PAHs And Parking Lots: A Field Study on PAHs Exported From Sealed and Unsealed Parking Lots at the UNH Stormwater Center

Alison W. Watts, Thomas Ballestero, Robert Roseen, Jamie Houle
University of New Hampshire Stormwater Center
Dedicated to the protection of water resources through effective stormwater management
UNHSC Study
Controlled field experiment

Lot A - Sealed (0.3 acre)

Lot B - Sealed (0.25 acre)

Lot C - No sealant (9 acres)

Primary UNHSC Field Site
Sampling

Objective – Measure mass of PAH in each pathway

• Stormwater runoff
  (24 storms, 11/07-12/09)
• Downstream sediments
  Swale, stormwater devices
• Adjacent surface soil
• Pavement dust
• Air

All samples analyzed for PAHS, GC/MS, subset analyzed for PAHs/homologs/SIMs
PAH (Σ 16) Concentrations
Unfiltered Composite Stormwater Samples

![Graph showing PAH concentrations over time for different lots.
A Sealed Lot
B Sealed Lot
C Unsealed Lot

X-axis: Date (Sep 07 to Apr 10)
Y-axis: Total PAH (μg/L)

Legend:
- A Sealed Lot
- B Sealed Lot
- C Unsealed Lot

Data points indicate varying concentrations over time for each condition.

Source: University of New Hampshire Stormwater Center]
“First Flush ” samples collected during the first rain event

Lot A: 5,890 µg/L
Lot B: 642 µg/L
Lot C: 4.39 µg/L
Sediment Samples

Unsealed control
9 acres

Coal tar sealant
0.3 acres
Sample locations, concentrations in mg/kg
Pre sealant - Oct 2007
9 months after sealant June 2008
12 months after sealant Oct 2008
30 months after sealant April 2010
4% of surface sealed
109-162 mg/kg
(Gravel Wetland, Bioretention, Detention Pond)

100% of surface sealed
390 – 1,700 mg/kg
(Tree Filter)

Unsealed
1.6 mg/kg
(Bioretention)
Stormwater sediments (Σ16PAH):

<table>
<thead>
<tr>
<th>Condition</th>
<th>Concentration (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsealed</td>
<td>&lt;5</td>
</tr>
<tr>
<td>4% of area sealed</td>
<td>100</td>
</tr>
<tr>
<td>100% sealed</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Concentrations increase when coal tar sealant is applied to watershed surface.
Total Mass: Calculate Mean Concentration in 6 Month Intervals
### Mass of PAHs Exported in Stormwater

<table>
<thead>
<tr>
<th></th>
<th>C-Unsealed 9 acre</th>
<th>A-Sealed 0.3 acre</th>
<th>B-Sealed 0.25 acre</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Oct-Dec 07</strong></td>
<td>0.05</td>
<td>0.59</td>
<td>0.09</td>
</tr>
<tr>
<td><strong>2. Dec-June 08</strong></td>
<td>0.18</td>
<td>0.27</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>3. July-Dec 08</strong></td>
<td>0.1</td>
<td>0.18</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>4. Jan-June 09</strong></td>
<td>0.4</td>
<td>0.16</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>5. July-Dec 09</strong></td>
<td>0.5</td>
<td>0.21</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>Total per lot</strong></td>
<td><strong>1.23</strong></td>
<td><strong>1.41</strong></td>
<td><strong>0.54</strong></td>
</tr>
<tr>
<td><strong>Total per acre</strong></td>
<td><strong>0.13</strong></td>
<td><strong>4.27</strong></td>
<td><strong>2.16</strong></td>
</tr>
</tbody>
</table>

**Wear:** Approximately 25% of sealant remaining on A lot, 50% remaining on B lot.
Mass Balance – Stormwater

B Lot:

**Mass of PAHs applied**: 9 kg

- 1,000 liters applied
  (by volume estimates, and contractors estimate)
- Concentration (dried) 18,000 mg/kg => 9 kg PAHs

**50% remaining on lot**: 4.5 kg lost

**Mass in stormwater runoff**: 0.5 kg

Verified by volume: 1,000 liters applied
volume of sealant particles in tree filter
less than 100 liters.

Where did the rest go?
PAH Concentrations in Surface Soil and Dust

Total PAH = 411
Benzo(a)pyrene = 29.2

EPA PRG Industrial screening level for benzo(a)pyrene = 0.21 mg/kg
Sealant applied by professional paving company. Criteria – able to apply both coal tar and asphalt based sealant using different trucks. UNH Specified:

Neyra Brand “Tarconite”

<34% Refined coal tar

Neyra Brand “Paveshield”

Asphalt resin Ball clay Ground silica

Ball clay

Fluoranthene

Pyrene

C1 - Fluoranthene/Pyrene

C2 - Fluoranthene/Pyrene

C3 - Fluoranthene/Pyrene

C4 - Fluoranthene/Pyrene

Benz[a]anthracene

Chrysene

C1 - Benz[a]anthracene

C2 - Benz[a]anthracene

C3 - Benz[a]anthracene

C4 - Benz[a]anthracene

Benzo[b]fluoranthene

Benzo(e)pyrene

Benzo[a]pyrene

Perylene

Dibenz[a,h]anthracene

Benzo[g,h,i]perylene

Total PAH (16)

mg/kg

Asphalt?

Coal Tar

And Other Issues…
Application Matters


• Make sure no significant rainfall is forecast for at least 48 hours after application of the sealcoat;
• Only apply sealcoat when temperatures are above 60° Fahrenheit and rising throughout the application period;
• Take appropriate measures to ensure that newly applied sealcoat does not impinge on adjacent surfaces or enter storm or sewer drains; and
• Make sure that no traffic can access the newly sealcoated surface for at least 12 hours.

<table>
<thead>
<tr>
<th>Date</th>
<th>Min Temp (F)</th>
<th>Max Temp (F)</th>
<th>Precipitation (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 5, 2007</td>
<td>50.1 (6:33)</td>
<td>83.2 (15:56)</td>
<td>0</td>
</tr>
<tr>
<td>October 6, 2007</td>
<td>57.16 (7:15)</td>
<td>79.8 (13:38)</td>
<td>0.58 (19:00)</td>
</tr>
</tbody>
</table>

A and C Lots installed in 1996, B Lot installed in 2006
Conclusions

Stormwater
PAHs from sealed surfaces at least an order of magnitude higher than from unsealed control during first two years. Concentrations decrease with time. Not the only primary pathway for PAH transport from sealed sites.

Surface Soil
PAHs in adjacent surface soil up to 400mg/kg, Benzo(a)pyrene up to 29mg/kg.

Stormwater sediments
PAHs <5 mg/kg in unsealed areas, ≈ 100mg/kg in structures receiving flow from mixed surfaces, ≈ 1,000mg/kg in fully sealed watershed.

Application Matters
Best management practices could reduce ‘first flush’ concentrations, but contractors should not be relied upon to enforce (or put down the correct sealant!)
QUESTIONS?

Alison.watts@unh.edu
www.unh.edu/erg/cstev/
or search “UNH stormwater”
## Filtered Stormwater

<table>
<thead>
<tr>
<th>Date</th>
<th>Surface</th>
<th>Lot</th>
<th>Concentration (ug/l)</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unfiltered</td>
<td>Filtered</td>
</tr>
<tr>
<td>5/27/2009</td>
<td>A</td>
<td></td>
<td>41.4</td>
<td>21.9</td>
</tr>
<tr>
<td>5/28/2009</td>
<td>B</td>
<td></td>
<td>25.7</td>
<td>6.5</td>
</tr>
<tr>
<td>8/22/2009</td>
<td>A</td>
<td></td>
<td>33.3</td>
<td>3.4</td>
</tr>
<tr>
<td>8/22/2009</td>
<td>B</td>
<td></td>
<td>29</td>
<td>11.3</td>
</tr>
<tr>
<td>12/10/2009</td>
<td>A</td>
<td></td>
<td>36.07</td>
<td>0.77</td>
</tr>
<tr>
<td>12/10/2009</td>
<td>B</td>
<td></td>
<td>14.9</td>
<td>0.54</td>
</tr>
<tr>
<td>12/10/2009</td>
<td>C</td>
<td></td>
<td>0.22</td>
<td>0.09</td>
</tr>
</tbody>
</table>
Stormwater Sampling
Discrete and flow weighted composite samples analyzed for PAHs

March 19, 2008, 1 inch of rain (30,000 liters)

Total PAH (ug/l)
-500
-400
-300
-200
-100
0

Flow (m3/s)

344 ug/l
76 ug/l
## Storm Characteristics and Total Volume

### Rainfall Event Details

<table>
<thead>
<tr>
<th>Rainfall Event</th>
<th>Storm Duration (min)</th>
<th>Rain Depth (in)</th>
<th>Storm Volume (liters)</th>
<th>Antecedent Dry Period (days)</th>
<th>Season</th>
<th>Concentration (ug/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>C lot</td>
<td>A lot</td>
<td>B lot</td>
<td></td>
</tr>
<tr>
<td>10/6/2007</td>
<td>720</td>
<td>0.58</td>
<td>536557</td>
<td>19674</td>
<td>14904</td>
<td>7.00 Fall</td>
</tr>
<tr>
<td>10/10/2007</td>
<td>235</td>
<td>0.24</td>
<td>318783</td>
<td>11689</td>
<td>8855</td>
<td>0.5 Fall</td>
</tr>
<tr>
<td>10/24/2007</td>
<td>90</td>
<td>0.05</td>
<td>63504</td>
<td>2328</td>
<td>1764</td>
<td>3 Fall</td>
</tr>
<tr>
<td>11/3/2007</td>
<td>485</td>
<td>1.25</td>
<td>1211312</td>
<td>44415</td>
<td>33648</td>
<td>6 Fall</td>
</tr>
<tr>
<td>12/23/2007</td>
<td>470</td>
<td>0.27</td>
<td>760328</td>
<td>27879</td>
<td>21120</td>
<td>2 Winter</td>
</tr>
<tr>
<td>2/13/2008</td>
<td>815</td>
<td>2.74</td>
<td>2367721</td>
<td>86816</td>
<td>65770</td>
<td>2 Winter</td>
</tr>
</tbody>
</table>