Evaluation of Analytical Methodologies to Differentiate Biogenic Organic Carbon from Heavy Petroleum Hydrocarbons in Tropical Rainforest Soils

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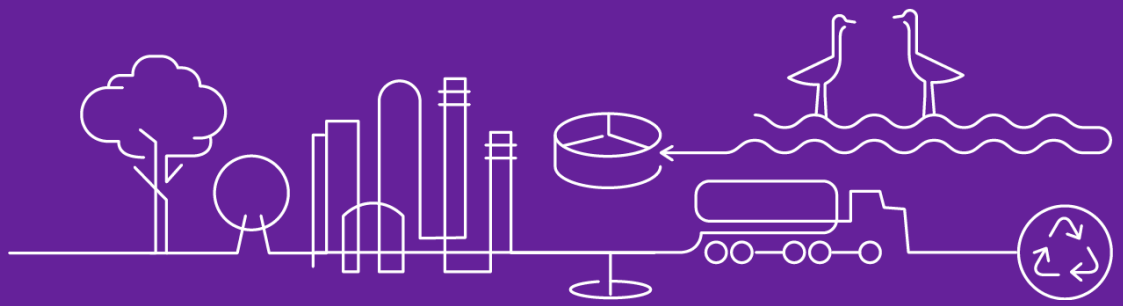
ch2m SM



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Historical Crude Oil Contamination in Peruvian Rainforest Organic Soils

Rhino Beetle

Peruvian Soil TPH Analysis Method
Adaptation of USEPA SW846 8015 Method

- F2 (C10-C28); regulatory limit 1,200 mg/kg
- F3 (C28-C40); regulatory limit 3,000 mg/kg

- Microwave extraction in acetone, hexane and dichloromethane solvents
- Silica gel cartridge cleanup of polar (biogenic) compounds
- F2 and F3 concentrations quantified by Gas Chromatography - Flame Ionization Detector (GC-FID) on a 3 minute run
- Chromatograms were provided for all samples

2015 Contaminated Site Study Overview

- 30 years of crude oil extraction activities contaminated a 721 hectare (ha) rainforest area.
- 17,132 soil samples were analyzed for TPH
- Most of the 5,569 peat soil samples exceeded TPH F3 regulatory limits
- CH2M resolved false exceedances of TPH regulatory limits due to background peat soils

What is Peat/Turba?

Peat (English); Turba (Spanish)

Saturated Soil and Decayed Plants

+

Thousands of Years

=

Peat/Turba

- Typically has >40% total organic carbon (TOC) content
- Natural Biogenic Organic Compounds (BOCs) are often falsely detected as Total Petroleum Hydrocarbons (TPH)

Biogenic Organic Compounds are the Building Blocks of Life



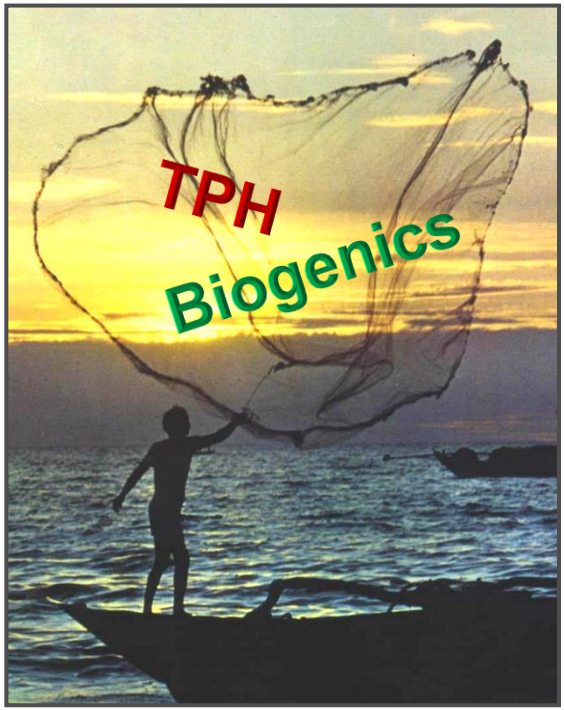


- Natural carbon-based compounds biosynthesized by living organisms.

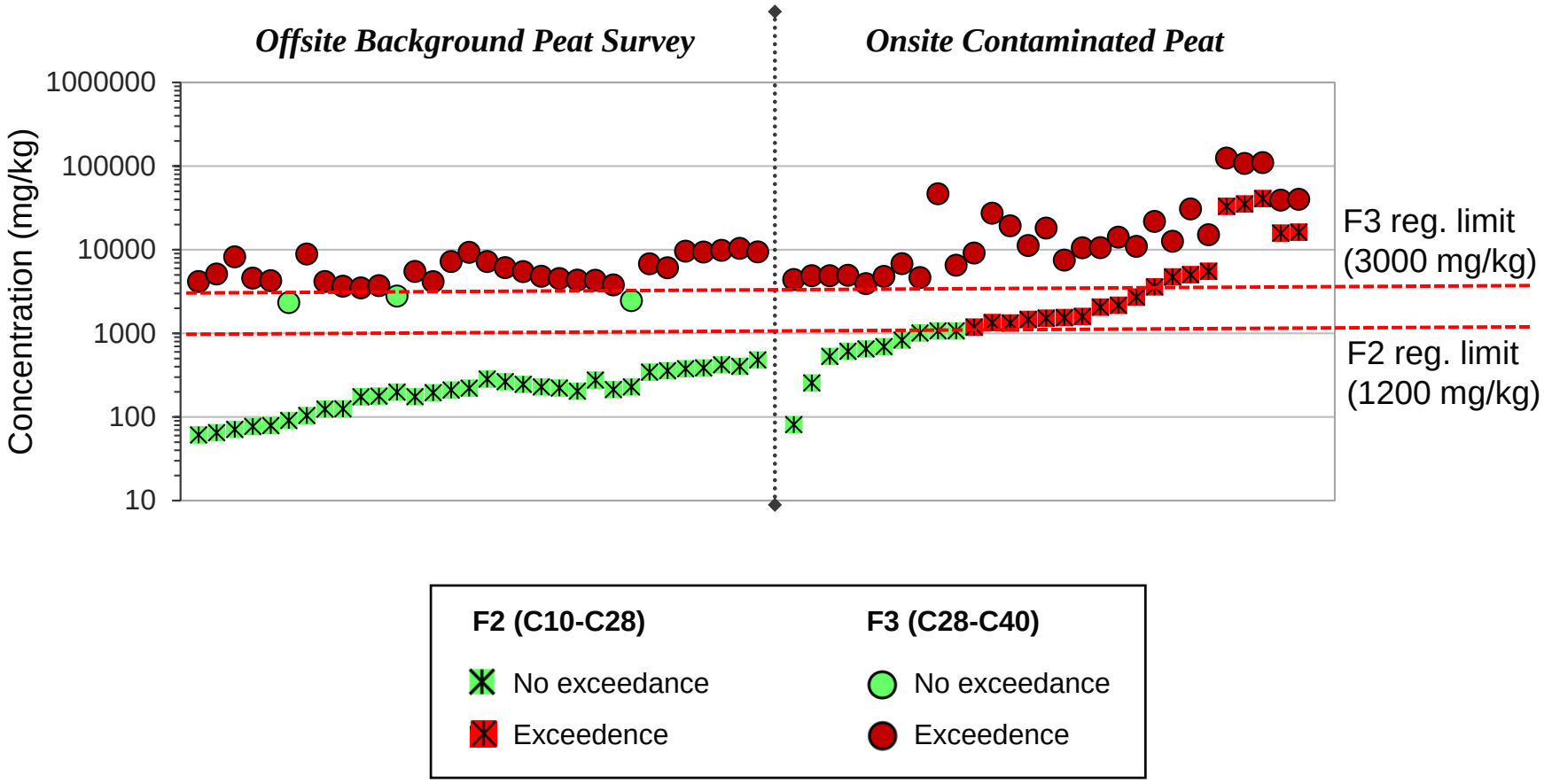
- BOC groups contain alkanes, lipids, carbohydrates, proteins, etc.

Why Do BOCs Cause False TPH Detections?

Laboratories use organic solvents to indiscriminately extract all carbon regardless of petroleum or natural biogenic sources.

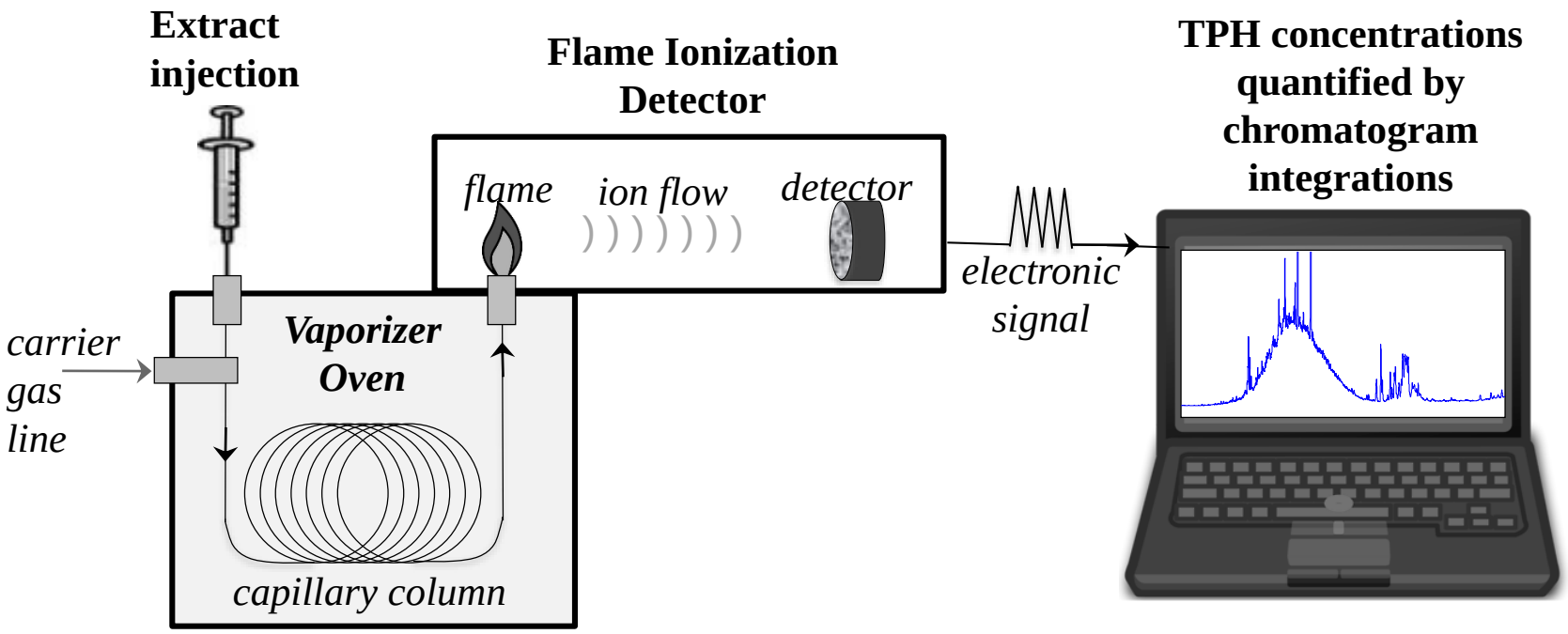


- 90% of clean samples falsely exceeded F3 limit
- 0% of clean samples exceeded F2 limit



CH2M's Solution?

GC-FID Chromatogram & Carbon Range Analysis



Canadian PhD Research Applied to Peru Study

2007-2010

Contamination Experiments

2007-2015

Clean Background Soil Surveys

2005-2017

Contaminated Site Studies

Publications

SETAC PRESS

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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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Environmental Chemistry

FIELD SURVEY OF CANADIAN BACKGROUND SOILS: IMPLICATIONS FOR A NEW MATHEMATICAL GAS CHROMATOGRAPHY–FLAME IONIZATION DETECTION APPROACH FOR RESOLVING FALSE DETECTIONS OF PETROLEUM HYDROCARBONS IN CLEAN SOILS

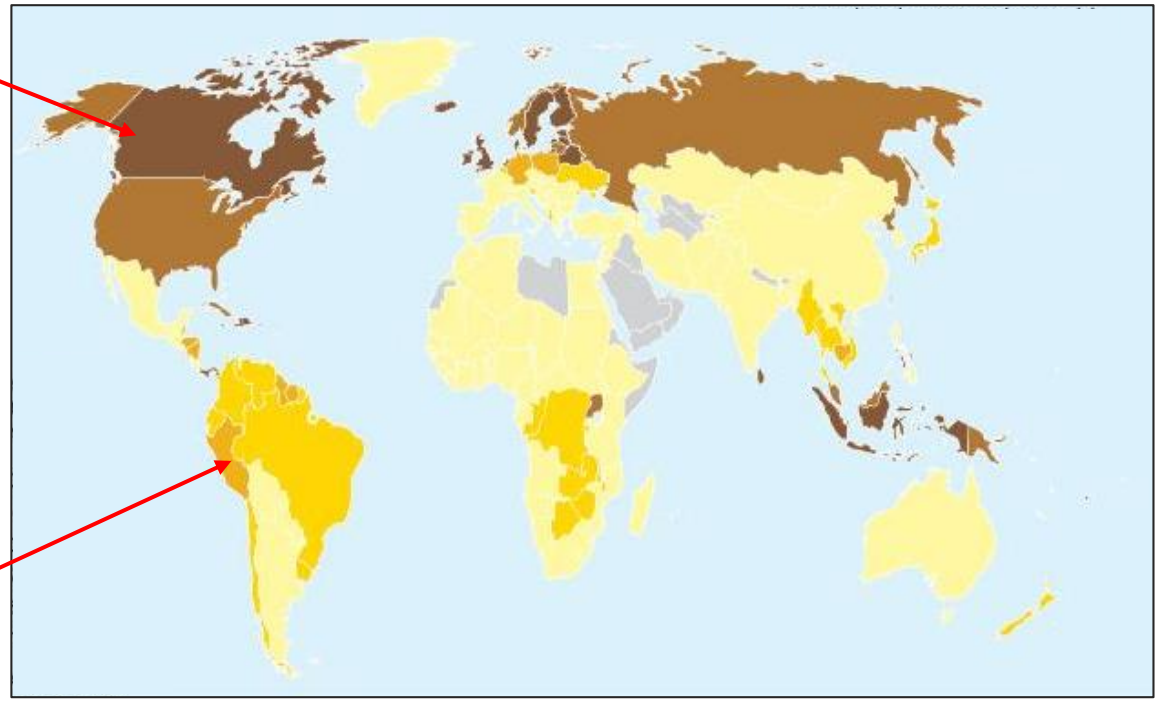
FRANCINE KELLY-HOOPER,*† ANDREA J. FARWELL,† GLENNA PIKE,‡ JOCELYN KENNEDY,‡ ZHENDI WANG,§ ERIC C. GRUNSKY,‖ and D. GEORGE DIXON†

Global Peat Distribution Map

Canadian Peat

Same Carbon Distribution Patterns Provided the Basis of the Peru Study Approach

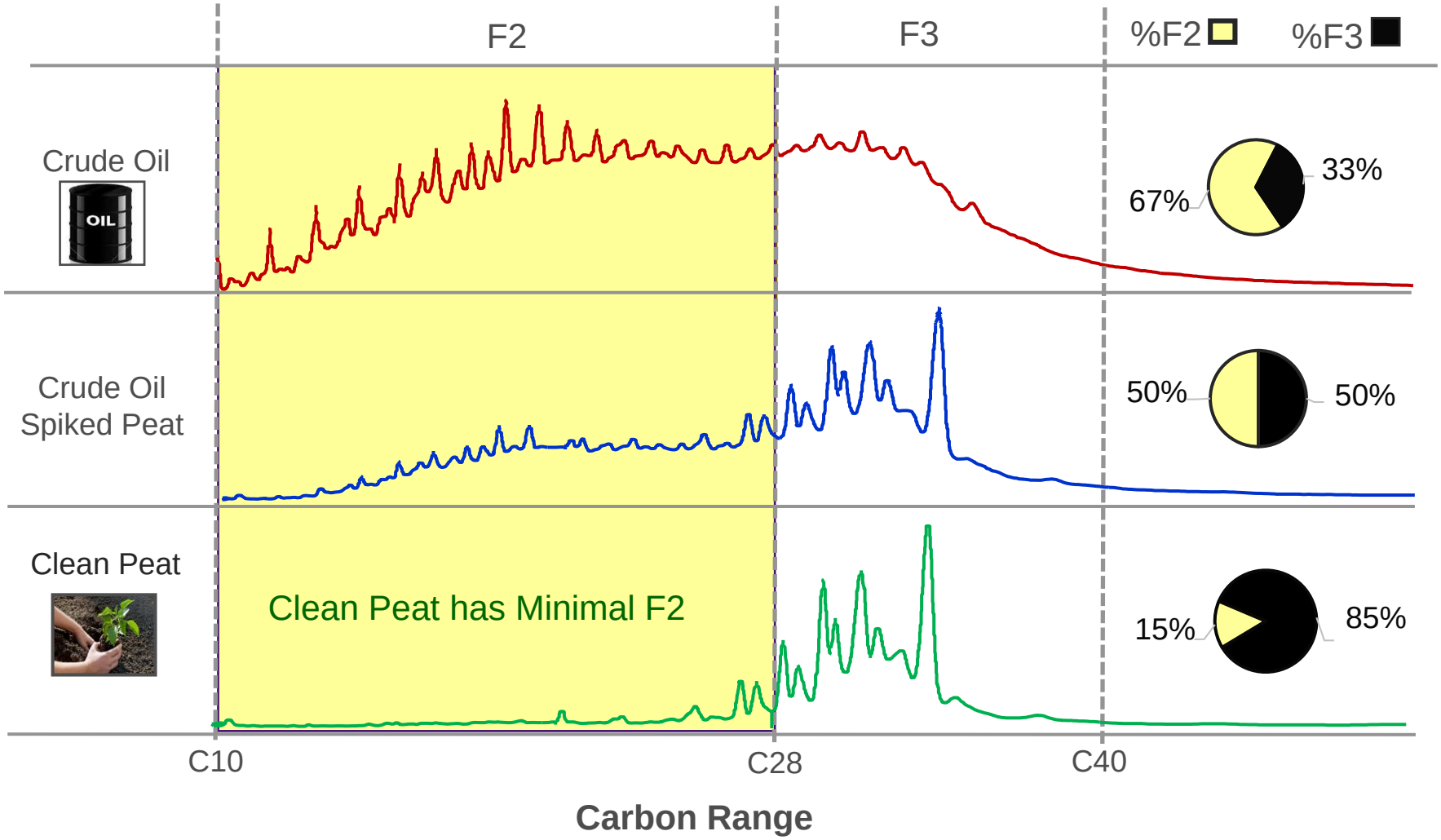
Peruvian Peat



Source: Parish et al. 2008

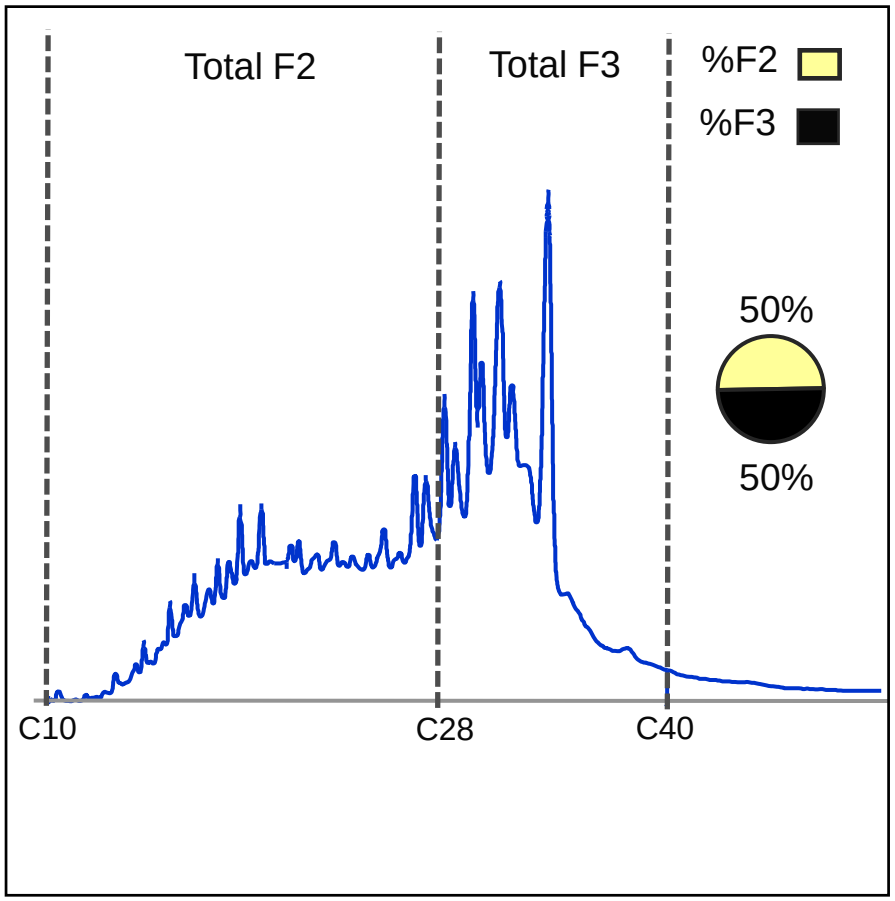
Peru Results

Carbon distribution patterns were used to calculate TPH versus BOC concentrations in peat samples

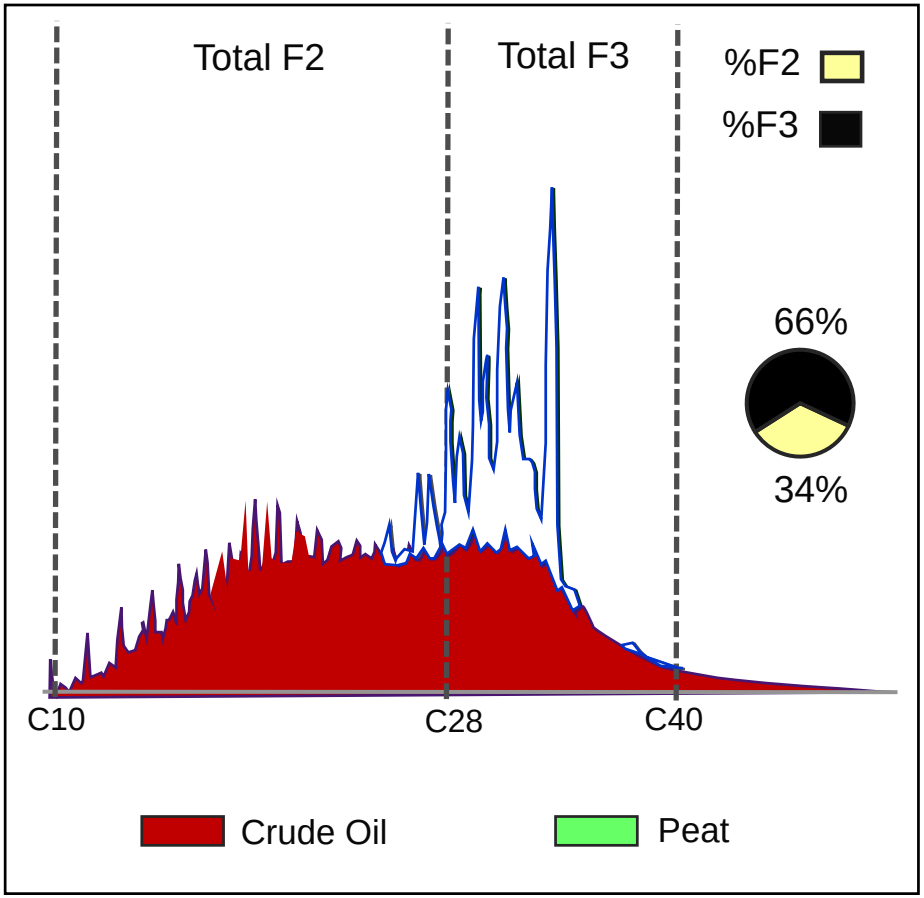


Crude Oil Spiked Peat

Total F2 & F4 percentages

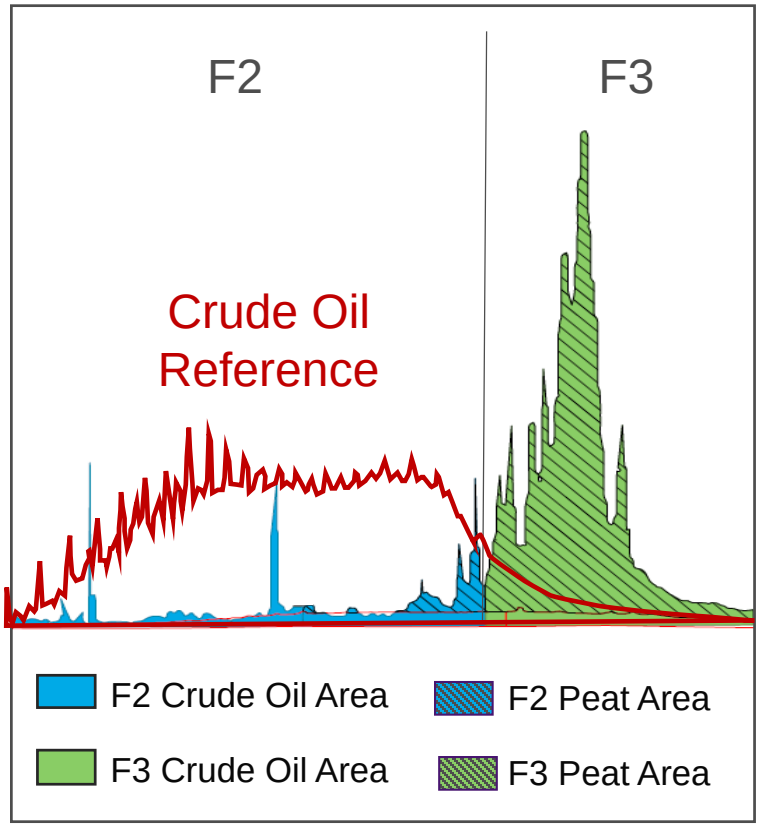


Calculated true TPH percentages when BOC area is subtracted from total area

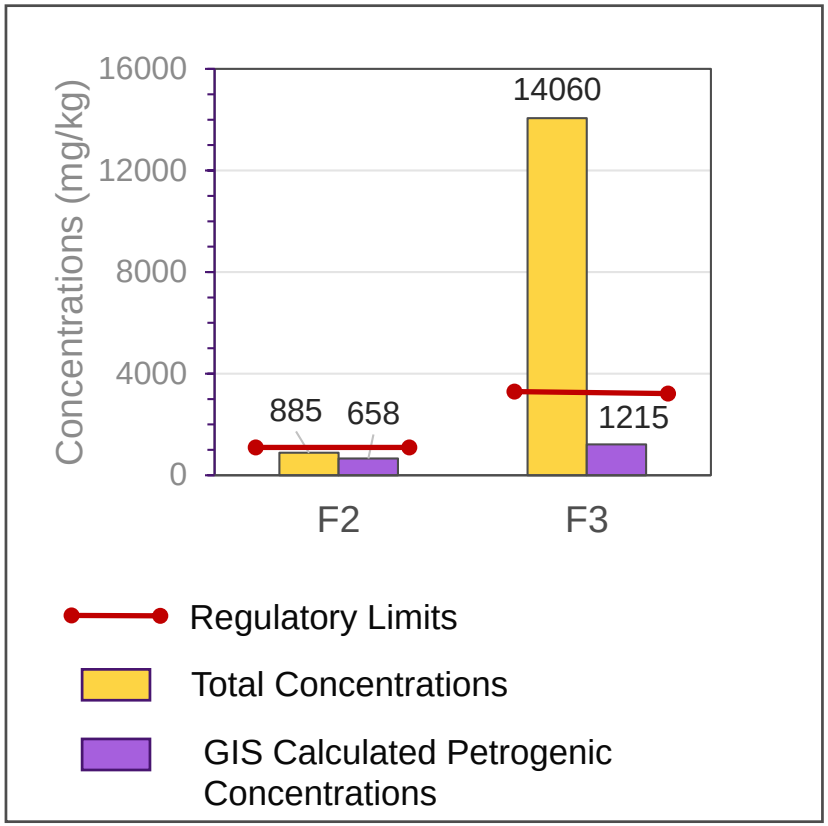


GIS Calculated F2 and F3 Petrogenic Concentrations

GIS Area Measurements of Contaminated Peat Sample



Total TPH Versus Calculated Petrogenic Concentrations



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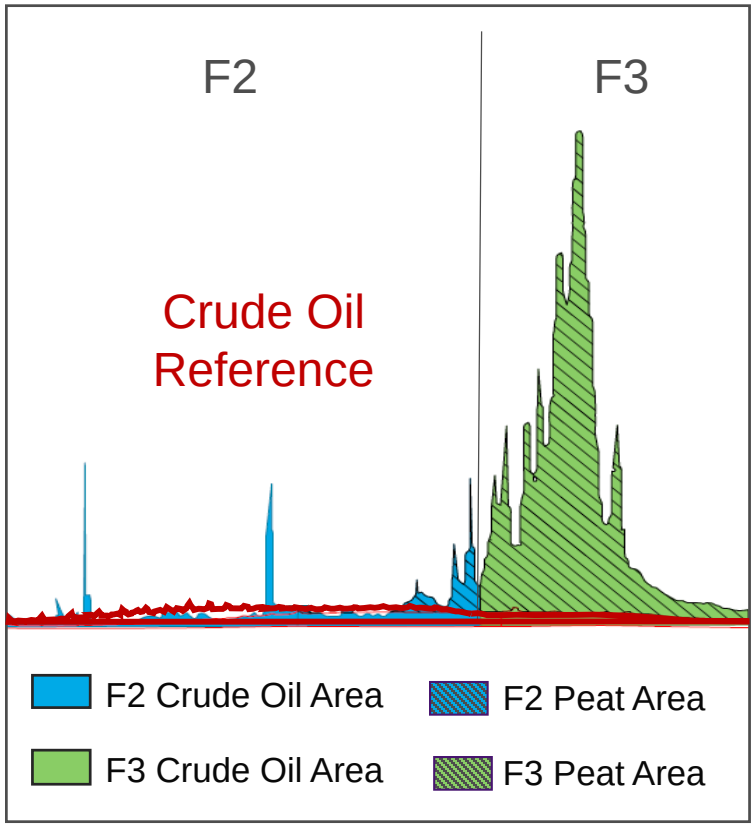

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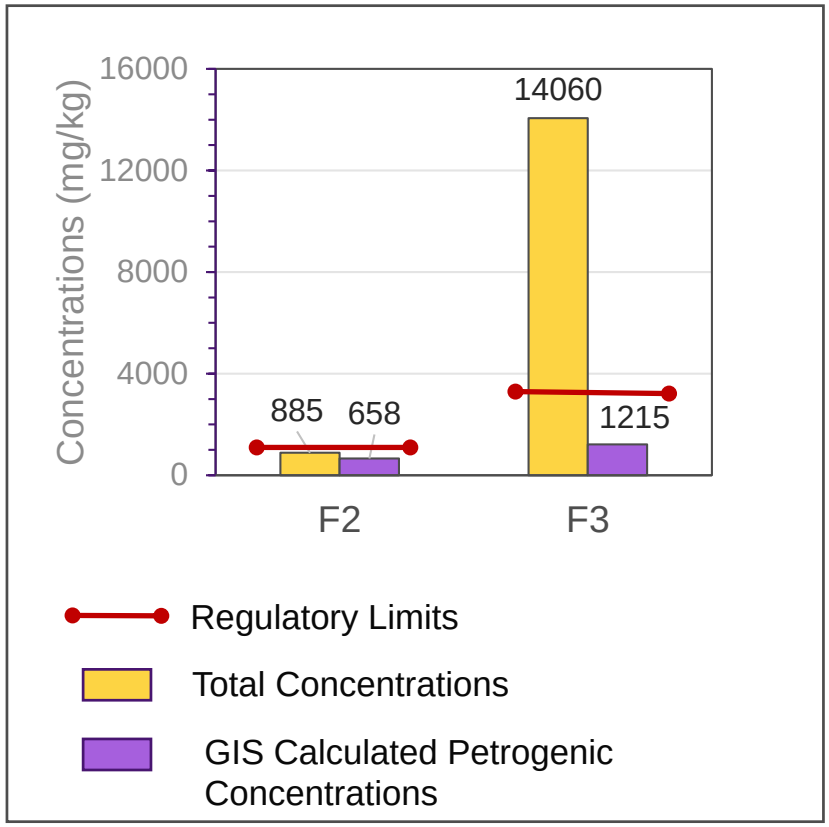
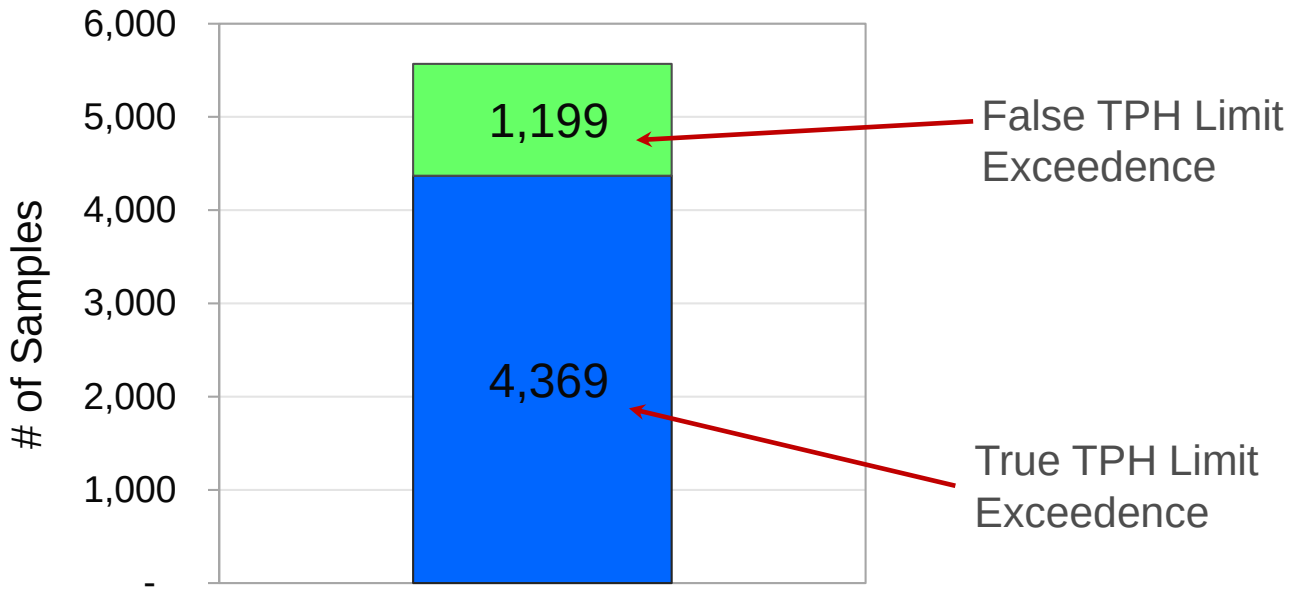


Final Results

1,199 (22%) of 5,568 contaminated soil samples were identified as falsely exceeding the F3 regulatory limit due to background peat



Project Challenges and Opportunities

- The Peruvian Ministry of Environment had recently adopted TPH soil chemistry analysis and site remediation requirements, which provided CH2M with an opportunity to conduct one of the first projects under these new requirements.

- CH2M's study approach was initially based on a Canadian template, which was adapted to meet Peruvian analytical methods and regulatory limits.

- The laboratory's electronic GC-FID files were not accessible for this study. CH2M developed an alternative graphical software technique for quantifying chromatogram areas and TPH concentrations.

Thank you!

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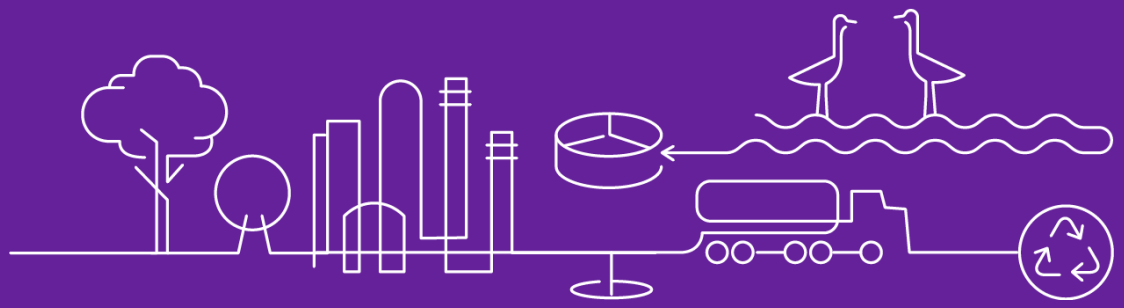

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