Tetra Tech EM Inc.

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September 14, 2000

Mr. Thomas Alcamo
Work Assignment Manager
Remedial Response Unit No. 1
U.S. Environmental Protection Agency
77 West Jackson Boulevard
Chicago, IL 60604

Subject: **Air Emission Modeling of Polychlorinated Biphenyl (PCB) Deposition Near Lemon Lane Landfill Site, Bloomington, Indiana**
Contract No. 68-W7-0003, Work Assignment No. 019-RSBD-0529

Dear Mr. Alcamo:

Tetra Tech EM Inc. (Tetra Tech) was requested by the U.S. Environmental Protection Agency to perform a dispersion modeling analysis of the PCB air emissions resulting from the remedial actions being undertaken at the Lemon Lane Landfill Site in Bloomington, Indiana. The modeling analysis focussed on the higher PCB emissions encountered at the site during July 12 through 17, 2000.

The enclosed memorandum prepared by Eric Farstad summarizes the results of the dispersion modeling analysis. The results indicate that, even with conservative assumptions for depositional velocity, the PCB accumulation in yards surrounding the site ranges from 0.075 to 0.455 mg/kg.

Please call me at (847) 818-7189 if you have any questions.

Sincerely,

Raj Rajaram
Project Manager

Enclosure

cc: Steve Nathan, EPA Project Officer (letter only)
David Alberts, EPA Contracting Officer (letter only)
Tom Kouris, Tetra Tech Program Manager (letter only)

ENCLOSURE

POLYCHLORINATED BIPHENYL (PCB) DEPOSITION NEAR LEMON LANE LANDFILL SITE

(Four Pages)

MEMORANDUM

Date: September 11, 2000

To: Raj Rajaram, Site Manager, Tetra Tech EM Inc.
Lemon Lane Landfill Site File

From: Eric Farstad, Tetra Tech EM Inc.

Re: Polychlorinated Biphenyl (PCB) Deposition Near Lemon Lane Landfill Site

Remediation activities at the Lemon Lane Landfill site in Bloomington, Indiana, resulted in PCB concentrations in air that exceeded the 1,000 nanogram per cubic meter (ng/m^3) action level set by the U.S. Environmental Protection Agency (EPA). Five PCB monitors were operated during remediation activities at the site. These monitors were located at or slightly outside the site perimeter in varying directions from the remediation activities.

A dispersion modeling analysis was completed to estimate PCB concentrations downwind from the monitors at locations that represent residential yards. Measured and modeled PCB concentrations were then used to estimate the rate at which PCBs are deposited in residential yards; the rate of deposition is referred to as deposition flux. EPA's SCREEN3 model (EPA 1995) was used to estimate plume dispersion between the PCB monitors and locations 30 and 60 meters downwind of the monitors. The model output was used to calculate dilution factors that represent the amount of plume dilution between each monitor and the downwind locations. These dilution factors, along with PCB concentrations measured at each monitor, were used to estimate downwind PCB concentrations. The modeling methodology, modeling results, and PCB deposition estimates are briefly discussed below. References cited are listed at the end of the text.

Modeling Methodology

SCREEN3 was run using the area source dispersion algorithm to simulate the grids exposed during site remediation activities. The area source dimensions were determined using grid maps and windroses presented in "Review of Probable Causes of Elevated PCB Emissions and Effectiveness of Mitigation Efforts – Lemon Lane Landfill Site, Bloomington, Indiana" (PSARA Technologies Inc. 2000). First, windrose data were reviewed to determine the predominant wind direction during each elevated PCB concentration event. Second, the PCB emission source upwind of the monitor was established based on the windrose data, and the dimensions of that source were measured on a grid map for use in modeling.

For each of the five monitors, the highest PCB concentration was likely the result of remediation activities associated with Toxic Substances Control Act (TSCA) and non-TSCA grids on the west side of the landfill. The dimensions of these cleanup areas were entered in the model along with downwind receptor distances. A unit emission rate of 1.0 gram per second per meter squared ($g/s\text{-}m^2$) was also entered in the model. Because the model algorithms establish a linear relationship between emission rate and concentration, using a unit emission rate is a simple way to evaluate modeling results in terms of the dilution between the source and a specific receptor location.

The model was run using a full array of meteorological conditions, including worst-case stable atmospheric conditions. Although most of the elevated PCB concentrations likely resulted from PCB emissions during working hours when less stable atmospheric conditions existed, worst-case conditions produced conservatively high modeling results.

Modeling Results

The modeled PCB concentrations at locations downwind of each monitor were calculated by multiplying the PCB concentration measured at the monitor with the dilution factor ratio between the downwind location and the monitor. For example, the maximum modeled PCB concentration 30 meters downwind of the north monitor (C_{PCB} (30-m)) was calculated as follows:

$$C_{PCB}\text{ (30-m)} = C_{PCB}\text{ (north monitor) x (30-m dilution factor / north monitor dilution factor)}$$

Both maximum and average PCB concentrations were calculated. Table A-1 in Attachment A shows the measured PCB concentration for each monitor location, the modeled downwind dilution factors, and the estimated maximum and average downwind PCB concentrations. A SCREEN3 model output summary is presented in Attachment B.

PCB Deposition Estimates

Some of the PCBs released to air and transported downwind will be deposited on ground surfaces. The rate at which gases and very small particles are deposited on the ground depends on many variables. Generally, deposition occurs as a result of turbulent diffusion, Brownian motion, and the chemical and biological processes that cause the pollutant to be retained by the surface material (Hanna, Briggs, and Hosker 1982). The deposition flux is a function of deposition velocity and pollutant concentration and is calculated as follows:

$$F_d = V_d \times C$$

where

F_d = Deposition flux
V_d = Deposition velocity
C = Pollutant concentration

Table A-1 presents the pollutant (PCB) concentrations. Deposition velocities are highly variable and difficult to predict. For the site analysis, the deposition velocity was estimated based on a graph of deposition velocities for small particles presented in "Handbook on Atmospheric Diffusion" (Hanna, Briggs, and Hosker 1982). The graph presents deposition velocity to a grass surface as a function of particle diameter. Deposition processes for very small particles and gases are similar. Unlike large particles, which are deposited on the ground primarily as a result of gravitational settling, very small particles and gases are deposited as a result of turbulent diffusion and Brownian motion. The PCB deposition near the Lemon Lane Landfill site was assumed to resemble deposition of a very small particle (< 0.1 microns). This is a reasonable assumption because the measured PCB concentrations were detected primarily on the polyurethane foam sampling medium and virtually no concentrations were detected on the prefilter, where larger particles would collect.

The deposition velocity for very small particles is between 0.01 and 1.0 centimeter per second (cm/s). Using the maximum deposition velocity in this range (1.0 cm/s), a conservative PCB deposition velocity to grass surfaces of 1.0 cm/s was assumed for the site analysis. This estimated deposition velocity was used for screening purposes only and is subject to a high degree of uncertainty. Actual deposition velocities are chemical-specific and could range between 0.01 and 10 cm/sec.

Using the estimated deposition velocity value along with measured and modeled PCB concentrations, the average PCB deposition flux to grass surfaces was estimated for various distances from the Lemon Lane Landfill site. These estimated deposition values are presented in Table A-2. The values presented in Table A-2 are screening-level estimates and are subject to a considerable degree of uncertainty. Nevertheless, every effort was made to generate worst-case deposition flux estimates.

Finally, the deposition flux estimates were used to estimate PCB accumulation on residential yards. The following equation, which is derived from EPA guidance, was used to estimate PCB accumulation in soil (EPA 1998):

$$C_s = 100 \times (dep/(Z_s \times BD)) \times tD$$

where

C_s = Average soil concentration over exposure duration (milligrams per kilogram [mg/kg])
100 = Unit conversion factor (milligram- square meter per kilogram square centimeter [$mg\text{-}m^2/kg\text{-}cm^2$])
dep = Deposition rate (grams per square meter per year [$g/m^2\text{-}yr$])
Z_s = Soil mixing zone depth (centimeters [cm])
BD = Soil bulk density (grams per cubic centimeter [g/cm^3])
tD = Time period over which deposition occurs (year [yr])

This equation does not account for loss of PCB in soil as a result of processes such as leaching and runoff. However, the equation is used herein to make initial estimates of PCB accumulation. Using a soil mixing zone depth of 6 inches (15.2 cm), a soil bulk density of 1.5 g/cm^3, and a deposition time period of 0.667 yr (the estimated cleanup time), the PCB accumulation in residential soil was estimated. The PCB accumulation results, presented in Table A-3 are all below 0.5 mg/kg, which is lower than the method detection level of 1 mg/kg.

The site analysis was conducted using measured PCB values that often exceeded the 1000 ng/m^3 action level. Because additional precautions are now being taken at the site, it is not expected that the 1000 ng/m^3 action level will be exceeded in the future.

References

Hanna, S.R., G.A. Briggs, and R.P. Hosker, Jr. 1982. "Handbook on Atmospheric Diffusion." Technical Information Center. U.S. Department of Energy.

PSARA Technologies, Inc. 2000. "Review of Probable Causes of Elevated PCB Emissions and Effectiveness of Mitigation Efforts – Lemon Lane Landfill Site, Bloomington, Indiana." August.

U.S. Environmental Protection Agency (EPA). 1995. "SCREEN3 Model User's Guide." Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina. EPA-454/B-95-004.

EPA. 1998. "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities." Office of Solid Waste and Emergency Response. EPA-530D-98-001A.

ATTACHMENT A

TABLES

(Three Pages)

TABLE A-1
Lemon Lane Landfill
PCB Dispersion Modeling Results

PCB Monitor Location	Measured PCB Concentration (ng/m^3)	Date	Modeled Dilution Factor 30 Meters Downwind of Monitor	Modeled Dilution Factor 60 Meters Downwind of Monitor	Estimated PCB Concentration 30 Meters Downwind of Monitor (ng/m^3)	Estimated PCB Concentration 60 Meters Downwind of Monitor (ng/m^3)
Maximum Concentrations						
West	759.5	07/12/00	0.83	0.70	629.4	534.6
North	2,042.7	07/14/00	0.84	0.72	1,716.2	1,474.4
South	4,239.8	07/16/00	0.85	0.74	3,601.7	3,127.4
East	2,960.7	07/17/00	0.86	0.75	2,547.8	2,231.5
Southeast	5,630.6	07/17/00	0.86	0.75	4,815.4	4,200.0
Average Concentrations						
West	115.6	07/12/00	0.83	0.70	95.8	81.4
North	336.8	07/14/00	0.84	0.72	283.0	243.1
South	491.0	07/16/00	0.85	0.74	417.1	362.2
East	289.0	07/17/00	0.86	0.75	248.7	217.8
Southeast	494.2	07/17/00	0.86	0.75	422.6	368.6

TABLE A-2
Lemon Lane Landfill
Estimated PCB Deposition Values

PCB Monitor Location	Estimated Average PCB Deposition Rate at Monitor[(a)] (ng/m^2-s)	Estimated Average PCB Deposition Rate 30 Meters Downwind of Monitor[(a)] (ng/m^2-s)	Estimated Average PCB Deposition Rate 60 Meters Downwind of Monitor[(a)] (ng/m^2-s)
West	1.16	0.96	0.81
North	3.37	2.83	2.43
South	4.91	4.17	3.62
East	2.89	2.49	2.18
Southeast	4.94	4.23	3.69

Note: (a) Assumes a deposition velocity of 1.0 cm/s

TABLE A-3
Lemon Lane Landfill
Estimated PCB Concentrations in Residential Soil

PCB Deposition Location	Average Deposition (ng/m^2-s)	Average Deposition (g/m^2-yr)	Average Soil Concentration (mg PCB/kg soil)
west monitor	1.160	0.037	0.107
30 meters downwind of west monitor	0.960	0.030	0.088
60 meters downwind of west monitor	0.810	0.026	0.075
north monitor	3.370	0.106	0.310
30 meters downwind of north monitor	2.830	0.089	0.260
60 meters downwind of north monitor	2.430	0.077	0.224
south monitor	4.910	0.155	0.452
30 meters downwind of south monitor	4.170	0.132	0.384
60 meters downwind of south monitor	3.620	0.114	0.333
east monitor	2.890	0.091	0.266
30 meters downwind of east monitor	2.490	0.079	0.229
60 meters downwind of east monitor	2.180	0.069	0.201
southeast monitor	4.940	0.156	0.455
30 meters downwind of southeast monitor	4.230	0.133	0.389
60 meters downwind of southeast monitor	3.690	0.116	0.340

Assumptions:
Soil mixing zone depth is 6 inches (15.24 cm)
Deposition occurs for 0.667 years (8 months)
Soil bulk density is 1.5 g/cm^3
No PCB loss from soil

ATTACHMENT B

SCREEN3 MODEL OUTPUT SUMMARY

(Two Pages)

08/27/00
20:49:55

*** SCREEN3 MODEL RUN ***
*** VERSION DATED 96043 ***

Lemon Lane Landfill, PCB Dispersion

SIMPLE TERRAIN INPUTS:

SOURCE TYPE	=	AREA
EMISSION RATE (G/(S-M**2))	=	1.00000
SOURCE HEIGHT (M)	=	1.0000
LENGTH OF LARGER SIDE (M)	=	61.0000
LENGTH OF SMALLER SIDE (M)	=	37.0000
RECEPTOR HEIGHT (M)	=	.0000
URBAN/RURAL OPTION	=	RURAL

THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION

BUOY. FLUX = .000 M**4/S**3; MOM. FLUX = .000 M**4/S**2.

*** FULL METEOROLOGY ***

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*** SCREEN DISCRETE DISTANCES ***
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*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	MAX DIR (DEG)
10.	.1504E+08	5	1.0	1.0	10000.0	1.00	28.
100.	.2087E+08	6	1.0	1.0	10000.0	1.00	27.
122.	.1780E+08	6	1.0	1.0	10000.0	1.00	25.
152.	.1475E+08	6	1.0	1.0	10000.0	1.00	22.
182.	.1253E+08	6	1.0	1.0	10000.0	1.00	19.
137.	.1614E+08	6	1.0	1.0	10000.0	1.00	24.
167.	.1356E+08	6	1.0	1.0	10000.0	1.00	21.
197.	.1165E+08	6	1.0	1.0	10000.0	1.00	17.
152.	.1475E+08	6	1.0	1.0	10000.0	1.00	22.
182.	.1253E+08	6	1.0	1.0	10000.0	1.00	19.
212.	.1088E+08	6	1.0	1.0	10000.0	1.00	14.
168.	.1348E+08	6	1.0	1.0	10000.0	1.00	20.
198.	.1160E+08	6	1.0	1.0	10000.0	1.00	17.
228.	.1016E+08	6	1.0	1.0	10000.0	1.00	10.
160.	.1409E+08	6	1.0	1.0	10000.0	1.00	21.
190.	.1205E+08	6	1.0	1.0	10000.0	1.00	17.
220.	.1051E+08	6	1.0	1.0	10000.0	1.00	12.

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*** SUMMARY OF SCREEN MODEL RESULTS ***
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CALCULATION MAX CONC DIST TO TERRAIN

PROCEDURE	(UG/M**3)	MAX (M)	HT (M)
SIMPLE TERRAIN	.2087E+08	100.	0.

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** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
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