PORT 2024 LANDS

June 2, 2022

The Port Lands Flood Protection Project – How Advanced Petroleum Hydrocarbon Forensic Tools Can Be Used To Support Successful Bioremediation Programs

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Canada Ontario Toronto WATERFRONTToronto Stantec

Port Lands Flood Protection and Enabling Infrastructure Project

- PLFP is a $1.25B project designed to support the redevelopment of Toronto's Port Lands
- Flood protect 240 hectares
- Carve a new 1.3km long naturalized river channel through a former industrial Brownfield
- Establish 23 hectares of wetland and aquatic habitat
- Create 11 hectares of parkland
- Upgrade utilities and services to allow higher density, mixed use development

Project Partners and Stakeholders

- City of Toronto
- Toronto and Region Conservation Authority (TRCA)
- CreateTO

Earthworks and Environmental Project Team Members

- Michael Van Valkenburg & Associates with Stantec
- Ellis Don with Quantum Murray

Overview

- The Port Lands Flood Protection and Enabling Infrastructure Project Overview
- Past Investigations
- Pilot Studies
- Implementation Phase
- Bioremediation Challenges and Solutions

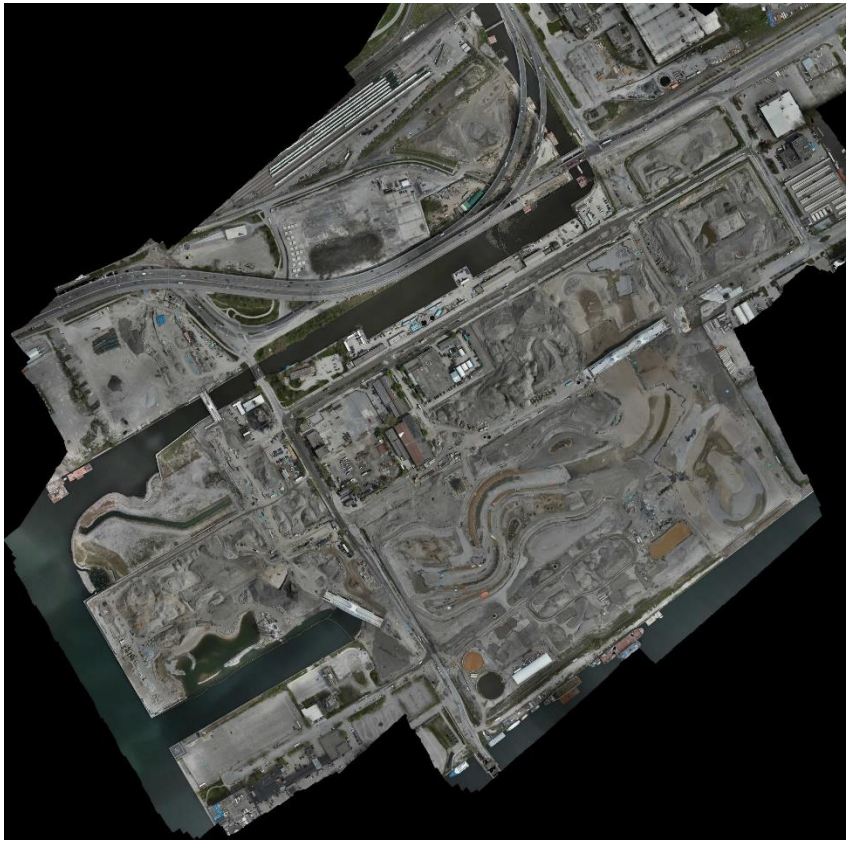
Port Land Flood Protection Project

Project Vision

Port Land Flood Protection Project

Current Status

- Site Prep & Demo
- Cut Off Walls
- Dewatering
- Excavation
- Filling and Surcharging in Parks
- Roads & Utilities
- Bridges
- River Valley Finishes



Port Land Flood Protection Project

A Legacy of Contamination

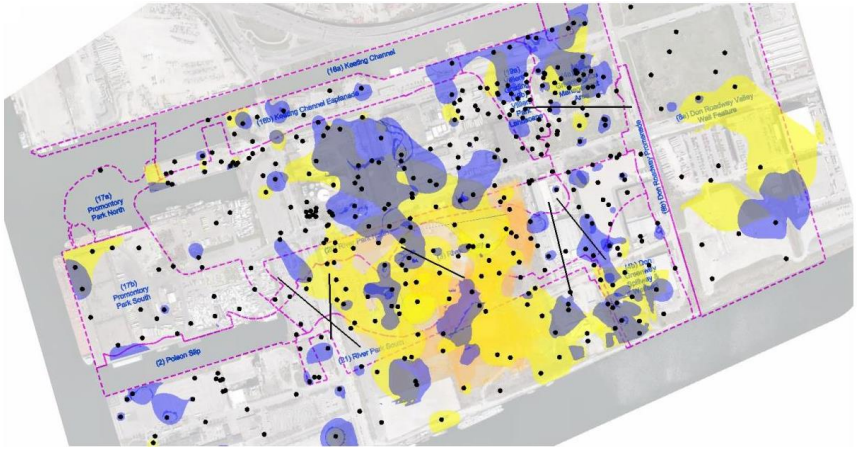
Coal Storage & Processing

- Coal tar
- Creosote

Crude Oil Storage & Processing

- Fuels
- Engine Oils
- Asphalt

Extent of Contamination

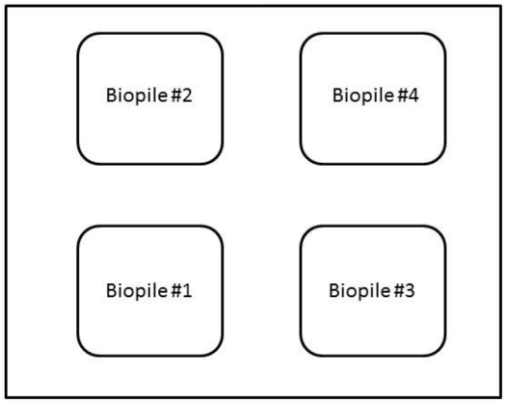


PHC Contamination

Metal Contamination

Proven for the Port Lands

- Treatability Study (2017-2018)
- Pilot Tests (Winter 2020)
  - Review site data, determine location to obtain suitable soils for small-scale biopile testing (4 MT)
  - Create 4 small-scale biopiles, determine parameters for full-scale (soil turning rates, contaminant half-lives)



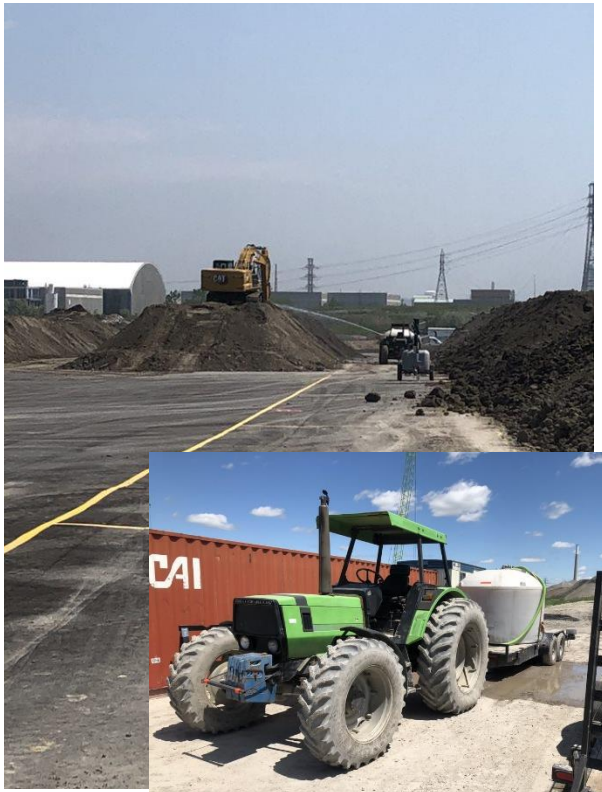
Pilot Study Data Analysis

- Bioremediation Half Lives
  - F1 – 1 week
  - F2 – 3 weeks
  - F3 – 6 weeks
  - B(a)P – 6 months

- Treatment Time For ***Average*** PHC Concentrations
  - F1 – 0.9 months
  - F2 – 1.2 months
  - F3 – 1.7 months
  - B(a)P – 2.1 months

- Treatment Time For ***Maximum*** PHC Concentrations
  - F1 – 0.9 months
  - F2 – 2 months
  - F3 – 2 months
  - B(a)P – 3.5 months

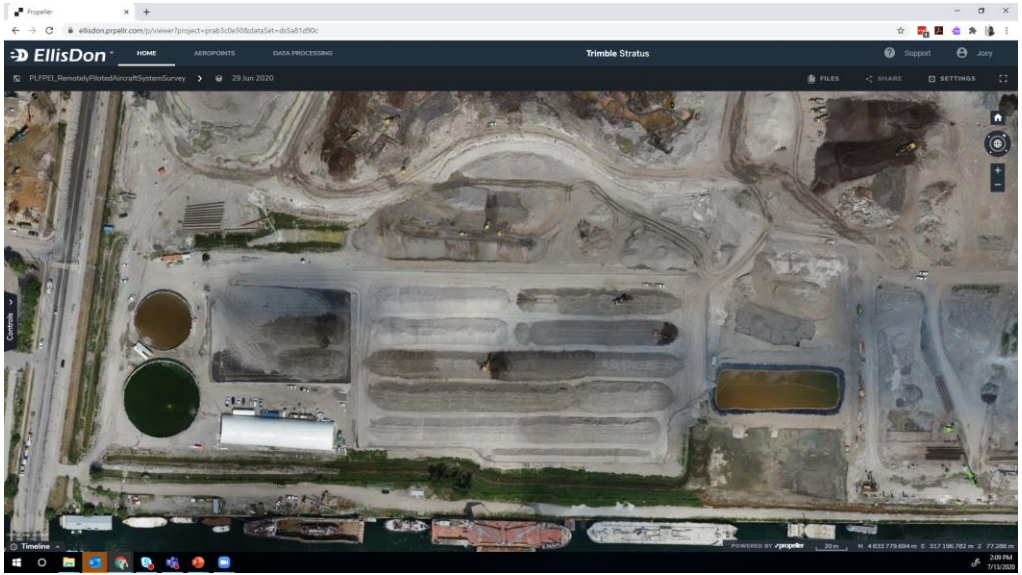
Soil Remediation - Bioremediation



Soil Bioremediation Applicability for PLFP

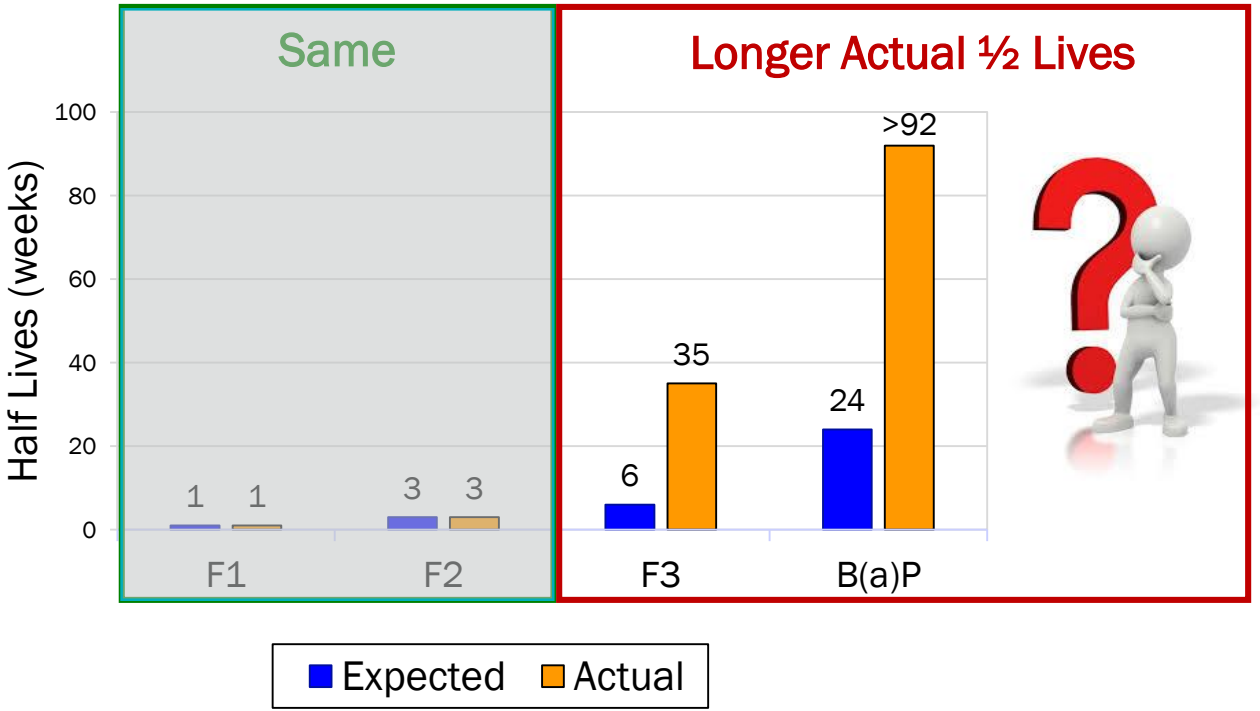
- PLFP Targets
  - 200,000 + m3
  - Heterogenous Fill and Soil
  - PHC's, PAH's, VOC's, Metals

- Scale & Speed
  - Soil Management Area capacity
    - 60,000 m3
  - Excavation and fill timelines



Expected Versus Actual Half Lives of PHCs and PAHs

- Bioremediation was taking place but rates were much slower than anticipated
  - Light PHC and PAH concentrations were reduced
  - Heavy PHCs and PAHs were not



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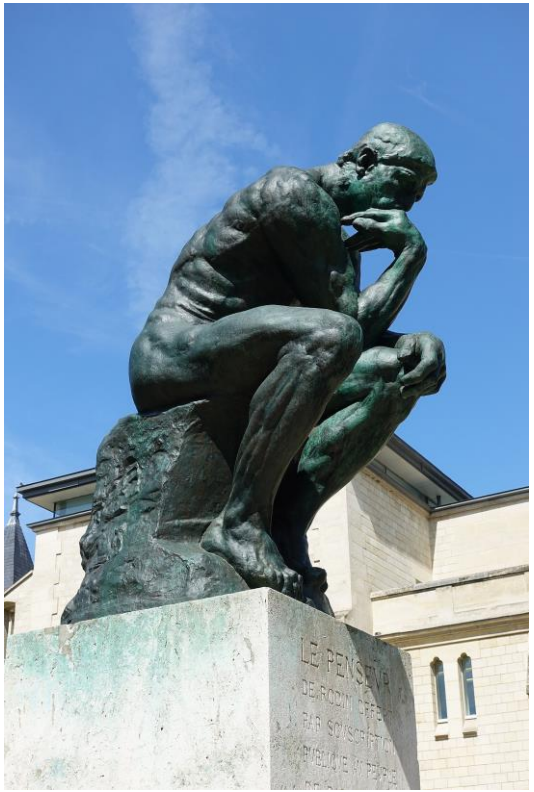
Results and Challenges

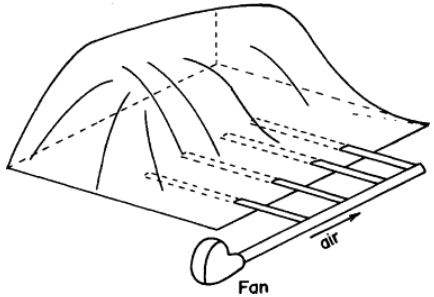
- Why are we not seeing degradation at the rate we were anticipating and of the full spectrum of PHC's and PAH's?
- How do we figure this out?
  - Engage the team we have available to us
    - Waterfront Toronto
    - Ellis Don, Quantum Murray, Vertex
    - MVVA, Stantec, Geosyntec



Process Improvement Recommendations

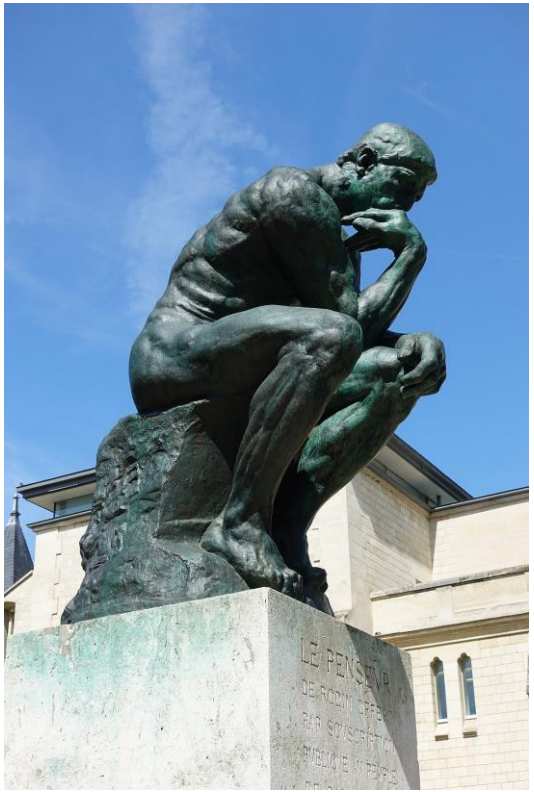
Geosyntec - past experience with large scale bioremediation programs lead to process improvements

- Oxygenation
  - Is sufficient oxygen available for bioremediation
  - Means to improve oxygenation
    - Mixing Methods
    - Forced air supply
- Mixing Methods
  - Excavator with standard bucket
  - Excavator with allu bucket
  - Windrow Mixing
- Optimization of Moisture Content



Results and Challenges

- Can the contaminants we have, at the concentrations we've found them be successfully bioremediated?
- How do we assess the bioavailability of these specific compounds?
- Why are the full scale results so much different than the pilot studies?
- Go back to the team of experts we have and keep working the problem.



ABCs of Petroleum Hydrocarbon Chemistry

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Hydrogen
1
H
1.0078

What are Total Petroleum Hydrocarbons (TPH)?

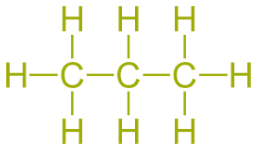
Carbon
6
C
12.011

- Mixtures of hydrogen and carbon that are found in crude oil and coal
- PHC products: e.g. gasoline, diesel, jet fuel, asphalt, tires, coal tar, etc.

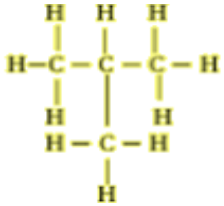
1) Aliphatic PHC Examples

Straight chains, branched trains
non-aromatic rings

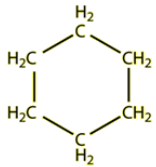
Propane

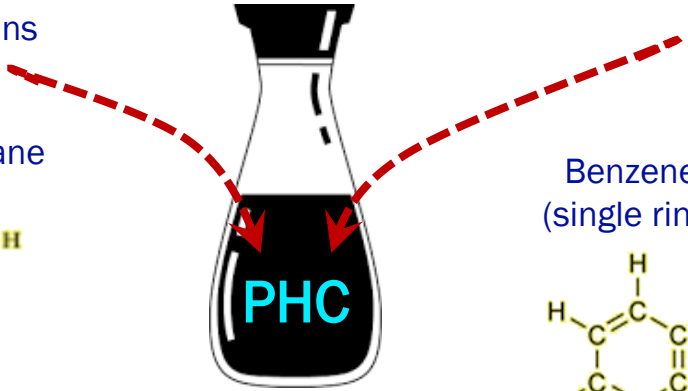


2-methyl-propane



Cyclohexane

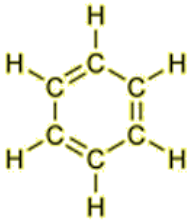




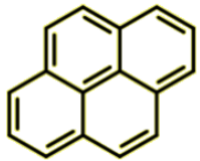
2) Aromatic PHC Examples

Single and Multiple Benzene
Rings

Benzene
(single ring)

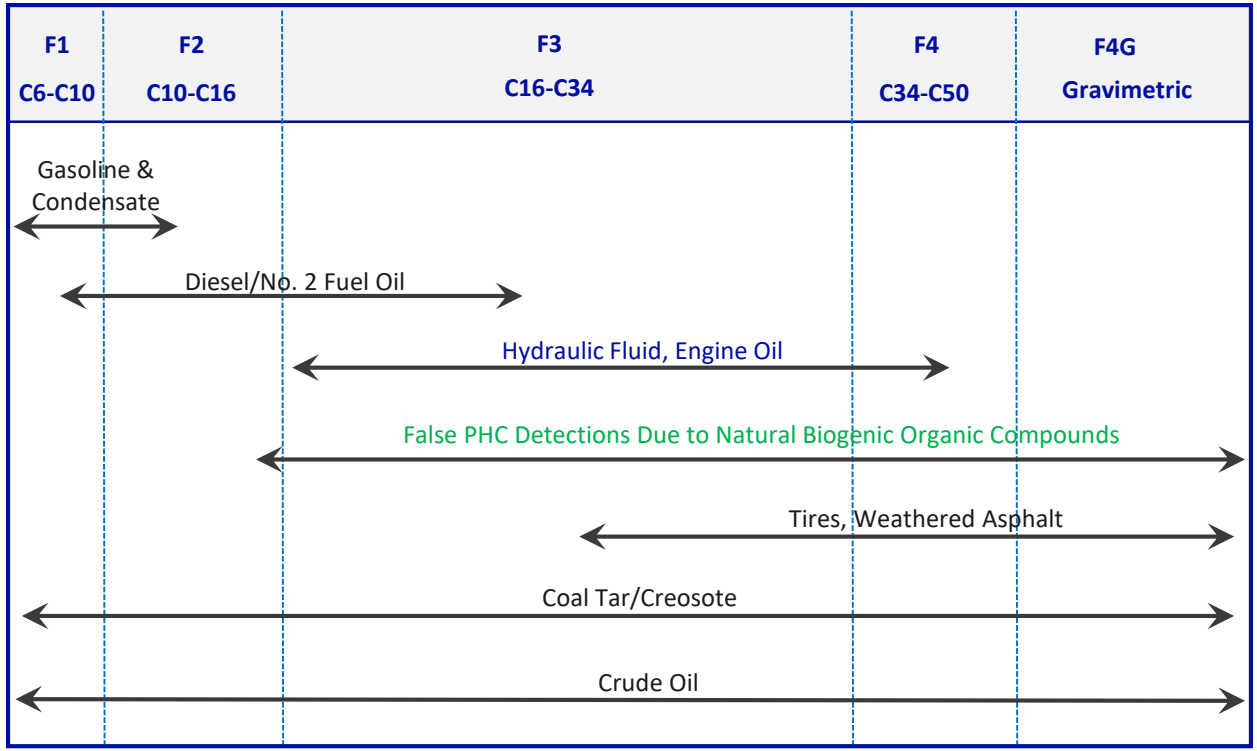


Polyaromatic Hydrocarbons
(PAHs)
Multiple Benzene Rings



Pyrene

O.Reg. 153/04 PHC Carbon Ranges & Sources



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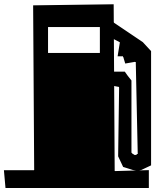
Different PHC Product Solubility & Toxicity Risks

Higher Risk (Liquids)



e.g. gasoline, diesel, etc.

e.g. asphalt, tires, etc.

Lower Risks (Solids)

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Weight-of-Evidence Forensic Analysis

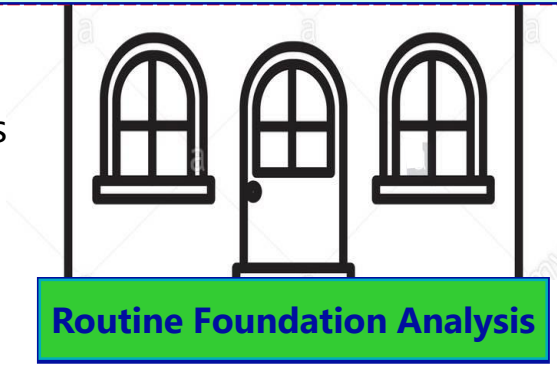
Routine methods were applied to the Port Lands study

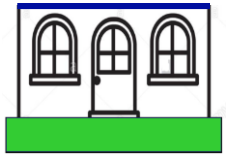
Level 1: Foundation forensics for all samples

Standard analysis: BTEX, F1-F4 PHCs, chromatograms & routine PAHs

Fast lab analysis time

Least expensive





Foundation Forensic Analysis Tools

Stantec has developed this weight of evidence protocol to obtain 5 of the only waste management Environmental Compliance Approval (ECAs) for beneficial reuse of asphalt contaminated soils and sediments in Ontario.

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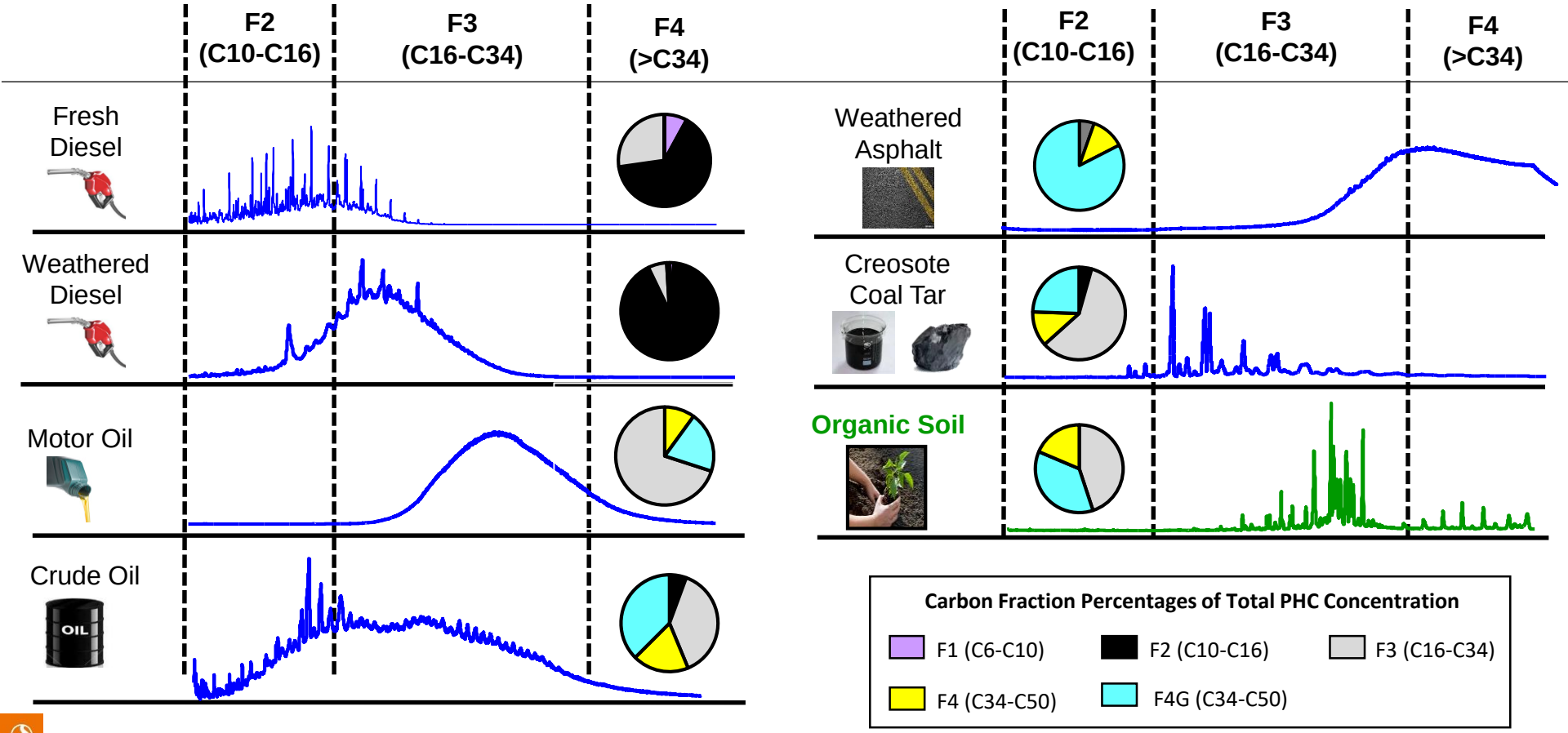
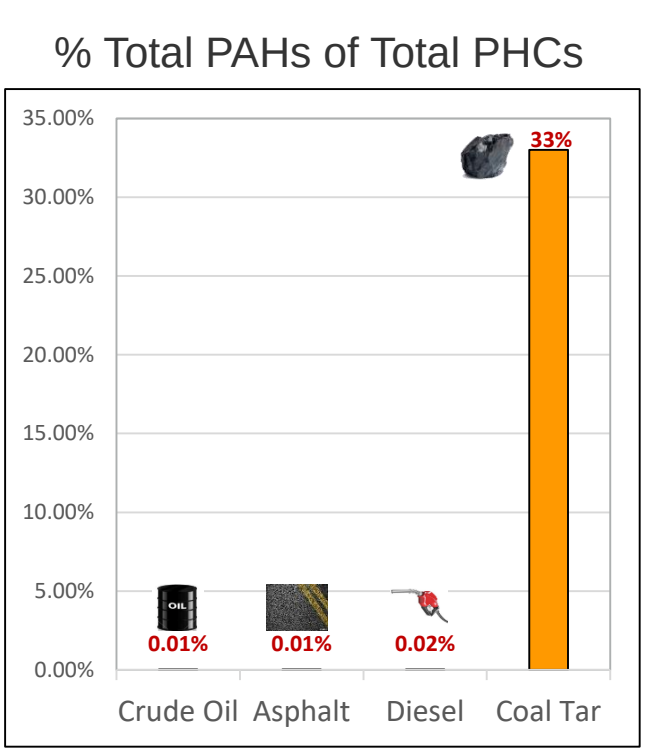
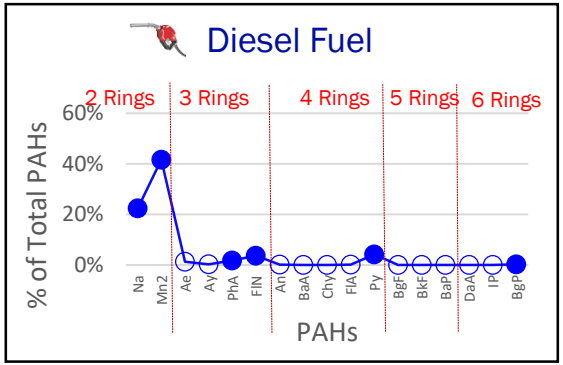
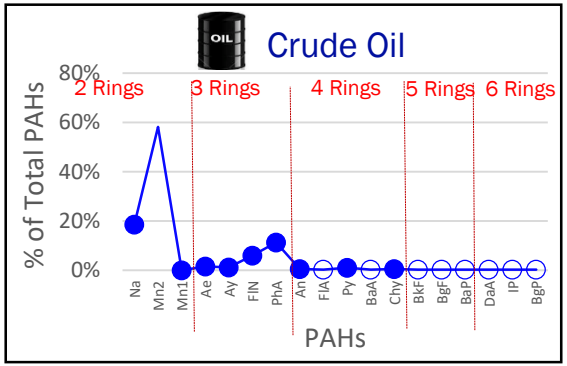
Carbon Fractions & Chromatograms

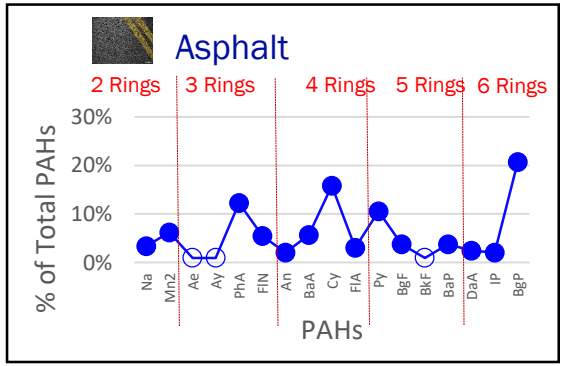


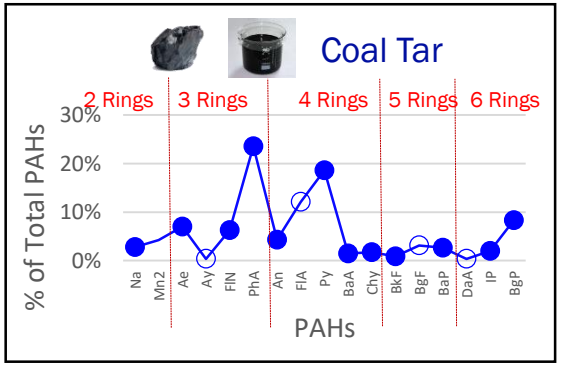
Stantec PAH Source Reference Library











● Detectable PAHs ○ Non-detectable PAHs

Biogenic Interference Calculation (BIC) for False PHC Exceedances

F. Kelly-Hooper PhD Thesis

Organic Soil Matter

Wildlife/Pet Droppings

Soil Organisms

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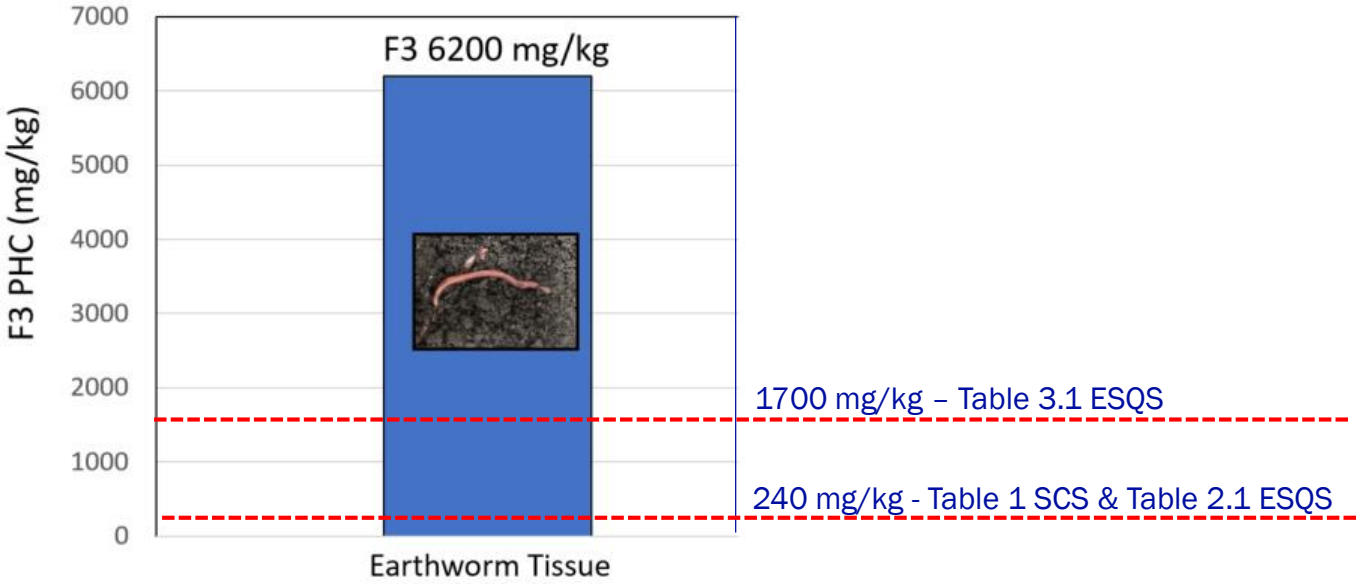
False PHC Exceedances Can Happen at Any Site

Example: clean earthworm tissue



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Alberta Environment Adopted the Biogenic Interference Calculation in 2018 for Resolving False Exceedances

MECP Allows the BIC on a Tier 2 Basis

Alberta Government

Guide

Title:	BIC Scale for Delineating Petroleum Hydrocarbons in Organic Soils and Compost
Number:	AEP Land Policy 2018-1
Program Name:	Land Conservation and Reclamation Policy
Effective Date:	April 3, 2018

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Printed in the USA

IS IT CLEAN OR CONTAMINATED SOIL? USING PETROGENIC VERSUS BIOGENIC GC-FID CHROMATOGRAM PATTERNS TO MATHEMATICALLY RESOLVE FALSE PETROLEUM HYDROCARBON DETECTIONS IN CLEAN ORGANIC SOILS: A CRUDE OIL–SPIKED PEAT MICROCOSM EXPERIMENT

FRANCINE KELLY-HOOPER,*† ANDREA J. FARWELL,† GLENNA PIKE,‡ JOCELYN KENNEDY,‡ ZHENDI WANG,§ ERIC C. GRUNSKY,‖ and D. GEORGE DIXON†

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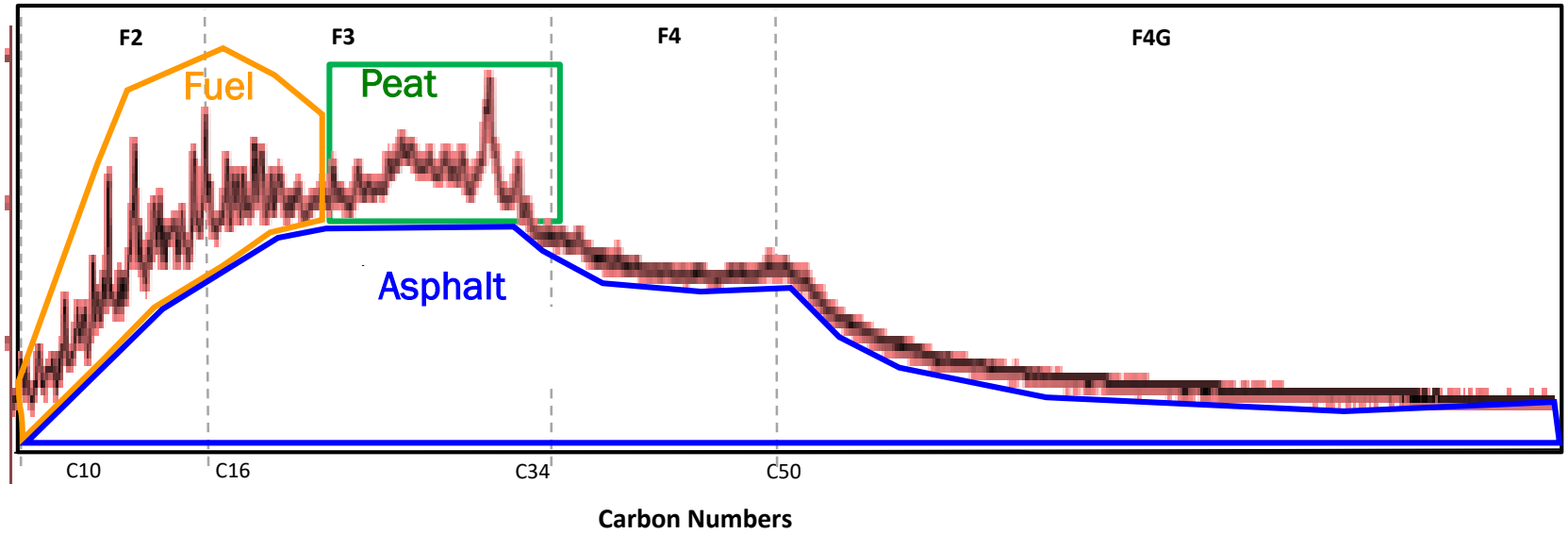
Day 0 - Diesel & asphalt contaminated biopile sample



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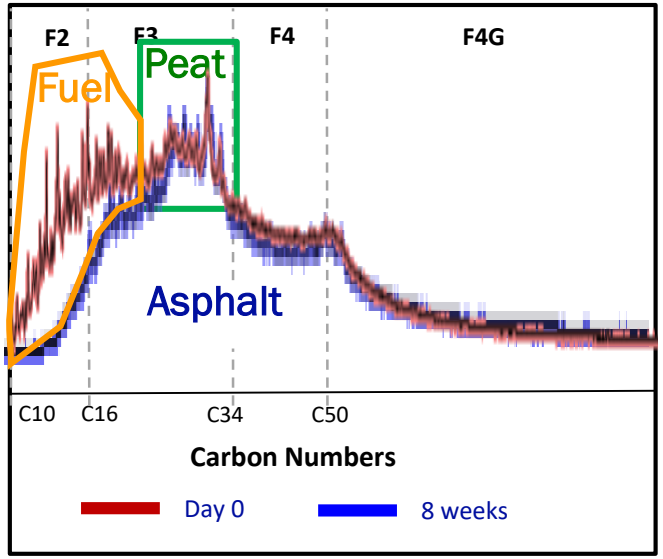
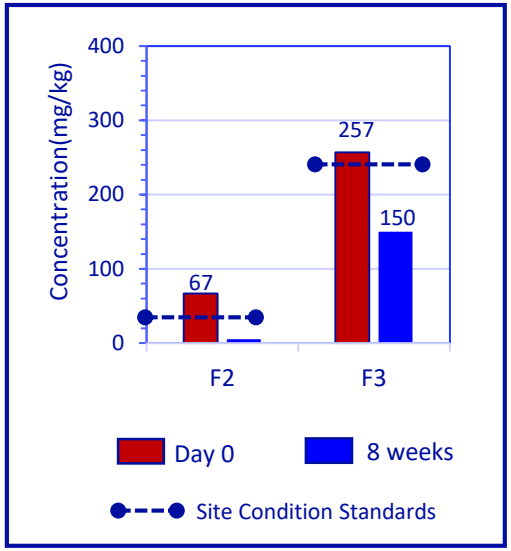
Diesel & asphalt contaminated biopile sample – Day 0 vs 8 weeks

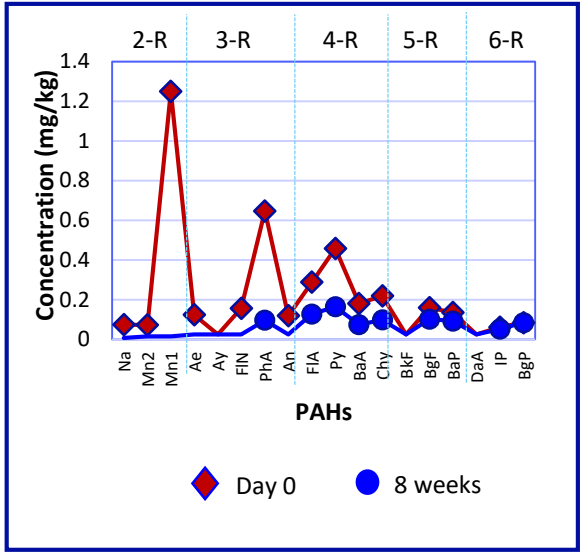
8 Weeks of Treatment



F2 and F3 PHC exceedances



2- to 6-ring PAH exceedances



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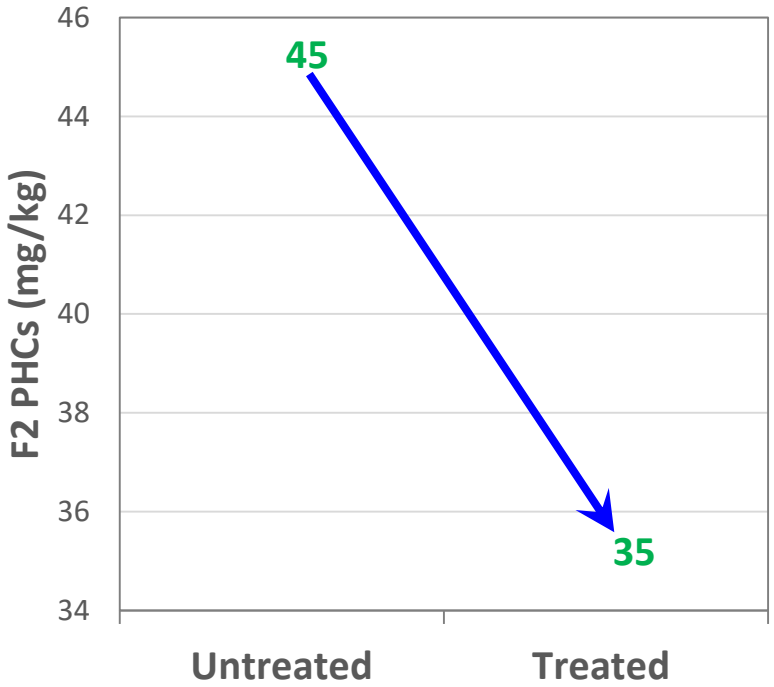
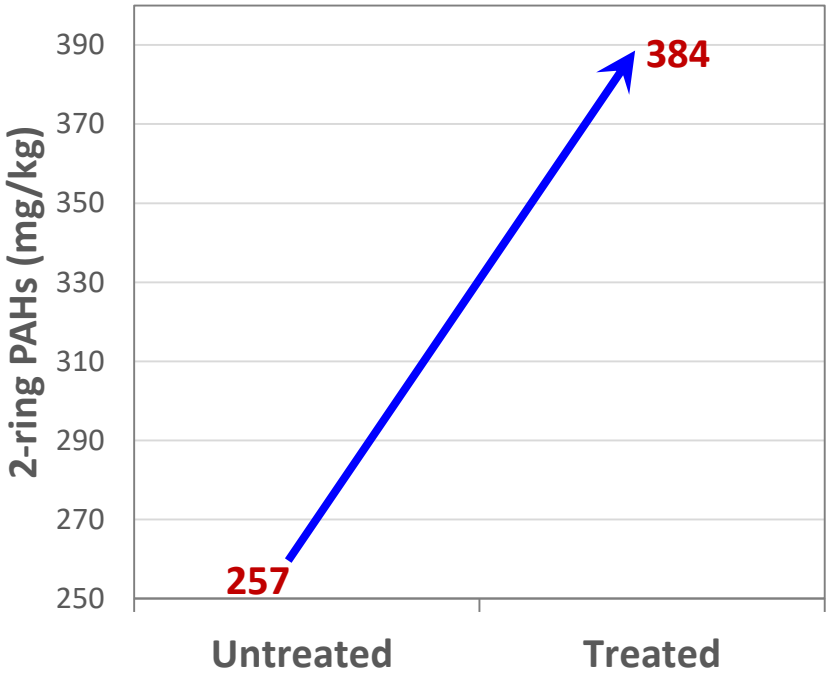
Median **PHC** Concentrations for 297 Treated vs Untreated Soil Samples

Lighter F2 PHCs (lower)



Heavier F3 PHCs (higher)



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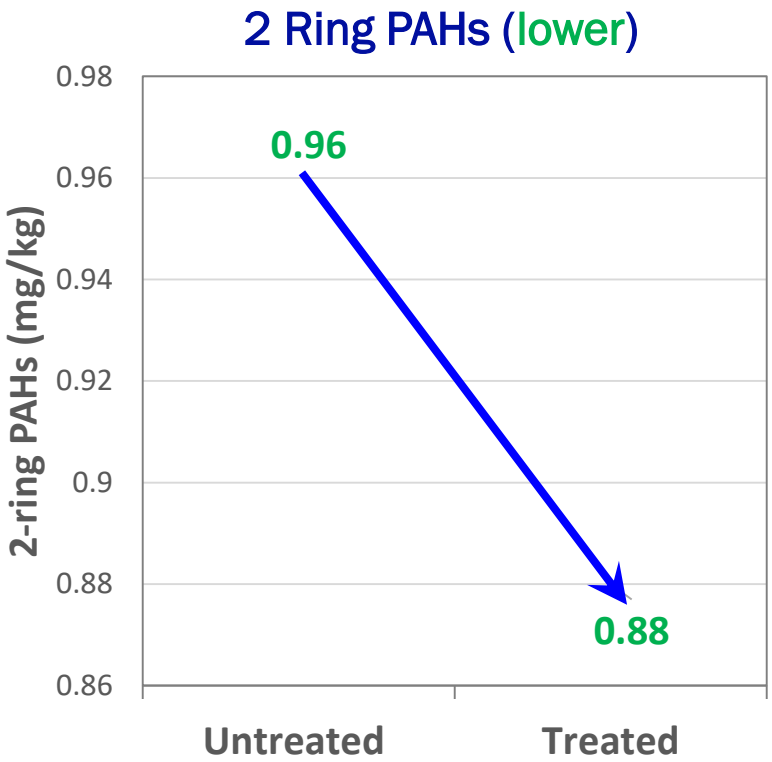
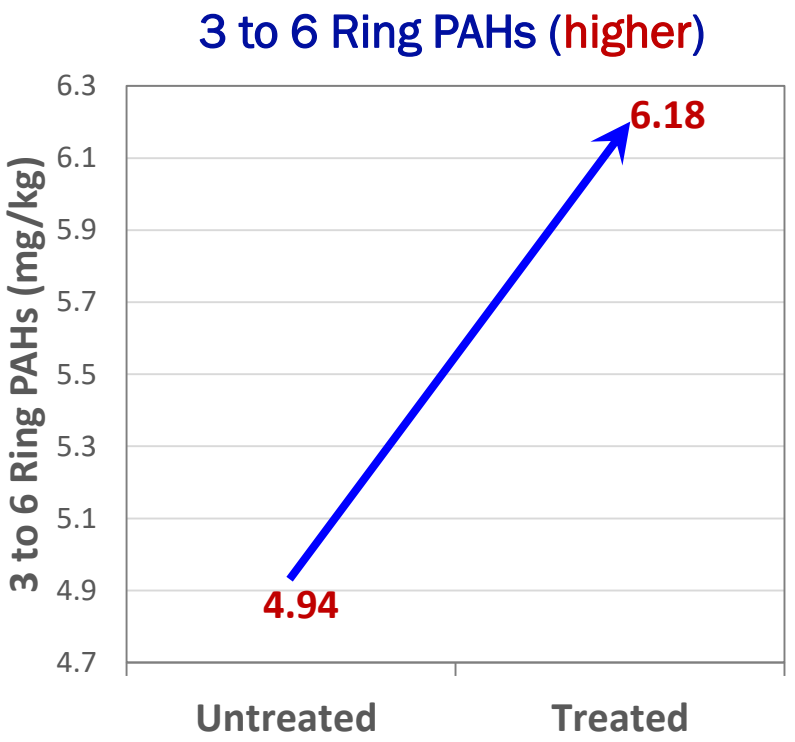
Median **PAH** Concentrations for 297 Treated vs Untreated Soil Samples





Biopile Treatability Conclusions for 297 Samples

- **0.6%** were full treatable
- **47%** were partially treatable
- **52%** were non-treatable, but could be safely left on-site with proper MECP approvals

Maximized onsite soil reuse within the criteria established by the community based risk assessment, while considering future areas that could be changed to more stringently protected land use categories.

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Lessons Learned

- Optimize the bioremediation plan through an understanding of PHC sources and different bioavailabilities
- Liquid PHC products are relatively easier to remediate than solid PHC products
- Risk evaluations to determine if highly recalcitrant PHCs can be left safely in place without remediation
- Further peer review of the Pilot Studies may have helped improve understanding of this complex remedial environment
  - Broad mix of contaminants
  - Contaminants were of different vintages and stages of weathering
  - Very heterogenous mixture of soil and fill

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Questions?

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