Use of In-Pile Thermal Desorption to Treat Persistent Organic Pollutants in Dredged Sediment

Presented by
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Outline

- Background on thermal treatment and in-situ thermal desorption (ISTD)
- Treatment mechanisms
- Treating Persistent Organic Pollutants
- Application to dredged materials
- Recent technology advancements

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Background on Thermal Treatment

Shell E&P

- Late 1980s: Invented ISTD
- 1997-99: TerraTherm Environmental Services Inc (TESI) completed 5 commercial ISTD projects
- 1999: Exited remediation business and donated IP to Univ. of Texas at Austin

TerraTherm, Inc.

- 2000: Secured US license from UT
- 2002: Secured worldwide license from Shell Oil Co.

Early ISTD: Shell-TerraTherm First Full-Scale Projects

Over $40M has been invested in basic research and development of this technology.

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In-Situ Thermal Desorption - ISTD

- Involves the combination of heat and vacuum
- Applied to the subsurface with an array of heater and extraction wells
- Electrically powered thermal conduction heaters allows for uniform subsurface heating
- Vapors are captured and treated in traditional treatment systems
- Can be applied to a wide range of contaminants
- No excavation required

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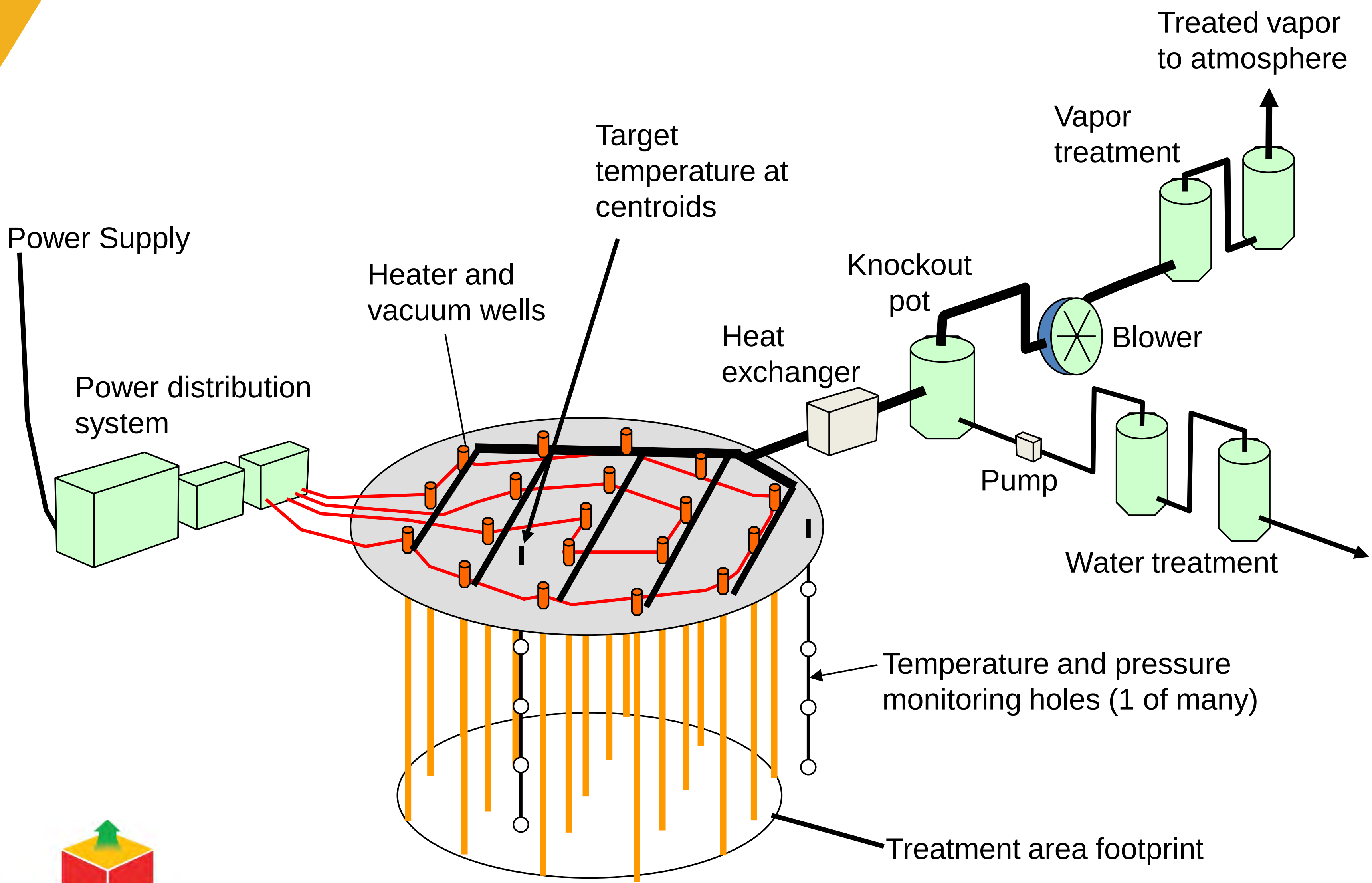
In-Situ Thermal Desorption - ISTD



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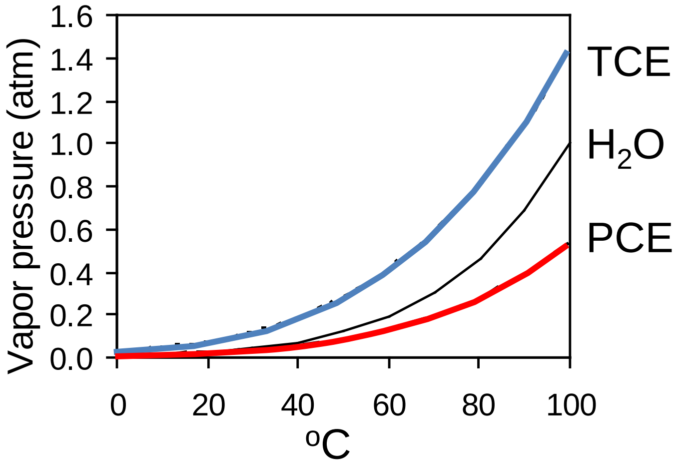
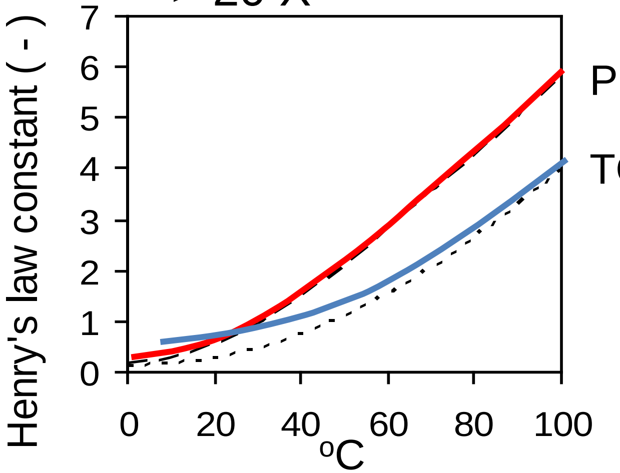
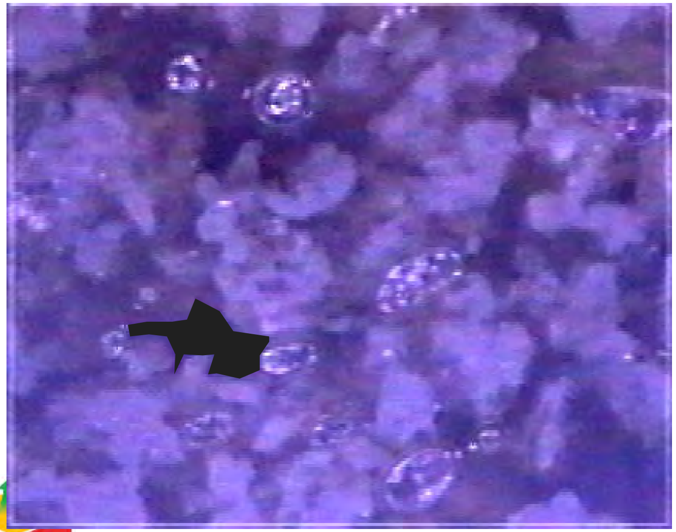
Mechanisms – for VOCs

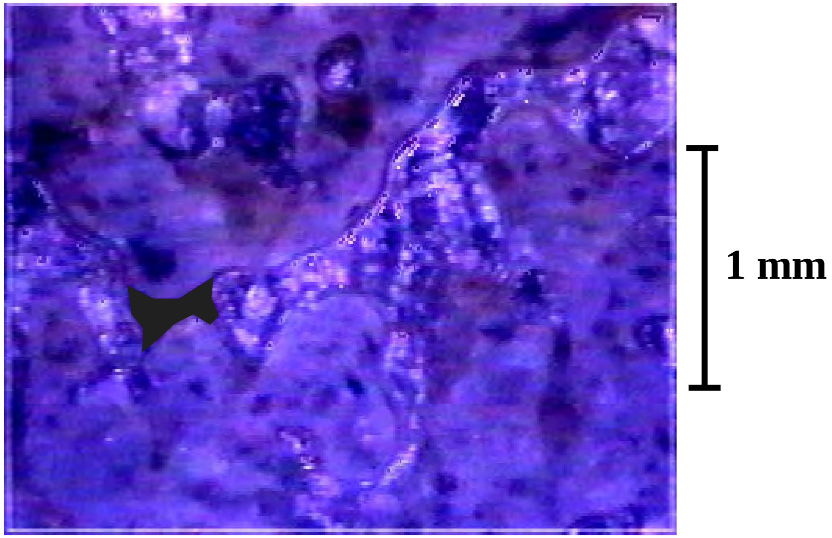
Vapor Pressure Increase > 40X



Solubility Increase > 20 X







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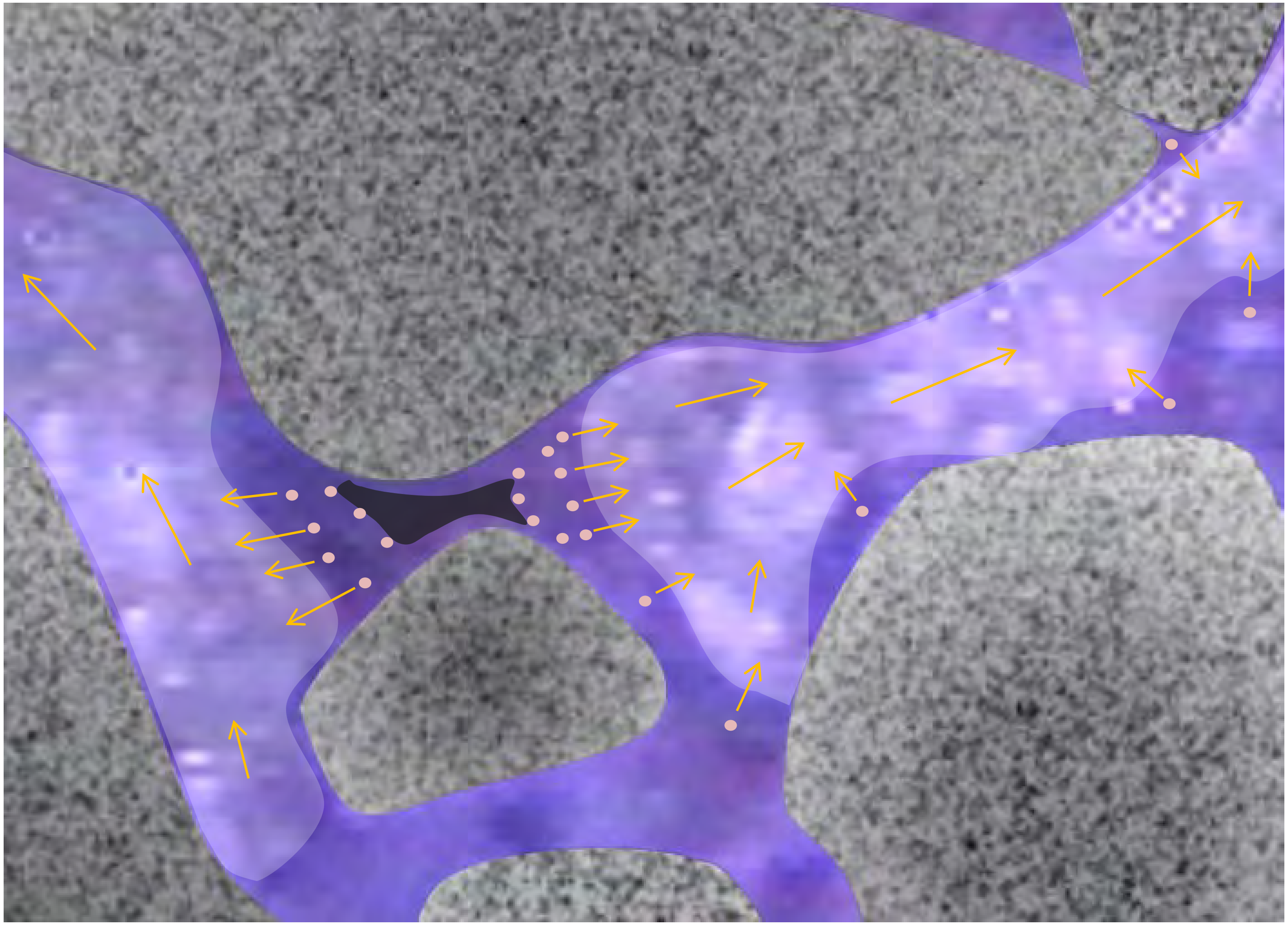

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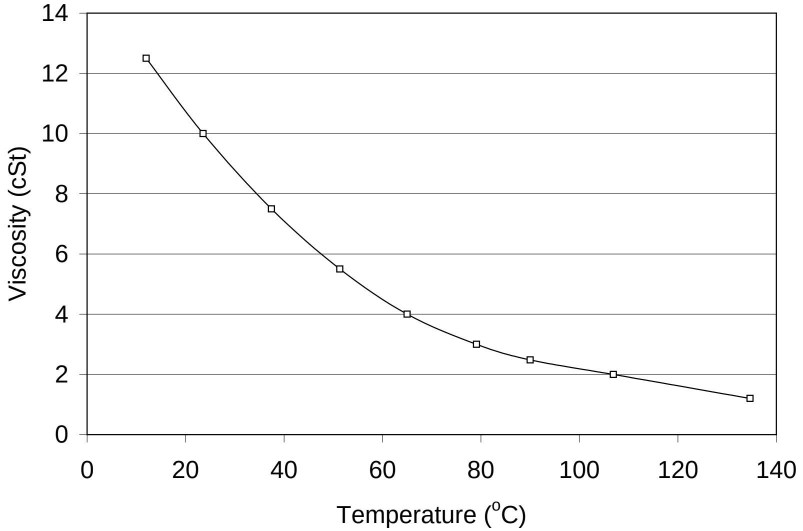
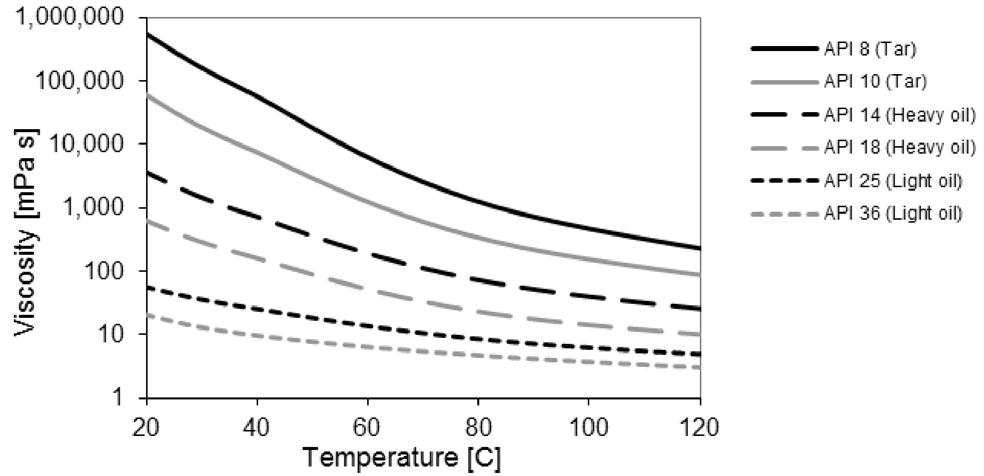
Oils - Viscosity Reduction

No. 5 fuel oil





Reduction up to 100+ times.

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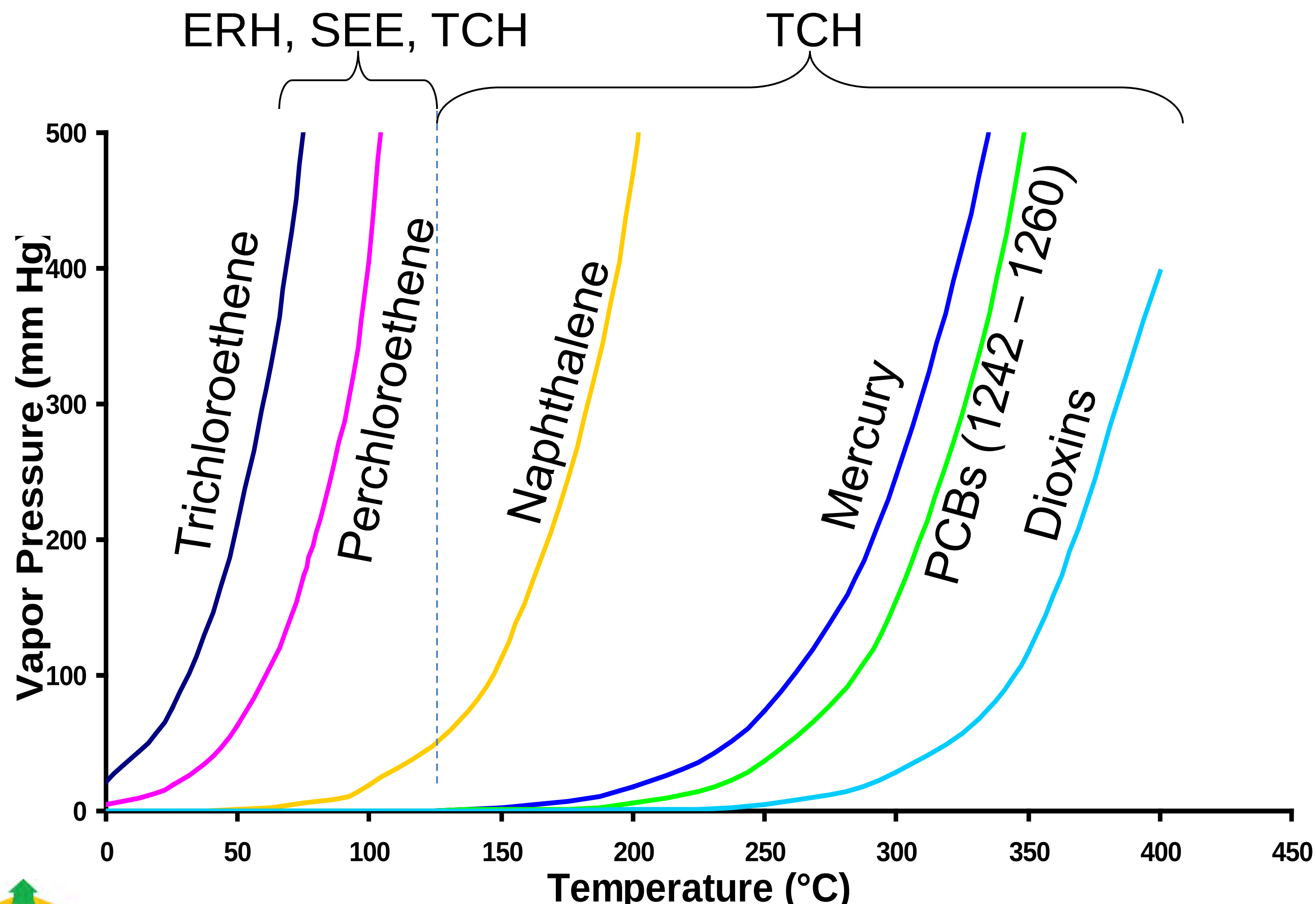
Vapor Pressure vs. Temperature



Vapor pressures increase exponentially with temperature

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Treating Persistent Organic Pollutants

- Typically target 200º – 335º C
- Selection of the target temperature is based on contaminants being treated
- Not necessary to achieve the boiling point of the contaminant being treated to accomplish desorption
- Greater than 95% of the contaminant mass is destroyed in-situ, as the contaminated vapors pass through superheated soil
- Vapors are further treated through air pollution control equipment

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Treatment of Furan and Dioxin – Soil Concentrations

Site	Type	Target Media	Average Pre-Treatment Concentration (ng-TEQ/kg)	Average Post-Treatment Concentration (ng-TEQ/kg)	Mass Removal
Yamaguchi, Japan	IPTD®	Soil/Sediment	1,800	67.75	96.24%
Alhambra, CA USA	ISTD	Soil	18,000	110	99.39%
Cape Girardeau, MO USA	ISTD	Soil	6,500	3.2	99.95%
Ferndale, CA USA	ISTD	Soil	3,200	7.3	99.77%

Ng-TED/kg - Nanograms of Dioxin equivalent per kg

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Treatment of PCBs – Soil Concentrations

Location	Year	Major Contaminant	Type(s) of Soil, Water Table	Mean/Maximum Pretreatment Concentration (mg/kg)	Remedial Goal (mg/kg)	Mean Post-treatment Concentration (mg/kg)	Mass Removal
Cape Girardeau, MO USA	1997	PCB (Aroclor 1260)	silty clay; water table at 12 m (40 ft) depth	Max: 19,900 Mean: 649	2	< 0.033	>99.99%
Vallejo, CA USA	1997	PCB (Arochlors 1254/1260)	silt/clay; water table at ~ 6 m (20 ft) depth	Max: 2,200 Mean: 53.5	2	< 0.033	>99.94%
Saipan, NMI	1998	PCB (Arcolors 1254/1260)	silty sands and crushed coral vadose zone	Max: 10,000 Mean: 500	10	< 10	>98.00%
Ferndale, CA USA	1998	PCB (Arcolors 1254/1260)	silty and clayey colluvium	Max: 860 Mean: 302	1	< 0.17	>99.94%
Alhambra, CA USA	2006	PAHs, PCP and PCDD/PCDF	Silty sand; vadose zone	PAHs [B(a)P-Eq]: Mean: 30.6	PAHs [B(a)P-Eq]: 0.065	PAHs [B(a)P-Eq]: 0.059	99.81%

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Application to Contaminated Sediments

- Contaminated sediments options
  - Natural Attenuation
  - In-situ Stabilization
  - Capping with sand or active amendments
  - Dredge & Landfill or CAD
  - Dredge & Incinerator
  - **Dredge, Thermal Desorption and Beneficial Reuse**

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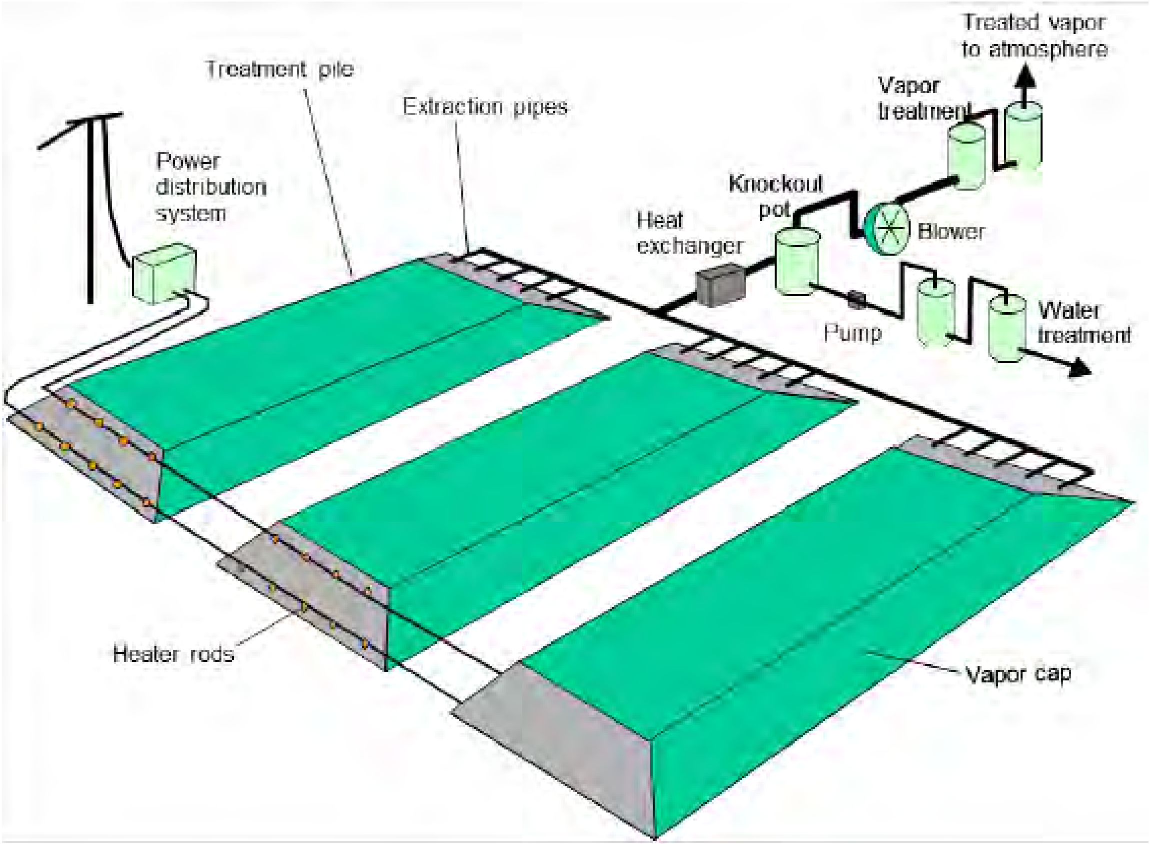
In-Pile Thermal Desorption - IPTD®



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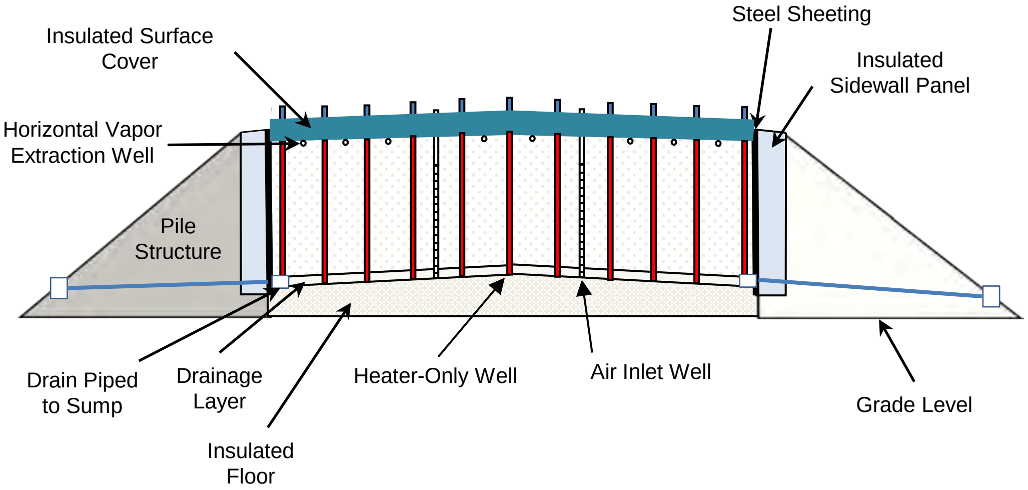
Treatment of Agent Orange in Vietnam



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Vietnam - Danang IPTD®

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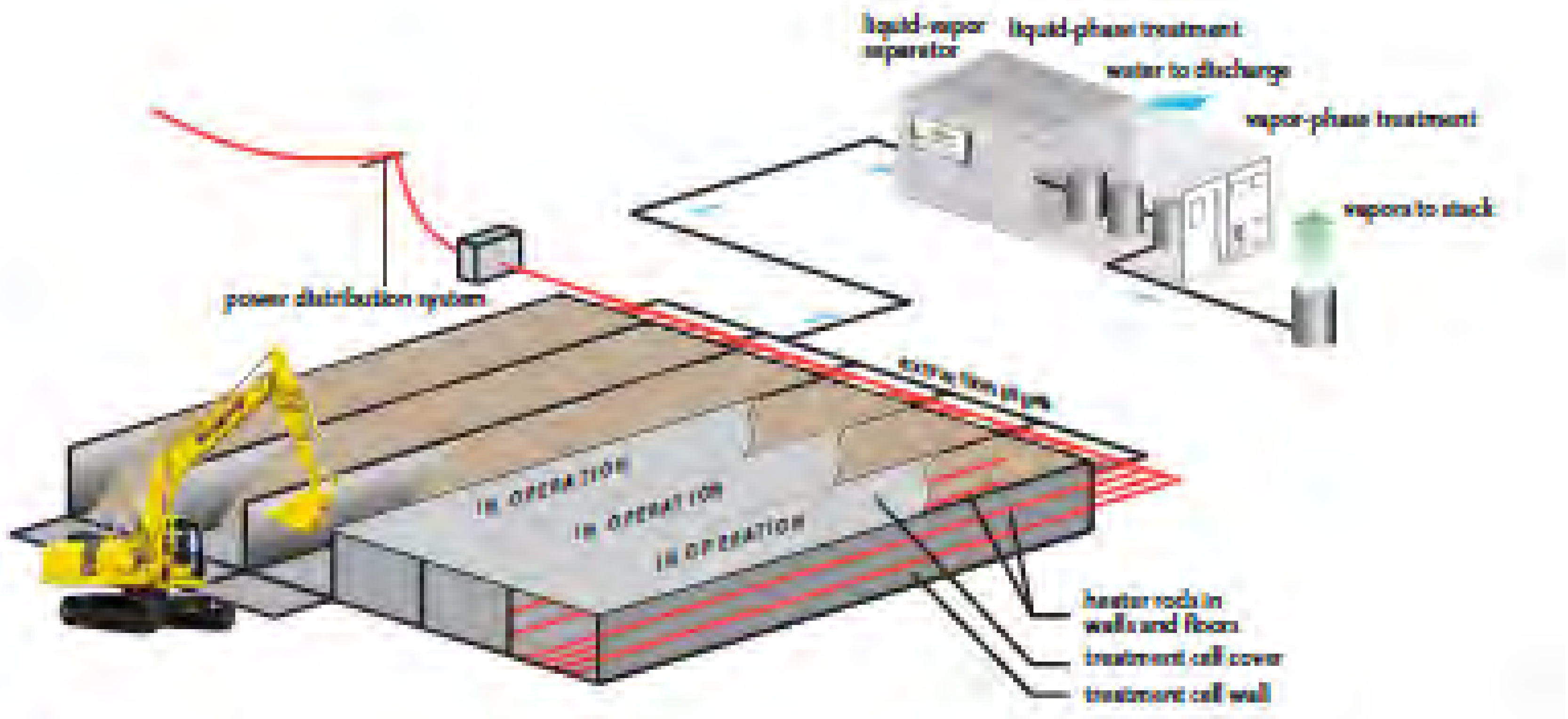
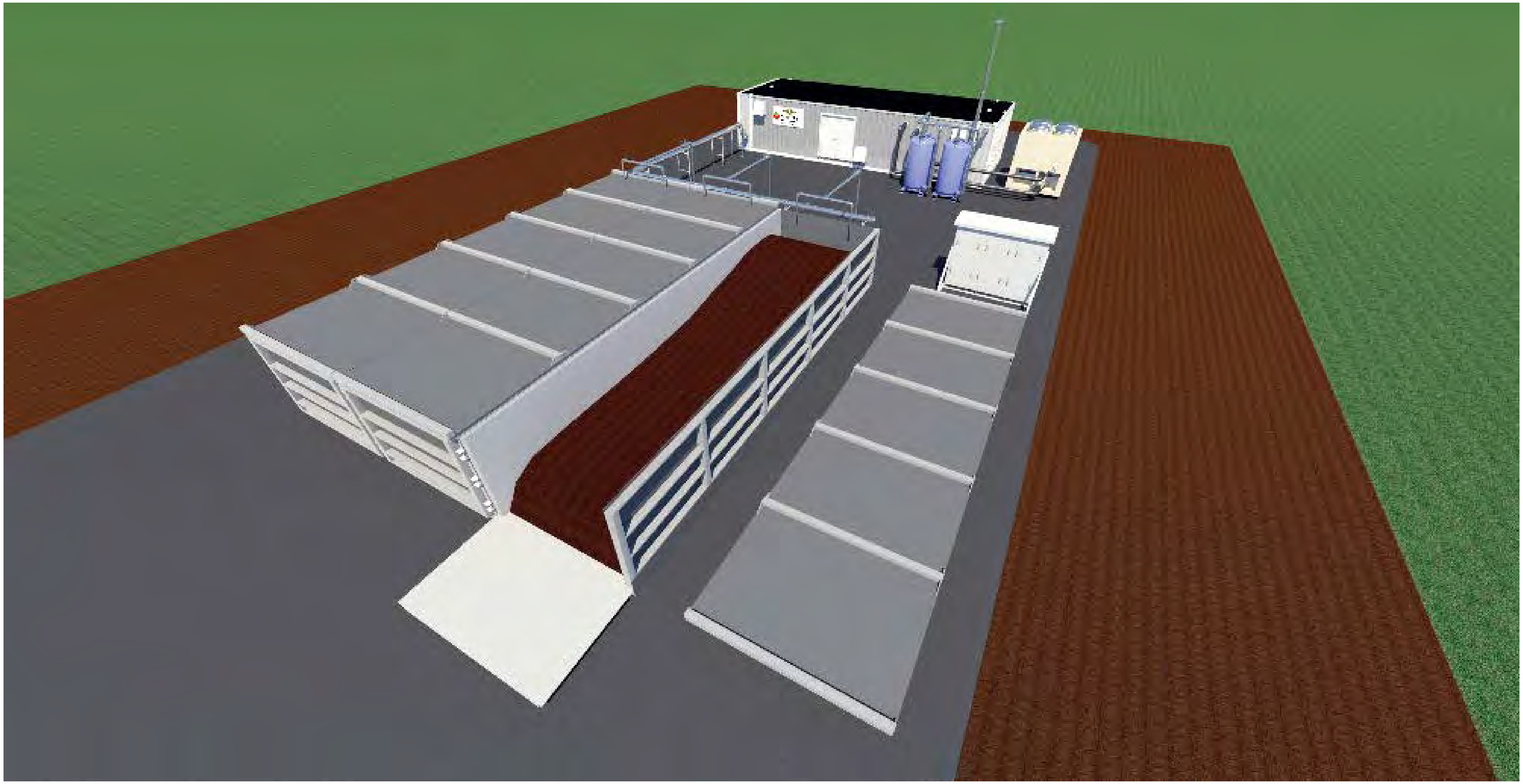
Modular Thermal Treatment Units



HB1100 units in sequential treatment

Mobile Thermal Treatment Units



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Tier One APC Unit

- Engineered to support with modular heated box units
- Simplifies the system design process – efficient
- Contains APC equipment, switches, meters and controllers for power distribution, system monitoring & control panels, data management telemetry

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Treating Dredged Materials

- Electrically powered heaters capable of heating above the boiling point of water.
- Effectively destroys/removes a wide variety of VOCs and SVOCs including PCBs, pesticides, PAHs, furans (PCDF) and dioxins (PCDD).
- Relatively insensitive to variations in moisture content, particle size, humic/organic content, and dredged debris.
- May be applied to drums, super-sacks, or stockpiled media.

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Pilot Test One

- Conducted under supervision of NYDEC
- Targeted VOCs and light end SVOCs
- Demonstrated ability to heat to 300ºC in 28 days
- Unrestricted land use clean up goals met
- 381 kWh cost of $45 per cubic yard

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Pilot Test Two

- Conducted under supervision of NYDEC
- Targeted MGP waste including coal tar (DNAPL)
- Demonstrated ability to heat to 368^{o}C for 32 days
- Unrestricted land use clean up goals met
- 664 kWh cost of $80 per cubic yard

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System and Infrastructure Requirements

- Applicable to projects as small as 1000 cubic yards
- Lower unit costs associated with higher volumes
- Broadly distributed shallow contamination generally more cost effective to consolidate than treat in place

Typical Equipment Needs

- Power supply - transformer
- Power distribution system; switches meters and controllers
- Cables and wiring
- Heater and extraction wells
- Manifold system and conveyance piping for extracted vapors and fluids
- APC system for extracted vapors and liquids
- Energy requirements vary depending on treatment temperature. Typically 400-600 kWh per M^3

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Summary & Conclusions

- Numerous demonstration and full scale projects have successfully treated SVOCs and high boiling point contaminants both in-situ and ex-situ
- Recent pilot tests of modular thermal treatment units have also proven to successfully treat these contaminants
- This technology is applicable to the treatment of Persistent Organic Pollutants such as PCBs, pesticides, dioxin and furans in dredged materials

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Thank you

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