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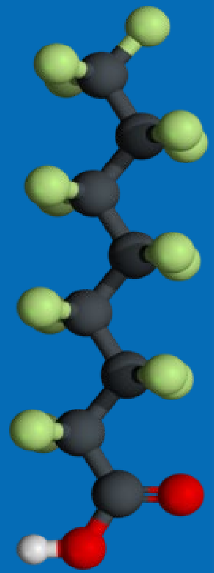
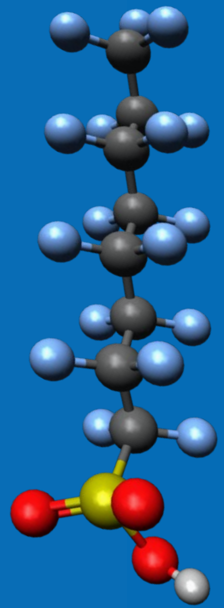


SUMMARY OF THE PFAS INNOVATIVE TREATMENT TEAM (PITT) ACCOMPLISHMENTS AND STATUS



Hoosick Falls Community Participation Working Group
January 27, 2021

Progress for a Stronger Future

Outline

- The PITT
- Goals
- Challenges
- Non-Combustion Technologies
  - Mechanisms
- Combustion Technologies
  - Mechanisms
- Outputs
- Status and PITT Legacy

PFAS Innovative Treatment Team (PITT)

- Full-time team that brought together a multi-disciplined research staff
- Concentrated efforts and expertise on a single problem: **how to remove, destroy, and test PFAS-contaminated media and waste**
- For 6 months, the PITT worked to achieve the following goals:
  - Assess current and emerging destruction methods being explored by EPA, universities, other research organizations, and industry
  - Explore the efficacy of methods while considering by-products to avoid creating new environmental hazards
  - Evaluate methods’ feasibility, performance and costs to validate potential solutions

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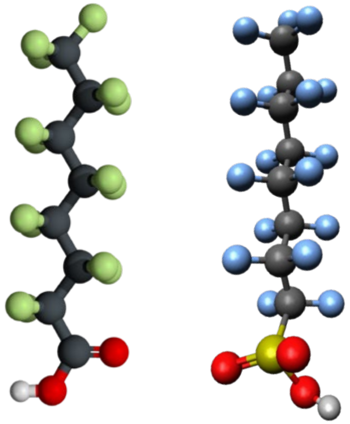
PITT's Goals and Timing

- Develop a "Toolbox" of reviewed solution(s) for the destruction of PFAS in media and contaminated waste to meet the needs of EPA programs and regions, states and tribes, federal agencies, and industry
  - Traditional (combustion) destruction
    - Temperature and time conditions for C-F bond breakage
    - Performance of flue gas cleaning systems
    - Analysis of by-products
  - Innovative (high risk), non-traditional approaches
    - Destruction performance
    - By-products

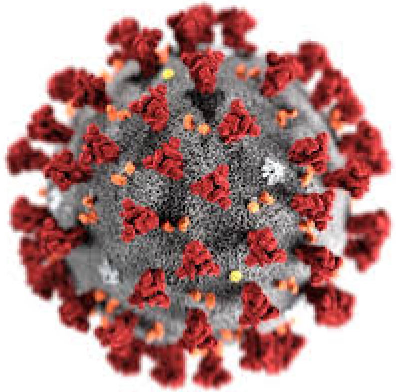
- Provide officials with state of the science data on incineration effectiveness enabling them to better manage end-of-life disposal of PFAS-containing materials
- By CY 2020 contribute to OLEM's interim guidance required by the NDAA

PFAS Sources

- Biosolids, sludge
- AFFF concentrate, spent AFFF
- Aqueous film forming foam (AFFF)-contaminated soils
- Municipal Waste Combustors (MWCs), landfills, landfill leachate
- Spent granular activated carbon (GAC), anion exchange resins



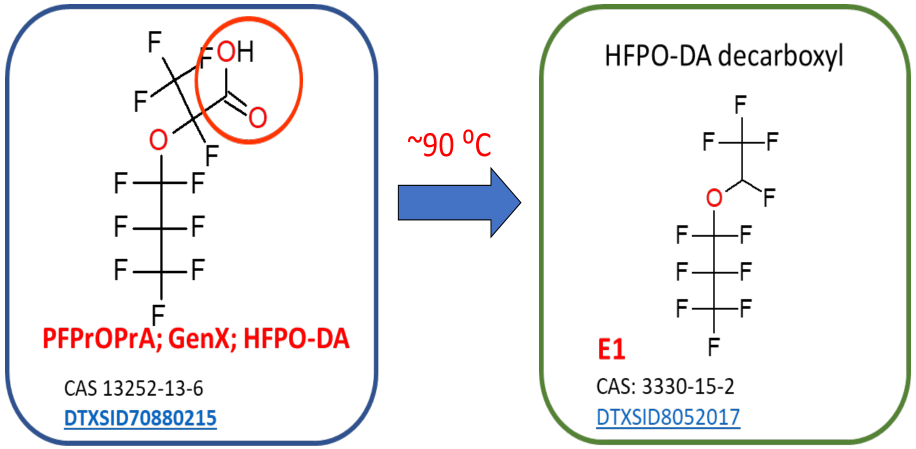
PITT Challenges



- COVID-19
  - Building closures
  - Lab closures
  - Restricted partner access to labs
  - Closure of suppliers
  - Unavailable instrument repairs
- Finding field test partners
- Concurrent field sampling and sampling methods development

Challenges of PFAS Destruction

- **Complicated chemistry-** thousands of PFAS exist
- **Widely used** in industrial processes and consumer products
- Efficacy of thermal treatment
  - C-F bond is the strongest bond in organic chemistry
  - Emission sampling and analytical methods are under development
    - Volatile, non-volatile, polar, non-polar
    - Limited number of analytical standards available
  - Field data lacking
  - Historical laboratory research on "destructibility" lacks information about products of incomplete combustion **(PICs)**



Non-Combustion Technologies Selected

- Chemical
- Biological
- Plasma
- **Mechanochemical**
- Sonolysis
- Ebeam
- UV
- **Supercritical water oxidation**
- Deep well injection
- Sorption/stabilization
- **Electrochemical**
- Landfill
- Land application
- **Pyrolysis**

Technologies selected for further investigation

Assessment Factors:

- Technology readiness
- Applicability
- Cost
- Required development remaining
- Risk/reward of technology adoption

Assessment Methods:

- Subject matter expert discussions
- Literature reviews
- PITT discussions

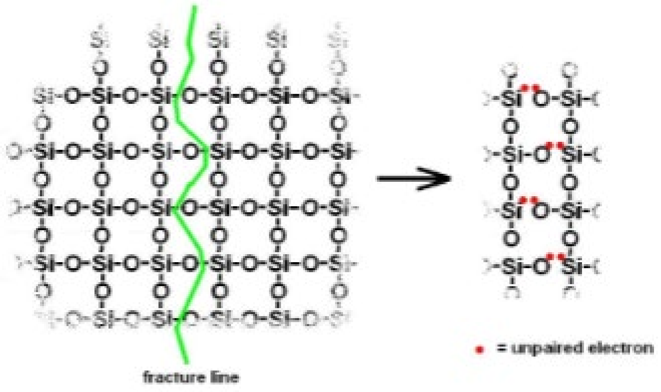
Mechanochemical Treatment

Works by:

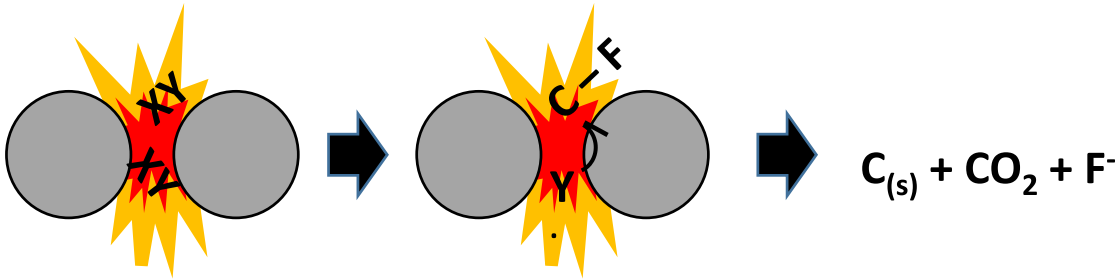
- Introduction of dry solids into a ball mill
- Co-milling reagents: Al, Fe, SiO_2, CaO, MgO, Al_2O_3, KOH, NaOH, MnO_2, TiO_2
- High energy ball impacts fracture solids generating localized high temperatures and radicals that react and breakdown organic molecules
- Technology derived from POPs-contaminated soil treatment
  - EDL (NZ) showed >99.8% DRE of PCBs in 45 min (US Navy, Hunters Point, 2006).

Our Steps:

- In-house study to verify mechanochemical effectiveness, data gaps
- Contract with EDL (New Zealand)
  - AFFF impacted soil study
  - AFFF destruction study



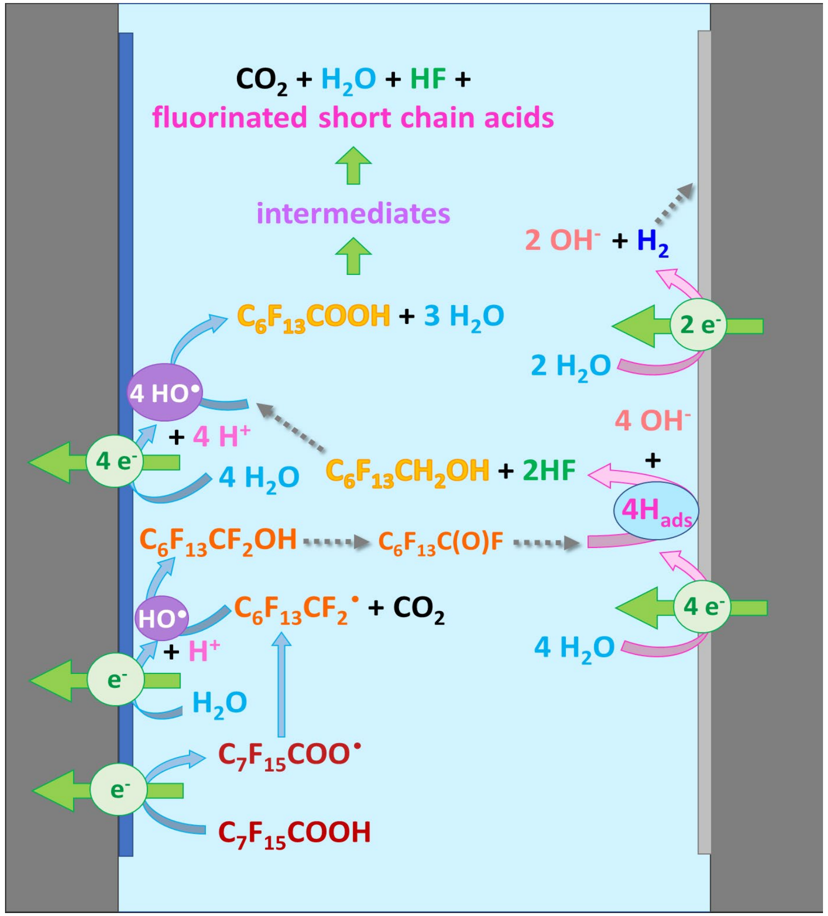
Bulley, M.; Black, B. EDL



Electrochemical Treatment

Works by:
- A high overpotential (>3 V) is applied to an electrolytic cell
- Stepwise degradation ultimately produces CO_2 and HF

Our Steps:
- Testing on AECOM reactors
- Data gaps:
  - Uncertain byproducts
  - Volatile loss
  - Matrix effects
- Results expected in early '21

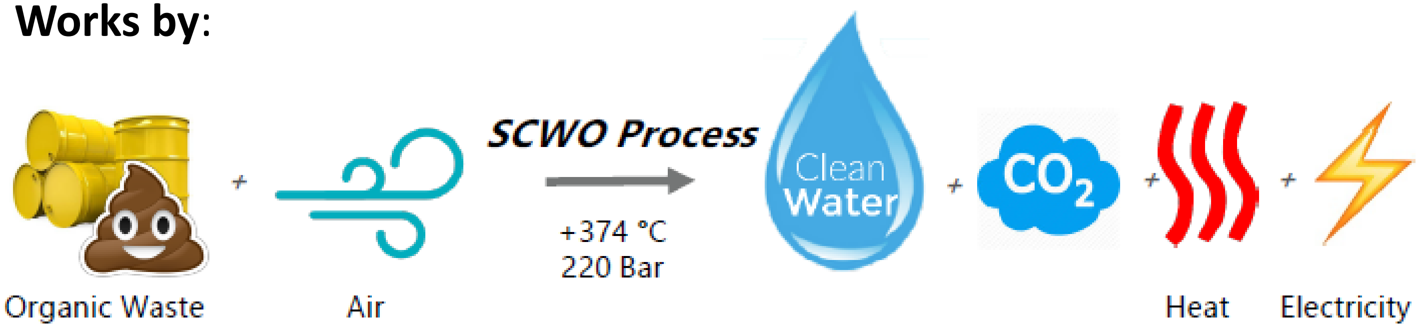


Anode (+) Cathode (-)

Image from doi:10.20944/preprints202007.0561.v1

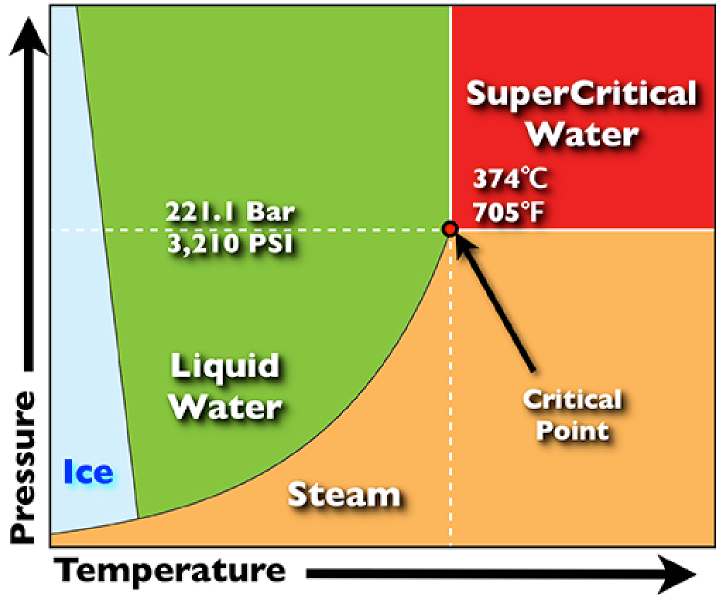
Supercritical Water Oxidation (SCWO)

Works by:



SCWO converts organic waste into clean water, heat, electricity and CO_2 ***in seconds!*** Duke UNIVERSITY

At T and P, water becomes supercritical and organics are solubilized and oxidized



Our Steps:

- **Focus on AFFF concentrate** (*stockpile destruction alternative*)
- In-house laboratory study on Hydrothermal oxidation
- Contract for Battelle's SCWO "Annihilator"
- Contract with 374Water/Duke
- Procurement with Aquarden (Denmark)
- General Atomics MCRADA

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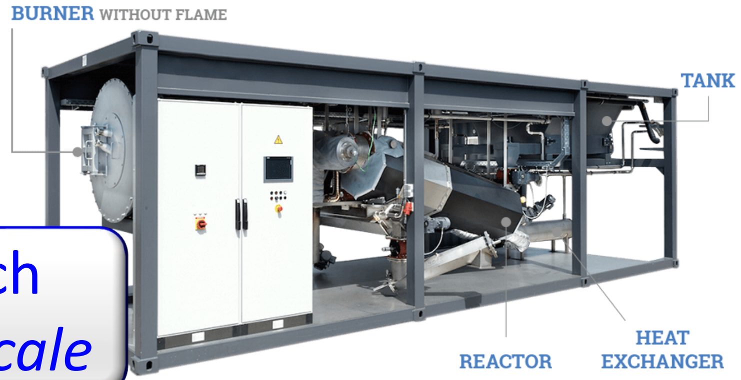
Biosolids Pyrolysis/Gasification

Works by:

- Pyrolysis is a process that decomposes materials at moderately elevated temperatures in an oxygen-free environment.
- Gasification is similar to pyrolysis but uses small quantities of oxygen, taking advantage of the partial combustion process to provide the heat to operate the process.
- The oxygen-free environment in pyrolysis and the low oxygen environment of gasification distinguish these techniques from incineration.
- Pyrolysis, and certain forms of gasification, can transform input materials, like biosolids, into a biochar while generating a hydrogen-rich synthetic gas (syngas).
- Both biochar and syngas can be valuable products.

Our Steps:

- Field test of Pyrolysis unit (with emission controls) that produces Biochar with energy to "BioDryer"
- Field test completed – Aug. 25-27, 2020
  - Samples input Biosolids
  - Produced Biochar
  - Scrubber Water
  - Multi-position FTIR
- No reportable PFAS found in produced biochar, but additional research needed to understand potential releases to air and water.



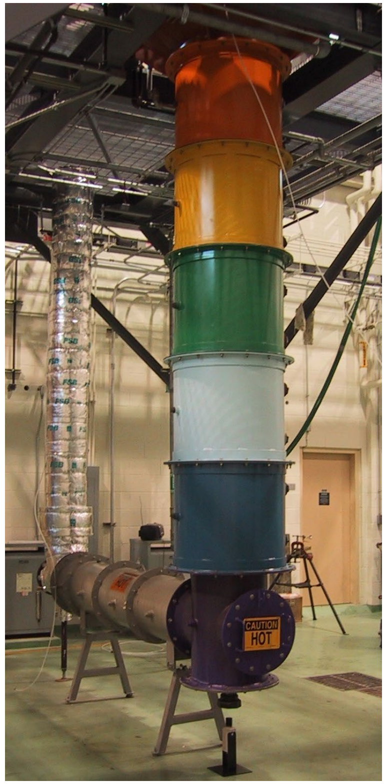
BioForceTech
commercial scale

Testing Completed!

Combustion Technologies

- Laboratory studies
  - At EPA (Rainbow furnace)
    - Indicators for Destruction Removal Efficiency (DRE) and Products of Incomplete Combustion (PICs)
    - FTIR applicability
  - At University of Dayton Research Institute
    - Temperature (T), time (t) effects
    - By-products
    - Flame radical studies
    - Spent GAC/Ion Exchange resin
- Considering field sampling efforts at facilities with different types of combustion process
  - Muncipal Waste
  - Wastewater Treatment
  - Rotary Kiln Incineration

Goals:
- Develop sampling method
  - All PFAS products
- Determine destruction efficiency
  - T, t
  - By-products
- Evaluate air pollution cleaning system effectiveness



Rainbow Furnace
RTP, NC campus

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Research Briefs

SCWO | Electrochemical Oxidation | Ball Milling | Pyrolysis & Gasification

Innovative Ways to Destroy PFAS

PER- AND POLYFLUOROALKYL SUBSTANCES

Partners

- US DOD: Strategic Environmental Research and Development Program (SERDP) & Environmental Security Technology Certification Program (ESTCP)
- ECOS/ERIS
- Colorado Department of Public Health & Environment
- Michigan Department of Environment, Great Lakes, & Energy

https://www.epa.gov/innovation/innovative-ways-destroy-pfas-challenge

- Goal: novel, alternative, non-incineration methodologies that offer a pathway to complete destruction of PFAS compounds found in unused PFAS-containing aqueous film forming foam (AFFF), a type of fire suppressant agent, while not creating hazardous by-products.
- Up to $50K for the best design concept for non-thermal technologies.

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Challenge Status

Aug	• 25th Challenge Launched
Sept	• 16th Public Webinar • Est 500 Participants
Nov	• 23rd Challenge Closed
Dec	• 18th First round judging complete • Some solvers notified of elimination
Jan	• 18th Judging Panel Selection • 25th Propose Winners to Management
Feb	• Winner Announced

Submissions by Location

As of December 15,

- 212 solvers
- 64 submissions from 18 countries
- 23 solvers met the minimum acceptable criteria

Overall Summary of PITT Accomplishments

- The PITT was a full-time team of EPA research scientists dedicated to a single goal for 6-months: To identify, develop, and verify a suite of effective approaches and technologies for destroying or disposing of PFAS-contaminated media.
- The team was successful in significantly accelerating research to evaluate "traditional" thermal treatment of PFAS waste and catalyzing research to identify and evaluate potential innovative approaches for PFAS waste treatment.
- Preliminary results in laboratory and pilot-scale treatment systems demonstrate up to 99% loss of initial PFAS compounds in contaminated waste. However, there is a need to more fully understand the potential for fluorinated byproduct formation.
- PITT scientists contributed to recently released EPA "Interim Guidance on Destroying and Disposing of Certain PFAS and PFAS-Containing Materials That Are Not Consumer Products"
  - https://www.epa.gov/pfas/interim-guidance-destroying-and-disposing-certain-pfas-and-pfas-containing-materials-are-not

Next Steps/Status

- Continuation of laboratory and pilot-scale studies on thermal incineration/combustion, supercritical water oxidation, pyrolysis/gasification, electrochemical oxidation, and mechanochemical treatment.
  - The studies include identifying potential fluorinated byproducts formed during the application of these treatment approaches.
  - Research Briefs describing ORD's research efforts on thermal and innovative treatment approaches are expected to be released in February.
- Explore opportunities for field efforts with industrial and utility facilities
  - No field activities are currently underway.
- An introductory research paper on innovative PFAS destruction technologies is expected to be submitted to a peer-reviewed scientific journal in spring 2021.
- Winners of the "Innovative Ways to Destroy PFAS" Challenge are expected to be announced in February. We are currently reviewing more than 60 potential solutions from 18 countries.
- Enlist support to develop/demonstrate/validate innovative technologies
  - Partner with DoD (e.g., SCWO demo)
  - Potential Challenge follow up

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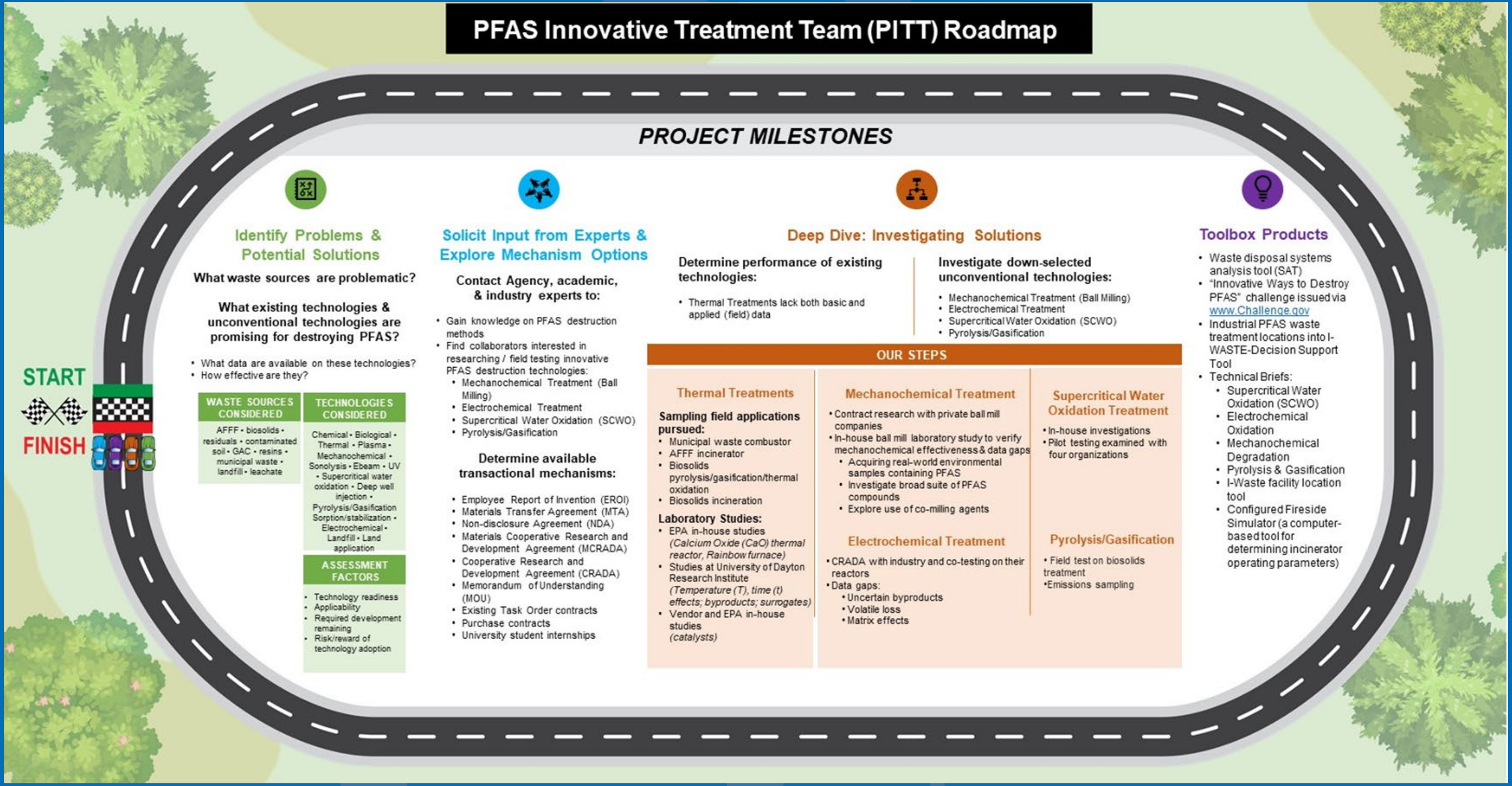

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