



Case Study on Sustainable Management of POPs Contaminated Sites

Best Available Techniques
and
Best Environmental Practices

26 January 2023

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Soil Consultancy



TÜRKİYE CUMHURİYETİ
ÇEVRE, ŞEHİRCİLİK VE
İKLİM DEĞİŞİKLİĞİ BAKANLIĞI



Çevre ve İklim Eylemi
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Bu proje Avrupa Birliği ve Türkiye Cumhuriyeti tarafından finanse edilmektedir.

Content of presentation

1. Introduction

- Objectives presentation
- History of the company, site and project
- Objectives remediation

2. Phase 1

- Initial Conceptual Site Model
- Tier 1 Risk Assessment

3. Phase 3

- Pilot
- Design remediation

4. Phase 2 and 4

- Installation of remedial system and mapping
- Site Conceptual Site Model
- Mass removal, monitoring and maintenance
- Adaptation objectives

5. Conclusive remarks

Phase 1 Preliminary Site Assessment

Phase 2 Site Assessment

Phase 3 Site Remediation Assessment

Phase 4 Site Remediation Management

Phase 5 Site Monitoring & Aftercare



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(1) Introduction

- Objectives presentation
- History of the company, site and project
- Objectives remediation



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(1) Introduction - Objectives presentation

- Demonstrate project-specific phased approach
- Discuss the importance of the Conceptual Site Model (CSM)
- Share hurdles, pitfalls and successes



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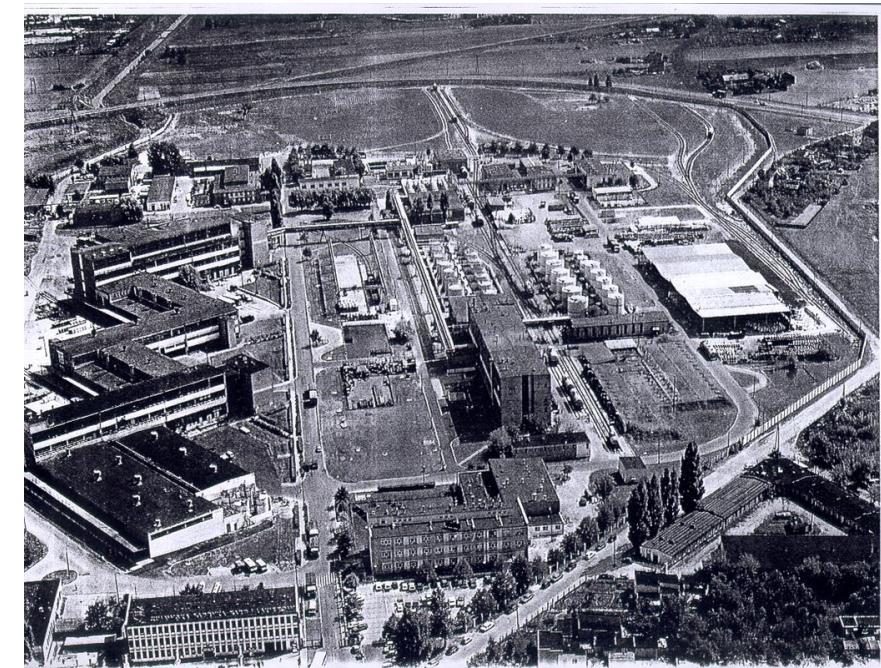
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(1) Introduction – Company history

- **1897** Coating company founded, vegetable oils and natural resins were used in the production
- **1897 - 1917** Several fold increase in size and range of production
- **1917 - 1937** Paint production kept on increasing for automotive, shipbuilding, railway and aviation industries
- **1939 - 1945** Production for the needs of the German army
- **1945 - 1965** Production mainly for the Polish automotive industry
- **1965 – 1967** Licensed for large EU automobile factory
- **1967 – 1970** Construction new plant at a new location
- **1970 - 1996** Paint production at current site
- **1996** Employee shares were bought by Multi National Industry (MNI)
- **1996 - 2015** Production varies paints
- **2015** Divestment MNI



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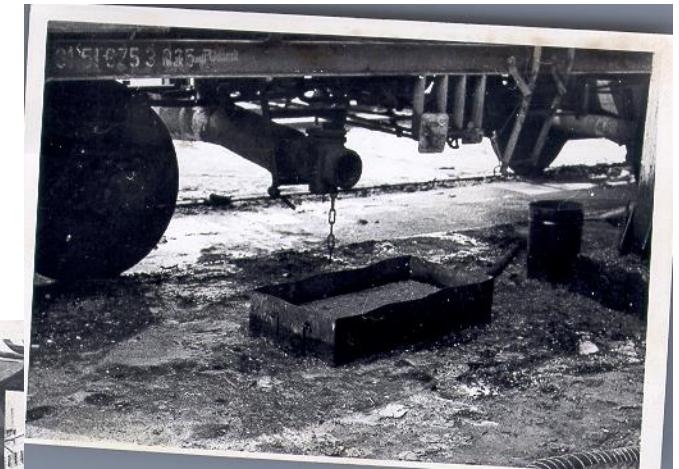
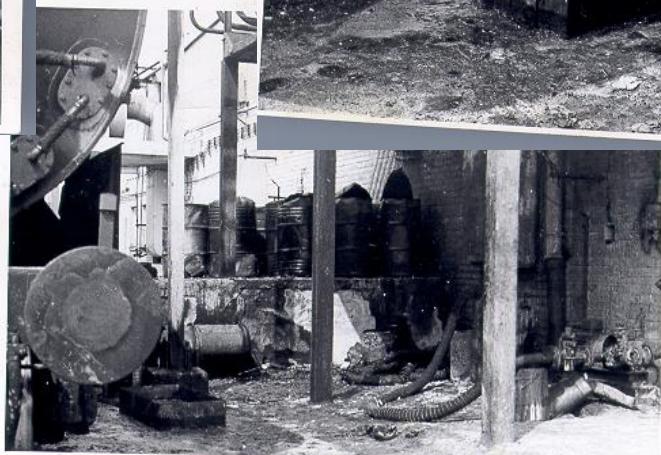
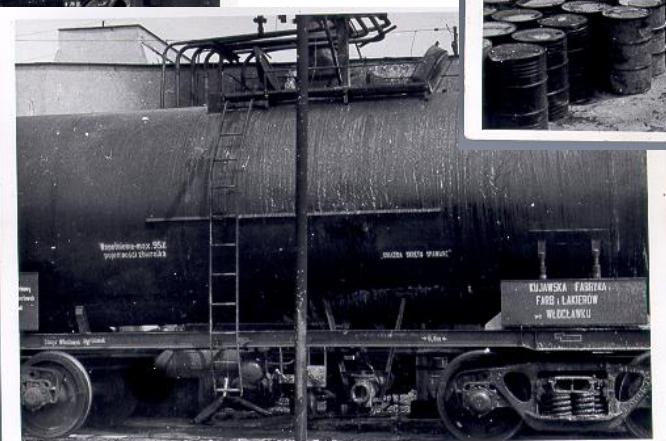


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(1) Introduction – Site history



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(1) Introduction – Project history

- **1996** TAUW Vendor (technical and environmental) due diligence
- **1996** Presence of groundwater contamination including LNAPL discovered
- **1998** Removal of Underground Storage Tanks the primary source of contamination
- **1998 - 2000** TAUW Pilot tests LNAPL removal
- **2000 - 2003** Installation and full-scale operation of LNAPL removal system, managed by TAUW
- **2003 - 2009** TAUW Monitoring and maintenance updating CSM and extension system
- **2010 - 2011** Installation new system to remediate LNAPL residue and groundwater
- **2011 - 2016** TAUW Monitoring and maintenance



LNAP = Light Non Aqueous Phase Liquid



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(1) Introduction – Summary history

- 1970 – 1996 Paint factory in former USSR
- 1996 Privatization of industrial sites
- A multinational paint producer wanted to invest
- 1996 Vendor due diligence TAUW to assess condition buildings with installation and **soil and groundwater**
- Off-loading and storage in underground storage tanks of base liquid materials for paint production caused large groundwater contamination
- MNI decided to invest and remediate
- Remediation 1999 - 2016



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(1) Introduction - Objectives remediation

- **Short-term**

- Remove primary source, the UST, used for liquid base material for paint production which were volatile aromatic hydrocarbons (BTEX)

- **Mid-term objectives**

- Stop off-site migration of Light Non Aqueous Phase Liquid (LNAPL)
- Removal of the LNAPL

- **Long-term objectives**

- Removal of residues of LNAPL
- Stop off-site migration of contaminated groundwater
- On-site BTEX concentration in groundwater below 1,000 µg/litre





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(2) Phase 1 – Preliminary Site Assessment

- Initial Conceptual Site Model
- Tier 1 Risk Assessment



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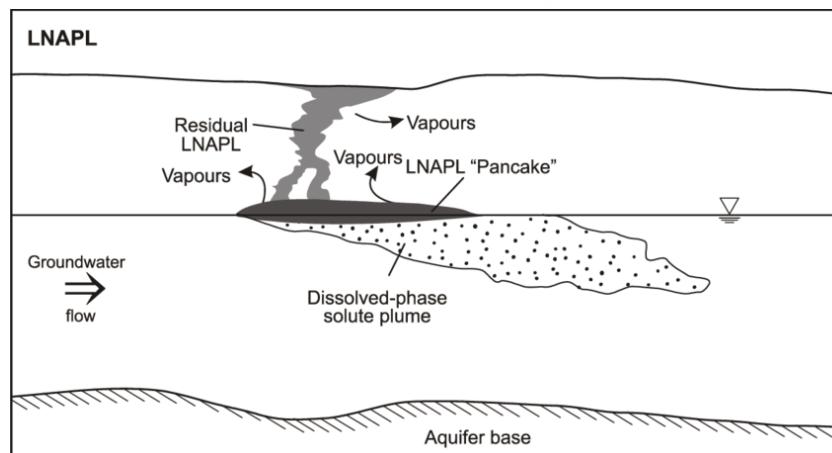
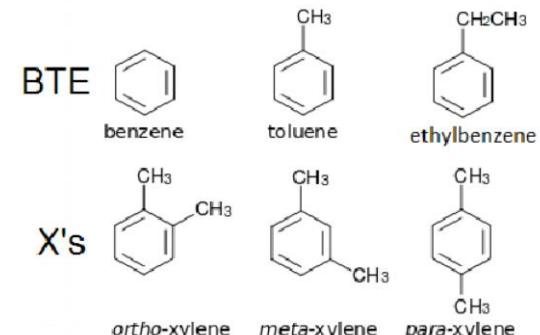


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BTEX

(2) Phase 1 – Initial Conceptual Site Model

- Benzene, Toluene, Ethylbenzene, and xylenes (BTEX) are
 - Volatile
 - Water-soluble
 - Lighter than water form LNAPL's
 - Good solvent properties - used as paint solvents
- Benzene has carcinogenic properties



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(2) Phase 1 – Initial Conceptual Site Model

Source of contamination

- Tank pit of removed USTs
- LNAPL
- Groundwater contaminated with
 - Benzene 320 - 150 µg/litre
 - Toluene 86,000 – 13,000 µg/litre
 - Ethylbenzene 57,000 – 21,000 µg/litre
 - Xylene 170,000 – 22,000 µg/litre

LNAPL Pure product

Emulsion

Groundwater



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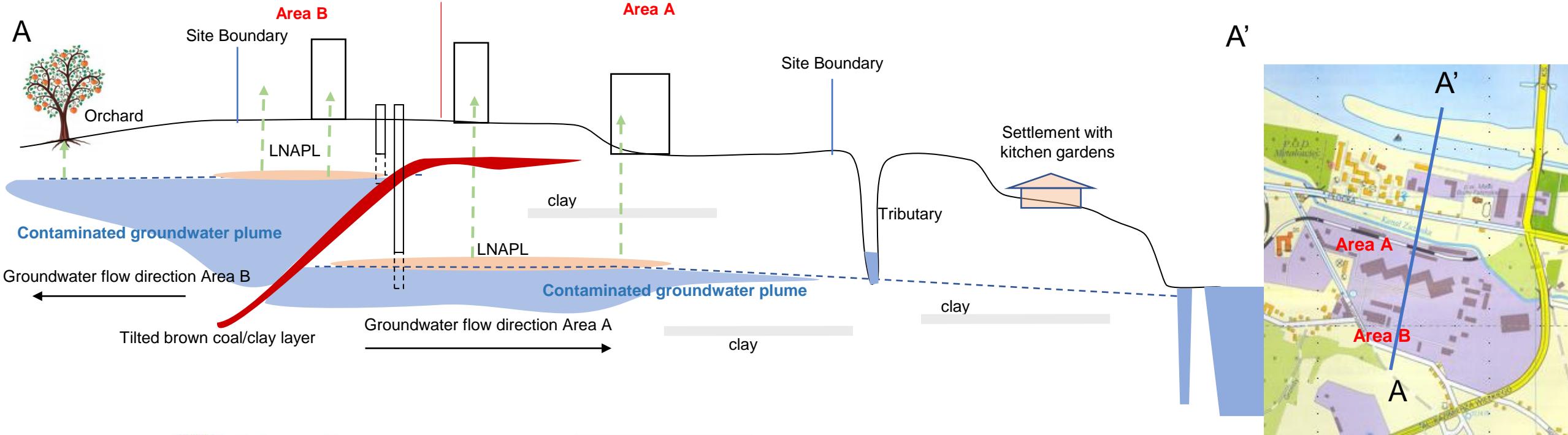




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(2) Phase 1 – Initial Conceptual Site Model

Source receptor pathways



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(2) Phase 1 - Initial Conceptual Site Model

Receptors

- The onsite workers are exposed to contaminated soil vapor when inside buildings
- The onsite workers carrying out earthworks are exposed to contaminated vapour, soil, groundwater and LNAPL
- Groundwater used to water kitchen garden and taken up by fruit trees
- The surrounding ecosystem including downstream river are exposed to contaminated groundwater and LNAPL





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(2) Phase 1 - Tier 1 Risk Assessment

- When onsite workers are excavating in contaminated soil it is very likely that they are having direct contact with the contaminants, this may have a direct effect on the health of the workers
- As factory buildings are above contaminated groundwater with LNAPL, contaminated soil vapor enters the buildings and workers are exposed, this may have a direct effect on the health of the workers
- People watering the kitchen gardens and eating vegetables from these kitchen gardens and fruits from orchard
- The surrounding ecosystem including downstream river are exposed to contaminated groundwater and LNAPL as groundwater flows on both sides off-site
- The migration of the contaminants will pollute soil and groundwater of adjacent sites



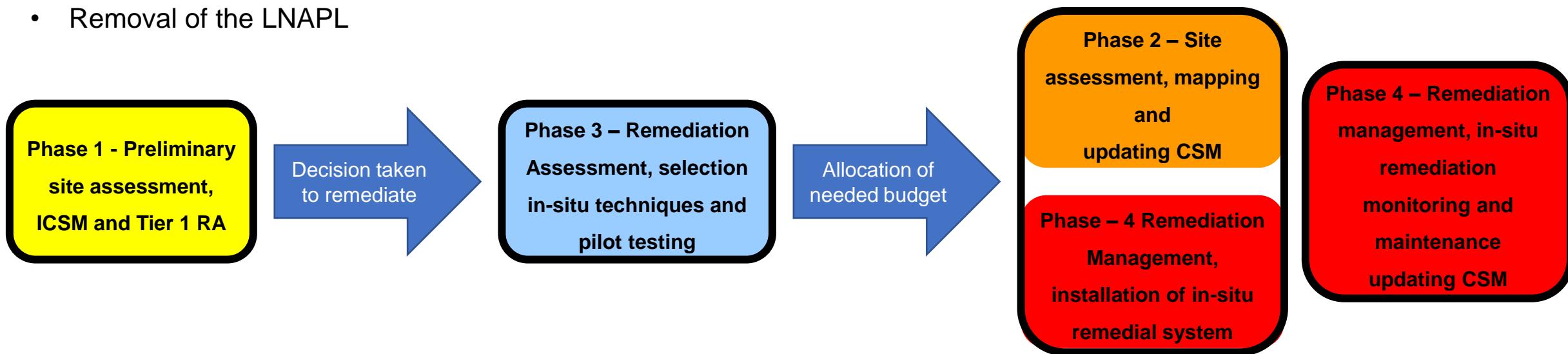


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Project specific phased approach

Mid-term objectives

- Stop off-site migration of Light Non Aqueous Phase Liquid (LNAPL)
- Removal of the LNAPL





Bu proje Avrupa Birliği ve Türkiye Cumhuriyeti tarafından finanse edilmektedir.

(3) Phase 3 - Remediation Assessment

- Pilot
- Remediation design



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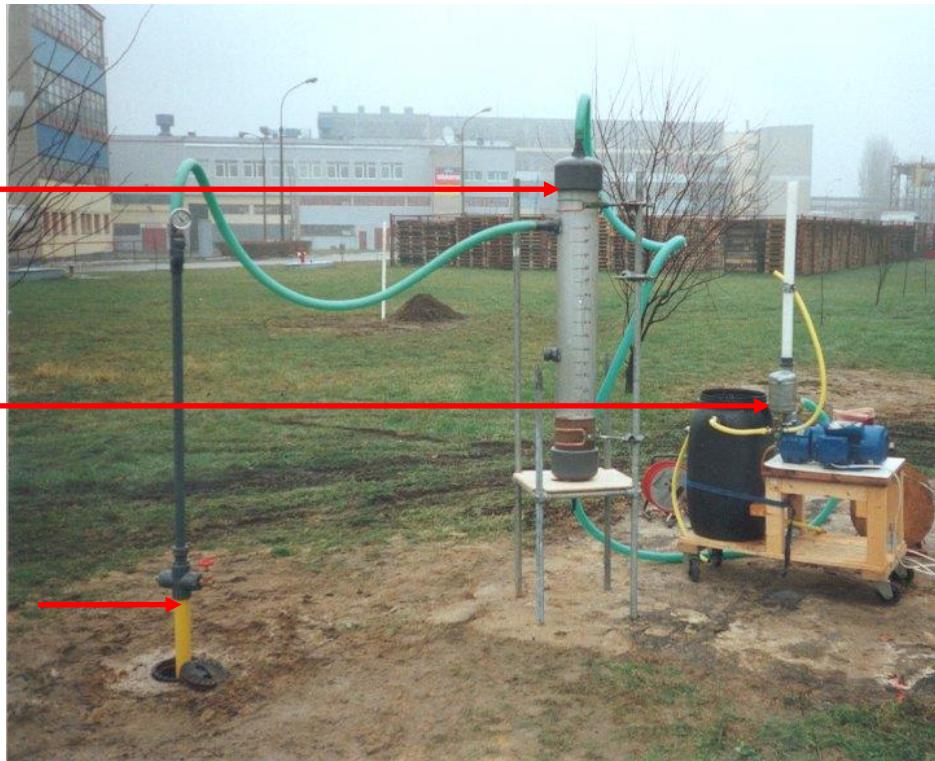
(3) Phase 3 - Pilot

Pilot bio-slurping

Vacuum tank

Compressor

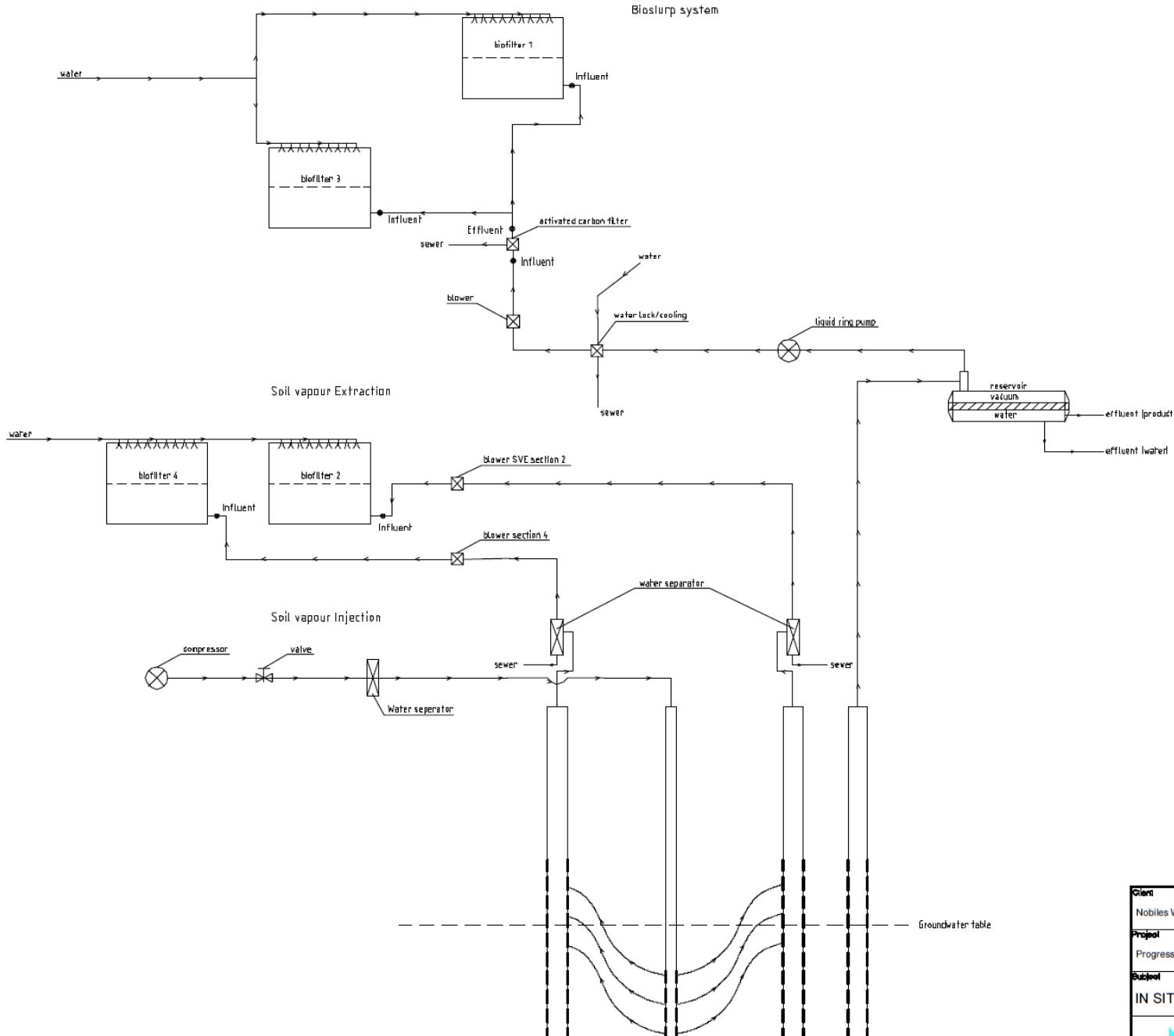
Bio-slurp with MPE well



detail multiphase extraction well

MPE-well





Client	Scale	Status
Nobles Wodzawek Poland	1 : 100	FINAL
Project	Formal	Project number
Progress report oct. 2002 through nov. 2003	A3	3800784
Subject	Date 24-02-04	Draughtsman
IN SITU REMEDIATION SYSTEM	QdL BPF	101
	ABP BFF	



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(4) Phase 2 and 4 Site Assessment and Remediation Management

- Installation of remedial system and mapping
- Site Conceptual Site Model
- Mass removal, monitoring and maintenance
- Adaptation objectives



Bu proje Avrupa Birliği ve Türkiye Cumhuriyeti tarafından finanse edilmektedir.

(4) Phase 2 and 4 Installation of remedial system and mapping



Well installation outdoors



Well installation indoors



Bio-slurp installation



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(4) Phase 2 and 4 installation of remedial system and mapping



Bio-filters northern boundary



Barrier air-sparging and bio-slurping northern boundary

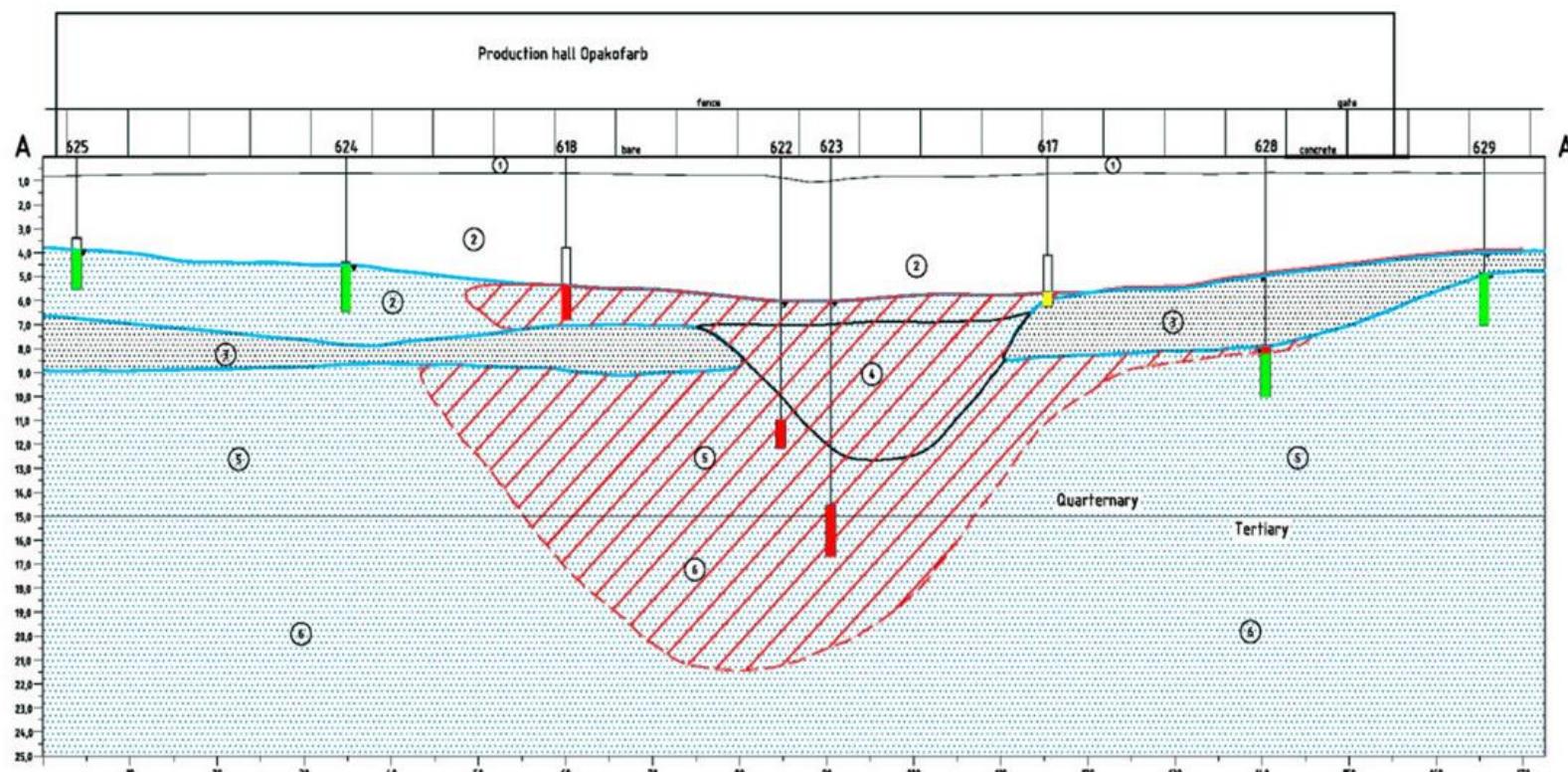


Barrier air-sparging and bio-slurping southern boundary



CROSS SECTION A - A'
NORTHERN BOUNDARY
NOBILES - OPAKOFARB

Appendix 7



Legend

- | | | |
|---------------------------------|--|--------------------------|
| groundwater | ① man made brownish top soil with stones | ≤ S of < detection limit |
| ▼ groundwater level in borehole | ② light brown sand to coarse sand | > S en ≤ T-value |
| dry | ③ grayish clay (dry) | > T en ≤ I-value |
| ☒ groundwater contamination | ④ grayish gravel | > I-value |
| | ⑤ grayish sand | |
| | ⑥ grayish clay | |

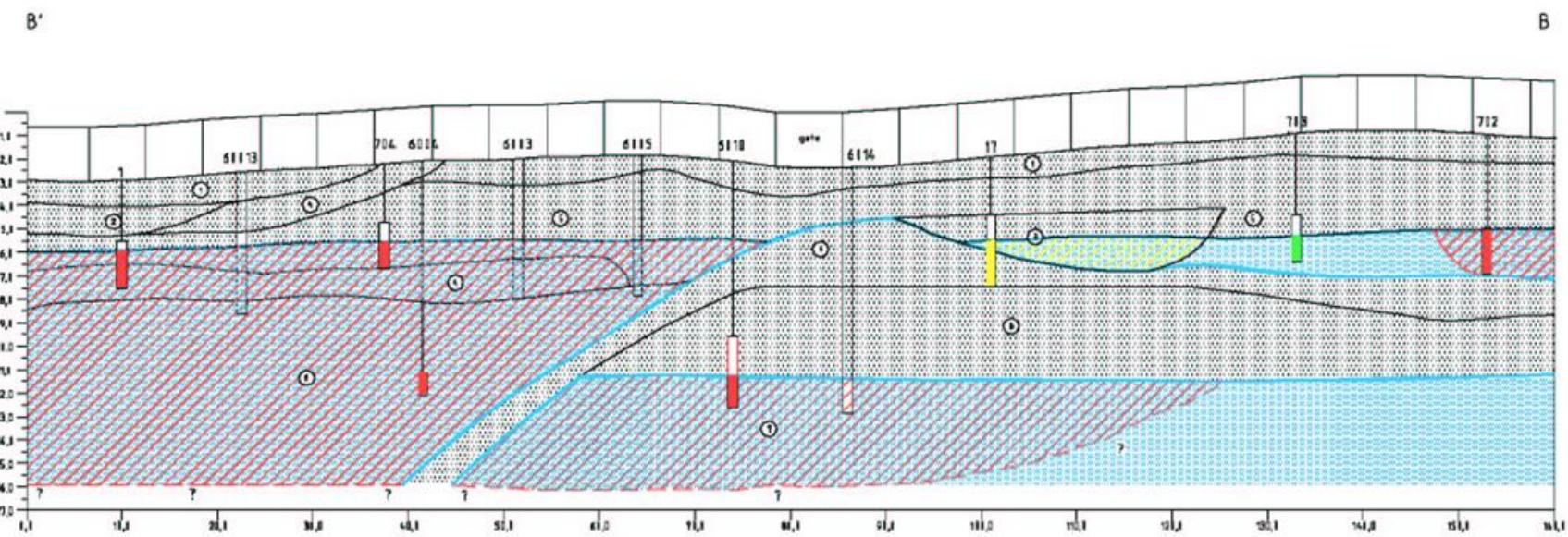
Horizontal scale: 1:500, vertical 1:200

Client	Scale	Date
Nobiles Włodzimierz Poland	1:500	FINAL
Project	Project	Projectnumber
Progress report oct. 2002 through nov. 2003	A3	3800784
Submitted	Date	Drawn by
CROSS SECTION A - A'	04-05-04	102
NORTHERN BOUNDARY	04-05-04	



Tauw

P.O. Box
7400 AC Dordrecht
Tel. (010) 69 99 1
Fax (010) 69 99 66
D0302558.DWG



Legend

- [dry pattern] dry
- [red hatched pattern] groundwater contamination
- [white square] monitoring well
- [light blue square] bore hole

(1) top soil medium sand

(2) peat

(3) very coarse sand with gravel

(4) sandy loam/clay

(5) fine medium sand

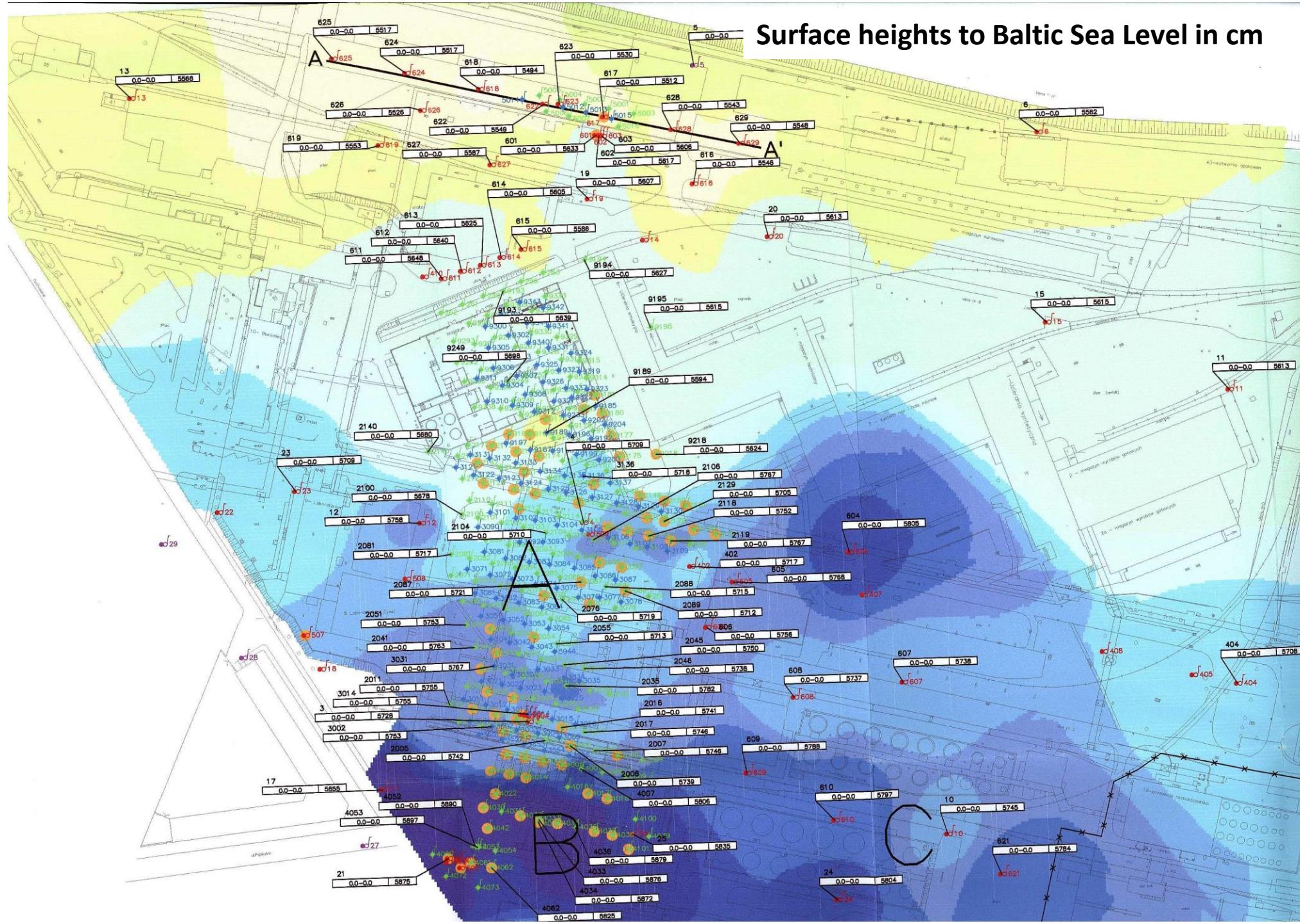
(6) medium course sand

(7) very coarse sand

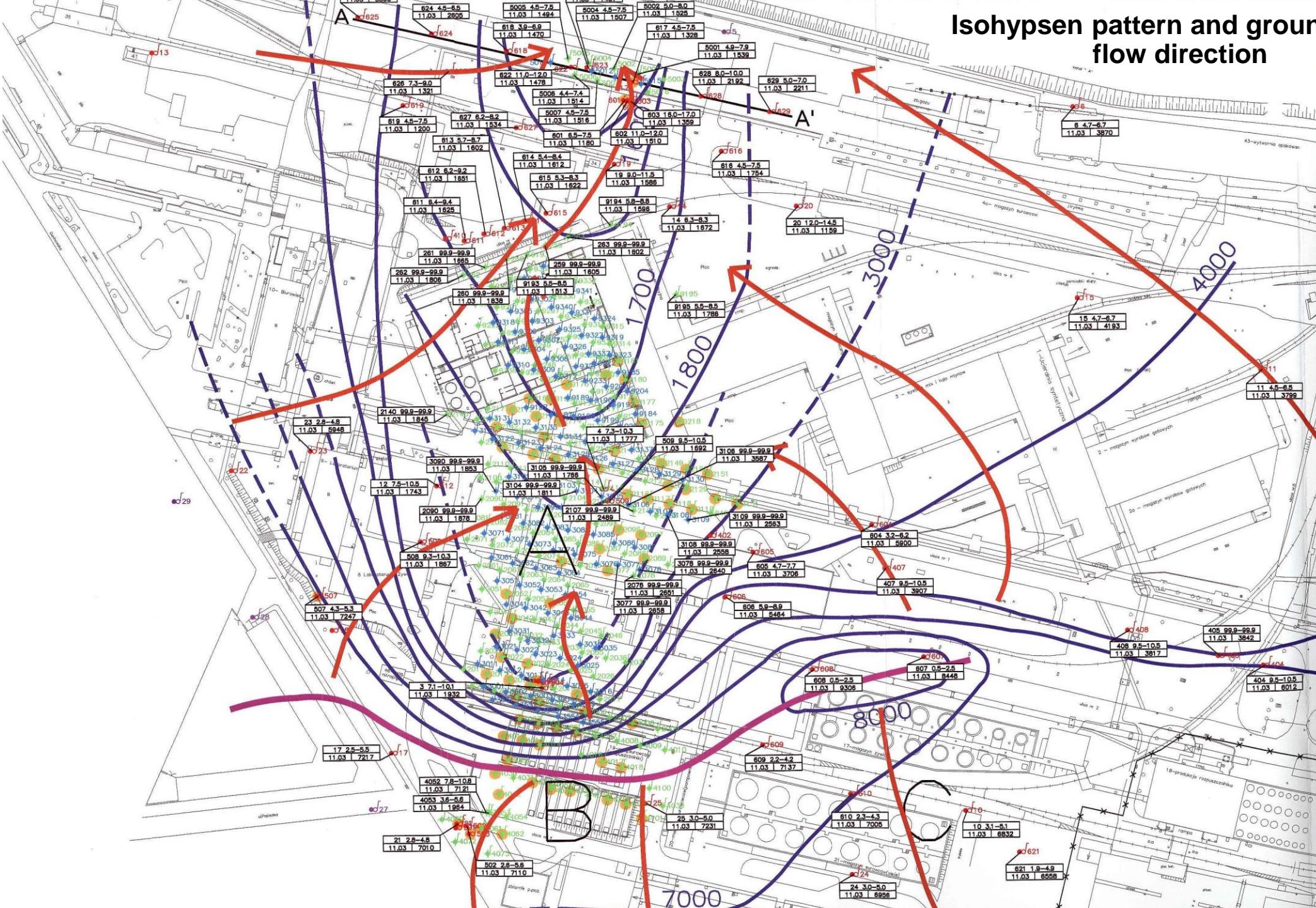
 $\leq S \text{ of } < \text{detection limit}$ $> S \text{ en } \leq T\text{-value}$ $> T \text{ en } \leq I\text{-value}$ $> I\text{-value}$

Onderzoeker		Scalen	Scal
Nobles Włodziszew, Poland		1:500	DEFINITIE
Project		Formaat	Projectnummer
Progress report oct. 2002 through nov. 2003		A3	3800784
Onderzoek		Datum: 28-02-04	Tekeningnummer
Cross-section B'-B		Gedate: AAT	103
		Gedate: IFF	
Tauw		Postbus 100 7400 AD Deventer Telefoon: (0320) 88 88 88 Fax (0320) 88 88 88	
0 12,5 25m			

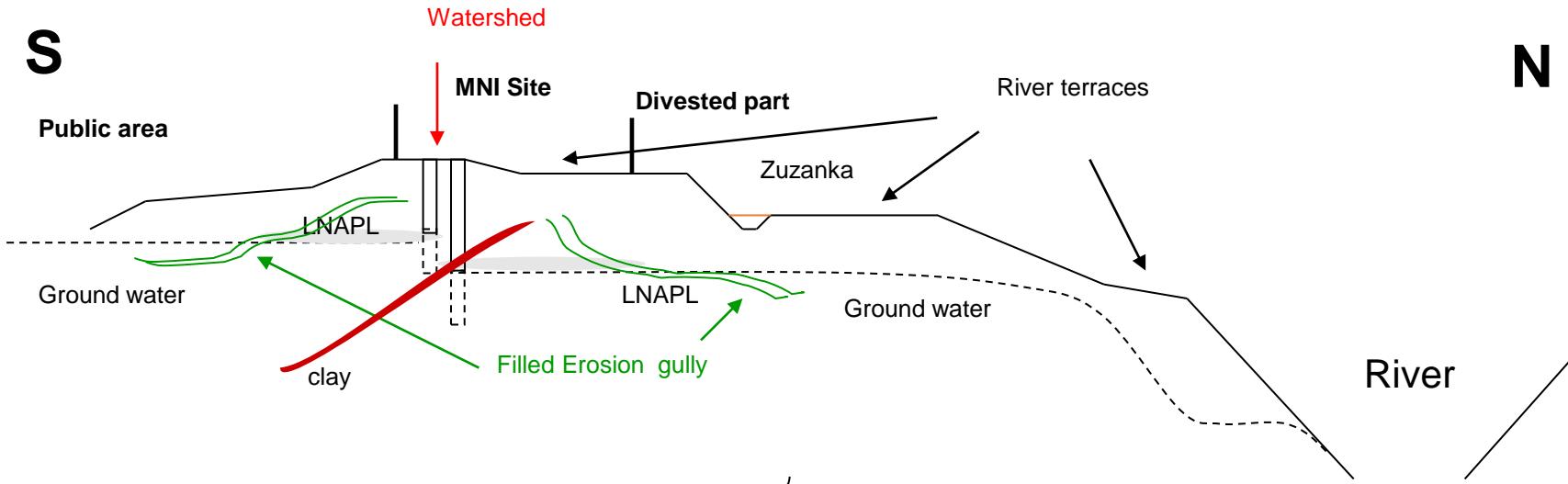
Surface heights to Baltic Sea Level in cm



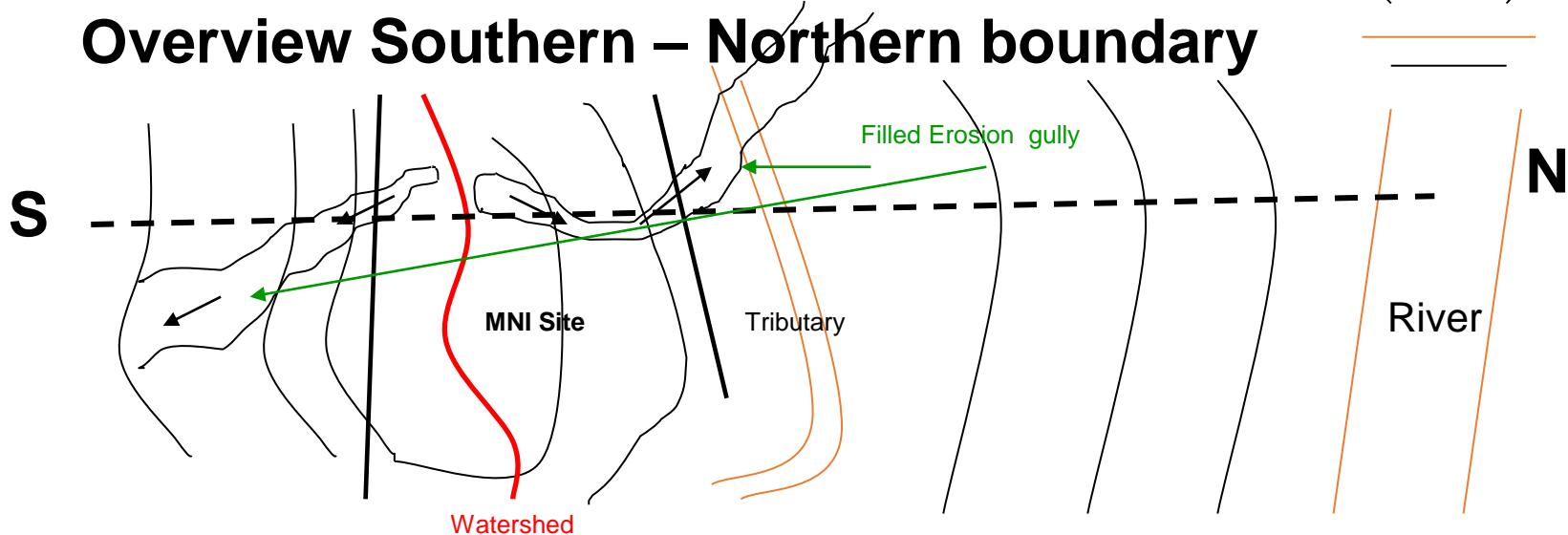
Isohypsen pattern and groundwater flow direction



Cross section Southern – Northern boundary



Overview Southern – Northern boundary

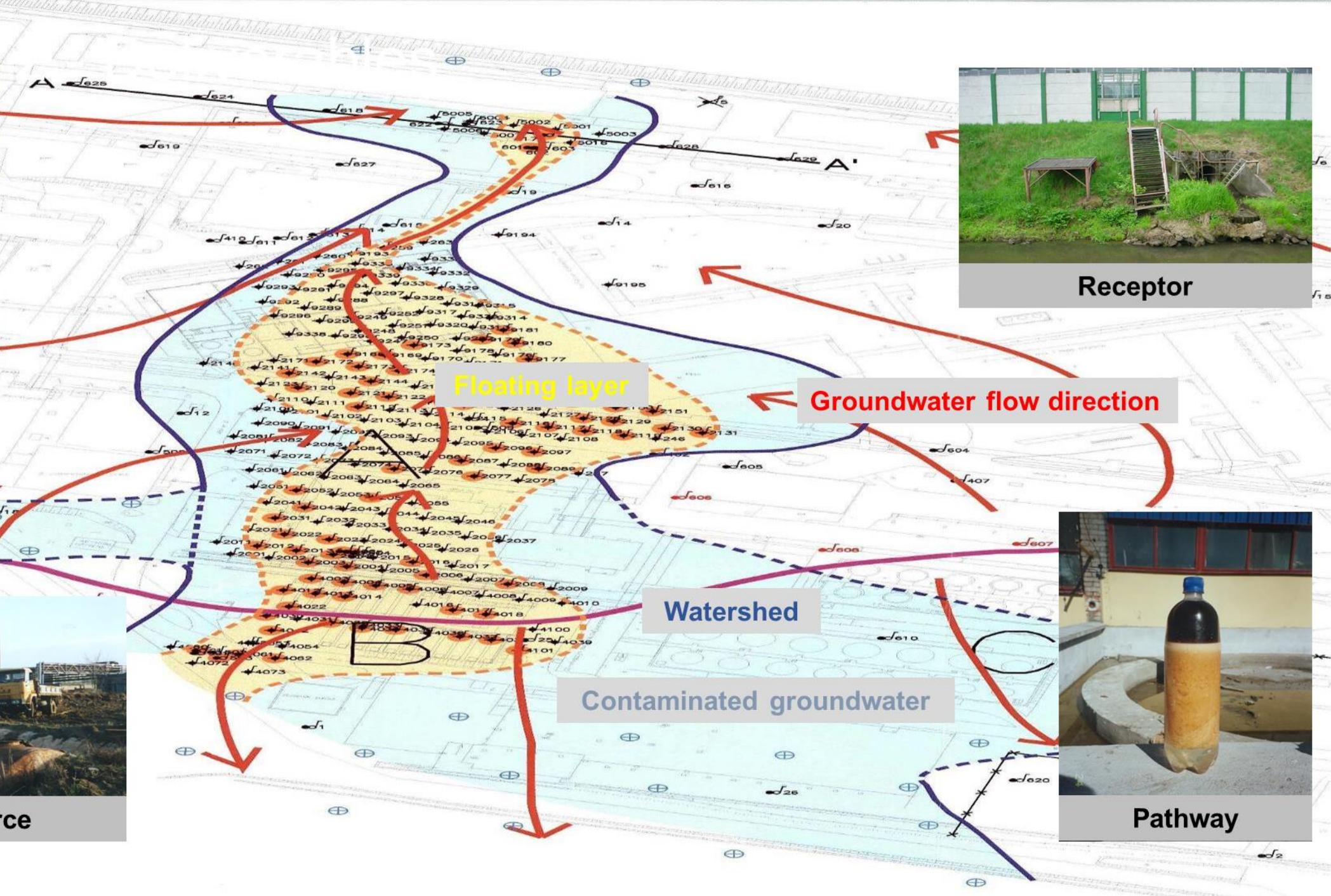




Secondary Source



Primary Source

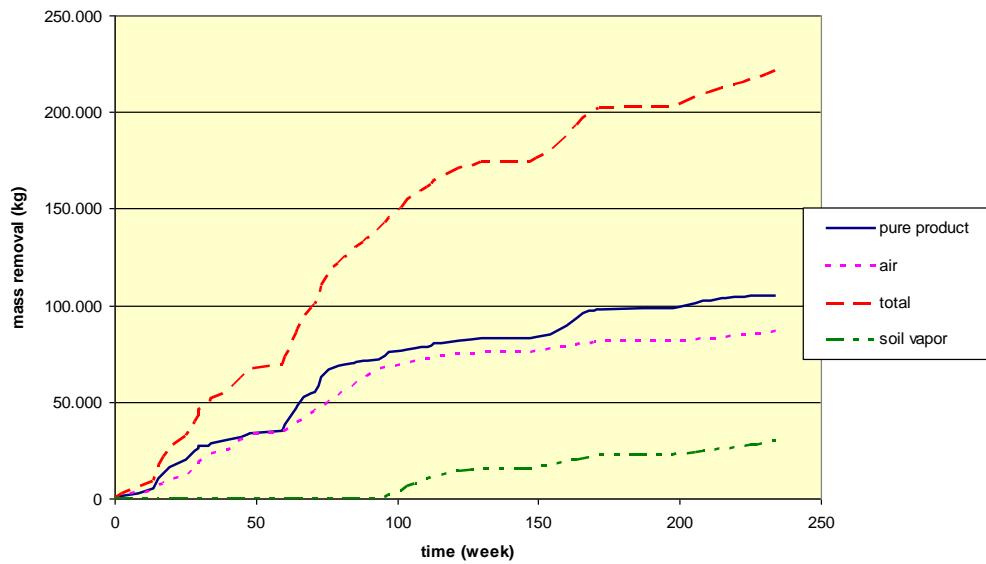




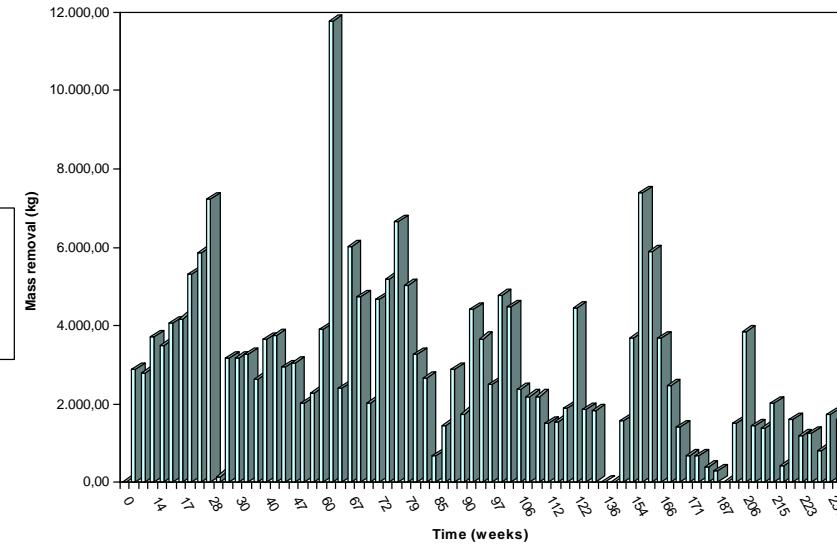
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(4) Phase 2 and 4 Mass removal, monitoring and maintenance

Total mass removal bioslurping and SVE system



Mass removal per period



Sampling bio-slurping well 9218



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(4) Phase 2 and 4 Mass removal, monitoring and maintenance



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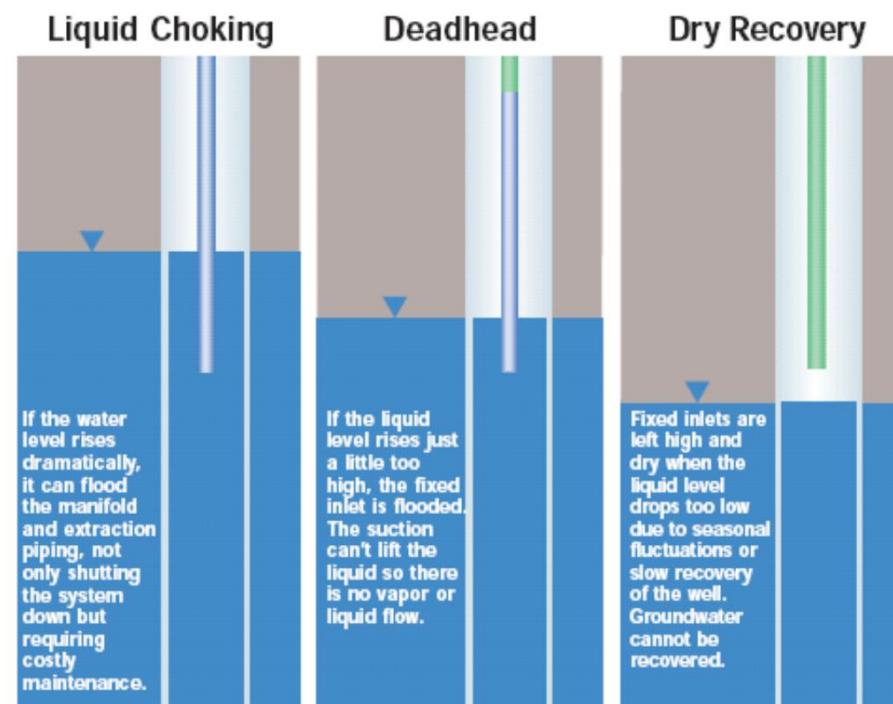


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(4) Phase 2 and 4 Mass removal and monitoring and maintenance

Bio-slurping not effective because of

- Liquid choking
- Deadhead
- Dry recovery



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(4) Phase 2 and 4 Mass removal, monitoring and maintenance

- Cause of dry recovery
 - LNAPL level too low
 - Suction pipe too high
- Effects of dry recovery
 - Thickening free phase
 - Too high viscosity
 - Inside filter coated
 - Filter blocked



Test solving clogged product in TAUW test lab



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(4) Phase 2 and 4 Mass removal, monitoring and maintenance

- **Prevent dry recovery**
 - Measure LNAPL at regular intervals
 - Adjust bio-slurp suction pipe
- **Regeneration of blocked filters**
 - Steam cleaning
- **Permanent blocked filters**
 - Abandon
 - Reinstall



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(4) Phase 2 and 4 Adaptation objectives

- **Mid-term objectives**
 - Removal of LNAPL
 - Prevent off-site migration of LNAPL
- **Long-term Objectives**
 - Prevent off-site migration of floating layer
 - Removal of remains of LNAPL
 - Prevent off site migration contaminants in groundwater
 - Fine tuning installation or replacement
 - Delineate off site contamination
 - Off-site remediation

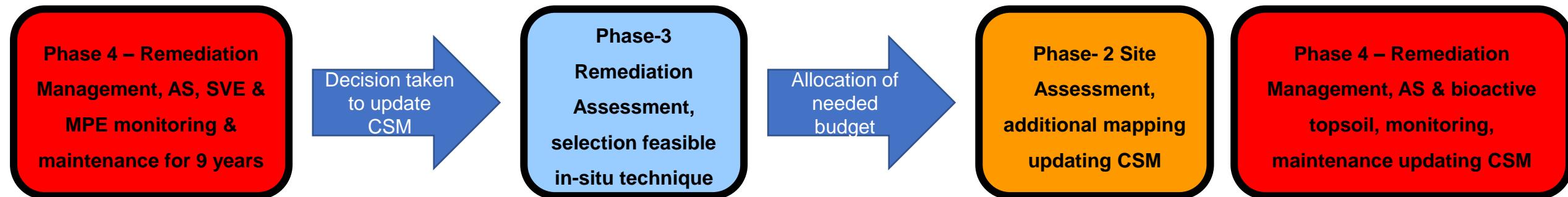


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Project specific phased approach

Long-term objectives

- Removal of residues of LNAPL
- Stop off-site migration of contaminated groundwater
- On-site BTEX concentration in groundwater below 1,000 µg/litre





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(4) Phase 2 and 4 Adaptation objectives

Additional mapping

- Extent of groundwater contamination in vertical and horizontal direction on- and off-site
- Extent of remain of LNAPL on- and off-site
- Membrane Interface Probe (MIP) was selected mapping technique
- Geo-probe was used to install additional wells
- Groundwater sampling and analyses



Membrane Interface Probe



Geo-probe



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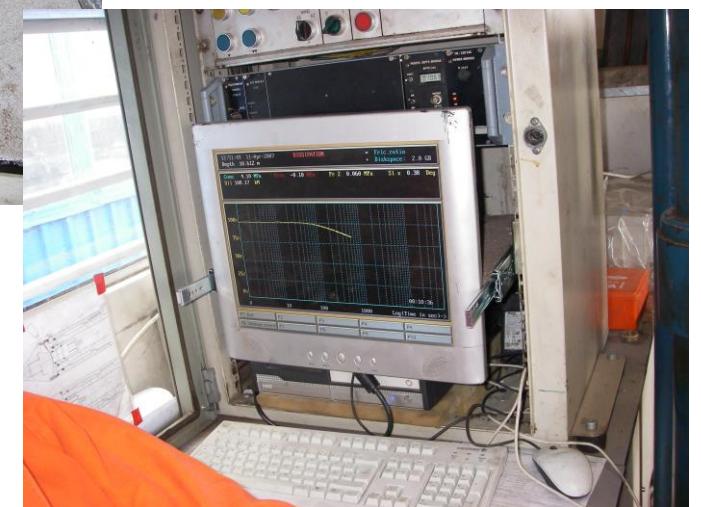


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(4) Phase 2 and 4 Adaptation objectives

Membrane Interface Probe measures

1. Cone resistance
2. Frictional resistance
3. Temperature
4. Electric current of Dry Electrolytic Conductivity Detector (DELCD)
5. Electric current of Photo Ionisation Detector (PID)
6. Electric current of Flame Ionisation Detector (FID)



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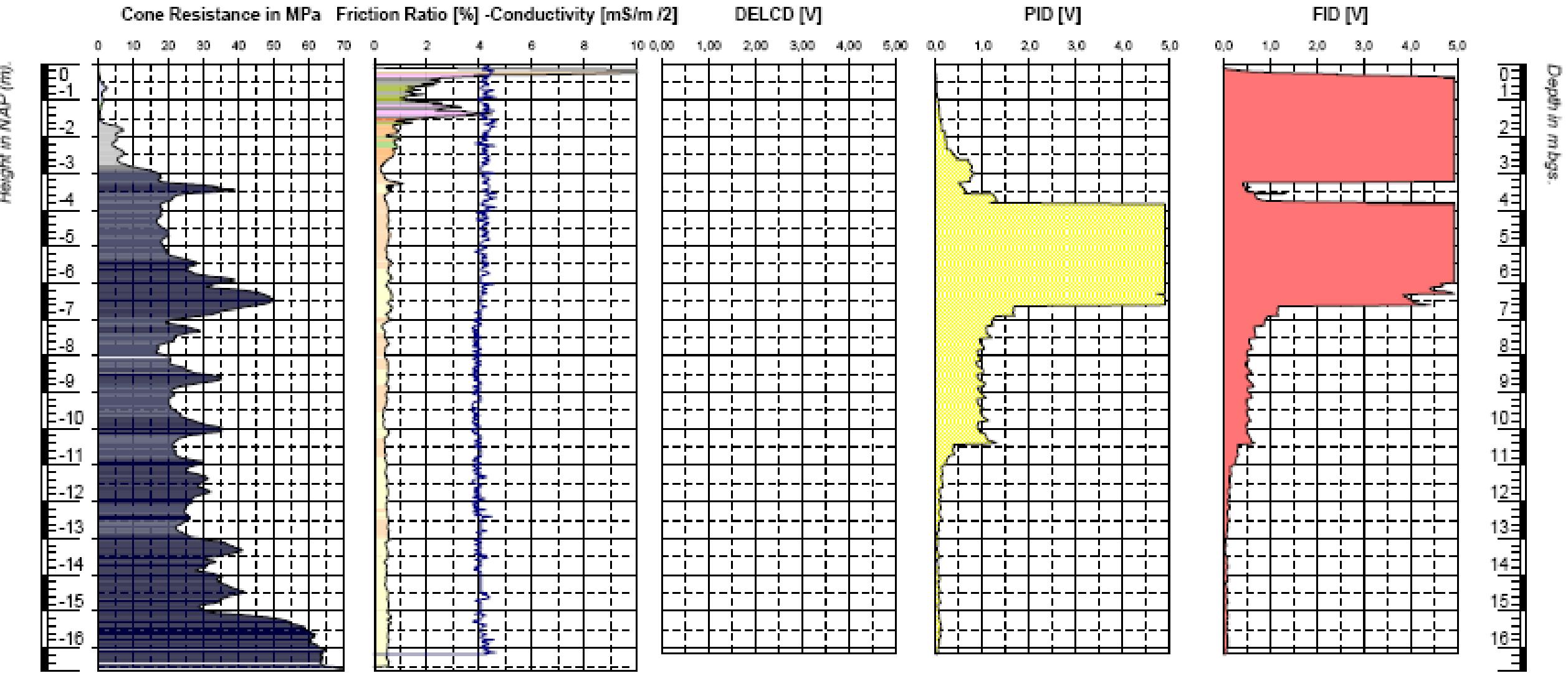
(4) Phase 2 and 4 Adaptation objectives

Detector MIP	Aromatic hydrocarbons	Chlorinated hydrocarbons	Hydrocarbons
PID	Yes	Yes	No
FID	Yes	Yes	Yes
DELCD	No	Yes	No



Vertical Scale 1:160

MIP6C

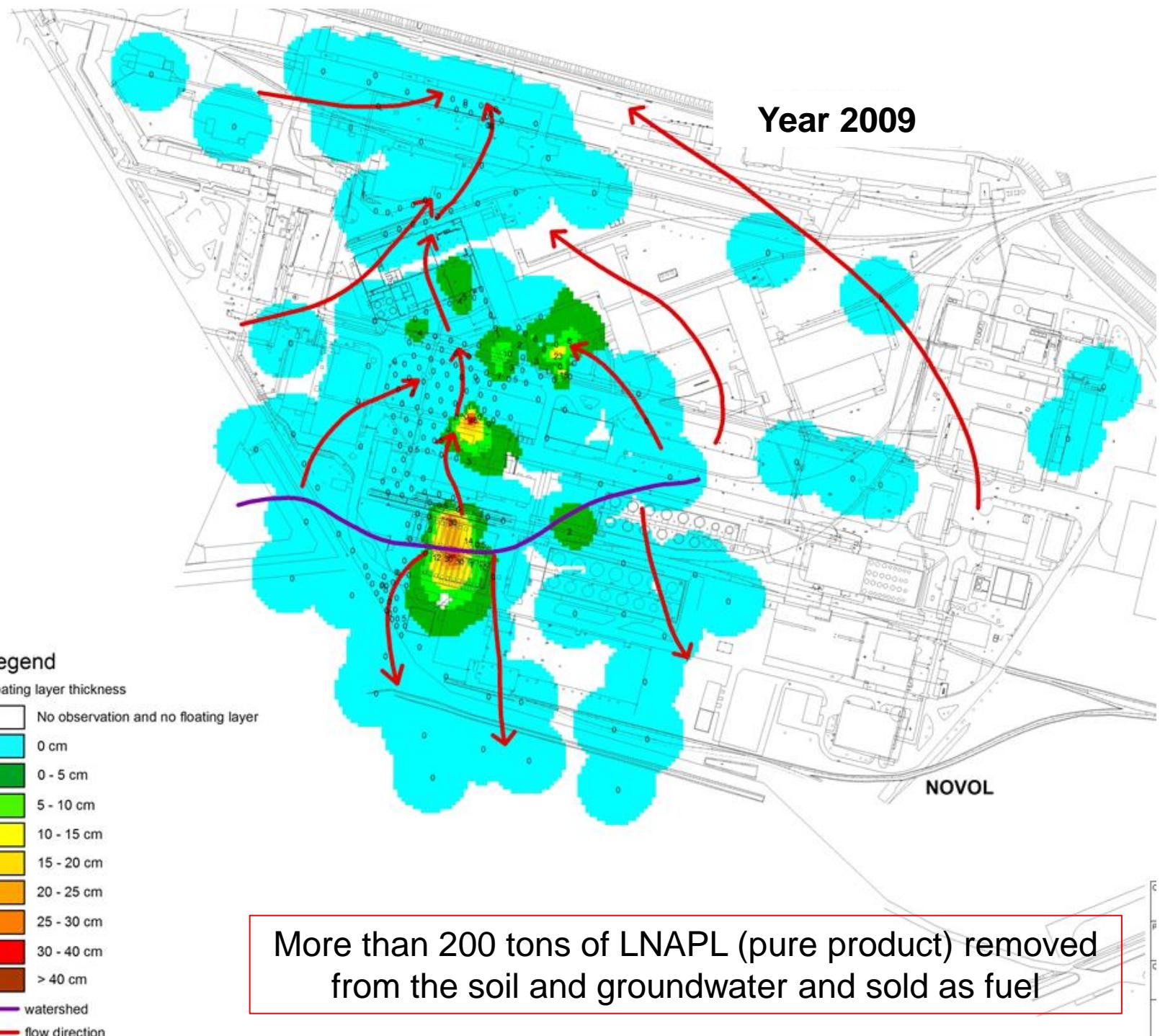
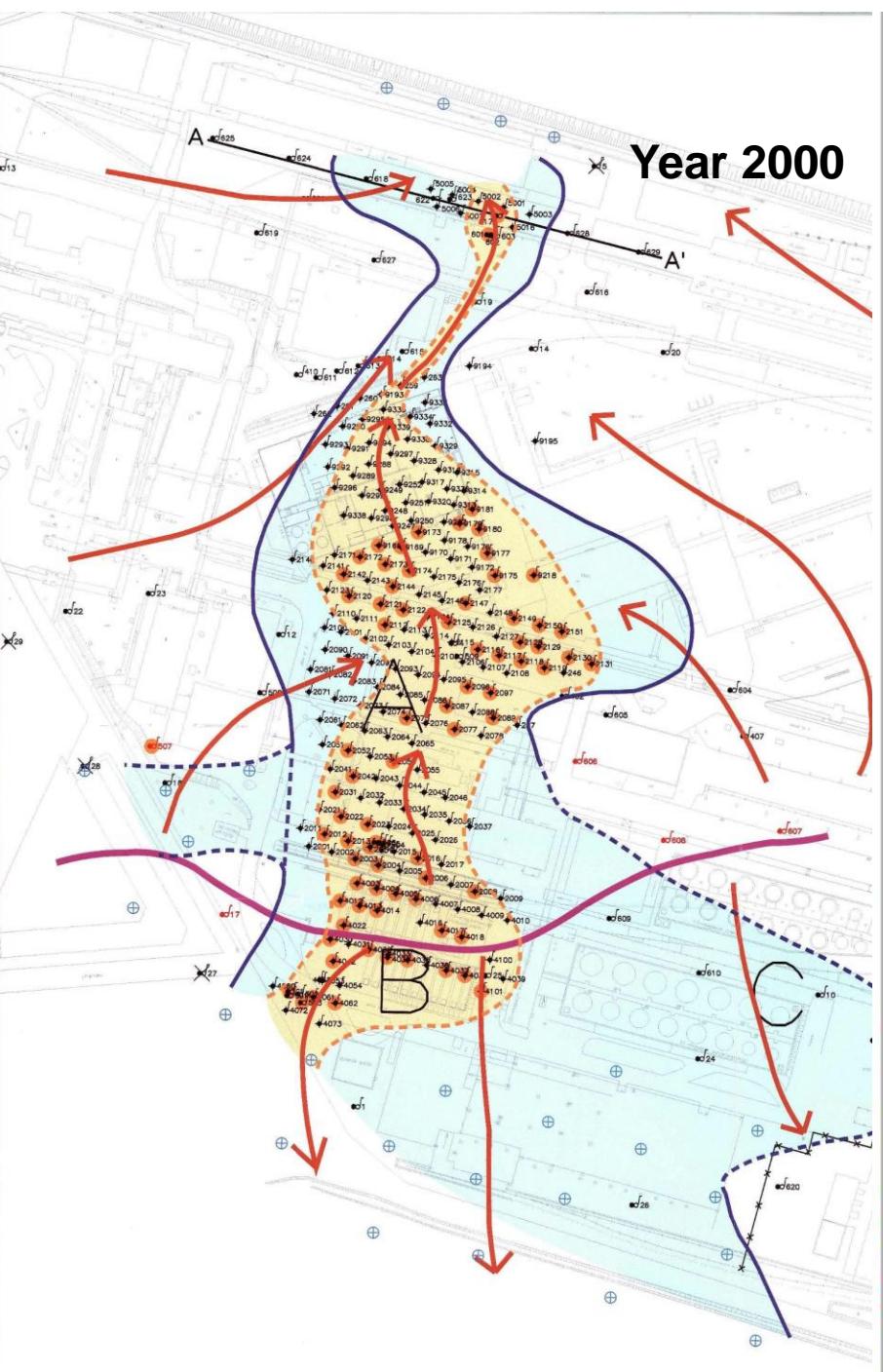


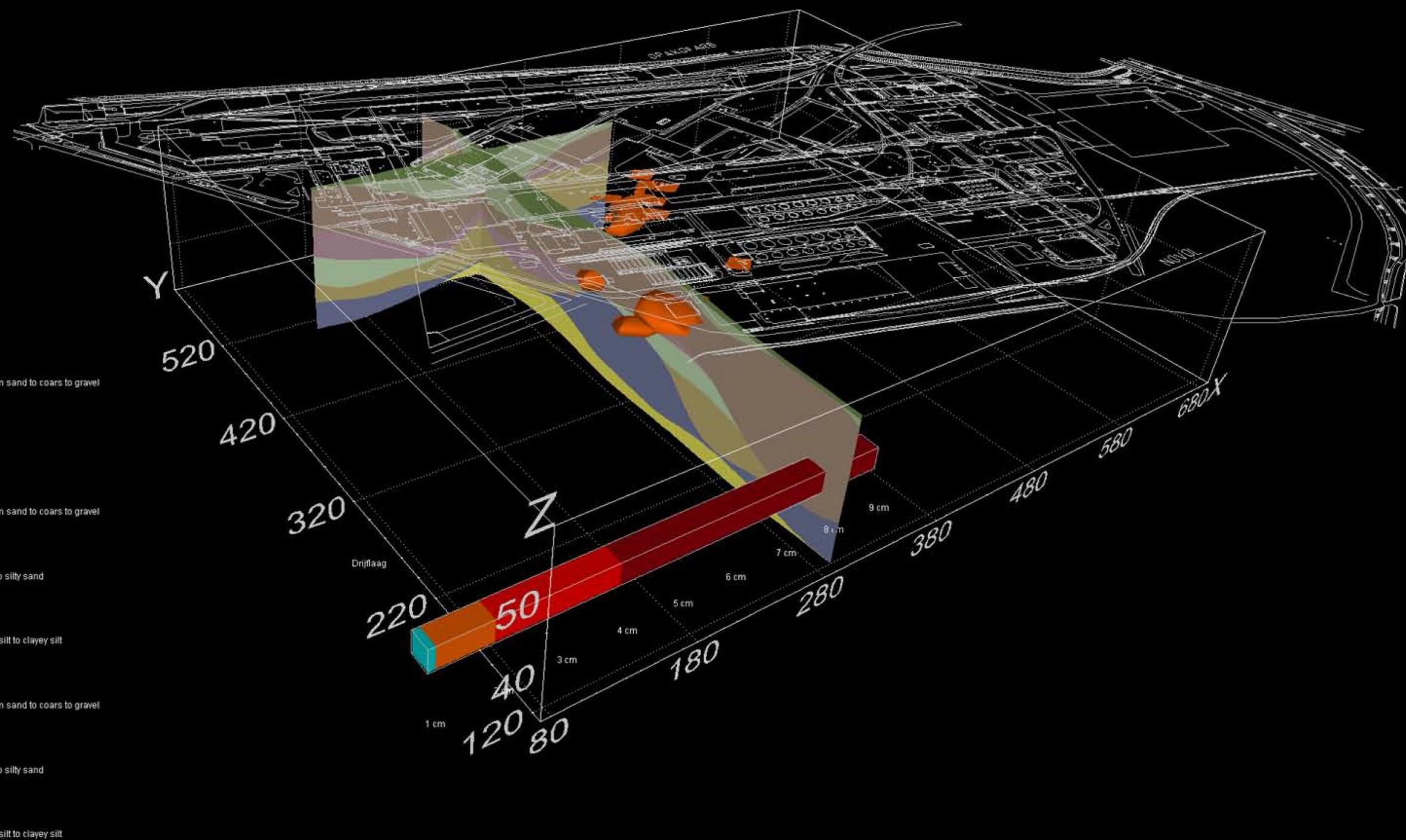


Bu proje Avrupa Birliği ve Türkiye Cumhuriyeti tarafından finanse edilmektedir.

(4) Phase 2 and 4 Adaptation objectives

- **Data used to update CSM**
 - MIPs
 - Soil drillings
 - Groundwater monitoring data (LNAPL, concentrations BTEX)
- **Update CSM used to**
 - Present understanding of the contamination situation
 - Support decision making process
 - Selection and designing new remediation techniques



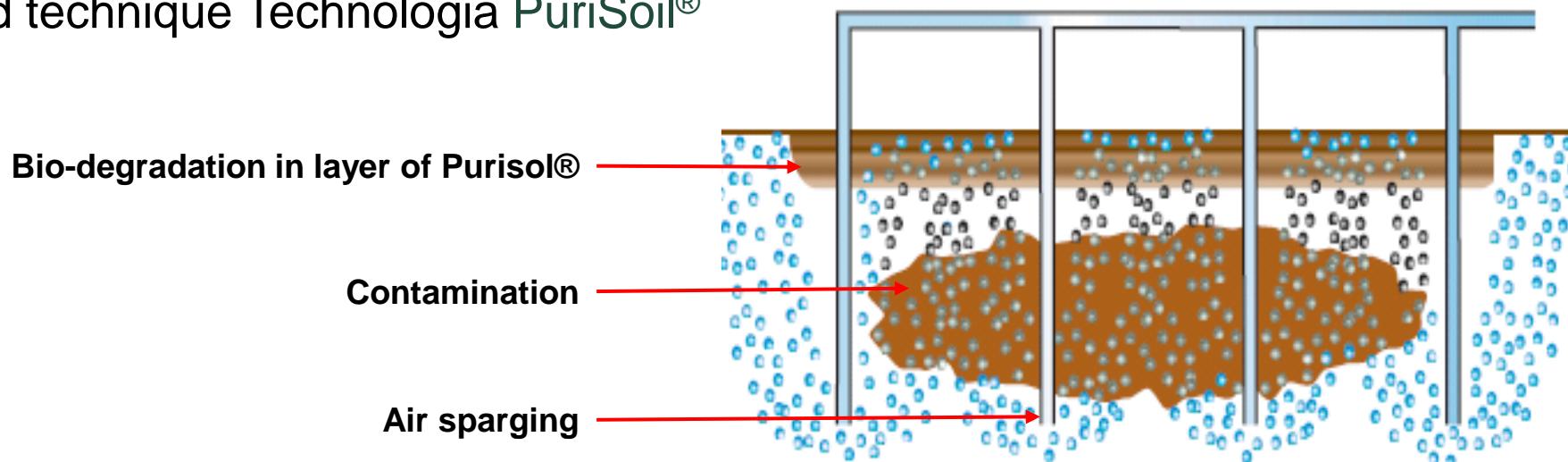




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(4) Phase 2 and 4 Adaptation objectives

Selected technique Technologia PuriSoil®



- Stripping groundwater, LNAPL and Soil
- Contamination is carried to Purisol
- In Purisol degradation of contaminants



Bu proje Avrupa Birliği ve Türkiye Cumhuriyeti tarafından finanse edilmektedir.

(4) Phase 2 and 4 Adaptation objectives



Installation of sparging wells





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(4) Phase 2 and 4 Adaptation objectives



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(4) Phase 2 and 4 Adaptation objectives



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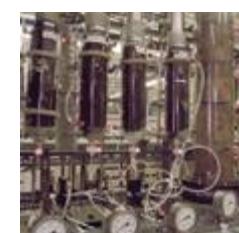
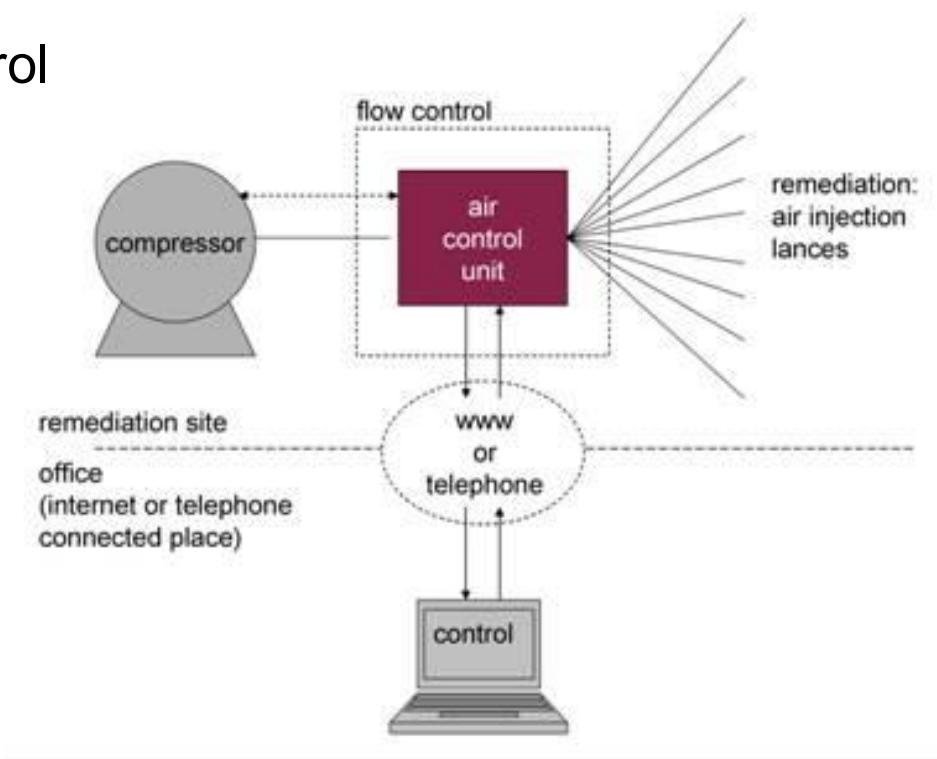
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(4) Phase 2 and 4 Adaptation objectives

Air-sparging control



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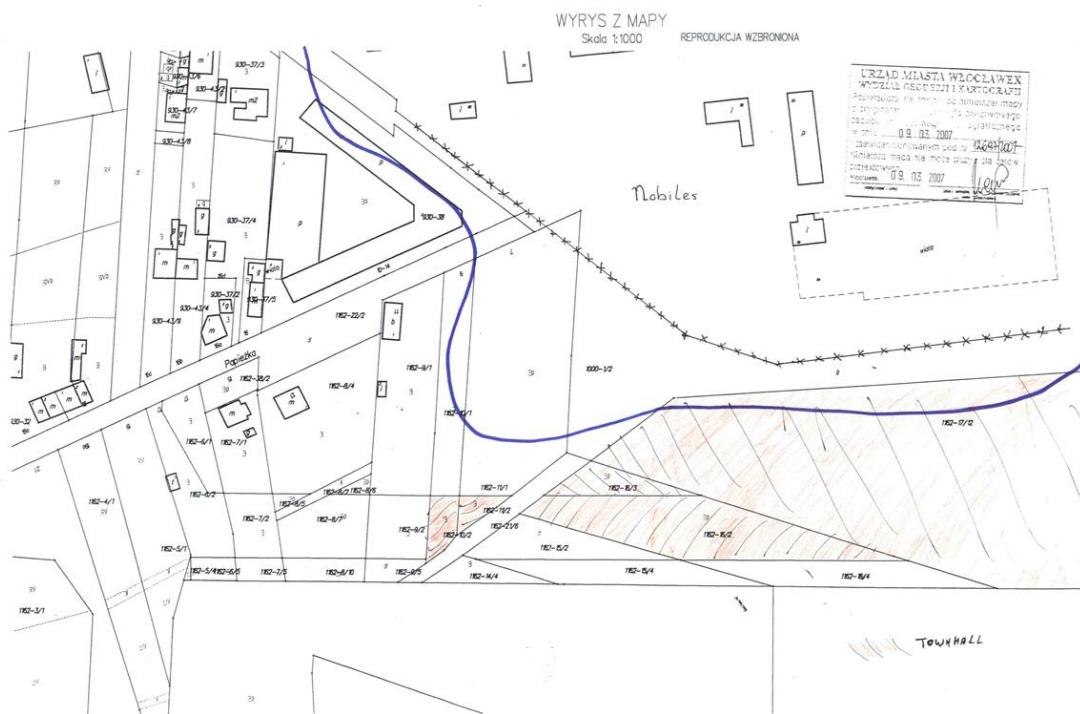
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Bu proje Avrupa Birliği ve Türkiye Cumhuriyeti tarafından finanse edilmektedir.

(5) Conclusive remarks

- Watershed at the former on-site tank farm
- LNAPL and groundwater contamination south of MNI site
- MNI was advised to remediate also outside the site-boundaries
- MNI did not follow advice to avoid claims of landowners
- Arguments
 - Source removed no further spreading off-site
 - Natural Attenuation (NA) of off-site contamination
 - NA stimulated by air sparging on-site



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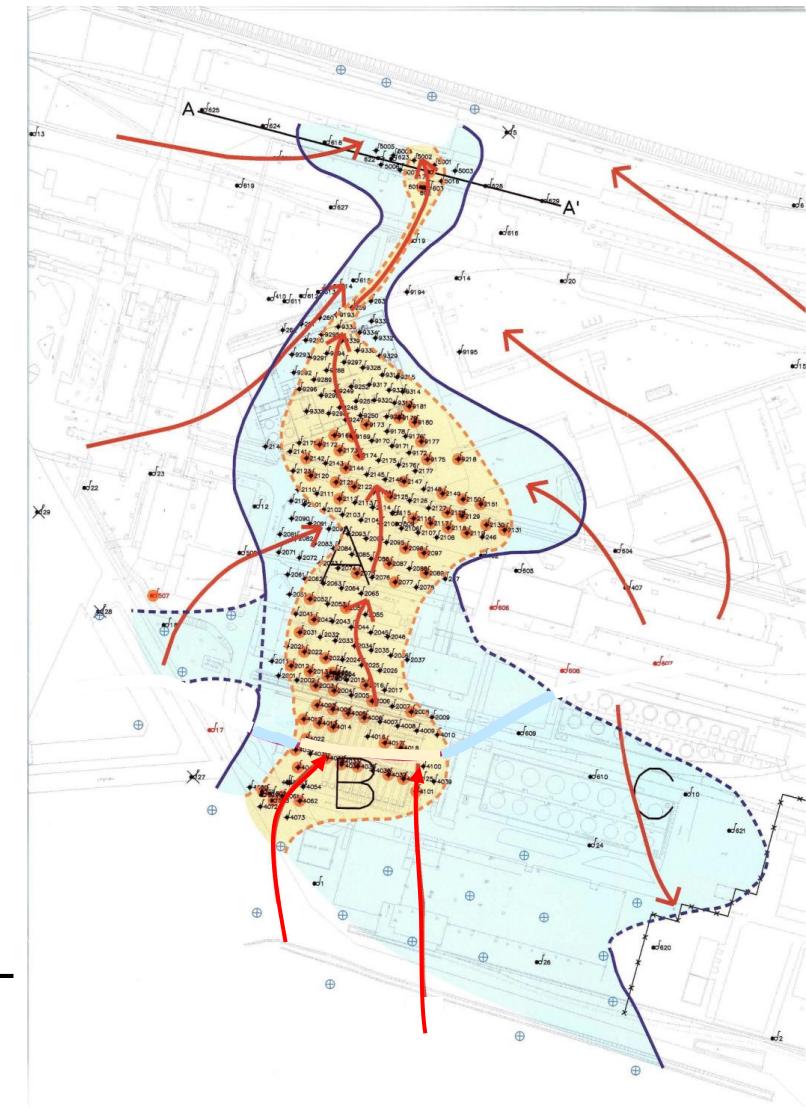
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(5) Conclusive remarks

- Large industrial pumped groundwater for decades
- This was unknown by TAUW, MNI and local contractor
- Large industrial groundwater pumping stopped around 2015
- Groundwater flow direction south turned 180°
- Situation, the CSM changed
- Consequence was that contaminated groundwater and LNAPL from outside flows into the remediated part onsite



Industrial groundwater pumping



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(5) Conclusive remarks

- Last contractor had a turn key contract with the objectives
 - Removal of residues of LNAPL
 - Stop off-site migration of contaminated groundwater
 - On-site BTEX concentration in groundwater below 1,000 µg/litre
- Court case MNI – Contractor settled
- MNI new contract with other contractor to remediate last part





Bu proje Avrupa Birliği ve Türkiye Cumhuriyeti tarafından finanse edilmektedir.

(5) Conclusive remarks

- **Lessons learned**
 - Industrial groundwater pumping should have been known
 - CSM has to be updated constantly
 - Work with flexible workplan
 - Approach contamination as a whole regardless administrative boundaries
 - Focus on source removal
 - Be prepared for the unexpected





Bu proje Avrupa Birliği ve Türkiye Cumhuriyeti
tarafından finanse edilmektedir.

Thank you very much for your attention

Any questions?



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