EnISSA
enhanced in-situ soil analysis

State-of-the-art site characterisation methods applied to support the design of pilot remediations in the RESANAT project

21e Edition
intersol 2022
Congrès-Exposition International sur les Sols, les Sédiments et l'Eau
International Conference-Exhibition on Soils, Sediments and Water

June 22nd – Intersol 2022 Lyon

Pieter Buffel

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Outline

EnISSA: decreasing uncertainties in Soil and groundwater projects: HRSC services

Resanat pilot sites: Reactive barrier/Phytoremediation/Biostimulation

HRSC tools applied at coal tar/creosote impacted sites

- The Membrane interface Probe
- The Optical Image Profiler : OIP

Decrease uncertainties in soil and groundwater projects

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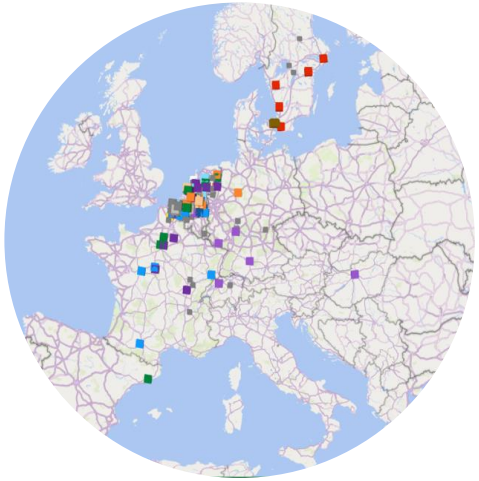

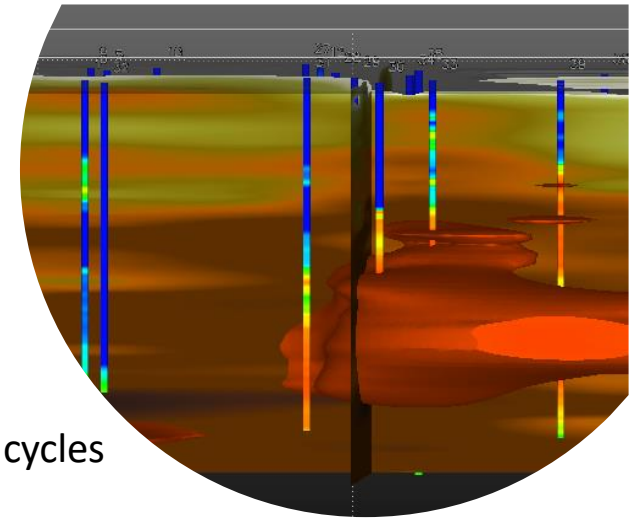

High Resolution Site Characterization

Scale appropriate measurement methods

On-site Cost effective High Resolution data

Dynamic sampling approach & shorter investigation cycles

Reduced uncertainties & Improved insights

EnISSA-MIP with GC-MS : Component specific and sensitive in-situ VOC –depth profiles

Optical Image Profiler (OIP): hydrocarbon fuels and oils profile

EC, HPT or CPT: Soil stratification profiling

Field Lab : Screening of individual VOC's in soil gas, indoor/ambient air

Advanced data processing and visualization insight based on clear and interactive datasets

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Resanat

Interreg
EUROPESE UNIE
Vlaanderen-Nederland
Europees Fonds voor Regionale Ontwikkeling

EU funded Interreg Project:

support cross border cooperation

Health, Environment, Research&education, transport, sustainable energy

REANAT: Improve and promote **nature-based soil remediation** methods

Focus on sites contaminated with **PAHs**

OVAM (public waste agency of Flanders) and:

Deltares
Enabling Delta Life

Witteveen + Bos

TAUW

DJN
Jan De Nul
GROUP

DURA VERMEER

bio2clean
GROWING CLEAN SOILS

TTE
consultants

iFLUX

Resanat : Pilot Sites

Gent [BE] - canal ‘de Lieve’ :
to improve surface water quality

Reactive mats

Zeebrugge [BE] – Carcoke – Bacteria assisted **phytoremediation** (poplars, phytopiles)

‘s Gravenmoer [NL]- former wood treatment (creosote) **in situ Bio stimulation** (nitrate/sulfate injections)

Uncertainties in soil and groundwater investigation

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Dealing with DNAPL's….

Density > water

sink to great depth ➔ DNAPL Pool

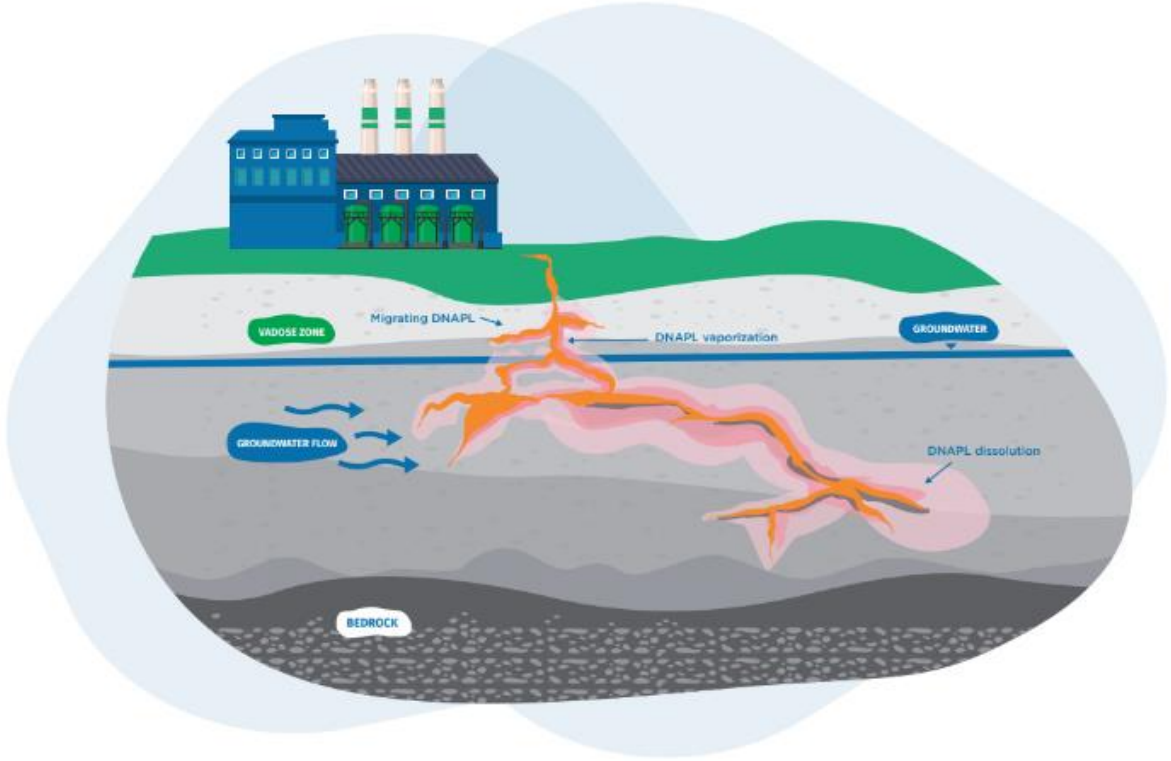
DNAPL distribution is highly dependent on differences in soil characteristics

finer soil structure acts a capillary barrier

DNAPL pooling & lateral distribution (can be opposite of GW flow direction!)

Diffusion: DNAPL storage in narrow pores.

Advection: formation of long-lasting GW plumes



….Major challenges

Horizontal and vertical distribution is controlled by (subtle) variations in soil

unpredictable architecture of source and plume

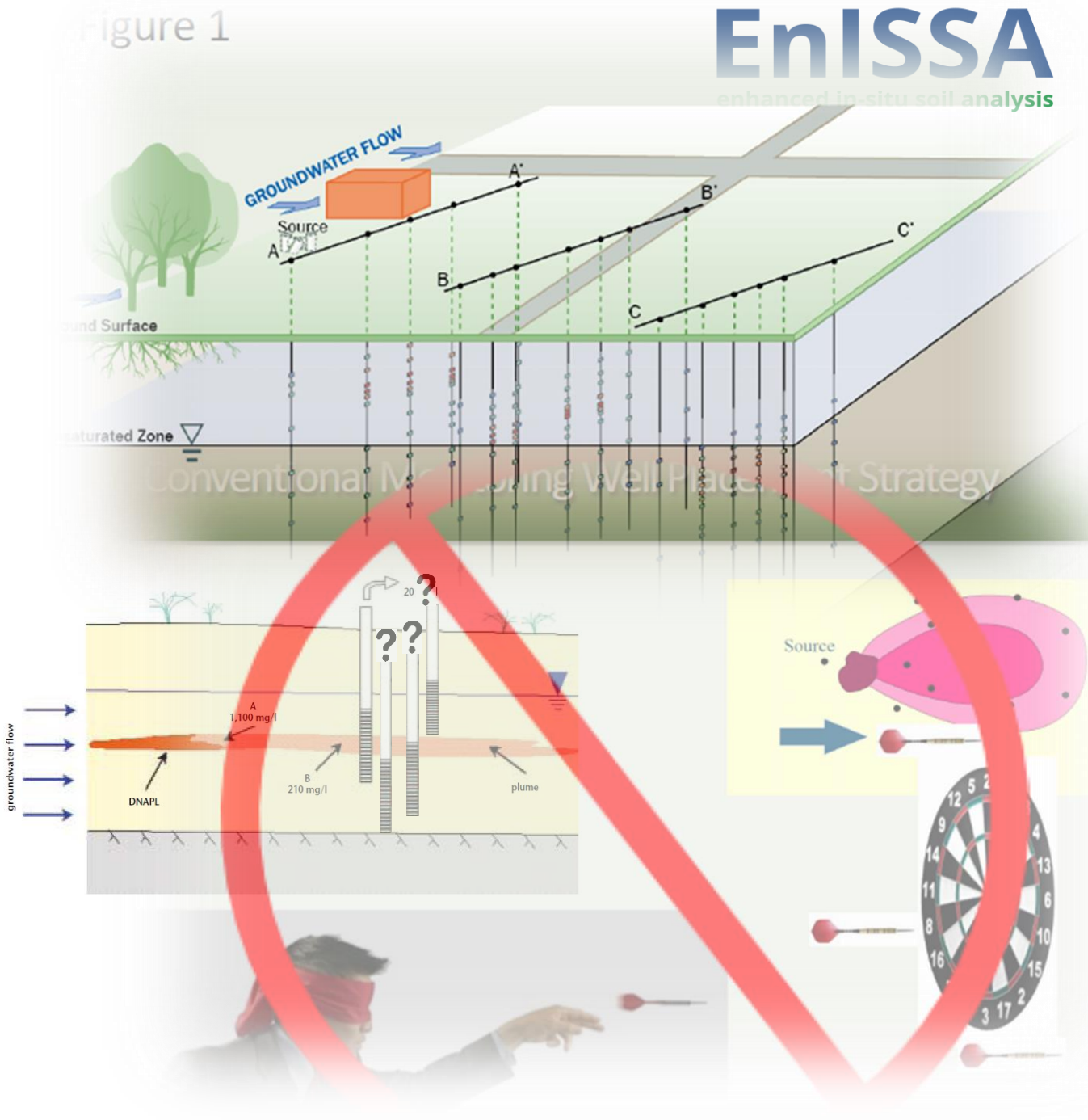
HRSC

High Resolution Site Characterisation

https://clu-in.org/characterization/technologies/hrsc/

Scale of measurement adapted to scale of subject of investigation

Data density and location



HRSC Tools : MIP

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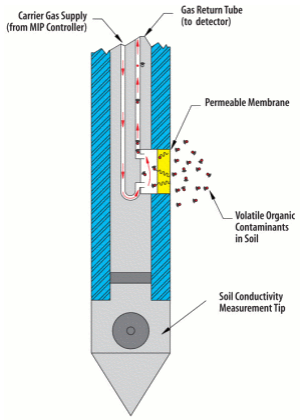

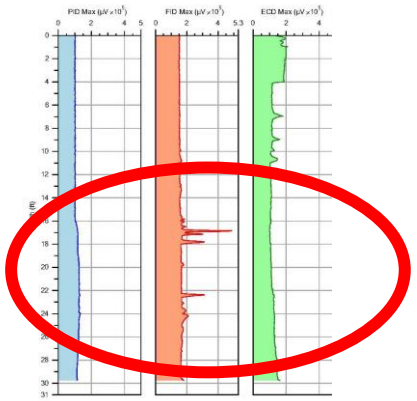

MIP: Membrane Interface Probe

- Geoprobe ™ Direct push tool
- On-site Screening tool for VOC's in soil and groundwater

- Local heating of soil
- Volatilization and diffusion through membrane
- Inert carrier gas & transport to detector

MIP: application @ Coaltar/creosote/PAH impacts?

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Carry-Over Effects of the Membrane Interface Probe

by Jan Bumberger[1], Dirk Radny[2], Andreas Berndsen[3], Tobias Goblirsch[4], Johannes Flachowsky[4], and Peter Dietrich[4]

Abstract

The membrane interface probe (MIP) is widely used to characterize the subsurface distribution of volatile organic compounds (VOCs). One problem that arises during MIP application is that disproportionately high MIP signals are obtained after passing source zones which contain mobile or residual phases. This serious problem occurs because of a carry-over effect, in particular caused by compound-specific retention times in the conventional unheated transfer line, commonly used during such an investigation. The objective of this study

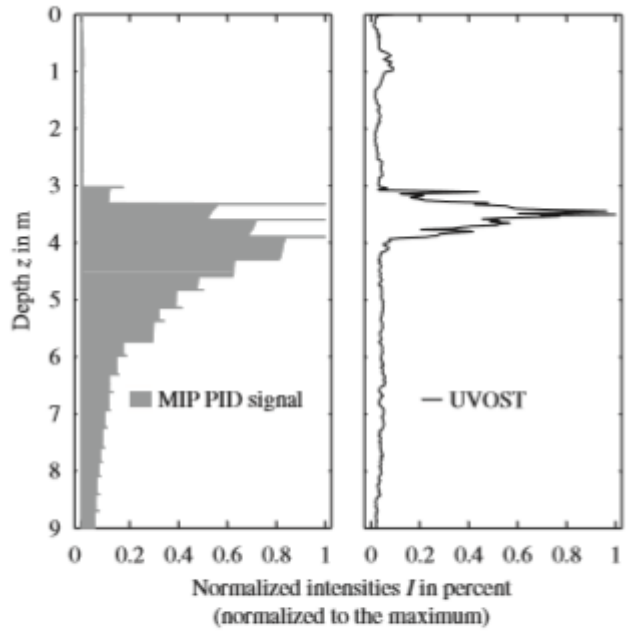

Figure 2. Conventional MIP PID signal results using standard MIP data acquisition software and UVOST for the probing location at the Elsterwerda field test site.

"This serious problem occurs because of a carry-over effect which is caused by cross-contamination and specific individual retention times of different substances in the unheated transfer line."

Variable individual retention times in MIP trunkline

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Probe is connected by the trunkline wired through the rods to the regulation and detection instruments.

Typical 45m of cable with gas lines transporting the VOC's
Coal tar/creosote: broad range of compounds

BTEX : comparable and stable "travel time"

Heavier compounds: important delays!

MIP detector signal is a combination of all individual compounds reaching the detectors

Variable individual retention times in MIP trunkline

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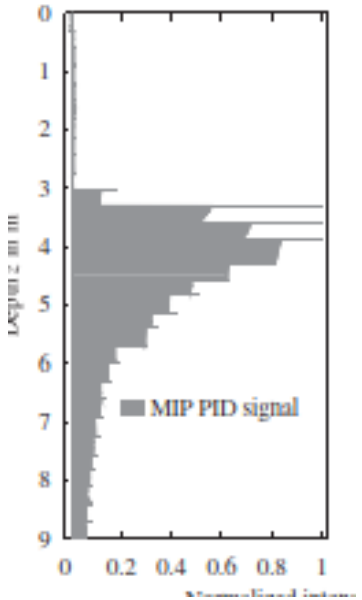
MIP results : detector signals vs depth

Interpretation assumes a constant ‘travel time’

Variable retention times and non discriminant detector

Multi component contamination (tar, cresosote)?

Overestimation of the impacted interval
Poor correlation with verification sampling



EnISSA MIP

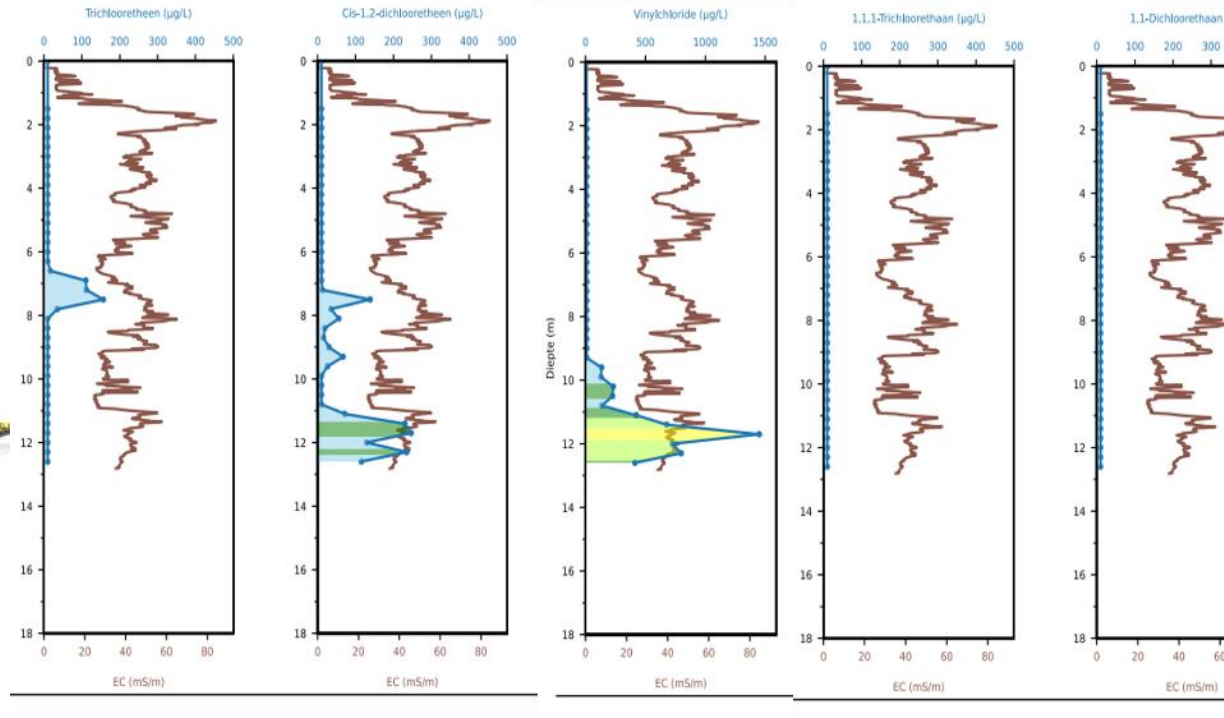
DETECTION OF INDIVIDUAL VOC's

- EnISSA: Lab in the Field
  - MIP directly connected to GC-MS

    Individual detection of 12 compounds each 1 min

    Detailed information on degradation products

    Low detection limits for plume delineation



EnISSA –MIP compounds

- Chlorinated Solvents:
  - PCE; TCE; cis-1,2-DCE; 1,1-DCE, trans-1,2-DCE, VC
  - 1,1,1-TCA; 1,1,2-TCA; 1,1-DCA; 1,2-DCA, chloorethaan
  - Tetrachloormethaan, Trichloormethaan, dichloormethaan, chloormethaan
  - Freons
  - Monochlorobenzene,
  - ….
- BTEX, Naphthalene
- MTBE, TBA
- trimethylbenzene
- tetrahydrofuran, aceton, Isopropyl Alcohol, hexaan, methyl-hexaan, cyclohexane, Diethyl ether, MEK, n-butylacetate
- Indane, indene,
- 2,2,5,5-Tetramethyltetrahydrofuran , 2-methyl-2-propanol
- tetrahydrothiophene

Specific depth correction factor for Naphthalene

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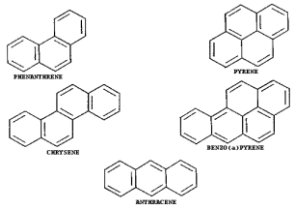
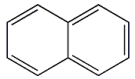
MIP is limited to detection of volatiles.➔ PAH's ? Naphtalene most volatile and most mobile'



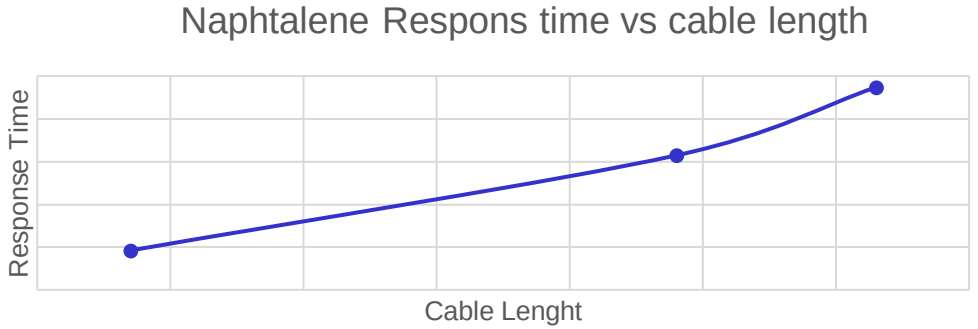


Lab test:

GCMS Method development for simultaneous detection of BTEX and naphthalene

MIP respons Naphthalene: respons time difference with BTEX

➔ longer travel time: related to trunkline interactions



Specific depth correction factor for Naphthalene

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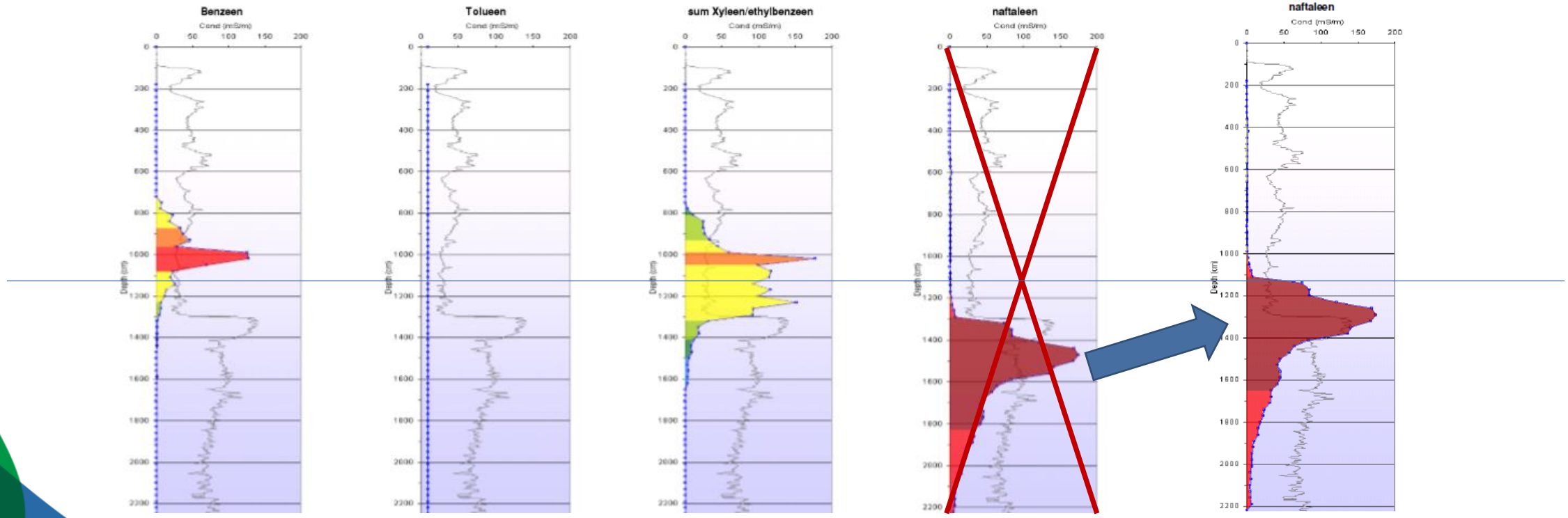

MIP: application @ Coaltar/creosote/PAH impacts?

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Standard MIP detectors impacted by trip time discrepancy!

EnISSA MIP with GCMS detection :

- Naphthalene, trimethylbenzene, indene and indane can be analysed and calibrated
- Application of specific correction factors

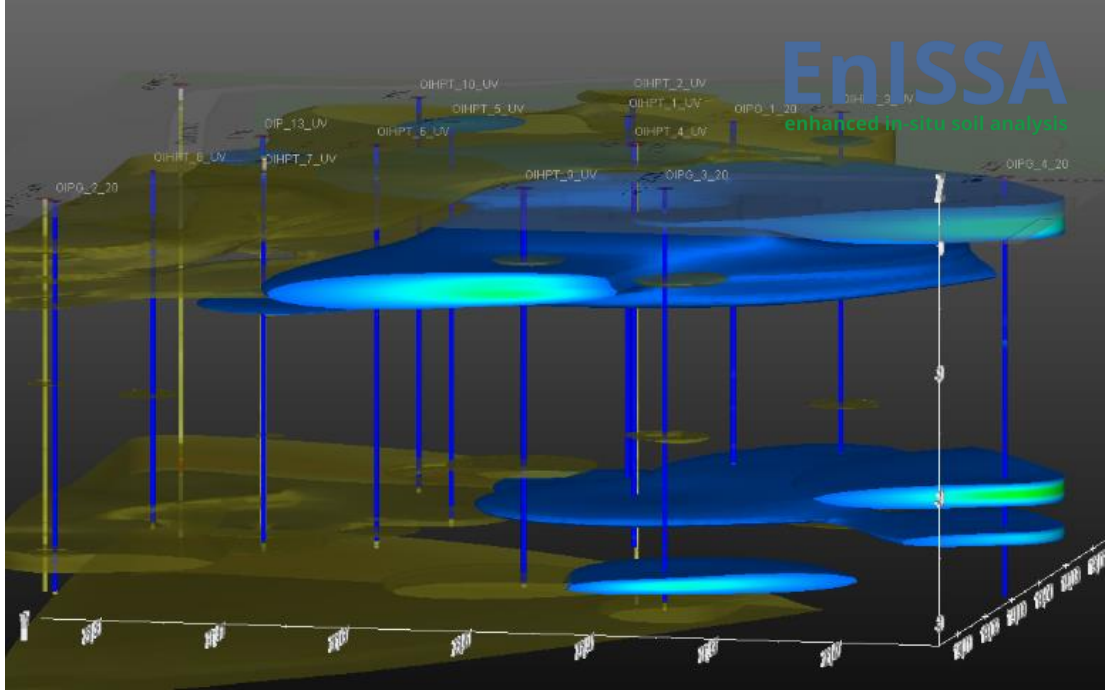
Tailing of ‘Heavy’ compounds

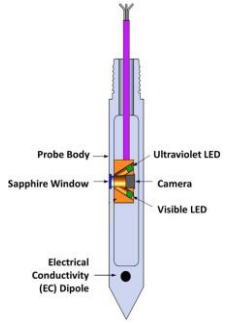
- Interpretation of vertical delineation
- Outside-in approach
- Alternating multiple probe/cable sets

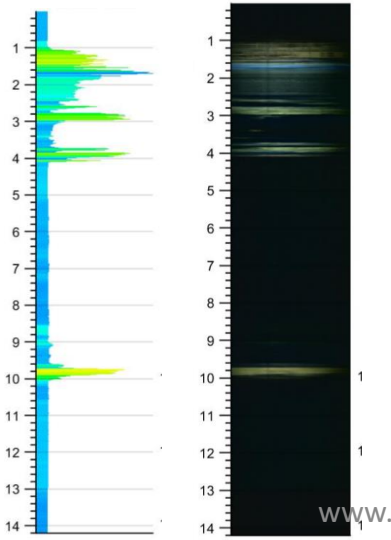
HRSC Tools: Optical Image Profiler

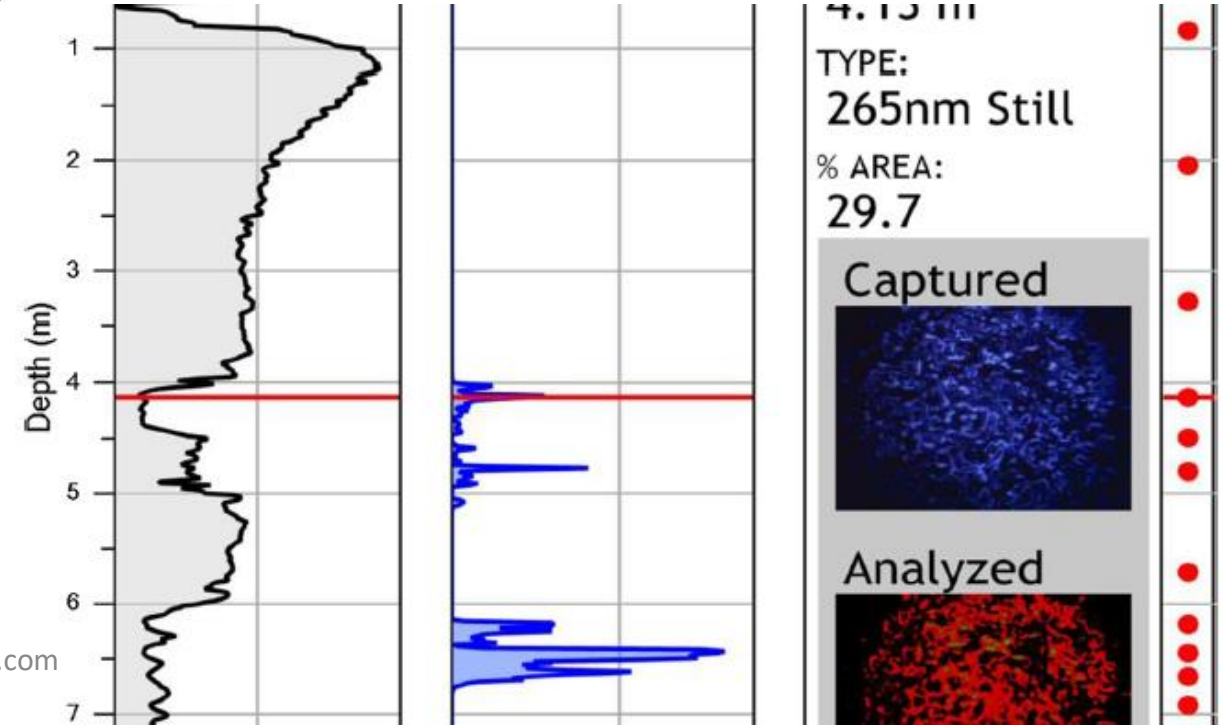
- New Geoprobe ™ direct push tool for determination of presence and distribution of petroleum NAPLs in the subsurface

- Fluorescence of PAH's is induced by UV or green LEDs and captured by the in-probe Camera

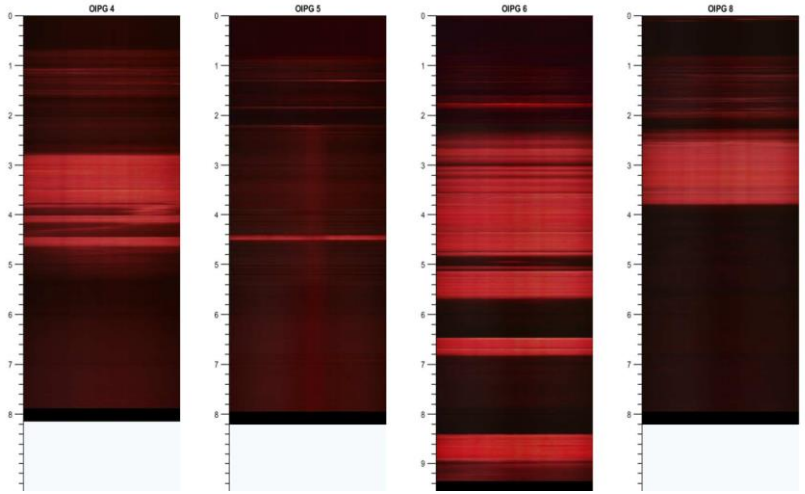


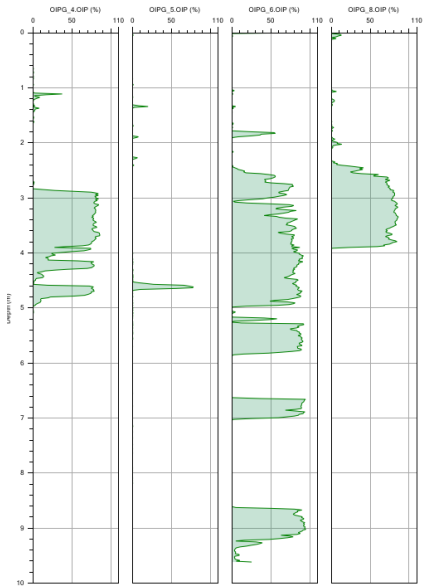






OIP results on Pilot Sites: “de Lieve”





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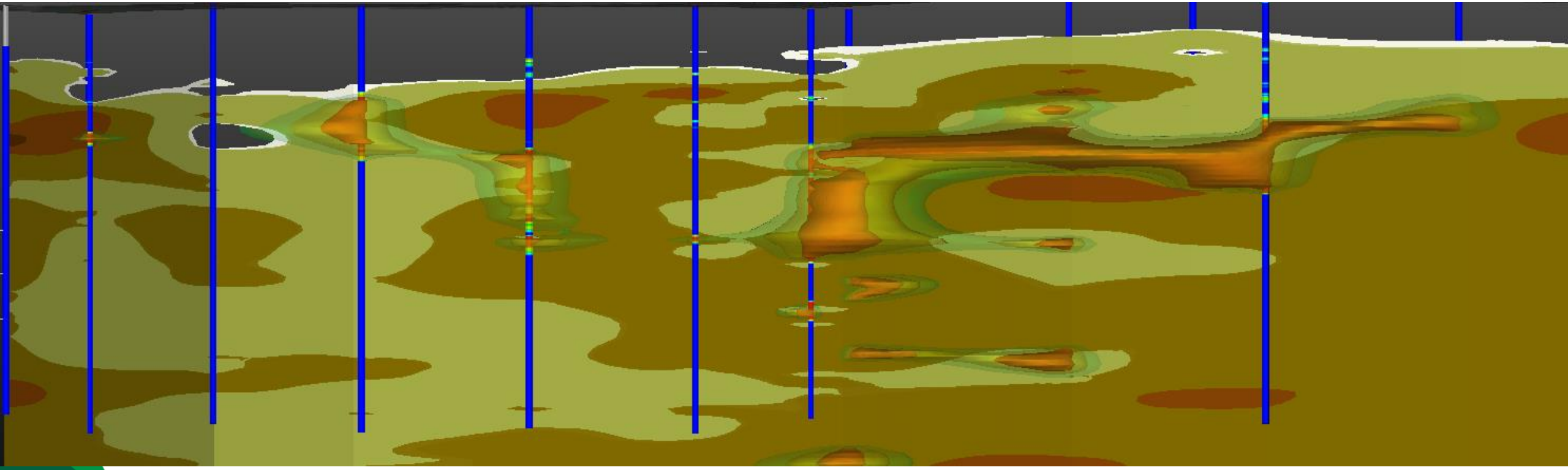

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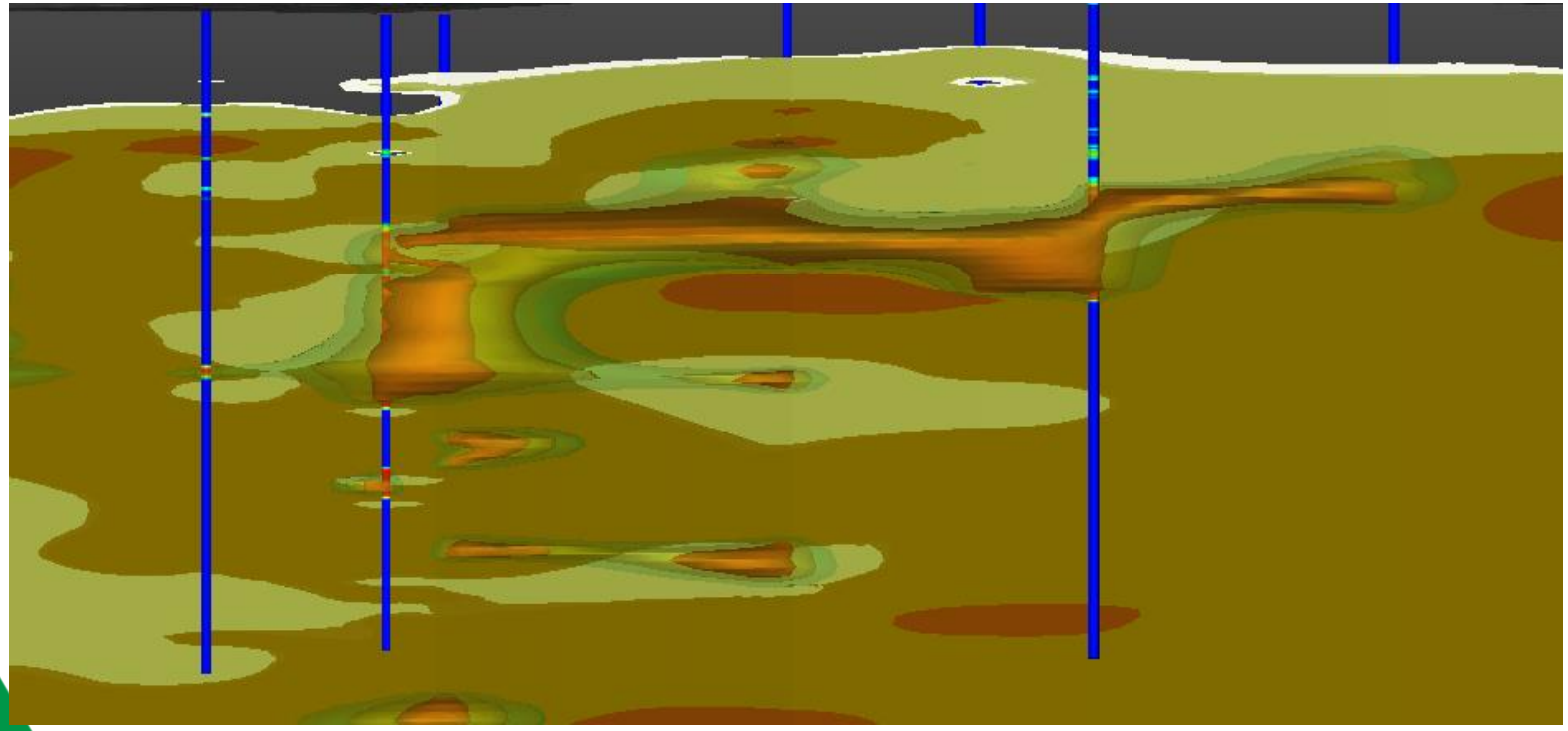

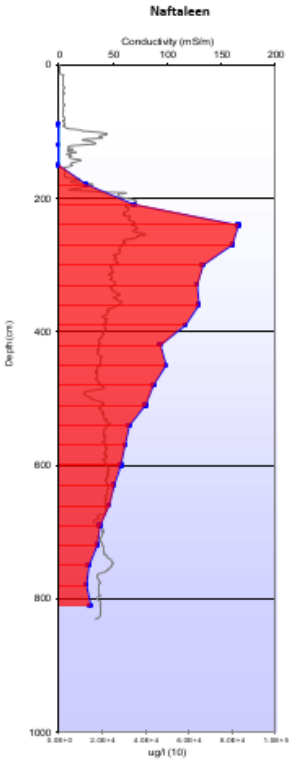

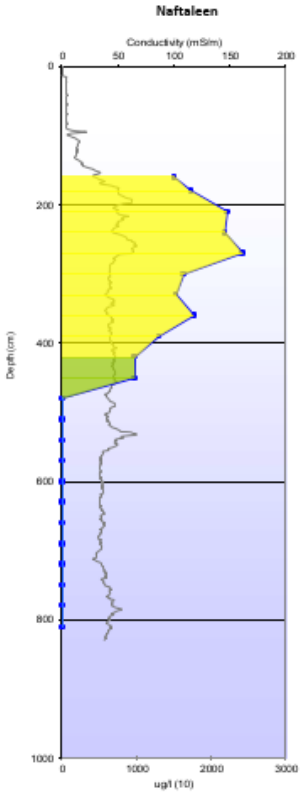

HRSC Tools: EC and HPT

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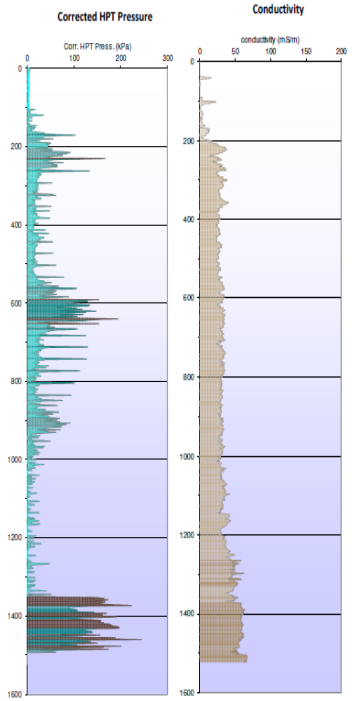
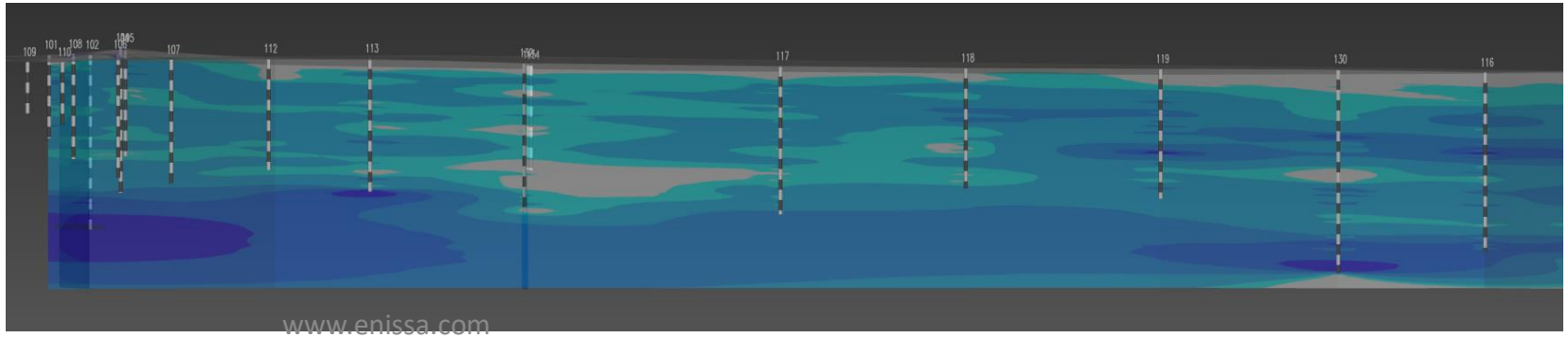
- Additional sensors on MIP and OIP
  - CPT: soil classification
  - Electrical Conductivity (EC) ~ grain size
  - Hydraulic Profiling Tool (HPT)
    - continuous injection of water by flow controlled pump
    - Injection pressure is a measure for local permeability
    - A real-time detailed pressure and flow log is generated for each probing location giving more insight in hydrogeology.



  - Soil stratification
  - Understand contaminant pathways
  - Storage and transport zones



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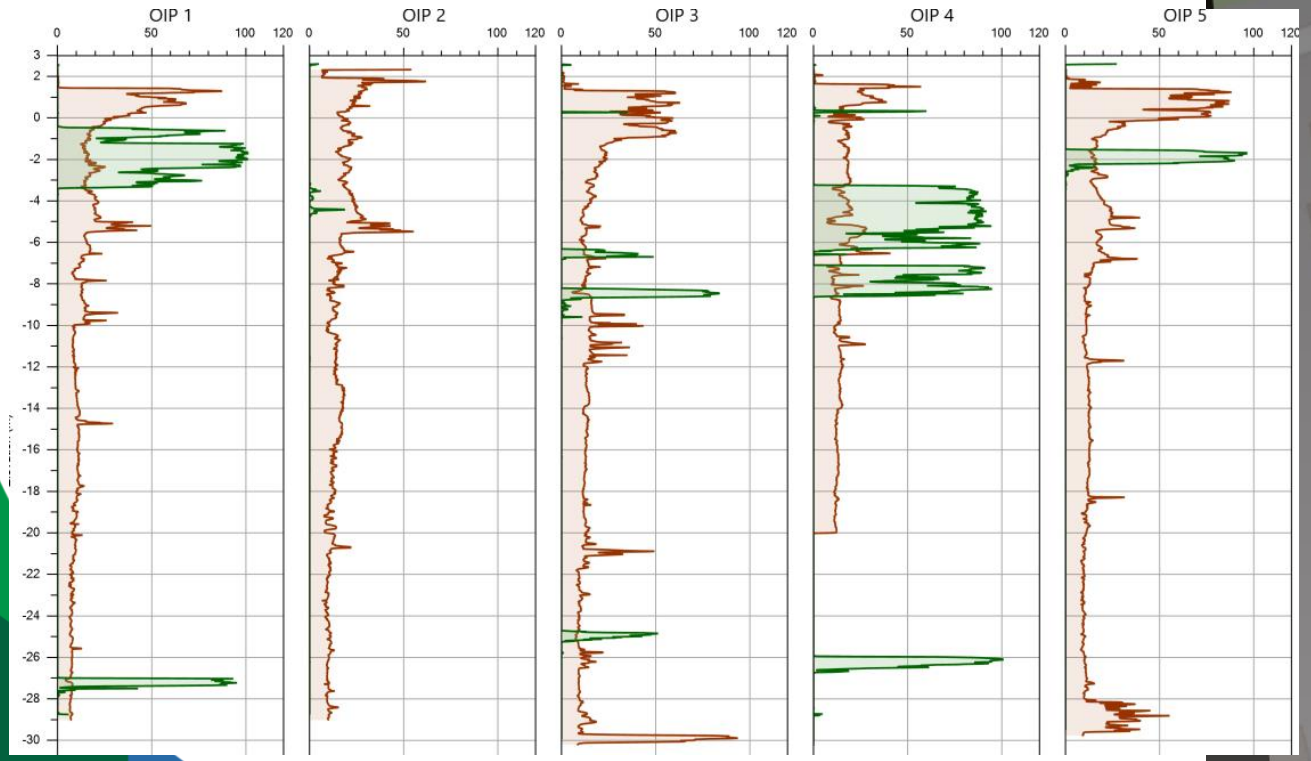
OIP results on Pilot Sites: ‘s Gravenmoer



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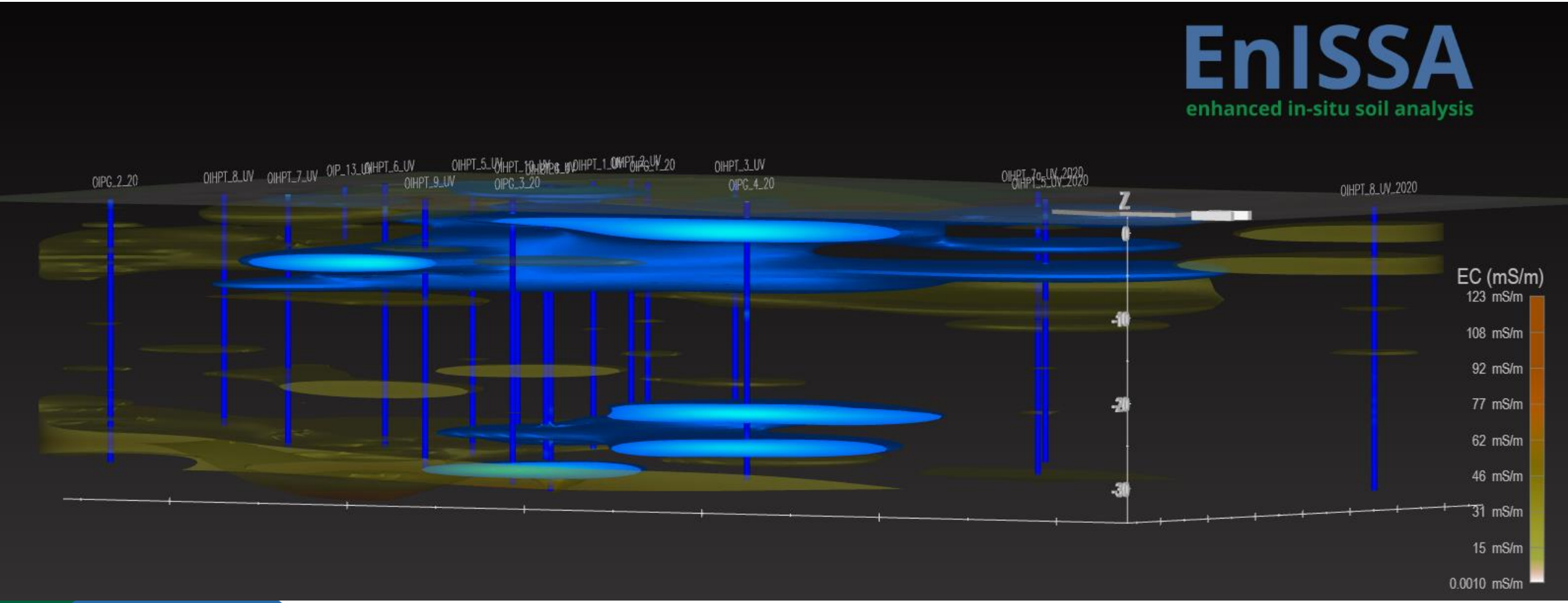

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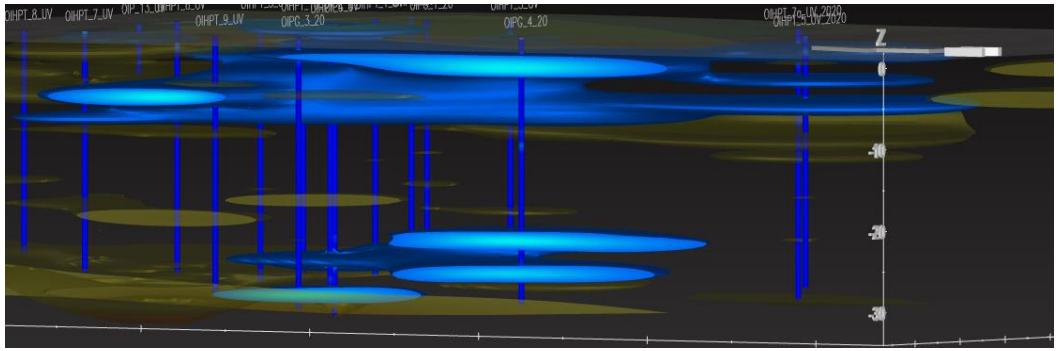
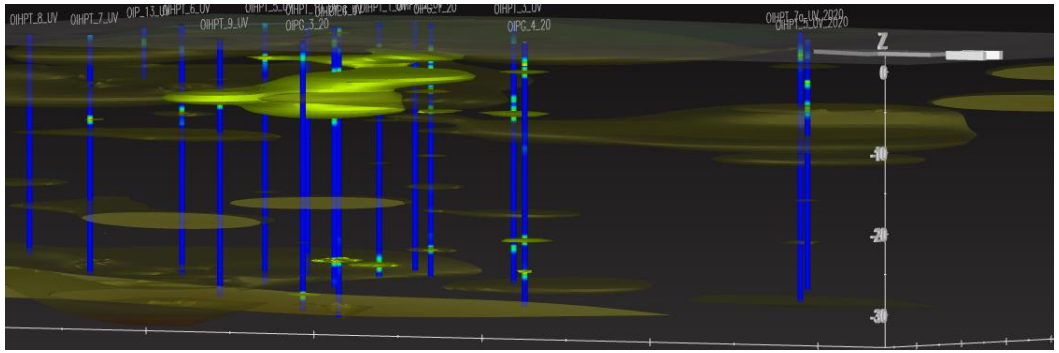
OIP results on Pilot Sites: ‘s Gravenmoer

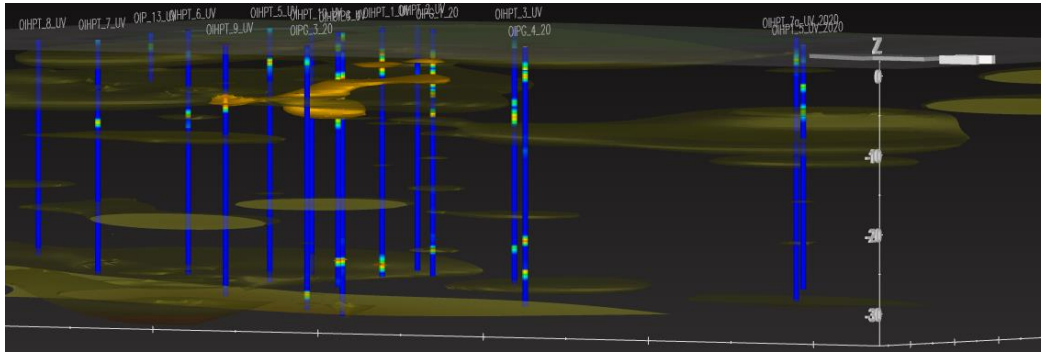
10% fluorescence ca 30 000 m³



50% fluorescence ca 1800 m³



70% fluorescence ca 300 m³



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