Polycyclic Aromatic Hydrocarbons (PAHs) in Surface Soils in Western New York

Follow-up Report for New York State Soils

Technical Report

Polycyclic Aromatic Hydrocarbons (PAHs) in Surface Soils in Western New York

Follow-up Report for New York State Soils

1005296

Final Report, October 2003

Cosponsors
New York State Electric & Gas Corporation
Rochester Gas and Electric Corporation
Public Service Enterprise Group Services, LLP

EPRI Project Manager
A. Coleman

EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

THIS DOCUMENT WAS PREPARED BY THE ORGANIZATION(S) NAMED BELOW AS AN ACCOUNT OF WORK SPONSORED OR COSPONSORED BY THE ELECTRIC POWER RESEARCH INSTITUTE, INC. (EPRI). NEITHER EPRI, ANY MEMBER OF EPRI, ANY COSPONSOR, THE ORGANIZATION(S) BELOW, NOR ANY PERSON ACTING ON BEHALF OF ANY OF THEM:

(A) MAKES ANY WARRANTY OR REPRESENTATION WHATSOEVER, EXPRESS OR IMPLIED, (I) WITH RESPECT TO THE USE OF ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, OR (II) THAT SUCH USE DOES NOT INFRINGE ON OR INTERFERE WITH PRIVATELY OWNED RIGHTS, INCLUDING ANY PARTY'S INTELLECTUAL PROPERTY, OR (III) THAT THIS DOCUMENT IS SUITABLE TO ANY PARTICULAR USER'S CIRCUMSTANCE; OR

(B) ASSUMES RESPONSIBILITY FOR ANY DAMAGES OR OTHER LIABILITY WHATSOEVER (INCLUDING ANY CONSEQUENTIAL DAMAGES, EVEN IF EPRI OR ANY EPRI REPRESENTATIVE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES) RESULTING FROM YOUR SELECTION OR USE OF THIS DOCUMENT OR ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT.

ORGANIZATION(S) THAT PREPARED THIS DOCUMENT

META Environmental, Inc.

ORDERING INFORMATION

Requests for copies of this report should be directed to EPRI Orders and Conferences, 1355 Willow Way, Suite 278, Concord, CA 94520, (800) 313-3774, press 2 or internally x5379, (925) 609-9169, (925) 609-1310 (fax).

Electric Power Research Institute and EPRI are registered service marks of the Electric Power Research Institute, Inc. EPRI. ELECTRIFY THE WORLD is a service mark of the Electric Power Research Institute, Inc.

Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

CITATIONS

This report was prepared by

META Environmental, Inc.
49 Clarendon Street
Watertown, MA 02472

Principal Investigators
D. Mauro
P. De Clercq

This report was prepared for

EPRI
3412 Hillview Avenue
Palo Alto, California 94304

and

New York State Electric & Gas Corporation
P.O. Box 5224
Binghamton, NY 13902

Project Managers
T. Blazicek
J. Simone

and

Rochester Gas and Electric Corporation
89 East Avenue
Rochester, NY 14649

Project Managers
K. Sahler
K. Hylton

and

Public Service Enterprise Group Services, LLP
80 Park Plaza
Newark, NJ 07101

Project Manager
W. Max

This report describes research sponsored by EPRI, New York State Electric & Gas Corporation, Rochester Gas and Electric Corporation, and Public Service Enterprise Group Services, LLP.

The report is a corporate document that should be cited in the literature in the following manner:

Polycyclic Aromatic Hydrocarbons (PAHs) in Surface Soils in Western New York: Follow-up Report for New York State Soils, EPRI, Palo Alto, CA, New York State Electric & Gas Corporation, Binghamton, NY, Rochester Gas and Electric Corporation, Rochester, NY, and Public Service Enterprise Group Services, LLP, Newark, NJ: 2003. 1005296.

PRODUCT DESCRIPTION

Natural and anthropogenic sources of polycyclic aromatic hydrocarbons (PAHs) in the environment are quite diverse due to many different factors of human activity or inactivity in an area. Consequently, PAHs are found in many samples of soil, water, and biota throughout the world. This report provides an update of ongoing EPRI research performed to examine the distribution of PAH concentrations in surface soils of populated areas, with emphasis here on recently collected data in western New York State. This specific project completes the data set of EPRI's sampling of background soils in western and northwestern New York State (report 1005295).

Results & Findings

A total of 30 sites from two municipalities (Canandaigua and Rochester) in western New York State were sampled as part of an ongoing EPRI background study of PAHs in surface soil. Each municipality had a population of at least 10,000 people and a population density of at least 1000 people per square mile. At each site, two locations were sampled from 0 – 2.54 cm below grade and from 2.54 – 15 cm below grade, after removing surface vegetation, if present. At all sites, samples were composited to generate one sample representative of 0 – 15 cm below grade.

The patterns of PAHs seen in the samples were consistent with those in surface soil samples containing PAHs from pyrogenic sources that have been subjected to environmental weathering. To compare the concentrations of individual PAHs for all of the sites, summary statistics were performed with not-detected results equal to one half of the detection limit. The results for the individual PAHs were generally lognormally distributed. Benzo(a)pyrene concentrations ranged from a non-detectable 7.5 – 4740 µg/kg, with a median concentration of 431 µg/kg. The upper quartile concentration was 1040 µg/kg, while the upper 95th percentile concentration was 2770 µg/kg. These concentrations appear to be consistent with literature-reported levels for anthropogenic background in small- to medium-sized residential, commercial, and light industrial areas, but notably lower than background observed in more highly populated cities and commercial/industrial areas.

Challenges & Objectives

At many sites, it becomes very important to be able to determine where the site-specific contamination ends and where the local background PAHs begin. EPRI's primary objectives in the study of background PAHs in Illinois and western New York were as follows:

- To collect, composite (if appropriate), analyze, and interpret the results of surface soil samples from commercial/industrial, residential, municipal, and rural locations.
- To compile the data, determine their distribution and statistics, and correlate the PAH concentrations and patterns to site conditions or histories, when possible.

- To generate detailed information on typical PAH levels found at different locations as an aid in establishing appropriate and realistic cleanup levels for surface soil PAHs at sites undergoing remedial actions.

Applications, Values & Use

The frequent detection of PAHs in surface soil and sediment samples is of particular importance for environmental investigations and cleanups, because PAH concentrations often define the extent of contamination and influence the estimated risk from contamination at a variety of sites. This EPRI Background PAH Study was designed to generate an internally consistent, rugged set of PAH concentrations in surface soils from numerous locations covering a range of land uses, for application in site remediation plans.

EPRI Perspective

The technical and cost considerations that guide remediation are diverse, and during remediation, background conditions must be considered. Although there are many literature references concerning the presence of PAHs in environmental media, including surface soils, a review of those references indicated that there is a lack of consistent data on background distributions and concentrations of PAHs in surface soils. Indeed, there is no consistent definition of "background" in a regulatory sense. This study—cosponsored by EPRI, New York State Electric & Gas Corporation, Rochester Gas and Electric Corporation, and Public Service Enterprise Group Services—describes the nature of the distribution of PAH concentrations in populated areas. It identifies factors that affect distribution, such as type of setting (urban or rural), sample depth, soil type, and proximity to known sources. Finally, it examines, in a systematic manner, chemicals or chemical patterns that provide indications of PAH sources detected in background samples. Such information will prove invaluable in remediation of PAH-contaminated soil and in further differentiating between petrogenic and pyrogenic wastes.

Approach

The study objectives were achieved through a program of sample collection and analysis based on random sampling of a large number of sites with no known point sources of PAH-containing wastes. Sites were selected from urban areas and included utility-owned land, parks, forested areas, roadside rights of way, fields, public properties, and commercial properties. Selected samples were composited in the laboratory prior to analysis, with only two and rarely three samples combined into one composite sample. Samples were analyzed for PAHs and total organic carbon (TOC).

Keywords

Soils
Contamination
Hydrocarbons
Manufactured Gas Plant Sites
Coal Tar
Polycyclic Aromatic Hydrocarbons

ABSTRACT

The frequent detection of polycyclic aromatic hydrocarbons (PAHs) in surface soil and sediment samples is of particular importance for environmental investigations and cleanups, because PAH concentrations often define the extent of contamination and influence the estimated risk from contamination at a variety of sites. A total of 30 sites from two municipalities (Canandaigua and Rochester) in western New York State were sampled as part of an ongoing EPRI background study of PAHs in surface soil. Each municipality sampled has a population of at least 10,000 people and a population density of at least 1000 people per square mile. At each site, two locations were sampled from 0 – 2.54 cm below grade and from 2.54 – 15 cm below grade, after removing surface vegetation, if present. At all sites, samples were composited to generate one sample representative of 0 – 15 cm below grade.

The patterns of PAHs seen in the samples were consistent with those in surface soil samples containing PAHs from pyrogenic sources that have been subjected to environmental weathering. To compare the concentrations of individual PAHs for all of the sites, summary statistics were performed, with not-detected results equal to one half of the detection limit. The results for the individual PAHs were generally lognormally distributed. Benzo(a)pyrene concentrations ranged from a non-detectable 7.5 – 4740 µg/kg, with a median concentration of 431 µg/kg. The upper quartile concentration was 1040 µg/kg, while the upper 95th percentile concentration was 2770 µg/kg. These concentrations appear to be consistent with literature-reported levels for anthropogenic background in small- to medium-sized residential, commercial, and light industrial areas, but notably lower than background observed in more highly populated cities and commercial/industrial areas.

CONTENTS

1 INTRODUCTION 1-1

Background 1-1

Objectives 1-2

Summary of Approach 1-2

EPRI Perspective 1-3

Report Organization 1-3

2 SAMPLING AND ANALYSIS METHODS 2-1

Definitions 2-1

Sampling Design 2-1

Selecting Areas to Sample 2-2

Selecting Sites to Sample 2-2

Selecting Locations to Sample at Each Site 2-2

Sample Compositing and Analysis Scheme 2-2

Composites 2-2

Sample Analysis 2-3

Data Management and Analysis 2-3

3 PRESENTATION OF RESULTS 3-1

Field Activities 3-1

Site and Area Land Use Types 3-1

Summary of Physical Sample Characteristics 3-3

Sample Results for PAHs 3-3

Summary Statistics for PAH Results from All Sites 3-4

Quality Assurance/Quality Control (QA/QA) Results 3-7

4 CONCLUSIONS 4-1

5 REFERENCES 5-1

A TABLES A-1

LIST OF FIGURES

Figure 3-1 Example of Municipal Site – Department of Public Works 3-2
Figure 3-2 Example of a Heavy Residential Area Use Classification – Right of Way Site.....3-3
Figure 3-3 Normal Histogram and Probability Plot for Pyrene 3-8
Figure 3-4 Normal Histogram and Probability Plot for Benzo(a)pyrene.....3-9
Figure 3-5 Lognormal Histogram and Probability Plot for Pyrene.....3-10
Figure 3-6 Lognormal Histogram and Probability Plot for Benzo(a)pyrene.....3-11

LIST OF TABLES

Table 3-1 Summary Statistics for Raw PAH Data in Western New York (µg/kg) 3-5
Table 3-2 Summary Statistics of Normalized PAH Data in Western New York (µg/kg) 3-12
Table 3-3 Back-Transformed PAH Statistics in Western New York (µg/kg) 3-14
Table 4-1 Summary Benzo(a)pyrene Statistics for Other Data Sets Compared to this Study (µg/kg) 4-2
Table A-1 Sample Soil Descriptions, Total Organic Carbon, and Percent Solids A-1
Table A-2 Key to Abbreviations for PAHs A-2
Table A-3 Polycyclic Aromatic Hydrocarbon (PAH) Results in Background Surface Soils A-3
Table A-4 Field Duplicate Results with Relative Percent Differences (RPDs) A-7
Table A-5 Laboratory Duplicate Results with Relative Percent Differences (RPDs) A-8

1
INTRODUCTION

This report provides an update of ongoing EPRI research that is being performed to examine the distribution of polycyclic aromatic hydrocarbon (PAH) concentrations in surface soils of populated areas. For inclusion in this study, all of the areas sampled had populations of at least 10,000 people and population densities of at least 1,000 people per square mile. This report summarizes the purposes of this research, the procedures used during the study, as well as the results and conclusions obtained from recently collected data in western New York State. Results from the first 18 municipalities in Illinois (16) and central New York (2) sampled for this study are presented in the report entitled *Polycyclic Aromatic Hydrocarbons (PAHs) in Surface Soil* (EPRI, 2002).

Background

The natural and anthropogenic sources of PAHs to the environment are many and diverse. Consequently, PAHs are found in most samples of soil, water, and biota throughout the world (Blumer, 1976). The frequent detection of PAHs in surface soil and sediment is of particular importance for environmental investigations and cleanups, because the concentrations of PAHs often define the extent of contamination and influence the estimated risk from contamination at a variety of sites.

Further, at many sites, it becomes very important to be able to determine where the site-specific contamination ends and where the local background PAHs begin. Although there are many literature references concerning the presence of PAHs in environmental media, including surface soils, a review of those references indicated that there is a lack of consistent data on distributions and concentrations of PAHs in surface soils (EPRI, 2000). This study was designed to generate an internally consistent, rugged set of PAH concentrations in surface soils from a statistically significant number of locations in populated areas above a set size and density. The samples were collected and analyzed so that PAH data collected at different times and from different locations would be comparable, and would not contain unacceptable sampling or analytical bias.

Objectives

The overall objectives of the EPRI study of background PAHs were as follows:

1. Collect, composite (if appropriate), analyze, and interpret the results of surface soil samples from commercial/industrial, residential, municipal, and some rural locations.
2. Compile the data and determine their distribution and statistics. Correlate the PAH concentrations and patterns to site conditions or histories, when possible. For example, determine if PAH distributions and concentrations observed in soils near a municipal parking lot in one urban area are similar to PAH distributions and concentrations found in soils near a municipal parking lot in another urban area in a different part of the country.
3. Generate detailed information of typical PAH levels found at different locations as an aid in establishing appropriate and realistic cleanup levels for surface soil PAHs at sites undergoing remedial actions.

Summary of Approach

The following list gives general descriptions of the sampling and analysis approach.

- Thus far, samples have been collected from sites in the States of New York and Illinois. The sites were selected from urban areas and included utility-owned sites, parks, forested areas, roadside rights of way, fields, public properties, and selected commercial properties.
- For each state or region, a pseudo-random process was used to select the sample locations. The process involved randomly selecting populated areas within each state, randomly selecting a pre-determined number of sites within each area, and then selecting sampling locations at each site that were representative of the site and not impacted by known sources of PAHs.
- Sample collection locations were selected to be representative of the overall site conditions based on a visual assessment of the site and field judgment. Samples were not collected in immediate proximity to known sources of PAHs, such as railroad tracks.
- Since sites varied significantly in size, shape, and proximity to potential sources of PAHs, the sampling configurations were site-specific. The sample configurations were designed so that the soil samples collected were representative of the site as a whole or a specific portion of the site, if appropriate. Sampling locations for each site were kept in relatively close proximity to each other so that compositing these samples would be appropriate.
- Selected samples were composited in the laboratory prior to analysis, with only two and rarely three samples combined into one composite sample. Samples were analyzed for PAHs and total organic carbon (TOC).
- The precision and accuracy of the data were estimated using the results of quality control samples. The distribution and basic statistics of the data were calculated and reported. Also, the data were carefully examined for factors that correlate with the PAH concentrations, such as land use types and proximity to identifiable PAH sources.

EPRI Perspective

Natural and anthropogenic sources of polycyclic aromatic hydrocarbons (PAHs) in the environment are quite diverse due to many different factors of human activity or inactivity in an area. Consequently, PAHs are found in many samples of soil, water, and biota throughout the world. The frequent detection of PAHs in surface soil and sediment samples is of particular importance for environmental investigations and cleanups, because the concentrations of PAHs often define the extent of contamination and influence the estimated risk from contamination at a variety of sites. At many sites, it becomes very important to be able to determine where the site-specific contamination ends and where the local background PAHs begin. The EPRI Background PAH Study was designed to generate an internally consistent; rugged set of PAH concentrations in surface soils from numerous locations covering a range of land uses. This specific project completes the data set of a former effort to sample background soils in western and northwestern New York State. (EPRI Tech Report 1005295).

Report Organization

Section 2 presents the sampling and analysis methods used for this study, including the sampling design. The results obtained from this work are presented in Section 3. Section 4 contains a discussion of conclusions based on the results from the study. The references used in the development of this document are shown in Section 5.

2
SAMPLING AND ANALYSIS METHODS

Definitions

- *Sample Location* - the actual place where an individual sample was collected. Each sample location corresponds with the sample identification number on its sample jar and on the chain-of-custody form.
- *Site* - the property or plot of land containing one or more sample locations. For example, "Chestnut Hill Park" or "highway 1 median" was designated as the "site".
- *Area* - A city, town, county, or other locality that may contain multiple sites.
- *Urbanized Area (UA)* - an area consisting of a central place and adjacent urban fringe that together have a minimum residential population of at least 50,000 people and an overall population density of 1,000 people per square mile of land area (U.S. Census Bureau, 2000).
- *Populated Area* - an area that has a population density of 1,000 people per square mile of land area (equivalent to the UA), but with a minimum residential population of 10,000 people. The populated area designation includes smaller cities and towns that have significant urban centers, but do not meet the U.S. Census Bureau's definition of an urbanized area.

Sampling Design

A layered sampling design based on random sampling was used for the study. For western New York, two cities were selected for sampling based in part on their position on a randomly ranked list of populated areas in the service area of the participating utility, as well as judgments about the ease of gaining permission from city officials to perform the sampling and the value of performing a study in that area for the utility.

Next, a similar pseudo-random selection scheme was used to select a pre-determined number of sites within each area. The number of sites was based on an estimate of the number of samples needed for statistical significance and the number of areas chosen for the particular state or region.

As was generally the case during previous sampling, samples were collected from two areal locations at each site. The field engineer chose the sample locations at each site at the time of sample collection.

Selecting Areas to Sample

In New York, two populated areas were selected for sampling based on a combination of factors. First, only urbanized and populated areas within the service area of the participating utility were included in the mix of possible sampling areas. Then, the random number generator function in Microsoft® Excel was used to rank these areas. Finally, the principal investigators made judgments with the participating utility to determine the practicability of each potential sampling area. Based on these judgments, two areas were selected for sampling.

Selecting Sites to Sample

Once areas were selected for sampling, road maps and USGS 7.5 minute quad(s) for each area were used to select the actual sites to be sampled. The sites within each area were also selected randomly. A coordinate system was laid out over maps of each area and a random number generator was used to select points that fell on this coordinate system. In the field, the closest suitable site to each selected point was sampled. Suitable sampling sites included parks, roadway medians, utility rights-of-way, municipal properties, residential properties, parking lot buffers, or vacant lots. In western New York, 20 sites were sampled in one urbanized area (Rochester), while 10 sites were sampled in one populated area (Canandaigua).

Selecting Locations to Sample at Each Site

Two locations were sampled at each site and were selected by the field engineer to be representative of the overall site conditions based on a visual assessment of the site and judgment. The field engineer considered the area of the site, obstructions, visible evidence of contamination, and other practical matters. Samples were not collected in immediate proximity to known sources of PAHs, such as railroad tracks.

Sample Compositing and Analysis Scheme

Composites

At every location in this study, samples were collected from both 0 to 2.54 cm below grade and 2.54 to 15 cm below grade. The samples were labeled and shipped to META Environmental, Inc. in Watertown, Massachusetts for analysis. As described in the QAPP, all of the field samples were composited in the laboratory to decrease the number of analyses.

The samples from all 30 sites in western New York were composited in the same way. At each site, the four discrete samples collected were composited to create one sample that represented 0 to 15 cm for that site. Specifically, 10 grams from each of the 0 to 2.54 cm samples was mixed with 50 grams from each of the 2.54 to 15 cm samples to create a composite sample representative of the interval from 0 to 15 cm.

The original discrete samples are stored frozen for possible future analysis.

Sample Analysis

Each composited soil sample was analyzed for PAHs using vigorous Soxhlet extraction, EPA Method 3540C. A portion of each extract was cleaned up using silica gel columns (EPA Method 3630C mod.). The cleaned extracts were analyzed using GC/MS, EPA Method 8270 for PAHs only. (U.S. EPA, 1986)

Lastly, samples were analyzed for total organic carbon (TOC) using a modification (digestion with additional heat) of the Walkley-Black method (90-3, 1963).

Data Management and Analysis

All data were checked for errors and quality control acceptability. Deviations from the data quality objectives were noted on raw data worksheets. No quality control deviations were identified that were significant enough to reject any data. The sample identifiers, sample descriptions, and final data were entered into a database constructed using Microsoft® Access software. The data were coded so that simple queries could be used to extract subsets of the data, such as by depth or by populated area. For the purposes of this report, the data were exported to Microsoft® Excel spreadsheets for formatting.

All statistical and graphical analyses were conducted using commercial software (Statistica, version 6.0, from StatSoft, Inc.)

3
PRESENTATION OF RESULTS

Field Activities

For western New York, samples were collected from the cities of Canandaigua and Rochester. On July 29, 2003, ten sites in Canandaigua were sampled. From July 30 to August 1, 2003, 20 sites were sampled in Rochester. Two locations were sampled from each of the 30 sites samples in these two cities. Random locations were generated on maps of these two cities, and the nearest appropriate sampling locations were identified in the field.

The sampling procedures used for all of the locations in this study were the same. At each location, samples were collected with a clean stainless steel trowel from 0 to 2.54 cm and from 2.54 to 15 cm below grade, after peeling back surface vegetation, if present. Next, the soil from each interval was placed in a stainless steel bowl and homogenized. Then, the homogenized soil was placed in 4 oz soil jars with Teflon-lined screw caps. Lastly, the jars were labeled and placed on ice for shipment to the laboratory.

Site and Area Land Use Types

A total of 30 sites were sampled in western New York, including a variety of different types of sites. Based on observations made in the field, a subjective classification of the land use was made for each site sampled as part of this study. The site use classifications included recreational (40%), rights of way (30%), municipal (27%), and conservation (3%). No commercial, industrial, open land, residential, or utility sites were sampled in western New York. Recreational sites included ball fields and recreational parks. Sites where a municipal right of way existed, such as the areas near streets, were designated as rights of way even if they formed part of a residential or commercial lawn. The municipal designation was used for public areas such as police stations, fire stations, and town buildings, including schools. An example of a municipal site (Department of Public Works) is shown in Figure 3-1. Conservation sites included areas such as forest and nature preserves. Sites were considered utility sites either if they were owned by a utility or if there was a utility right of way in the area sampled. The residential sites were home lots or apartment complexes. Sites with businesses on them were designated as commercial for retail business, or as industrial for manufacturing or similar operations. The open land designation was used for land with no specific purpose or structures.

In addition to site use classifications, a subjective characterization of the surrounding area use was made at each of the 30 sites. The resulting area use classifications included heavy residential (57%), commercial (23%), light industrial (13%), heavy industrial (3%), and rural (3%). No sites were sampled in agricultural or light residential areas in western New York.

Areas were considered heavy residential if houses were present at a density of at least one house per acre. Figure 3-2 shows an example of a site in an area designated as heavy residential. Otherwise, if the houses were sparse, the area was assigned the light residential designation. Similarly, areas with a high density of non-retail businesses were considered heavy industrial, particularly if manufacturing was present. On the other hand, areas with just one or a few non-retail businesses were considered light industrial. Commercial was used to describe areas with retail businesses. For sites bordering farmland, the area was considered agricultural. Lastly, areas with very few businesses or residences, and without farmland, were designated as rural.

Figure 3-1
Example of Municipal Site – Department of Public Works

Figure 3-2
Example of a Heavy Residential Area Use Classification – Right of Way Site

Summary of Physical Sample Characteristics

Table A-1 (Appendix A) lists the sample identification, soil description, total organic carbon (TOC) content, and percent solids content for each of the samples analyzed. Consistent with the intent of the sampling plan, the samples contained various amounts of silt, sand, clay and gravel. For the 30 samples analyzed from western New York, the TOC levels ranged from 0.6% to slightly more than 10% with a median TOC of 3.1%. Similarly, the TOC levels from previously reported samples (EPRI, 2002) ranged from 0.5% to slightly more than 11% with a median TOC of 2.4%. The percent solids content was generally 80 to 95%, with a median of 90%, which was slightly higher overall compared with the previous data set (EPRI, 2002) but not unexpectedly, given the dry soil conditions at the time of the western New York sampling.

Sample Results for PAHs

The names of the PAHs have been codified in some tables and figures for ease of formatting. Table A-2 (Appendix A) shows the PAH names and codes used in this report.

Table A-3 (Appendix A) presents the full data set of PAH concentrations for the 30 sites sampled. Non-detects are reported as not detected below the sample-specific quantitation limits, as indicated by the "U" flag next to the concentration.

Summary Statistics for PAH Results from All Sites

For the previously reported data (EPRI, 2002), a reduced data set was generated for most of the statistical and graphical analyses that were conducted. The reduced data set was generated in two ways. First, one half the sample-specific quantitation limit was substituted for non-detects. Then, arithmetic composites were generated where the 0 to 2.54 cm and 2.54 to 15 cm samples were analyzed separately. This was done by generating weighted averages based on the sampling intervals, which are representative of the 0 to 15 cm interval at those locations.

For western New York, all of the samples analyzed were composite samples from 0 to 15 cm below grade. Table 3-1 lists the summary description statistics for all 30 samples. Included in the statistics for each compound are the mean, 95% confidence intervals of the mean, geometric mean, median, minimum and maximum values, range, upper and lower quartiles, quartile range, 5th and 95th percentiles, variance, standard deviation, standard error, skewness, and kurtosis. All statistics reported in Table 3-1 were performed on the raw data, assuming that the concentrations of each variable (PAH analyte) are normally distributed. As shown in Table 3-1, benzo(a)pyrene concentrations ranged from 7.5 to 4,740 µg/kg with a median concentration of 431 µg/kg. The upper quartile concentration was 1,040 µg/kg, while the upper 95th percentile concentration was 2,770 µg/kg. These concentrations appear to be consistent with literature-reported levels for anthropogenic background in small to medium-sized residential, commercial, and light industrial areas, but notably lower than background observed in more highly populated cities and commercial/industrial areas (Bradley et al., 1994 and MA DEP, 2002).

Table 3-1
Summary Statistics for Raw PAH Data in Western New York (µg/kg)

PAHs	Valid N	Mean	Lower 95% Confidence	Upper 95% Confidence	Geometric Mean	Median	Minimum	Maximum	Range
NAP	30	100	47.1	153	51.8	42.6	8.01	667	659
2MN	30	89.8	27.2	152	30.3	29.8	2.25	816	814
ACY	30	119	55.1	183	42.6	52.8	3.18	713	710
ACE	30	47.1	20.9	73.3	19.2	15.5	2.67	260	257
FLU	30	55.3	26	84.7	23.5	24.7	1.91	319	317
PHE	30	797	400	1,190	328	353	6.48	4,820	4,810
ANT	30	205	99.7	311	78.8	83.8	1.37	1,330	1,330
FLR	30	1,470	765	2,170	677	715	19.5	9,010	8,990
PYR	30	1,160	615	1,700	542	553	17	6,750	6,730
BAA	30	690	363	1,020	298	330	8.44	3,910	3,900
CHR	30	794	434	1,150	376	391	11.6	4,330	4,320
BBF	30	728	405	1,050	308	358	5.3	3,340	3,330
BKF	30	613	344	881	306	383	9.36	3,350	3,340
BAP	30	830	440	1,220	370	431	7.48	4,740	4,730
IND	30	502	253	752	193	246	5.03	2,330	2,320
DAA	30	181	92	270	68.6	88.8	1.83	819	817
BGP	30	541	280	801	223	247	7.28	2,420	2,410

All statistics calculated with not-detected results equal to one half of the detection limits, which are shown for each sample in Table A-3.

Table 3-1 (cont.)
Summary Statistics for Raw PAH Data in Western New York (µg/kg)

PAHs	Lower Quartile	Upper Quartile	Quartile Range	5th Percentile	95th Percentile	Variance	Standard Deviation	Standard Error	Skewness	Kurtosis
NAP	21.5	114	92.5	10.3	443	20,200	142	26	2.86	9
2MN	10.3	68	57.7	2.51	360	28,100	168	30.6	3.29	12.2
ACY	8.36	128	120	4.06	514	29,200	171	31.2	2.16	4.64
ACE	7.2	51.8	44.6	3.78	231	4,920	70.1	12.8	2.09	3.6
FLU	8.02	79.4	71.4	3.93	254	6,180	78.6	14.4	2.18	4.49
PHE	107	1,070	963	14.9	2,820	1,130,000	1,060	194	2.33	6.39
ANT	20.3	317	297	10.3	592	80,100	283	51.7	2.47	7.77
FLR	240	1,760	1,520	27.6	4,970	3,540,000	1,880	344	2.58	8.32
PYR	199	1,450	1,250	24.1	4,090	2,120,000	1,460	266	2.38	6.84
BAA	95.2	983	888	9.01	2,250	766,000	875	160	2.16	5.43
CHR	129	1,120	991	18.3	2,490	930,000	964	176	2.1	5.23
BBF	111	968	857	10.3	2,370	748,000	865	158	1.55	1.73
BKF	106	749	643	13.7	1,760	519,000	720	131	2.24	6.25
BAP	135	1,040	905	10.6	2,770	1,090,000	1,040	191	2.25	5.95
IND	81.3	489	408	8.17	2,170	446,000	667	122	1.76	2.02
DAA	27.3	187	160	2.3	818	56,900	238	43.5	1.75	2.09
BGP	95.8	542	446	12.9	2,100	487,000	698	127	1.65	1.57

All statistics calculated with not-detected results equal to one half of the detection limits, which are shown for each sample in Table A-3.

The differences between the mean concentrations and the median concentrations, as well as the skewness value (skewness near zero is indicative of a normal distribution) strongly suggest that the data are not normally distributed. This observation was explored further using normal probability plots and frequency histograms. Figures 3-4 and 3-5 show normal probability plots and frequency histograms for pyrene and benzo(a)pyrene that clearly indicate the lognormal distribution of the data for those analytes. Similar plots were developed for the other analytes with similar results, but are not included in this report. Considering the underlying distributions of the data, the summary statistics for the full data set were recalculated on the natural logarithms of the raw data and then back-transformed to concentrations.

Figures 3-6 and 3-7 show the normal probability plots and frequency histograms for the log-transformed concentration data of pyrene and benzo(a)pyrene. In contrast to the raw concentration data, the log-transformed data are clearly normally distributed.

Table 3-2 shows the summary description statistics for the data set determined from the log-normalized data and Table 3-3 shows these values back-transformed to concentrations. The values for skewness and kurtosis are generally near zero, which suggests that the concentrations of the various PAHs in the samples have a lognormal distribution. As shown in Table 3-3, statistics such as the median, quartiles, and percentiles do not change when using transformed data because they are not based on parametric statistics. However, the mean, variance, standard error, and confidence intervals about the mean change substantially when using log-transformed data. Again, these concentrations appear to be consistent with literature-reported levels for anthropogenic background in small to medium-sized residential, commercial, and light industrial areas, but notably lower than background observed in more highly populated cities and commercial/industrial areas.

As discussed above, the individual PAH distributions are generally lognormal. In particular, analytes for which there were few non-detects, such as pyrene, clearly show lognormal distributions. However, some deviations from a lognormal distribution were noted. Specifically, analytes for which there were relatively many non-detects and low concentrations, such as acenaphthene and naphthalene, are not as well behaved. This is common for data sets with many measurements near or below the detection limits.

Quality Assurance/Quality Control (QA/QA) Results

Laboratory QC followed the Quality Assurance Project Plan (QAPP) with regard to holding times, blanks, surrogate and matrix spikes, and replicates. The results of laboratory QC checks were well within the QAPP-specified criteria with few exceptions.

The reporting limits were based on the sample equivalent of the lowest linear calibration standard. The reporting limits ranged from about 4 µg/kg to about 20 µg/kg, depending on the compound and sample conditions. Detection limits were about one half of the reporting limits and based on actual signal to noise ratios.

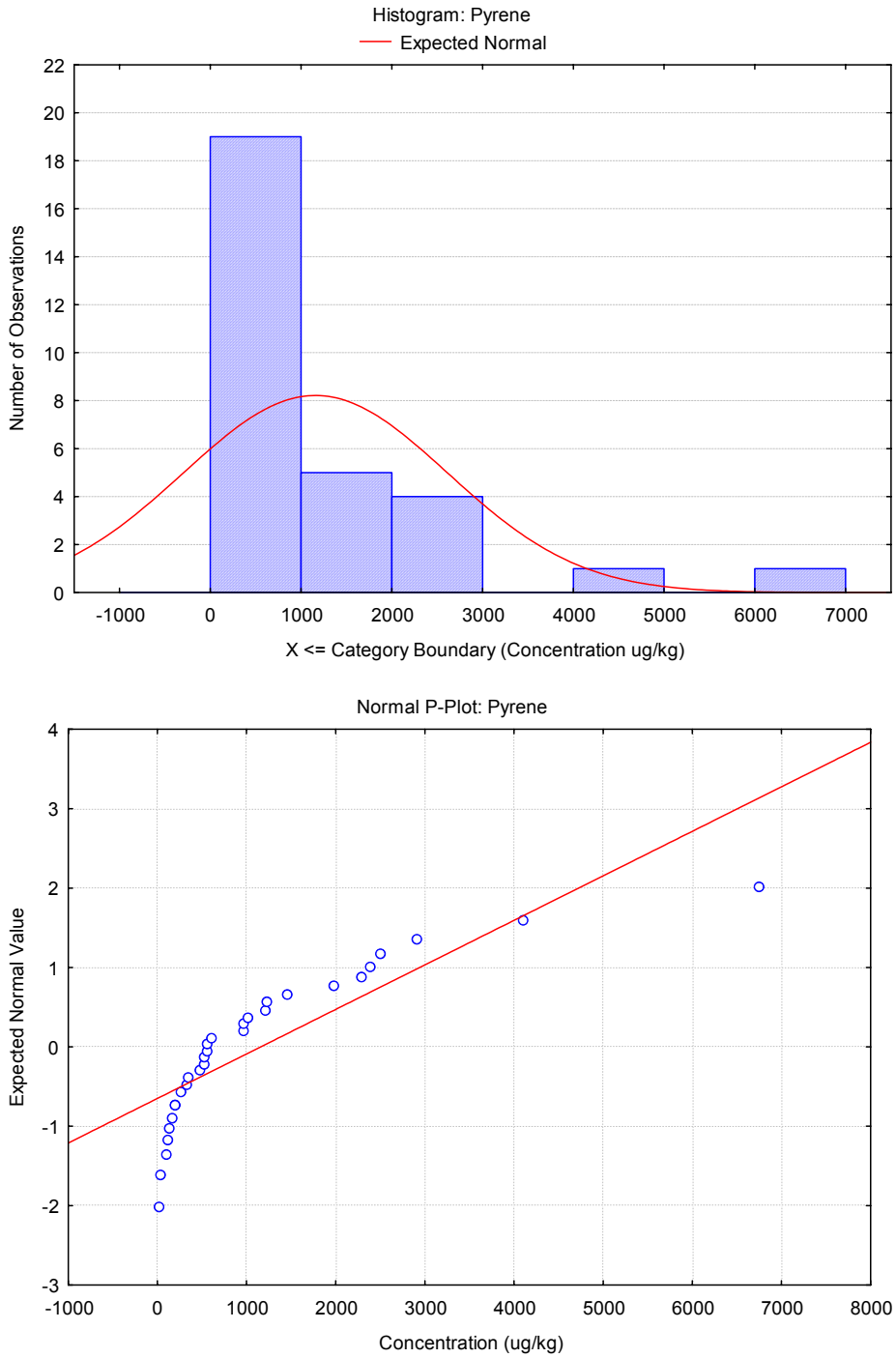

Figure 3-3
Normal Histogram and Probability Plot for Pyrene

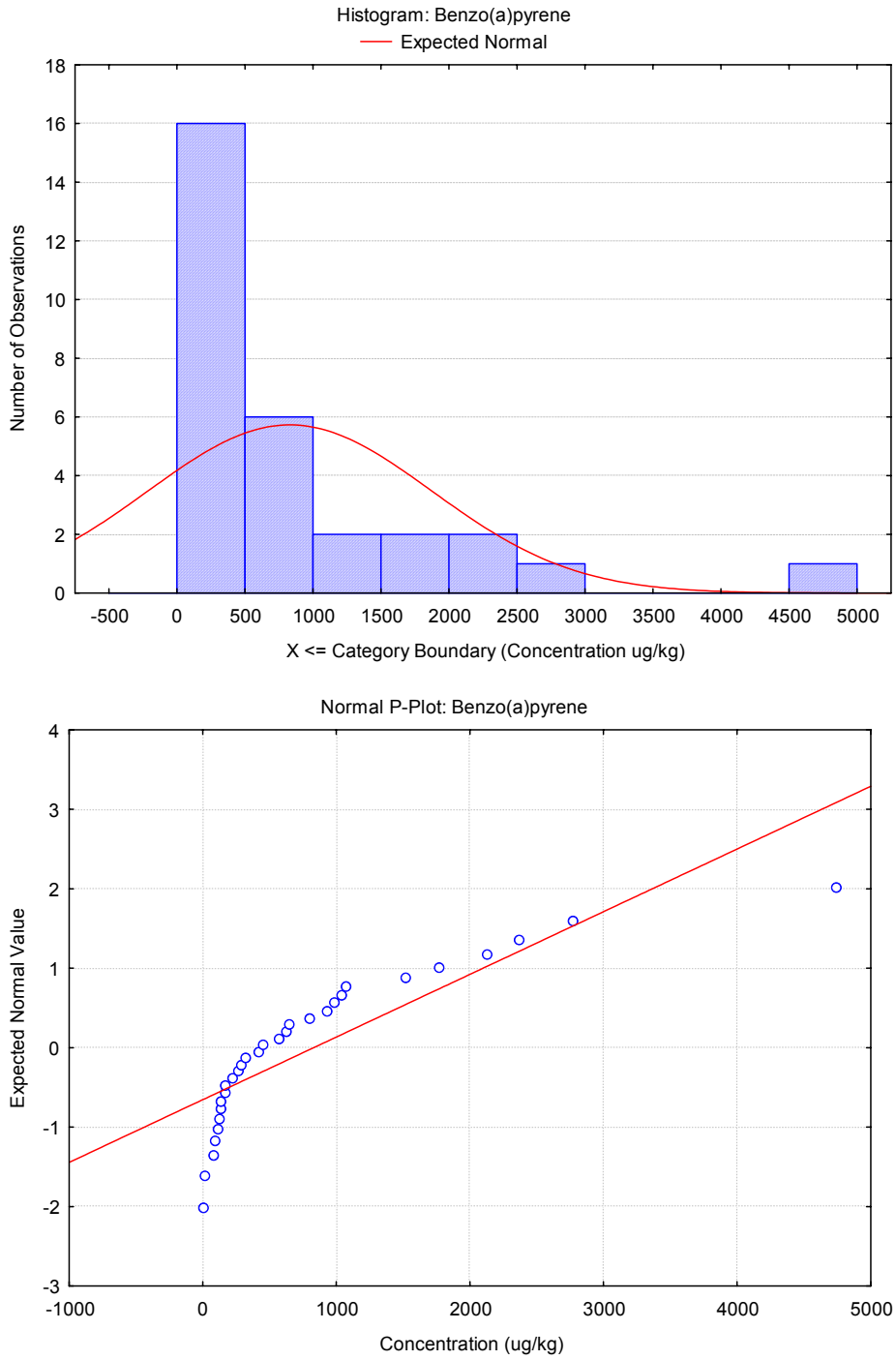

Figure 3-4
Normal Histogram and Probability Plot for Benzo(a)pyrene

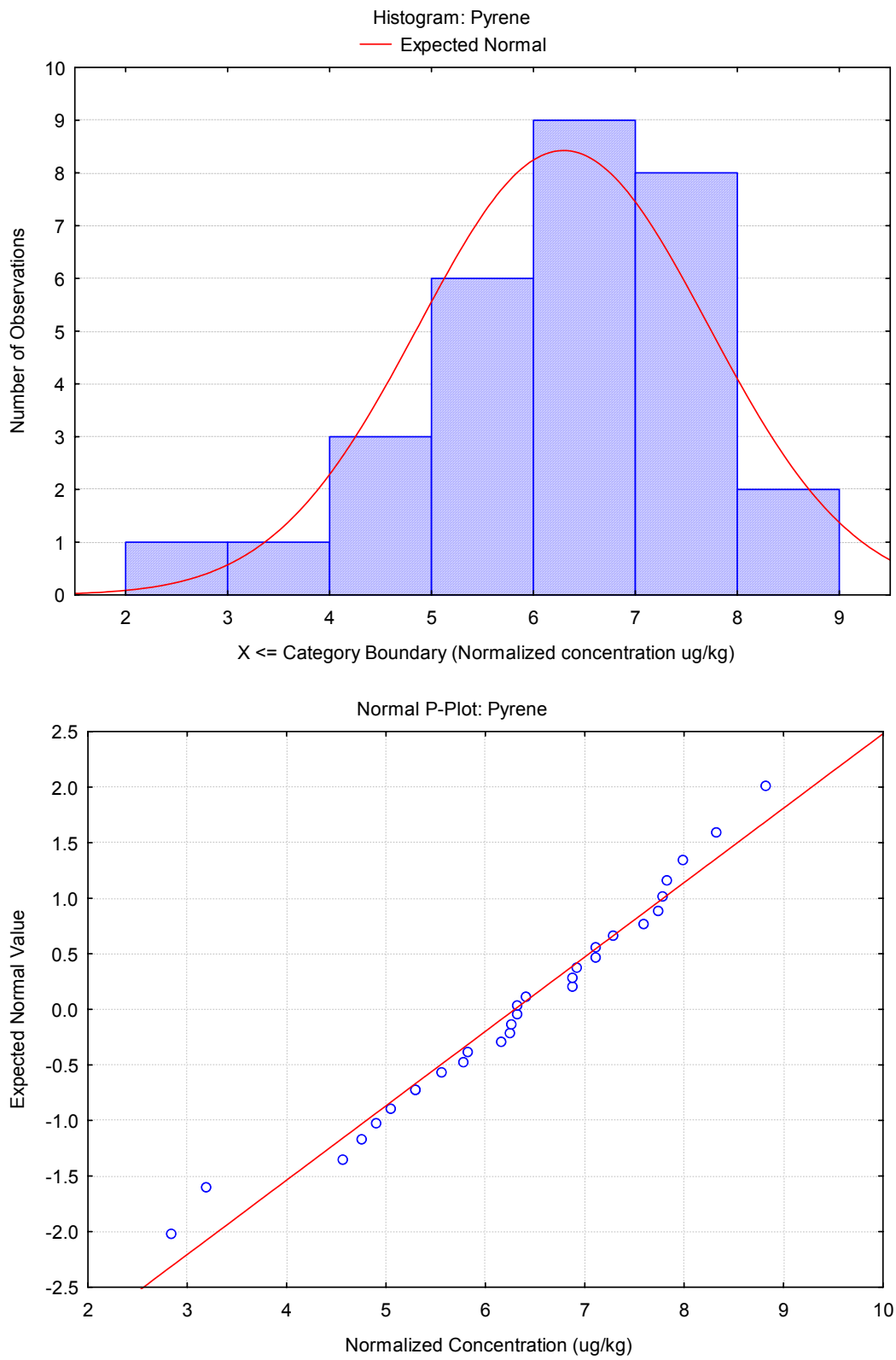

Figure 3-5
Lognormal Histogram and Probability Plot for Pyrene

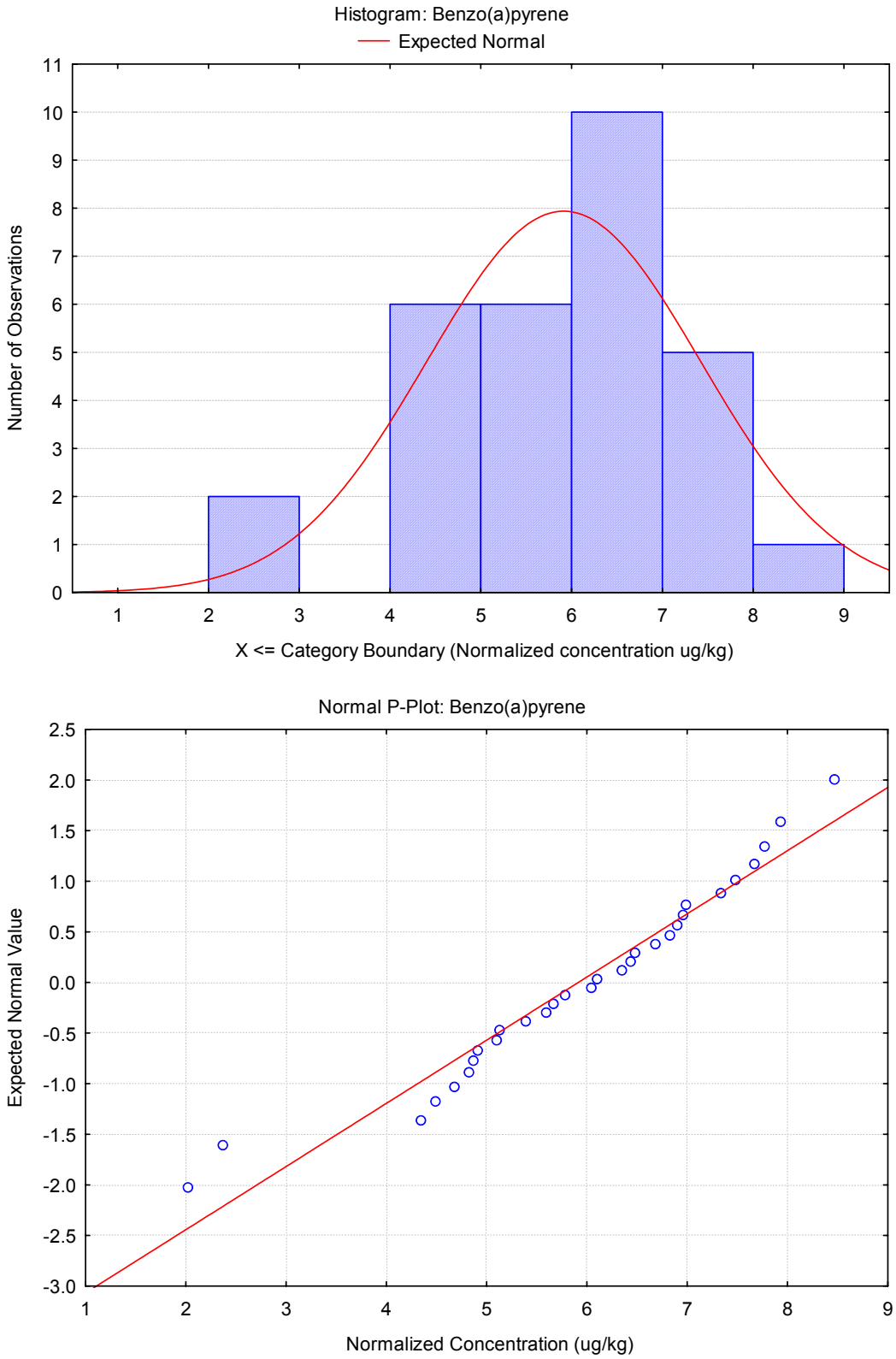

Figure 3-6
Lognormal Histogram and Probability Plot for Benzo(a)pyrene

Table 3-2
Summary Statistics of Normalized PAH Data in Western New York (µg/kg)

PAHs	Valid N	Mean	Lower 95% Confidence	Upper 95% Confidence	Geometric Mean	Median	Minimum	Maximum	Range
NAP	30	3.95	3.52	4.37	3.79	3.75	2.08	6.5	4.42
2MN	30	3.41	2.86	3.96	3.07	3.36	0.81	6.7	5.89
ACY	30	3.75	3.16	4.34	3.38	3.92	1.16	6.57	5.41
ACE	30	2.95	2.45	3.45	2.66	2.74	0.98	5.56	4.58
FLU	30	3.16	2.65	3.66	2.84	3.21	0.65	5.77	5.12
PHE	30	5.79	5.22	6.37	5.55	5.86	1.87	8.48	6.61
ANT	30	4.37	3.77	4.96	3.92	4.43	0.31	7.19	6.88
FLR	30	6.52	5.98	7.06	6.34	6.57	2.97	9.11	6.14
PYR	30	6.3	5.77	6.83	6.11	6.32	2.83	8.82	5.98
BAA	30	5.7	5.13	6.26	5.45	5.8	2.13	8.27	6.14
CHR	30	5.93	5.4	6.45	5.74	5.97	2.45	8.37	5.92
BBF	30	5.73	5.14	6.32	5.46	5.87	1.67	8.11	6.45
BKF	30	5.72	5.21	6.24	5.53	5.94	2.24	8.12	5.88
BAP	30	5.91	5.35	6.48	5.67	6.06	2.01	8.46	6.45
IND	30	5.26	4.66	5.86	4.96	5.5	1.62	7.75	6.14
DAA	30	4.23	3.62	4.84	3.77	4.49	0.6	6.71	6.1
BGP	30	5.41	4.85	5.97	5.17	5.51	1.99	7.79	5.81

All statistics calculated with not-detected results equal to one half of the detection limits, which are shown for each sample in Table A-3.

Table 3-2 (cont.)
Summary Statistics of Normalized PAH Data in Western New York (µg/kg)

PAHs	Lower Quartile	Upper Quartile	Quartile Range	5th Percentile	95th Percentile	Variance	Standard Deviation	Standard Error	Skewness	Kurtosis
NAP	3.07	4.74	1.67	2.33	6.09	1.29	1.14	0.21	0.39	-0.45
2MN	2.33	4.22	1.89	0.92	5.89	2.16	1.47	0.27	0.38	-0.27
ACY	2.12	4.85	2.73	1.4	6.24	2.51	1.58	0.29	0.01	-1.15
ACE	1.97	3.95	1.97	1.33	5.44	1.79	1.34	0.24	0.55	-0.82
FLU	2.08	4.37	2.29	1.37	5.54	1.85	1.36	0.25	0.23	-0.83
PHE	4.67	6.98	2.3	2.7	7.94	2.38	1.54	0.28	-0.5	0.19
ANT	3.01	5.76	2.75	2.33	6.38	2.52	1.59	0.29	-0.36	-0.16
FLR	5.48	7.47	1.99	3.32	8.51	2.07	1.44	0.26	-0.6	0.35
PYR	5.29	7.28	1.99	3.18	8.32	2.02	1.42	0.26	-0.57	0.26
BAA	4.56	6.89	2.33	2.2	7.72	2.3	1.52	0.28	-0.58	0.18
CHR	4.86	7.02	2.16	2.91	7.82	1.97	1.4	0.26	-0.53	0.23
BBF	4.71	6.88	2.17	2.33	7.77	2.49	1.58	0.29	-0.69	0.38
BKF	4.66	6.62	1.96	2.62	7.47	1.89	1.37	0.25	-0.69	0.54
BAP	4.91	6.95	2.04	2.36	7.93	2.27	1.51	0.28	-0.75	0.79
IND	4.4	6.19	1.79	2.1	7.68	2.59	1.61	0.29	-0.44	-0.21
DAA	3.31	5.23	1.92	0.83	6.71	2.69	1.64	0.3	-0.48	-0.22
BGP	4.56	6.3	1.73	2.56	7.65	2.25	1.5	0.27	-0.3	-0.32

All statistics calculated with not-detected results equal to one half of the detection limits, which are shown for each sample in Table A-3.

Table 3-3
Back-Transformed PAH Statistics in Western New York (µg/kg)

PAHs	Valid N	Mean	Lower 95% Confidence	Upper 95% Confidence	Geometric Mean	Median	Minimum	Maximum	Range
NAP	30	51.8	33.9	79.2	44.2	42.6	8.01	667	83.3
2MN	30	30.3	17.5	52.5	21.5	29.8	2.25	816	363
ACY	30	42.6	23.6	77	29.5	52.8	3.18	713	224
ACE	30	19.2	11.6	31.6	14.4	15.5	2.67	260	97.4
FLU	30	23.5	14.1	39	17.1	24.7	1.91	319	167
PHE	30	328	184	583	257	353	6.48	4,820	744
ANT	30	78.8	43.5	143	50.5	83.8	1.37	1,330	971
FLR	30	677	396	1,160	565	715	19.5	9,010	462
PYR	30	542	319	922	452	553	17	6,750	397
BAA	30	298	169	525	234	330	8.44	3,910	463
CHR	30	376	222	634	310	391	11.6	4,330	373
BBF	30	308	171	555	234	358	5.3	3,340	630
BKF	30	306	183	511	251	383	9.36	3,350	358
BAP	30	370	211	650	291	431	7.48	4,740	634
IND	30	193	106	352	143	246	5.03	2,330	463
DAA	30	68.6	37.2	127	43.2	88.8	1.83	819	448
BGP	30	223	128	391	177	247	7.28	2,420	332

All statistics calculated with not-detected results equal to one half of the detection limits, which are shown for each sample in Table A-3.

Table 3-3 (cont.)
Back-Transformed PAH Statistics in Western New York (µg/kg)

PAHs	Lower Quartile	Upper Quartile	Quartile Range	5th Percentile	95th Percentile	Variance	Standard Deviation	Standard Error	Skewness	Kurtosis
NAP	21.5	114	5.3	10.3	443	3.63	3.11	1.23	1.48	0.64
2MN	10.3	68	6.6	2.51	360	8.69	4.35	1.31	1.46	0.76
ACY	8.36	128	15.3	4.06	514	12.3	4.88	1.34	1.01	0.32
ACE	7.2	51.8	7.19	3.78	231	5.97	3.81	1.28	1.73	0.44
FLU	8.02	79.4	9.9	3.93	254	6.38	3.9	1.28	1.26	0.44
PHE	107	1,070	10	14.9	2,820	10.8	4.67	1.33	0.61	1.2
ANT	20.3	317	15.6	10.3	592	12.5	4.9	1.34	0.7	0.85
FLR	240	1,760	7.33	27.6	4,970	7.96	4.22	1.3	0.55	1.41
PYR	199	1,450	7.29	24.1	4,090	7.52	4.14	1.3	0.56	1.3
BAA	95.2	983	10.3	9.01	2,250	9.99	4.56	1.32	0.56	1.2
CHR	129	1,120	8.68	18.3	2,490	7.17	4.07	1.29	0.59	1.25
BBF	111	968	8.72	10.3	2,370	12	4.84	1.33	0.5	1.46
BKF	106	749	7.07	13.7	1,760	6.6	3.95	1.29	0.5	1.72
BAP	135	1,040	7.7	10.6	2,770	9.7	4.52	1.32	0.47	2.21
IND	81.3	489	6.01	8.17	2,170	13.4	5.01	1.34	0.64	0.81
DAA	27.3	187	6.85	2.3	818	14.7	5.15	1.35	0.62	0.8
BGP	95.8	542	5.66	12.9	2,100	9.52	4.49	1.32	0.74	0.72

All statistics calculated with not-detected results equal to one half of the detection limits, which are shown for each sample in Table A-3.

Two field duplicate samples were collected in western New York. Field duplicates were samples from the same site and interval placed in separate jars in the field by the field engineer. They were shipped to the laboratory separately and processed by the laboratory as independent samples. The precision of soil duplicates was measured using the relative percent difference (RPD) statistic. This statistic is the range divided by the mean times 100. The RPDs varied by sample and by compound, but were all less than 50%. Table A-4 shows the field duplicate results.

Two laboratory duplicate samples were prepared in the laboratory by analyzing two separate aliquots of two composited samples from western New York. The laboratory duplicates provide information on the combined effects of the effectiveness of the soil homogenization step and the variability in sample extraction and analysis. Duplicate sample RPDs can vary substantially between soil samples dependent on the inherent soil heterogeneity and matrix complexity. RPDs less than about 50% are considered good for soil samples. Table A-5 shows the laboratory duplicate results.

Surrogate compounds were added to each sample prior to extraction to monitor the analytical performance. The surrogate compounds used for this study included nitrobenzene-d5, 2-fluorobiphenyl, p-terphenyl-d14, and benzo(a)pyrene-d12. The recoveries of surrogate compounds were within the QAPP-specified limits of 50 to 150% with few exceptions.

In addition to surrogate compound spikes, selected samples were spiked with all 17 PAHs at known concentrations. The recoveries of matrix-spiked compounds were within the QAPP-specified limits of 50 to 150% with few exceptions.

4
CONCLUSIONS

As part of the ongoing EPRI nationwide background PAH study, two municipalities in western New York with a population of at least 10,000 people and a population density of at least 1,000 people per square mile were sampled. Samples were collected from ten sites in Canandaigua and 20 sites in Rochester, with two locations sampled at each site. At each location, samples were collected from 0 to 2.54 cm and 2.54 to 15 cm below grade, after removing surface vegetation, if present. During sampling, subjective classifications of the site use and area use were made along with detailed descriptions of the soil types contained in each sample. A total of 30 sites were sampled during this part of the study.

The samples that were collected in western New York were composited in the laboratory, with one composite sample generated for each site. Specifically, the four discrete samples collected from each site were composited to create one sample that represented 0 to 15 cm for that site.

The soil characteristics were representative of typical surface soils found in many areas of the United States. The samples contained various amounts of silt, sand, clay, and gravel. The median TOC content was 3.1% and the median percent solids content was 90%.

Summary statistics were performed on the data set, with all samples expressed as a 0 to 15 cm sample interval. The results of these manipulations indicate that the data are generally lognormally distributed for all of the PAHs. As shown in Table 3-1, benzo(a)pyrene concentrations ranged from 7.5 to 4,740 µg/kg with a median concentration of 431 µg/kg. The upper quartile concentration was 1,040 µg/kg, while the upper 95th percentile concentration was 2,770 µg/kg.

These concentrations appear to be consistent with literature-reported levels for anthropogenic background in small to medium-sized residential, commercial, and light industrial areas, but notably lower than background observed in more highly populated cities and commercial/industrial areas, as shown in Table 4-1 (Bradley et al., 1994 and MA DEP, 2002). In comparison to the previous EPRI study results, these benzo(a)pyrene concentrations were generally higher, as illustrated by the mean, median, and 95th percentile values, although the maximum concentration measured was lower.

Table 4-1
Summary Benzo(a)pyrene Statistics for Other Data Sets Compared to this Study (µg/kg)

Data Set	N	Range	Mean	Median	95th Percentile
CA/T Project[1]	873	31 – 230,000	NA	300	17,000
LSPA Project[2]	489	ND – 222,000	NA	440	NA
Watertown[3]	17	600 – 6,080	NA	NA	4,770
Med City/Mill Brook[4]	67	ND – 9,700	NA	NA	3,300
ENSR – Urban Soils[5]	62	ND – 13,000	1,320	NA	NA
EPRI Study – 2002[6]	218	ND – 11,700	382	98.2	1,510
EPRI Study – Western NY Data	*30*	*7.5 – 4,740*	*830*	*431*	*2,770*

[1] Data collected by the Massachusetts Highway Department as part of the Central Artery/Tunnel (CA/T) project in Boston, presented in the draft document "CA/T ROW Background Soil Contaminant Assessment", Camp Dresser and McKee, April 1996.

[2] Preliminary data submitted to the Massachusetts Licensed Site Professional Association by its members and compiled in the personal communication, "Summary of Selected Results, LSPA Anthropogenic Fill Soils Projects", LSPA, April 2001.

[3] Site-specific background samples collected in Watertown, MA.

[4] Site-specific background samples collected in Worcester, MA.

[5] Data from background surficial samples collected in Boston, MA, Providence, RI, and Springfield, MA by ENSR (published in Bradley et al., 1994).

[6] EPRI background PAH study data from New York and Illinois reported in Technical Update 1005295 (EPRI, 2002).

5
REFERENCES

Blumer, M., "Polycyclic Aromatic Compounds in Nature," Scientific American, Vol. 243, pp. 35-45 (1976).

Bradley, L.J.N., B.H. Magee, and S.L. Allen, "Background Levels of Polycyclic Aromatic Hydrocarbons (PAHs) and Selected Metals in New England Urban Soils". Journal of Soil Contamination. Vol. 3, pp. 349-361 (1994).

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring. John Wiley & Sons, Inc., New York, NY.

Literature Review of Polycyclic Aromatic Hydrocarbons, EPRI, Palo Alto, CA: 2000. TR-114755.

Massachusetts Department of Environmental Protection (MA DEP). May 2002. *Technical Update – Background Levels of Polycyclic Aromatic Hydrocarbons and Metals in Soil.*

Polycyclic Aromatic Hydrocarbons (PAHs) in Surface Soil, EPRI, Palo Alto, CA: 2002. 105295.

90-3, Standard Methods of Chemical Analysis, 6th Edition, D. Van Nostrand Co., Princeton, NJ, 1963.

Statistica version 6.0, StatSoft, Inc., Tulsa OK 74104.

U.S. EPA, 1986. Test Methods for Evaluating Solid Waste Physical/Chemical Methods. SW-846 Third Edition. Office of Solid Waste, U.S. EPA, Washington, D.C.

A
TABLES

Table A-1
Sample Soil Descriptions, Total Organic Carbon, and Percent Solids

Field ID	Sample Description	TOC (mg/kg)	% Solids
NYCA01-Comp(0-15	Silt with sand	37,300	82.5%
NYCA02-Comp(0-15	Silt with gravel and clay	22,800	80.8%
NYCA03-Comp(0-15	Silt with sand and gravel	63,100	86.9%
NYCA04-Comp(0-15	Silt with sand and gravel	29,600	83.1%
NYCA05-Comp(0-15	Sand with silt	6,010	90.9%
NYCA06-Comp(0-15	Silt with sand	39,300	81.2%
NYCA07-Comp(0-15	Silt with clay and gravel	31,300	85.6%
NYCA08-Comp(0-15	Silt with sand and clay	30,800	84.5%
NYCA09-Comp(0-15	Silt with sand	25,900	85.2%
NYCA10-Comp(0-15	Silt with sand and gravel	28,300	85.4%
NYRO01-Comp(0-15	Silt with sand and gravel	31,700	90.6%
NYRO02-Comp(0-15	Silt with clay and gravel	23,900	88.4%
NYRO03-Comp(0-15	Sand with silt	23,100	94.6%
NYRO04-Comp(0-15	Silt with sand and gravel	14,400	88.2%
NYRO05-Comp(0-15	Silt with clay and gravel	33,700	94.2%
NYRO06-Comp(0-15	Silt with sand and clay	48,700	92.2%
NYRO07-Comp(0-15	Silt with sand and gravel	101,000	92.6%
NYRO08-Comp(0-15	Silt with sand and clay	31,400	92.5%
NYRO09-Comp(0-15	Silt with sand and gravel	32,400	91.5%
NYRO10-Comp(0-15	Sand with silt and gravel	23,100	95.1%
NYRO11-Comp(0-15	Silt with sand and clay	22,300	92.8%
NYRO12-Comp(0-15	Silt with gravel and sand	24,500	91.3%
NYRO13-Comp(0-15	Silt with sand and gravel	22,600	89.6%
NYRO14-Comp(0-15	Silt with sand and clay	45,800	85.1%
NYRO15-Comp(0-15	Sand with silt and gravel	30,900	92.5%
NYRO16-Comp(0-15	Sand with silt and clay	18,800	94.4%
NYRO17-Comp(0-15	Silt with sand and gravel	31,100	88.5%
NYRO18-Comp(0-15	Silt with sand and gravel	35,400	92.0%
NYRO19-Comp(0-15	Silt with sand and gravel	38,600	90.4%
NYRO20-Comp(0-15	Silt with sand and gravel	30,000	88.5%

Table A-2
Key to Abbreviations for PAHs

Compounds	Abbreviation
Naphthalene	NAP
2-Methylnaphthalene	MN2
Acenaphthylene	ACY
Acenaphthene	ACE
Fluorene	FLU
Phenanthrene	PHE
Anthracene	ANT
Fluoranthene	FLR
Pyrene	PYR
Benz(a)anthracene	BAA
Chrysene	CHR
Benzo(b)fluoranthene	BBF
Benzo(k)fluoranthene	BKF
Benzo(a)pyrene	BAP
Indeno(1,2,3-cd)pyrene	IND
Dibenz(a,h)anthracene	DAA
Benzo(g,h,i)perylene	BGP

Table A-3
Polycyclic Aromatic Hydrocarbon (PAH) Results in Background Surface Soils

Site	NYCA01		NYCA02		NYCA03	NYCA04	NYCA05		NYCA06	NYCA07		NYCA08	
Sample	Comp(0-15)		Comp(0-15)		Comp(0-15)	Comp(0-15)	Comp(0-15)		Comp(0-15)	Comp(0-15)		Comp(0-15)	
Units	µg/Kg		µg/Kg		µg/Kg	µg/Kg	µg/Kg		µg/Kg	µg/Kg		µg/Kg	
Naphthalene	21.5		20.6	U	89.9	114	8.01	J	98.7	46.3		276	
2-Methylnaphthalene	4.47	J	20.6	U	92.1	38.9	2.51	J	57.2	22.4		265	
Acenaphthylene	6.08	J	20.6	U	417	514	4.06	J	76.5	89.8		128	
Acenaphthene	7.23	J	20.6	U	31.2	50.7	18.3	U	29.9	10.3	J	16.5	J
Fluorene	8.02	J	20.6	U	41.8	88.3	18.3	U	40.5	25.2		28.7	
Phenanthrene	159		6.48	J	1,070	1,550	14.9	J	664	316		546	
Anthracene	30		20.6	U	297	583	1.37	J	142	97.3		106	
Fluoranthene	418		19.5	J	3,010	3,550	27.6		1,210	732		1,310	
Pyrene	320		17	J	2,490	2,910	24.1		962	522		1,010	
Benz(a)anthracene	131		9.01	J	1,420	2,100	8.44	J	493	335		538	
Chrysene	173		11.6	J	1,820	2,120	18.3		616	383		621	
Benzo(b)fluoranthene	116		5.3	J	1,770	2,370	10.3	J	480	316		539	
Benzo(k)fluoranthene	162		9.36	J	1,370	1,760	13.7	J	466	420		549	
Benzo(a)pyrene	164		7.48	J	1,770	2,770	10.6	J	572	417		647	
Indeno(1,2,3-	84.5		5.03	J	1,240	2,170	8.17	J	331	340		344	
Dibenz(a,h)anthracene	27.3	J	1.83	J	476	819	4.93	J	130	114		129	
Benzo(g,h,i)perylene	102		7.28	J	1,360	2,420	12.9	J	370	367		356	

D Concentration obtained from a diluted extract
E Estimated concentration detected above calibration limit
J Estimated value detected below the quantitation limit but above the detection limit
U Target compound not detected at or above the given concentration

Table A-3 (cont.)
Polycyclic Aromatic Hydrocarbon (PAH) Results in Background Surface Soils

Site	NYCA09		NYCA10		NYRO01		NYRO02		NYRO03	NYRO04	NYRO05		NYRO06	
Sample	Comp(0-15)		Comp(0-15)		Comp(0-15)		Comp(0-15)		Comp(0-15)	Comp(0-15)	Comp(0-15)		Comp(0-15)	
Units	µg/Kg		µg/Kg		µg/Kg		µg/Kg		µg/Kg	µg/Kg	µg/Kg		µg/Kg	
Naphthalene	38.8		34.7		133		32.1		90.8	27.5	443		88	
2-Methylnaphthalene	18.3	J	11.9	J	101		13.9	J	41.9	20.7	360		64	
Acenaphthylene	174		67.7		306		7.12	J	222	37.8	713		91.9	
Acenaphthene	10.5	J	5.14	J	209		3.78	J	51.8	4.07	260		14.4	J
Fluorene	7.08	J	15.3	J	209		3.93	J	51	7	319		28.3	
Phenanthrene	168		239		2,820		77.3		971	118	4,820	D	401	
Anthracene	86.2		70.7		579		12.9	J	308	30.6	1,330		73.5	
Fluoranthene	577		706		4,970	D	240		2,760	354	9,010	D	724	
Pyrene	513		551		4,090	D	199		2,280	338	6,750	D	604	
Benz(a)anthracene	399		308		2,250		92.8		1,860	179	3,910	D	324	
Chrysene	437		306		2,490		129		2,090	218	4,330	D	398	
Benzo(b)fluoranthene	466		210		2,240		111		1,990	239	3,340	D	399	
Benzo(k)fluoranthene	418		282		988		106		1,440	230	3,350	D	347	
Benzo(a)pyrene	622		321		2,130		135		2,360	218	4,740	D	444	
Indeno(1,2,3-	460		150		1,700		81.3		1,850	104	2,330	D	251	
Dibenz(a,h)anthracene	187		51.8		648		29.1	J	552	39.4	818	D	89	
Benzo(g,h,i)perylene	542		143		1,880		90.4		2,010	95.8	2,100	D	269	

D Concentration obtained from a diluted extract
E Estimated concentration detected above calibration limit
J Estimated value detected below the quantitation limit but above the detection limit
U Target compound not detected at or above the given concentration

Table A-3 (cont.)
Polycyclic Aromatic Hydrocarbon (PAH) Results in Background Surface Soils

Site	NYRO07	NYRO08	NYRO09	NYRO10	NYRO11	NYRO12	NYRO13	NYRO14
Sample	Comp(0-15)	Comp(0-15)	Comp(0-15)	Comp(0-15)	Comp(0-15)	Comp(0-15)	Comp(0-15)	Comp(0-15)
Units	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg
Naphthalene	667	149	122	74.9	36.6	17.5 J	16.2 J	12.9 J
2-Methylnaphthalene	816	68	155	37.1	37.2	13.8 J	7 J	9.26 J
Acenaphthylene	287	32.6	36.7	72.8	17.1 J	13.8 J	7.58 J	8.36 J
Acenaphthene	80.3	231	16.5	107	17.7 J	7.2 J	18.6 U	4.54 J
Fluorene	79.4	254	26.1	111	24.2	9.72 J	18.6 U	4.83 J
Phenanthrene	1,550	2,570	390	1,660	313	148	68.9	96
Anthracene	395	592	81.4	378	58.9	28.6	11.4 J	19.6 J
Fluoranthene	1,580	3,040	648	1,550	588	334	117	236
Pyrene	1,220	2,380	555	966	473	259	95.8	199
Benz(a)anthracene	983	1,040	265	864	206	119	53.2	83.3
Chrysene	1,190	1,120	299	930	262	169	77.2	127
Benzo(b)fluoranthene	791	968	305	697	272	135	55.3	101
Benzo(k)fluoranthene	645	749	280	659	242	155	59.4	105
Benzo(a)pyrene	1,040	1,070	267	982	286	167	76.2	130
Indeno(1,2,3-	814	479	118	693	156	94.1	13.7 J	77.1
Dibenz(a,h)anthracene	306	186	52.9	238	58.1	25.5 J	2.3 J	27.7 J
Benzo(g,h,i)perylene	966	524	114	822	187	109	31.2	98.4

D Concentration obtained from a diluted extract
E Estimated concentration detected above calibration limit
J Estimated value detected below the quantitation limit but above the detection limit
U Target compound not detected at or above the given concentration

Table A-3 (cont.)
Polycyclic Aromatic Hydrocarbon (PAH) Results in Background Surface Soils

Site Sample Units	NYRO15 Comp(0-15) µg/Kg		NYRO16 Comp(0-15) µg/Kg		NYRO17 Comp(0-15) µg/Kg		NYRO18 Comp(0-15) µg/Kg		NYRO19 Comp(0-15) µg/Kg	NYRO20 Comp(0-15) µg/Kg
Naphthalene	33.4		25.1		16.8	J	11.7	J	221	47.6
2-Methylnaphthalene	12.5	J	9.17	J	8.79	J	2.25	J	356	38.4
Acenaphthylene	73.6		5.17	J	6.81	J	3.18	J	103	35.4
Acenaphthene	16.6	J	2.67	J	4.34	J	5.53	J	88.4	97.9
Fluorene	18.5		1.91	J	4.1	J	5.26	J	104	115
Phenanthrene	650		82.4		92.8		107		1,190	1,060
Anthracene	117		13.1	J	18.4	J	20.3		353	317
Fluoranthene	1,580		151		175		206		2,470	1,760
Pyrene	1,210		116		134		155		1,980	1,450
Benz(a)anthracene	561		63.8		75		95.2		1,140	801
Chrysene	792		106		111		124		1,420	943
Benzo(b)fluoranthene	701		57.4		56.5		84.2		1,890	1,110
Benzo(k)fluoranthene	514		82.9		94.5		89.2		1,640	1,150
Benzo(a)pyrene	798		88.1		107		124		1,520	923
Indeno(1,2,3-	339		30.2	J	31.6	J	50		489	240
Dibenz(a,h)anthracene	105		8.53	J	12.7	J	18.3	J	185	88.6
Benzo(g,h,i)perylene	426		43.5		39.8		62.4		448	225

D Concentration obtained from a diluted extract
E Estimated concentration detected above calibration limit
J Estimated value detected below the quantitation limit but above the detection limit
U Target compound not detected at or above the given concentration

Table A-4
Field Duplicate Results with Relative Percent Differences (RPDs)

Site Sample Units	NYRO04 Comp(0-15) µg/Kg	NYRO04 Comp(0-15)D µg/Kg	RPD	NYRO09 Comp(0-15) µg/Kg	NYRO09 Comp(0-15)D µg/Kg	RPD
Naphthalene	27.5	36.3	28	122	161	28
2-Methylnaphthalene	20.7	31.2	40	155	211	31
Acenaphthylene	37.8	52.8	33	36.7	40.7	10
Acenaphthene	4.07	4.14	2	16.5	23.9	37
Fluorene	7	8.49	19	26.1	35.4	30
Phenanthrene	118	177	40	390	464	17
Anthracene	30.6	38.6	23	81.4	92.7	13
Fluoranthene	354	523	39	648	721	11
Pyrene	338	463	31	555	633	13
Benz(a)anthracene	179	223	22	265	286	8
Chrysene	218	272	22	299	349	15
Benzo(b)fluoranthene	239	284	17	305	313	3
Benzo(k)fluoranthene	230	297	25	280	316	12
Benzo(a)pyrene	218	245	12	267	295	10
Indeno(1,2,3-	104	112	7	118	122	3
Dibenz(a,h)anthracene	39.4	41.8	6	52.9	55.6	5
Benzo(g,h,i)perylene	95.8	101	5	114	124	8

D Concentration obtained from a diluted extract
E Estimated concentration detected above calibration limit
J Estimated value detected below the quantitation limit but above the detection limit
U Target compound not detected at or above the given concentration
RPD Relative percent difference, equal to the difference divided by the average of the numbers multiplied by 100

Table A-5
Laboratory Duplicate Results with Relative Percent Differences (RPDs)

Site Sample Units	NYCA03 Comp(0-15) µg/Kg	NYCA03 Comp(0-15)R µg/Kg		RPD	NYRO10 Comp(0-15) µg/Kg	NYRO10 Comp(0-15)R µg/Kg	RPD
Naphthalene	89.9	127		34	74.9	60.4	21
2-Methylnaphthalene	92.1	106		14	37.1	33.5	10
Acenaphthylene	417	1,060		87	72.8	40.1	58
Acenaphthene	31.2	81.4		89	107	74.2	36
Fluorene	41.8	163		118	111	71.7	43
Phenanthrene	1,070	2,550		82	1,660	1,070	43
Anthracene	297	1,080		114	378	221	52
Fluoranthene	3,010	8,080	D	91	1,550	939	49
Pyrene	2,490	5,900	D	81	966	647	40
Benz(a)anthracene	1,420	4,230	D	99	864	562	42
Chrysene	1,820	4,460	D	84	930	647	36
Benzo(b)fluoranthene	1,770	3,340	D	61	697	461	41
Benzo(k)fluoranthene	1,370	4,290	D	103	659	496	28
Benzo(a)pyrene	1,770	4,760	D	92	982	670	38
Indeno(1,2,3-	1,240	3,120		86	693	518	29
Dibenz(a,h)anthracene	476	1,210		87	238	148	47
Benzo(g,h,i)perylene	1,360	3,350		85	822	596	32

D Concentration obtained from a diluted extract
E Estimated concentration detected above calibration limit
J Estimated value detected below the quantitation limit but above the detection limit
U Target compound not detected at or above the given concentration
RPD Relative percent difference, equal to the difference divided by the average of the numbers multiplied by 100

Program:
MGP Site Management

About EPRI

EPRI creates science and technology solutions for the global energy and energy services industry. U.S. electric utilities established the Electric Power Research Institute in 1973 as a nonprofit research consortium for the benefit of utility members, their customers, and society. Now known simply as EPRI, the company provides a wide range of innovative products and services to more than 1000 energy-related organizations in 40 countries. EPRI's multidisciplinary team of scientists and engineers draws on a worldwide network of technical and business expertise to help solve today's toughest energy and environmental problems.

EPRI. Electrify the World

© 2003 Electric Power Research Institute (EPRI), Inc. All rights reserved. Electric Power Research Institute and EPRI are registered service marks of the Electric Power Research Institute, Inc.
EPRI. ELECTRIFY THE WORLD is a service mark of the Electric Power Research Institute, Inc.

Printed on recycled paper in the United States of America

1005296

EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com