GEOAMBIENTE®

High-Resolution Site Characterization Workflow **for Hydrocarbon Remediation**

Danielle Carvalho

Case Study

Preliminary Information

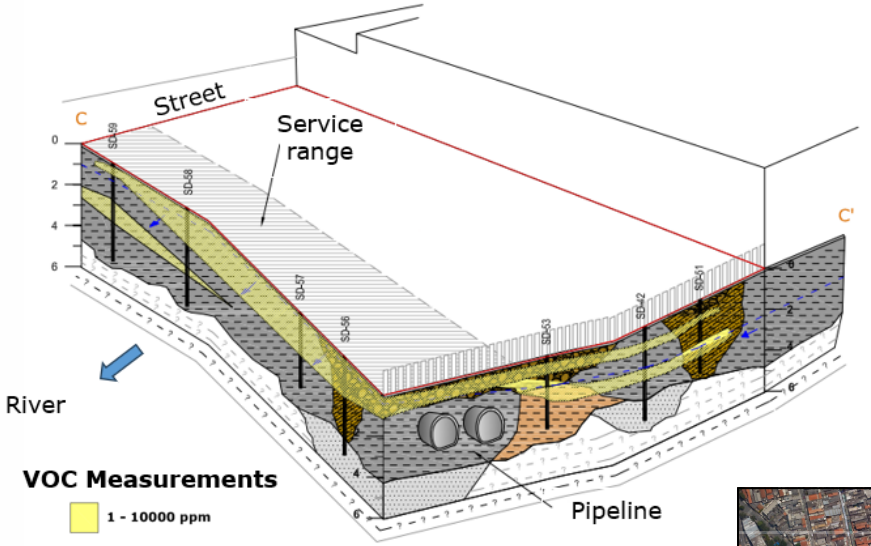


A fuel theft at a gas pipeline leading to a hydrocarbon spill in the middle of a highly populated neighborhood of a big city.

- ~25km **oil pipeline operating** at an average pressure of 14kgf/cm²
- Loss of 275 m³ of **petrochemical naphtha**
- ~100 meters of **visibly impacted area**
- Removal of 732.68 Tons of **soil and waste.**

Case Study

Conceptual Model



Leaking area

Residencial ocupation

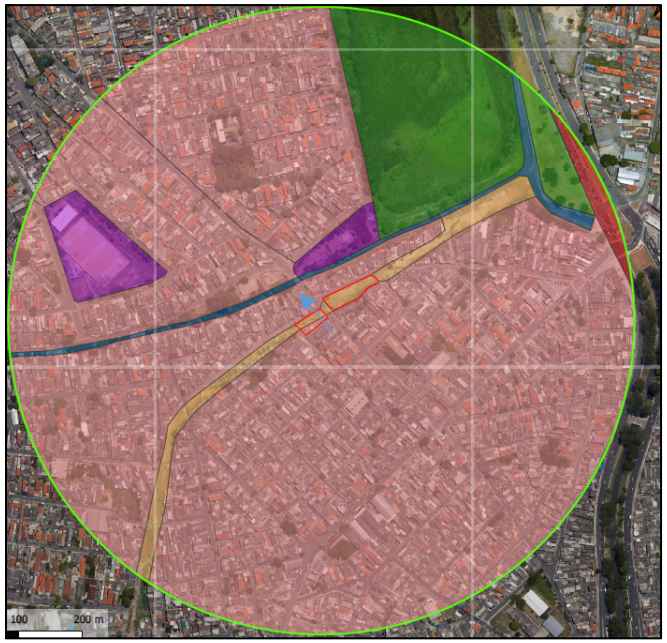
Green area

River

Recreation area

Highway

Groundwater flow



RISKS

Groundwater Ingestion, Dermic Contact and Vapor Inhalation of BTEX and PAH's

Receptors

- Residential population
- Green area biota (~70m from the leaking point)
- Soil, groundwater and Downstream river (~50m from the leaking point)

Explosion Alert!

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Emergency Containment Measures

Operations disrupted

Suction of accumulated naphta

Absorvent blankets

Containment barrirers

Installation of an exhaust fan in the sewage gallery

Continuos monitoring of local atmosphere

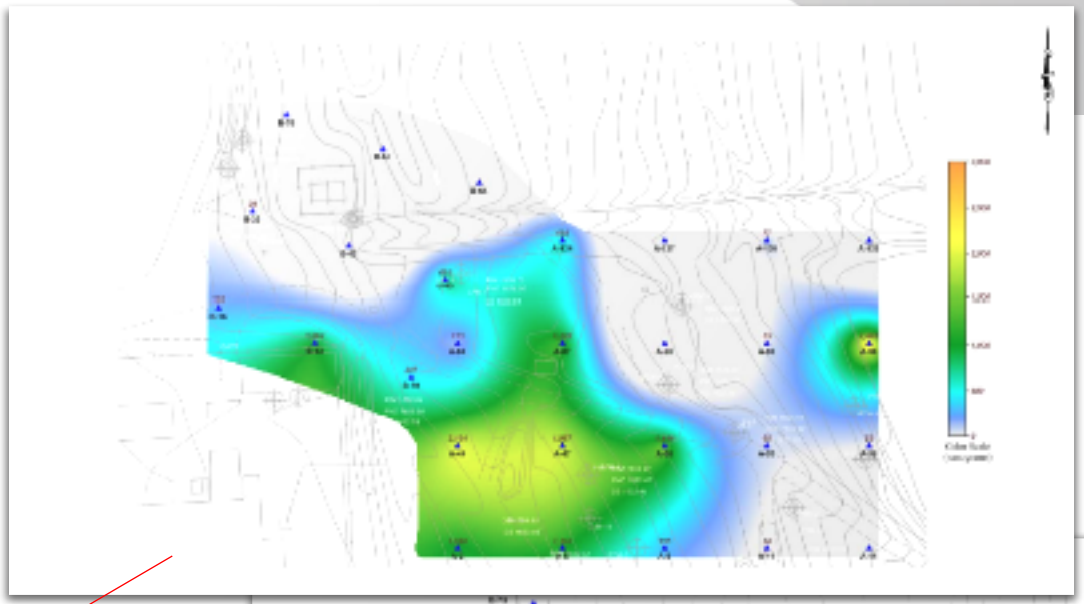
Enviromental Investigation and monitoring protocols start

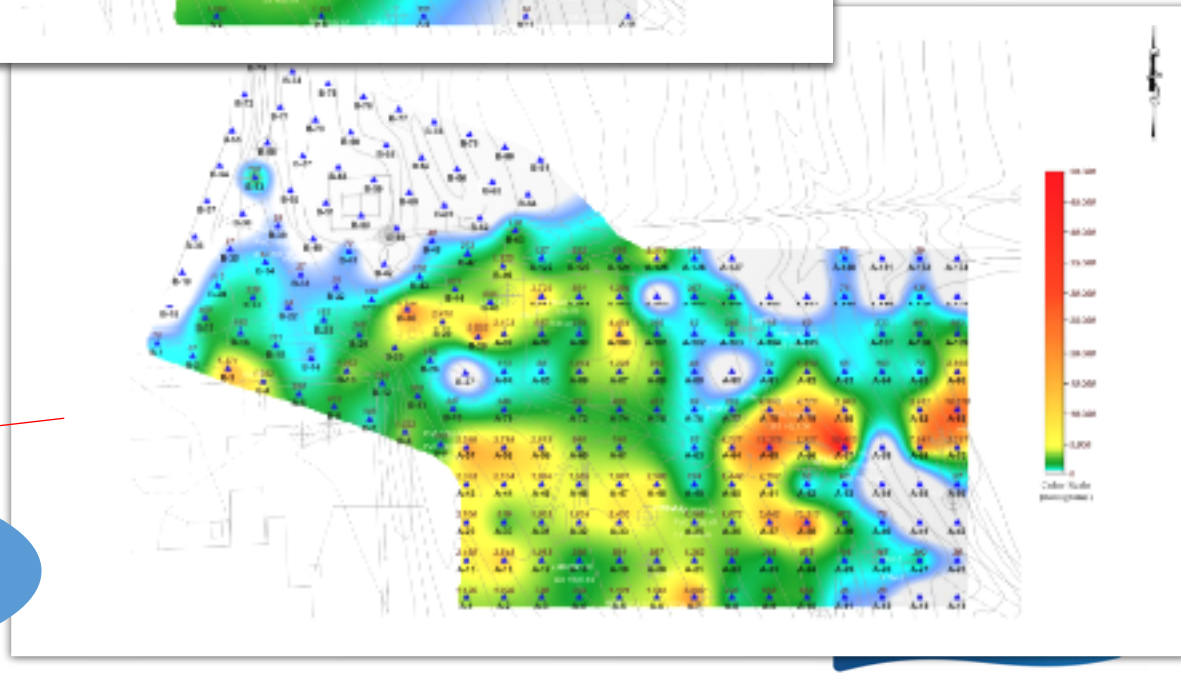
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Data Bases

A lot of data has been acquired over time. But is that enough?







What we think the situation is

versus

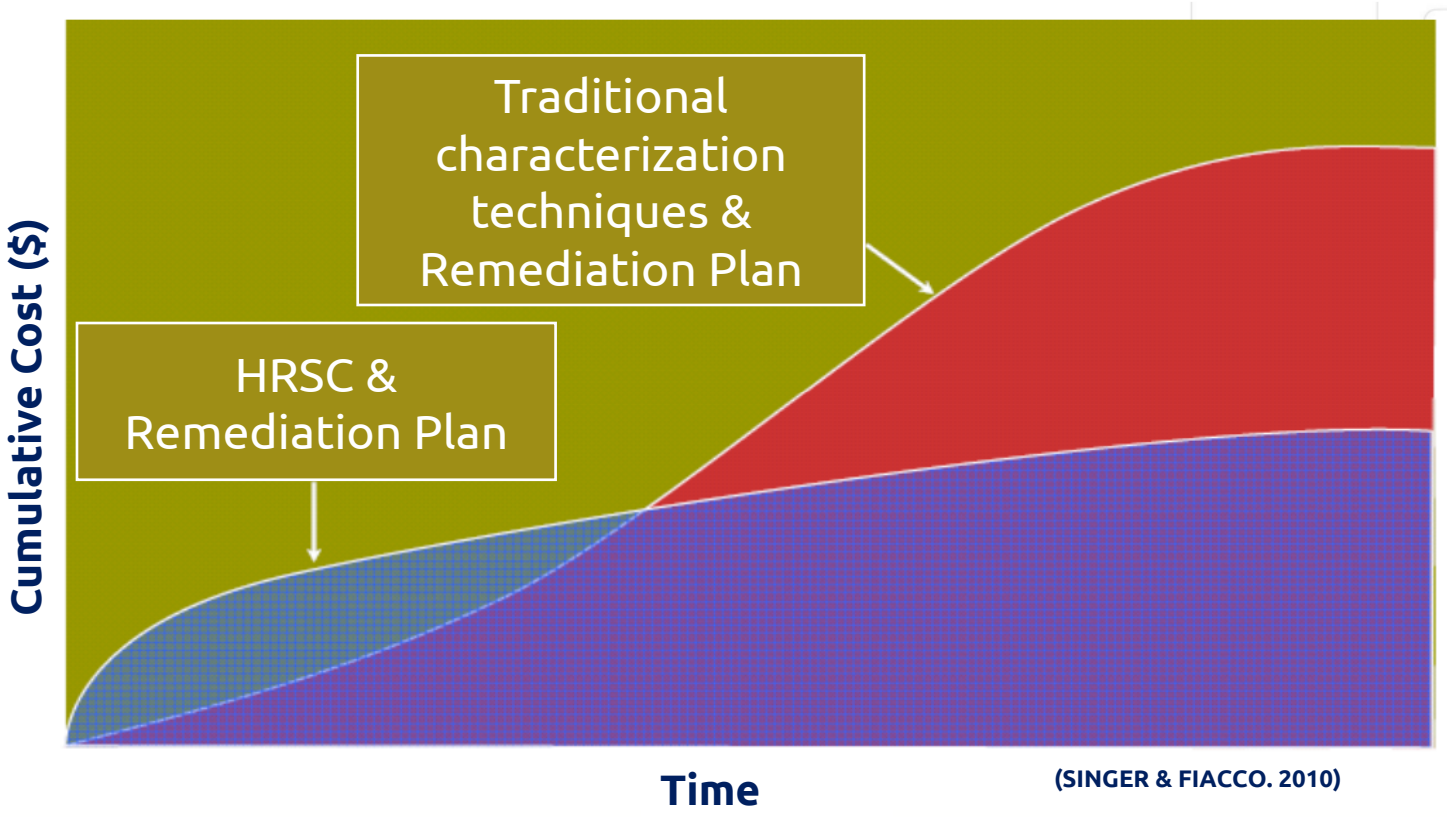
What we are missing

Why is it important?

HRSC AS A **REMEDIATION ALLY**

“A high-quality investigation can help reduce the amount invested for remediation” (QUINNAN. 2012)

- **Scale-apropriate** measurement and sample density to build accurate **Conceptual Models;**
- Faster decision making and time saving. **reducing ROI** (Return on Investigation);
- Better comprehension of **contaminant distributions** and **physical context** reducing uncertainties and total project costs;

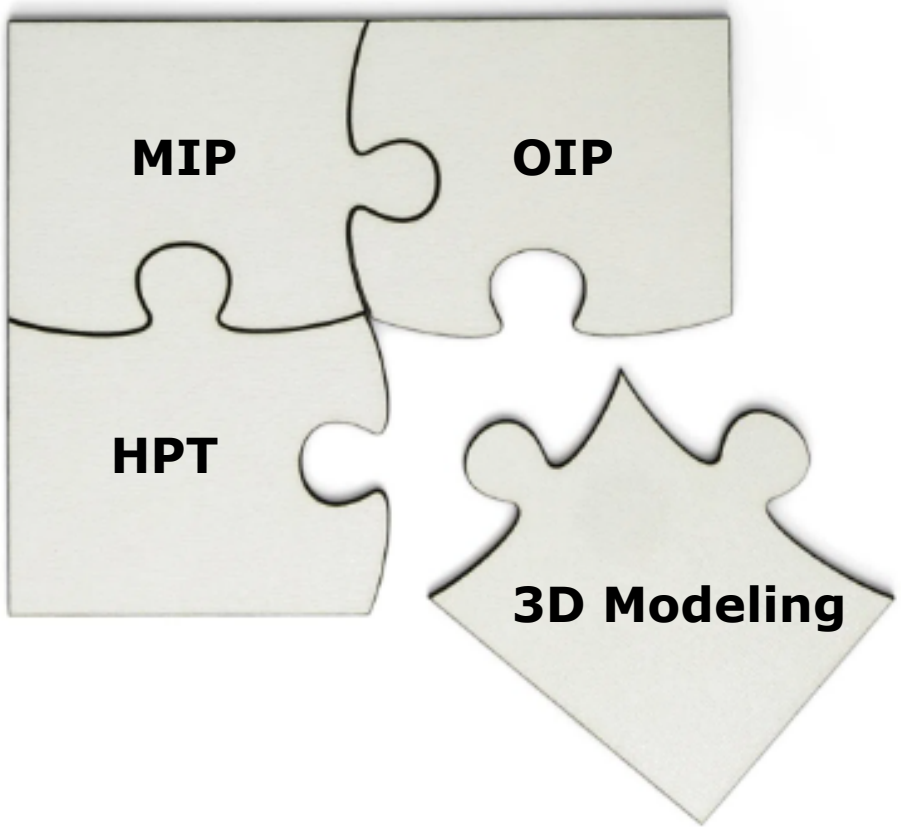


(SINGER & FIACCO. 2010)

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Wich Thecniques **Were Applied?**

Over 400 soil samples
Over 150 monitoring wells
(groungwater and vapor)
At least 5 campaings of
groundwater monitring



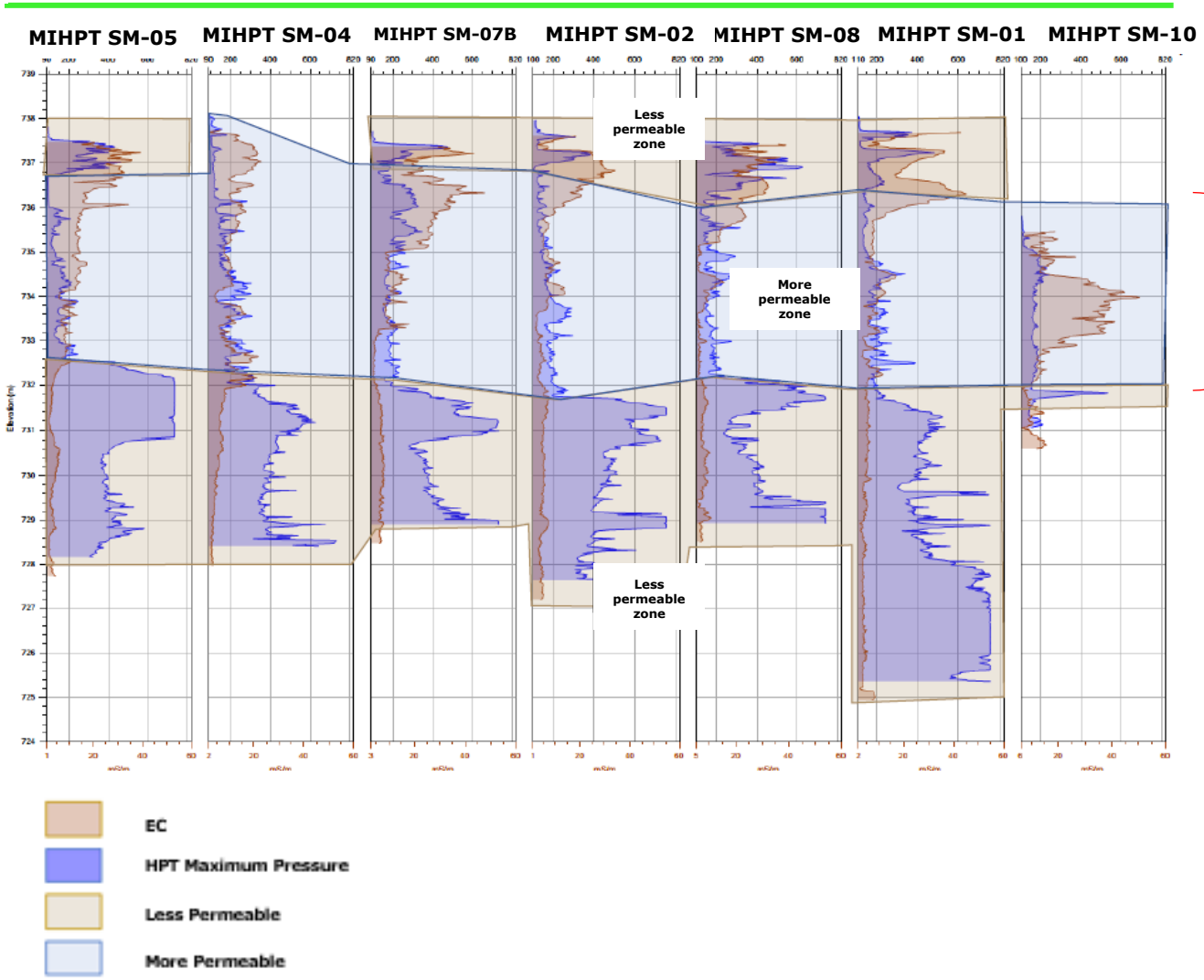
Goals:

- Mapping center of mass and delimited contamination plumes
- Mapping LNAPL/ Hydrocarbon compounds and residual phase
- Hydrostratigraphic Characterization
- Investigation data interpolation to optmize Remediation Plan

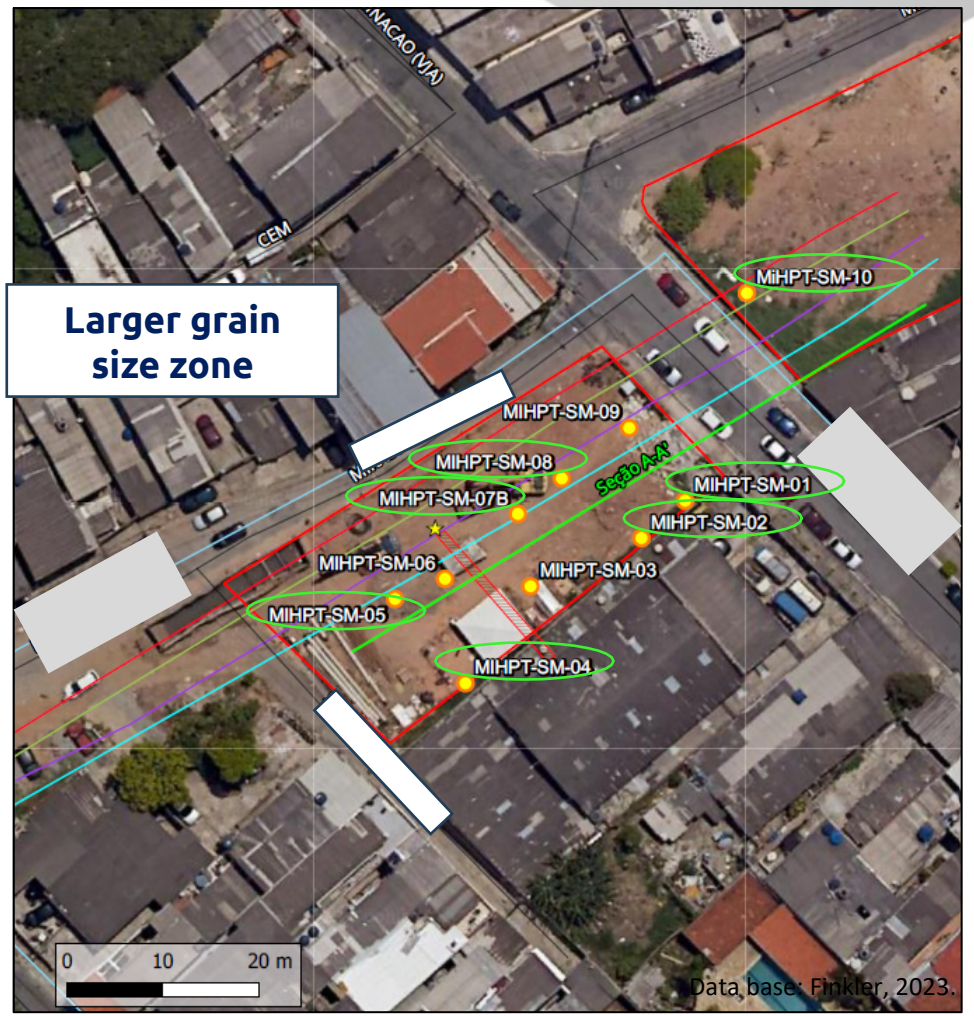
EC - Electrical Conductivity

A

A’

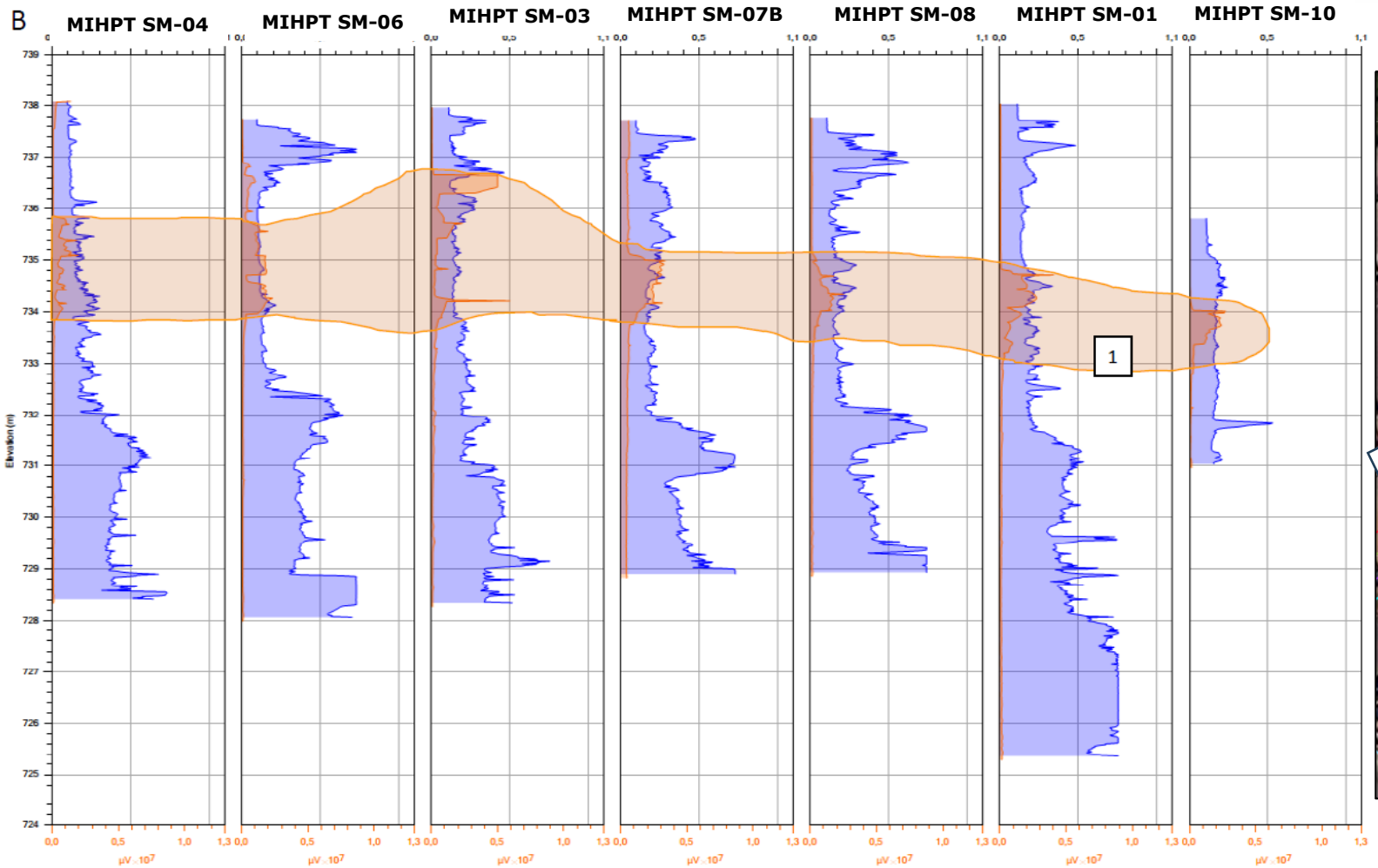


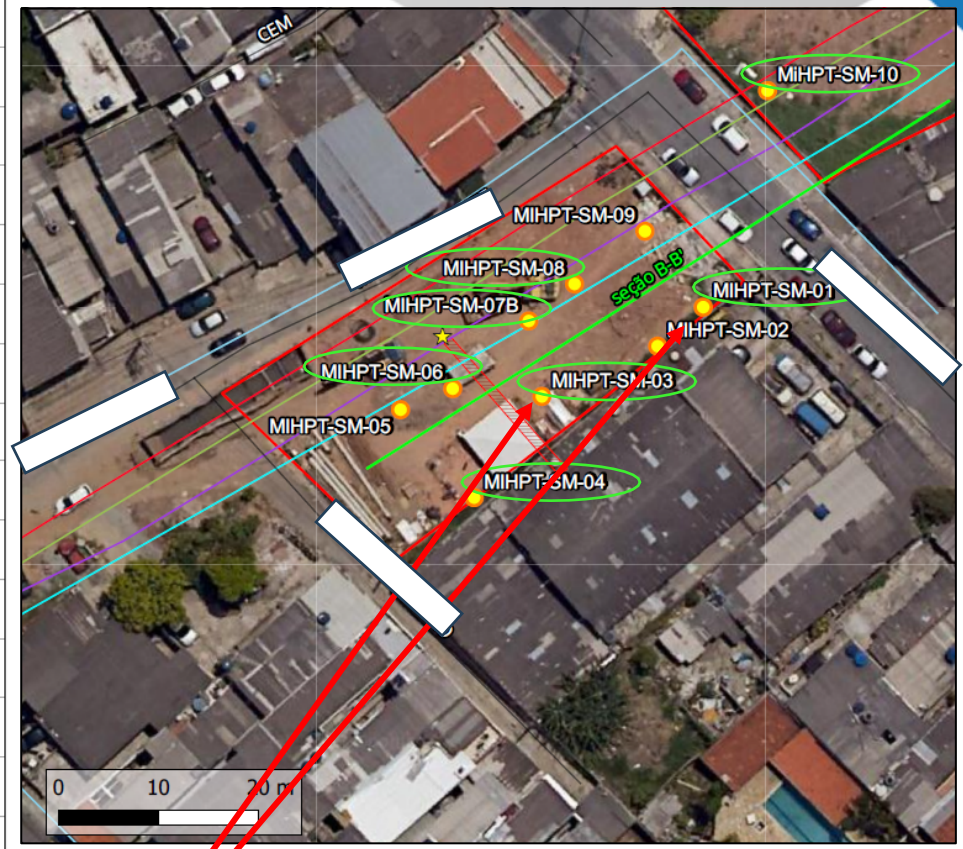
Larger grain size zone



Data base: Finkler, 2023.

PID Detection





PID

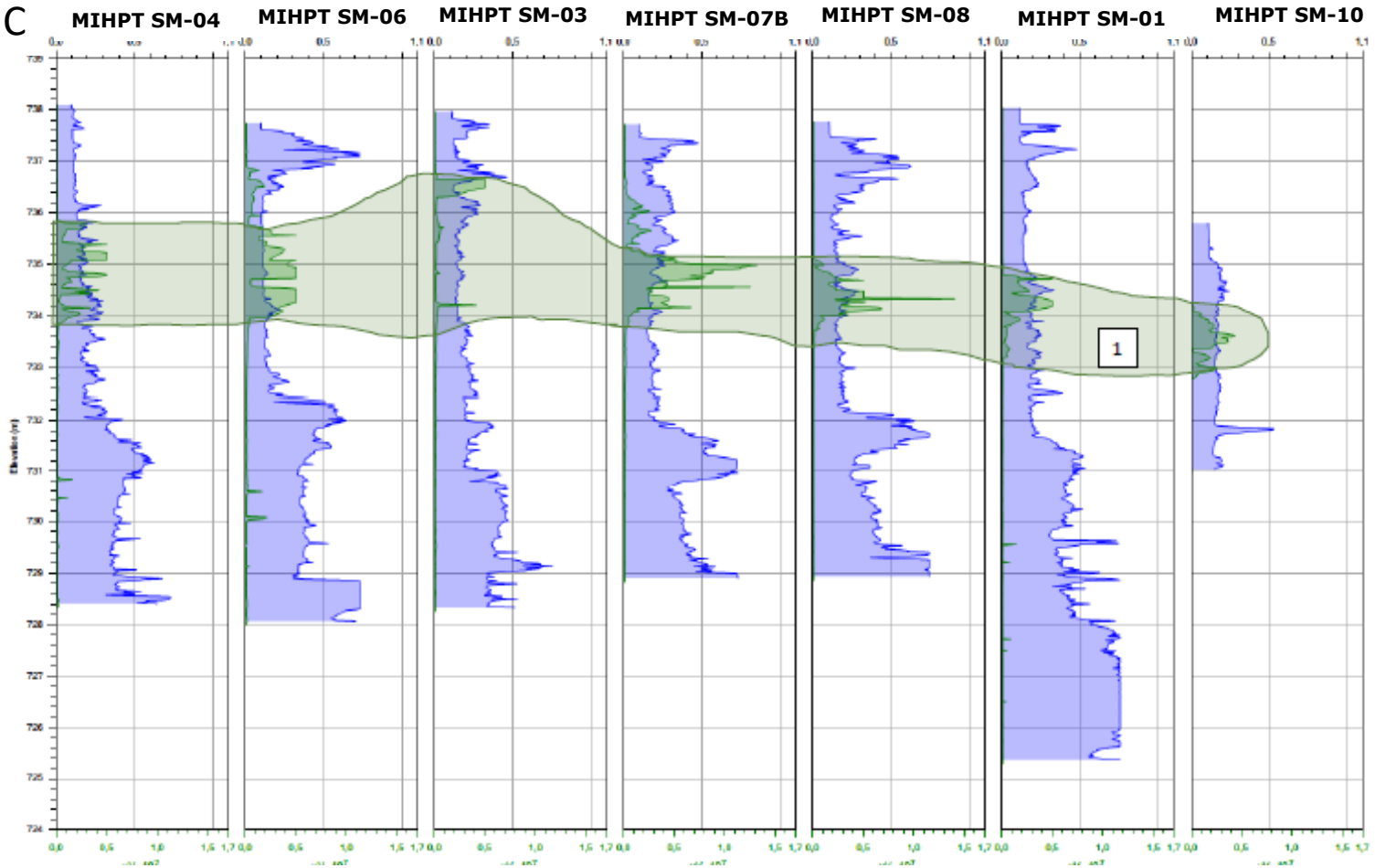
HPT Maximum Pressure

1 **Highers PID detections**

Highest values in MiHPT-SM-03 and 01 with detected interference values of up to **5.93x106 µv** and **4.05x106 µv,** respectively.

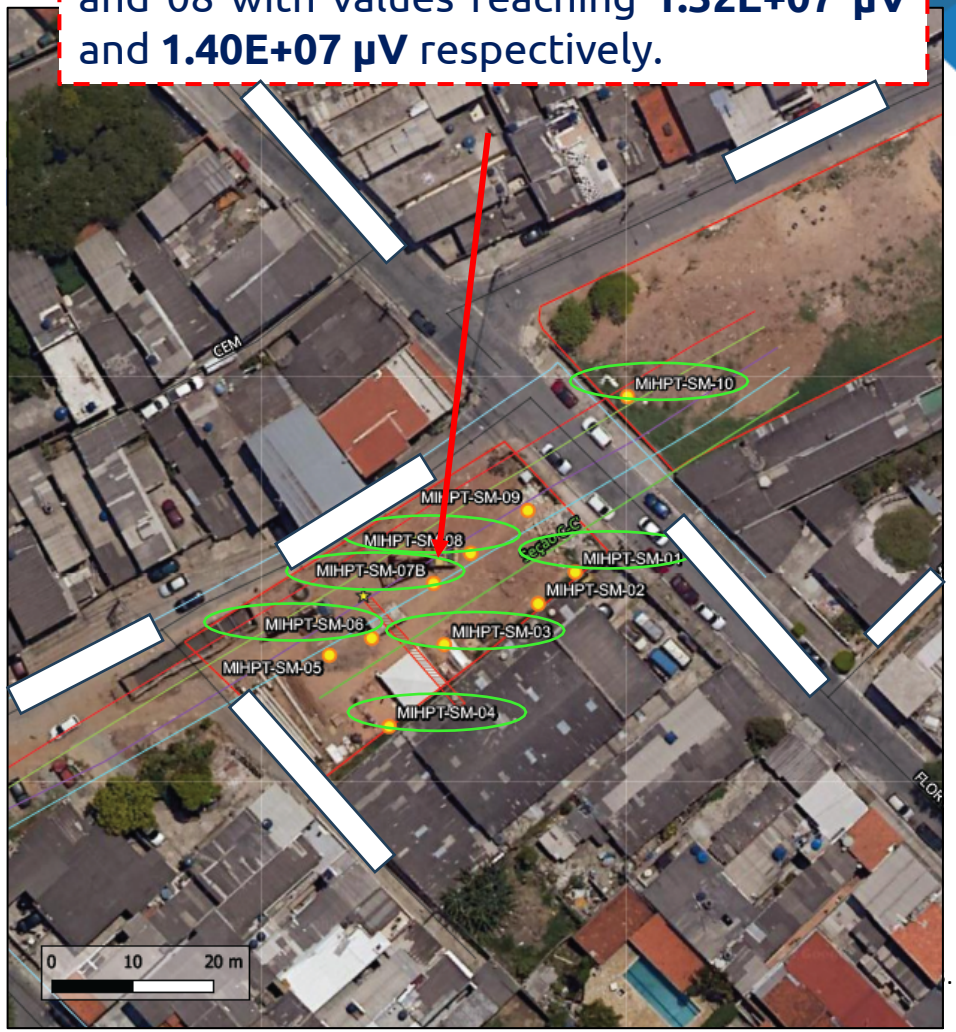
FID Detection

C



C'

Highest FID values occur close to the derivation point mainly in MiHPT-SM-07 and 08 with values reaching **1.32E+07 µV** and **1.40E+07 µV** respectively.



FID

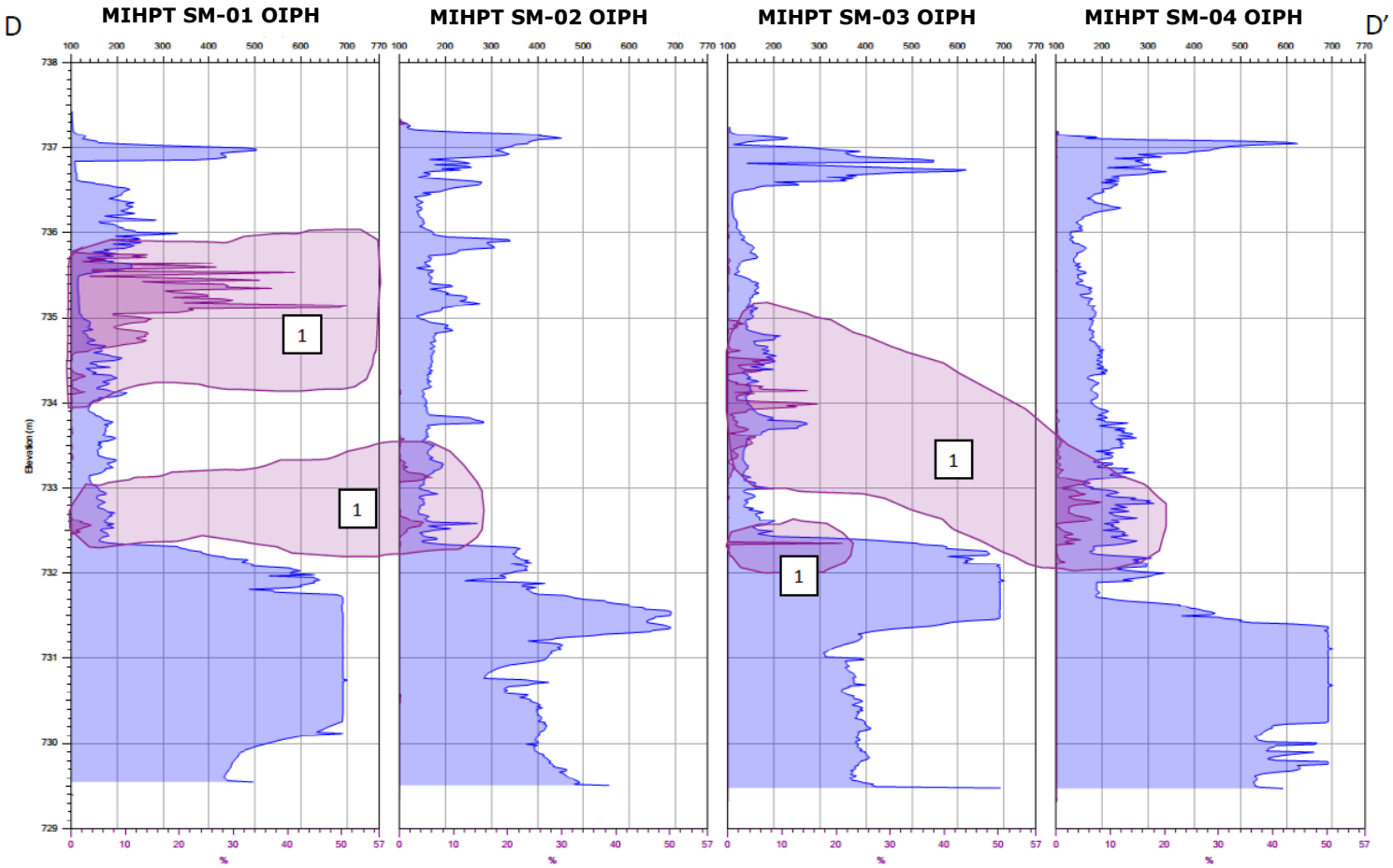
HPT Maximum Pressure

1 **Higher FID detections**

FID detections are similar in depth, thickness and detection range to the PID values, indicating petroleum hydrocarbons and/or BTEX presence.

→ **Naphta leak**

Fluorescence





Fluorescence

HPT Maximum Pressure

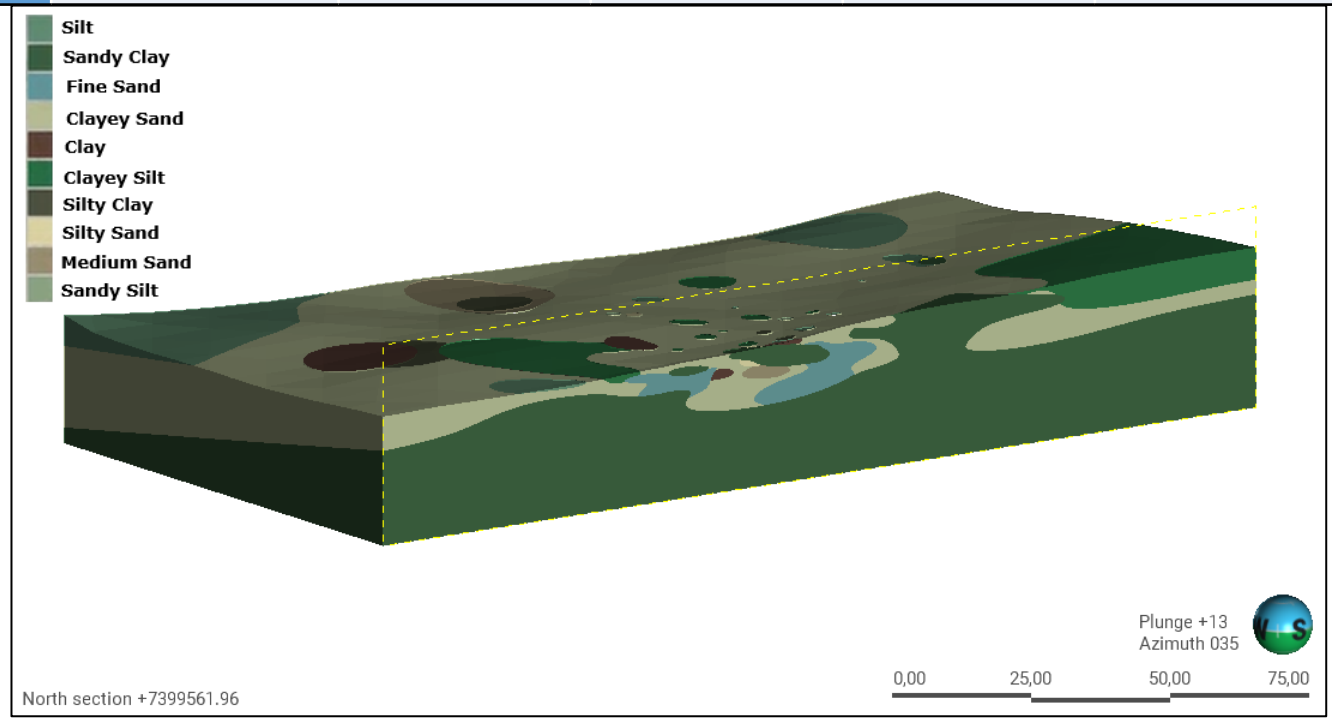
1 **Higher Fluorescence detections (51%)**

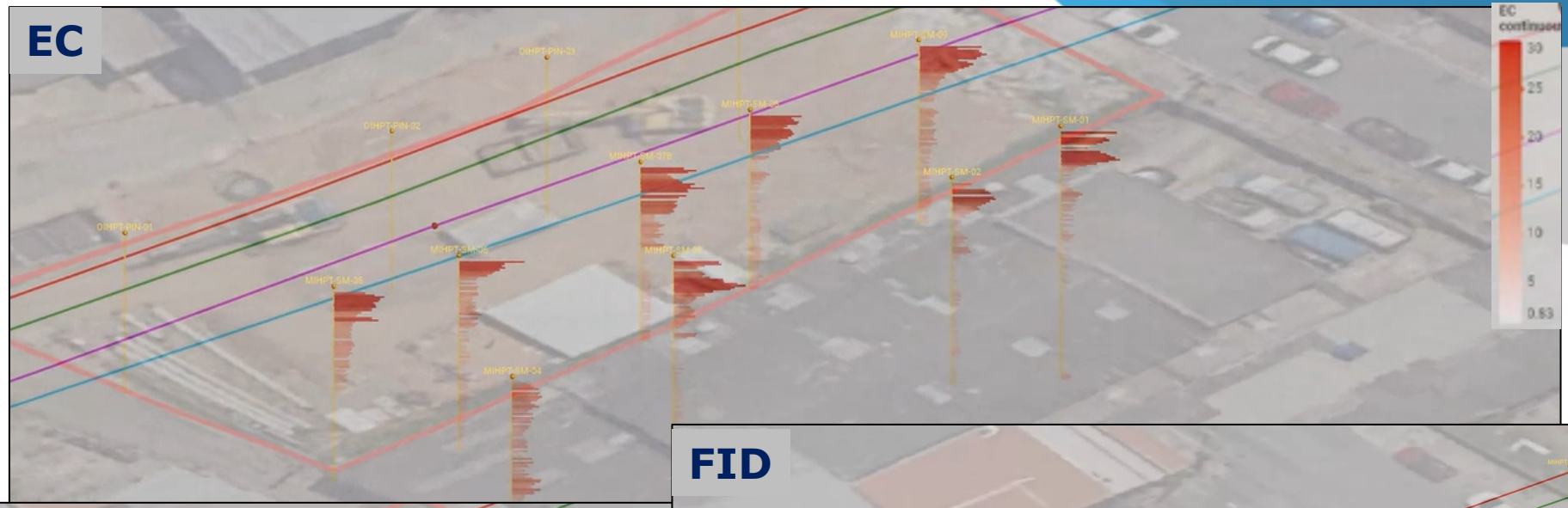
Highest values are located in the vertical layer located between **1.0 and 5 meters** deep. This layer reached maximum HPT values close to **400 kPa.**

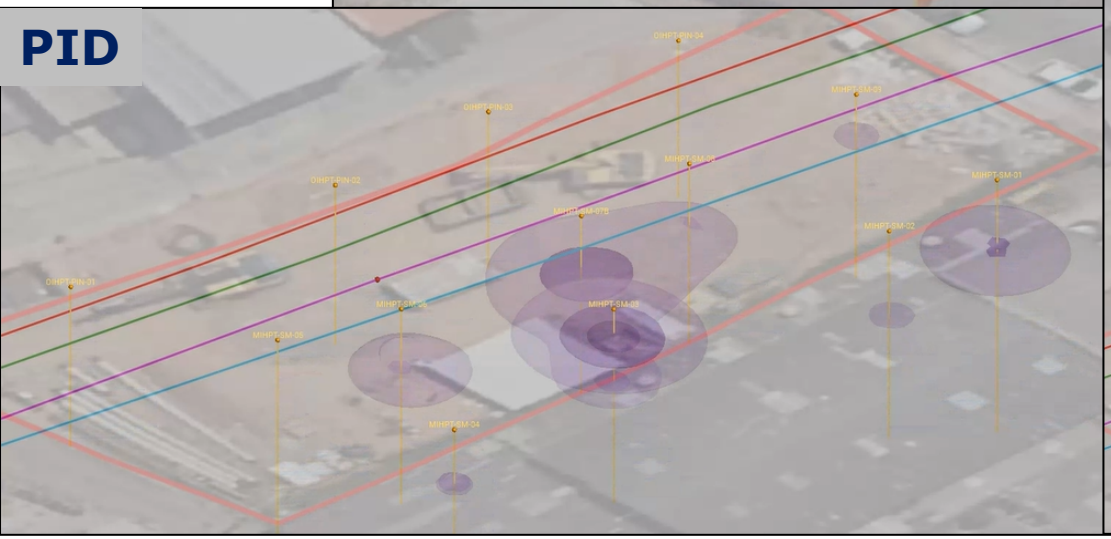
Hydrostratigraphic units **characterization**

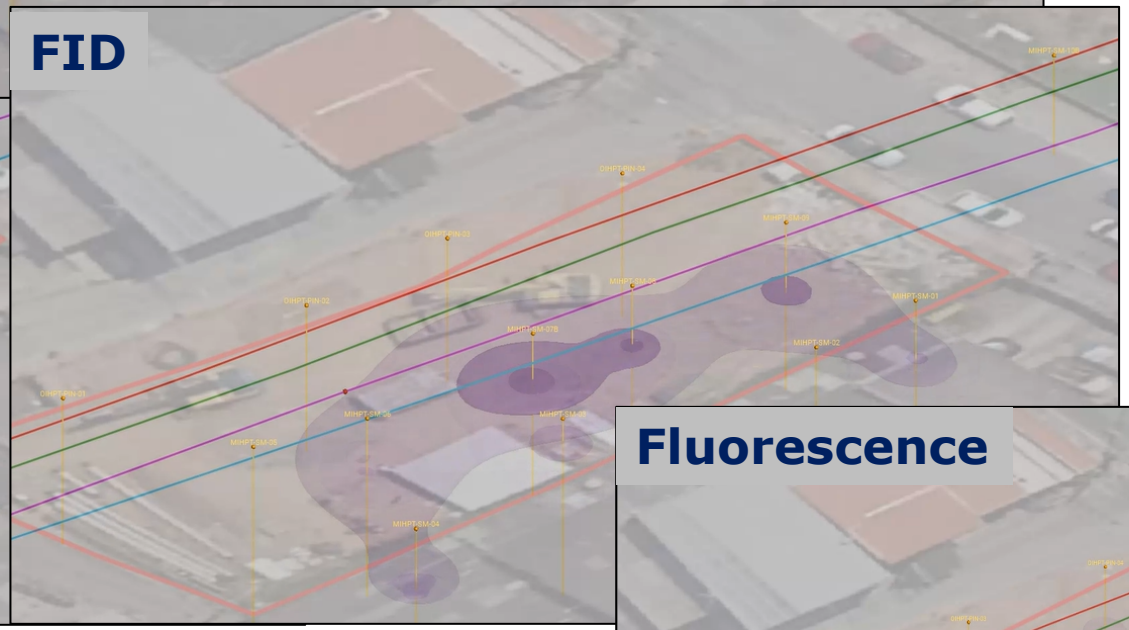
Soil Characterization by Grain Size	Data Amount	Maximum Thickness (m)	Medium Thickness (m)	Minimal Thickness (m)	Hydrostratigraphic Unit
Clayey Sand	192	5.50	1.31	0.10	Bg01
Sandy Clay	73	5.90	1.61	0.25	Lt01
Fine Sand	51	3.90	1.56	0.40	Lt02
Clay	40	3.20	1.09	0.10	Lt03
Clayey Silt	25	4.00	1.52	0.50	Lt04
Silty Clay	16	5.80	1.47	0.20	Lt05
Silt	15	2.00	0.98	0.30	Lt06
Silty Sand	15	4.80	2.19	1.05	Lt07
edium Sand	11	3.40	1.39	0.50	Lt08
Sandy Silt	2	1.20	1.10	1.00	Lt09

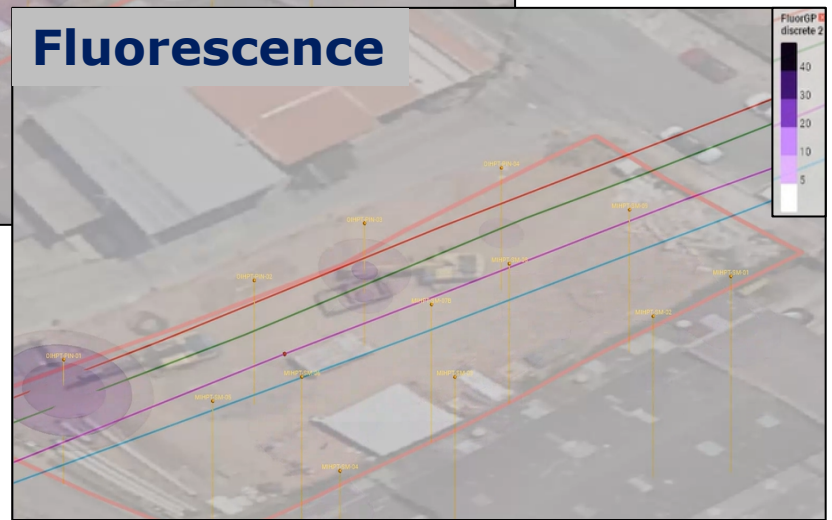




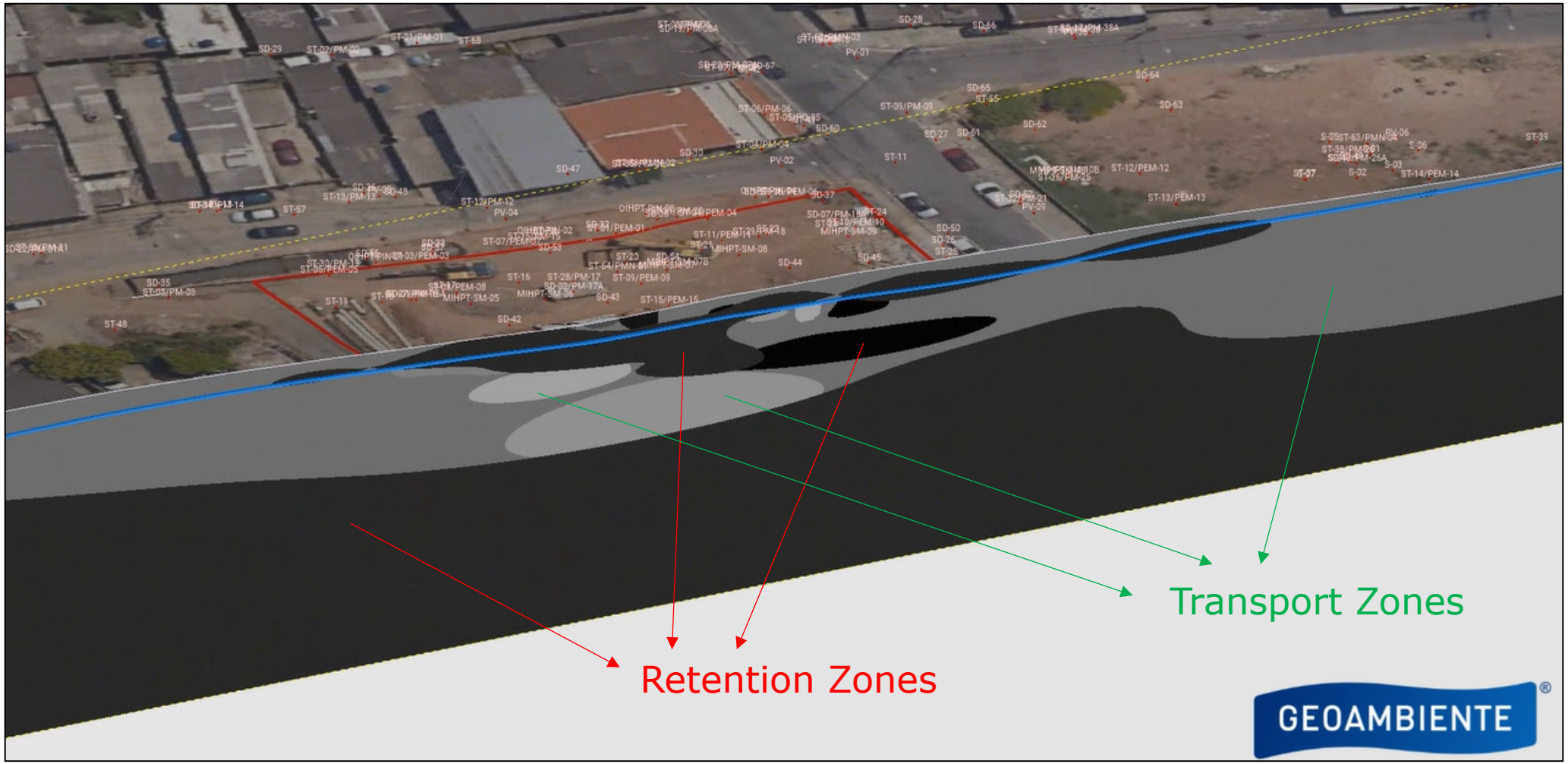

EC
EC continuous
30
25
20
15
10
5
0.83


PID


FID


Fluorescence
FluorGP discrete 2
40
30
20
10
5

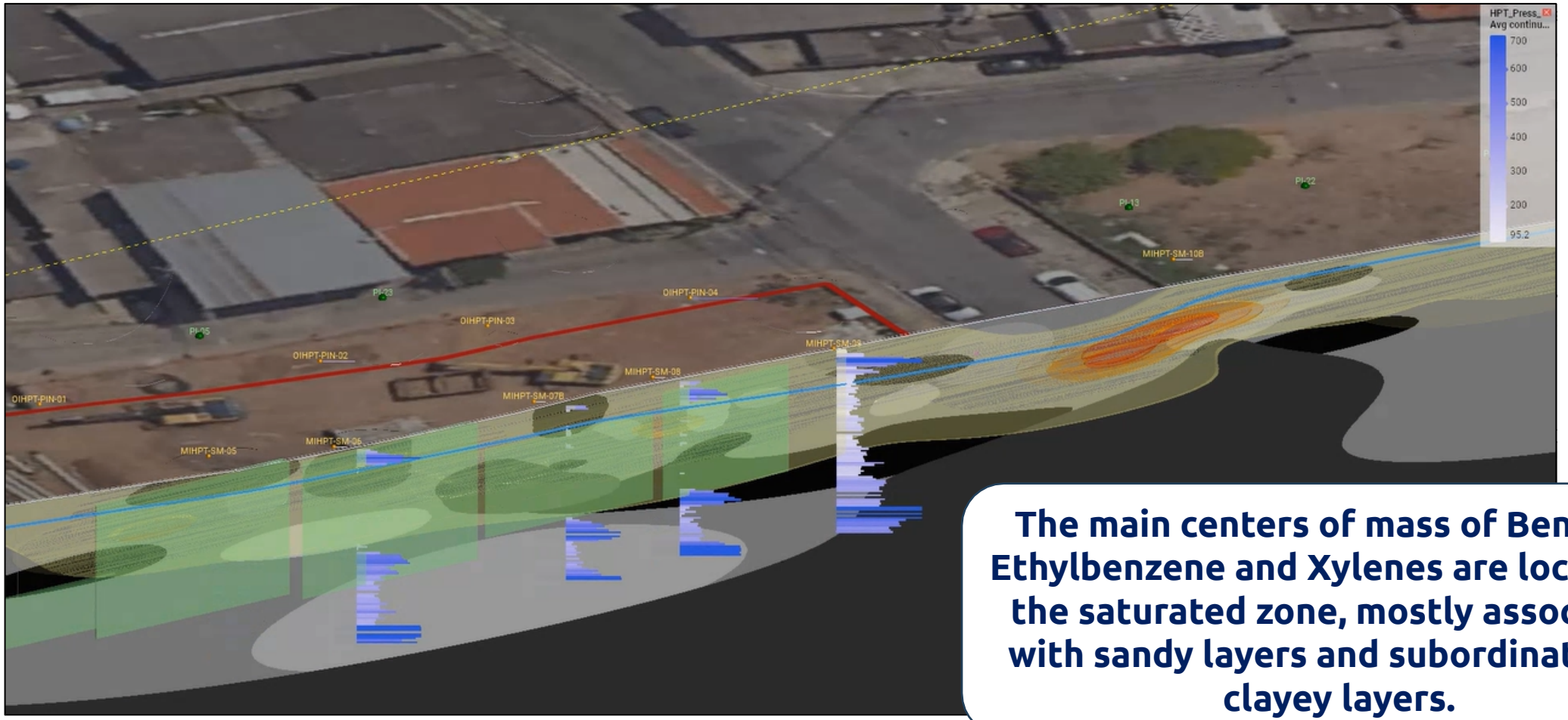
Permeability
Model



Contaminants Spatial Distribution

Contamination plumes are vertically distributed in the **finest grain size.**

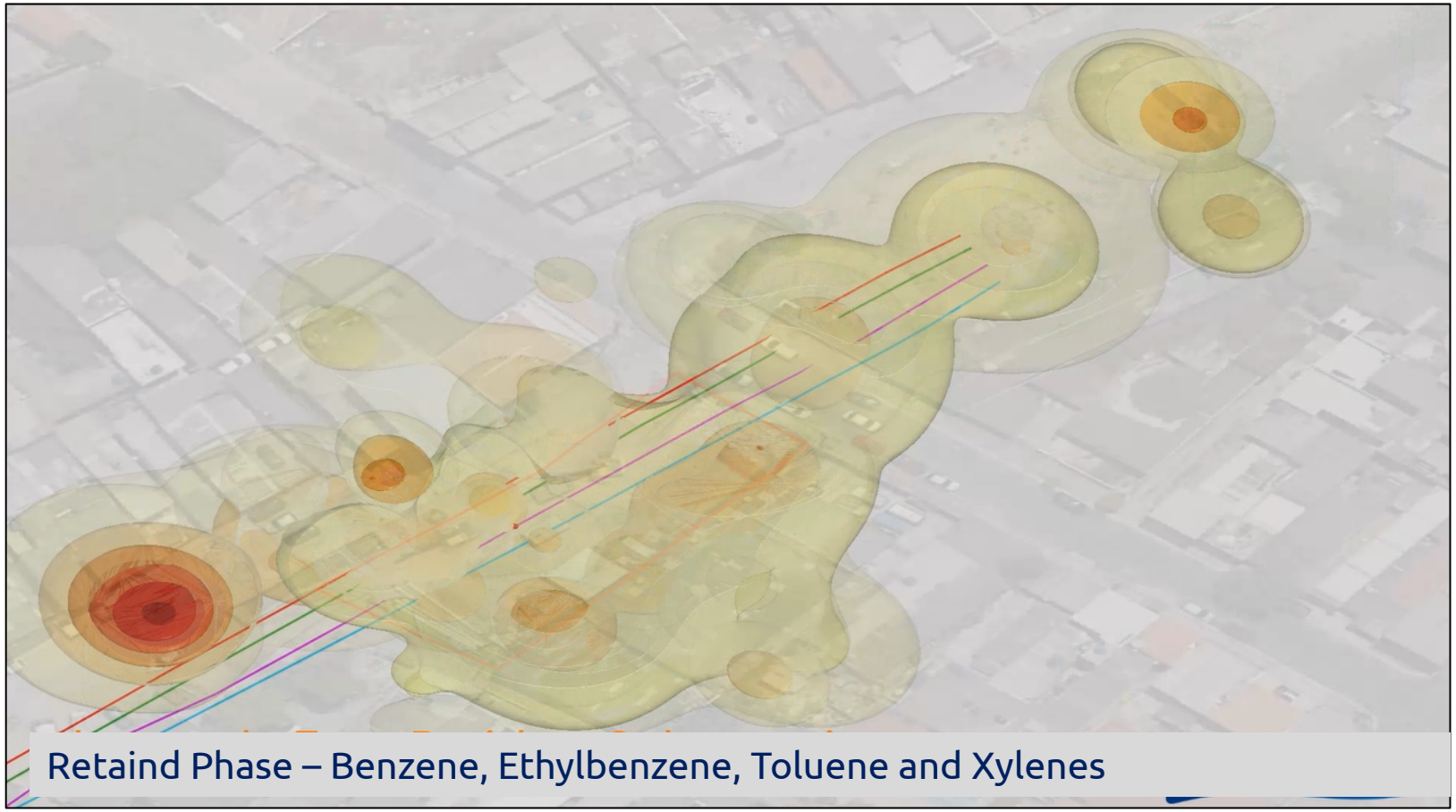
Medium depht range of plumes ocurrences: **1.9m to 3.3m**



The main centers of mass of Benzene, Ethylbenzene and Xylenes are located in the saturated zone, mostly associated with sandy layers and subordinately in clayey layers.

HRSC WORKFLOW
ACHIEVEMENTS

- Contaminant plume characterization (free phase and dissolved phase);
- Information regarding the area hydrogeological behavior of the soil layers.
- 3D modeling allowed the interpolation and interpretation of HRSC data, resulting in a less estimated and more accurate model.



Retaind Phase – Benzene, Ethylbenzene, Toluene and Xylenes

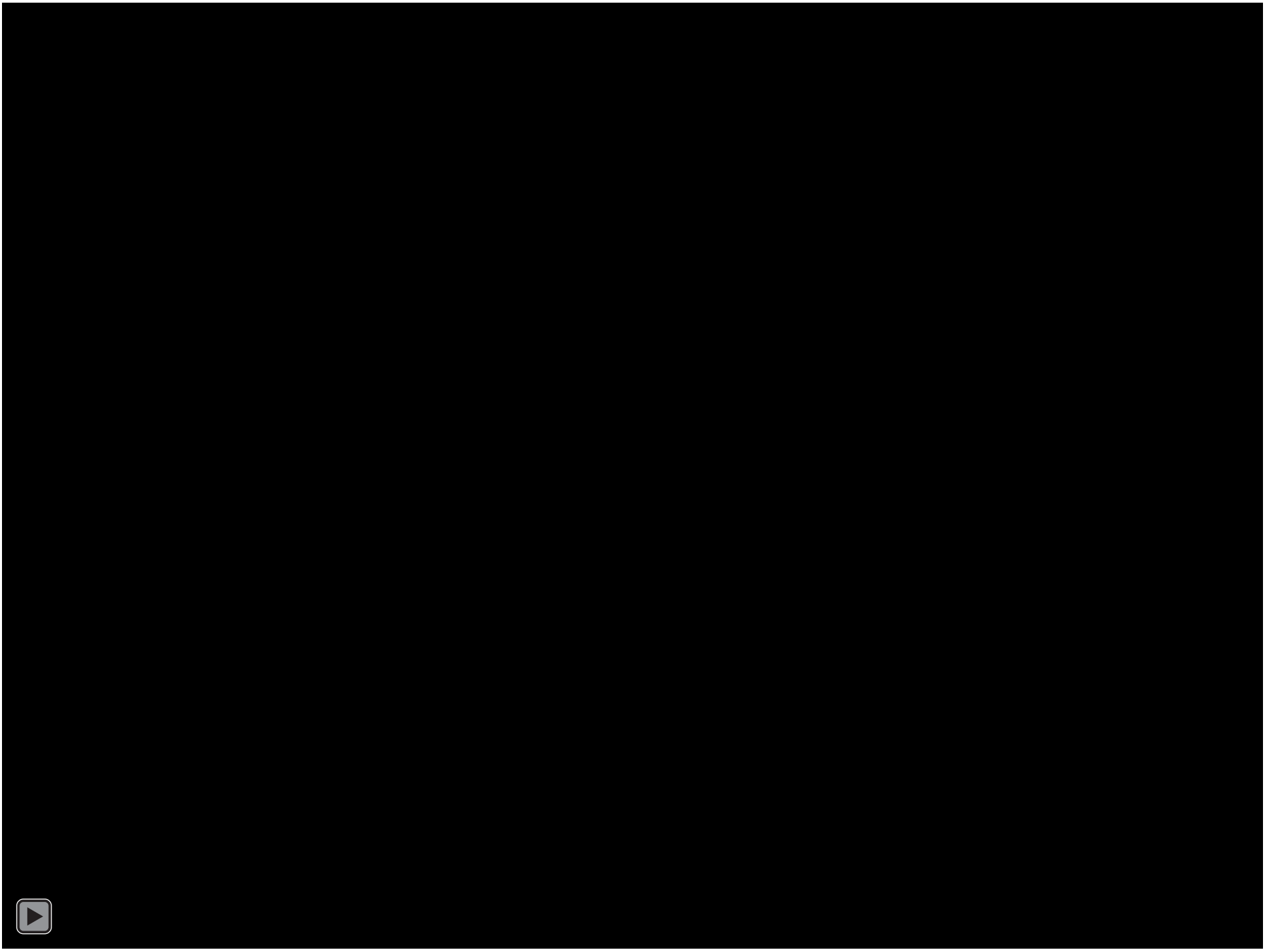
Next step: **Remediation Plan**

Remediation
Projetc Sizing

- ❑ 30 injection points (9.0 m apart from each other)
- ❑ 13 points downstream of the service range
- ❑ 17 points upstream of the service
- ❑ Average influence radius of 5.0 m

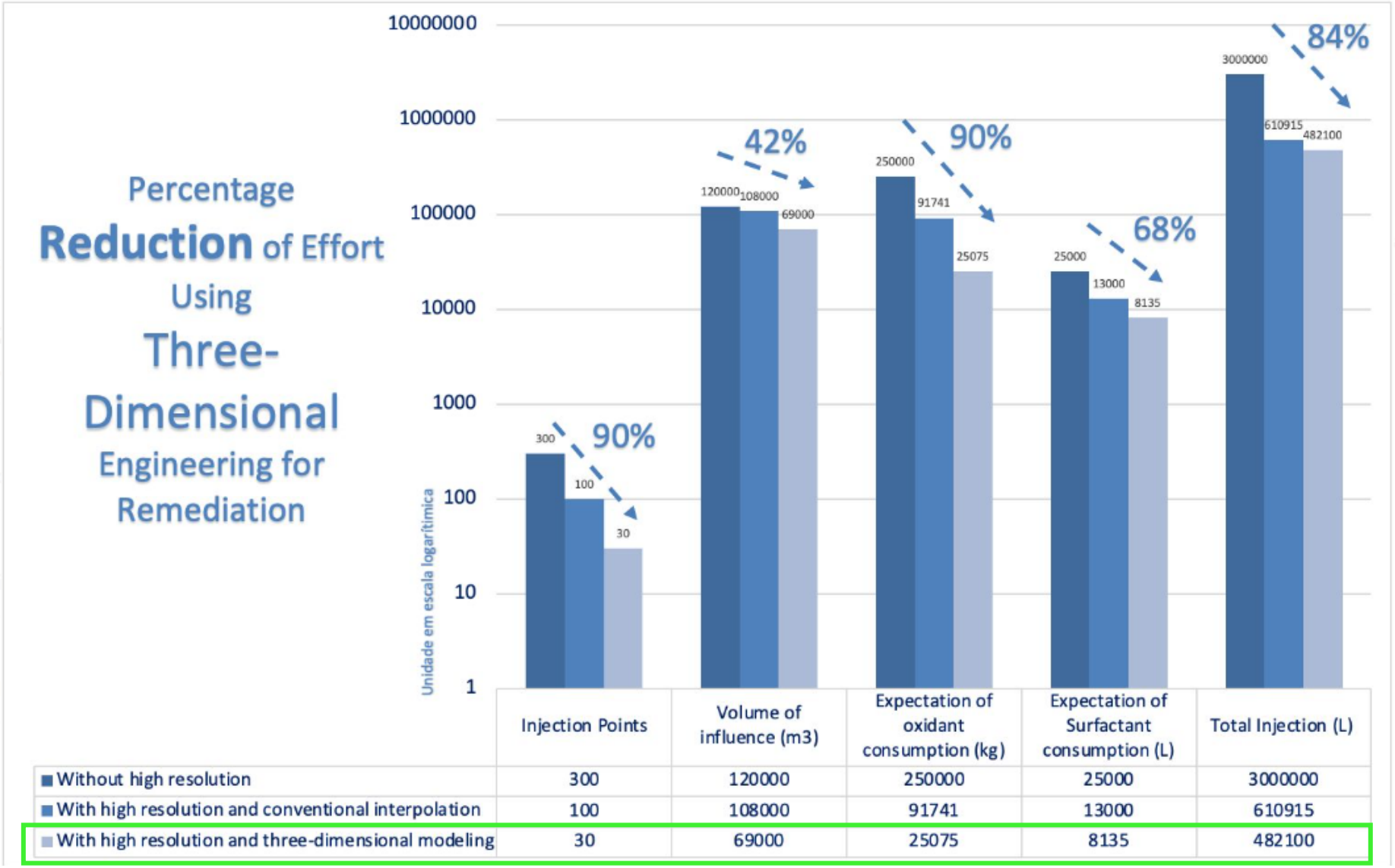


Injection Points



Remediation Projetc Sizing

Advantages of HRSC



	Injection Points	Volume of influence (m3)	Expectation of oxidant consumption (kg)	Expectation of Surfactant consumption (L)	Total Injection (L)
Without high resolution	300	120000	250000	25000	3000000
With high resolution and conventional interpolation	100	108000	91741	13000	610915
With high resolution and three-dimensional modeling	30	69000	25075	8135	482100

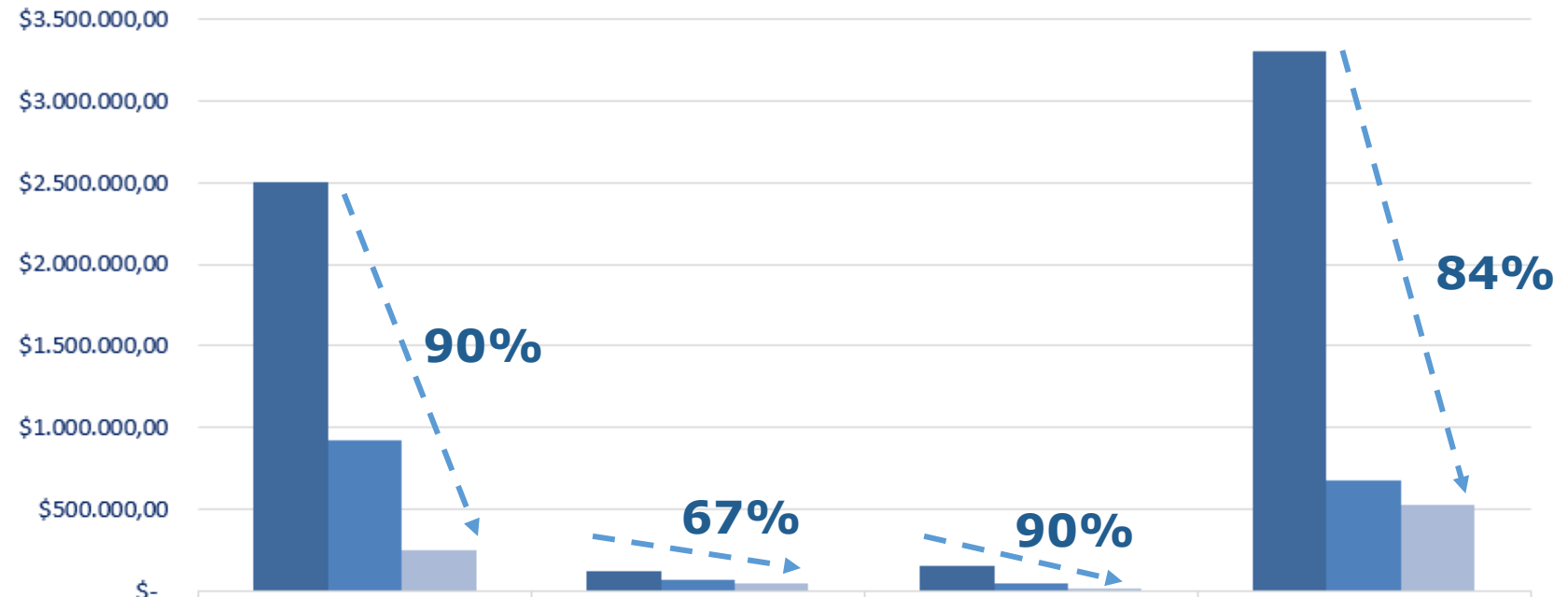
Remediation Projetc Sizing

Advantages of HRSC



~80% remediation costs reduction

Remediation **costs** simulation for each scenario



	Expectation of oxidant consumption (kg)	Expectation of Surfactant consumption (L)	Injection Points	Total Injection (L)
Without high resolution	$2.500.000,00	$125.000,00	$150.000,00	$3.300.000,00
With high resolution and conventional interpolation	$917.410,00	$65.000,00	$50.000,00	$672.006,50
With high resolution and three-dimensional modeling	$250.750,00	$40.675,00	$15.000,00	$530.310,00



That’s all…for now!

Thanks!

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