
1	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
1	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	113.42	226.85	0.00	0.00	340.27
1	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
1	AFFECTED AREA	7	226.85	0.00	0.00	0.00	0.00	113.42	0.00	0.00	340.27	680.54
1	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
1	AFFECTED AREA	7	0.00	113.42	0.00	0.00	0.00	453.70	0.00	113.42	0.00	680.54
1	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	340.27	0.00	0.00	113.42	453.70
1	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	113.42
1	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	0.00	226.85
1	AFFECTED AREA	7	0.00	0.00	0.00	113.42	0.00	113.42	0.00	0.00	0.00	226.85
1	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	7	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
1	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42	226.85
1	AFFECTED AREA	7	0.00	340.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	340.27
1	AFFECTED AREA	8	226.85	0.00	0.00	0.00	0.00	567.12	0.00	226.85	113.42	1134.24
1	AFFECTED AREA	8	0.00	113.42	0.00	0.00	0.00	340.27	0.00	0.00	113.42	567.12
1	AFFECTED AREA	8	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
1	AFFECTED AREA	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	8	0.00	113.42	0.00	0.00	0.00	113.42	0.00	0.00	0.00	226.85
1	AFFECTED AREA	8	0.00	0.00	0.00	0.00	0.00	453.70	0.00	0.00	0.00	453.70
1	AFFECTED AREA	8	0.00	0.00	0.00	113.42	0.00	453.70	0.00	0.00	0.00	567.12
1	AFFECTED AREA	8	0.00	0.00	0.00	113.42	0.00	226.85	0.00	0.00	113.42	453.70
1	AFFECTED AREA	8	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
1	AFFECTED AREA	8	0.00	0.00	113.42	0.00	0.00	113.42	0.00	113.42	0.00	340.27
1	AFFECTED AREA	8	0.00	340.27	0.00	0.00	0.00	226.85	0.00	0.00	0.00	567.12
1	AFFECTED AREA	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
1	AFFECTED AREA	8	0.00	226.85	226.85	0.00	0.00	340.27	0.00	0.00	0.00	793.97
1	AFFECTED AREA	8	0.00	113.42	0.00	0.00	0.00	226.85	0.00	0.00	0.00	340.27
1	AFFECTED AREA	10	0.00	0.00	0.00	0.00	0.00	4.73	4.73	4.73	0.00	14.18
1	AFFECTED AREA	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	10	793.97	113.42	0.00	0.00	0.00	113.42	226.85	0.00	0.00	1247.66
1	AFFECTED AREA	10	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	0.00	226.85
1	AFFECTED AREA	10	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	0.00	226.85
1	AFFECTED AREA	10	0.00	340.27	0.00	0.00	0.00	113.42	113.42	0.00	0.00	567.12
1	AFFECTED AREA	10	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42	226.85
1	AFFECTED AREA	10	0.00	113.42	226.85	0.00	0.00	0.00	0.00	0.00	0.00	340.27
1	AFFECTED AREA	10	0.00	113.42	0.00	0.00	0.00	113.42	0.00	0.00	0.00	226.85
1	AFFECTED AREA	10	0.00	0.00	226.85	0.00	0.00	0.00	113.42	0.00	0.00	340.27
1	AFFECTED AREA	10	0.00	226.85	226.85	0.00	0.00	0.00	113.42	0.00	0.00	567.12
1	AFFECTED AREA	10	0.00	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	226.85

1	AFFECTED AREA	10	0.00	0.00	340.27	0.00	0.00	0.00	0.00	0.00	0.00	340.27
1	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	11	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
1	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	113.42	1247.66	113.42	1587.94	3062.45
1	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	11	0.00	113.42	0.00	0.00	0.00	226.85	0.00	0.00	0.00	340.27
1	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	340.27	0.00	0.00	0.00	340.27
1	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	113.42
1	AFFECTED AREA	11	0.00	113.42	0.00	0.00	0.00	113.42	0.00	113.42	0.00	340.27
1	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
1	AFFECTED AREA	11	0.00	226.85	0.00	113.42	0.00	113.42	0.00	0.00	0.00	453.70
1	AFFECTED AREA	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
1	AFFECTED AREA	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
1	AFFECTED AREA	12	0.00	113.42	113.42	0.00	0.00	0.00	113.42	0.00	0.00	340.27
1	AFFECTED AREA	12	0.00	0.00	113.42	0.00	0.00	226.85	113.42	0.00	113.42	567.12
1	AFFECTED AREA	12	0.00	226.85	0.00	0.00	0.00	340.27	0.00	0.00	0.00	567.12
1	AFFECTED AREA	12	0.00	0.00	0.00	0.00	0.00	226.85	0.00	113.42	0.00	340.27
1	AFFECTED AREA	12	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
1	AFFECTED AREA	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	12	0.00	0.00	0.00	113.42	0.00	113.42	0.00	113.42	0.00	340.27
1	AFFECTED AREA	12	0.00	567.12	0.00	0.00	0.00	113.42	113.42	0.00	0.00	793.97
1	AFFECTED AREA	12	0.00	0.00	0.00	0.00	0.00	340.27	0.00	113.42	0.00	453.70
1	AFFECTED AREA	12	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	113.42	340.27
1	AFFECTED AREA	12	0.00	113.42	0.00	0.00	0.00	793.97	0.00	113.42	226.85	1247.66
1	AFFECTED AREA	12	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
1	EAST CONTROL	1	0.00	0.00	0.00	0.00	0.00	28.36	4.73	0.00	0.00	33.08
1	EAST CONTROL	2	0.00	4.73	0.00	14.18	0.00	61.44	4.73	28.36	9.45	122.88
1	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	61.44	0.00	4.73	4.73	70.89
1	EAST CONTROL	4	0.00	56.16	0.00	18.90	0.00	33.08	0.00	9.45	42.53	170.14
1	EAST CONTROL	5	0.00	14.18	0.00	14.18	4.73	141.78	198.49	9.45	170.14	552.94
1	EAST CONTROL	6	4.73	28.36	0.00	14.18	0.00	127.60	18.90	23.63	23.63	291.03
1	EAST CONTROL	7	0.00	18.90	0.00	0.00	0.00	4.73	4.73	0.00	14.18	42.53
1	EAST CONTROL	8	0.00	0.00	0.00	9.45	0.00	179.59	51.99	18.90	28.36	288.29
1	EAST CONTROL	9	0.00	30.34	0.00	0.00	0.00	18.90	0.00	0.00	28.36	127.60
1	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	340.27	0.00	0.00	113.42	453.70
1	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	453.70	226.85	0.00	0.00	680.54
1	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	113.42	113.42	0.00	0.00	226.85
1	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
1	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	680.54	340.27	0.00	0.00	1020.82
1	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	453.70	226.85	0.00	0.00	680.54
1	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	340.27	340.27	0.00	0.00	680.54
1	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	113.42	340.27	0.00	0.00	453.70
1	EAST CONTROL	9	0.00	0.00	0.00	113.42	0.00	453.70	226.85	0.00	226.85	1020.82
1	EAST CONTROL	9	0.00	0.00	0.00	113.42	0.00	453.70	113.42	0.00	0.00	680.54
1	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	226.85	1247.66	0.00	226.85	1701.36
1	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	793.97	0.00	113.42	907.39
1	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	793.97	0.00	0.00	793.97
1	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	1020.82	0.00	0.00	1020.82
1	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	340.27	453.70	0.00	0.00	793.97
1	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42	226.85
1	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	226.85	340.27	113.42	226.85	907.39
1	EAST CONTROL	10	0.00	0.00	226.85	0.00	0.00	340.27	567.12	0.00	0.00	1134.24
1	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	EAST CONTROL	11	680.54	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	793.97
1	EAST CONTROL	11	1587.94	0.00	0.00	0.00	0.00	226.85	0.00	0.00	113.42	1928.21
1	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
1	WEST CONTROL	2	0.00	4.73	0.00	0.00	4.73	0.00	0.00	0.00	0.00	9.45
1	WEST CONTROL	3	0.00	9.45	0.00	0.00	4.73	0.00	4.73	14.18	0.00	33.08
1	WEST CONTROL	4	0.00	28.36	0.00	0.00	14.18	0.00	0.00	18.90	0.00	61.44
1	WEST CONTROL	5	0.00	4.73	0.00	0.00	9.45	0.00	0.00	0.00	0.00	14.18
1	WEST CONTROL	6	0.00	9.45	0.00	4.73	4.73	0.00	0.00	0.00	0.00	18.90
1	WEST CONTROL	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1	WEST CONTROL	8	0.00	0.00	0.00	0.00	4.73	0.00	0.00	0.00	0.00	4.73
1	WEST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	10	0.00	4.73	0.00	0.00	4.73	0.00	0.00	0.00	4.73	14.18
1	WEST CONTROL	11	0.00	4.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.73
1	WEST CONTROL	12	0.00	9.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.45
1	WEST CONTROL	13	0.00	0.00	0.00	18.90	0.00	0.00	0.00	0.00	4.73	23.63
1	WEST CONTROL	14	0.00	14.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.18
1	WEST CONTROL	15	0.00	0.00	0.00	4.73	0.00	0.00	0.00	9.45	9.45	23.63
1	WEST CONTROL	16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	17	0.00	33.08	4.73	0.00	4.73	0.00	0.00	14.18	0.00	56.71
1	WEST CONTROL	18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.45	9.45
2	AFFECTED AREA	1	0.00	14.18	0.00	23.63	9.45	0.00	0.00	4.73	4.73	56.71
2	AFFECTED AREA	2	9.45	217.94	0.00	0.00	28.36	127.60	0.00	9.45	61.44	444.24
2	AFFECTED AREA	3	9.45	137.05	0.00	9.45	51.99	1644.65	137.05	0.00	23.63	2013.28
2	AFFECTED AREA	4	604.93	1389.44	4.73	4.73	42.53	959.38	212.67	4.73	51.99	3275.12
2	AFFECTED AREA	5	9.45	4.73	0.00	0.00	108.70	0.00	75.62	4.73	42.53	245.75
2	AFFECTED AREA	6	888.49	453.70	0.00	4.73	33.08	1966.02	1176.77	14.18	42.53	4579.49
2	AFFECTED AREA	6	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42	226.85
2	AFFECTED AREA	6	340.27	0.00	0.00	0.00	113.42	340.27	226.85	0.00	226.85	1247.66
2	AFFECTED AREA	6	0.00	113.42	0.00	0.00	226.85	226.85	0.00	0.00	113.42	680.54
2	AFFECTED AREA	6	113.42	0.00	226.85	0.00	0.00	113.42	0.00	0.00	0.00	453.70
2	AFFECTED AREA	8	42.53	500.96	0.00	4.73	14.18	70.89	47.26	4.73	288.29	973.56
2	AFFECTED AREA	9	0.00	89.79	9.45	4.73	4.73	1105.88	137.05	4.73	99.25	1455.61
2	AFFECTED AREA	9	1020.82	0.00	0.00	0.00	113.42	2835.60	0.00	0.00	0.00	3969.84
2	AFFECTED AREA	9	0.00	1020.82	113.42	113.42	0.00	1814.78	340.27	0.00	226.85	3629.57
2	AFFECTED AREA	9	0.00	453.70	0.00	0.00	0.00	2268.48	226.85	0.00	0.00	2949.02
2	AFFECTED AREA	9	113.42	0.00	113.42	0.00	0.00	340.27	340.27	0.00	0.00	907.39
2	AFFECTED AREA	9	0.00	567.12	0.00	0.00	0.00	2041.63	340.27	0.00	0.00	2949.02
2	AFFECTED AREA	9	0.00	567.12	0.00	0.00	0.00	453.70	340.27	0.00	0.00	1361.09
2	AFFECTED AREA	9	0.00	453.70	680.54	0.00	0.00	2268.48	340.27	0.00	226.85	3969.84
2	AFFECTED AREA	9	0.00	1247.66	680.54	0.00	0.00	2268.48	453.70	0.00	340.27	4990.66
2	AFFECTED AREA	11	0.00	9.45	0.00	4.73	9.45	926.30	189.04	23.63	9.45	1172.05
2	EAST CONTROL	1	420.61	330.82	14.18	14.18	14.18	2552.04	378.08	0.00	103.97	3828.06
2	EAST CONTROL	2	576.57	1001.91	0.00	0.00	0.00	1866.77	1843.14	33.08	420.61	5742.09
2	EAST CONTROL	3	638.01	538.76	0.00	0.00	0.00	5226.96	4499.15	103.97	326.09	11332.95
2	EAST CONTROL	4	3076.63	127.60	9.45	0.00	4.73	5373.46	5671.20	89.79	132.33	14485.19
2	EAST CONTROL	5	5505.79	382.81	0.00	4.73	4.73	7145.71	12457.74	179.59	236.30	25917.38
2	EAST CONTROL	5	0.00	226.85	2041.63	0.00	0.00	6011.47	12476.64	113.42	453.70	21323.71
2	EAST CONTROL	5	6351.74	907.39	1020.82	0.00	0.00	11002.13	17127.02	226.85	567.12	37203.07
2	EAST CONTROL	5	2155.06	0.00	0.00	0.00	0.00	8166.53	14404.85	113.42	113.42	24953.28
2	EAST CONTROL	5	0.00	340.27	567.12	0.00	0.00	7712.83	15765.94	226.85	340.27	24953.28
2	EAST CONTROL	6	0.00	0.00	0.00	0.00	0.00	8847.07	3742.99	0.00	113.42	12703.49
2	EAST CONTROL	6	0.00	0.00	0.00	0.00	0.00	8166.53	9073.92	113.42	0.00	17353.87
2	EAST CONTROL	6	1361.09	0.00	0.00	0.00	0.00	11342.40	7485.98	113.42	0.00	20302.90
2	EAST CONTROL	6	3175.87	113.42	226.85	0.00	113.42	14291.42	8960.50	226.85	113.42	27221.76
2	EAST CONTROL	6	0.00	0.00	0.00	0.00	0.00	5898.05	6578.59	113.42	0.00	12590.06
2	EAST CONTROL	7	3629.57	453.70	0.00	0.00	113.42	7939.68	7712.83	0.00	1134.24	20983.44
2	EAST CONTROL	7	0.00	113.42	0.00	0.00	0.00	6351.74	5104.08	0.00	113.42	11682.67
2	EAST CONTROL	7	0.00	113.42	0.00	0.00	0.00	7372.56	5104.08	0.00	113.42	12703.49
2	EAST CONTROL	7	7259.14	0.00	113.42	0.00	0.00	7372.56	6692.02	0.00	567.12	22004.26
2	EAST CONTROL	7	0.00	0.00	0.00	0.00	113.42	6805.44	6238.32	0.00	567.12	13724.30
2	EAST CONTROL	7	0.00	0.00	0.00	113.42	0.00	5557.78	5330.93	0.00	0.00	11002.13
2	EAST CONTROL	8	907.39	0.00	0.00	0.00	0.00	1361.09	907.39	226.85	113.42	3516.14
2	EAST CONTROL	8	0.00	113.42	0.00	0.00	0.00	1020.82	907.39	0.00	226.85	2268.48
2	EAST CONTROL	8	0.00	0.00	0.00	0.00	0.00	1701.36	1247.66	113.42	340.27	3402.72
2	EAST CONTROL	8	1587.94	0.00	226.85	0.00	113.42	1587.94	1020.82	226.85	340.27	5104.08
2	WEST CONTROL	2	4.73	108.70	0.00	9.45	14.18	4.73	56.71	0.00	4.73	203.22
2	WEST CONTROL	3	80.34	245.75	0.00	0.00	23.63	0.00	18.90	0.00	51.99	420.61
2	WEST CONTROL	4	9.45	9.45	4.73	0.00	9.45	56.71	66.16	9.45	33.08	198.49
2	WEST CONTROL	5	0.00	119.15	33.08	14.18	18.90	4.73	56.71	0.00	89.79	335.55
2	WEST CONTROL	6	4.73	4.73	0.00	0.00	4.73	4.73	28.36	0.00	0.00	47.26
3	AFFECTED AREA	1	0.00	4.73	37.81	0.00	0.00	4.73	4.73	0.00	61.44	113.42
3	AFFECTED AREA	1	113.42	113.42	567.12	0.00	0.00	226.85	1020.82	0.00	113.42	2155.06
3	AFFECTED AREA	1	1928.21	567.12	0.00	0.00	0.00	340.27	680.54	0.00	113.42	3629.57
3	AFFECTED AREA	1	0.00	567.12	113.42	0.00	0.00	226.85	0.00	0.00	0.00	907.39
3	AFFECTED AREA	1	0.00	567.12	0.00	0.00	0.00	113.42	680.54	113.42	0.00	1474.51

3	AFFECTED AREA	1	0.00	1247.66	0.00	0.00	0.00	226.85	793.97	226.85	113.42	2608.75
3	AFFECTED AREA	1	0.00	793.97	0.00	0.00	113.42	113.42	340.27	0.00	0.00	1361.09
3	AFFECTED AREA	1	0.00	226.85	0.00	0.00	0.00	0.00	226.85	0.00	113.42	567.12
3	AFFECTED AREA	1	0.00	453.70	0.00	0.00	0.00	0.00	340.27	0.00	0.00	793.97
3	AFFECTED AREA	1	0.00	680.54	0.00	0.00	0.00	453.70	340.27	0.00	113.42	1587.94
3	AFFECTED AREA	1	0.00	0.00	0.00	0.00	0.00	113.42	113.42	113.42	0.00	340.27
3	AFFECTED AREA	1	0.00	340.27	453.70	0.00	0.00	340.27	226.85	0.00	113.42	1474.51
3	AFFECTED AREA	1	0.00	453.70	113.42	0.00	113.42	113.42	113.42	0.00	113.42	1020.82
3	AFFECTED AREA	2	2041.63	226.85	0.00	0.00	0.00	113.42	226.85	0.00	0.00	2608.75
3	AFFECTED AREA	2	0.00	340.27	0.00	0.00	0.00	226.85	113.42	0.00	0.00	680.54
3	AFFECTED AREA	2	3289.30	567.12	226.85	0.00	0.00	793.97	680.54	0.00	0.00	5557.78
3	AFFECTED AREA	2	0.00	226.85	0.00	0.00	226.85	226.85	453.70	113.42	0.00	1247.66
3	AFFECTED AREA	2	0.00	0.00	0.00	0.00	0.00	113.42	907.39	0.00	0.00	1020.82
3	AFFECTED AREA	2	0.00	340.27	113.42	0.00	0.00	113.42	340.27	0.00	0.00	907.39
3	AFFECTED AREA	2	0.00	0.00	0.00	0.00	113.42	0.00	226.85	113.42	0.00	453.70
3	AFFECTED AREA	2	0.00	1247.66	793.97	0.00	0.00	340.27	453.70	0.00	113.42	2949.02
3	AFFECTED AREA	2	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
3	AFFECTED AREA	2	0.00	567.12	453.70	0.00	113.42	226.85	907.39	113.42	113.42	2495.33
3	AFFECTED AREA	2	0.00	226.85	453.70	0.00	0.00	226.85	226.85	113.42	0.00	1247.66
3	AFFECTED AREA	2	0.00	1474.51	0.00	113.42	0.00	0.00	0.00	113.42	567.12	2268.48
3	AFFECTED AREA	2	0.00	226.85	113.42	0.00	113.42	453.70	567.12	0.00	0.00	1474.51
3	AFFECTED AREA	3	0.00	113.42	0.00	0.00	0.00	113.42	113.42	0.00	0.00	340.27
3	AFFECTED AREA	3	113.42	453.70	0.00	0.00	0.00	113.42	340.27	0.00	0.00	1020.82
3	AFFECTED AREA	3	0.00	0.00	0.00	0.00	0.00	113.42	226.85	0.00	0.00	340.27
3	AFFECTED AREA	3	0.00	453.70	0.00	0.00	226.85	340.27	453.70	0.00	0.00	1474.51
3	AFFECTED AREA	3	0.00	0.00	0.00	0.00	0.00	340.27	680.54	113.42	0.00	1134.24
3	AFFECTED AREA	3	0.00	567.12	113.42	0.00	113.42	340.27	340.27	0.00	0.00	1474.51
3	AFFECTED AREA	3	0.00	340.27	0.00	0.00	0.00	907.39	680.54	0.00	0.00	1928.21
3	AFFECTED AREA	3	0.00	0.00	0.00	0.00	113.42	226.85	567.12	0.00	0.00	907.39
3	AFFECTED AREA	3	0.00	1247.66	340.27	0.00	0.00	567.12	1247.66	0.00	113.42	3516.14
3	AFFECTED AREA	3	0.00	113.42	0.00	0.00	0.00	567.12	1020.82	0.00	113.42	1814.78
3	AFFECTED AREA	3	0.00	0.00	0.00	0.00	0.00	453.70	453.70	0.00	0.00	907.39
3	AFFECTED AREA	3	0.00	113.42	0.00	0.00	0.00	567.12	226.85	0.00	0.00	907.39
3	AFFECTED AREA	3	0.00	0.00	0.00	0.00	0.00	0.00	226.85	113.42	0.00	340.27
3	AFFECTED AREA	4	1587.94	340.27	0.00	0.00	0.00	567.12	1474.51	0.00	0.00	3969.84
3	AFFECTED AREA	4	0.00	226.85	0.00	0.00	0.00	113.42	907.39	0.00	0.00	1247.66
3	AFFECTED AREA	4	453.70	113.42	0.00	0.00	0.00	0.00	1020.82	113.42	0.00	1701.36
3	AFFECTED AREA	4	0.00	226.85	113.42	0.00	113.42	226.85	680.54	0.00	113.42	1474.51
3	AFFECTED AREA	4	0.00	226.85	0.00	0.00	0.00	567.12	907.39	0.00	0.00	1701.36
3	AFFECTED AREA	4	0.00	340.27	0.00	0.00	0.00	793.97	1701.36	113.42	0.00	2949.02
3	AFFECTED AREA	4	0.00	340.27	0.00	0.00	0.00	453.70	1134.24	226.85	0.00	2155.06
3	AFFECTED AREA	4	0.00	226.85	0.00	0.00	0.00	0.00	680.54	0.00	0.00	907.39
3	AFFECTED AREA	4	0.00	793.97	0.00	0.00	0.00	453.70	567.12	113.42	0.00	1928.21
3	AFFECTED AREA	4	0.00	680.54	453.70	0.00	113.42	680.54	680.54	0.00	0.00	2608.75
3	AFFECTED AREA	5	0.00	113.42	0.00	0.00	113.42	113.42	0.00	0.00	0.00	340.27
3	AFFECTED AREA	5	0.00	113.42	0.00	0.00	0.00	113.42	1134.24	113.42	113.42	1587.94
3	AFFECTED AREA	5	113.42	113.42	0.00	0.00	0.00	226.85	340.27	0.00	0.00	793.97
3	AFFECTED AREA	5	0.00	0.00	0.00	0.00	0.00	907.39	680.54	0.00	113.42	1701.36
3	AFFECTED AREA	5	0.00	113.42	0.00	0.00	0.00	567.12	226.85	0.00	113.42	1020.82
3	AFFECTED AREA	5	0.00	0.00	0.00	0.00	0.00	226.85	680.54	0.00	0.00	907.39
3	AFFECTED AREA	5	0.00	453.70	113.42	0.00	0.00	226.85	907.39	0.00	0.00	1701.36
3	AFFECTED AREA	5	0.00	113.42	0.00	0.00	0.00	113.42	340.27	0.00	0.00	567.12
3	AFFECTED AREA	5	0.00	113.42	0.00	0.00	113.42	226.85	567.12	0.00	0.00	1020.82
3	AFFECTED AREA	7	0.00	217.40	0.00	4.73	4.73	137.05	179.59	9.45	42.53	595.48
3	AFFECTED AREA	7	793.97	226.85	0.00	0.00	0.00	113.42	113.42	0.00	0.00	1247.66
3	AFFECTED AREA	7	0.00	226.85	0.00	0.00	0.00	113.42	0.00	113.42	113.42	567.12
3	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	113.42	113.42	0.00	0.00	226.85
3	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	113.42	340.27	0.00	113.42	567.12
3	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	113.42	226.85	113.42	0.00	453.70
3	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	226.85	226.85	0.00	0.00	453.70
3	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	113.42	567.12	0.00	0.00	680.54
3	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
3	AFFECTED AREA	8	0.00	0.00	0.00	0.00	0.00	0.00	453.70	0.00	0.00	453.70
3	AFFECTED AREA	8	0.00	340.27	0.00	0.00	0.00	340.27	793.97	0.00	113.42	1587.94
3	AFFECTED AREA	9	340.27	0.00	0.00	0.00	0.00	567.12	567.12	113.42	226.85	1814.78
3	AFFECTED AREA	8	226.85	0.00	0.00	0.00	0.00	567.12	226.85	0.00	340.27	1361.09

3	AFFECTED AREA	8	0.00	226.85	113.42	0.00	0.00	113.42	226.85	0.00	0.00	680.54
3	AFFECTED AREA	8	0.00	340.27	0.00	0.00	0.00	113.42	340.27	0.00	226.85	1020.82
3	EAST CONTROL	1	0.00	113.42	793.97	0.00	0.00	5671.20	8279.95	113.42	0.00	14971.97
3	EAST CONTROL	1	0.00	567.12	0.00	0.00	0.00	4536.96	7485.98	0.00	0.00	12590.06
3	EAST CONTROL	1	7259.14	0.00	1134.24	0.00	0.00	5330.93	6578.59	0.00	226.85	20529.74
3	EAST CONTROL	1	1928.21	226.85	0.00	0.00	0.00	2041.63	4083.26	0.00	340.27	8620.22
3	EAST CONTROL	1	0.00	680.54	0.00	0.00	0.00	2381.90	3175.87	0.00	0.00	6238.32
3	EAST CONTROL	1	0.00	680.54	226.85	0.00	0.00	4650.38	6351.74	0.00	226.85	12136.37
3	EAST CONTROL	1	0.00	113.42	0.00	0.00	0.00	3062.45	6692.02	0.00	113.42	9981.31
3	EAST CONTROL	1	0.00	113.42	0.00	0.00	0.00	4196.69	6578.59	0.00	0.00	10888.70
3	EAST CONTROL	1	0.00	0.00	113.42	0.00	0.00	2608.75	5217.50	113.42	113.42	8166.53
3	EAST CONTROL	1	0.00	340.27	0.00	0.00	0.00	5217.50	5784.62	0.00	113.42	11455.82
3	EAST CONTROL	2	0.00	226.85	0.00	0.00	113.42	453.70	793.97	0.00	0.00	1587.94
3	EAST CONTROL	2	4423.54	453.70	340.27	0.00	0.00	113.42	113.42	0.00	226.85	5671.20
3	EAST CONTROL	2	1134.24	340.27	0.00	0.00	113.42	793.97	680.54	0.00	113.42	3175.87
3	EAST CONTROL	2	0.00	340.27	340.27	0.00	0.00	793.97	453.70	0.00	0.00	1928.21
3	EAST CONTROL	2	0.00	0.00	113.42	0.00	113.42	680.54	340.27	0.00	0.00	1247.66
3	EAST CONTROL	2	0.00	680.54	567.12	0.00	0.00	680.54	340.27	113.42	567.12	2949.02
3	EAST CONTROL	2	0.00	340.27	0.00	0.00	0.00	680.54	226.85	0.00	113.42	1361.09
3	EAST CONTROL	2	0.00	567.12	680.54	0.00	0.00	226.85	113.42	0.00	113.42	1701.36
3	EAST CONTROL	2	0.00	453.70	226.85	0.00	0.00	113.42	0.00	0.00	113.42	907.39
3	EAST CONTROL	2	0.00	0.00	113.42	0.00	0.00	340.27	453.70	0.00	226.85	1134.24
3	EAST CONTROL	2	0.00	113.42	0.00	0.00	0.00	453.70	340.27	0.00	113.42	1020.82
3	EAST CONTROL	3	0.00	113.42	113.42	0.00	0.00	1701.36	5217.50	0.00	113.42	7259.14
3	EAST CONTROL	3	0.00	0.00	113.42	0.00	0.00	1361.09	6918.86	0.00	113.42	8506.80
3	EAST CONTROL	3	1134.24	226.85	0.00	0.00	0.00	2495.33	3969.84	0.00	113.42	7939.68
3	EAST CONTROL	3	1701.36	0.00	113.42	0.00	0.00	1587.94	6124.90	0.00	0.00	9527.62
3	EAST CONTROL	4	113.42	226.85	0.00	0.00	113.42	453.70	1474.51	0.00	113.42	2495.33
3	EAST CONTROL	4	0.00	226.85	0.00	113.42	226.85	1361.09	907.39	0.00	0.00	2835.60
3	EAST CONTROL	4	113.42	113.42	0.00	226.85	0.00	226.85	907.39	113.42	0.00	1701.36
3	EAST CONTROL	4	0.00	226.85	0.00	0.00	0.00	1134.24	1701.36	0.00	0.00	3062.45
3	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	0.00	226.85
3	EAST CONTROL	5	0.00	0.00	113.42	0.00	226.85	0.00	0.00	0.00	0.00	340.27
3	EAST CONTROL	5	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42
3	EAST CONTROL	5	113.42	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	226.85
3	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	EAST CONTROL	5	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42
3	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	226.85
3	EAST CONTROL	5	0.00	113.42	0.00	0.00	0.00	113.42	113.42	0.00	0.00	340.27
3	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	340.27	113.42	0.00	0.00	453.70
3	EAST CONTROL	5	0.00	0.00	0.00	0.00	113.42	113.42	226.85	113.42	0.00	567.12
3	EAST CONTROL	5	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42	0.00	226.85
3	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
3	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	226.85	226.85	0.00	113.42	567.12
3	EAST CONTROL	6	0.00	453.70	226.85	0.00	0.00	340.27	793.97	0.00	226.85	2041.63
3	EAST CONTROL	6	0.00	0.00	0.00	0.00	0.00	226.85	793.97	0.00	113.42	1134.24
3	EAST CONTROL	6	226.85	113.42	226.85	0.00	0.00	1361.09	1247.66	0.00	113.42	3289.30
3	EAST CONTROL	6	907.39	340.27	0.00	0.00	0.00	453.70	907.39	226.85	0.00	2835.60
3	EAST CONTROL	6	0.00	453.70	0.00	0.00	0.00	793.97	907.39	0.00	0.00	2155.06
3	EAST CONTROL	6	0.00	113.42	226.85	0.00	113.42	226.85	567.12	0.00	0.00	1247.66
3	EAST CONTROL	6	0.00	226.85	0.00	0.00	0.00	226.85	567.12	0.00	0.00	1020.82
3	EAST CONTROL	6	0.00	453.70	226.85	113.42	0.00	226.85	1020.82	0.00	226.85	2268.48
3	EAST CONTROL	6	0.00	226.85	0.00	0.00	113.42	567.12	680.54	113.42	0.00	1701.36
3	EAST CONTROL	7	6918.86	113.42	0.00	0.00	0.00	1701.36	1474.51	0.00	113.42	10321.58
3	EAST CONTROL	7	0.00	0.00	0.00	0.00	0.00	1134.24	2495.33	0.00	0.00	3629.57
3	EAST CONTROL	7	0.00	113.42	0.00	0.00	0.00	1701.36	2041.63	0.00	113.42	3969.84
3	EAST CONTROL	7	0.00	0.00	0.00	0.00	0.00	567.12	453.70	113.42	0.00	1134.24
3	EAST CONTROL	7	0.00	0.00	226.85	0.00	0.00	567.12	0.00	0.00	0.00	793.97
3	EAST CONTROL	7	0.00	0.00	0.00	0.00	0.00	113.42	226.85	0.00	0.00	340.27
3	EAST CONTROL	7	0.00	0.00	0.00	0.00	0.00	680.54	1928.21	0.00	113.42	2722.18
3	EAST CONTROL	7	0.00	453.70	0.00	0.00	113.42	1928.21	2268.48	0.00	0.00	4763.81
3	EAST CONTROL	7	0.00	113.42	907.39	0.00	0.00	793.97	2608.75	0.00	0.00	4423.54
3	EAST CONTROL	7	0.00	0.00	680.54	0.00	0.00	1247.66	907.39	0.00	0.00	2835.60
3	EAST CONTROL	7	0.00	0.00	453.70	0.00	0.00	680.54	1134.24	113.42	226.85	2608.75
3	EAST CONTROL	7	0.00	1247.66	567.12	0.00	0.00	1361.09	3402.72	113.42	113.42	6805.44
3	EAST CONTROL	9	845.95	143.04	4.73	0.00	23.63	75.62	146.51	47.26	33.08	1365.81

3	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	1814.78	4763.81	113.42	0.00	6692.02
3	EAST CONTROL	9	0.00	226.85	0.00	0.00	0.00	1814.78	2949.02	0.00	226.85	5217.50
3	EAST CONTROL	9	6578.59	113.42	113.42	0.00	0.00	2268.48	3516.14	113.42	226.85	12930.34
3	EAST CONTROL	9	17127.02	793.97	0.00	0.00	0.00	1701.36	4196.69	0.00	0.00	23819.04
3	EAST CONTROL	9	0.00	567.12	113.42	0.00	0.00	2381.90	4990.66	113.42	226.85	8393.38
3	EAST CONTROL	9	0.00	1020.82	113.42	0.00	0.00	3402.72	5444.35	0.00	0.00	9981.31
3	EAST CONTROL	9	0.00	226.85	0.00	0.00	0.00	2722.18	5671.20	113.42	113.42	8847.07
3	EAST CONTROL	9	0.00	226.85	113.42	0.00	0.00	1587.94	3175.87	226.85	113.42	5444.35
3	EAST CONTROL	9	0.00	226.85	0.00	0.00	0.00	1587.94	3062.45	0.00	113.42	4990.66
3	EAST CONTROL	9	0.00	567.12	453.70	0.00	113.42	2722.18	6124.90	0.00	0.00	9981.31
3	EAST CONTROL	10	3742.99	340.27	113.42	0.00	0.00	1701.36	2608.75	113.42	113.42	8733.65
3	EAST CONTROL	10	0.00	1474.51	0.00	0.00	0.00	1361.09	2835.60	226.85	113.42	6011.47
3	EAST CONTROL	10	0.00	113.42	0.00	0.00	113.42	1361.09	2268.48	0.00	0.00	3856.42
3	EAST CONTROL	10	1134.24	567.12	0.00	0.00	0.00	1814.78	1814.78	0.00	0.00	5330.93
3	EAST CONTROL	11	0.00	113.42	0.00	0.00	113.42	453.70	340.27	0.00	0.00	1020.82
3	EAST CONTROL	11	340.27	113.42	0.00	0.00	0.00	226.85	1134.24	0.00	0.00	1814.78
3	EAST CONTROL	11	0.00	0.00	0.00	0.00	113.42	453.70	1247.66	0.00	0.00	1814.78
3	EAST CONTROL	11	0.00	340.27	0.00	0.00	0.00	453.70	907.39	113.42	0.00	1814.78
3	EAST CONTROL	12	0.00	113.42	0.00	0.00	0.00	1134.24	2041.63	113.42	340.27	3742.99
3	EAST CONTROL	12	0.00	113.42	0.00	0.00	0.00	2835.60	1814.78	113.42	453.70	5330.93
3	EAST CONTROL	12	1020.82	0.00	226.85	0.00	113.42	1814.78	3175.87	0.00	567.12	6918.86
3	EAST CONTROL	12	3629.57	0.00	0.00	0.00	0.00	1928.21	2722.18	0.00	453.70	8733.65
3	WEST CONTROL	2	0.00	80.34	0.00	0.00	4.73	0.00	0.00	0.00	0.00	85.07
3	WEST CONTROL	3	4.73	51.44	9.45	18.90	0.00	0.00	0.00	0.00	0.00	94.52
3	WEST CONTROL	4	0.00	99.25	4.73	0.00	9.45	0.00	9.45	0.00	4.73	127.60
3	OTHER AREAS	1	0.00	61.44	0.00	9.45	0.00	4.73	4.73	0.00	4.73	85.07
3	OTHER AREAS	1	340.27	113.42	113.42	0.00	113.42	226.85	2949.02	0.00	113.42	3969.84
3	OTHER AREAS	1	0.00	0.00	113.42	0.00	0.00	0.00	2495.33	113.42	0.00	2722.18
3	OTHER AREAS	1	340.27	0.00	0.00	0.00	0.00	113.42	1701.36	0.00	0.00	2155.06
3	OTHER AREAS	1	0.00	113.42	0.00	0.00	0.00	453.70	2495.33	226.85	0.00	3289.30
3	OTHER AREAS	2	113.42	0.00	0.00	0.00	0.00	113.42	1587.94	0.00	113.42	1928.21
3	OTHER AREAS	2	1814.78	680.54	0.00	0.00	0.00	113.42	567.12	0.00	226.85	3402.72
3	OTHER AREAS	2	680.54	0.00	0.00	0.00	0.00	113.42	2381.90	0.00	113.42	3289.30
3	OTHER AREAS	2	0.00	340.27	0.00	0.00	0.00	0.00	340.27	0.00	0.00	680.54
3	OTHER AREAS	4	9.45	89.79	0.00	0.00	0.00	4.73	18.90	4.73	0.00	127.60
3	OTHER AREAS	5	75.62	42.53	14.18	4.73	0.00	392.26	647.46	14.18	9.45	1200.40
3	OTHER AREAS	5	0.00	0.00	0.00	0.00	0.00	113.42	226.85	0.00	113.42	453.70
3	OTHER AREAS	5	0.00	0.00	0.00	0.00	0.00	226.85	113.42	0.00	0.00	340.27
3	OTHER AREAS	5	1701.36	113.42	0.00	0.00	0.00	340.27	226.85	0.00	113.42	2495.33
3	OTHER AREAS	5	0.00	0.00	113.42	0.00	0.00	567.12	567.12	0.00	0.00	1247.66
3	OTHER AREAS	6	226.85	0.00	226.85	0.00	113.42	340.27	340.27	0.00	113.42	1361.09
3	OTHER AREAS	6	340.27	113.42	453.70	0.00	0.00	226.85	0.00	113.42	340.27	1587.94
3	OTHER AREAS	6	0.00	226.85	680.54	0.00	0.00	113.42	567.12	0.00	113.42	1701.36
3	OTHER AREAS	6	0.00	0.00	0.00	0.00	567.12	113.42	226.85	113.42	113.42	1134.24
3	OTHER AREAS	7	0.00	113.42	0.00	0.00	0.00	2722.18	2155.06	0.00	0.00	4990.66
3	OTHER AREAS	7	6011.47	226.85	0.00	0.00	0.00	2381.90	3289.30	0.00	226.85	12136.37
3	OTHER AREAS	7	0.00	226.85	340.27	0.00	0.00	4536.96	4196.69	0.00	113.42	9414.19
3	OTHER AREAS	7	7939.68	793.97	113.42	0.00	0.00	3062.45	2155.06	113.42	113.42	14291.42
3	OTHER AREAS	7	0.00	0.00	0.00	0.00	0.00	2495.33	2155.06	113.42	0.00	4763.81
4	AFFECTED AREA	1	113.42	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	AFFECTED AREA	1	0.00	0.00	226.85	0.00	0.00	226.85	0.00	0.00	0.00	453.70
4	AFFECTED AREA	1	0.00	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	1	340.27	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42	567.12
4	AFFECTED AREA	1	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	113.42	340.27
4	AFFECTED AREA	1	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	1	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42	340.27
4	AFFECTED AREA	1	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	226.85
4	AFFECTED AREA	1	0.00	113.42	0.00	0.00	0.00	113.42	0.00	0.00	0.00	226.85
4	AFFECTED AREA	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	1	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	1	0.00	0.00	113.42	0.00	0.00	0.00	0.00	0.00	113.42	226.85
4	AFFECTED AREA	1	0.00	113.42	0.00	0.00	0.00	0.00	0.00	113.42	113.42	340.27
4	AFFECTED AREA	1	0.00	0.00	0.00	0.00	0.00	340.27	0.00	0.00	0.00	0.00
4	AFFECTED AREA	1	0.00	0.00	113.42	0.00	113.42	340.27	0.00	0.00	0.00	567.12
4	AFFECTED AREA	3	0.00	9.45	9.45	4.73	4.73	9.45	0.00	9.45	0.00	47.26

4	AFFECTED AREA	4	0.00	56.71	4.73	9.45	9.45	9.45	0.00	0.00	0.00	89.79
4	AFFECTED AREA	5	0.00	4.73	14.18	0.00	4.73	0.00	0.00	0.00	0.00	23.63
4	AFFECTED AREA	6	0.00	37.81	0.00	0.00	4.73	0.00	9.45	4.73	18.90	75.62
4	AFFECTED AREA	6	0.00	113.42	113.42	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	AFFECTED AREA	6	0.00	113.42	0.00	0.00	113.42	0.00	0.00	0.00	0.00	226.85
4	AFFECTED AREA	6	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	6	0.00	226.85	0.00	0.00	113.42	0.00	0.00	0.00	0.00	340.27
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	6	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42	226.85
4	AFFECTED AREA	6	0.00	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	6	0.00	113.42	113.42	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	6	0.00	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	6	0.00	0.00	113.42	0.00	113.42	0.00	0.00	0.00	0.00	226.85
4	AFFECTED AREA	6	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	6	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	7	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	7	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	113.42	0.00	113.42	0.00	0.00	226.85
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	0.00	113.42	0.00	0.00	0.00	0.00	113.42	0.00	0.00	226.85
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	7	113.42	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42	340.27
4	AFFECTED AREA	7	226.85	113.42	113.42	0.00	0.00	0.00	0.00	0.00	0.00	453.70
4	AFFECTED AREA	7	0.00	113.42	0.00	0.00	113.42	0.00	0.00	0.00	0.00	226.85
4	AFFECTED AREA	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	8	0.00	453.70	0.00	0.00	0.00	113.42	0.00	0.00	0.00	567.12
4	AFFECTED AREA	8	0.00	453.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	453.70
4	AFFECTED AREA	8	0.00	340.27	113.42	0.00	0.00	113.42	226.85	0.00	0.00	793.97
4	AFFECTED AREA	8	0.00	0.00	113.42	0.00	0.00	113.42	0.00	0.00	0.00	226.85
4	AFFECTED AREA	8	0.00	113.42	0.00	0.00	0.00	113.42	0.00	0.00	0.00	226.85
4	AFFECTED AREA	8	0.00	226.85	0.00	0.00	113.42	0.00	226.85	113.42	0.00	680.54
4	AFFECTED AREA	H	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	4	0.00	226.85	0.00	0.00	0.00	0.00	0.00	113.42	0.00	340.27
4	AFFECTED AREA	8	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	AFFECTED AREA	8	0.00	680.54	0.00	0.00	0.00	113.42	113.42	113.42	0.00	1020.82
4	AFFECTED AREA	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
4	AFFECTED AREA	9	0.00	226.85	0.00	0.00	0.00	0.00	113.42	0.00	0.00	340.27
4	AFFECTED AREA	8	0.00	340.27	0.00	0.00	113.42	0.00	0.00	0.00	0.00	453.70
4	AFFECTED AREA	8	0.00	453.70	0.00	0.00	113.42	0.00	0.00	0.00	0.00	567.12
4	AFFECTED AREA	8	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	AFFECTED AREA	4	0.00	0.00	0.00	0.00	0.00	113.42	226.85	0.00	0.00	340.27

4	AFFECTED AREA	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	8	0.00	113.42	0.00	0.00	0.00	0.00	0.00	113.42	113.42	340.27
4	AFFECTED AREA	9	0.00	113.42	0.00	0.00	113.42	0.00	0.00	0.00	0.00	226.85
4	AFFECTED AREA	9	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	226.85	340.27
4	AFFECTED AREA	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	9	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42	226.85
4	AFFECTED AREA	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	9	0.00	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	9	226.85	226.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	680.54
4	AFFECTED AREA	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	9	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	9	226.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	340.27
4	AFFECTED AREA	9	0.00	226.85	113.42	0.00	113.42	0.00	0.00	0.00	113.42	567.12
4	AFFECTED AREA	9	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	9	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42	226.85
4	AFFECTED AREA	9	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	9	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	9	0.00	0.00	0.00	0.00	226.95	0.00	113.42	0.00	0.00	340.27
4	AFFECTED AREA	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	9	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	AFFECTED AREA	10	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42	226.85
4	AFFECTED AREA	10	453.70	113.42	226.85	0.00	0.00	0.00	0.00	0.00	226.85	1020.82
4	AFFECTED AREA	10	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	340.27	567.12
4	AFFECTED AREA	10	0.00	0.00	0.00	0.00	113.42	113.42	113.42	226.85	0.00	567.12
4	AFFECTED AREA	10	226.85	113.42	226.85	0.00	113.42	113.42	0.00	0.00	226.85	1020.82
4	AFFECTED AREA	10	0.00	0.00	113.42	0.00	0.00	113.42	0.00	0.00	0.00	226.85
4	AFFECTED AREA	10	453.70	340.27	0.00	0.00	0.00	0.00	113.42	0.00	0.00	1134.24
4	AFFECTED AREA	10	0.00	113.42	226.85	0.00	0.00	113.42	113.42	0.00	0.00	567.12
4	AFFECTED AREA	10	0.00	226.85	113.42	0.00	0.00	0.00	113.42	0.00	113.42	567.12
4	AFFECTED AREA	10	0.00	340.27	0.00	0.00	0.00	0.00	0.00	0.00	226.85	567.12
4	AFFECTED AREA	10	0.00	0.00	0.00	0.00	113.42	0.00	113.42	0.00	0.00	226.85
4	AFFECTED AREA	10	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	10	0.00	0.00	226.85	0.00	0.00	0.00	0.00	113.42	0.00	340.27
4	AFFECTED AREA	10	0.00	453.70	0.00	0.00	0.00	113.42	113.42	226.85	0.00	907.39
4	AFFECTED AREA	10	0.00	567.12	0.00	0.00	226.95	113.42	0.00	453.70	0.00	1361.09
4	AFFECTED AREA	10	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	113.42	340.27
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	11	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42	226.85
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	11	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	11	0.00	113.42	0.00	0.00	0.00	0.00	0.00	113.42	0.00	226.85
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	11	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	11	0.00	113.42	0.00	0.00	0.00	113.42	113.42	0.00	0.00	340.27
4	AFFECTED AREA	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	11	0.00	113.42	0.00	0.00	0.00	0.00	113.42	0.00	0.00	226.85
4	AFFECTED AREA	12	0.00	113.42	113.42	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	AFFECTED AREA	12	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	340.27	567.12
4	AFFECTED AREA	12	226.85	226.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	453.70
4	AFFECTED AREA	12	0.00	453.70	0.00	0.00	0.00	0.00	0.00	0.00	113.42	567.12
4	AFFECTED AREA	12	0.00	340.27	113.42	0.00	0.00	0.00	0.00	0.00	113.42	567.12
4	AFFECTED AREA	12	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	12	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	AFFECTED AREA	12	0.00	113.42	0.00	0.00	113.42	0.00	0.00	0.00	113.42	340.27
4	AFFECTED AREA	12	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42
4	AFFECTED AREA	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	12	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42

4	AFFECTED AREA	13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	13	0.00	0.00	226.85	0.00	0.00	0.00	113.42	0.00	0.00	340.27
4	AFFECTED AREA	13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	13	0.00	340.27	0.00	0.00	0.00	113.42	340.27	0.00	113.42	907.39
4	AFFECTED AREA	13	0.00	0.00	226.85	0.00	0.00	0.00	113.42	0.00	0.00	340.27
4	EAST CONTROL	1	0.00	113.42	0.00	0.00	0.00	113.42	0.00	0.00	0.00	226.85
4	EAST CONTROL	1	0.00	0.00	0.00	113.42	0.00	0.00	226.85	0.00	0.00	340.27
4	EAST CONTROL	1	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	EAST CONTROL	1	0.00	0.00	113.42	0.00	113.42	0.00	226.85	0.00	0.00	453.70
4	EAST CONTROL	1	0.00	113.42	0.00	0.00	0.00	0.00	113.42	0.00	0.00	226.85
4	EAST CONTROL	1	0.00	113.42	113.42	0.00	113.42	0.00	113.42	0.00	226.85	680.54
4	EAST CONTROL	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	1	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	EAST CONTROL	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	1	0.00	226.85	0.00	0.00	0.00	0.00	113.42	0.00	226.85	567.12
4	EAST CONTROL	1	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42	113.42	340.27
4	EAST CONTROL	1	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42	0.00	226.85
4	EAST CONTROL	1	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	113.42	340.27
4	EAST CONTROL	1	0.00	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	EAST CONTROL	1	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	EAST CONTROL	1	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	EAST CONTROL	1	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	226.85	340.27
4	EAST CONTROL	1	0.00	226.85	0.00	0.00	226.85	0.00	0.00	0.00	113.42	567.12
4	EAST CONTROL	1	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42	226.85
4	EAST CONTROL	2	0.00	0.00	113.42	0.00	113.42	340.27	226.85	113.42	0.00	907.39
4	EAST CONTROL	2	0.00	0.00	340.27	0.00	0.00	907.39	340.27	340.27	113.42	2041.63
4	EAST CONTROL	2	0.00	0.00	340.27	0.00	0.00	567.12	453.70	567.12	0.00	1928.21
4	EAST CONTROL	2	0.00	113.42	340.27	0.00	0.00	453.70	680.54	0.00	0.00	1587.94
4	EAST CONTROL	2	0.00	113.42	226.85	0.00	0.00	793.97	907.39	0.00	0.00	2041.63
4	EAST CONTROL	2	0.00	113.42	453.70	0.00	0.00	907.39	567.12	340.27	0.00	2381.90
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	3	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	3	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	113.42	226.85
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	113.42	113.42	0.00	0.00	0.00	226.85
4	EAST CONTROL	3	0.00	113.42	0.00	0.00	0.00	0.00	113.42	0.00	0.00	226.85
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
4	EAST CONTROL	3	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	EAST CONTROL	3	0.00	113.42	0.00	0.00	113.42	0.00	0.00	113.42	113.42	453.70
4	EAST CONTROL	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	4	226.85	0.00	0.00	0.00	0.00	0.00	567.12	0.00	113.42	907.39
4	EAST CONTROL	4	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42	0.00	226.85
4	EAST CONTROL	4	226.85	0.00	226.85	0.00	0.00	0.00	226.85	113.42	0.00	793.97
4	EAST CONTROL	4	567.12	0.00	0.00	0.00	0.00	113.42	1020.82	113.42	113.42	1928.21
4	EAST CONTROL	4	0.00	0.00	0.00	0.00	0.00	0.00	453.70	340.27	0.00	793.97
4	EAST CONTROL	4	0.00	0.00	0.00	0.00	0.00	0.00	453.70	113.42	0.00	567.12
4	EAST CONTROL	4	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	226.85
4	EAST CONTROL	4	0.00	0.00	113.42	0.00	0.00	113.42	453.70	113.42	0.00	793.97

4	EAST CONTROL	4	0.00	0.00	0.00	0.00	0.00	113.42	226.85	0.00	0.00	340.27
4	EAST CONTROL	4	0.00	113.42	113.42	0.00	0.00	0.00	680.54	340.27	113.42	1361.09
4	EAST CONTROL	4	0.00	113.42	0.00	0.00	0.00	0.00	340.27	226.85	0.00	680.54
4	EAST CONTROL	4	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	226.85
4	EAST CONTROL	4	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
4	EAST CONTROL	4	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	EAST CONTROL	4	0.00	0.00	113.42	0.00	0.00	0.00	113.42	226.85	0.00	453.70
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	113.42	113.42	113.42	226.85	0.00	567.12
4	EAST CONTROL	5	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	5	0.00	113.42	0.00	0.00	0.00	0.00	340.27	113.42	0.00	567.12
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	340.27	0.00	113.42	453.70
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	113.42	113.42	113.42	0.00	340.27
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	340.27	113.42	0.00	453.70
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	5	0.00	113.42	0.00	0.00	0.00	0.00	226.85	0.00	0.00	340.27
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	5	0.00	113.42	0.00	0.00	0.00	0.00	226.85	0.00	0.00	340.27
4	EAST CONTROL	5	0.00	226.85	0.00	0.00	0.00	0.00	113.42	0.00	0.00	340.27
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	113.42	0.00	226.85	0.00	0.00	340.27
4	EAST CONTROL	5	0.00	113.42	0.00	0.00	0.00	0.00	113.42	226.85	0.00	453.70
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	EAST CONTROL	5	0.00	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	340.27	0.00	0.00	340.27
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	226.85
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42	226.85
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	113.42	0.00	113.42	113.42	0.00	340.27
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	340.27	0.00	0.00	340.27
4	EAST CONTROL	5	0.00	0.00	0.00	0.00	0.00	0.00	340.27	0.00	0.00	340.27
4	EAST CONTROL	7	4.73	23.63	0.00	0.00	0.00	0.00	14.18	9.45	0.00	51.99
4	EAST CONTROL	7	0.00	113.42	0.00	0.00	0.00	0.00	0.00	226.85	0.00	340.27
4	EAST CONTROL	7	226.85	113.42	113.42	0.00	0.00	0.00	226.85	0.00	226.85	907.39
4	EAST CONTROL	7	113.42	0.00	0.00	0.00	0.00	0.00	226.85	0.00	113.42	453.70
4	EAST CONTROL	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	113.42
4	EAST CONTROL	7	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	EAST CONTROL	7	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	226.85
4	EAST CONTROL	7	0.00	0.00	113.42	0.00	0.00	113.42	0.00	0.00	0.00	226.85
4	EAST CONTROL	7	0.00	0.00	113.42	0.00	0.00	113.42	0.00	0.00	0.00	226.85
4	EAST CONTROL	7	0.00	0.00	0.00	0.00	113.42	113.42	113.42	0.00	0.00	340.27
4	EAST CONTROL	7	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	EAST CONTROL	7	0.00	0.00	0.00	0.00	113.42	0.00	226.85	0.00	0.00	340.27
4	EAST CONTROL	7	0.00	0.00	113.42	0.00	0.00	0.00	226.85	0.00	0.00	340.27
4	EAST CONTROL	7	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	113.42	340.27
4	EAST CONTROL	7	0.00	113.42	0.00	0.00	0.00	0.00	340.27	113.42	0.00	567.12
4	EAST CONTROL	8	0.00	226.85	0.00	0.00	113.42	113.42	340.27	340.27	0.00	1134.24
4	EAST CONTROL	8	113.42	226.85	0.00	0.00	0.00	0.00	340.27	226.85	113.42	1020.82
4	EAST CONTROL	8	0.00	0.00	0.00	0.00	226.85	0.00	226.85	340.27	0.00	793.97
4	EAST CONTROL	8	0.00	226.85	113.42	0.00	0.00	113.42	453.70	340.27	113.42	1361.09
4	EAST CONTROL	8	0.00	113.42	0.00	0.00	0.00	340.27	453.70	226.85	0.00	1134.24
4	EAST CONTROL	8	0.00	113.42	0.00	0.00	0.00	0.00	226.85	0.00	0.00	340.27
4	EAST CONTROL	8	0.00	226.85	0.00	0.00	0.00	0.00	680.54	226.85	113.42	1247.66
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	113.42
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	226.85
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	226.85
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	226.85	113.42	0.00	340.27
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42	113.42	340.27
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	340.27	113.42	0.00	453.70
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	113.42	680.54	0.00	113.42	907.39
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	340.27	226.85	0.00	567.12
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	226.85
4	EAST CONTROL	9	0.00	113.42	0.00	0.00	113.42	0.00	453.70	0.00	0.00	680.54
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	113.42	226.85	113.42	0.00	453.70

4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	226.85
4	EAST CONTROL	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	9	0.00	226.85	0.00	0.00	0.00	0.00	0.00	113.42	0.00	340.27
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42	0.00	226.85
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	226.85
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85	113.42	340.27
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85	226.85
4	EAST CONTROL	10	0.00	113.42	0.00	0.00	0.00	0.00	0.00	226.85	0.00	340.27
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	226.85	340.27
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	113.42	0.00	0.00	226.85	0.00	340.27
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	226.85	340.27
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42	226.85	453.70
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	113.42
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	113.42	113.42	0.00	226.85
4	EAST CONTROL	10	0.00	0.00	0.00	0.00	0.00	0.00	226.85	113.42	0.00	340.27
4	EAST CONTROL	11	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	113.42	113.42	0.00	0.00	226.85
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	11	0.00	0.00	113.42	0.00	113.42	0.00	0.00	0.00	0.00	226.85
4	EAST CONTROL	11	0.00	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85	0.00	226.85
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42	226.85
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	12	1134.24	0.00	0.00	0.00	226.85	113.42	1247.66	113.42	340.27	3175.87
4	EAST CONTROL	12	340.27	0.00	0.00	0.00	0.00	0.00	226.85	0.00	0.00	567.12
4	EAST CONTROL	12	0.00	0.00	0.00	0.00	0.00	0.00	340.27	0.00	0.00	340.27
4	EAST CONTROL	12	0.00	0.00	0.00	0.00	0.00	0.00	907.39	453.70	0.00	1361.09
4	EAST CONTROL	12	0.00	0.00	0.00	0.00	113.42	0.00	1134.24	226.85	113.42	1587.94
4	EAST CONTROL	12	0.00	0.00	0.00	0.00	0.00	0.00	1020.82	113.42	0.00	1134.24
4	EAST CONTROL	12	0.00	0.00	0.00	0.00	0.00	0.00	1474.51	680.54	113.42	2268.48
4	EAST CONTROL	12	0.00	0.00	0.00	0.00	113.42	113.42	1134.24	680.54	226.85	2268.48
4	EAST CONTROL	12	1134.24	0.00	0.00	0.00	0.00	0.00	907.39	113.42	340.27	2495.33
4	EAST CONTROL	12	1020.82	0.00	0.00	0.00	113.42	0.00	1701.36	113.42	340.27	3289.30
4	EAST CONTROL	12	1474.51	0.00	0.00	0.00	226.85	0.00	1134.24	226.85	340.27	3402.72
4	EAST CONTROL	12	0.00	0.00	0.00	0.00	0.00	113.42	453.70	0.00	0.00	567.12
4	EAST CONTROL	12	0.00	0.00	113.42	0.00	226.85	0.00	1247.66	226.85	113.42	1928.21
4	EAST CONTROL	12	0.00	113.42	0.00	0.00	0.00	0.00	680.54	340.27	0.00	1134.24
4	EAST CONTROL	12	0.00	113.42	0.00	0.00	0.00	113.42	1247.66	113.42	113.42	1701.36
4	EAST CONTROL	12	0.00	0.00	0.00	0.00	113.42	0.00	453.70	340.27	113.42	1020.82
4	EAST CONTROL	13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	13	113.42	113.42	0.00	0.00	113.42	0.00	113.42	0.00	0.00	453.70
4	EAST CONTROL	13	0.00	113.42	0.00	0.00	0.00	0.00	113.42	0.00	0.00	226.85
4	EAST CONTROL	13	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	EAST CONTROL	13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	EAST CONTROL	13	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	113.42	226.85
4	WEST CONTROL	2	0.00	132.33	4.73	4.73	33.08	0.00	4.73	4.73	42.53	226.85
4	WEST CONTROL	3	4.73	118.15	4.73	23.63	4.73	4.73	0.00	0.00	14.18	174.86
4	WEST CONTROL	4	0.00	23.63	0.00	0.00	9.45	4.73	4.73	0.00	0.00	42.53
4	OTHER AREAS	1	0.00	133.97	61.44	4.73	0.00	18.90	4.73	4.73	0.00	198.49
4	OTHER AREAS	2	5099.35	248.23	530.82	18.90	85.07	1625.74	2150.33	51.99	1190.95	10841.44

4	OTHER AREAS	2	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	OTHER AREAS	2	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	OTHER AREAS	4	0.00	47.25	0.00	0.00	4.73	56.71	33.08	0.00	4.73	146.51
4	OTHER AREAS	4	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	OTHER AREAS	4	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	OTHER AREAS	4	0.00	0.00	113.42	0.00	0.00	113.42	0.00	0.00	0.00	226.85
4	OTHER AREAS	4	0.00	0.00	0.00	0.00	0.00	226.85	226.85	113.42	113.42	680.54
4	OTHER AREAS	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	OTHER AREAS	4	0.00	0.00	226.85	0.00	0.00	226.85	0.00	0.00	0.00	453.70
4	OTHER AREAS	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	OTHER AREAS	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	OTHER AREAS	4	0.00	0.00	0.00	0.00	0.00	113.42	226.85	113.42	113.42	567.12
4	OTHER AREAS	4	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	0.00	113.42
4	OTHER AREAS	4	0.00	113.42	0.00	0.00	0.00	226.85	0.00	113.42	113.42	567.12
4	OTHER AREAS	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	OTHER AREAS	4	0.00	226.85	0.00	0.00	0.00	340.27	113.42	113.42	0.00	793.97
4	OTHER AREAS	4	0.00	0.00	0.00	0.00	0.00	226.85	113.42	113.42	0.00	453.70
4	OTHER AREAS	6	0.00	23.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.63
4	OTHER AREAS	7	0.00	28.35	0.00	33.08	0.00	0.00	0.00	0.00	9.45	70.89
4	OTHER AREAS	7	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	OTHER AREAS	7	0.00	113.42	113.42	0.00	0.00	0.00	0.00	226.85	0.00	453.70
4	OTHER AREAS	7	0.00	226.85	226.85	0.00	0.00	0.00	0.00	113.42	0.00	567.12
4	OTHER AREAS	7	0.00	0.00	0.00	0.00	0.00	226.85	226.85	113.42	113.42	680.54
4	OTHER AREAS	7	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	0.00	113.42
4	OTHER AREAS	7	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42	226.85
4	OTHER AREAS	7	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	OTHER AREAS	7	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42	226.85
4	OTHER AREAS	7	0.00	0.00	113.42	0.00	0.00	113.42	0.00	113.42	0.00	340.27
4	OTHER AREAS	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	OTHER AREAS	7	0.00	0.00	113.42	0.00	0.00	0.00	0.00	0.00	113.42	226.85
4	OTHER AREAS	7	0.00	340.27	0.00	0.00	113.42	0.00	0.00	0.00	0.00	453.70
4	OTHER AREAS	7	0.00	226.85	0.00	0.00	0.00	0.00	0.00	113.42	0.00	340.27
4	OTHER AREAS	7	0.00	0.00	113.42	0.00	0.00	0.00	0.00	113.42	0.00	226.85
4	OTHER AREAS	8	0.00	340.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	340.27
4	OTHER AREAS	8	113.42	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	OTHER AREAS	8	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	113.42	340.27
4	OTHER AREAS	8	113.42	113.42	0.00	0.00	113.42	0.00	0.00	0.00	0.00	340.27
4	OTHER AREAS	8	0.00	113.42	113.42	113.42	0.00	0.00	113.42	0.00	0.00	453.70
4	OTHER AREAS	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	OTHER AREAS	8	0.00	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	OTHER AREAS	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	OTHER AREAS	8	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	OTHER AREAS	8	0.00	113.42	0.00	0.00	113.42	0.00	0.00	0.00	0.00	226.85
4	OTHER AREAS	8	0.00	113.42	113.42	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	OTHER AREAS	8	0.00	340.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	340.27
4	OTHER AREAS	8	0.00	0.00	113.42	0.00	0.00	0.00	0.00	0.00	113.42	226.85
4	OTHER AREAS	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	OTHER AREAS	9	0.00	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	OTHER AREAS	9	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	OTHER AREAS	9	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	OTHER AREAS	9	226.85	0.00	113.42	0.00	0.00	0.00	0.00	0.00	113.42	453.70
4	OTHER AREAS	9	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	OTHER AREAS	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	OTHER AREAS	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	OTHER AREAS	9	0.00	113.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42
4	OTHER AREAS	9	0.00	340.27	113.42	0.00	0.00	0.00	0.00	113.42	113.42	680.54
4	OTHER AREAS	9	0.00	453.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	453.70
4	OTHER AREAS	9	0.00	226.85	0.00	0.00	113.42	0.00	0.00	113.42	0.00	453.70
4	OTHER AREAS	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	OTHER AREAS	9	0.00	226.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	226.85
4	OTHER AREAS	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	113.42	0.00	113.42
4	OTHER AREAS	10	0.00	0.00	113.42	0.00	113.42	0.00	340.27	0.00	0.00	567.12
4	OTHER AREAS	10	0.00	0.00	113.42	0.00	0.00	340.27	567.12	113.42	0.00	1134.24
4	OTHER AREAS	10	0.00	113.42	113.42	0.00	0.00	0.00	340.27	0.00	113.42	680.54
4	OTHER AREAS	10	0.00	113.42	226.85	0.00	113.42	113.42	907.39	226.85	113.42	1814.78
4	OTHER AREAS	10	0.00	113.42	0.00	0.00	0.00	340.27	340.27	0.00	0.00	793.97

4	OTHER AREAS	10	0.00	567.12	226.85	0.00	0.00	793.97	907.39	113.42	453.70	3052.45
4	OTHER AREAS	10	0.00	453.70	113.42	0.00	0.00	226.85	1587.94	453.70	453.70	3289.30

APPENDIX B.2
Marsh Fauna Densities

This appendix is a computer listing of the converted data (densities per 0.25 m^2) for the marsh sediment fauna in nine taxonomic categories and their sum. Multiple entries for the same phase, site, station, and sample number represent subsamples generated in the laboratory.

DENSITY (PER 0.25 SQUARE METER) OF MARSH BENTHIC FAUNA

PHASE	SITE	STATION/ SAMPLE	NEMATODA	OLIGOCHAETA		BIVALVIA	AMPHIPODA			MISC.	TOTAL
				POLYCHAETA		GASTROPODA	TANAIDACEA		ISOPODA		
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	96.00	0.00	0.00	0.00	24.00	120.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	48.00	0.00	0.00	0.00	0.00	48.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	96.00	0.00	0.00	0.00	0.00	96.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	72.00	0.00	0.00	0.00	0.00	72.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	48.00	0.00	0.00	0.00	0.00	48.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.00	48.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	24.00	0.00	0.00	0.00	96.00	120.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	16-1-B (333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	5-9-B (140)	120.00	0.00	0.00	96.00	24.00	24.00	0.00	192.00	336.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	24.00	72.00	0.00	72.00	168.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.00	48.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	120.00	0.00	0.00	144.00	216.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	48.00	72.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	72.00	96.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	72.00	24.00	0.00	0.00	96.00	192.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	24.00	96.00	0.00	0.00	0.00	72.00	192.00
1	AFFECTED AREA	5-9-B (140)	48.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	24.00	48.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	0.00	24.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	120.00	0.00	24.00	72.00	216.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	24.00	24.00	0.00	0.00	0.00	0.00	48.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	24.00	48.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	48.00	72.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	48.00	96.00	0.00	0.00	24.00	168.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.00	48.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	48.00	24.00	0.00	48.00	120.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	72.00	0.00	0.00	0.00	72.00
1	AFFECTED AREA	5-9-B (140)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	72.00	96.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	144.00	0.00	0.00	0.00	0.00	48.00	192.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	168.00	0.00	0.00	0.00	0.00	24.00	192.00
1	AFFECTED AREA	9-1-B (335)	120.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	0.00	24.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	120.00	0.00	0.00	0.00	0.00	0.00	120.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	24.00	48.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	0.00	24.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	0.00	24.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	48.00	0.00	0.00	0.00	0.00	24.00	72.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	24.00	0.00	0.00	24.00	0.00	0.00	48.00

1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (335)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	16-1-B (330)	96.00	0.00	0.00	144.00	0.00	0.00	0.00	0.00	0.00	144.00
1	AFFECTED AREA	16-1-B (330)	0.00	0.00	0.00	48.00	0.00	0.00	0.00	0.00	48.00	96.00
1	AFFECTED AREA	16-1-B (330)	0.00	0.00	0.00	120.00	0.00	0.00	0.00	0.00	0.00	120.00
1	AFFECTED AREA	16-1-B (330)	0.00	48.00	0.00	120.00	0.00	0.00	0.00	0.00	0.00	168.00
1	AFFECTED AREA	9-10-B (146)	0.00	24.00	0.00	0.00	144.00	576.00	96.00	0.00	168.00	984.00
1	AFFECTED AREA	9-10-B (146)	336.00	0.00	0.00	0.00	96.00	624.00	96.00	0.00	24.00	840.00
1	AFFECTED AREA	9-10-B (146)	192.00	0.00	0.00	0.00	72.00	456.00	192.00	0.00	144.00	864.00
1	AFFECTED AREA	9-10-B (146)	0.00	24.00	0.00	24.00	288.00	480.00	120.00	0.00	0.00	936.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	24.00	120.00	24.00	24.00	576.00	744.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	0.00	216.00	0.00	0.00	120.00	336.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	0.00	0.00	48.00	0.00	216.00	264.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	0.00	72.00	0.00	0.00	0.00	72.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	0.00	168.00	24.00	0.00	0.00	192.00
1	AFFECTED AREA	9-10-B (147)	96.00	0.00	0.00	0.00	0.00	360.00	0.00	0.00	120.00	480.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	24.00	144.00	0.00	0.00	48.00	216.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	0.00	144.00	24.00	0.00	24.00	192.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	0.00	120.00	48.00	0.00	72.00	240.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	24.00	72.00	24.00	0.00	0.00	120.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	0.00	120.00	48.00	0.00	192.00	360.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	0.00	288.00	0.00	0.00	0.00	288.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	24.00	144.00	24.00	0.00	0.00	192.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	0.00	168.00	0.00	0.00	312.00	480.00
1	AFFECTED AREA	9-10-B (147)	0.00	0.00	0.00	0.00	0.00	120.00	0.00	0.00	96.00	216.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	48.00	0.00	0.00	72.00	72.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	24.00	0.00	0.00	0.00	48.00	72.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	24.00	0.00	0.00	0.00	24.00	48.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	24.00	24.00	0.00	0.00	0.00	48.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	24.00	48.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	96.00	0.00	0.00	24.00	120.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	24.00	48.00	0.00	0.00	120.00	192.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	24.00	24.00	0.00	0.00	72.00	120.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	48.00	72.00	0.00	0.00	288.00	408.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	24.00	96.00	0.00	0.00	96.00	216.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	48.00	0.00	0.00	0.00	48.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	24.00	48.00	0.00	0.00	0.00	72.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	48.00	72.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	24.00	48.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	72.00	72.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	24.00	0.00	0.00	0.00	24.00	48.00
1	AFFECTED AREA	5-9-B (139)	0.00	0.00	0.00	0.00	0.00	72.00	0.00	0.00	48.00	120.00
1	AFFECTED AREA	2-9-B (143)	0.00	24.00	0.00	0.00	0.00	0.00	0.00	24.00	0.00	48.00
1	AFFECTED AREA	2-9-B (143)	0.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00
1	AFFECTED AREA	2-9-B (143)	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	2-9-B (143)	24.00	0.00	0.00	0.00	24.00	24.00	24.00	0.00	24.00	96.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	24.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.00	48.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	24.00	0.00	24.00	0.00	0.00	0.00	0.00	48.00

-	FFECTED AREA	2-9-B (143)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	24.00	0.00	24.00	0.00	0.00	24.00	0.00	72.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	24.00	48.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	72.00	72.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	24.00	48.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	24.00	0.00	0.00	24.00	0.00	0.00	24.00	72.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	48.00	0.00	0.00	24.00	0.00	0.00	0.00	72.00
1	AFFECTED AREA	2-9-B (143)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	2-9-B (141)	984.00	0.00	888.00	0.00	192.00	1248.00	336.00	0.00	264.00	2880.00
1	AFFECTED AREA	2-9-B (141)	0.00	0.00	72.00	0.00	168.00	1152.00	384.00	0.00	24.00	1800.00
1	AFFECTED AREA	2-9-B (141)	0.00	0.00	600.00	0.00	168.00	1584.00	336.00	24.00	168.00	2880.00
1	AFFECTED AREA	2-9-B (141)	480.00	0.00	528.00	0.00	456.00	1320.00	432.00	48.00	288.00	3072.00
1	AFFECTED AREA	9-1-B (248)	48.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	0.00	24.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	0.00	24.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.00	48.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	72.00	0.00	0.00	0.00	0.00	0.00	72.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	24.00	48.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	AFFECTED AREA	9-1-B (248)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	AFFECTED AREA	2-9-B (144)	336.00	24.00	24.00	0.00	72.00	936.00	96.00	0.00	24.00	1176.00
1	AFFECTED AREA	2-9-B (144)	0.00	24.00	0.00	0.00	48.00	648.00	120.00	0.00	48.00	888.00
1	AFFECTED AREA	2-9-B (144)	0.00	120.00	0.00	0.00	72.00	1248.00	120.00	0.00	24.00	1584.00
1	AFFECTED AREA	2-9-B (144)	240.00	0.00	0.00	0.00	48.00	792.00	144.00	24.00	24.00	1032.00
1	AFFECTED AREA	9-10-B (145)	240.00	48.00	0.00	0.00	288.00	792.00	576.00	0.00	120.00	1728.00
1	AFFECTED AREA	9-10-B (145)	0.00	48.00	96.00	24.00	264.00	2400.00	792.00	0.00	312.00	3936.00
1	AFFECTED AREA	9-10-B (145)	744.00	0.00	0.00	0.00	288.00	2184.00	912.00	0.00	288.00	3600.00
1	AFFECTED AREA	9-10-B (145)	0.00	72.00	120.00	0.00	408.00	2304.00	576.00	24.00	120.00	3624.00
1	AFFECTED AREA	5-9-B (137)	0.00	24.00	72.00	0.00	0.00	96.00	0.00	0.00	24.00	216.00
1	AFFECTED AREA	5-9-B (137)	0.00	0.00	0.00	0.00	0.00	48.00	0.00	0.00	96.00	144.00
1	AFFECTED AREA	5-9-B (137)	1488.00	0.00	792.00	0.00	0.00	0.00	0.00	0.00	192.00	888.00
1	AFFECTED AREA	5-9-B (137)	1944.00	24.00	504.00	0.00	0.00	120.00	24.00	0.00	216.00	816.00
1	WEST CONTROL	4-2-B (373)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	4-2-B (373)	0.00	24.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	48.00
1	WEST CONTROL	4-2-B (373)	48.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL		0.00	24.00	96.00	0.00	0.00	0.00	0.00	0.00	24.00	144.00
1	WEST CONTROL		0.00	24.00	72.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00
1	WEST CONTROL		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.00	24.00
1	EAST CONTROL	E8-2-B (468)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	EAST CONTROL	E8-2-B (468)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	EAST CONTROL	E8-2-B (468)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	EAST CONTROL	E8-2-B (468)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	EAST CONTROL	E8-2-B (468)	0.00	0.00	0.00	48.00	0.00	0.00	0.00	0.00	0.00	48.00
1	EAST CONTROL	E8-2-B (468)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	EAST CONTROL	E5-2-B (442)	0.00	3.00	0.00	0.00	0.00	12.00	5.00	0.00	1.00	21.00

1	EAST CONTROL	E4-2-B (456)	0.00	9.00	25.00	0.00	0.00	0.00	1.00	0.00	4.00	39.00
1	EAST CONTROL	E7-2-B (466)	0.00	1.00	2.00	0.00	0.00	3.00	3.00	1.00	9.00	19.00
1	WEST CONTROL	6-2-B (371)	0.00	48.00	24.00	0.00	120.00	120.00	936.00	0.00	216.00	1464.00
1	WEST CONTROL	6-2-B (371)	0.00	72.00	120.00	0.00	48.00	24.00	456.00	0.00	0.00	720.00
1	WEST CONTROL	6-2-B (371)	0.00	72.00	0.00	0.00	240.00	48.00	960.00	0.00	192.00	1512.00
1	WEST CONTROL	6-2-B (371)	120.00	72.00	48.00	0.00	264.00	120.00	816.00	0.00	96.00	1416.00
1	WEST CONTROL	6-2-B (371)	0.00	48.00	0.00	0.00	168.00	168.00	816.00	0.00	144.00	1344.00
1	WEST CONTROL	6-2-B (371)	0.00	48.00	0.00	0.00	96.00	144.00	432.00	0.00	96.00	816.00
1	WEST CONTROL	6-2-B (371)	360.00	144.00	336.00	0.00	240.00	168.00	1128.00	0.00	96.00	2112.00
1	WEST CONTROL	6-2-B (371)	0.00	0.00	48.00	0.00	144.00	24.00	504.00	0.00	72.00	792.00
1	WEST CONTROL	6-2-B (371)	24.00	96.00	72.00	0.00	216.00	144.00	816.00	0.00	168.00	1512.00
1	WEST CONTROL	6-2-B (371)	24.00	72.00	0.00	0.00	192.00	72.00	840.00	0.00	72.00	1248.00
1	WEST CONTROL	6-2-B (371)	144.00	216.00	48.00	0.00	240.00	288.00	1656.00	0.00	144.00	2592.00
1	WEST CONTROL	6-2-B (371)	360.00	360.00	48.00	0.00	240.00	96.00	576.00	0.00	48.00	1368.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00
1	WEST CONTROL	5-2-B (423)	0.00	24.00	336.00	0.00	0.00	0.00	0.00	0.00	24.00	384.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	408.00	0.00	0.00	0.00	0.00	0.00	72.00	480.00
1	WEST CONTROL	5-2-B (423)	0.00	48.00	192.00	0.00	24.00	0.00	0.00	0.00	72.00	312.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	72.00	24.00	0.00	0.00	0.00	0.00	72.00	168.00
1	WEST CONTROL	5-2-B (423)	0.00	24.00	0.00	0.00	72.00	0.00	0.00	0.00	0.00	96.00
1	WEST CONTROL	5-2-B (423)	0.00	48.00	0.00	24.00	0.00	0.00	0.00	0.00	216.00	288.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	24.00	48.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	96.00	0.00	0.00	0.00	0.00	0.00	24.00	120.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	0.00	24.00	48.00	0.00	0.00	0.00	24.00	96.00
1	WEST CONTROL	5-2-B (423)	0.00	24.00	0.00	0.00	48.00	0.00	0.00	0.00	120.00	192.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00	96.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	24.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	5-2-B (423)	0.00	24.00	72.00	0.00	24.00	0.00	0.00	0.00	0.00	120.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	24.00	0.00	24.00	0.00	0.00	0.00	24.00	72.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	240.00	0.00	0.00	0.00	0.00	0.00	24.00	264.00
1	WEST CONTROL	5-2-B (423)	0.00	0.00	360.00	0.00	0.00	0.00	0.00	0.00	120.00	480.00
1	WEST CONTROL	9-2-B (383)	480.00	72.00	216.00	0.00	0.00	24.00	720.00	0.00	336.00	1368.00
1	WEST CONTROL	9-2-B (383)	1728.00	48.00	240.00	0.00	0.00	144.00	1368.00	0.00	120.00	1896.00
1	WEST CONTROL	9-2-B (383)	96.00	24.00	144.00	0.00	24.00	48.00	456.00	24.00	696.00	1176.00
1	WEST CONTROL	9-2-B (383)	624.00	0.00	72.00	0.00	120.00	168.00	1968.00	72.00	240.00	2616.00
1	WEST CONTROL	9-2-B (383)	120.00	24.00	144.00	0.00	72.00	72.00	1704.00	0.00	216.00	2184.00
1	WEST CONTROL	9-2-B (383)	0.00	24.00	48.00	0.00	24.00	96.00	1440.00	24.00	144.00	1800.00
1	WEST CONTROL	9-2-B (383)	0.00	0.00	384.00	0.00	264.00	0.00	2088.00	24.00	864.00	3096.00
1	WEST CONTROL	9-2-B (383)	0.00	96.00	360.00	0.00	0.00	48.00	2208.00	48.00	120.00	2880.00
1	WEST CONTROL	9-2-B (383)	0.00	0.00	552.00	0.00	48.00	0.00	1848.00	24.00	144.00	2520.00
1	WEST CONTROL	9-2-B (383)	0.00	0.00	96.00	0.00	24.00	120.00	1848.00	24.00	96.00	2208.00
1	WEST CONTROL	9-2-B (383)	0.00	24.00	48.00	0.00	48.00	120.00	2208.00	48.00	312.00	2808.00
1	WEST CONTROL	9-2-B (383)	0.00	0.00	24.00	0.00	48.00	144.00	720.00	48.00	96.00	1080.00
1	WEST CONTROL	9-2-B (383)	0.00	0.00	96.00	0.00	48.00	120.00	1872.00	24.00	192.00	2352.00
1	WEST CONTROL	9-2-B (383)	0.00	0.00	0.00	0.00	168.00	24.00	2304.00	72.00	216.00	2784.00
1	WEST CONTROL	9-2-B (383)	72.00	48.00	24.00	0.00	240.00	0.00	1776.00	24.00	168.00	2280.00
1	WEST CONTROL	9-2-B (383)	0.00	72.00	240.00	0.00	192.00	264.00	1944.00	24.00	456.00	3144.00
1	WEST CONTROL	9-2-B (383)	0.00	24.00	0.00	0.00	144.00	120.00	1776.00	0.00	192.00	2256.00
1	WEST CONTROL	9-2-B (383)	0.00	24.00	24.00	0.00	48.00	96.00	1056.00	0.00	72.00	1320.00
1	WEST CONTROL	9-2-B (383)	0.00	0.00	0.00	0.00	48.00	72.00	1608.00	0.00	264.00	1992.00
1	WEST CONTROL	9-2-B (383)	0.00	72.00	24.00	0.00	72.00	120.00	2472.00	24.00	360.00	3144.00
1	WEST CONTROL	9-2-B (383)	0.00	0.00	0.00	0.00	72.00	192.00	1944.00	0.00	288.00	2496.00
1	WEST CONTROL	9-2-B (383)	0.00	0.00	0.00	0.00	120.00	24.00	1536.00	0.00	72.00	1752.00
1	WEST CONTROL	9-2-B (383)	0.00	24.00	96.00	0.00	0.00	48.00	2040.00	24.00	216.00	2448.00
1	WEST CONTROL	9-2-B (383)	0.00	0.00	48.00	0.00	168.00	120.00	2616.00	24.00	408.00	3384.00
	WEST CONTROL	9-2-B (385)	0.00	24.00	0.00	0.00	0.00	0.00	264.00	0.00	0.00	[illegible]0

1	WEST CONTROL	9-2-8 (385)	24.00	24.00	120.00	0.00	0.00	96.00	216.00	0.00	24.00	480.00
1	WEST CONTROL	9-2-8 (385)	24.00	0.00	144.00	0.00	0.00	24.00	216.00	0.00	0.00	384.00
1	WEST CONTROL	9-2-8 (385)	0.00	48.00	24.00	0.00	24.00	24.00	192.00	0.00	24.00	336.00
1	WEST CONTROL	9-2-8 (385)	0.00	0.00	0.00	0.00	0.00	48.00	144.00	0.00	0.00	192.00
1	WEST CONTROL	9-2-8 (385)	0.00	24.00	96.00	0.00	24.00	48.00	96.00	0.00	0.00	288.00
1	WEST CONTROL	9-2-8 (385)	0.00	0.00	48.00	0.00	0.00	0.00	984.00	0.00	0.00	1032.00
1	WEST CONTROL	9-2-8 (385)	24.00	72.00	264.00	0.00	0.00	144.00	336.00	0.00	0.00	816.00
1	WEST CONTROL	9-2-8 (385)	24.00	48.00	144.00	0.00	0.00	24.00	216.00	0.00	0.00	432.00
1	WEST CONTROL	9-2-8 (385)	0.00	72.00	120.00	0.00	0.00	48.00	288.00	0.00	0.00	528.00
1	WEST CONTROL	9-2-8 (385)	0.00	96.00	144.00	0.00	0.00	24.00	336.00	0.00	0.00	600.00
1	WEST CONTROL	9-2-8 (385)	0.00	0.00	0.00	0.00	24.00	72.00	240.00	0.00	24.00	360.00
1	WEST CONTROL	9-2-8 (385)	0.00	0.00	0.00	0.00	0.00	72.00	168.00	0.00	0.00	240.00
1	WEST CONTROL	9-2-8 (385)	24.00	0.00	0.00	0.00	24.00	48.00	72.00	0.00	72.00	216.00
1	WEST CONTROL	9-2-8 (385)	0.00	0.00	120.00	0.00	48.00	48.00	336.00	0.00	0.00	552.00
1	WEST CONTROL	9-2-8 (385)	48.00	24.00	120.00	0.00	0.00	96.00	216.00	0.00	0.00	456.00
1	WEST CONTROL	9-2-8 (385)	24.00	72.00	168.00	0.00	0.00	0.00	408.00	0.00	0.00	648.00
1	WEST CONTROL	8-2-8 (389)	432.00	48.00	0.00	0.00	0.00	48.00	0.00	0.00	96.00	168.00
1	WEST CONTROL	8-2-8 (389)	504.00	48.00	384.00	0.00	48.00	0.00	24.00	0.00	96.00	600.00
1	WEST CONTROL	8-2-8 (389)	168.00	0.00	480.00	0.00	48.00	48.00	0.00	0.00	24.00	600.00
1	WEST CONTROL	8-2-8 (389)	240.00	48.00	768.00	0.00	24.00	0.00	48.00	0.00	96.00	984.00
1	WEST CONTROL	8-2-8 (389)	120.00	24.00	48.00	0.00	48.00	0.00	24.00	0.00	72.00	216.00
1	WEST CONTROL	8-2-8 (389)	408.00	48.00	672.00	0.00	0.00	24.00	0.00	0.00	48.00	792.00
1	WEST CONTROL	8-2-8 (389)	0.00	48.00	264.00	0.00	0.00	0.00	24.00	0.00	72.00	408.00
1	WEST CONTROL	8-2-8 (389)	0.00	48.00	720.00	0.00	0.00	0.00	0.00	0.00	72.00	840.00
1	WEST CONTROL	8-2-8 (389)	0.00	48.00	72.00	72.00	0.00	24.00	48.00	0.00	24.00	288.00
1	WEST CONTROL	8-2-8 (389)	0.00	48.00	0.00	0.00	0.00	0.00	0.00	0.00	48.00	96.00
1	WEST CONTROL	8-2-8 (389)	0.00	72.00	0.00	0.00	0.00	24.00	0.00	0.00	72.00	168.00
1	WEST CONTROL	8-2-8 (389)	0.00	48.00	72.00	0.00	24.00	0.00	24.00	0.00	0.00	168.00
1	WEST CONTROL	8-2-8 (389)	0.00	0.00	24.00	0.00	0.00	0.00	0.00	0.00	24.00	48.00
1	WEST CONTROL	8-2-8 (389)	24.00	48.00	0.00	0.00	24.00	0.00	24.00	0.00	24.00	120.00
1	WEST CONTROL	8-2-8 (389)	0.00	72.00	48.00	0.00	0.00	0.00	0.00	0.00	24.00	144.00
1	WEST CONTROL	8-2-8 (389)	0.00	24.00	144.00	0.00	24.00	0.00	0.00	0.00	24.00	216.00
1	WEST CONTROL	8-2-8 (389)	0.00	24.00	0.00	0.00	24.00	0.00	24.00	0.00	48.00	120.00
1	WEST CONTROL	8-2-8 (389)	0.00	24.00	432.00	0.00	0.00	48.00	0.00	0.00	672.00	1176.00
1	WEST CONTROL	8-2-8 (389)	0.00	48.00	840.00	0.00	48.00	0.00	24.00	0.00	24.00	984.00
1	WEST CONTROL	8-2-8 (389)	0.00	0.00	120.00	0.00	0.00	0.00	0.00	0.00	24.00	144.00
1	WEST CONTROL	8-2-8 (389)	0.00	120.00	144.00	0.00	0.00	0.00	24.00	0.00	0.00	288.00
1	WEST CONTROL	8-2-8 (389)	0.00	0.00	48.00	0.00	48.00	24.00	24.00	0.00	0.00	144.00
1	WEST CONTROL	8-2-8 (389)	0.00	72.00	1320.00	0.00	0.00	0.00	0.00	0.00	168.00	1560.00
1	WEST CONTROL	7-2-8 (432)	0.00	1.00	0.00	2.00	2.00	0.00	1.00	0.00	79.00	83.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	240.00	48.00	0.00	0.00	48.00	0.00	120.00	456.00
1	WEST CONTROL	4-2-8 (377)	1224.00	0.00	48.00	48.00	0.00	0.00	24.00	0.00	24.00	120.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	216.00	0.00	0.00	0.00	0.00	0.00	48.00	264.00
1	WEST CONTROL	4-2-8 (377)	4224.00	24.00	576.00	72.00	0.00	0.00	48.00	0.00	648.00	864.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	168.00	0.00	0.00	0.00	48.00	0.00	24.00	240.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	144.00	0.00	0.00	0.00	0.00	0.00	48.00	192.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	168.00	24.00	0.00	0.00	0.00	0.00	72.00	264.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	96.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	264.00	72.00	0.00	0.00	0.00	0.00	24.00	360.00
1	WEST CONTROL	4-2-8 (377)	0.00	24.00	240.00	0.00	0.00	0.00	24.00	0.00	168.00	456.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	240.00	24.00	0.00	24.00	24.00	0.00	144.00	456.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	168.00	0.00	0.00	0.00	24.00	0.00	0.00	192.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	456.00	0.00	0.00	0.00	24.00	0.00	192.00	672.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	96.00	0.00	0.00	0.00	24.00	0.00	24.00	144.00
1	WEST CONTROL	4-2-8 (377)	0.00	24.00	216.00	0.00	0.00	0.00	72.00	0.00	0.00	312.00
1	WEST CONTROL	4-2-8 (377)	0.00	0.00	96.00	0.00	0.00	0.00	24.00	0.00	48.00	168.00
1	WEST CONTROL	3-2-8 (349)	3192.00	0.00	432.00	0.00	0.00	312.00	720.00	24.00	312.00	1776.00
1	WEST CONTROL	3-2-8 (349)	11784.00	0.00	960.00	0.00	0.00	552.00	504.00	0.00	960.00	2232.00
1	WEST CONTROL	3-2-8 (349)	0.00	0.00	24.00	0.00	0.00	192.00	432.00	0.00	24.00	672.00

1	WEST CONTROL	3-2-B (349)	0.00	24.00	840.00	0.00	48.00	576.00	984.00	0.00	864.00	3336.00
1	WEST CONTROL	3-2-B (349)	0.00	24.00	192.00	0.00	0.00	288.00	480.00	0.00	0.00	984.00
1	WEST CONTROL	3-2-B (349)	0.00	48.00	552.00	0.00	48.00	456.00	768.00	0.00	312.00	2184.00
1	WEST CONTROL	3-2-B (349)	0.00	0.00	168.00	0.00	24.00	432.00	672.00	0.00	72.00	1368.00
1	WEST CONTROL	3-2-B (349)	0.00	0.00	72.00	0.00	48.00	192.00	408.00	0.00	48.00	768.00
1	WEST CONTROL	3-2-B (349)	0.00	0.00	120.00	0.00	0.00	288.00	312.00	0.00	0.00	720.00
1	WEST CONTROL	3-2-B (349)	0.00	0.00	240.00	0.00	0.00	360.00	624.00	24.00	0.00	1248.00
1	WEST CONTROL	3-2-B (349)	0.00	0.00	120.00	0.00	0.00	288.00	312.00	0.00	0.00	720.00
1	WEST CONTROL	3-2-B (349)	0.00	0.00	792.00	0.00	72.00	336.00	600.00	0.00	48.00	1848.00
1	WEST CONTROL	3-2-B (349)	0.00	24.00	168.00	0.00	24.00	312.00	432.00	0.00	0.00	960.00
1	WEST CONTROL	1-2-B (361)	1920.00	0.00	216.00	0.00	0.00	0.00	48.00	0.00	288.00	528.00
1	WEST CONTROL	1-2-B (361)	1992.00	48.00	1896.00	0.00	0.00	0.00	24.00	0.00	264.00	2040.00
1	WEST CONTROL	1-2-B (361)	0.00	24.00	336.00	0.00	0.00	0.00	0.00	0.00	72.00	432.00
1	WEST CONTROL	1-2-B (361)	0.00	0.00	672.00	0.00	0.00	0.00	48.00	0.00	24.00	744.00
1	WEST CONTROL	1-2-B (361)	0.00	0.00	96.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00
1	WEST CONTROL	1-2-B (361)	0.00	24.00	360.00	0.00	0.00	0.00	24.00	0.00	480.00	888.00
1	WEST CONTROL	1-2-B (361)	0.00	24.00	912.00	0.00	24.00	0.00	0.00	0.00	672.00	1632.00
1	WEST CONTROL	1-2-B (361)	0.00	24.00	432.00	0.00	0.00	0.00	0.00	0.00	24.00	480.00
1	WEST CONTROL	1-2-B (361)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.00	48.00
1	WEST CONTROL	1-2-B (361)	0.00	24.00	72.00	0.00	0.00	0.00	0.00	0.00	216.00	312.00
1	WEST CONTROL	1-2-B (361)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.00	48.00
1	WEST CONTROL	1-2-B (361)	0.00	24.00	120.00	0.00	0.00	0.00	24.00	0.00	0.00	168.00
1	WEST CONTROL	1-2-B (361)	0.00	48.00	48.00	0.00	0.00	0.00	0.00	0.00	48.00	144.00
1	WEST CONTROL	1-2-B (361)	0.00	96.00	624.00	0.00	0.00	24.00	24.00	0.00	552.00	1320.00
1	WEST CONTROL	1-2-B (361)	0.00	0.00	336.00	0.00	0.00	0.00	48.00	0.00	96.00	480.00
1	WEST CONTROL	1-2-B (361)	0.00	48.00	120.00	0.00	0.00	0.00	24.00	0.00	168.00	360.00
1	WEST CONTROL	1-2-B (361)	0.00	48.00	144.00	0.00	0.00	0.00	24.00	0.00	144.00	360.00
1	WEST CONTROL	1-2-B (361)	0.00	0.00	120.00	0.00	0.00	0.00	24.00	0.00	96.00	240.00
1	WEST CONTROL	1-2-B (361)	0.00	24.00	96.00	0.00	0.00	0.00	24.00	0.00	288.00	432.00
1	WEST CONTROL	1-2-B (361)	0.00	48.00	144.00	0.00	0.00	0.00	24.00	0.00	24.00	240.00
1	WEST CONTROL	1-2-B (361)	72.00	0.00	24.00	0.00	0.00	720.00	24.00	0.00	408.00	1176.00
1	WEST CONTROL	2-2-B (355)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	2-2-B (355)	0.00	48.00	0.00	0.00	24.00	0.00	24.00	0.00	24.00	120.00
1	WEST CONTROL	2-2-B (355)	384.00	72.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	96.00
1	WEST CONTROL	2-2-B (355)	1104.00	0.00	504.00	0.00	0.00	24.00	0.00	0.00	48.00	528.00
1	WEST CONTROL	2-2-B (355)	0.00	24.00	120.00	24.00	0.00	0.00	0.00	0.00	0.00	168.00
1	WEST CONTROL	2-2-B (355)	0.00	72.00	0.00	24.00	144.00	0.00	48.00	0.00	24.00	312.00
1	WEST CONTROL	2-2-B (355)	0.00	0.00	48.00	0.00	0.00	0.00	0.00	0.00	168.00	216.00
1	WEST CONTROL	2-2-B (355)	0.00	288.00	0.00	0.00	0.00	0.00	0.00	0.00	72.00	360.00
1	WEST CONTROL	2-2-B (355)	0.00	24.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	48.00
1	WEST CONTROL	2-2-B (355)	0.00	0.00	48.00	0.00	48.00	0.00	48.00	0.00	0.00	144.00
1	WEST CONTROL	2-2-B (355)	0.00	0.00	216.00	0.00	24.00	0.00	0.00	0.00	96.00	336.00
1	WEST CONTROL	2-2-B (355)	24.00	0.00	96.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00
1	WEST CONTROL	2-2-B (355)	0.00	48.00	72.00	0.00	48.00	0.00	48.00	0.00	0.00	216.00
1	WEST CONTROL	2-2-B (355)	0.00	24.00	264.00	0.00	0.00	0.00	24.00	0.00	0.00	312.00
1	WEST CONTROL	2-2-B (355)	0.00	0.00	0.00	24.00	0.00	0.00	0.00	0.00	0.00	24.00
1	WEST CONTROL	2-2-B (355)	0.00	48.00	432.00	0.00	24.00	0.00	0.00	0.00	168.00	672.00
1	WEST CONTROL	2-2-B (355)	0.00	72.00	528.00	0.00	0.00	0.00	24.00	0.00	24.00	648.00
1	WEST CONTROL	2-2-B (355)	0.00	96.00	864.00	24.00	24.00	0.00	24.00	0.00	72.00	1104.00
1	WEST CONTROL	2-2-B (355)	0.00	192.00	1776.00	0.00	48.00	24.00	24.00	0.00	48.00	2112.00
1	WEST CONTROL	1-2-B (365)	168.00	48.00	144.00	0.00	0.00	0.00	0.00	0.00	0.00	192.00
1	WEST CONTROL	1-2-B (365)	0.00	216.00	48.00	0.00	24.00	0.00	48.00	0.00	0.00	336.00
1	WEST CONTROL	1-2-B (365)	0.00	0.00	144.00	0.00	0.00	0.00	24.00	0.00	0.00	168.00
1	WEST CONTROL	1-2-B (365)	0.00	48.00	240.00	0.00	48.00	24.00	24.00	0.00	72.00	456.00
1	WEST CONTROL	1-2-B (365)	0.00	0.00	48.00	0.00	24.00	0.00	0.00	0.00	0.00	72.00
1	WEST CONTROL	1-2-B (365)	0.00	216.00	0.00	0.00	48.00	0.00	0.00	0.00	24.00	288.00
1	WEST CONTROL	1-2-B (365)	0.00	24.00	168.00	0.00	48.00	0.00	0.00	0.00	0.00	240.00
1	WEST CONTROL	1-2-B (365)	0.00	168.00	288.00	0.00	72.00	24.00	24.00	0.00	72.00	648.00
	WEST CONTROL	1-2-B (365)	0.00	24.00	96.00	0.00	0.00	0.00	24.00	0.00	0.00	[illegible] 00

-	WEST CONTROL	1-2-B (365)	0.00	0.00	48.00	0.00	72.00	0.00	0.00	0.00	0.00	120.00
1	WEST CONTROL	1-2-B (365)	0.00	144.00	168.00	0.00	96.00	0.00	0.00	0.00	0.00	408.00
1	WEST CONTROL	2-2-B (357)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	2-2-B (357)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	2-2-B (357)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	2-2-B (357)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	1-2-B (363)	0.00	144.00	72.00	0.00	0.00	0.00	72.00	0.00	360.00	624.00
1	WEST CONTROL	1-2-B (363)	384.00	0.00	312.00	0.00	0.00	0.00	48.00	0.00	168.00	456.00
1	WEST CONTROL	1-2-B (363)	0.00	0.00	0.00	0.00	0.00	0.00	144.00	0.00	288.00	432.00
1	WEST CONTROL	1-2-B (363)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	24.00
1	WEST CONTROL	4-2-B (373)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL	4-2-B (373)	0.00	24.00	0.00	0.00	0.00	0.00	24.00	0.00	0.00	48.00
1	WEST CONTROL	4-2-B (373)	48.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	WEST CONTROL		0.00	24.00	96.00	0.00	0.00	0.00	0.00	0.00	24.00	144.00
1	WEST CONTROL		24.00	72.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	72.00
1	WEST CONTROL		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.00	48.00
1	WEST CONTROL		0.00	0.00	72.00	0.00	24.00	0.00	24.00	0.00	0.00	120.00
1	WEST CONTROL		0.00	48.00	312.00	0.00	0.00	0.00	24.00	0.00	24.00	408.00
1	WEST CONTROL		0.00	72.00	96.00	24.00	0.00	0.00	0.00	0.00	48.00	240.00
1	WEST CONTROL		2232.00	960.00	936.00	0.00	168.00	0.00	648.00	0.00	0.00	2712.00
1	WEST CONTROL		0.00	120.00	3024.00	0.00	192.00	0.00	792.00	24.00	24.00	4176.00
1	WEST CONTROL		0.00	168.00	2376.00	0.00	72.00	48.00	672.00	0.00	24.00	3360.00
1	WEST CONTROL		5784.00	144.00	3936.00	0.00	288.00	24.00	1128.00	0.00	240.00	5592.00
2	AFFECTED AREA	M-2 (677)	0.00	1536.00	3648.00	0.00	0.00	480.00	96.00	192.00	1344.00	6432.00
2	AFFECTED AREA	M-2 (677)	0.00	768.00	1056.00	0.00	96.00	864.00	384.00	0.00	1728.00	3360.00
2	AFFECTED AREA	M-2 (677)	0.00	1824.00	5376.00	0.00	96.00	864.00	192.00	0.00	960.00	8544.00
2	AFFECTED AREA	M-2 (677)	0.00	864.00	2112.00	0.00	96.00	576.00	192.00	0.00	192.00	3936.00
2	AFFECTED AREA	M-2 (677)	0.00	960.00	1536.00	0.00	0.00	672.00	1152.00	96.00	1248.00	4512.00
2	AFFECTED AREA	M-2 (677)	3264.00	480.00	480.00	0.00	0.00	384.00	288.00	96.00	384.00	2112.00
2	AFFECTED AREA	M-2 (677)	0.00	672.00	1824.00	0.00	96.00	192.00	0.00	0.00	288.00	2976.00
2	AFFECTED AREA	M-2 (677)	0.00	768.00	1824.00	0.00	0.00	960.00	96.00	96.00	192.00	3936.00
2	AFFECTED AREA	M-2 (677)	0.00	960.00	1248.00	0.00	0.00	864.00	576.00	0.00	384.00	4032.00
2	AFFECTED AREA	M-2 (677)	0.00	2208.00	7104.00	96.00	0.00	768.00	768.00	96.00	1920.00	11808.00
2	AFFECTED AREA	M-2 (677)	0.00	96.00	0.00	0.00	0.00	480.00	288.00	0.00	192.00	1056.00
2	AFFECTED AREA	M-2 (677)	0.00	2976.00	5952.00	0.00	0.00	576.00	768.00	96.00	1248.00	10656.00
2	AFFECTED AREA	M-2 (677)	4128.00	576.00	1440.00	0.00	0.00	384.00	96.00	0.00	96.00	2592.00
2	AFFECTED AREA	M-2 (677)	0.00	2016.00	6432.00	0.00	0.00	1056.00	1920.00	192.00	3168.00	11808.00
2	AFFECTED AREA	M-2 (677)	0.00	384.00	576.00	0.00	96.00	768.00	672.00	0.00	288.00	2784.00
2	AFFECTED AREA	M-2 (677)	0.00	960.00	1632.00	0.00	0.00	480.00	192.00	96.00	192.00	3552.00
2	AFFECTED AREA	M-2 (677)	0.00	960.00	0.00	0.00	480.00	1152.00	384.00	0.00	672.00	2784.00
2	AFFECTED AREA	M-2 (677)	0.00	96.00	192.00	0.00	0.00	384.00	192.00	96.00	0.00	960.00
2	AFFECTED AREA	M-2 (677)	0.00	96.00	192.00	0.00	0.00	192.00	192.00	192.00	576.00	960.00
2	AFFECTED AREA	M-6 (681)	192.00	96.00	0.00	0.00	0.00	1728.00	0.00	0.00	96.00	1920.00
2	AFFECTED AREA	M-6 (681)	0.00	192.00	0.00	0.00	288.00	2880.00	96.00	0.00	0.00	3456.00
2	AFFECTED AREA	M-6 (681)	768.00	96.00	0.00	0.00	0.00	2400.00	288.00	0.00	0.00	2784.00
2	AFFECTED AREA	M-6 (681)	0.00	0.00	0.00	0.00	0.00	11712.00	96.00	0.00	192.00	12000.00
2	AFFECTED AREA	M-6 (681)	0.00	0.00	0.00	0.00	96.00	1440.00	192.00	0.00	0.00	1728.00
2	AFFECTED AREA	M-6 (681)	0.00	0.00	96.00	0.00	0.00	2880.00	192.00	0.00	96.00	3264.00
2	AFFECTED AREA	M-6 (681)	0.00	0.00	96.00	0.00	0.00	2688.00	288.00	0.00	0.00	3072.00
2	AFFECTED AREA	M-6 (681)	0.00	0.00	0.00	0.00	0.00	1824.00	96.00	0.00	0.00	1920.00
2	AFFECTED AREA	M-6 (681)	0.00	192.00	384.00	0.00	0.00	1920.00	384.00	96.00	96.00	3072.00
2	AFFECTED AREA	M-6 (681)	0.00	0.00	0.00	0.00	0.00	1536.00	0.00	0.00	0.00	1536.00
2	AFFECTED AREA	M-6 (681)	0.00	192.00	192.00	0.00	96.00	2592.00	0.00	0.00	0.00	3072.00
2	AFFECTED AREA	M-6 (681)	0.00	0.00	96.00	0.00	96.00	1728.00	96.00	96.00	96.00	2208.00
2	AFFECTED AREA	M-6 (681)	0.00	96.00	96.00	0.00	96.00	2496.00	0.00	96.00	0.00	2880.00
2	AFFECTED AREA	M-6 (681)	0.00	0.00	96.00	0.00	0.00	1344.00	96.00	96.00	0.00	1632.00
2	AFFECTED AREA	M-6 (681)	0.00	0.00	96.00	0.00	0.00	2784.00	288.00	0.00	0.00	3168.00
2	AFFECTED AREA	M-6 (681)	0.00	192.00	0.00	0.00	96.00	2688.00	288.00	0.00	0.00	3264.00
2	AFFECTED AREA	M-6 (681)	0.00	96.00	192.00	0.00	0.00	2880.00	0.00	0.00	0.00	3168.00

2	AFFECTED AREA	M-8 (683)	0.00	288.00	0.00	0.00	96.00	7008.00	768.00	0.00	0.00	8160.00
2	AFFECTED AREA	M-8 (683)	0.00	192.00	96.00	0.00	192.00	7776.00	672.00	0.00	0.00	8928.00
2	AFFECTED AREA	M-8 (683)	0.00	288.00	0.00	0.00	192.00	15840.00	960.00	0.00	96.00	17376.00
2	AFFECTED AREA	M-8 (683)	0.00	288.00	0.00	0.00	192.00	8064.00	1056.00	0.00	0.00	9600.00
2	AFFECTED AREA	M-8 (683)	0.00	0.00	0.00	0.00	96.00	4800.00	864.00	0.00	96.00	5856.00
2	AFFECTED AREA	M-8 (683)	0.00	192.00	96.00	0.00	192.00	5472.00	960.00	0.00	0.00	6912.00
2	AFFECTED AREA	M-8 (683)	0.00	480.00	0.00	0.00	192.00	4320.00	384.00	0.00	0.00	5376.00
2	AFFECTED AREA	M-8 (683)	0.00	0.00	96.00	0.00	0.00	5568.00	960.00	0.00	96.00	6720.00
2	AFFECTED AREA	M-8 (683)	0.00	864.00	0.00	0.00	0.00	11520.00	1920.00	0.00	96.00	14400.00
2	AFFECTED AREA	M-8 (683)	4992.00	480.00	0.00	0.00	192.00	7200.00	1440.00	0.00	192.00	9408.00
2	AFFECTED AREA	M-8 (683)	0.00	96.00	0.00	0.00	288.00	9888.00	1344.00	96.00	0.00	11712.00
2	AFFECTED AREA	M-8 (683)	0.00	192.00	192.00	0.00	768.00	3840.00	96.00	192.00	288.00	5280.00
2	AFFECTED AREA	M-8 (683)	0.00	96.00	96.00	0.00	192.00	11232.00	1728.00	0.00	864.00	13536.00
2	AFFECTED AREA	M-8 (683)	0.00	0.00	192.00	0.00	96.00	8352.00	384.00	96.00	96.00	9216.00
2	AFFECTED AREA	M-8 (683)	0.00	192.00	0.00	0.00	96.00	7776.00	672.00	0.00	0.00	8736.00
2	AFFECTED AREA	M-8 (683)	0.00	384.00	864.00	0.00	384.00	8640.00	1152.00	0.00	2112.00	11616.00
2	AFFECTED AREA	M-8 (683)	0.00	96.00	0.00	0.00	192.00	8352.00	576.00	0.00	0.00	9216.00
2	AFFECTED AREA	M-8 (683)	0.00	0.00	0.00	0.00	192.00	7392.00	1248.00	96.00	96.00	9024.00
2	AFFECTED AREA	M-8 (683)	0.00	96.00	0.00	0.00	0.00	3840.00	768.00	0.00	0.00	4704.00
2	AFFECTED AREA	M-8 (683)	0.00	0.00	0.00	0.00	96.00	5760.00	576.00	0.00	0.00	6432.00
2	AFFECTED AREA	M-8 (683)	0.00	96.00	0.00	0.00	96.00	5568.00	480.00	0.00	96.00	6336.00
2	AFFECTED AREA	M-8 (683)	3648.00	384.00	192.00	0.00	384.00	8352.00	192.00	192.00	96.00	9792.00
2	AFFECTED AREA	M-8 (683)	0.00	384.00	0.00	0.00	576.00	6816.00	768.00	0.00	96.00	8640.00
2	AFFECTED AREA	M-8 (683)	0.00	96.00	0.00	0.00	576.00	12288.00	576.00	96.00	192.00	13824.00
2	AFFECTED AREA	M-16 (763)	3840.00	288.00	192.00	0.00	480.00	1728.00	1632.00	480.00	1728.00	6336.00
2	AFFECTED AREA	M-16 (763)	0.00	0.00	0.00	0.00	384.00	3648.00	2784.00	576.00	1152.00	8160.00
2	AFFECTED AREA	M-16 (763)	0.00	96.00	0.00	0.00	0.00	2688.00	1728.00	288.00	0.00	4800.00
2	AFFECTED AREA	M-16 (763)	0.00	0.00	0.00	0.00	0.00	1344.00	1440.00	0.00	0.00	2784.00
2	AFFECTED AREA	M-16 (763)	1920.00	0.00	0.00	0.00	0.00	288.00	480.00	96.00	192.00	1056.00
2	AFFECTED AREA	M-16 (763)	9216.00	0.00	0.00	0.00	96.00	1632.00	192.00	384.00	576.00	2880.00
2	AFFECTED AREA	M-16 (763)	0.00	384.00	0.00	0.00	96.00	960.00	1152.00	384.00	288.00	3264.00
2	AFFECTED AREA	M-16 (763)	0.00	192.00	0.00	0.00	96.00	384.00	480.00	96.00	96.00	1344.00
2	AFFECTED AREA	M-16 (763)	0.00	0.00	0.00	0.00	96.00	768.00	1248.00	480.00	288.00	2880.00
2	AFFECTED AREA	M-16 (763)	0.00	0.00	0.00	0.00	0.00	480.00	768.00	0.00	96.00	1344.00
2	AFFECTED AREA	M-16 (763)	0.00	0.00	192.00	0.00	0.00	1056.00	480.00	0.00	576.00	1920.00
2	AFFECTED AREA	M-16 (763)	0.00	0.00	0.00	0.00	0.00	192.00	288.00	0.00	0.00	480.00
2	AFFECTED AREA	M-16 (763)	0.00	96.00	0.00	0.00	0.00	1248.00	1056.00	96.00	192.00	2688.00
2	AFFECTED AREA	M-16 (763)	0.00	0.00	0.00	0.00	0.00	576.00	768.00	96.00	0.00	1440.00
2	AFFECTED AREA	M-16 (763)	0.00	480.00	0.00	0.00	96.00	1824.00	864.00	288.00	0.00	3552.00
2	AFFECTED AREA	M-38 (789)	0.00	0.00	384.00	0.00	192.00	3360.00	1536.00	192.00	768.00	5952.00
2	AFFECTED AREA	M-38 (789)	0.00	0.00	288.00	0.00	96.00	2400.00	0.00	192.00	1344.00	2976.00
2	AFFECTED AREA	M-38 (789)	1824.00	384.00	0.00	0.00	192.00	3840.00	3456.00	288.00	288.00	8448.00
2	AFFECTED AREA	M-38 (789)	0.00	480.00	384.00	0.00	96.00	4128.00	3072.00	192.00	2592.00	8448.00
2	AFFECTED AREA	M-38 (789)	0.00	192.00	0.00	0.00	0.00	1920.00	2304.00	192.00	1728.00	4608.00
2	AFFECTED AREA	M-38 (789)	0.00	288.00	0.00	0.00	0.00	2976.00	5472.00	192.00	768.00	9600.00
2	AFFECTED AREA	M-38 (789)	0.00	192.00	96.00	0.00	0.00	1536.00	1536.00	0.00	0.00	3360.00
2	AFFECTED AREA	M-38 (789)	1728.00	96.00	0.00	0.00	384.00	3168.00	2784.00	288.00	96.00	6816.00
2	AFFECTED AREA	M-38 (789)	0.00	192.00	96.00	0.00	0.00	3648.00	2688.00	96.00	96.00	6816.00
2	AFFECTED AREA	M-38 (789)	0.00	192.00	96.00	0.00	96.00	4608.00	3456.00	96.00	384.00	8832.00
2	AFFECTED AREA	M-38 (789)	0.00	0.00	0.00	0.00	0.00	2688.00	1248.00	96.00	96.00	4128.00
2	AFFECTED AREA	M-38 (789)	0.00	288.00	0.00	0.00	192.00	2496.00	2304.00	384.00	192.00	5856.00
2	AFFECTED AREA	M-38 (789)	0.00	0.00	0.00	0.00	0.00	2400.00	3072.00	96.00	384.00	5952.00
2	AFFECTED AREA	M-68 (841)	0.00	192.00	0.00	0.00	96.00	5376.00	1920.00	384.00	0.00	7968.00
2	AFFECTED AREA	M-68 (841)	0.00	96.00	0.00	0.00	96.00	3648.00	960.00	480.00	0.00	5280.00
2	AFFECTED AREA	M-68 (841)	0.00	0.00	0.00	0.00	192.00	3936.00	1728.00	576.00	288.00	6720.00
2	AFFECTED AREA	M-68 (841)	1920.00	96.00	0.00	0.00	96.00	6240.00	1440.00	1632.00	480.00	9888.00
2	AFFECTED AREA	M-68 (841)	8352.00	0.00	0.00	0.00	96.00	5472.00	1152.00	480.00	576.00	7392.00
2	AFFECTED AREA	M-68 (841)	0.00	0.00	0.00	0.00	0.00	3360.00	1440.00	288.00	0.00	5088.00
2	AFFECTED AREA	M-68 (841)	0.00	96.00	0.00	0.00	0.00	4800.00	0.00	288.00	0.00	84.00

2	AFFECTED AREA	M-68 (841)	0.00	480.00	0.00	0.00	96.00	6144.00	1440.00	768.00	192.00	9120.00
2	AFFECTED AREA	M-68 (841)	0.00	96.00	0.00	0.00	192.00	2496.00	1344.00	480.00	96.00	4704.00
2	AFFECTED AREA	M-68 (841)	0.00	0.00	0.00	0.00	192.00	3360.00	960.00	384.00	672.00	5568.00
2	AFFECTED AREA	M-68 (841)	0.00	0.00	0.00	0.00	192.00	5280.00	2496.00	576.00	672.00	8832.00
2	AFFECTED AREA	M-34 (782)	0.00	1632.00	2304.00	0.00	192.00	11712.00	6624.00	0.00	0.00	22464.00
2	AFFECTED AREA	M-34 (782)	0.00	1248.00	4512.00	0.00	192.00	16800.00	8640.00	384.00	1056.00	32832.00
2	AFFECTED AREA	M-34 (782)	23232.00	480.00	2592.00	0.00	384.00	9600.00	5856.00	0.00	480.00	18912.00
2	AFFECTED AREA	M-34 (782)	16704.00	1536.00	0.00	0.00	0.00	11136.00	5184.00	192.00	0.00	18048.00
2	EAST CONTROL	EC-24 (816)	3648.00	0.00	96.00	0.00	0.00	6144.00	576.00	192.00	672.00	7008.00
2	EAST CONTROL	EC-24 (816)	0.00	0.00	0.00	0.00	96.00	5568.00	864.00	0.00	0.00	6528.00
2	EAST CONTROL	EC-24 (816)	768.00	96.00	192.00	0.00	0.00	7200.00	1248.00	0.00	0.00	8736.00
2	EAST CONTROL	EC-24 (816)	0.00	0.00	0.00	0.00	0.00	5472.00	480.00	0.00	0.00	5952.00
2	EAST CONTROL	EC-2 (888)	0.00	0.00	0.00	0.00	768.00	6144.00	3456.00	192.00	192.00	10752.00
2	EAST CONTROL	EC-2 (888)	3168.00	96.00	0.00	96.00	96.00	2304.00	1248.00	0.00	1248.00	4512.00
2	EAST CONTROL	EC-2 (888)	0.00	0.00	0.00	0.00	192.00	5280.00	96.00	0.00	288.00	5856.00
2	EAST CONTROL	EC-2 (888)	7200.00	0.00	0.00	0.00	192.00	3936.00	1824.00	0.00	480.00	5952.00
2	EAST CONTROL	EC-2 (888)	8352.00	0.00	96.00	0.00	288.00	5376.00	1536.00	192.00	480.00	7488.00
2	EAST CONTROL	EC-2 (888)	0.00	0.00	0.00	0.00	288.00	3744.00	3072.00	0.00	0.00	7104.00
2	EAST CONTROL	EC-2 (888)	0.00	384.00	192.00	96.00	864.00	8832.00	3840.00	96.00	4416.00	14688.00
2	EAST CONTROL	EC-2 (888)	5952.00	0.00	0.00	0.00	384.00	4608.00	2112.00	0.00	96.00	7200.00
2	EAST CONTROL	EC-2 (888)	0.00	0.00	0.00	0.00	384.00	5952.00	2112.00	0.00	0.00	8448.00
2	EAST CONTROL	EC-2 (888)	0.00	288.00	768.00	0.00	384.00	2592.00	1728.00	0.00	192.00	5856.00
2	EAST CONTROL	EC-2 (888)	0.00	96.00	0.00	0.00	1536.00	9312.00	3552.00	96.00	2976.00	14688.00
2	EAST CONTROL	EC-2 (888)	0.00	0.00	0.00	0.00	672.00	4608.00	3840.00	96.00	192.00	9312.00
2	EAST CONTROL	EC-8 (894)	0.00	0.00	0.00	0.00	96.00	1632.00	4416.00	0.00	3648.00	7008.00
2	EAST CONTROL	EC-8 (894)	0.00	384.00	384.00	0.00	384.00	2400.00	6720.00	0.00	1824.00	10464.00
2	EAST CONTROL	EC-8 (894)	22080.00	672.00	5376.00	96.00	384.00	2304.00	4896.00	96.00	1056.00	14880.00
2	EAST CONTROL	EC-8 (894)	0.00	96.00	192.00	0.00	384.00	2016.00	6336.00	96.00	4320.00	11040.00
2	EAST CONTROL	EC-8 (894)	4800.00	0.00	0.00	0.00	96.00	1536.00	2304.00	0.00	2304.00	4512.00
2	EAST CONTROL	EC-8 (894)	0.00	96.00	672.00	96.00	384.00	3168.00	5856.00	96.00	864.00	10752.00
2	EAST CONTROL	EC-8 (894)	0.00	0.00	0.00	0.00	480.00	3168.00	7584.00	288.00	2112.00	11904.00
2	EAST CONTROL	EC-8 (894)	0.00	192.00	192.00	0.00	192.00	2112.00	3648.00	0.00	672.00	6528.00
2	EAST CONTROL	EC-8 (894)	0.00	0.00	0.00	96.00	192.00	2688.00	4800.00	192.00	8544.00	9024.00
2	EAST CONTROL	EC-8 (894)	0.00	288.00	192.00	0.00	192.00	3072.00	8352.00	0.00	864.00	12960.00
2	EAST CONTROL	EC-8 (894)	0.00	0.00	288.00	0.00	192.00	2400.00	6336.00	0.00	1632.00	10848.00
2	EAST CONTROL	EC-32 (902)	0.00	96.00	192.00	0.00	0.00	10752.00	4512.00	0.00	1728.00	15648.00
2	EAST CONTROL	EC-32 (902)	27360.00	480.00	1248.00	0.00	0.00	15264.00	5856.00	96.00	960.00	23136.00
2	EAST CONTROL	EC-32 (902)	0.00	0.00	0.00	0.00	0.00	9312.00	4128.00	0.00	192.00	13440.00
2	EAST CONTROL	EC-32 (902)	0.00	0.00	0.00	0.00	0.00	8928.00	5376.00	0.00	384.00	14496.00
2	EAST CONTROL	EC-32 (902)	0.00	96.00	192.00	0.00	0.00	11040.00	4992.00	0.00	480.00	16512.00
2	EAST CONTROL	EC-32 (902)	0.00	288.00	384.00	0.00	0.00	15648.00	7968.00	0.00	1920.00	24576.00
2	EAST CONTROL	EC-32 (902)	0.00	96.00	0.00	0.00	0.00	8928.00	4608.00	0.00	2496.00	14304.00
2	EAST CONTROL	EC-32 (902)	4608.00	288.00	672.00	96.00	0.00	15552.00	5568.00	96.00	1152.00	22656.00
2	WEST CONTROL	WC-16 (819)	480.00	96.00	0.00	0.00	96.00	0.00	768.00	0.00	288.00	1056.00
2	WEST CONTROL	WC-16 (819)	0.00	288.00	288.00	0.00	0.00	288.00	864.00	96.00	192.00	2016.00
2	WEST CONTROL	WC-16 (819)	1632.00	480.00	384.00	0.00	0.00	480.00	288.00	96.00	96.00	1824.00
2	WEST CONTROL	WC-16 (819)	0.00	0.00	0.00	0.00	0.00	96.00	480.00	0.00	0.00	576.00
2	WEST CONTROL	WC-16 (819)	0.00	288.00	192.00	0.00	0.00	480.00	384.00	96.00	96.00	1536.00
2	WEST CONTROL	WC-16 (819)	0.00	96.00	1632.00	0.00	0.00	96.00	480.00	96.00	0.00	2400.00
2	WEST CONTROL	WC-16 (819)	0.00	96.00	576.00	0.00	0.00	288.00	384.00	96.00	0.00	1440.00
2	WEST CONTROL	WC-2 (849)	0.00	0.00	288.00	0.00	0.00	3456.00	6432.00	288.00	480.00	10944.00
2	WEST CONTROL	WC-2 (849)	0.00	96.00	0.00	0.00	0.00	576.00	2784.00	96.00	96.00	3648.00
2	WEST CONTROL	WC-2 (849)	0.00	0.00	0.00	0.00	0.00	1344.00	2304.00	0.00	96.00	3744.00
2	WEST CONTROL	WC-2 (849)	0.00	96.00	96.00	0.00	0.00	2208.00	1440.00	0.00	0.00	3840.00
2	WEST CONTROL	WC-2 (849)	0.00	96.00	192.00	0.00	0.00	1728.00	2880.00	0.00	96.00	4992.00
2	WEST CONTROL	WC-2 (849)	0.00	0.00	0.00	0.00	96.00	1152.00	3840.00	96.00	96.00	5280.00
2	WEST CONTROL	WC-2 (849)	0.00	0.00	192.00	0.00	0.00	2208.00	2880.00	96.00	192.00	5568.00
2	WEST CONTROL	WC-2 (849)	0.00	192.00	288.00	0.00	0.00	960.00	1536.00	0.00	0.00	2976.00
2	WEST CONTROL	WC-2 (849)	0.00	96.00	0.00	0.00	0.00	2976.00	6336.00	0.00	0.00	9408.00

2	WEST CONTROL	WC-2 (849)	0.00	96.00	96.00	0.00	0.00	1920.00	4320.00	192.00	96.00	6720.00
2	WEST CONTROL	WC-2 (849)	0.00	0.00	0.00	0.00	0.00	1344.00	2880.00	0.00	96.00	4320.00
2	WEST CONTROL	WC-2 (849)	1440.00	96.00	192.00	0.00	0.00	3264.00	5472.00	192.00	0.00	9216.00
2	WEST CONTROL	WC-2 (849)	0.00	0.00	0.00	0.00	0.00	3840.00	5856.00	96.00	1344.00	9792.00
2	WEST CONTROL	WC-2 (849)	0.00	96.00	960.00	0.00	0.00	1920.00	3360.00	0.00	480.00	6336.00
2	WEST CONTROL	WC-4 (851)	0.00	192.00	1440.00	0.00	0.00	288.00	0.00	0.00	96.00	2016.00
2	WEST CONTROL	WC-4 (851)	1248.00	0.00	192.00	0.00	96.00	96.00	576.00	0.00	0.00	960.00
2	WEST CONTROL	WC-4 (851)	0.00	0.00	864.00	0.00	96.00	672.00	864.00	0.00	96.00	2592.00
2	WEST CONTROL	WC-4 (851)	0.00	0.00	576.00	0.00	96.00	0.00	960.00	0.00	288.00	1632.00
2	WEST CONTROL	WC-4 (851)	1152.00	0.00	96.00	0.00	96.00	288.00	960.00	0.00	0.00	1440.00
2	WEST CONTROL	WC-4 (851)	0.00	96.00	576.00	0.00	0.00	288.00	480.00	0.00	96.00	1536.00
2	WEST CONTROL	WC-4 (851)	0.00	480.00	0.00	0.00	0.00	480.00	672.00	0.00	0.00	1632.00
2	WEST CONTROL	WC-10 (857)	0.00	96.00	0.00	0.00	0.00	96.00	0.00	96.00	192.00	384.00
2	WEST CONTROL	WC-10 (857)	0.00	96.00	0.00	0.00	0.00	96.00	0.00	384.00	96.00	672.00
2	WEST CONTROL	WC-10 (857)	96.00	0.00	192.00	96.00	96.00	192.00	192.00	0.00	96.00	768.00
2	WEST CONTROL	WC-10 (857)	576.00	0.00	96.00	0.00	0.00	384.00	96.00	96.00	288.00	864.00
2	WEST CONTROL	WC-12 (859)	2784.00	288.00	864.00	0.00	96.00	864.00	192.00	0.00	192.00	2496.00
2	WEST CONTROL	WC-12 (859)	0.00	192.00	960.00	0.00	384.00	1248.00	384.00	0.00	0.00	3168.00
2	WEST CONTROL	WC-12 (859)	0.00	0.00	864.00	0.00	0.00	480.00	576.00	0.00	0.00	1920.00
2	WEST CONTROL	WC-12 (859)	0.00	288.00	576.00	0.00	192.00	1344.00	480.00	0.00	288.00	3072.00
2	WEST CONTROL	WC-12 (859)	0.00	0.00	384.00	0.00	96.00	576.00	192.00	0.00	96.00	1344.00
2	WEST CONTROL	WC-12 (859)	864.00	192.00	1152.00	0.00	0.00	1632.00	576.00	96.00	0.00	3648.00
2	WEST CONTROL	WC-12 (859)	0.00	0.00	0.00	0.00	0.00	480.00	288.00	0.00	0.00	768.00
2	WEST CONTROL	WC-12 (859)	0.00	1056.00	0.00	0.00	0.00	864.00	768.00	0.00	0.00	2688.00
2	WEST CONTROL	WC-12 (859)	0.00	0.00	576.00	0.00	192.00	1536.00	960.00	96.00	384.00	3744.00
2	WEST CONTROL	WC-14 (817)	7776.00	1536.00	2400.00	192.00	0.00	4224.00	4992.00	96.00	3936.00	13536.00
2	WEST CONTROL	WC-14 (817)	0.00	288.00	0.00	0.00	96.00	1824.00	3552.00	0.00	96.00	5856.00
2	WEST CONTROL	WC-14 (817)	12864.00	1152.00	3840.00	0.00	96.00	3168.00	4224.00	192.00	7584.00	13056.00
2	WEST CONTROL	WC-14 (817)	0.00	0.00	288.00	0.00	0.00	2112.00	2304.00	0.00	0.00	4704.00
2	WEST CONTROL	WC-14 (817)	0.00	0.00	960.00	0.00	0.00	2208.00	4032.00	0.00	192.00	7200.00
2	WEST CONTROL	WC-14 (817)	0.00	576.00	288.00	0.00	0.00	3456.00	2592.00	0.00	0.00	6912.00
2	WEST CONTROL	WC-14 (817)	0.00	960.00	1152.00	0.00	0.00	3648.00	3744.00	0.00	192.00	9696.00
2	WEST CONTROL	WC-14 (817)	0.00	864.00	2976.00	0.00	0.00	3168.00	3264.00	0.00	96.00	10368.00
2	WEST CONTROL	WC-6 (883)	288.00	0.00	864.00	0.00	0.00	288.00	576.00	0.00	96.00	1824.00
2	WEST CONTROL	WC-6 (883)	0.00	0.00	384.00	0.00	0.00	96.00	672.00	0.00	0.00	1152.00
2	WEST CONTROL	WC-6 (883)	0.00	192.00	0.00	0.00	0.00	96.00	480.00	0.00	96.00	864.00
2	WEST CONTROL	WC-6 (883)	1920.00	192.00	288.00	0.00	0.00	384.00	864.00	96.00	288.00	2112.00
2	WEST CONTROL	WC-6 (883)	0.00	0.00	96.00	0.00	0.00	96.00	576.00	0.00	0.00	768.00
2	WEST CONTROL	WC-6 (883)	0.00	0.00	192.00	0.00	0.00	96.00	1056.00	0.00	96.00	1440.00
2	WEST CONTROL	WC-8 (885)	2400.00	288.00	576.00	0.00	0.00	1344.00	480.00	96.00	0.00	2784.00
2	WEST CONTROL	WC-8 (885)	480.00	0.00	0.00	0.00	96.00	864.00	288.00	192.00	288.00	1728.00
2	WEST CONTROL	WC-8 (885)	0.00	192.00	0.00	0.00	0.00	864.00	384.00	288.00	384.00	2112.00
2	WEST CONTROL	WC-8 (885)	0.00	384.00	192.00	0.00	96.00	768.00	672.00	192.00	0.00	2304.00
2	NORTH CONTROL	NC-2 (821)	0.00	0.00	0.00	0.00	96.00	0.00	0.00	0.00	96.00	192.00
2	NORTH CONTROL	NC-2 (821)	0.00	0.00	96.00	0.00	96.00	0.00	0.00	0.00	384.00	384.00
2	NORTH CONTROL	NC-2 (821)	480.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	NORTH CONTROL	NC-2 (821)	0.00	0.00	0.00	0.00	192.00	0.00	0.00	0.00	0.00	192.00
2	NORTH CONTROL	NC-2 (821)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	NORTH CONTROL	NC-2 (821)	0.00	0.00	0.00	0.00	192.00	0.00	0.00	0.00	0.00	192.00
2	NORTH CONTROL	NC-8 (827)	288.00	0.00	0.00	0.00	192.00	0.00	0.00	0.00	96.00	192.00
2	NORTH CONTROL	NC-8 (827)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	NORTH CONTROL	NC-8 (827)	768.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	NORTH CONTROL	NC-8 (827)	0.00	0.00	0.00	0.00	0.00	0.00	96.00	0.00	0.00	96.00
2	NORTH CONTROL	NC-8 (827)	0.00	0.00	0.00	0.00	288.00	0.00	288.00	0.00	0.00	576.00
2	NORTH CONTROL	NC-8 (827)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	NORTH CONTROL	NC-18 (862)	0.00	0.00	0.00	0.00	192.00	0.00	0.00	0.00	0.00	192.00
2	NORTH CONTROL	NC-18 (862)	576.00	0.00	0.00	0.00	96.00	0.00	0.00	0.00	0.00	96.00
2	NORTH CONTROL	NC-18 (862)	0.00	0.00	96.00	0.00	0.00	0.00	0.00	0.00	96.00	192.00
	NORTH CONTROL	NC-18 (862)	192.00	192.00	0.00	0.00	288.00	0.00	96.00	0.00	0.00	576.00

2	NORTH CONTROL	NC-18 (862)	0.00	0.00	0.00	0.00	576.00	0.00	96.00	0.00	0.00	672.00
2	NORTH CONTROL	NC-18 (862)	0.00	96.00	576.00	0.00	96.00	96.00	96.00	0.00	0.00	960.00
2	NORTH CONTROL	NC-37 (882)	0.00	0.00	96.00	0.00	288.00	96.00	0.00	0.00	96.00	576.00
2	NORTH CONTROL	NC-37 (882)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	NORTH CONTROL	NC-37 (882)	0.00	96.00	0.00	0.00	0.00	0.00	480.00	0.00	0.00	576.00
2	NORTH CONTROL	NC-37 (882)	0.00	96.00	192.00	0.00	0.00	0.00	288.00	0.00	384.00	768.00
2	NORTH CONTROL	NC-37 (882)	0.00	0.00	192.00	0.00	192.00	0.00	96.00	0.00	96.00	576.00
2	NORTH CONTROL	NC-37 (882)	0.00	0.00	0.00	0.00	192.00	0.00	96.00	0.00	192.00	480.00
3	AFFECTED AREA	M-4 (1125)	1344.00	192.00	288.00	0.00	0.00	96.00	96.00	0.00	3264.00	672.00
3	AFFECTED AREA	M-4 (1125)	0.00	96.00	96.00	0.00	192.00	192.00	576.00	0.00	0.00	1152.00
3	AFFECTED AREA	M-4 (1125)	0.00	0.00	288.00	0.00	96.00	192.00	288.00	0.00	0.00	864.00
3	AFFECTED AREA	M-4 (1125)	0.00	0.00	192.00	0.00	96.00	288.00	96.00	0.00	0.00	672.00
3	AFFECTED AREA	M-4 (1125)	1152.00	0.00	288.00	0.00	0.00	96.00	288.00	0.00	2304.00	672.00
3	AFFECTED AREA	M-4 (1125)	0.00	0.00	576.00	0.00	0.00	384.00	288.00	0.00	96.00	1344.00
3	AFFECTED AREA	M-4 (1125)	0.00	96.00	288.00	0.00	96.00	0.00	96.00	0.00	0.00	576.00
3	AFFECTED AREA	M-12 (1133)	0.00	192.00	0.00	0.00	96.00	480.00	864.00	96.00	0.00	1728.00
3	AFFECTED AREA	M-12 (1133)	480.00	576.00	192.00	0.00	96.00	384.00	1056.00	96.00	0.00	2400.00
3	AFFECTED AREA	M-12 (1133)	0.00	192.00	192.00	0.00	0.00	384.00	480.00	96.00	0.00	1344.00
3	AFFECTED AREA	M-12 (1133)	576.00	0.00	192.00	0.00	0.00	0.00	672.00	0.00	0.00	864.00
3	AFFECTED AREA	M-12 (1133)	0.00	192.00	192.00	0.00	0.00	192.00	480.00	0.00	0.00	1056.00
3	AFFECTED AREA	M-12 (1133)	0.00	0.00	384.00	0.00	384.00	384.00	1536.00	96.00	0.00	2784.00
3	AFFECTED AREA	M-12 (1133)	0.00	0.00	0.00	0.00	96.00	480.00	864.00	0.00	0.00	1440.00
3	AFFECTED AREA	M-12 (1133)	0.00	0.00	0.00	0.00	0.00	576.00	288.00	192.00	0.00	1056.00
3	AFFECTED AREA	M-20 (1141)	0.00	672.00	576.00	0.00	0.00	2016.00	5432.00	0.00	96.00	9792.00
3	AFFECTED AREA	M-20 (1141)	20352.00	1632.00	96.00	0.00	192.00	2112.00	4128.00	0.00	44544.00	8160.00
3	AFFECTED AREA	M-20 (1141)	0.00	288.00	288.00	0.00	0.00	1344.00	4320.00	96.00	192.00	6528.00
3	AFFECTED AREA	M-20 (1141)	33792.00	672.00	3840.00	96.00	0.00	1248.00	3168.00	0.00	49040.00	9312.00
3	AFFECTED AREA	M-20 (1141)	0.00	288.00	96.00	0.00	96.00	672.00	2880.00	0.00	0.00	4032.00
3	AFFECTED AREA	M-20 (1141)	3072.00	192.00	288.00	0.00	0.00	960.00	2112.00	0.00	27648.00	3552.00
3	AFFECTED AREA	M-20 (1141)	9216.00	288.00	192.00	0.00	96.00	1440.00	3168.00	0.00	1344.00	5280.00
3	AFFECTED AREA	M-20 (1141)	0.00	96.00	0.00	0.00	0.00	1056.00	2016.00	0.00	0.00	3168.00
3	AFFECTED AREA	M-20 (1141)	0.00	576.00	0.00	96.00	0.00	1344.00	2688.00	96.00	96.00	4896.00
3	AFFECTED AREA	M-20 (1141)	0.00	96.00	0.00	0.00	0.00	576.00	1728.00	96.00	0.00	2496.00
3	AFFECTED AREA	M-20 (1141)	0.00	0.00	0.00	0.00	0.00	1440.00	4224.00	0.00	0.00	5664.00
3	AFFECTED AREA	M-20 (1141)	0.00	0.00	0.00	0.00	0.00	960.00	4896.00	0.00	0.00	5856.00
3	AFFECTED AREA	M-22 (1159)	96.00	0.00	0.00	0.00	0.00	960.00	1344.00	0.00	192.00	2304.00
3	AFFECTED AREA	M-22 (1159)	192.00	0.00	0.00	0.00	96.00	576.00	1344.00	96.00	192.00	2112.00
3	AFFECTED AREA	M-22 (1159)	0.00	0.00	192.00	0.00	0.00	768.00	1440.00	0.00	0.00	2400.00
3	AFFECTED AREA	M-22 (1159)	0.00	192.00	96.00	0.00	0.00	480.00	768.00	0.00	0.00	1536.00
3	AFFECTED AREA	M-22 (1159)	0.00	96.00	96.00	0.00	0.00	864.00	1056.00	96.00	0.00	2208.00
3	AFFECTED AREA	M-22 (1159)	0.00	192.00	96.00	0.00	0.00	1152.00	1056.00	96.00	0.00	2592.00
3	AFFECTED AREA	M-28 (1165)	0.00	0.00	0.00	0.00	0.00	864.00	672.00	0.00	0.00	1536.00
3	AFFECTED AREA	M-28 (1165)	576.00	0.00	192.00	192.00	192.00	480.00	960.00	0.00	480.00	2016.00
3	AFFECTED AREA	M-28 (1165)	0.00	0.00	0.00	0.00	0.00	192.00	192.00	0.00	192.00	384.00
3	AFFECTED AREA	M-28 (1165)	0.00	96.00	96.00	0.00	96.00	672.00	864.00	192.00	0.00	2016.00
3	AFFECTED AREA	M-28 (1165)	0.00	96.00	0.00	0.00	96.00	960.00	1152.00	0.00	0.00	2304.00
3	AFFECTED AREA	M-28 (1165)	0.00	0.00	0.00	0.00	0.00	288.00	384.00	0.00	0.00	672.00
3	AFFECTED AREA	M-28 (1165)	0.00	0.00	96.00	96.00	0.00	288.00	1536.00	96.00	0.00	2112.00
3	AFFECTED AREA	M-28 (1165)	0.00	0.00	0.00	0.00	0.00	384.00	960.00	96.00	0.00	1440.00
3	AFFECTED AREA	M-38 (1261)	384.00	0.00	0.00	0.00	0.00	384.00	960.00	0.00	0.00	1344.00
3	AFFECTED AREA	M-38 (1261)	0.00	96.00	96.00	0.00	0.00	576.00	480.00	0.00	96.00	1344.00
3	AFFECTED AREA	M-38 (1261)	0.00	0.00	0.00	0.00	96.00	288.00	384.00	0.00	0.00	768.00
3	AFFECTED AREA	M-38 (1261)	960.00	192.00	0.00	0.00	288.00	480.00	1344.00	0.00	96.00	2400.00
3	AFFECTED AREA	M-38 (1261)	0.00	0.00	0.00	0.00	0.00	384.00	672.00	0.00	0.00	1056.00
3	AFFECTED AREA	M-38 (1261)	0.00	0.00	0.00	0.00	0.00	864.00	768.00	0.00	0.00	1632.00
3	AFFECTED AREA	M-38 (1261)	0.00	0.00	0.00	0.00	96.00	576.00	1056.00	0.00	0.00	1728.00
3	AFFECTED AREA	M-38 (1261)	0.00	0.00	0.00	0.00	0.00	384.00	576.00	96.00	0.00	1056.00
3	AFFECTED AREA	M-38 (1261)	0.00	0.00	0.00	0.00	96.00	192.00	480.00	0.00	0.00	768.00
3	AFFECTED AREA	M-38 (1261)	0.00	0.00	0.00	0.00	0.00	480.00	1248.00	0.00	0.00	1728.00

3	AFFECTED AREA	M-16 (1137)	2880.00	1248.00	1440.00	0.00	96.00	2112.00	2880.00	384.00	3456.00	8928.00
3	AFFECTED AREA	M-16 (1137)	0.00	384.00	192.00	0.00	192.00	1536.00	3072.00	96.00	288.00	5760.00
3	AFFECTED AREA	M-16 (1137)	0.00	288.00	2784.00	0.00	96.00	4224.00	5568.00	0.00	672.00	13632.00
3	AFFECTED AREA	M-16 (1137)	2592.00	192.00	768.00	0.00	0.00	2880.00	3072.00	0.00	2592.00	7488.00
3	AFFECTED AREA	M-16 (1137)	0.00	960.00	0.00	0.00	0.00	3456.00	3552.00	0.00	1056.00	9024.00
3	AFFECTED AREA	M-8 (1129)	3648.00	0.00	1632.00	0.00	96.00	1632.00	2304.00	0.00	8256.00	6240.00
3	AFFECTED AREA	M-8 (1129)	0.00	0.00	192.00	0.00	0.00	576.00	672.00	0.00	0.00	1440.00
3	AFFECTED AREA	M-8 (1129)	0.00	0.00	576.00	0.00	0.00	864.00	1824.00	0.00	0.00	3264.00
3	AFFECTED AREA	M-8 (1129)	96.00	96.00	96.00	0.00	0.00	768.00	1152.00	96.00	672.00	2208.00
3	AFFECTED AREA	M-8 (1129)	0.00	96.00	0.00	0.00	0.00	480.00	1920.00	0.00	96.00	2592.00
3	AFFECTED AREA	M-8 (1129)	0.00	0.00	0.00	0.00	0.00	768.00	768.00	0.00	0.00	1536.00
3	AFFECTED AREA	M-8 (1129)	0.00	0.00	384.00	0.00	0.00	576.00	768.00	0.00	96.00	1824.00
3	AFFECTED AREA	M-8 (1129)	0.00	0.00	96.00	0.00	0.00	672.00	1440.00	0.00	0.00	2208.00
3	AFFECTED AREA	M-8 (1129)	0.00	0.00	0.00	0.00	0.00	0.00	960.00	0.00	0.00	960.00
3	AFFECTED AREA	M-8 (1129)	0.00	0.00	672.00	0.00	0.00	1152.00	1248.00	0.00	96.00	3168.00
3	AFFECTED AREA	M-8 (1129)	0.00	0.00	576.00	0.00	0.00	1152.00	1824.00	0.00	0.00	3552.00
3	AFFECTED AREA	M-8 (1129)	0.00	0.00	0.00	0.00	0.00	864.00	1536.00	96.00	0.00	2496.00
3	AFFECTED AREA	M-32 (1169)	0.00	96.00	0.00	0.00	0.00	1344.00	2016.00	0.00	0.00	3456.00
3	AFFECTED AREA	M-32 (1169)	576.00	576.00	0.00	0.00	0.00	1344.00	1248.00	0.00	192.00	3360.00
3	AFFECTED AREA	M-32 (1169)	288.00	96.00	96.00	96.00	0.00	1440.00	1536.00	0.00	96.00	3360.00
3	AFFECTED AREA	M-32 (1169)	0.00	576.00	384.00	96.00	96.00	1824.00	2112.00	0.00	96.00	5184.00
3	AFFECTED AREA	M-40 (1263)	1248.00	0.00	96.00	0.00	0.00	1728.00	2592.00	0.00	288.00	4416.00
3	AFFECTED AREA	M-40 (1263)	480.00	0.00	0.00	0.00	0.00	2112.00	2112.00	0.00	0.00	4224.00
3	AFFECTED AREA	M-40 (1263)	0.00	0.00	96.00	0.00	0.00	1632.00	1152.00	0.00	0.00	2880.00
3	AFFECTED AREA	M-40 (1263)	0.00	0.00	192.00	0.00	96.00	1728.00	1632.00	0.00	0.00	3648.00
3	EAST CONTROL	EC-11 (1274)	960.00	0.00	480.00	0.00	0.00	1536.00	864.00	0.00	0.00	2880.00
3	EAST CONTROL	EC-11 (1274)	0.00	0.00	96.00	0.00	0.00	576.00	96.00	0.00	0.00	768.00
3	EAST CONTROL	EC-11 (1274)	0.00	0.00	192.00	0.00	0.00	1440.00	0.00	0.00	0.00	1632.00
3	EAST CONTROL	EC-11 (1274)	4800.00	96.00	1440.00	0.00	0.00	4896.00	672.00	0.00	480.00	7392.00
3	EAST CONTROL	EC-11 (1274)	0.00	0.00	384.00	0.00	0.00	3168.00	384.00	0.00	0.00	3936.00
3	EAST CONTROL	EC-11 (1274)	0.00	384.00	0.00	0.00	0.00	3072.00	192.00	0.00	0.00	3648.00
3	EAST CONTROL	EC-11 (1274)	0.00	0.00	384.00	0.00	0.00	2016.00	192.00	0.00	0.00	2592.00
3	EAST CONTROL	EC-11 (1274)	0.00	0.00	0.00	0.00	0.00	1056.00	768.00	0.00	0.00	1824.00
3	EAST CONTROL	EC-12 (1275)	0.00	0.00	96.00	0.00	0.00	384.00	0.00	0.00	96.00	576.00
3	EAST CONTROL	EC-12 (1275)	3552.00	0.00	192.00	0.00	0.00	1824.00	0.00	0.00	0.00	2016.00
3	EAST CONTROL	EC-12 (1275)	1728.00	96.00	0.00	0.00	0.00	1824.00	96.00	0.00	96.00	2112.00
3	EAST CONTROL	EC-12 (1275)	0.00	192.00	192.00	0.00	0.00	1056.00	0.00	0.00	0.00	1440.00
3	EAST CONTROL	EC-6 (1269)	1440.00	480.00	288.00	0.00	384.00	2688.00	960.00	0.00	384.00	4992.00
3	EAST CONTROL	EC-6 (1269)	0.00	0.00	288.00	0.00	96.00	2496.00	960.00	96.00	0.00	3936.00
3	EAST CONTROL	EC-6 (1269)	0.00	0.00	384.00	0.00	384.00	2112.00	1536.00	96.00	0.00	4512.00
3	EAST CONTROL	EC-6 (1269)	1344.00	288.00	480.00	0.00	96.00	3552.00	2688.00	0.00	576.00	7296.00
3	EAST CONTROL	EC-4 (1267)	23520.00	288.00	19872.00	384.00	1536.00	9024.00	5664.00	192.00	16896.00	37152.00
3	EAST CONTROL	EC-4 (1267)	13824.00	480.00	14976.00	384.00	864.00	9216.00	6144.00	192.00	4896.00	32256.00
3	EAST CONTROL	EC-4 (1267)	0.00	0.00	768.00	384.00	0.00	5856.00	2112.00	0.00	0.00	9120.00
3	EAST CONTROL	EC-4 (1267)	0.00	0.00	11712.00	288.00	384.00	11712.00	8064.00	96.00	384.00	32640.00
3	WEST CONTROL	WC-4 (1245)	480.00	0.00	0.00	0.00	384.00	864.00	960.00	192.00	96.00	2400.00
3	WEST CONTROL	WC-4 (1245)	192.00	0.00	0.00	0.00	192.00	480.00	672.00	0.00	0.00	1344.00
3	WEST CONTROL	WC-4 (1245)	0.00	96.00	0.00	0.00	288.00	672.00	576.00	0.00	0.00	1632.00
3	WEST CONTROL	WC-4 (1245)	0.00	0.00	0.00	0.00	192.00	480.00	672.00	0.00	96.00	1440.00
3	WEST CONTROL	WC-4 (1245)	0.00	0.00	0.00	0.00	768.00	480.00	1728.00	0.00	0.00	2976.00
3	WEST CONTROL	WC-4 (1245)	0.00	0.00	0.00	0.00	96.00	480.00	864.00	0.00	0.00	1440.00
3	WEST CONTROL	WC-10 (1304)	1248.00	192.00	0.00	0.00	0.00	864.00	192.00	0.00	0.00	1248.00
3	WEST CONTROL	WC-10 (1304)	480.00	0.00	192.00	0.00	0.00	288.00	480.00	96.00	96.00	1056.00
3	WEST CONTROL	WC-10 (1304)	0.00	0.00	96.00	0.00	0.00	672.00	96.00	0.00	0.00	864.00
3	WEST CONTROL	WC-10 (1304)	0.00	0.00	96.00	0.00	0.00	768.00	288.00	0.00	0.00	1152.00
3	WEST CONTROL	WC-28 (1322)	0.00	96.00	384.00	0.00	0.00	384.00	768.00	0.00	0.00	1632.00
3	WEST CONTROL	WC-28 (1322)	1632.00	0.00	480.00	0.00	0.00	96.00	672.00	0.00	1056.00	1440.00
3	WEST CONTROL	WC-28 (1322)	288.00	0.00	0.00	0.00	0.00	192.00	288.00	0.00	1056.00	480.00
3	WEST CONTROL	WC-28 (1322)	0.00	0.00	0.00	0.00	0.00	0.00	288.00	0.00	0.00	288.00

3	WEST CONTROL	WC-28 (1322)	0.00	0.00	96.00	0.00	0.00	96.00	192.00	0.00	0.00	384.00
3	WEST CONTROL	WC-28 (1322)	0.00	96.00	192.00	0.00	0.00	480.00	960.00	0.00	0.00	1728.00
3	WEST CONTROL	WC-28 (1322)	0.00	0.00	0.00	0.00	0.00	192.00	672.00	0.00	0.00	864.00
3	WEST CONTROL	WC-28 (1322)	0.00	0.00	0.00	0.00	0.00	288.00	96.00	0.00	0.00	384.00
3	WEST CONTROL	WC-28 (1322)	0.00	0.00	192.00	0.00	0.00	96.00	672.00	0.00	0.00	960.00
3	WEST CONTROL	WC-28 (1322)	0.00	0.00	288.00	0.00	0.00	288.00	96.00	0.00	0.00	672.00
3	WEST CONTROL	WC-28 (1322)	0.00	0.00	0.00	0.00	0.00	384.00	288.00	0.00	0.00	672.00
3	WEST CONTROL	WC-28 (1322)	0.00	0.00	0.00	0.00	0.00	0.00	480.00	0.00	0.00	480.00
3	WEST CONTROL	WC-28 (1322)	0.00	192.00	480.00	0.00	96.00	192.00	576.00	0.00	0.00	1536.00
3	WEST CONTROL	WC-28 (1322)	0.00	0.00	96.00	0.00	0.00	192.00	576.00	0.00	0.00	864.00
3	WEST CONTROL	WC-30 (1324)	288.00	0.00	96.00	0.00	0.00	96.00	192.00	0.00	192.00	480.00
3	WEST CONTROL	WC-30 (1324)	0.00	0.00	288.00	0.00	0.00	96.00	384.00	0.00	0.00	768.00
3	WEST CONTROL	WC-30 (1324)	0.00	96.00	480.00	0.00	0.00	0.00	0.00	0.00	0.00	576.00
3	WEST CONTROL	WC-30 (1324)	288.00	0.00	96.00	0.00	0.00	96.00	0.00	0.00	192.00	192.00
3	WEST CONTROL	WC-30 (1324)	0.00	96.00	192.00	0.00	0.00	96.00	0.00	0.00	0.00	384.00
3	WEST CONTROL	WC-30 (1324)	0.00	0.00	96.00	0.00	0.00	0.00	384.00	0.00	0.00	480.00
3	WEST CONTROL	WC-16 (1310)	288.00	288.00	0.00	0.00	0.00	288.00	384.00	0.00	384.00	1344.00
3	WEST CONTROL	WC-16 (1310)	0.00	96.00	192.00	0.00	0.00	192.00	384.00	0.00	0.00	864.00
3	WEST CONTROL	WC-16 (1310)	576.00	0.00	480.00	0.00	0.00	192.00	288.00	96.00	960.00	2016.00
3	WEST CONTROL	WC-16 (1310)	0.00	96.00	672.00	0.00	0.00	288.00	192.00	96.00	96.00	1440.00
3	WEST CONTROL	WC-16 (1310)	0.00	0.00	96.00	0.00	0.00	192.00	576.00	0.00	384.00	1248.00
3	WEST CONTROL	WC-16 (1310)	0.00	0.00	384.00	0.00	0.00	192.00	192.00	96.00	288.00	1152.00
3	WEST CONTROL	WC-12 (1306)	0.00	0.00	0.00	0.00	96.00	384.00	0.00	0.00	192.00	672.00
3	WEST CONTROL	WC-12 (1306)	0.00	192.00	96.00	0.00	0.00	288.00	0.00	192.00	96.00	864.00
3	WEST CONTROL	WC-12 (1306)	0.00	96.00	96.00	0.00	0.00	192.00	96.00	96.00	0.00	576.00
3	WEST CONTROL	WC-12 (1306)	384.00	0.00	288.00	0.00	0.00	480.00	96.00	0.00	0.00	864.00
3	WEST CONTROL	WC-34 (1328)	0.00	384.00	672.00	0.00	0.00	192.00	1920.00	0.00	192.00	3360.00
3	WEST CONTROL	WC-34 (1328)	1056.00	192.00	288.00	0.00	0.00	672.00	2784.00	96.00	2400.00	4416.00
3	WEST CONTROL	WC-34 (1328)	1440.00	192.00	768.00	0.00	0.00	1056.00	1920.00	0.00	2208.00	3936.00
3	WEST CONTROL	WC-34 (1328)	0.00	288.00	384.00	0.00	0.00	1344.00	2784.00	0.00	192.00	4992.00
3	WEST CONTROL	WC-14 (1308)	1152.00	288.00	1152.00	0.00	0.00	672.00	480.00	192.00	288.00	2784.00
3	WEST CONTROL	WC-14 (1308)	0.00	0.00	768.00	0.00	0.00	960.00	672.00	0.00	0.00	2400.00
3	WEST CONTROL	WC-14 (1308)	0.00	0.00	384.00	0.00	0.00	96.00	288.00	0.00	960.00	1728.00
3	WEST CONTROL	WC-14 (1308)	192.00	0.00	0.00	0.00	0.00	192.00	192.00	96.00	1344.00	1824.00
3	WEST CONTROL	WC-36 (1330)	0.00	96.00	288.00	0.00	0.00	96.00	0.00	0.00	96.00	576.00
3	WEST CONTROL	WC-36 (1330)	4800.00	0.00	1056.00	0.00	0.00	0.00	384.00	0.00	12480.00	2304.00
3	WEST CONTROL	WC-36 (1330)	0.00	0.00	192.00	0.00	0.00	0.00	480.00	0.00	0.00	672.00
3	WEST CONTROL	WC-36 (1330)	0.00	0.00	1920.00	0.00	192.00	96.00	960.00	96.00	96.00	3360.00
3	WEST CONTROL	WC-36 (1330)	0.00	0.00	864.00	0.00	0.00	96.00	288.00	96.00	96.00	1440.00
3	WEST CONTROL	WC-36 (1330)	0.00	0.00	3360.00	0.00	0.00	672.00	864.00	96.00	96.00	5088.00
3	WEST CONTROL	WC-36 (1330)	0.00	96.00	1536.00	0.00	0.00	0.00	288.00	0.00	0.00	1920.00
3	WEST CONTROL	WC-36 (1330)	0.00	96.00	1728.00	0.00	0.00	192.00	480.00	96.00	96.00	2688.00
3	NORTH CONTROL	NC-8 (1457)	96.00	0.00	288.00	0.00	0.00	0.00	0.00	0.00	96.00	288.00
3	NORTH CONTROL	NC-8 (1457)	0.00	480.00	0.00	0.00	96.00	0.00	0.00	0.00	192.00	768.00
3	NORTH CONTROL	NC-8 (1457)	0.00	96.00	96.00	0.00	96.00	0.00	0.00	0.00	0.00	288.00
3	NORTH CONTROL	NC-8 (1457)	0.00	0.00	0.00	0.00	96.00	0.00	0.00	0.00	0.00	96.00
3	NORTH CONTROL	NC-8 (1457)	0.00	96.00	0.00	0.00	192.00	0.00	0.00	0.00	0.00	288.00
3	NORTH CONTROL	NC-8 (1457)	0.00	192.00	0.00	0.00	0.00	0.00	0.00	0.00	192.00	384.00
3	NORTH CONTROL	NC-16 (1490)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	NORTH CONTROL	NC-16 (1490)	0.00	0.00	96.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00
3	NORTH CONTROL	NC-16 (1490)	0.00	0.00	192.00	0.00	0.00	96.00	0.00	0.00	192.00	480.00
3	NORTH CONTROL	NC-16 (1490)	384.00	96.00	96.00	0.00	96.00	0.00	576.00	0.00	0.00	864.00
3	NORTH CONTROL	NC-16 (1490)	96.00	96.00	0.00	0.00	0.00	96.00	288.00	0.00	0.00	480.00
3	NORTH CONTROL	NC-16 (1490)	0.00	96.00	0.00	0.00	0.00	0.00	192.00	0.00	96.00	384.00
3	NORTH CONTROL	NC-24 (1498)	480.00	288.00	576.00	0.00	0.00	0.00	1632.00	0.00	11616.00	2496.00
3	NORTH CONTROL	NC-24 (1498)	0.00	0.00	192.00	0.00	0.00	96.00	1632.00	0.00	0.00	1920.00
3	NORTH CONTROL	NC-24 (1498)	0.00	192.00	0.00	0.00	0.00	0.00	864.00	0.00	3936.00	1056.00
3	NORTH CONTROL	NC-24 (1498)	0.00	0.00	192.00	0.00	0.00	0.00	1728.00	0.00	96.00	2016.00
3	NORTH CONTROL	NC-24 (1498)	0.00	0.00	96.00	0.00	0.00	0.00	864.00	0.00	0.00	960.00

3	NORTH CONTROL	NC-24 (1498)	0.00	96.00	96.00	0.00	0.00	0.00	1152.00	0.00	288.00	1632.00
3	NORTH CONTROL	NC-24 (1498)	288.00	0.00	288.00	0.00	0.00	0.00	1056.00	0.00	288.00	1632.00
3	NORTH CONTROL	NC-24 (1498)	768.00	96.00	576.00	0.00	0.00	192.00	1056.00	0.00	7680.00	2112.00
3	NORTH CONTROL	NC-24 (1498)	0.00	96.00	96.00	0.00	0.00	192.00	1344.00	0.00	192.00	1920.00
3	NORTH CONTROL	NC-24 (1498)	0.00	0.00	384.00	0.00	0.00	192.00	1056.00	0.00	192.00	1824.00
3	NORTH CONTROL	NC-14 (1463)	0.00	96.00	288.00	0.00	0.00	96.00	96.00	0.00	0.00	576.00
3	NORTH CONTROL	NC-14 (1463)	0.00	192.00	480.00	0.00	96.00	0.00	0.00	0.00	96.00	864.00
3	NORTH CONTROL	NC-14 (1463)	384.00	192.00	960.00	0.00	0.00	96.00	384.00	0.00	1728.00	1920.00
3	NORTH CONTROL	NC-14 (1463)	96.00	0.00	0.00	0.00	0.00	192.00	0.00	0.00	192.00	384.00
4	AFFECTED AREA	M-10 (1647)	0.00	0.00	96.00	0.00	96.00	384.00	384.00	96.00	288.00	1344.00
4	AFFECTED AREA	M-10 (1647)	2784.00	288.00	576.00	0.00	192.00	672.00	960.00	192.00	0.00	2880.00
4	AFFECTED AREA	M-10 (1647)	768.00	288.00	192.00	0.00	192.00	768.00	960.00	192.00	96.00	2688.00
4	AFFECTED AREA	M-10 (1647)	0.00	96.00	0.00	0.00	96.00	192.00	672.00	96.00	0.00	1152.00
4	AFFECTED AREA	M-10 (1647)	0.00	672.00	0.00	0.00	96.00	480.00	960.00	0.00	0.00	2208.00
4	AFFECTED AREA	M-10 (1647)	0.00	96.00	480.00	0.00	0.00	672.00	768.00	0.00	96.00	2112.00
4	AFFECTED AREA	M-14 (1693)	2784.00	576.00	1920.00	0.00	96.00	0.00	288.00	0.00	96.00	2976.00
4	AFFECTED AREA	M-14 (1693)	1056.00	480.00	1056.00	0.00	0.00	96.00	384.00	0.00	192.00	2208.00
4	AFFECTED AREA	M-14 (1693)	1152.00	1152.00	1248.00	0.00	0.00	192.00	768.00	0.00	288.00	3648.00
4	AFFECTED AREA	M-14 (1693)	768.00	672.00	288.00	0.00	96.00	192.00	384.00	0.00	0.00	1632.00
4	AFFECTED AREA	M-14 (1693)	0.00	1056.00	0.00	0.00	96.00	0.00	192.00	0.00	0.00	1344.00
4	AFFECTED AREA	M-14 (1693)	0.00	576.00	288.00	0.00	0.00	96.00	96.00	0.00	0.00	1056.00
4	AFFECTED AREA	M-14 (1693)	0.00	384.00	480.00	0.00	0.00	0.00	0.00	0.00	96.00	960.00
4	AFFECTED AREA	M-14 (1693)	0.00	576.00	384.00	0.00	0.00	384.00	960.00	0.00	0.00	2304.00
4	AFFECTED AREA	M-14 (1693)	0.00	96.00	192.00	0.00	0.00	0.00	384.00	384.00	0.00	1056.00
4	AFFECTED AREA	M-14 (1693)	0.00	1152.00	864.00	0.00	0.00	96.00	576.00	0.00	192.00	2880.00
4	AFFECTED AREA	M-18 (1697)	768.00	0.00	96.00	0.00	0.00	0.00	96.00	96.00	0.00	288.00
4	AFFECTED AREA	M-18 (1697)	0.00	0.00	0.00	0.00	0.00	192.00	192.00	0.00	0.00	384.00
4	AFFECTED AREA	M-18 (1697)	1632.00	288.00	480.00	0.00	0.00	192.00	288.00	0.00	288.00	1536.00
4	AFFECTED AREA	M-18 (1697)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00	0.00	96.00
4	AFFECTED AREA	M-18 (1697)	0.00	192.00	192.00	0.00	0.00	96.00	288.00	96.00	192.00	1056.00
4	AFFECTED AREA	M-18 (1697)	0.00	0.00	96.00	0.00	96.00	96.00	288.00	0.00	96.00	672.00
4	AFFECTED AREA	M-18 (1697)	0.00	96.00	384.00	0.00	96.00	96.00	192.00	288.00	0.00	1152.00
4	AFFECTED AREA	M-18 (1697)	0.00	192.00	96.00	0.00	96.00	192.00	1056.00	0.00	96.00	1728.00
4	AFFECTED AREA	M-18 (1697)	0.00	0.00	96.00	0.00	0.00	96.00	384.00	0.00	0.00	576.00
4	AFFECTED AREA	M-18 (1697)	0.00	0.00	0.00	0.00	96.00	0.00	288.00	96.00	0.00	480.00
4	AFFECTED AREA	M-18 (1697)	0.00	0.00	0.00	0.00	0.00	192.00	480.00	0.00	0.00	672.00
4	AFFECTED AREA	M-18 (1697)	0.00	96.00	192.00	0.00	0.00	96.00	384.00	0.00	0.00	768.00
4	AFFECTED AREA	M-18 (1697)	0.00	0.00	192.00	0.00	96.00	192.00	384.00	192.00	96.00	1152.00
4	AFFECTED AREA	M-22 (1709)	3456.00	1152.00	576.00	0.00	0.00	384.00	1728.00	192.00	672.00	4704.00
4	AFFECTED AREA	M-22 (1709)	0.00	864.00	1152.00	0.00	0.00	576.00	1152.00	0.00	0.00	3744.00
4	AFFECTED AREA	M-22 (1709)	3840.00	192.00	1728.00	0.00	0.00	288.00	1056.00	192.00	192.00	3648.00
4	AFFECTED AREA	M-22 (1709)	0.00	768.00	0.00	0.00	96.00	192.00	0.00	0.00	0.00	1056.00
4	AFFECTED AREA	M-22 (1709)	0.00	480.00	96.00	0.00	0.00	96.00	672.00	96.00	96.00	1536.00
4	AFFECTED AREA	M-22 (1709)	0.00	288.00	96.00	0.00	0.00	0.00	288.00	0.00	0.00	672.00
4	AFFECTED AREA	M-22 (1709)	0.00	96.00	288.00	0.00	0.00	96.00	576.00	96.00	0.00	1152.00
4	AFFECTED AREA	M-22 (1709)	0.00	480.00	192.00	0.00	96.00	384.00	864.00	0.00	0.00	2016.00
4	AFFECTED AREA	M-22 (1709)	0.00	1248.00	672.00	0.00	96.00	288.00	576.00	0.00	0.00	2880.00
4	AFFECTED AREA	M-22 (1709)	0.00	960.00	192.00	0.00	0.00	384.00	384.00	0.00	96.00	2016.00
4	AFFECTED AREA	M-22 (1709)	0.00	192.00	288.00	0.00	0.00	0.00	864.00	96.00	0.00	1440.00
4	AFFECTED AREA	M-22 (1709)	0.00	480.00	576.00	0.00	0.00	96.00	768.00	96.00	0.00	2016.00
4	AFFECTED AREA	M-24 (1711)	0.00	0.00	192.00	0.00	0.00	0.00	192.00	0.00	192.00	576.00
4	AFFECTED AREA	M-24 (1711)	0.00	96.00	96.00	0.00	0.00	96.00	192.00	0.00	0.00	480.00
4	AFFECTED AREA	M-24 (1711)	0.00	192.00	0.00	0.00	0.00	96.00	96.00	0.00	0.00	384.00
4	AFFECTED AREA	M-24 (1711)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	AFFECTED AREA	M-24 (1711)	0.00	96.00	0.00	0.00	0.00	192.00	0.00	0.00	384.00	672.00
4	AFFECTED AREA	M-24 (1711)	0.00	0.00	0.00	0.00	0.00	96.00	96.00	96.00	96.00	384.00
4	AFFECTED AREA	M-24 (1711)	0.00	96.00	0.00	0.00	0.00	96.00	96.00	0.00	0.00	288.00
4	AFFECTED AREA	M-24 (1711)	0.00	0.00	96.00	0.00	0.00	0.00	96.00	96.00	96.00	384.00
4	AFFECTED AREA	M-24 (1711)	0.00	96.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00

4	FECTED AREA	M-24 (1711)	0.00	0.00	96.00	0.00	0.00	96.00	0.00	0.00	96.00	288
4	AFFECTED AREA	M-24 (1711)	0.00	192.00	0.00	0.00	0.00	0.00	96.00	96.00	0.00	384.00
4	AFFECTED AREA	M-4 (1641)	0.00	96.00	0.00	0.00	0.00	96.00	0.00	0.00	0.00	192.00
4	AFFECTED AREA	M-4 (1641)	0.00	96.00	0.00	96.00	192.00	288.00	384.00	0.00	0.00	1056.00
4	AFFECTED AREA	M-4 (1641)	96.00	96.00	384.00	0.00	192.00	192.00	480.00	0.00	96.00	1440.00
4	AFFECTED AREA	M-4 (1641)	96.00	0.00	0.00	0.00	96.00	288.00	288.00	0.00	96.00	768.00
4	AFFECTED AREA	M-4 (1641)	0.00	96.00	96.00	0.00	0.00	288.00	192.00	96.00	0.00	768.00
4	AFFECTED AREA	M-4 (1641)	0.00	96.00	0.00	0.00	96.00	288.00	96.00	0.00	0.00	576.00
4	AFFECTED AREA	M-4 (1641)	0.00	0.00	192.00	0.00	96.00	96.00	384.00	0.00	0.00	768.00
4	AFFECTED AREA	M-4 (1641)	0.00	0.00	96.00	0.00	0.00	96.00	96.00	0.00	0.00	288.00
4	AFFECTED AREA	M-4 (1641)	0.00	96.00	96.00	0.00	96.00	384.00	192.00	0.00	0.00	864.00
4	AFFECTED AREA	M-4 (1641)	0.00	0.00	0.00	0.00	0.00	384.00	192.00	0.00	96.00	672.00
4	AFFECTED AREA	M-30 (1717)	960.00	1824.00	192.00	0.00	672.00	480.00	2208.00	768.00	96.00	6240.00
4	AFFECTED AREA	M-30 (1717)	0.00	288.00	1344.00	0.00	288.00	288.00	2208.00	192.00	288.00	4896.00
4	AFFECTED AREA	M-30 (1717)	0.00	576.00	576.00	0.00	1248.00	0.00	3072.00	384.00	384.00	6240.00
4	AFFECTED AREA	M-30 (1717)	1152.00	672.00	288.00	0.00	576.00	672.00	2304.00	192.00	192.00	4896.00
4	AFFECTED AREA	M-38 (1725)	576.00	1056.00	576.00	0.00	0.00	672.00	2496.00	96.00	0.00	4896.00
4	AFFECTED AREA	M-38 (1725)	0.00	960.00	480.00	0.00	192.00	384.00	1440.00	192.00	0.00	3648.00
4	AFFECTED AREA	M-38 (1725)	0.00	384.00	96.00	0.00	0.00	192.00	576.00	96.00	0.00	1344.00
4	AFFECTED AREA	M-38 (1725)	0.00	192.00	192.00	0.00	96.00	96.00	1632.00	0.00	96.00	2304.00
4	AFFECTED AREA	M-38 (1725)	576.00	1440.00	192.00	0.00	96.00	288.00	1248.00	96.00	0.00	3360.00
4	AFFECTED AREA	M-38 (1725)	0.00	960.00	0.00	0.00	0.00	0.00	960.00	0.00	192.00	2112.00
4	AFFECTED AREA	M-38 (1725)	0.00	1152.00	576.00	0.00	0.00	576.00	2496.00	288.00	96.00	5184.00
4	AFFECTED AREA	M-38 (1725)	0.00	1728.00	960.00	0.00	0.00	480.00	2976.00	288.00	0.00	6432.00
4	AFFECTED AREA	M-38 (1725)	0.00	672.00	288.00	0.00	288.00	384.00	1728.00	96.00	96.00	3552.00
4	AFFECTED AREA	M-8 (1645)	0.00	576.00	4800.00	0.00	0.00	192.00	192.00	192.00	0.00	5952.00
4	AFFECTED AREA	M-8 (1645)	0.00	384.00	96.00	0.00	96.00	0.00	768.00	0.00	96.00	1440.00
4	AFFECTED AREA	M-8 (1645)	288.00	288.00	192.00	0.00	0.00	192.00	0.00	0.00	288.00	960.00
4	AFFECTED AREA	M-8 (1645)	480.00	384.00	576.00	0.00	96.00	0.00	192.00	0.00	576.00	1824.00
4	AFFECTED AREA	M-8 (1645)	0.00	576.00	0.00	0.00	192.00	0.00	192.00	96.00	288.00	1344.00
4	AFFECTED AREA	M-8 (1645)	0.00	960.00	96.00	0.00	96.00	288.00	384.00	0.00	384.00	2208.00
4	AFFECTED AREA	M-8 (1645)	0.00	384.00	960.00	0.00	192.00	96.00	0.00	96.00	384.00	2112.00
4	AFFECTED AREA	M-8 (1645)	1824.00	192.00	96.00	0.00	96.00	576.00	768.00	0.00	0.00	1728.00
4	AFFECTED AREA	M-40 (1727)	2688.00	2112.00	2304.00	0.00	288.00	672.00	2208.00	96.00	384.00	8064.00
4	AFFECTED AREA	M-40 (1727)	0.00	1632.00	96.00	0.00	0.00	672.00	1152.00	96.00	96.00	3744.00
4	AFFECTED AREA	M-40 (1727)	0.00	672.00	96.00	0.00	96.00	288.00	480.00	192.00	96.00	1920.00
4	AFFECTED AREA	M-40 (1727)	3360.00	1920.00	2592.00	0.00	288.00	1152.00	3936.00	384.00	384.00	10656.00
4	AFFECTED AREA	M-40 (1727)	0.00	2112.00	192.00	0.00	288.00	288.00	1536.00	480.00	192.00	5088.00
4	AFFECTED AREA	M-40 (1727)	0.00	1536.00	768.00	0.00	192.00	192.00	1536.00	192.00	384.00	4800.00
4	AFFECTED AREA	M-40 (1727)	0.00	1344.00	576.00	0.00	192.00	480.00	3168.00	0.00	288.00	6048.00
4	AFFECTED AREA	M-40 (1727)	0.00	1920.00	1152.00	0.00	192.00	672.00	2208.00	288.00	480.00	6912.00
4	AFFECTED AREA	M-40 (1727)	0.00	768.00	1056.00	0.00	0.00	576.00	2112.00	96.00	384.00	4992.00
4	AFFECTED AREA	M-40 (1727)	0.00	1536.00	960.00	0.00	0.00	576.00	2496.00	288.00	480.00	6336.00
4	AFFECTED AREA	M-26 (1713)	0.00	1152.00	2016.00	0.00	2400.00	1248.00	13152.00	576.00	960.00	21504.00
4	AFFECTED AREA	M-26 (1713)	0.00	1248.00	864.00	0.00	1824.00	1056.00	8544.00	192.00	0.00	13728.00
4	AFFECTED AREA	M-26 (1713)	0.00	1344.00	1440.00	0.00	4032.00	1344.00	12288.00	384.00	192.00	21024.00
4	AFFECTED AREA	M-26 (1713)	0.00	2208.00	5664.00	0.00	2016.00	2592.00	12768.00	0.00	768.00	26016.00
4	AFFECTED AREA	M-26 (1713)	0.00	960.00	1728.00	0.00	384.00	96.00	3552.00	0.00	96.00	6816.00
4	AFFECTED AREA	M-26 (1713)	1920.00	1824.00	1632.00	0.00	480.00	768.00	4224.00	0.00	384.00	9312.00
4	AFFECTED AREA	M-26 (1713)	0.00	1920.00	2688.00	0.00	0.00	672.00	7776.00	0.00	288.00	13344.00
4	AFFECTED AREA	M-26 (1713)	1440.00	1344.00	2592.00	0.00	576.00	576.00	3840.00	96.00	288.00	9312.00
4	AFFECTED AREA	M-34 (1721)	0.00	1632.00	192.00	0.00	0.00	1056.00	2400.00	0.00	192.00	5472.00
4	AFFECTED AREA	M-34 (1721)	0.00	960.00	960.00	0.00	288.00	1248.00	4320.00	288.00	0.00	8064.00
4	AFFECTED AREA	M-34 (1721)	0.00	1728.00	288.00	0.00	96.00	1152.00	3840.00	192.00	96.00	7392.00
4	AFFECTED AREA	M-34 (1721)	0.00	1920.00	1248.00	0.00	672.00	864.00	5568.00	480.00	0.00	10752.00
4	AFFECTED AREA	M-34 (1721)	1728.00	1728.00	1344.00	0.00	384.00	1920.00	5184.00	576.00	864.00	12000.00
4	AFFECTED AREA	M-34 (1721)	1344.00	2016.00	1056.00	0.00	96.00	1536.00	6144.00	384.00	576.00	11808.00
4	AFFECTED AREA	M-34 (1721)	0.00	960.00	768.00	0.00	288.00	1056.00	3168.00	96.00	0.00	6336.00
4	AFFECTED AREA	M-34 (1721)	0.00	1248.00	1440.00	0.00	96.00	384.00	3264.00	192.00	192.00	6816.00

4	AFFECTED AREA	M-28 (1715)	0.00	1440.00	768.00	0.00	96.00	672.00	2688.00	96.00	192.00	5952.00
4	AFFECTED AREA	M-28 (1715)	0.00	2016.00	480.00	0.00	0.00	2016.00	3360.00	192.00	480.00	8544.00
4	AFFECTED AREA	M-28 (1715)	864.00	1440.00	672.00	0.00	96.00	864.00	2784.00	96.00	384.00	6336.00
4	AFFECTED AREA	M-28 (1715)	0.00	192.00	0.00	0.00	0.00	576.00	2304.00	96.00	0.00	3168.00
4	AFFECTED AREA	M-6 (1643)	0.00	96.00	288.00	0.00	288.00	384.00	480.00	576.00	0.00	2112.00
4	AFFECTED AREA	M-6 (1643)	0.00	96.00	288.00	0.00	0.00	384.00	576.00	0.00	192.00	1536.00
4	AFFECTED AREA	M-6 (1643)	288.00	0.00	672.00	0.00	192.00	480.00	672.00	0.00	192.00	2208.00
4	WEST CONTROL	WC-8 (1778)	480.00	672.00	480.00	0.00	192.00	0.00	288.00	96.00	96.00	1824.00
4	WEST CONTROL	WC-8 (1778)	0.00	96.00	288.00	0.00	96.00	96.00	192.00	96.00	0.00	864.00
4	WEST CONTROL	WC-8 (1778)	0.00	864.00	384.00	0.00	96.00	0.00	96.00	96.00	96.00	1632.00
4	WEST CONTROL	WC-8 (1778)	0.00	480.00	0.00	0.00	0.00	96.00	192.00	0.00	0.00	768.00
4	WEST CONTROL	WC-8 (1778)	0.00	192.00	96.00	0.00	96.00	288.00	96.00	0.00	192.00	960.00
4	WEST CONTROL	WC-8 (1778)	0.00	96.00	0.00	0.00	96.00	0.00	288.00	0.00	0.00	480.00
4	WEST CONTROL	WC-8 (1778)	0.00	480.00	384.00	0.00	0.00	0.00	0.00	96.00	0.00	960.00
4	WEST CONTROL	WC-8 (1778)	0.00	384.00	384.00	0.00	384.00	0.00	384.00	96.00	192.00	1824.00
4	WEST CONTROL	WC-8 (1778)	0.00	480.00	0.00	0.00	384.00	0.00	96.00	192.00	0.00	1152.00
4	WEST CONTROL	WC-8 (1778)	0.00	480.00	0.00	0.00	480.00	96.00	1824.00	576.00	0.00	3456.00
4	WEST CONTROL	WC-8 (1778)	384.00	2976.00	0.00	0.00	1056.00	288.00	2208.00	288.00	480.00	7296.00
4	WEST CONTROL	WC-10 (1780)	0.00	192.00	1248.00	0.00	384.00	672.00	3360.00	768.00	288.00	6912.00
4	WEST CONTROL	WC-10 (1780)	5664.00	288.00	864.00	0.00	384.00	1440.00	2688.00	288.00	1056.00	7008.00
4	WEST CONTROL	WC-10 (1780)	0.00	192.00	96.00	0.00	576.00	384.00	2592.00	192.00	96.00	4128.00
4	WEST CONTROL	WC-10 (1780)	4128.00	576.00	480.00	0.00	384.00	288.00	2784.00	288.00	1056.00	5856.00
4	WEST CONTROL	WC-10 (1780)	0.00	192.00	0.00	0.00	192.00	96.00	2016.00	288.00	0.00	2784.00
4	WEST CONTROL	WC-10 (1780)	0.00	672.00	576.00	0.00	384.00	288.00	3632.00	288.00	288.00	4128.00
4	WEST CONTROL	WC-12 (1782)	0.00	1632.00	1536.00	0.00	2304.00	864.00	21984.00	2208.00	1056.00	31584.00
4	WEST CONTROL	WC-12 (1782)	35520.00	7680.00	864.00	0.00	5280.00	864.00	28224.00	3264.00	4800.00	48960.00
4	WEST CONTROL	WC-12 (1782)	46560.00	1536.00	8256.00	0.00	3456.00	672.00	34752.00	5664.00	8448.00	57888.00
4	WEST CONTROL	WC-12 (1782)	0.00	960.00	3936.00	96.00	1728.00	576.00	20256.00	2112.00	2880.00	32544.00
4	WEST CONTROL	WC-12 (1782)	0.00	1920.00	3168.00	0.00	2880.00	1728.00	25344.00	3552.00	2496.00	42048.00
4	WEST CONTROL	WC-12 (1782)	0.00	384.00	288.00	0.00	480.00	384.00	13872.00	1152.00	288.00	18048.00
4	WEST CONTROL	WC-12 (1782)	0.00	1920.00	384.00	0.00	1248.00	576.00	14976.00	960.00	1056.00	21120.00
4	WEST CONTROL	WC-12 (1782)	0.00	0.00	1536.00	0.00	4224.00	1344.00	25632.00	2592.00	672.00	37056.00
4	WEST CONTROL	WC-12 (1782)	0.00	1248.00	5856.00	0.00	1536.00	1152.00	30624.00	4128.00	3264.00	47808.00
4	WEST CONTROL	WC-12 (1782)	0.00	2208.00	8160.00	0.00	2496.00	1920.00	34368.00	5088.00	5856.00	60096.00
4	WEST CONTROL	WC-14 (1784)	672.00	576.00	960.00	0.00	96.00	0.00	1056.00	0.00	96.00	2784.00
4	WEST CONTROL	WC-14 (1784)	768.00	1056.00	1056.00	0.00	672.00	192.00	960.00	288.00	96.00	4224.00
4	WEST CONTROL	WC-14 (1784)	0.00	0.00	0.00	0.00	192.00	0.00	768.00	96.00	192.00	1248.00
4	WEST CONTROL	WC-14 (1784)	0.00	192.00	0.00	0.00	0.00	0.00	1056.00	96.00	0.00	1344.00
4	WEST CONTROL	WC-14 (1784)	0.00	1152.00	2112.00	0.00	384.00	96.00	1440.00	0.00	96.00	5280.00
4	WEST CONTROL	WC-14 (1784)	0.00	288.00	384.00	0.00	192.00	0.00	672.00	96.00	0.00	1632.00
4	WEST CONTROL	WC-14 (1784)	0.00	480.00	576.00	0.00	0.00	192.00	864.00	192.00	192.00	2496.00
4	WEST CONTROL	WC-14 (1784)	0.00	1344.00	1056.00	0.00	384.00	0.00	288.00	0.00	96.00	3168.00
4	WEST CONTROL	WC-14 (1784)	0.00	768.00	960.00	0.00	0.00	0.00	1056.00	0.00	0.00	2784.00
4	WEST CONTROL	WC-14 (1784)	0.00	672.00	0.00	0.00	96.00	0.00	480.00	0.00	0.00	1248.00
4	WEST CONTROL	WC-14 (1784)	0.00	288.00	288.00	0.00	288.00	96.00	1920.00	192.00	96.00	3168.00
4	WEST CONTROL	WC-14 (1784)	0.00	1728.00	0.00	0.00	96.00	288.00	768.00	0.00	0.00	2880.00
4	WEST CONTROL	WC-14 (1784)	0.00	480.00	576.00	0.00	0.00	192.00	864.00	192.00	192.00	2496.00
4	WEST CONTROL	WC-16 (1786)	9120.00	1248.00	960.00	0.00	480.00	192.00	2880.00	96.00	384.00	6240.00
4	WEST CONTROL	WC-16 (1786)	0.00	864.00	960.00	0.00	192.00	96.00	1632.00	384.00	288.00	4416.00
4	WEST CONTROL	WC-16 (1786)	0.00	1056.00	0.00	0.00	672.00	0.00	0.00	96.00	96.00	1920.00
4	WEST CONTROL	WC-16 (1786)	5912.00	1056.00	1440.00	0.00	0.00	96.00	1344.00	0.00	288.00	4224.00
4	WEST CONTROL	WC-16 (1786)	0.00	1056.00	288.00	0.00	192.00	0.00	2208.00	0.00	192.00	3936.00
4	WEST CONTROL	WC-16 (1786)	0.00	1440.00	1056.00	0.00	480.00	96.00	2400.00	0.00	576.00	6048.00
4	WEST CONTROL	WC-22 (1792)	1152.00	1440.00	0.00	0.00	480.00	0.00	480.00	0.00	192.00	2592.00
4	WEST CONTROL	WC-22 (1792)	1440.00	960.00	672.00	0.00	192.00	0.00	1248.00	480.00	288.00	3648.00
4	WEST CONTROL	WC-22 (1792)	0.00	960.00	1824.00	0.00	384.00	0.00	960.00	192.00	96.00	4416.00
4	WEST CONTROL	WC-22 (1792)	0.00	1152.00	1152.00	0.00	288.00	0.00	1632.00	0.00	0.00	4224.00
4	WEST CONTROL	WC-22 (1792)	0.00	1248.00	0.00	0.00	192.00	96.00	288.00	192.00	0.00	2016.00
4	WEST CONTROL	WC-22 (1792)	0.00	96.00	1056.00	0.00	96.00	288.00	1248.00	96.00	288.00	3168.00

4	WEST CONTROL	WC-36 (1806)	0.00	0.00	384.00	0.00	96.00	0.00	288.00	96.00	96.00	960.00
4	WEST CONTROL	WC-36 (1806)	1248.00	192.00	960.00	0.00	0.00	0.00	480.00	480.00	480.00	2592.00
4	WEST CONTROL	WC-36 (1806)	576.00	480.00	288.00	0.00	0.00	192.00	768.00	0.00	192.00	1920.00
4	WEST CONTROL	WC-36 (1806)	0.00	192.00	576.00	0.00	0.00	0.00	288.00	192.00	96.00	1344.00
4	WEST CONTROL	WC-36 (1806)	0.00	0.00	0.00	0.00	0.00	0.00	96.00	96.00	0.00	192.00
4	WEST CONTROL	WC-36 (1806)	0.00	0.00	96.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00
4	WEST CONTROL	WC-36 (1806)	0.00	96.00	384.00	0.00	0.00	96.00	192.00	288.00	0.00	1056.00
4	WEST CONTROL	WC-36 (1806)	0.00	0.00	288.00	0.00	0.00	0.00	864.00	192.00	0.00	1344.00
4	WEST CONTROL	WC-36 (1806)	0.00	0.00	0.00	0.00	0.00	0.00	192.00	192.00	96.00	480.00
4	WEST CONTROL	WC-36 (1806)	0.00	0.00	96.00	0.00	0.00	0.00	192.00	288.00	96.00	672.00
4	WEST CONTROL	WC-36 (1806)	0.00	0.00	288.00	0.00	0.00	0.00	0.00	0.00	96.00	384.00
4	WEST CONTROL	WC-36 (1806)	0.00	0.00	288.00	0.00	288.00	96.00	288.00	96.00	0.00	1056.00
4	WEST CONTROL	WC-36 (1806)	0.00	0.00	288.00	0.00	192.00	0.00	288.00	288.00	288.00	1344.00
4	WEST CONTROL	WC-2 (1629)	576.00	768.00	0.00	0.00	384.00	192.00	192.00	0.00	0.00	1536.00
4	WEST CONTROL	WC-2 (1629)	0.00	576.00	0.00	0.00	192.00	0.00	192.00	0.00	0.00	960.00
4	WEST CONTROL	WC-2 (1629)	0.00	480.00	96.00	0.00	0.00	0.00	192.00	96.00	0.00	864.00
4	WEST CONTROL	WC-2 (1629)	288.00	480.00	96.00	0.00	288.00	0.00	0.00	96.00	0.00	960.00
4	WEST CONTROL	WC-2 (1629)	0.00	864.00	192.00	0.00	288.00	0.00	192.00	0.00	0.00	1536.00
4	WEST CONTROL	WC-2 (1629)	0.00	192.00	0.00	0.00	384.00	96.00	96.00	288.00	0.00	1056.00
4	WEST CONTROL	WC-28 (1798)	11520.00	1344.00	1344.00	0.00	384.00	768.00	5472.00	576.00	0.00	9888.00
4	WEST CONTROL	WC-28 (1798)	0.00	864.00	480.00	0.00	480.00	288.00	3360.00	288.00	0.00	5760.00
4	WEST CONTROL	WC-28 (1798)	1056.00	1344.00	2016.00	0.00	864.00	0.00	4128.00	672.00	192.00	9216.00
4	WEST CONTROL	WC-28 (1798)	0.00	1248.00	288.00	0.00	672.00	288.00	2496.00	96.00	0.00	5088.00
4	WEST CONTROL	WC-28 (1798)	0.00	1536.00	2208.00	0.00	960.00	288.00	4800.00	288.00	288.00	10368.00
4	WEST CONTROL	WC-28 (1798)	0.00	1248.00	1440.00	0.00	480.00	288.00	4992.00	192.00	192.00	8832.00
4	WEST CONTROL	WC-28 (1798)	0.00	1344.00	1536.00	0.00	576.00	192.00	5376.00	768.00	384.00	10176.00
4	WEST CONTROL	WC-28 (1798)	0.00	1248.00	288.00	0.00	672.00	288.00	2496.00	96.00	0.00	5088.00
4	WEST CONTROL	WC-40 (1810)	0.00	384.00	2496.00	0.00	288.00	0.00	576.00	672.00	96.00	4512.00
4	WEST CONTROL	WC-40 (1810)	0.00	192.00	1152.00	0.00	480.00	96.00	1056.00	96.00	96.00	3168.00
4	WEST CONTROL	WC-40 (1810)	384.00	768.00	864.00	96.00	96.00	96.00	1344.00	192.00	192.00	3648.00
4	WEST CONTROL	WC-40 (1810)	672.00	1248.00	768.00	0.00	0.00	0.00	1056.00	576.00	288.00	3936.00
4	WEST CONTROL	WC-18 (1788)	0.00	1248.00	96.00	0.00	768.00	384.00	2592.00	192.00	192.00	5472.00
4	WEST CONTROL	WC-18 (1788)	0.00	1056.00	480.00	0.00	192.00	0.00	768.00	96.00	0.00	2592.00
4	WEST CONTROL	WC-18 (1788)	0.00	1152.00	672.00	0.00	864.00	96.00	2112.00	480.00	576.00	5952.00
4	WEST CONTROL	WC-18 (1788)	0.00	768.00	576.00	0.00	576.00	0.00	2400.00	192.00	192.00	4704.00
4	WEST CONTROL	WC-18 (1788)	0.00	576.00	480.00	0.00	288.00	96.00	1632.00	480.00	0.00	3552.00
4	WEST CONTROL	WC-18 (1788)	0.00	1056.00	192.00	0.00	576.00	0.00	2112.00	192.00	96.00	4224.00
4	WEST CONTROL	WC-24 (1794)	0.00	960.00	1344.00	0.00	96.00	0.00	2208.00	0.00	96.00	4704.00
4	WEST CONTROL	WC-24 (1794)	1728.00	480.00	1344.00	0.00	0.00	192.00	2496.00	96.00	0.00	4608.00
4	WEST CONTROL	WC-24 (1794)	0.00	960.00	1536.00	0.00	96.00	192.00	3360.00	96.00	192.00	6432.00
4	WEST CONTROL	WC-24 (1794)	1152.00	192.00	1728.00	0.00	96.00	0.00	2016.00	0.00	96.00	4128.00
4	WEST CONTROL	WC-4 (1748)	0.00	480.00	192.00	0.00	96.00	0.00	192.00	0.00	0.00	960.00
4	WEST CONTROL	WC-4 (1748)	0.00	288.00	288.00	0.00	384.00	192.00	288.00	0.00	96.00	1536.00
4	WEST CONTROL	WC-4 (1748)	672.00	1056.00	384.00	0.00	96.00	96.00	192.00	0.00	0.00	1824.00
4	WEST CONTROL	WC-4 (1748)	768.00	384.00	96.00	0.00	192.00	192.00	384.00	288.00	192.00	1728.00
4	NORTH CONTROL	NC-14 (1737)	2976.00	1632.00	288.00	0.00	672.00	0.00	3648.00	0.00	4992.00	7296.00
4	NORTH CONTROL	NC-14 (1737)	0.00	288.00	672.00	0.00	576.00	0.00	2976.00	96.00	192.00	4800.00
4	NORTH CONTROL	NC-14 (1737)	0.00	96.00	96.00	0.00	96.00	0.00	1056.00	0.00	0.00	1344.00
4	NORTH CONTROL	NC-14 (1737)	1728.00	192.00	1440.00	0.00	576.00	0.00	1728.00	96.00	192.00	4224.00
4	NORTH CONTROL	NC-14 (1737)	0.00	96.00	288.00	0.00	576.00	0.00	2976.00	0.00	672.00	4608.00
4	NORTH CONTROL	NC-14 (1737)	0.00	480.00	0.00	0.00	288.00	0.00	1632.00	0.00	672.00	3072.00
4	NORTH CONTROL	NC-14 (1737)	0.00	384.00	0.00	0.00	480.00	0.00	2112.00	0.00	384.00	3360.00
4	NORTH CONTROL	NC-14 (1737)	0.00	96.00	480.00	0.00	384.00	0.00	960.00	0.00	96.00	2016.00
4	NORTH CONTROL	NC-14 (1737)	0.00	288.00	768.00	0.00	384.00	0.00	2496.00	0.00	192.00	4128.00
4	NORTH CONTROL	NC-14 (1737)	0.00	960.00	0.00	0.00	288.00	0.00	2016.00	0.00	0.00	3264.00
4	NORTH CONTROL	NC-18 (1741)	0.00	864.00	960.00	288.00	480.00	0.00	6048.00	192.00	864.00	9696.00
4	NORTH CONTROL	NC-18 (1741)	0.00	2016.00	0.00	0.00	1056.00	0.00	7008.00	0.00	192.00	10272.00
4	NORTH CONTROL	NC-18 (1741)	1440.00	1728.00	672.00	0.00	96.00	96.00	4992.00	288.00	768.00	8640.00

4	NORTH CONTROL	NC-18 (1741)	672.00	1056.00	1248.00	0.00	384.00	0.00	7296.00	384.00	1152.00	11520.00
4	NORTH CONTROL	NC-4 (1767)	0.00	480.00	384.00	0.00	0.00	0.00	672.00	0.00	96.00	1632.00
4	NORTH CONTROL	NC-4 (1767)	0.00	384.00	384.00	0.00	96.00	192.00	864.00	0.00	192.00	2112.00
4	NORTH CONTROL	NC-4 (1767)	0.00	480.00	1536.00	96.00	192.00	96.00	2304.00	0.00	96.00	4800.00
4	NORTH CONTROL	NC-4 (1767)	192.00	768.00	2592.00	0.00	480.00	0.00	3360.00	0.00	768.00	7968.00
4	NORTH CONTROL	NC-4 (1767)	0.00	384.00	192.00	0.00	0.00	96.00	1152.00	0.00	0.00	1824.00
4	NORTH CONTROL	NC-4 (1767)	0.00	384.00	576.00	0.00	288.00	96.00	2304.00	0.00	0.00	3648.00
4	NORTH CONTROL	NC-4 (1767)	0.00	576.00	2208.00	0.00	576.00	0.00	4416.00	96.00	480.00	8352.00
4	NORTH CONTROL	NC-4 (1767)	0.00	480.00	480.00	0.00	192.00	0.00	2304.00	0.00	480.00	3936.00
4	NORTH CONTROL	NC-4 (1767)	0.00	192.00	288.00	0.00	0.00	192.00	960.00	0.00	0.00	1632.00
4	NORTH CONTROL	NC-4 (1767)	0.00	96.00	0.00	0.00	0.00	0.00	288.00	0.00	0.00	384.00
4	NORTH CONTROL	NC-4 (1767)	0.00	288.00	0.00	0.00	0.00	0.00	1152.00	0.00	0.00	1440.00
4	NORTH CONTROL	NC-4 (1767)	0.00	192.00	2784.00	0.00	480.00	96.00	2304.00	0.00	864.00	6720.00
4	NORTH CONTROL	NC-4 (1767)	0.00	192.00	0.00	0.00	96.00	0.00	384.00	0.00	0.00	672.00
4	NORTH CONTROL	NC-4 (1767)	0.00	192.00	960.00	0.00	0.00	96.00	1728.00	0.00	0.00	2976.00
4	NORTH CONTROL	NC-4 (1767)	0.00	768.00	2592.00	0.00	768.00	288.00	3840.00	192.00	864.00	9312.00
4	NORTH CONTROL	NC-4 (1767)	0.00	96.00	288.00	0.00	96.00	0.00	960.00	0.00	96.00	1536.00
4	NORTH CONTROL	NC-4 (1767)	0.00	672.00	480.00	0.00	576.00	192.00	3360.00	0.00	1056.00	6336.00
4	NORTH CONTROL	NC-4 (1767)	0.00	288.00	1824.00	0.00	480.00	0.00	2784.00	0.00	192.00	5568.00
4	NORTH CONTROL	NC-10 (1773)	768.00	0.00	0.00	0.00	0.00	96.00	0.00	0.00	0.00	96.00
4	NORTH CONTROL	NC-10 (1773)	672.00	96.00	96.00	0.00	96.00	0.00	768.00	0.00	192.00	1248.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	0.00	0.00	192.00	0.00	0.00	0.00	96.00	288.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	96.00	0.00	192.00	0.00	96.00	96.00	288.00	768.00
4	NORTH CONTROL	NC-10 (1773)	0.00	96.00	0.00	0.00	192.00	0.00	96.00	0.00	0.00	384.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	0.00	0.00	96.00	0.00	384.00	0.00	0.00	480.00
4	NORTH CONTROL	NC-10 (1773)	0.00	192.00	0.00	0.00	0.00	96.00	96.00	0.00	0.00	384.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	0.00	0.00	0.00	0.00	288.00	0.00	0.00	288.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	96.00	0.00	0.00	0.00	96.00	0.00	0.00	192.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	NORTH CONTROL	NC-10 (1773)	0.00	192.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	192.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	0.00	0.00	96.00	0.00	0.00	0.00	0.00	96.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	0.00	0.00	96.00	0.00	288.00	0.00	0.00	384.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	0.00	0.00	288.00	0.00	96.00	0.00	192.00	576.00
4	NORTH CONTROL	NC-10 (1773)	0.00	192.00	0.00	0.00	96.00	0.00	672.00	0.00	480.00	1440.00
4	NORTH CONTROL	NC-10 (1773)	0.00	96.00	0.00	0.00	96.00	0.00	0.00	0.00	0.00	192.00
4	NORTH CONTROL	NC-10 (1773)	0.00	192.00	96.00	0.00	0.00	0.00	0.00	0.00	0.00	288.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	192.00	0.00	96.00	0.00	96.00	0.00	96.00	480.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	0.00	0.00	96.00	0.00	96.00	0.00	0.00	192.00
4	NORTH CONTROL	NC-10 (1773)	0.00	96.00	0.00	0.00	96.00	0.00	192.00	0.00	0.00	384.00
4	NORTH CONTROL	NC-10 (1773)	0.00	96.00	192.00	0.00	0.00	0.00	384.00	0.00	192.00	864.00
4	NORTH CONTROL	NC-10 (1773)	0.00	192.00	0.00	0.00	192.00	0.00	480.00	0.00	0.00	864.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	NORTH CONTROL	NC-10 (1773)	0.00	0.00	768.00	0.00	0.00	0.00	768.00	0.00	0.00	1536.00

APPENDIX B.3
Computer Programs Developed For This Assessment

This appendix is a listing of the computer programs developed during this study to analyze the biological data. These programs were written in Super Fortran language and were compiled and executed on a Univac 1108 time-sharing computer operated by United Computing Service of Kansas City, Missouri. They were designed to perform a variety of analytical functions, the most significant of which are:

1. Data conversion (counts per subsample to densities per 0.25 m^2)

2. Calculation of mean density, variance, and standard error (by taxon, site, and phase)

3. Estimation of the number of additional samples and subsamples required by the analysis to achieve the desired sensitivity (detection of a 51 percent faunal change at the 95 percent confidence level)

4. Calculation of summary statistics for two-level analyses of variance among phases, sites, stations and replicates

```
0001:       PROGRAM LAKE (INPUT,OUTPUT,TAPE6=OUTPUT,TAPE5=INPUT)
0002: C.............
0003: C.. THIS PROGRAM ANALYZES LAKE BENTHIC DATA.
0004: C.............
0005:       COMMON/D/TV(3,34)
0006:       COMMON MAX(4,4,20),LAX(4,4),KAX(4),GRAND(14),GRAS(14),SQA(14),
0007:      1SQC(14),SQE(14),ANS(4,4),ANS(4,4),BN(4),BNS(4)
0008:        COMMON/C/SPECIE(14),SITE(4),STAID(4,4,20)
0009:       DIMENSION PONAR(18),SUM(4,14,4,20),SUMSQ(4,14,4,20),
0010:      1SUML(4,14,4),SUMLS(4,14,4),SUMK(4,14),SUMKS(4,14),SQB(4,14,4),
0011:      2SQD(4,14),AVER(4,14,4),VAR(4,14,4),SE(4,14,4)
0012:       DIMENSION SUMA(4,14,4),SJMAQ(4,14,4),SAQ(4,14,4)
0013:       DIMENSION DUM(18)
0014:       DIMENSION SS(12),SST(12),T(12),TQ(12),NT(12),TC(12),SA(12)
0015:       CHARACTER SPECIE*20,SITE*14,STAID*13
0016:       INTEGER W
0017:       DATA (TV(1,I),I=1,34)/12.706,4.303,3.182,2.776,2.571,2.447,2.365,2
0018:      1.306,2.262,2.228,2.201,2.179,2.16,2.145,2.131,2.12,2.11,2.101,2.09
0019:      23,2.086,2.08,2.074,2.069,2.064,2.06,2.056,2.052,2.048,2.045,2.042,
0020:      32.021,2.0,1.98,1.96/
0021:       DATA (TV(2,I),I=1,34)/6.314,2.92,2.353,2.132,2.015,1.943,1.895,1.8
0022:      16,1.833,1.812,1.796,1.782,1.771,1.761,1.753,1.746,1.74,1.734,1.729
0023:      2,1.725,1.721,1.717,1.714,1.711,1.709,1.706,1.703,1.701,1.699,1.697
0024:      3,1.684,1.671,1.658,1.645/
0025:       DATA (TV(3,I),I=1,34)/3.078,1.886,1.638,1.533,1.476,1.44,1.415,1.3
0026:      197,1.383,1.372,1.363,1.356,1.35,1.345,1.341,1.337,1.333,1.33,1.328
0027:      2,1.325,1.323,1.321,1.319,1.318,1.316,1.315,1.314,1.313,1.311,1.31,
0028:      31.303,1.296,1.289,1.282/
0029:       WRITE (6,241)
0030:   241 FORMAT (1H1,30X,59HDENSITY (PER 0.25 SQUARE METER) OF BLACK LAKE B
0031:      1ENTHIC FAUNA//1X,5HPHASE,5X,4HSITE,9X,8HSTATION/,6X,8HNEMATODA,7X,
0032:      211HOLIGOCHAETA,6X,8HBIVALVIA,8X,9HAMPHIPODA,9X,5HMISC./24X,6HSAMPL
0033:      3E,14X,10HPOLYCHAETA,6X,10HGASTROPODA,6X,10HTANAIDACEA,7X,7HISOPODA
0034:      4,13X,5HTOTAL//)
0035: C.............
0036: C.. THIS PROGRAM SEGMENT READS IN DATA AND CONVERTS COUNTS TO DENSITIES.
0037: C.............
0038:     1 READ (5,2) I,K,L,M,(PONAR(J),J=1,14)
0039:     2 FORMAT(2I1,2I2,14F5.0)
0040:       IF (I.EQ.0) GO TO 480
0041:       IF(M.GT.MAX(I,K,L)) MAX(I,K,L)=M
0042:       IF(L.GT.LAX(I,K))LAX(I,K)=L
0043:       IF(K.GT.KAX(I)) KAX(I)=K
0044:       IF(I.GT.IAX) IAX=I
0045:       DO 481 J = 1,9
0046:   481 PONAR(10) = PONAR(10) + PONAR(J)
0047:       IF (M.EQ. 1) GO TO 483
0048:       IF ((M.EQ.2).AND.(KOUNT.EQ.1)) GO TO 484
0049:       DO 482 J = 1,14
0050:       PONAR(J) = PONAR(J)*113.424
0051:       SUM(I,J,K,L) = SUM(I,J,K,L) + PONAR(J)
0052:       SUMSQ(I,J,K,L) = SUMSQ(I,J,K,L) + PONAR(J)**2
0053:       IF (K.EQ.4) GO TO 482
0054:       GRAND(J) = GRAND(J) + PONAR(J)
0055:       GRAS(J) = GRAS(J) - PONAR(J)**2
0056:   482 CONTINUE
0057:       WRITE (6,242) I,SITE(K),STAID(I,K,L),(PONAR(JJJ),JJJ=1,10)
0058:   242 FORMAT (3X,I1,2X,A14,1X,A13,3X,9F8.2,F10.2)
0059:       GO TO 1
0060:   484 CONTINUE
```

```
0061:       DO 485 J = 1,14
0062:       DUM(J) = DUM(J)+113.424
0063:       PONAR(J) = PONAR(J)+113.424
0064:       SUM(I,J,K,L)=SUM(I,J,K,L)+DUM(J)+PONAR(J)
0065:       SUMSQ(I,J,K,L)=SUMSQ(I,J,K,L)+DUM(J)**2+PONAR(J)**2
0066:       IF (K.EQ.4) GO TO 485
0067:       GRAND(J) = GRAND(J) + DUM(J) + PONAR(J)
0068:       GRAS(J) = GRAS(J) + DUM(J)**2 + PONAR(J)**2
0069:   485 CONTINUE
0070:       WRITE (6,242) I,SITE(K),STAID(I,K,L),(DUM(JJJ),JJJ=1,10)
0071:       WRITE (6,242) I,SITE(K),STAID(I,K,L),(PONAR(JJJ),JJJ=1,10)
0072:       KOUNT = 0
0073:       GO TO 1
0074:   483 IF (KOUNT.EQ.1) GO TO 486
0075:       KOUNT = 1
0076:       DO 487 J = 1,14
0077:   487 DUM(J) = PONAR(J)
0078:       GO TO 1
0079:   486 DO 488 J = 1,14
0080:       DUM(J) = DUM(J)*4.726
0081:       SUM(I,J,K,L) = SUM(I,J,K,L) + DUM(J)
0082:       SUMSQ(I,J,K,L) = SUMSQ(I,J,K,L) + DUM(J)**2
0083:       IF (K.EQ.4) GO TO 488
0084:       GRAND(J) = GRAND(J) + DUM(J)
0085:       GRAS(J) = GRAS(J) + DUM(J)**2
0086:   488 CONTINUE
0087:       WRITE (6,242) I,SITE(K),STAID(I,K,L),(DUM(JJJ),JJJ=1,10)
0088:       DO 933 J = 1,14
0089:   933 DUM(J) = PONAR(J)
0090:       GO TO 1
0091:   480 CONTINUE
0092:       IF (IAX.GT.4) WRITE (6,270)
0093:   270 FORMAT (/3X,21HTOO MANY PHASES FOUND)
0094:       IF (IAX.GT.4) IAX = 4
0095:       DO 3 I=1,IAX
0096:       IF (KAX(I).GT.4) WRITE (6,271) I
0097:   271 FORMAT (/3X,29HTOO MANY SITES FOUND IN PHASE,I3)
0098:       IF (KAX(I).GT.4) KAX(I) = 4
0099:       DO 3 K=1,KAX(I)
0100:       IF (LAX(I,K).GT.20) WRITE (6,272) I,K
0101:   272 FORMAT (/3X,32HTOO MANY STATIONS FOUND IN PHASE,I3,8H AT SITE,I3)
0102:       IF (LAX(I,K).GT.20) LAX(I,K) = 20
0103:       DO 3 L=1,LAX(I,K)
0104:       IF (MAX(I,K,L).GT.24) WRITE (6,273) I,K,L
0105:   273 FORMAT (/3X,34HTOO MANY REPLICATES FOUND IN PHASE,I3,8H AT SITE,I3
0106:      1,10H IN SAMPLE,I3)
0107:     3 CONTINUE
0108: C...........
0109: C.. THIS PROGRAM SEGMENT CALCULATES MEANS, VARIANCES AND STANDARD
0110: C.. ERRORS.
0111: C...........
0112:       DO 8 J=1,14
0113:       DO 8 I=1,IAX
0114:       DO 8 K = 1,3
0115:       DO 7 L=1,LAX(I,K)
0116:       SUML(I,J,K)=SUML(I,J,K)+SUM(I,J,K,L)
0117:     7 SUMLS(I,J,K)=SUMLS(I,J,K)+SUMSQ(I,J,K,L)
0118:       SUMK(I,J)=SUMK(I,J)+SUML(I,J,K)
0119:     8 SUMKS(I,J)=SUMKS(I,J)+SUMLS(I,J,K)
0120:       DO 91 I = 1,IAX
```

```
0121:       DO 91 K = 1,3
0122:       DO 91 L = 1, LAX(I,K)
0123:       AN(I,K)=AN(I,K)+MAX(I,K,L)
0124:       ANS(I,K)=ANS(I,K)+MAX(I,K,L)**2
0125:       TN=TN+MAX(I,K,L)
0126:       BN(I)=BN(I)+MAX(I,K,L)
0127:    91 BNS(I) = BNS(I) +MAX(I,K,L)**2
0128:       DO 11 J=1,14
0129:       DO 11 I = 1, IAX
0130:       DO 10 K = 1,3
0131:       DO 9 L=1,LAX(I,K)
0132:       IF(MAX(I,K,L).NE.0)SQA(J)=SQA(J)+SUM(I,J,K,L)**2/MAX(I,K,L)
0133:       IF(MAX(I,K,L).NE.0)SUMA(I,J,K)=SUMA(I,J,K)+(SUM(I,J,K,L)/MAX(I,K,L
0134:      1))
0135:       IF(MAX(I,K,L).NE.0)SUMAQ(I,J,K)=SUMAQ(I,J,K)+(SUM(I,J,K,L)/MAX(I,K
0136:      1,L))**2
0137:     9 CONTINUE
0138:       NN=AN(I,K)
0139:       IF(NN.NE.0)SQB(I,J,K)=SUM(I,J,K)**2/AN(I,K)
0140:       IF(LAX(I,K).NE.0)SAQ(I,J,K)=SUMA(I,J,K)**2/LAX(I,K)
0141:       IF(LAX(I,K).NE.0)AVER(I,J,K)=SUMA(I,J,K)/LAX(I,K)
0142:       IF(LAX(I,K).NE.1)VAR(I,J,K)=(SUMAQ(I,J,K)-SAQ(I,J,K))/(LAX(I,K)-1)
0143:       IF(LAX(I,K).NE.0)SE(I,J,K)=SQRT(VAR(I,J,K)/LAX(I,K))
0144:    10 SQC(J)=SQC(J)+SQB(I,J,K)
0145:       NN=BN(I)
0146:       IF(NN.NE.0)SQD(I,J)=SQD(I,J)+SUMK(I,J)**2/BN(I)
0147:    11 SQE(J)=SQE(J)+SQD(I,J)
0148:       DO 201 I=1,IAX
0149:       DO 209 K=1,KAX(I)
0150:       WRITE(6,203) I, SITE(K)
0151:   203 FORMAT (1H1,1X,5HPHASE,I3,5X,A10//)
0152:       DO 208 L=1,LAX(I,K)
0153:       WRITE (6,204) L,STAID(I,K,L),MAX(I,K,L)
0154:   204 FORMAT (/8H STATION,I4,3X,A13,2X,6HMAX = ,I3//2X,9HREPLICATE,40X,2
0155:      12HDENSITY FOR EACH TAXON//16X,4HNEMA,5X,4HPOLY,4X,4HOLIG,3X,4HGAST
0156:      2,2X,4HBIVL,5X,4HTANA,7X,4HAMPH,4X,4HISOP,2X,4HOTHR,6X,5HTOTAL,6X,4
0157:      3HCAPI,2X,4HNERE,2X,4HTEKA,5X,4HCORO//)
0158:   208 WRITE(6,207)(SUM(I,J,K,L),J=1,14),(SUMSQ(I,J,K,L),J=1,14)
0159:   207 FORMAT(/3X,3HSUM,4X,F9.0,F9.0,F8.0,2F6.0,2F11.0,2F7.0,F14.0,F7.0,2
0160:      1F6.0,F11.0/3X,5HSUMSQ,2X,F9.0,F9.0,F8.0,2F6.0,2F11.0,2F7.0,F14.0,F
0161:      27.0,2F6.0,F11.0//)
0162:   209 WRITE(6,210)(SUML(I,J,K),J=1,14),(SUMLS(I,J,K),J=1,14),(AVER(I,J,K
0163:      1),J=1,14),(VAR(I,J,K),J=1,14),(SE(I,J,K),J=1,14),(SQB(I,J,K),J=1,1
0164:      24),AN(I,K),ANS(I,K)
0165:   210 FORMAT(/2X,11HSITE TOTALS/3X,4HSUML,3X,F9.0,F9.0,F8.0,2F6.0,2F11.0
0166:      1,2F7.0,F14.0,F7.0,2F6.0,F11.0/3X,5HSUMLS,2X,F9.0,F9.0,F8.0,2F6.0,2
0167:      2F11.0,2F7.0,F14.0,F7.0,2F6.0,F11.0/3X,4HAVER,3X,F9.0,F9.0,F8.0,2F6
0168:      3.0,2F11.0,2F7.0,F14.0,F7.0,2F6.0,F11.0/3X,3HVAR,4X,F9.0,F9.0,F8.0,
0169:      42F6.0,2F11.0,2F7.0,F14.0,F7.0,2F6.0,F11.0/3X,2HSE,5X,F9.0,F9.0,F8.
0170:      50,2F6.0,2F11.0,2F7.0,F14.0,F7.0,2F6.0,F11.0/3X,3HSQB,4X,F9.0,F9.0,
0171:      6F8.0,2F6.0,2F11.0,2F7.0,F14.0,F7.0,2F6.0,F11.0/3X,2HAN,7X,F7.0/3X,
0172:      73HANS,6X,F7.0///)
0173:   201 WRITE(6,211)(SUMK(I,J),J=1,14),(SUMKS(I,J),J=1,14),(SQD(I,J),J=1,1
0174:      14),BN(I),BNS(I)
0175:   211 FORMAT(/2X,12HPHASE TOTALS//3X,4HSUMK,3X,2F9.0,F8.0,2F6.0,2F11.0,2
0176:      1F7.0,F14.0,F7.0,2F6.0,F11.0/3X,5HSUMKS,2X,2F9.0,F8.0,2F6.0,2F11.0,
0177:      22F7.0,F14.0,F7.0,2F6.0,F11.0/3X,3HSQD,4X,2F9.0,F8.0,2F6.0,2F11.0,2
0178:      3F7.0,F14.0,F7.0,2F6.0,F11.0/3X,2HBN,5X,F9.0/3X,3HBNS,4X,F9.0//)
0179:       DO 142 I = 1,IAX
0180:       DO 142 K = 1,3
```

```
0181:        WRITE(6,141) I, SITE(K)
0182:    141 FORMAT(1H1////5X,59HDENSITIES (PER 0.25 SQUARE METER) OF SELECTED
0183:       1TAXA IN PHASE,I2,24H PONAR SAMPLES FROM THE ,A14,5H SITE//)
0184:        WRITE(6,140)
0185:    140 FORMAT(//10X,5HTAXON,21X,4HMEAN,12X,8HVARIANCE,6X,14HSTANDARD ERRO
0186:       1R,3X,10HPROPORTION//)
0187:        DO 143 J = 1,14
0188:        IF (AVER(I,10,K).GE.0.0001) PROP = AVER(I,J,K)/AVER(I,10,K)
0189:    143 WRITE (6,144) SPECIE(J),AVER(I,J,K),VAR(I,J,K),SE(I,J,K),PROP
0190:    144 FORMAT (3X,A20,5X,F12.2,5X,F15.3,5X,F15.3,5X,F8.6)
0191:    142 CONTINUE
0192: C.....
0193: C.. THIS PROGRAM SEGMENT ESTIMATES THE NUMBER OF ADDITIONAL SAMPLES
0194: C.. WHICH MUST BE ANALIZED.
0195: C.....
0196:        WRITE (6,351)
0197:    351 FORMAT(1H1//2X,119HESTIMATED NUMBER OF SAMPLES REQUIRED TO DETECT
0198:       1A 51 PERCENT CHANGE IN FAUNAL DENSITY AT THE 95 PERCENT CONFIDENCE
0199:       2 LEVEL//)
0200:        JP = 10
0201:        DO 130 I= 1,IAX
0202:        DO 130 K = 1,3
0203:        LLAX = LAX(I,K)
0204:        IF((LLAX.GT.0).AND.(AVER(I,JP,K).GT.0.0001)) PERCH = ((SQRT(2.0/LL
0205:       1AX)*SE(I,JP,K)*TV(1,LLAX-1))/AVER(I,JP,K))*100.0
0206:        NAVER = AVER(I,JP,K)*1000.0
0207:        IF (NAVER .EQ. 0) GO TO 130
0208:        PARA = (2.0*VAR(I,JP,K))/((0.51*AVER(I,JP,K))**2)
0209:        CALL NSIZE (PARA,LLAX,NL,NLA,1)
0210:        WRITE(6,132)SPECIE(JP),I,SITE(K),LAX(I,K),NL,NLA
0211:    132 FORMAT(/2X,22HNUMBER OF SAMPLES FOR ,A20,10H IN PHASE ,I2,4H AT ,A
0212:       114,5H SITE,6X,9HOBSERVED ,I3,4X,9HREQUIRED ,I3,3H  (,I3,1H))
0213:        LLAX = LAX(I,K)
0214:        PARA = (2.0*VAR(I,JP,K))/((0.51*AVER(I,JP,K))**2)
0215:        CALL NSIZE (PARA,LLAX,NL,NLA,2)
0216:        WRITE (6,220) NL,NLA
0217:    220 FORMAT (4X,62HNUMBER OF SAMPLES REQUIRED AT THE 90 PERCENT CONFIDE
0218:       1NCE LEVEL ,I3,3H  (,I3,1H))
0219:        LLAX = LAX(I,K)
0220:        PARA = (2.0*VAR(I,JP,K))/((0.51*AVER(I,JP,K))**2)
0221:        CALL NSIZE (PARA,LLAX,NL,NLA,3)
0222:        WRITE (6,221) NL,NLA
0223:    221 FORMAT (4X,62HNUMBER OF SAMPLES REQUIRED AT THE 80 PERCENT CONFIDE
0224:       1NCE LEVEL ,I3,3H  (,I3,1H)/)
0225:        WRITE (6,240) PERCH
0226:    240 FORMAT (/2X,79HPERCENT CHANGE IN MEAN DENSITY DETECTABLE AT THE 95
0227:       1 PERCENT CONFIDENCE LEVEL = ,F10.6)
0228:        DO 131 L=1,LAX(I,K)
0229:        CV = 0.0
0230:        IF(MAX(I,K,L).EQ.0) GO TO 131
0231:        IF(MAX(I,K,L).NE.0) PEM = SUM(I,JP,K,L)/MAX(I,K,L)
0232:        IF(MAX(I,K,L).GT.1)PEV=(SUMSQ(I,JP,K,L)-(SUM(I,JP,K,L)**2/MAX(I,K,
0233:       1L)))/(MAX(I,K,L)-1)
0234:        IF(PEM.LT.0.0001) GO TO 131
0235:        CV = (PEV/PEM)*100.0
0236:        IF (MAX(I,K,L).EQ.1) CV = 0.0
0237:        IF(MAX(I,K,L).EQ.1) GO TO 610
0238:        PARK = (2.0*PEV)/((0.51*PEM)**2)
0239:        MMAX = MAX(I,K,L)
0240:        CALL NSIZE (PARK,MMAX,NM,NMA,1)
```

```
0241:        GO TO 611
0242:    610 NM=1
0243:        NMA=1
0244:    611 WRITE(6,133) L, STAID(I,K,L),MAX(I,K,L),NM,NMA,CV
0245:    133 FORMAT(5X,33HNUMBER OF SUBSAMPLES FOR STATION ,I3,3X,A13,6X,9HOBSE
0246:       1RVED ,I3,4X,9HREQUIRED ,I3,3H  (,I3,1H),7H  CV = ,F11.2)
0247:    131 CONTINUE
0248:        WRITE(6,74)
0249:     74 FORMAT (/2X,70H( ) = NUMBER OF ANALYSES REQUIRED IF ONLY TYPE I ER
0250:       1RORS ARE CONSIDERED/)
0251:    130 CONTINUE
0252:        CALL TRINES(IAX,TN)
0253:    903 CONTINUE
0254:        END
```

```
0001:       BLOCK DATA
0002:        COMMON/C/SPECIE(14),SITE(4),STAID(4,4,20)
0003:       CHARACTER SPECIE*20,SITE*14,STAID*13
0004:       DATA SPECIE/"NEMATODA","POLYCHAETA","OLIGOCHAETA","GASTROPODA","BI
0005:      1VALVIA","TANAIDACEA","AMPHIPODA","ISOPODA","OTHER SPECIES","TOTAL
0006:      2ANIMALS","CAPITELLA CAPITATA","NEREIDAE","TEXADINA SPHINCTOSOM","C
0007:      3OROPHIUM LOUISIANUM"/
0008:       DATA SITE/"AFFECTED AREA","EAST CONTROL","WEST CONTROL","OTHER ARE
0009:      1AS"/
0010:       DATA (STAID(1,1,L),L=1,13)/"3-30-B (116)","3-30-B (173)","4-30-B (
0011:      1175)","4-30-B (176)","6-30-B (185)","5-30-B (181)","5-30-B (183)",
0012:      2"6-30-B (187)","2-30-B (6)","3-30-B (172)","5-30-B (182)","5-30-B
0013:      3(180)","1-30-B (5)"/
0014:       DATA (STAID(1,2,L),L=1,10)/"14-3-B (296)","15-3-B (302)","15-3-B (
0015:      1303)","17-3-B (306)","14-3-B (309)","15-3-B (395)","16-3-B (410)",
0016:      2"15-3-B (411)","16-3-B (299)","17-3-B (400)"/
0017:       DATA (STAID (1,3,L),L=1,18)/"10-30-3 (190)","10-30-B (206)","10-30
0018:      2-B (209)","10-3-B (298)","12-3-B (304)","13-3-B (305)","10-3-B (30
0019:      38)","10-3-B (310)","11-3-B (396)","11-3-B (398)","13-3-B (401)","1
0020:      42-3-B (402)","13-3-B (403)","11-3-B (404)","11-3-B (405)","13-3-B
0021:      5(407)","12-3-B (408)","11-3-B (409)"/
0022:       DATA (STAID(4,4,L),L=1,10)/"4-B (1826)","30-12-C(1728)","9-1-C (18
0023:      124)","9-2-C (1825)","10-3-C (1829)","30-15-C(1830)","9-11-C (1831)
0024:      2","30-2-C (1832)","30-13-C(1828)","9-10-B (1730)"/
0025:       DATA (STAID(4,2,L),L=1,13)/"BL-26 (1757)","BL-27 (1758)","BL-28 (1
0026:      1759)","BL-18 (1707)","BL-20 (1751)","BL-23 (1754)","BL-22 (1753)",
0027:      2"BL-31 (1762)","BL-19 (1708 )","BL-21 (1752)","BL-25 (1756)","BL-1
0028:      37 (1706)","BL-24 (1755)"/
0029:       DATA (STAID(4,3,L),L=1,4)/"BL-35 (1918)","BL-36 (1819)","BL-37 (18
0030:      120)","BL-39 (1822)"/
0031:       DATA (STAID(4,1,L),L=1,13)/"BL-6 (1531)","BL-7 (1632)","BL-11 (163
0032:      16)","BL-14 (1703)","BL-15 (1704)","BL-16 (1705)","BL-2 (1571)","BL
0033:      2-4 (1637)","BL-13 (1702)","BL-1 (1570)","BL-5 (1630)","BL-12 (1701
0034:      3)","BL-3 (1572)"/
0035:       DATA (STAID(2,1,L),L=1,12)/"BL-4 (654)","BL-7 (667)","BL-8 (668)",
0036:      1"BL-13 (673)","BL-15 (675)","BL-16 (772)","BL-1 (661)","BL-2 (662)
0037:      2","BL-6 (666)","BL-9 (669)","BL-10 (670)","BL-11 (671)"/
0038:       DATA (STAID(2,2,L),L=1,8)/"BL-18 (730)","BL-20 (732)","BL-22 (734)
0039:      1","BL-19 (731)","BL-21 (733)","BL-25 (742)","BL-27 (743)","BL-28 (
0040:      2744)"/
0041:       DATA (STAID(2,3,L),L=1,6)/"BL-35 (904)","BL-42 (911)","BL-36 (905)
0042:      1","BL-40 (909)","BL-41 (910)","BL-38 (907)"/
0043:       DATA (STAID(3,1,L),L=1,8)/"BL-5 (1146)","BL-11 (1152)","BL-14 (115
0044:      15)","BL-16 (1157)","BL-3 (1144)","BL-8 (1149)","BL-4 (1145)","BL-1
0045:      23 (1154)"/
0046:       DATA (STAID(3,2,L),L=1,13)/"BL-32 (1440)","BL-40 (1448)","BL-31 (1
0047:      1439)","BL-33 (1441)","BL-38 (1446)","BL-36 (1444)","BL-27 (1435)",
0048:      2"BL-25 (1433)","BL-29 (1437)","BL-35 (1443)","BL-28 (1436)","BL-35
0049:      3 (1443)","BL-30 (1438)"/
0050:       DATA (STAID(3,3,L),L=1,4)/"BL-20 (1338)","BL-23 (1341)","BL-21 (13
0051:      139)","BL-22 (1340)"/
0052:       DATA (STAID(3,4,L),L=1,7)/"9-11-C (1346)","30-12-C(1347)","30-15-C
0053:      1(1348)","6-2-B (1431)","9-2-B (1432)","9-1-C (1343)","9-2-C (1344)
0054:      2"/
0055:       END
```

```
0001:       SUBROUTINE NSIZE(PARM,NOBS,NEST,NESTA,W)
0002:       COMMON/D/TV(3,34)
0003:       INTEGER W
0004:       IF (NOBS.LE.1) RETURN
0005:       KOUNT=1
0006:       NOBS = NOBS - 1
0007:       NKA=NOBS
0008:       IF(NOBS.LE.30)601,602
0009:   601 NEST = ((2.0*TV(W,NOBS))**2*PARM+1.0)
0010:       NESTA = (TV(W,NKA)**2*PARM+1.0)
0011:       IF(KOUNT.GT.1) RETURN
0012:       IF (NESTA.LE.NOBS) RETURN
0013:       KOUNT=2
0014:       NOBS=NEST
0015:       NKA=NESTA
0016:       IF (NOBS.LE.1) RETURN
0017:       IF(NOBS.LE.30) 603,602
0018:   603 NEST = ((2.0*TV(W,NOBS))**2*PARM+1.0)
0019:       IF(NKA.LE.30) 604,605
0020:   604 NESTA = (TV(W,NKA)**2*PARM+1.0)
0021:       RETURN
0022:   602 IF (NOBS.LE.1) RETURN
0023:       IF(NOBS.LT.40) EST = (2.0*TV(W,30))**2*PARM
0024:       IF((NOBS.GE.40).AND.(NOBS.LT.60)) EST = (2.0*TV(W,31))**2*PARM
0025:       IF((NOBS.GE.60).AND.(NOBS.LT.120)) EST=(2.0*TV(W,32))**2*PARM
0026:       IF(NOBS.EQ.120) EST = (2.0*TV(W,33))**2*PARM
0027:       IF(NOBS.GT.120) EST = (2.0*TV(W,34))**2*PARM
0028:       NEST=EST + 1.0
0029:       IF(NKA.LE.1) RETURN
0030:       IF(NKA.LE.30) GO TO 604
0031:   605 IF(NKA.LE.1) RETURN
0032:       IF(NKA.LT.40) ESTA = TV(W,30)**2*PARM
0033:       IF((NKA.GE.40).AND.(NKA.LT.60))ESTA = TV(W,31)**2*PARM
0034:       IF((NKA.GE.60).AND.(NKA.LT.120))ESTA = TV(W,32)**2*PARM
0035:       IF(NKA.EQ.120) ESTA = TV(W,33)**2*PARM
0036:       IF(NKA.GT.120) ESTA = TV(W,34)**2*PARM
0037:       NESTA=ESTA+1.0
0038:       IF(KOUNT.GT.1) RETURN
0039:       KOUNT=2
0040:       NOBS=NEST
0041:       NKA=NESTA
0042:       IF(NOBS.LE.30) 603,602
0043:   600 CONTINUE
0044:       RETURN
0045:       END
```

```
0001:       SUBROUTINE TRINES(IAX,TN)
0002: C...........
0003: C.. THIS SUBROUTINE CALCULATES THREE-LEVE. ANALYSES OF VARIANCE.
0004: C...........
0005:       COMMON MAX(4,4,20),LAX(4,4),KAX(4),GRAND(14),GRAS(14),SQA(14),
0006:      1SQC(14),SQE(14),AN(4,4),ANS(4,4),BN(4),BNS(4)
0007:        COMMON/C/SPECIE(14),SITE(4),STAID(4,4,20)
0008:       DIMENSION ANOV(5,5),SAN(4)
0009:       CHARACTER SPECIE*20,SITE*14
0010:       DO 17 J = 2,10
0011:       KAXA=0
0012:       LAXA=0
0013:       MAXA=0
0014:       MAXB=0
0015:       MAXSQ=0
0016:       AMAXE=0.0
0017:       AMAXD=0.0
0018:       AMAXI=0.0
0019:       AMAXO=0.0
0020:       ANOV(5,1) = 0.0
0021:       ANOV(5,2) = 0.0
0022:       CT=GRAND(J)**2/TN
0023:       SST=GRAS(J)-CT
0024:       SSG=SQE(J)-CT
0025:       SSS=SQC(J)-SQE(J)
0026:       SUB=SQA(J)-SQC(J)
0027:       SSW=GRAS(J)-SQA(J)
0028:       ANOV(1,1)=IAX-1
0029:       ANOV(1,5)=TN-1.0
0030:       DO 13 I=1,IAX
0031:       SAN(I)=0.0
0032:       KAXA=KAXA+KAX(I)
0033:       DO 13 K = 1,3
0034:       DO 12 L=1,LAX(I,K)
0035:    12 MAXA=MAXA+MAX(I,K,L)
0036:    13 LAXA=LAXA+LAX(I,K)
0037:       ANOV(1,2)=KAXA-IAX
0038:       ANOV(1,3)=LAXA-KAXA
0039:       ANOV(1,4)=MAXA-LAXA
0040:       ANOV(2,1)=SSG
0041:       ANOV(2,2)=SSS
0042:       ANOV(2,3)=SUB
0043:       ANOV(2,4)=SSW
0044:       ANOV(2,5) = SST
0045:       DO 14 N=1,4
0046:       NN=ANOV(1,N)
0047:    14 IF(NN.NE.0)ANOV(3,N)=ANOV(2,N)/ANOV(1,N)
0048:       NN=ANOV(3,4)*10000.0
0049:       IF(NN.NE.0)ANOV(4,3)=ANOV(3,3)/ANOV(3,4)
0050:       DO 16 I=1,IAX
0051:       DO 15 K = 1,3
0052:       MAXB=MAXB+AN(I,K)**2
0053:       MAXSQ=MAXSQ+ANS(I,K)
0054:       NN=AN(I,K)
0055:    15 IF(NN.NE.0)AMAXE=AMAXE+ANS(I,K)/AN(I,K)
0056:       AMAXD=AMAXD+BN(I)**2
0057:       NN=BN(I)
0058:       IF(NN.NE.0)AMAXI=AMAXI+BNS(I)/BN(I)
0059:       DO 20 KK = 1,3
0060:    20 SAN(I)=SAN(I)+AN(I,KK)**2
```

```
0061:    16 IF(NN.NE.0)AMAXO=AMAXO+SAN(I)/BV(I)
0062:       NN=ANOV(1,1)*10000.0
0063:       IF(NN.NE.0)ANPPO=(AMAXI-MAXSQ/TN)/ANOV(1,1)
0064:       IF(NN.NE.0)ANCP=(AMAXO-MAXB/TN)/ANOV(1,1)
0065:       IF(NN.NE.0)ANCB=(TN-AMAXO/TN)/ANOV(1,1)
0066:       NA=ANOV(1,2)*10000.0
0067:       IF(NA.NE.0)ANPO=(AMAXE-AMAXI)/ANOV(1,2)
0068:       IF(NA.NE.0)ANCO=(TN-AMAXO)/ANOV(1,2)
0069:       NB=ANOV(1,3)*10000.0
0070:       IF(NB.NE.0)ANO=(TN-AMAXE)/ANOV(1,3)
0071:       NC=ANO*10000.0
0072:       IF(NC.NE.0)BOV=(ANOV(3,3)-ANOV(3,4))/ANO
0073:       NO=ANCO*10000.0
0074:       IF(ND.NE.0) BOVA=(ANOV(3,2)-ANOV(3,4)-ANPO*BOV)/ANCO
0075:       NE=ANCB*10000.0
0076:       IF(NE.NE.0)BOVB=(ANOV(3,1)-ANOV(3,4)-(ANPPO*BOV)-(ANCP*BOVA))/ANCB
0077:       BOVC=ANOV(3,4)+(ANPO*BOV)
0078:       NATE = ANOV(3,4)*10000.0
0079:       IF(NATE.EQ.0) BOVC = 0.0
0080:       NN=BOVC*10000.0
0081:       IF(NN.NE.0)ANOV(4,2)=ANOV(3,2)/BOVC
0082:       NN=ANOV(1,4)*10000.0
0083:       IF(NC.NE.0)21,22
0084:    21 IF(NN.NE.0)TEM=(((1.0-ANPO/ANO)*ANOV(3,4))**2/ANOV(1,4))
0085:       NN=ANOV(1,3)*10000.0
0086:       IF(NN.NE.0)TEMA=((ANPO/ANO)*ANOV(3,3))**2/ANOV(1,3)
0087:    22 TEM=TEM+TEMA
0088:       IF((NC.EQ.0).OR.(NN.EQ.0)) TEM = 0.0
0089:       NN=TEM*10000.0
0090:       IF(NN.NE.0)ANOV(5,2)=BOVC**2/TEM
0091:       BOVE=ANOV(3,4)+(ANPPO*BOV)+(ANCP*BOVA)
0092:       IF(NATE.EQ.0) BOVE = 0.0
0093:       NN=BOVE*10000.0
0094:       IF(NN.NE.0)ANOV(4,1)=ANOV(3,1)/BOVE
0095:       NN=ANCO*ANO*10000.0
0096:       IF(NN.NE.0)BANO=(ANCP*ANPO)/(ANCO*ANO)
0097:       N12=ANOV(1,2)*10000.0
0098:       IF(ND.NE.0)23,24
0099:    23 IF(N12.NE.0)TEM=(((ANCP/ANCO)*ANOV(3,2))**2/ANOV(1,2))
0100:       GO TO 25
0101:    24 TEM=0.0
0102:    25 N13 = ANOV(1,3)*10000.0
0103:       IF(NC.NE.0)26,27
0104:    26 IF(N13.NE.0)TEMH=((ANPPO/ANO-BANO)*ANOV(3,3))**2/ANOV(1,3)
0105:    27 IF(NC.NE.0)TEMM=1.0-(ANPPO/ANO)
0106:       IF(ND.NE.0)TEML=ANCP/ANCO
0107:       N14 = ANOV(1,4)*10000.0
0108:       IF(N14.NE.0)TEMP=((TEMM-TEML*BANO)*ANOV(3,4))**2/ANOV(1,4)
0109:       TEM=TEM+TEMP+TEMH
0110:       IF((N12.EQ.0).OR.(N13.EQ.0).OR.(N14.EQ.0)) TEM = 0.0
0111:       NN=TEM*10000.0
0112:       IF(NN.NE.0)ANOV(5,1)=BOVE**2/TEM
0113:       ITEM=ANOV(5,1)+0.5
0114:       ANOV(5,1)=ITEM
0115:       ITEM=ANOV(5,2)+0.5
0116:       ANOV(5,2)=ITEM
0117:       WRITE(6,30) SPECIE(J)
0118:    30 FORMAT(1H1////34X,53HTHREE WAY NESTED ANALYSIS OF VARIANCE FOR BLA
0119:      1CK LAKE ,A20//25X,19HSOURCE OF VARIATION,7X,2HDF,9X,15HSUMS OF SQU
0120:      2ARES,9X,11HMEAN SQUARE,7X,7HF RATIO,7X,2HDF///)
```

```
0121:       WRITE(6,32)((ANOV(K,L),K=1,5),L=1,5)
0122:    32 FORMAT(25X,12HAMONG PHASES,13X,F4.0,1X,E22.12,2X,E22.12,3X,F9.2,3X
0123:      1,F7.0//25X,11HAMONG SITES,14X,F4.0,1X,E22.12,2X,E22.12,3X,F9.2,3X,
0124:      2F7.1//25X,14HAMONG STATIONS,11X,F4.0,1X,E22.12,2X,E22.12,3X,F9.2,3
0125:      3X,F7.0//25X,15HWITHIN STATIONS,10X,F4.0,1X,F22.1,2X,F22.1,3X,F9.2,
0126:      43X,F7.0//25X,5HTOTAL,20X,F4.0,1X,F22.0,2X,F22.1,3X,F9.2,3X,F7.0//)
0127:       N11 = ANOV(1,1)
0128:       N51 = ANOV(5,1)
0129:       IF(N51.EQ.0) N51 = ANOV(1,2)
0130:       WRITE(6,163) ANOV(4,1),N11,N51
0131:   163 FORMAT(25X,22HCRITICAL VALUE OF F = ,F7.2,10H FOUND AT ,I2,2H, ,I2
0132:      1,19H DEGREES OF FREEDOM//)
0133:    17 CONTINUE
0134:       RETURN
0135:       END
0136:
```

```
0137:       PROGRAM MARSH(INPUT, OUTPUT,TAPE6=OUTPUT,TAPE5=INPUT)
0138: C.............
0139: C.. THIS PROGRAM ANALYZES MARSH BENTHIC DATA.
0140: C.............
0141:       COMMON MAX(4,4,17),LAX(4,4),KAX(4),GRAND(17),GRAS(17),SQA(17),
0142:      1SQC(15),SQE(15),AN(4,4),ANS(4,4),BN(4),BNS(4)
0143:       COMMON/C/SPECIE(18),SITE(4)
0144:       COMMON/A/STAIC(4,4,20)
0145:       CHARACTER SPECIE*20,SITE*14,STAID*13
0146:       COMMON/D/TV(3,34)
0147:       DIMENSION BOG(18),SUM(4,18,4,17),SUMSQ(4,12,4,17),
0148:      1SUML(4,12,4),SUMLS(4,12,4),SUMK(4,12),SUMKS(4,12),SQB(4,12,4),
0149:      2SQD(4,12),AVER(4,18,4),VAR(4,18,4),SE(4,18,4)
0150:       DIMENSION SUMA(4,18,4),SUMAQ(4,18,4),SAQ(4,12,4)
0151:       DIMENSION DUM(11), BIG(4,12,4,17)
0152:       DIMENSION SS(16),SST(16),T(16),TQ(16),NT(16),TC(16),SA(16)
0153:       EQUIVALENCE (BIG,SE)
0154:       INTEGER W
0155:       DATA (TV(1,I),I=1,34)/12.706,4.303,3.182,2.776,2.571,2.447,2.365,2
0156:      1.306,2.262,2.228,2.201,2.179,2.16,2.145,2.131,2.12,2.11,2.101,2.09
0157:      23,2.086,2.08,2.074,2.069,2.064,2.06,2.056,2.052,2.048,2.045,2.042,
0158:      32.021,2.0,1.98,1.96/
0159:       DATA (TV(2,I),I=1,34)/6.314,2.92,2.353,2.132,2.015,1.943,1.895,1.8
0160:      16,1.833,1.812,1.796,1.782,1.771,1.761,1.753,1.746,1.74,1.734,1.729
0161:      2,1.725,1.721,1.717,1.714,1.711,1.709,1.706,1.703,1.701,1.699,1.697
0162:      3,1.684,1.671,1.658,1.645/
0163:       DATA (TV(3,I),I=1,34)/3.078,1.886,1.638,1.533,1.476,1.44,1.415,1.3
0164:      197,1.383,1.372,1.363,1.356,1.35,1.345,1.341,1.337,1.333,1.33,1.328
0165:      2,1.325,1.323,1.321,1.319,1.318,1.316,1.315,1.314,1.313,1.311,1.31,
0166:      31.303,1.296,1.289,1.282/
0167:       WRITE (6,241)
0168:   241 FORMAT (1H1,30X,54HDENSITY (PER 0.25 SQUARE METER) OF MARSH BENTHI
0169:      1C FAUNA//1X,5HPHASE,5X,4HSITE,8X,8HSTATION/,6X,8HNEMATODA,7X,11HOL
0170:      2IGOCHAETA,6X,8HBIVALVIA,8X,9HAMPHIPODA,9X,5HMISC./24X,6HSAMPLE,14X
0171:      3,10HPOLYCHAETA,6X,10HGASTROPODA,6X,10HTANAIDACEA,7X,7HISOPODA,15X,
0172:      45HTOTAL//)
0173:     1 READ (5,2) I,K,L,M,(DUM(J),J=1,11)
0174:     2 FORMAT (2I1,2I2,9F5.0,5X,F3.0,14X,F4.0)
0175:       IF (I.EQ.0) GO TO 343
0176:       IF (L.GT.17) WRITE (6,270) I,K
0177:   270 FORMAT (/3X,32HTOO MANY SAMPLES FOUND AT PHASE ,I2,5H SITE,I2)
0178:       IF (L.GT.17) GO TO 1
0179:       IF(M-25)101,102,1
0180:   101 DO 104 J=1,9
```

```
0181:   104 HOG(J) = DUM(J)
0182:       BOG(10) = 0.0
0183:       BOG(11) = DUM(10)
0184:       BOG(12) = DUM(11)
0185:       IF(M.GT.MAX(I,K,L)) MAX(I,K,L)=M
0186:       GO TO 105
0187:   102 DO 106 J = 1,9
0188:   106 BIG(I,J,K,L) = DUM(J)
0189:       BIG(I,11,K,L) = DUM(10)
0190:       BIG(I,12,K,L) = DUM(11)
0191:       IF (I.LE.1) GO TO 1
0192:       DO 277 J = 1,12
0193:   277 BIG(I,J,K,L) = BIG(I,J,K,L)*4.0
0194:       GO TO 1
0195:   105 CONTINUE
0196:       IF(L.GT.LAX(I,K)) LAX(I,K)=L
0197:       IF(K.GT.KAX(I)) KAX(I)=K
0198:       IF(I.GT.IAX) IAX=I
0199:       IF (IAX.GT.4) WRITE (6,271)
0200:   271 FORMAT (/3X,21HTOO MANY PHASES FOUND)
0201:       IF (IAX.GT.4) IAX = 4
0202:       DO 3 J = 2,9
0203:     3 BOG(10) = BOG(10) + BOG(J)
0204:       BOG(10) = BOG(10) - BOG(12)
0205:       DO 6 J = 1,12
0206:       IF(I.GT.1) GO TO 5
0207:       IF((I.EQ.1).AND.(K.EQ.2)) GO TO 344
0208:       GO TO 345
0209:   344 IF((L.GT.1).AND.(L.LT.5)) GO TO 9
0210:   345 CONTINUE
0211:       IF((I.EQ.1).AND.(K.EQ.3).AND.(L.EQ.5)) GO TO 9
0212:       BOG(J) = BOG(J)*24.0
0213:       GO TO 9
0214:     5 BOG(J) = BOG(J)*96.0
0215:     9 CONTINUE
0216:       IF(J.LE.10) SUM(I,J,K,L) = SUM(I,J,K,L) + BOG(J)
0217:       IF(J.LE.10) SUMSQ(I,J,K,L) = SUMSQ(I,J,K,L) + BOG(J)**2
0218:       IF(J.LE.10) GRAND(J) = GRAND(J) + BOG(J)
0219:       IF(J.LE.10) GRAS(J) = GRAS(J) + BOG(J)**2
0220:     6 CONTINUE
0221:       WRITE (6,242) I,SITE(K),STAID(I,K,L),(BOG(JJJ),JJJ=1,10)
0222:   242 FORMAT (3X,I1,2X,A14,1X,A13,3X,9F8.2,F10.2)
0223:       GO TO 1
0224:   343 CONTINUE
0225:       DO 4 I=1,IAX
0226:       IF (KAX(I).GT.4) WRITE (6,272) I
0227:   272 FORMAT(/3X,29HTOO MANY SITES FOUND IN PHASE,I3)
0228:       IF (KAX(I).GT.4) KAX(I) = 4
0229:       DO 4 K=1,KAX(I)
0230:       IF (LAX(I,K).GT.17) WRITE (6,273) I,K
0231:   273 FORMAT (/3X,32HTOO MANY STATIONS FOUND IN PHASE,I3,8H AT SITE,I3)
0232:       IF (LAX(I,K).GT.17) LAX(I,K) = 17
0233:       DO 4 L=1,LAX(I,K)
0234:       DO 108 J=1,9
0235:   108 BIG(I,10,K,L) = BIG(I,10,K,L) + BIG(I,J,K,L)
0236:       IF(MAX(I,K,L).GT.24) WRITE (6,274) I,K,L
0237:   274 FORMAT (/3X,34HTOO MANY REPLICATES FOUND IN PHASE,I3,8H AT SITE,I3
0238:      1,11H IN STATION,I3)
0239:     4 CONTINUE
0240:       IF(MAX(I,K,L).GT.24) MAX(I,K,L) = 24
```

```
0241:       DO 8 J = 1,12
0242:       DO 8 I = 1,IAX
0243:       DO 8 K = 1,KAX(I)
0244:       DO 7 L=1,LAX(I,K)
0245:       SUML(I,J,K)=SUML(I,J,K)+SUM(I,J,K,L)
0246:       IF(MAX(I,K,L).GT.1)SUM(I,J,K,L)=SUM(I,J,K,L)+(BIG(I,J,K,L)*(MAX(I,
0247:      1K,L)/24.0))
0248:       IF(MAX(I,K,L).EQ.1)SUM(I,J,K,L)=SUM(I,J,K,L)+BIG(I,J,K,L)
0249:     7 SUMLS(I,J,K)=SUMLS(I,J,K)+SUMSQ(I,J,K,L)
0250:       SUMK(I,J)=SUMK(I,J)+SUML(I,J,K)
0251:     8 SUMKS(I,J)=SUMKS(I,J)+SUMLS(I,J,K)
0252:       DO 91 I = 1,IAX
0253:       DO 91 K = 1,KAX(I)
0254:       DO 91 L = 1, LAX(I,K)
0255:       AN(I,K)=AN(I,K)+MAX(I,K,L)
0256:       ANS(I,K)=ANS(I,K)+MAX(I,K,L)**2
0257:       TN=TN+MAX(I,K,L)
0258:       BN(I)=BN(I)+MAX(I,K,L)
0259:    91 BNS(I) = BNS(I) +MAX(I,K,L)**2
0260:       DO 11 J = 1,18
0261:       DO 11 I = 1, IAX
0262:       DO 10 K=1,KAX(I)
0263:       DO 90 L=1,LAX(I,K)
0264:       IF(J.EQ.1) GO TO 75
0265:       IF (J.GT.12) GO TO 360
0266:       IF(MAX(I,K,L).EQ.1)SQA(J)=SQA(J)+(SUM(I,J,K,L)-BIG(I,J,K,L))**2/MA
0267:      1X(I,K,L)
0268:       IF(MAX(I,K,L).GT.1)SQA(J)=SQA(J)+(SUM(I,J,K,L)-(BIG(I,J,K,L)+(MAX(
0269:      1I,K,L)/24.0)))**2/MAX(I,K,L)
0270:   360 IF(MAX(I,K,L).NE.0)SUMA(I,J,K)=SUMA(I,J,K)+(SUM(I,J,K,L)/MAX(I,K,L
0271:      1))
0272:       IF(MAX(I,K,L).NE.0)SUMAQ(I,J,K)=SUMAQ(I,J,K)+(SUM(I,J,K,L)/MAX(I,K
0273:      1,L))**2
0274:       GO TO 90
0275:    75 IF(MAX(I,K,L).LE.1) GO TO 90
0276:       SQA(1)=SQA(1)+SUM(I,1,K,L)**2/2.0
0277:       SUMA(I,1,K)=SUMA(I,1,K)+SUM(I,1,K,L)/2.0
0278:       SUMAQ(I,1,K)=SUMAQ(I,1,K) + (SUM(I,1,K,L)/2.0)**2
0279:    90 CONTINUE
0280:       IF (J.GT.12) GO TO 361
0281:       NN=AN(I,K)
0282:       IF((NN.NE.0).AND.(J.GE.2)) SQB(I,J,K)=SUML(I,J,K)**2/AN(I,K)
0283:       IF(J.EQ.1) SQB(I,1,K)=SUML(I,1,K)**2/2.0
0284:       IF(LAX(I,K).NE.0)SAQ(I,J,K)=SUMA(I,J,K)**2/LAX(I,K)
0285:   361 IF(LAX(I,K).NE.0)AVER(I,J,K)=SUMA(I,J,K)/LAX(I,K)
0286:       IF(LAX(I,K).NE.1)VAR(I,J,K)=(SUMAQ(I,J,K)-SAQ(I,J,K))/(LAX(I,K)-1)
0287:       IF((VAR(I,J,K).LE.0.0).OR.(LAX(I,K).LE.0)) GO TO 10
0288:       IF(LAX(I,K).NE.0)SE(I,J,K)=SQRT(VAR(I,J,K)/LAX(I,K))
0289:    10 SQC(J)=SQC(J)+SQB(I,J,K)
0290:       NN=BN(I)
0291:       IF(NN.NE.0)SQD(I,J)=SQD(I,J)+SUMK(I,J)**2/BN(I)
0292:       SQE(J)=SQE(J)+SQD(I,J)
0293:    11 CONTINUE
0294:       DO 201 I=1,IAX
0295:       DO 209 K=1,KAX(I)
0296:       WRITE(6,203) I, SITE(K)
0297:   203 FORMAT (1H1,1X,5HPHASE,I3,5X,A14/)
0298:       DO 208 L=1,LAX(I,K)
0299:       WRITE (6,204) L,STAID(I,K,L),MAX(I,K,L)
0300:   204 FORMAT (/8H STATION,I4,3X,A13,2X,6HMAX = ,I3//2X,9HREPLICATE,49X,2
```

```
0301:       12HDENSITY FOR EACH TAXON//16X,4HNEMA,5X,4HPOLY,4X,4HOLIG,3X,4HGAST
0302:      2,2X,4HBIVL,5X,4HTANA,7X,4HAMPH,4X,4HISOP,2X,4HOTHR,6X,5HTOTAL,6X,4
0303:      3HCAPA,7X,4HCOPE/)
0304:       WRITE(6,110) (BIG(I,N,K,L),N=1,12)
0305:   110 FORMAT(4X,5HLARGE,4X,F8.0,F9.0,F8.0,2F6.0,2F11.0,2F6.0,F14.0,F6.0,
0306:      1F11.0)
0307:   208 WRITE(6,207)(SUM(I,N,K,L),N=1,12),(SUMSQ(I,N,K,L),N=1,12)
0308:   207 FORMAT(/5X,3HSUM,5X,F8.0,F9.0,F8.0,2F6.0,2F11.0,2F6.0,F14.0,F6.0,F
0309:      111.0/5X,5HSUMSQ,3X,F8.0,F9.0,F8.0,2F6.0,2F11.0,2F6.0,F14.0,F6.0,F1
0310:      21.0)
0311:   209 WRITE(6,210)(SUML(I,N,K),N=1,12),(SUMLS(I,N,K),N=1,12),(AVER(I,N,K
0312:      1),N=1,12),(VAR(I,N,K),N=1,12),(SE(I,N,K),N=1,12),(SQB(I,N,K),N=1,1
0313:      22),AN(I,K),ANS(I,K),(SUMA(I,N,K),N=1,10)
0314:   210 FORMAT(/2X,11HSITE TOTALS/5X,4HSUML,4X,F8.0,F9.0,F8.0,2F6.0,2F11.0
0315:      1,2F6.0,F14.0,F6.0,F11.0/5X,5HSUMLS,3X,F8.0,F9.0,F8.0,2F6.0,2F11.0,
0316:      22F6.0,F14.0,F6.0,F11.0/5X,4HAVER,4X,F8.0,F9.0,F8.0,2F6.0,2F11.0,2F
0317:      36.0,F14.0,F6.0,F11.0/5X,3HVAR,5X,F8.0,F9.0,F8.0,2F6.0,2F11.0,2F6.0
0318:      4,F14.0,F6.0,F11.0/5X,2HSE,6X,F8.0,F9.0,F8.0,2F6.0,2F11.0,2F6.0,F14
0319:      5.0,F6.0,F11.0/5X,3HSQB,5X,F8.0,F9.0,F8.0,2F6.0,2F11.0,F6.0,F7.0,F1
0320:      63.0,F6.0,F11.0/5X,2HAN,7X,F7.0/5X,3HANS,6X,F7.0/5X,4HSUMA,4X,F8.0,
0321:      7F9.0,F8.0,2F6.0,2F11.0,2F6.0,F14.0///)
0322:   201 WRITE(6,211)(SUMK(I,N),N=1,10),(SUMKS(I,N),N=1,10),(SQD(I,N),N=1,1
0323:      10),BN(I),BNS(I)
0324:   211 FORMAT(/2X,12HPHASE TOTALS//3X,4HSUMK,3X,2F9.0,F8.0,2F6.0,2F11.0,2
0325:      1F7.0,F14.0/3X,5HSUMKS,2X,2F9.0,F8.0,2F6.0,2F11.0,2F7.0,F14.0/3X,3H
0326:      2SQD,4X,2F9.0,F8.0,2F6.0,2F11.0,2F7.0,F14.0/3X,2HBN,5X,F9.0/3X,3HBN
0327:      3S,4X,F9.0//)
0328:       DO 142 I = 1,IAX
0329:       DO 142 K = 1,KAX(I)
0330:       WRITE(6,141) I, SITE(K)
0331:   141 FORMAT(1H1////5X,59HDENSITIES (PER 0.25 SQUARE METER) OF SELECTED
0332:      1TAXA IN PHASE,I2,24H MARSH SAMPLES FROM THE ,A14,5H SITE//)
0333:       WRITE(6,140)
0334:   140 FORMAT(//10X,5HTAXON,21X,4HMEAN,12X,8HVARIANCE,6X,14HSTANDARD ERRO
0335:      1R,3X,10HPROPORTION//)
0336:       DO 143 J = 1,18
0337:       PROP = AVER(I,J,K)/AVER(I,10,K)
0338:   143 WRITE(6,144) SPECIE(J),AVER(I,J,K),VAR(I,J,K),SE(I,J,K),PROP
0339:   144 FORMAT (3X,A20,5X,F12.2,5X,F15.3,5X,F15.3,5X,F8.6)
0340:   142 CONTINUE
0341:       WRITE (6,351)
0342:   351 FORMAT(1H1//2X,119HESTIMATED NUMBER OF SAMPLES REQUIRED TO DETECT
0343:      1A 51 PERCENT CHANGE IN FAUNAL DENSITY AT THE 95 PERCENT CONFIDENCE
0344:      2 LEVEL//)
0345:       JP = 10
0346:       DO 130 I= 1,IAX
0347:       DO 130 K=1,KAX(I)
0348:       LLAX = LAX(I,K)
0349:       IF((LLAX.GT.0).AND.(AVER(I,JP,K).GT.0.0001)) PERCH = ((SQRT(2.0/LL
0350:      1AX)*SE(I,JP,K)*TV(1,LLAX-1))/AVER(I,JP,K))*100.0
0351:       NAVER = AVER(I,JP,K)*1000.0
0352:       IF (NAVER .EQ. 0) GO TO 130
0353:       PARA = (2.0*VAR(I,JP,K))/((0.51*AVER(I,JP,K))**2)
0354:       CALL NSIZE (PARA,LLAX,NL,NLA,1)
0355:       WRITE(6,132)SPECIE(JP),I,SITE(K),LAX(I,K),NL,NLA
0356:   132 FORMAT(/2X,22HNUMBER OF SAMPLES FOR ,A20,10H IN PHASE ,I2,4H AT ,A
0357:      114,5H SITE,6X,9HOBSERVED ,I3,4X,9HREQUIRED ,I3,3H  (,I3,1H))
0358:       LLAX = LAX(I,K)
0359:       PARA = (2.0*VAR(I,JP,K))/((0.51*AVER(I,JP,K))**2)
0360:       CALL NSIZE (PARA,LLAX,NL,NLA,2)
```

```
0361:       WRITE (6,220) NL,NLA
0362:   220 FORMAT (4X,62HNUMBER OF SAMPLES REQUIRED AT THE 90 PERCENT CONFIDE
0363:      1NCE LEVEL ,I3,3H  (,I3,1H))
0364:       LLAX = LAX(I,K)
0365:       PARA = (2.0*VAR(I,JP,K))/((0.51*AVE(I,JP,K))**2)
0366:       CALL NSIZE (PARA,LLAX,NL,NLA,3)
0367:       WRITE (6,221) NL,NLA
0368:   221 FORMAT (4X,62HNUMBER OF SAMPLES REQUIRED AT THE 80 PERCENT CONFIDE
0369:      1NCE LEVEL ,I3,3H  (,I3,1H)/)
0370:       WRITE (6,240) PERCH
0371:   240 FORMAT (/2X,79HPERCENT CHANGE IN MEAN DENSITY DETECTABLE AT THE 95
0372:      1 PERCENT CONFIDENCE LEVEL = ,F10.6)
0373:       DO 131 L=1,LAX(I,K)
0374:       CV = 0.0
0375:       IF (MAX(I,K,L) .EQ. 0) GO TO 131
0376:       IF(MAX(I,K,L).NE.0) PEM = SUM(I,JP,K,L)/MAX(I,K,L)
0377:       IF(MAX(I,K,L).GT.1)PEV=(SUMSQ(I,JP,K,L)-(SUM(I,JP,K,L)**2/MAX(I,K,
0378:      1L)))/(MAX(I,K,L)-1)
0379:       IF(PEM.LT.0.0001) GO TO 131
0380:       CV = (PEV/PEM)*100.0
0381:       IF (MAX(I,K,L).EQ.1) CV = 0.0
0382:       IF(MAX(I,K,L).EQ.1) GO TO 610
0383:       PARK = (2.0*PEV)/((0.51*PEM)**2)
0384:       MMAX = MAX(I,K,L)
0385:       CALL NSIZE (PARK,MMAX,NM,NMA,1)
0386:       GO TO 611
0387:   610 NM=1
0388:       NMA=1
0389:   611 WRITE(6,133) L, STAID(I,K,L),MAX(I,K,L),NM,NMA,CV
0390:   133 FORMAT(5X,33HNUMBER OF SUBSAMPLES FOR STATION ,I3,3X,A13,6X,9HOBSE
0391:      1RVED ,I3,4X,9HREQUIRED ,I3,3H  (,I3,1H),7H  CV = ,F11.2)
0392:   131 CONTINUE
0393:       WRITE(6,74)
0394:    74 FORMAT (/2X,70H( ) = NUMBER OF ANALYSES REQUIRED IF ONLY TYPE I ER
0395:      1RORS ARE CONSIDERED/)
0396:   130 CONTINUE
0397:       CALL TRINES(IAX,TN)
0398:       END
```

```
0001:       BLOCK DATA
0002:       COMMON/C/SPECIE(18),SITE(4)
0003:       COMMON/A/STAID(4,4,20)
0004:       CHARACTER SPECIE*20,SITE*14,STAID*13
0005:       DATA SPECIE/"NEMATODA","POLYCHAETA","OLIGOCHAETA","GASTROPODA","BI
0006:      1VALVIA","TANAIDACEA","AMPHIPODA","ISOPODA","OTHER SPECIES","TOTAL
0007:      2ANIMALS","CAPITELLA CAPITATA","NEREIDAE","TEXADINA SPHINCTOSOM","G
0008:      3EUKENSIA DEMISSA","COROPHIUM LOUISIANUM","COPEPODA","DECAPODA","AL
0009:      4L SPP EXC NEMATODA"/
0010:       DATA SITE/"AFFECTED AREA","EAST CONTROL","WEST CONTROL","NORTH CON
0011:      1TROL"/
0012:       DATA (STAID(1,1,N),N=1,13)/"16-1-B (333)","5-9-B (140)","9-1-B (33
0013:      15)","16-1-B (330)","9-10-B (146)","3-10-B (147)","5-9-B (139)","2-
0014:      29-B (143)","2-9-B (141)","9-1-B (248)","2-9-B (144)","9-10-B (145)
0015:      3","5-9-B (137)"/
0016:       DATA (STAID(1,2,N),N=1,4)/"E8-2-B (468)","E5-2-B (442)","E4-2-B (4
0017:      156)","E7-2-B (466)"/
0018:       DATA (STAID(1,3,N),N=1,14)/"6-2-B (371)","5-2-B (423)","9-2-B (383
0019:      1)","9-2-B (385)","8-2-B (389)","7-2-9 (432)","4-2-B (377)","3-2-B
0020:      2(349)","1-2-B (361)","2-2-B (355)","1-2-B (365)","2-2-B (357)","1-
0021:      32-B (363)","4-2-B (373)"/
0022:       DATA (STAID(2,1,N),N=1,7)/"M-2 (677)","M-6 (681)","M-8 (683)","M-1
0023:      16 (763)","M-38 (789)","M-68 (841)","M-34 (782)"/
0024:       DATA (STAID(2,2,N),N=1,4)/"EC-24 (816)","EC-2 (888)","EC-8 (894)",
0025:      1"EC-32 (902)"/
0026:       DATA (STAID(2,3,N),N=1,8)/"WC-16 (819)","WC-2 (849)","WC-4 (851)",
0027:      "WC-10 (857)","WC-12 (859)","WC-14 (817)","WC-6 (883)","WC-8 (885)"
0028:      2/
0029:       DATA (STAID(2,4,N),N=1,4)/"NC-2 (821)","NC-8 (827)","NC-18 (862)",
0030:      1"NC-37 (882)"/
0031:       DATA (STAID(3,1,N),N=1,10)/"M-4 (1125)","M-12 (1133)","M-20 (1141)
0032:      1","M-22 (1159)","M-28 (1165)","M-38 (1251)","M-16 (1137)","M-8 (11
0033:      229)","M-32 (1169)","M-40 (1263)"/
0034:       DATA (STAID(3,2,N),N=1,4)/"EC-11 (1274)","EC-12 (1275)","EC-6 (126
0035:      19)","EC-4 (1267)"/
0036:       DATA (STAID(3,3,N),N=1,9)/"WC-4 (1295)","WC-10 (1304)","WC-28 (132
0037:      12)","WC-30 (1324)","WC-16 (1310)","WC-12 (1306)","WC-34 (1328)","W
0038:      2C-14 (1308)","WC-36 (1330)"/
0039:       DATA (STAID(3,4,N),N=1,6)/"NC-8 (1457)","NC-16 (1490)","NC-24 (149
0040:      18)","NC-14 (1463)","NC-22 (1496)","NC-18 (1492)"/
0041:       DATA (STAID(4,1,N),N=1,14)/"M-10 (1647)","M-14 (1693)","M-18 (1697
0042:      1)","M-22 (1709)","M-24 (1711)","M-4 (1641)","M-30 (1717)","M-38 (1
0043:      2725)","M-8 (1645)","M-40 (1727)","M-26 (1713)","M-34 (1721)","M-28
0044:      3 (1715)","M-6 (1643)"/
0045:       DATA (STAID(4,3,N),N=1,13)/"WC-8 (1778)","WC-10 (1780)","WC-12 (17
0046:      182)","WC-14 (1784)","WC-16 (1786)","WC-22 (1792)","WC-36 (1806)","
0047:      2WC-2 (1629)","WC-28 (1798)","WC-40 (1810)","WC-18 (1788)","WC-24 (
0048:      31794)","WC-4 (1748)"/
0049:       DATA (STAID(4,4,N),N=1,4)/"NC-14 (1737)","NC-18 (1741)","NC-4 (176
0050:      17)","NC-10 (1773)"/
0051:       END
```

```
0001:       SUBROUTINE NSIZE(PARM,NOBS,NEST,NESTA,W)
0002:       COMMON/D/TV(3,34)
0003:       INTEGER W
0004:       IF (NOBS.LE.1) RETURN
0005:       KOUNT=1
0006:       NOBS = NOBS - 1
0007:       NKA=NOBS
0008:       IF(NOBS.LE.30)601,602
0009:   601 NEST = ((2.0*TV(W,NOBS))**2*PARM+1.0)
0010:       NESTA = (TV(W,NKA)**2*PARM+1.0)
0011:       IF(KOUNT.GT.1) RETURN
0012:       IF (NESTA.LE.NOBS) RETURN
0013:       KOUNT=2
0014:       NOBS=NEST
0015:       NKA=NESTA
0016:       IF (NOBS.LE.1) RETURN
0017:       IF(NOBS.LE.30) 603,602
0018:   603 NEST = ((2.0*TV(W,NOBS))**2*PARM+1.0)
0019:       IF(NKA.LE.30) 604,605
0020:   604 NESTA = (TV(W,NKA)**2*PARM+1.0)
0021:       RETURN
0022:   602 IF (NOBS.LE.1) RETURN
0023:       IF(NOBS.LT.40) EST = (2.0*TV(W,30))**2*PARM
0024:       IF((NOBS.GE.40).AND.(NOBS.LT.60)) EST = (2.0*TV(W,31))**2*PARM
0025:       IF((NOBS.GE.60).AND.(NOBS.LT.120)) EST=(2.0*TV(W,32))**2*PARM
0026:       IF(NOBS.EQ.120) EST = (2.0*TV(W,33))**2*PARM
0027:       IF(NOBS.GT.120) EST = (2.0*TV(W,34))**2*PARM
0028:       NEST=EST + 1.0
0029:       IF(NKA.LE.1) RETURN
0030:       IF(NKA.LE.30) GO TO 604
0031:   605 IF(NKA.LE.1) RETURN
0032:       IF(NKA.LT.40) ESTA = TV(W,30)**2*PARM
0033:       IF((NKA.GE.40).AND.(NKA.LT.60))ESTA = TV(W,31)**2*PARM
0034:       IF((NKA.GE.60).AND.(NKA.LT.120))ESTA = TV(W,32)**2*PARM
0035:       IF(NKA.EQ.120) ESTA = TV(W,33)**2*PARM
0036:       IF(NKA.GT.120) ESTA = TV(W,34)**2*PARM
0037:       NESTA=ESTA+1.0
0038:       IF(KOUNT.GT.1) RETURN
0039:       KOUNT=2
0040:       NOBS=NEST
0041:       NKA=NESTA
0042:       IF(NOBS.LE.30) 603,602
0043:   600 CONTINUE
0044:       RETURN
0045:       END
```

```
0001:        SUBROUTINE TRINES(IAX,TN)
0002:        COMMON MAX(9,9,17),LAX(9,9),KAX(9),GRAND(17),GRAS(17),SQA(17),
0003:       1SQC(15),SQE(15),AN(9,9),ANS(9,9),BN(9),BNS(9)
0004:        COMMON/C/SPECIE(18),SITE(9)
0005:        DIMENSION ANOV(5,5),SAN(9)
0006:        CHARACTER SPECIE*20,SITE*14
0007:        DO 17 J = 2,10
0008:        KAXA=0
0009:        LAXA=0
0010:        MAXA=0
0011:        MAXB=0
0012:        MAXSQ=0
0013:        AMAXE=0.0
0014:        AMAXD=0.0
0015:        AMAXI=0.0
0016:        AMAXO=0.0
0017:        ANOV(5,1) = 0.0
0018:        ANOV(5,2) = 0.0
0019:        CT=GRAND(J)**2/TN
0020:        SST=GRAS(J)-CT
0021:        SSG=SQE(J)-CT
0022:        SSS=SQC(J)-SQE(J)
0023:        SUB=SQA(J)-SQC(J)
0024:        SSW=GRAS(J)-SQA(J)
0025:        ANOV(1,1)=IAX-1
0026:        ANOV(1,5)=TN-1.0
0027:        DO 13 I=1,IAX
0028:        SAN(I)=0.0
0029:        KAXA=KAXA+KAX(I)
0030:        DO 13 K = 1,3
0031:        DO 12 L=1,LAX(I,K)
0032:     12 MAXA=MAXA+MAX(I,K,L)
0033:     13 LAXA=LAXA+LAX(I,K)
0034:        ANOV(1,2)=KAXA-IAX
0035:        ANOV(1,3)=LAXA-KAXA
0036:        ANOV(1,4)=MAXA-LAXA
0037:        ANOV(2,1)=SSG
0038:        ANOV(2,2)=SSS
0039:        ANOV(2,3)=SUB
0040:        ANOV(2,4)=SSW
0041:        ANOV(2,5) = SST
0042:        DO 14 N=1,4
0043:        NN=ANOV(1,N)
0044:     14 IF(NN.NE.0)ANOV(3,N)=ANOV(2,N)/ANOV(1,N)
0045:        NN=ANOV(3,4)*10000.0
0046:        IF(NN.NE.0)ANOV(4,3)=ANOV(3,3)/ANOV(3,4)
0047:        DO 16 I=1,IAX
0048:        DO 15 K = 1,3
0049:        MAXB=MAXB+AN(I,K)**2
0050:        MAXSQ=MAXSQ+ANS(I,K)
0051:        NN=AN(I,K)
0052:     15 IF(NN.NE.0)AMAXE=AMAXE+ANS(I,K)/AN(I,K)
0053:        AMAXO=AMAXO+BN(I)**2
0054:        NN=BN(I)
0055:        IF(NN.NE.0)AMAXI=AMAXI+BNS(I)/BN(I)
0056:        DO 20 KK = 1,3
0057:     20 SAN(I)=SAN(I)+AN(I,KK)**2
0058:     16 IF(NN.NE.0)AMAXO=AMAXO+SAN(I)/BN(I)
0059:        NN=ANOV(1,1)*10000.0
0060:        IF(NN.NE.0)ANPPO=(AMAXI-MAXSQ/TN)/ANOV(1,1)
```

```
0061:       IF(NN.NE.0)ANCP=(AMAXD-MAXB/TN)/ANOV(1,1)
0062:       IF(NN.NE.0)ANCB=(TN-AMAXD/TN)/ANOV(1,1)
0063:       NA=ANOV(1,2)*10000.0
0064:       IF(NA.NE.0)ANPO=(AMAXE-AMAXI)/ANOV(1,2)
0065:       IF(NA.NE.0)ANCO=(TN-AMAXD)/ANOV(1,2)
0066:       NB=ANOV(1,3)*10000.0
0067:       IF(NB.NE.0)ANO=(TN-AMAXE)/ANOV(1,3)
0068:       NC=ANO*10000.0
0069:       IF(NC.NE.0)BOV=(ANOV(3,3)-ANOV(3,4))/ANO
0070:       ND=ANCO*10000.0
0071:       IF(ND.NE.0) BOVA=(ANOV(3,2)-ANOV(3,4)-ANPO*BOV)/ANCO
0072:       NE=ANCB*10000.0
0073:       IF(NE.NE.0)BOVB=(ANOV(3,1)-ANOV(3,4)-(ANPPO*BOV)-(ANCP*BOVA))/ANCB
0074:       BOVC=ANOV(3,4)+(ANPO*BOV)
0075:       NATE = ANOV(3,4)*10000.0
0076:       IF(NATE.EQ.0) BOVC = 0.0
0077:       NN=BOVC*10000.0
0078:       IF(NN.NE.0)ANOV(4,2)=ANOV(3,2)/BOVC
0079:       NN=ANOV(1,4)*10000.0
0080:       IF(NC.NE.0)21,22
0081:    21 IF(NN.NE.0)TEM=(((1.0-ANPO/ANO)*ANOV(3,4))**2/ANOV(1,4))
0082:       NN=ANOV(1,3)*10000.0
0083:       IF(NN.NE.0)TEMA=((ANPO/ANO)*ANOV(3,3))**2/ANOV(1,3)
0084:    22 TEM=TEM+TEMA
0085:       IF((NC.EQ.0).OR.(NN.EQ.0)) TEM = 0.)
0086:       NN=TEM*10000.0
0087:       IF(NN.NE.0)ANOV(5,2)=BOVC**2/TEM
0088:       BOVE=ANOV(3,4)+(ANPPO*BOV)+(ANCP*BOVA)
0089:       IF(NATE.EQ.0) BOVE = 0.0
0090:       NN=BOVE*10000.0
0091:       IF(NN.NE.0)ANOV(4,1)=ANOV(3,1)/BOVE
0092:       NN=ANCO*ANO*10000.0
0093:       IF(NN.NE.0)BANO=(ANCP*ANPO)/(ANCO*ANO)
0094:       N12=ANOV(1,2)*10000.0
0095:       IF(ND.NE.0)23,24
0096:    23 IF(N12.NE.0)TEM=(((ANCP/ANCO)*ANOV(3,2))**2/ANOV(1,2))
0097:       GO TO 25
0098:    24 TEM=0.0
0099:    25 N13 = ANOV(1,3)*10000.0
0100:       IF(NC.NE.0)26,27
0101:    26 IF(N13.NE.0)TEMM=((ANPPO/ANO-BANO)*ANOV(3,3))**2/ANOV(1,3)
0102:    27 IF(NC.NE.0)TEMM=1.0-(ANPPO/ANO)
0103:       IF(ND.NE.0)TEML=ANCP/ANCO
0104:       N14 = ANOV(1,4)*10000.0
0105:       IF(N14.NE.0)TEMP=((TEMM-TEML*BANO)*ANOV(3,4))**2/ANOV(1,4)
0106:       TEM=TEM+TEMP+TEMM
0107:       IF((N12.EQ.0).OR.(N13.EQ.0).OR.(N14.EQ.0)) TEM = 0.0
0108:       NN=TEM*10000.0
0109:       IF(NN.NE.0)ANOV(5,1)=BOVE**2/TEM
0110:       ITEM=ANOV(5,1)+0.5
0111:       ANOV(5,1)=ITEM
0112:       ITEM=ANOV(5,2)+0.5
0113:       ANOV(5,2)=ITEM
0114:       WRITE(6,30) SPECIES(J)
0115:    30 FORMAT(1H1////31X,53HTHREE WAY NESTED ANALYSIS OF VARIANCE FOR MAR
0116:      1SH       ,A20//25X,19HSOURCE OF VARIATION,7X,2HDF,3X,15HSUMS OF SQU
0117:      2ARES,4X,11HMEAN SQUARE,3X,7HF RATIO,7X,2HDF//)
0118:       WRITE(6,32)((ANOV(K,L),K=1,5),L=1,5)
0119:    32 FORMAT(25X,12HAMONG PHASES,13X,F4.0,1X,F22.1,2X,F22.1,3X,F9.2,3X,F
0120:      17.0//25X,11HAMONG SITES,14X,F4.0,1X,F22.1,2X,F22.1,3X,F9.2,3X,F7.1
```

```
0121:       2//25X,14HAMONG STATIONS,11X,F4.0,1X,F22.1,2X,F22.1,3X,F9.2,3X,F7.0
0122:       3//25X,15HWITHIN STATIONS,10X,F4.0,1X,F22.1,2X,F22.1,3X,F9.2,3X,F7.
0123:       40//25X,5HTOTAL,20X,F4.0,1X,F22.1,2X,F22.1,3X,F9.2,3X,F7.0////)
0124:        N11 = ANOV(1,1)
0125:        N51 = ANOV(5,1)
0126:        IF(N51.EQ.0) N51 = ANOV(1,2)
0127:        WRITE(6,163) ANOV(4,1),N11,N51
0128:    163 FORMAT(25X,22HCRITICAL VALUE OF F = ,F7.2,10H FOUND AT ,I2,2H, ,I2
0129:       1,19H DEGREES OF FREEDOM//)
0130:     17 CONTINUE
0131:        RETURN
0132:        END
0133:
```

APPENDIX B.4
Variance Ratios (F) For Two-Level Analyses of Variances

This appendix contains two tables representing the F values, degrees of freedom, and levels of significance for pair-wise comparisons between sites using two-level analyses of variance. These tables represent lake sediment and marsh sediment results, respectively.

TABLE B.4-1

VARIANCE RATIOS (F) FOR TWO-LEVEL COMPARISONS BETWEEN SITES FOR BLACK LAKE BENTHOS

Taxon	Phase	Sites Compared[a]	F	df[b]	Probability[c]
All Species	I	AFF, EC	2.46	1, 22	<0.25
		AFF, WC	21.34	1, 29	<0.001
		EC, WC	20.61	1, 27	<0.001
	II	AFF, EC	16.32	1, 17	<0.001
		AFF, WC	3.80	1, 15	<0.10
		EC, WC	10.22	1, 12	0.01
	III	AFF, EC	5.81	1, 18	<0.05
		AFF, WC	10.86	1, 10	<0.10
		EC, WC	5.10	1, 14	<0.50
	IV	AFF, EC	3.94	1, 23	<0.10
		AFF, WC	0.56	1, 15	<0.50
		EC, WC	1.76	1, 14	<0.25
Polychaeta	I	AFF, EC	3.50	1, 22	<0.10
		AFF, WC	11.49	1, 29	<0.005
		EC, WC	1.28	1, 27	<0.50
	II	AFF, EC	0.10	1, 17	>0.75
		AFF, WC	1.16	1, 15	<0.50
		EC, WC	2.99	1, 12	<0.25
	III	AFF, EC	0.08	1, 18	>0.75
		AFF, WC	3.80	1, 10	<0.10
		EC, WC	2.64	1, 14	<0.25
	IV	AFF, EC	1.78	1, 23	<0.25
		AFF, WC	<0.01	1, 15	>0.75
		EC, WC	1.32	1, 14	<0.50
Oligochaeta	I	AFF, EC	1.44	1, 22	<0.25
		AFF, WC	3.96	1, 29	<0.10
		EC, WC	1.08	1, 27	<0.50
	II	AFF, EC	1.27	1, 17	<0.50
		AFF, WC	0.52	1, 15	<0.025
		EC, WC	0.95	1, 12	<0.50
	III	AFF, EC	1.10	1, 18	<0.50
		AFF, WC	2.28	1, 10	<0.25
		EC, WC	3.32	1, 14	<0.05
	IV	AFF, EC	0.45	1, 23	<0.75
		AFF, WC	1.83	1, 15	<0.25
		EC, WC	0.53	1, 14	<0.50

TABLE B.4-1 (Cont.)

Taxon	Phase	Sites Compared[a]	F	df[b]	Probability[c]
Gastropoda	I	AFF, EC	4.12	1, 22	<0.10
		AFF, WC	0.48	1, 29	<0.50
		EC, WC	6.97	1, 27	<0.025
	II	AFF, EC	0.33	1, 17	<0.75
		AFF, WC	0.33	1, 15	<0.75
		EC, WC	0.00	1, 12	----
	III	AFF, EC	0.67	1, 18	<0.50
		AFF, WC	1.20	1, 10	<0.25
		EC, WC	0.06	1, 14	>0.75
	IV	AFF, EC	0.02	1, 23	>0.75
		AFF, WC	2.81	1, 15	<0.25
		EC, WC	4.12	1, 14	<0.10
Tanaidacea	I	AFF, EC	0.94	1, 22	<0.50
		AFF, WC	21.34	1, 29	<0.001
		EC, WC	23.33	1, 27	<0.001
	II	AFF, EC	21.79	1, 17	<0.001
		AFF, WC	3.65	1, 15	<0.10
		EC, WC	15.11	1, 12	<0.005
	III	AFF, EC	5.97	1, 18	<0.05
		AFF, WC	13.58	1, 10	<0.005
		EC, WC	4.47	1, 14	<0.10
	IV	AFF, EC	1.15	1, 23	<0.50
		AFF, WC	1.17	1, 15	<0.50
		EC, WC	0.51	1, 14	<0.50
Amphipoda	I	AFF, EC	2.59	1, 22	<0.25
		AFF, WC	5.95	1, 29	<0.025
		EC, WC	5.06	1, 27	<0.05
	II	AFF, EC	9.85	1, 17	<0.01
		AFF, WC	2.35	1, 15	<0.25
		EC, WC	5.31	1, 12	<0.05
	III	AFF, EC	5.18	1, 18	<0.05
		AFF, WC	9.15	1, 10	<0.025
		EC, WC	4.00	1, 14	<0.10
	IV	AFF, EC	7.18	1, 23	<0.025
		AFF, WC	0.82	1, 15	<0.50
		EC, WC	2.34	1, 14	<0.25

[a]AFF = Affected Area, EC = East Control Area, WC = West Control Area

[b]df = Degrees of freedom

[c]Probability of obtaining a difference as great or greater than that observed by chance alone.

TABLE B.4-2

VARIANCE RATIOS (F) FOR TWO-LEVEL COMPARISONS BETWEEN SITES FOR MARSH BENTHOS

Taxon	Phase	Sites Compared[a]	F	df[b]	Probability[c]
All Species	I	AFF, EC	1.61	1, 15	<0.25
		AFF, WC	0.01	1, 28	>0.75
		EC, WC	1.89	1, 19	<0.25
	II	AFF, NC	4.76	1, 9	<0.10
		AFF, WC	3.40	1, 13	<0.10
		WC, NC	3.70	1, 10	<0.10
	III	AFF, NC	3.43	1, 12	<0.10
		AFF, WC	3.03	1, 17	<0.10
		WC, NC	1.75	1, 11	<0.25
	IV	AFF, NC	0.12	1, 16	<0.75
		AFF, WC	0.72	1, 25	<0.50
		WC, NC	0.12	1, 15	<0.75
Polychaeta	I	AFF, EC	0.65	1, 15	<0.50
		AFF, WC	3.00	1, 28	<0.10
		EC, WC	1.20	1, 19	<0.50
	II	AFF, NC	2.52	1, 9	<0.25
		AFF, WC	1.33	1, 13	<0.50
		WC, NC	2.93	1, 10	<0.25
	III	AFF, NC	0.43	1, 12	<0.75
		AFF, WC	1.77	1, 17	<0.50
		WC, NC	0.44	1, 11	<0.75
	IV	AFF, NC	0.08	1, 16	>0.75
		AFF, WC	0.42	1, 25	<0.75
		WC, NC	0.68	1, 15	<0.50
Oligochaeta	I	AFF, EC	0.59	1, 15	<0.50
		AFF, WC	1.55	1, 28	<0.25
		EC, WC	0.83	1, 19	<0.50
	II	AFF, NC	1.32	1, 9	<0.50
		AFF, WC	0.28	1, 13	<0.75
		WC, NC	3.34	1, 10	<0.25
	III	AFF, NC	0.13	1, 12	<0.75
		AFF, WC	0.44	1, 17	<0.75
		WC, NC	0.59	1, 11	<0.50
	IV	AFF, NC	0.03	1, 16	>0.75
		AFF, WC	0.90	1, 25	<0.50
		WC, NC	0.57	1, 15	<0.50

TABLE B.4-2 (Cont.)

Taxon	Phase	Sites Compared[a]	F	df[b]	Probability[c]
Gastropoda	I	AFF, EC	0.77	1, 15	<0.50
		AFF, WC	2.90	1, 28	<0.25
		EC, WC	0.19	1, 19	<0.75
	II	AFF, NC	0.13	1, 19	<0.75
		AFF, WC	1.29	1, 13	<0.50
		WC, NC	0.90	1, 10	<0.50
	III	AFF, NC	1.06	1, 12	<0.50
		AFF, WC	2.48	1, 17	<0.25
		WC, NC	0.00	1, 11	>0.75
	IV	AFF, NC	3.39	1, 16	<0.10
		AFF, WC	0.84	1, 25	<0.50
		WC, NC	2.26	1, 15	<0.25
Tanaidacea	I	AFF, EC	1.40	1, 15	<0.25
		AFF, WC	5.01	1, 28	<0.05
		EC, WC	0.70	1, 19	<0.50
	II	AFF, NC	4.84	1, 9	<0.10
		AFF, WC	5.91	1, 13	<0.05
		WC, NC	3.47	1, 10	<0.10
	III	AFF, NC	5.73	1, 12	<0.05
		AFF, WC	5.42	1, 17	<0.05
		WC, NC	6.66	1, 11	<0.05
	IV	AFF, NC	4.83	1, 16	<0.05
		AFF, WC	3.04	1, 25	<0.10
		WC, NC	1.66	1, 15	<0.25
Amphipoda	I	AFF, EC	0.90	1, 15	<0.50
		AFF, WC	1.15	1, 28	<0.50
		EC, WC	1.11	1, 19	<0.50
	II	AFF, NC	2.48	1, 9	<0.25
		AFF, WC	0.37	1, 13	<0.75
		WC, NC	2.51	1, 10	<0.25
	III	AFF, NC	3.93	1, 12	<0.10
		AFF, WC	5.03	1, 17	<0.05
		WC, NC	0.30	1, 11	<0.75
	IV	AFF, NC	0.61	1, 16	<0.50
		AFF, WC	0.69	1, 25	<0.50
		WC, NC	0.03	1, 15	>0.70

[a]AFF = Affected Area, EC = East Control Area, WC = West Control Area

[b]df = Degrees of freedom

[c]Probability of obtained a difference as great or greater than that observed by chance alone.

APPENDIX B.5
Marsh Vegetation Data

This appendix contains six tables representing a detailed description of Phase IV vegetation samples. A similar description was not obtained from Phases I through III.

TABLE B.5-1

LIVE BIOMASS DATA SUMMARY FOR AFFECTED AREA SAMPLES

Site Number Sample Number	Stubble Height[c] (cm)	Water Depth at Time of Sample (cm)	HEALTHY LIVE STEMS (L) Weight (g)	Total Number	Number of "Recruits"[a]	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height[b] (cm)	DYING LIVE STEMS (DY) Weight (g)	Total Number	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height (cm)
M1 1638	< 1	< 0.5													
Juncus roemerianus			48.3	46	3	1.05	135	18	60	138.2	68	2.03	146	20	110
M3 1640	1-2	< 0.5													
Juncus roemerianus			33.8	34	7	0.99	133	21	65	71.6	45	1.59	130	30	95
M5 1642	1-2	< 0.5													
Juncus roemerianus			53.8	53	6	1.02	125	25	75	82.6	52	1.59	145	20	90
M7 1644	2-4	< 0.5													
Juncus roemerianus			74.8	45	5	1.66	160	15	110	160.7	85	1.89	155	35	110
M9 1646	1-2	2													
Juncus roemerianus			5.4	21	13	0.26	100	10	40	60.5	--	--	145	31	80
M11 1648	2	1-2													
Juncus roemerianus			66.8	83	28	0.81	126	5	70	87.7	80	1.10	142	16	80
Spartina patens			--	--		--	--	--	--	3.6	4	0.60	--	--	--
Total			66.8	83		0.81				91.3	84	1.09			
M13 1650	2-3	2-3													
Juncus roemerianus			27.0	50	16	0.54	109	5	65	107.7	114	0.95	155	11	90
M15 1694	1-2	4													
Juncus roemerianus			66.0	121	22	0.55	126	6	75	111.7	104	1.07	151	30	110

TABLE B.5-1 (Cont.)

Site Number Sample Number	Stubble Height[c] (cm)	Water Depth at Time of Sample (cm)	HEALTHY LIVE STEMS (L) Weight (g)	Total Number	Number of "Recruits"[a]	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height[b] (cm)	DYING LIVE STEMS (DY) Weight (g)	Total Number	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height (cm)
M17 1696	2	2 (9-1-C)													
Juncus roemerianus			32.7	61	27	0.54	135	5	60	189.7	185	1.03	148	25	100
M19 1698	4-5	4-5													
Juncus roemerianus			65.4	110	29	0.60	116	4	65	164.8	159	1.04	134	17	100
M21 1700	4-5	5-6													
Juncus roemerianus			33.4	64	24	0.52	105	8	60	79.3	88	0.90	131	20	100
M23 1710	3-4	5-6													
Juncus roemerianus			49.0	111	41	0.44	115	3	65	158.5	169	0.94	152	7	90
M25 1712	1-2	2													
Juncus roemerianus			20.1	54	31	0.37	126	3	60	117.6	110	1.07	151	17	110
M27 1714	2-3	3													
Juncus roemerianus			16.4	72	30	0.23	97	7.5	55	70.7	96	0.74	127	12	75
M29 1716	2	2													
Juncus roemerianus			10.9	38	16	0.29	119	9	50	83.5	84	0.99	151	13	80
M31 1718	2-3	3													
Juncus roemerianus			60.3	107	49	0.56	135	9	--	112.4	88	1.28	170	20	100
Spartina patens			0.1	3		0.02	22	--	--	0.3	1	0.30	--	--	--
Total			60.4	110		0.55				112.7	89	1.27			

TABLE B.5-1 (Cont.)

Site Number Sample Number	Stubble Height[c] (cm)	Water Depth at Time of Sample (cm)	HEALTHY LIVE STEMS (L) Weight (g)	Total Number	Number of "Recruits"[a]	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height[b] (cm)	DYING LIVE STEMS (DY) Weight (g)	Total Number	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height (cm)
M33 1720	1-2	1 (9-10-B)													
Juncus roemerianus			14.7	70	46	0.21	118	5	50	168.4	214	0.79	133	5	90-95
Spartina patens			0.3	4		0.08	54	10	22	--	--	--			
Total			15.0	74		0.29									
M35 1722	1-2	3													
Juncus roemerianus			9.5	46	28	0.21	101	5	50	77.5	128	0.61	110	17	75
M37 1724	1	4													
Juncus roemerianus			29.4	78	36	0.38	116	7.5	60	115.3	97	1.19	136	13	75
M39 1726	1-2	1-2													
Juncus roemerianus			5.5	25	19	0.22	85	5	--	59.3	62	0.96	137	25	--
MEAN	2.2	2.69													
Juncus roemerianus			36.2	64.45	23.8	0.57	118.1	8.8	63.1	111.2	106.7	1.14	142.4	19.2	91.5
STANDARD ERROR	.197	.339													
Juncus roemerianus			5.1	6.58	3.0	0.08	3.74	1.38	3.48	8.97	10.5	0.09	2.92	1.82	3.01

[a] "Recruits" equals the number of stems that were less than 40 cm in height in each sample.
[b] "Average" height was estimated visually on a gridded table after sorting was completed. Maximum and minimum heights were directly measured, but average height does not represent the average of those two measurements.
[c] "Stubble" refers to how much stem was left standing (rooted) on the plot after 0.25 m^2 sample was clipped and represents a visual estimate in the field at the time of collection.

TABLE B.5-2

LIVE BIOMASS DATA SUMMARY FOR NORTH CONTROL SAMPLES

Site Number Sample Number	Stubble Height[c] (cm)	Water Depth at Time of Sample (cm)	HEALTHY LIVE STEMS (L) Weight (g)	Total Number	Number of "Recruits"[a]	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height[b] (cm)	DYING LIVE STEMS (DY) Weight (g)	Total Number	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height (cm)
NC1 1764	3	6													
Juncus roemerianus			22.3	53	23	0.42	108	8	≤50	102.2	150	0.68	112	22	80
NC3 1766	3	6													
Juncus roemerianus			39.0	109	37	0.36	110	4	50	63.2	103	0.61	109	15	75
Spartina patens			56.1	99		0.57	88	21	60	--	--	--	--	--	--
Total			95.1	208		0.46				63.2	103	0.61			
NC5 1768	2-3	4													
Juncus roemerianus			133.7	151	27	0.89	130	8	75	164.0	119	1.37	119	19	80
Spartina patens			--	--		--	--	--	--	21.2	41	0.52	114	13	70
Total										185.2	160	1.16	--	--	--
NC7 1770	2-3	3													
Juncus roemerianus			51.3	126	49	0.41	95	4	1 55	77.6	121	0.64	100	8	80
NC9 1772	1	2													
Juncus roemerianus			127.4	117	45	1.09	144	7	60	235.9	136	1.74	143	19	105-110
NC1 1764	3	6													
Juncus roemerianus			22.3	53	23	0.42	108	8	≤50	102.2	150	0.681	112	22	80
NC11 1774	1-2	6-8													
Juncus roemerianus			64.2	172	54	0.37	120	5	70	152.7	171	0.89	135	35	100
Spartina patens			125.6	74		1.70	110	10	80	21.5	17	1.26	--	--	--
Aster sp.			2.9	1		2.90	40			--	--	--			
Total			192.6	247		0.78	--	--	--	174.2	188	0.93			

TABLE B.5-2 (Cont.)

Site Number Sample Number	Stubble Height[c] (cm)	Water Depth at Time of Sample (cm)	HEALTHY LIVE STEMS (L) Weight (g)	Total Number	Number of "Recruits"[a]	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height[b] (cm)	DYING LIVE STEMS (DY) Weight (g)	Total Number	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height (cm)
NC13 1734	1-2	6-8													
Juncus roemerianus			153.1	155	29	0.99	141	4	80	168.9	102	1.66	154	10	120
NC15 1738	2-3	8													
Juncus roemerianus			150.3	204	49	0.74	120	7	75	235.0	169	1.39	161	15	100
NC17 1740	2-3	4-5													
Juncus roemerianus			153.9	218	59	0.71	134	3	70	246.3	204	1.21	140	27	100
NC19 1742	1-2	5-6													
Juncus roemerianus			110.9	175	58	0.63	140	5	70	195.5	161	1.21	160	27	85
NC21 1744	1-2	4-5													
Juncus roemerianus			104.9	132	27	0.80	139	8	70	155.4	102	1.52	168	17	120
NC23 1746	2-3	4													
Juncus roemerianus			19.8	52	21	0.38	92	10	45	118.4	107	1.11	151	22	80
MEAN	1.76	5.29													
Juncus roemerianus			94.2	138.7	39.8	0.65	122.8	6.08	64.2	159.6	137.1	1.17	137.7	19.7	93.9
STANDARD ERROR	.136	0.418													
Juncus roemerianus			15.0	15.03	4.1	0.08	5.25	0.633	3.36	17.7	9.73	0.11	6.57	2.193	4.65

[a] "Recruits" equals the number of stems that were less than 40 cm in height in each sample.
[b] "Average" height was estimated visually on a gridded table after sorting was completed. Maximum and minimum heights were directly measured, but average height does not represent the average of those two measurements.
[c] "Stubble" refers to how much stem was left standing (rooted) on the plot after 0.25 m^2 sample was clipped and represents a visual estimate in the field at the time of collection.

TABLE B.5-3

LIVE BIOMASS DATA SUMMARY FOR WEST CONTROL SAMPLES

Site Number Sample Number	Stubble Height[c] (cm)	Water Depth at Time of Sample (cm)	HEALTHY LIVE STEMS (L) Weight (g)	Total Number	Number of "Recruits"[a]	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height[b] (cm)	DYING LIVE STEMS (DY) Weight (g)	Total Number	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height (cm)
WC1 1628	2-3	1													
Juncus roemerianus			105.8	140	43	0.76	118	7	60	249.9	186	1.34	137	16	75
WC3 1750	1-2	1													
Juncus roemerianus			72.5	80	19	0.91	133	9	80	176.8	121	1.46	145	40	110
WC5 1749	3	2													
Juncus roemerianus			68.2	104	32	0.66	100	7	55	86.1	86	1.00	124	22	90
WC7 1777	2	1-2													
Juncus roemerianus			60	54	8	1.11	130	13	90	110.7	76	1.46	135	22	100
Spartina patens			--	--		--				9.3	5	1.86	115	11	80
Total										120.0	81	1.48			
WC9 1779	2-3	2													
Juncus roemerianus			15.6	34	22	0.46	140	5	50	119.0	94	1.27	160	15	110-110
WC11 1781	3	3													
Juncus roemerianus			17.6	51	31	0.35	98	11	45	48.2	53	0.91	109	8	65
WC13 1783	2-3	6													
Juncus roemerianus			58.4	82	20	0.71	132	17	75	51.3	50	1.03	142	20	85

TABLE B.5-3 (Cont.)

Site Number Sample Number	Stubble Height[c] (cm)	Water Depth at Time of Sample (cm)	HEALTHY LIVE STEMS (L) Weight (g)	Total Number	Number of "Recruits"[a]	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height[b] (cm)	DYING LIVE STEMS (DY) Weight (g)	Total Number	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height (cm)
WC15 1785	2-3	6													
Juncus roemerianus			46.3	70	32	0.66	125	5	80	120.4	133	0.90	125	10	100
WC17 1787	1-2	1-2													
Juncus roemerianus			51.0	84	31	0.61	112	3	70	120.3	133	0.90	125	10	80
WC19 1789	3	3													
Juncus roemerianus			94.9	163	64	0.58	131	3	65	173.3	179	0.97	134	10	100
WC21 1791	3	4													
Juncus roemerianus			110.6	131	30	0.84	159	9	110	114.8	91	1.26	160	13	120
Spartina patens			--	--		--				38.7	49	6.79	100	17	65
Total			110.6	131		0.84				153.5	140	1.10			
WC23 1793	1-2	2													
Juncus roemerianus			46.0	87	36	0.53	125	4	60	135.5	138	0.98	142	13	110
WC25 1795	1-2	2													
Juncus roemerianus			28.5	80	39	0.36	94	4	50	108.6	160	0.68	130	7	70
WC27 1797	2-3	5													
Juncus roemerianus			45.6	94	32	0.49	138	4	60	108.2	97	1.12	170	14	80
Spartina patens			--	--		--				2.5	3	0.83			
Total										110.7	100	1.11			
WC29 1799	2	3													
Juncus roemerianus			25.0	50	24	0.50	115	4	60	87.6	176	1.15	163	8	115

TABLE B.5-3 (Cont.)

Site Number Sample Number	Stubble Height[c] (cm)	Water Depth at Time of Sample (cm)	HEALTHY LIVE STEMS (L) Weight (g)	Total Number	Number of "Recruits"[a]	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height[b] (cm)	DYING LIVE STEMS (DY) Weight (g)	Total Number	Mean Weight Per Shoot (g)	Maximum Height (cm)	Minimum Height (cm)	Average Height (cm)
WC31 1801	2-3	3													
Juncus roemerianus			71.1	110	45	0.65	145	5	70	137.8	129	1.07	160	15	100
WC33 1803	2-3	0													
Juncus roemerianus			107.6	142	41	0.76	129	3	90	141.3	160	0.88	130	15	90
WC35 1805	2-3	2													
Juncus roemerianus			11.2	29	15	0.39	112	10	50	102.7	99	1.04	149	12	75
Spartina patens			1.2	1		1.2	35								
Total			12.4	30		0.41									
WC37 1807	3	3													
Juncus roemerianus			24.1	30	9	0.80	85	5	--	59.2	152	1.14	160	30	--
Spartina patens			4.9	9			75	32							
Total			29.0	39		0.74									
WC39 1809	3	3													
Juncus roemerianus			40.2	40	16	1.01	132	4	70	181.5	121	1.50	152	20	90
Spartina patens			2.2	4		0.55	85	8	40	10.0	5	2.00	120	80	110
Total			42.4	44		0.96				191.5	126	1.52			
MEAN	2.3	2.59													
Juncus roemerianus			55.0	82.8	29.5	0.66	122.7	6.6	66.5	121.7	110.5	1.11	143.3	16.4	92.6
STANDARD ERROR	0.117	0.333													
Juncus roemerianus			7.0	8.86	3.0	0.05	4.13	0.85	3.89	10.8	9.1	0.05	3.55	1.78	3.63

[a] "Recruits" equals the number of stems that were less than 40 cm in height in each sample.
[b] "Average" height was estimated visually on a gridded table after sorting was completed. Maximum and minimum heights were directly measured, but average height does not represent the average of those two measurements.
[c] "Stubble" refers to how much stem was left standing (rooted) on the plot after 0.25 m^2 sample was clipped and represents a visual estimate in the field at the time of collection.

TABLE B.5-4

TOTAL BIOMASS DATA SUMMARY FOR AFFECTED AREA SAMPLES

Site Number/ Sample Number	TOTAL LIVE (TL) Weight (g)	Total Number	Weight Per Shoot (g/sh)	Dead (D) Biomass (g)	Total (T) Biomass T = D+TL (g)	Biomass Percentages $\frac{TL}{T}$x100	$\frac{DY}{T}$x100	$\frac{DY}{L}$x100	Comments
M1/1638									
Juncus roemerianus	186.5	114	1.636	182.8	369.3	50.5	37.4	74.1	Dry
M3/1640									
Juncus roemerianus	105.4	79	1.334	88.6	194.0	54.3	36.9	67.9	Dying stems heavily parasitized
M5/1642									
Juncus roemerianus	136.4	105	1.299	70.2	206.6	66	40	60.6	
M7/1644									
Juncus roemerianus	235.5	130	1.812	182.9	418.4	53.7	36.6	68.2	Stems heavily parasitized
M9/1646									
Juncus roemerianus	65.9	--	--	70.1	136.0	48.5	44.5	91.8	Paspalum = 6 stems & runners
Paspalum spicata				2.1	2.1				
Total				72.2	138.1				
M11/1648									
Juncus roemerianus	154.5	163	0.948	95.1	249.6	61.9	35.1	56.8	
Spartina patens	3.6	4		2.0	5.6	64.3	64.3	100.0	
Total	158.1	167	0.95	97.1	255.2				
M13/1650									
Juncus roemerianus	141.3	164	0.862	123.8	265.1	53.3	43.1	80.9	
Paspalum vaginatum				0.5	0.5				
Total				124.3	265.6				
M15/1694									
Juncus roemerianus	178.5	225	0.793	74.3	252.8	70.5	44.3	62.9	
Paspalum vaginatum				0.6	0.6				
Total				74.9	253.4				
M17/1696									
Juncus roemerianus	222.4	246	0.904	144.9	367.3	60.5	51.6	85.3	

TABLE B.5-4 (Cont.)

Site Number/ Sample Number	TOTAL LIVE (TL) Weight (g)	Total Number	Weight Per Shoot (g/sh)	Dead (D) Biomass (g)	Total (T) Biomass T = D+TL (g)	Biomass Percentages $\frac{TL}{T}$x100	$\frac{DY}{T}$x100	$\frac{DY}{L}$x100	Comments
M19/1698									
Juncus roemerianus	230.2	269	0.856	92.3	322.5	71.4	51.1	71.6	Almost all stems parasitized to some degree.
M21/1700									
Juncus roemerianus	112.7	152	0.741	70.1	182.8	61.7	43.4	70.4	
Spartina patens				0.5	0.5				
Total				70.6	183.3				
M23/1710									
Juncus roemerianus	207.5	280	0.741	101.9	309.4	67.1	51.2	76.4	
M25/1712									
Juncus roemerianus	137.7	164	0.84	128.9	266.6	51.7	49.1	85.4	
Paspalum vaginatum				0.2	0.2				
Total				129.1	266.8				
M27/1714									
Juncus roemerianus	87.1	168	0.518	75.4	162.5	53.6	43.5	81.2	
M29/1716									
Juncus roemerianus	94.4	122	0.774	61.4	155.8	60.6	53.6	88.4	
Spartina patens				7.6	7.6				
Total				69.0	163.4	57.8	51.1	88.4	
M31/1718									
Juncus roemerianus	172.7	195	0.885	86.4	259.1	66.6	43.4	65.1	
Spartina patens	0.4	4		2.7	3.1				
Total	173.1	199	0.869	89.1	262.2	66.6	43.0	64.8	
M33/1720									
Juncus roemerianus	183.1	284	0.645	84.8	267.9	58.3	62.9	92.0	
Spartina patens	0.3	4	0.075	0.2	0.5	--	--	--	
Paspalum/Spartina mix				11.4	11.4	(with rhizome, 23 stalks)			
Total	183.4	288	0.637	96.4	279.8	65.5	60.2	91.8	

TABLE B.5-4 (Cont.)

Site Number/ Sample Number	TOTAL LIVE (TL) Weight (g)	Total Number	Weight Per Shoot (g/sh)	Dead (D) Bicmass (g)	Total (T) Biomass T = D+TL (g)	Biomass Percentages $\frac{TL}{T}$x100	$\frac{DY}{T}$x100	$\frac{DY}{L}$x100	Comments
M35/1722									
Juncus roemerianus	87.0	174	0.5	60.7	147.7	58.9	52.5	89.1	
M37/1724									
Juncus roemerianus	144.7	175	0.827	67.0	211.7	68.0	54.5	79.7	
M39/1726									
Juncus roemerianus	64.8	87	0.744	44.1	108.9	59.5	54.5	91.6	Heavily parasitized.
MEAN									
Juncus roemerianus	147.4	173.5	0.926	95.3	242.7	60.3	46.2	77.0	
STANDARD ERROR									
Juncus roemerianus	12.04	14.4	0.076	8.66	18.9	1.59	1.66	2.50	

TABLE B.5-5

TOTAL BIOMASS DATA SUMMARY FOR NORTH CONTROL SAMPLES

Site Number/ Sample Number	TOTAL LIVE (TL) Weight (g)	Total Number	Weight Per Shoot (g/sh)	Dead (D) Biomass (g)	Total (T) Biomass T = D+TL (g)	Biomass Percentages $\frac{TL}{T}$x100	$\frac{DY}{T}$x100	$\frac{DY}{L}$x100	Comments
NC1/1764									
Juncus roemerianus	124.5	203	0.6133	97.7	222.2	56	46	82.1	Stems have much smaller diameter than previously sorted plots.
NC3/1766									
Juncus roemerianus	102.2	212	0.482	52.6	154.8	66	40.8	61.8	Juncus color faded.
Spartina patens	56.1	99	0.567	39.3	95.4	59.4	0	0	
Total	158.3	311	0.509	91.9	250.2	63.3	25.3	39.9	
NC5/1768									
Juncus roemerianus	297.7	271	1.099	142	439.7	67.7	37.3	55.1	
Spartina patens	21.2	41	0.517	11.9	33.1	64.0	64.0	100.0	
Total	318.9	312	1.022	153.9	472.8				
NC7/1770									
Juncus roemerianus	128.9	247	0.522	58.3	187.2	68.9	41.5	60.2	
NC9/1772									
Juncus roemerianus	363.3	253	1.436	244.4	607.7	59.0	38.8	64.9	
NC11/1774									
Juncus roemerianus	216.9	343	0.632	133.4	350.3	61.9	43.6	70.4	DY) Most not obviously parasitized, evidence of oiling on stems.
Spartina patens	147.1	91	1.616	51.4	198.5	74.1	10.8	14.6	
Aster sp.	2.9	1	2.9	--	2.9	100%	0	0	
Total	365.9	435	0.843	184.8	551.7	66.5	31.6	47.5	
NC13/1734									
Juncus roemerianus	322	257	1.253	146.7	468.7	68.7	36.0	52.8	
NC15/1738									
Juncus roemerianus	385.3	373	1.033	215.5	600.8	64.1	39.1	61.0	15 stems w/obvious oil clumps (8 D, 7 DY), quite sticky.
NC17/1740									
Juncus roemerianus	400.2	422	0.948	232	632.2	63	39	62.0	

TABLE B.5-5 (Cont.)

Site Number/ Sample Number	TOTAL LIVE (TL) Weight (g)	Total Number	Weight Per Shoot (g/sh)	Dead (D) Biomass (g)	Total (T) Biomass T = D+TL (g)	Biomass Percentages $\frac{TL}{T}$x100	$\frac{DY}{T}$x100	$\frac{DY}{L}$x100	Comments
NC19/1742									
Juncus roemerianus	306.4	336	0.912	132.3	438.7	69.8	44.6	63.8	
NC21/1744									
Juncus roemerianus	260.3	234	1.112	121.2	381.5	68.2	40.7	59.7	
NC23/1745									
Juncus roemerianus	138.2	159	0.869	229.8	368.0	37.6	32.2	85.7	
MEAN									
Juncus roemerianus	253.8	275.8	0.909	150.5	404.3	62.6	40.0	65.0	
STANDARD ERROR									
Juncus roemerianus	31.4	22.3	0.037	19.2	46.5	2.58	1.1	2.9	

TABLE B.5-6

TOTAL BIOMASS DATA SUMMARY FOR WEST CONTROL SAMPLES

Site Number/ Sample Number	TOTAL LIVE (TL) Weight (g)	TOTAL LIVE (TL) Total Number	TOTAL LIVE (TL) Weight Per Shoot (g/sh)	Dead (D) Biomass (g)	Total (T) Biomass T = D+TL (g)	Biomass Percentages $\frac{TL}{T}$x100	Biomass Percentages $\frac{DY}{T}$x100	Biomass Percentages $\frac{DY}{L}$x100	Comments
WC1/1628									
Juncus roemerianus	355.7	326	1.091	194.6	550.3	64.6	45.4	70.3	
Distichlis spicata				2.5	2.5				
Total				197.1	552.8				
WC3/1750									
Juncus roemerianus	249.3	201	1.24	166.1	415.4	60.0	42.6	70.9	Looks recently oiled.
WC5/1749									
Juncus roemerianus	154.3	190	0.812	94.2	248.5	62.1	34.6	55.8	Oily.
Distichlis spicata				0.3	0.3				
Total				94.5	248.8				
WC7/1777									
Juncus roemerianus	170.7	130	1.313	126.3	297.0	57.5	37.3	64.9	
Spartina patens	9.3	5	1.86	31.9	41.2	22.6	22.6	100.0	
Total	180.0	135	1.333	158.2	338.2	53.2	35.5	66.7	
WC9/1779									
Juncus roemerianus	134.6	128	1.052	264.3	398.9	33.7	29.8	88.4	Probably not oiled.
Spartina patens				1.2	1.2				Sp = 3 L stems, 1 D, + roots
Total				265.5	399.1				
WC11/1781									
Juncus roemerianus	65.8	104	0.633	79.8	145.6	45.2	33.1	73.3	
WC13/1783									
Juncus roemerianus	109.7	132	0.831	118.2	227.9	48.1	22.5	46.8	
WC15/1785									
Juncus roemerianus	166.7	179	0.931	134.9	301.6	55.3	39.9	72.2	Oiled
WC17/1787									
Juncus roemerianus	171.3	217	0.789	127.9	299.2	57.3	40.2	70.2	Oiled - good fungus colony on stems, 35-40 cm

TABLE B.5-6 (Cont.)

Site Number/ Sample Number	TOTAL LIVE (TL) Weight (g)	Total Number	Weight Per Shoot (g/sh)	Dead (D) Biomass (g)	Total (T) Biomass T = D+TL (g)	Biomass Percentages $\frac{TL}{T}$x100	$\frac{DY}{T}$x100	$\frac{DY}{L}$x100	Comments
WC19/1789									
Juncus roemerianus	268.2	342	0.784	254.9	523.1	51.3	33.1	64.6	
WC21/1791									
Juncus roemerianus	225.4	222	1.015	272.0	497.4	45.3	23.1	50.9	
Spartina patens	38.7	49	0.790	21.1	59.8	64.7	64.7	100.0	
Total	264.1	271	0.975	293.1	557.2	47.4	27.5	58.1	
WC23/1973									
Juncus roemerianus	181.5	225	0.807	167.8	349.3	52.0	38.8	74.7	
WC25/1795									
Juncus roemerianus	137.1	240	0.571	134.3	271.4	50.5	40.0	79.2	
WC27/1797									
Juncus roemerianus	153.8	191	0.805	243.8	397.6	38.7	27.2	70.4	
Spartina patens	2.5	3	0.833	1.0	3.5	71.4	71.4	100.0	
Total	156.3	194	0.806	244.8	401.1				
WC29/1799									
Juncus roemerianus	112.6	126	0.895	157.5	270.1	41.7	32.4	77.8	Visible oil sheen from sediment (field note)
WC31/1801									
Juncus roemerianus	208.9	239	0.874	226.3	435.2	48.0	31.7	66.0	
WC33/1803									
Juncus roemerianus	248.9	302	0.824	248.2	497.1	50.1	28.4	56.8	Definitely oiled. Abrupt size jump from 30 to 50 cm.
WC35/1805									
Juncus roemerianus	113.9	128	0.890	248.6	362.5	31.4	28.3	90.2	DY Juncus heavily parasitized, color of live stems yellowish.
Spartina patens	1.2	1	1.2	0	1.2	100.0	0	0.0	
Total	115.1	129	0.892	248.6	363.7				

TABLE B.5-6 (Cont.)

Site Number/ Sample Number	TOTAL LIVE (TL) Weight (g)	Total Number	Weight Per Shoot (g/sh)	Dead (D) Biomass (g)	Total (T) Biomass T = D+TL (g)	Biomass Percentages $\frac{TL}{T}$x100	$\frac{DY}{T}$x100	$\frac{DY}{L}$x100	Comments
WC37/1807									
Juncus roemerianus	83.3	82	1.0157	103.8	187.1	44.5	31.6	71.1	Oil sheen coming up from sediment (field note)
Spartina patens	4.9	9		14.7	19.6	25.0	0.0	0.0	
Total	88.2	91	0.969	118.5	206.7	42.6	28.6	67.1	
WC39/1809									
Juncus roemerianus	221.7	161	1.377	200.6	422.3	52.5	43.0	81.9	
Spartina patens	12.2	9	1.356	1.2	13.4	91.0	74.6	82.0	
Total	233.9	170	1.376	201.8	435.7	53.7	44.0	81.9	
MEAN									
Juncus roemerianus	164.1	193.3	0.928	178.2	354.9	49.5	34.2	69.8	
STANDARD ERROR									
Juncus roemerianus	13.9	16.3	0.467	14.0	25.6	1.98	1.47	2.53	

APPENDIX C

Chemistry

APPENDIX C.1
Representative Gas Chromatographic Data

The following figures are gas chromatograms of representative samples not described in the text. Figures C.1-1 through C.1-20 represent samples analyzed by the University of New Orleans.

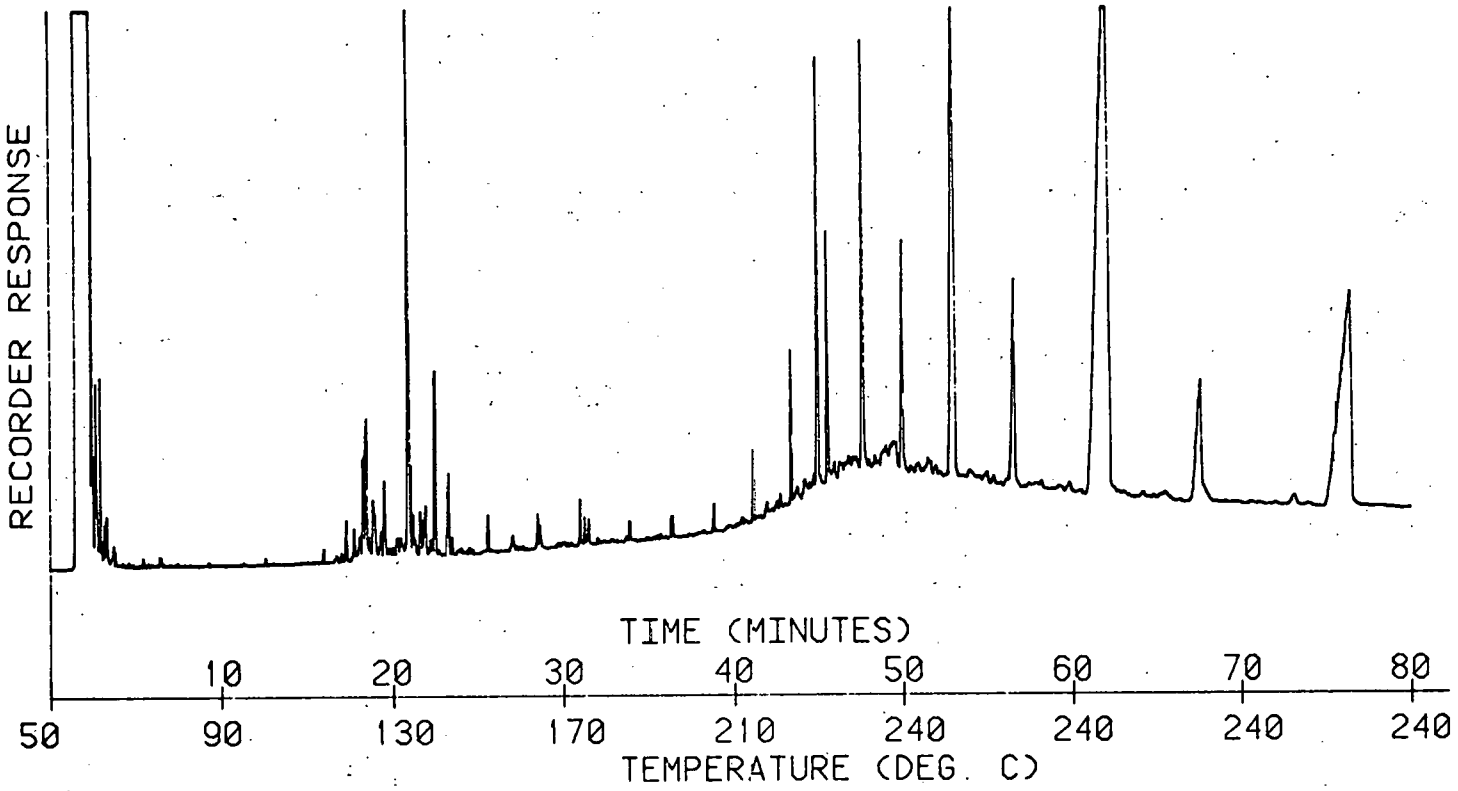


FIGURE C.1-1A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A FOLIAGE SAMPLE COLLECTED NEAR WELLPAD 6 AND HEAVILY IMPACTED WITH CAVERN 6 OIL (SAMPLE NO. 3)

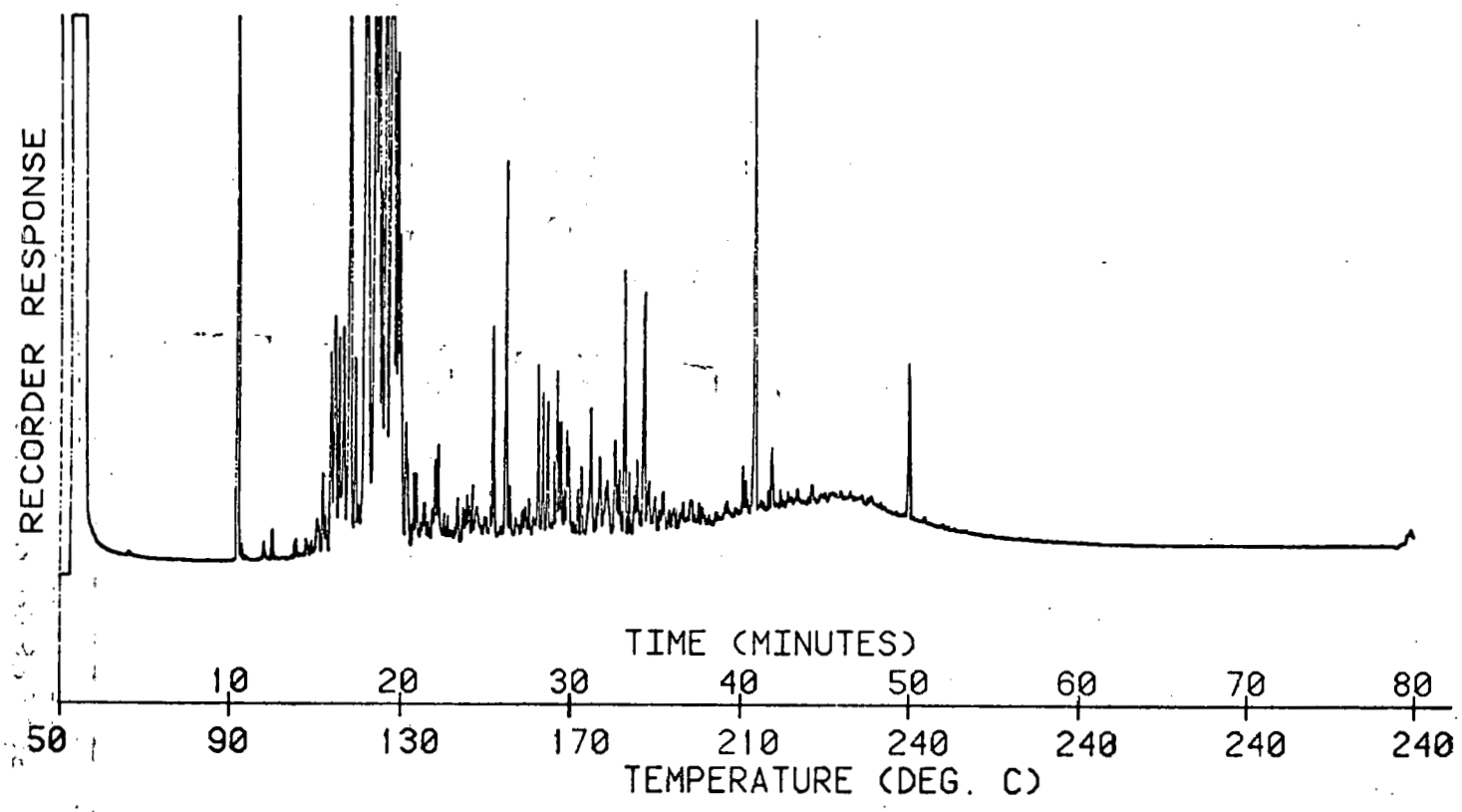


FIGURE C.1-1B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A FOLIAGE SAMPLE COLLECTED NEAR WELLPAD 6 AND HEAVILY IMPACTED WITH CAVERN 6 OIL (SAMPLE NO. 3)

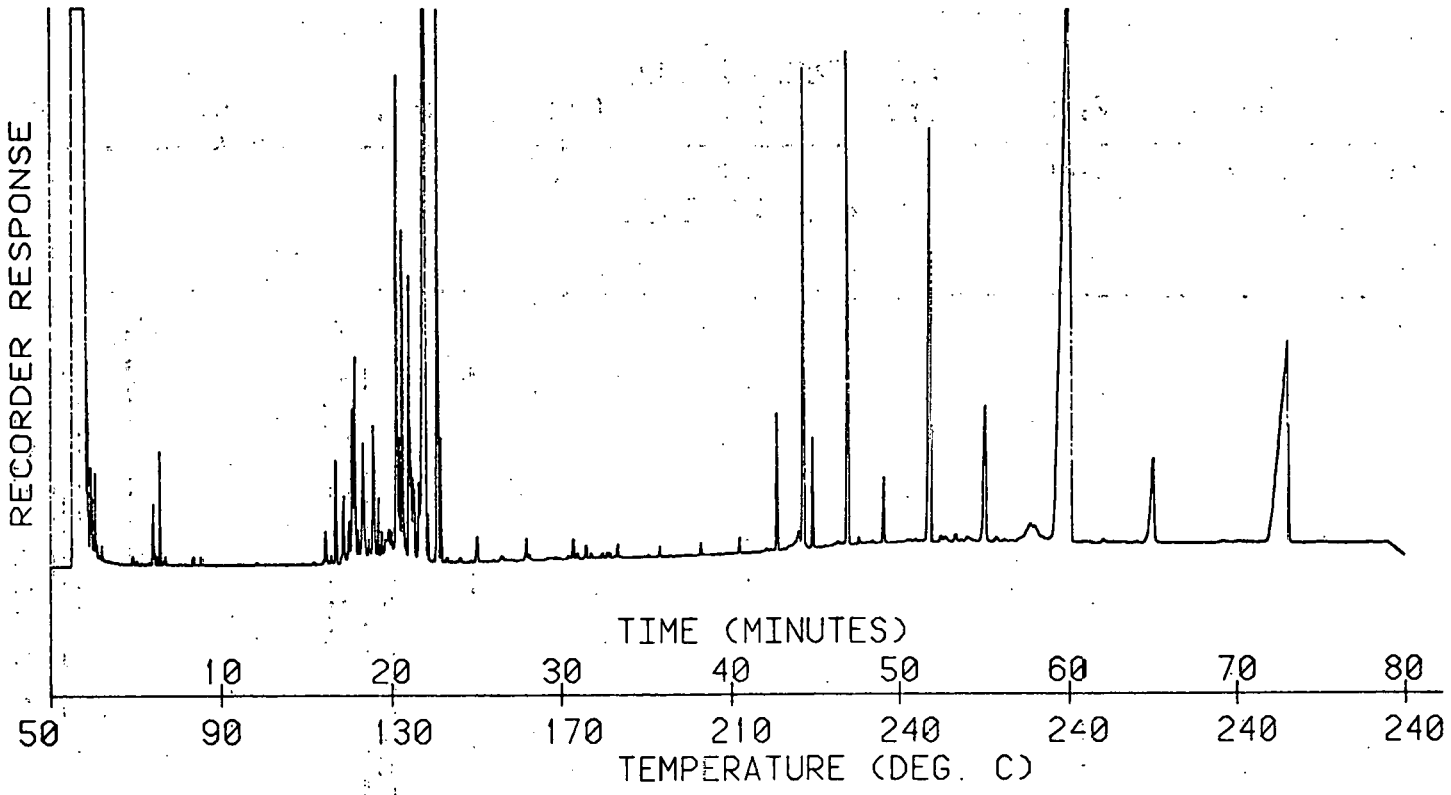


FIGURE C.1-2A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL FOLIAGE SAMPLE (SAMPLE NO. 43)

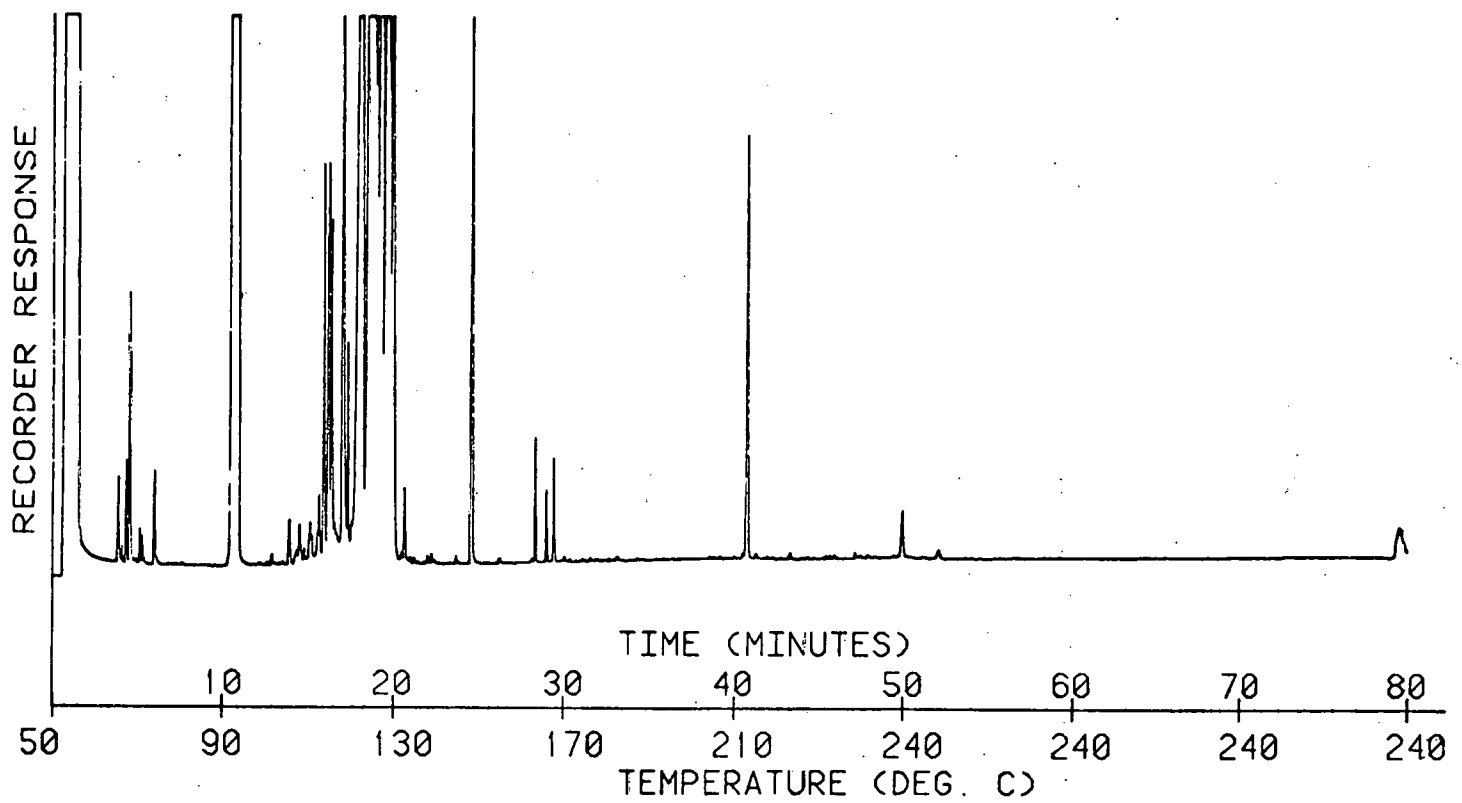


FIGURE C.1-2B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL FOLIAGE SAMPLE (SAMPLE NO.43)

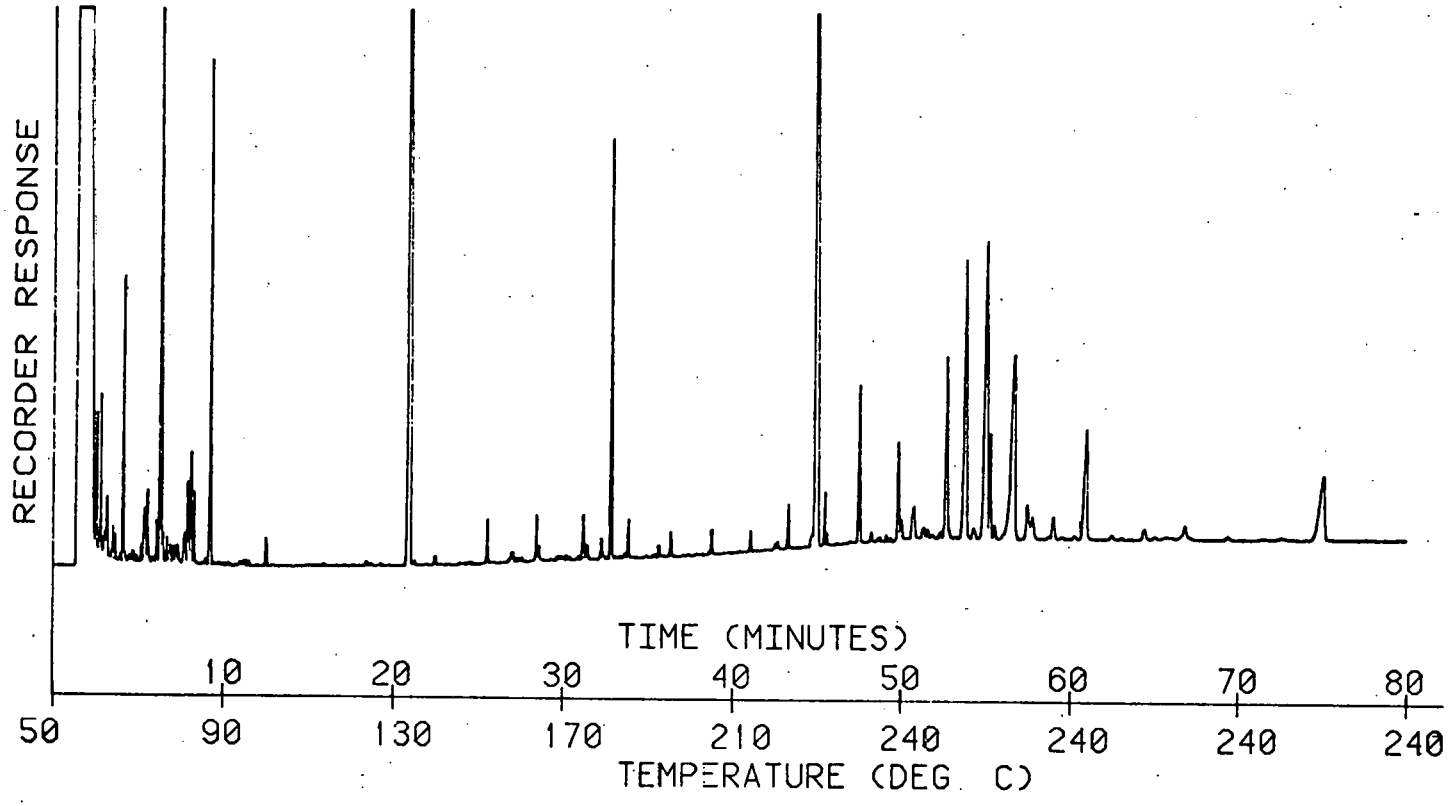
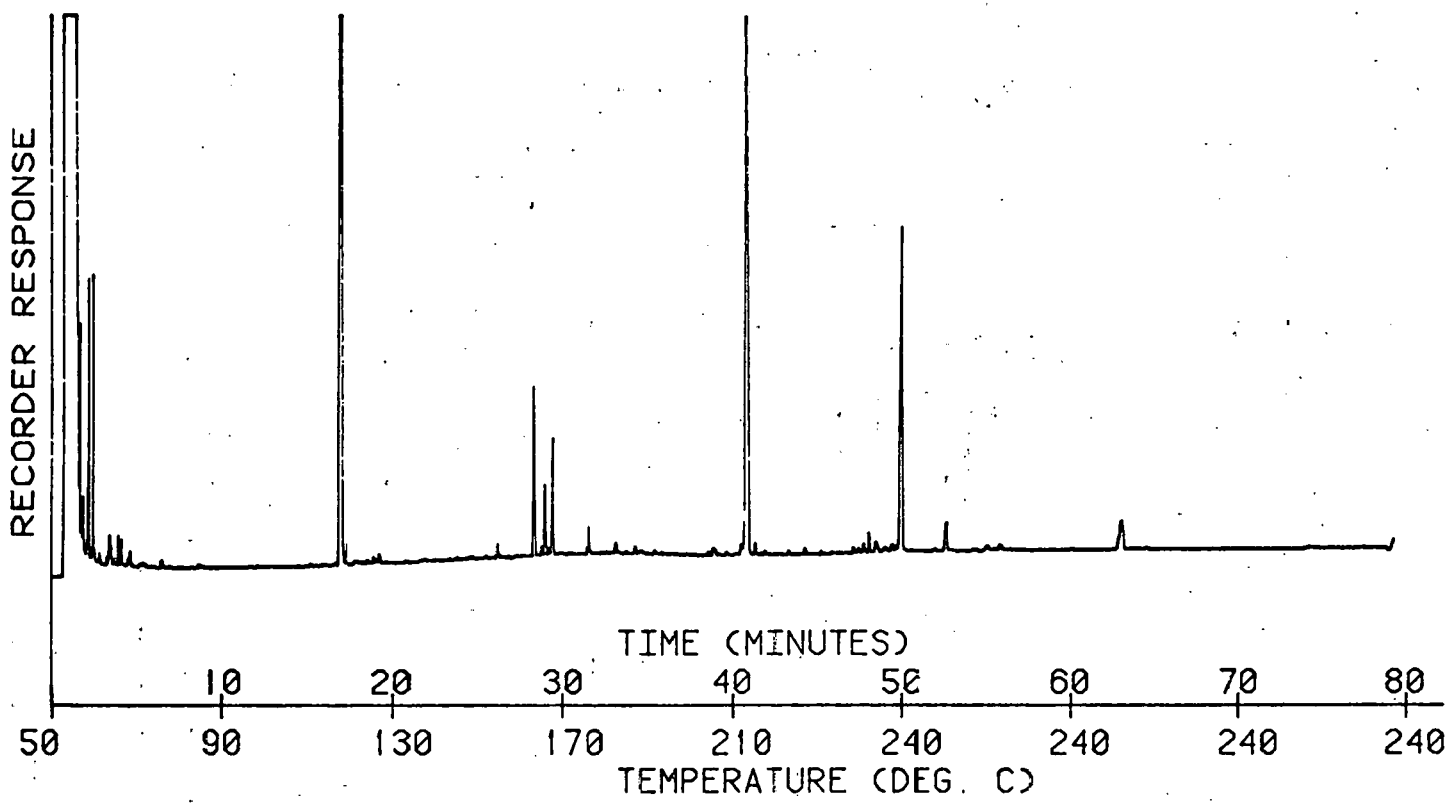


FIGURE C.1-3A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SOIL SAMPLE (SAMPLE NO. 640)



FRACTIONS) OF A TYPICAL SOIL SAMPLE (SAMPLE NO. 640)

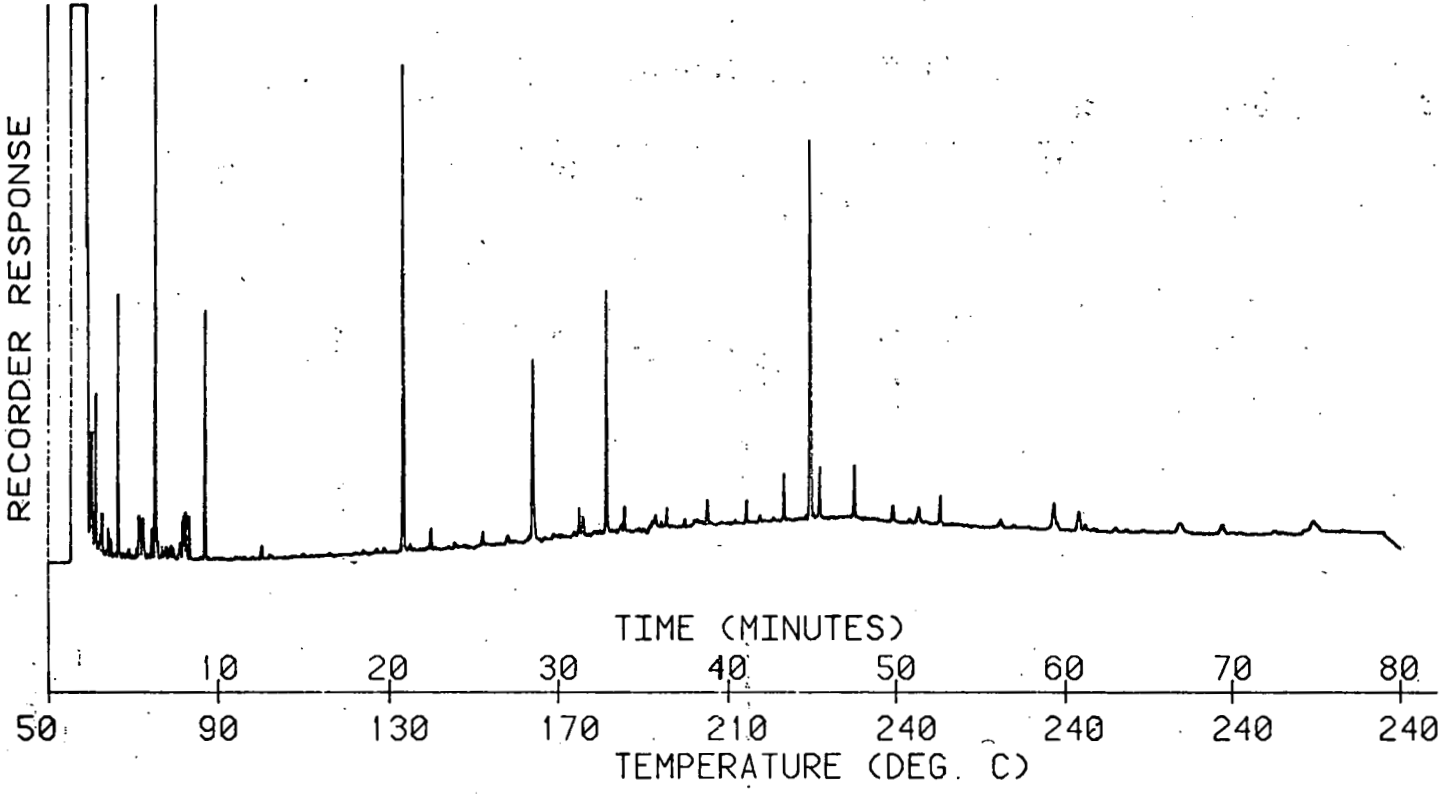


FIGURE C.1-4A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN THE IMPACT AREA LIGHTLY CONTAMINATED WITH CAVERN 6 OIL (SAMPLE NO. 627)

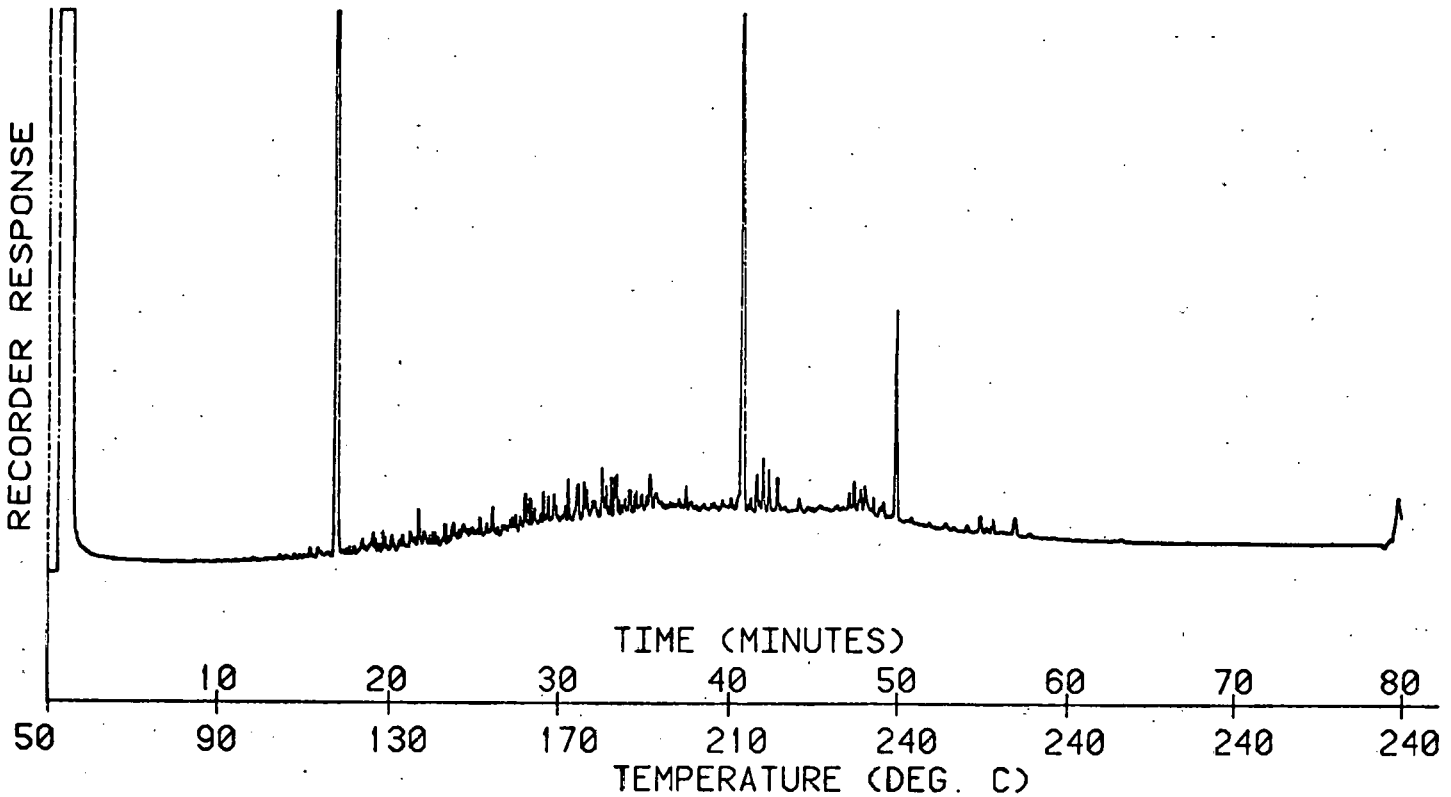


FIGURE C.1-4B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN THE IMPACT AREA LIGHTLY CONTAMINATED WITH CAVERN 6 OIL (SAMPLE NO. 627)

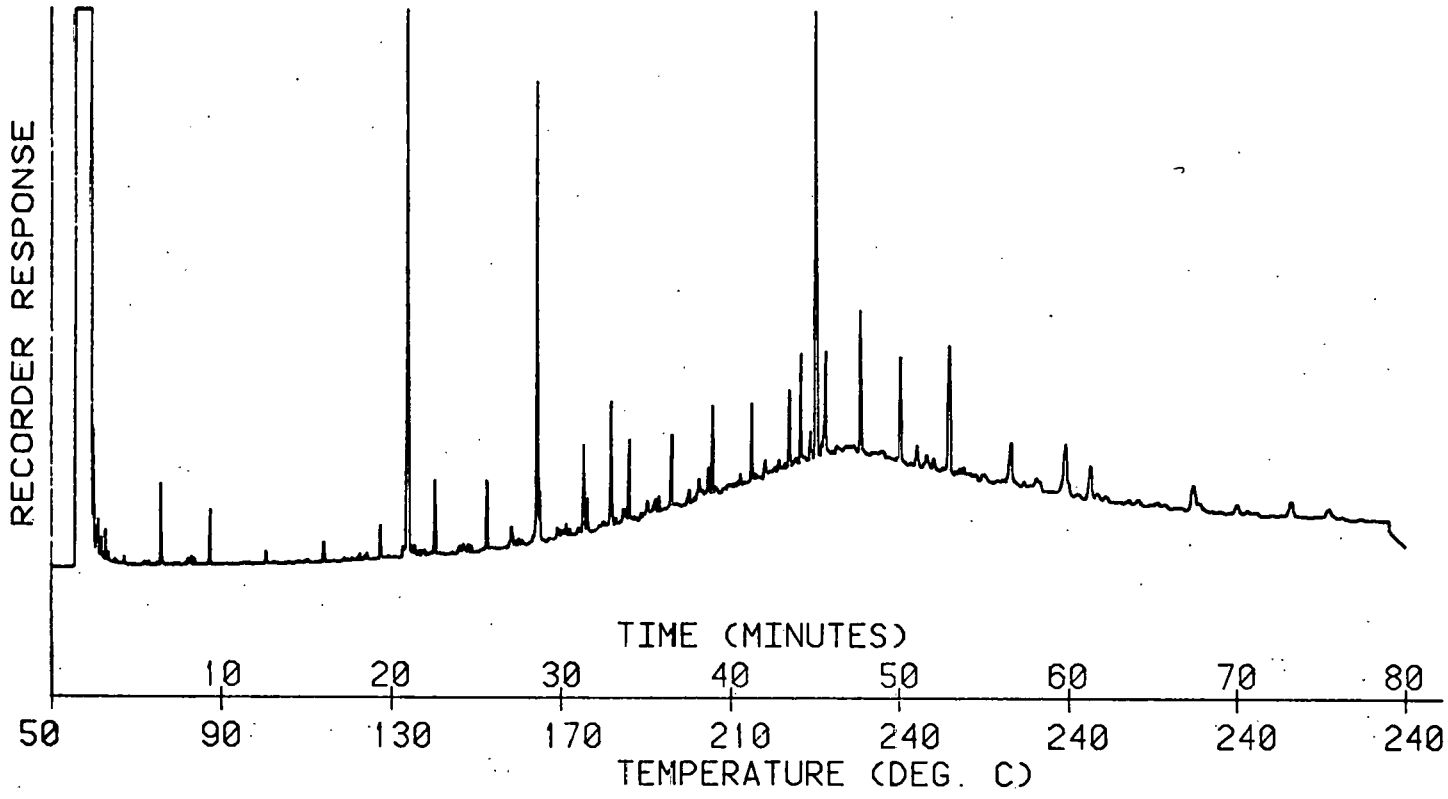


FIGURE C.1-5A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE I) IN THE IMPACT AREA MODERATELY CONTAMINATED WITH CAVERN 6 OIL (SAMPLE NO. 13)

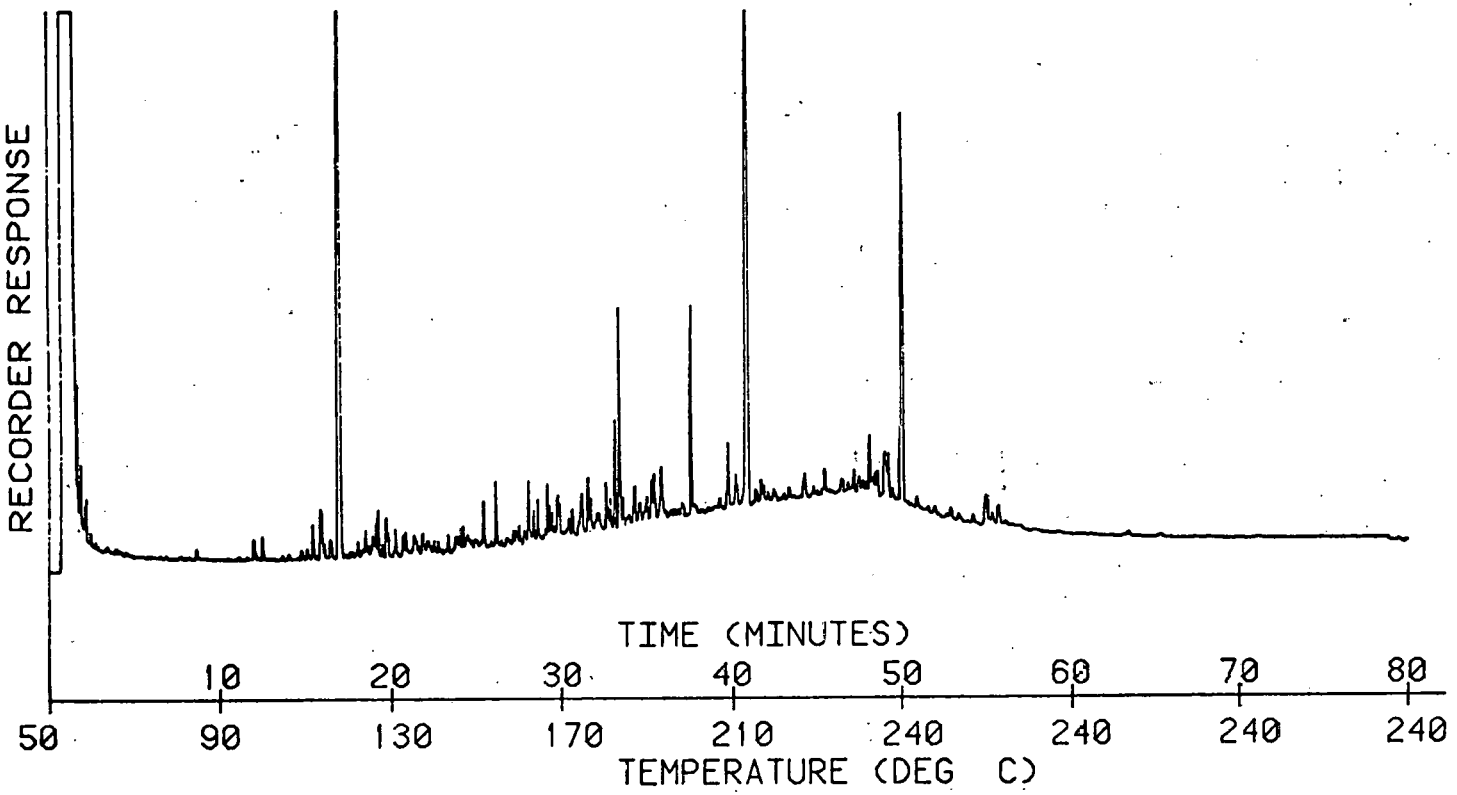


FIGURE C.1-5B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE I) IN THE IMPACT AREA MODERATELY CONTAMINATED WITH CAVERN 6 OIL (SAMPLE NO. 13)

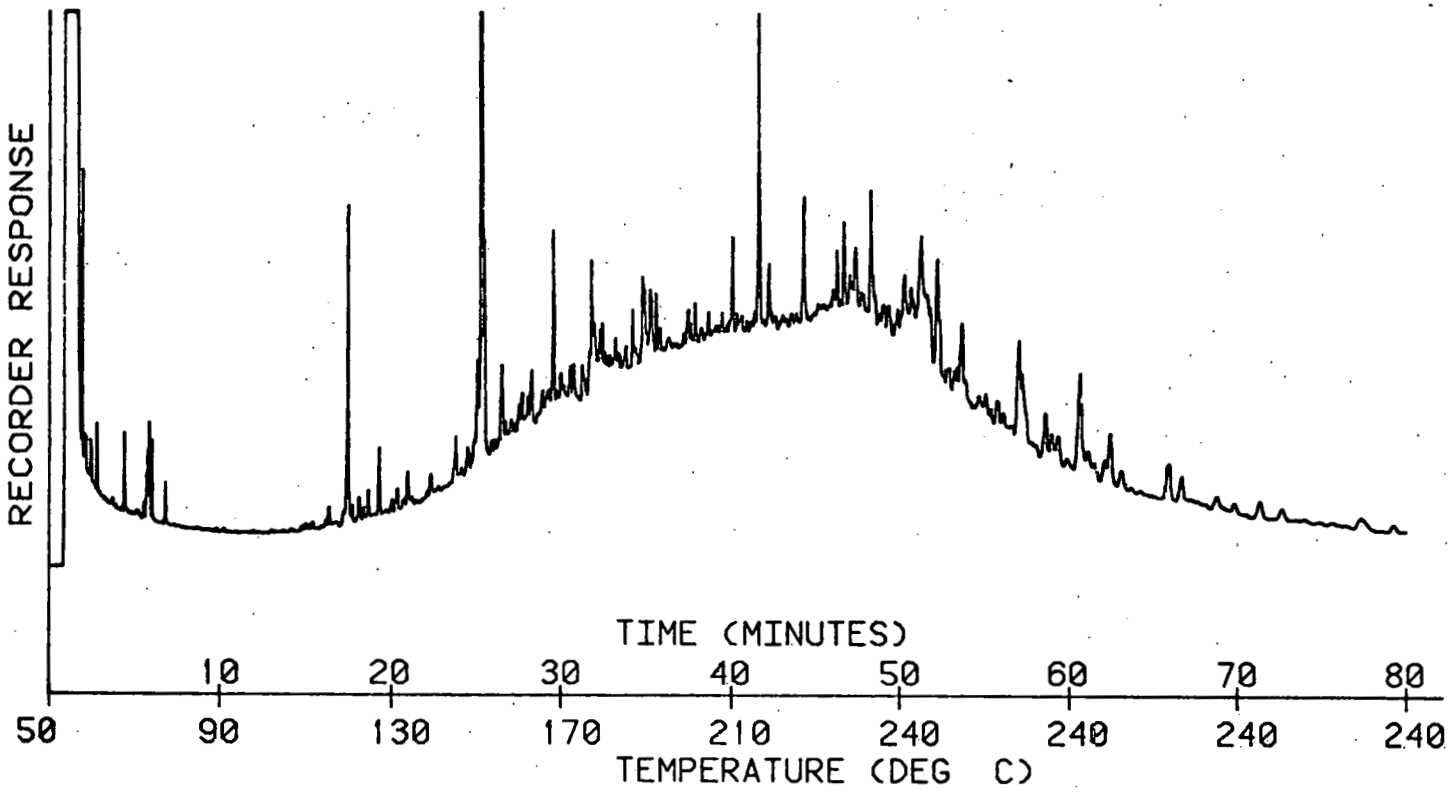


FIGURE C.1-6A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE III) IN THE IMPACT AREA MODERATELY CONTAMINATED WITH CAVERN 6 OIL BUT SUBSTANTIALLY WEATHERED (SAMPLE NO. 1254)

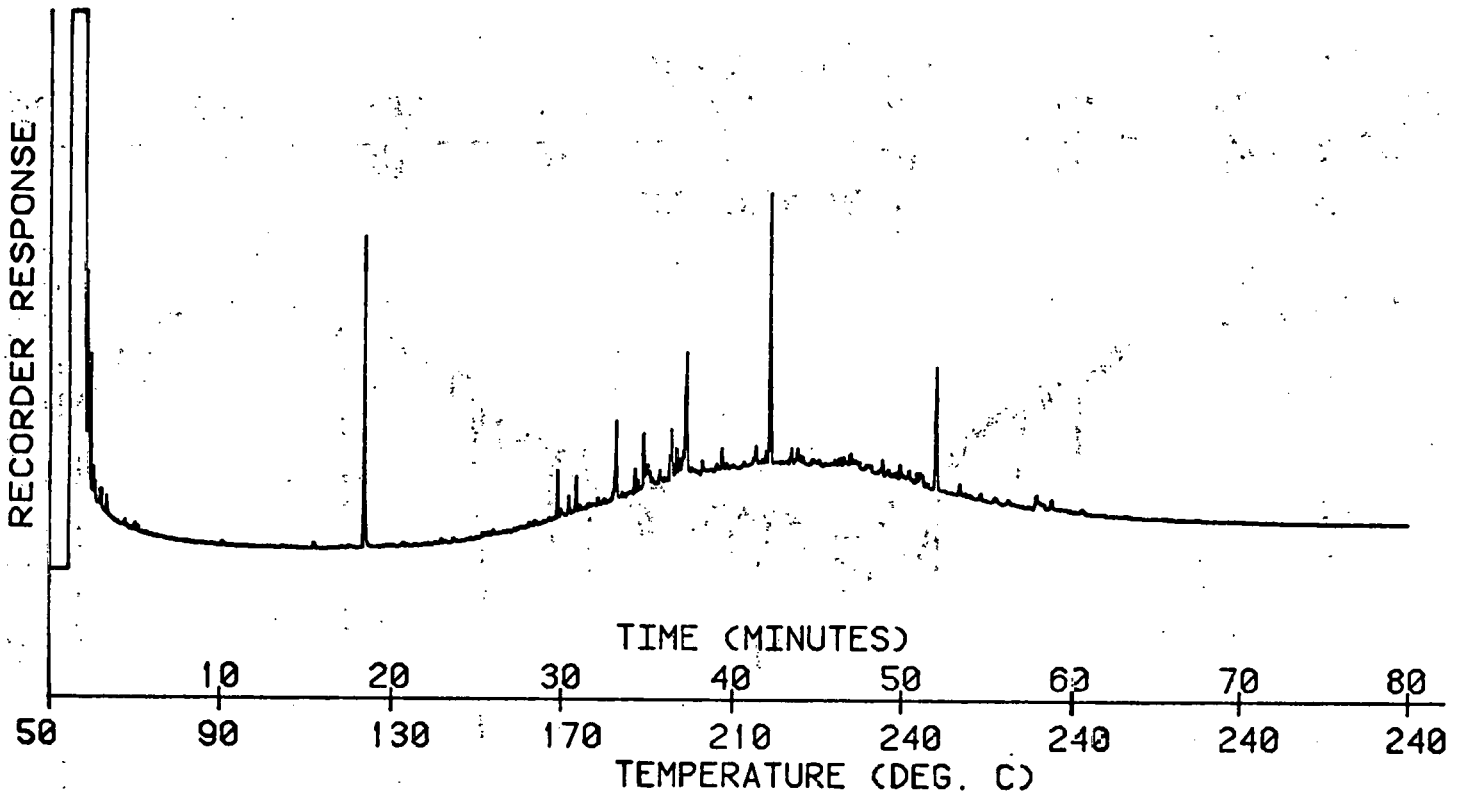


FIGURE C.1-6B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE III) IN THE IMPACT AREA MODERATELY CONTAMINATED WITH CAVERN 6 OIL BUT SUBSTANTIALLY WEATHERED (SAMPLE NO. 1254)

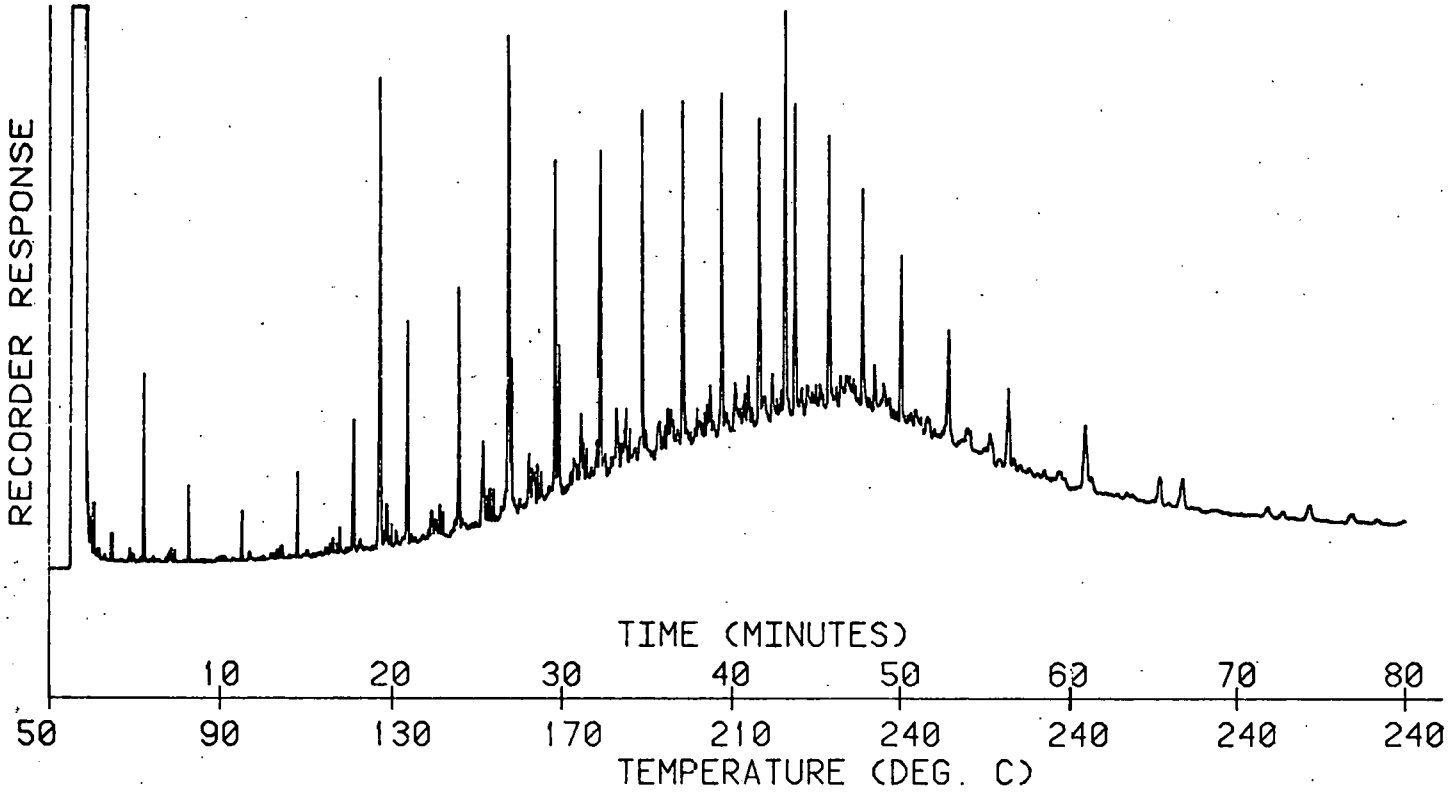


FIGURE C.1-7A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE I) IN THE IMPACT AREA HEAVILY CONTAMINATED WITH CAVERN 6 OIL (SAMPLE NO. 122)

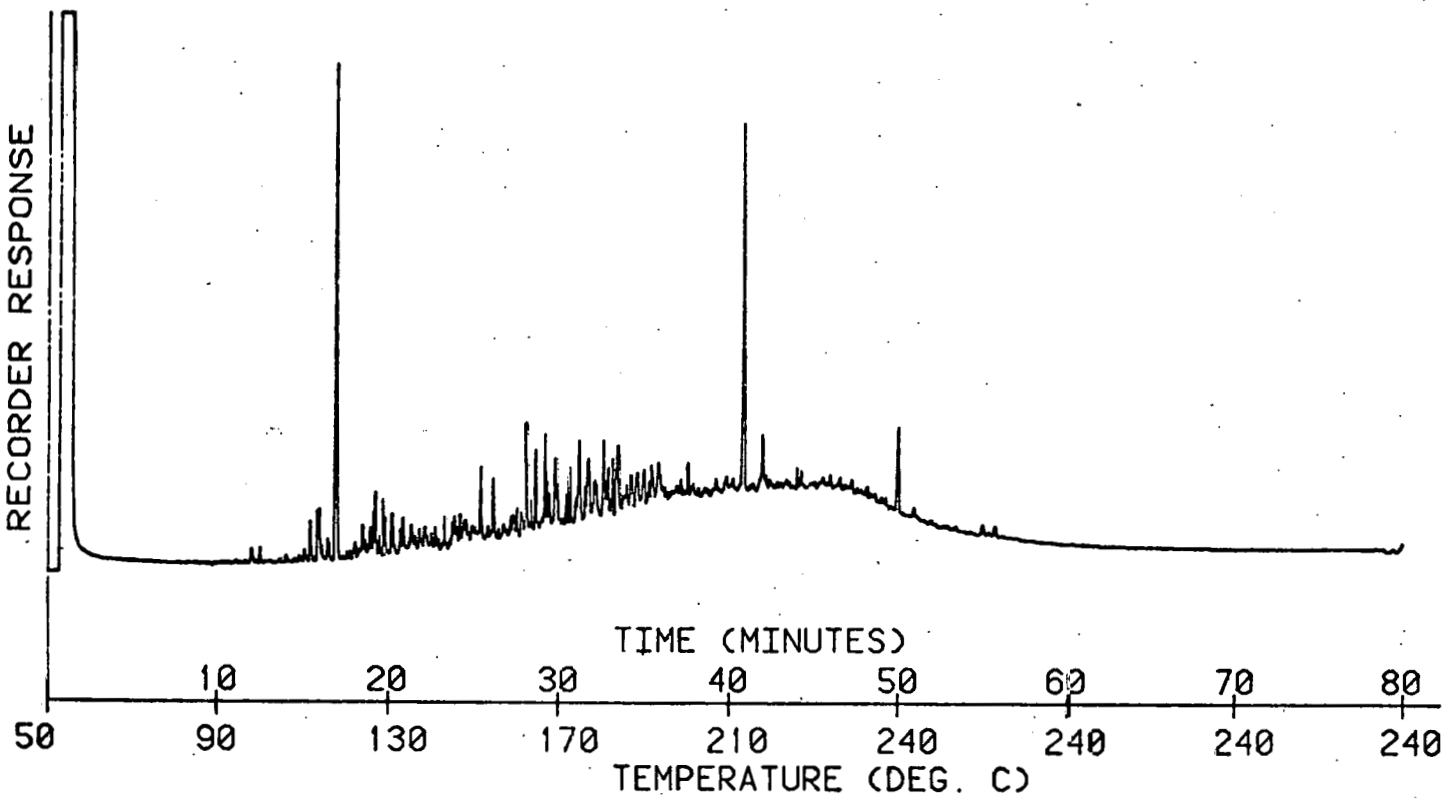


FIGURE C.1-7B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE I) IN THE IMPACT AREA HEAVILY CONTAMINATED WITH CAVERN 6 OIL (SAMPLE NO. 122)

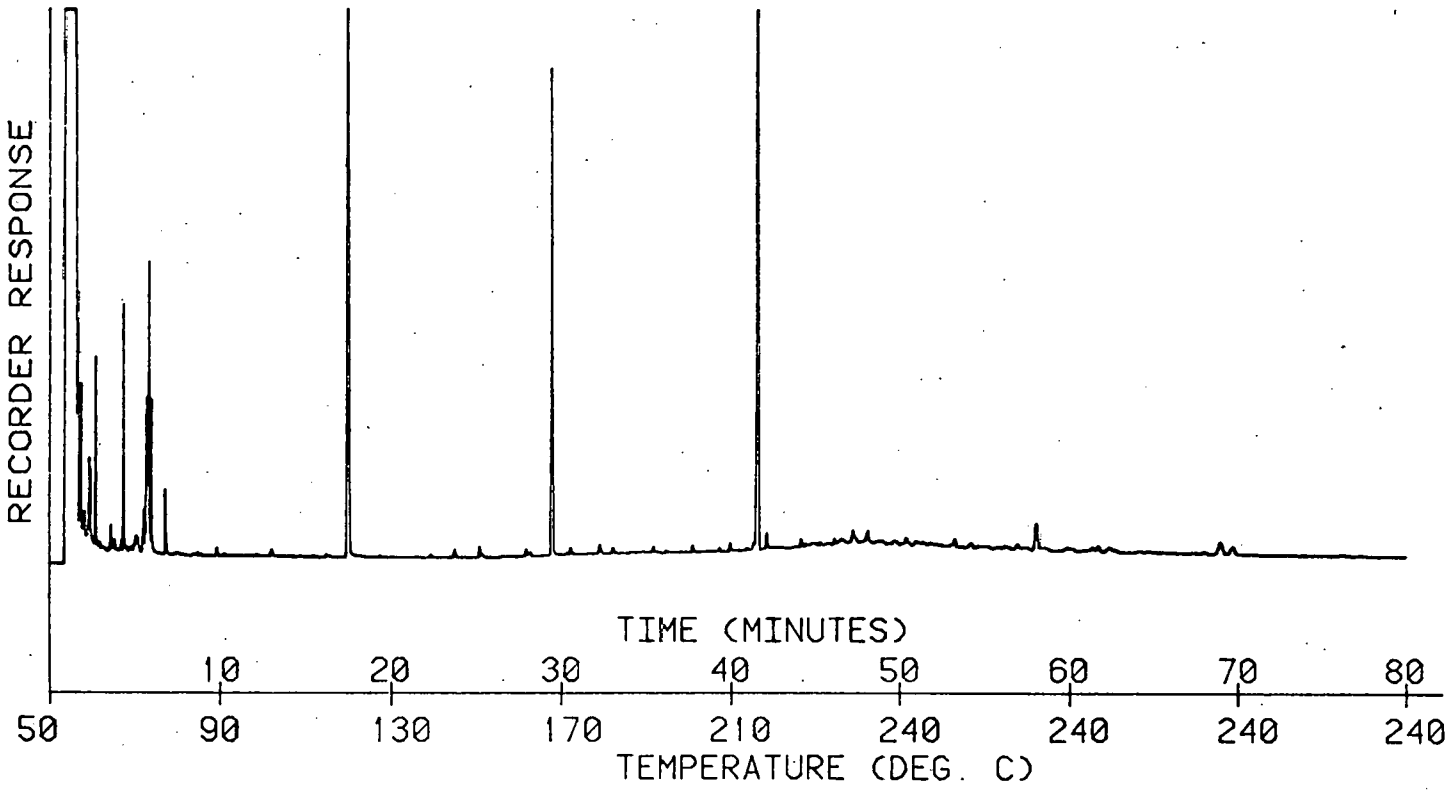


FIGURE C.1-8A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE III) IN THE IMPACT AREA RELATIVELY UNCONTAMINATED (SAMPLE NO. 1282)

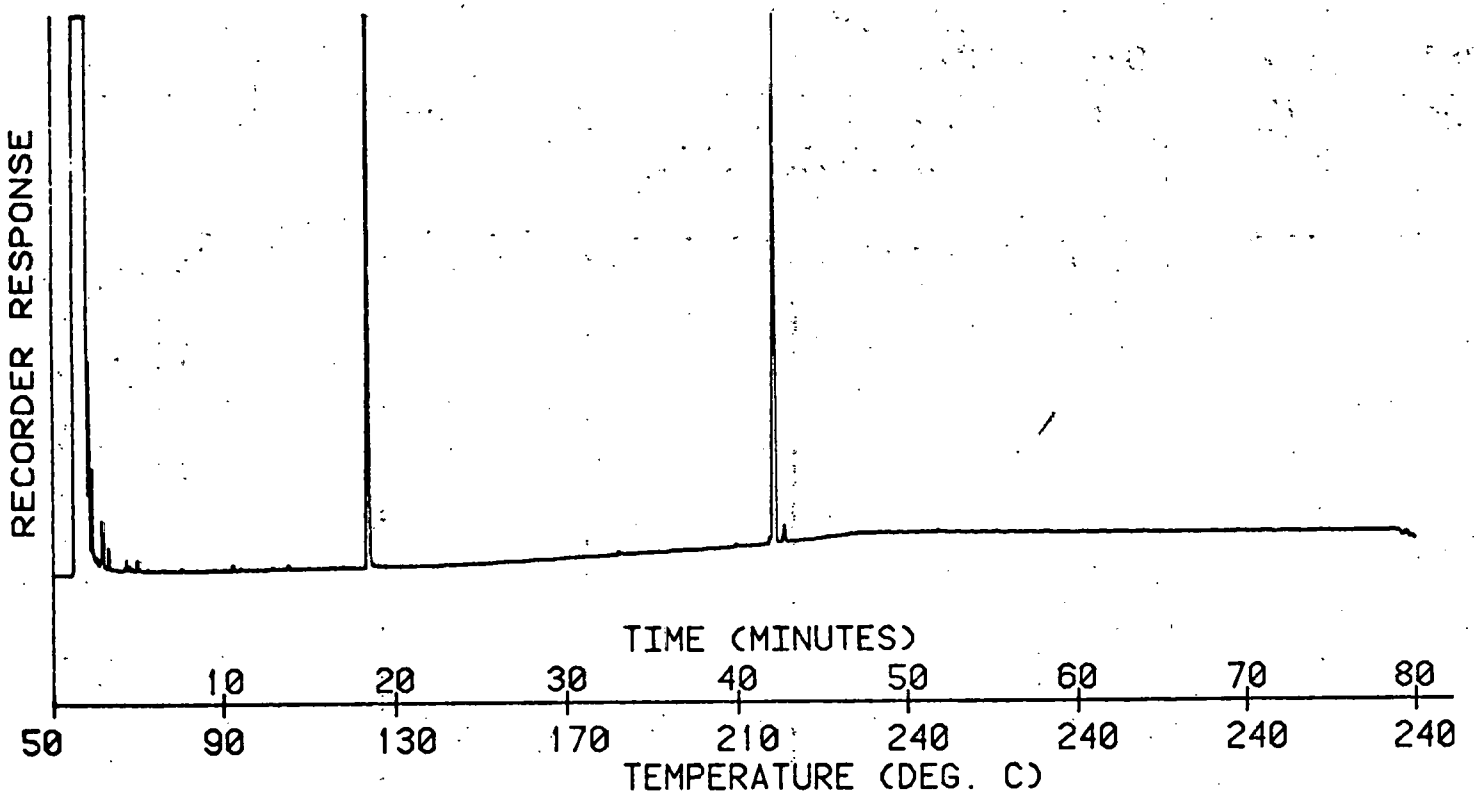


FIGURE C.1-8B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE III) IN THE IMPACT AREA RELATIVELY UNCONTAMINATED (SAMPLE NO. 1282)

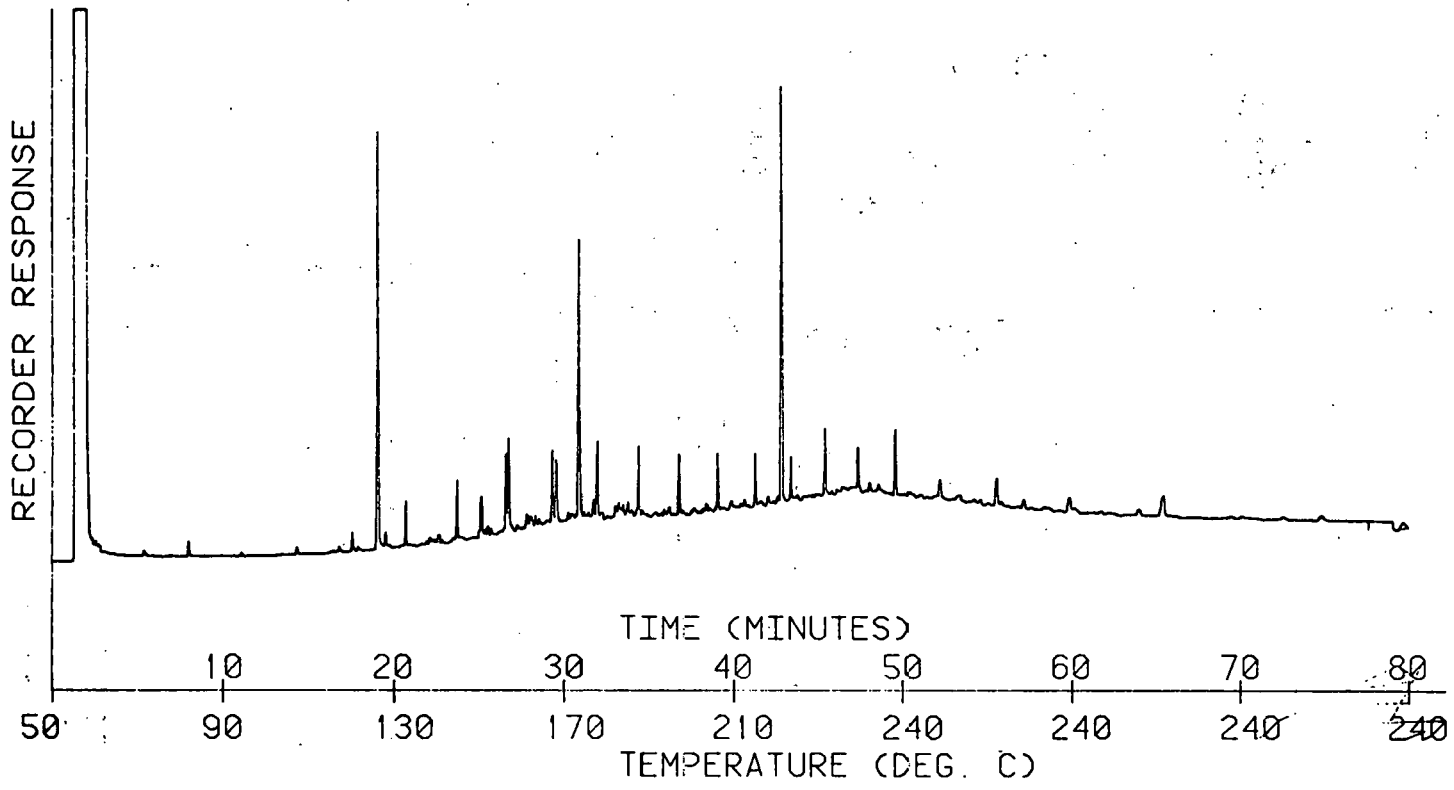


FIGURE C.1-9A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN THE IMPACT AREA MODERATELY CONTAMINATED WITH INDIGENOUS OIL (SAMPLE NO. 942)

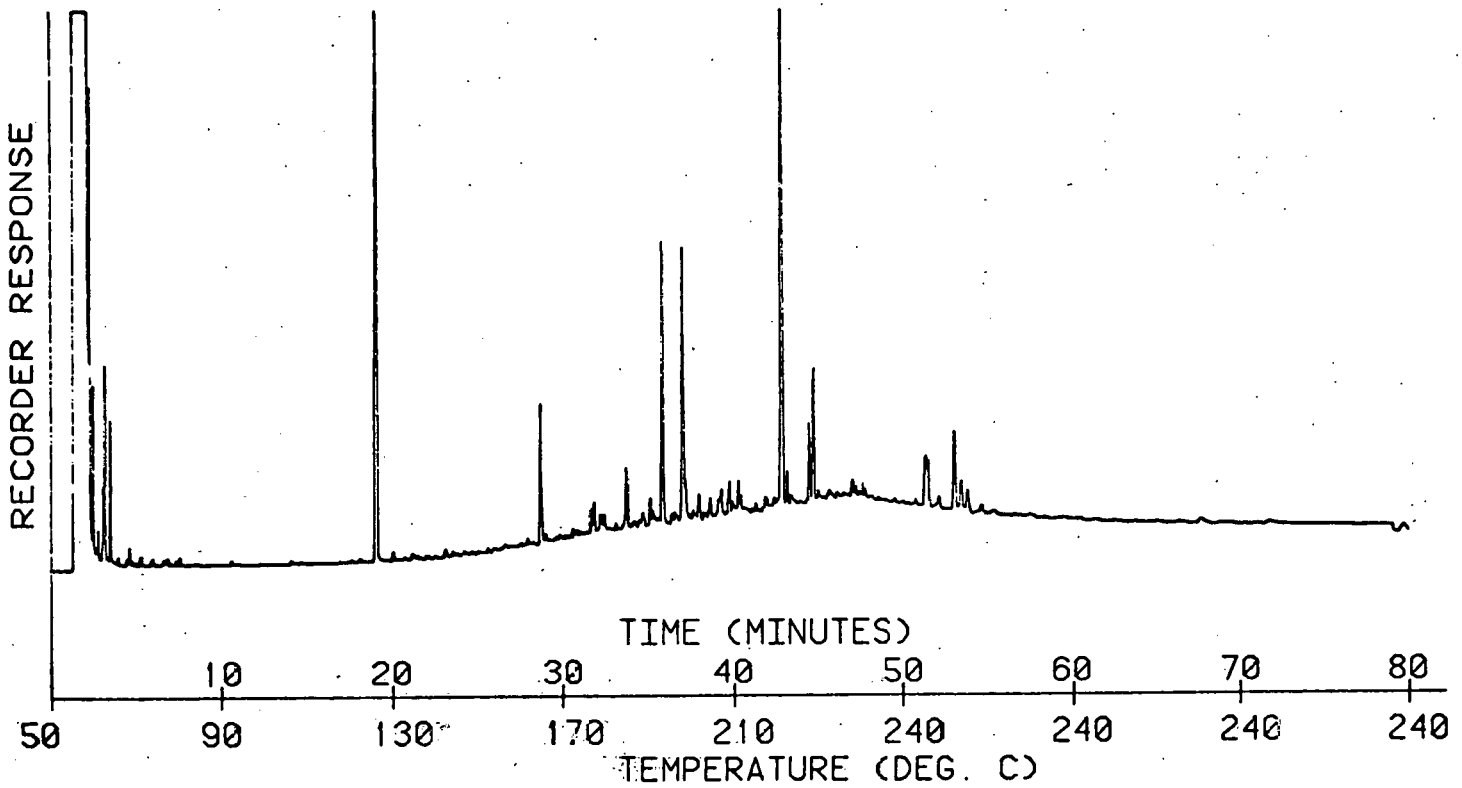


FIGURE C.1-9B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN THE IMPACT AREA MODERATELY CONTAMINATED WITH INDIGENOUS OIL (SAMPLE NO. 942)

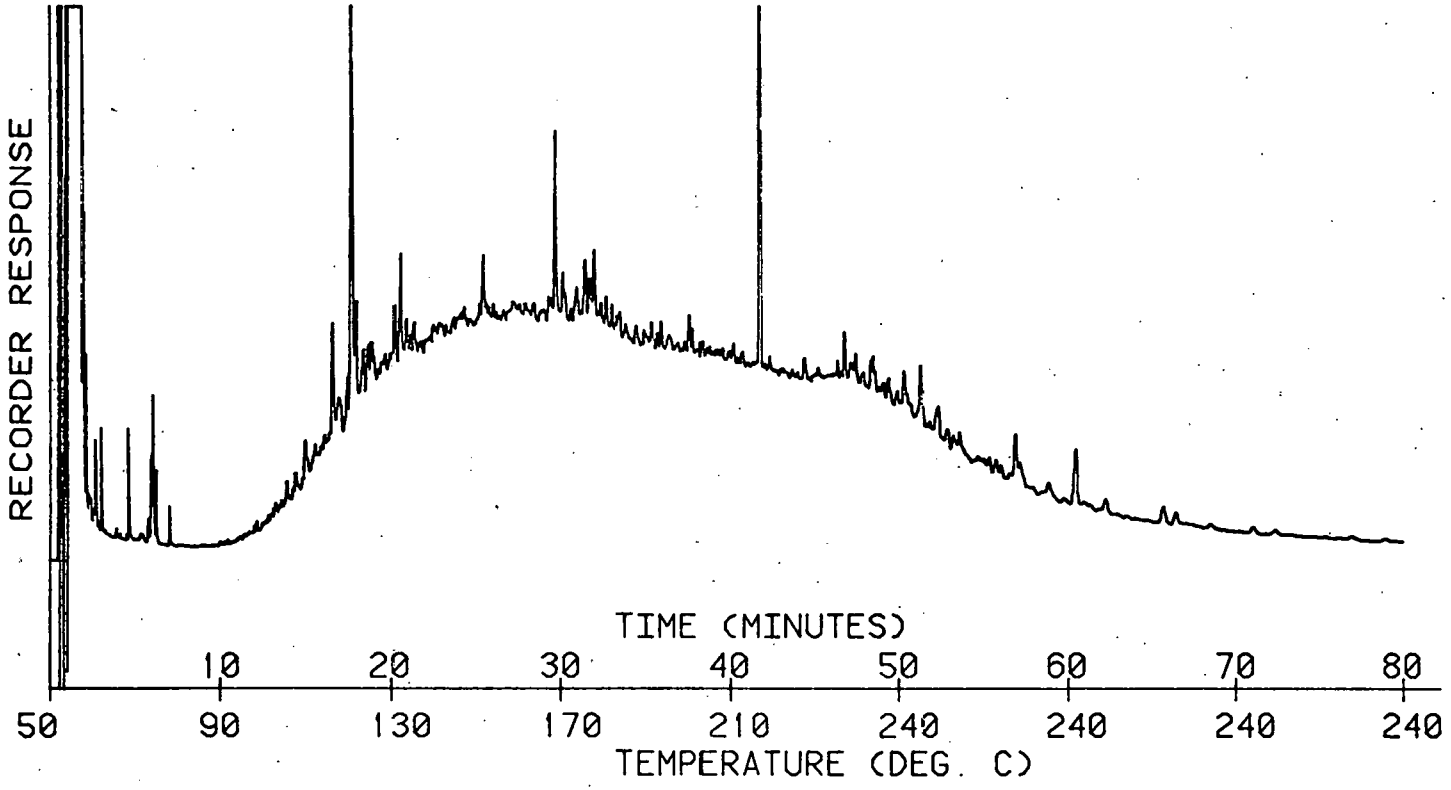


FIGURE C.1-10A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN THE IMPACT AREA WITH SUBSTANTIALLY WEATHERED INDIGENOUS OIL (SAMPLE NO. 946)

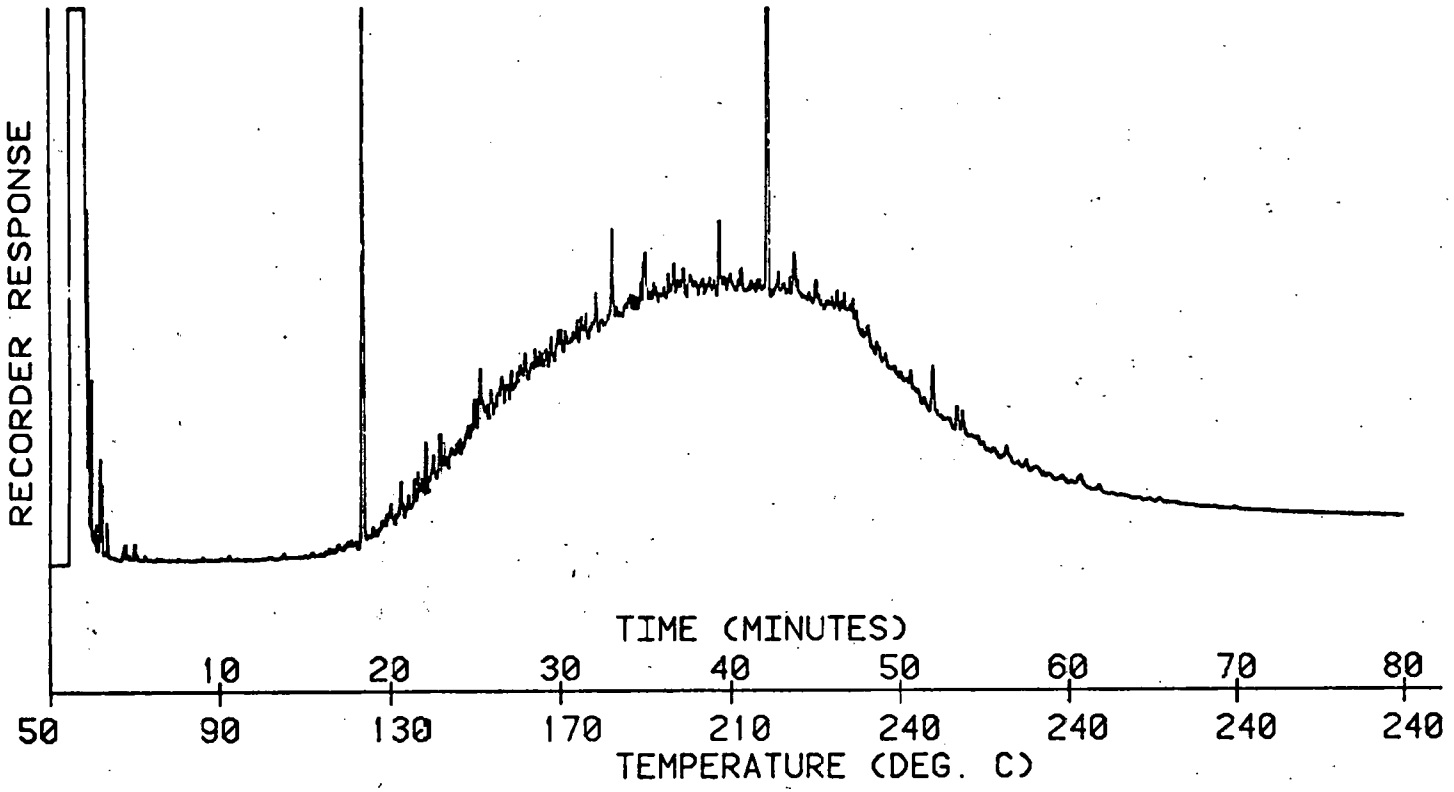


FIGURE C.1-10B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN THE IMPACT AREA WITH SUBSTANTIALLY WEATHERED INDIGENOUS OIL (SAMPLE NO. 946)

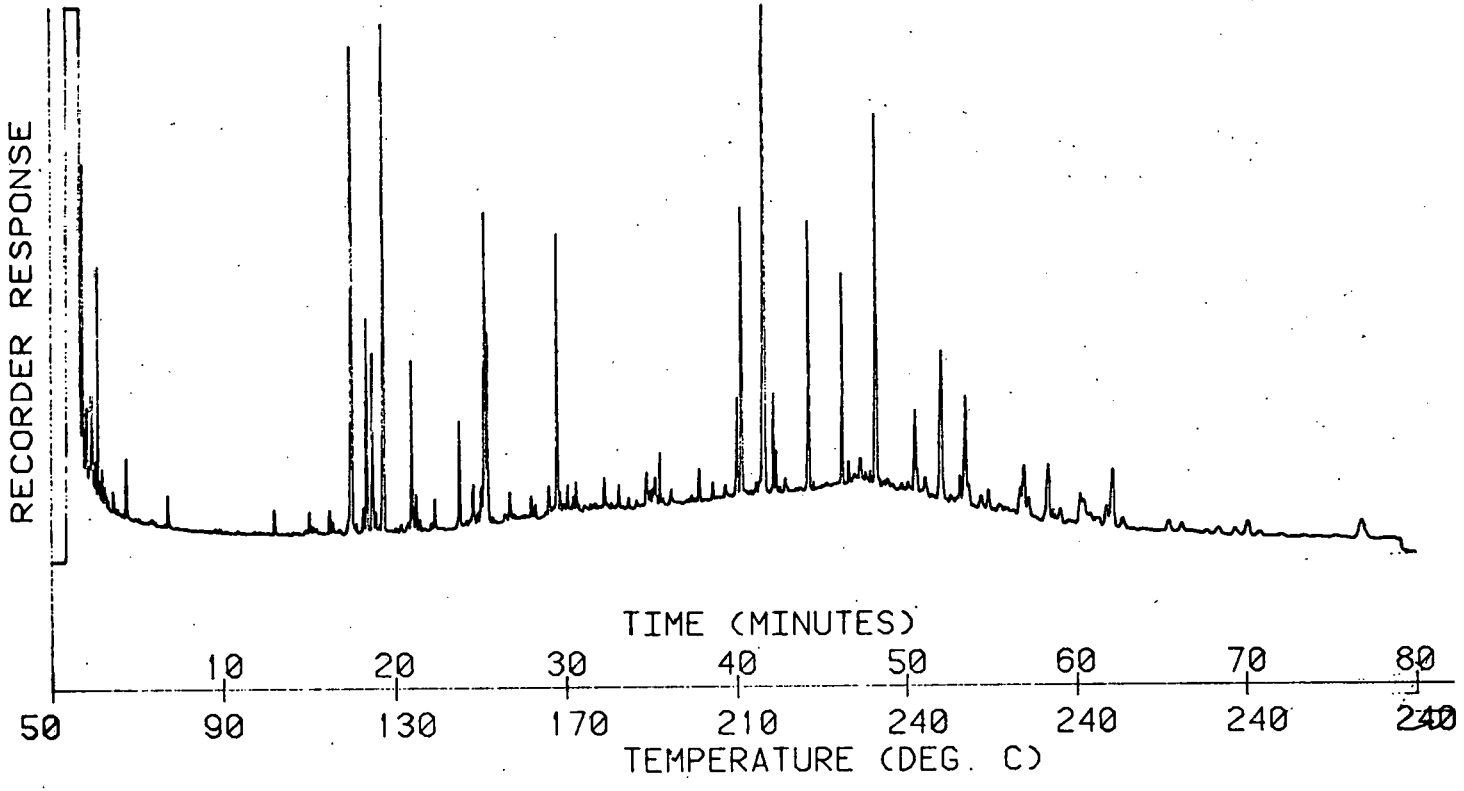


FIGURE C.1-11A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN EASTERN BLACK LAKE WITH LITTLE INDIGENOUS OIL CONTAMINATION (SAMPLE NO. 604)

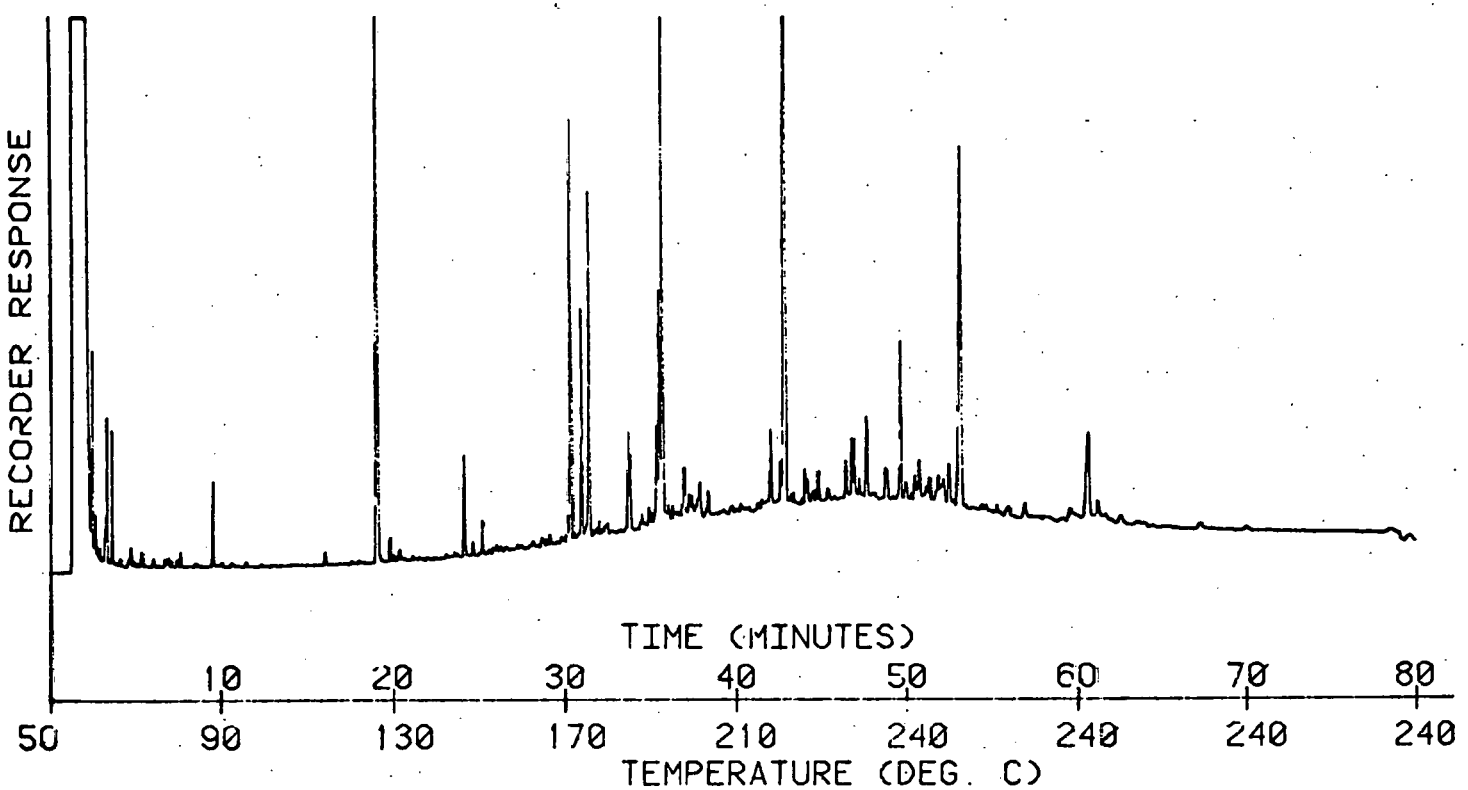


FIGURE C.1-11B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN EASTERN BLACK LAKE WITH LITTLE INDIGENOUS OIL CONTAMINATION (SAMPLE NO. 604)

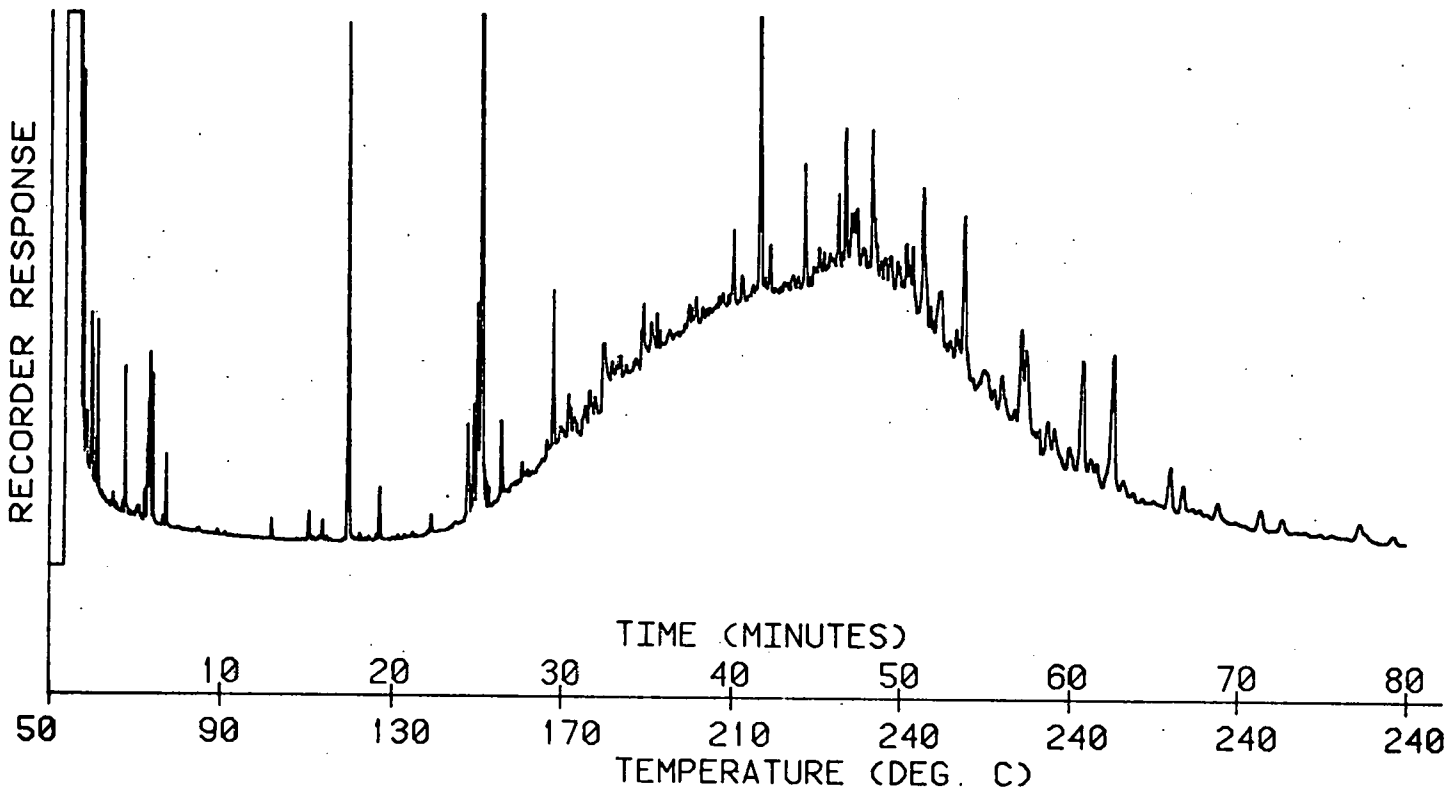


FIGURE C.1-12A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE III) IN EASTERN BLACK LAKE WITH HEAVILY WEATHERED INDEGENOUS OIL (SAMPLE NO. 1187)

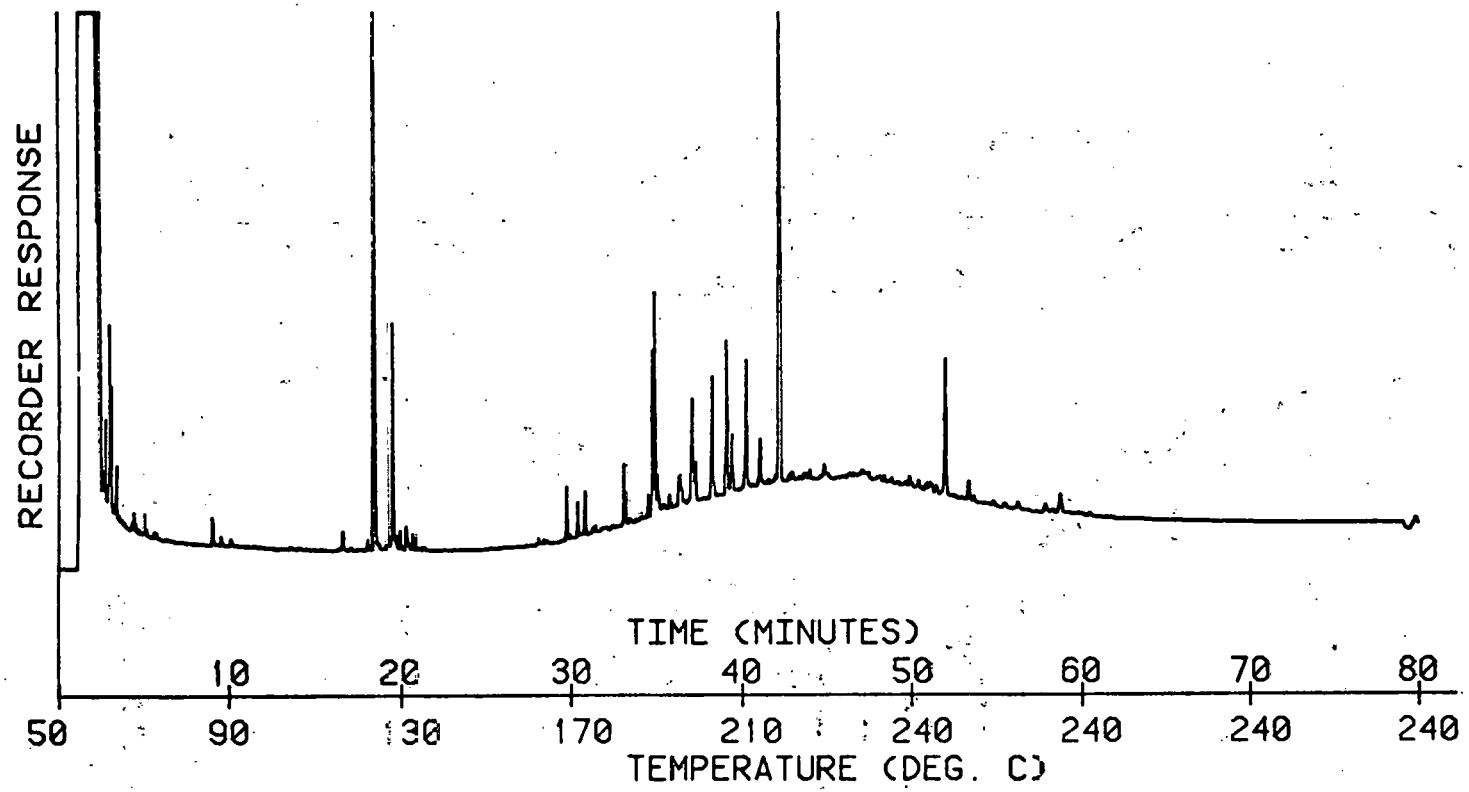


FIGURE C.1-12B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE III) IN EASTERN BLACK LAKE WITH HEAVILY WEATHERED INDIGENOUS OIL (SAMPLE NO. 1187)

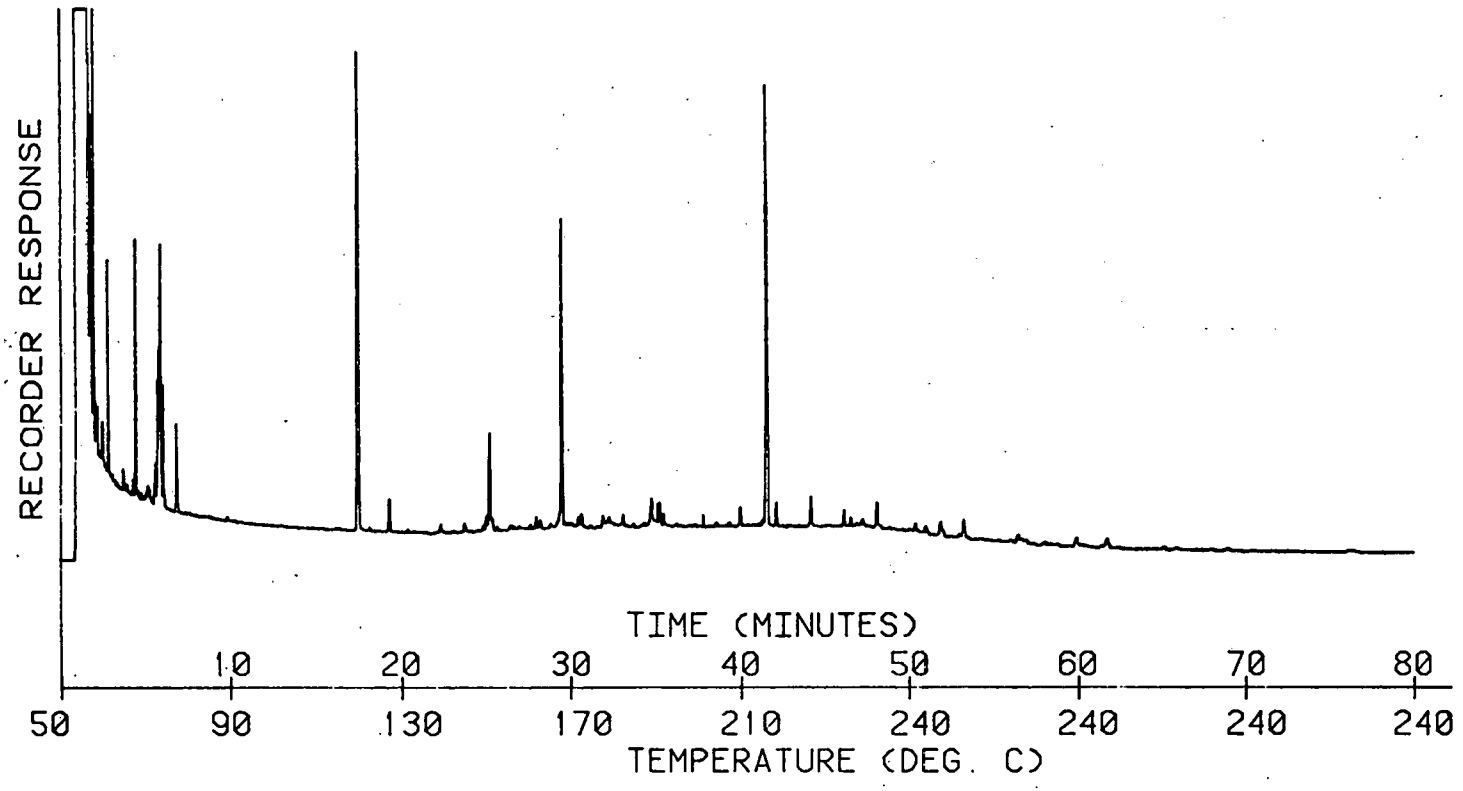


FIGURE C.1-13A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN WESTERN BLACK LAKE WITH LITTLE INDIGENOUS OIL CONTAMINATION (SAMPLE NO. 631)

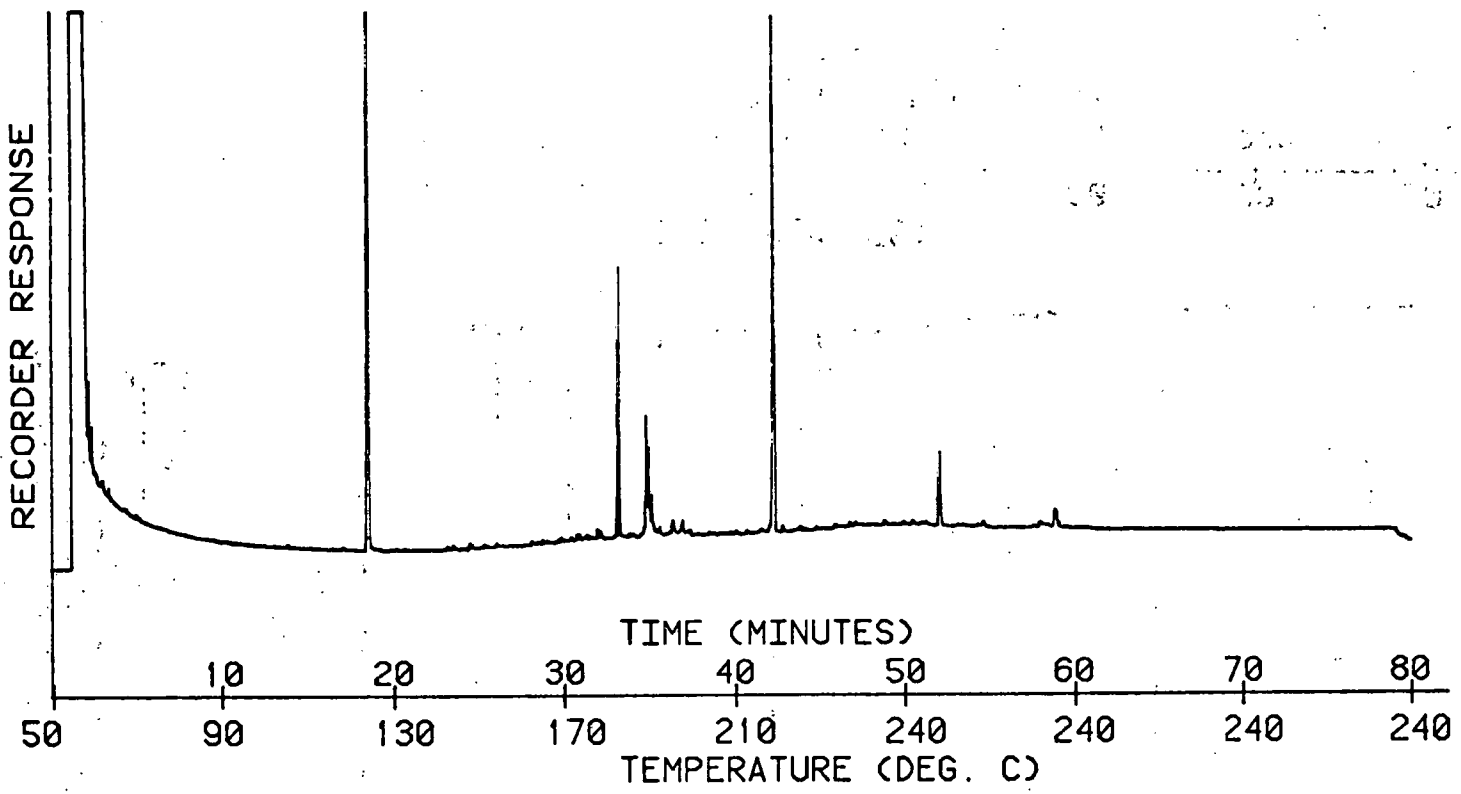


FIGURE C.1-13B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN WESTERN BLACK LAKE WITH LITTLE INDIGENOUS OIL CONTAMINATION (SAMPLE NO. 631)

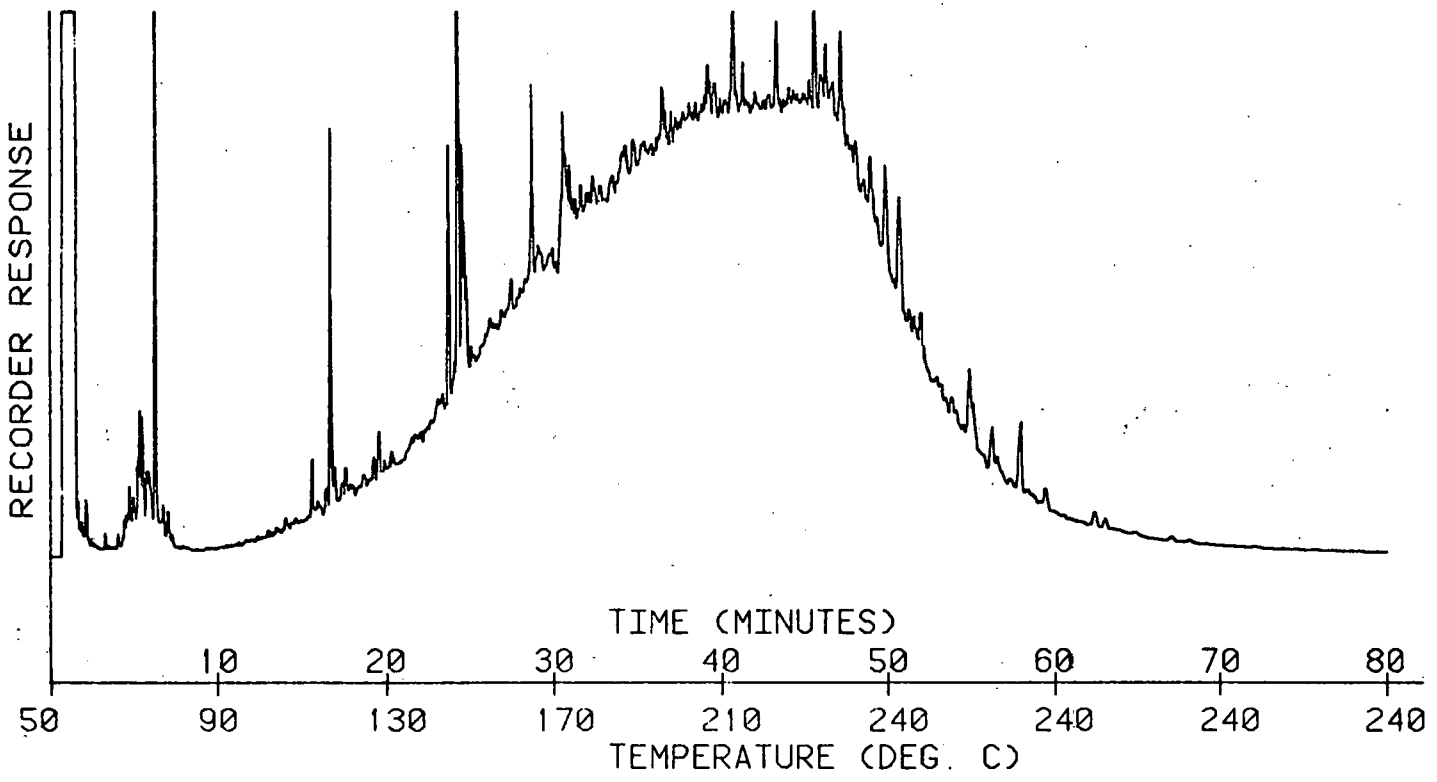


FIGURE C.1-14A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE IV) IN WESTERN BLACK LAKE WITH HEAVILY WEATHERED INDIGENOUS OIL (SAMPLE NO. 1657)

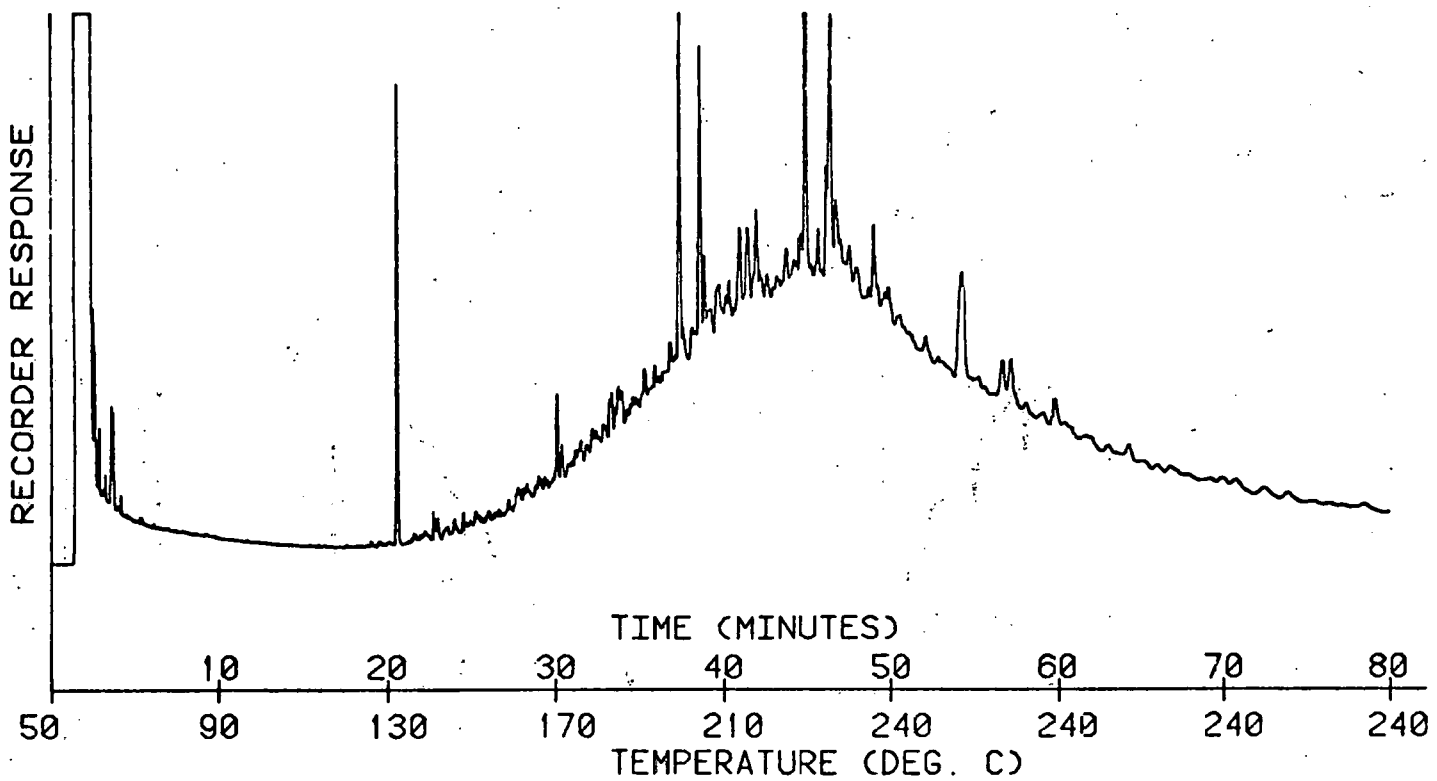


FIGURE C.1-14B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE IV) IN WESTERN BLACK LAKE WITH HEAVILY WEATHERED INDEGENOUS OIL (SAMPLE NO. 1657)

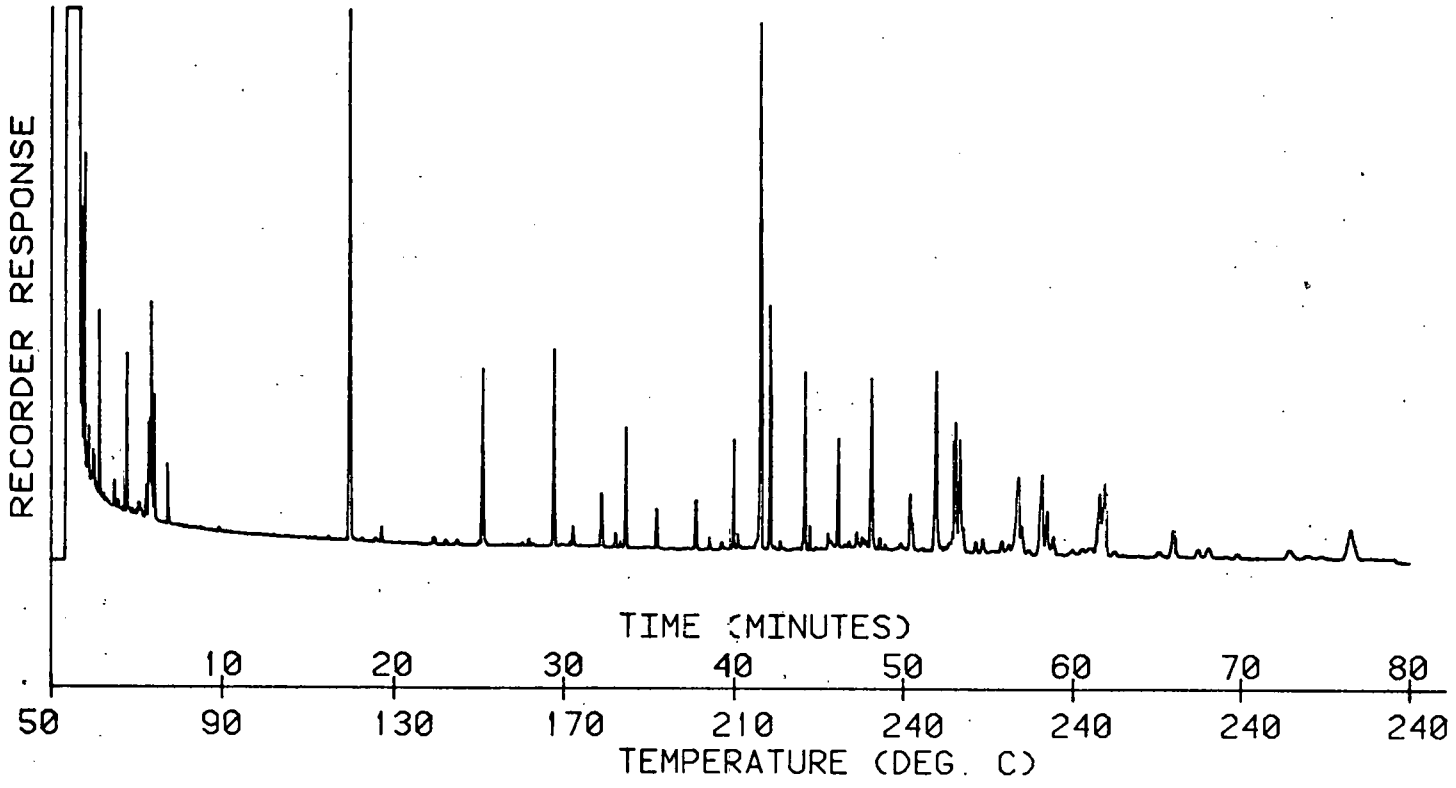


FIGURE C.1-15A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE I) NORTH OF CAVERN 6 WITH LITTLE INDIGENOUS OIL CONTAMINATION (SAMPLE NO. 234)

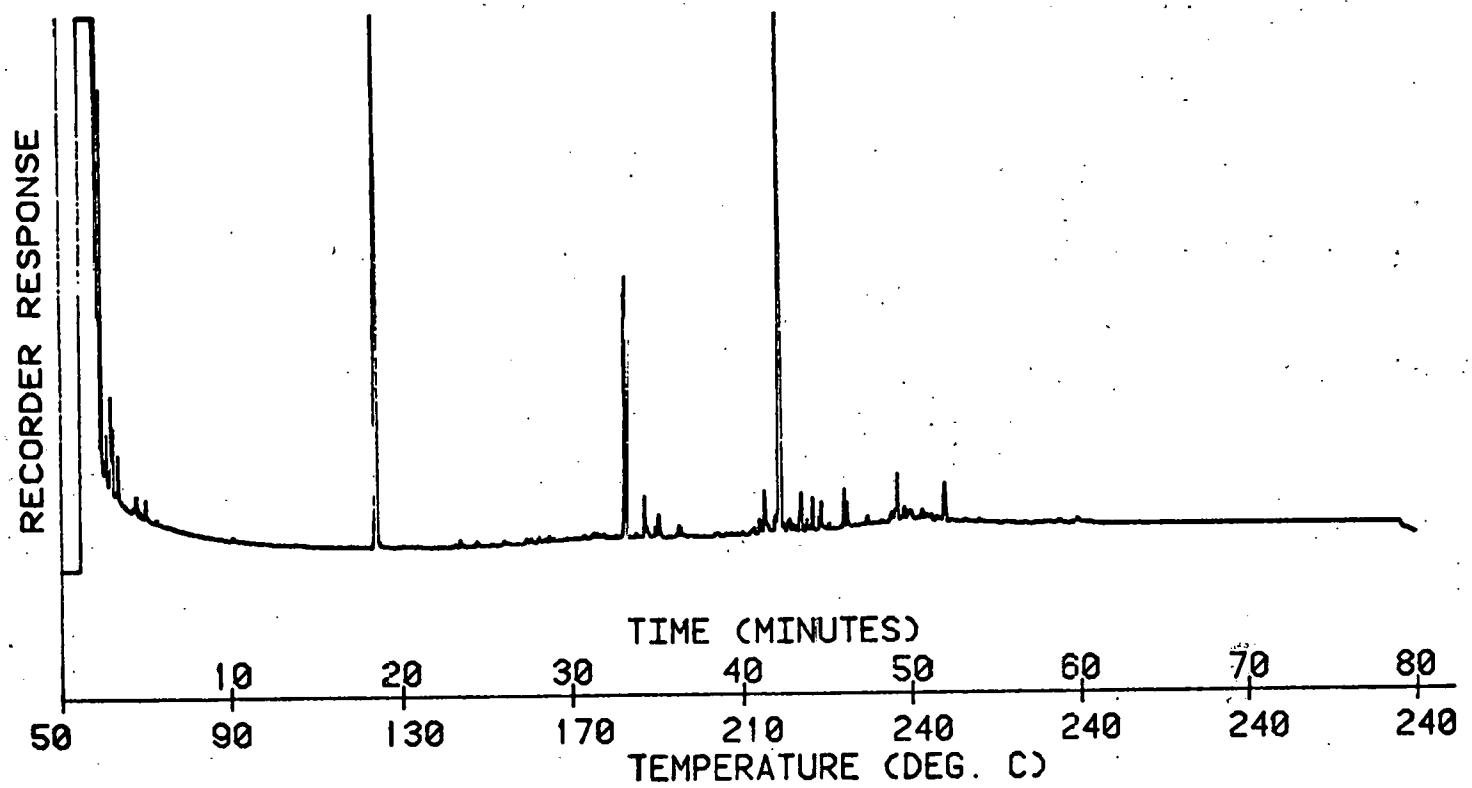


FIGURE C.1-15B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE I) NORTH OF CAVERN 6 WITH LITTLE INDIGENOUS OIL CONTAMINATION (SAMPLE NO. 234)

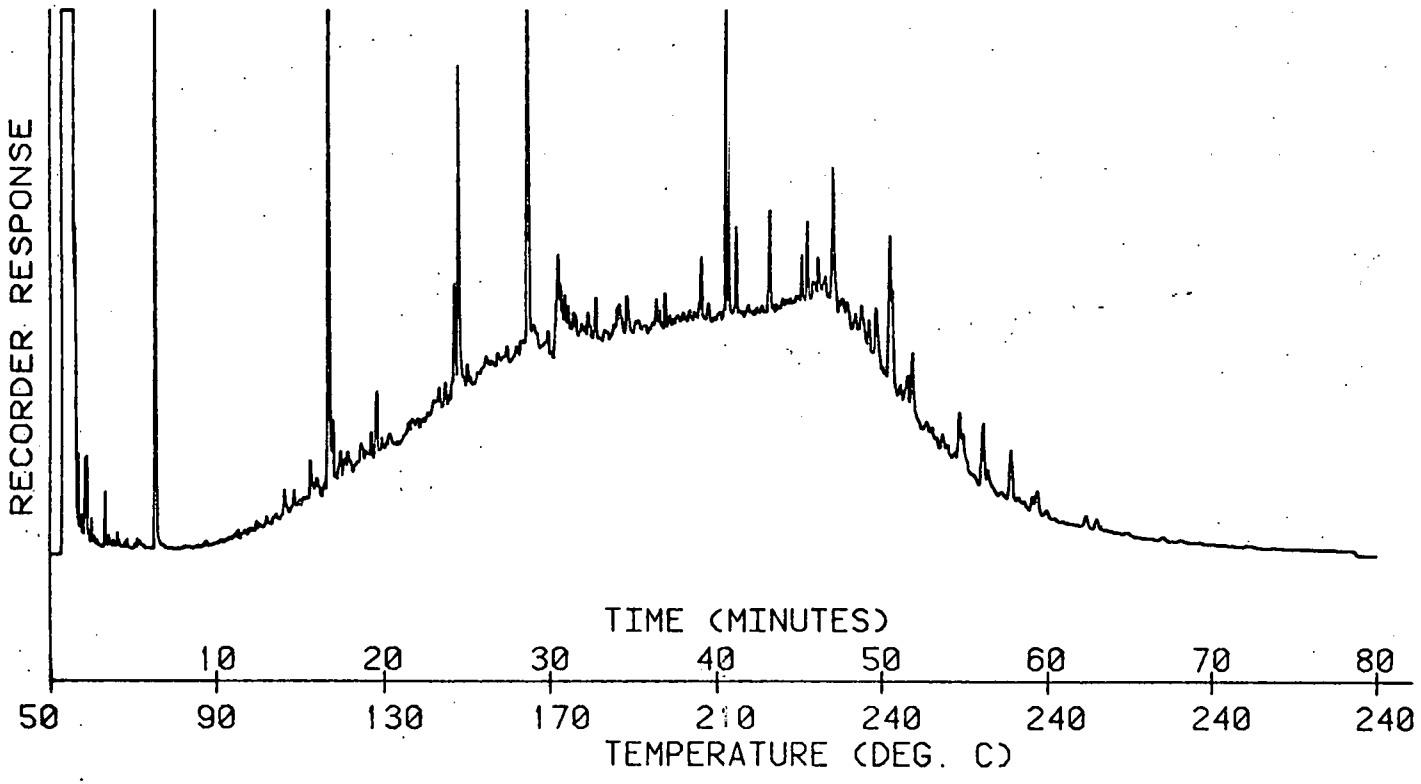


FIGURE C.1-16A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE IV) NORTH OF CAVERN 6 WITH SUBSTANTIALLY WEATHERED INDIGENOUS OIL (SAMPLE NO. (1533)

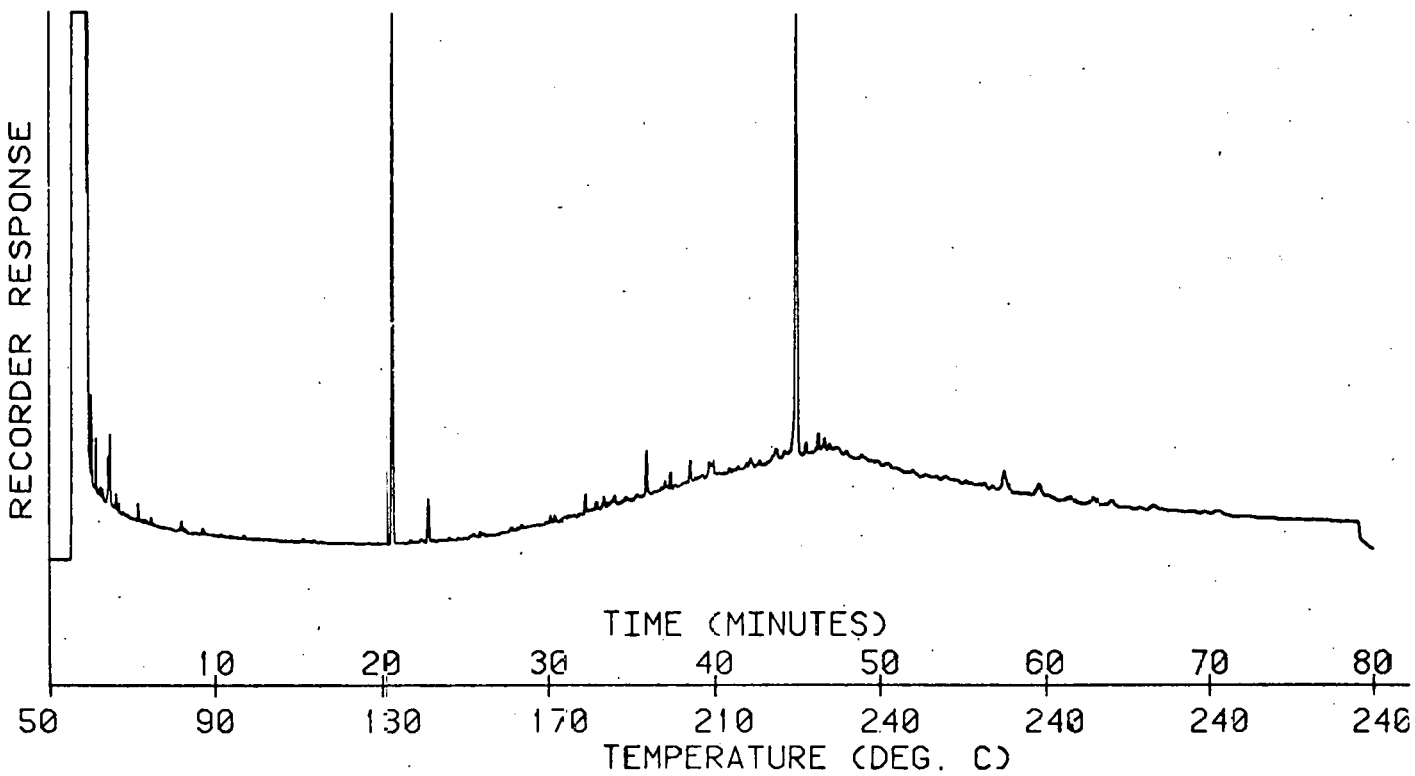


FIGURE C.1-16B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE IV) NORTH OF CAVERN 6 WITH SUBSTANTIALLY WEATHERED INDIGENOUS OIL (SAMPLE NO. 1533)

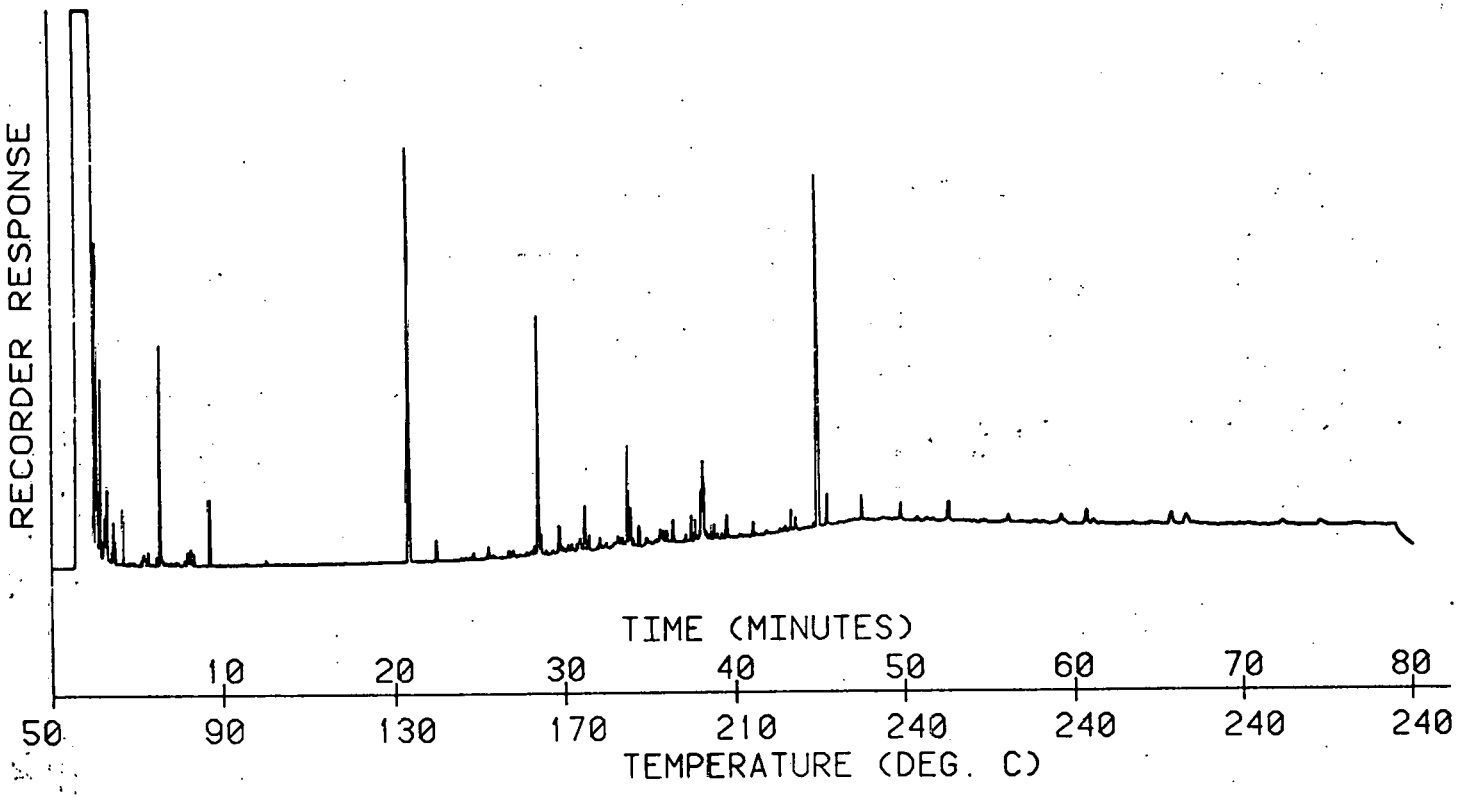


FIGURE C.1-17A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE I) IN THE FAR NORTH AREA OF BLACK LAKE WITH LITTLE INDIGENOUS OIL CONTAMINATION (SAMPLE NO. 197)

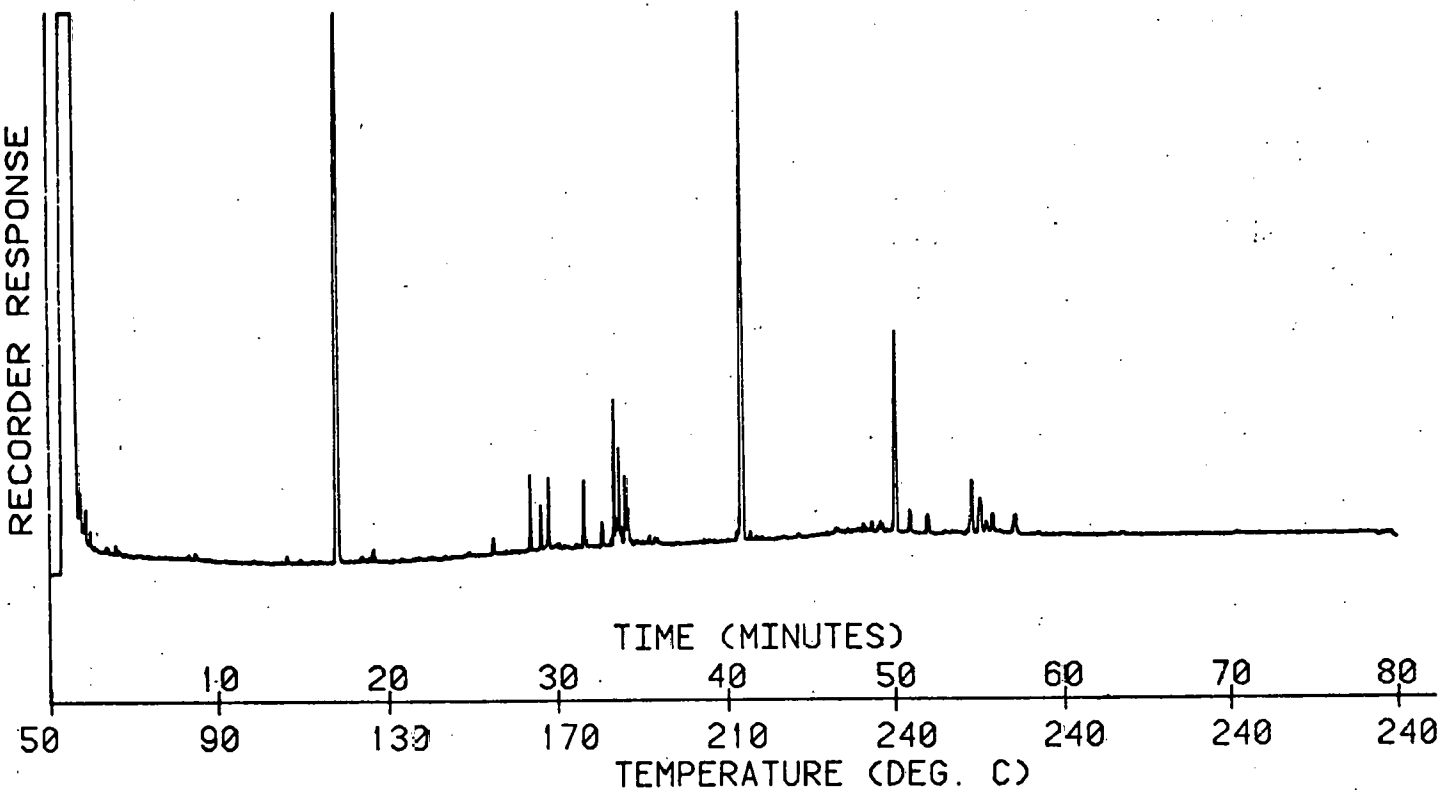


FIGURE C.1-17B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE I) IN THE FAR NORTH AREA OF BLACK LAKE WITH LITTLE INDIGENOUS OIL CONTAMINATION (SAMPLE NO. 197)

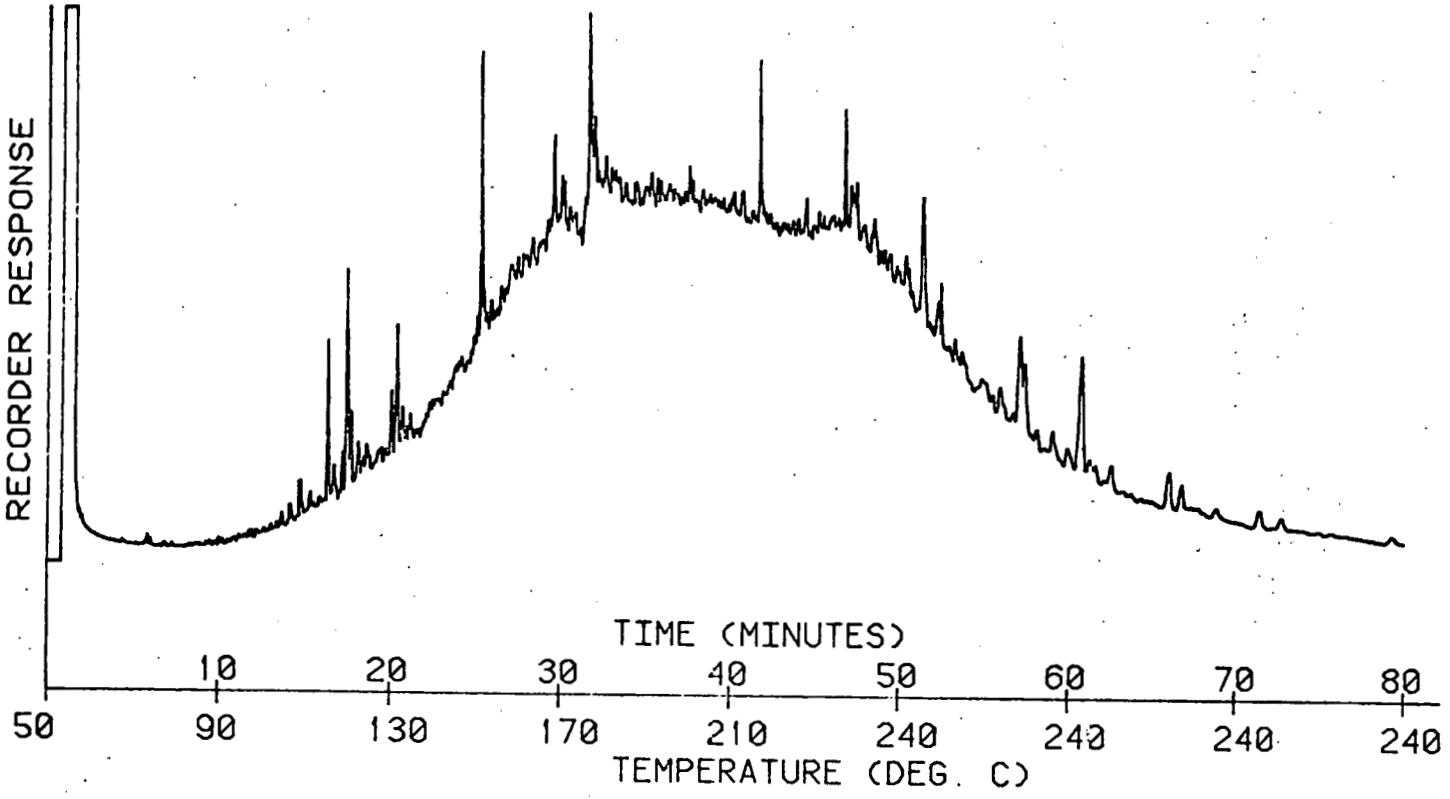


FIGURE C.1-18A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN THE FAR NORTH AREA OF BLACK LAKE WITH SUBSTANTIALLY WEATHERED INDIGENOUS OIL (SAMPLE NO. 963)

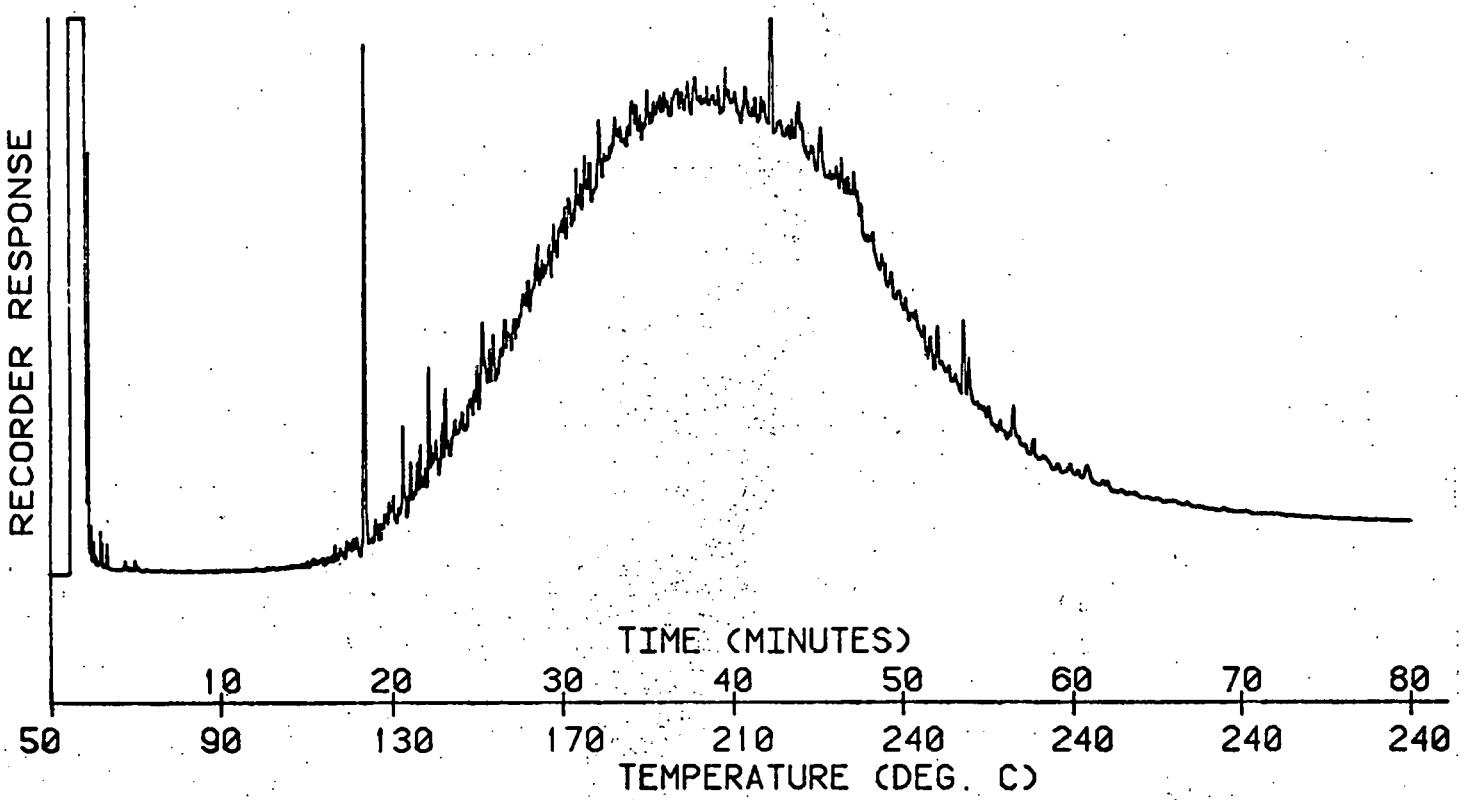


FIGURE C.1-18B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE II) IN THE FAR NORTH AREA OF BLACK LAKE WITH SUBSTANTIALLY WEATHERED INDIGENOUS OIL (SAMPLE NO. 963)

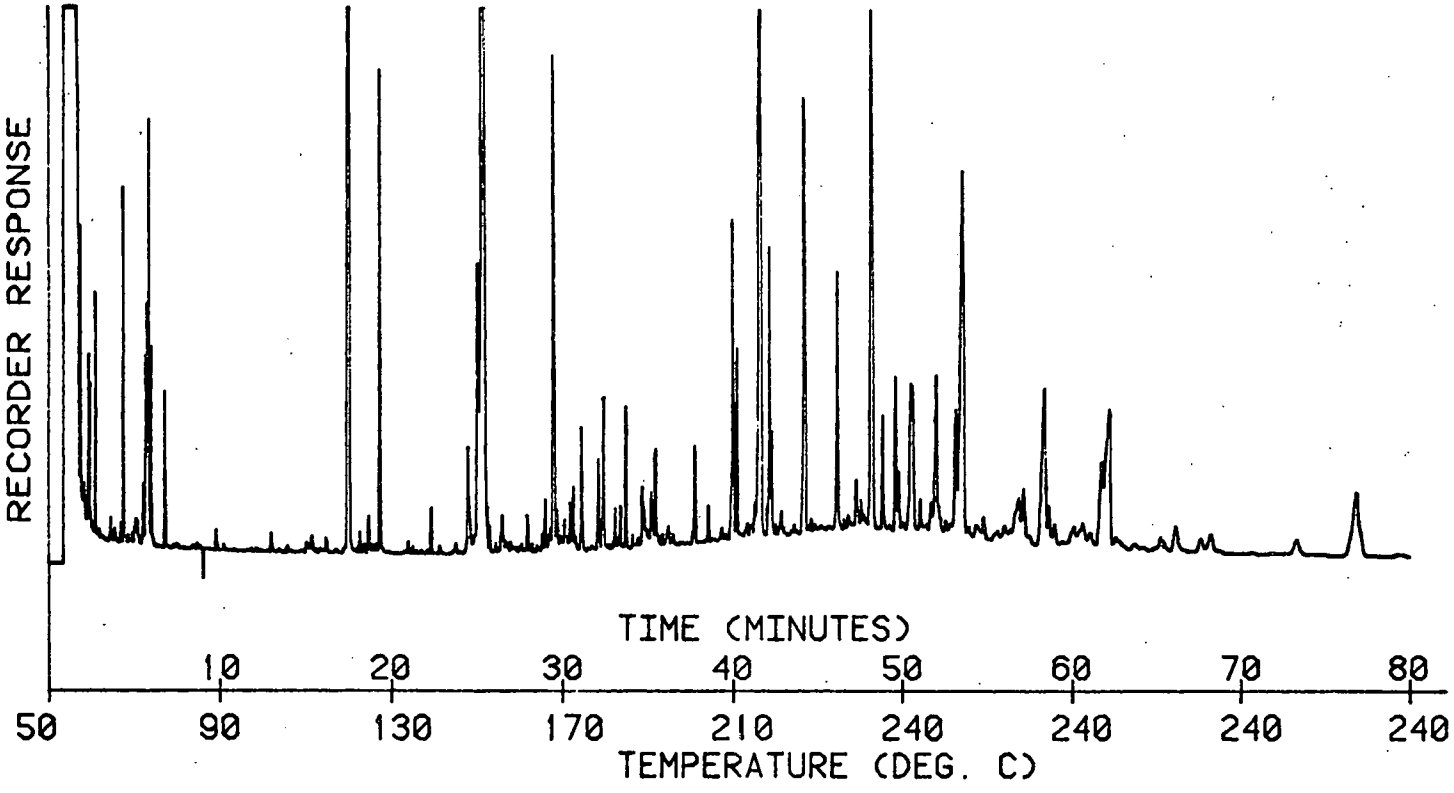


FIGURE C.1-19A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE I) ALONG THE NORTH STARK CANAL (SAMPLE NO. 65)

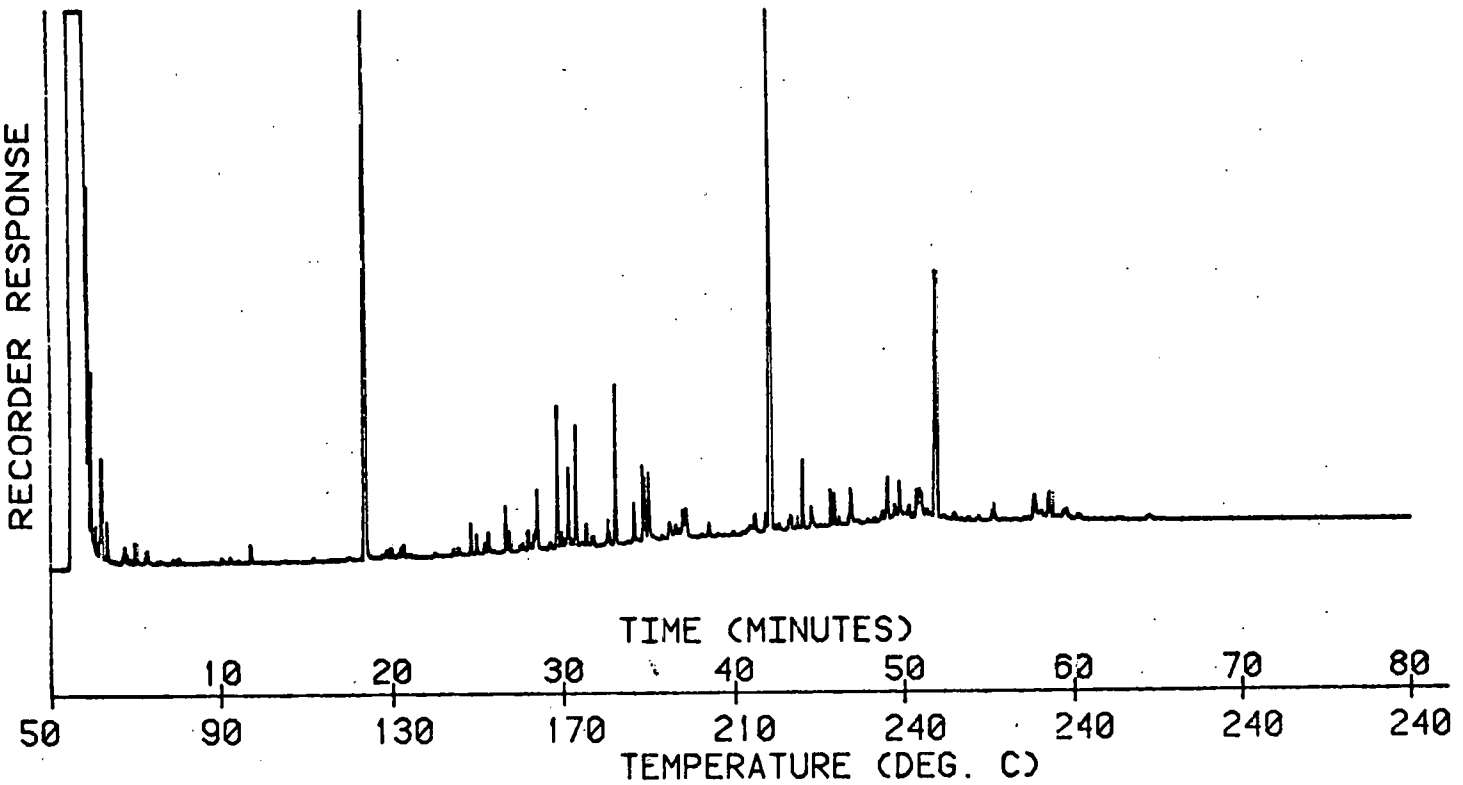


FIGURE C.1-19B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE I) ALONG THE NORTH STARK CANAL (SAMPLE NO. 65)

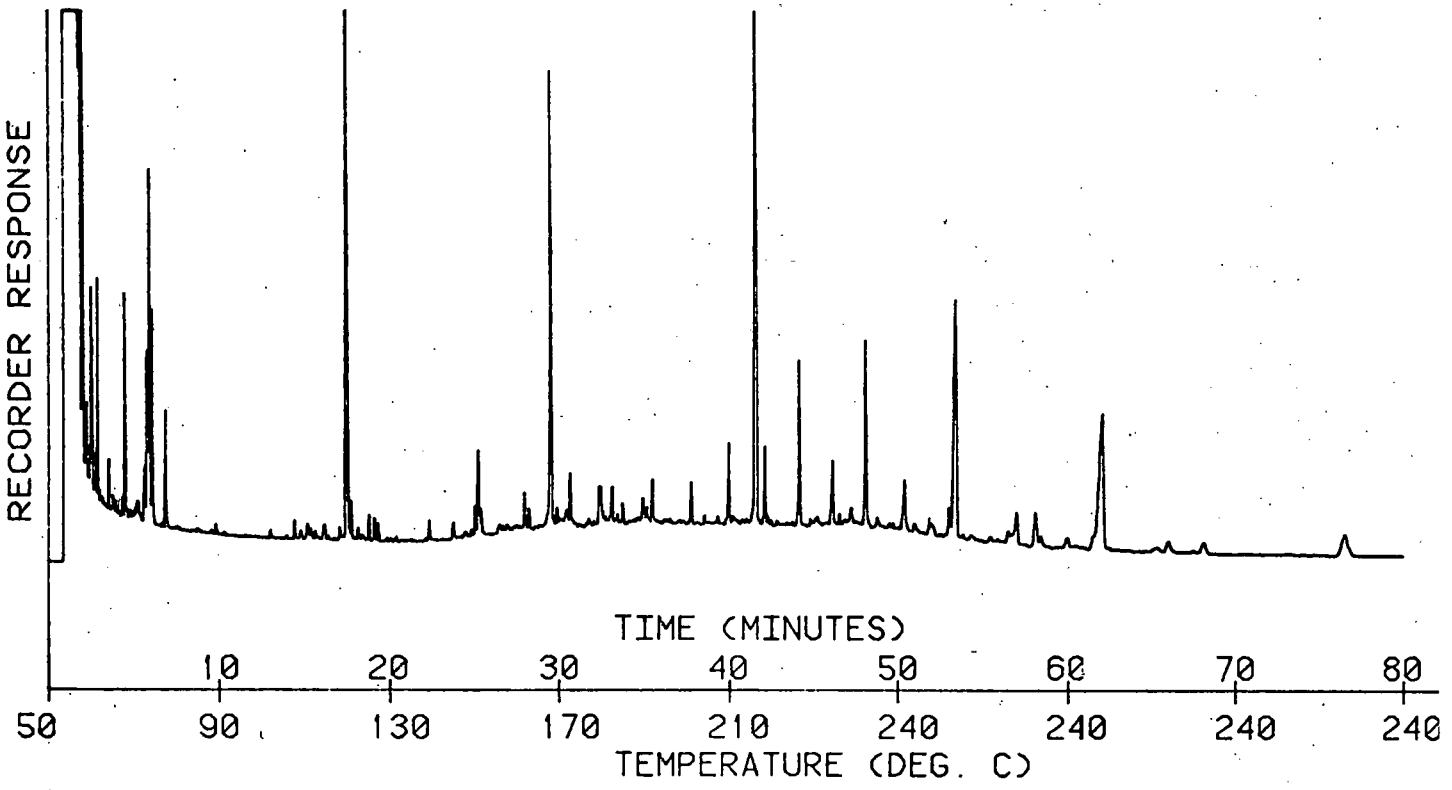


FIGURE C.1-20A GAS CHROMATOGRAMS (HEXANE FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE III) IN THE SABINE WILDLIFE REFUGE (SAMPLE NO. 1083)

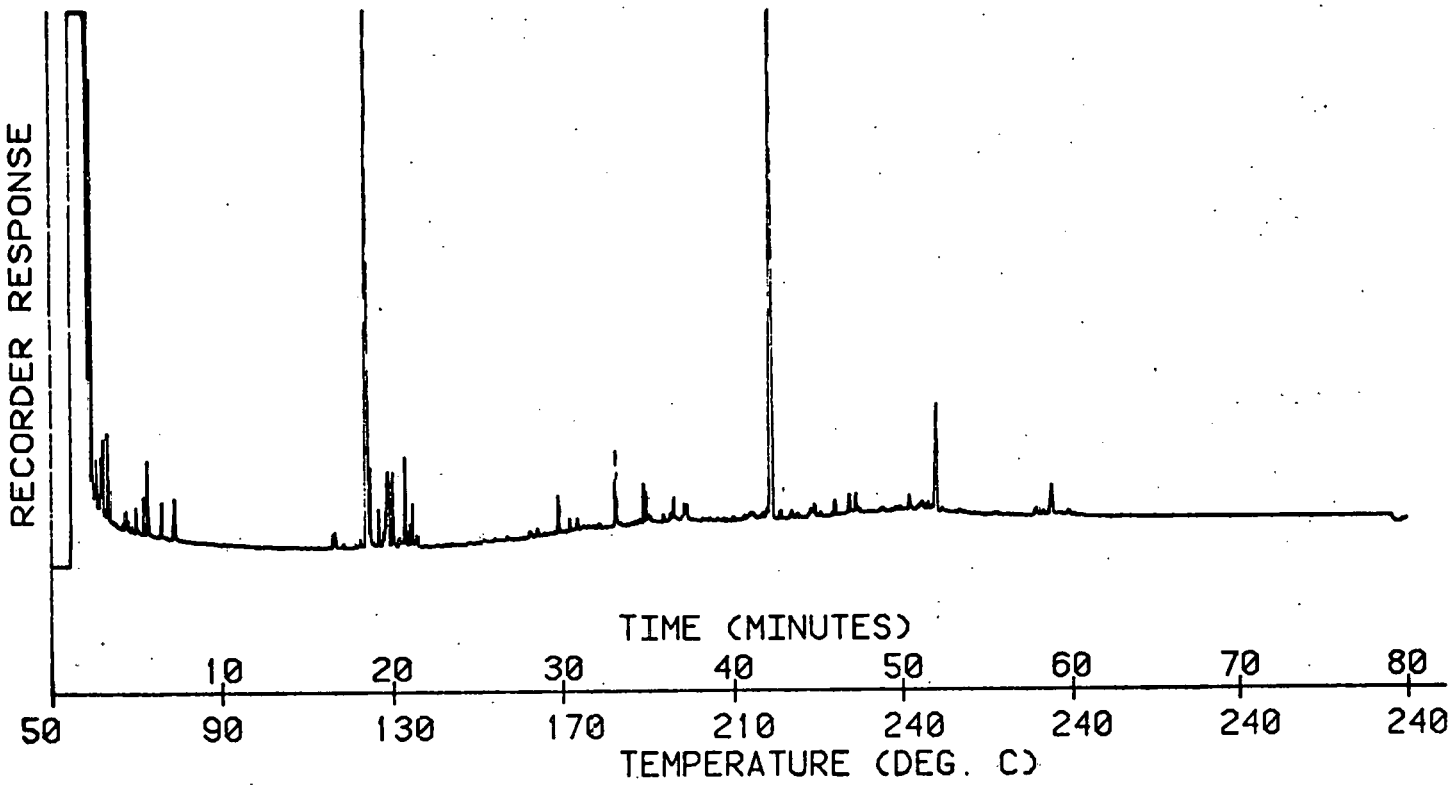


FIGURE C.1-20B GAS CHROMATOGRAMS (AROMATIC FRACTIONS) OF A TYPICAL SEDIMENT SAMPLE (PHASE III) IN THE SABINE WILDLIFE REFUGE (SAMPLE NO. 1083)

APPENDIX C.2

This appendix includes the mass chromatographic data which was generated for Sample No. 128. This type of information was obtained for every sample analyzed by the University of New Orleans.

Explanation of Error Bars

The inherent error of the mass spectrometer - computer quantification is approximately $\pm$ 1,000 area counts. This error is not significantly affected by the magnitude of the quantities integrated. However, the range of imprecision in ratios calculated from mass spectrometric data would vary inversely with the magnitude of quantities used in the calculations. Thus, ratios of large numbers have a small range of inherent error, while the ratios of small quantities have a relatively large range of error. The error bars illustrate these estimated limits of error. As 1,000 area counts is a "worst case" error, the error bars bracket the high and low "worst case" values for the ratios.

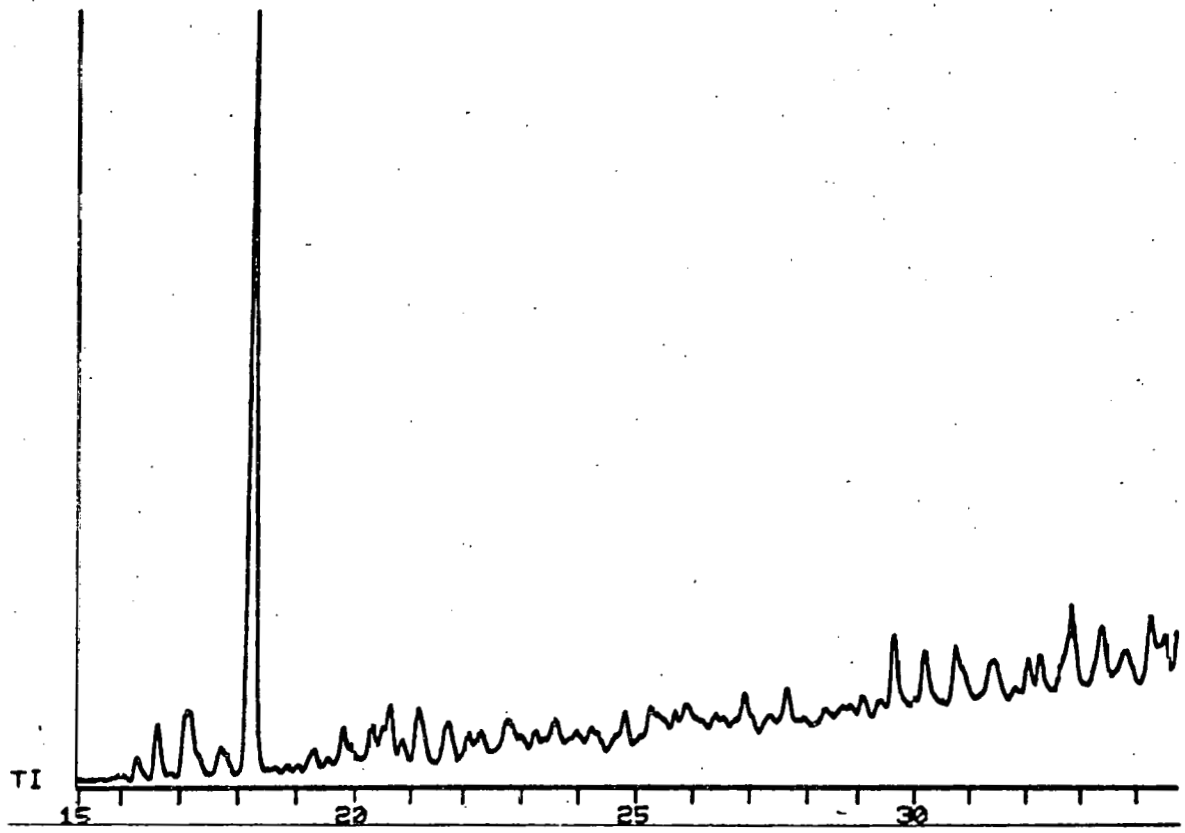


FIGURE C.2-1 TOTAL ION CHROMATOGRAM (15 - 55 MINUTES) FOR SAMPLE NO. 128

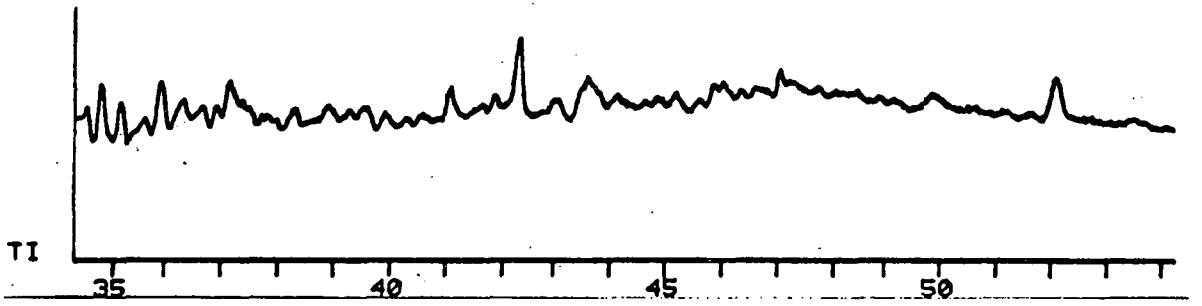


FIGURE C.2-1 (CONTINUED) TOTAL ION CHROMATOGRAM (15 - 55 MINUTES) FOR SAMPLE NO. 128

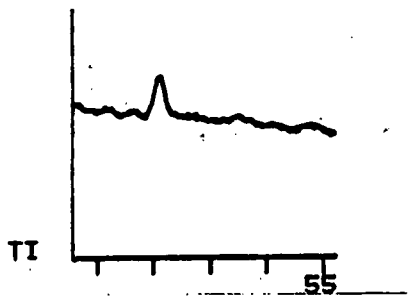


FIGURE C.2-1 (CONTINUED) TOTAL ION CHROMATOGRAM (15 - 55 MINUTES) FOR SAMPLE NO. 128

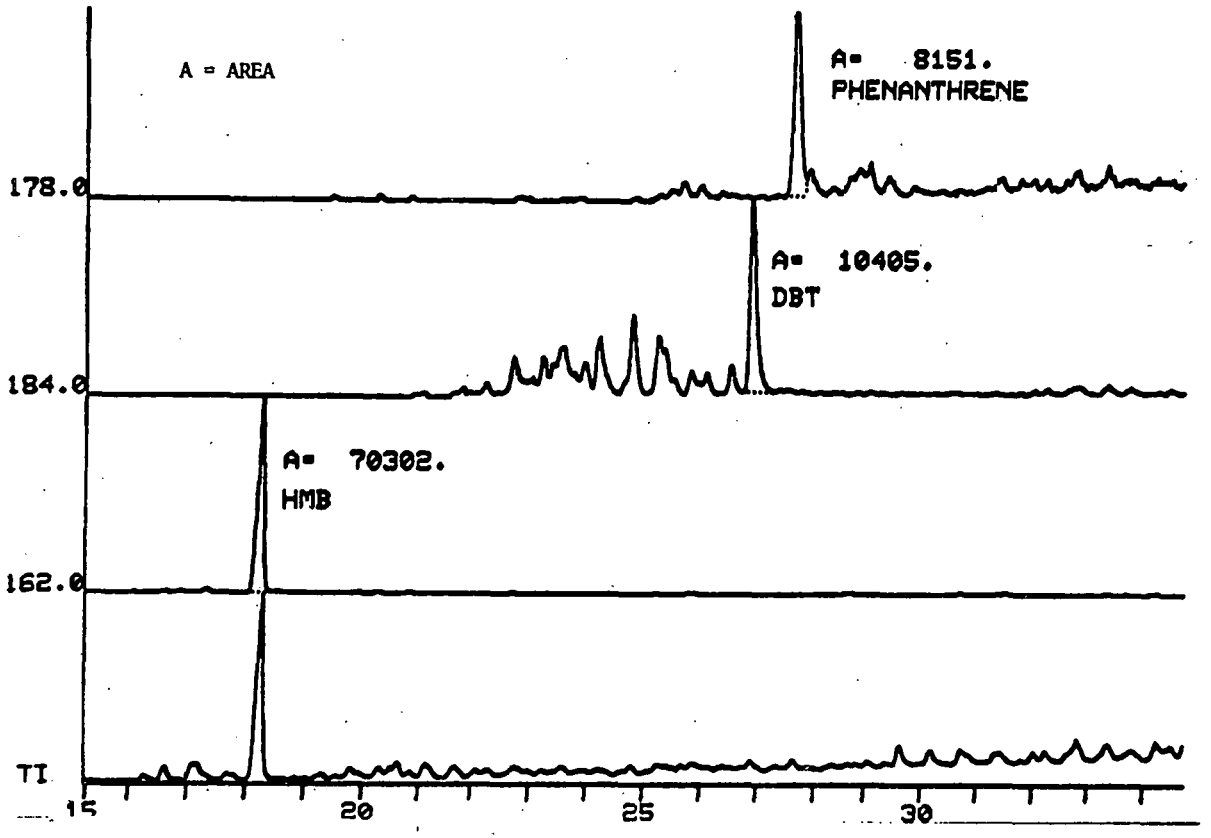


FIGURE C.2-2 TOTAL ION CHROMATOGRAM (15 - 35 MINUTES) AND THE MASS CHROMATOGRAMS FOR THE QUANTITATIVE INTERNAL STANDARD HEXAMETHYLBENZENE (162), DIBENZOTHIOPHENE (184), AND PHENANTHRENE (178)

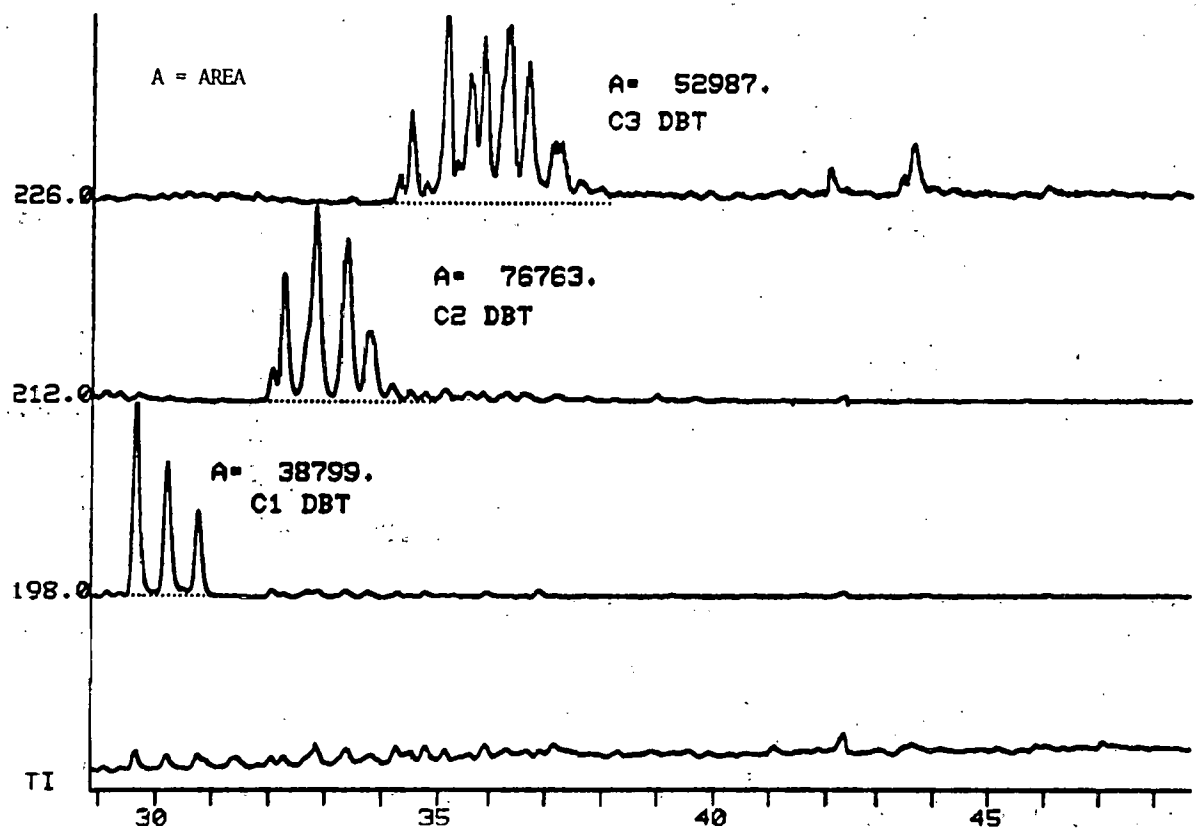


FIGURE C.2-3 TOTAL ION CHROMATOGRAM (29 - 48 MINUTES) AND THE MASS CHROMATOGRAMS FOR THE C_1, C_2 AND C_3 ALKYLATED DIBENZOTHIOPHENES (IONS 198, 212, AND 226)

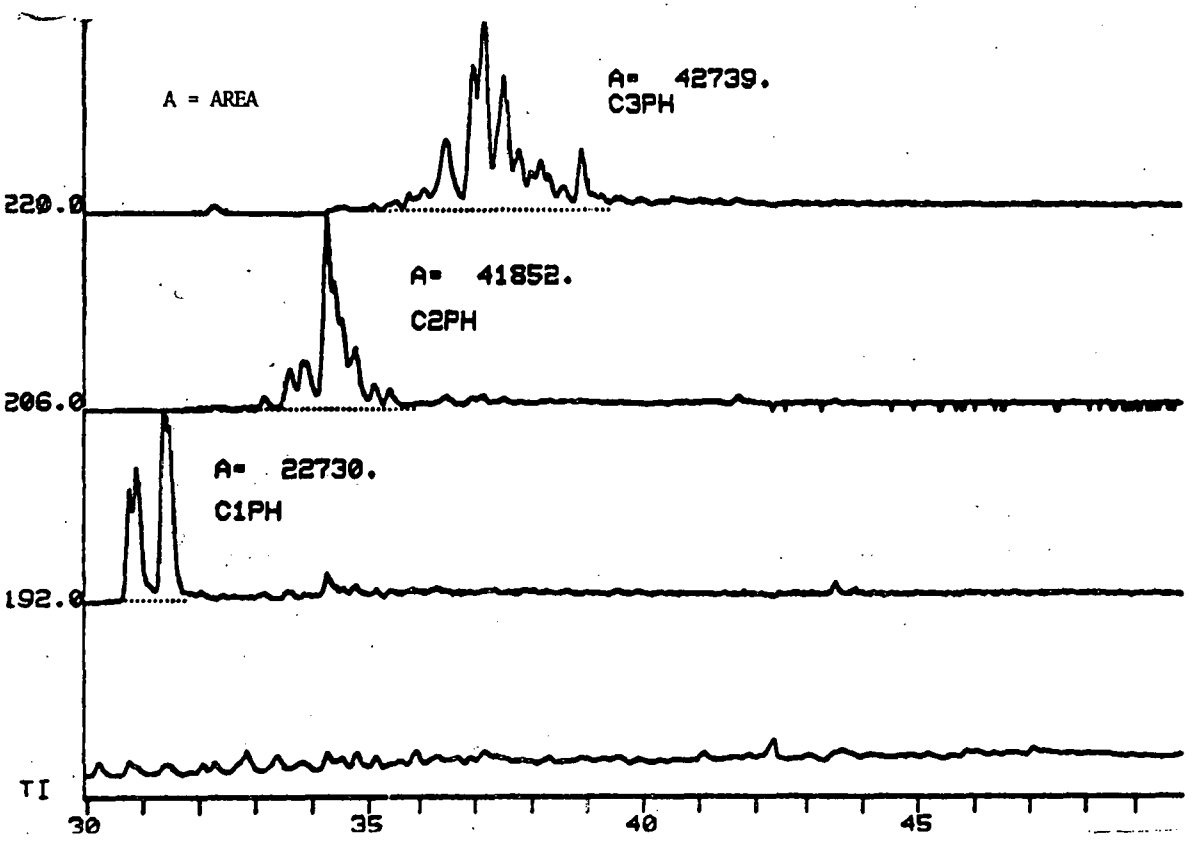


FIGURE C.2-4 TOTAL ION CHROMATOGRAM (30 - 50 MINUTES) AND THE MASS CHROMATOGRAMS FOR THE C_1, C_2, and C_3 ALKYLATED PHENANTHRENES (IONS 192, 206, AND 220)

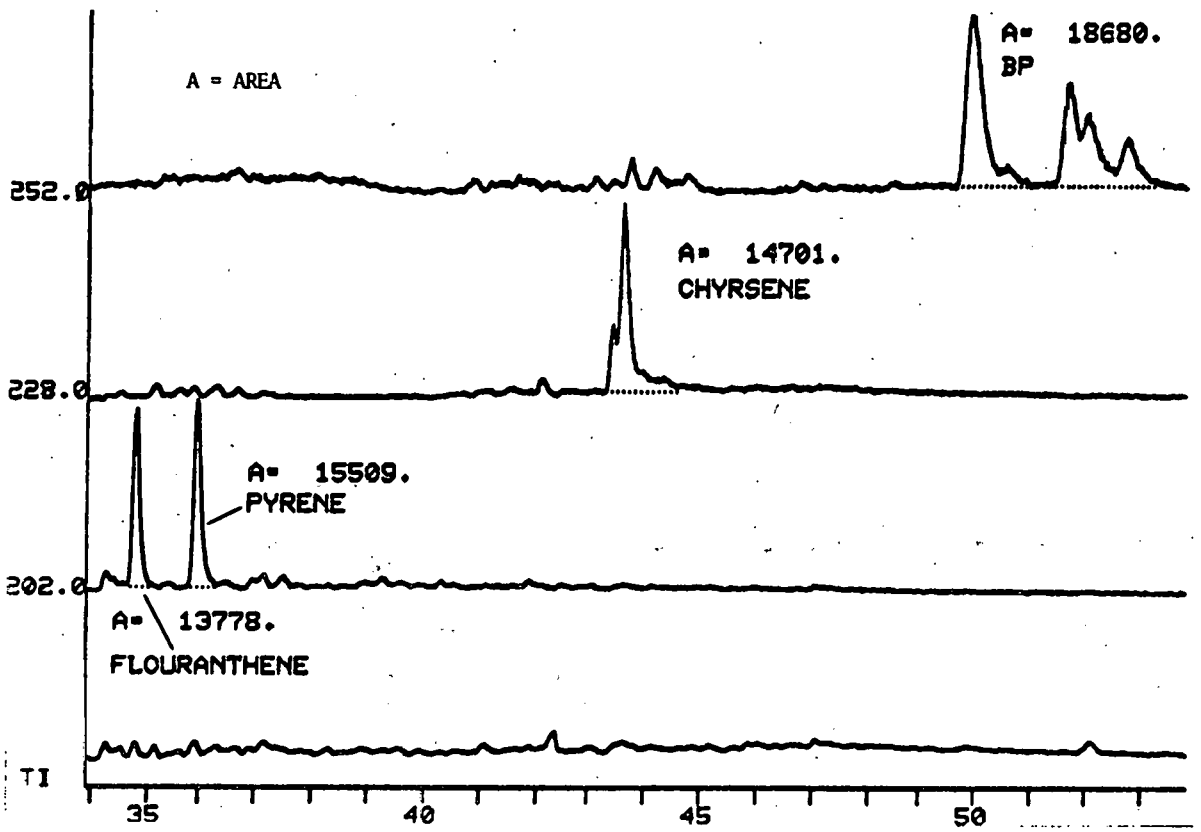


FIGURE C.2-5 TOTAL ION CHROMATOGRAM (34 - 54 MINUTES) AND THE MASS CHROMATOGRAMS FOR FLOURANTHENE (202), PYRENE (202), MEMBERS OF THE CHYRSENE FAMILY (228), AND MEMBERS OF THE BENZOPYRENE FAMILY (252)

APPENDIX C.3
Discriminant Analysis Results

This appendix contains the computer output from three runs of a commercially available discriminant analysis program (Nie and others, 1975):

1. Output from a run using six hydrocarbon parameters to distinguish Cavern 6 crude oil-contaminated sediment samples from those lacking Cavern 6 crude oil.

2. Unique output from a run using the best two parameters in the run above.

3. Output from a run using three pyrogenic products parameters for soil and sediment samples.

UNITED COMPUTING SYSTEMS INC.
S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

VERSION 6.5 - - SEPT. 1, 1976

```
RUN NAME        DISCRIMINANT ANALYSIS BETWEEN STATIONS WITH ALC AND SLC OILS
VARIABLE LIST   STATION,SAMPLE,PHASE,ZONE,CLASS,LAB,C1RATIO,C2RATIO,C3RATIO,
                PRISPHY,TIME,HC
INPUT MEDIUM    CARD
INPUT FORMAT    FIXED (A7,1F8.4,3F1.0,A3,3F8.0,F16.0,F3.0,F4.0)
```

ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

VARIABLE	FORMAT	RECORD	COLUMNS
STATION	A 7	1	1- 7
SAMPLE	F 8. 4	1	8- 15
PHASE	F 1. 0	1	16- 16
ZONE	F 1. 0	1	17- 17
CLASS	F 1. 0	1	18- 18
LAB	A 3	1	19- 21
C1RATIO	F 8. 0	1	22- 29
C2RATIO	F 8. 0	1	30- 37
C3RATIO	F 8. 0	1	38- 45
PRISPHY	F16. 0	1	46- 61
TIME	F 3. 0	1	62- 64
HC	F 4. 0	1	65- 68

THE INPUT FORMAT PROVIDES FOR 12 VARIABLES. 12 WILL BE READ
IT PROVIDES FOR 1 RECORDS (*CARDS*) PER CASE. A MAXIMUM OF 68 *COLUMNS* ARE USED ON A RECORD.

WARNING - A NUMERIC VARIABLE HAS A WIDTH GREATER THAN 14. SMALL ROUNDING/TRUNCATION ERRORS MAY OCCUR.

```
N OF CASES      66
RECODE          C1RATIO TO HC (BLANK = 99)
VAR LABELS      SAMPLE  TAG NUMBER OF HYDROCARBON SAMPLE/ LAB  LABORATORY CONDUCT
                ING HYDROCARBON ANALYSES/C1RATIO  RATIO OF C-1 PHENANTHRENE TO C-
                1 DIBENZOTHIOPHENE/C2RATIO  RATIO OF C-2 PHENANTHRENE TO C-2 DIBE
                NZOTHIOPHENE/C3RATIO  RATIO OF C-3 PHENANTHRENE TO C-3 DIBENZOTHI
                OPHENE/PRISPHY  RATIO OF PRISTANE TO PHYTANE/TIME  NUMBER OF WEEK
                S AFTER THE SPILL THAT THE SAMPLES WERE COLLECTED/HC HYDROCARBON
                CONCENTRATION IN PPM
VALUE LABELS    CLASS (1)KNOWN ALC STATIONS (2)KNOWN SLC STATIONS (3)UNCLASSIFIED
                 STATIONS/ZONE (1)SPILL AFFECTED AREA (2)PLUME AFFECTED AREA
                (3)CONTROL AREA
MISSING VALUES  C1RATIO TO HC (99)
PRINT FORMATS   STATION(A)/LAB(A)/C1RATIO(2)/C2RATIO(2)/C3RATIO(2)/PRISPHY(2)
LIST CASES      CASES = 66/VARIABLES = ALL
READ INPUT DATA
```

(ENTS OF CASE NUMBER 1

SEQNUM	1.	SUBFILE	NONAME	CASWGT	1.0000	STATION	ALC OIL	SAMPLE	4.
PHASE	1.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.30
C2RATIO	.70	C3RATIO	.30	PRISPHY	.90	TIME	1.	HC	99.

CONTENTS OF CASE NUMBER 2

SEQNUM	2.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-7-C	SAMPLE	13.
PHASE	1.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.70
C2RATIO	.90	C3RATIO	.10	PRISPHY	1.00	TIME	1.	HC	20.

CONTENTS OF CASE NUMBER 3

SEQNUM	3.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-4-C	SAMPLE	15.
PHASE	1.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.50
C2RATIO	.70	C3RATIO	.40	PRISPHY	99.00	TIME	1.	HC	18.

CONTENTS OF CASE NUMBER 4

SEQNUM	4.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-3-C	SAMPLE	16.
PHASE	1.	ZONE	-0	CLASS	2.	LAB	UNO	C1RATIO	1.20
C2RATIO	1.00	C3RATIO	1.90	PRISPHY	1.20	TIME	1.	HC	27.

CONTENTS OF CASE NUMBER 5

SEQNUM	5.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-11-C	SAMPLE	18.
PHASE	1.	ZONE	1.	CLASS	3.	LAB	UNO	C1RATIO	2.70
C2RATIO	3.80	C3RATIO	3.70	PRISPHY	99.00	TIME	1.	HC	2.

CONTENTS OF CASE NUMBER 6

SEQNUM	6.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-13-C	SAMPLE	19.
PHASE	1.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.60
C2RATIO	1.70	C3RATIO	.90	PRISPHY	1.20	TIME	1.	HC	11.

CONTENTS OF CASE NUMBER 7

SEQNUM	7.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-2-C	SAMPLE	85.
PHASE	1.	ZONE	-0	CLASS	1.	LAB	UNO	C1RATIO	.90
C2RATIO	1.20	C3RATIO	.30	PRISPHY	1.00	TIME	1.	HC	19.

CONTENTS OF CASE NUMBER 8

SEQNUM	8.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-5-C	SAMPLE	122.
PHASE	1.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.40
C2RATIO	.70	C3RATIO	.40	PRISPHY	.70	TIME	1.	HC	99.

CONTENTS OF CASE NUMBER 9

SEQNUM	9.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-9-C	SAMPLE	128.
PHASE	1.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.50

C2RATIO	.50	C3RATIO	.80	PRISPHY	.80	TIME	1.	HC	64.

CONTENTS OF CASE NUMBER 10

SEQNUM	10.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-3-C	SAMPLE	193.
PHASE	1.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	2.20
C2RATIO	2.40	C3RATIO	1.30	PRISPHY	99.00	TIME	1.	HC	6.

CONTENTS OF CASE NUMBER 11

SEQNUM	11.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-6-C	SAMPLE	197.
PHASE	1.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	3.10
C2RATIO	5.80	C3RATIO	2.50	PRISPHY	1.50	TIME	1.	HC	7.

CONTENTS OF CASE NUMBER 12

SEQNUM	12.	SUBFILE	NONAME	CASWGT	1.0000	STATION	SLC OIL	SAMPLE	208.
PHASE	1.	ZONE	2.	CLASS	2.	LAB	UNO	C1RATIO	1.50
C2RATIO	2.90	C3RATIO	1.50	PRISPHY	2.70	TIME	1.	HC	99.

CONTENTS OF CASE NUMBER 13

SEQNUM	13.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-16-C	SAMPLE	153.
PHASE	1.	ZONE	-3	CLASS	2.	LAB	UNO	C1RATIO	13.60
C2RATIO	6.10	C3RATIO	99.00	PRISPHY	1.10	TIME	1.	HC	26.

CONTENTS OF CASE NUMBER 14

SEQNUM	14.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-17-C	SAMPLE	226.
PHASE	1.	ZONE	-0	CLASS	2.	LAB	UNO	C1RATIO	1.00
C2RATIO	2.40	C3RATIO	1.60	PRISPHY	99.00	TIME	1.	HC	6.

CONTENTS OF CASE NUMBER 15

SEQNUM	15.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-7-C	SAMPLE	229.
PHASE	1.	ZONE	-0	CLASS	2.	LAB	UNO	C1RATIO	1.00
C2RATIO	1.30	C3RATIO	1.20	PRISPHY	99.00	TIME	1.	HC	11.

CONTENTS OF CASE NUMBER 16

SEQNUM	16.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-12-C	SAMPLE	234.
PHASE	1.	ZONE	1.	CLASS	2.	LAB	UNO	C1RATIO	1.80
C2RATIO	2.20	C3RATIO	1.30	PRISPHY	2.90	TIME	1.	HC	4.

CONTENTS OF CASE NUMBER 17

SEQNUM	17.	SUBFILE	NONAME	CASWGT	1.0000	STATION	15-3-B	SAMPLE	586.
PHASE	2.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	1.90
TIO	3.30	C3RATIO	1.30	PRISPHY	7.90	TIME	16.	HC	4.

SEQNUM	18.	SUBFILE	NONAME	CASWGT	1.0000	STATION	E6-2-9	SAMPLE	594.
PHASE	2.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	1.90
C2RATIO	3.20	C3RATIO	1.40	PRISPHY	8.70	TIME	16.	HC	4.

CONTENTS OF CASE NUMBER 19

SEQNUM	19.	SUBFILE	NONAME	CASWGT	1.0000	STATION	8-2-B	SAMPLE	597.
PHASE	2.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	1.90
C2RATIO	2.10	C3RATIO	1.70	PRISPHY	6.30	TIME	16.	HC	5.

CONTENTS OF CASE NUMBER 20

SEQNUM	20.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-2-B	SAMPLE	599.
PHASE	2.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	2.30
C2RATIO	2.60	C3RATIO	1.30	PRISPHY	9.10	TIME	16.	HC	6.

CONTENTS OF CASE NUMBER 21

SEQNUM	21.	SUBFILE	NONAME	CASWGT	1.0000	STATION	16-3-B	SAMPLE	601.
PHASE	2.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	3.90
C2RATIO	3.90	C3RATIO	1.50	PRISPHY	4.00	TIME	16.	HC	3.

CONTENTS OF CASE NUMBER 22

SEQNUM	22.	SUBFILE	NONAME	CASWGT	1.0000	STATION	17-3-B	SAMPLE	604.
PHASE	2.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	2.00
C2RATIO	2.30	C3RATIO	1.20	PRISPHY	9.50	TIME	16.	HC	5.

CONTENTS OF CASE NUMBER 23

SEQNUM	23.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-12-C	SAMPLE	623.
PHASE	2.	ZONE	1.	CLASS	2.	LAB	UNO	C1RATIO	1.40
C2RATIO	1.40	C3RATIO	.90	PRISPHY	1.20	TIME	16.	HC	4.

CONTENTS OF CASE NUMBER 24

SEQNUM	24.	SUBFILE	NONAME	CASWGT	1.0000	STATION	2-C	SAMPLE	627.
PHASE	2.	ZONE	-3	CLASS	1.	LAB	UNO	C1RATIO	.60
C2RATIO	.60	C3RATIO	.60	PRISPHY	.80	TIME	16.	HC	4.

CONTENTS OF CASE NUMBER 25

SEQNUM	25.	SUBFILE	NONAME	CASWGT	1.0000	STATION	GILLNET	SAMPLE	631.
PHASE	2.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	1.70
C2RATIO	2.30	C3RATIO	1.70	PRISPHY	1.40	TIME	16.	HC	1.

CONTENTS OF CASE NUMBER 26

SEQNUM	26.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-3-C	SAMPLE	929.
PHASE	2.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	1.90

C2RATIO	2.20	C3RATIO	1.10	PRISPHY	99.00	TIME	16.	HC	10.

CONTENTS OF CASE NUMBER 27

SEQNUM	27.	SUBFILE	NONAME	CASWGT	1.0000	STATION	245-1-C	SAMPLE	938.
PHASE	2.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.20
C2RATIO	.40	C3RATIO	.30	PRISPHY	.70	TIME	15.	HC	99.

CONTENTS OF CASE NUMBER 28

SEQNUM	28.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-3-C	SAMPLE	940.
PHASE	2.	ZONE	-3	CLASS	2.	LAB	UNO	C1RATIO	2.10
C2RATIO	1.50	C3RATIO	2.10	PRISPHY	1.60	TIME	15.	HC	14.

CONTENTS OF CASE NUMBER 29

SEQNUM	29.	SUBFILE	NONAME	CASWGT	1.0000	STATION	201-30C	SAMPLE	942.
PHASE	2.	ZONE	1.	CLASS	2.	LAB	UNO	C1RATIO	2.90
C2RATIO	2.40	C3RATIO	1.60	PRISPHY	1.40	TIME	16.	HC	15.

CONTENTS OF CASE NUMBER 30

SEQNUM	30.	SUBFILE	NONAME	CASWGT	1.0000	STATION	7-C	SAMPLE	945.
PHASE	2.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.40
C2RATIO	.50	C3RATIO	.40	PRISPHY	.70	TIME	16.	HC	99.

CONTENTS OF CASE NUMBER 31

SEQNUM	31.	SUBFILE	NONAME	CASWGT	1.0000	STATION	5-C	SAMPLE	946.
PHASE	2.	ZONE	-3	CLASS	2.	LAB	UNO	C1RATIO	99.00
C2RATIO	2.30	C3RATIO	2.30	PRISPHY	99.00	TIME	15.	HC	99.

CONTENTS OF CASE NUMBER 32

SEQNUM	32.	SUBFILE	NONAME	CASWGT	1.0000	STATION	2-C	SAMPLE	948.
PHASE	2.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	1.20
C2RATIO	2.20	C3RATIO	.70	PRISPHY	1.50	TIME	16.	HC	3.

CONTENTS OF CASE NUMBER 33

SEQNUM	33.	SUBFILE	NONAME	CASWGT	1.0000	STATION	6-C	SAMPLE	954.
PHASE	2.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.70
C2RATIO	.70	C3RATIO	.40	PRISPHY	.80	TIME	15.	HC	99.

CONTENTS OF CASE NUMBER 34

SEQNUM	34.	SUBFILE	NONAME	CASWGT	1.0000	STATION	16-1-B	SAMPLE	957.
E	2.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.10
TIO	1.50	C3RATIO	99.00	PRISPHY	99.00	TIME	16.	HC	5.

SEQNUM	35.	SUBFILE	NONAME	CASWGT	1.0000	STATION	NC 41	SAMPLE	963.
PHASE	3.	ZONE	-3	CLASS	2.	LAB	UNO	C1RATIO	99.00
C2RATIO	1.30	C3RATIO	2.40	PRISPHY	99.00	TIME	16.	HC	99.

CONTENTS OF CASE NUMBER 36

SEQNUM	36.	SUBFILE	NONAME	CASWGT	1.0000	STATION	SNR 6	SAMPLE	1040.
PHASE	3.	ZONE	2.	CLASS	3.	LAB	UNO	C1RATIO	3.40
C2RATIO	99.00	C3RATIO	99.00	PRISPHY	99.00	TIME	29.	HC	0

CONTENTS OF CASE NUMBER 37

SEQNUM	37.	SUBFILE	NONAME	CASWGT	1.0000	STATION	RC 107	SAMPLE	1083.
PHASE	3.	ZONE	2.	CLASS	2.	LAB	UNO	C1RATIO	3.10
C2RATIO	2.90	C3RATIO	2.00	PRISPHY	1.40	TIME	29.	HC	2.

CONTENTS OF CASE NUMBER 38

SEQNUM	38.	SUBFILE	NONAME	CASWGT	1.0000	STATION	RC 107	SAMPLE	1084.
PHASE	3.	ZONE	-0	CLASS	2.	LAB	UNO	C1RATIO	99.00
C2RATIO	4.30	C3RATIO	99.00	PRISPHY	2.00	TIME	29.	HC	1.

CONTENTS OF CASE NUMBER 39

SEQNUM	39.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-3-C	SAMPLE	1116.
PHASE	3.	ZONE	-0	CLASS	2.	LAB	UNO	C1RATIO	1.30
C2RATIO	1.00	C3RATIO	2.70	PRISPHY	1.30	TIME	29.	HC	20.

CONTENTS OF CASE NUMBER 40

SEQNUM	40.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-7-C	SAMPLE	1118.
PHASE	3.	ZONE	-3	CLASS	2.	LAB	UNO	C1RATIO	99.00
C2RATIO	1.90	C3RATIO	2.80	PRISPHY	1.20	TIME	29.	HC	13.

CONTENTS OF CASE NUMBER 41

SEQNUM	41.	SUBFILE	NONAME	CASWGT	1.0000	STATION	203-30C	SAMPLE	1181.
PHASE	3.	ZONE	2.	CLASS	1.	LAB	UNO	C1RATIO	.10
C2RATIO	.30	C3RATIO	.20	PRISPHY	.60	TIME	29.	HC	99.

CONTENTS OF CASE NUMBER 42

SEQNUM	42.	SUBFILE	NONAME	CASWGT	1.0000	STATION	203-30C	SAMPLE	1182.
PHASE	3.	ZONE	-0	CLASS	1.	LAB	UNO	C1RATIO	.20
C2RATIO	.40	C3RATIO	.30	PRISPHY	.60	TIME	29.	HC	99.

CONTENTS OF CASE NUMBER 43

SEQNUM	43.	SUBFILE	NONAME	CASWGT	1.0000	STATION	NORCONT	SAMPLE	1188.
PHASE	3.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	2.10

C2RATIO	2.10	C3RATIO	1.40	PRISPHY	20.10	TIME	29.	HC	3.

CONTENTS OF CASE NUMBER 44

SEQNUM	44.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-2-8	SAMPLE	1193.
PHASE	3.	ZONE	3.	CLASS	3.	LAB	URI	C1RATIO	99.00
C2RATIO	99.00	C3RATIO	99.00	PRISPHY	3.60	TIME	29.	HC	1.

CONTENTS OF CASE NUMBER 45

SEQNUM	45.	SUBFILE	NONAME	CASWGT	1.0000	STATION	8-2-8	SAMPLE	1194.
PHASE	3.	ZONE	3.	CLASS	3.	LAB	UNC	C1RATIO	99.00
C2RATIO	99.00	C3RATIO	1.20	PRISPHY	3.80	TIME	29.	HC	1.

CONTENTS OF CASE NUMBER 46

SEQNUM	46.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-3-C	SAMPLE	1247.
PHASE	3.	ZONE	-0	CLASS	1.	LAB	UNO	C1RATIO	.30
C2RATIO	1.50	C3RATIO	.70	PRISPHY	1.10	TIME	29.	HC	36.

CONTENTS OF CASE NUMBER 47

SEQNUM	47.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-2-C	SAMPLE	1251.
PHASE	3.	ZONE	-0	CLASS	1.	LAB	UNO	C1RATIO	.40
C2RATIO	1.60	C3RATIO	1.30	PRISPHY	99.00	TIME	29.	HC	43.

CONTENTS OF CASE NUMBER 48

SEQNUM	48.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-3-C	SAMPLE	1253.
PHASE	3.	ZONE	1.	CLASS	3.	LAB	UNO	C1RATIO	.80
C2RATIO	2.40	C3RATIO	1.00	PRISPHY	2.00	TIME	29.	HC	10.

CONTENTS OF CASE NUMBER 49

SEQNUM	49.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-3-C	SAMPLE	1254.
PHASE	3.	ZONE	-0	CLASS	1.	LAB	UNO	C1RATIO	.80
C2RATIO	1.50	C3RATIO	.60	PRISPHY	99.00	TIME	29.	HC	20.

CONTENTS OF CASE NUMBER 50

SEQNUM	50.	SUBFILE	NONAME	CASWGT	1.0000	STATION	NW DIKE	SAMPLE	1465.
PHASE	3.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	4.20
C2RATIO	4.40	C3RATIO	2.10	PRISPHY	99.00	TIME	29.	HC	4.

CONTENTS OF CASE NUMBER 51

SEQNUM	51.	SUBFILE	NONAME	CASWGT	1.0000	STATION	POS1234	SAMPLE	1466.
SE	3.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	2.60
ATIO	3.10	C3RATIO	2.00	PRISPHY	2.10	TIME	29.	HC	7.

SEQNUM	52.	SUBFILE	NONAME	CASWGT	1.0000	STATION	SNR 2	SAMPLE	1499.
PHASE	2.	ZONE	2.	CLASS	2.	LAB	UNO	C1RATIO	3.80
C2RATIO	3.60	C3RATIO	4.00	PRISPHY	1.40	TIME	16.	HC	5.

CONTENTS OF CASE NUMBER 53

SEQNUM	53.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-5-C	SAMPLE	1500.
PHASE	2.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	1.80
C2RATIO	1.60	C3RATIO	1.40	PRISPHY	1.50	TIME	16.	HC	5.

CONTENTS OF CASE NUMBER 54

SEQNUM	54.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-3-C	SAMPLE	1533.
PHASE	4.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	1.30
C2RATIO	2.30	C3RATIO	1.40	PRISPHY	1.20	TIME	53.	HC	4.

CONTENTS OF CASE NUMBER 55

SEQNUM	55.	SUBFILE	NONAME	CASWGT	1.0000	STATION	203-30C	SAMPLE	1545.
PHASE	4.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.30
C2RATIO	.50	C3RATIO	.50	PRISPHY	.60	TIME	53.	HC	50.

CONTENTS OF CASE NUMBER 56

SEQNUM	56.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-3-C	SAMPLE	1551.
PHASE	4.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.20
C2RATIO	.70	C3RATIO	.40	PRISPHY	.60	TIME	53.	HC	99.

CONTENTS OF CASE NUMBER 57

SEQNUM	57.	SUBFILE	NONAME	CASWGT	1.0000	STATION	2-C	SAMPLE	1555.
PHASE	4.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	99.00
C2RATIO	1.80	C3RATIO	.50	PRISPHY	99.00	TIME	53.	HC	8.

CONTENTS OF CASE NUMBER 58

SEQNUM	58.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-7-C	SAMPLE	1563.
PHASE	4.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.10
C2RATIO	.60	C3RATIO	.40	PRISPHY	.70	TIME	53.	HC	99.

CONTENTS OF CASE NUMBER 59

SEQNUM	59.	SUBFILE	NONAME	CASWGT	1.0000	STATION	201-30C	SAMPLE	1567.
PHASE	4.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.30
C2RATIO	.70	C3RATIO	.40	PRISPHY	.80	TIME	53.	HC	41.

CONTENTS OF CASE NUMBER 60

SEQNUM	60.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-1-C	SAMPLE	1568.
PHASE	4.	ZONE	1.	CLASS	2.	LAB	UNO	C1RATIO	.90

C2RATIO	2.70	C3RATIO	1.40	PRISPHY	3.80	TIME	53.	HC	4.

CONTENTS OF CASE NUMBER 61

SEQNUM	61.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-2-C	SAMPLE	1573.
PHASE	4.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.60
C2RATIO	1.50	C3RATIO	.30	PRISPHY	99.00	TIME	53.	HC	24.

CONTENTS OF CASE NUMBER 62

SEQNUM	62.	SUBFILE	NONAME	CASWGT	1.0000	STATION	8-2-C	SAMPLE	1657.
PHASE	4.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	1.00
C2RATIO	2.90	C3RATIO	1.60	PRISPHY	2.40	TIME	53.	HC	12.

CONTENTS OF CASE NUMBER 63

SEQNUM	63.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-7-C	SAMPLE	1665.
PHASE	4.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	1.30
C2RATIO	1.40	C3RATIO	1.60	PRISPHY	2.20	TIME	53.	HC	6.

CONTENTS OF CASE NUMBER 64

SEQNUM	64.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-12-C	SAMPLE	1679.
PHASE	4.	ZONE	1.	CLASS	1.	LAB	UNO	C1RATIO	.40
C2RATIO	1.00	C3RATIO	.40	PRISPHY	99.00	TIME	53.	HC	6.

CONTENTS OF CASE NUMBER 65

SEQNUM	65.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-4-C	SAMPLE	1683.
PHASE	4.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	99.00
C2RATIO	5.90	C3RATIO	1.80	PRISPHY	1.90	TIME	53.	HC	8.

CONTENTS OF CASE NUMBER 66

SEQNUM	66.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-5-C	SAMPLE	1735.
PHASE	4.	ZONE	3.	CLASS	2.	LAB	UNO	C1RATIO	99.00
C2RATIO	99.00	C3RATIO	1.30	PRISPHY	1.60	TIME	53.	HC	6.

FILE NONAME (CREATION DATE = 12/10/79.)

VARIABLE C1RATIO RATIO OF C-1 PHENANTHRENE TO C-1 DIBENZO

MEAN	1.605	STD ERR	.256	STD DEV	1.929
VARIANCE	3.722	KURTOSIS	24.382	SKEWNESS	4.373
MINIMUM	.100	MAXIMUM	13.600	SUM	91.500
C.V. PCT	120.187	.95 C.I.	1.093	TO	2.117

VALID CASES 57 MISSING CASES 9

- -

VARIABLE C2RATIO RATIO OF C-2 PHENANTHRENE TO C-2 DIBENZO

MEAN	2.023	STD ERR	.172	STD DEV	1.354
VARIANCE	1.834	KURTOSIS	1.308	SKEWNESS	1.182
MINIMUM	.300	MAXIMUM	6.100	SUM	125.400
C.V. PCT	66.961	.95 C.I.	1.679	TO	2.367

VALID CASES 62 MISSING CASES 4

- -

VARIABLE C3RATIO RATIO OF C-3 PHENANTHRENE TO C-3 DIBENZO

MEAN	1.321	STD ERR	.114	STD DEV	.888
VARIANCE	.789	KURTOSIS	3.124	SKEWNESS	1.385
MINIMUM	.200	MAXIMUM	4.900	SUM	80.600
C.V. PCT	67.227	.95 C.I.	1.094	TO	1.549

VALID CASES 61 MISSING CASES 5

- -

VARIABLE PRISPHY RATIO OF PRISTANE TO PHYTANE

MEAN	2.602	STD ERR	.484	STD DEV	3.425
VARIANCE	11.728	KURTOSIS	12.373	SKEWNESS	3.280
MINIMUM	.600	MAXIMUM	20.100	SUM	130.100
C.V. PCT	131.617	.95 C.I.	1.629	TO	3.575

VALID CASES 50 MISSING CASES 16

- -

FILE NONAME (CREATION DATE = 12/10/79.)

VARIABLE TIME NUMBER OF WEEKS AFTER THE SPILL THAT THE

MEAN	22.803	STD ERR	2.215	STD DEV	17.994
VARIANCE	323.791	KURTOSIS	-.340	SKEWNESS	.504
MINIMUM	1.000	MAXIMUM	53.000	SUM	1505.000
C.V. PCT	78.911	.95 C.I.	18.380	TO	27.227

VALID CASES 66 MISSING CASES 0

- -

VARIABLE HC HYDROCARBON CONCENTRATION IN PPM

MEAN	11.926	STD ERR	1.824	STD DEV	13.401
VARIANCE	179.579	KURTOSIS	3.995	SKEWNESS	2.033
MINIMUM	0	MAXIMUM	54.000	SUM	644.000
C.V. PCT	112.366	.95 C.I.	9.268	TO	15.584

VALID CASES 54 MISSING CASES 12

FILE NONAME (CREATION DATE = 12/10/79.)

- - - - - - - - - - - - PEARSON CORRELATION COEFFICIENTS - - - - - - - - - - - -

	C1RATIO	C2RATIO	C3RATIO	PRISPHY	TIME	HC
C1RATIO	1.0000	.7703	.7644	.1097	-.2346	-.1493
	(0)	(56)	(54)	(44)	(57)	(47)
	S= .000	S= .001	S= .001	S= .478	S= .079	S= .320
C2RATIO	.7703	1.0000	.6270	.2169	-.0660	-.4009
	(56)	(0)	(59)	(47)	(62)	(50)
	S= .001	S= .001	S= .001	S= .143	S= .610	S= .004
C3RATIO	.7644	.6270	1.0000	.1677	-.1483	-.3179
	(54)	(59)	(0)	(47)	(61)	(49)
	S= .001	S= .001	S= .001	S= .260	S= .254	S= .026
PRISPHY	.1097	.2169	.1677	1.0000	-.0208	-.3147
	(44)	(47)	(47)	(0)	(50)	(40)
	S= .478	S= .143	S= .260	S= .001	S= .886	S= .048
TIME	-.2346	-.0660	-.1483	-.0208	1.0000	.0258
	(57)	(62)	(61)	(50)	(0)	(54)
	S= .079	S= .610	S= .254	S= .886	S= .001	S= .853
HC	-.1493	-.4009	-.3179	-.3147	.0258	1.0000
	(47)	(50)	(49)	(40)	(54)	(0)
	S= .320	S= .004	S= .026	S= .048	S= .853	S= .001

(COEFFICIENT / CASES / SIGNIFICANCE) (99.0000 MEANS UNCOMPUTABLE)

FILE NONAME (CREATION DATE = 12/10/79.)

GROUP COUNTS

	GROUP 1	GROUP 2	TOTAL
NUMBER	9.	23.	32.

MEANS

	GROUP 1	GROUP 2	TOTAL
C1RATIO	.51111	2.05652	1.55000
C2RATIO	1.08487	2.50435	2.10625
C3RATIO	.53333	1.33043	1.43375
PRISPHY	.97778	4.13478	3.20688
TIME	19.00000	22.73913	21.58750
HC	27.55556	7.26087	12.96875

STANDARD DEVIATIONS

	GROUP 1	GROUP 2	TOTAL
C1RATIO	.30185	.83548	.97716
C2RATIO	.50300	1.06022	1.14439
C3RATIO	.16583	.78707	.86358
PRISPHY	.26822	4.54679	4.09508
TIME	21.58124	16.21228	17.59662
HC	21.34895	6.29009	15.21986

WILKS LAMBDA (U-STATISTIC) AND UNIVARIATE F-RATIO WITH 1 AND 30 DEGREES OF FREEDOM

VARIABLE	WILKS LAMBDA	F
C1RATIO	.5434	25.2053
C2RATIO	.6809	14.0577
C3RATIO	.5990	20.0814
PRISPHY	.8760	4.2473
TIME	.9906	.2853
HC	.6290	17.6965

WITHIN GROUPS COVARIANCE MATRIX

	C1RATIO	C2RATIO	C3RATIO	PRISPHY	TIME	HC
C1RATIO	.55618					
C2RATIO	.43085	.92123				
C3RATIO	.23833	.29931	.55152			
PRISPHY	.21893	.19341	-.62225	15.17359		

TIME	-5.25203	-3.02581	-1.99059	-2.20971	316.94783	
HC	-1.99316	-3.97902	.53169	-7.30325	35.45217	152.55523

WITHIN GROUPS CORRELATION MATRIX

	C1RATIO	C2RATIO	C3RATIO	PRISPHY	TIME	HC
C1RATIO	1.00000					
C2RATIO	.61302	1.00000				
C3RATIO	.48020	.32050	1.00000			
PRISPHY	.09662	.05183	-.23507	1.00000		
TIME	-.40365	-.17707	-.16457	-.03146	1.00000	
HC	-.22184	-.33786	.06379	-.15277	.16229	1.00000

TOTAL COVARIANCE MATRIX

	C1RATIO	C2RATIO	C3RATIO	PRISPHY	TIME	HC
C1RATIO	.95484					
C2RATIO	.84387	1.30964				
C3RATIO	.59225	.55585	.74577			
PRISPHY	.97048	1.12002	.18643	16.76367		
TIME	-3.96452	-1.82379	-.99234	.32480	339.64113	
HC	-8.05000	-9.84496	-4.55504	-20.45720	18.47379	231.64415

FILE NONAME (CREATION DATE = 12/10/79.)

- D I S C R I M I N A N T A N A L Y S I S -

ANALYSIS NUMBER 1

TOLERANCE LEVEL	.00100	MAXIMUM STEPS	10
P LEVEL FOR INCLUSION	.01000	P LEVEL FOR DELETION	.01000

SOLUTION METHOD - STEPWISE. SELECT VARIABLE WHICH WILL MAXIMIZE RAOS V.

PRIOR PROBABILITIES - EQUAL

GROUP 1	GROUP 2
.50000	.50000

- - - - - - - - - - - - - - - - - - - -

VARIABLE ENTERED ON STEP NUMBER 2.. HC

				DEGREES OF FREEDOM		SIGNIFICANCE
WILKS LAMBDA	.45965	APPROXIMATE F	17.04574	2	29.00	.000
RAOS V	35.26705	CHANGE IN V	10.06175	1		.002

VARIABLES IN THE ANALYSIS			VARIABLES NOT IN THE ANALYSIS			
VARIABLE	ENTRY CRITERION	F TO REMOVE	VARIABLE	TOLERANCE	F TO ENTER	ENTRY CRITERION
C1RATIO	89.61886	10.63303	C2RATIO	.58135	.00020	92.19911
HC	125.39396	5.26555	C3RATIO	.73890	3.99888	109.42750
			PRISPHY	.97588	1.03641	104.23744
			TIME	.83150	4.03734	117.47125

VARIABLE ENTERED ON STEP NUMBER 3.. TIME

				DEGREES OF FREEDOM		SIGNIFICANCE
WILKS LAMBDA	.40173	APPROXIMATE F	13.89981	3	28.00	.000
RAOS V	44.67795	CHANGE IN V	9.41090	1		.002

VARIABLES IN THE ANALYSIS			VARIABLES NOT IN THE ANALYSIS			
VARIABLE	ENTRY CRITERION	F TO REMOVE	VARIABLE	TOLERANCE	F TO ENTER	ENTRY CRITERION
C1RATIO	89.61886	14.48454	C2RATIO	.57249	.04684	125.39560
TIME	158.85492	4.03734	C3RATIO	.73859	3.23269	158.53618
HC	125.39396	5.16378	PRISPHY	.97551	.94251	133.98364

VARIABLE ENTERED ON STEP NUMBER 4.. C3RATIO

				DEGREES OF FREEDOM		SIGNIFICANCE
WILKS LAMBDA	.35877	APPROXIMATE F	12.06429	4	27.00	.000
RAOS V	53.61908	CHANGE IN V	8.94114	1		.003

VARIABLES IN THE ANALYSIS			VARIABLES NOT IN THE ANALYSIS			
VARIABLE	ENTRY CRITERION	F TO REMOVE	VARIABLE	TOLERANCE	F TO ENTER	ENTRY CRITERION
C1RATIO	89.61886	3.18006	C2RATIO	.56752	.12794	159.31559
C3RATIO	190.64563	3.23269	PRISPHY	.91534	1.84121	168.12366
TIME	158.85492	3.26903				
HC	125.39396	6.13087				

VARIABLE ENTERED ON STEP NUMBER 5.. PRISPHY

				DEGREES OF FREEDOM		SIGNIFICANCE
WILKS LAMBDA	.33504	APPROXIMATE F	10.32037	5	26.00	.000
RAOS V	59.54062	CHANGE IN V	5.92154	1		.015

VARIABLES IN THE ANALYSIS			VARIABLES NOT IN THE ANALYSIS			
VARIABLE	ENTRY CRITERION	F TO REMOVE	VARIABLE	TOLERANCE	F TO ENTER	ENTRY CRITERION
C1RATIO	89.61886	2.35748	C2RATIO	.56620	.16113	192.10859
C3RATIO	190.64563	4.12309				
PRISPHY	211.69999	1.84121				
TIME	158.85492	2.99446				
HC	125.39396	4.55693				

VARIABLE ENTERED ON STEP NUMBER 6.. C2RATIO

				DEGREES OF FREEDOM		SIGNIFICANCE
WILKS LAMBDA	.33290	APPROXIMATE F	8.34963	6	25.00	.000
RAOS V	60.11775	CHANGE IN V	.57712	1		.447

-------- VARIABLES IN THE ANALYSIS --------			---------- VARIABLES NOT IN THE ANALYSIS ----------			
VARIABLE	ENTRY CRITERION	F TO REMOVE	VARIABLE	TOLERANCE	F TO ENTER	ENTRY CRITERION
C1RATIO	89.61886	2.27193				
C2RATIO	192.10859	.16113				
C3RATIO	190.64563	4.09163				
PRISPHY	211.69999	1.81101				
TIME	158.85492	3.00953				
HC	125.39396	4.53845				

ALL ELIGIBLE VARIABLES INCLUDED

FILE NONAME (CREATION DATE = 12/10/79.)

- D I S C R I M I N A N T A N A L Y S I S -

SUMMARY TABLE

STEP NUMBER	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	NUMBER INCLUDED	WILKS LAMBDA	SIG.	RAOS V	CHANGE IN RAOS V	SIG.
1	C1RATIO		25.20531	1	.54343	.000	25.20531	25.20531	.000
2	HC		5.28565	2	.45965	.000	35.26705	10.06175	.002
3	TIME		4.03754	3	.40173	.000	44.67795	9.41090	.002
4	C3RATIO		3.23269	4	.35877	.000	53.61908	8.94114	.003
5	PRISPHY		1.84121	5	.33504	.001	59.54062	5.92154	.015
6	C2RATIO		.16113	6	.33290	.000	60.11775	.57712	.447

CLASSIFICATION FUNCTION COEFFICIENTS

	GROUP 1	GROUP 2
C1RATIO	1.1808	3.3495
C2RATIO	1.8061	1.3925
C3RATIO	.21829	2.7061
PRISPHY	.17341	.43395
TIME	.72878E-01	.14883
HC	.23687	.10582
CONSTANT	-5.4539	-10.638

NUMBER REMOVED	EIGENVALUE	CANONICAL CORRELATION	PERCENT OF TRACE	WILKS LAMBDA	CHI-SQUARE	D.F.	SIGNIFICANCE
0	2.00392	.81676	100.0	.33290	39.79775	6	.000

1 FUNCTIONS WILL BE USED IN REMAINING ANALYSES

STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS

	1
C1RATIO	-.69512
C2RATIO	.15525
C3RATIO	-.70474
PRISPHY	-.34999
TIME	-.43841
HC	.65428

UNSTANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS

	1
C1RATIO	-.711370
C2RATIO	.135650
C3RATIO	-.816075
PRISPHY	-.854658E-01
TIME	-.249147E-01
HC	.429883E-01
CONSTANT	2.16737

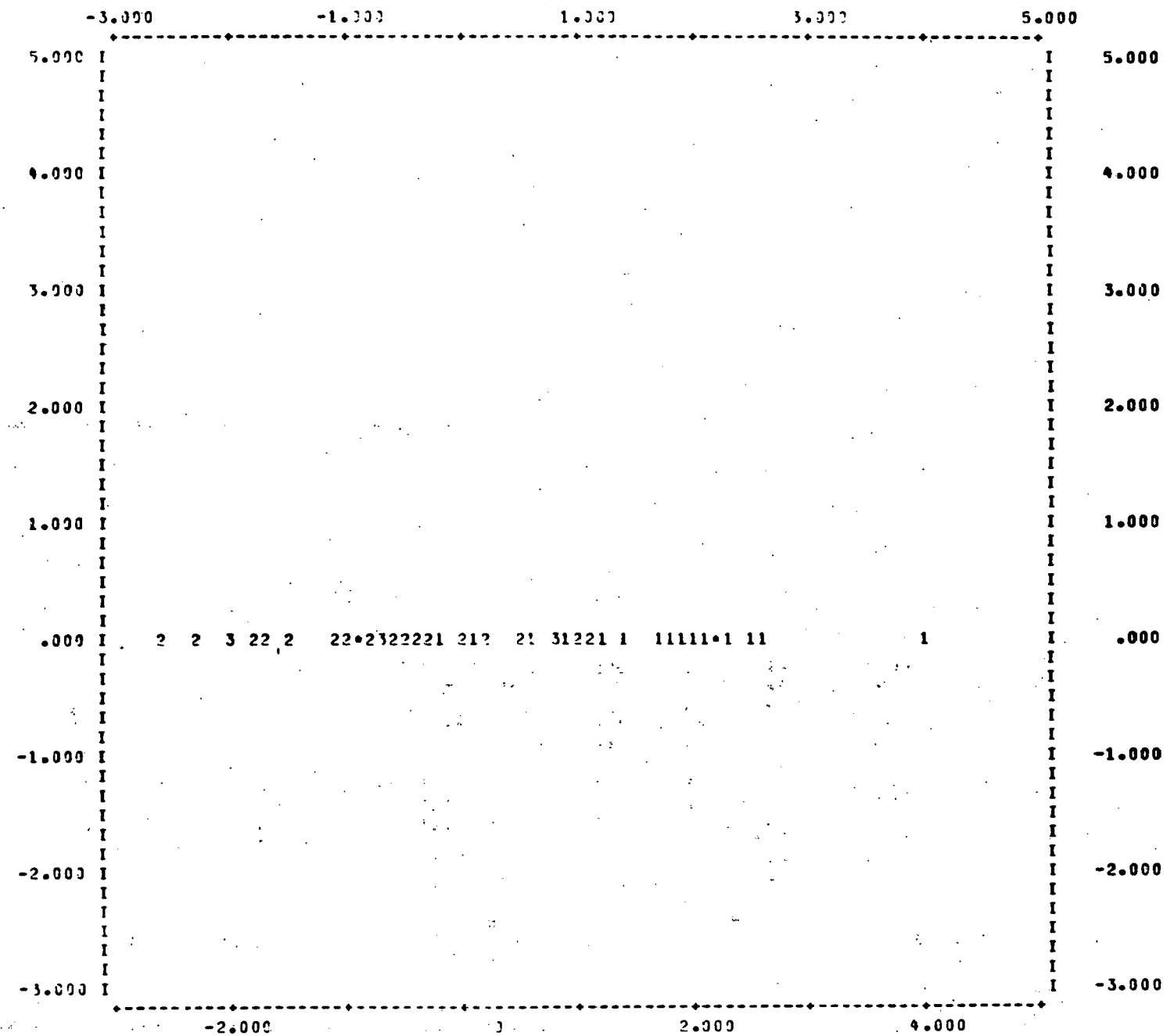
CENTROIDS OF GROUPS IN REDUCED SPACE

GROUP 1	2.19113
GROUP 2	-.85740

CASE SUBFIL	SEQNUM	MISSING VALUES	ACTUAL GROUP		HIGHEST PROBABILITY GROUP	D** 2	P(X/G)	P(G/X)	2ND HIGHEST GROUP	P(G/X)	DISCRIMINANT SCORES 1
	1	1	1		1	.072	.788	.996	2	.004	2.460
	2		1		1	.011	.918	.987	2	.013	2.088
	3	1	1		1	.004	.952	.992	2	.008	2.252
	4		2	***	1	1.122	.293	.805	2	.195	1.132
	5	1	NONE		2	2.006	.157	1.000			-2.274
	6		1		1	.107	.741	.975	2	.025	1.864
	7		1		1	.006	.937	.993	2	.007	2.270
	8	1	1		1	.018	.894	.994	2	.006	2.324
	9		1		1	3.321	.064	1.000			4.013
	10	1	2		2	.774	.379	.877	1	.123	.023
	11		2		2	.007	.931	.993	1	.007	-.943
	12	1	2	***	1	2.016	.156	.579	2	.421	.771
	13	1	2		2	34.136	.000	1.000			-6.700
	14	1	2		2	2.216	.137	.527	1	.473	.631
	15	1	2	***	1	1.363	.243	.748	2	.252	1.024
	16		2		2	1.169	.280	.794	1	.206	.224
	17		2		2	.017	.895	.994	1	.006	-.989
	18		2		2	.047	.828	.995	1	.005	-1.075
	19		2		2	.022	.961	.989	1	.011	-.809
	20		2		2	.040	.841	.995	1	.005	-1.059
	21		2		2	.756	.384	.999	1	.001	-1.727
	22		2		2	.013	.889	.986	1	.014	-.718
	23		2		2	1.836	.175	.626	1	.374	.498
	24		1		1	.910	.340	.851	2	.149	1.237
	25		2		2	.216	.642	.962	1	.038	-.393
	26	1	2		2	.747	.387	.882	1	.118	.007
	27	1	1		1	.003	.954	.989	2	.011	2.134
	28		2		2	.090	.764	.977	1	.023	-.557
	29		2		2	.095	.758	.976	1	.024	-.549
	30	1	1		1	.065	.799	.980	2	.020	1.937
	31	3	2		2	.027	.870	.984	1	.016	-.694
	32		1		1	1.817	.178	.631	2	.369	.843
	33	1	1		1	.214	.644	.962	2	.038	1.728
	34	2	1	***	2	.932	.334	.846	1	.154	.108
	35	3	2		2	.023	.881	.985	1	.015	-.707
	36	3	NONE		2	1.271	.260	1.000			-1.985
	37		2		2	.951	.329	1.000			-1.833
	38	2	2		2	.319	.572	.949	1	.051	-.293
	39		2		2	.067	.795	.979	1	.021	-.599
	40	1	2		2	.059	.808	.995	1	.005	-1.100
	41	1	1		1	.055	.815	.981	2	.019	1.957
	42	1	1		1	.139	.707	.971	2	.029	1.818
	43		2		2	2.068	.150	1.000			-2.296
	44	3	NONE		2	.017	.896	.986	1	.014	-.727
	45	2	NONE		2	.125	.724	.973	1	.027	-.504
	46		1		1	.106	.744	.996	2	.004	2.517
	47	1	1		1	.011	.917	.987	2	.013	2.087
	48		NONE		1	1.814	.178	.632	2	.368	.844
	49	1	1		1	.671	.413	.895	2	.104	1.372
	50	1	2		2	2.917	.089	1.000			-2.565
	51		2		1	.361	.548	.998	1	.002	-1.458
	52		2		2	13.838	.001	1.000			-4.150
	53		2		2	.520	.491	.924	1	.076	-.150
	54		2		2	.048	.827	.982	1	.018	-.639

CASE SUBFIL	SEQNUM	MISSING VALUES	ACTUAL GROUP		HIGHEST PROBABILITY GROUP D**2	P(X/G)	P(G/X)	2ND HIGHEST GROUP	P(G/X)	DISCRIMINANT SCORES 1
	55		1		1 .150	.58?	.957	2	.003	2.591
	56	1	1		1 1.024	.313	.827	2	.173	1.179
	57	2	1	***	2 .401	.527	.938	1	.062	-.224
	58	1	1		1 .927	.336	.847	2	.153	1.228
	59		1		1 .011	.913	.993	2	.007	2.296
	60		2		2 .112	.738	.974	1	.026	-.522
	61	1	1		1 1.403	.235	.687	2	.313	.925
	62		2		2 .350	.554	.945	1	.055	-.266
	63		2		2 .030	.949	.950	1	.010	-.842
	64	1	1	***	2 1.986	.159	.587	1	.413	.552
	65	1	2		2 .059	.808	.980	1	.020	-.614
	66	2	2		2 .006	.939	.988	1	.012	-.781

PLOT OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). * INDICATES A GROUP CENTROID.



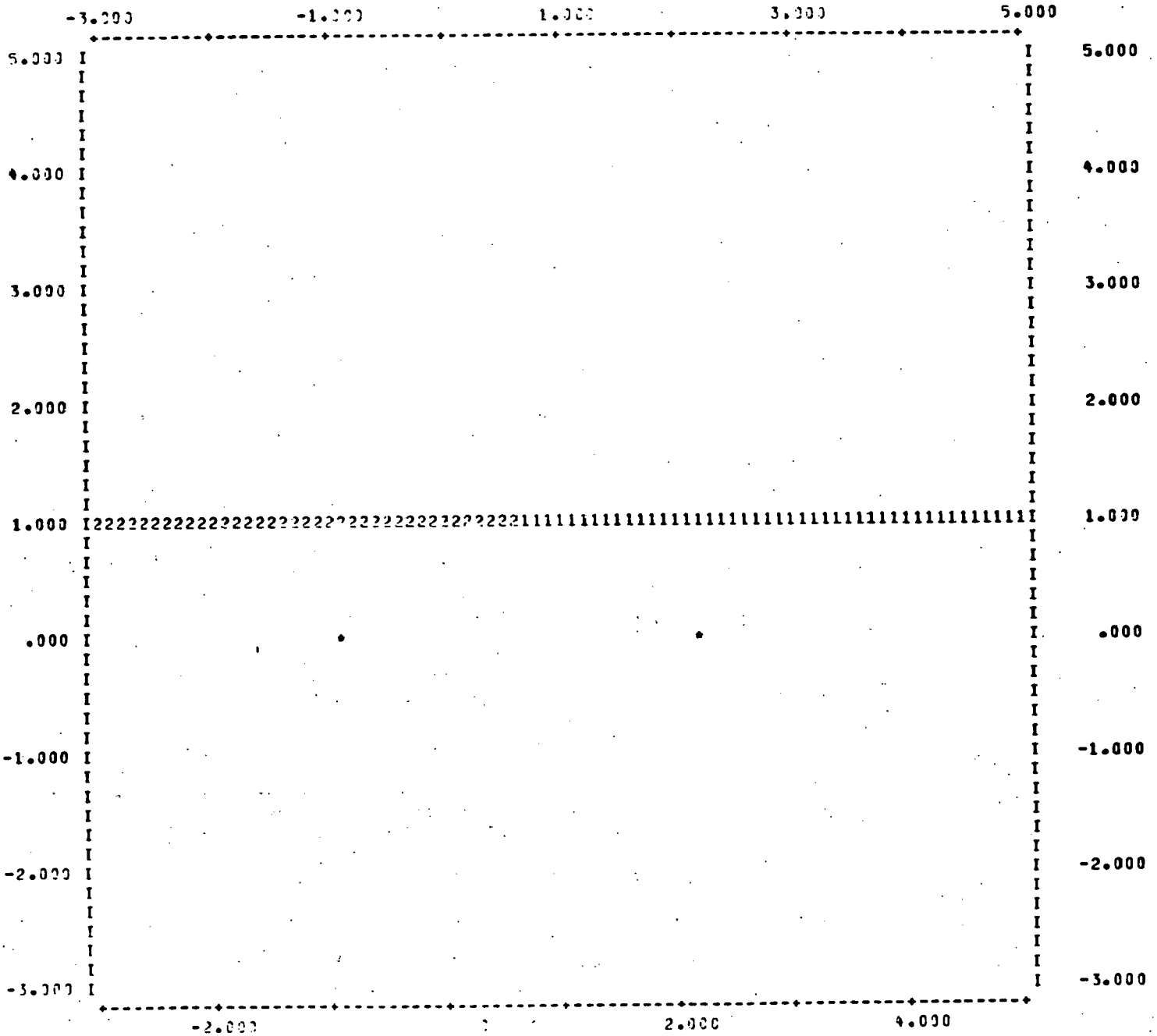
PREDICTION RESULTS -

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2
GROUP 1	1	25	22. 88.0 PCT	3. 12.0 PCT
GROUP 2	2	36	3. 8.3 PCT	33. 91.7 PCT
UNGROUPD	3	5	1. 20.0 PCT	4. 80.0 PCT

90.2 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 39.361 SIGNIFICANCE = .000

TERRITORIAL MAP OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). • INDICATES A GROUP CENTROID.



FILE NONAME (CREATION DATE = 12/11/79.)

- D I S C R I M I N A N T A N A L Y S I S -

ANALYSIS NUMBER 1

TOLERANCE LEVEL .00100 MAXIMUM STEPS 10

P LEVEL FOR INCLUSION .01000 P LEVEL FOR DELETION .0100

SOLUTION METHOD - STEPWISE. SELECT VARIABLE WHICH WILL MAXIMIZE RAOS V.

PRIOR PROBABILITIES - EQUAL

GROUP 1	GROUP 2
.50000	.50000

- - - - - - - - - - - - - - - - - - - -

VARIABLE ENTERED ON STEP NUMBER 2.. C3RATIO

				DEGREES OF FREEDOM		SIGNIFICANCE
WILKS LAMBDA	.49361	APPROXIMATE F	14.87530	2	29.00	.000
RAOS V	30.77648	CHANGE IN V	5.57118	1		.018

-------- VARIABLES IN THE ANALYSIS --------

VARIABLE	ENTRY CRITERION	F TO REMOVE
C1RATIO	89.61886	6.19304
C3RATIO	71.40064	2.92661

ALL ELIGIBLE VARIABLES INCLUDED

---------- VARIABLES NOT IN THE ANALYSIS ----------

VARIABLE	TOLERANCE	F TO ENTER	ENTRY CRITERION

FILE NONAME (CREATION DATE = 12/11/79.)

- D I S C R I M I N A N T A N A L Y S I S -

SUMMARY TABLE

STEP NUMBER	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	NUMBER INCLUDED	WILKS LAMBDA	SIG.	RAOS V	CHANGE IN RAOS V	SIG.
1	C1RATIO		25.20531	1	.54343	.000	25.20531	25.20531	.000
2	C3RATIO		2.92661	2	.49361	.000	30.77648	5.57118	.018

CLASSIFICATION FUNCTION COEFFICIENTS

	GROUP 1	GROUP 2
C1RATIO	.68682	2.6887
C3RATIO	1.0165	2.5737
CONSTANT	-.53176	-5.1202

NUMBER REMOVED	EIGENVALUE	CANONICAL CORRELATION	PERCENT OF TRACE	WILKS LAMBDA	CHI-SQUARE	D.F.	SIGNIFICANCE
0	1.02588	.71161	100.0	.49361	21.18017	2	.000

1 FUNCTIONS WILL BE USED IN REMAINING ANALYSES

STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS

	1
C1RATIO	.89684
C3RATIO	.61651

UNSTANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS

	1
C1RATIO	.917801
C3RATIO	.713908
CONSTANT	-2.58077

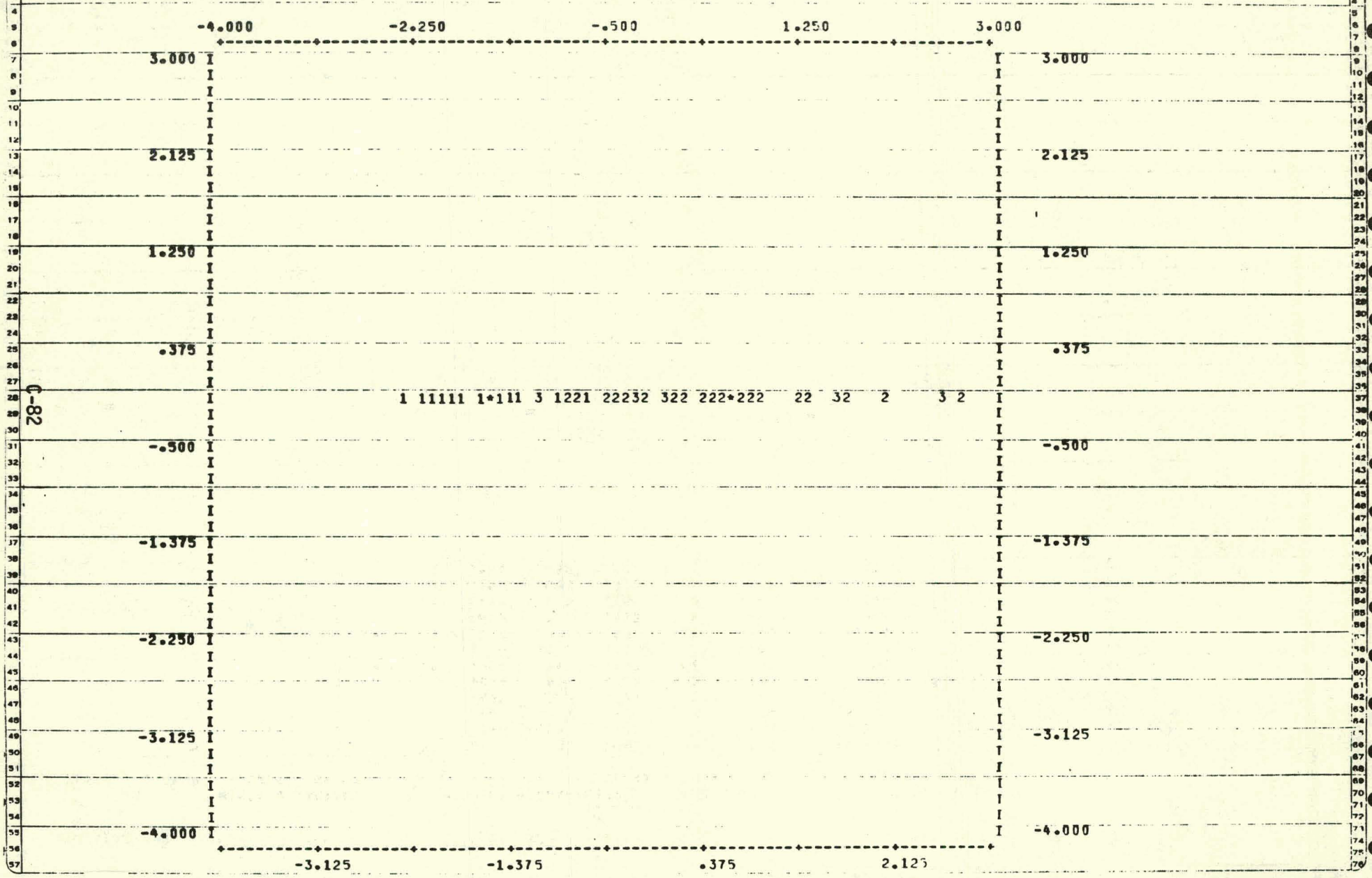
CENTROIDS OF GROUPS IN REDUCED SPACE

GROUP 1	-1.56775
GROUP 2	.61347

CASE SUBFIL	SEQNUM	MISSING VALUES	ACTUAL GROUP		HIGHEST PROBABILITY GROUP	D**2	P(X/G)	P(G/X)	2ND HIGHEST GROUP	P(G/X)	DISCRIMINANT SCORES 1
	1	0	1		1	.274	.601	.971	2	.029	-2.031
	2		1		1	.040	.841	.875	2	.125	-1.367
	3	0	1		1	.072	.788	.951	2	.049	-1.836
	4		2		2	.542	.461	.684	1	.316	-.123
	5	0	NONE		2	3.707	.054	.999	1	.001	2.539
	6		1		1	.012	.913	.895	2	.105	-1.459
	7		1		1	.010	.921	.897	2	.103	-1.469
	8	0	1		1	.130	.719	.959	2	.041	-1.928
	9		1		1	.012	.913	.895	2	.105	-1.459
	10	0	2		2	.061	.805	.863	1	.137	.366
	11		2		2	2.061	.151	.996	1	.004	2.049
	12	0	2		2	.558	.455	.679	1	.321	-.133
	13	1	2		2107	.211	0	1.000			10.968
	14	0	2	***	1	1.096	.295	.524	2	.476	-.521
	15	0	2	***	1	.580	.446	.672	2	.328	-.806
	16		2		2	.377	.539	.739	1	.261	-.001
	17		2		2	.009	.925	.898	1	.102	.519
	18		2		2	.027	.869	.883	1	.117	.448
	19		2		2	.056	.813	.866	1	.134	.377
	20		2		2	.000	.990	.913	1	.087	.601
	21		2		2	2.120	.145	.996	1	.004	2.070
	22		2		2	.252	.616	.783	1	.217	.112
	23		2	***	1	.836	.360	.595	2	.405	-.653
	24		1		1	.001	.973	.921	2	.079	-1.602
	25		2		2	.177	.674	.812	1	.188	.193
	26	0	2		2	.273	.601	.775	1	.225	.091
	27	0	1		1	.379	.538	.976	2	.024	-2.183
	28		2		2	.054	.816	.947	1	.053	.846
	29		2		2	.372	.542	.976	1	.024	1.223
	30	0	1		1	.130	.719	.959	2	.041	-1.928
	31	1	2		2	.011	.916	.931	1	.069	.718
	32		1		1	.346	.556	.750	2	.250	-.980
	33	0	1		1	.007	.932	.929	2	.071	-1.653
	34	1	1		1	1.130	.288	.515	2	.485	-.505
	35	1	2		2	.001	.973	.921	1	.079	.647
	36	1	NONE		2	.985	.321	.989	1	.011	1.606
	37		2		2	1.164	.281	.991	1	.009	1.692
	38	2	2		2	.376	.540	.739	1	.261	-.000
	39		2		2	.005	.941	.902	1	.098	.540
	40	1	2		2	.102	.750	.956	1	.044	.933
	41	0	1		1	.606	.436	.983	2	.017	-2.346
	42	0	1		1	.379	.538	.976	2	.024	-2.183
	43		2		2	.071	.789	.858	1	.142	.346
	44	2	NONE		2	.376	.540	.739	1	.261	-.000
	45	1	NONE		2	.678	.410	.642	1	.358	-.210
	46		1		1	.057	.812	.948	2	.052	-1.806
	47	0	1		1	.080	.778	.854	2	.146	-1.296
	48		NONE		1	.189	.663	.807	2	.193	-1.133
	49	0	1		1	.022	.881	.986	2	.114	-1.419
	50	0	2		2	4.664	.031	.999	1	.001	2.773
	51		2		2	.582	.446	.983	1	.017	1.376
	52		2		2	14.376	.000	1.000			4.405
	53		2		2	.295	.587	.768	1	.232	.071
	54		2		2	1.003	.317	.548	1	.452	-.389

CASE SUBFIL	SEQNUM	MISSING VALUES	ACTUAL GROUP		HIGHEST PROBABILITY GROUP	D**2	P(X/G)	P(G/X)	2ND HIGHEST GROUP	P(G/X)	DISCRIMINANT SCORES 1
	55		1		1	.145	.703	.961	2	.039	-1.948
	56	0	1		1	.296	.587	.972	2	.028	-2.112
	57	1	1		1	.737	.391	.624	2	.376	-.709
	58	0	1		1	.404	.525	.977	2	.023	-2.203
	59		1		1	.204	.651	.967	2	.033	-2.020
	60		2	***	1	.660	.417	.647	2	.353	-.755
	61	0	1		1	.012	.913	.895	2	.105	-1.459
	62		2	***	1	1.096	.295	.524	2	.476	-.521
	63		2		2	.865	.352	.587	1	.413	-.317
	64	0	1		1	.130	.719	.959	2	.041	-1.928
	65	1	2		2	.156	.693	.820	1	.180	.219
	66	1	2		2	.565	.452	.677	1	.323	-.138

PLOT OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). * INDICATES A GROUP CENTROID.



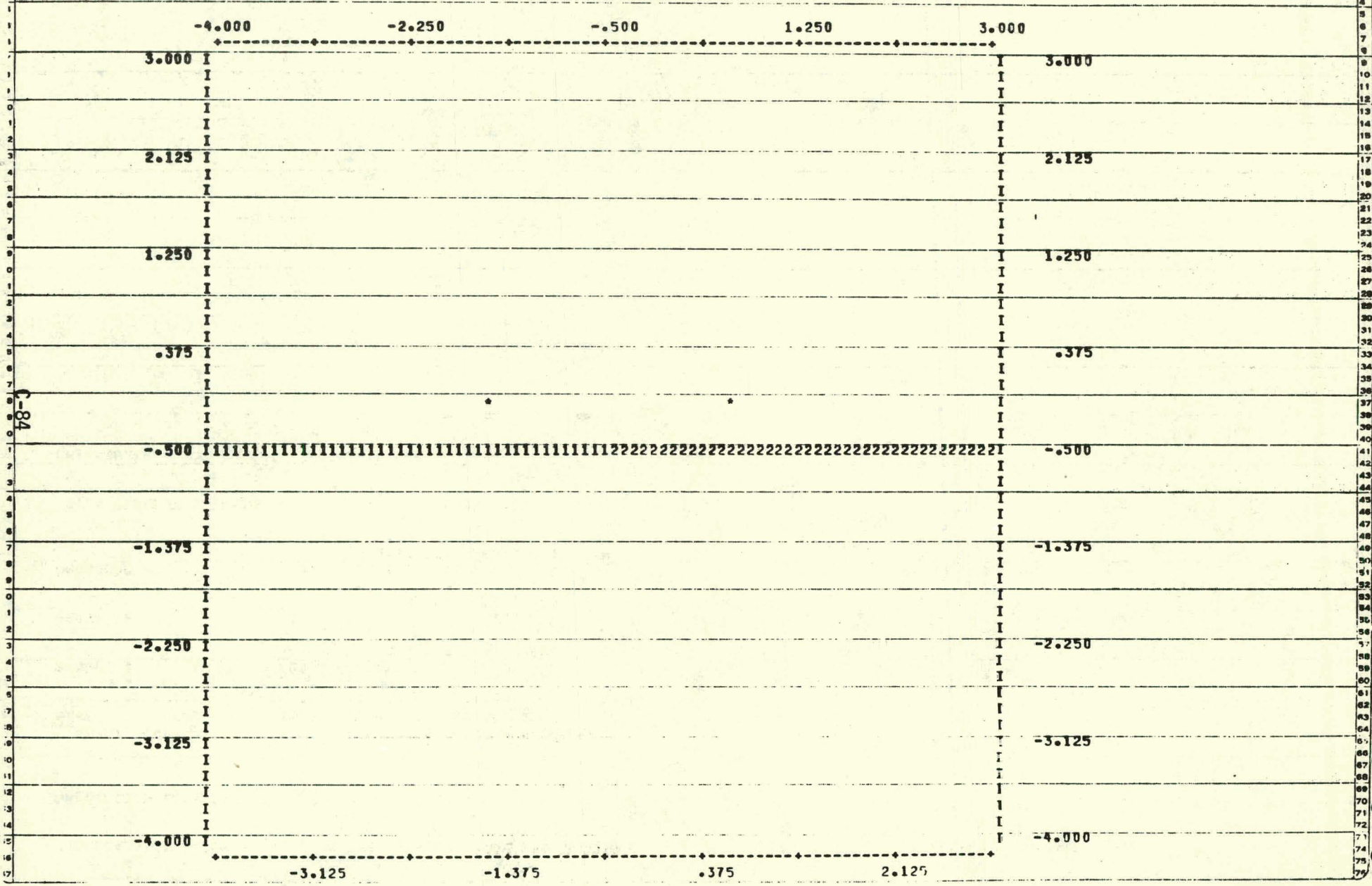
PREDICTION RESULTS -

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2
GROUP 1	1	25	25.	0
			100.0 PCT	0 PCT
GROUP 2	2	36	5.	31.
			13.9 PCT	86.1 PCT
UNGROUPD	3	5	1.	4.
			20.0 PCT	80.0 PCT

91.8 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 42.639 SIGNIFICANCE = .000

TERRITORIAL MAP OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). * INDICATES A GROUP CENTROID.



UNITED COMPUTING SYSTEMS INC.
S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

VERSION 6.5 - - SEPT. 1, 1976

```
RUN NAME        DISCRIMINANT ANALYSIS OF SOIL AND SEDIMENT PYROGENICS
VARIABLE LIST   STATION,SAMPLE,PHASE,CLASS,FLOUR,PYRENE,CHRYSE,BENZOPY
INPUT MEDIUM    CARD
INPUT FORMAT    FIXED (A8,F4.0,2F1.0,4F6.0)

ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

VARIABLE  FORMAT  RECORD    COLUMNS

STATION     A 8       1     1-  8
SAMPLE    F 4. 0      1     9-  12
PHASE     F 1. 0      1    13-  13
CLASS     F 1. 0      1    14-  14
FLOUR     F 6. 0      1    15-  20
PYRENE    F 6. 0      1    21-  26
CHRYSE    F 6. 0      1    27-  32
BENZOPY   F 6. 0      1    33-  38
```



```
THE INPUT FORMAT PROVIDES FOR   8 VARIABLES.    8 WILL BE READ
IT PROVIDES FOR  1 RECORDS (*CARDS*) PER CASE.  A MAXIMUM OF   38 *COLUMNS* ARE USED ON A RECORD.

N OF CASES      21
RECODE          FLOUR TO BENZOPY (BLANK = 99)
VAR LABELS      SAMPLE  TAG NUMBER/FLOUR  FLOURANTHENE/CHRYSE  CHRYSENE/BENZOPY
                BENZOPYRENE
VALUE LABELS    CLASS (1) KNOWN FIRE AFFECTED STATIONS  (2) KNOWN BACKGROUND STAT
                IONS  (3) UNCLASSIFIED STATIONS
IF              (PYRENE GT 0.01) FLAPYR=FLOUR/PYRENE
IF              (PYRENE GT 0.01) CHRPYR=CHRYSE/PYRENE
IF              (PYRENE GT 0.01) BPPYR=BENZOPY/PYRENE
MISSING VALUES  FLAPYR TO BPPYR (99)
MISSING VALUES  FLOUR TO BENZOPY (99)
PRINT FORMATS   STATION(A),FLAPYR(3),CHRYSE(3),BPPYR(3)
LIST CASES      CASES = 21/VARIABLES = ALL
READ INPUT DATA


CONTENTS OF CASE NUMBER     1

SEQNUM          1.      SUBFILE   NONAME          CASWGT      1.0000      STATION   A-2           SAMPLE          3.
PHASE           1.      CLASS           1.      FLOUR       240000.       PYRENE      230000.     CHRYSE   19000.000
BENZOPY      4300.      FLAPYR       1.043      CHRPYR           0.       BPPYR           .019

CONTENTS OF CASE NUMBER     2

SEQNUM          2.      SUBFILE   NONAME          CASWGT      1.0000      STATION   9-7-C         SAMPLE         13.
```

PHASE	1.	CLASS	3.	FLOUR	420.	PYRENE	460.	CHRYSE	310.000
BENZOPY	350.	FLAPYR	.913	CHRPYR	1.	BPPYR	.761		

CONTENTS OF CASE NUMBER 3

SEQNUM	3.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-4-C	SAMPLE	15.
PHASE	1.	CLASS	2.	FLOUR	580.	PYRENE	730.	CHRYSE	320.000
BENZOPY	340.	FLAPYR	.795	CHRPYR	.	BPPYR	.466		

CONTENTS OF CASE NUMBER 4

SEQNUM	4.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-3-C	SAMPLE	16.
PHASE	1.	CLASS	3.	FLOUR	1200.	PYRENE	1200.	CHRYSE	810.000
BENZOPY	800.	FLAPYR	1.000	CHRPYR	1.	BPPYR	.667		

CONTENTS OF CASE NUMBER 5

SEQNUM	5.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-11-C	SAMPLE	18.
PHASE	1.	CLASS	3.	FLOUR	570.	PYRENE	560.	CHRYSE	180.000
BENZOPY	330.	FLAPYR	1.018	CHRPYR	.	BPPYR	.589		

CONTENTS OF CASE NUMBER 6

SEQNUM	6.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-13-C	SAMPLE	19.
PHASE	1.	CLASS	2.	FLOUR	120.	PYRENE	170.	CHRYSE	52.000
BENZOPY	100.	FLAPYR	.706	CHRPYR	.	BPPYR	.588		

CONTENTS OF CASE NUMBER 7

SEQNUM	7.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-12-C	SAMPLE	20.
PHASE	1.	CLASS	3.	FLOUR	230.	PYRENE	130.	CHRYSE	79.000
BENZOPY	150.	FLAPYR	1.769	CHRPYR	1.	BPPYR	1.154		

CONTENTS OF CASE NUMBER 8

SEQNUM	8.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-14-C	SAMPLE	21.
PHASE	1.	CLASS	2.	FLOUR	140.	PYRENE	220.	CHRYSE	57.000
BENZOPY	370.	FLAPYR	.636	CHRPYR	.	BPPYR	1.682		

CONTENTS OF CASE NUMBER 9

SEQNUM	9.	SUBFILE	NONAME	CASWGT	1.0000	STATION	SNR 2	SAMPLE	54.
PHASE	1.	CLASS	1.	FLOUR	770.	PYRENE	520.	CHRYSE	290.000
BENZOPY	330.	FLAPYR	1.481	CHRPYR	1.	BPPYR	.635		

CONTENTS OF CASE NUMBER 10

SEQNUM	10.	SUBFILE	NONAME	CASWGT	1.0000	STATION	SNR 4	SAMPLE	61.
PHASE	1.	CLASS	3.	FLOUR	410.	PYRENE	300.	CHRYSE	320.000
BENZOP	490.	FLAPYR	1.139	CHRPYR	1.	BPPYR	1.361		

CONTENTS OF CASE NUMBER 11

SEQNUM	11.	SUBFILE	NONAME	CASWGT	1.0000	STATION	SNR 5	SAMPLE	65.
PHASE	1.	CLASS	3.	FLOUR	540.	PYRENE	410.	CHRYSE	290.000
BENZOPY	360.	FLAPYR	1.317	CHRPYR	1.	BPPYR	.878		

CONTENTS OF CASE NUMBER 12

SEQNUM	12.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-2-C	SAMPLE	85.
PHASE	1.	CLASS	3.	FLOUR	3700.	PYRENE	4500.	CHRYSE	1100.000
BENZOPY	740.	FLAPYR	.822	CHRPYR	.	BPPYR	.164		

CONTENTS OF CASE NUMBER 13

SEQNUM	13.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-5-C	SAMPLE	122.
PHASE	1.	CLASS	2.	FLOUR	1200.	PYRENE	1700.	CHRYSE	700.000
BENZOPY	1000.	FLAPYR	.706	CHRPYR	.	BPPYR	.588		

CONTENTS OF CASE NUMBER 14

SEQNUM	14.	SUBFILE	NONAME	CASWGT	1.0000	STATION	9-9-C	SAMPLE	128.
PHASE	1.	CLASS	2.	FLOUR	710.	PYRENE	790.	CHRYSE	570.000
BENZOPY	650.	FLAPYR	.899	CHRPYR	1.	BPPYR	.823		

C-87

CONTENTS OF CASE NUMBER 15

SEQNUM	15.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-16-C	SAMPLE	153.
PHASE	1.	CLASS	3.	FLOUR	500000.	PYRENE	470000.	CHRYSE	500000.000
BENZOPY	470000.	FLAPYR	1.064	CHRPYR	1.	BPPYR	1.000		

CONTENTS OF CASE NUMBER 16

SEQNUM	16.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-17-C	SAMPLE	154.
PHASE	1.	CLASS	3.	FLOUR	0	PYRENE	0	CHRYSE	0
BENZOPY	0	FLAPYR	99.000	CHRPYR	99.	BPPYR	99.000		

CONTENTS OF CASE NUMBER 17

SEQNUM	17.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-3-C	SAMPLE	193.
PHASE	1.	CLASS	2.	FLOUR	550.	PYRENE	880.	CHRYSE	320.000
BENZOPY	490.	FLAPYR	.625	CHRPYR	.	BPPYR	.557		

CONTENTS OF CASE NUMBER 18

SEQNUM	18.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-5-C	SAMPLE	197.
PHASE	1.	CLASS	3.	FLOUR	230.	PYRENE	140.	CHRYSE	49.000
BENZOPY	74.	FLAPYR	1.429	CHRPYR	.	BPPYR	.629		

CONTENTS OF CASE NUMBER 19

SEQNUM	19.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-17-C	SAMPLE	226.
PHASE	-0	CLASS	2.	FLOUR	620.	PYRENE	900.	CHRYSE	590.000
BENZOPY	690.	FLAPYR	.689	CHRPYR	1.	BPPYR	.767		

CONTENTS OF CASE NUMBER 20

SEQNUM	20.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-7-C	SAMPLE	229.
PHASE	-0	CLASS	2.	FLOUR	810.	PYRENE	980.	CHRYSE	540.000
BENZOPY	770.	FLAPYR	.827	CHRPYR	1.	BPPYR	.786		

CONTENTS OF CASE NUMBER 21

SEQNUM	21.	SUBFILE	NONAME	CASWGT	1.0000	STATION	30-12-C	SAMPLE	234.
PHASE	-0	CLASS	1.	FLOUR	520.	PYRENE	270.	CHRYSE	100.000
BENZOPY	130.	FLAPYR	1.926	CHRPYR	.	BPPYR	.481		

FILE NONAME (CREATION DATE = 12/15/79.)

VARIABLE FLCUR FLCURANTHENE

MEAN	35870.952	STD ERR	25847.514	STD DEV	118448.190
VARIANCE	.1402E+11	KURTOSIS	9.847	SKEWNESS	3.319
MINIMUM	0	MAXIMUM	500000.000	SUM	753290.000
C.V. PCT	330.206	.95 C.I.	-18046.017	TO	89787.922

VALID CASES 21 MISSING CASES 0

VARIABLE PYRENE

MEAN	34043.810	STD ERR	24372.651	STD DEV	111689.515
VARIANCE	.1247E+11	KURTOSIS	9.692	SKEWNESS	3.298
MINIMUM	0	MAXIMUM	470000.000	SUM	714920.000
C.V. PCT	328.076	.95 C.I.	-16796.649	TO	84884.268

VALID CASES 21 MISSING CASES 0

VARIABLE CHRYSE CHRYSENE

MEAN	25032.238	STD ERR	23765.024	STD DEV	108905.022
VARIANCE	.1186E+11	KURTOSIS	15.997	SKEWNESS	4.239
MINIMUM	0	MAXIMUM	500000.000	SUM	525677.000
C.V. PCT	435.059	.95 C.I.	-24540.734	TO	74605.210

VALID CASES 21 MISSING CASES 0

VARIABLE BENZOPY BENZOPYRENE

MEAN	22974.476	STD ERR	22352.110	STD DEV	102430.237
VARIANCE	.1049E+11	KURTOSIS	16.047	SKEWNESS	4.248
MINIMUM	0	MAXIMUM	470000.000	SUM	482464.000
C.V. PCT	445.844	.95 C.I.	-23651.209	TO	69600.161

VALID CASES 21 MISSING CASES 0

FILE NONAME (CREATION DATE = 12/15/79.)

PEARSON CORRELATION COEFFICIENTS

	FLOUR	PYRENE	CHRYSE	BENZOPY
FLOUR	1.0000	1.0000	.9136	.9014
	(0)	(21)	(21)	(21)
	S= .001	S= .001	S= .001	S= .001
PYRENE	1.0000	1.0000	.9104	.8980
	(21)	(0)	(21)	(21)
	S= .001	S= .001	S= .001	S= .001
CHRYSE	.9136	.9104	1.0000	.9996
	(21)	(21)	(0)	(21)
	S= .001	S= .001	S= .001	S= .001
BENZOPY	.9014	.8980	.9996	1.0000
	(21)	(21)	(21)	(0)
	S= .001	S= .001	S= .001	S= .001

(COEFFICIENT / CASES / SIGNIFICANCE) (99.0000 MEANS UNCOMPUTABLE)

FILE NONAME (CREATION DATE = 12/15/79.)

GROUP COUNTS

	GROUP 1	GROUP 2	TOTAL
NUMBER	3.	8.	11.

MEANS

	GROUP 1	GROUP 2	TOTAL
FLOUR	80430.00000	591.25000	22365.45455
PYRENE	76930.00000	796.25000	21560.00000
CHRYSE	6463.33333	393.62500	2049.00000
BENZOPY	1586.66667	551.25000	833.63636
FLAPYR	1.48339	.73523	.93927
CHRPYR	.33689	.46335	.42886
BPPYR	.37826	.78200	.67189

STANDARD DEVIATIONS

	GROUP 1	GROUP 2	TOTAL
FLOUR	138191.73022	350.69065	72181.83405
PYRENE	132562.56749	477.64115	69133.09106
CHRYSE	10857.48743	246.64256	5626.51795
BENZOPY	2351.94246	283.62135	1181.75524
FLAPYR	.44123	.09590	.40927
CHRPYR	.23930	.16520	.18451
BPPYR	.32067	.38497	.39984

WILKS LAMBDA (U-STATISTIC) AND UNIVARIATE F-RATIO WITH 1 AND 9 DEGREES OF FREEDOM

VARIABLE	WILKS LAMBDA	F
FLOUR	.7331	3.2771
PYRENE	.7354	3.2384
CHRYSE	.7461	3.0628
BENZOPY	.8325	1.8107
FLAPYR	.2709	24.2238
CHRPYR	.8975	1.0278
BPPYR	.7775	2.5750

WITHIN GROUPS COVARIANCE MATRIX

	FLOUR	PYRENE	CHRYSE	BENZOPY	FLAPYR	CHRPYR	BPPYR
FLOUR	.424286E+10						

PYRENE	.407102E+10	.390525E+10					
CHRYSE	.333477E+09	.319914E+09	.262439E+08				
BENZOPY	.722345E+08	.693194E+08	5721404.	1203712.	91817.12963		
FLAPYR	-11696.49752	-11223.91403	-915.96487	-199.22817	.05042		
CHRPYR	-6738.38491	-6462.61206	-505.77006	-94.28180	.02258	.03395	
BPPYR	-9606.66730	-9234.54992	-777.62452	-169.71402	.01549	.00516	.13812

WITHIN GROUPS CORRELATION MATRIX

	FLOUR	PYRENE	CHRYSE	BENZOPY	FLAPYR	CHRPYR	BPPYR
FLOUR	1.00000						
PYRENE	1.00000	1.00000					
CHRYSE	.99924	.99930	1.00000				
BENZOPY	.97558	.97596	.98262	1.00000			
FLAPYR	-.79963	-.79990	-.79630	-.78066	1.00000		
CHRPYR	-.56137	-.56125	-.53581	-.45019	.54584	1.00000	
BPPYR	-.39680	-.39762	-.40844	-.40178	.18559	.07540	1.00000

TOTAL COVARIANCE MATRIX

	FLOUR	PYRENE	CHRYSE	BENZOPY	FLAPYR	CHRPYR	BPPYR
FLOUR	.521021E+10						
PYRENE	.459012E+10	.477938E+10					
CHRYSE	.405860E+09	.388747E+09	.316577E+08				
BENZOPY	.830473E+08	.795868E+08	6520466.	1000013	96545.45455		
FLAPYR	2505.72468	2326.25977	166.42761	-10.28789	.16750		
CHRPYR	-8267.44658	-7917.02315	-622.66764	-113.42270	-.00032	.03405	
BPPYR	-15678.87868	-15017.60503	-1234.53375	-243.95095	-.05197	.01579	.15987

FILE NONAME (CREATION DATE = 12/15/79.)

DISCRIMINANT ANALYSIS

ANALYSIS NUMBER 1

TOLERANCE LEVEL	.00100	MAXIMUM STEPS	10
P LEVEL FOR INCLUSION	.01000	P LEVEL FOR DELETION	.01000

SOLUTION METHOD - STEPWISE. SELECT VARIABLE WHICH WILL MAXIMIZE RAOS V.

PRIOR PROBABILITIES - EQUAL

GROUP 1	GROUP 2
.50000	.50000

VARIABLE ENTERED ON STEP NUMBER 1.. FLAPYR

				DEGREES OF FREEDOM		SIGNIFICANCE
WILKS LAMBDA	.27089	APPROXIMATE F	24.22383	1	9.00	.001
RAOS V	24.22383	CHANGE IN V	24.22383	1		.000

C-93

VARIABLES IN THE ANALYSIS			VARIABLES NOT IN THE ANALYSIS			
VARIABLE	ENTRY CRITERION	F TO REMOVE	VARIABLE	TOLERANCE	F TO ENTER	ENTRY CRITERION
FLAPYR	88.82069	24.22383	CHRPYR	.70205	4.69618	3.76843
			BPPYR	.96555	1.58131	9.44158

VARIABLE ENTERED ON STEP NUMBER 2.. CHRPYR

				DEGREES OF FREEDOM		SIGNIFICANCE
WILKS LAMBDA	.17069	APPROXIMATE F	19.43420	2	8.00	.001
RAOS V	43.72694	CHANGE IN V	19.50312	1		.000

-------- VARIABLES IN THE ANALYSIS --------

VARIABLE	ENTRY CRITERION	F TO REMOVE
FLAPYR	88.82069	34.06481
CHRPYR	160.33213	4.69618

---------- VARIABLES NOT IN THE ANALYSIS ----------

VARIABLE	TOLERANCE	F TO ENTER	ENTRY CRITERION
BPPYR	.96460	.96994	112.90025

VARIABLE ENTERED ON STEP NUMBER 3.. BPPYR

				DEGREES OF FREEDOM		SIGNIFICANCE
WILKS LAMBDA	.14992	APPROXIMATE F	13.23075	3	7.00	.003
RAOS V	51.03291	CHANGE IN V	7.30597	1		.007

-------- VARIABLES IN THE ANALYSIS --------

VARIABLE	ENTRY CRITERION	F TO REMOVE
FLAPYR	88.82069	26.95358
CHRPYR	160.33213	3.56095
BPPYR	112.90025	.96994

ALL ELIGIBLE VARIABLES INCLUDED

---------- VARIABLES NOT IN THE ANALYSIS ----------

VARIABLE	TOLERANCE	F TO ENTER	ENTRY CRITERION

FILE NONAME (CREATION DATE = 12/15/79.)

DISCRIMINANT ANALYSIS

SUMMARY TABLE

STEP NUMBER	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	NUMBER INCLUDED	WILKS LAMBDA	SIG.	RAOS V	CHANGE IN RAOS V	SIG.
1	FLAPYR		24.22383	1	.27089	.001	24.22383	24.22383	.000
2	CHRPYR		4.69618	2	.17069	.001	43.72694	19.50312	.000
3	BPPYR		.96994	3	.14992	.003	51.03291	7.30597	.007

CLASSIFICATION FUNCTION COEFFICIENTS

	GROUP 1	GROUP 2
FLAPYR	35.839	10.617
CHRPYR	-13.800	5.9391
BPPYR	-.76407	4.2493
CONSTANT	-24.112	-6.9406

NUMBER REMOVED	EIGENVALUE	CANONICAL CORRELATION	PERCENT OF TRACE	WILKS LAMBDA	CHI-SQUARE	D.F.	SIGNIFICANCE
0	5.67032	.92200	100.0	.14992	16.13018	3	.001

1 FUNCTIONS WILL BE USED IN REMAINING ANALYSES

STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS

	1
FLAPYR	2.13434
CHRPYR	-.75307
BPPYR	-.41448

UNSTANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS

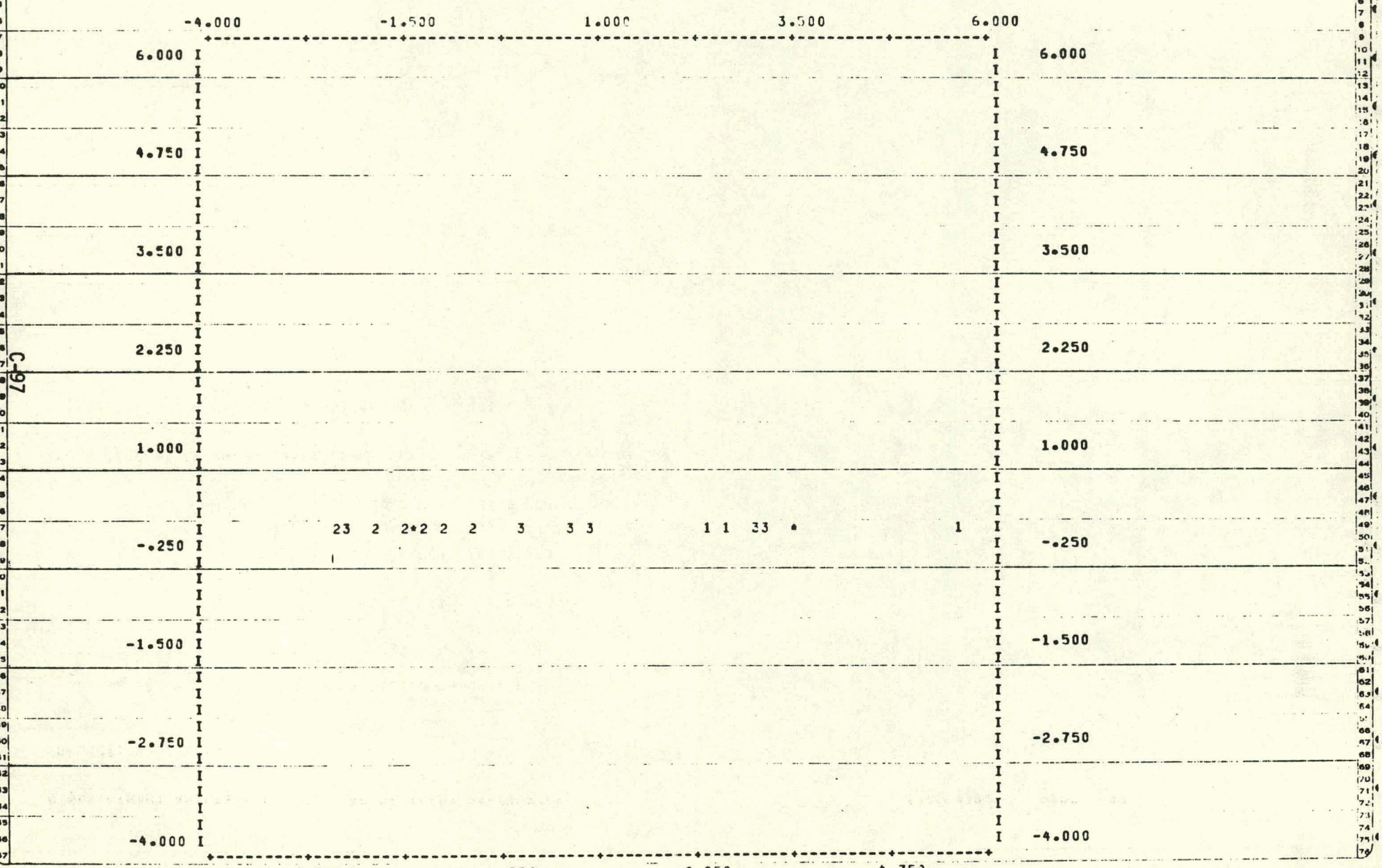
	1
FLAPYR	5.21498
CHRPYR	-4.08135
BPPYR	-1.03661
CONSTANT	-2.45144

CENTROIDS OF GROUPS IN REDUCED SPACE

GROUP 1 3.51733
GROUP 2 -1.31900

CASE SUBFIL	SEQNUM	MISSING VALUES	ACTUAL GROUP	HIGHEST PROBABILITY GROUP	D**2	P(X/G)	P(G/X)	2ND HIGHEST GROUP	P(G/X)	DISCRIMINANT SCORES 1
	1		1	1	.781	.377	.999	2	.001	2.634
	2		NONE	2	.008	.928	1.000			-1.229
	3		2	2	.546	.460	1.000			-.580
	4		NONE	2	.405	.524	1.000			-.682
	5		NONE	2	5.076	.024	.690	1	.310	.934
	6		2	2	.477	.490	1.000			-.628
	7		NONE	1	.175	.676	1.000			3.099
	8		2	2	.378	.539	1.000			-1.934
	9		1	1	1.394	.238	.997	2	.003	2.337
	10		NONE	2	.054	.817	1.000			-1.551
	11		NONE	2	3.760	.052	.910	1	.090	.620
	12		NONE	2	3.949	.047	.889	1	.111	.668
	13		2	2	.067	.796	1.000			-1.061
	14		2	2	.059	.808	1.000			-1.562
	15		NONE	2	.927	.336	1.000			-2.282
	16	3	NONE	2	1.740	.187	.995	1	.005	0
	17		2	2	.004	.948	1.000			-1.253
	18		NONE	1	.245	.620	1.000			3.022
	19		2	2	1.020	.312	1.000			-2.329
	20		2	2	.013	.909	1.000			-1.204
	21		1	1	4.261	.039	1.000			5.582

PLOT OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). * INDICATES A GROUP CENTROID.



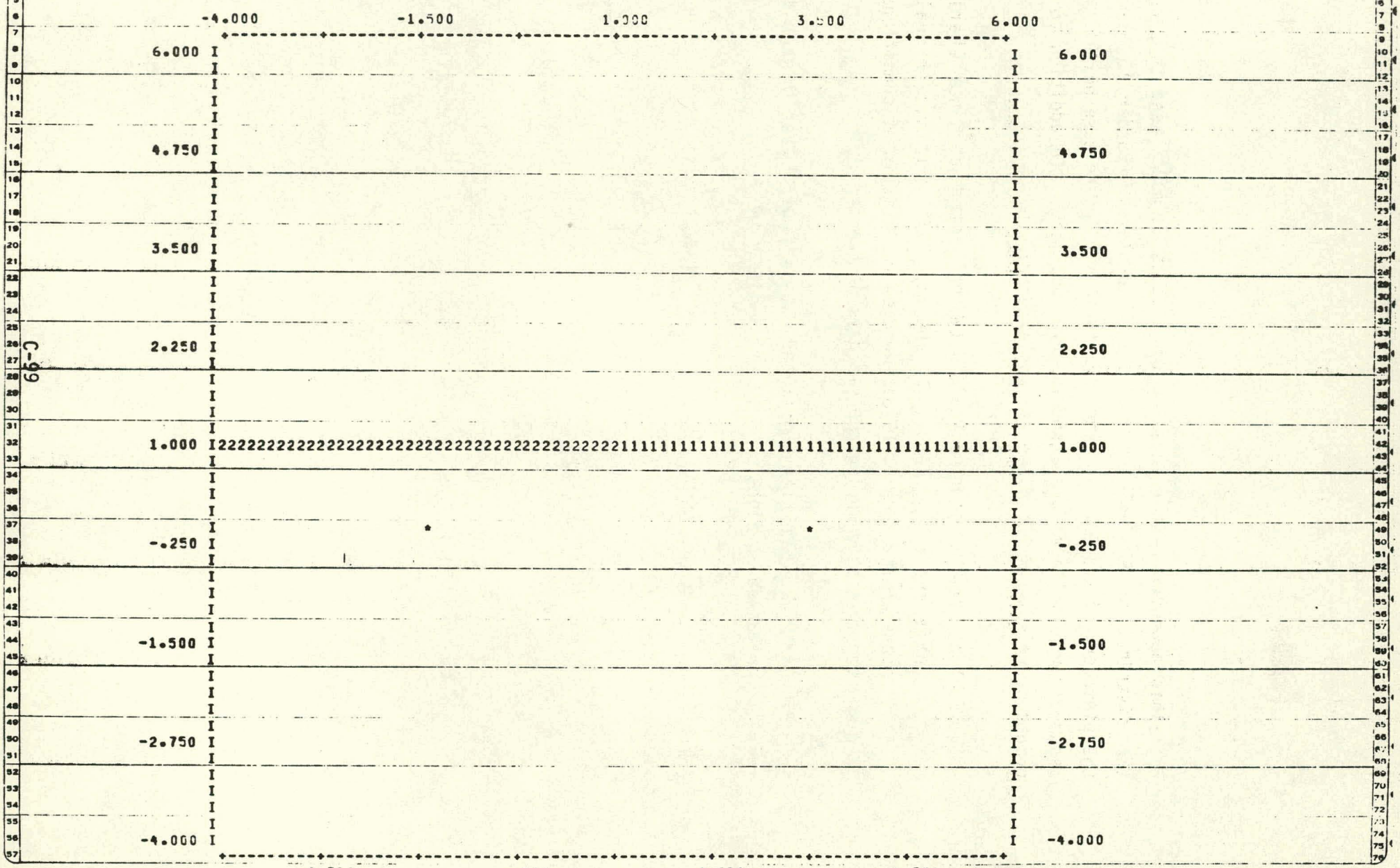
PREDICTION RESULTS -

ACTUAL GROUP NAME	CODE	N OF CASES	PREDICTED GROUP MEMBERSHIP GROUP 1	GROUP 2
GROUP 1	1	3	3.	0
			100.0 PCT	0 PCT
GROUP 2	2	8	0	8.
			0 PCT	100.0 PCT
UNGROUPD	3	10	2.	8.
			20.0 PCT	80.0 PCT

100.0 PERCENT OF KNOWN CASES CORRECTLY CLASSIFIED

CHI-SQUARE = 11.000 SIGNIFICANCE = .001

TERRITORIAL MAP OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). * INDICATES A GROUP CENTROID.



APPENDIX C.4

Plume Models

This appendix is a discussion of a Gaussian model used to predict the distribution of fallout from the fire plume in order to improve the placement of trace metal sampling stations. Two release heights were assumed: ground level and 1,500 m above the fire. In addition to the points of release of the plume, it was assumed:

1. That the meteorological data collected at Lake Charles, Louisiana on September 25 and 26, 1978, during air quality measurements (Henry, 1978), were characteristic of conditions at the fire site during the six days of the fire.

2. Class B stability prevailed in daytime; Class D stability prevailed at night.

The Pasquill (Gaussian) model was used to obtain a first order approximation of the plume's behavior during the fire. The meteorological data was obtained from the National Weather Service, Lake Charles, Louisiana. The Lake Charles weather station is 24 km northeast of the West Hackberry site. The wind data used are summarized in Table C.4-1. For a ground level station, the concentration of vanadium can be estimated by the following equation (Turner, 1970):

$$X = \frac{Q}{\pi u \sigma_y \sigma_z} \exp\left[-\tfrac{1}{2}\left(\frac{y}{\sigma_y}\right)^2 - \tfrac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right]$$

where:

X = Concentration of vanadium (g/m^3)

Q = Emission rate (g/sec)

σ_y = Plume's horizontal standard deviation at downwind distance

σ_z = Plume's vertical standard deviation at downwind distance

y = Cross wind distance to station (m)

u = Wind speed (m/sec)

H = Release height of plume (m)

π = 3.14

TABLE C.4-1

SUMMARY OF WIND CONDITIONS
LAKE CHARLES, LOUISIANA
SEPTEMBER 25-26, 1978

Direction	% of Time	Average Speed (mph)
350	6.3	7.3
360/0	14.6	7.4
10	10.4	8.2
20	10.4	8.0
30	18.8	8.4
40	12.5	8.2
50	14.6	8.4
60	12.5	9.4

Overall average speed = 8.0 mph

Net Wind Movement	Resultant Wind Direction
7.7 mph	30°

The standard deviations of plume concentration, σ_y and σ_z, have been observed to be related to the downwind distance and stability class (Turner, 1970).

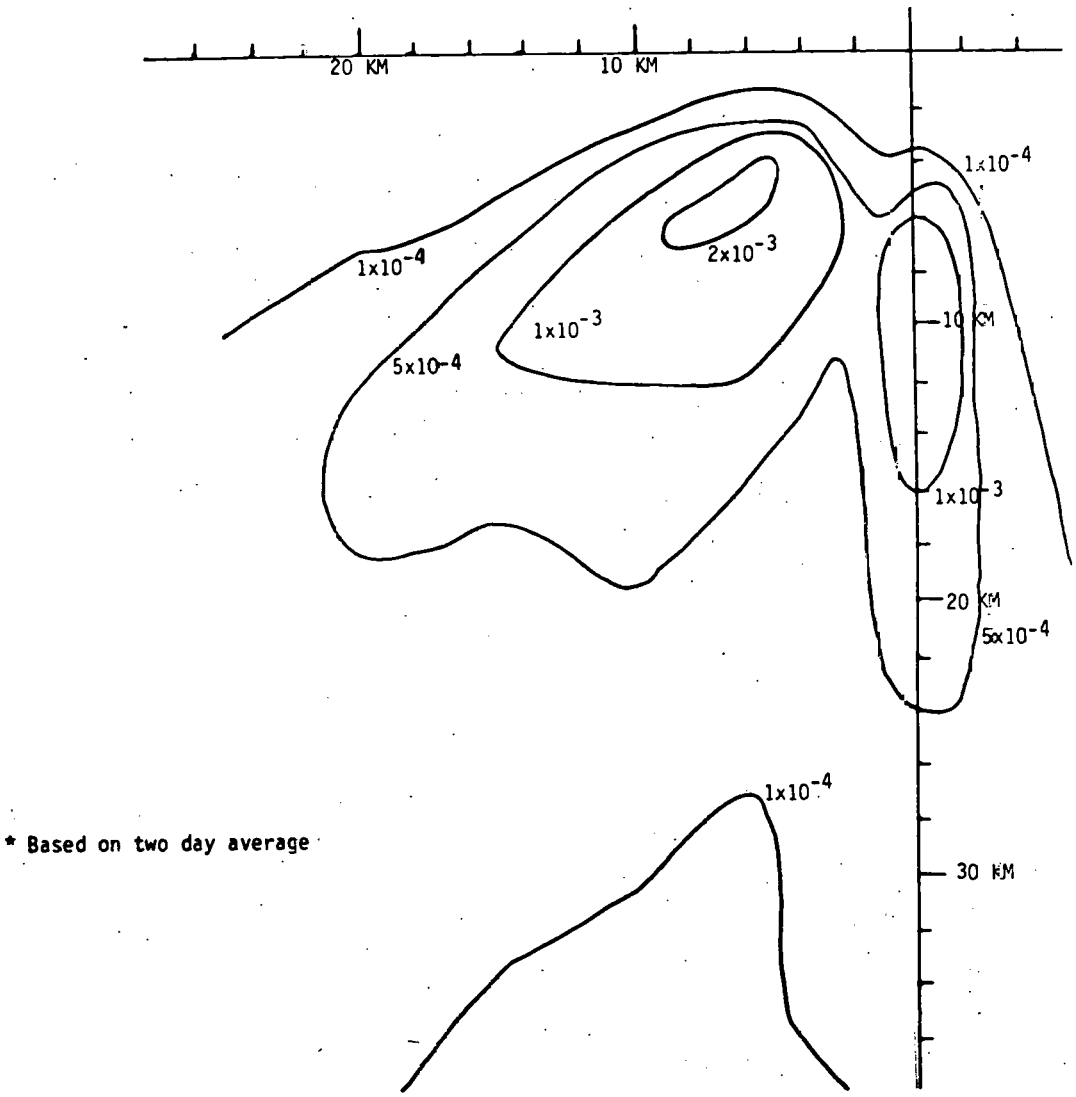
For daytime periods with strong solar radiation and windspeeds averaging 3.6 m/sec (= 8 mph), stability Class B was assumed to have been present, while during night time periods, Class D was assumed to predominate.

The emission rate (Q) can be estimated by dividing the estimated total emission of vanadium (1.3×10^5 g) by the time of release (approximately 5 days).

$$Q = \frac{1.3 \times 10^5 \ \mu g \ V}{5 \text{ days}} = 3.0 \times 10^5 \ \mu g \ V/sec$$

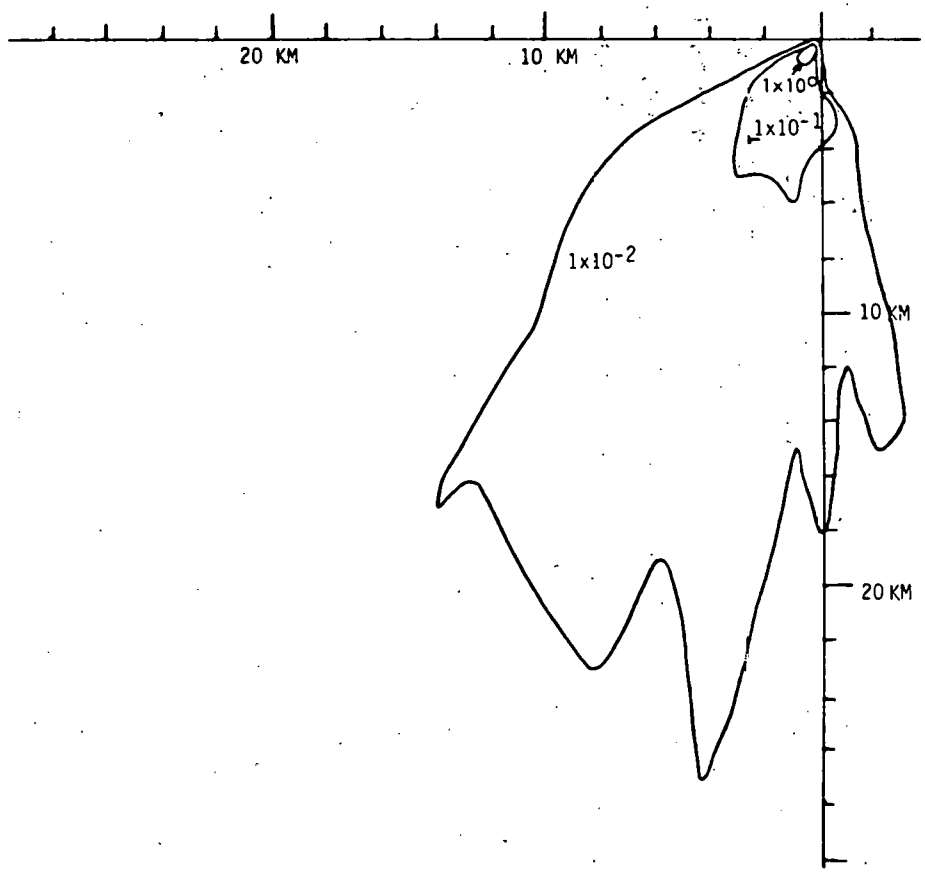
The average ambient concentration of vanadium $\mu g/m^3$ was calculated for distances up to 20 km and isopleth charts constructed showing the extent and intensity of plume-contributed vanadium (Figures C.4-2 and C.2-3). This was done for two release heights (0 m and 1,500 m).

Figure C.4-2 shows the isopleths for a 1500 m release of 3.0×10^5 μg V/sec averaged over two days. The isopleth plot indicated that the point of maximum impact occurred some 8 km away from the fire. The average vanadium concentration in the plume at this point was $2 \times 10^{-3} \frac{\mu g \ V}{m^3}$. To obtain a rough estimate of how much vanadium was deposited on the ground at the point of maximum impact, Stokes' law was employed to determine the settling velocity of water drops 50 μm in size. This settling velocity (V) was used to obtain an approximation of the flux to the surface.



* Based on two day average

FIGURE C.4-1 ISOPLETHS OF AVERAGE MICROGRAMS OF VANADIUM PER CUBIC METER OF AIR FOR A 1500 METER RELEASE



*Based on Hourly Values

FIGURE C.4-2 ISOPLETHS OF AVERAGE MICROGRAMS OF VANADIUM PER CUBIC METER OF AIR FOR A GROUND RELEASE

If all the oil was burned on the ground with little if any plume rise (i.e., ground release), ground-level concentrations would decrease with distance from the fire. For this case, the corresponding isopleths are drawn in Figure C.4-3. An area of concentration exceeding 0.1 μg/m vanadium extends to 3 km from Wellpad 6 and the maximum value is three orders of magnitude larger than in the 1,500 m plume rise case. This is also a maximum estimate since not all of the oil was burned on the ground with no plume use.

A regression of distance with $\frac{\mu g\ V}{g\ leaf}$ showed a relationship of concentration of leaf = a distance^b (Section 8.2.4.3). Thus, the predicted average concentrations in the air can be regressed against distance and the resulting coefficient b_{air} compared with the coefficient b from the foliar regression (b_{foliar} = -1.289). If b_{air} is greater than b_{foliar}, the vanadium concentration decreased faster with increasing distance than the plume model would predict. If b_{air} is less than b_{foliar}, then the plume model is predicting the vanadium concentration to decrease faster (with increasing distance) than the foliage indicates. This assumes foliage contamination is a linear function of air contamination.

Table C.4-2 is a summary of the observed foliar vanadium concentrations along with the predicted average concentrations of vanadium in air. Values of a and b are given at the bottom of Table C.4-2, and the form of the regression equation is:

$$\text{concentration} = a \times \text{distance}^b$$

As can be seen in Table C.4-2, for all release heights 100 m and above, the model predicts a downwind maximum, while the ground release predicts decreasing concentration with distance. The isopleths for the ground release case are shown in more detail in Figure C.4-4,

TABLE C.4-2

COMPARISON OF VANADIUM DEPOSITION CALCULATED FROM PLUME MODEL WITH VANADIUM FOUND ON THE TALLOW LEAVES

Sample Tag No.	Site	X (km)	Y (km)	Distance (km)	Excess ngV/cm^2 on leaf	Plume Model Predictions µg/m^3 For Various Release Heights				
						1500 m	1000 m	500 m	100 m	0 m
224	13	0.114	0.020	0.116	1600	0	0	0	3E-30[a]	4E+0
112	2	0.457	0.267	0.529	60	0	0	6E-19	3E-1	2E+0
108	3	0.610	0.171	0.633	0.1	0	0	1E-14	6E-2	2E-1
17	5	0.572	1.01	1.16	21	1E-30	2E-14	1E-4	2E-1	2E+0
258	4	1.30	0.381	1.35	14	2E-24	5E-12	1E-4	3E-2	4E-2
24	6	0.648	1.52	1.66	21	3E-15	9E-8	3E-3	1E-1	7E-1
107	12	0.057	1.96	1.96	17	5E-11	7E-6	8E-3	1E-1	4E-1
95	8	1.505	2.13	2.611	2	5E-7	3E-4	1E-2	1E-1	3E-1
255	15	2.61	1.37	2.95	1	5E-6	7E-4	1E-2	5E-2	9E-2
90, 93	7	2.13	2.29	3.13	6	2E-5	1E-3	2E-2	8E-2	2E-1
101	10	2.53	2.21	3.36	0.1	6E-5	2E-3	2E-2	6E-2	1E-1
254	14	2.21	3.43	4.08	4	3E-4	1E-2	1E-2	9E-2	2E-1
Vanadium Concentration = a x distance^b										
				a	11	4E-29	8E-14	7E-10	3E-6	0.49
				b	-1.54	+48	+20	+17	+14	-0.93

[a] 3E-30 = 3 x 10^{-30}

along with the locations of the UNO land stations, the predicted vanadium concentration in air, each site's leaf vanadium and the correlation between the two measures of the fire's impact. The correlation between the two is +0.831, $p < 0.01$. Hence, one can conclude that the plume from the fire may have reached 1,500 m, but much of the plume must have rolled across the land as well. Visual observations during the fire verify that the ground level release was responsible for foliage contamination near the fire while the upper level plume contributed to lesser contamination at more remote sites (distances greater than 4 Km).

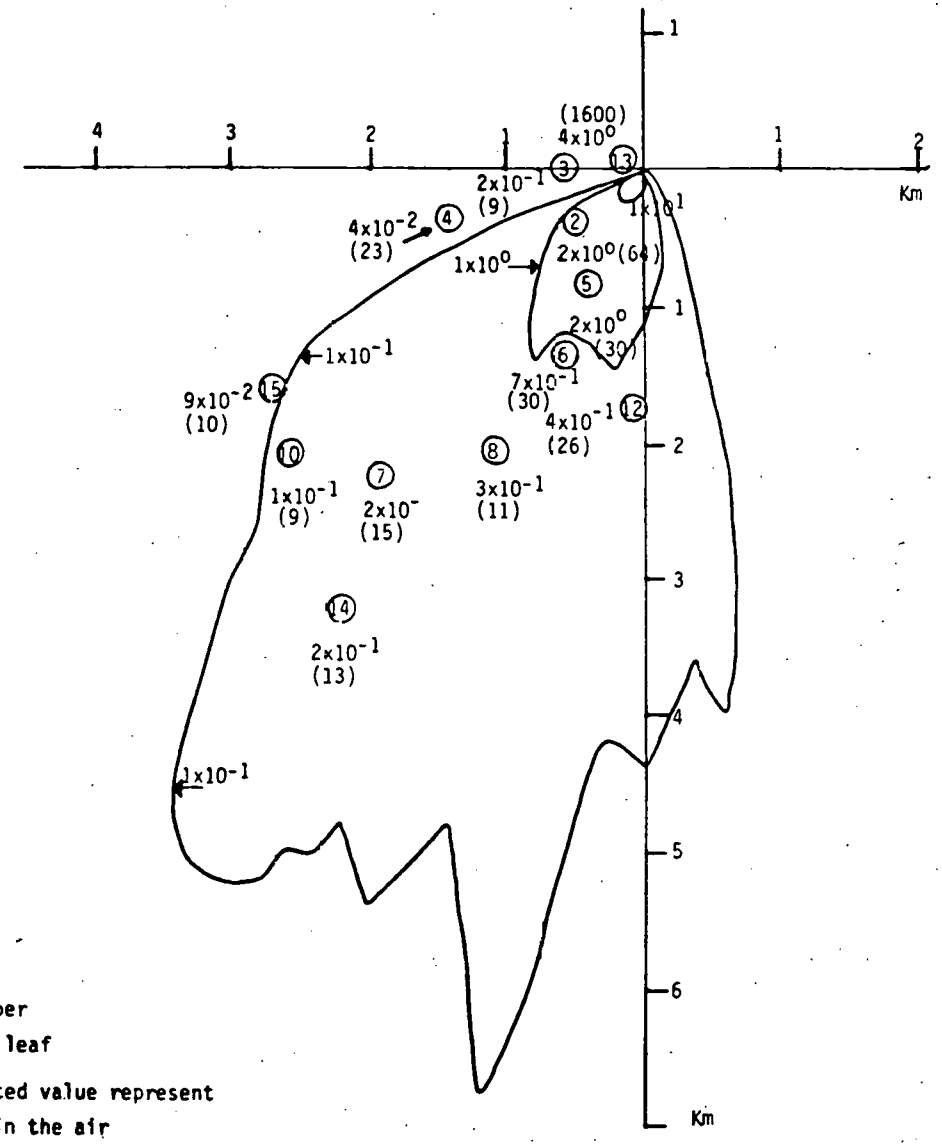


FIGURE C.4-3 COMPARISON OF CALCULATED VANADIUM CONCENTRATION FROM A GROUND RELEASE WITH EXCESS VANADIUM FOUND ON THE VEGETATION

APPENDIX C.5
Trace Metal Data

This appendix contains six tables of results of sample analyses for trace metal concentrations.

TABLE C.5.1

TRACE ELEMENT ANALYSIS - Mean ng of Elements/cm^2 of Tallow Leaf

PHASE I

Site	I	Br	Mg	Na	V	Al	Mn	Cl	Ca
2	<100	<210	16,000	3,400	< 29	1,300	8,500	4,200	46,000
			12,000	550		530	4,100	860	18,000
3	< 48	< 61	6,800	1,600	7.5	250	2,400	730	13,000
			1,300	320	0.4	37	270	130	2,200
4	< 63	120	22,000	1,500	< 15	1,200	3,300	3,400	110,000
		16	3,300	91		130	390	930	2,200
7 NE	< 49	230	13,000	< 450	< 8.1	490	2,200	720	92,000
		220	370			27	220	22	6,000
7 SW	< 63	150	20,000	980	< 16	320	3,300	4,300	52,000
		21	4,500	250		64	880	910	13,000
8	< 28	55	10,000	1,600	11	550	390	2,700	64,000
		19	980	760	6.1	97	56	300	7,000
9	< 24	31	9,500	450	< 4.8	180	340	1,600	31,000
			3,100	180		98	220	1,100	22,000
10	< 20	24	9,800	560	9.4	590	130	1,000	56,000
		7	1,900	300	3.0	130	33	260	15,000
11	< 99	<130	12,000	830	< 14	440	8,400	1,300	52,000
			4,600			230	3,300	780	22,000

TABLE C.5.1 (Cont.)

Site	I	Br	Mg	Na	V	Al	Mn	Cl	Ca
12	< 80	180	16,000	4,800	26	1,800	4,400	6,800	100,000
		58	5,700	6,900	17	1,600	2,100	4,000	52,000
13	180	1,400	26,000	160,000	1,600	3,700	11,000	85,000	82,000
		530	8,000	53,000	950	800	2,500	28,000	20,000
14	< 33	< 55	7,100	650	13	520	750	1,900	32,000
			1,500	330	3.1	71	240	130	3,700
15	< 64	300	14,000	2,700	9.7	400	3,300	6,700	56,000
		180	8,300	300	4.6	260	1,900	4,100	32,000
Average Angiosperm (ppm) (Bowen, 1966)	0.4	15	3,200	1,200	1.6	550	630	2,000	18,000

TABLE C.5.2

TRACE METAL DATA FOR SOIL SAMPLES
(ppm - dry weight)

PHASE II

Site	Mg	Na	V	Al	Mn	Cl	Ca	V/Al Ratio ($\times 10^{-3}$)
14	4,620	2,540	31.2	21,700	227.0	86.0	2,150	1.44
	2,380	273	1.27	599	3.1	--	341	
12	4,110	3,580	25.1	19,600	186.0	70.9	1,494	1.28
	1,130	552	2.7	2,760	26.7	35.9	106	
11	4,574	3,380	46.7	28,400	276.0	--	1,924	1.65
	417	199	3.4	1,750	29.0		406	
10	4,430	2,730	29.3	21,400	79.3	107.0	6,980	1.37
	2,320	63	1.64	657	5.8	14.5	691	
9	3,614	1,882	33.1	21,800	106.7	78.4	13,800	1.52
	1,126	98	1.3	1,245	4.2	20.3	1,043	
8	5,290	3,730	41.6	30,400	141.0	--	5,430	1.37
	1,430	590	7.0	3,030	13.3		267	
7 NE	4,371	2,670	31.3	22,700	300.0	96.1	30,500	1.38
	175	333	3.36	2,030	28.9	22.0	2,670	
7 SW	5,110	2,130	30.1	21,100	289.0	51.5	5,670	1.43
	--	32	0.15	304	9.0	5.31	353	

TABLE C.5.2 (Cont.)

Site	Mg	Na	V	Al	Mn	Cl	Ca	V/Al Ratio ($\times 10^{-3}$)
6	3,600 281	2,426 143	34.2 1.32	21,300 1,360	640.0 43.0	136.0 35.8	2,080 636	1.60
5	5,000 1,960	2,300 477	34.6 4.3	23,000 4,700	537.0 117.0	81.9 25.5	37,970 7,060	1.50
4	4,500 377	1,884 112	35.4 4.2	23,270 2,130	153.0 16.0	--	3,600 650	1.52
3	5,210 881	2,300 17.8	40.8 3.3	25,080 1,800	628.0 40.9	--	1,220 266	1.63
2	3,920 --	1,585 205	32.9 3.1	17,900 1,870	606.0 60.0	87.8 --	657 70.7	1.84
1	4,640 1,732		43.4 4.06	24,200 2,300	513.0 58.6	67.0 35.0	1,800 34.9	1.79

TABLE C.5.3

TRACE METAL DATA FOR SEDIMENT SAMPLES
(ppm - dry weight)

PHASE II

Site	Mg	Na	V	Al	Mn	Cl	Ca	V/Al Ratio ($\times 10^{-3}$)
Gill Net	2,610	4,480	19.7	16,200	190.0	1,120	2,130	1.22
	55.6	324	.14	1,150	10.8	108	205	
Back of Gill Net	3,565	4,905	17.8	17,400	175.0	1,480	1,960	1.02
	281	239	.33	251	0.16	75.7	290	
30-18-C	13,000	25,200	55.1	35,200	239.0	33,500	8,310	1.57
	2,680	151	1.2	255	8.4	1,190	925	
1-3-C 1 cm	2,840	4,024	25.3	18,400	187.0	2,380	914	1.38
	1,100	213	2.4	1,262	14.4	149	109	
1-3-C 2 cm	5,240	4,050	24.9	18,200	99.7	2,410	1,100	1.37
	968	118	1.9	1,120	6.7	107	241	
1-2-C	4,060	5,470	31.3	23,800	158.0	3,300	1,850	1.32
	402	258	2.08	630	7.5	142	147	
30-16-C	13,500	12,800	73.7	50,700	485.0	10,400	7,610	1.45
	1,840	530	6.1	3,140	23.0	588	600	
30-4-C	6,540	7,970	30.3	31,100	238.0	2,052	4,450	0.973
	1,210	320	2.56	1,400	5.7	74	647	

TABLE C.5.3 (Cont.)

Site	Mg	Na	V	Al	Mn	Cl	Ca	V/Al Ratio ($\times 10^{-3}$)
30-13-C	4,920	6,130	23.7	21,690	420.0	2,410	2,370	1.09
Top 2.5 cm	1,250	183	1.2	243	5.5	67.1	248	
2-C	7,050	7,590	45.3	32,800	120.0	2,930	1,640	1.38
	1,150	235	2.1	926	6.2	64	302	
30-19-C	7,360	8,150	44.0	34,600	89.3	2,620	2,360	1.27
	804	196	1.0	868	2.3	161	90	
30-13-C	12,200	19,600	52.8	32,000	212.0	23,500	8,020	1.65
2.5-4 cm	2,250	1,660	7.6	2,760	18.6	1,930	754	
30-15-C	7,903	7,300	34.9	30,100	104.0	2,350	2,520	1.17
	3,500	877	4.4	3,780	10.3	232	520	
30-3-C	12,900	12,500	63.5	47,600	191.0	10,000	3,770	1.33
	1,990	1,050	5.2	3,790	15.0	710	340	

TABLE C.5.4

TRACE METAL DATA FOR SOIL SAMPLES

PHASE III

Tag #	Site #	Soil Depth (cm)	a) Micrograms Element Per Gram Dry Soil							b) Weight Ratio to Aluminum ($\times 10^{-3}$)
			Al	Mg	Na	V	Mn	Cl	Ca	V/Al
1427	URI-19	0 - 1	38,000	7,590	3,830	43.8	229	112	5,920	1.15
1428	URI-19	1 - 2	37,500	6,990	3,100	48.8	162	80	17,000	1.3
1424	URI-18	0 - 1	23,100	3,810	1,720	37.2	113	158	4,080	1.61
1425	URI-18	1 - 2	23,500	4,110	1,620	36.4	88	78	2,770	1.54
1409	UNO-7	0 - 1	17,300	3,240	1,430	23.6	225	90	5,400	1.36
1410	UNO-7	1 - 2	17,900	2,580	1,350	26.3	149	66	2,700	1.5
1044	SNR-6	0 - 1	39,600	6,480	4,180	56.8	145	443	2,930	1.4
1065	RC-104	0 - 1	26,800	5,140	4,190	27.9	149	649	2,000	1.0
1066	RC-104	1 - 2	28,800	5,090	4,050	32.0	166	261	2,190	1.1
1096	RC-107	0 - 1	40,100	9,850	6,360	53.5	268	2,980	4,680	1.3
1095	RC-107	1 - 2	49,200	8,700	5,480	69.6	268	974	4,120	1.4
1092	RC-109	0 - 1	22,000	4,000	4,900	16.0	454	679	32,500	0.73
1091	RC-109	1 - 2	22,800	4,140	4,900	14.4	315	217	28,200	0.63
1079	RS-111	0 - 1	53,100	11,300	5,850	74.5	603	290	5,420	1.4
1080	RS-111	1 - 2	54,000	11,700	5,390	80.0	526	142	4,560	1.5
1464	POST 234-W	0 - 1	36,100	11,800	7,710	54.6	238	8,470	8,600	1.5
1467	POST 234-E	0 - 1	21,800	4,890	4,150	27.4	79	1,314	3,220	1.3
1468	POST 234-E	1 - 2	35,200	9,180	4,310	55.7	95	2,850	3,790	1.6

TABLE C.5.5

DATA FOR VEGETATIONAL TRACE METAL SAMPLES
(ppm - dry weight)

PHASE IV

Site	Mg	Na	V	Al	Mn	Cl	Ca	V/Al Ratio ($\times 10^{-3}$)
UNO 1	2,394	97	.555	295	326	1,831	17,600	1.88
UNO 3	2,110	185	.39	186	1,180	2,140	9,060	2.10
UNO 4	2,150	134	.87	458	101	1,660	20,900	1.90
UNO 5	2,450	159	.67	388	161	2,360	20,400	1.73
UNO 6	2,600	246	--	217	2,160	2,370	17,300	--
UNO 7	2,800	126	.28	129	373	602	16,300	2.17
UNO 8	2,670	271	.35	139	457	1,440	16,700	2.52
UNO 9	4,130	696	.24	118	185	7,930	19,800	2.03
UNO 10	4,130	92	.35	192	254	1,820	22,500	1.82
UNO 12	3,400	194	.20	113	127	1,750	16,100	1.77
UNO 14	3,080	138	--	100	1,030	4,020	17,400	--
UNO 15	1,970	195	.32	115	612	934	16,800	2.78
UNO 18	2,580	76	.47	232	167	1,380	15,000	2.03
UNO 19	3,040	89	.48	303	104	1,310	12,200	1.58
RN101	4,280	704	--	165	714	2,840	11,100	--
RC106	1,750	136	.15	102	983	2,190	7,720	1.47
Clubhouse	3,060	1,150	.22	103	347	4,650	10,600	2.14
T-camp	1,790	82	--	66	222	1,910	11,400	--

TABLE C.5.6

DATA FOR SOIL TRACE METAL SAMPLES
(ppm - dry weight)

PHASE IV

Site	Sample Size	Mg	Na	V	Al	Mn	Cl	Ca	V/Al Ratio ($\times 10^{-3}$)
3	2	4,300	1,930	37	20,300	440	64	1,100	1.82
4	2	4,620	1,930	39	26,900	130	67	3,620	1.47
5	3	4,440	1,800	30	20,300	570	365	11,000	1.48
6	3	6,680	2,390	31	21,400	512	126	6,790	1.45
7	3	6,380	2,500	44	30,600	221	61	63,300	1.44
8	3	5,470	2,470	47	29,700	97	213	1,820	1.58
10	3	4,760	4,990	35	22,600	89	4,700	2,770	1.55
11	3	3,540	2,110	36	19,300	183	62	928	1.87
12	2	3,730	3,070	35	25,600	286	120	18,900	1.37
14	1	6,800	4,500	31	20,300	949	3,415	2,680	1.53
15	2	3,440	2,560	15	9,920	522	--	226,000	1.51
16	1	19,100	7,620	137	71,200	200	3,500	3,930	1.92
18	2	3,272	2,270	44	20,200	124	146	8,140	2.18
19	2	5,860	4,550	41	30,500	63	--	4,260	1.34
RC102	3	4,950	6,450	28	24,700	116	592	2,630	1.13
	Average RSD (%)	15	15	15	10	15	20	15	

TABLE C.5.7

(a) WEATHER DATA FOR SEPTEMBER 25, 1978*

Hourly Record Wind:	Direction (degrees)	Velocity (mph)	Temperature (degrees F.)	Relative Humidity (%)	Rain Total (Inch)
0000					
0100	350	9	67	78	0.00
0200	10	7	66	78	0.00
0300	10	9	66	78	0.00
0400	60	9	65	78	0.00
0500	30	9	64	78	0.00
0600	10	8	63	78	0.00
0700	30	9	64	75	0.00
0800	20	10	67	68	0.00
0900	50	8	68	68	0.00
1000	60	12	74	62	0.00
1100	60	9	78	60	0.00
1200	50	8	82	57	0.00
1300	60	10	82	55	0.00
1400	50	9	82	55	0.00
1500	20	9	83	53	0.00
1600	40	8	84	48	0.00
1700	50	8	82	53	0.00
1800	50	8	78	62	0.00
1900	360	7	73	76	0.00
2000	350	7	71	81	0.00
2100	360	9	72	79	0.00
2200	30	8	74	74	0.00
2300	40	7	73	76	0.00
2400	10	9	73	76	0.00

*Data from National Weather Service, Lake Charles, Louisiana (Henry, 1978)

TABLE C.5.7 (Cont.)

(b) WEATHER DATA FOR SEPTEMBER 26, 1978*

Hourly Record Wind:	Direction (degrees)	Velocity (mph)	Temperature (degrees F.)	Relative Humidity (%)	Rain Total (Inch)
0000					
0100	20	8	71	72	0.00
0200	30	8	71	72	0.00
0300	30	9	68	76	0.00
0400	40	8	67	78	0.00
0500	20	8	67	78	0.00
0600	360	8	67	78	0.00
0700	40	9	67	78	0.00
0800	30	10	69	76	0.00
0900	30	8	74	69	0.00
1000	40	8	78	69	0.00
1100	60	10	81	65	0.00
1200	50	9	83	63	0.00
1300	60	8	84	61	0.00
1400	360	8	85	57	0.00
1500	360	7	85	55	0.00
1600	360	7	85	57	0.00
1700	350	6	83	63	0.00
1800	350	6	79	72	0.00
1900	30	6	77	76	0.00
2000	20	5	76	79	0.00
2100	30	9	77	76	0.00
2200	50	9	76	79	0.00
2300	40	9	75	79	0.00
2400	10	8	74	74	0.00

*Data from National Weather Service, Lake Charles, Louisiana (Henry, 1978)

APPENDIX C.6
Quantification of Oil Results

This appendix contains nine tables of results for the quantification of oil contamination and pyrogenic products.

TABLE C.6-1

MULTIPARAMETER QUANTIFICATION OF CAVERN 6 CRUDE OIL*
DOE HACKBERRY SEDIMENT SAMPLES ANALYZED BY UNO

		CORRECTED			
TAG NO.	T.R.	C_{18}-C_{23}	Pr	Ph	F2
PHASE I					
13	31	22	24	17	37
15	24	21	41	14	30
16	69	21	53	32	49
18	6	4	0	0	4
19	19	9	21	12	8
20	22	8	8	0	12
21	21	10	21	14	13
54	68	20	+	5	39
61	37	13	11	3	30
65	>100	8	+	0	21
85	52	27	17	11	29
122	>100	>100	>100	>100	72
128	70	67	63	60	48
153	78	25	42	26	>100
154	36	7	+	0	17
193	27	7	9	5	13
197	21	7	16	6	15
226	49	5	13	7	64
229	47	7	18	14	27
234	30	8	3	0	18
PHASE II					
586	28	5	50	2	15
594	29	4	80	4	29
597	25	4	61	5	26
599	52	7	89	5	43
601	31	3	30	3	11
604	34	5	76	4	44
609	18	7	11	7	15
623	16	3	9	4	21
627	17	4	5	3	4
631	7	1	2	0	11
929	41	10	13	9	27

TABLE C.6-1 (Cont.)

TAG NO.	CORRECTED T.R.	C_{18}-C_{23}	Pr	Ph	F2
938	>100	>100	>100	>100	>100
940	51	11	38	17	22
942	15	10	39	20	24
945	>100	>100	>100	>100	>100
946	>100	56	>100	>100	>100
948	20	4	6	1	18
949	15	3	4	0	14
954	>100	>100	>100	>100	60
957	34	8	+	1	40
963	>100	>100	>100	>100	>100
964	>100	28	36	35	80
990	22	5	8	2	16
1498	8	1	2	0	5
1499	24	9	5	1	14
1500	37	5	11	4	25
PHASE III					
1040	7	0	0	0	4
1083	13	3	6	1	12
1084	9	2	4	0	9
1098	45	9	23	15	30
1116	>100	15	>100	75	>100
1118	41	11	25	14	25
1177	24	5	14	0	14
1181	>100	>100	>100	>100	>100
1182	>100	>100	>100	>100	>100
1187	85	5	24	2	45
1188	71	5	15	0	33
1193	11	2	7	0	6
1194	13	2	10	0	8
1247	>100	36	>100	>100	>100
1251	>100	24	>100	71	77
1253	45	8	36	12	31
1254	77	7	>100	33	47
1282	6	0	0	0	0
1290	15	2	3	0	11
1292	20	3	12	4	20
1296	16	2	1	0	11

TABLE C.6-1 (Cont.)

TAG NO.	CORRECTED T.R.	C_{18}-C_{23}	Pr	Ph	F2
1297	12	2	1	0	6
1465	32	7	3	1	21
1466	38	10	14	3	29
PHASE IV					
1533	25	4	7	3	12
1545	90	50	>100	>100	89
1551	>100	42	>100	>100	>100
1555	28	5	39	10	22
1563	>100	>100	>100	>100	>100
1567	65	41	>100	>100	66
1568	29	6	22	2	21
1573	49	24	>100	95	30
1657	43	7	61	17	75
1665	34	8	18	4	21
1679	28	7	19	5	38
1683	36	8	23	7	32
1735	34	8	11	3	23

T.R. - Total Resolvable Saturate Hydrocarbons

C_{18}-C_{23} - Quantity of C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}

Pr - Pristane Concentration

Ph - Phytane Concentration

F2 - Total Resolvable Aromatic Hydrocarbons

*Values expressed in ppm (µg/g wet weight)

+Peak interference with pristane

>100 indicates these values were beyond the range of the spiked sediment experiments

TABLE C.6-2

MULTIPARAMETER QUANTIFICATION OF CAVERN 6 CRUDE OIL*
DOE HACKBERRY SOIL SAMPLES ANALYZED BY UNO

TAG NO.	CORRECTED T.R.	C_{18}-C_{23}	Pr	Ph	F2
PHASE II					
640	14	2	0	0	10
641	9	4	3	0	8
642	13	3	0	0	6
654	34	9	22	9	12
690	9	2	0	0	9
702	19	4	0	6	0
703	0	2	0	0	10
934	14	4	0	0	12
PHASE III					
1238	26	4	0	0	22
1239	26	6	5	2	25
1240	21	4	2	0	21
1424	17	3	2	0	6
1425	8	1	0	0	5
1427	15	2	1	0	10
1428	8	1	0	0	5
PHASE IV					
1502	10	4	3	0	0
1503	0	1	1	0	3
1505	25	5	1	1	19
1507	11	3	0	0	6
1509	12	4	0	0	11
1511	9	1	0	0	0
1516	25	7	1	0	0
1519	63	21	18	42	78
1527	16	4	3	0	6
1529	19	4	1	0	0

*Values expressed in ppm (µg/g wet weight)
T.R. - Total Resolvable Saturate Hydrocarbons
C_{18}-C_{23} - Quantity of C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}
Pr - Pristane Concentration
Ph - Phytane Concentration
F2 - Total Resolvable Aromatic Hydrocarbons

TABLE C.6-3

MULTIPARAMETER QUANTIFICATION OF CAVERN 6 CRUDE OIL*
DOE HACKBERRY FOLIAGE SAMPLES ANALYZED BY UNO

TAG NO.	CORRECTED C_{18}-C_{23}	CORRECTED Pr	CORRECTED Ph
PHASE I			
3	>100	>100	>100
41	>100	0	0
43	57	0	0
47	0	0	0
48	>100	>100	0
53	0	0	0
57	31	24	0
60	38	82	0
63	33	39	0
67	33	67	46
69	16	0	0
87	>100	63	77
88	66	>100	>100
PHASE II			
644	0	0	0
645	>100	93	25
650	89	77	44
653	>100	>100	77
691	44	46	23
700	>100	>100	75
701	87	>100	46
704	16	0	0
PHASE III			
1067	19	0	0
1365	4	0	65
1366	31	35	35
1367	22	84	46
1426	27	49	36
1429	24	0	0

C_{18}-C_{23} - Quantity of C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}
Pr - Pristane Concentration
Ph - Phytane Concentration
*Values expressed in ppm (µg/g wet weight)
>100 indicates these values were beyond the range of spiked sediment experiments

TABLE C.6-4

MULTIPARAMETER QUANTIFICATION OF CAVERN 6 CRUDE OIL*
DOE HACKBERRY TISSUE SAMPLES ANALYZED BY UNO

TAG NO.	T.R.	CORRECTED C_{18}-C_{23}	Pr	Ph	F2
PHASE II					
846	>100	>100	>100	>100	>100
PHASE III					
1430	85	0	>100	44	>100

*Values expressed in ppm (µg/g wet weight)

T.R. - Total Resolvable Saturate Hydrocarbons

C_{18}-C_{23} - Quantity of C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}

Pr - Pristane Concentration

Ph - Phytane Concentration

F2 - Total Resolvable Aromatic Hydrocarbons

>100 indicates these values were beyond the range of spiked sediment experiments

TABLE C.6-5

QUANTITATION OF PYROGENIC PRODUCTS*
DOE HACKBERRY SAMPLES ANALYZED BY UNO

PHASE I

TAG #[&]	SITE #	DBT[+]	PHENANTHRENE	FLUORANTHENE	PYRENE	CHRYSENE**	BENZOPYRENE**
3	A2	31000	180000	240000	230000	19000	4300
13	9-7-C	380	350	420	460	310	350
15	9-4-C	120	550	580	730	320	340
16	9-3-C	130	290	1200	1200	810	800
18	9-11-C	11	180	570	560	180	330
19	9-13-C	22	77	120	170	52	100
20	9-12-C	17	150	230	130	79	150
21	9-14-C	22	77	140	220	57	370
41	UNO #2	990	7600	19000	18000	1800	0
43	UNO #3	4.8	510	840	660	93	0
47	UNO #4	0	90	0	0	0	0
48	UNO #5	4.6	1800	3100	2400	430	100
53	SNR-1	0	770	1300	890	200	85
54	SNR-2	36	270	770	520	290	330
57	SNR-2	0	2100	6300	4600	1000	340
60	SNR-3	37	1700	0	0	730	340
61	SNR-4	0	160	410	360	320	490
63	SNR-4	0	1500	4100	3200	410	0
65	SNR-5	6.1	150	540	410	290	360
67	SNR-5	0	1100	3500	2800	990	530
69	SNR-6	0	890	2200	1900	250	0
85	9-2-C	140	790	3700	4500	1100	740
87	UNO #7	83	4600	7200	9200	2400	370
88	UNO #7	0	6600	12000	8600	1700	640
122	9-5-C	1500	1200	1200	1700	700	1000
128	9-9-C	410	270	710	790	570	650
153	30-16-C	9300	81000	500000	470000	500000	470000

TABLE C.6-5 (Cont.)

TAG #[&]	SITE #	DBT[+]	PHENANTHRENE	FLUORANTHENE	PYRENE	CHRYSENE**	BENZOPYRENE**
154	30-17-C	0	0	0	0	0	0
193	30-3-C	11	45	550	880	320	490
197	30-6-C	7.8	210	200	140	49	74
226	30-17-C	0	100	620	900	590	690
229	30-7-C	0	0	810	980	540	770
234	30-12-C	15	64	520	270	100	130

*Values expressed as ng present in one gram of sample and determined by gas chromatography/mass spectrometry

**Includes all possible isomers of these compounds

[+]Dibenzothiophene

[&]Tag #s 3, 41, 43, 47, 48, 53, 57, 60, 63, 65, 67, 69, 87, and 88 are foliage samples, all other samples are sediments.

TABLE C.6-6

QUANTITATION OF PYROGENIC PRODUCTS*
DOE HACKBERRY SAMPLES ANALYZED BY UNO

PHASE II

TAG #[&]	SITE #	DBT[+]	PHENANTHRENE	FLUORANTHENE	PYRENE	CHRYSENE**	BENZOPYRENE**
586	15-3-B	0	94	610	750	340	470
594	E6-2-B	0	77	500	630	300	430
597	8-2-B	0	89	570	830	280	310
599	9-2-B	9.5	110	530	750	340	480
601	16-3-B	11	110	250	360	140	270
604	17-3-B	18	92	480	580	220	300
609	7-9-B	0	0	220	410	180	190
623	30-12-C	41	480	1600	1200	460	590
627	2-C	100	110	270	310	210	250
631	WC Gill Net	5.7	60	190	260	82	110
640	UNO #1	20	90	150	140	85	120
641	UNO #1	0	37	210	210	76	87
642	UNO #1	0	56	370	310	220	540
644	UNO #1	31	1500	3100	2100	330	130
645	UNO #1	54	4800	13000	8800	1900	560
650	UNO #1	0	1900	14000	11000	2300	1400
653	UNO #4	46	8700	26000	15000	2300	370
654	UNO #4	7.1	190	800	800	570	1000
690	UNO #6	0	31	120	130	120	160
691	UNO #6	0	0	0	0	0	0
700	UNO #7	0	2700	6200	4500	530	0
701	UNO #7	960	9600	13000	7800	730	0
702	UNO #7	1.1	96	270	230	190	380
703	UNO #7	0	63	160	130	120	160
704	UNO #7	0	2700	5200	4500	0	0
846	9-10-B	11	1300	1200	1600	130	0
929	30-3-C	0	79	800	1200	440	600

TABLE C.6-6 (Cont.)

TAG #[&]	SITE #	DBT[+]	PHENANTHRENE	FLUORANTHENE	PYRENE	CHRYSENE**	BENZOPYRENE**
934	UNO #2	0	17	83	73	18	13
938	245-1-C	0	0	0	0	68000	75000
940	9-3-C	31	56	610	730	750	770
942	201/202-30-C	54	960	5200	4200	2300	3600
945	7-C	8900	5200	4700	7200	4700	2200
946	5-C	0	95	2300	3700	8900	9600
948	2-C	14	77	270	230	87	160
949	2-C	0	64	240	250	79	95
954	6-C	150	340	1700	2300	1800	2300
957	16-1-B	5.7	49	210	180	160	330
963	NC 41	0	0	540	1500	3800	1300
964	NC 42	11	100	490	950	1200	870
990	30-13-C	0	0	230	260	210	420
1498	SNR 1	4.7	63	130	140	25	54
1499	SNR 2	14	210	520	330	110	190
1500	30-5-C	7.3	80	410	850	210	340

*Values expressed as ng present in one gram of sample and determined by gas chromatography/mass spectrometry

**Includes all possible isomers of these compounds

[+]Dibenzothiophene

[&]Tag # 846 is a mussel; 640, 641, 642, 654, 690, 702, 703, and 934 are soil samples; 644, 645, 650, 653, 691, 700, 701, and 704 are foliage samples; all other samples are sediments.

TABLE C.6-7

QUANTITATION OF PYROGENIC PRODUCTS*
DOE HACKBERRY SAMPLES ANALYZED BY UNO

PHASE III

TAG #[&]	SITE #	DBT[+]	PHENANTHRENE	FLUORANTHENE	PYRENE	CHRYSENE**	BENZOPYRENE**
1040	SNR-6	23	57	67	210	11	23
1067	RS 111	0	0	0	0	0	0
1083	RC 107	10	47	85	110	31	83
1084	RC 107	1.4	34	120	84	75	150
1098	30-4-C	0	150	1300	1800	790	1200
1116	30-3-C	50	210	2800	3800	3600	3500
1118	30-7-C	13	150	1300	1700	700	480
1177	9-11-C	3.0	95	280	230	37	41
1181	203-30-C	35000	11000	60000	50000	62000	140000
1182	203-30-C	410	1700	17000	61000	26000	7300
1187	S of 30-19-C	0	90	390	400	160	130
1188	S of 30-19-C	6.7	100	390	370	250	440
1193	9-2-B	0	14	30	41	20	0
1194	8-2-B	3.5	15	70	88	41	75
1238	UNO #7	8.0	310	1700	1400	970	1600
1239	UNO #7	2.0	170	810	720	200	170
1240	UNO #7	0	95	260	240	53	64
1247	9-7-C	60	460	6400	5600	890	480
1251	9-2-C	6.8	18	290	390	91	93
1253	9-3-C	17	74	350	500	140	310
1254	9-3-C	7.1	35	360	530	130	74
1282	2-C	0	0	0	0	0	0
1290	RS 109	0	31	50	68	10	140
1292	RS 109	0	0	0	0	0	0
1296	RS 111	0	20	24	20	14	0
1297	RS 111	0	11	15	43	0	0
1365	UNO #7	0	750	0	0	0	0

TABLE C.6-7 (Cont.)

TAG #[&]	SITE #	DBT[+]	PHENANTHRENE	FLUORANTHENE	PYRENE	CHRYSENE**	BENZOPYRENE**
1366	UNO #7	0	0	0	0	0	0
1367	UNO #7	0	0	0	0	0	0
1424	URI #18	0	0	0	0	0	0
1425	URI #18	0	0	0	0	0	0
1426	URI #18	0	0	0	0	0	0
1427	URI #19	0	0	0	0	0	0
1428	URI #19	0	12	57	52	19	14
1429	URI #19	0	0	0	0	0	0
1430	West Control	0	570	400	470	66	0
1465	North site/ west of dike	25	300	830	600	180	250
1466	Post 234	29	280	860	740	180	210

*Values expressed as ng present in one gram of sample and determined by gas chromatography/mass spectrometry

**Includes all possible isomers of these compounds

[+]Dibenzothiophene

[&]Tag # 1430 is a mussel; 1238, 1239, 1240, 1424, 1425, 1427, and 1428 are soil samples; 1067, 1365, 1366, 1367, 1426, and 1429 are foliage samples; all other samples are sediments.

TABLE C.6-8

QUANTITATION OF PYROGENIC PRODUCTS*
DOE HACKBERRY SAMPLES ANALYZED BY UNO

PHASE IV

TAG #[&]	SITE #	DBT[+]	PHENANTHRENE	FLUORANTHENE	PYRENE	CHRYSENE**	BENZOPYRENE**
1502	UNO #3	2.4	22	63	110	16	5.5
1503	UNO #4	0	3.0	12	13	0.2	0
1505	UNO #5	0	15	150	160	73	41
1507	UNO #6	0	19	35	35	7.6	1.3
1509	UNO #12	0	39	260	260	50	13
1511	UNO #11	0	15	21	25	0	0
1516	UNO #14	0.4	18	83	84	16	6.9
1519	UNO #7	0	260	1400	1100	230	67
1527	URI #18	1.3	22	75	110	10	1.2
1529	URI #19	0	8.3	35	46	8.3	4.0
1533	30-3-C	0.6	9.2	65	120	12	4.6
1545	203-30-C	0	340	1800	1700	140	19
1551	9-3-C	380	790	2200	3000	650	360
1555	2-C	0	80	450	450	110	29
1563	9-7-C	800	2700	1900	2700	860	0
1567	201/202-30-C	28	970	1900	1800	260	20
1568	9-1-C	0	36	290	370	150	28
1573	9-2-C	2.2	45	350	520	100	28
1657	8-2-B	8.1	320	4100	3800	710	97
1665	30-7-C	0.4	34	460	560	53	14
1679	30-12-C	12	290	1200	940	200	82
1683	30-4-C	5.5	190	2500	2000	310	91
1735	30-5-C	0	35	360	520	60	7.9

*Values expressed as ng present in one gram of sample and determined by gas chromatography/mass spectrometry

**Includes all possible isomers of these compounds

[+]Dibenzothiophene

[&]Tag Nos. 1502, 1503, 1505, 1509, 1511, 1516, 1519, 1527 and 1529 are soil samples, all others are sediments.

TABLE C.6-9

QUANTITATION OF PYROGENIC PRODUCTS BY AREA*

	DBT+	PHENANTHRENE	FLUORANTHENE	PYRENE	CHRYSENE**	BENZOPYRENE**
Impact Area (Lake)	150	350	810	970	360	350
Nonimpacted Area (Lake)	9	120	780	900	500	450
Land Soil and Canal Sediments	3	74	280	240	120	180
Foliage	8	950	1200	1500	260	80

*Values expressed in PPB and determined by gas chromatography/mass spectrometry. Values which were obviously greatly elevated were not included in average.

**Includes all possible isomers of these compounds.

+Dibenzothiophene

APPENDIX D

Wind Frequency Distributions
Onsite Meteorological Measurements
West Hackberry, Louisiana
September 29, 1978 - December 27, 1978

TABLE D.1-1
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 1
SEPTEMBER 29, 1978 - SEPTEMBER 30, 1978

	Speed (kts)							
Direction	1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	4	9					13	4.1
NNE		6					6	5.0
NE		6	2				8	5.9
ENE		4	1				5	5.7
E								
ESE								
SE								
SSE								
S								
SSW								
SW								
WSW								
W								
WNW								
NW								
NNW								
Total	4	25	3				32	

Number of Hourly Observations of Calm 0

Total Number of Hourly Observations 32

TABLE D.1-2
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 1
SEPTEMBER 29, 1978 - SEPTEMBER 30, 1978

	Speed (kts)						
Direction	0-3	4-6	7-10	11-16	17-21	>21	Total
N	.125000	.281250					.406250
NNE		.187500					.187500
NE		.187500	.062500				.250000
ENE		.125000	.031250				.156250
E							
ESE							
SE							
SSE							
S							
SSW							
SW							
WSW							
W							
WNW							
NW							
NNW							
Total	.125000	.781250	.093750				1.00000
			Relative Frequency of Calms Distributed Above				.000000

TABLE D.1-3
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 1
OCTOBER 1978

Direction	Speed (kts) 1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	35	39	25	6	1		106	5.4
NNE	17	46	31	20	2		116	7.2
NE	15	24	23	5			67	6.2
ENE	18	35	7	4			64	5.1
E	12	15					27	3.7
ESE	16	15	5				36	4.2
SE	16	4	3				23	3.4
SSE	28	21	6				55	3.9
S	30	26	9				65	4.1
SSW	26	12					38	2.9
SW	11	1					12	2.3
WSW	6	2					8	2.8
W	7	4					11	2.9
WNW	1	7	1				9	5.1
NW	3	1	2				6	4.7
NNW	5	7	8	1	1		22	6.6
Total	246	259	120	36	4		665	5.1

Number of Hourly Observations of Calm 14

Total Number of Hourly Observations 679

TABLE D.1-4
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRRY SITE, STATION 1
OCTOBER 1978

Direction	Speed (kts) 0-3	4-6	7-10	11-16	17-21	>21	Total
N	.058910	.057437	.036819	.008837	.001472		.163476
NNE	.025037	.067747	.045655	.029455	.002946		.170839
NE	.023564	.035346	.033873	.007364			.100147
ENE	.026510	.051546	.010310	.005891			.094256
E	.017673	.022091					.039764
ESE	.025037	.022091	.007364				.054492
SE	.025037	.005891	.004418				.035346
SSE	.041237	.030928	.008837				.081001
S	.045655	.038292	.013255				.097202
SSW	.038292	.017673					.055965
SW	.016200	.001472					.017673
WSW	.008837	.002946					.011782
W	.011782	.005891					.017673
WNW	.005891	.010310	.001472				.017673
NW	.005891	.001472	.002946				.010310
NNW	.007364	.010310	.011782	.001472	.001472		.032401
Total	.368189	.381443	.176730	.053019	.005891		1.00000
			Relative Frequency of Calms Distributed Above				.020619

TABLE D.1-5
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 1
NOVEMBER 1978

Direction	Speed (kts) 1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	15	14	28	5			62	6.5
NNE	9	20	25	6	1		61	7.1
NE	10	17	35	4	1		67	7.1
ENE	13	19	28	3	1		64	6.5
E	25	18	2	2			47	3.9
ESE	17	41	14	5			77	5.5
SE	5	28	20	2			55	6.3
SSE	9	19	23	16			67	7.8
S	15	4	18				37	5.5
SSW	16	7	2				25	3.4
SW	3	3	1				7	3.6
WSW	4	4					8	3.5
W	9	3					12	2.8
WNW	2	3	1	2			8	6.8
NW	2	1	5	11			19	10.5
NNW	10	4	8	22			44	9.2
Total	164	205	210	78	3		660	6.4

Number of Hourly Observations of Calm 9

Total Number of Hourly Observations 669

TABLE D.1-6
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 1
NOVEMBER 1978

Direction	Speed (kts) 0-3	4-6	7-10	11-16	17-21	> 21	Total
N	.026906	.020927	.041854	.007474			.097160
NNE	.017937	.029895	.037369	.008967	.001494		.095665
NE	.014948	.025411	.052317	.005979	.001494		.100150
ENE	.019432	.028401	.041854	.004484	.001494		.095665
E	.037369	.026906	.002990	.002990			.070254
ESE	.025411	.061286	.020927	.007474			.115097
SE	.007474	.041854	.029895	.002990			.082212
SSE	.013453	.028401	.034380	.023916			.100150
S	.022422	.005979	.026906				.055306
SSW	.023916	.010463	.002990				.037369
SW	.004484	.004484	.001494				.010463
WSW	.005979	.005979					.011958
W	.016442	.004484					.020927
WNW	.002990	.004484	.001494	.002990			.011958
NW	.002990	.001494	.007474	.016442			.028401
NNW	.016442	.005979	.011958	.032885			.067265
Total	.258595	.306428	.313901	.116592	.004484		1.00000

Relative Frequency of Calms Distributed Above .013453

TABLE D.1-7
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 1
DECEMBER 1978

Direction	Speed (kts) 1-3	4-6	7-10	11-16	17-21	> 21	Total	Avg. Speed
N	15	9	4	12			40	6.7
NNE	3	6	2	4			15	7.1
NE	6	6	12	13	2		39	9.2
ENE	19	17	7	2			45	4.7
E	33	32	11				76	4.2
ESE	19	31	17	3	3		73	6.0
SE	2	12	13	4	1		32	7.7
SSE	20	14	49	10	1		94	7.2
S	5	13	17	5			40	7.2
SSW	4	6	3	6	3		22	9.2
SW	1	1					2	3.5
WSW	4	2	1	1			8	5.0
W	2	3					5	3.8
WNW	2						2	2.0
NW	6	2	1	9	5		23	10.7
NNW	14	13	9	46	13		95	10.9
Total	155	167	146	115	28		611	7.3

Number of Hourly Observations of Calm 16

Total Number of Hourly Observations 627

TABLE D.1-8
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 1
DECEMBER 1978

Direction	Speed (kts) 0-3	4-6	7-10	11-16	17-21	>21	Total
N	.025518	.014354	.006380	.019139			.065391
NNE	.006380	.009570	.003190	.006380			.025518
NE	.009570	.009570	.019139	.020734	.003190		.062201
ENE	.031898	.027113	.011164	.003190			.073365
E	.052632	.051034	.017544				.121212
ESE	.031898	.049442	.017544	.004785	.004785		.118022
SE	.003190	.019139	.020734	.006380	.001595		.051037
SSE	.033493	.022329	.078150	.015949	.001595		.151515
S	.007974	.020734	.027113	.007974			.063796
SSW	.007975	.009570	.004785	.009570	.004785		.036683
SW	.001595	.001595					.003190
WSW	.009570	.003190	.001595	.001595			.015949
W	.006380	.004785					.011164
WNW	.003190						.003190
NW	.015950	.003190	.001595	.014354	.007974		.043062
NNW	.025519	.020734	.014354	.073365	.020734		.154705
Total	.272727	.266348	.232855	.183413	.046570		1.00000

Relative Frequency of Calms Distributed Above .025518

TABLE D.1-9
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 1
SEPTEMBER 29 - DECEMBER 27, 1978

Direction	Speed (kts) 1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	69	71	57	23	1		221	5.9
NNE	29	78	58	30	3		198	7.0
NE	31	53	72	22	3		181	5.5
ENE	50	75	43	9	1		178	4.8
E	70	65	13	2			150	4.0
ESE	52	87	36	8	3		186	5.4
SE	23	44	36	6	1		110	6.1
SSE	57	54	78	26	1		216	6.6
S	50	43	44	5			142	5.3
SSW	46	25	5	6	3		85	4.6
SW	15	5	1				21	3.0
WSW	14	8	1	1			24	3.7
W	18	10					28	3.0
WNW	5	10	2	2			19	5.5
NW	11	4	8	20	5		48	9.9
NNW	29	24	25	69	14		161	9.9
Total	569	656	479	229	35		1968	6.2

Number of Hourly Observations of Calm 39

Total Number of Hourly Observations 2007

TABLE D.1-10
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 1
SEPTEMBER 29 - DECEMBER 27, 1978

	Speed (kts)						
Direction	0-3	4-6	7-10	11-16	17-21	>21	Total
N	.038864	.035376	.028401	.011460	.000498		.114599
NNE	.016442	.038864	.028899	.014948	.001495		.100648
NE	.015944	.026408	.035874	.010962	.001495		.090683
ENE	.025411	.037369	.021425	.004484	.000498		.089188
E	.034878	.032387	.006478	.000997			.074738
ESE	.026906	.043348	.017937	.003986	.001495		.093672
SE	.011958	.021923	.017937	.002990	.000498		.055306
SSE	.028899	.026906	.038864	.012955	.000498		.108122
S	.025411	.021425	.021923	.002491			.071251
SSW	.023418	.012456	.002491	.002990	.001495		.042850
SW	.007474	.002491	.000498				.010463
WSW	.007973	.003986	.000498	.000498			.012955
W	.011460	.004983					.016442
WNW	.003986	.004983	.000997	.000997			.010962
NW	.007972	.001993	.003986	.009965	.002491		.026408
NNW	.015945	.011958	.012456	.034380	.006976		.081715
Total	.302940	.326856	.238665	.114101	.017439		1.00000

Relative Frequency of Calms Distributed Above .019432

TABLE D.1-11
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
SEPTEMBER 29, 1978 - SEPTEMBER 30, 1978

	Speed (kts)							
Direction	1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	4	7	2				13	4.6
NNE	1	1	1				3	5.2
NE		5					5	5.0
ENE		3	12				15	7.8
E								
ESE								
SE								
SSE								
S								
SSW								
SW								
WSW								
W								
WNW								
NW								
NNW	1						2	
Total	6	16	15				37	

Number of Hourly Observations of Calm 1

Total Number of Hourly Observations 38

TABLE D.1-12
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
SEPTEMBER 29, 1978 - SEPTEMBER 30, 1978

Direction	Speed (kts) 0-3	4-6	7-10	11-16	17-21	>21	Total
N	.105263	.184211	.052632				.342105
NNE	.026316	.026316	.026316				.078947
NE		.131579					.131579
ENE		.078947	.315789				.394737
E							
ESE							
SE							
SSE							
S							
SSW							
SW							
WSW							
W							
WNW							
NW							
NNW	.052632						.052632
Total	.184211	.421053	.394737				1.00000
			Relative Frequency of Calms Distributed Above				.026316

TABLE D.1-13
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
OCTOBER 1978

Direction	Speed (kts) 1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	23	25	32	4	2		86	6.2
NNE	21	31	20	9	7		88	7.1
NE	21	31	26	5			83	5.8
ENE	16	49	26	14			105	6.5
E	17	12	2	3			34	4.5
ESE	11	16	1				28	3.9
SE	18	5	2				25	3.1
SSE	25	8	2				35	2.6
S	25	21	1				50	3.4
SSW	50	3	1				54	2.3
SW	11	1					12	2.3
WSW	6						6	2.0
W	9	5	1				15	3.4
WNW	7	10	2				19	4.3
NW	2	3	1				6	4.6
NNW	4	5	8	2			19	6.7
Total	269	225	125	37	9		665	5.1

Number of Hourly Observations of Calm 80

Total Number of Hourly Observations 745

TABLE D.1-14
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
OCTOBER 1978

Direction	Speed (kts) 0-3	4-6	7-10	11-16	17-21	> 21	Total
N	.037584	.033557	.042953	.005369	.002685		.122148
NNE	.030872	.041611	.026846	.012081	.009396		.120805
NE	.033557	.041611	.034900	.006711			.116779
ENE	.024161	.065772	.034900	.018792			.143624
E	.022819	.016107	.002685	.004027			.045638
ESE	.026846	.021477	.001342				.049664
SE	.033557	.006711	.002685				.042953
SSE	.060403	.010738	.002685				.073826
S	.052349	.028188	.001342				.081879
SSW	.076510	.004027	.001342				.081879
SW	.018792	.001342					.020134
WSW	.012081						.012081
W	.013423	.006711	.001342				.021477
WNW	.013423	.013423	.002685				.029530
NW	.002685	.004027	.001342				.008054
NNW	.009396	.006711	.010738	.002685			.029530
Total	.468456	.302013	.167785	.049664	.012081		1.00000
			Relative Frequency of Calms Distributed Above				.107383

TABLE D.1-15
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
NOVEMBER 1978

Direction	Speed (kts) 1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	14	9	18	10			51	6.8
NNE	5	20	20	10			55	7.5
NE	14	17	28	2	1		62	6.4
ENE	10	15	20	11	2		58	7.8
E	19	14	4				37	3.8
ESE	34	28	5				67	3.7
SE	23	44	18				85	5.0
SSE	9	19	13				41	5.5
S	6	10	6				22	5.1
SSW	16	5					21	2.7
SW	7	5					12	3.2
WSW	4	2					6	3.0
W	2						2	2.0
WNW	2	2	2	2			8	7.3
NW	4			11	2		17	11.4
NNW	6	5	10	24	1		46	10.1
Total	175	195	144	70	6		590	6.1
						Number of Hourly Observations of Calm	38	
						Total Number of Hourly Observations	628	

TABLE D.1-16
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
NOVEMBER 1978

Direction	Speed (kts) 0-3	4-6	7-10	11-16	17-21	> 21	Total
N	.025478	.014331	.028662	.015924			.084395
NNE	.009554	.031847	.031847	.015924			.089172
NE	.027071	.027070	.044586	.003185	.001592		.103503
ENE	.022293	.023885	.031847	.017516	.003185		.098726
E	.036623	.022293	.006369				.065287
ESE	.057325	.044586	.007962				.109873
SE	.047770	.070064	.028662				.146497
SSE	.014331	.030254	.020701				.065287
S	.015923	.015924	.009554				.041401
SSW	.033440	.007962					.041401
SW	.012738	.007962					.020701
WSW	.007961	.003185					.011146
W	.004777						.004778
WNW	.003185	.003185	.003185	.003185			.012739
NW	.009554			.017516	.003185		.030255
NNW	.011146	.007962	.015924	.038217	.001592		.074841
Total	.339172	.310510	.229300	.111465	.009554		1.00000

Relative Frequency of Calms Distributed Above .060510

TABLE D.1-17
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
DECEMBER 1978

Direction	Speed (kts) 1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	6	3	3	3	2	1	18	8.5
NNE	3	4					7	7.6
NE	2	2	2	7			13	9.7
ENE	10	11	3	7	1		32	6.7
E	8	13	4	1			26	4.9
ESE	11	5	4				20	4.0
SE	7	1	2	1			11	4.5
SSE	8	10	13				31	5.7
S	6	7	5				18	5.0
SSW	5	11	4	1			21	5.4
SW	2	2	7	4			15	8.5
WSW	1	1	1	1			4	3.4
W	3						3	2.0
WNW	2	1					3	3.0
NW	1						1	2.0
NNW	4		5	5	2		16	9.8
Total	79	71	53	30	5	1	239	6.2

Number of Hourly Observations of Calm 21

Total Number of Hourly Observations 260

TABLE D.1-18
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
DECEMBER 1978

Direction	Speed (kts) 0-3	4-6	7-10	11-16	17-21	>21	Total
N	.023077	.011538	.011538	.011538	.007692	.003846	.069231
NNE	.019230	.015385					.034615
NE	.011538	.007692	.007692	.026923			.053846
ENE	.038462	.042308	.011538	.026923	.003846		.123077
E	.042308	.050000	.015385	.003846			.111538
ESE	.042308	.019230	.015385				.076923
SE	.034615	.003846	.007692	.003846			.050000
SSE	.046154	.038462	.050000				.134615
S	.034615	.026923	.019230				.080769
SSW	.023077	.042308	.015385	.003846			.084615
SW	.007692	.007692	.026923	.015385			.057692
WSW	.007692	.003846	.003846	.003846			.019230
W	.019230						.019230
WNW	.007692	.003846					.011538
NW	.011538						.011538
NNW	.015385		.019230	.019230	.007692		.061538
Total	.384615	.273077	.203846	.115385	.019230	.003846	1.00000
			Relative Frequency of Calms Distributed Above				.080770

TABLE D.1-19
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
SEPTEMBER 29 - DECEMBER 27, 1978

Direction	Speed (kts) 1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	47	99	55	17	4		222	6.1
NNE	30	56	41	19	7		153	7.0
NE	37	55	56	14	1		163	6.3
ENE	36	78	61	32	3		210	7.0
E	44	39	10	4			97	4.3
ESE	56	49	10				115	3.8
SE	48	50	22	1			121	4.5
SSE	42	37	28				107	4.7
S	40	38	12				90	4.1
SSW	71	19	5	1			96	3.7
SW	20	8	7	4			39	5.0
WSW	11	3	1	1			16	3.6
W	14	5	1				20	3.0
WNW	11	13	4	2			30	5.0
NW	7	3	1	11	2		24	9.3
NNW	15	10	23	31	3		82	9.2
Total	529	562	337	137	20		1585	5.7

Number of Hourly Observations of Calm 140

Total Number of Hourly Observations 1725

TABLE D.1-20
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 2
SEPTEMBER 29 - DECEMBER 27, 1978

Direction	Speed (kts) 0-3	4-6	7-10	11-16	17-21	> 21	Total
N	.031304	.057391	.031884	.009855	.002319		.132754
NNE	.020290	.032464	.023768	.011014	.004058		.091594
NE	.026088	.031884	.032464	.008116	.000580		.099130
ENE	.024348	.045217	.035362	.018551	.001739		.125217
E	.029565	.022609	.005798	.002319			.060290
ESE	.038841	.028406	.005798				.073043
SE	.037101	.028986	.012754	.000580			.079420
SSE	.038261	.021449	.016232				.075942
S	.033623	.022029	.006957				.062609
SSW	.048695	.011014	.002899	.000580			.063189
SW	.013913	.004638	.004058	.002319			.024928
WSW	.009276	.001739	.000580	.000580			.012174
W	.010435	.002899	.000580				.013913
WNW	.008116	.007536	.002319	.001160			.019130
NW	.006377	.001739	.000580	.006377	.001160		.016232
NNW	.011595	.005798	.013333	.017971	.001739		.050435
Total	.387828	.325797	.195362	.079420	.011595		1.00000
			Relative Frequency of Calms Distributed Above				.081159

TABLE D.1-21
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
SEPTEMBER 29, 1978 - SEPTEMBER 30, 1978

	Speed (kts)							
Direction	1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N		4	3				7	6.5
NNE	2	1	7				10	6.9
NE		1	5				6	7.9
ENE			8				8	8.5
E								
ESE								
SE								
SSE								
S	2						2	2.0
SSW								
SW								
WSW								
W	1						1	1.0
WNW								
NW								
NNW								
Total	5	6	23				34	6.9

Number of Hourly Observations of Calm 0

Total Number of Hourly Observations 34

TABLE D.1-22
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
SEPTEMBER 29, 1978 - SEPTEMBER 30, 1978

	Speed (kts)						
Direction	0-3	4-6	7-10	11-16	17-21	>21	Total
N		.117647	.088235				.205882
NNE	.058824	.029412	.205882				.294118
NE		.029412	.147059				.176471
ENE			.235294				.235294
E							
ESE							
SE							
SSE							
S	.058824						.058824
SSW							
SW							
WSW							
W	.029412						.029412
WNW							
NW							
NNW							
Total	.147059	.176471	.676471				1.00000
			Relative Frequency of Calms Distributed Above				0.00000

TABLE D.1-23
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
OCTOBER, 1978

	Speed (Kts)							
Direction	1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	18	30	42	13	1		104	7.1
NNE	10	54	33	13	10	1	121	7.9
NE	7	21	23	11	4		65	8.3
ENE	20	37	11	2			70	4.9
E	16	13	8				37	4.5
ESE	18	13	16	1			48	5.2
SE	10	6		1			17	3.7
SSE	33	28	11				72	4.2
S	24	13	12				49	4.4
SSW	31	4	1				36	2.5
SW	4		1				5	3.3
WSW	18	2					20	2.3
W	10	2	1				13	3.0
WNW	11	7	3				21	3.9
NW	4		1				5	3.3
NNW	7	3	5	2	1		18	6.5
Total	241	233	167	43	16	1	735	5.4

Number of Hourly Observations of Calm 7

Total Number of Hourly Observations 742

TABLE D.1-25
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
OCTOBER, 1978

	Speed (kts)						
Direction	0-3	4-6	7-10	11-16	17-21	>21	Total
N	.025606	.040431	.056604	.017520	.001348		.141509
NNE	.013477	.072776	.044474	.017520	.013477	.001348	.163073
NE	.009434	.028302	.030997	.014825	.005391		.087601
ENE	.026954	.049865	.014825	.002695			.094340
E	.021563	.017520	.010782				.049865
ESE	.026954	.017520	.021563	.001348			.067385
SE	.013477	.008086		.001348			.022911
SSE	.044474	.037736	.014825				.097035
S	.033693	.017520	.016173				.067385
SSW	.043127	.005391	.001348				.049865
SW	.005391		.001348				.006739
WSW	.024259	.002695					.026954
W	.013477	.002695	.001348				.017520
WNW	.016172	.009434	.004043				.029650
NW	.005391		.001348				.006739
NNW	.010782	.004043	.006739	.002695			.025606
Total	.334232	.314016	.225067	.057951	.001348	.001348	1.000000
				Relative Frequency of Calms Distributed Above			.009434

TABLE D.1-25
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
NOVEMBER, 1978

Direction	Speed (kt) 1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	7	14	20	14	2		57	8.2
NNE	8	19	28	16	1		72	8.1
NE	2	14	22	4	3		45	8.3
ENE	11	12	26	7	1		57	7.3
E	12	30	2	3			47	4.9
ESE	12	28	14	8			62	6.3
SE	11	40	27	4			82	6.2
SSE	6	22	48	18			94	8.2
S	11	6	6				23	4.5
SSW	13	5	1				19	3.1
SW	5	2					7	2.8
WSW	12	1					13	2.2
W	5	1					6	2.5
WNW	3	2		6	1		12	9.7
NW	1	1	1	14	3		20	13.1
NNW	3	10	4	31	2		50	11.0
Total	122	207	199	125	13		666	7.4
						Number of Hourly Observations of Calm	9	
						Total Number of Hourly Observations	675	

TABLE D.1-26
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
NOVEMBER 1978

	Speed (kts)						
Direction	0-3	4-6	7-10	11-16	17-21	> 21	Total
N	.019259	.020741	.029630	.020741	.002963		.093333
NNE	.013333	.028148	.041481	.023704	.001481		.108148
NE	.002963	.020741	.032593	.005926	.004444		.066667
ENE	.017777	.017778	.038519	.010370	.001481		.085926
E	.017778	.044444	.002963	.004444			.069630
ESE	.017778	.041481	.020741	.011852			.091852
SE	.016297	.059259	.040000	.005926			.121481
SSE	.010370	.032593	.071111	.026667			.140741
S	.016297	.008889	.008889				.034074
SSW	.019259	.007407	.001481				.028148
SW	.007407	.002963					.010370
WSW	.017778	.001481					.019259
W	.007407	.001481					.008889
WNW	.004444	.002963		.008889	.001481		.017778
NW	.001481	.001481	.001481	.020741	.004444		.029630
NNW	.004444	.014815	.005926	.045926	.002963		.074074
Total	.194074	.306667	.294815	.185185	.019259		1.00000
				Relative Frequency of Calms Distributed Above			.013333

TABLE D.1-27
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
DECEMBER, 1978

	Speed (kts)							
Direction	1-3	4-6	7-10	11-16	17-21	>21	Total	Avg. Speed
N	6	8	5	7	2		28	8.1
NNE	1	4	5				10	6.5
NE	3	8	7	14			32	9.2
ENE	5	18	10	7			40	7.0
E	11	18	3				32	4.3
ESE	17	33	18	4	2		74	6.0
SE	3	9	6	5	3		26	8.7
SSE	10	13	32	37	1		93	9.4
S	8		11	3	1		23	7.3
SSW	2	2	1	2	1		8	7.1
SW		1	3				5	7.6
WSW	3	2					5	3.2
W	4						4	2.0
WNW	2	1		1			5	5.6
NW				2		1	3	16.3
NNW	10	1	9	8	32	17	77	15.5
Total	85	118	110	90	41	18	462	8.8

Number of Hourly Observations of Calm 3

Total Number of Hourly Observations 465

TABLE D.1-28
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
DECEMBER 1978

	Speed (kts)						
Direction	0-3	4-6	7-10	11-16	17-21	>21	Total
N	.012903	.017204	.010753	.015054	.004301		.060215
NNE	.002151	.008602	.010753				.021505
NE	.006452	.017204	.015054	.030108			.068817
ENE	.010753	.038710	.021505	.015054			.086022
E	.023656	.038710	.006452				.068817
ESE	.036559	.070968	.038710	.008602	.004301		.159140
SE	.006452	.019355	.012903	.010753	.006452		.055914
SSE	.021505	.027957	.068817	.079570	.002151		.200000
S	.017204		.023656	.006452	.002151		.049462
SSW	.006452	.004301	.002151	.004301			.017204
SW	.002151	.002151	.006452				.010753
WSW	.006452	.004301					.010753
W	.008602						.008602
WNW	.006452	.002151		.002151			.010753
NW				.004301		.002151	.006452
NNW	.021505	.002151	.019355	.017204	.068817	.036559	.165591
Total	.189247	.253763	.236560	.193549	.088172	.038710	1.00000

Relative Frequency of Calms Distributed Above .006452

TABLE D.1-29
FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
SEPTEMBER 29 - DECEMBER 27, 1978

	Speed (kts)							
Direction	1-3	4-6	7-10	11-16	17-21	> 21	Total	Avg. Speed
N	30	56	70	34	5		195	7.6
NNE	21	78	73	29	11	1	213	7.9
NE	12	44	57	29	7		149	8.4
ENE	36	67	55	16	1		175	6.3
E	39	61	13	3			116	4.6
ESE	47	74	48	13	2		184	5.4
SE	24	55	33	10	3		125	6.4
SSE	49	63	91	55	1		259	7.2
S	45	19	29	3	1		97	3.2
SSW	46	11	3	2			62	3.2
SW	9	3	4				16	4.2
WSW	33	5					38	2.5
W	20	3	1				24	2.6
WNW	16	10	3	7	1		37	5.3
NW	5	1	2	16	3	1	28	9.0
NNW	20	14	18	41	35	17	145	12.8
Total	452	564	500	258	70	19	1863	7.1

Number of Hourly Observations of Calm 19

Total Number of Hourly Observations 1882

TABLE D.1-30
RELATIVE FREQUENCY DISTRIBUTION OF WINDS
WEST HACKBERRY SITE, STATION 3
SEPTEMBER 29 - DECEMBER 27, 1978

Direction	Speed (kts) 0-3	4-6	7-10	11-16	17-21	> 21	Total
N	.019659	.029756	.037194	.018066	.002657		.107333
NNE	.011689	.041445	.038788	.015410	.005845	.000531	.113709
NE	.006376	.023379	.030287	.015410	.003720		.079171
ENE	.019660	.035600	.029224	.008501	.000531		.093518
E	.020727	.032412	.006901	.001594			.061637
ESE	.026036	.039320	.025505	.006908	.001063		.098831
SE	.012752	.029224	.017535	.005313	.001594		.066419
SSE	.026567	.033475	.048353	.029224	.000531		.138151
S	.024442	.010096	.015410	.001594	.000531		.052072
SSW	.025505	.005845	.001594	.001063			.034006
SW	.005313	.001594	.002125				.009033
WSW	.017535	.002657					.020191
W	.010627	.001594	.000531				.012752
WNW	..009565	.005313	.001594	.003719	.000531		.020723
NW	.002657	.000531	.001063	.008502	.001594	.000531	.014878
NNW	.011158	.007439	.009564	.021785	.018597	.009033	.077578
Total	.250266	.299681	.265675	.137088	.037194	.010096	1.00000

Relative Frequency of Calms Distributed Above .010096

APPENDIX E

Quality Assurance

SAMPLE CHAIN-OF-CUSTODY

Properly executed chain-of-custody tags were affixed to each sample as it was collected in the field and pertinent sample data was recorded in a field notebook. Upon return to the field headquarters at the Hackberry site, the chain-of-custody was transferred to temporary storage. Upon completion of collection of the samples for each phase, the custody of samples was transferred for deposition to the Dames & Moore Environmental Laboratory, Houston.

Upon receipt in the Dames & Moore Environmental Laboratory, all samples were recorded in a Dames & Moore log book which was kept on file. Each chain-of-custody tag was signed by the Lab Manager, thus assuring receipt of each sample.

All chemical samples were stored in locked freezers until distribution to the University of New Orleans or the University of Rhode Island was requested. These samples retained the tags during shipment to these universities.

The benthic and vegetation samples were retained in the Environmental Laboratory and processed by Dames & Moore lab technicians. Once completed, the sample tags were removed and retained in the Dames & Moore project file.

Chemistry samples sent to the universities were signed upon receipt by a scientist from the laboratory involved in sample analysis and were kept stored in a locked freezer.

A master sample log was maintained which detailed the history of each sample as it was analyzed. Sample log books and original calculation sheets, gas chromatographic, gas chromatographic/mass spectrometric,

and infrared spectral data were dated, signed and stored in a locked filing cabinet. Mass spectral, gas chromatographic and infrared spectral data acquired by the computer systems were stored either on cartridge disks, magnetic tapes or floppy disks.

Copy No._____

QUALITY ASSURANCE PROCEDURES
ENVIRONMENTAL ASSESSMENT TEAM
WEST HACKBERRY SPR SITE

Return this copy to Dames & Moore

Prepared by: R. M. Freeman
Accepted by:_____
for:_____
Date accepted:_____

Copy No._____

QUALITY ASSURANCE PROCEDURES
ENVIRONMENTAL ASSESSMENT TEAM
WEST HACKBERRY SPR SITE

Prepared by: R. M. Freeman
Accepted by:_____
for:_____
Date accepted:_____

QUALITY ASSURANCE PROCEDURES

INTRODUCTION

This document contains the procedures to be used by the environmental assessment team (EAT) in conjunction with the quality assurance program. The primary goal of these procedures is to provide traceability and documentation for all work performed in association with the environmental assessment of the West Hackberry Cavern 6 Blowout.

The procedures covered under this program are control and retention of communications; control and calibration of measuring and testing equipment; sample control; and control and retention of raw data, reduced data and calculations.

CONTROL AND RETENTION OF COMMUNICATIONS

This procedure establishes responsibilities and methods for the control and retention of communications in the form of correspondence, memoranda, telephone conversations, and meetings.

Flowcharts illustrating the steps of this procedure are shown as Exhibits A and B.

1. All incoming correspondence is assigned a sequential incoming correspondence number as it is received and is entered into the Correspondence Log (Exhibit C). Copies are made and distributed, as required.

2. The original correspondence is filed in the job file and copies in any other appropriate files.

3. Outgoing correspondence is handled in the same manner as that described for incoming, with the exception that the sequential correspondence number and entry into the Correspondence Log is that for outgoing rather than incoming correspondence.

   (Example: The first letter from Dames & Moore to DOE will be numbered DMDO-1. It will be entered in the Dames & Moore Correspondence Log under outgoing correspondence to DOE. It will be entered by DOE upon receipt in their Correspondence Log under incoming correspondence from Dames & Moore using the same number as above, DMDO-1.)

4. Purchase orders and other procurement documents for instrumentation and outside services are retained in procurement files and, if applicable, in an appropriate job file.

5. Telephone calls are documented on a Record of Telephone Conversation form (Exhibit D) by the participating person. A copy of the record is retained for the project file.

6. Copies of minutes of meetings are distributed to the attendees with a copy for the project file.

7. Copies of ALL correspondence (letters, memoranda, telephone calls, etc.) are forwarded to Dames & Moore for filing in the Master Correspondence File.

CONTROL AND CALIBRATION OF MEASURING AND TESTING EQUIPMENT

This procedure outlines the steps necessary to control and calibrate instruments.

All measuring and test equipment should be regularly calibrated using recommended procedures provided in the instrument manual for the designated instrument.

The schedule of calibration for project instruments is specified in the project plan and includes calibration:

1. Upon initial receipt.

2. At regular intervals in accordance with the instrument operation instructions.

3. Wherever an out-of-calibration condition is discovered.

The individual who manages calibration:

1. Maintains a history and schedule of instrument calibration for each instrument.

2. Schedules technician visits at required intervals to conduct regular calibration.

3. Maintains documentation of traceability of all calibration instruments to National Bureau Standards.

The Principal Investigator or Laboratory Supervisor reviews and surveys calibration operations and notifies the Project Manager when deficiencies are detected. The Project Manager in turn notifies the Project Quality Assurance Coordinator.

The Project Quality Assurance Coordinator reviews calibration documentation. When an instrument is discovered to be out of calibration, the PQAC labels as suspect all results obtained from it since the last successful calibration. These suspect data results are resolved on a case-by-case basis by the Principal Investigator and the PQAC.

When an instrument is identified as out-of-calibration (such as during the checks performed as part of the start-up procedure, or while running calibrated test samples) calibration is immediately requested. This request is originated by the Project Manager, Principal Investigator, Project Quality Assurance Coordinator or Laboratory Supervisor. The instrument is labeled "Out of Calibration" and taken out of service by the cognizant supervisor. Results obtained with the instrument since it was last calibrated are considered suspect and whether or not to use them is resolved on a case-by-case basis.

When new instruments are received, an initial calibration will be performed in accordance with the instrument manual.

Calibration procedures used will be those given in the instrument manual provided by the manufacturer.

The cognizant Principal Investigator or Laboratory Supervisor will review, sign and date the instrument calibration documentation to verify compliance with this procedure. Any instrument which cannot be calibrated will be labeled as nonconforming and will not be used.

Documentation for each instrument will consist of:

1. Checkoff sheets, prepared from the instrument manual or provided with the new instrument, which provide evidence of a receipt inspection and initial calibration.

2. The calibration log (Sample: Exhibit E).

3. A calibration label affixed to the instrument (Sample: Exhibit F).

SAMPLE CONTROL

EPA Sample Custody Tags (Exhibit G) will be maintained and will remain with the sample throughout analyses.

CONTROL AND RETENTION OF RAW DATA, REDUCED DATA AND CALCULATIONS

All data records are to be signed and dated. Records shall be retained in the proper job files.

All calculation sheets will be signed and dated by the person performing the calculations. Calculations will be reviewed and checked, with the reviewer also signing and dating the calculation sheet.

EXHIBIT A

INCOMING CORRESPONDENCE

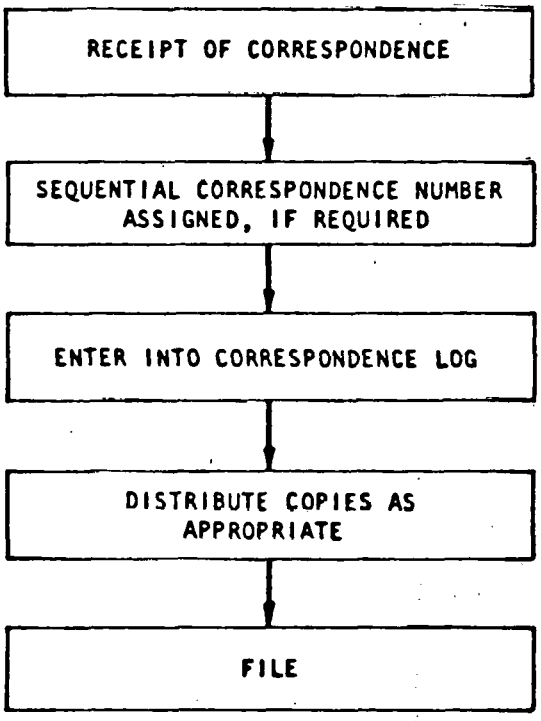
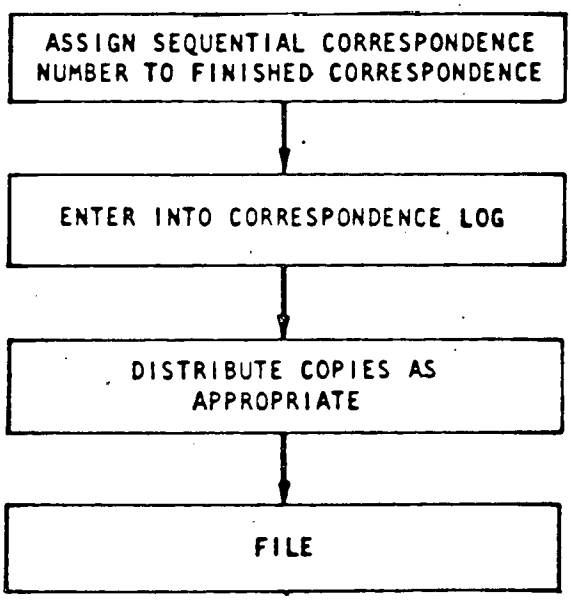


EXHIBIT B

OUTGOING CORRESPONDENCE



CORRESPONDENCE LOG

ENVIRONMENTAL ASSESSMENT - WEST HACKBERRY CAVERN 6 BLOWOUT

SHEET ___ OF ___

NUMBER	WRITER	ADDRESSEE	DATE	SUBJECT	FILE LOCATION	DATE REC'D (INCOMING ONLY)

EXHIBIT C

EXHIBIT D

RECORD OF TELEPHONE CONVERSATION

DATE _____ JOB NO : _____

RECORDED BY: _____ OWNER/CLIENT: _____

TALKED WITH: _____ OF _____

NATURE OF CALL: INCOMING ☐ OUTGOING ☐

ROUTE TO: INFORMATION ACTION

_____ _____

_____ _____

_____ _____

MAIN SUBJECT OF CALL: _____

ITEMS DISCUSSED: _____

117.1 (12/73) DAMES & MOORE

EXHIBIT E

INSTRUMENT CALIBRATION LOG

INSTRUMENT NAME _____

MANUFACTURER _____

EQUIPMENT SERIAL NO. _____

DATE ACQUIRED OR PLACED IN SERVICE _____

CALIBRATION RECORD

DATE _____

CALIBRATED BY _____

COMMENTS: _____

_____

_____

LABORATORY SUPERVISOR (SIGN)*

CALIBRATION RECORD

DATE _____

CALIBRATED BY _____

COMMENTS: _____

_____

_____

LABORATORY SUPERVISOR (SIGN)*

CALIBRATION RECORD

DATE _____

CALIBRATED BY _____

COMMENTS: _____

_____

_____

LABORATORY SUPERVISOR (SIGN)*

* or his local representative

EXHIBIT F

SAMPLE CALIBRATION LABEL

DATE CALIBRATED	DATE DUE
EQUIPMENT: model, serial no.	
NAME (TECHNICIAN)	

EXHIBIT G

SAMPLE CUSTODY TAG

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL PROTECTION AGENCY

SAMPLE NO.	TIME TAKEN (HOURS)	DATE TAKEN

SOURCE OF SAMPLE	PRESERVATIVE

SAMPLE COLLECTOR			WITNESS(ES)		
TEAM 1	TEAM 2	TEAM 3	TEAM 1	TEAM 2	TEAM 3

REMARKS: (ANALYSES REQUIRED, SAMPLE TYPE, ETC.)

I hereby certify that I received this sample and disposed of it as noted below:

RECEIPT OF SAMPLE	RECEIVED FROM	DATE RECEIVED	TIME RECEIVED
	DISPOSITION OF SAMPLE	SIGNATURE	

I hereby certify that I received this sample and disposed of it as noted below:

RECEIPT OF SAMPLE	RECEIVED FROM	DATE RECEIVED	TIME RECEIVED
	DISPOSITION OF SAMPLE	SIGNATURE	

I hereby certify that I obtained this sample and dispatched it as shown below:

DISPATCH OF SAMPLE	DATE OBTAINED	TIME OBTAINED	SOURCE
	DATE DISPATCHED	TIME DISPATCHED	METHOD OF SHIPMENT
	SENT TO		SIGNATURE

APPENDIX F

Assessment Team Members

The following is a list of the principal participants in the environmental assessment. Numerous other personnel also contributed measurably in the collection and analysis of samples and in the review of this report.

DAMES α MOORE (Houston):

Arthur R. Taylor
Nick Fotheringham, Ph.D.
Mary Kutac
Gary J. Penn, Ph.D.
Jimmy Salinas
Alan L. Smith, Ph.D.

EGαG (Las Vegas):

Bill Ginsberg, Ph.D.
Sheldon Levy
Dave Holly
Tim McCreary

PARSONS-GILBANE (New Orleans):

Robert E. Cox
Austin R. Arabie
Mark L. Boudreaux
Forrest W. Frazier
Glenn A. Miller
Joseph A. Shearer

UNIVERSITY OF NEW ORLEANS (New Orleans):

John L. Laseter, Ph.D.
Edward B. Overton, Ph.D.
Jo Ann McFall
S. Wayne Mascarella
Shelley R. Antoine
Ileana I. Nuiry
Patrick C. Remele
Douglas R. Carlisle
Jayanti R. Patel, Ph.D.

UNIVERSITY OF RHODE ISLAND (Kingston):

Mason P. Wilson, Jr., Ph.D.
Mark Admadjian
Robert Boldi
Chris W. Brown, Ph.D.
Robert A. Duce, Ph.D.
Gina Garofalo
Patricia F. Lynch
Christopher J. Ordzie, Ph.D.
Alexander A. Pszenny

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle
Strategic Petroleum Reserve
West Hackberry Oil Storage; Cavern Fire and Spill
of September 21, 1978
An Environmental Assessment

5. Report Date
29 February 1980

6. Performing Organization Code

8. Performing Organization Report No.

7. Author(s)
Taylor, A., et al.

9. Performing Organization Name and Address
Environmental Assessment Team
c/o Dames & Moore
4321 Directors Row
Houston, Texas 77092

10. Work-Unit No.

11. Contract or Grant No.

13. Type of Report and Period Covered
Final
Sept. 21, 1978 to Oct. 12, 1979

12. Sponsoring Agency Name and Address
Strategic Petroleum Reserve
Project Management Office
U. S. Department of Energy
New Orleans, LA 70123

14. Sponsoring Agency Code

15. Supplementary Notes
U. S. Department of Energy Technical Project Officer: John M. Cece, Ph.D.

16. Abstract

This report summarizes an environmental assessment of the fire and oil spill at the Strategic Petroleum Reserve site, West Hackberry, Louisiana. Subjective identification of oil contaminated habitats was supported by a more rigorous classification of samples utilizing discriminant analysis. Fourteen contaminated stations were identified along the shore of Black Lake just north and west of Wellpad 6, encompassing approximately 9 hectares. Seasonal variation in the structures of marsh and lake bottom communities in this contaminated area were not generally distinguishable from that of similar communities in uncontaminated habitats along the southern and southeastern shores of Black Lake. The major impact of spilled oil on the marsh vegetation was to accelerate the natural marsh deterioration which will eventually impact animals dependent on marsh vegetation for habitat structure. Vanadium, the predominate trace metal in the oil, and pyrogenic products due to the fire were found at the most distant sampling site (5 km) from Cavern 6 during Phase I, but were not detected downwind of the fire in excess of background levels in the later phases. Remote sensing evaluation of vegetation under the plume also indicated that stress existed immediately after the fire, but had disappeared by the end of the 1-year survey.

17. Key Words		18. Distribution Statement
Oil Spill	Southwestern Louisiana	This document is available from the:
Oil Fire	Oil Fingerprinting	National Technical Information Service
Marsh	Pyrogenic Products	5285 Port Royal Road
Remote Sensing		Springfield, VA 22161
Environmental Assessment		

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLAS	UNCLAS		

Reproduction of completed page authorized

1,340,000

1,350,000

500,000

490,000

480,000

AREA III
(WATER)

AREA I

AREA II
(LAND)

30-5-C
30-18-C
17-LAKE
19 LAKE
30-4-C
30-10-C
30-19-C
16 LAKE
30-15-C
30-9-C
30-7-C
30-3-C
15 LAKE
WEATHER STATION NO. 1
9-10-C
30-12-C
30-8-C
50-13-C
30-14-C
50-11-C
FRONT OF GILL NET
BACK OF GILL NET
WEATHER STATION NO. 2
UNO-1
UNO-2
UNO-3
UNO-4
UNO-5
UNO-6
UNO-7
UNO-8
UNO-9
UNO-10
UNO-11
UNO-12
UNO-14
1-1-C
1-2-C
1-3-C
SNR-1
SNR-2
SNR-3
SNR-4
SNR-5
SNR-6

PLANIMETRIC MAP
SCALE
0 2,000

N

FIGURE A.1-2 SAMPLE LOCATIONS IN AND AROUND WELL PAD 6 AND BLACK LAKE