TERRATHERM
ASIA

Thermal Conduction Heating

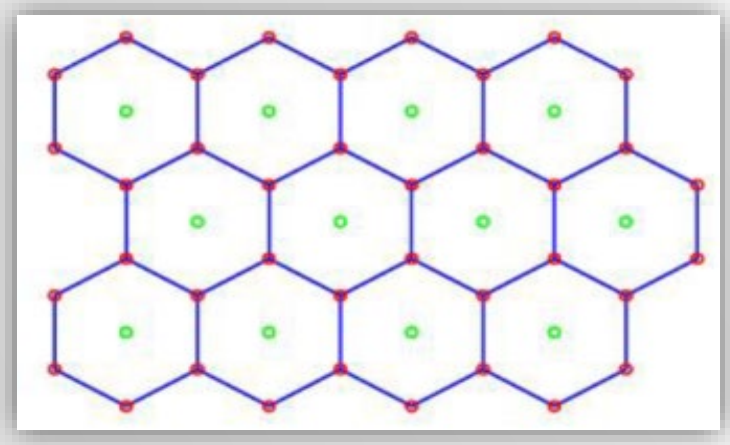
October, 2020

Thermal Conduction Heating

- Thermal Conduction Heating (TCH) is a soil remediation process in which heat and vacuum are applied simultaneously to contaminated soils
- TCH can be applied both in situ (in place) or ex situ (in pile, above ground)
- Contaminants are vaporized or destroyed by a number of mechanisms:
    1. Evaporation (removed in the air stream)
    2. Steam distillation (removed in the water vapor stream)
    3. Boiling
    4. Oxidation
    5. Pyrolysis
- Site target temperatures typically range between 100°C – 350°C
- TCH can be implemented in tight soils, clay layers, and soils with a wide heterogeneity in permeability or moisture content that are impacted by a broad range of volatile and semi-volatile contaminants, such as:
    - DNAPL
    - LNAPL
    - Tar
    - PCBs
    - Pesticides
    - PAHs
    - Explosive Residue
    - Mercury
    - Dioxins
    - Chlorinated Solvents
    - Heavy Hydrocarbons
- TCH is effective at virtually any depth in almost any media, above and below the water table, inside, beneath and near buildings and infrastructure.

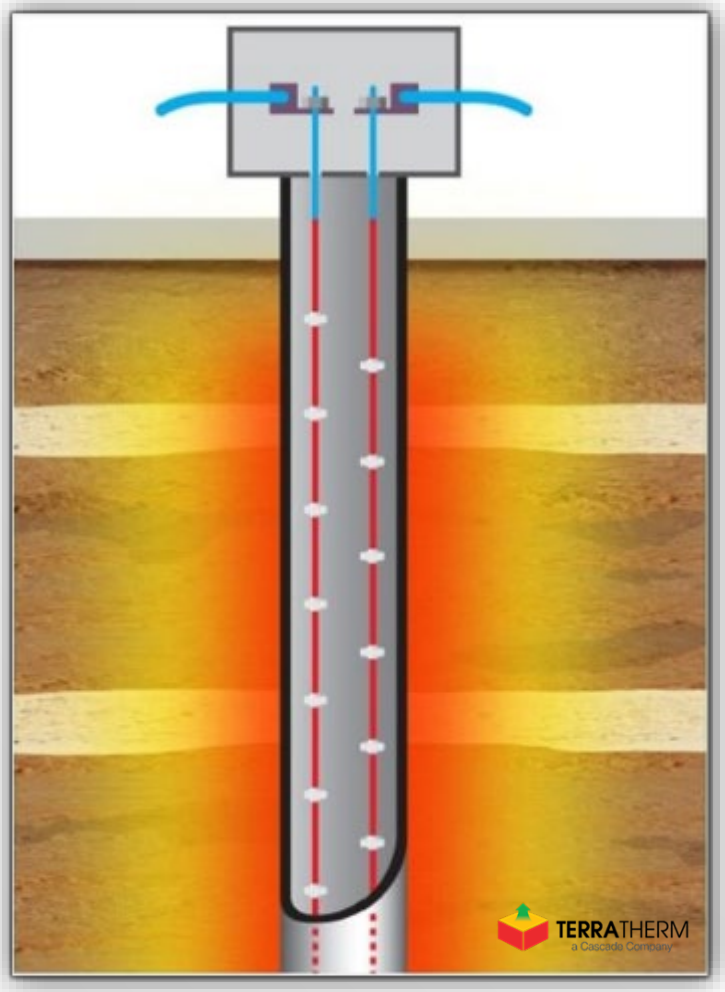
Thermal Conduction Heater

- TerraTherm, Inc. patented electrically-powered heater
- A network of heaters and extraction wells are installed in-situ or in pile
- Electricity is supplied to each heater at a junction box
- The heater gets hot and heat is conducted into the contaminated material

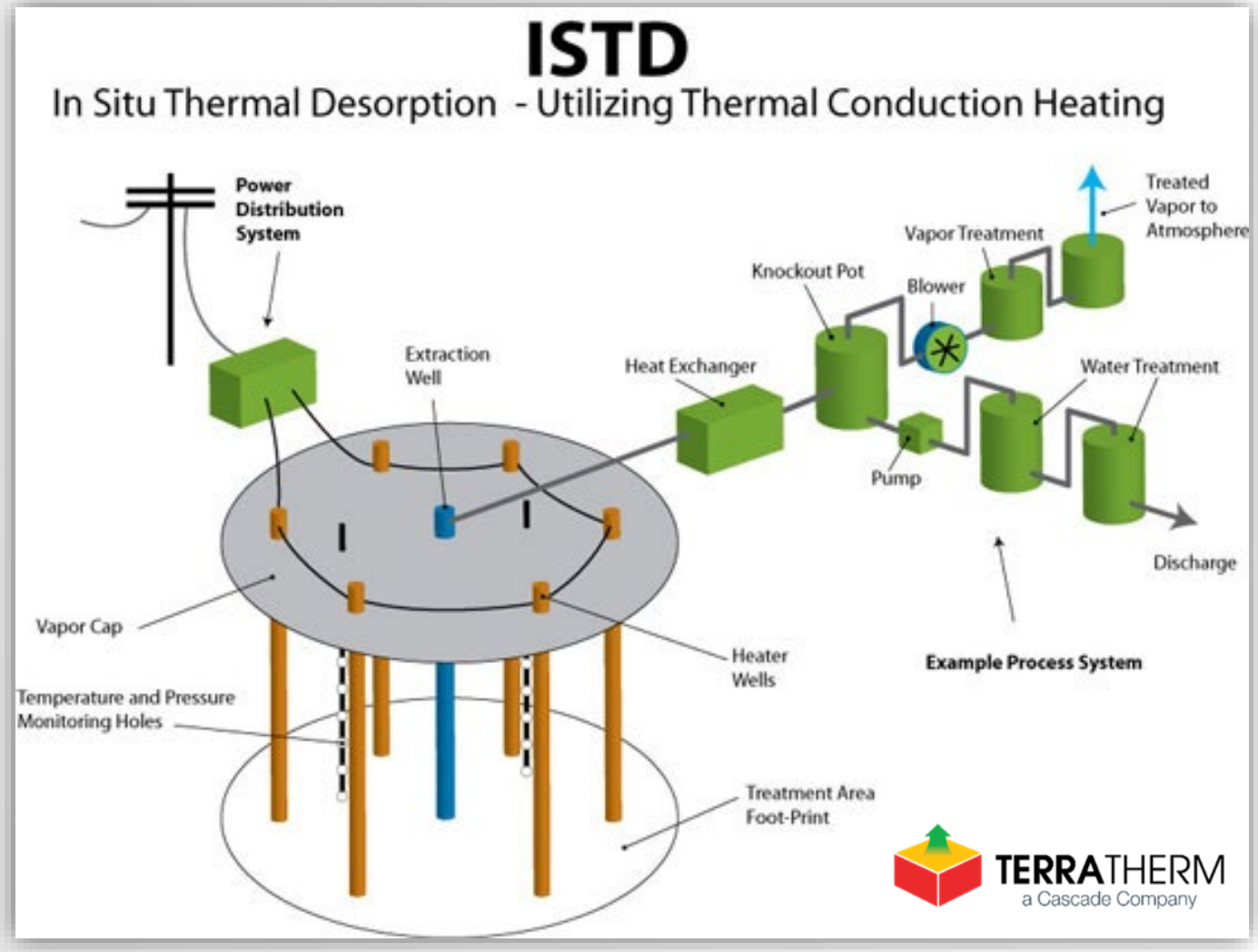


Heater

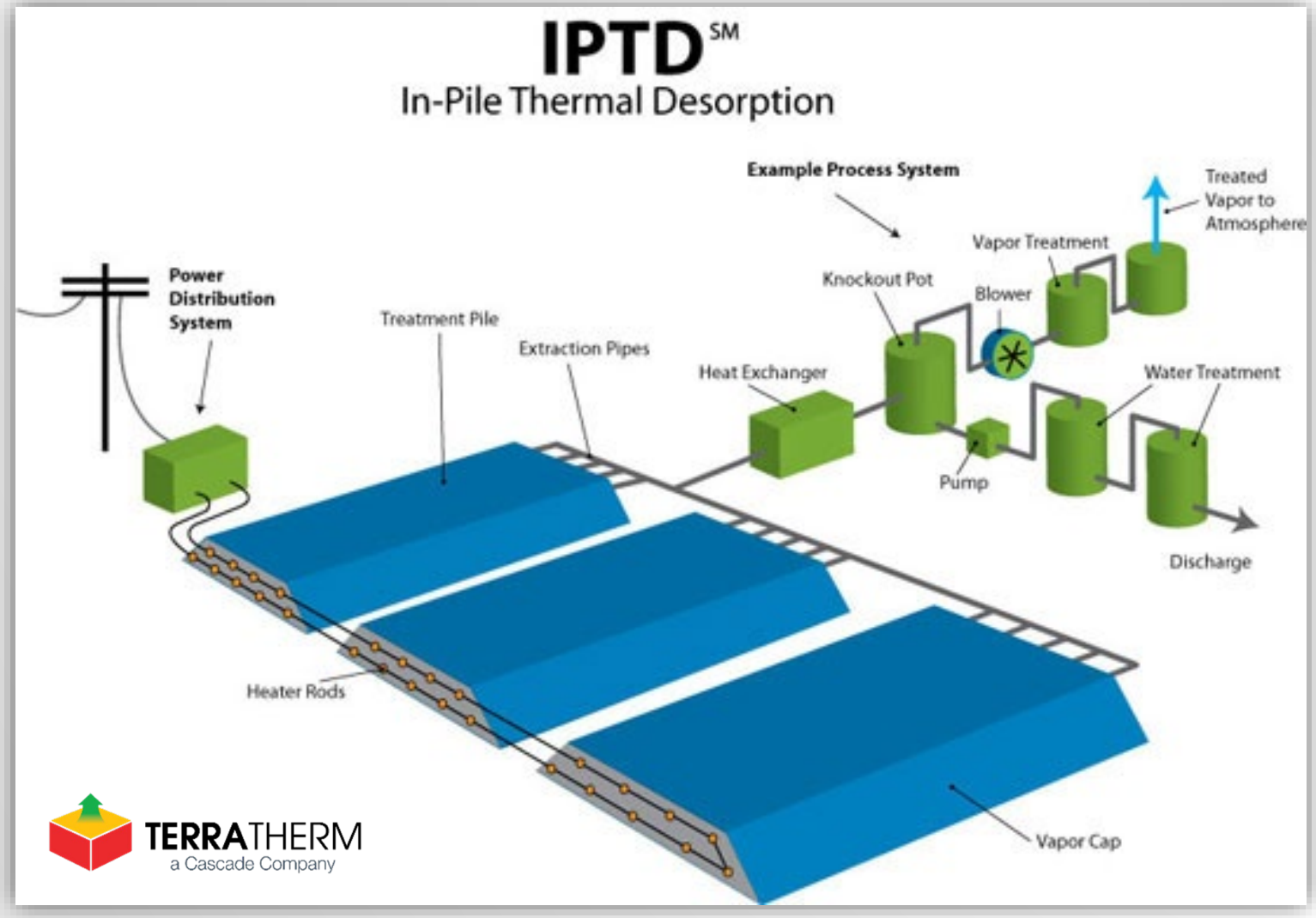
Extraction/Temp. Monitoring Point



In-situ Thermal Desorption (ISTD)



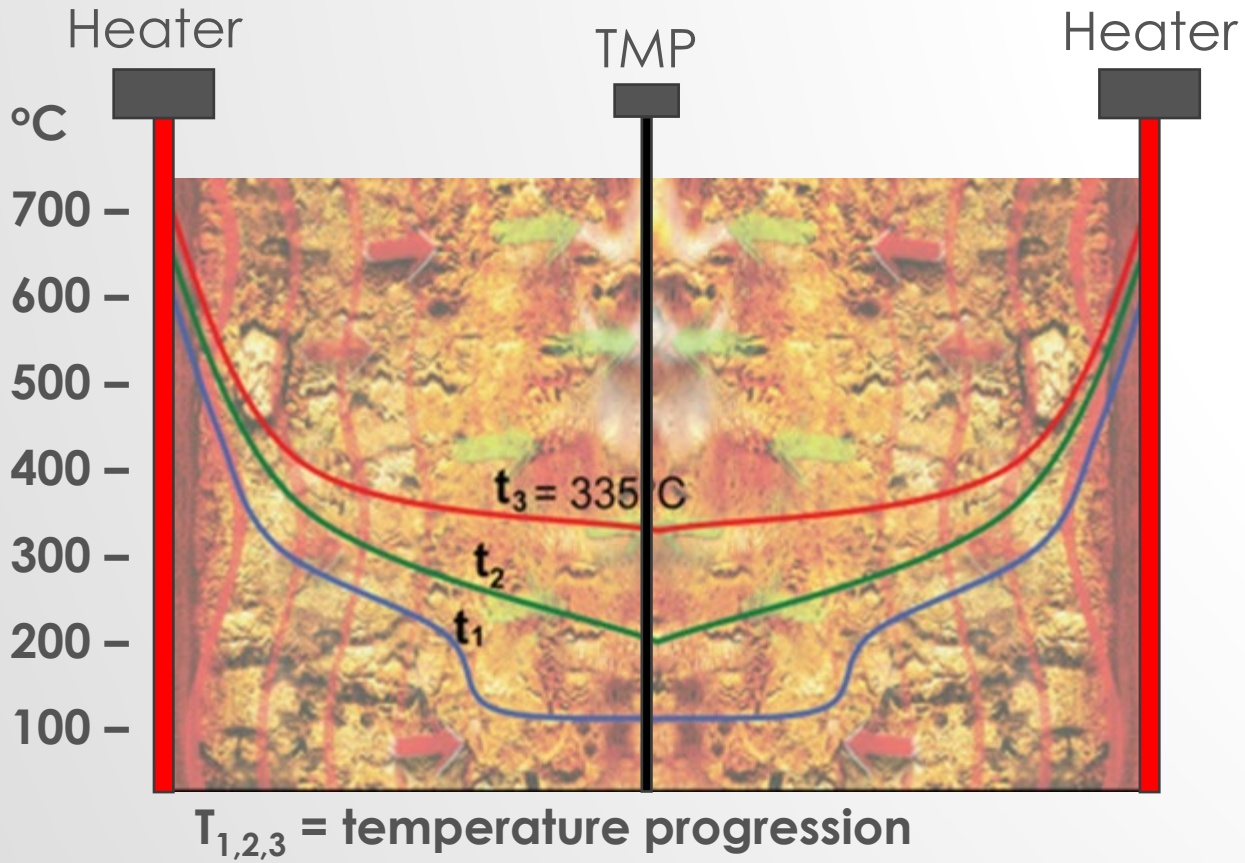
In-Pile Thermal Desorption



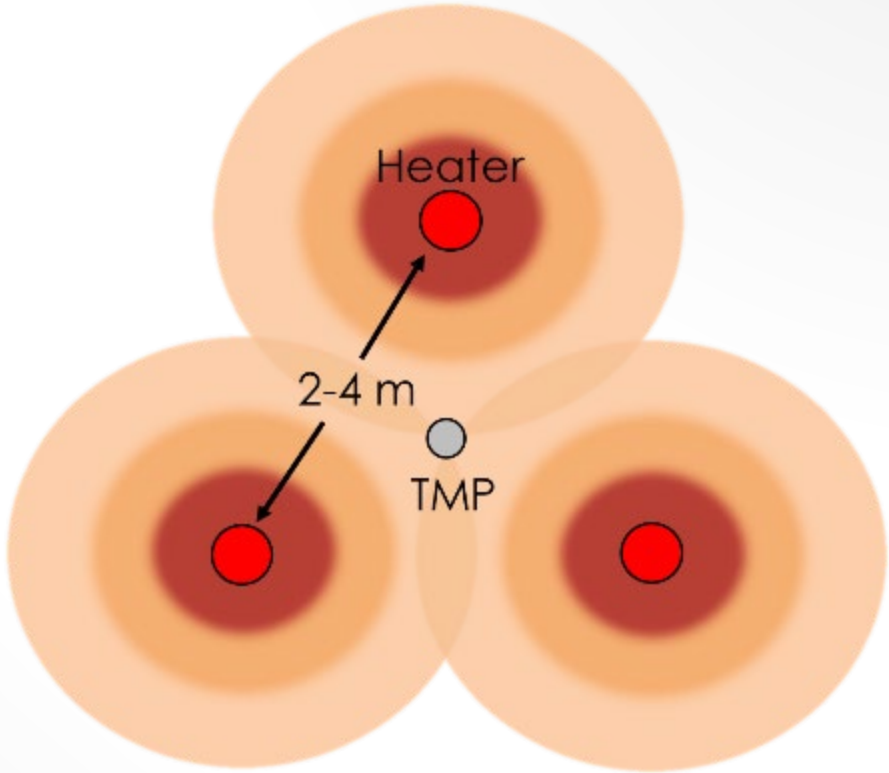
Typical TCH Wellfield

http://www.terratherm.com/thermal/tch/index.htm

Temperature Monitoring

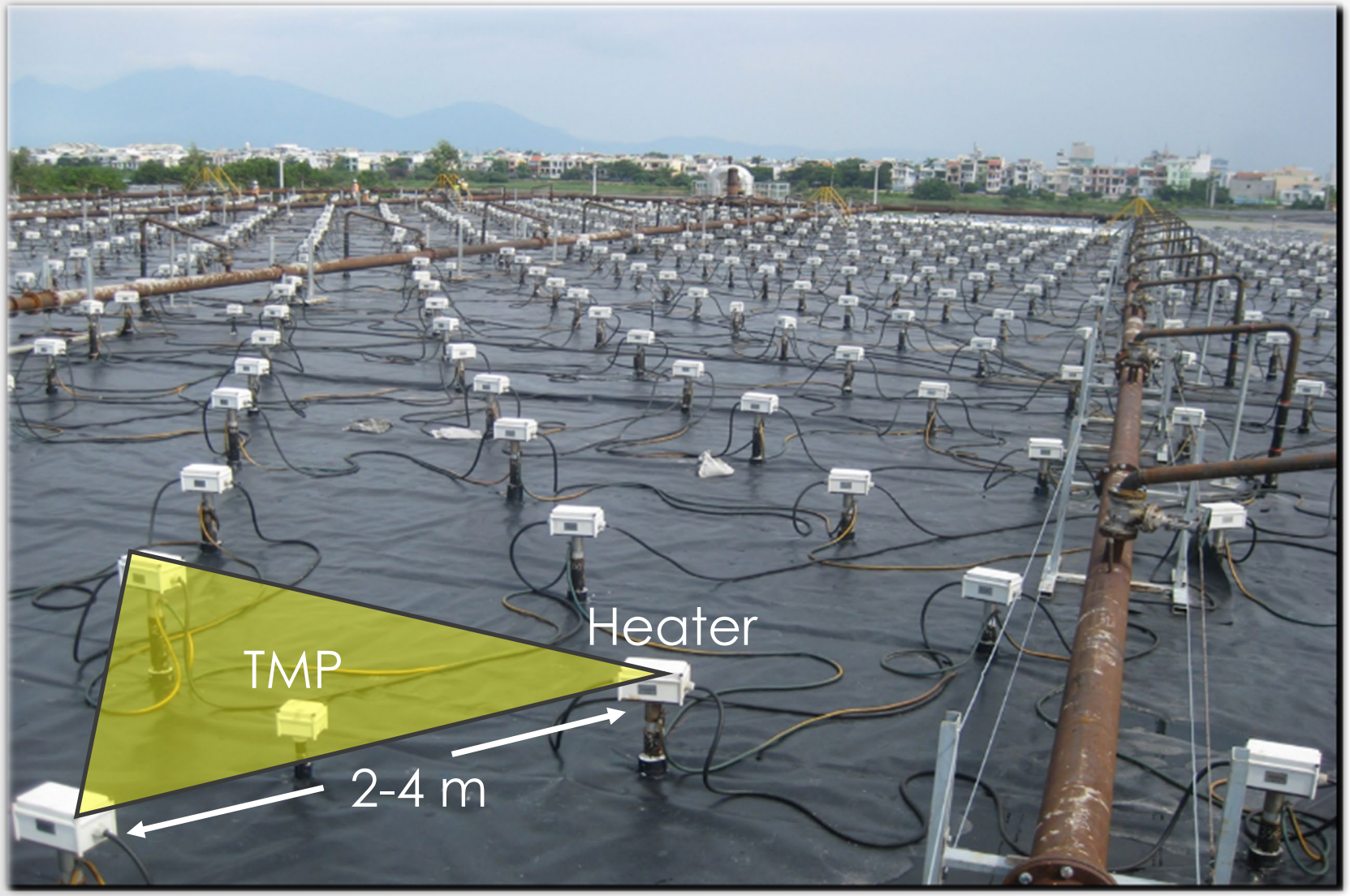


$T_{1,2,3}$ = temperature progression



TMP = Temperature Monitoring Point

Temperature Monitoring



Kawasaki, Japan

Technical Design

- Two phases of 1,750 and 1,470 m^3
- 100°C target temperature
- TCE and 1,2-DCE
- 15 and 18 heaters
- 6 Temperature monitoring points
- 164 and 167 days
- Treatment by cooling, phase separation, filtration and adsorption
- Target goals of 0.03 mg/l and 0.004 mg/l was met for both soil and water
- *Project Completed By:*

TERRATHERM ASIA

Teterboro Landing, NJ, USA

Technical Design

- ISTD
- 77,900 m^3
- Mix of CVOCs including TCE/PCE
- 100°C target temperature
- 907 heaters
- 80 Temperature monitoring points
- 238 days
- Treatment by cooling, phase separation, filtration and Thermal oxidation with acid gas scrubbing
- Target goals of 1 mg/kg for PCE and TCE was met
- *Project completed by:*

TERRATHERM
a Cascade Company

Franklin, NJ, USA

Technical Design

- ISTD
- 3,780 m^3
- TCE and PCE
- 100°C target temperature
- 43 heaters
- 9 Temperature monitoring points
- 180 days
- Treatment by cooling, phase separation, filtration and adsorption
- Target goals of 0.0885 mg/kg for PCE and 0.0179 mg/kg for TCE was met
- *Project completed by:*

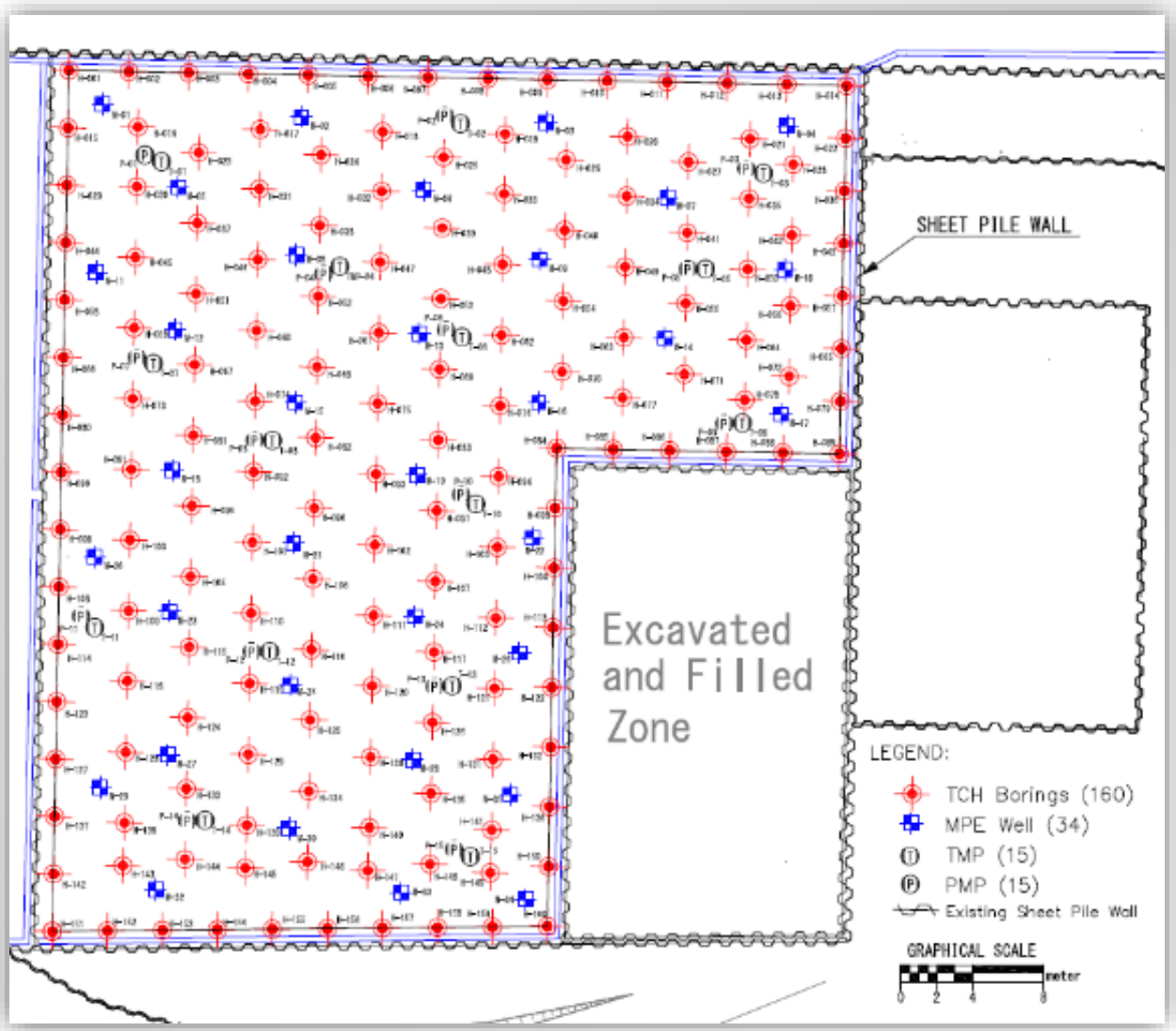
TERRATHERM
a Cascade Company

Kuwana, Japan

Technical Design

- ISTD
- 14,000 m^3 (GL- 8.5m)
- Mixed oil
- 100°C target temperature
- 160 heaters
- 15 Temperature and pressure monitoring points
- Estimated 246 days
- Treatment by cooling, phase separation, thermal oxidation filtration and adsorption
- *Project Awarded To:*

TERRATHERM ASIA



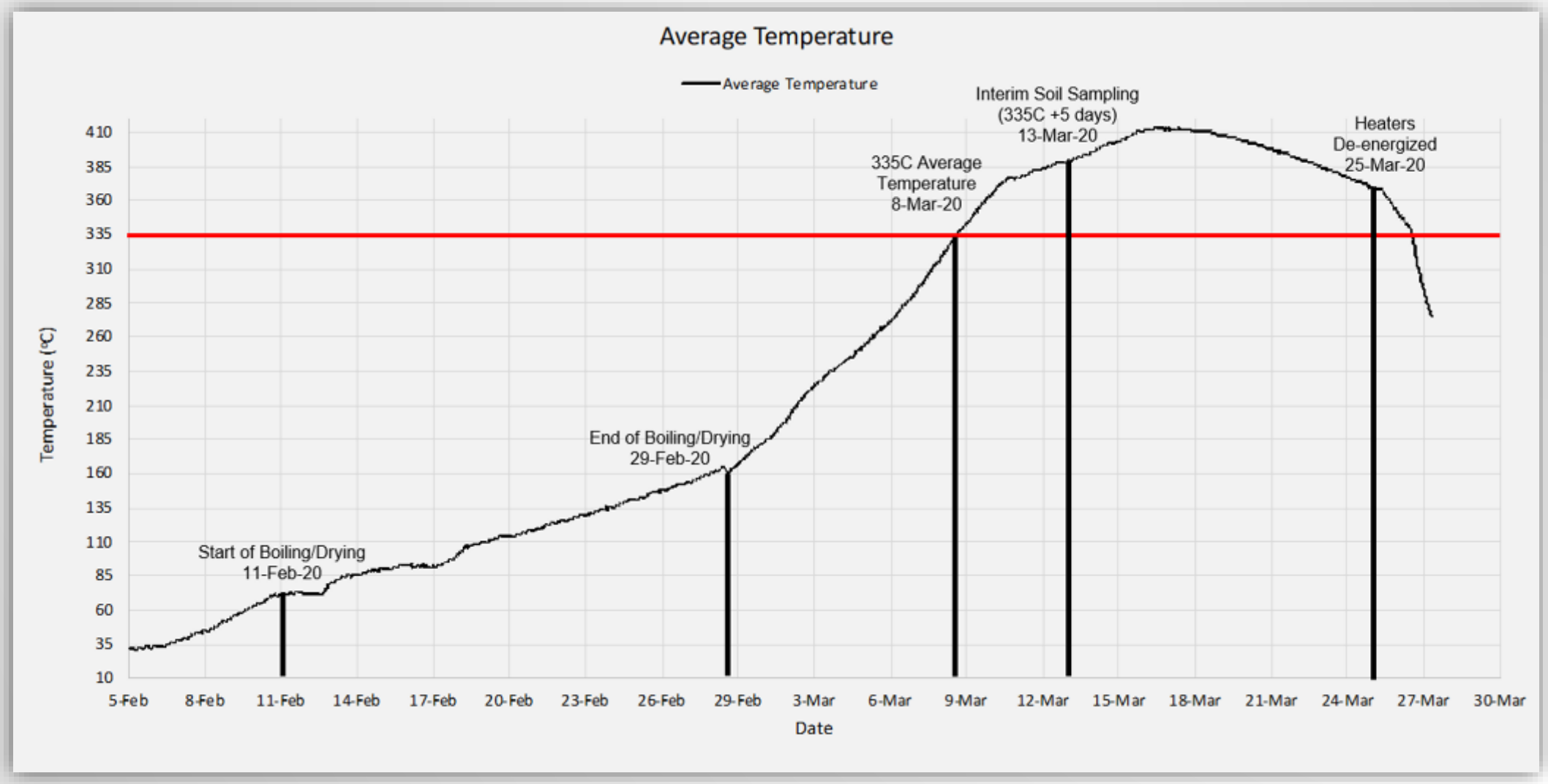
Bien Hoa Airbase, Vietnam

Technical Design

- Heated Box™
- 45 m^3
- Dioxins
- 335°C target temperature
- 9 heaters horizontally positioned
- 6 Temperature monitoring points
- 50 days
- Clean up target of 100 ppt met (<5 ppt)
- Vapor treatment by thermal oxidation
- *Project Completed By:*

TERRATHERM ASIA

Heating Profile



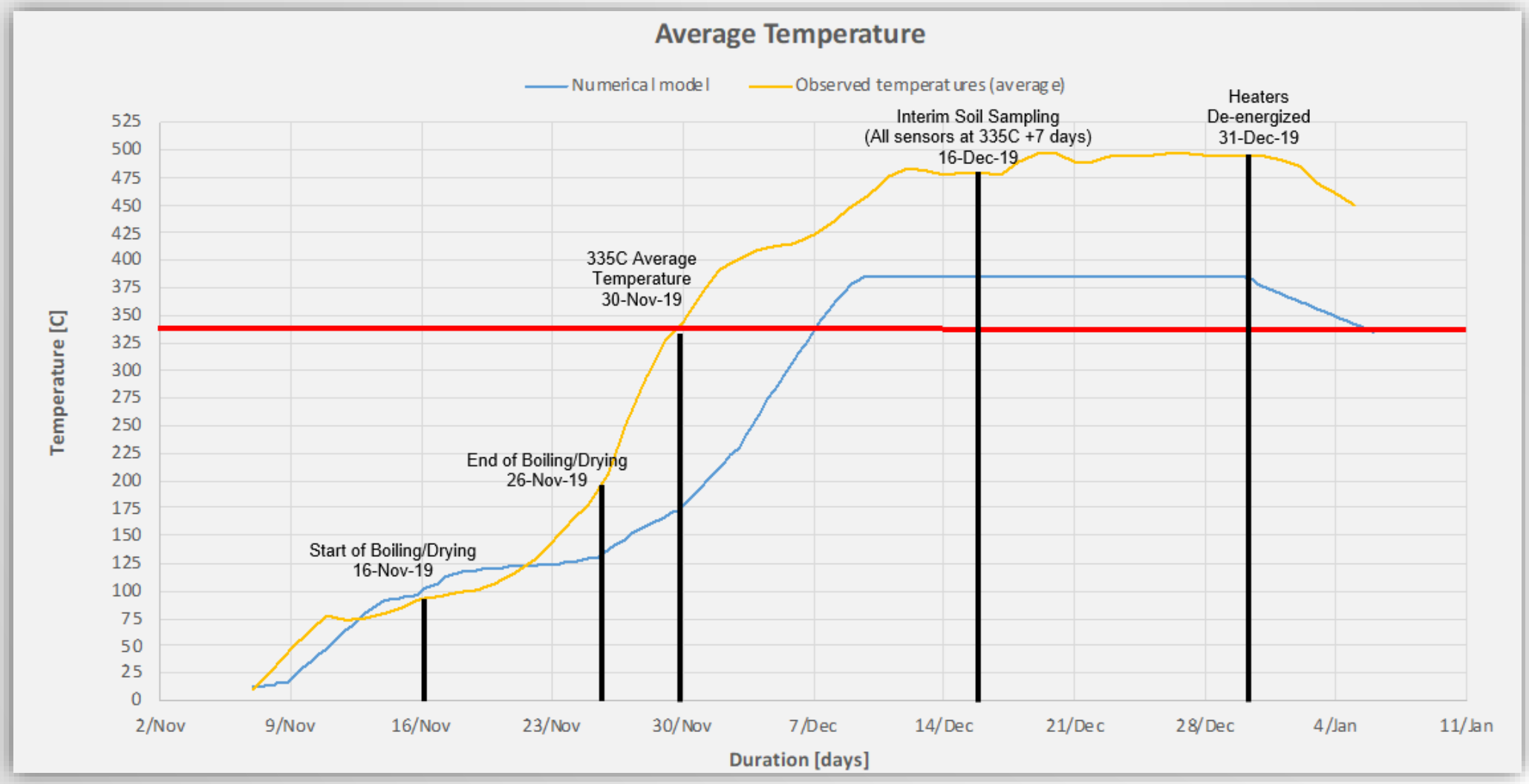
Incheon, South Korea

Technical Design

- IPTD® pilot
- 68 m^3
- 335°C target temperature
- 9 heaters horizontally positioned
- 4 Temperature monitoring points
- 54 days
- Vapor treatment by thermal oxidation
- Target goals of 100 ppt were met (<10 ppt)
- *Project Completed By:*

TERRATHERM ASIA

Heating Profile



Incheon, South Korea

Technical Design

- IPTD®
- 10,500 m^3
- Dioxins
- 335°C target temperature
- 186 heaters
- 24 Temperature monitoring points
- Estimated 161 days
- Thermal oxidation
- Target goals of 100 ppt
- *Project is being implemented by:*

TERRATHERM ASIA

Large Scale IPTD®

Project completed by TERRATHERM a Cascade Company and KRÜGER VEOLIA

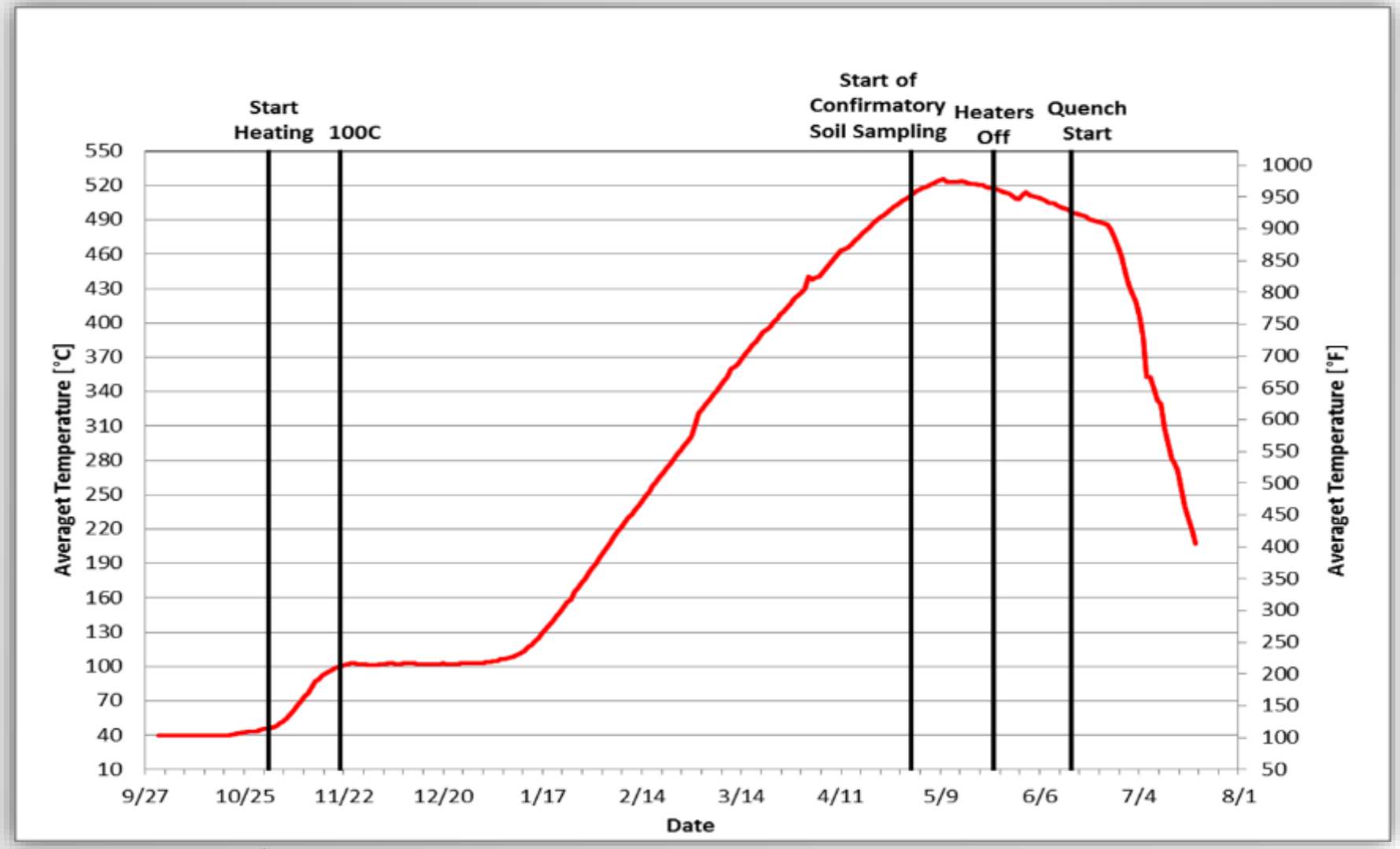
Danang, Vietnam

Technical Design

- IPTD®
- Two phases, 87,000 m^3 total
- Dioxins
- 335°C target temperature
- 1,254 heaters
- 56 Temperature monitoring points
- 205 days (Phase 2)
- 150 ppt treatment goal was met (<1 ppt)
- Treatment by cooling, phase separation, filtration and adsorption
- *Project completed by:*

TERRATHERM
a Cascade Company
and
KRÜGER VEOLIA

Heating Profile (Phase 2)



TERRATHERM a Cascade Company

KRÜGER VEOLIA

Properties of Mercury (Hg)

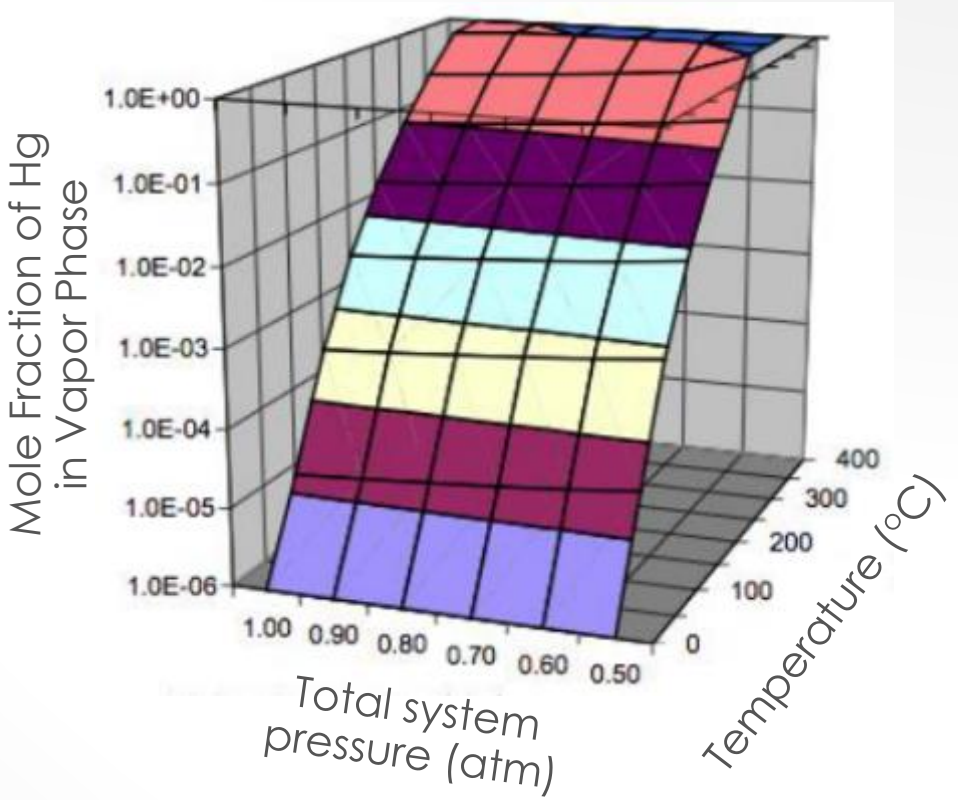
- Stable element – not capable of chemically reacting to a less toxic form
- Soluble in water at low part per billion levels – removed by granular activated carbon (GAC)
- Liquid density approximately 13 times that of water
- Molecular weight of 200.6 – vapor roughly 7 times as dense as air
- Atmospheric boiling point of 360°C
- Stable viscosity near 1 centipoise over a wide temperature range
- Very low liquid heat capacity – 1/30th that of water
- Low heat of vaporization – 125 Btu/lb at 360°C
- Significant vapor pressure variation between ambient temperature and boiling point

Mercury (Hg) TCH Treatability Study

Technical Design

- 15 grams of Hg for each test
- Temperatures between 243-259°C (boiling point of Hg is 356.5°C)
- Air volume 48 – 51.2 L (267 to 284 pore volumes)
- Treatment time 11 h, 35 min – 13 h, 5 min
- Mass reduced to <0.025 grams of Hg (99.87% removal)
- *Project completed by:*

Department of Civil, Architectural, and Environmental Engineering, University of Texas, Austin



Mercury Pilot, Denmark

Technical Design

- Heated Box Pilot Test
- 25 m^3
- Mercury, parathion, methyl parathion, malathion and Sulfotep
- 350°C target temperature
- 6 heaters
- 3 Temperature monitoring points
- 219 days
- Treatment by catalytic oxidation, condensing, scrubbing and GAC
- 99.9% pesticide removal achieved
- 99.5% mercury removal achieved
- *Project completed by:*

KRÜGER VEOLIA