THE ADDED VALUE OF A MULTIDISCIPLINARY APPROACH FOR THE CHARACTERIZATION OF A COMPLEX SITE

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Background and Site history

- Industrial Site of ~17,000 m^2 (**industrial furniture production**), active since the 60s
- **Land use**: commercial and industrial area

- Till 1990s, **solvents containing trichlorethylene and tetrachloroethylene were used in degreasing and painting processes**

VOCs and **Hydrocarbons** contamination in groundwater

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Site settings

- Site located in a **mountainous area**
- **River** located 20 m from the Site boundary
- **Geology**:
  - Loose fluvio-glacial and colluvial deposits of limited thickness (max. 10m)
  - Presence of clay sands, gravels and pebbles with silt and clay lenses
  - Bedrock represented by top of *Dolomia Principale.* Depth between few cm (surfacing bedrock) and ~ 10m bgl
- **Local hydrogeology**:
  - Shallow unconfined aquifer
  - Absent where bedrock surfaces
  - Ephemeral recharge system (local precipitation)
  - Flow directions toward nearby river (aquifer drained by the river)

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Evolution of Site understanding

Preliminary MIP investigation to refine understanding of contaminants distribution

→ MIP highlights level of complexity previously unknown

- Confirmation of bedrock deepening trend, BUT
- Bedrock is irregular with presence of significant highs and depressions

Contaminants transport mechanisms and hydrogeology might be more complex than initially understood → is groundwater control feasible and/or effective ?

- Highs = aquifer might be unsaturated during dry periods
- Depressions = points of accumulation in case of presence of historical DNAPL

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Refinement of Conceptual Site Model

INITIAL CSM
not adequate for remedial action

INVESTIGATION	UNDERSTANDING
MIP / MiHPT	Contaminant distribution Geology / Bedrock profile
Drilling → Integration of monitoring network	Contaminant distribution Lithology and geology Bedrock profile
Pumping test	Hydrogeology
Tracer test	Transport mechanisms
DPE pilot test	System response
N.2 seismic surveys	Bedrock profile Detailed system design

IMPROVED CSM

CSM development

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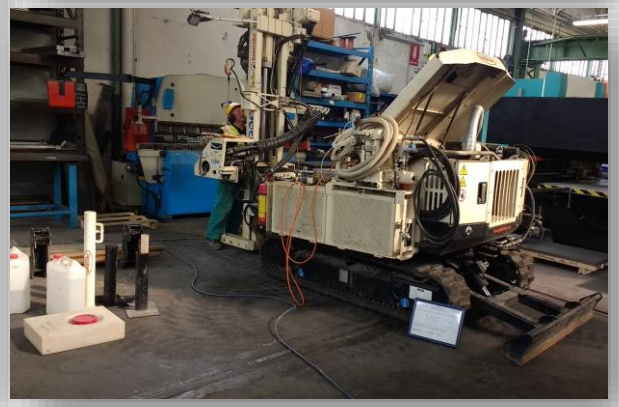
Membrane Interface Probe + Hydraulic Profiling Tool

- MiHPT (21 investigation points), using GeoProbe

→ **Spatial variability in the bedrock elevation:**

  - deepening along the west-east direction (0,5 - 11 m b.g.l.)
  - irregularity and presence of local depressions



→ Presence of **VOCs** and **Hydrocarbons**

→ Identification of potential **historical source of contamination** (buried concrete basin formerly used for degreasing activities)

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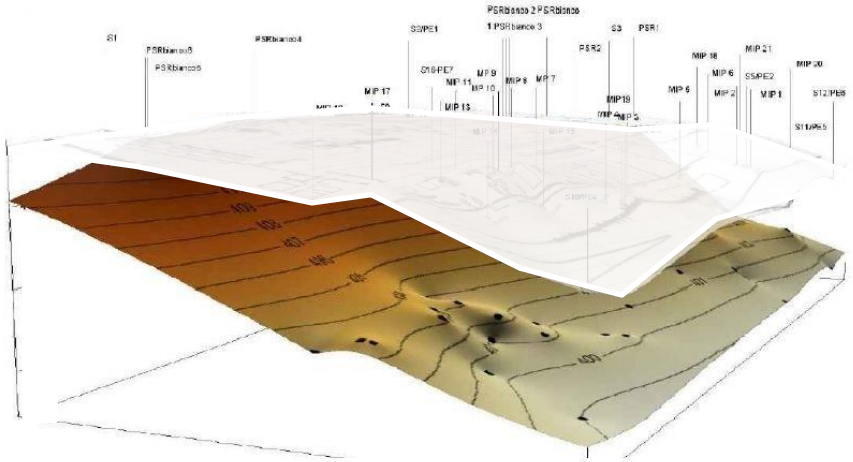
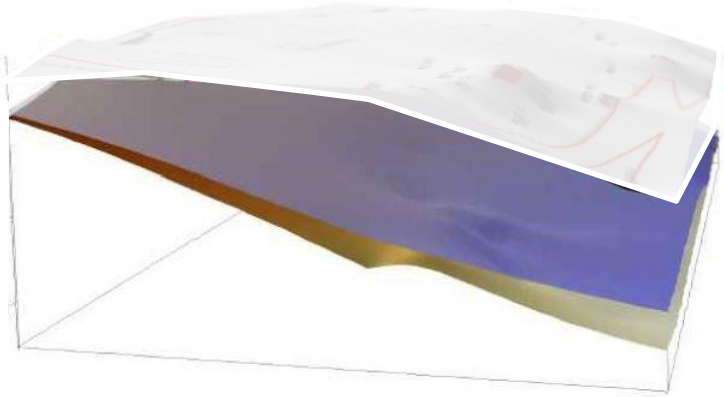
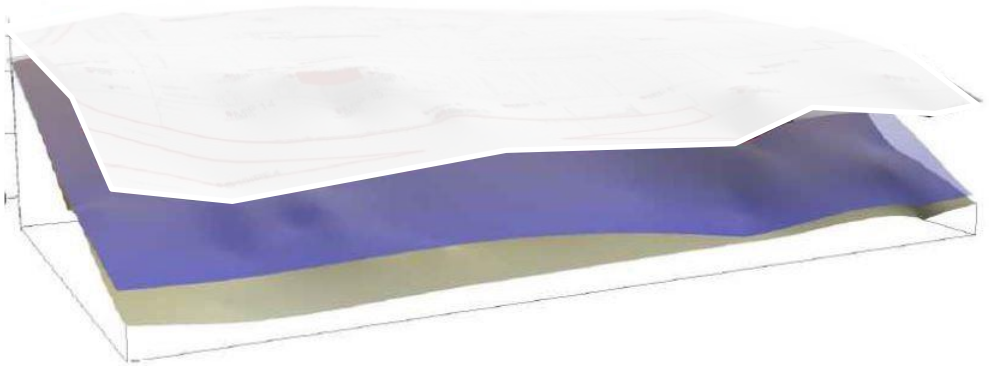
Bedrock 3D model







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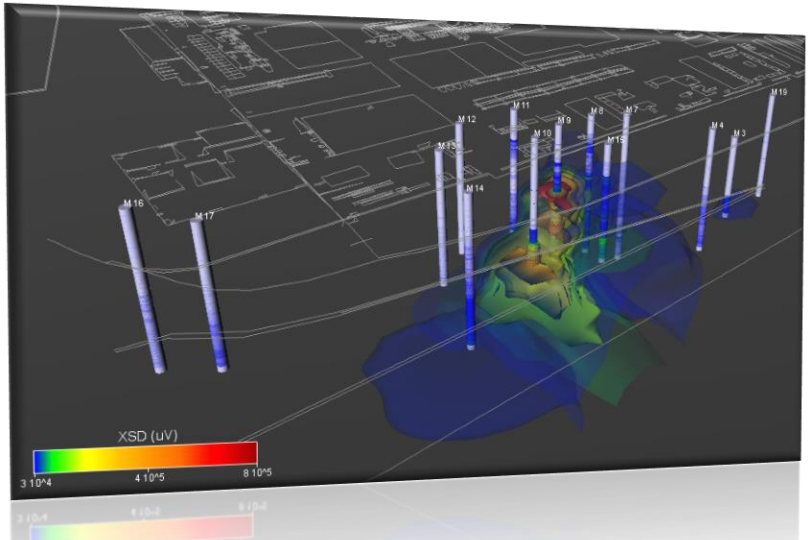
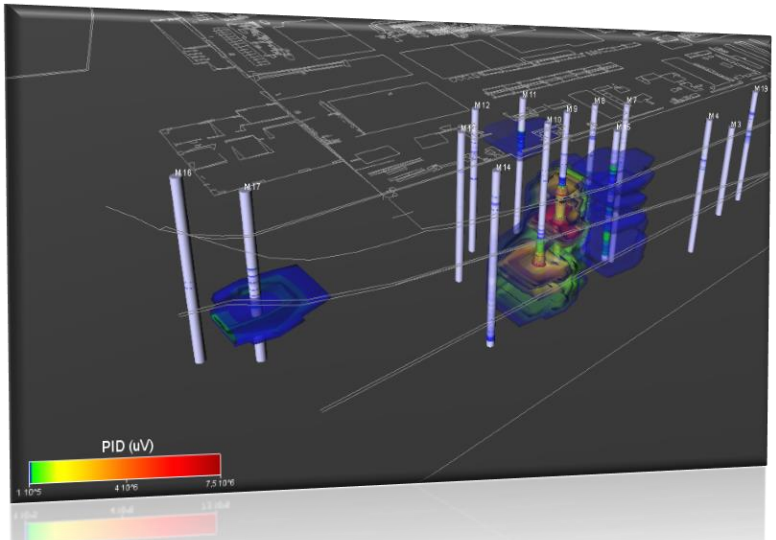
3D representation of VOCs and Hydrocarbons distribution

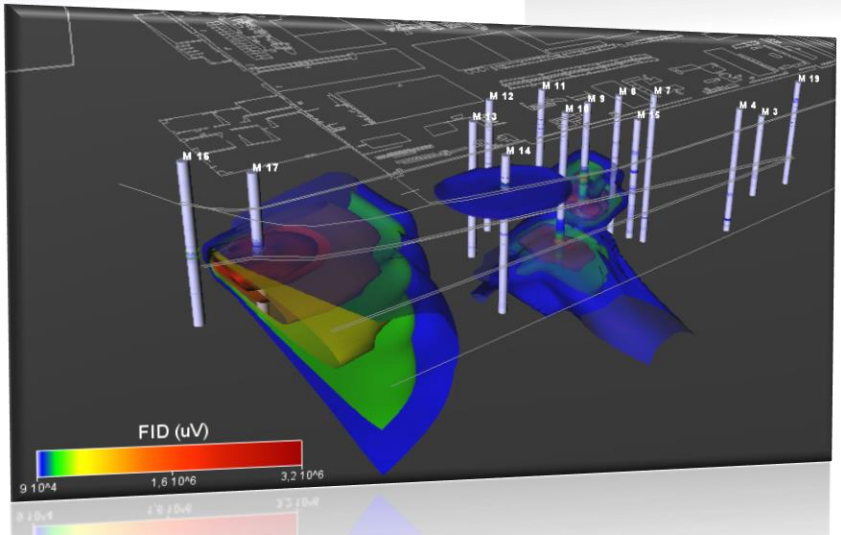
XSD sensor – VOCs detection



PID sensor – HCs detection



FID sensor – VOCs and HCs detection



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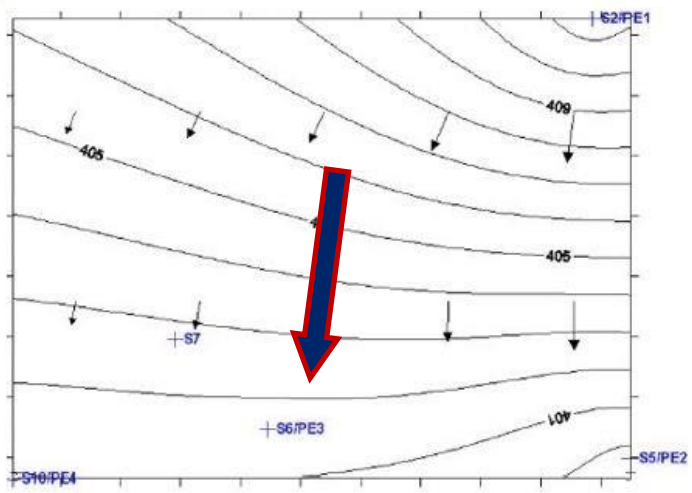
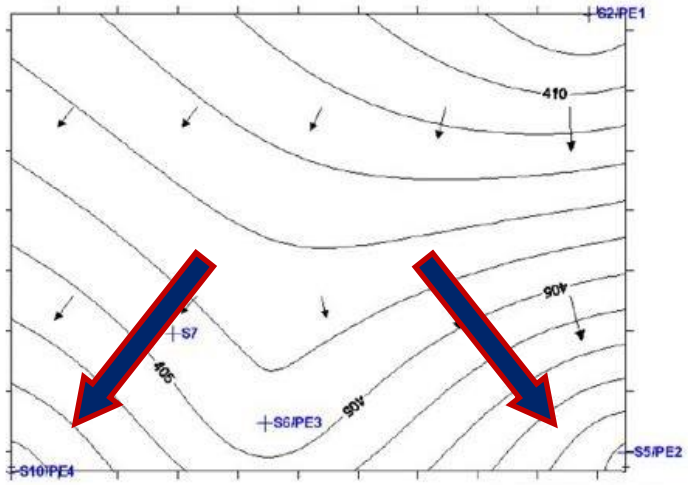
Drilling – integration of monitoring network

- Drilling of n.16 boreholes (**7 monitoring wells**). Improved understanding of:
  - → **Bedrock profile** and lithology
  - → **Hydrogeology:** aquifer (2 m thick, on average) strongly **influenced by precipitation regime**: <u>impact on contaminants transport mechanisms and directions</u>



Water table – dry conditions



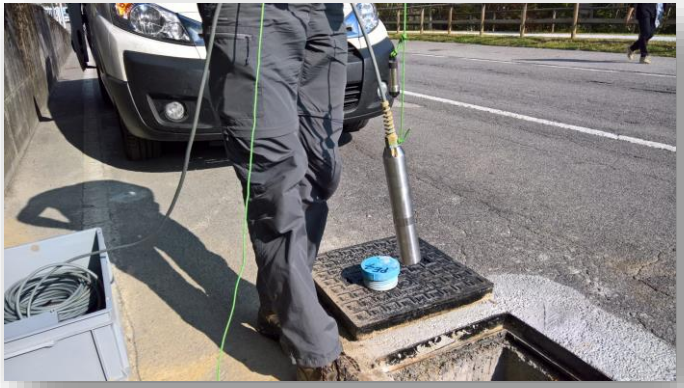
Water table – rainy conditions

Hydraulic testing

- Step drawdown tests
- Constant rate tests

→ No stabilization during SDT even at low flow (2 – 12 l/min) → **poor productivity and slow recharge**

→ Calculation of the aquifer **transmissivity and permeability** to support remedial design



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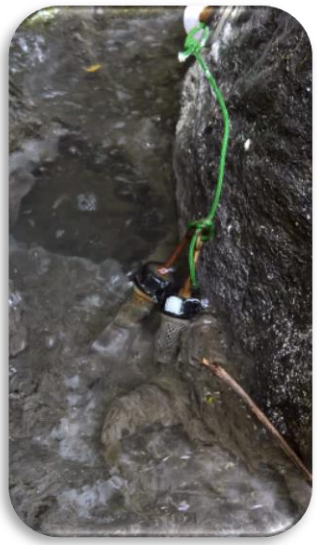
Tracer test

Injection (sodium fluorescein) at historical source of contamination

- **Tracer detected side-gradient of injection point** → confirmed that aquifer responds almost instantaneously to precipitation event; confirm radial pattern with a predominant southern direction, consistent with the bedrock profile
- Estimate of **groundwater flow velocity** → indicates that the flow occurs primarily via surficial deposits, with no evidence of fractured portion of the bedrock



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Dual Phase Extraction (DPE) – Pilot Test

1. **Feasibility of DPE** as hydraulic control system
2. Confirmation of **ephemeral recharge system of the aquifer**
3. **Logging of additional hydrogeological parameters**, useful for DPE Full Scale design (radius of influence…)

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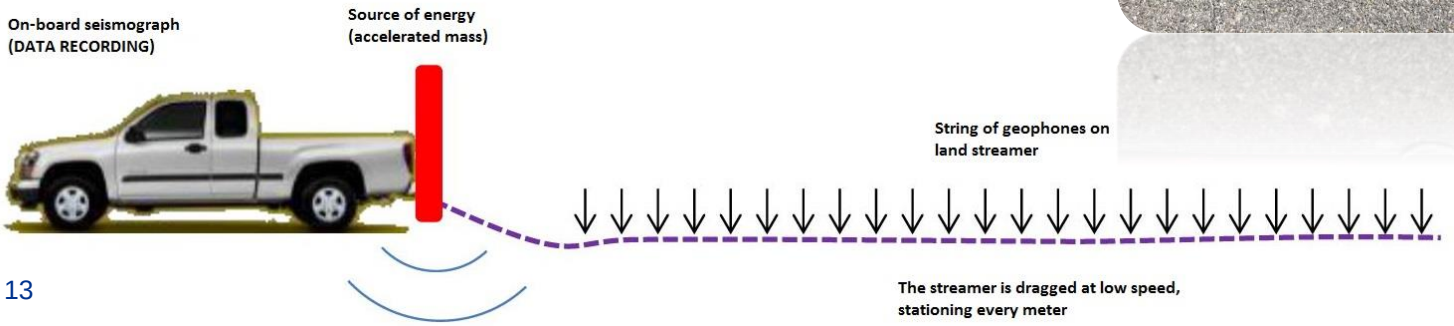
Seismic surveys

- 1st survey along East border of the Site, to **support design of DPE Full Scale** (hydraulic control)
- 2nd seismic survey downgradient of potential primary source of contamination, to **support installation of additional MW**

→ **Detailed mapping of the bedrock profile**



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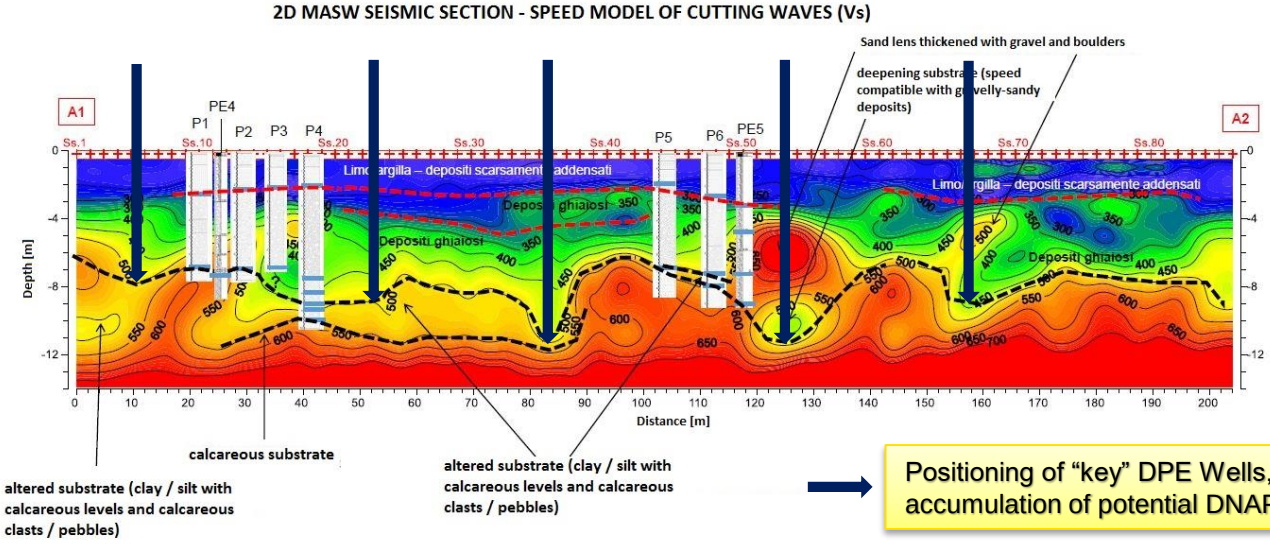
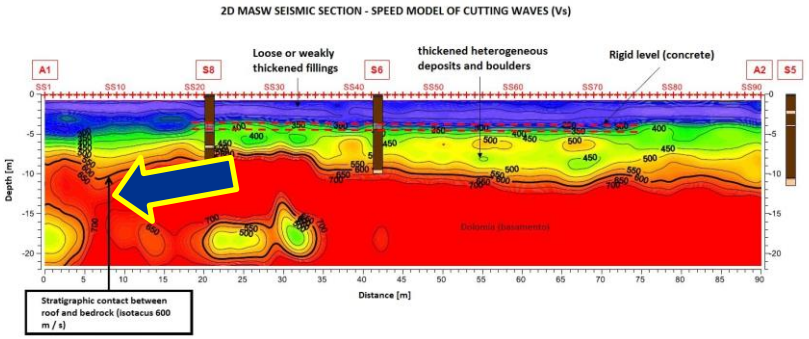
Seismic surveys output



Positioning of “key” DPE Wells, to intercept accumulation of potential DNAPL

2D MASW Seismic section 1 (170 m)



Bedrock profile consistent with contaminants distribution in groundwater downgradient of the basin

2D MASW Seismic section 2 – Line downstream potential primary source of contamination (concrete degreasing basin) (90 m)

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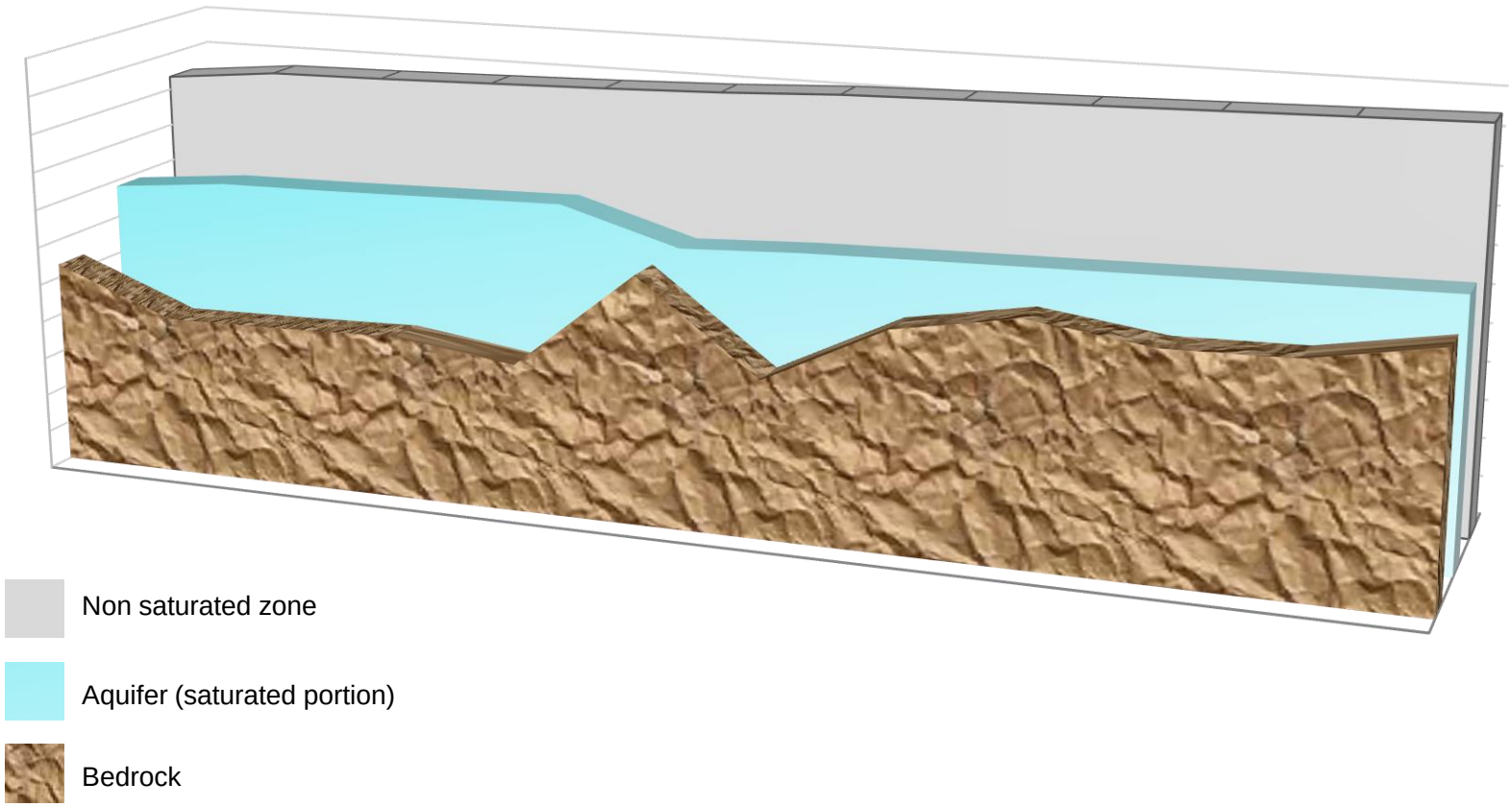
Geological model obtained through integrated characterization



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Conclusions

Phased and integrated approach (use of complementary investigation techniques) allowed development of adequate Site Conceptual Model

Phased approach allowed targeted investigation strategy, ultimately resulting in **cost savings** to the Client

Improved understanding of the CSM allowed implementation of a tailored remedial solution, thus **reducing project risks**

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Thank you!

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