Massachusetts Department of ENVIRONMENTAL PROTECTION

t e c h n i c a l u p d a t e

Background Levels of Polycyclic Aromatic Hydrocarbons and Metals in Soil

Updates: Section 2.3 *Guidance for Disposal Site Risk Characterization – In Support of the Massachusetts Contingency Plan* (1992)

Discussion

Polycyclic Aromatic Hydrocarbons ("PAHs") are ubiquitous and consistently present in the environment and are typically formed during the incomplete burning of organic material including wood, coal, oil, gasoline and garbage. PAHs are also found in crude oil, coal tar, creosote and asphalt. Historically, PAHs have been associated with human activities such as cooking, heating homes and industries and fuel for operating automobiles, although low levels of PAHs are also present in the environment from natural sources, such as forest fires. Their presence in the environment at higher concentrations is an artifact of habitation and is due to the widespread practice of emptying fireplaces, stoves, boilers, garbage, etc. in rural and urban areas over the past several hundred years. As a result, it is very common to detect "background" levels of PAHs in soils. Metals are both naturally occurring and found in man-made materials (such as paint, fuel, fertilizers and pesticides) widely distributed in the environment. Naturally occurring metals present in wood and coal are often found concentrated in ash residue.

DEP has obtained background data from various sources documenting the concentrations of PAHs and metals in soil affected by human activities, particularly soil associated with wood ash and coal ash. These levels are representative of typical concentrations found in areas with fill material, *not* pristine conditions. DEP has also compiled background soil data for metals that are representative of undisturbed, natural conditions.

The identification of generic values for PAHs and metals in soil is intended to streamline the risk characterization process (310 CMR 40.0900) and determination of applicable Response Action Outcome Category (310 CMR 40.1000). Nothing in this Technical Update obviates the need to establish location-specific background conditions for other purposes, such as compliance with the anti-degradation provisions of the Massachusetts Contingency Plan ("MCP") described at 310 CMR 40.0032(3).

Definition of Background (310 CMR 40.0006)

Background means those levels of oil and hazardous material that would exist in the absence of the disposal site of concern which are either:

(a) ubiquitous and consistently present in the environment at and in the vicinity of the disposal site of concern; and attributable to geologic or ecological conditions, or atmospheric deposition of industrial process or engine emissions;
(b) attributable to coal ash or wood ash associated with fill material;
(c) releases to groundwater from a public water supply system; or
(d) petroleum residues that are incidental to the normal operation of motor vehicles.

Basis of the Background Levels for Soil

The background levels were selected following an analysis of several datasets, including:

- Data (30-140 samples) collected to represent background at c.21E sites located in non-urban areas, gathered from a review of DEP files,
- Site-specific background samples generated for locations in Worcester (68 samples) and Watertown (17 samples),
- Data (750-1,000 samples) collected by Mass Highway Department as part of the Central Artery/Tunnel (CA/T) project and presented in a draft document *Background Soil Contaminant Assessment* (CDM, April 1996),
- Data (590 natural soil samples from depths of 10 to 70 feet) collected by Haley & Aldrich, Inc. in the Boston Area
- Preliminary data compiled by the Massachusetts Licensed Site professional Association from background data submitted by its members,
- Published data (62 samples) from ENSR, Inc. from 3 New England locations, and
- Generic background data published by the Agency for Toxic Substances and Disease Registry (ATSDR).

There is not one concentration of a chemical, of course, which can correctly be labeled ***the*** background level. Hundreds of years of human activities have only broadened the naturally occurring range of concentrations reported as "background", and this range is best thought of as a statistical distribution. In the evaluation of environmental contamination, we often select point values from the range of background levels, and consider these to be representative of background. The use of such point-value "background" levels is essentially a short-cut method that allows consideration of background in the absence of site-specific information. The intent of DEP policy is to protect public health while minimizing the routine site-specific determinations at sites in the statewide cleanup program.

"Natural" Soil

- Generally, the 90th percentile value from the MA DEP 1995 dataset was the point-value identified as background.
- In the absence of data in the MA DEP 1995 dataset, a lower percentile value from the CDM 1996 dataset was chosen as background.

Soil Containing Fill Material

- Generally, the 90th percentile value from the CDM 1996 dataset was point-value identified as background.
- In the absence of data in the CDM 1996 dataset, the 90th percentile value from the "natural" soil (MA DEP, 1995) dataset was chosen as background.

Applicability of the Values Listed in Table 1

Table 1 presents two lists of background concentrations: one for use with natural soils, and the second for use with soils containing either coal ash or wood ash associated with fill material, or other material consistent with the regulatory definition of background. The list for use with natural soils may be compared to site soil concentrations with no site-specific justification. The use of the list for soil containing fill material must be accompanied by documentation that the soil at the site does, in fact, contain coal ash or wood ash associated with fill material (or other material consistent with the regulatory definition of background). Such documentation may include information about the site history, soil strata, physical evidence or visual observations (including microscopic).

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Elevated chemical concentrations and/or and urban setting are not, *per se*, sufficient evidence to justify use of the higher background levels.

Comparison of Site Concentrations to the Background Levels for Soil

Section 2.3 of the DEP's *Guidance for Disposal Site Risk Characterization – In Support of the Massachusetts Contingency Plan* (1995) describes the use of DEP-published generic background values. If the site investigation indicates the presence of fill material in the soil, and *all* reported concentrations of an oil or hazardous material ("OHM") fall below the applicable value published in Table 1, then it may concluded that the OHM is present at background concentrations. In other words, the values published in Table 1 are to be compared to the maximum reported concentration at the site. This Technical Update does not modify or change this comparison.

Table 1 lists background levels for "natural" soil and for soil containing coal ash and wood ash associated with fill material. A detailed summary of the data is attached in Appendix A. The applicability of these background concentrations to a site should be determined based upon the presence or absence of fill material containing coal ash or wood ash. If all contaminant concentrations are found to be equal to or less than the applicable background concentrations, a Class A-1 Response Action Outcome may be an option at the site, and no Activity and Use Limitation is required.

Background Concentrations Different Than The MADEP-Published Values

Appendix A describes the wide ranges seen in the distributions of background concentrations. MADEP's choice of point values within these ranges balances the need to eliminate background chemicals from the risk assessment with the need to retain for evaluation those chemicals whose presence is related to the disposal practices at the site.

It is inevitable that at some sites the use of the values listed in Table 1 will incorrectly require the assessment of some "true" background concentrations of OHM at the high end of the background range. Conversely, some chemicals that *are* related to the disposal practices at a site (and are not background) will be screened out of the risk assessment by the use of the Table 1 concentrations. The goal is to minimize **both** kinds of error.

In many cases, additional information about the location of the site, the nature of the soils or the known or suspected disposal practices may be used to justify the application of different literature values or site-specific background information. DEP's adoption of the generic, statewide values presented in this Technical Update does not negate the validity of site-specific background information, when such information is available and of appropriate data quality. The level of effort necessary for such a justification will depend on the specific circumstances. For example, such a justification would be straightforward for elevated arsenic concentrations in soil at a gasoline-release site in an area of the state known to have geological formations rich in arsenic. The level of effort would be significantly higher at a tannery site in the same area due to the facility's historic use of arsenic. Similarly, the presence of elevated chromium or barium concentrations in marine clay deposits could generally be attributable to natural background absent known or suspected sources of the chemical at the site.

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Minimizing Exposure to Soils Containing Elevated Background Material and/or Material Exempt from M.G.L. c.21E

As discussed in this Technical Update, M.G.L. Chapter 21E and the Massachusetts Contingency Plan (the statute and regulations) do not require remediation of chemicals present at levels consistent with background, even if such concentrations would otherwise pose a significant risk of harm to health, safety, public welfare or the environment. The statute also exempts several other environmental conditions (such as lead from lead paint or gasoline and pesticides applied according to their label) that could pose a Significant Risk.

While such conditions are not subject to regulation by DEP, the Department encourages parties to mitigate potential exposures whenever possible. Such mitigation measures could include:

- providing clean soil (down to a depth of 3 feet) in residential settings, and
- providing clean corridors for utility lines.

For Further Information

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References

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Table 1.

MADEP Identified Background Levels in Soil

OIL OR HAZARDOUS MATERIAL	Concentration in "Natural" Soil mg/kg	Concentration in Soil Containing Coal Ash or Wood Ash Associated With Fill Material mg/kg
ACENAPHTHENE[2]	0.5	2
ACENAPHTHYLENE[2]	0.5	1
ANTHRACENE[2]	1	4
ALUMINUM[1]	10,000	10,000
ANTIMONY	1	7
ARSENIC	20	20
BARIUM[1]	50	50
BENZO(a)ANTHRACENE[2]	2	9
BENZO(a)PYRENE[2]	2	7
BENZO(b)FLUORANTHENE[2]	2	8
BENZO(g,h,i)PERYLENE[2]	1	3
BENZO(k)FLUORANTHENE[2]	1	4
BERYLLIUM	0.4	0.9
CADMIUM	2	3
CHROMIUM (TOTAL)	30	40
CHROMIUM(III)	30	40
CHROMIUM(VI)	30	40
CHRYSENE[2]	2	7
COBALT[1]	4	4
COPPER	40	200
DIBENZO(a,h)ANTHRACENE[2]	0.5	1
FLUORANTHENE[2]	4	10
FLUORENE[2]	1	2
INDENO(1,2,3-cd)PYRENE[2]	1	3
IRON[1]	20,000	20,000
LEAD	100	600
MAGNESIUM[1]	5,000	5,000
MANGANESE[1]	300	300
MERCURY	0.3	1
METHYLNAPHTHALENE, 2-[2]	0.5	1
NAPHTHALENE[2]	0.5	1
NICKEL	20	30
PHENANTHRENE[2]	3	20
PYRENE[2]	4	20
SELENIUM	0.5	1
SILVER	0.6	5
THALLIUM	0.6	5
VANADIUM[1]	30	30
ZINC	100	300

(Values rounded to one significant figure.)

[1] In the absence of fill-specific data, the "natural" soil value has been adopted.

[2] In the absence of data specific to "natural" soil, a lower percentile value from the fill data set has been adopted.

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Levels of PAHs and Metals in Soil from Various Datasets
Appendix A - Detailed Data Summary

	Number of Samples	Geometric Mean or Median mg/kg	Minimum mg/kg	50th mg/kg	90th mg/kg	95th mg/kg	Maximum mg/kg
			<---------- PERCENTILES ---------->				
Total PAHs							
CA/T Project	873	2.7	0.08	2.6	92	230	3000
ENSR - Urban Soils	62	10.97	2.292				167
Total Carcingenic PAHs							
CA/T Project	873	1.5	0.022	1.1	42	95	1200
ENSR - Urban Soils	62	4.86	0.68				78
Total Noncarcinogenic PAHs							
CA/T Project	873	1.9	0.08	1.6	54	140	1900
ENSR - Urban Soils	62	6.11	1.612				89
Acenaphthene							
CA/T Project	868	0.18	0.024	0.18	1.9	4.1	42
Med City/Mill Brook	67	NC	ND (64)	NC	NC	NC	1.7
ENSR - Urban Soils	62	0.128	ND (32)				3.4
Acenaphthylene							
CA/T Project	869	0.17	0.037	0.17	1	1.9	10
Med City/Mill Brook	67	NC	ND (65)	NC	NC	NC	0.76
ENSR - Urban Soils	62	0.133	ND (38)				1.1
Anthracene							
CA/T Project	872	0.2	0.033	0.2	3.8	10	130
Med City/Mill Brook	68	NC	ND (52)	NC	0.592	1.2	3.4
ENSR - Urban Soils	62	0.184	ND (8)				5.7
Benzo[a]pyrene							
CA/T Project	873	0.3	0.031	0.3	7.4	17	230
LSPA Project	489	0.44	ND (220)	0.44	15.3	NC	222
Watertown	17	0.95	0.6	NC	3.39	4.77	6.08
Med City/Mill Brook	67	NC	ND (43)	NC	2.02	3.3	9.7
ENSR - Urban Soils	62	0.686	ND (5)				13
ATSDR Range:			0.165				0.22
Benzo[a]anthracene							
CA/T Project	872	0.33	0.045	0.33	8.5	19	250
LSPA Project	490	0.563	ND (206)	0.563	17.6	NC	796
Watertown	17	0.411	0.021	0.48	2.52	6.04	6.05
Med City/Mill Brook	68	NC	ND (38)	NC	2.39	3.8	15
ENSR - Urban Soils	62	0.672	ND (4)				15
ATSDR Range:			0.169				59
Benzo[b]fluoranthene							
CA/T Project	873	0.68	0.045	0.4	8.4	18	270
LSPA Project	486	NC	ND (258)	NC	11	NC	250
Watertown	17	1.4	0.6	0.6	6.78	6.79	7.08
ENSR - Urban Soil	62	0.722	ND (7)				12
ATSDR Range:			15				62

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			<---------- PERCENTILES ---------->				
Benzo[g,h,i]perylene							
CA/T Project	871	0.2	0.045	0.2	3.1	7.7	77
Med City/Mill Brook	67	NC	ND (52)	NC	1.2	1.41	5.2
ENSR - Urban Soil	62	0.461	ND (26)				5.9
ATSDR Range:			0.9				47
Benzo[k]fluoranthene							
CA/T Project	869	0.21	0.045	0.21	4	9.7	150
LSPA Project	475	NC	ND (289)	NC	11.4	NC	110
Watertown	17	0.502	0.065	0.406	3.35	4.47	5.13
ENSR - Urban Soil	62	0.834	ND (3)				25
ATSDR Range:			0.3				26
Chrysene							
CA/T Project	873	0.35	0.022	0.35	7.3	18	240
LSPA Project	490	0.59	ND (204)	0.59	20.3	NC	420
Watertown	17	0.32	0.016	0.404	4.55	5.06	6.6
Med City/Mill Brook	68	NC	ND (42)	NC	2.1	3.6	14
ENSR - Urban Soil	62	0.844	ND (2)				21
ATSDR Range:			0.251				0.64
Dibenzo[a,h]anthracene							
CA/T Project	866	0.17	0.045	0.17	1.1	2.1	39
Watertown	17	0.195	0.155	NC	0.494	0.604	0.64
Med City/Mill Brook	68	NC	ND (65)	NC	NC	NC	1.6
ENSR - Urban Soils	62	0.245	ND (30)				2.9
Fluoranthene							
CA/T Project	873	0.89	0.035	0.61	14	33	490
Med City/Mill Brook	68	NC	ND (32)	0.376	4.2	11	40
ENSR - Urban Soils	62	1.38	ND (2)				39
ATSDR Range:			0.2				166
Fluorene							
CA/T Project	873	0.18	0.028	0.18	2.3	5.5	79
Med City/Mill Brook	68	NC	ND (65)	NC	NC	NC	2
ENSR - Urban Soils	62	0.141	ND (27)				3.3
Indeno[1,2,3-cd]pyrene							
CA/T Project	871	0.2	0.022	0.2	2.8	7	100
LSPA Project	475	NC	ND (304)	NC	6.3	NC	130
Watertown	17	1.752	1.2	NC	5.64	6.2	7.2
Med City/Mill Brook	68	NC	ND (50)	NC	1.5	2	6
ENSR - Urban Soil	62	0.532	ND (19)				6
ATSDR Range:			8				61
2-Methylnaphthalene							
CA/T Project	789	0.15	0.03	0.15	0.96	2.2	13
Med City/Mill Brook	68		ND (67)	NC	NC	NC	0.77
ENSR - Urban Soil	62	0.121	ND (43)				0.64

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			<---------- PERCENTILES ---------->				
Naphthalene							
CA/T Project	867	0.17	0.016	0.17	1.4	3	28
Med City/Mill Brook	68	NC	ND (65)	NC	NC	NC	1.9
ENSR - Urban Soils	62	0.0917	ND (27)				0.66
Phenanthrene							
CA/T Project	873	0.8	0.029	0.47	15	38	480
Med City/Mill Brook	68	NC	ND (38)	NC	2.7	5.6	16
ENSR - Urban Soils	62	0.788	ND (1)				36
Pyrene							
CA/T Project	873	0.89	0.034	0.61	16	35	440
Med City/Mill Brook	68	NC	ND (32)	0.343	4.29	9	30
ENSR - Urban Soil	62	1.54	ND (1)				11
ATSDR Range:			0.145				147
Aluminum							
DEP 1995	30	5536	387	7800	13000	16000	24000
Antimony							
DEP 1995	90	0.2	ND (0.002)	0.34	1.4	4.8	22
CA/T Project	746	NC	0.25	1	7	12	160
Arsenic							
DEP 1995	139	4.7	ND (0.1)	4.8	16.7	24.5	99
CA/T Project	754	5.3	0.25	5.4	14	21	99
H&A 2001	589	5.5	ND	5.57	11	12.9	23
Barium							
DEP 1995	64	15	0.42	15.7	45.2	52.8	104
H&A 2001	490	35	ND	35.7	80.9	89.3	680
Beryllium							
DEP 1995	103	0.21	0.03	0.23	0.39	0.53	1.6
CA/T Project	746	0.5	0.03	0.5	0.88	2	7.5
H&A 2001	22	0.5	ND	0.63	1.15	1.2	1.3
Cadmium							
DEP 1995	127	0.43	ND (0.01)	0.29	2.06	3.4	5.9
CA/T Project	756	0.5	0.1	0.5	3	5	25
H&A 2001	572	1.8	ND	1.26	1.63	1.63	3
Chromium							
DEP 1995	147	10.3	0.02	10.6	28.6	38.8	105
CA/T Project	756	13	1	15	39	50	530
H&A 2001	589	22	ND	22	43.9	49.6	94
Cobalt							
DEP 1995	10	0.8	ND (0.5)	NC	4.4	4.5	4.7
Copper							
DEP 1995	103	7.7	ND (0.5)	7.3	37.7	56.1	160
CA/T Project	742	34	1	30	170	320	5300
H&A 2001	22	26	6	27	47.5	64.5	130

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	Number of Samples	Geometric Mean or Median mg/kg	Minimum mg/kg	50th mg/kg	90th mg/kg	95th mg/kg	Maximum mg/kg
			<---------- PERCENTILES ---------->				
Iron							
DEP 1995	30	6031	444	7200	17000	22500	50000
Lead							
DEP 1995	141	19.5	1	19.1	98.7	158	326
CA/T Project	850	51	0.05	53	570	1100	11000
LSPA Project	457	83	ND (5)	83	640	NC	10600
H&A 2001	583	15	ND	24.4	78.9	112	300
Magnesium							
DEP 1995	30	1028	ND (250)	1300	4900	6700	11000
Manganese							
DEP 1995	30	81.5	ND (3)	110	300	365	460
Mercury							
DEP 1995	107	0.043	ND (0.0002)	0.066	0.28	0.43	1.4
CA/T Project	785	0.15	0.001	0.15	1.4	2.6	23
H&A 2001	583	0.2	ND	0.19	0.74	1.1	2.5
Nickel							
DEP 1995	103	4.6	ND (0.5)	5.1	16.6	22.7	48
CA/T Project	740	14	1	14	31	41	220
H&A 2001	22	34.5	5	35	67.5	70	101
Selenium							
DEP 1995	93	0.1	ND (0.0005)	0.17	0.5	1	4.6
CA/T Project	756	0.5	0.1	0.5	1	2.1	57
H&A 2001	426	0.84	ND	0.74	1.36	1.58	2.8
Silver							
DEP 1995	117	0.09	ND (0.003)	0.07	0.58	0.91	82
CA/T Project	756	1	0.19	1	5	7.3	81
H&A 2001	335	0.64	ND	NC	NC	NC	0.64
Thallium							
DEP 1995	71	0.1	ND (0.005)	NC	0.6	1.65	5
CA/T Project	734	NC	0.035	1	5	5	50
Vanadium							
DEP 1995	30	7.6	ND (1)	10.3	28.5	38.5	46.6
Zinc							
DEP 1995	112	29.3	3.52	27.7	116.4	131.2	190
CA/T Project	746	84	5.8	73	340	590	5000
H&A 2001	22	67	15	58.5	103	106	120