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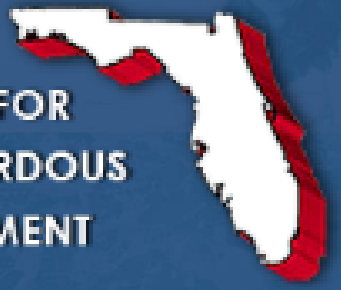

Understanding the Environmental Impacts of Reclaimed Asphalt Pavement

Kickoff Meeting

PI, John Bowden, PhD
Co-PI, Timothy Townsend, PhD
GRA, Ashley Lin

Technical Advisory Group Kickoff Meeting

April 6th , 2021

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Meeting Overview and Agenda

- Review of background information of Reclaimed Asphalt Pavement (RAP), Polycyclic Aromatic Hydrocarbons (PAHs), and laboratory leaching
- Summary of our group's previous work with the Hinkley Center (HC) and National Asphalt Pavement Association (NAPA)
- Discussion of emerging concerns with RAP
- Introduction to 2021 HC project
- Open the floor for discussion

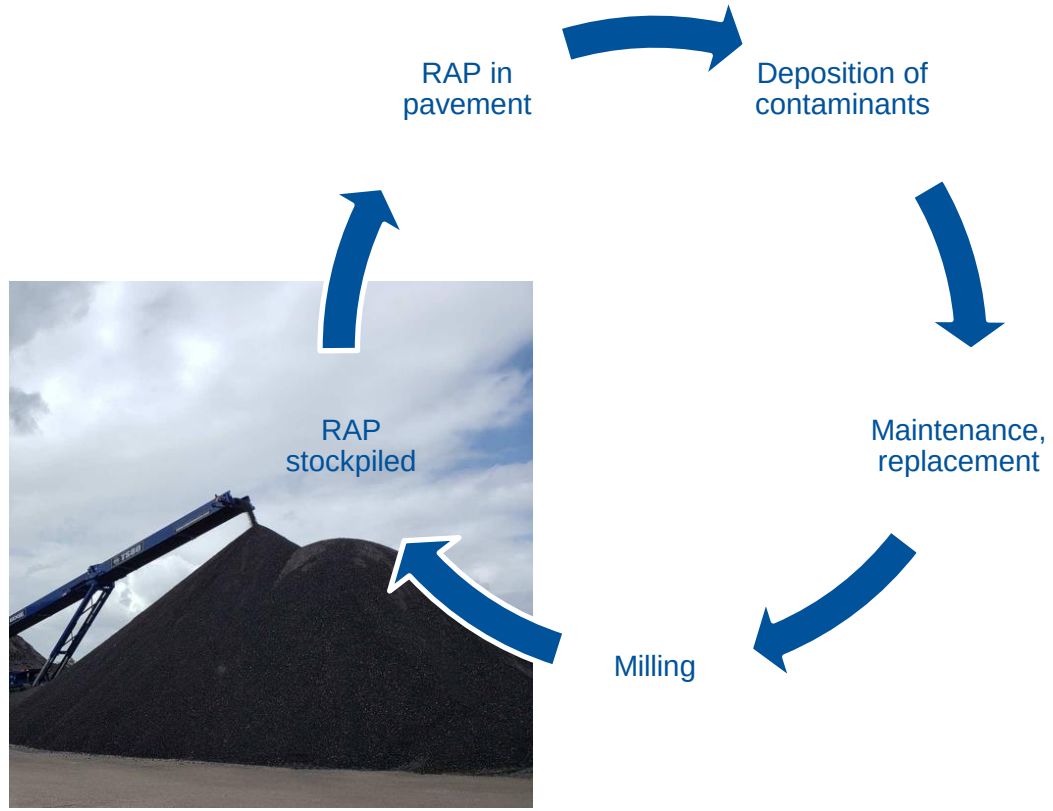
Background on Reclaimed Asphalt Pavement RAP… and more

RAP lifecycle

- **Reclaimed Asphalt Pavement (RAP):** Granular pieces of asphalt pavement removed during roadway maintenance or replacement for later reuse

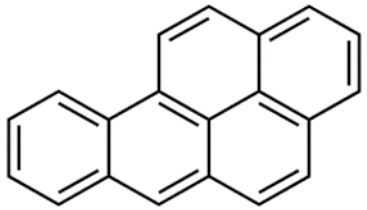
Three primary substances:

1. Aggregate
2. Binder
3. Depositions



Polycyclic Aromatic Hydrocarbons (PAHs)

- Present in coal, crude oil, and gasoline
- Sometimes carcinogenic
- Toxic
- Mutagenic



Benzo(a)pyrene

EPA 16 Priority PAHs

Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(g,h,i)perylene
Benzo(k)fluoranthene
Chrysene
Dibenz(a,h)anthracene
Fluoranthene
Fluorene
Indeno(1,2,3-cd)pyrene
Naphthalene
Phenanthrene
Pyrene

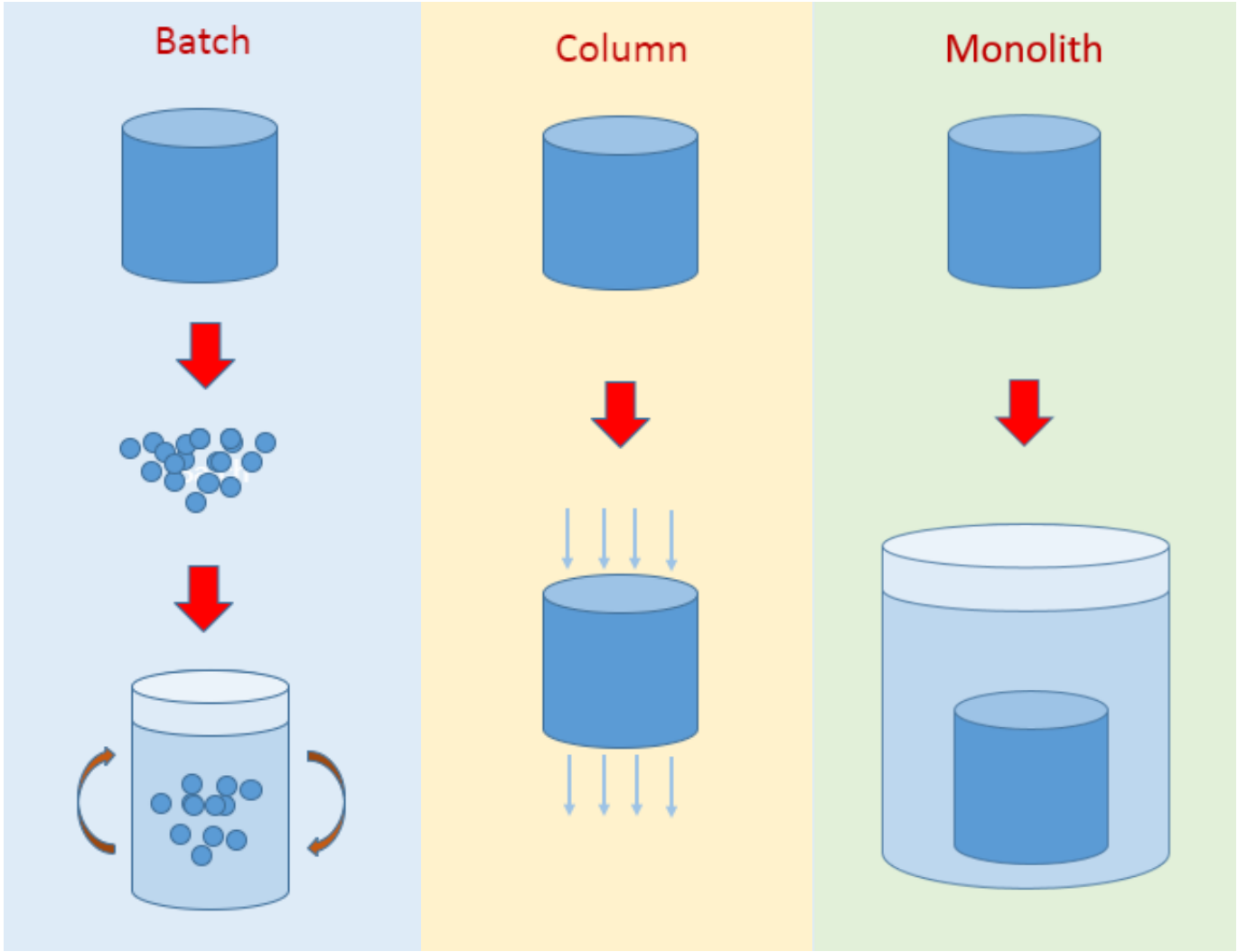
Leaching Procedure Types

Traditional EPA Methods

- 1311 Toxicity Characteristic Leaching Procedure (**TCLP**)
- 1312 Synthetic Precipitation Leaching Procedure (**SPLP**)

Leaching Environmental Assessment Framework (LEAF)

- 1313 Liquid Solid Partitioning as a Function of Extract pH
- 1314 Liquid Solid Partitioning using Up-Flow Percolation column
- 1315 Mass Transfer Rates of Constituents in Monolithic or Compacted Granular Materials
- 1316 Liquid Solid Partitioning as a Function of L/S



Previous RAP Work

Past HC Projects

- Leaching of Pollutants from Reclaimed Asphalt Pavement (Brantley & Townsend, 1999)

- Contribution of Asphalt Products to Total and Bioaccessible Polycyclic Aromatic Hydrocarbons (Su et al., 2013)

Contribution of Asphalt Products to Total and Bioaccessible Polycyclic Aromatic Hydrocarbons

Jing Su[1] · Peng Gao[2] · Steven James Laux[1] · Lena Qiying Ma[2] · Timothy Glyndon Townsend[1]

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Abstract
Soil-like waste products such as construction and demolition debris fines, street sweepings and catch basin sediments often contain elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) resulting from anthropogenic activities. Previous research suggested that small pieces of asphalt may contribute to PAHs in these wastes. The objective of this research was to investigate this idea by analyzing total PAHs concentrations in various asphalt products to assess their contribution to PAHs in these wastes. Five types of asphalt products (new and used asphalt shingles, new asphalt pavement, reclaimed asphalt pavement [RAP], and bitumen) were selected. PAHs concentrations were relatively low in most of the asphalt products except for RAP. The benzo[a]pyrene-equivalent (BaP-equivalent) concentrations in two RAP samples exceeded both Florida and EPA risk thresholds. PAHs bioaccessibility tests were conducted using a mild solvent extraction method on asphalt product samples of several different samples sizes (< 0.5 cm and < 250 μm); bioaccessibility was measured at < 10% for most samples. When asphalt products were mixed with clean sand to mimic soil-like waste, PAHs concentrations and bioaccessibility for most products decreased with decreasing asphalt percentages. Though PAHs sources for asphalt products are petrogenic, the few detected diagnostic ratios did not indicate a clear petrogenic source for these materials, suggesting that caution be taken when using diagnostic ratios for source apportionment related to these materials.

Article Highlights

- **Polycyclic aromatic hydrocarbon (PAH) in asphalt products were analyzed.**
- **Asphalt products have been a suspected source of PAH in soil-like wastes.**
- **PAH concentrations were found to be low in most asphalt products.**
- **Asphalt does not appear to be a significant source of PAH in soil-like wastes.**

Past Work with NAPA

- A critical analysis of leaching and environmental risk assessment for reclaimed asphalt pavement management (Spreadbury et al., 2021)
- Major takeaways:
  - Research gaps in PAH leaching
  - Lack of representative leaching data

NATIONAL ASPHALT PAVEMENT ASSOCIATION

Contents lists available at ScienceDirect
Science of the Total Environment
journal homepage: www.elsevier.com/locate/scitotenv

Review

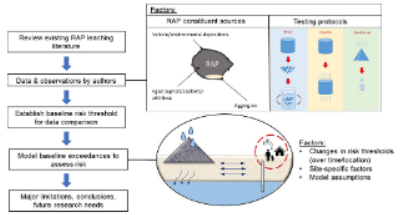
A critical analysis of leaching and environmental risk assessment for reclaimed asphalt pavement management

Chad J. Spreadbury, Kyle A. Clavier, Ashley M. Lin, Timothy G. Townsend *
Department of Environmental Engineering Sciences, University of Florida, P.O. Box 116450, Gainesville, FL 32611-6450, USA.

HIGHLIGHTS

- Critical literature analysis of RAP leaching and total concentration data
- Approaches and risk-thresholds are highly variable, and comparison is challenging.
- Direct exposure risk associated with RAP stockpiling is generally low.
- Fate and transport modeling indicate low leaching risk from RAP stockpiles.
- RAP stockpiling unlikely to contaminate underlying or adjacent water supplies

GRAPHICAL ABSTRACT



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ABSTRACT

In the last couple of decades, studies have examined the potential environmental risks associated with reclaimed asphalt pavement (RAP) management through a range of approaches. Variable risk assessment methodologies and uncertainty on RAP behavior in a stockpile or during reuse have led to inconsistent regulatory oversight in many jurisdictions. The objective of this literature review is to provide clarity on the findings pertaining to RAP leaching and assess the potential human and environmental health risks associated with reported constituent mobility from RAP. The reviewed literature focuses on the leaching of metals and organic compounds; direct exposure risk was briefly reviewed and found not to exceed natural soils or aggregates. On occasion, the literature reports elevated leached concentrations of certain metals (e.g., lead) and some polycyclic aromatic hydrocarbons (PAHs) from a few RAP samples. These elevated RAP leachate concentrations are assessed via fate and transport model (US EPA IWEM) to estimate dilution and attenuation of select metals and PAHs under typical environmental conditions and reuse or storage scenarios (e.g., stockpiling). This analysis suggests that most reported leachate concentrations of potential concern would be effectively attenuated at the most conservative conditions simulated (10 m, 100% infiltration); limitations with modeling are acknowledged. Pavement materials and external sources, along with chosen testing protocols, influence RAP leachate concentrations, affecting conclusions for potential environmental impacts of RAP in the literature. Understanding how these variables impact leaching and risk assessment is necessary to maximize and continue beneficial reuse of RAP while safeguarding human and environmental health.
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Emerging Concerns

Concerns regarding RAP

- Thurston County, WA – Herrera report
- Lingering concerns from agencies and states on human/environmental risks
- Unknown best management practices for RAP stockpiles

2021 Hinkley Center Project

Project Objectives

- Address knowledge gaps of the environmental impacts of RAP
- Measure total and leachable pollutant concentrations in RAP
- Potential toxicity assessment
- Development of BMPs for use of RAP in Florida

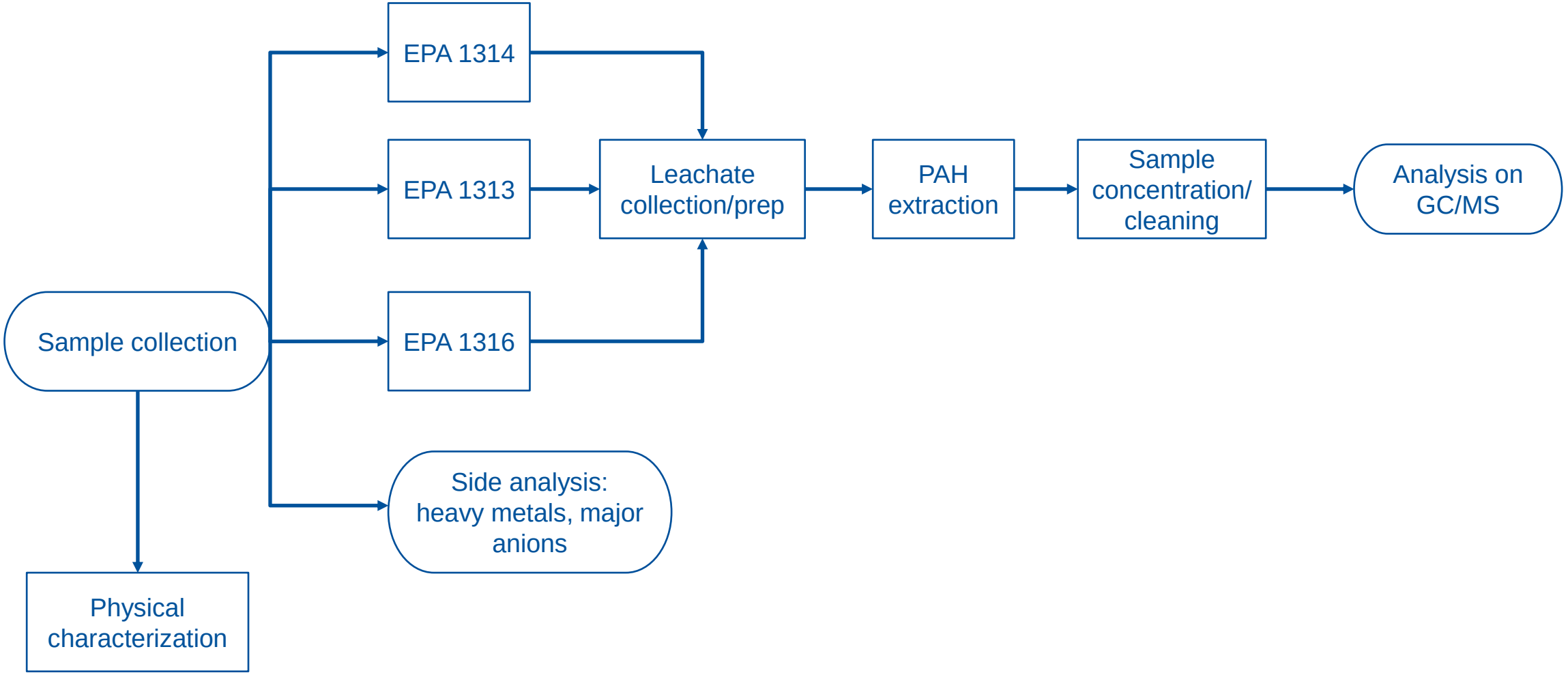
Project Phases

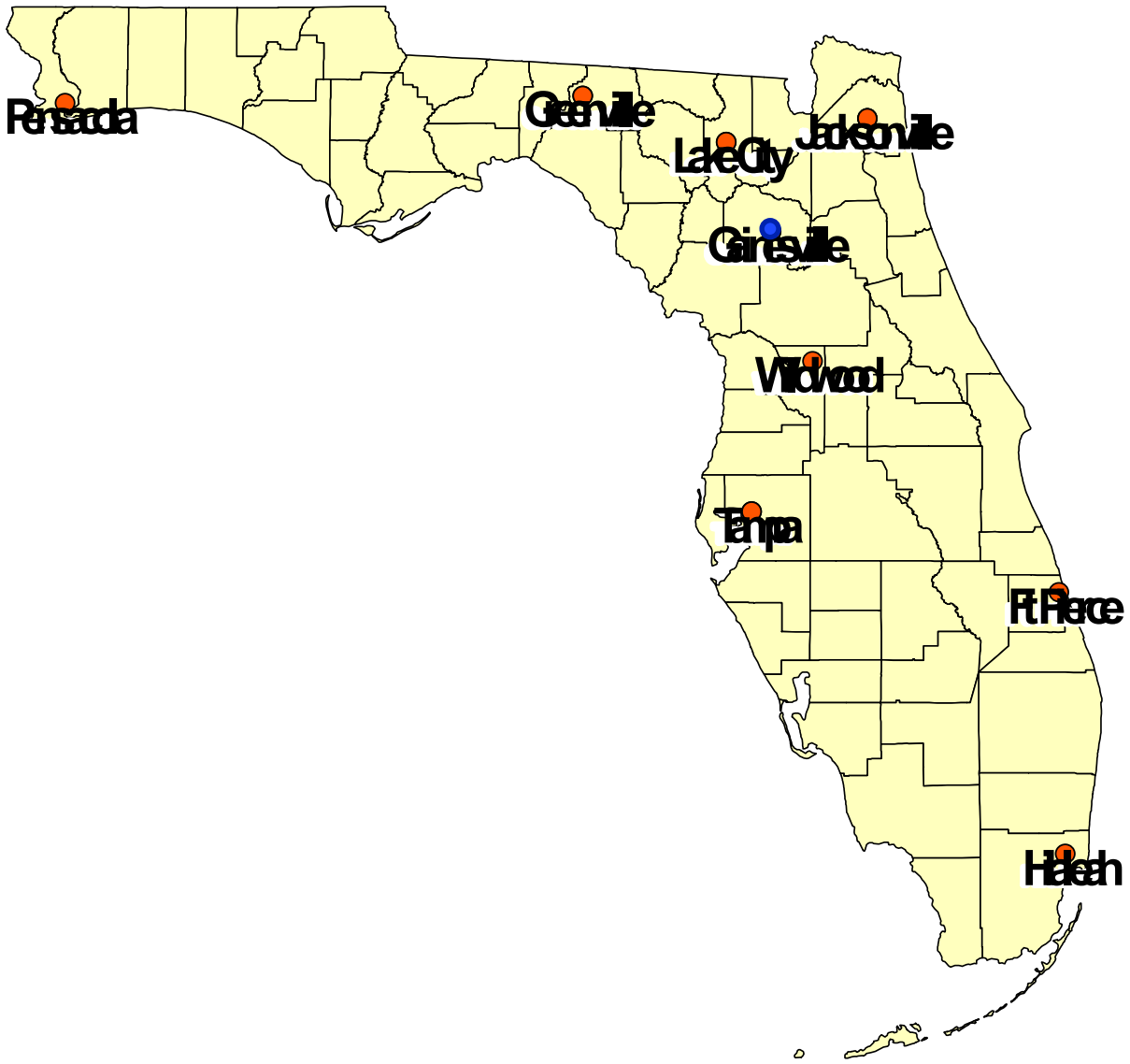
Phase 1 – Measure the amount of total and leachable pollutants in RAP

- Method 1314 – Percolation Column
- Method 1313 – pH dependent LSP
- Method 1316 – L/S dependent LSP

Phase 2 – Preliminary toxicity assessment and development of BMPs for RAP use in Florida

Brief Methodology


EPA 1314
EPA 1313
EPA 1316
Leachate collection/prep
PAH extraction
Sample concentration/ cleaning
Analysis on GC/MS
Sample collection
Side analysis: heavy metals, major anions
Physical characterization



- 9 Total sampling sites chosen by accessibility
- Source specific and mixed source RAP
- Preliminary run through of EPA 1314 conducted on RAP from Gainesville

PAHs of Interest

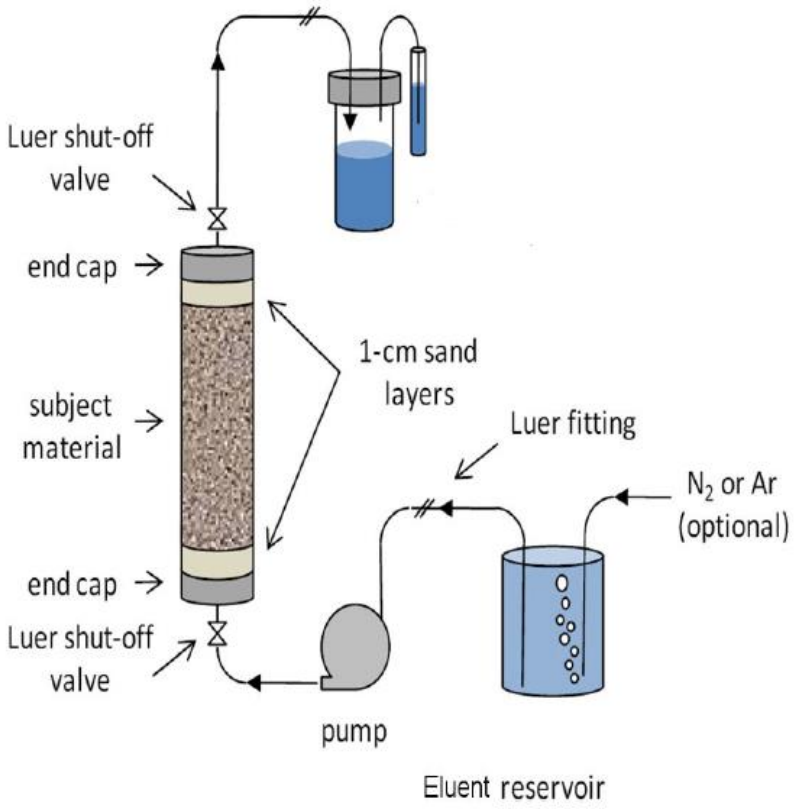
Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(g,h,i)perylene
Benzo(k)fluoranthene
Chrysene
Dibenz(a,h)anthracene
Fluoranthene
Fluorene
Indeno(1,2,3-cd)pyrene
Naphthalene
Phenanthrene
Pyrene

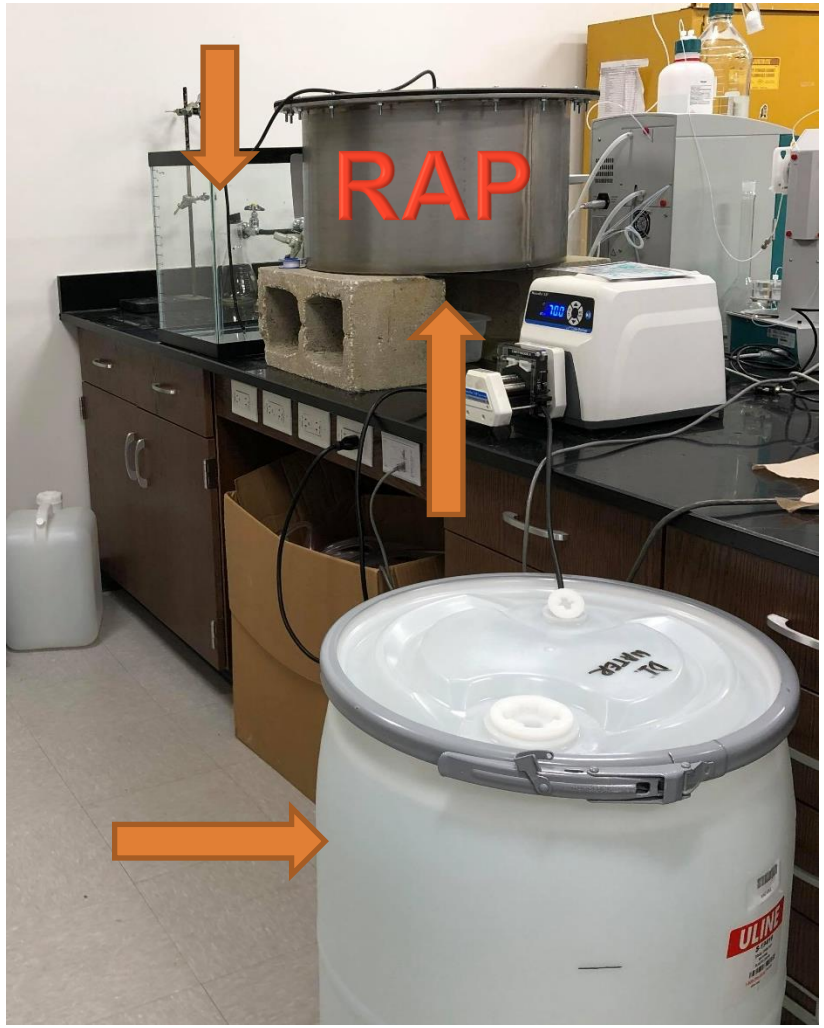
1-Methylnaphthalene
2-Methylnaphthalene
1,2-Dimethylnaphthalene
1,6-Dimethylnaphthalene
2,6-Dimethylnaphthalene
1,7-Dimethylphenanthrene
1-Methylfluoranthene
3-Methylfluoranthene
1-Methylpyrene
4-Methylpyrene
Retene
3-Methylchrysene
6-Methylchrysene
Biphenyl
Perylene

Benzo[e]pyrene
Benzo[j]fluoranthene
Benzo[c]phenanthrene
Dibenz[a,j]acridine
Dibenzo[a,e]pyrene
Dibenzo[a,h]pyrene
Dibenzo[a,i]pyrene
Dibenzo[a,l]pyrene
5-Methylchrysene
1,8-Dimethylnaphthalene
9-Chloroanthracene
6-PPD

GC/MS Triple Quadrupole

EPA Method 1314 - Liquid Solid Partitioning as a Function of Liquid Solid Ratio for Constituents in Solid Materials Using an Up-flow Percolation Column Procedure





EPA Method 1314 - Leachate Collection

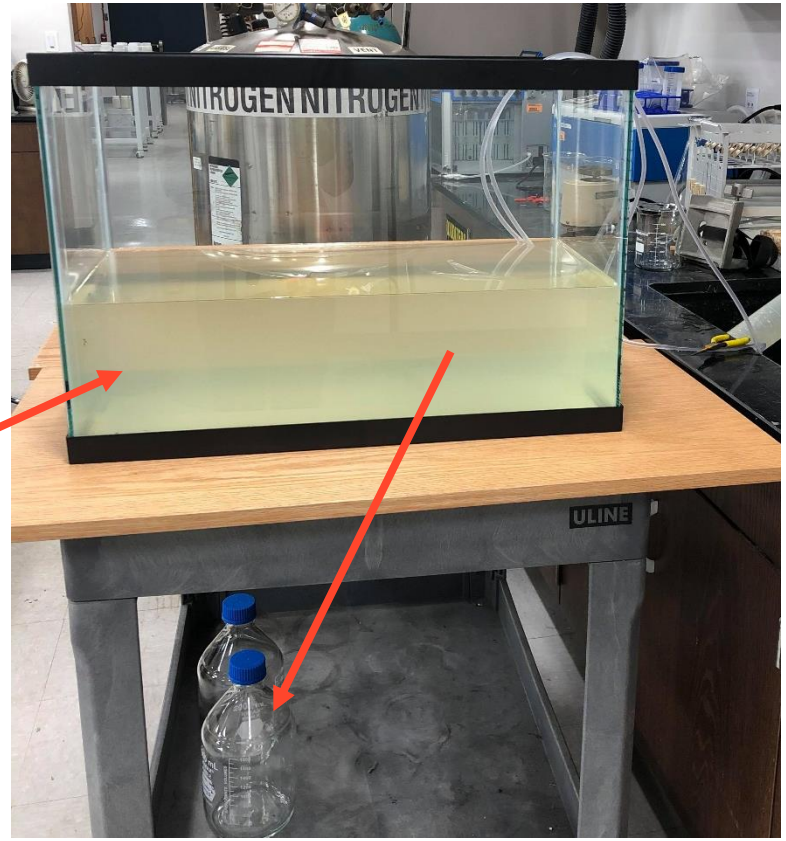
SCHEDULE OF ELUATE FRACTIONS FOR COLLECTION WITH EXAMPLE VOLUMES

Interval Label	End Point ΣL/S (mL/g-dry)	Fraction L/S (mL/g-dry)	Example Fraction Volume (mL)
T01	0.2 ± 0.1	0.2	60
T02	0.5 ± 0.1	0.3	90
T03	1.0 ± 0.1	0.5	150
T04	1.5 ± 0.2	0.5	150
T05	2.0 ± 0.2	0.5	150
T06	4.5 ± 0.3	2.5	750
T07	5.0 ± 0.2	0.5	150
T08	9.5 ± 0.3	4.5	1350
T09	10.0 ± 0.2	0.5	150
B01	Eluent		100

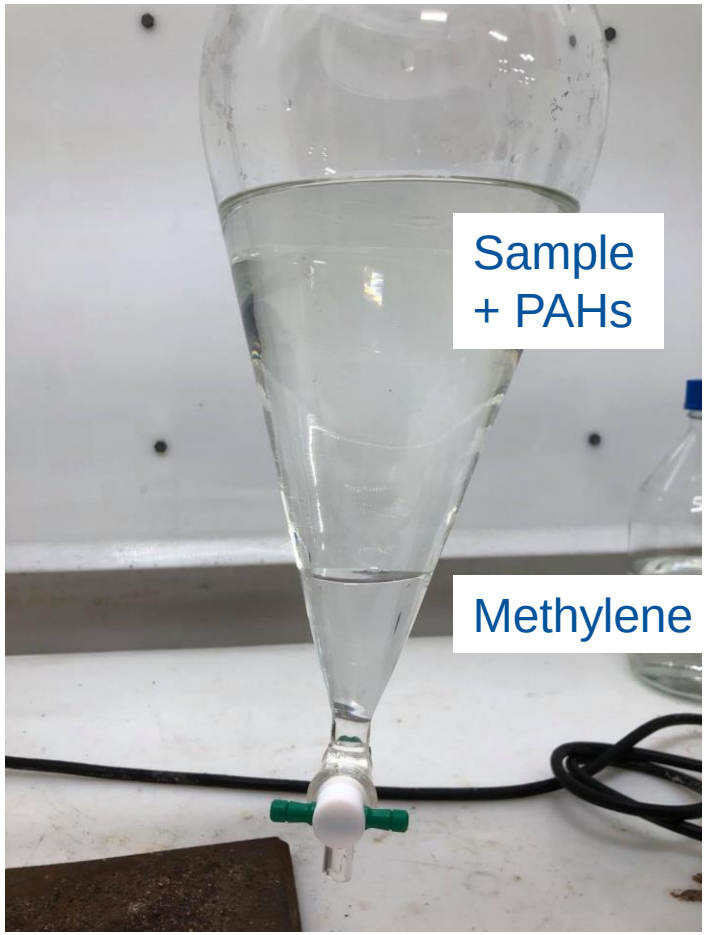
NOTE: Example fraction volumes based on assumed packing mass of 300 g-dry

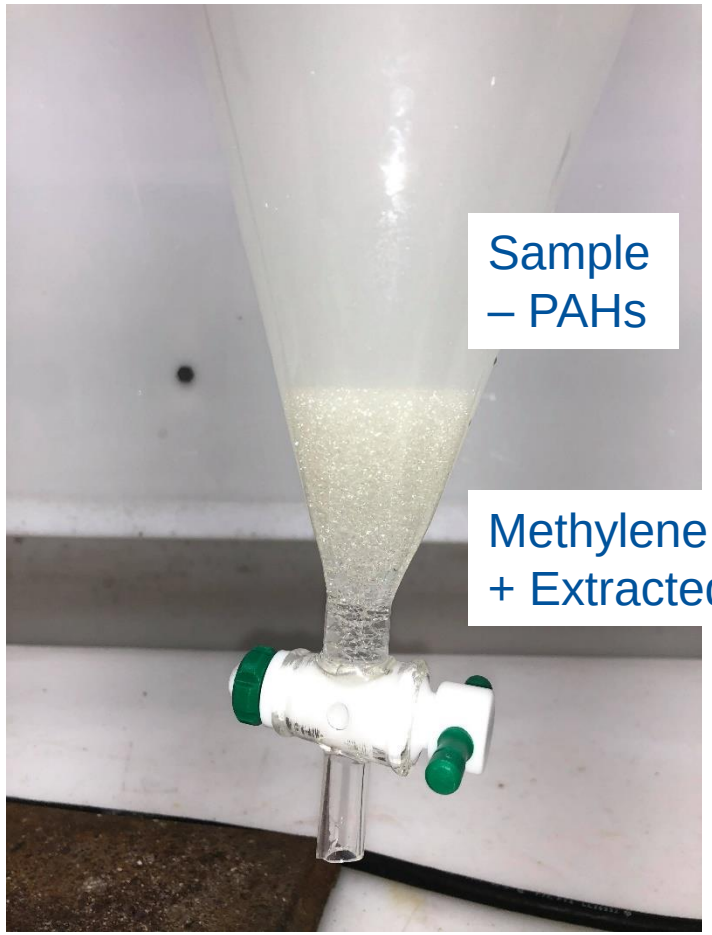
Our Fraction Volumes	
L	Gal
15.7	4.1
23.5	6.2
39.2	10.4
39.2	10.4
39.2	10.4
195.9	51.8
39.2	10.4
352.6	93.2
39.2	10.4

Approximately 80 kg sample



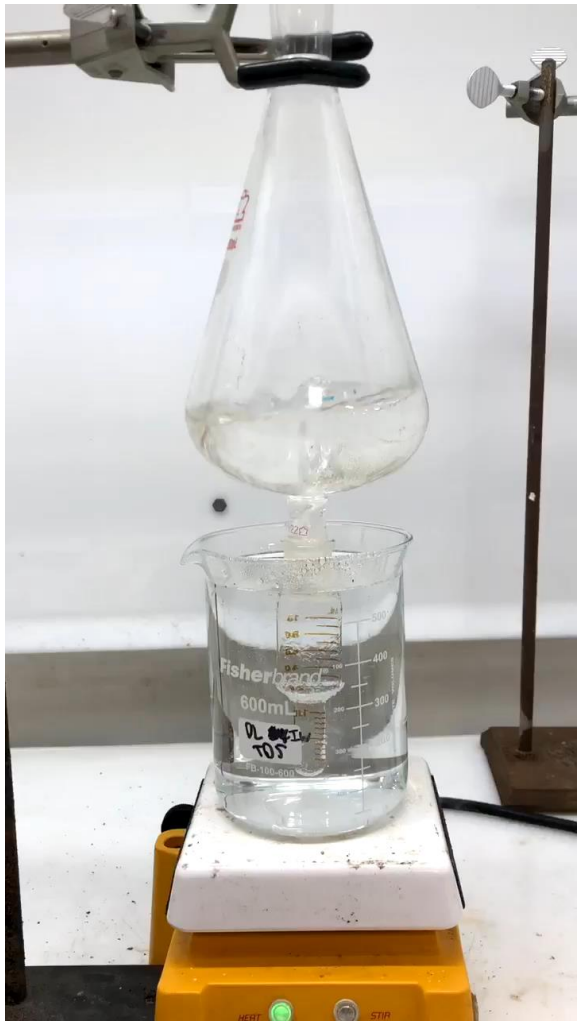
EPA Method 3510c – Separatory Funnel Liquid-Liquid Extraction





EPA Method 3510c – Kuderna Danish Concentration

360mL Methylene Chloride + PAHs



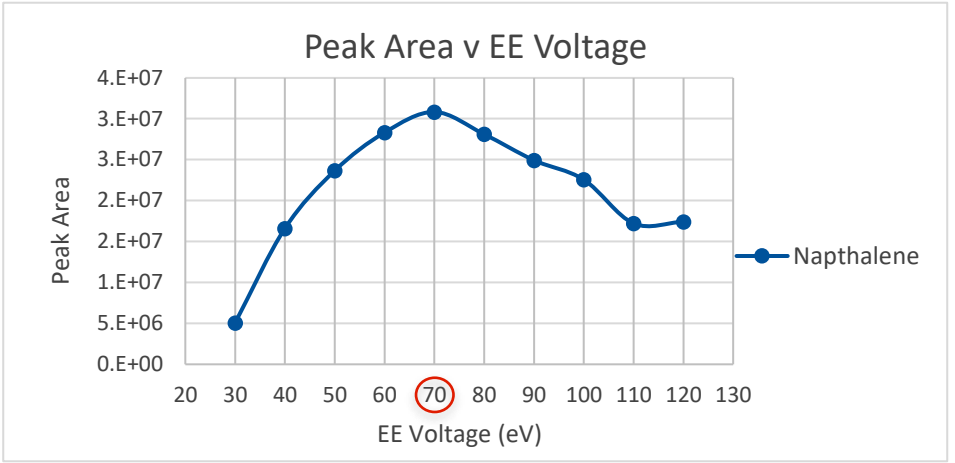
1mL Methylene Chloride + PAHs

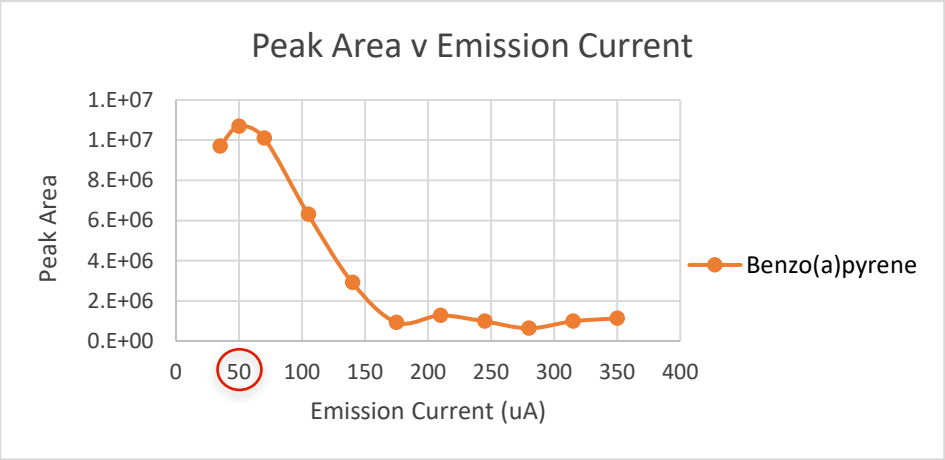
Ready for GC/MS analysis

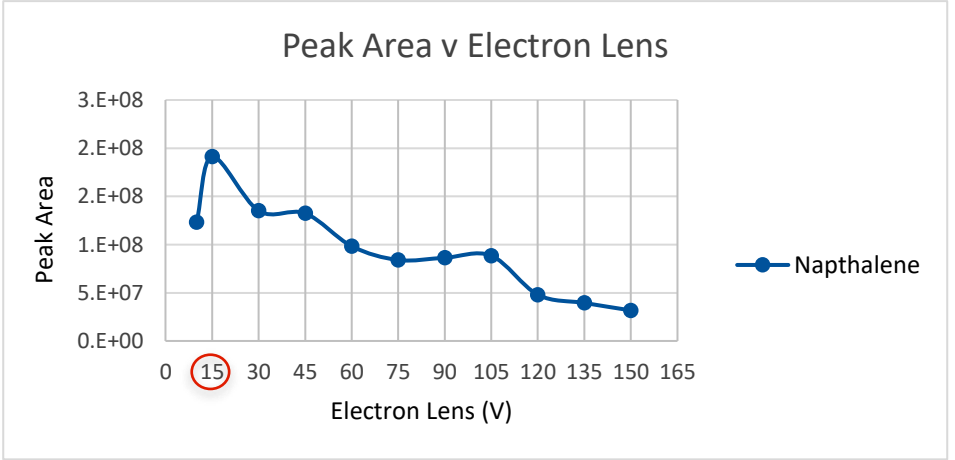
GC/MS Method Optimization

Three Parameters Optimized

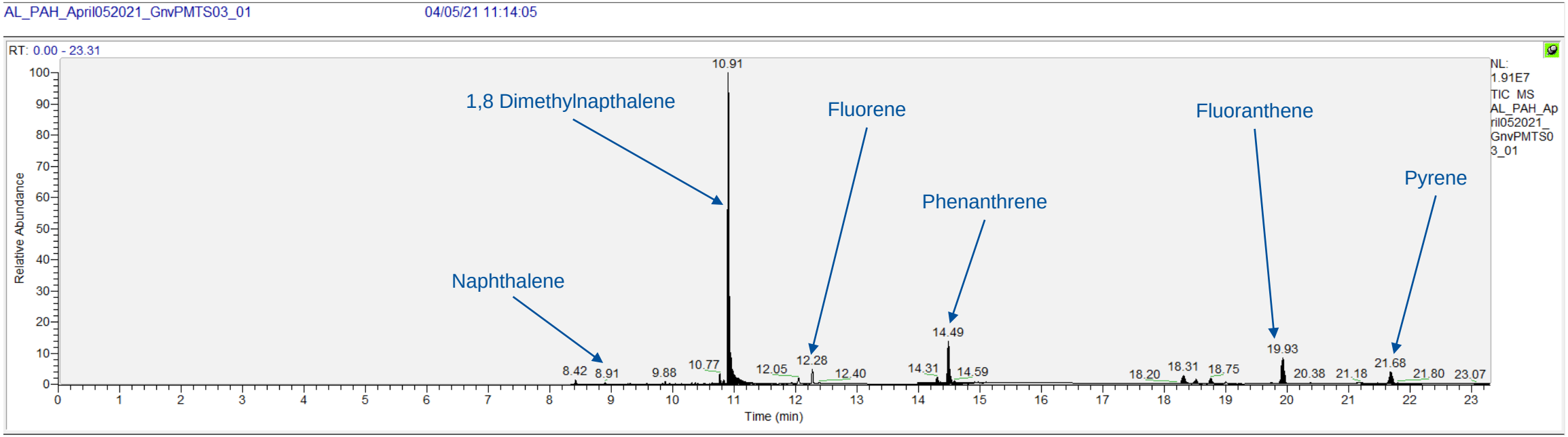
1. Electron Energy
2. Emission Current
3. Electron Lens







Test Run Results From the GC/MS



Ongoing/Future Work

- Extraction efficiency refinement
- GC/MS method finalization
- Sample collection and processing
- Phase 2 toxicity assessments
- Secondary TAG meeting in Fall 2021 to present result

Any Questions?

Recording and Powerpoint will be made available here:

https://faculty.eng.ufl.edu/timothy-townsend/research/florida-solid-waste-issues/understanding-the-environmental-impacts-of-reclaimed-asphalt-pavement/

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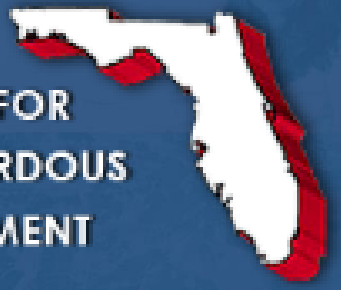

Thank you

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