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Challenges and Advances in Site Remediation

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Managing Risks

- Water management
- Land management
- Environmental matrices
  - Air
  - Water
  - Soil
  - Sediment

Water Management

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- Integrated watershed management approach for
  - Water quality improvement
  - Climate change adaptation with built-in resilience
  - Aging water infrastructure (including green infrastructure and storm water management)
  - And more…

Land Management

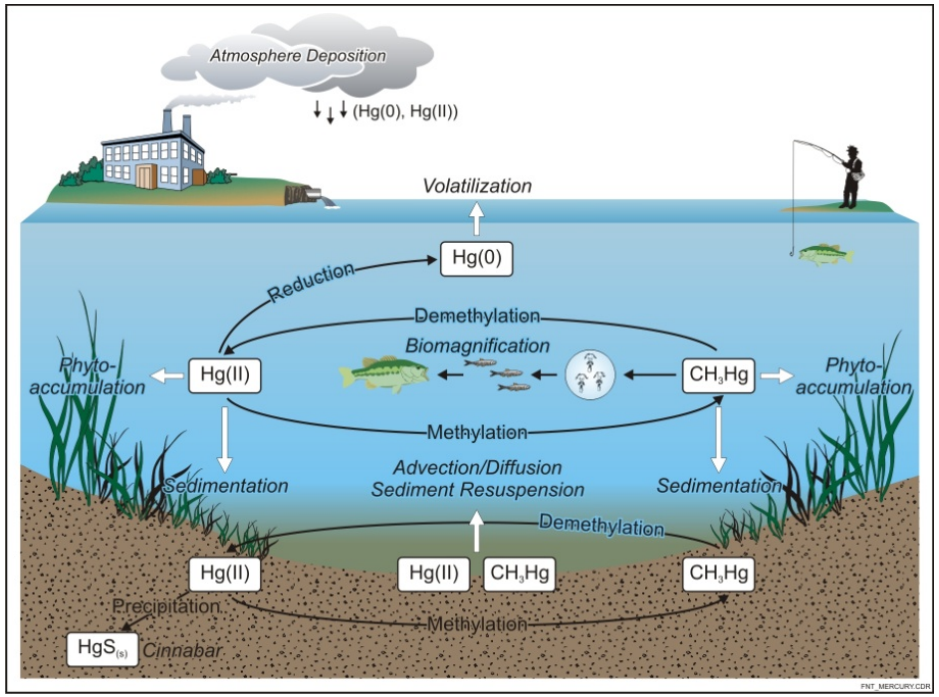
- Contaminated sediment management
- Soil and groundwater decontamination/restoration

Contaminated Sediment Management

- Dredged material disposal and treatment
- Site characterization and source ID
- Monitored natural recovery
- Capping
- Innovative capping
- Dredge residuals

Mercury Methylation

- Bench scale experiments designed to provide better understanding of factors (SRBs, sulfate, nutrients) that promote/limit methyl mercury production
- Strategic evaluation of cost effective capping materials designed to sequester Hg and inhibit methylation
- Materials include commercially available clay-based Hg-sorbents and site-specific clay-rich soils; and readily available and local material.



Soil/Groundwater Remediation

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- CERCLA Singed in 1980 and amended in 1986
  - PA/SI
  - RI/FS
  - PP/ROD
  - RD/RA
  - LTM/RAO
  - 5-year review
  - Site closure

LNAPL/Petroleum Hydrocarbons

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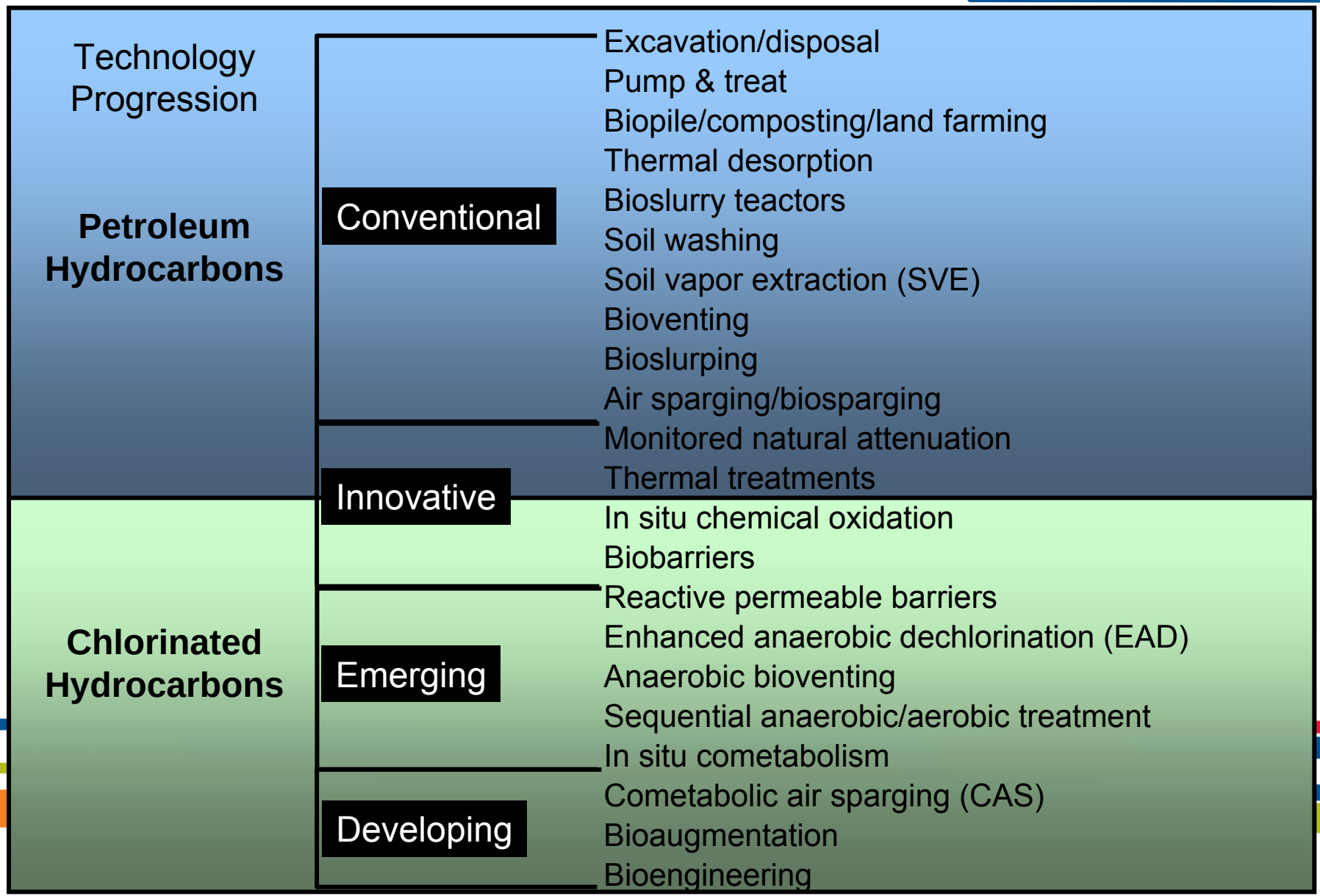
- Sources: Refineries, distribution terminals, pipelines, storage tanks, service stations, etc.
- LNAPLs: Gasoline, diesel, jet fuels, heating oils, waste oils, weathered fuels, etc.
- Contaminated Soil
  - TPH
  - Vapor (BETX, VOCs)
- Contaminated Groundwater
  - LNAPLs
  - Oil/grease, $TPH_{g,\ d}$
  - Dissolved phase
    - BETX, VOCs,
    - MTBE

DNAPL/CVOCs

- Heavier than water
- Hard to locate DNAPL pools and residuals
- Fractured bedrock
- Low solubility/high volatility
- Extensive CVOC plumes in vadose and saturated zones
- Varying lateral and vertical extent of contamination
- Costly to delineate source zones and plumes
- Costly to remediate
- Need innovative in situ solutions but must overcome simple physics

Technology Evolution



Fundamental Challenges

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- All in situ technologies must deliver/distribute agents to where contaminants are
- But subsurface is extremely complex and heterogeneous

Finding/Treating DNAPL

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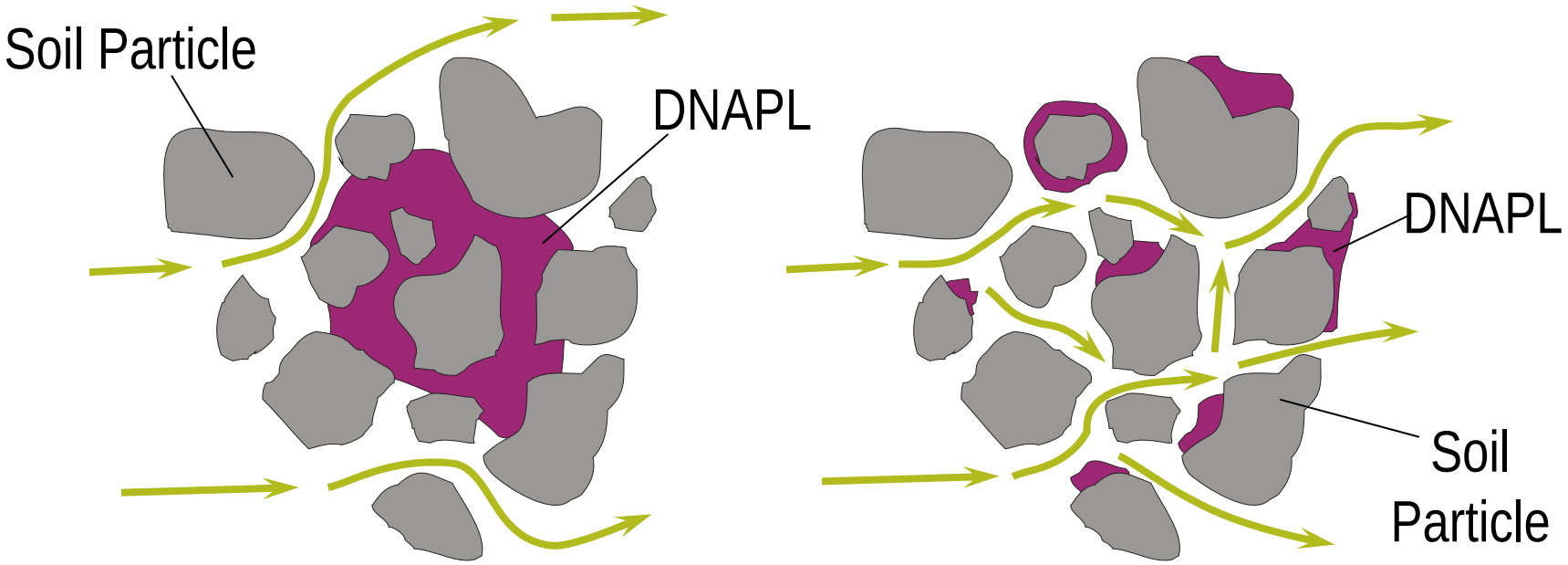
DNAPLs completely filling in pores

DNAPLs coating soil particles



Challenges (DNAPL/CVOCs)

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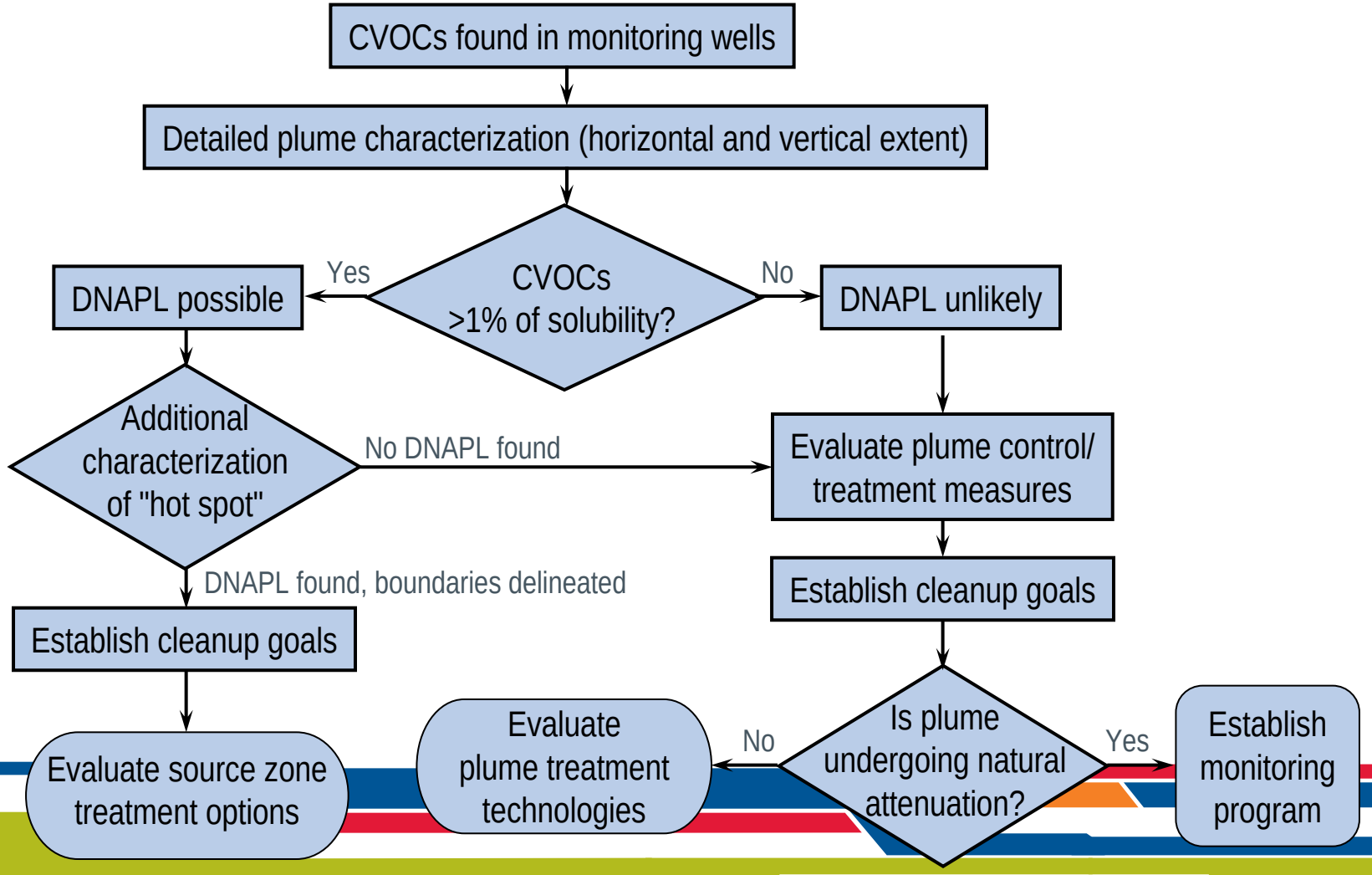
- Regulatory framework
- Technical impractability (TI)
- Monitored natural attenuation (NA)
- Human health risk assessment
- Site characterization
- Source removal vs. plume control
- technology screening/selection

Evaluation/Remediation Steps



DNAPL and CVOC Remediation

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- Source zone (DNAPL pools and residuals) when location is known
- Plume control/treatment when location is not known or pools are hard to retrieve
- Plume control
- Plume treatment
- Combined approach

DNAPL Source Zone Technologies

- Thermal
  - Steam injection/extraction
  - Resistive heating/RF heating/SPH
  - Hot water flooding
- Physical/Chemical
  - $KMnO_4$/fenton's reagent/persulfate
  - Surfactant flushing
  - Cosolvent (e.g., alcohol) flushing
- Containment
- Excavation

Plume Control/Treatment

- Permeable/Reactive barrier with ZVI
- Nano-ZVI particles
- In situ air sparging/SVE (IAS/SVE)
- Bioremediation
  - Cometabolic
  - Bioaugmentation
  - HRC
- Intrinsic bioremediation (NA)
- Pump-and-treat
  - Plume containment at edges
  - Isolating the source
  - Plume remediation

Contaminants to Watch

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- Perchlorate
- MTBE
- 1,4-dioxane
- Nitrate
- Endocrine disruptor compounds (EDCs)
- Fluoride
- Metals (As, Cr[VI])
- Radionuclides (U, Ra 226/228, gross α, β emitters)

2010 Monterey Conference

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- Characterization, monitoring, and risk Assessment
- Site management and closure
- Green and sustainable remediation
- Chemical oxidation/reduction technologies
- In situ delivery approaches
- Thermal/physical/chemical treatment/barrier technologies
- Biological technologies
- Sediment/vapor intrusion