Upcycling plastics recovered from landfill into liquid fuels and chemicals through pyrolysis

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UK Engineering and Physical Sciences Research Council (EPSRC) (EP/N509450/1).

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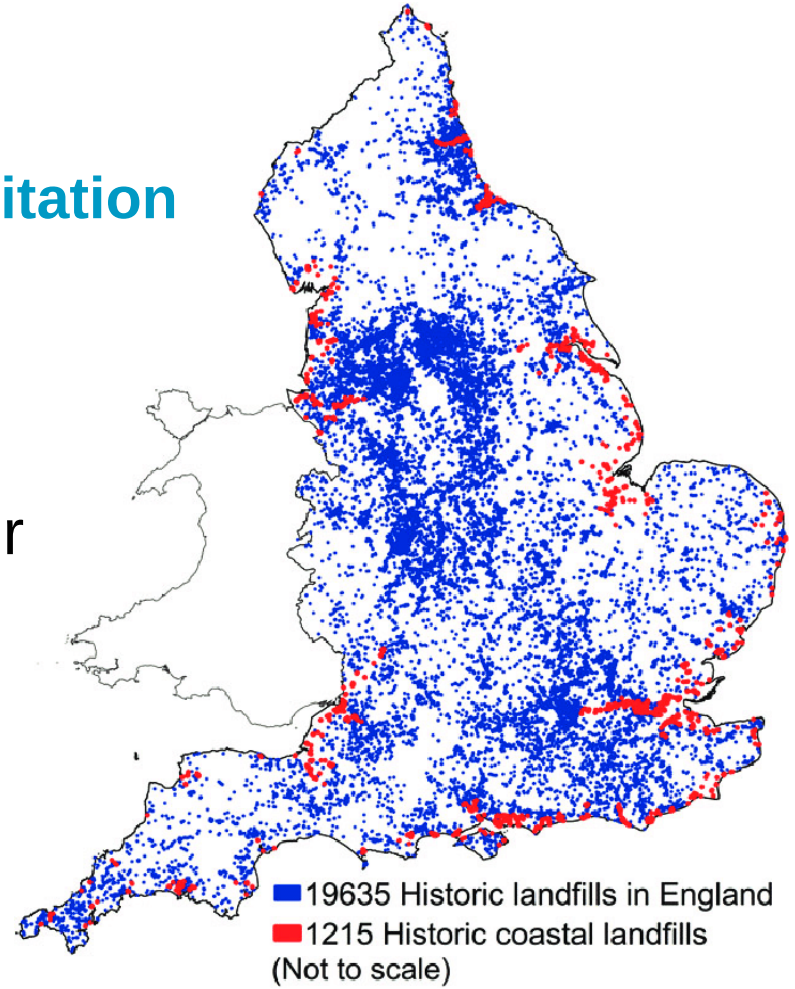
Landfills in UK

Substantial resource for future exploitation

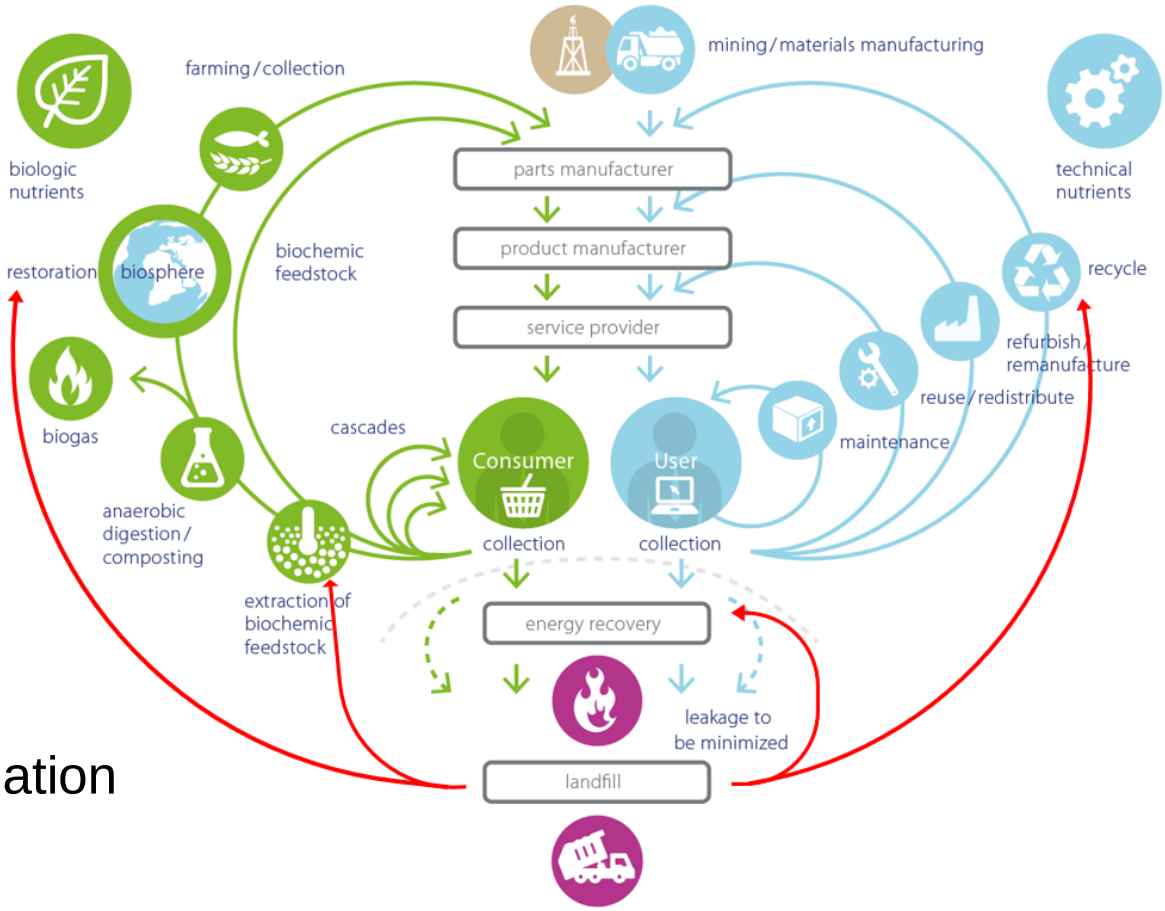
- Over 20,000 legacy and current landfills in the UK
- Licences required from 1974 under the Control of Pollution Act
- Over 4,000 licensed sites, most of which are now closed



Source- *Brand et al. 2017*
doi: 10.1002/wat2.1264

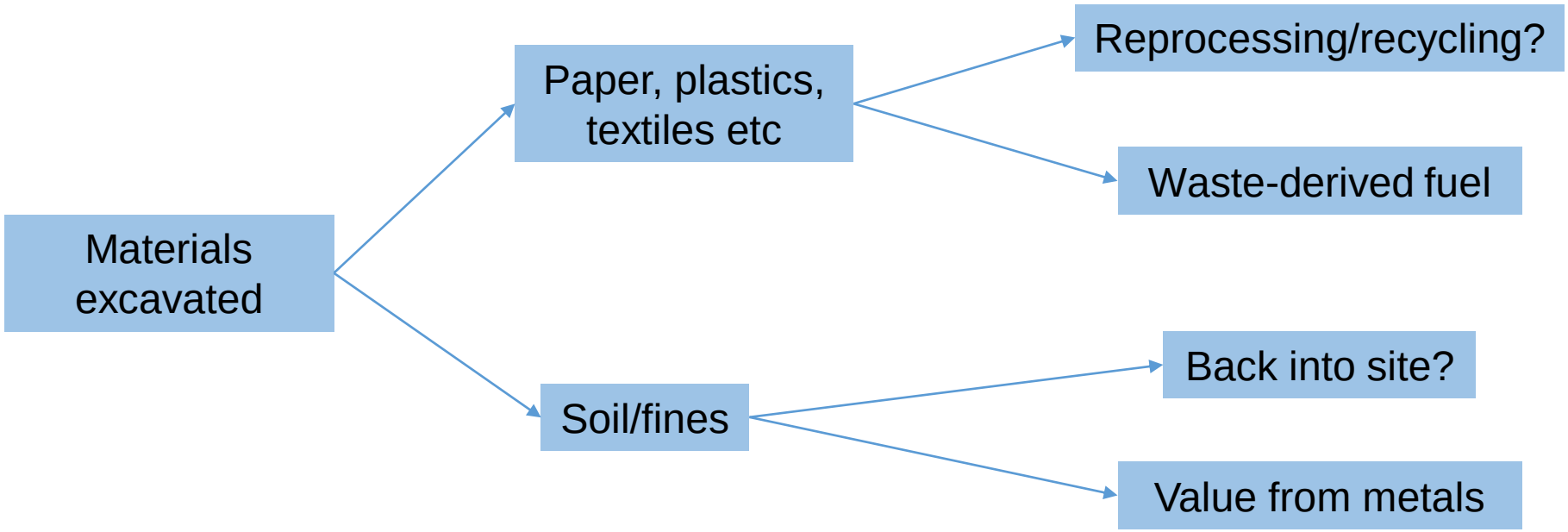
Enhanced landfill mining in the circular economy

- Waste-to-Energy
- Waste-to-Material
- Chemical feedstock
- Land restoration/reclamation



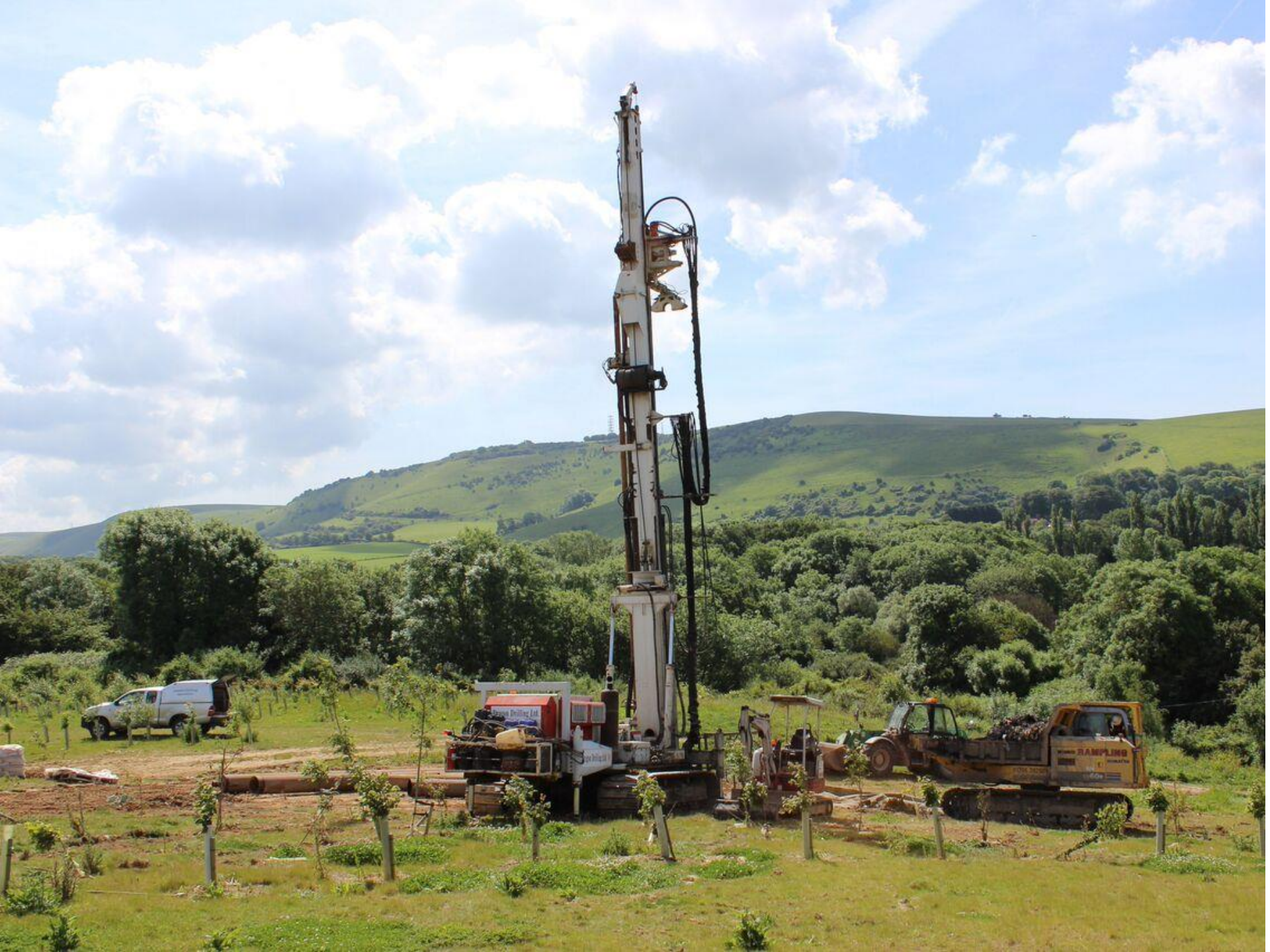
Integration of landfill mining in the circular economy
Modified from Ellen Macarthur Foundation system diagram

Resource or a fuel?

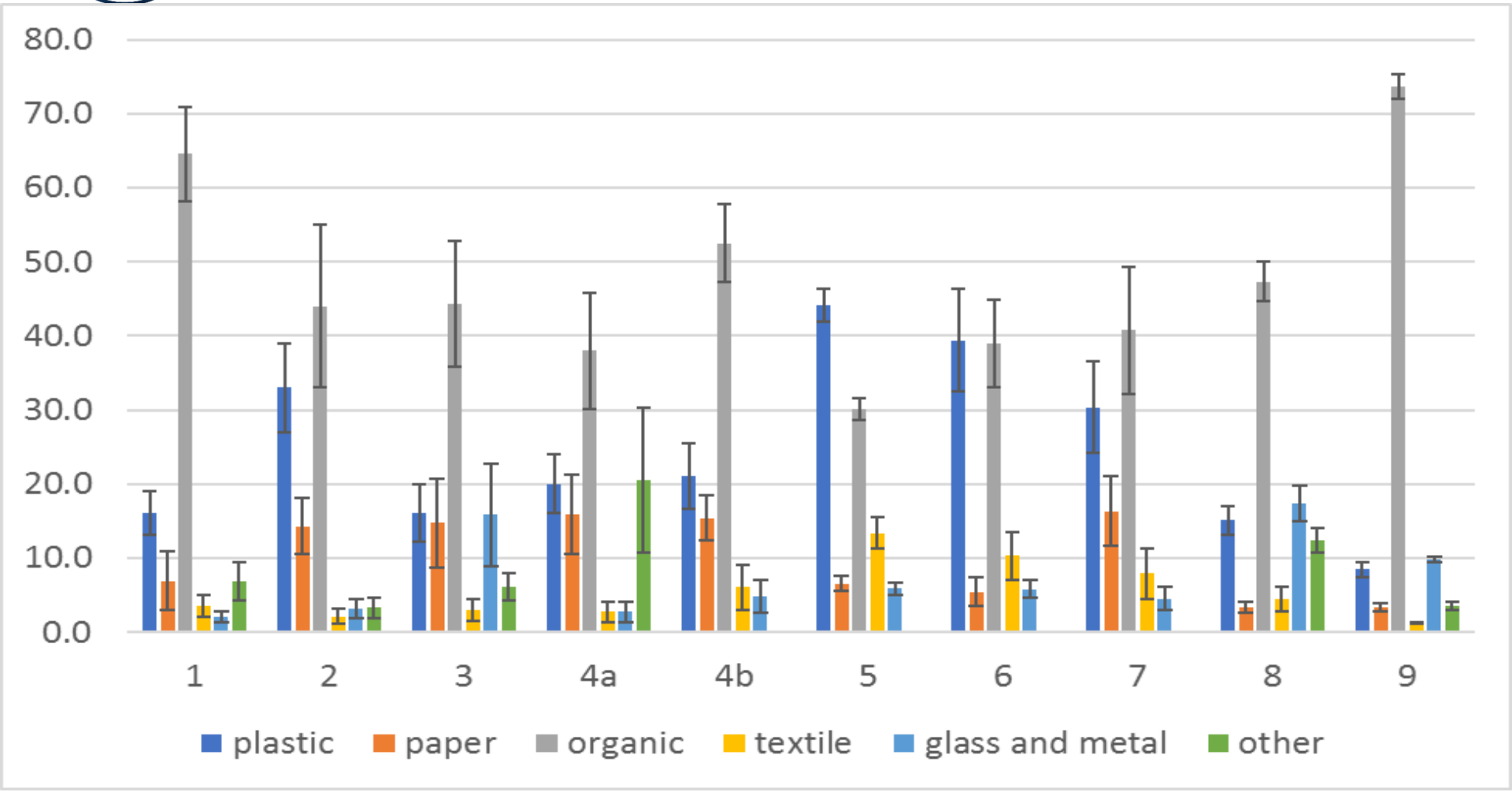


Key considerations include:

- **Significantly increased proportion of soil/fines vs fresh MSW**
- **Surface contamination and degradation of recovered commodities (impact on reprocessing and use as a fuel)**

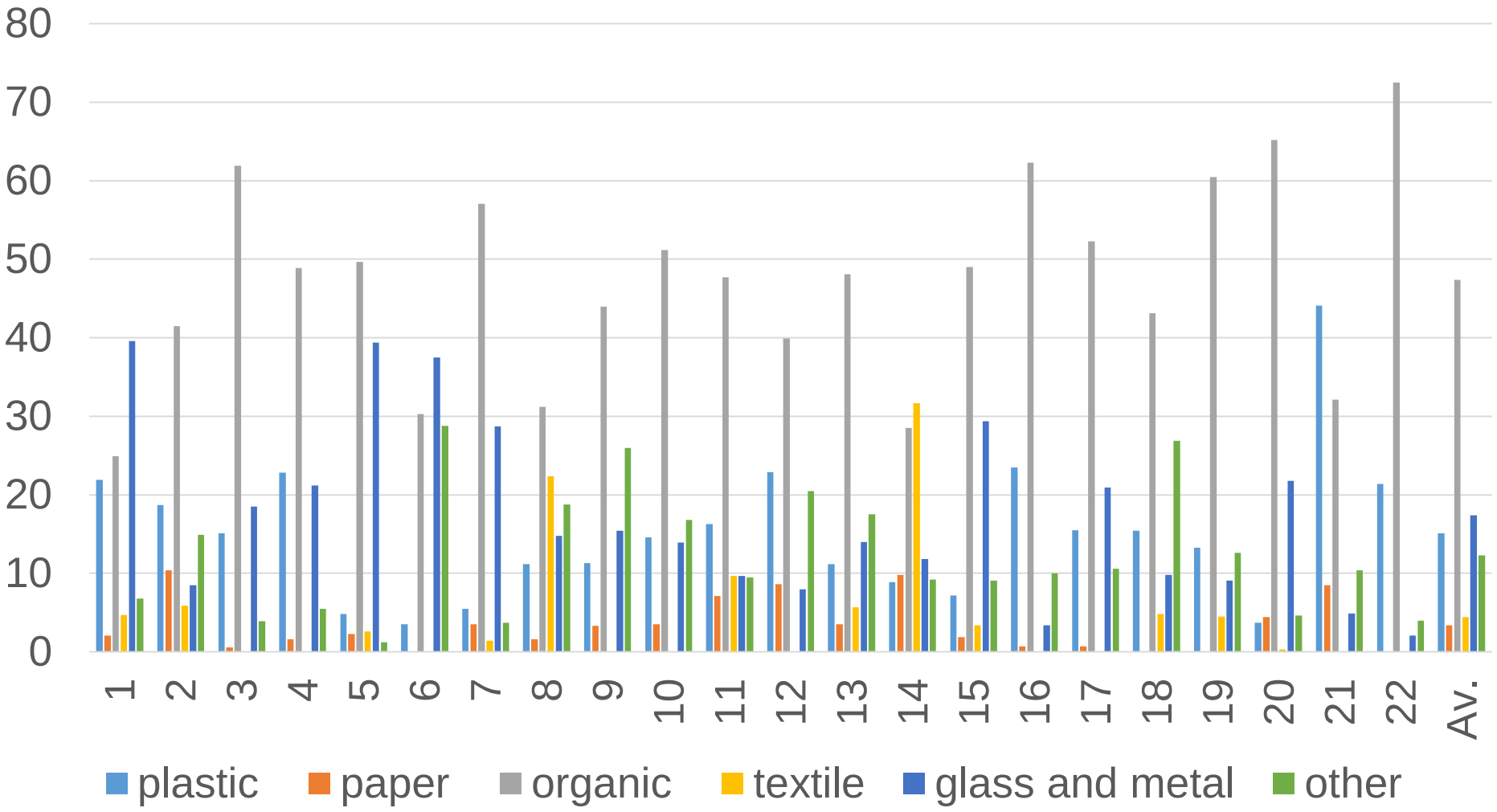

RAMPLING

Composition overview (% w/w)



Lots of data accumulated

Site 8- 1x core drill, but split into 22 samples (at 1 metre intervals)

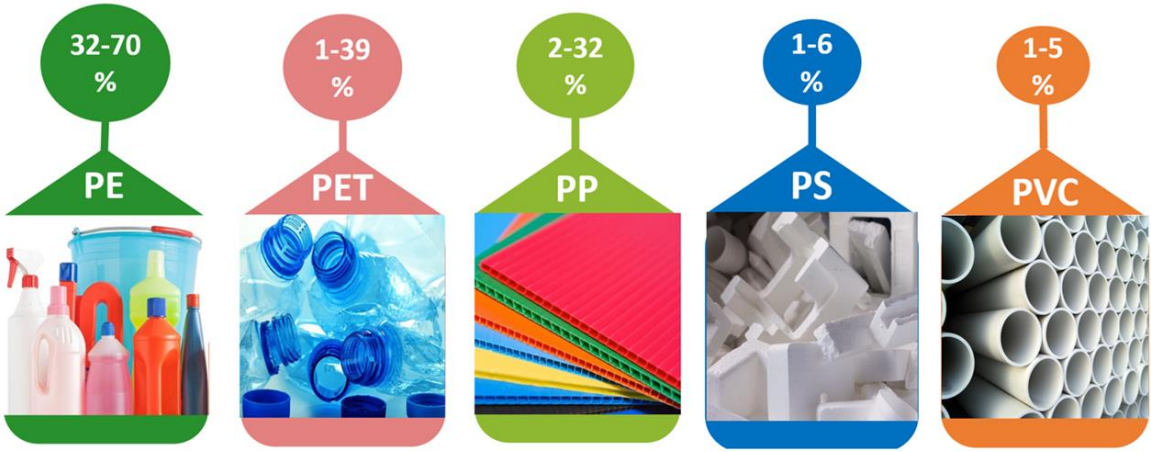


So, what can we do with the plastics?

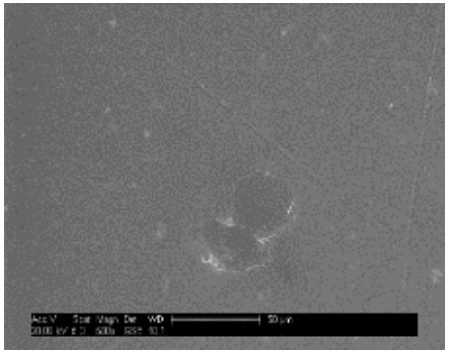
All images courtesy of Luisa Canopoli

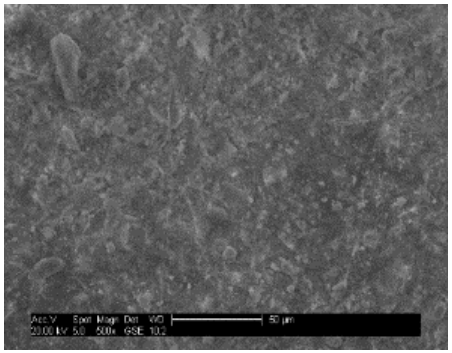
How contaminated and/or degraded are plastics?

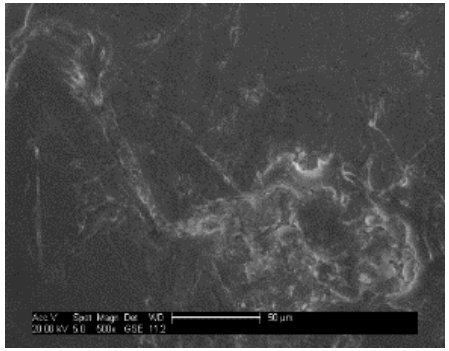
- Plastics represent around 20-30% by weight of excavated landfill material

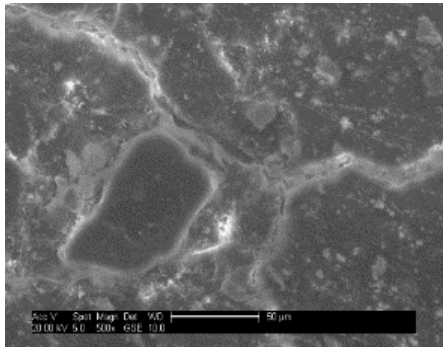


- Understanding degradation and contamination



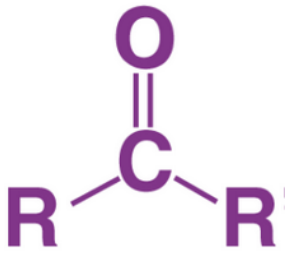






Fresh PP | 5 m | 6-8 m | 39 m

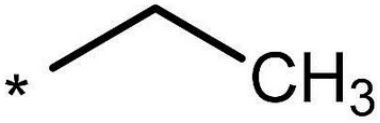
Impacts on thermochemical conversion



Changes in carbonyl index is indicative of degradation

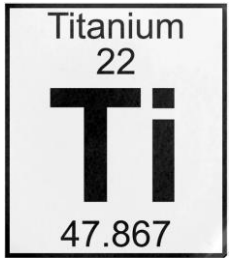
Polypropylene – carbonyl index **<u>increases</u>** from ~0.25 to ~1.75, fresh PP vs >10 year old PP

Polyethylene indicated no significant changes



Reduction in alkyl groups is also indicative of degradation

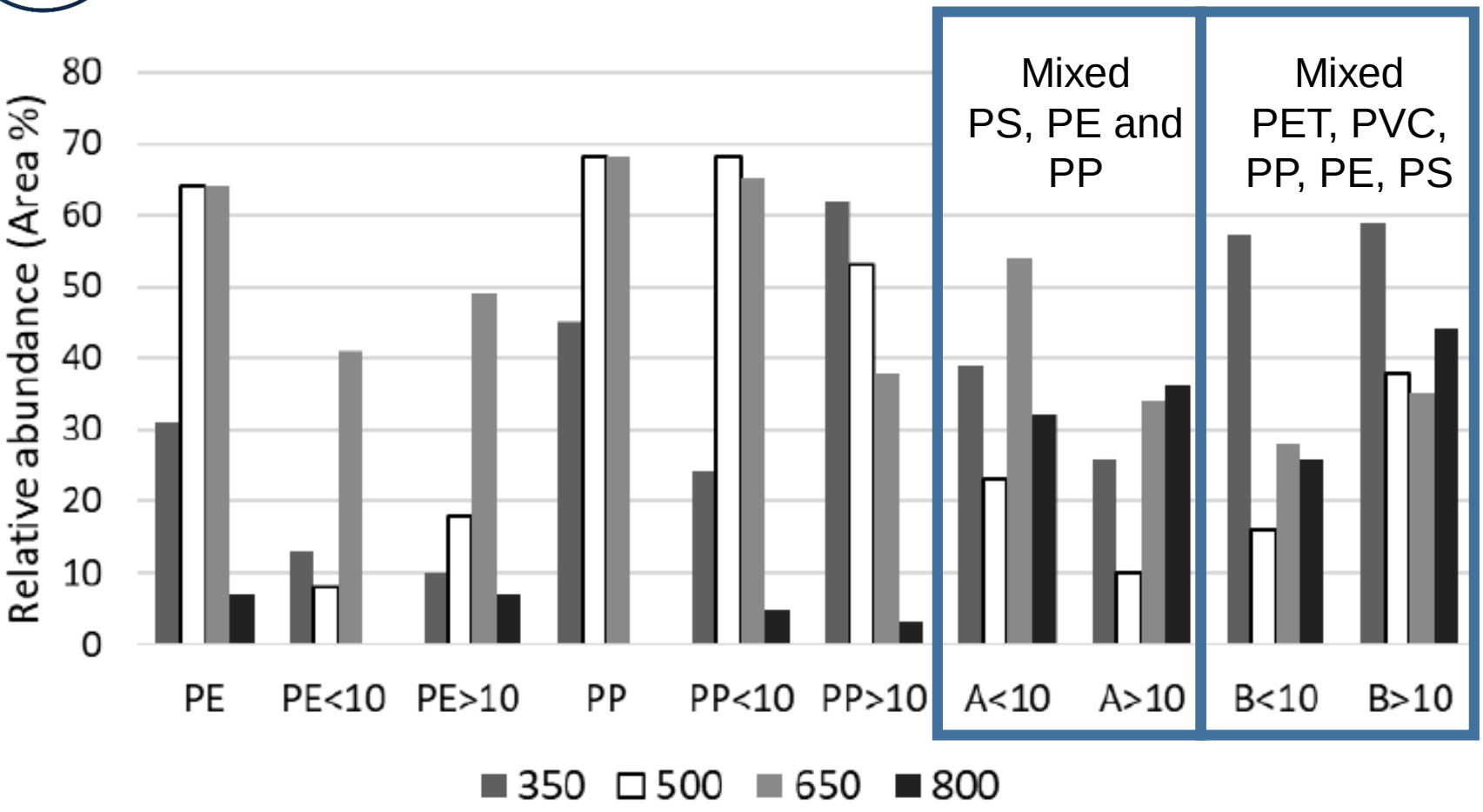
PP and PE, fresh vs >10 year old, indicated a significant reduction



Unexpected finding- Titanium content in excavated PE was lower than in fresh PE

Titanium = Zeigler-Natta catalyst in production of PE

Pyrolysis products- aliphatic hydrocarbons



Pyrolysis products (500˚C and 650˚C)

C_6-C_{10} Naptha

In all cases, generally:

Older plastics = lower yields of compounds in this range

C_{10}-C_{16} Kerosene

As above, but less significant. Most notable reduction in yield from PP

C_{14} + Diesel, waxes, bitumen etc

No significant impacts on yields

Summary

- High volumes of soil/fines to manage, potential value exists here
- Direct recycling of plastics fraction might not be economically or practically viable due to contamination and degradation;
- Advanced Thermal Treatment [ATT], specifically pyrolysis, presents a viable alternative for plastics- energy plus liquid fuels and chemicals
- A successful ELFM project will maximise the resource values from all components

Contact

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