NERC SCIENCE OF THE ENVIRONMENT

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Potential consequences of waste release from historic landfills

Kate Spencer

James Brand, Francis O'Shea

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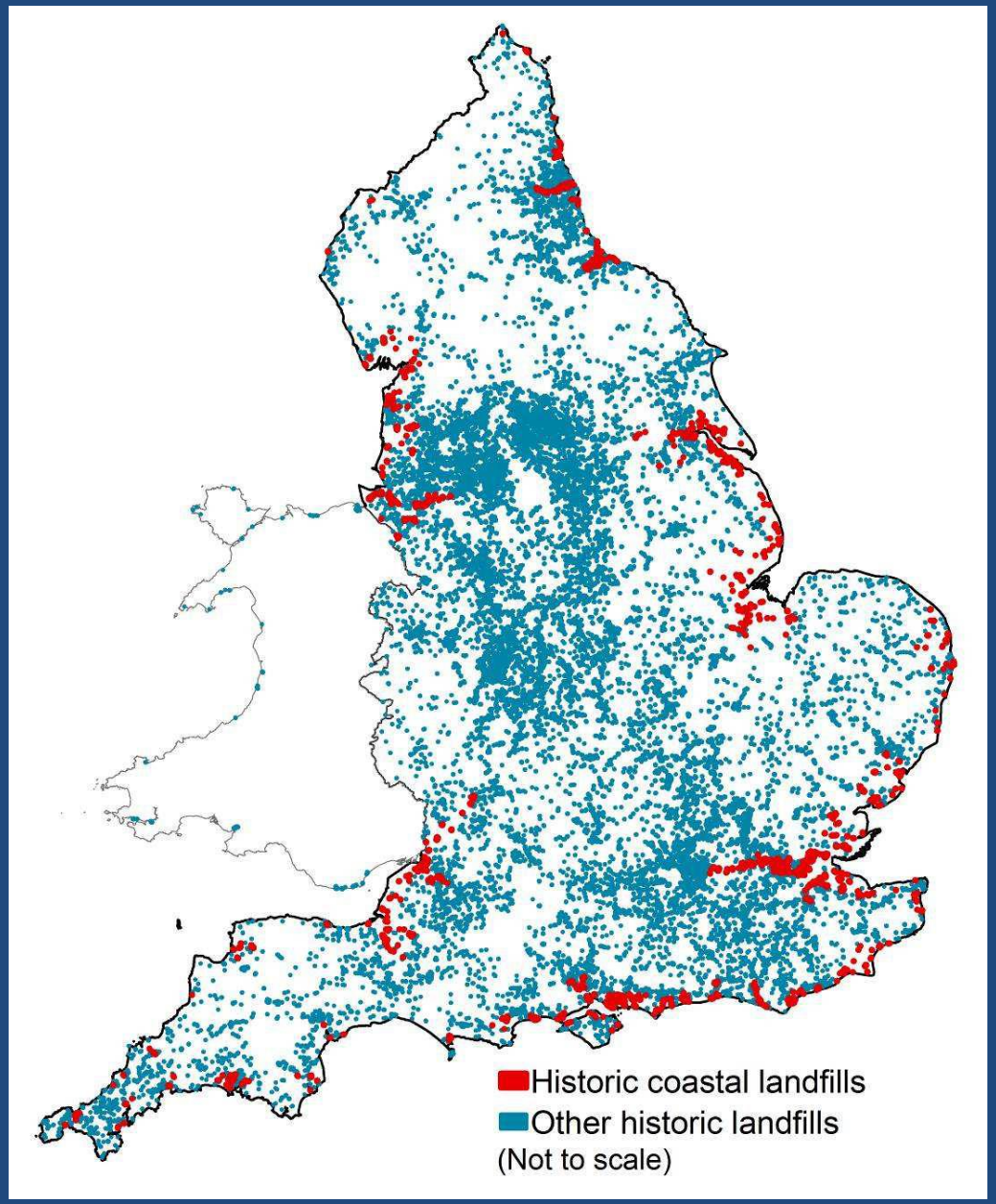
Eroded early 20th century landfill waste covers the beach at East Tilbury in Essex

Queen Mary University of London

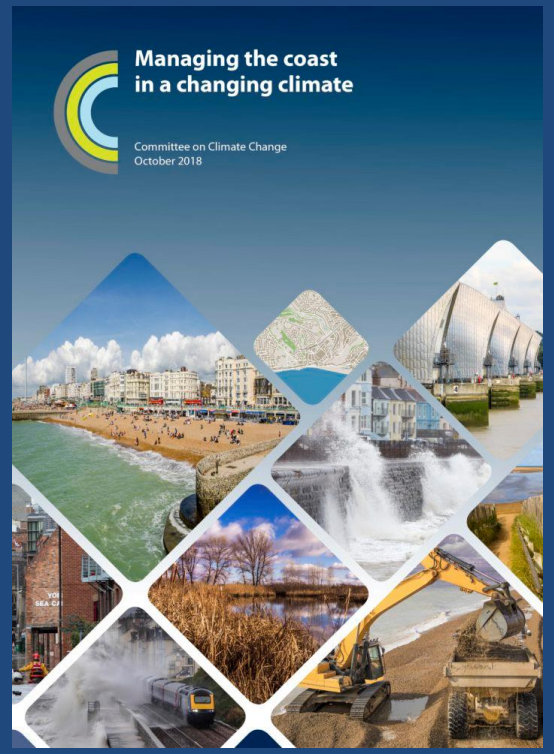
What is meant by ‘historic landfill’?

- Constructed prior to modern environmental regulation – e.g. lining, methane collection, leachate management, requirement to keep records and restrictions of type/quantity of waste.
- In Europe – EU Landfill Directive 2001 (requirements for pollution control, abatement and monitoring).
- In UK – Waste Regulations 1994 – requirements for record-keeping; Landfill Regulations 2002 – translation of the EU directive into UK law.



Historic Landfill, England

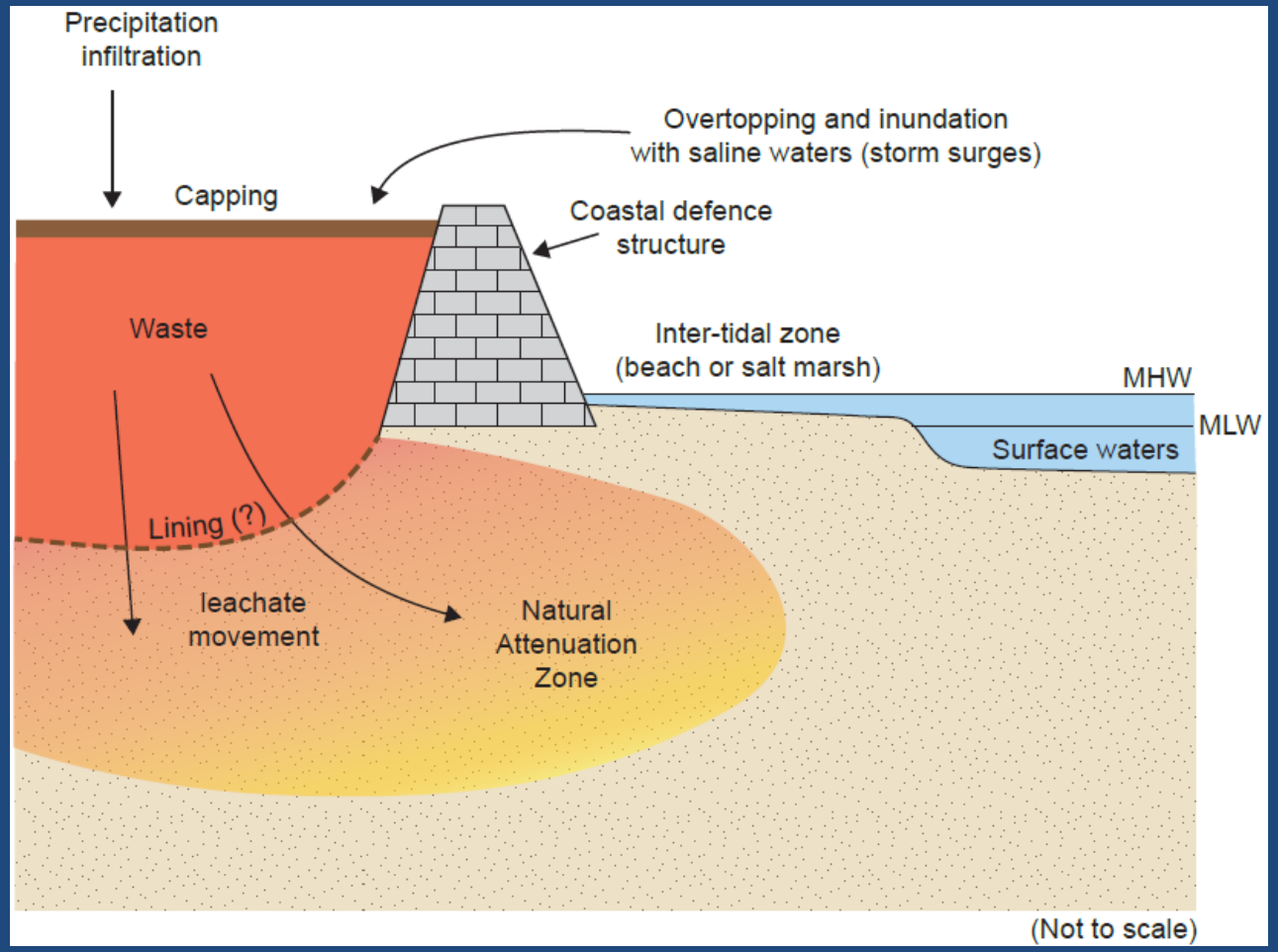
- C. 20,000 historic landfill.
- > 1200 in tidal flood zones (1 in 200 year) or eroding coasts.
- 1 in 10 at risk of erosion by 2050 (Brand et al. 2017).
- Europe c. 0.5 million HLs, 10,000 sites at risk of coastal/fluvial flooding.
- SLR, erosion, storm surges and coastal flooding presented significant threats to urban infrastructure including landfills (CCC, 2018)

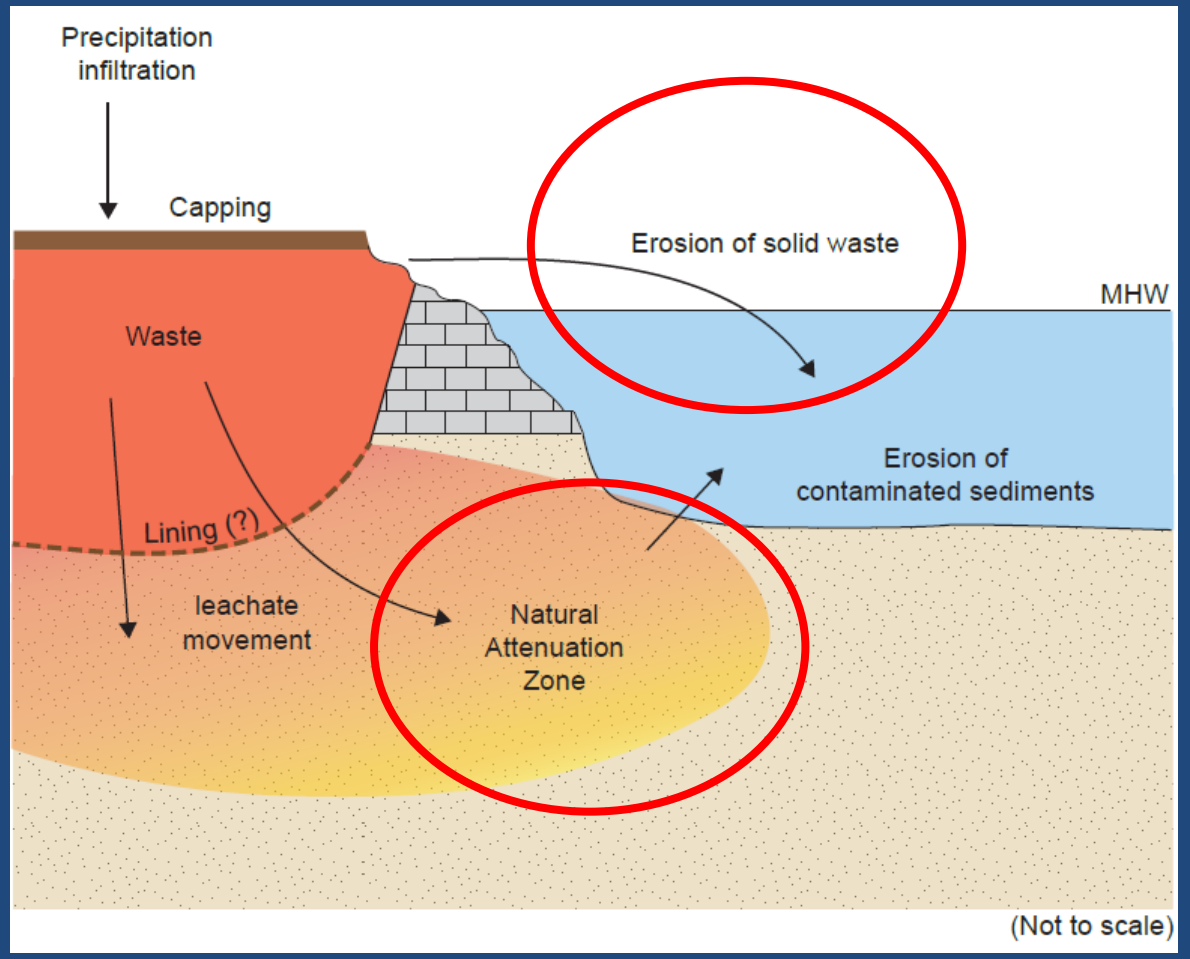


Fox Glacier Landfill, New Zealand

Fox Glacier Landfill closed in 2000.
March 2019 floods – 63 km coastline, 1000 ha floodplain
Clean up $1 million NZ

Potential scenarios for release of soluble leachates and solid waste





Brand et al., 2017. Potential pollution risks of historic landfills on low-lying coasts and estuaries. WIREs Water, e1264.

What is the potential for contaminant release and adverse effects on ecological health, surface waters and/or human health?

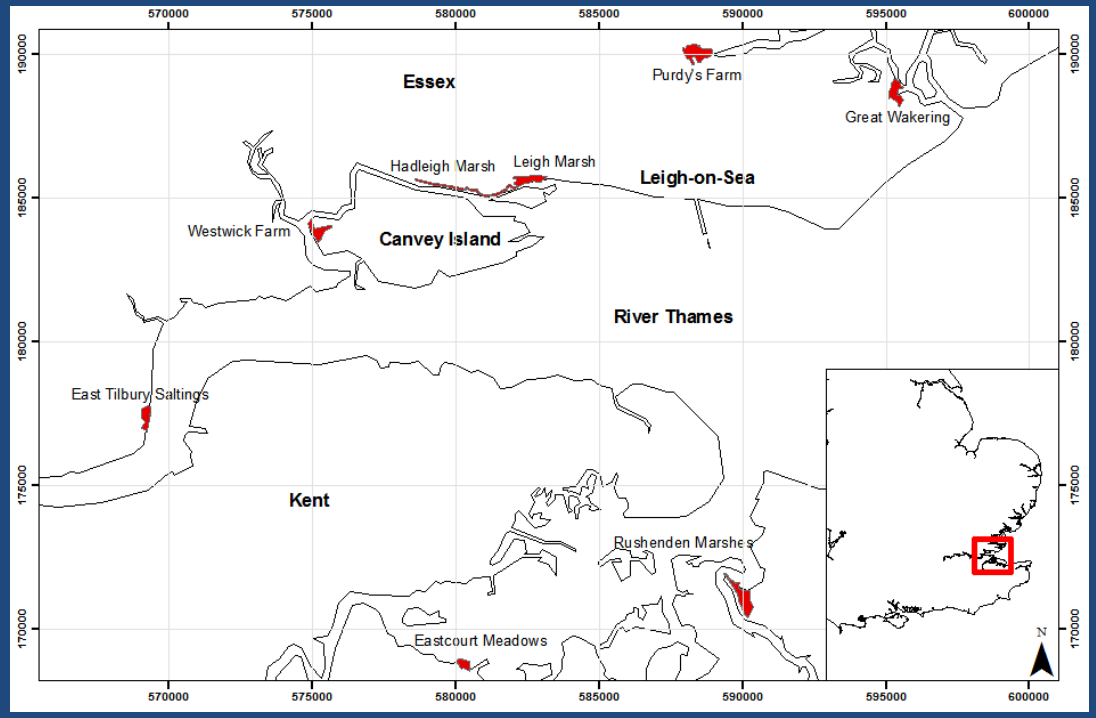
Potential scenarios:

- Sediments contaminated through historic leachate (‘attenuation zone’) are exposed to the coastal environment.
- Landfill is inundated, but waste is contained: Water percolates through waste → metal contaminants leach into surface waters
- Solid waste material erodes and is released → Contaminants leach directly into surface waters, or solid waste enters the coastal and marine environment

Diffuse pollution from historic leachate plumes

- Sampled sediment from surface and depth in saltmarshes adjacent to nine historic landfills in the greater Thames Estuary, Essex and Kent coast.
- Identified a ‘halo’ of contamination at depth at every site.
- Moderate contamination levels which present an ongoing and <u>future</u> source of diffuse pollution – erosional coastlines.
- Moderate contaminant loads – 100s to 1000s kg Cu, Pb and Zn for each site – what is the impact on a regional or national scale?
- How does this vary under different geological and hydrological conditions?
- Over what timescales is this a threat?

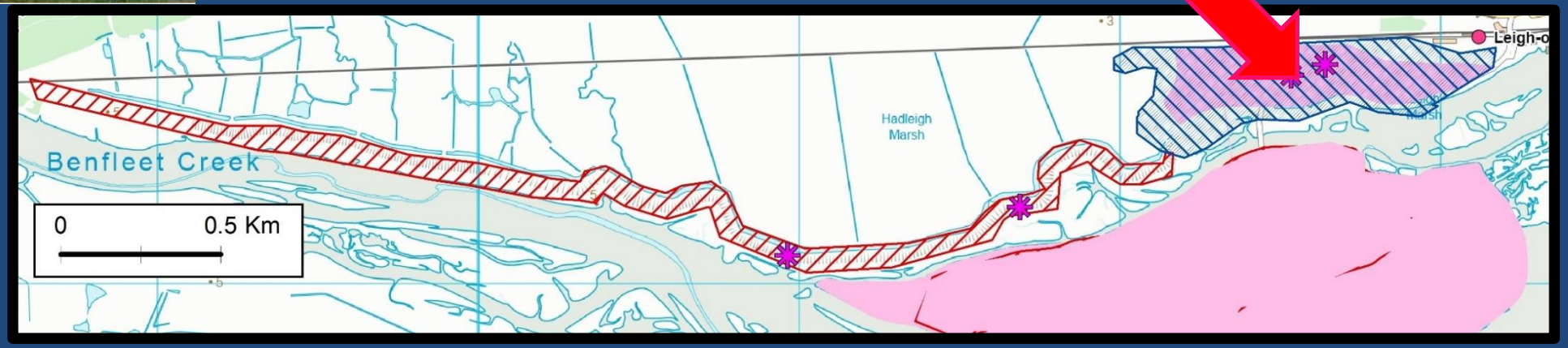
(O’Shea et al. 2018)



Historic landfill sites – Essex and Kent

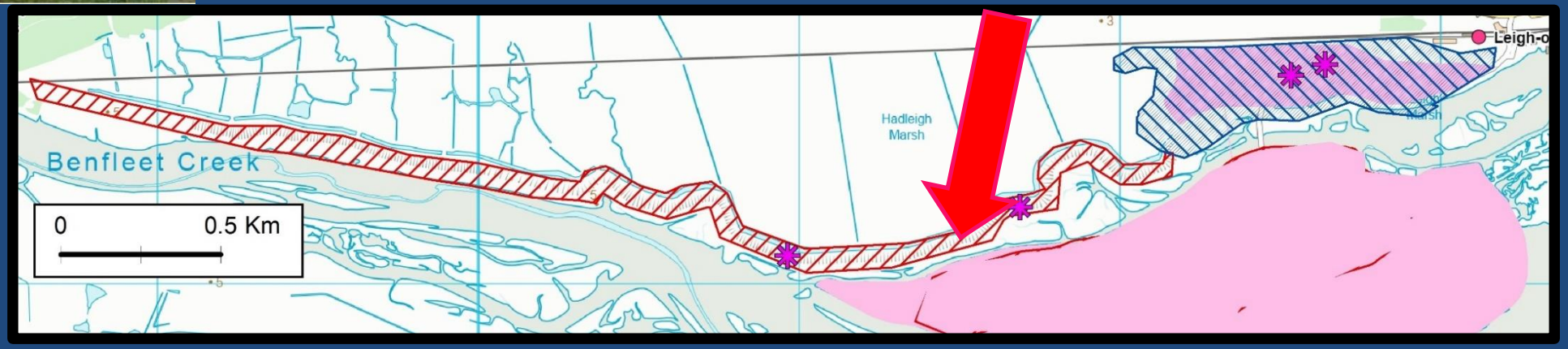
Potential contaminant release through inundation and erosion

Leigh Marshes: household, commercial and industrial waste protected by embankment
'Old site': 1955 to 1967



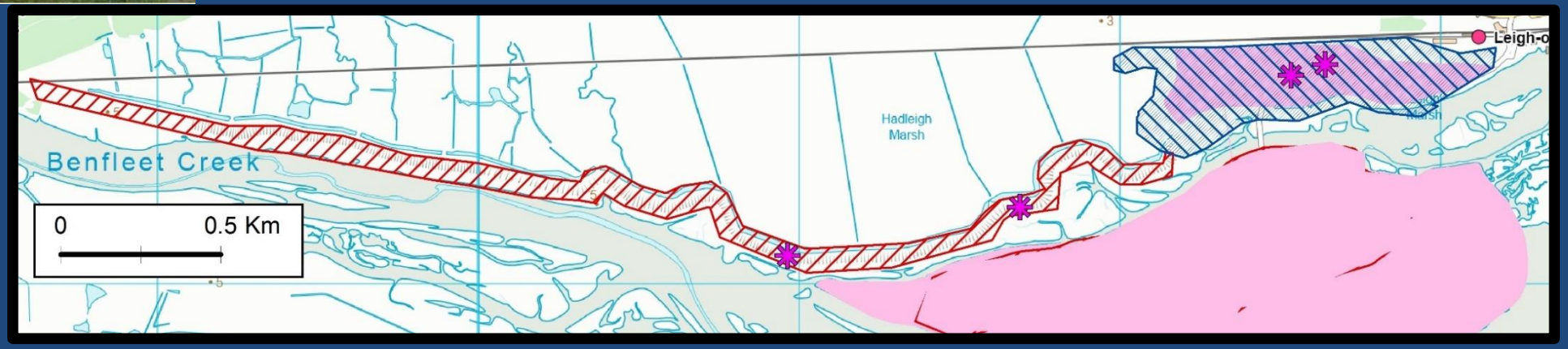
Potential contaminant release through inundation and erosion

Hadleigh Marsh: household and commercial waste filled embankment ‘New site’: 1980-87.

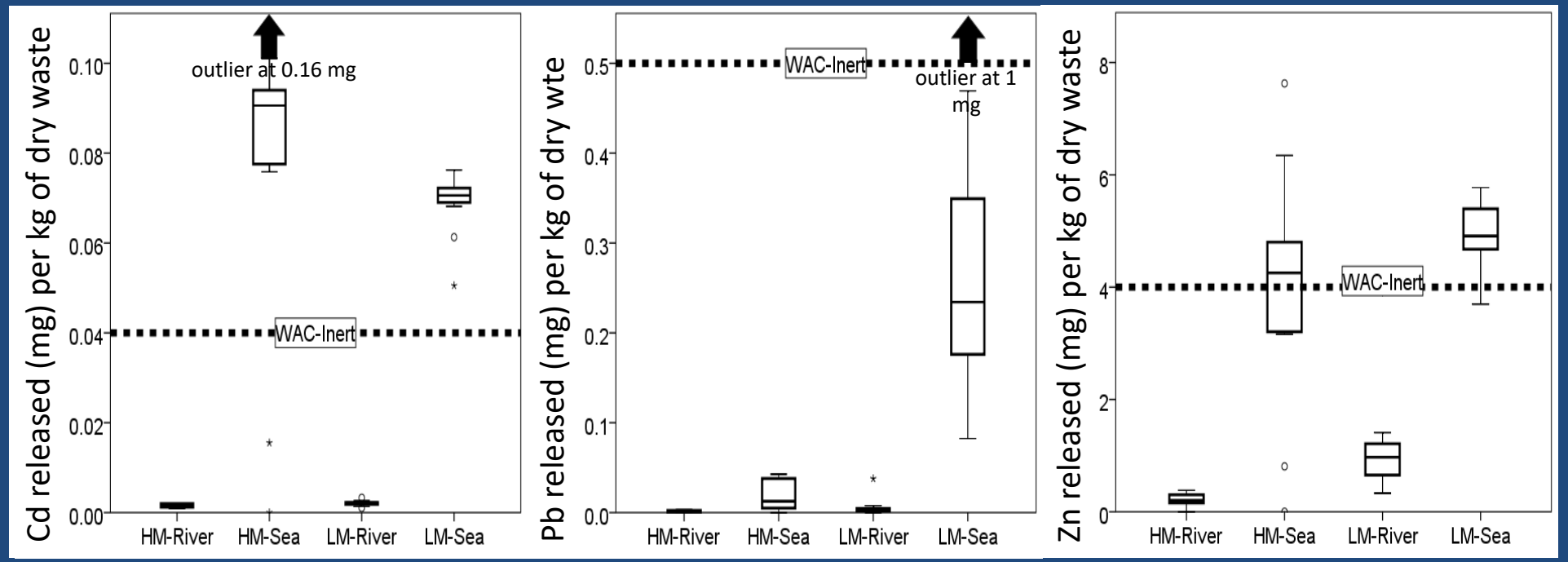


Potential contaminant release through inundation and erosion

How do we collect representative samples without damaging the integrity of the defence?



Metals leached from solid waste



- Considered the release of contaminants through either inundation of contained waste or erosion of solid waste to surface water through leach tests.
- Seawater increases mobilisation of most metals - Cd & Zn to above WAC inert limits – could not be landfilled under current regulation.
- Proportion leached is highly variable but c. < 1% leached, except cadmium in seawater up to ~5%
- Brand and Spencer (in press)

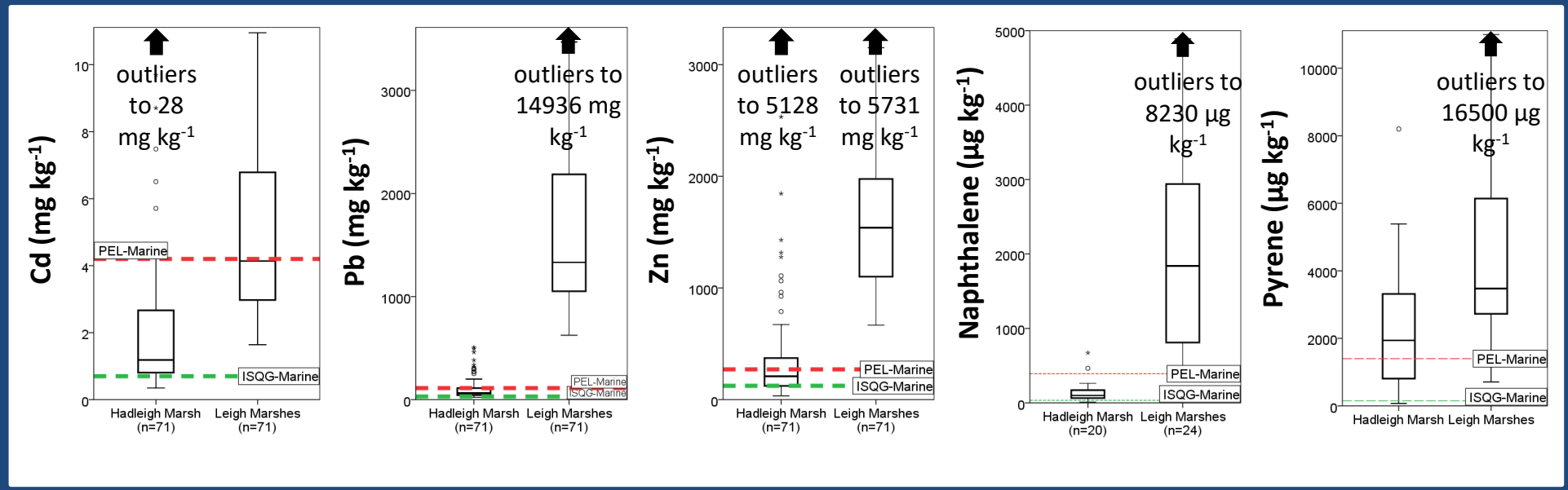
How do we assess this risk?

- All protocols for assessing soluble contaminant release from landfill waste assume contact with freshwaters – are we using the right protocols to assess soluble contaminant release?
- What is the impact on mobility and availability for other pollutants e.g. POPs?
- How do we assess the impact of contaminant release from other solid waste?
- Low risk of adverse ecological effects from leached metals from both landfills assuming dilution in the Thames Estuary - but other biological pathways may exist, e.g. pore waters

Zn – Cd battery, foreshore E. Tilbury, Thames Estuary.

Sediment pollution from eroded solid waste: matrix

- Metal and PAH concentrations are highly heterogeneous
- Concentrations exceed sediment quality guidelines and CEFAS action levels for the disposal of dredged material.
- Significant ecotoxicological harm if the solid waste is released to adjacent saline wetlands and unlikely that a dredge license would be issued.



Brand and Spencer 2019

How do we assess this risk?

- How do we deal with high heterogeneity – risk based approach that focusses more on the presence of waste, likelihood of erosion and sensitivity of receptors? (Brand and Spencer 2018).
- Are there adequate tools to assess and model landfill failure – what are the physical and engineering characteristics of waste in aquatic settings?
- Leigh marsh landfill – if the whole site failed there could be a significant load released.

	Cd	Cr	Cu	Pb	Zn	PAHs
Estimated total metals (kg) - whole site	1,130	17,440	164,840	362,915	419,585	9,310
Annual metal inputs to the estuary from all known other sources (kg)[14]			25,820		128,425	
Landfill failure could increase annual input			6.4x		3.3x	

How do we assess this risk?

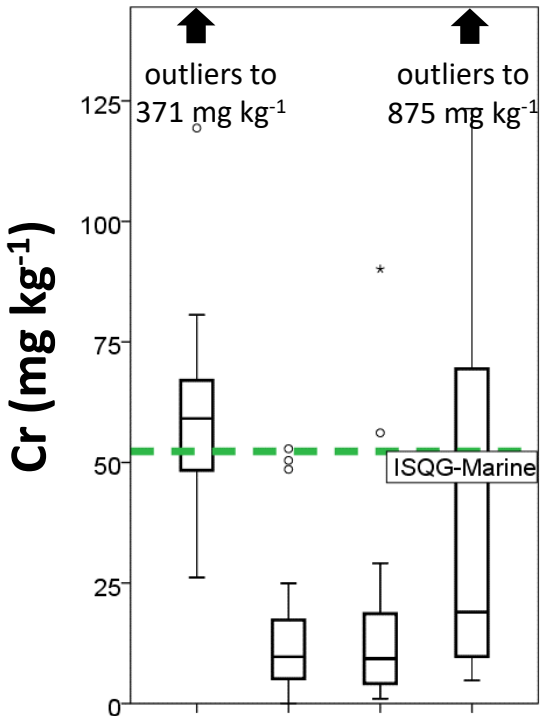
- We’re assuming the solid waste has similar physical and chemical characteristics to natural minerogenic sediment – focus on waste matrix.
- Are the physical and biological uptake pathways the same?

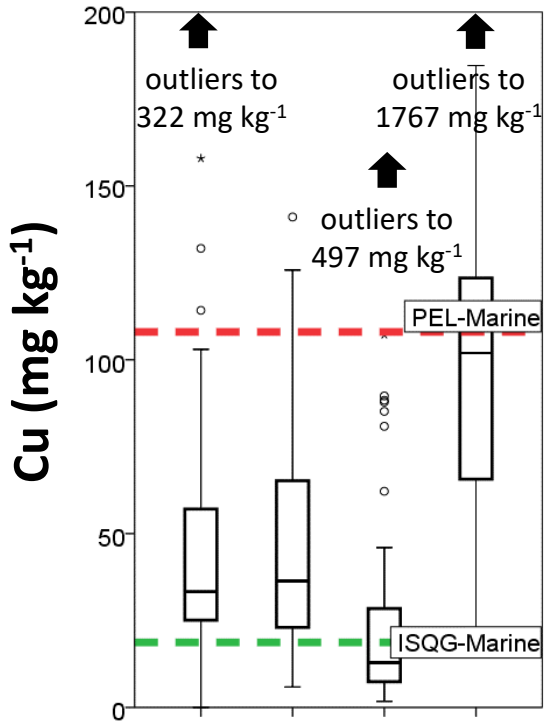
How do we assess this risk?

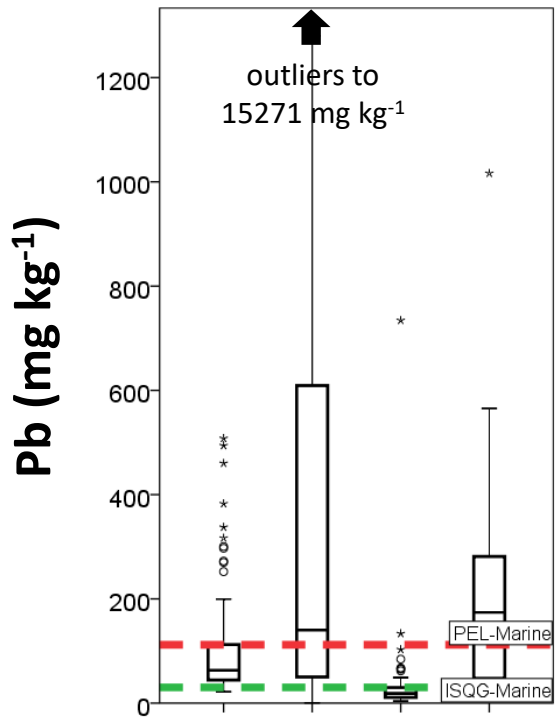
- Solid waste is highly heterogeneous in terms of size, composition, morphology, surface chemistry, hydrophobicity, surface charge…..
- Very little understanding of how this material behaves in aquatic environments – entrainment, transport and deposition.
- What are the biological uptake rates and pathways for e.g. asbestos fibres or microplastics?

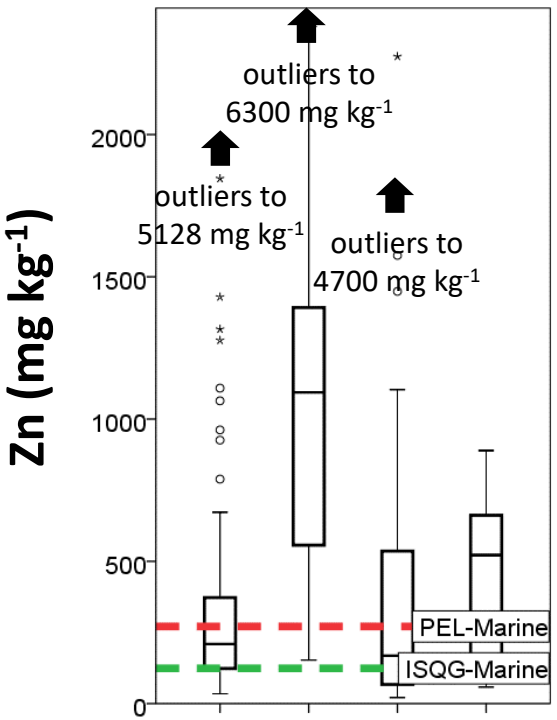
Sediment pollution - eroded wood, paper & textiles

- Paper & textiles may significantly contribute to total metal load – sorbent?
- What are the biological pathways for the uptake of these materials?
- What is their ultimate fate?
- Brand and Spencer 2019

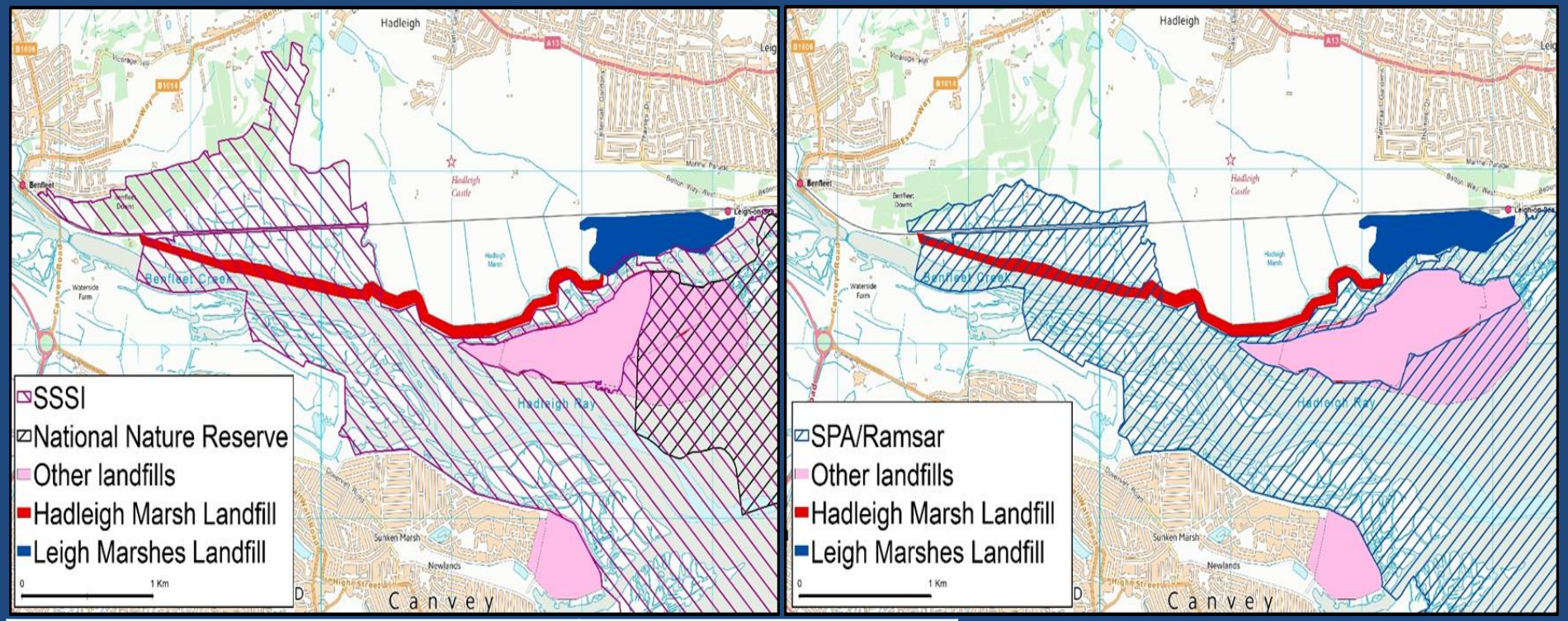








Impacts – Sensitivity of receptors



Across England and Wales	No. near/on coastal landfills
SSSI	192
Bathing Catchments	122
Shell fisheries	137
SPA	39
Ramsar	36

Large number of ecologically sensitive areas are in close proximity (100 m) to these landfill sites. (Brand et al. 2017)