International Journal of Soil, Sediment and Water
Documenting the Cutting Edge of Environmental Stewardship

Volume 1 | Issue 2 Article 2

12-16-2008

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International Journal of Soil, Sediment and Water, vol 1, no 2, 2008
ISSN: 1940-3259

POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) IN URBAN SOIL: A FLORIDA RISK ASSESSMENT PERSPECTIVE

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ABSTRACT

Over the past decade, polycyclic aromatic hydrocarbons (PAHs) have steadily climbed in importance on the CERCLA list of hazardous substances. Though the listing does not necessarily imply that these chemicals exhibit the greatest degree of toxicity, such recognition by ATSDR and USEPA is predicated at least in part on their demonstrated ubiquity, coupled with toxicity considerations. Regulatory agencies increasingly are under pressure to define and interpret data describing urban background levels, and to appropriately determine the relative importance of waste-producing activities and concentrations resulting from typical natural and/or human activity. Three case studies from Florida are presented that confirm the ubiquity of the PAHs at low levels, and that demonstrate the need for more sophisticated and transparent treatment by regulatory agencies. We discuss assessment and risk assessment activities related to two urban redevelopment projects, as well as one property transaction project. In each case, considerable sampling of surficial soils and sediment identified total benzo(a)pyrene-equivalent (BAPE) concentrations in the range of less than 1 ppm to about 5 ppm. Although those concentrations frequently exceeded the default Florida cleanup target level for both residential and commercial/industrial land use by a wide margin, it was concluded that they are completely consistent with levels reported in a great many urban settings. There is an ongoing need to consider the development of a default urban background level for PAHs in areas characterized by busy roadways or multiple industrial facilities, in much the same way that geological or anthropogenic background levels are established for some inorganics.

Keywords: Polycyclic aromatic hydrocarbons, soil, sediments, water, background, health risk assessment, urban, toxicology, PAH

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1. INTRODUCTION

Over the past decade, polycyclic aromatic hydrocarbons (PAHs) have climbed towards the top of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) list of hazardous substances (ATSDR, 2006). In the biennial ranking comprised of chemicals deemed to pose the greatest possible risk to human health, PAHs placed tenth in 1999 before moving to fifth in 2001 and settling in at seventh in 2005 (ATSDR, 2006). Both the Agency for Toxic Substances and Disease Registry (ATSDR) and US Environmental Protection Agency (EPA) recognize the potential importance of PAHs due to their ubiquity in many urban and rural environments. Acknowledgment of their burgeoning presence means regulatory agencies must define and interpret urban background levels to appropriately determine whether industrial facilities or contaminated sites are impacting the environment beyond concentrations resulting from typical natural and human activity.

PAHs are a collection of over 100 different fused benzene ring chemical compounds with varying prevalence and regulatory concern. Background is defined as concentrations in a common area, such as a road easement, residential yard or non-industrialized locale, due to sources independent of a known waste site (IEPA, 2005). The multitude of non-point, diffuse, and mobile sources of PAHs ranges from automobile exhaust to road asphalt to cigarette smoke (NPI, 2004). These sources create urban background concentrations that often exceed health based regulatory recommendations (Delgado, 2000). Heightened awareness of this potentially costly inconsistency has increased the vigor of efforts to determine local background levels before targeting sites for remediation. Local and state agencies like the Illinois EPA (IEPA) have begun to more actively consider background levels when establishing risk-based objectives in order to determine realistic goals (IEPA, 2005).

In Florida, the Department of Environmental Protection (FDEP) is increasingly aware of and potentially receptive to site-specific demonstrations of urban background, rather than site-related activities, being the cause of or at least a significant contributor to observed PAH impacts. However, at this point, procedural constraints, political climate or financial considerations result in a strict adherence to the much lower default cleanup guidelines.

In this report, we briefly touch on the toxicity of the PAHs, we evaluate the natural and anthropogenic sources of PAHs in the environment, including discussions of the levels observed in air, water, soil and sediment, and we present three case studies from Florida that demonstrate the ubiquity of the PAHs and the challenges they bring to the regulatory framework.

2. HUMAN HEALTH EFFECTS

The potential carcinogenicity of seven common PAH list compounds [benzo(a)anthracene (B(a)A), benzo(a)pyrene (B(a)P), benzo(b)fluoranthene (B(b)F), benzo(k)fluoranthene (B(k)F), chrysene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene] warrant reasonable regulation and remediation. Due to their ubiquity, PAH exposure occurs constantly whether an individual

breathes roadside air, comes into contact with a hazardous waste site, eats grilled food, or drinks contaminated water (NPI, 2004). In the US, lifestyle considerations represent the greatest exposure potential to carcinogenic PAHs for an individual, with general population estimates indicating daily intake averages of 0.207 ug from air, 0.027 ug via water, and 0.16-1.6 ug through food (ATSDR, 1995). Inhalation of tobacco and wood smoke, and residence near a hazardous waste site may increase intake of carcinogenic PAHs further (ATSDR, 1995). Significant time spent in metropolitan areas boosts risk since several studies indicate PAHs in urban ambient air exceeds rural air by ten times (IDPH, 2005). Once entering the body, the kidneys, liver, fat, spleen, adrenal glands and ovaries can store PAHs until they are released in urine and feces within a few days (ATSDR, 1995; Grosenheider et al., 2005). Short-term effects have yet to be determined since other chemicals that commonly co-occur with PAHs (e.g., volatile hydrocarbons) often cause immediate symptoms such as eye irritation, nausea, diarrhea, and confusion (IDPH, 2005). Detrimental long-term, high-level exposure may lead to consequences including cataracts, kidney and liver damage, jaundice, and skin irritation and redness, specifically for naphthalene contact. The immune system also is vulnerable and B(a)P in large doses suppresses the system and damages erythrocytes. Moreover, sufficient doses may cause developmental and reproductive deficiencies in animals (BCERF, 2001).

The above effects, though more likely, seem inconsequential in most literature because of the overwhelming focus on cancer from long-term exposure. Laboratory research on female rats, as summarized by the Cornell University Program on Breast Cancer and Environmental Risk Factors (BCERF, 2001), indicates breast tissue injection and consistent high dose ingestion of B(a)P and dibenzo(a,l)pyrene caused a significant increase in the development of breast cancer (BCERF, 2001). However these results have not been proven with any consistency in human studies. One of the pioneering PAH cancer studies in humans began in the early 1980's after women in Long Island, New York appeared to have a 30% higher breast cancer rate than the national average (NBCC, 2002). The first of the 12 studies forming the Long Island Breast Cancer Study Project targeted PAHs since these compounds bind to DNA and form DNA adducts, the sites of tissue damage. Detectable adducts increased the chance of breast cancer by 35%, a statistically significant figure; however, the association does not appear to be dose dependent, and a possible threshold effect was noted in the observed endpoints (Gammon et al., 2002).

3. SOURCES OF PAHs IN URBAN ENVIRONMENTS

3.1 Natural Sources

Petroleum and coal formations contain PAHs, and forest fires or volcanic eruptions also release PAHs (Delgado, 2000). Volcanoes and forest fires are by far the most common means by which natural producers release PAHs into a given environment (ATSDR, 1995). Coal tar, crude oil, and shale oil are all important repositories of PAHs, and human conversion and incomplete combustion of fuels increases their abundance in the contemporary environment (NPI, 2004). Products such as creosote and asphalt also contribute to PAH occurrence in the environment (IDPH, 2005).

3.2 Anthropogenic Sources

Although readily identifiable point sources garner the wealth of federal and government attention and budget, diffuse and mobile sources strongly influence total PAH concentrations in a given medium (NPI, 2004). Non-point sources are unavoidable, with virtually every citizen culpable. Common daily anthropogenic contributions of importance include cigarette smoke, internal combustion engines, oil-based heating, indoor and outdoor grilling, jet exhaust, and road paving (Delgado, 2000).

Total PAH concentrations, especially indoors, can rise significantly as a result of smoking. One study conducted in Durham, North Carolina observed that smoking increased indoor levels considerably in smoking households, ranging from 0.08 to 3,600 ng/m^3, while outdoor levels in Durham were between 0.03 and 1,700 ng/m^3 (USEPA, 1997). Fires resulting from agricultural activities, home heating and cooking purposes also cause widespread PAH emissions. These are difficult to control since nearly every urban environment contributes PAHs to some degree (NPI, 2004). In fact, the largest anthropogenic source of PAH emissions in many areas is reportedly residential wood combustion (Grosenheider et al., 2005). Motor vehicle exhaust supplements PAHs' expanding presence alongside several vital consumer products with mobile sources contributing an estimated 25% of total PAH emissions in the 1980's (Li, 2003).

Regardless of their source, PAHs behave similarly in the environment. Once discharged, most PAHs will enter the air before subsequent transport to other media. Surface water receives its share primarily from airborne deposition, but other major contributors include urban runoff, effluents from industrial plants, petroleum processing, and occasionally oil spills. Urban runoff, a common non-point source of residential communities, accounted for an estimated 36% of the total PAH input into Rhode Island's Narragansett Bay, as well as an atypical 71% of all high molecular weight toxins found (McCarthy, 2003; LBNL, 2004). Heavy hydrocarbons in water environments tend not to venture far from their anthropogenic source, and thus, aquatic areas near extensive human activity may exhibit significant impact (ATSDR, 1995).

Soil represents the medium that is most complex with regard to principal source determination for PAH impacts (Delgado, 2000; Hellmann, 1999). Local and long-range transport follows initial atmospheric entrance; therefore, areas seemingly unfettered by direct industrial activity could harbor significant baseline PAH concentrations. Soils adjacent to roadways and parking lots tend to have higher concentrations than rural soil due to auto and asphalt emissions and associated stormwater runoff (Mahler et al., 2005; Wagrowski and Hites, 1997). Additional contributors include public sewage treatment plants, bituminous coal leachate from storage sites, and compost-based fertilizers (ATSDR, 1995). Furthermore, higher organic carbon content and sorbent particle surface area have been associated with increased absorption and accumulation in sediments. For example, Karickhoff et al., (1979) and Gardner et al., (1979) established that silt and clay are twice as likely to amass B(a)P and B(a)A than a sand composition (ATSDR, 1995).

4. REPORTED AMBIENT LEVELS OF PAHs

Establishing a universal baseline for urban PAH background has occupied numerous researchers over the course of the past three decades. Intra-town levels can vary two or three-fold depending on different prevailing sources (traffic vs. domestic coal burning), heating fuels (coal vs. natural gas), and position relative to an industrial zone (downwind vs. upwind; EU, 2001). Urban and industrial land-use adjacent to river systems is just one example of the complications associated with source attribution and risk assessment for PAHs (Costa and Gensky, 2001). One specific challenge in attempting to normalize the available information relates to whether individual species or total PAHs are measured and reported. It has become common to utilize B(a)P-equivalents (BAPE) to develop values based on the carcinogenic potency of the seven PAH list compounds in relation to B(a)P, the most often measured and regulated PAH (Grosenheider et al., 2005).

4.1 Air

In the ATSDR's 1995 toxicological profile for polycyclic aromatic hydrocarbons, ambient air's unique role as a feeder to soil and water is identified and background ranges are provided. Rural ambient air for B(a)P ranged between 0.02-1.2 ng/m^3, and urban background in 120 US cities fluctuated between 0.15-19.3 ng/m^3 (ATSDR, 1995). The extent of this urban-rural discrepancy is once again noted in a New Jersey project from 1981 and 1982 that showed a 3-5 times higher concentration for PAHs in urban air as compared to rural air, and also discovered a 5-10 times higher PAH concentration in winter as opposed to summer. Another early 1980's project found that B(a)P had an urban baseline of 0.64 ng/m^3 in Los Angeles. B(g,h,i)PER, a byproduct of automobile emissions on LA's notorious freeways, had a mean geometric concentration of 3.27 ng/m^3. Legzdins et al. (1994) determined that B(g,h,i)PER was the highest individual PAH concentration among hydrocarbons measured in Hamilton, Ontario and New York City. The specific values, 4.3 ng/m^3 in Hamilton and 4.05 ng/m^3 in New York City, furthered the notion that urban ambient air levels follow a general pattern when free of point source contributions.

A worldwide study of 60 towns in the mid-1970's determined the range of B(a)P in European and US ambient air. For Europe, a range of 1-20 ng/m^3 was reported and the U.S. appeared to contain approximately 1 ng/m^3 (Menichini, 1992). However, Europe in the 1990's exhibited significantly improved ranges for B(a)P (EU, 2001). Rural background varied between 0.1 and 1 ng/m^3, and urban baselines ranged from 0.5 to 3 ng/m^3. Nonetheless, the EU (2001) reported 30 ng/m^3 as the commonly accepted background in zones close to industrial processes.

4.2 Soil

PAH compounds found in soil have been an increasing problem since the Industrial Revolution's promotion of PAH-producing anthropogenic behavior. A compilation of data by the ATSDR confirms the expected: urban background concentrations are greatest, followed by

agricultural and rural soil (ATSDR, 1995). Thomas' 1986 survey indicated that even soil in remote Wyoming woods contained 210 ug/kg of total PAHs; whilst, Black et al. (1989) later in the 1980's demonstrated the urban counterpoint by measuring New York City's Fountain Avenue Landfill, which contained concentrations between 400 and 10,000 ug/kg.

Several of the total PAH studies that were reviewed allow a general understanding of urban baseline levels through analysis of samples from several locations throughout an urban domain. The lowest observed levels were in rural soil located far from major highways (Lagoy and Quirk, 1994). According to the IARC (1983), concentrations were between 0.01-10 mg/kg for all PAHs, while urban background ranged from 1-100 mg/kg. Among the more volatile carcinogenic PAHs, Menzie et al. (1992) noted a range of 0.01 to 1.3 mg/kg in forest and rural soil. Based on the 15 samples used in this determination, urban soils ranged from 0.06 to 5.8 mg/kg with a median of 1.1 mg/kg.

A mid-1990's analysis in New England focused on the relationship between proximity to pavement and toxicity in conjunction with background range determinations (Bradley et al., 1994). The study found state regulatory standards, which commonly range from 0.1 to 0.66 mg/kg depending on the state and the particular PAH, difficult to reconcile with background levels. Frequently, the urban surface soil PAH levels dwarfed the cleanup levels for the PAHs. The 95% upper confidence limit on the mean concentrations of 60 samples from three New England cities were 12.4 mg/kg for total carcinogenic PAHs, and 3.3 mg/kg for BAPE. The BAPE for urban background was 30 times greater than the 0.1 mg/kg target cleanup level. Statistical analysis of pavement proximity involved tests for homogeneity of variance and equality of means. The mean for near pavement was 21.9 ppm total PAHs and 2.9 ppm BAPE, while samples away from pavement had means of 8.3 ppm total PAHs and 1.1 ppm BAPE. These tests demonstrated statistical significance at the 0.05 level on all accounts, but emphasized that ppm levels of PAHs were ubiquitous.

The Massachusetts DEP in 1995 attempted to interpret background concentrations in "natural soil," a term used to denote the 90th percentile value (MADEP, 2002). Lower than 90th percentile values were commonly applied when site-specific background information was absent. A common requirement when establishing urban PAH background levels is consideration of the soil type and historical uses of the study area. However, the MADEP methodology and specific urban background levels, serve as a solid foundation for other such efforts. Notable "natural" concentrations identified include B(a)P at 3 mg/kg, B(g,h,i)PER at 1 mg/kg, and chrysene at 2 mg/kg (MADEP, 2002).

Subsequently in 2005, the Illinois EPA, as part of their risk-based tiered remediation program, established their own carcinogenic PAH background levels in soil (IEPA, 2005). Their study separated locales based on population. Areas with over 50,000 residents were branded "Metropolitan Statistical Areas (MSA)," the equivalent of an urban area. Since they deemed the data lognormally distributed, a lognormal 95th percentile concentration, shown on Table 1, represented their conclusions regarding background.

4.3 Watershed/Sediment

Emissions from a host of mechanisms including stormwater runoff, direct deposition, surface runoff from roadways, and discharges from boats contribute heavily to aquatic sediment contamination (US Navy, 2003; Abrajano and Bopp, 2001). A US Navy review of properties along the Elizabeth River in Virginia examined 20 sediments, and concluded that urban background was 16 mg/kg for a 16-PAH list of priority pollutants and 26 mg/kg for all detectable PAHs. With those statistics in hand, the researchers proposed that 30 mg/kg of priority pollutants should be the cutoff above which urban background alone cannot account for the PAH concentration. Conversely, Stout et al (2004) reported on surficial sediments and reiterated the lack of one representative urban baseline value. Regardless, there was general consistency, with 96% of the 280 sampled sediments containing below 20 mg/kg of the16-PAH list of pollutants.

Table 1. Background concentrations of carcinogenic PAHs in IL (mg/kg)

Individual PAH	Chicago	MSA	Non-MSA
B(a)A	1.1	1.8	0.72
B(b)F	1.5	2.0	0.70
B(k)F	1.0	1.7	0.63
B(a)P	1.3	2.1	0.98
Chrysene	1.1	2.7	1.1
Dibenzo(a,h)A	0.20	0.42	0.15
Indeno(1,2,3-c,d)P	0.86	1.6	0.51

*Derived from IEPA, 2005; see text for full name of abbreviated PAHs

Low solubility and high organic carbon affinity in particulate matter makes sediments a major contributor to the overall watershed PAH content, often with total concentrations in the parts per billion (ug/kg) or parts per million (mg/kg) range, while water concentrations typically are in the parts per trillion (ng/kg) range due to low water solubility. In many instances, the surface water levels may be more closely related to the activity pattern in the surface water body and the local sediment concentrations.

Total PAHs in finished drinking water from 10 US cities, a final destination for PAHs via storm water runoff to reservoirs or infiltration through soil to groundwater, was shown to have levels between 4 and 24 ng/L with the raw water reporting concentrations from 6 to 125 ng/L (Sorrel et al., 1980). In a 1978 study, Basu and Saxena (1978a) reported a mean total PAH concentration of 600 ng/L for a surface water drinking water source in Pittsburg, Pennsylvania. Additionally, Basu and Saxena (1978b) identified groundwater levels between 3-20 ng/L in the bordering states of Ohio, Indiana, and Illinois. A 1986 analysis of the Mississippi River acknowledged that phenanthrene was the highest individual PAH with a maximum of 34 ng/L (DeLeon et al., 1986). This New Orleans industrial zone sample supports the notion that effluents and surface runoff are some of the most significant contributors to water background (McCarthy, 2003). Several studies presented by the ATSDR have uniformly shown the importance of urban runoff's role.

The United States Fish and Wildlife Service's (USFWS) 1987 report on PAHs is another comprehensive attempt to compile and evaluate cross-generational and cross-geographic background data to form remediation plans. As reported in that document, Lee and Grant's 1981 development of the idea that total PAHs in air are approximately 10 times higher than B(a)P levels is a helpful barometer to estimate total PAH concentrations, even with the observed statistical variation (USFWS, 1987).

Coal tar road sealants, 10-18% PAH content by weight, have had 5 to 600 times greater quantities of PAHs than asphalt sealant (Mahler et al., 2005). Coal tar sealant's high PAH composition yields direct effects in river sediments near asphalt parking lots sealed with coal tar (Grosenheider et al., 2005). This knowledge fostered research of asphalt runoff because of the known severity of runoff particulates being caught by sediment traps. The United States Geological Survey (USGS) determined PAH concentrations using 13 parking lots in Austin, Texas, where 600,000 gallons of coal tar sealant were applied each year (USGS, 2005). Particles in runoff from unsealed lots, serving as the control, contained 54 mg/kg, a concentration 65 times lower than the 3,500 mg/kg resulting from coal tar-based sealants (Mahler et al., 2004). The study also found asphalt-sealed parking lots produced 620 mg/kg in runoff. Due to vehicle exhaust, tire particles, motor oil, and atmospheric deposition, all values surpassed the 22.8 mg/kg sediment Probable Effects Concentration (PEC) used to assess risks from sediment. This hazard prompted Austin officials to ban coal tar sealants and penalize violators with $2,000 fines (Richardson, 2006).

According to a stormwater analysis in coastal Massachusetts, fluoranthene, phenanthrene, pyrene, and chrysene were the most pervasive PAH compounds (McCarthy, 2003). The authors then attempted to determine the source of origin by evaluating the various land uses capable of producing such a composition. Researchers concluded that the PAHs in coastal sediment were primarily due to stormwater discharges (McCarthy, 2003).

In 2003, the Ohio EPA conducted a detailed assessment on the Mad River Basin in order to shed more light regarding PAH concentrations in the state's aquatic environments (OH EPA, 2005). The results varied, but a large proportion of the samples were greater than the Probable Effects Concentration (PEC) guidance values suggested by MacDonald et al. (2000). The MacDonald document provides Threshold Effects Concentrations (TECs) that are defined as concentrations below which adverse effects are expected to occur infrequently, as well as the PEC levels, above which adverse effects are expected to frequently occur. Samples, summarized in Table 2, below, were collected at various junctions and tributaries in the Massachusetts River ecosystem.

Chrysene, fluoranthene, phenanthrene, and pyrene all were above PEC levels in all four locations in the Mad River area. B(a)P exceeded the PEC in three of the four sites, and exceeded the TEC in all four. Similarly, the total PAHs were above the PEC in three of the four tributaries and exceeded the TEC in all four. These levels are not novel to urban watersheds since effluents from anthropogenic activity inevitably enter these aquatic environments.

The principal aquatic stressors impacting the Lewis Creek Watershed in a Virginia study were lead, total PAHs and sediments (VADEQ, 2006). Sediments often accumulate PAHs due to surface runoff, streambank erosion, and other natural erosion; however, human activity catalyzes these natural processes. This sediment movement transferred a significant amount of PAHs into

previously uncontaminated areas in the watershed. With direct contamination a minor threat, the majority of hydrocarbons entered via urban areas such as the city of Staunton and known point sources of PAH impact. In 2001, an initial sampling of only one site in the study area showed several PAHs above PEC guidelines. During the subsequent 2005 sampling sweep, all except one of the 13 sites showed concentrations above the PEC, and all of them exceeded the TEC.

Table 2. PAH concentrations in Mad River Basin sediments (mg/kg)

PAH name	Moore Run	Dugan Run	St. Paris Tributary	Buck Creek
B(a)A	**1.62**	**3.18**	**1.27**	**2.22**
B(a)P	**2.04**	**2.99**	1.38	**2.39**
B(b)F	2.81	3.09	1.55	2.67
B(g,h,i)PER	1.75	2.04	1.09	1.81
B(k)F	2.31	2.96	1.45	2.10
Chrysene	**2.57**	**3.84**	**1.77**	**2.94**
Fluoranthene	**5.41**	**6.98**	**3.31**	**5.92**
Indeno[1,2,3-cd]pyrene	2.08	2.20	1.15	2.04
Phenanthrene	**2.07**	**3.60**	**1.43**	**2.91**
Pyrene	**4.24**	**5.75**	**2.64**	**4.60**
Total PAH	**26.90**	**37.26**	17.04	**29.60**

***Bolded values indicate a level above the PEC.**
**Derived from OH EPA (2005); see text for full name of abbreviated PAHs

5. FLORIDA PERSPECTIVE

In Florida, the Department of Environmental Protection (FDEP) is increasingly aware of and potentially receptive to site-specific demonstrations of urban background, rather than site-related activities, being the cause of observed PAH impacts. However, at this point, procedural constraints, political climate or financial considerations result in a strict adherence to the much lower default cleanup guidelines. The following case studies demonstrate the inconsistency of seemingly unrelated site impacts being cleaned up according to purely health-based Florida guidelines.

5.1 Florida Case Study #1

During investigations related to a former manufactured gas plant destined for urban redevelopment in north-central Florida, PAHs were discovered in soils and roadside ditch sediments at levels that exceeded the site-specific park user scenario soil cleanup target level (SCTL) of 0.35 ppm, as well as the default Florida SCTL for industrial/commercial sites of 0.7 ppm. The 95% upper confidence limit on the mean BAPE concentration for on-site soil samples was approximately 1.2 ppm. Site impacts were observed to be sporadic and not specifically associated with historical activities that may have resulted in PAH releases. Further, upstream roadside ditch samples contained higher levels of PAHs than those observed on the site, implicating general urban conditions.

The consultant demonstrated through literature review and site-specific data analysis that the observed concentrations were quite consistent with urban background for PAHs in such a setting. The federal and state agencies involved with the site concurred in principle, but procedurally required the enactment of an institutional control to notify future property owners of the presence of impacted soil and to prevent exposure.

5.2 Florida Case Study #2

A local housing authority in central Florida undertook the redevelopment of a decades old urban neighborhood bracketed by major roadways and an interstate highway. Surface soil investigations detected PAHs in excess of the default residential SCTL (0.1 ppm for BAPE) over most areas of the site. A statistical analysis of the data revealed a mean concentration of 0.6 ppm and a 95% UCL of the mean concentration of 1.1 ppm for 68 surface soil samples.

A background study was proposed by the consultants, and encouraged by the state, to support the literature-based and site-specific evidence of an urban background phenomenon. However, out of an abundance of caution, and in light of available funding for the remediation, the housing authority decided to excavate, and or cap with two feet of clean soil, the exposed areas of the site (i.e., those areas not covered by roads, driveways or buildings).

5.3 Florida Case Study #3

As part of the due diligence involved in a property transaction in west-central Florida, PAH impacts were discovered in soils adjacent to and beneath an asphalt parking lot of a former retail shopping center. The investigation was expanded multiple times in an attempt to delineate the impacts. No clear delineation was evident for samples beneath the asphalt, but concentrations adjacent to the parking lot decreased with increasing distance from the parking lot. This was a fairly obvious example of the ubiquity of PAHs, and, specifically was concluded to be related to vehicle emissions and parking lot runoff causing low level impacts.

With a maximum BAPE concentration of 2.1 ppm, and mean and 95% UCL concentrations of 0.4 ppm and 0.8 ppm, respectively, site concentrations were well within the widely published range of urban background PAH levels (i.e., typically 1-10 ppm, with some areas as high as 100 ppm). Once again, even though all parties agreed that historical site-related activities were not likely the cause of the observed PAH impacts, in order to facilitate the property transaction process, it was decided that soils adjacent to the parking lot would be excavated and replaced with clean fill. The soils beneath the parking lot were left in place, but an institutional control was enacted to notify future property owners of the presence of impacted soils.

6. DISCUSSION

- Stationary and mobile anthropogenic sources account for as much as 80% of PAHs, with great variability regionally and locally.

- Remediation should not commence without establishing a site-specific background, if possible.
- Recognition that background is an important contributor to understanding PAH sources is illustrated by the European Union (EU, 2003): "While natural events cannot be controlled they do contribute to the background and can have an important local impact. They may therefore affect the ability of a member state to meet any emission limit."
- Due to incongruity of nature and the variability in activity among people inhabiting a given area, background values vary a great deal.
- CERCLA [Section 104(3)(A)] addresses the impracticality and infeasibility of remediation to guideline levels if naturally occurring background exceeds the maximum allowable value. It deems remediation unnecessary and unproductive in such scenarios.
- Those monitoring health risks and PAH concentrations should first identify and control the principal point sources contributing to ambient levels.
- Urban background and evaluation of low levels of PAHs render assignment of risk to a specific site or site activities difficult.
- ALARA system (setting cleanup levels as low as reasonably achievable): "A tier 1 level of 1 mg/kg of PAHs measured as BAPE is recommended as a remediation goal; if PAHs are below this level, no further action is required. A tier 2 level of 10 mg/kg of PAHs measured as BAPE is recommended as well; if PAHs are below this level, a subjective evaluation of likely current and potential future land use is required. If it appears unlikely that frequent exposure would occur, no further action is required." (Lagoy and Quirk, 1994).
- A tier-based guideline system such as the Illinois TACO or ALARA is often ideal since minor contamination can be addressed through a nominal response.

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