

# Polycyclic Aromatic Hydrocarbons on the Kalamazoo River Shoreline Following the 2010 Enbridge Oil Spill

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### Abstract

- One of the nation's worst inland oil spills occurred near Marshall in Michigan in 2010.
- The recent Enbridge Line 6B rupture released over three million liters of diluted bitumen crude oil into the environment.
- The spilled oil entered the Talmadge Creek and flowed into the Kalamazoo River, a Lake Michigan tributary.
- Polycyclic Aromatic Hydrocarbons (PAHs) together with other pollutants were released into the environment.
- PAHs represents significant threats to aquatic organisms due to their carcinogenic and mutagenic properties and their persistence in the environment.
- Five years following the oil spill accident, the levels and identities of PAHs were investigated in six shoreline sites along the Kalamazoo river using Gas Chromatography-Mass Spectrometry (GC-MS).
- Thirteen PAHs were identified and their concentrations were quantified using GC-MS.

### Introduction

- PAHs are a class of organic compounds that are composed of two or more fused benzene rings, as shown in Table 1.
- PAHs are present in the atmospheric atmosphere due to the incomplete combustion of organic matter, while in aquatic environments PAHs come mostly from atmospheric deposition, municipal or industrial effluents, and oil spills.
- The Environmental Protection Agency (EPA) has listed 16 priority PAHs due to their carcinogenic and mutagenic properties.
- In this study, PAHs were investigated in six shoreline locations along the Kalamazoo River oil spill-affected area using GC-MS.

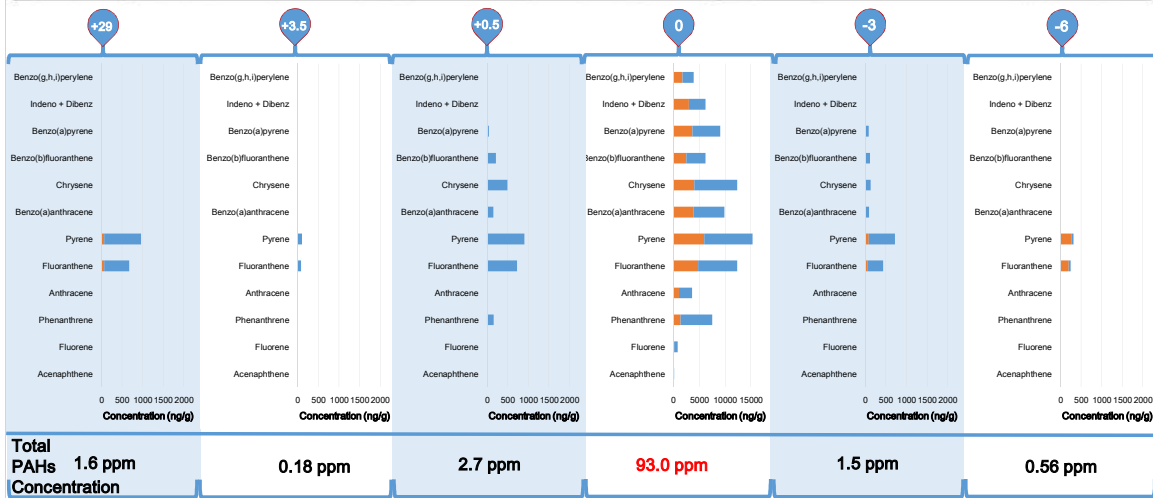
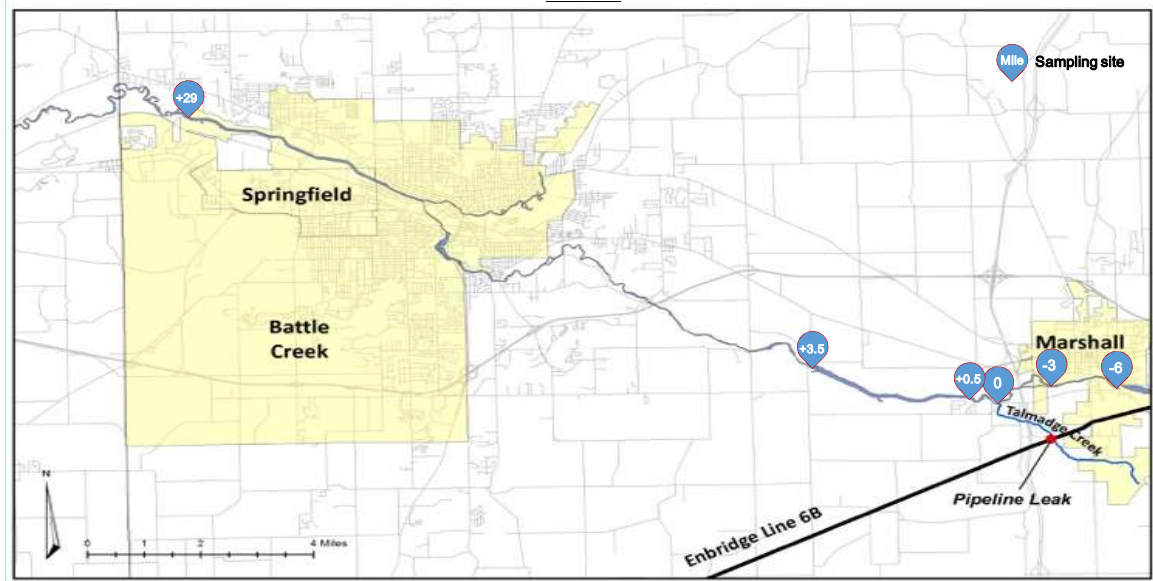
### Sampling Method

- Soil samples were taken from locations on the Kalamazoo river bank, previously inundated with oil during the oil spill and now exposed due to lower water level.
- Soil samples were collected from the six sampling sites using a split spoon sampler.
- Each sample was divided into two layers as shown below:

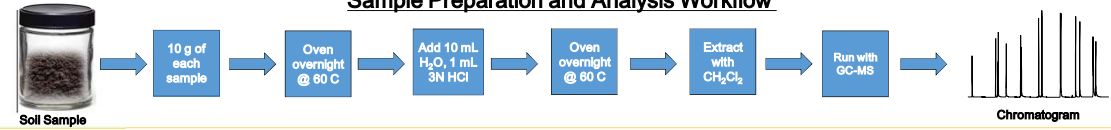


Dr. Barcelona sampling at the Olds Farm site (0 mile)

### Results



### Sample Preparation and Analysis Workflow



### PAH Structures

**Table 1**  
16 EPA List of PAHs

Naphthalene	<chem>c1ccc2ccccc2c1</chem>	anthracene	<chem>c1ccc2cc3ccccc3cc2c1</chem>	fluoranthene	<chem>c1ccc2c(c1)ccc3ccccc32</chem>
Fluorene	<chem>c1ccc2c(c1)ccc3ccccc3c2</chem>	phenanthrene	<chem>c1ccc2c(c1)ccc3ccccc23</chem>	pyrene	<chem>c1ccc2cc3cc4ccccc4cc3cc2c1</chem>
Chrysene	<chem>c1ccc2cc3cc4ccccc4cc3cc2c1</chem>	benzo(a)anthracene	<chem>c1ccc2c(c1)ccc3cc4ccccc4cc3c2</chem>	benzo(b)fluoranthene	<chem>c1ccc2c(c1)ccc3cc4ccccc4cc3c2</chem>
Benzo(a)pyrene	<chem>c1ccc2c(c1)ccc3cc4ccccc4cc3c2</chem>	Dibenz(a,h)anthracene	<chem>c1ccc2c(c1)ccc3cc4ccccc4cc3c2</chem>	benzo(ghi)perylene	<chem>c1ccc2c(c1)ccc3cc4ccccc4cc3c2</chem>
Indeno(1,2,3-cd)pyrene	<chem>c1ccc2c(c1)ccc3cc4ccccc4cc3c2</chem>				

### Conclusions

- Five years following the Kalamazoo River oil spill accident, an environmental investigation was conducted on the oil spill-affected area.
- Six shoreline locations along the Kalamazoo river oil spill affected-area were investigated using GC-MS to determine the level of PAHs.
- The oil spill rupture site has the highest PAH concentrations while upstream and down stream river sites have relatively low PAHs concentrations.
- The top layer of the accident site has double total PAHs concentration of the deeper layer.
- Pyrene, chrysene, fluoranthene, benzo(a)pyrene, and phenanthrene are dominant PAHs in the upper and lower layers of the accident site.
- Further cleanup of the accident site is recommended.

### Literature Cited

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