A Tier 2 Approach to Address Trace PAH Soil Impacts

Craig Harris (AECOM)

Tami Dolen (City of Edmonton)
Outline

• Historical Activities and Study Sites
• Municipal Driver & Regulatory Objectives
• Soil Characteristics
• CCME PAH Guidelines (FWAL)
• Results of Tier 2 Leachate Approach
• Optional Tier 2 Approaches for Impacted Groundwater
• Conclusions: Tier 2 Leachate Approach
Historical Activities in North Saskatchewan River Valley
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The Anderson brickyard in 1914, the year it was shut down because the owner went off to war. The millions of red bricks that were cut and baked from the clay of the flat were used to build countless buildings in Alberta, B.C. and even Ontario. Mi Creek runs under the bridge in the foreground. NC-6-1015
River Valley Parks and Historical Activities

Hawrelak Park – Former gravel pit; fill material

Rossdale – Power generation, water treatment and former fire training area, rail line, fill material

Queen Elizabeth/Kinsman Park – Former lumber mill; fill material

Louise McKinney Park – Former coal mine, landfill and fill material

Gallagher Park – Former brickyards, rail lines, landfill, incinerator, fill material
Municipal Driver & Regulatory Objectives

• North Saskatchewan River Valley Bylaw 7188 (adopted 1985)
  – Identifies boundaries for river valley and ravines;
  – Sets out policy and development approval procedures for lands within these boundaries;
  – Proposed developments require environmental sign-off (AEP); and
  – Past approach was to remediate only the footprint of the proposed development, ignoring broader contamination

• Tier 2 Risk Assessment and Risk Management
  – City seeks comprehensive park-wide approach addressing whole of the contamination
  – Applicable for future developments without having to seek AEP sign-off
Soil Characteristics – Random Fill

Queen Elizabeth

KinPark

Hawrelak

mg/kg

Naph Anthra Phena Fluora Pyrene Bl7Anthra

n = 33

n = 47

n = 41

Tier 2 Approach for Trace Soil PAH
CCME PAH Soil Quality Guidelines (FWAL)

SQG_{FWAL} \text{ back calculated from ambient water quality guidelines}
LEACHATE

LATERAL TRANSPORT
CCME PAH  SQG FWAL _ Random Fill/ Native
Are Back Calculated SQG\textsubscript{FWAL} To Conservative?

\[ C_l = \frac{C_s}{K_{oc} f_{oc} + \theta_w/\rho_b + H' \theta_a/\rho_b} \times 1000 \]

Where
- \( C_l \) = chemical concentration in leachate
- \( C_s \) = chemical concentration in soil
- \( K_{oc} \) = organic carbon partition coefficient (chemical specific)
- \( f_{oc} \) = fraction organic carbon (soil matrix)
- \( \theta_a \) = air filled porosity (soil matrix)
- \( \theta_w \) = water filled porosity (soil matrix)
- \( \rho_b \) = bulk density (soil matrix)
- \( H' \) = Henry Law Constant, dimensionless and chemical - specific

The equation is simply a re-arrangement of the Tier 1 Dilution Factor #1.
Methods and Field Program

- Drill, soil sampling, Shelby tubes and monitoring well installation
- Test fill and native material for PAH, metals & TOC
- Bulk density, porosity, moisture from Shelby tubes
- SPLP PAH leachate on selected soil samples above SQG_{FWAL}
- Groundwater analysis for PAHs in all wells
- Calculate theoretical PAH leachate concentrations based on site-specific matrix parameters
SPLP Leachate

• Synthetic precipitation leaching procedure (US EPA Method 1312);

• Designed for semi volatiles and imitates rain water leachate in soil matrix either rich in organic carbon, or poor in organic carbon; and

• 18 hour duration standardized test that most laboratories will be capable of running.
## Results (Hawrelak and Queen Elizabeth Parks)

<table>
<thead>
<tr>
<th>PAH Compound</th>
<th>Soil Input (mg/kg)</th>
<th>Predicted Leachate (µg/L)</th>
<th>SPLP Leachate (µg/L)</th>
<th>Measured Groundwater (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracene</td>
<td>0.003</td>
<td>0.004 – 0.003</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
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<tr>
<td></td>
<td>0.024</td>
<td>0.11 – 0.07</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
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<tr>
<td>Phenanthrene</td>
<td>0.01</td>
<td>0.117 – 0.035</td>
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<td>&lt; 0.1</td>
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<td>0.06</td>
<td>0.83 – 0.24</td>
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<td>&lt; 0.1</td>
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<tr>
<td>Fluoranthene</td>
<td>0.03</td>
<td>0.213 – 0.231</td>
<td>&lt; 0.01</td>
<td>&lt; 0.01</td>
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<tr>
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<td>0.04*</td>
<td>0.28 – 0.53</td>
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<td>0.01</td>
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<tr>
<td>Pyrene</td>
<td>0.07*</td>
<td>0.233 – 0.224</td>
<td>0.03</td>
<td>&lt; 0.01</td>
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<tr>
<td></td>
<td>0.14*</td>
<td>0.37 – 0.31</td>
<td>&lt; 0.01</td>
<td>0.020</td>
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<tr>
<td>Benzo[a]anthracene</td>
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<td>0.20 – 0.20</td>
<td>&lt; 0.01</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

**BOLD* - value exceeds Tier 1**

Site-specific $f_{oc}$ ranged 0.039 to 0.011
Site-specific bulk density 1.6 g/cm³
Site-specific moisture filled porosity 0.34 to 0.31
Site-specific air filled porosity 0.05 to 0.07
## Results – (Rossdale Power Plant Flyash)

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<thead>
<tr>
<th>PAH Compound</th>
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<th>SPLP Leachate (µg/L)</th>
<th>Measured Groundwater (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naphthalene</td>
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<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
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<tr>
<td>Anthracene</td>
<td>0.153*</td>
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<td>&lt; 0.005</td>
<td>0.035*</td>
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<tr>
<td>Phenanthrene</td>
<td>0.39*</td>
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<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>0.52*</td>
<td>--</td>
<td>&lt; 0.01</td>
<td>0.09*</td>
</tr>
<tr>
<td>Pyrene</td>
<td>0.52*</td>
<td>--</td>
<td>&lt; 0.01</td>
<td>0.10*</td>
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<tr>
<td>B[a]anthracene</td>
<td>0.26*</td>
<td>--</td>
<td>&lt; 0.01</td>
<td>0.06*</td>
</tr>
</tbody>
</table>

BOLD* - value exceeds Tier 1
Groundwater Results: Gallagher Park and Rossdale

Gallagher

n = 37

Rossdale

n = 31

mg/L

Naph
Anthra
Phena
Fluora
Pyrene
Bl@Anhra

Naph
Anthra
Phena
Fluora
Pyrene
Bl@Anhtra

Tier 2 Approach for Trace Soil PAH
Optional Tier 2 Approach for Groundwater Contamination

Exposure: Fate and Transport

Effects: Bioassays

LATERAL TRANSPORT
Conclusions for SPLP Leachate Tier 2 Approach

• The approach appears to predict an accurate outcome under the following conditions:
  – PAH contamination is present in random fill and native material and concentrations are within the same order of magnitude as Tier 1

• The approach does not necessarily predict an accurate outcome when:
  – PAH contamination is present as a finite source and concentrations are 1 and 2 orders of magnitude above Tier 1
Thank You

craig.harris@aecom.com
tami.dolen@edmonton.ca