

# STATE OF CONNECTICUT

## OFFICE OF POLICY AND MANAGEMENT

February 22, 2011

This is in response to the comments you submitted concerning the proposed transfer of the Seaside Regional Center.

As you are aware, the State is in the process of selling the former Seaside Regional Center (Seaside) which is located on Shore Road in Waterford and as such the Department of Public Works (DPW), in accordance with CGS 4b-47, placed the required public notice in the *Environmental Monitor* and the public was afforded the opportunity to comment upon the proposed transfer of this property.

### **No Identified State Reuse**

In January 2008, the State solicited reuse proposals from State agencies for the Seaside property. One agency, the Department of Public Safety, did submit a reuse proposal to utilize a structure on the property; however, that request was denied by this office. The Department of Environmental Protection's (DEP) comments indicate that DEP is currently working with DPW to transfer a Conservation and Public Recreation Easement on the subject property to the DEP. When the property is sold, the easement would assure public access to the entire waterfront portion of the site in perpetuity.

### **Determination of Current Market Value**

To determine the current market value of the Seaside property, DPW obtained two (2) independent appraisals. The \$8 million purchase price exceeds the current market value for the property as established by these appraisals.

### **Town of Waterford's Establishment of the Seaside Preservation Zoning District**

Since the State does not establish local zoning, the type and density of any future development on the property will be subject to the local zoning laws which have been established, and will be enforced, by the Town of Waterford.

### **Public Access, Open Space and Recreation**

Prior to disposition of the property, the Conservation and Public Recreation Easement will ensure public access to Long Island Sound for passive recreation in perpetuity. The easement area will include the entire length of waterfront, all land within the 500-year flood zone, some adjacent upland area and access from Shore Road. Dedicated public parking and appropriate signage will be provided. The DEP will determine allowed and prohibited uses within the easement area as well as hours of operation.

In addition, the Seaside Preservation Zoning District, Section 17a.11 of the Town's zoning regulations states that *"All areas not approved for development as defined shall be set aside as permanent open space or recreation area in perpetuity to be held in common by the owners within the district."*

#### ***Connecticut Environmental Policy Act***

*After granting of the easement, the property is being conveyed in "as is condition." Therefore, the transaction is not considered to be a state action that would trigger the preparation of an Environmental Impact Evaluation pursuant to CEPA.*

#### ***Natural Resource Inventory***

The conservation easement area, which includes the entire waterfront and most of an existing watercourse, will protect any significant ecological resources on the property. The balance of the property is essentially developed, with lawns and buildings.

#### **Site Plan Approvals**

*With regard to site plan approvals, Section 17a.12 of the Town zoning regulations states that "A site plan shall be submitted to the Commission in accordance with the provisions of Section 22 of these regulations and the purpose of this district, and no building or structure, parking lot, or outdoor use of land shall be used, constructed, enlarged, or moved until said site plan has been approved by the Commission. The development shall be constructed in accordance with these Regulations and the site plan as approved by the Commission. Changes to the approved plans may be made, the extent of which shall be set forth in the special permit."*

In addition, as part of local planning and zoning approvals, the Coastal Site Plan Review requirements of sections 22a-105 through 22a-110 of the Connecticut Coastal Management Act would be applicable.

#### **Development & Design**

*The design of any development of Seaside will be guided by Section 17a.13 of the Town zoning regulations which states "The architectural and site design of all buildings and improvements within the Seaside Preservation District, including typical floor plans and building elevations drawn to scale showing the exterior materials and treatment to be used, shall be submitted. The Plan submission shall specifically show how the development will result in the preservation and re-use of the Main Building, Employee Building I, the Duplex and the Superintendent's House, how the principal use is to be primarily located in these buildings and how all new construction will be integrated into a cohesive and unified development plan. The development shall be constructed in accordance with these design plans and the special permit shall specify the manner in which any changes to the design elements may be made."*

#### **Department of Public Works Request for Proposal (RFP) Process**

The RFP for the sale of Seaside was conducted by the DPW and the disclosure of any information concerning the RFP process at this time shall be subject to applicable State law or regulation.

**Council on Environmental Quality**

Requests related to suggested actions which should be undertaken by the Council on Environmental Quality (CEQ) should be sent directly to CEQ which can be reached at (860) 424-4000 or [www.ct.gov/ceq](http://www.ct.gov/ceq)

**Subdivision of the Property**

With regard to suggestions that the Seaside property be subdivided; it is the State's intent and desire to sell the Seaside property as a single parcel.

**Harkness Memorial State Park**

Comments concerning the operation of Harkness Memorial State Park should be directed to the Department of Environmental Protection (DEP). DEP can be reached at (860) 424-3000 or [www.ct.gov/dep](http://www.ct.gov/dep)

**Leasing of the Property**

It is the intent and desire of the State to sell the Seaside property.

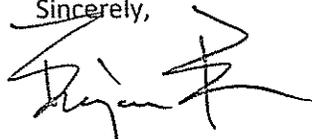
**Public Informational Meetings**

The disposition of the Seaside property is being conducted by the DPW in accordance with all applicable statutes, including Connecticut General Statute 4b-21 which does not include a public informational meeting requirement.

**Alternative Proposals**

With regard to suggestions for various alternative proposals; as the DPW's RFP process has concluded no alternative proposals are being solicited.

Sincerely,



Benjamin Barnes  
Secretary

**O'Brien, Patrick M.**

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**From:** saintrobert [saintrobert@comcast.net]  
**Sent:** Friday, June 04, 2010 10:16 AM  
**To:** O'Brien, Patrick M.  
**Cc:** Kathy Jacques; David Bingham; Kopetz, Kevin  
**Subject:** Re: Sale of Seaside Regional Center;Comments  
**Attachments:** Urban Sprawl Leaves Its PAH Signature.pdf

Here is the attachment to our letter.

Robert Fromer

----- Original Message -----

**From:** O'Brien, Patrick M.  
**To:** 'saintrobert'  
**Cc:** Kopetz, Kevin  
**Sent:** Friday, June 04, 2010 10:00 AM  
**Subject:** RE: Sale of Seaside Regional Center;Comments

Mr. Fromer,

We have received your comments concerning the proposed transfer of the Seaside Regional Center in Waterford. The attachments are somewhat blurred so if you could mail a hard copy I would appreciate it; my mailing address is below.

The public comment period regarding the proposed transfer of Seaside ends on June 17th; at that time, and in accordance with Connecticut General Statute 4b-47, the Office of Policy and Management, in consultation with the Department of Environmental Protection, will respond to all public comments received and publish both the public comments and the State's response in the Environmental Monitor. You will also receive an original hard copy response via US Mail.

In the meantime please feel free to contact me if you have any questions.

Patrick O'Brien  
Office of Policy and Management  
Office of Finance - Bureau of Assets Management  
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Web: [www.ct.gov/opm/property](http://www.ct.gov/opm/property)  
6-3-2010  
\* \*

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**From:** saintrobert [mailto:saintrobert@comcast.net]  
**Sent:** Thursday, June 03, 2010 6:43 PM  
**To:** O'Brien, Patrick M.  
**Cc:** Kopetz, Kevin  
**Subject:** Sale of Seaside Regional Center;Comments

Please confirm receipt of this e-mail. If the attachment is difficult to read, let me know, and I'll send it separately.

Robert Fromer

## Urban Sprawl Leaves Its PAH Signature

PETER C. VAN METRE,<sup>\*,1</sup>  
BARBARA J. MAHLER,<sup>1</sup> AND  
EDWARD T. FURLONG<sup>1</sup>

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Austin, Texas 78751, and U.S. Geological Survey,  
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Lakewood, Colorado 80225

The increasing vehicle traffic associated with urban sprawl in the United States is frequently linked to degradation of air quality, but its effect on aquatic sediment is less well-recognized. This study evaluates trends in PAHs, a group of contaminants with multiple urban sources, in sediment cores from 10 reservoirs and lakes in six U.S. metropolitan areas. The watersheds chosen represent a range in degree and age of urbanization. Concentrations of PAHs in all 10 reservoirs and lakes increased during the past 20-40 years. PAH contamination of the most recently deposited sediment at all sites exceeded sediment-quality guidelines established by Environment Canada, in some cases by several orders of magnitude. These results add a new chapter to the story told by previous coring studies that reported decreasing concentrations of PAHs after reaching highs in the 1950s. Concurrent with the increase in concentrations is a change in the assemblage of PAHs that indicates the increasing trends are driven by combustion sources. The increase in PAH concentrations tracks closely with increases in automobile use, even in watersheds that have not undergone substantial changes in urban land-use levels since the 1970s.

### Introduction

Polycyclic aromatic hydrocarbons (PAHs) represent the largest class of suspected carcinogens (1) and can present a threat to aquatic life (2). The presence and distribution of PAHs in the environment are largely a product of the incomplete combustion of petroleum, oil, coal, and wood (3). Anthropogenic sources such as vehicles, heating and power plants, industrial processes, and refuse and open burning are considered to be the principal sources to the environment (4). On the basis of 1989 data, vehicles produced 11% of PAH emissions in the United Kingdom, domestic coal burning produced 84%, and industrial processes produced 3% (5). Several studies in the 1970s and 1980s reported decreasing trends in PAH concentrations in the environment on a regional scale (United States and Europe) since their peak in the 1950s and 1960s (6-9), on the basis of data from sediment cores from remote and urban lakes and rivers. These reductions have been attributed to reduced use of coal for home heating, industrial emissions controls, and increased efficiency of power plants (7, 9-11).

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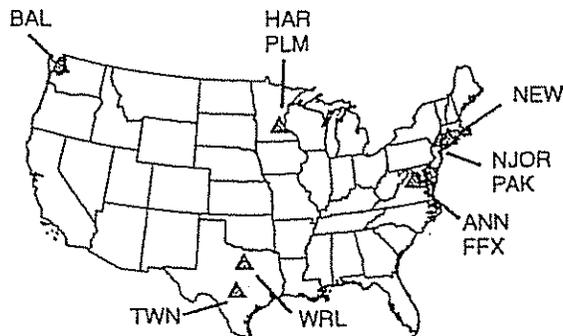


FIGURE 1. Locations of sampling sites. Abbreviations correspond to lake and reservoir names given in Table 1.

While loads of PAHs from some sources may have decreased, the changing face of the urban landscape has resulted in an increase in another source of PAHs: vehicle use. Growth in the use of land for residential and commercial purposes in the United States now far outstrips growth in population (12), a phenomenon termed urban sprawl. Increasing sprawl has resulted in decentralized employment and workplace facilities and greater dependence on vehicles, as reflected in number of miles traveled per capita and per vehicle (13, 14). What effect, if any, has this change had on urban water bodies?

As a part of the U.S. Geological Survey National Water Quality Assessment (NAWQA) Reconstructed Trends program, trends in PAHs were tracked over the last several decades to the mid-to-late 1990s in sediment cores from 10 lakes and reservoirs in six U.S. metropolitan areas. This study indicates that trends in PAH concentrations in developed watersheds over the last three decades, rather than decreasing, are increasing and that the increases may be linked to the increasing amount of urban sprawl and vehicle traffic in urban and suburban areas.

### Methods

Sediment cores from lakes and reservoirs can be used to reconstruct historical trends in water quality (15, 16). Trends are recorded for hydrophobic, persistent compounds, such as PAHs, that bind to sediment particles. PAHs sorb to particulates and are transported to receiving water bodies via atmospheric deposition (17), sewage effluent (18), and surface runoff (19). For this study, sediment cores were collected from seven reservoirs and three lakes across the United States (Figure 1). Land use in the watersheds of these reservoirs and lakes is largely mixed residential and commercial with percent urban land use ranging from 25 to nearly 100% (Table 1). Three sites are in watersheds experiencing rapid growth since the 1970s (58-122% increase in urban land use), three sites are in watersheds experiencing moderate growth (26-36%), and four sites are in watersheds with relatively stable levels of urban land use (0-5%). The onset of development ranges from the early 1900s (e.g., Lake Harriet and Newbridge Pond) to as recently as the 1970s (e.g., Palmer Lake).

Cores were collected from the deepest part of the lake or in the lower part of the reservoir and sectioned into vertically discrete subsamples for analysis of <sup>137</sup>Cs and PAHs. <sup>210</sup>Pb was analyzed for selected lakes. Samples were also analyzed for major and minor elements, chlorinated organic pesticides, and PCBs (not presented in this paper).

TABLE 1. Selected Characteristics of Lakes Sampled

reservoir or lake	sampling date	depth of water (m)	lake area (km <sup>2</sup> )	watershed area (km <sup>2</sup> )	% urban, 1970s <sup>a</sup>	% urban, 1990 <sup>b</sup>	% urban change, 1970s–1990 <sup>c</sup>
Lake Anne, VA (ANN)	Jun 1996	6.5	0.13	2.3	44.8	85.7	91
Lake Ballinger, WA (BAL)	Jun 1998	9.9	0.40	13.7	93.0	96.5	4
Lake Fairfax, VA (FFX)	Sep 1997	3.8	0.11	8.4	58.8	92.8	58
Lake Harriet, MN (HAR)	Jul 1997	21.3	1.2	6.1	79.7	79.7	0
Newbridge Pond, NY (NEW)	Sep 1997	2	0.042	7.9	99.6	99.6	0
Orange Reservoir, NJ (NJOR)	Sep 1997	nr <sup>d</sup>	0.35	11.7	77.1	97.1	26
Lake Packanack, NJ (PAK)	Sep 1997	3	0.33	4.8	73.2	93.2	27
Palmer Lake, MN (PLM)	Jul 1997	1	0.13	64.9	29.6	65.6	122
Town Lake, TX (TWN)	Aug 1998	8.5	0.73	404	23.8	25.1 <sup>e</sup>	5
White Rock Lake, TX (WRL)	Jun 1996	4.9	4.4	265	56.4	76.7	36

<sup>a</sup> Based on ref 20. <sup>b</sup> Based on ref 21. <sup>c</sup> Sites grouped by percent change in urban land use: rapid (ANN, FFX, PLM), moderate (NJOR, PAK, WRL), and stable (BAL, HAR, NEW, TWN) urbanization. <sup>d</sup> nr, not recorded. <sup>e</sup> Based on ref 22.

TABLE 2. Sediment Accumulation Rates and Age Assignments in Core

lake	basis of age dating <sup>a</sup>	corroborating evidence for age dating <sup>a</sup>	approx time period of core	sediment thickness (cm)	av linear sedimentation rate (cm/yr)	av mass accumulation rate (g cm <sup>-2</sup> yr <sup>-1</sup> )
Lake Anne	a, c, e, f	d	1968–1996	17	0.60	0.18
Lake Ballinger	c	d, e	1947–1998	23	0.45	0.11
Lake Fairfax	a, c	d	1952–1997	52	1.2	0.86
Lake Harriet	b, c	d, e	~1800–1997	16	0.60	0.07
Newbridge Pond	c	d, e	1952–1997	54	1.2	0.32
Orange Reservoir	d, e	e	1949–1997	32	0.66	0.24
Lake Packanack	a	d, f, Cu <sup>b</sup>	1932–1997	42	0.64	0.11
Palmer Lake	c, d	e	1949–1997	38	0.78	0.41
Town Lake	a, c	d, e	1959–1998	110	2.7	1.95
White Rock Lake	a, c	d, e	1913–1996	105	1.3	1.13

<sup>a</sup> a, construction date of reservoir; b, <sup>210</sup>Pb; c, <sup>137</sup>Cs; d, DDT and/or PCB profiles; e, total Pb peak; f, modeled exponential decrease in sedimentation rate following approach of ref 24. Sampling date used at top of all cores. <sup>b</sup> Dramatic trends in copper were matched to historical copper–sulfate treatments of the lake.

PAHs and alkyl-substituted PAHs (alkyl-PAHs) were extracted, isolated, and analyzed using a variation of the procedure of Furlong et al. (23). Briefly, wet bottom sediment was extracted overnight with dichloromethane in a Soxhlet apparatus. The extract was reduced and filtered. An aliquot of the extract was processed by automated gel-permeation chromatography (GPC) using a styrene–divinyl benzene column and a dichloromethane eluent to remove sulfur and partially isolate the PAHs from coextracted high molecular weight interferences such as humic substances. The PAH fraction was reduced in volume and solvent-exchanged to ethyl acetate in a micro-Snyder column. An aliquot of internal standard solution (a mixture of perdeuterated PAHs) was added to the final extract. PAHs were separated, identified, and quantified by capillary gas chromatography (GC) coupled to mass spectrometry (MS). The parent and alkyl-PAHs were resolved on a fused silica capillary GC column. Selected ion monitoring (SIM) was used to reduce chemical interferences and improve sensitivity. Parent PAHs were identified and quantified by comparison to authentic standards. Individual alkyl-PAHs were quantified when authentic alkyl-substituted standards were available. The multiple isomeric alkyl-PAHs were quantified from SIM mass chromatograms as the sum of all isomers at each alkylation level (C1-naphthalene, C2-naphthalene, etc.). When authentic alkyl-substituted standards were unavailable, a parent PAH was used for quantitation. Nineteen parent PAHs, 10 specific alkyl-PAHs, and the homologous series of alkyl-PAHs were determined for this study. Total PAHs ( $\Sigma$ PAH) was computed as the sum of these, excluding perylene.

Sediment <sup>137</sup>Cs activity profiles were measured in all 10 reservoirs and lakes (Table 2) by counting freeze-dried sediments in fixed geometry with a high-resolution, intrinsic germanium detector  $\gamma$ -spectrometer. The method is similar

to that reported by Callender and Robbins (24). Activity concentrations of <sup>210</sup>Pb were measured in two older reservoirs and two lakes (Table 2) by high-precision  $\gamma$ -ray spectrometry. A low-energy photon planar detector was used to detect  $\gamma$ -ray emissions between 40 and 400 keV (including <sup>210</sup>Pb), and a high-purity germanium coaxial detector was used for  $\gamma$ -ray emissions between 200 and 2000 keV (including <sup>137</sup>Cs).

Date of deposition for sediment intervals within each core was based on a variety of date–depth markers. Those indicators on which dates were based and those used to corroborate the dates assigned are listed in Table 2. The depth of the pre-reservoir surface in cores, for example, was matched with reservoir construction date in 5 of the 7 reservoirs. (In the other two, Newbridge Pond and Orange Reservoir, the age of the reservoirs and the presence of DDT, PCBs, and <sup>137</sup>Cs immediately above the pre-reservoir surface indicated a discontinuity.) The other major date–depth markers used were <sup>137</sup>Cs first occurrence (1953.0), <sup>137</sup>Cs peak concentration (1964.0), and sampling date. Additional and/or corroboratory date–depth markers included unsupported <sup>210</sup>Pb profile (Lake Harriet only), lead peak (mid-1970s (25)), and DDT and PCB profiles (first occurrence in the 1940s and peaks in the early and late 1960s, respectively (16)).

Cesium-137 profiles provided date markers in 8 of the 10 reservoirs and lakes. The core from White Rock Lake is a good example: <sup>137</sup>Cs is first detected at a depth of 58 cm, peaks sharply at 48 cm, and then exhibits a smooth exponential decrease to the top of the core. In addition to providing age control, this type of profile is strong evidence that sediments have not been disturbed by bioturbation or other post-depositional mixing. At one site, Lake Harriet, because the core penetrated sediment deposited long before the release of <sup>137</sup>Cs into the environment <sup>210</sup>Pb was used in addition to <sup>137</sup>Cs to provide date information for the lower

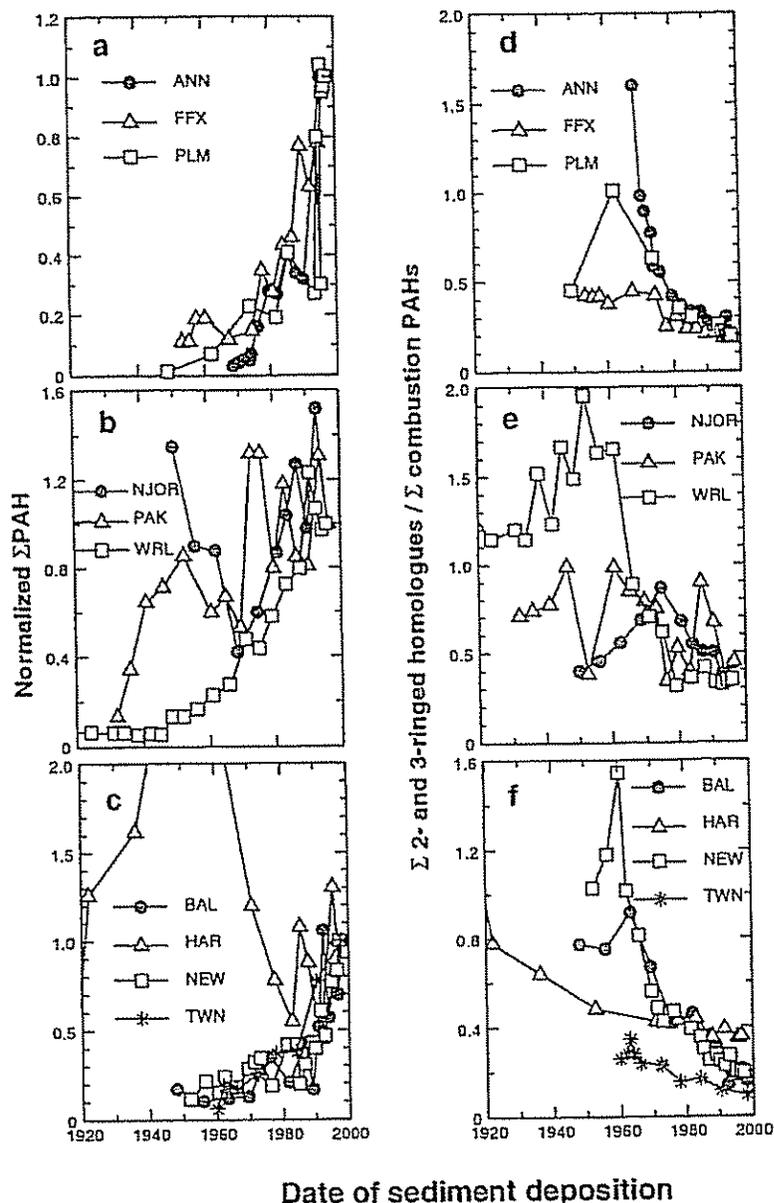


FIGURE 2. Normalized  $\Sigma$ PAH and ratios of PAH assemblages in sediment cores. Trends in  $\Sigma$ PAH among sites are compared by normalizing concentrations in samples from each core to the most recently deposited sample, thus showing trends relative to current conditions. Normalized  $\Sigma$ PAH are shown for watersheds with recent rapid increases (a), moderate increases (b), and stable levels (c) of urbanization. Ratios of PAH assemblages as indicators of PAH source are shown for recent rapid increases (d), moderate increases (e), and stable levels (f) of urbanization. Abbreviations for lake and reservoir sites are as given in Table 1.

portion of the core, following the constant delivery rate model (26).

A date—depth marker other than  $^{137}\text{Cs}$  was used for 2 of the 10 lakes (NJOR and PAK) because the  $^{137}\text{Cs}$  peak was not sufficiently defined. For NJOR, a well-defined DDT peak was evidence of undisturbed sediments, and a date of 1964 was assigned to that depth. For PAK, dates were assigned based on occurrence of Cu: treatment of the lake with  $\text{CuSO}_4$  began in about 1953, which we correlated to the sharp increase in Cu in the core at 18 cm. For all cores, other date markers such as the DDT peak in the early to mid-1960s and the lead peak in the mid-1970s were checked to see if their depths within the cores were consistent with the dates assigned.

Lakes Anne and Packanack were the only two lakes for which the assumption of constant sedimentation rate seemed

questionable. In these two lakes the initial dating scheme placed the lead peak in the 1980s, unrealistically late. This indicated that mass sedimentation rates must have decreased substantially between the occurrence of the older date markers ( $^{137}\text{Cs}$  for Anne and Cu for Packanack) and the top of the core. We therefore assumed that a gradual change in sedimentation rate occurred, possibly caused by gradual completion of urban construction in the watersheds resulting in a corresponding reduction in erosion. We modeled this change using an exponential function following the approach of ref 24, where an exponential decrease in mass accumulation rate was demonstrated in many reservoirs.

Although confidence intervals cannot be assigned to the dates corresponding to individual sample intervals in the cores, the consistency of multiple date markers suggests that

TABLE 3. Concentrations of Selected PAHs in Cores

lake <sup>b</sup>	surficial (top of core) concn				range in concn in core <sup>a</sup>			
	benzo[a]pyrene	fluoranthene	pyrene	total PAH	benzo[a]pyrene	fluoranthene	pyrene	total PAH
White Rock Lake	154	262	219	2,790	e3-154	e9-317	e8-262	135-3440
Town Lake	585	1320	1100	11,400	33-582	57-1,320	66-1,100	670-11 400
Lake Packanack	528	815	754	12,100	41-744	147-960	118-1,000	1610-15 900
Orange Reservoir	913	1480	1260	21 600	314-1500	522-2660	524-2370	13 000-29 100
Lake Anne	1020	4850	3410	30 300	20-1020	62-4850	54-3410	1030-30 300
Lake Fairfax	1540	3500	2680	30 800	124-1540	346-4170	278-2690	3410-30 800
Lake Harriet	1960	4210	3160	35 900	e8-3430	39-16 800	26-12 700	430-48 300
Palmer Lake	2110	5480	4380	44 000	19-2110	65-5930	46-4600	518-45 700
Lake Ballinger	2350	4120	4340	46 300	72-2910	185-7420	263-7430	4810-49 000
Newbridge Pond	10 800	27 200	22 100	224 000	597-10 800	1450-27 200	1,590-22 100	26 300-224 000
Canadian SQGs <sup>c</sup>	31.9/762	111/2355	53.0/875					

<sup>a</sup> Estimated values are marked with 'e'. <sup>b</sup> Lakes are ordered by total PAH concentrations in surficial samples. <sup>c</sup> Canadian sediment-quality guidelines; interim sediment-quality guideline/probable effect level (27).

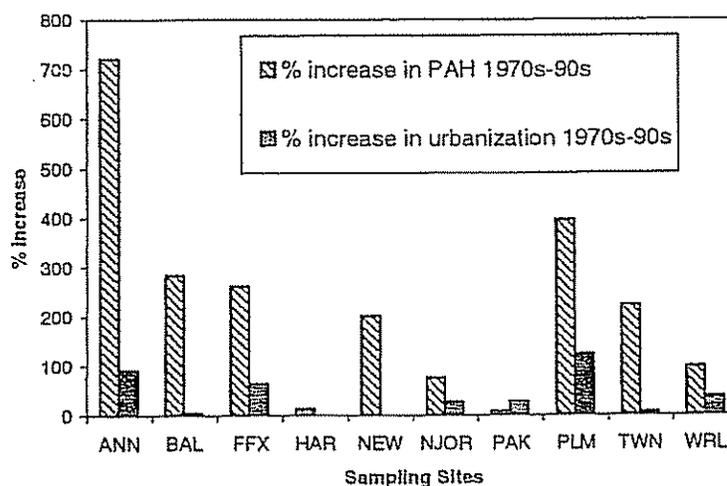


FIGURE 3. Comparison of percent increase in ΣPAH to percent increase in urban land use for each watershed (based on refs 21 and 22) from 1975 to 1995.

most dates are probably within a few years of the actual deposition dates. Pronounced peaks and systematic variations in chemical profiles indicate that contaminant trends have not been obscured by post-depositional mixing. We conclude therefore that these cores are recording multi-year to decadal trends in the contaminants of interest.

### Results

Modest to dramatic increases in ΣPAH concentrations are seen in sediments deposited in all 10 watersheds over the last 20-40 years (Figure 2a-c). In all three rapidly urbanizing sites, ΣPAH has increased sharply from pre-development levels to the present (Figure 2a). Recent concentrations were 1-2 orders of magnitude above pre-development concentrations at these sites. Among the moderately urbanizing and stable sites, differences in trends reflect the age of the onset of urbanization (Figure 2b,c). In those reservoirs in which the onset of urbanization was largely post-1960, ΣPAH increases steadily from the date of reservoir construction to the present, similar to the trends seen in the rapid-urbanization watersheds. In the three watersheds that underwent pre-1960s urbanization and in which the lake or reservoir was in place to record water-quality changes (HAR, PAK, and NJOR), ΣPAH peaked in the 1950s, similar to trends reported at other sites by other investigators (6-9), and then decreased (Figure 2b,c). In each case, however, this decrease was followed by a subsequent increase beginning in the 1960s in PAK and NJOR and in the 1980s in HAR.

Although many characteristics of the temporal trends are similar at these sites, the magnitude of concentrations varies greatly (Table 3). Concentrations of PAHs are a function not only of source strength but also of sedimentation rate and sediment dilution and thus can vary widely from site to site. The smallest concentrations are in White Rock Lake in Dallas, TX, with a ΣPAH at the sediment surface of 2790 μg/kg. The largest concentrations are in Newbridge Pond, a small reservoir in an older residential and commercial neighborhood on Long Island in New York, with a ΣPAH in recent sediments of 224 000 μg/kg. Intermediate concentrations, ranging from about 10 000 to 50 000 μg/kg in surficial sediments, occur at the other eight sites.

The assemblage of PAH compounds in the cores indicates a general shift in PAH source over the last 40 years from uncombusted to combusted fossil fuels, coincident with increased concentrations and urbanization. Uncombusted sources (e.g., oil seeps, petroleum spills) contain predominantly two- and three-ringed compounds, whereas combustion (e.g., vehicle exhaust, domestic heating with coal, forest fires) results in predominantly four- and five-ringed species (7, 18). Figure 2d-f shows the change over time in the ratio of two- and three-ringed PAH compounds plus homologues to the sum of the major "combustion" PAHs (28). The combustion PAHs are fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[e]pyrene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, and benzo[ghi,perylene]. A decrease in this ratio indicates

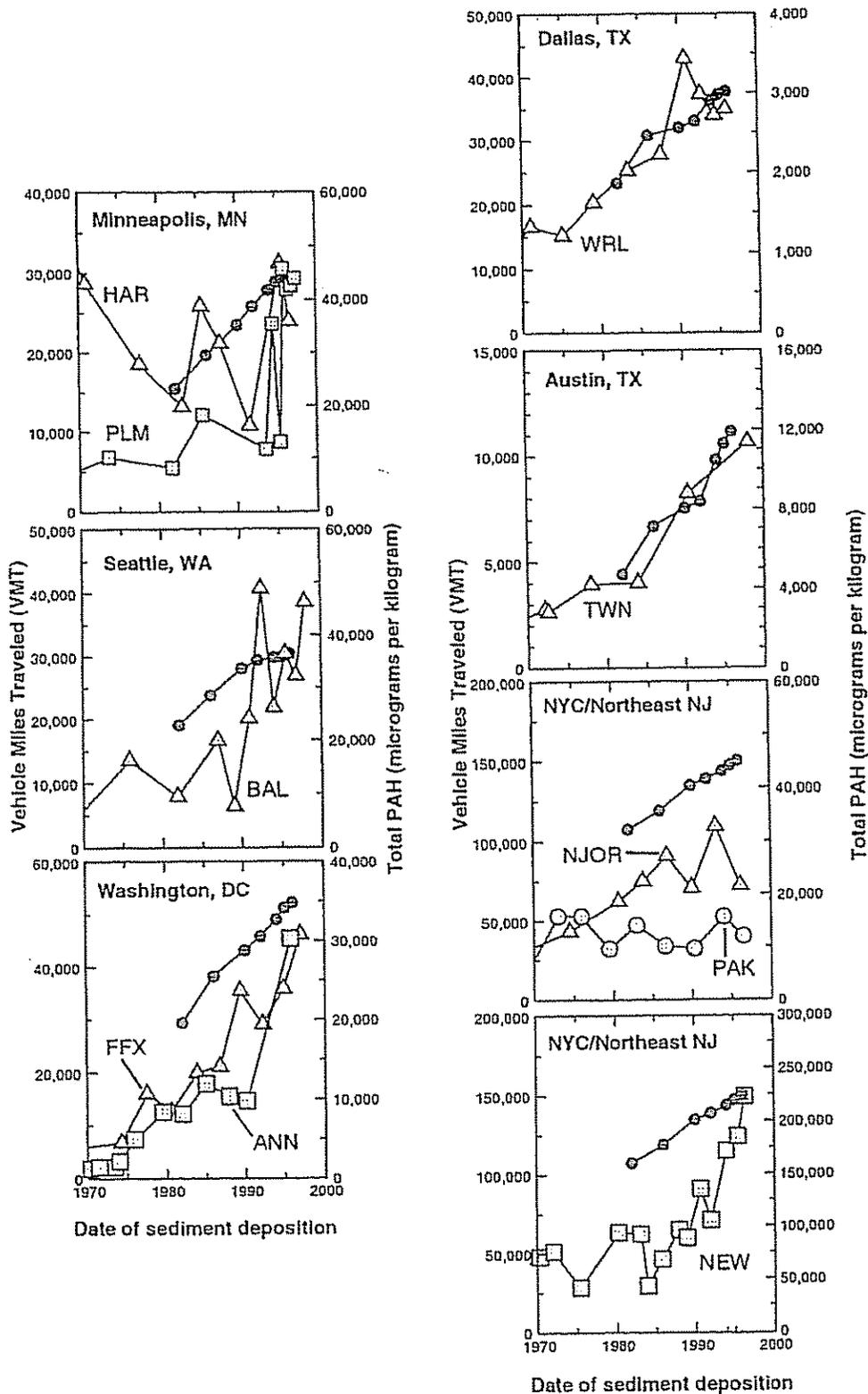


FIGURE 4. Comparison of increases in vehicle miles traveled (VMT) to changes in  $\Sigma$ PAH. Vehicle miles traveled per year over the entire metropolitan center (14) are shown by filled circles;  $\Sigma$ PAH for the lake or reservoir from the watershed within that area are shown by shaded symbols.

a shift from uncombusted to combusted fossil fuels as the PAH source. The proportion of noncombustion sources

relative to combustion sources increased during the early history of four watersheds (WRL, NEW, NJOR, and BAL).

peaking from the 1950s to the 1970s; all four sites had some degree of pre-1960s urban development. In contrast, over the last few decades, 9 of the 10 sites show an increase in the importance of combustion sources relative to noncombustion sources coincident with increasing concentrations. Only PAK shows a varying ratio with no trend.

The change in  $\Sigma$ PAH from the mid-1970s to the mid-1990s is compared to the change in the amount of urban land use for each watershed for the same period (Figure 3). In 9 out of 10 cases (PAK being the exception), increase in  $\Sigma$ PAH outpaces increase in urbanization. At some sites (BAL, NEW, and TWN), there was virtually no increase in the amount of urban land use during that period, yet  $\Sigma$ PAH more than doubled.

To investigate the possible effect of traffic on trends in  $\Sigma$ PAH, trends in vehicle use for the six metropolitan areas in this study were plotted versus  $\Sigma$ PAH (Figure 4). Trends in vehicle miles traveled (VMT) for each metropolitan area and  $\Sigma$ PAH for the 1970s–1990s show similar increases. This comparison is limited in that the VMT data are for entire metropolitan areas and are not specific to the sampled watersheds. In most cases the watersheds contributing runoff to the sampled lakes are much smaller than the urban area, and changes in traffic volume over time may not necessarily match those of the larger urban area. The possible correlation can be better investigated by looking at two reservoir watersheds that correspond well to the urban areas of the VMT data: Town Lake (TWN) in Austin and White Rock Lake (WRL) in Dallas, TX. Town Lake receives drainage from most of urban Austin; nonurban sediments from the Colorado River, which forms Town Lake, are trapped by a series of upstream reservoirs. The White Rock Lake Watershed covers 264 km<sup>2</sup> of diverse urban land use that is generally a similar mix of residential, commercial, industrial, and transportation land uses as greater Dallas (29). For these two sites, the slopes of PAH concentrations and VMT versus time are very similar (Figure 4), indicating that increases in PAHs are proportional to increases in vehicle traffic, at least for these two locations.

## Discussion

The results of this study indicate a reversal in the decreasing trend in PAHs in older urban watersheds; a rapid increase in PAHs in all watersheds over the last two decades, resulting in severe degradation of sediment quality at most of these sites; and a possible relation between vehicle traffic and recent deterioration of sediment quality with respect to PAHs in receiving water bodies in urban areas of all ages.

The decreasing trends in PAHs reported in studies carried out in the 1970s and 1980s have been largely attributed to the transition from home heating with coal to the use of oil and natural gas and increased efficiency of centralized power plants (6–9). A possible reversal of the decreasing trend is suggested by a few data points in two earlier studies, one rural and one urban (7, 8). Cores from older urban lakes sampled in this study (HAR, PAK, and NJOR) record the presence of the 1950s peak and subsequent decreasing trend but also document the reversal of the decreasing trend with variable but increasing PAH concentration to the present (1990s). This suggests that at older urban sites the improvements to sediment quality caused by changes in home heating and power generation technology have since been overwhelmed by increases in other sources of PAHs.

The increasing trends in  $\Sigma$ PAH in all 10 water bodies over the last 20–40 years have resulted in high to extremely high concentrations in recently deposited sediments. To put the concentrations of PAHs analyzed in this study into an ecological perspective, the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (27) for three of the most prevalent PAHs are listed at the bottom of Table 3. Concentrations in surficial sediments (top of core) for all

10 lakes exceed the interim freshwater sediment quality guidelines (ISQGs—the concentration below which adverse effects are unlikely to occur) for these three compounds and 6 or more of the 10 lakes exceed the probable effect levels (PELs—the concentration above which adverse biological effects are expected to occur) for these compounds. For the worst case, Newbridge Pond, concentrations of benzo[a]pyrene, fluoranthene, and pyrene are 14, 12, and 25 times the PELs, respectively. Clearly, increases in PAHs in urban water bodies have degraded sediment quality to the point that it is an ecological concern.

The increase in PAHs in new urban settings cannot be attributed solely to urbanization of the watersheds (Figure 3). This is most clearly illustrated by those watersheds in which urban levels are stable (Table 1; BAL, HAR, NEW, and TWN). The increase in PAH concentrations in these watersheds is, however, coincident with increases in automobile use (Figure 4). Among the sources of PAHs related to automobiles are tire wear, crankcase oil, roadway wear, and car soot and exhaust (19, 30–32). Trends in  $\Sigma$ PAH from the 1970s to the present compare well to trends in VMT on freeways and major arterial streets for the associated urban areas for all sites and ages of urban development (Figure 4).

One intriguing possibility suggested by the results of this study is that urban growth or sprawl outside the watershed may adversely affect water quality within the watershed. This is most evident when a watershed has undergone only a relatively minor change in degree of urbanization. For example, Austin, TX, is one of the most rapidly growing cities in the country, but the majority of the growth there has occurred around the fringes of the city and outside of the watershed of Town Lake. This growth has contributed to large increases in vehicle traffic in the Town Lake watershed; traffic on MoPac Expressway, most of which lies within the watershed and which crosses Town Lake, almost doubled between 1990 and 1997 (33). The large increases in traffic offer an explanation for why PAHs more than doubled in Town Lake from 1975 to 1990 while percent urban land use only increased by 5%. This suggests that urban sprawl in outlying areas may affect traffic patterns and water quality in the inner city.

The similar trends in VMT and PAHs in reservoir and lake sediments seen here indicate that, in the absence of reductions in vehicle-related PAH releases,  $\Sigma$ PAH will continue to increase at rates comparable to those projected for automobile use. Reduction of PAHs in the environment will not be easily achieved. Although fluxes of several contaminants (nitrogen oxides, airborne particulates <10  $\mu$ m, carbon monoxide, and volatile organic compounds) in transportation-related air emissions in the United States have been decreasing since the 1970s (34), PAHs in the environment, as shown here, are continuing to increase coincident with increasing VMT. This apparent contradiction may result from the fact that there are several sources of vehicle-related PAHs in addition to exhaust, including asphalt wear, tire wear, and leaks and spills of engine oil. The multiple vehicle-related sources, coupled with increasing dependence on the automobile, highlight the complexity of reducing PAH releases into the environment.

## Acknowledgments

We thank Robert Eganhouse and Tom Lopes (U.S. Geological Survey) for their many helpful comments. We also thank Corey Stephens (U.S. Geological Survey) for compilation of land-use data for the sampled watersheds. Mention of brand names in the text is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

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O'Brien, Patrick M.

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**From:** saintrobert [saintrobert@comcast.net]  
**Sent:** Thursday, June 03, 2010 6:43 PM  
**To:** O'Brien, Patrick M.  
**Cc:** Kopetz, Kevin  
**Subject:** Sale of Seaside Regional Center;Comments  
**Attachments:** 06.03. OPM. Comments.Ltr.doc

Please confirm receipt of this e-mail. If the attachment is difficult to read, let me know, and I'll send it separately.

Robert Fromer

June 03, 2010

SENT VIA E-MAIL TO: [patrick.obrien@ct.gov](mailto:patrick.obrien@ct.gov)

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Patrick O'Brien  
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Re: The proposed transfer of Seaside Regional Center, 36 Shore Road,  
Waterford, Connecticut 06385

The Connecticut Department of Public Works ("DPW") selected Mr. Mark Steiner as the successful bidder for the purchase and transfer of the Seaside Regional Center ("Seaside"), Waterford. The undersigned provide the following comments and recommendations for the Council on Environmental Quality's consideration.

The 32 acre Seaside parcel has about 1500 feet of direct shoreline access to Long Island Sound. The State removed most non-historic buildings from the property during the summer and fall of 2009. Approximately 70 percent of the site is undeveloped open space or field and meadow, populated with various specimens of mature trees. The property is home to a large selection of wildlife, including hawks, egrets and other shore birds, Baltimore Orioles, finches, hummingbirds, bats, butterflies and mammals, including deer, coyotes, turkeys, fisher cats, and possibly New England cottontail rabbits – a threatened species.

The fields on the west side have a high water table and there is a stream that traverses the property from north to south and empties into the Sound. There are four divisions of beachfront, two of which are sandy and suitable for swimming. There are several jetties, from which many people fish for stripers, blue fish, flounder and blackfish. One of the older jetties has a structure that was designed to provide handicap access. The water is extremely clean, which Kathleen Jacques can attest to, because the adjoining water was approved for shellfish depuration in the 1990s.

The site has a main road that divides the east and west sides, and the two buildings designed by Cass Gilbert are on the east side. The State owns a group home on the west side that has frontage on Shore Road. It would be very easy to subdivide the site and have the two Gilbert buildings sold for private use. A considerable amount would remain as open space with no hardship to the developer. Early in the process, the Office of Policy Management decided that subdivision would not be considered to prevent the entire site from being divided as opposed to just splitting it in half. The State could keep the group home side that also has a residential duplex and the former superintendent's homes. They are suitable for family respite or staff training facilities for the Department of Developmental Services; at one time Hospice expressed an interest in them. These houses abut the residents on Magonk Point with virtually no buffer between them.

Except for the group home and some security lights, there is very little light pollution emanating from the site. The fields are untreated by fertilizers or pesticides. There are no automobiles on the site, and a very small amount of paved area; the main road continues along the east side up to the main building, which has the remains of a staff parking lot there. There are smaller roads on the west side that lead to the two other buildings.

The property abuts a rural neighborhood of older modest sized lots, and is listed in the current Town of Waterford Plan of Preservation, Conservation and Development as desired open space and is included in a proposed trail system.

The site is accessed by Shore Road, which is winding and narrow in places. It is feared that the proposed development will require widening of this road, and perhaps a Stop Light at the corner of Shore Road and the heavily traveled Route 213.

Mr. Fromer provided a copy of the legislative history concerning the requirement for water dependent uses within the ocastal area and its interpretative application by the previous Commissioner of the Connecticut Department of Environmental Protection under the Connecticut Coastal Management Act ("CCMA"). The notice of the proposed transfer in the Environmental Monitor for May 18, 2010 reads in pertinent part as follows:

**The agency is proposing to transfer the property with the following restrictions on future uses:** The purchaser has offered to place a conservation/preservation easement over certain portions of the property, primarily over the floodplain areas, which include the beach area waterward of the seawall, and other upland areas. Purchaser has proposed providing public access in perpetuity to the conservation/preservation areas for passive recreation. The easement would be in favor of the State and the public.

The Connecticut General Statutes ("Conn. Gen. Stats."), section 22a-93(16) provides for public access as a defined "water dependent use" in the following manner:

"Water-dependent uses" means those uses and facilities which require direct access to, or location in, marine or tidal waters and which therefore cannot be located inland, including but not limited to: Marinas, recreational and commercial fishing and boating facilities, finfish and shellfish processing plants, waterfront dock and port facilities, shipyards and boat building facilities, water-based recreational uses, navigation aides, basins and channels, industrial uses dependent upon water-borne transportation or requiring large volumes of cooling or process water which cannot reasonably be located or operated at an inland site and uses which provide general public access to marine or tidal waters;

(Emphasis added.)

Further, although public access is a defined "water-dependent use", it is not legally permissible to justify primarily "water-enhanced uses" or water-related uses" such as condominiums, which has no requirement for direct access to Long Island Sound. The Conn. Gen. Stats, sections 22a-92(a)(3) and (b)(1)(A) require the "highest priority and preference for water dependent uses."

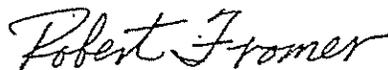
Mr. Steiner proposed parking areas for the residents and for public access. Normally, such parking surfaces, whether new or existing, are impermeable asphaltic materials. Further, future use of such parking surfaces often entail the

use of tar-based driveway sealers, which are known sources of Polycyclic Aromatic Hydrocarbons ("PAHs"). According to the attached article, PAHs are toxic pollutants to aquatic life.

Finally, DPW should seriously consider leasing, instead of selling, the land to the successful bidder. In this way, the state could acquire the developed assets of the site in the future should the improvements become financially unviable.

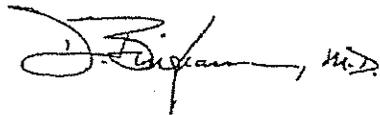
Therefore, we request that CEQ recommend that DPW prepare a phased Environmental Impact Evaluation ("EIE") in accordance with Conn. Gen. Stats., section 22a-1b. This means that DPW would completely characterize the existing environment and when the developer submits site plans to the land-use agencies, DPW would finalize the EIE. Additionally, we request the limitation of the condominiums to adaptive reuse of the historic structures, use of pervious pavement for any parking areas, and restriction on the use of driveway sealers. Further, we support leasing of the land, instead of its sale.

Cordially,



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Robert Fromer



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David Bingham

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/s/Kathleen Jacques

Kathleen Jacques

Office of Policy and Management  
Seaside Regional Center Transfer  
June 03, 2010  
Page - 5 -

Cc: Attorney Kevin Kopetz  
Department of Public Works  
165 Capitol Avenue, 443  
Hartford, CT 06106  
[Kevin.kopetz@ct.gov](mailto:Kevin.kopetz@ct.gov)

Attachment: U.S. Geological Survey, *Urban Sprawl Leaves Its PAH  
Signature*, Environ. Sci. Technol. 2000, 34, 4064-4070

## Urban Sprawl Leaves Its PAH Signature

PETER C. VAN METRE,<sup>1,2</sup>  
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The increasing vehicle traffic associated with urban sprawl in the United States is frequently linked to degradation of air quality, but its effect on aquatic sediments is less well recognized. This study evaluates trends in PAHs, a group of contaminants with multiple urban sources, in sediment cores from 10 reservoirs and lakes in six U.S. metropolitan areas. The watersheds chosen represent a range in degree and age of urbanization. Concentrations of PAHs in all 10 reservoirs and lakes increased during the past 20–40 years. PAH contamination of the most recently deposited sediment at all sites exceeded sediment quality guidelines established by Environment Canada, in some cases by several orders of magnitude. These results add a new chapter to the story told by previous coring studies that reported decreasing concentrations of PAHs after peaking in the 1950s. Consistent with the increase in concentrations is a change in the dominance of PAHs that indicates the increasing trends are driven by combustion sources. The increase in PAH concentrations tracks closely with increases in automobile use, even in watersheds that have not undergone substantial changes in urban land-use levels since the 1950s.

### Introduction

Polycyclic aromatic hydrocarbons (PAHs) represent the largest class of air-polluted carcinogens (1) and can persist a decade or more in air (2). The presence and degradation of PAHs in the environment are largely a product of the incomplete combustion of petroleum, oil, coal, and wood (3). Anthropogenic sources such as vehicles, heating and power plants, industrial processes, and refuse and open burning are considered to be the principal sources in the environment (4). Our best source of PAH data, electric power plants (5), of PAH emissions in the United Kingdom, commercial burning produced 84% and industrial processes produced 16% (6). Several studies in the 1970s and 1980s reported decreasing trends in PAH concentrations in the environment on a regional scale (United States and Europe) since they peaked in the 1940s and 1950s (6–8), an observation that was attributed to changes in land use (9), changes in fuel from petroleum to coal (10), and changes in combustion efficiency of power plants (7, 9–11).

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FIGURE 1. Locations of sampling sites. Abbreviations correspond to lake and reservoir codes given in Table 1.

While levels of PAHs from some sources may have decreased, the changing face of the urban landscape has resulted in an increase in another source of PAHs: vehicle use. Growth in the use of land for residential and commercial purposes in the United States over the century, growth in population (12), a phenomenon termed urban sprawl (13), increasing population density (14), increased automobile use, and new office facilities and growing dependence on vehicles, as reflected in a number of miles traveled per capita and per vehicle (15, 16). What effect, if any, has this change had on urban water bodies?

As a part of the U.S. Geological Survey National Water Quality Assessment (NAWQA) Systemwide Trends program, trends in PAHs were tracked over the last several decades in the mid to late 1990s in sediment cores from 10 lakes and reservoirs in six U.S. metropolitan areas. This study indicates that trends in PAH concentrations in developed watersheds over the last three decades, rather than decreasing, are increasing and that the increases may be linked to the increasing amount of urban sprawl and vehicle traffic in urban and suburban areas.

### Methods

Sediment cores from lakes and reservoirs can be used to reconstruct historical trends in water quality (15, 16). Trends are recorded for hydrophobic, persistent compounds, such as PAHs, that bind to sediment particles. PAHs, seen to partition and are transported to receiving water bodies via atmospheric deposition (17), sewage effluent (18), and surface runoff (19). For this study, sediment cores were collected from seven reservoirs and three lakes across the United States (Figure 1) and five in the majority of these reservoirs and lakes to largely mixed residential and commercial land use from urban land use ranging from 25 to nearly 100% (Table 1). Three sites are in watersheds experiencing rapid growth since the 1970s (18–22% increase in urban land use), three reservoirs in watersheds experiencing moderate growth (6%–18%), and four sites are in watersheds with relatively stable levels of urban land use (2–10%). The cores reflect long-term trends from the early 1900s (e.g., Lake Huron and Newbridge Pond) to recent decades (e.g., Palmer Lake).

Cores were collected from the deepest part of the lake or in the lower part of the reservoir and sectioned into regularly discrete sediment slices for analysis of <sup>13</sup>C and PAHs. <sup>13</sup>C was analyzed for selected lakes. Samples were also analyzed for nonyl and nonyl esters, chlorinated organic pesticides, and PCBs (see presented in this paper).

TABLE 1. Selected Characteristics of Lakes Sampled

name and lake	sampling date	depth of water (m)	lake area (km <sup>2</sup> )	weighted area (km <sup>2</sup> )	% urban 1970 <sup>a</sup>	% urban 1990 <sup>b</sup>	% urban during 1990-1997 <sup>c</sup>
Lake Anne, VA (ANM)	Jan 1996	6.5	0.71	2.3	14.6	33.3	91
Lake Hollinger, VA (HOL)	Jan 1996	9.9	0.40	1.1	91.0	96.5	4
Lake Fortia, VA (FTL)	Sep 1997	3.8	0.71	3.4	58.6	97.8	58
Lake Harris, MD (HAR)	Jul 1998	71.3	1.7	6.7	19.7	19.7	0
Marysberg Pond, NY (MRY)	Sep 1997	7	0.017	1.9	99.6	99.6	0
Orange Reservoir, NJ (ORR)	Sep 1997	cr <sup>d</sup>	0.15	11.7	11.1	97.1	26
Lake Rockaway, NJ (ROK)	Sep 1997	7	0.13	4.8	11.7	91.7	77
Quaker Lake, MD (QLM)	Jul 1998	1	0.13	64.9	19.6	65.6	177
Trent Lake, TX (TRM)	Aug 1998	2.5	0.11	10.1	73.5	75.7 <sup>e</sup>	4
White Rock Lake, TX (WRL)	Jan 1996	1.9	4.4	76.5	52.1	16.7	16

<sup>a</sup>Based on 1970. <sup>b</sup>Based on 1990. <sup>c</sup>Size-weighted percent change in urban characteristics (weighted by lake area) between 1990 and 1997. <sup>d</sup>Cratered. <sup>e</sup>Based on 1992.

TABLE 2. Sediment Accumulation Rates and Age Distributions in Core

lake	range of age (years)	accumulation rate (cm/yr)	age distribution period of core	sediment thickness (cm)	average sedimentation rate (cm/yr)	average accumulation rate (g cm <sup>-2</sup> yr <sup>-1</sup> )
Lake Anne	0, 0, 0, 7	0	1956-1996	17	0.60	0.18
Lake Hollinger	0	0, 0	1970-1996	23	0.45	0.11
Lake Fortia	0, 0	0	1957-1997	57	1.7	0.55
Lake Harris	0, 0	0, 0	~1970-1997	16	0.60	0.07
Marysberg Pond	0	0, 0	1957-1997	41	1.7	0.37
Orange Reservoir	0, 0	0	1945-1997	27	0.56	0.34
Lake Rockaway	0	0, 0, 0, 0	1970-1997	12	0.61	0.11
Quaker Lake	0, 0	0	1957-1997	19	0.76	0.41
Trent Lake	0, 0	0, 0	1959-1998	110	7.7	1.9
White Rock Lake	0, 0	0, 0	1971-1996	79	7.3	1.13

<sup>a</sup>Number of dates of age (0, 1, 2, 3, 4, 5, 6, 7). <sup>b</sup>Accumulation rate (cm/yr) based on 1996. <sup>c</sup>Period of age distribution (years) based on 1996. <sup>d</sup>Cratered. <sup>e</sup>Based on 1992.

PAHs and high-molecular-weight PAHs (hly-PAHs) were extracted, reduced, and analyzed using a variation of the procedure of芳原 et al. (20). Briefly, wet bottom sediment was extracted overnight with dichloromethane in Soxhlet apparatus. The extract was reduced and filtered. A subsample of the extract was processed by ion-exchange gel permeation chromatography (GPC) using a styrene-divinylbenzene column and a dichloromethane eluent to remove sulfur and partially reduce the PAHs from co-extracted high molecular-weight substances such as tar and sulfur. The PAH fraction was reduced in volume and solvent was changed to ethylacetone in micro-Supelco column. An aliquot of an equal sediment volume (a mixture of perfluorinated PAHs) was added to the final extract. PAHs were separated, identified and quantified by capillary gas chromatography (GC) coupled to mass spectrometry (MS). The parent and hly-PAHs were resolved on a fused silica capillary GC column. Selected ion monitoring (SIM) allowed to reduce identified interferences and improve sensitivity. Parent PAHs were identified and quantified by comparison with their standards. Individual hly-PAHs were quantified when an hly-PAH standard was available. The multiple source hly-PAHs were quantified from SIM mass chromatograms as the sum of all sources at each alkylation level (2,1-naphthalene, 2,1-naphthalene, etc.). When authentic hly-PAH standards were unavailable, a parent PAH was used for quantification. Nineteen parent PAHs, 10 specific hly-PAHs, and the hly-PAHs series of hly-PAHs were determined for this study. Total PAHs (TPAH) was computed as the sum of these, excluding perylene.

Sediment <sup>137</sup>Cs activity profiles were measured in all 10 reservoirs and lakes (Table 2) by counting freeze-dried sediments in fixed geometry with high-resolution, intrinsic germanium detector spectrometry. The method is similar

to that reported by Gaiser and Robinson (24). Activity concentrations of <sup>137</sup>Cs were measured in water reservoirs and wetlands (Table 2) by high-resolution, intrinsic spectrometry. A low energy phosphor detector was used to detect gamma emissions between 40 and 460 keV including <sup>137</sup>Cs, and a high purity germanium crystal detector was used for gamma emissions between 300 and 3000 keV (including <sup>137</sup>Cs).

Line of best position for sediment distribution curves here was based on a variety of date-depth markers. These indicators on which dates were based and those used to corroborate the dates are given in Table 2. The depth of the present core section in cores, for example, was matched with reservoir construction date in 5 of the 7 reservoirs. In the other two, Marysberg Pond and Orange Reservoir, the age of the reservoir and the presence of DDE, PCBs and <sup>137</sup>Cs immediately before the present core section indicated a discontinuity. The other major date-depth markers used were <sup>137</sup>Cs first occurrence (1963), <sup>137</sup>Cs peak concentration (1964), and sampling date. Additional date-depth correlations - depth markers are based on supported <sup>210</sup>Pb profile (Lise-Harveston), and parent and child <sup>137</sup>Cs, and <sup>137</sup>Cs and <sup>137</sup>Cs profiles (Lise-Harveston in the 1940s and 1950s, respectively) (66).

Cesium-137 profiles generated date markers in 8 of the 10 reservoirs and lakes. The core from White Rock Lake is a good example. <sup>137</sup>Cs is first detected at a depth of 58 cm, peaks sharply at 48 cm, and then exhibits a smooth exponential decrease to the top of the core. In addition to providing age control, this type of profile is very evidence that sediments have not been disturbed by bioturbation or other post-depositional mixing. As one site, Lake Harris, because there are present-day sediment deposited longer before the release of <sup>137</sup>Cs into the environment, <sup>210</sup>Pb was used in addition to <sup>137</sup>Cs to provide date information for the lower

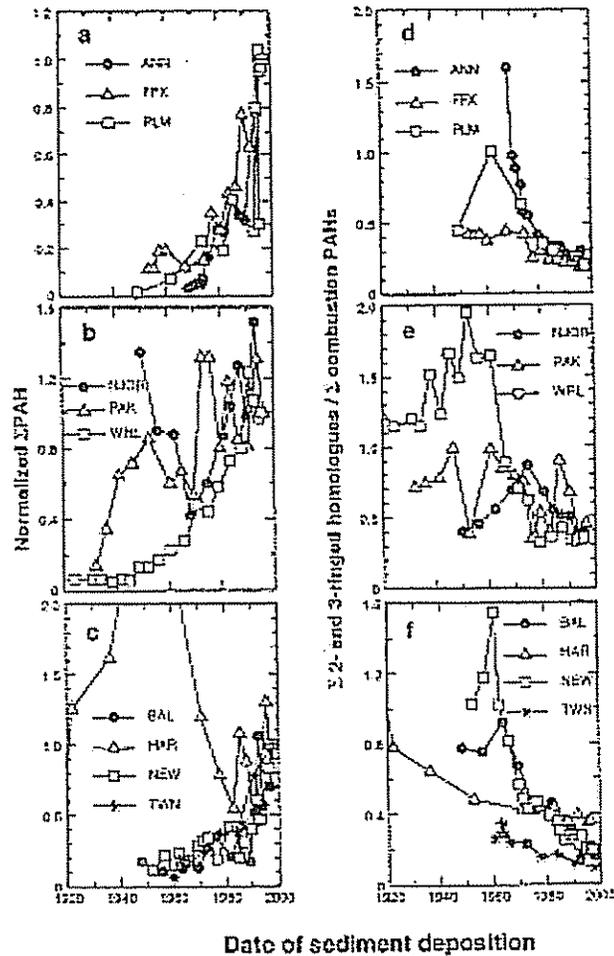


FIGURE 2. Normalized  $\Sigma$ PAH and ratios of PAH homologues in sediment cores from sites in the Washington area and by annual lake ice maximum date is plotted from each date to the most recently deposited sample, thus showing trends relative to local conditions. Normalized  $\Sigma$ PAH are shown for the cores with radiocarbon dates (a), and ratios for cores (b), and only for (c) of the initial stages of PAH accumulation as indicators of PAH source are shown for radiocarbon dates (d), radiocarbon dates (e), and radiocarbon (f) of sediment. Abbreviations for sites and radiocarbon dates are given in Table 1.

preparation were, following the current cleaning model (20).

A date-depth marker other than  $^{137}\text{Cs}$  was used for 2 of the 10 sites (NJOH and PAK) because the  $^{137}\text{Cs}$  peak was not sufficiently defined. For NJOH, a well-defined DDT peak was evidence of a major release time, and a date of 1964 was assigned to that depth. For PAK, dates were assigned based on occurrence of  $\text{Ca}^{2+}$  from mentofolite with  $\text{CaSO}_4$  (begin in about 1931, which we correlated to the sharp increase in  $\text{Ca}$  in the core at 18 cm). For all cores, other date markers such as the DDT peak in the early to mid-1960s and the lead peak in the mid-1970s were checked to see if they depths within the cores were consistent with the dates assigned.

Lakes Anne and Buckneck were the only two sites for which the composition of contaminants in the maximum sediment

was available. In these two lakes the initial dating scheme placed the lead peak in the 1980s, unacceptably late. This indicated that many of the contaminants must have decreased substantially between the occurrence of the older date markers ( $^{137}\text{Cs}$  for Anne and  $\text{Ca}^{2+}$  for Buckneck) and the top of the core. We therefore assumed that a gradual change in sedimentation rate occurred, possibly caused by gradual completion of urban construction in the watershed resulting in a corresponding reduction in erosion. We modeled this change using an exponential function following a hypothesis of  $1/t^2$  where a proportional decrease in mass accumulation rate was demonstrated in many reservoirs.

Although confidence in the marker cannot be assigned to the dates corresponding to individual sample intervals in the cores, the consistency of multiple date markers suggests that

TABLE 3. Concentrations of Selected PAHs in Cores

Site	surface (top of core) concentration				depth in core in core*			Total PAH
	benz[a]pyrene	fluoranthene	pyrene	total PAH	benz[a]pyrene	fluoranthene	pyrene	
Wings Rock Lake	14.1	29.7	7.79	2,730	63-15.1	69-37.7	65-25.2	115-31.40
Texas Lake	52.5	13.70	1,700	11,450	11-12.1	5.1-1,370	6.6-1,100	60-11,400
Lake Parkersburg	57.6	8.17	2.51	17,300	11-14.1	1.41-96.0	11.5-1,000	16.10-15,600
Orange Reservoir	91.1	11.20	1,250	71,450	11.4-15.00	5.77-25.00	52.4-2,770	11,000-29,100
Lake Anna	10.70	45.50	3.10	31,300	20-70.00	67-18.50	7.4-31.70	70.10-10,300
Lake Fortia	15.40	35.00	2.60	30,800	17.4-15.40	3.45-41.70	77.8-76.00	3170-10,800
Lake Fortia	19.00	42.70	3.70	35,900	65-14.10	19-16.800	24-17,300	470-45,300
Walker Lake	21.70	54.50	4.50	41,000	19-21.70	6.5-19.00	4.5-4.00	11.8-41,300
Lake Holkerer	23.50	11.70	4.10	48,300	12-29.10	1.65-24.70	25.1-7.10	45.10-19,600
Newbridge Pond	10,800	27,700	27,100	27,100	593-10,800	1,450-27,700	1,510-27,700	26,300-27,400
Concentration (ppb)	312/160	117/235	130/235					

\* Estimated values are based on linear interpolation of PAH concentrations in the cores. \* Grabbed sediment quality guidelines (SQGLs) for PAHs are based on the sediment quality guidelines (SQGLs) for PAHs (USEPA, 1995).

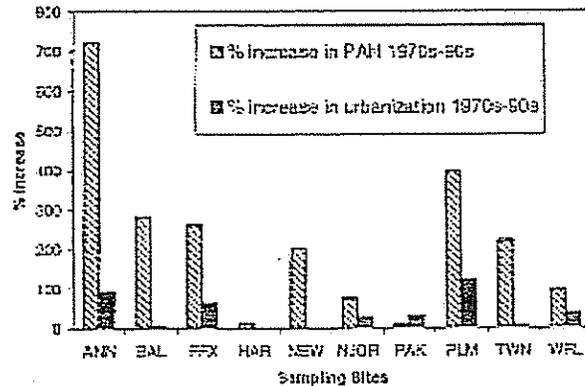


FIGURE 3. Comparison of percent increase in ΣPAH to percent increase in urbanization for 10 sampling sites located on Lake Fortia from 1975 to 1985.

most cases are probably within a few years of the actual deposition event. Persistence of peak and sporadic increases in chemical profiles indicate that contaminant trends have not been obscured by post-depositional mixing. We conclude that for the three cores the preceding multi-year to decadal trends in the concentrations of interest.

**Results**

Modern to dramatic increases in ΣPAH concentrations are seen in sediments deposited in all 10 marshes over the last 30-40 years (Figure 2a-c). In all three rapidly urbanizing sites, ΣPAH has increased sharply from pre-development levels to the present (Figure 2b). Because concentrations are 1-2 orders of magnitude above pre-development concentrations in these sites. Among the moderately urbanizing and stable sites, differences in trends reflect the age of the onset of urbanization (Figure 2a-c). In three reservoirs in which the onset of urbanization was largely post-1950, ΣPAH increases steadily from the time of reservoir construction to the present, similar to the trends seen in the rapidly-urbanizing marshes. In the three marshes that underwent pre-1950s urbanization and in which the site or reservoir was in place for several hundred years (HAR, PAK, and N:OR), ΣPAH peaked in the 1950s, similar to peaks reported elsewhere in older marshes (6-8), and then decreased (Figure 2a-c). In each case, however, this decrease was followed by a resurgence in ΣPAH during the 1980s in PAK and N:OR and in the 1990s in HAR.

Although many chemical compounds of the suspended matter similar to those seen in the marshes are concentrated in the marshes (Table 3). Concentrations of PAH have a long-term history of source strength but also of sedimentation rate and sediment dilution and thus can vary widely from site to site. The smallest concentrations are in the Rock Lake in Dallas, TX, with a ΣPAH in the sediment surface of 2,700 μg/kg. The largest concentrations are in Newbridge Pond, a small reservoir in an older residential and commercial neighborhood on Long Island in New York, with a ΣPAH in tree or sediment of 274,000 μg/kg. Intermediate concentrations, ranging from about 10,000 to 50,000 μg/kg in surface sediments, occur in the other eight sites.

The assemblage of PAH compounds in the cores indicates a general shift in PAH source over the last 40 years from unpurified to condensed fossil fuels, coincident with increased concentrations and sedimentation. Unpurified sources (e.g., oil seeps, petroleum spills) contain predominantly low- and three-ring compounds, in lesser amounts (e.g., n-alkyl esters, domestic heating oil, kerosene, fuel) results in predominantly four- and five-ring species (7, 18). Figure 2d-f shows the change over time in the ratio of five- and six-ring PAH compounds plus homologues to the sum of the major "condensed" PAHs (18). The condensed PAHs are benzo[a]pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[e]pyrene, benzo[a]pyrene, and benzo[a]perylene. A decrease in this ratio indicates

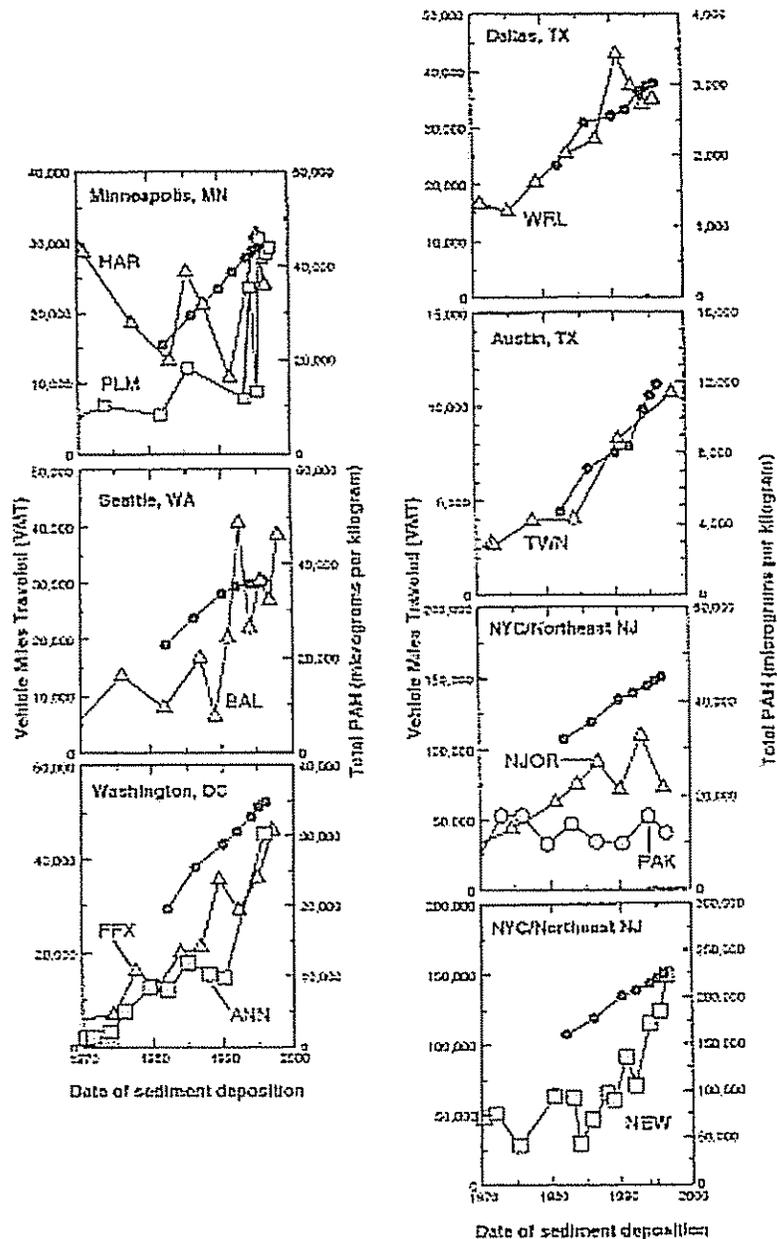


FIGURE 4. Comparison of increases in vehicle miles traveled (VMT) to changes in EPAH. Vehicle miles traveled per year over the entire watershed catchment (▲) are shown by filled triangles; EPAH for the total watershed from the watershed with that year are shown by filled squares.

a shift from nonpoint-source to increased point sources in the PAH source. The proportion of nonpoint-source sources

relative to point-source sources increased during the early history of four watersheds (WRL, NEW, NJOR, and ANN)

peaking from the 1950s to the 1970s at four sites had some degree of pre-1960s urban development. In contrast, over the last few decades, 9 of the 10 sites show a decrease in the importance of construction sources as being responsible for PAH sources coinciding with increasing concentrations. Only BAK shows a varying ratio with no trend.

The change in  $\Sigma$ PAH from the mid-1970s to the mid-1990s is compared to the change in the amount of urban land use for each watershed for the same period (Figure 3). In 9 out of 10 cases (BAK being the exception), increases in  $\Sigma$ PAH equities increase in urbanization. At some sites (BAL, NEW, and TON), there was actually an increase in the amount of urban land use during the period, yet  $\Sigma$ PAH decreased.

To investigate the possible effect of traffic on trends in  $\Sigma$ PAH, trends in vehicle use for the six metropolitan areas in this study were plotted versus  $\Sigma$ PAH (Figure 4). Trends in vehicle miles traveled (VMT) for each metropolitan area and  $\Sigma$ PAH for the 1970s–1990s show similar increases. This comparison is limited in that the VMT data are for entire metropolitan areas and are not specific to the sampled watersheds. However, since the watersheds containing the most of the sampled sites are much smaller than the urban area, and changes in traffic volume over time may not necessarily match those of the larger urban area. The possible correlation can be better investigated by looking at two receptor watersheds that correspond well to the urban areas of the VMT data: Town Lake (TON) in Austin and White Rock Lake (WRL) in Dallas, TX. Town Lake was the dominant urban area of urban Austin, nonurban sediments from the Colorado River, which drains Town Lake, are capped by a series of upstream reservoirs. The White Rock Lake Watersheds covers 264 km<sup>2</sup> of diverse urban land use that is generally a similar mix of residential, commercial, industrial and transportation land uses as seen in Dallas (20). For these two sites, the slopes of PAH concentrations and VMT versus time are very similar (Figure 4), indicating that increases in PAHs are proportional to increases in vehicle traffic, at least for the two locations.

## Discussion

The results of this study indicate a correlation between decreasing trends in PAHs in older urban watersheds, a rapid increase in PAHs in all watersheds over the last two decades, resulting in source degradation of sediment quality in most of these sites, and a possible relation between vehicle traffic and recent deterioration of sediment quality with respect to PAHs in receiving water bodies in urban areas of all ages.

The decreasing trends in PAHs reported in studies carried out in the 1970s and 1980s have been largely attributed to the transition from home heating with coal to the use of oil and natural gas and increased efficiency of residential power plants (6–9). A possible reversal of the decreasing trend is suggested by a few data points in two earlier studies, one rural and one urban (7, 8). Cases from other urban sites sampled in this study (BAK, and NICH) record the presence of 1980s peaks and subsequent decreasing trends but also document the reversal of the decreasing trend with notable but increasing PAH concentrations in the present (1990s). This suggests that as older urban sites the importance of sediment quality caused by changes in home heating and power generation technology have since been overwhelmed by increases in other sources of PAHs.

The increasing trends in  $\Sigma$ PAH in all the water bodies over the last 20–40 years have resulted in high to extremely high concentrations in recently deposited sediments. To put the concentrations of PAHs analyzed in this study into an ecological perspective, the Canadian Sediment Quality Guidelines for the protection of Aquatic Life (33) for three of the most prevalent PAHs have been used to determine if PAH concentrations in selected sediments (top of core) from 10

sites exceed the interim freshwater sediment quality guidelines (ISQG)–the concentration below which adverse effects are unlikely to occur) for these three compounds and if or more of the 10 sites exceed the probable effect levels (PEL)–the concentration above which adverse biological effects are expected to occur) for these compounds. For the worst case, Newbridge Pond, concentrations of benzo[a]pyrene, fluoranthene, and pyrene are 14, 12, and 23 times the PELs, respectively. Clearly, increases in PAHs in urban watersheds have degraded sediment quality to the point that it is an ecological concern.

The increase in PAHs in new urban settings cannot be measured solely in urbanization of the watersheds (Figure 3). This is more clearly illustrated by these watersheds in which urban land use has shrunk (Table 1: BAL, NEW, and TON). The increase in PAH concentrations in these watersheds, however, coincided with increases in automobile use (Figure 4). Among the sources of PAHs related to automobiles are the wear, maintenance oil, tire wear, and exhaust (36, 38–39). Trends in  $\Sigma$ PAH from the 1970s to the present compare well to trends in VMT on freeways and major arterial business for the associated urban areas for address and ages of urban development (Figure 4).

One intriguing possibility suggested by the results of this study is that urban growth sprawl outside the watershed may increase highway traffic within the watershed. This is most evident when a watershed has undergone only a relatively minor change in degree of urbanization. For example, Austin, TX, is one of the most rapidly growing cities in the country, but the majority of the growth there has occurred around the fringes of the city and outside of the watershed of Town Lake. This growth has contributed to large increases in vehicle traffic in the Town Lake watershed, traffic on M-630 Expressway, most of which flows thru the watershed and which crosses Town Lake, almost doubled between 1990 and 1997 (40). The large increases in traffic offer an explanation for why PAHs were also elevated in Town Lake from 1975 to 1995 while percent urban land use only increased by 2%. This suggests that urban sprawl in early stages may affect traffic patterns and water quality in the inner city.

The similar trends in VMT and PAHs in receptor and base sediments seen here indicate that, in the absence of reductions in vehicle-related PAH releases,  $\Sigma$ PAH will continue to increase at rates comparable to those projected for automobile use. Reduction of PAHs in the environment will not be easily achieved. Although states of several communities (largely cities, urban areas, populations >100,000, carbon monoxide, and vehicle engine components) in transportation to reduce emissions in the United States have been decreasing since the 1970s (41), PAHs in the environment, as shown here, are continuing to increase coincident with increasing VMT. To improve communities approach to reduce traffic there are several sources of vehicle-related PAHs in addition to exhaust, including splash, wear, tire wear, and brake and spindle squeal, etc. The multiple vehicle-related sources, coupled with increasing dependence on the automobile, highlight the complexity of reducing PAH releases from the environment.

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