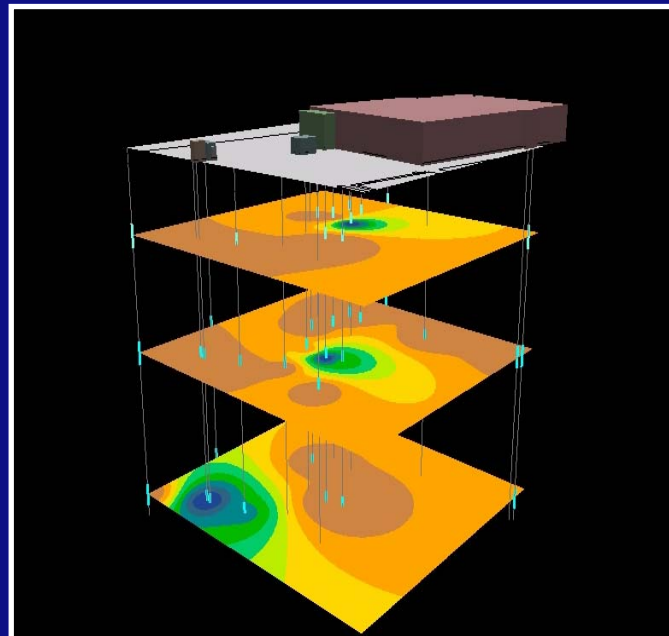
Bioscreen

Monitoring,
molecular characterization and
emanation

TNO | Knowledge for business



Nanne Hoekstra

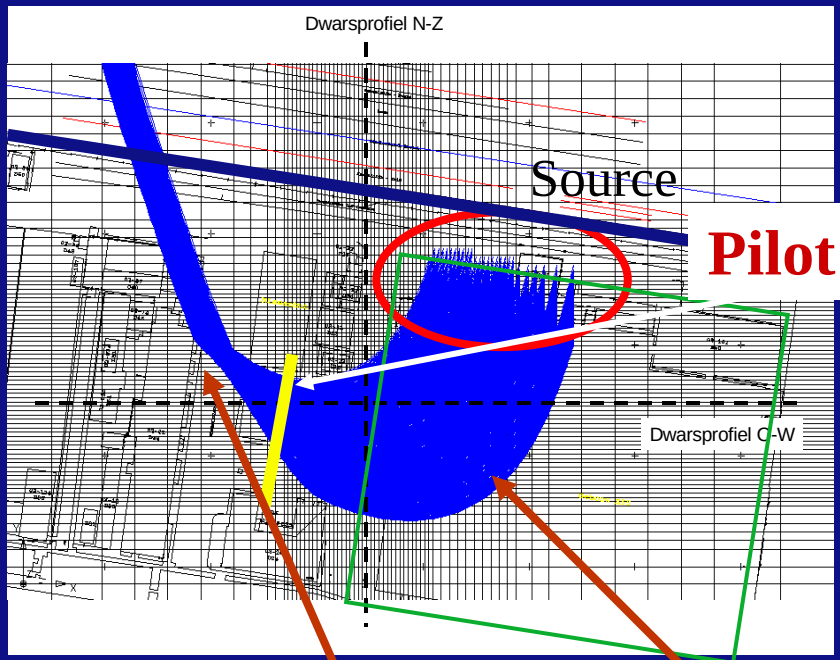
Pilot site description

- Former metal workshop of car and truck manufacturer
- Heterogeneous soil cover with fine sands, silt, peat and clay
- Groundwater flow influenced by canal, cork-screw shaped infiltration via natural funnel
- Soil contaminated with TCE and TCA and degradation products
- Source underneath most important production facility
- Complex and large source area, heterogeneous hot-spots.

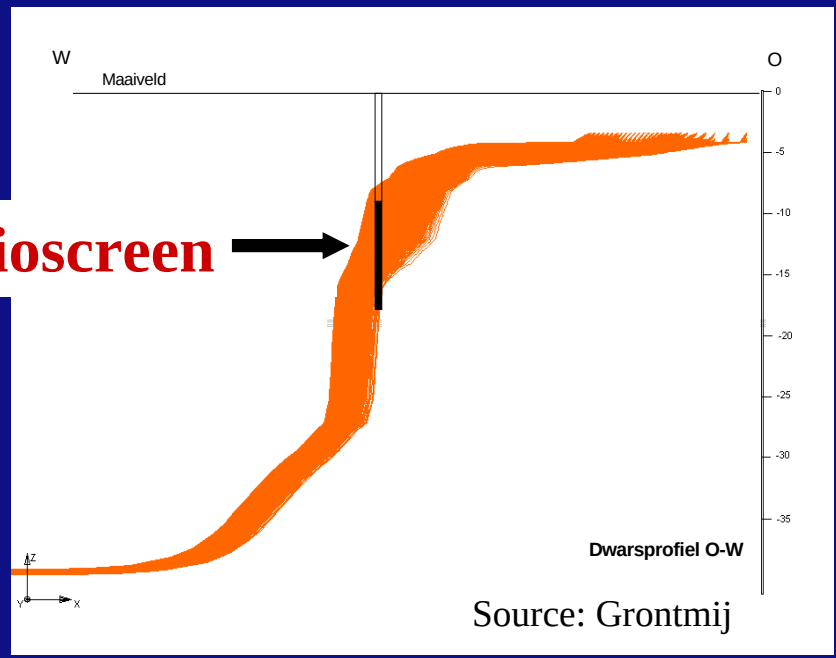
- Fast flow in aquifer
- Degradation in soil cover stagnates at natural funnel due to lack of electron donor
- Good accessible small groundwater plume just before transition to aquifer

Top view

Cross section



Pilot bioscreen

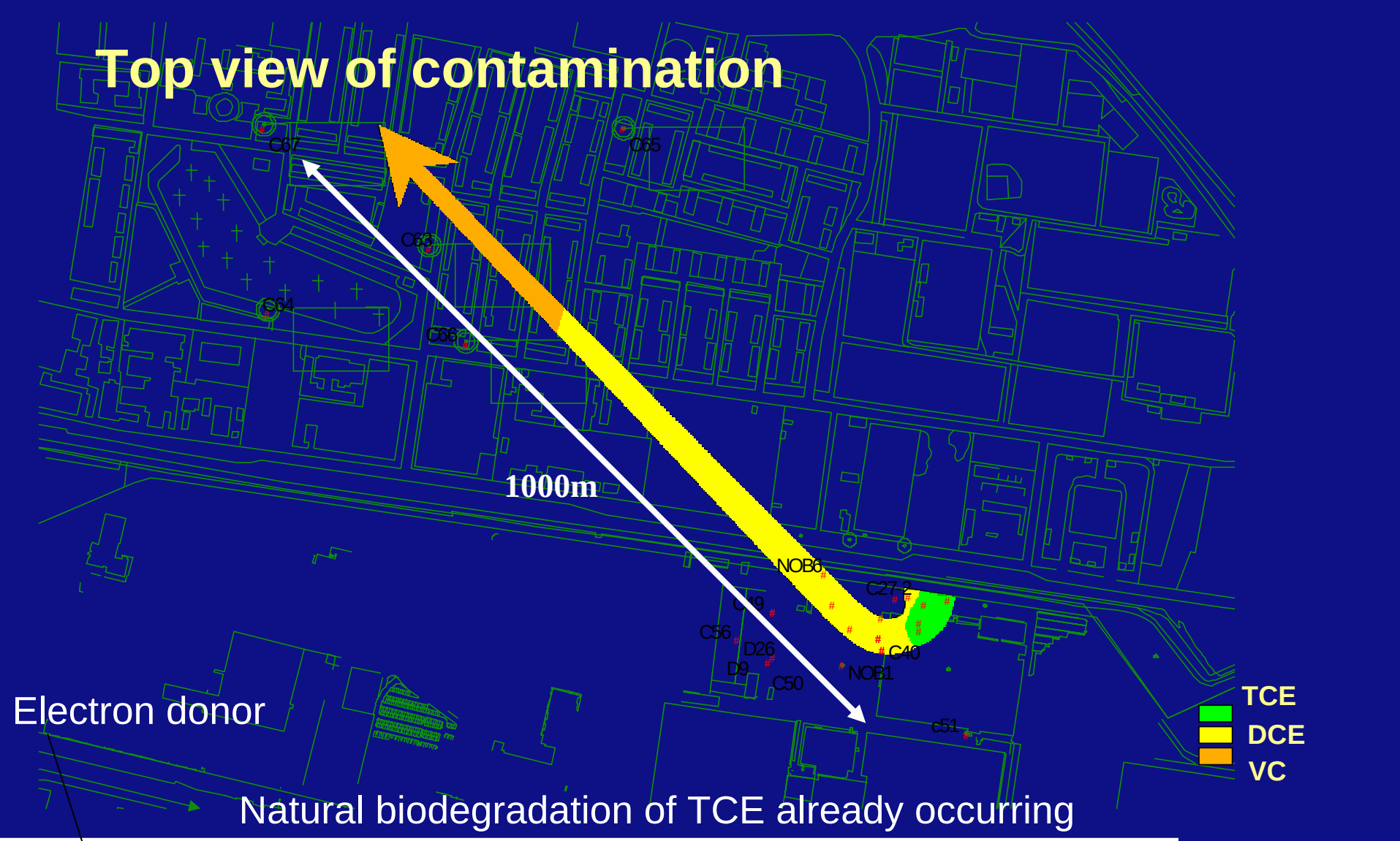


Source: Grontmij

Aquifer: 40-50 m/yr

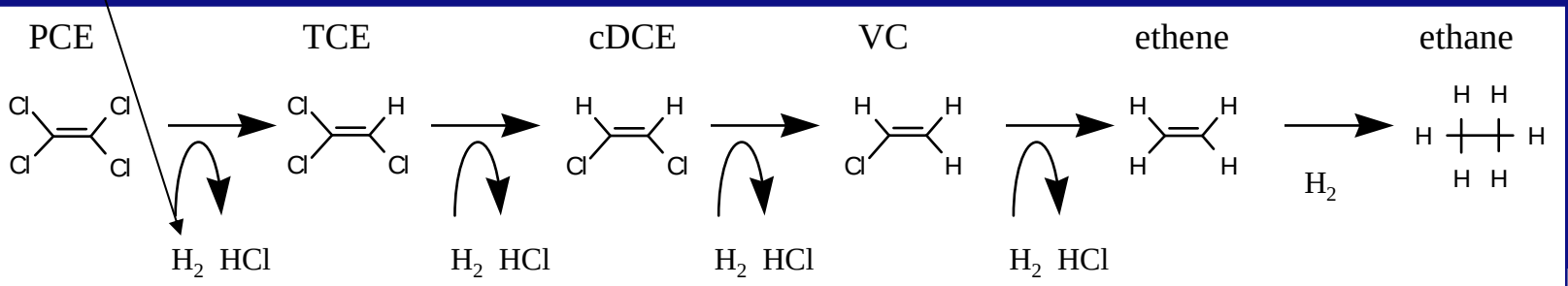
Soil cover: 3-5 m/yr

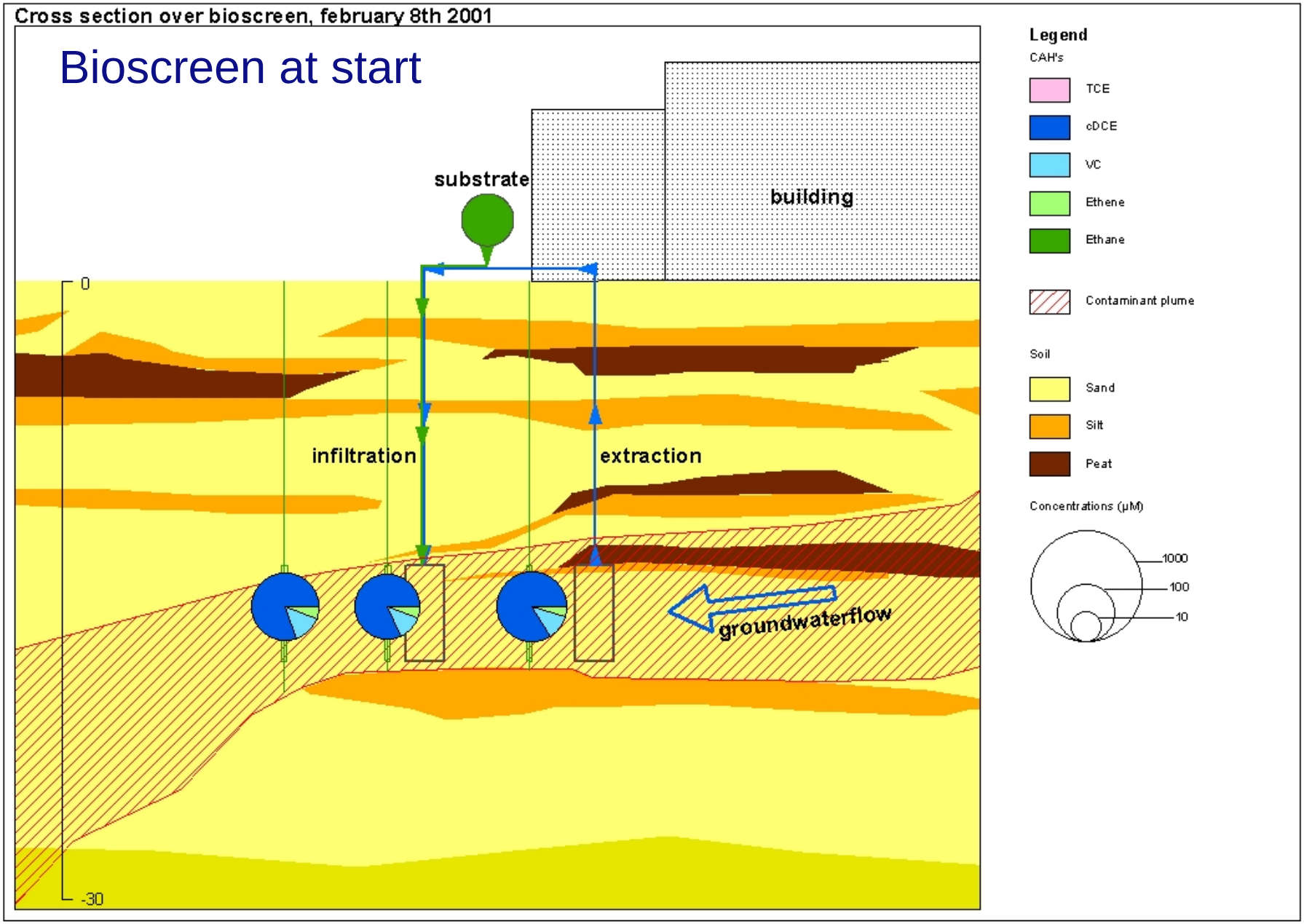
Top view of contamination

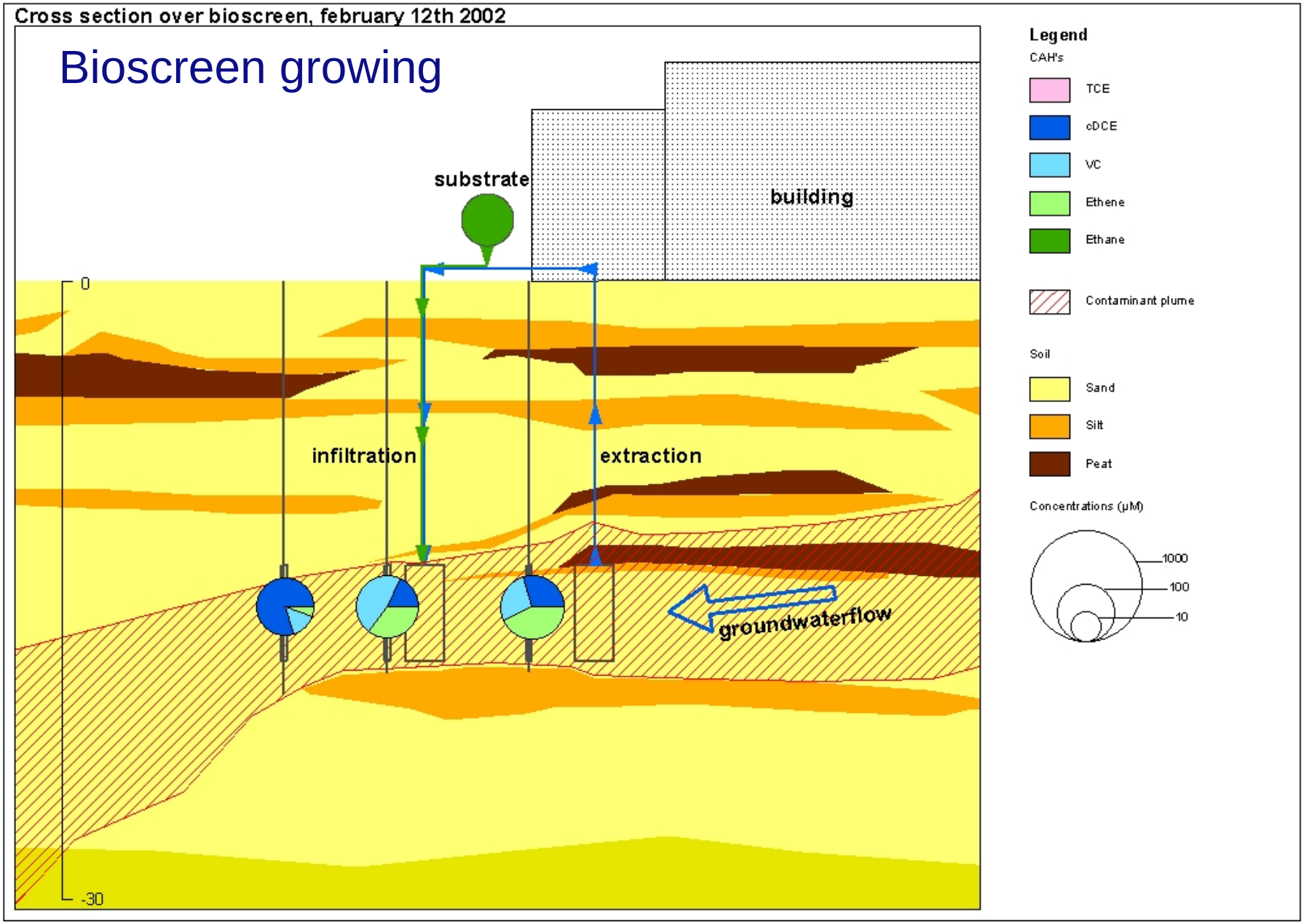


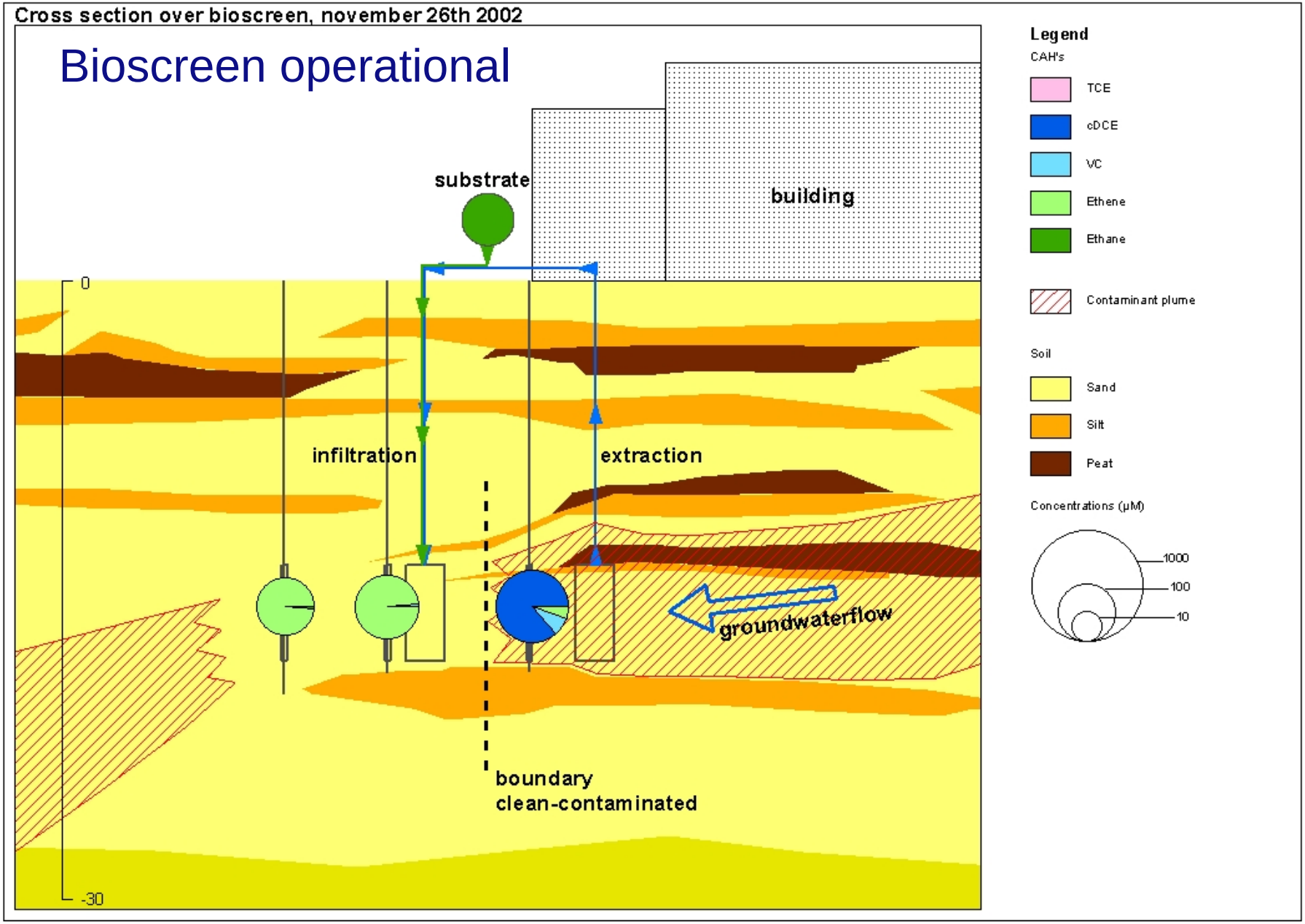
Electron donor

Natural biodegradation of TCE already occurring

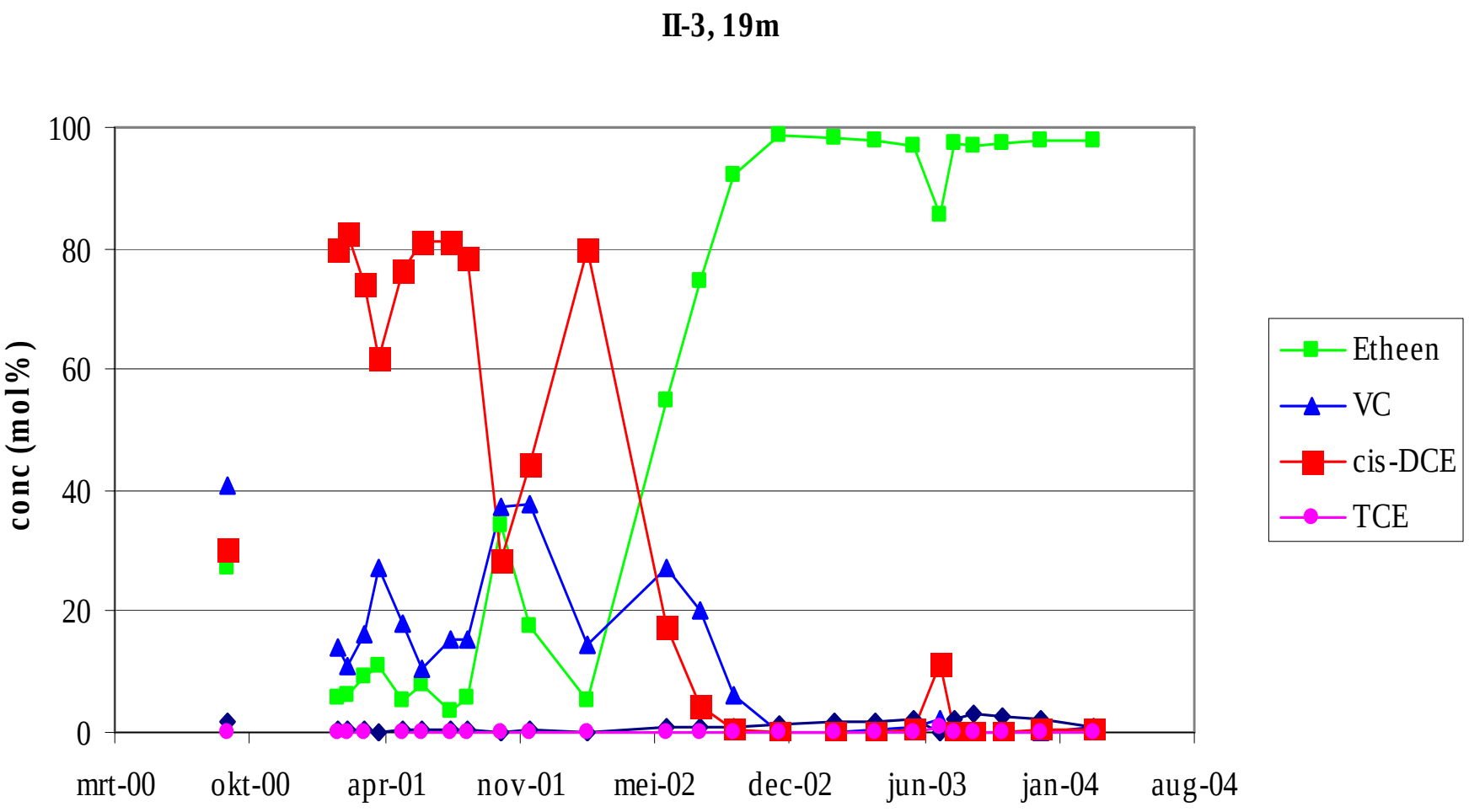



Cross section over bioscreen, february 8th 2001
Bioscreen at start
substrate
building
0
-30
infiltration
extraction
groundwaterflow
Legend
CAH's
TCE
cDCE
VC
Ethene
Ethane
Contaminant plume
Soil
Sand
Silt
Peat
Concentrations (µM)
1000
100
10

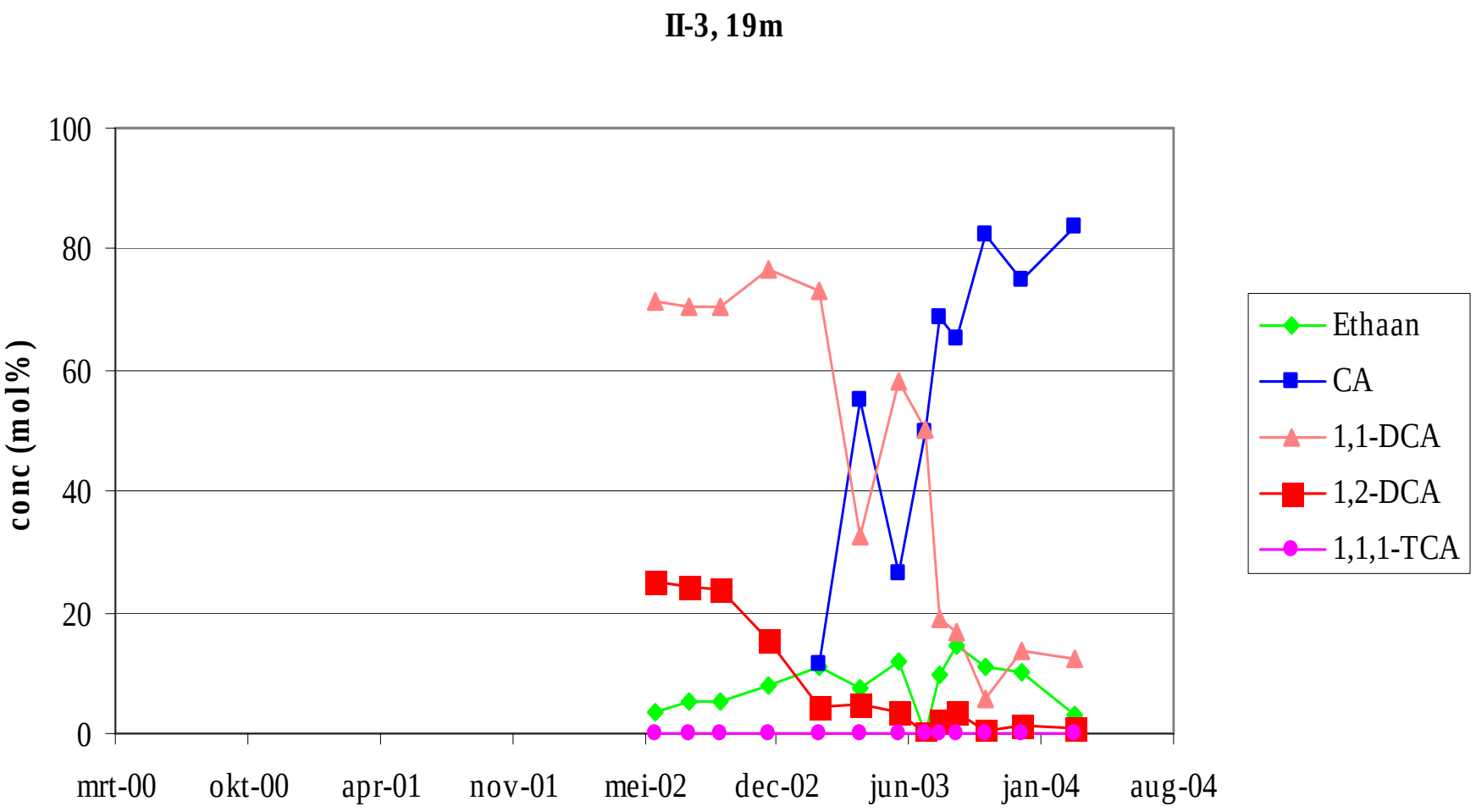

Cross section over bioscreen, february 12th 2002
Bioscreen growing
substrate
building
0
-30
infiltration
extraction
groundwaterflow
Legend
CAH's
TCE
cDCE
VC
Ethene
Ethane
Contaminant plume
Soil
Sand
Silt
Peat
Concentrations (µM)
1000
100
10


Cross section over bioscreen, november 26th 2002
Bioscreen operational
substrate
building
0
-30
infiltration
extraction
groundwaterflow
boundary
clean-contaminated
Legend
CAH's
TCE
cDCE
VC
Ethene
Ethane
Contaminant plume
Soil
Sand
Silt
Peat
Concentrations (µM)
1000
100
10

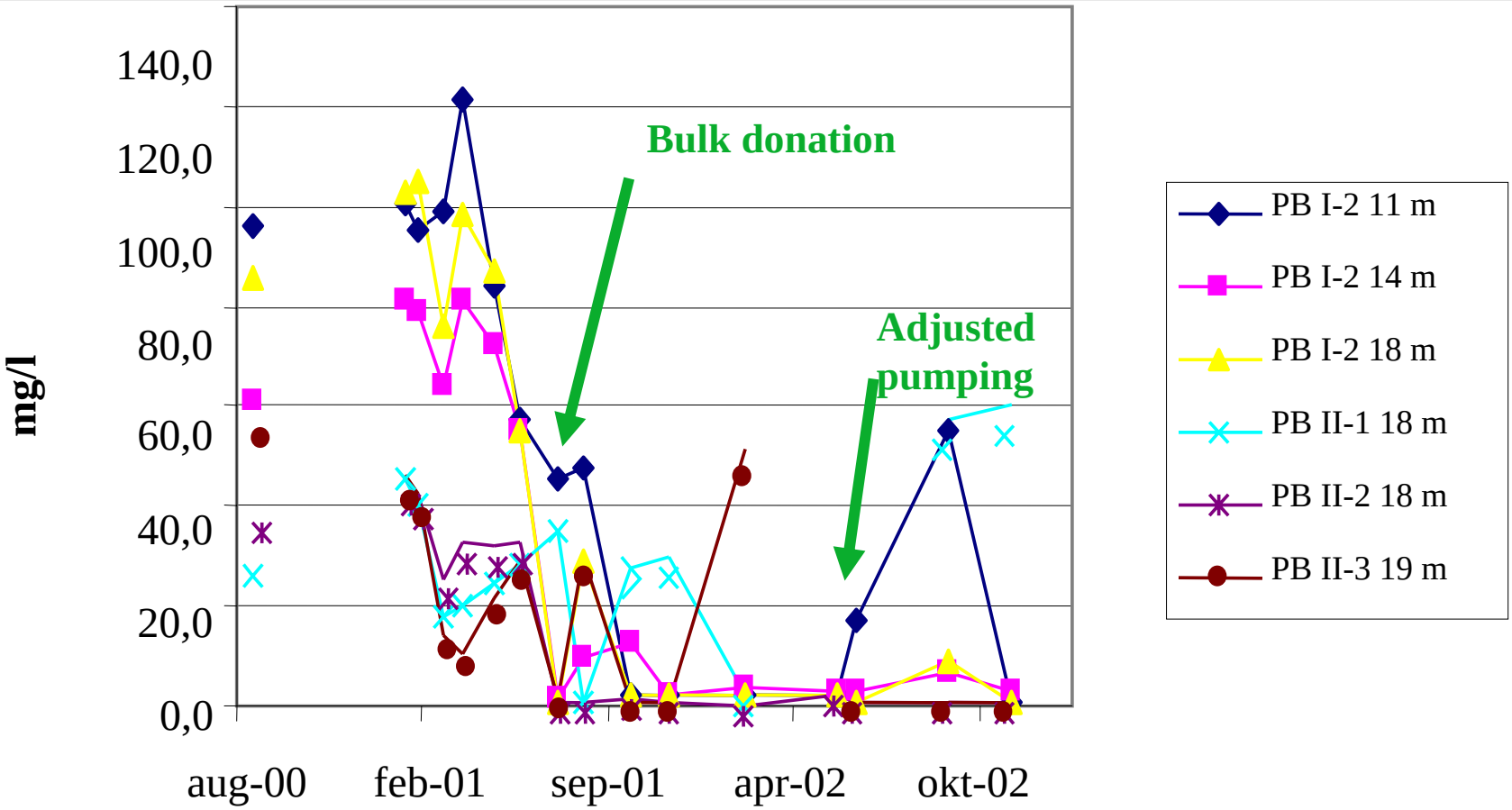
cDCE from 15 mg/l to 5 µg/l
VC from 1 mg/l to < 1 µg/l



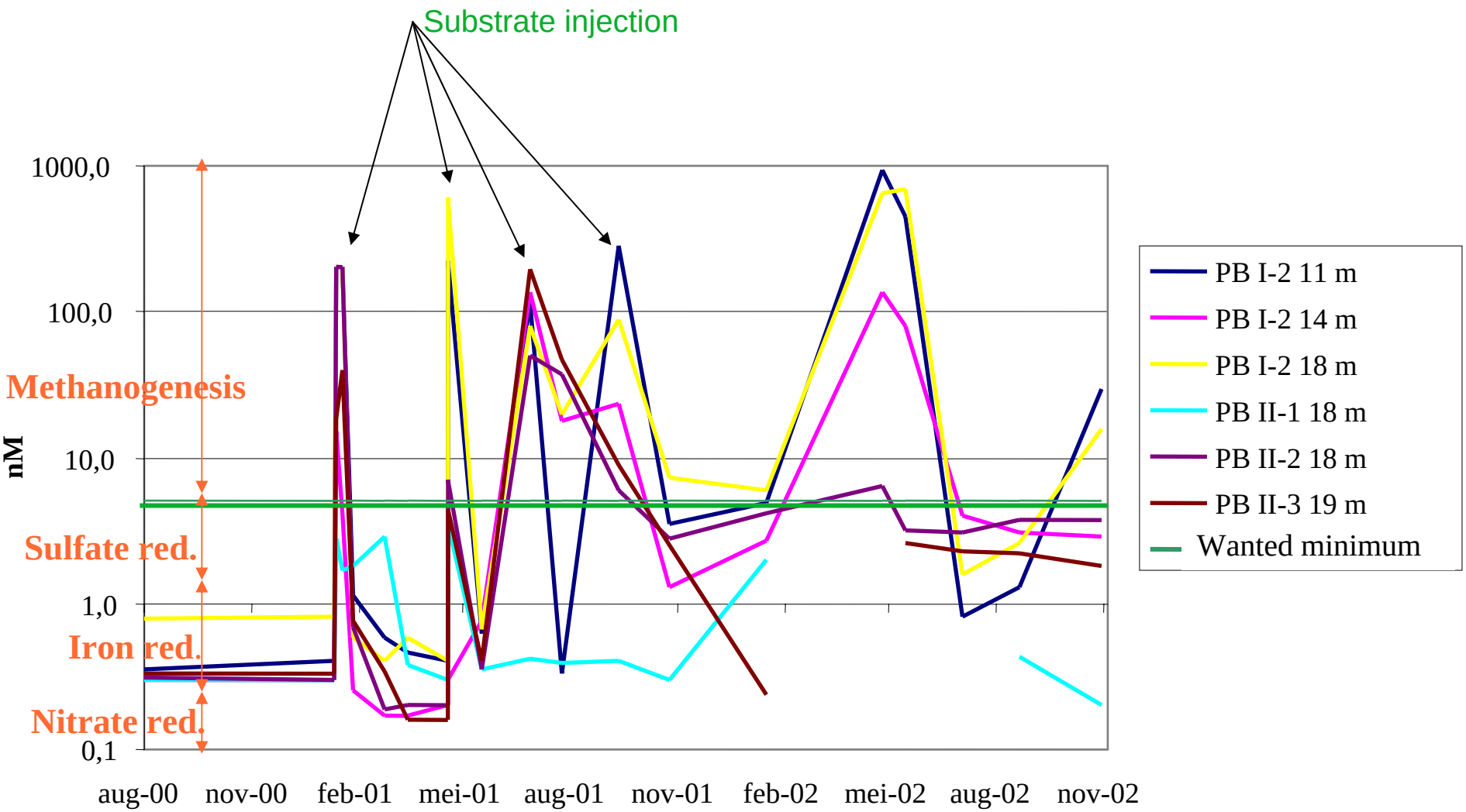
1,1-DCA	from	1 mg/l	to	20 µg/l
1,2-DCA	from	1 mg/l	to	< 10 µg/l



Example monitoring parameter as input for bioscreen operation : Sulfate

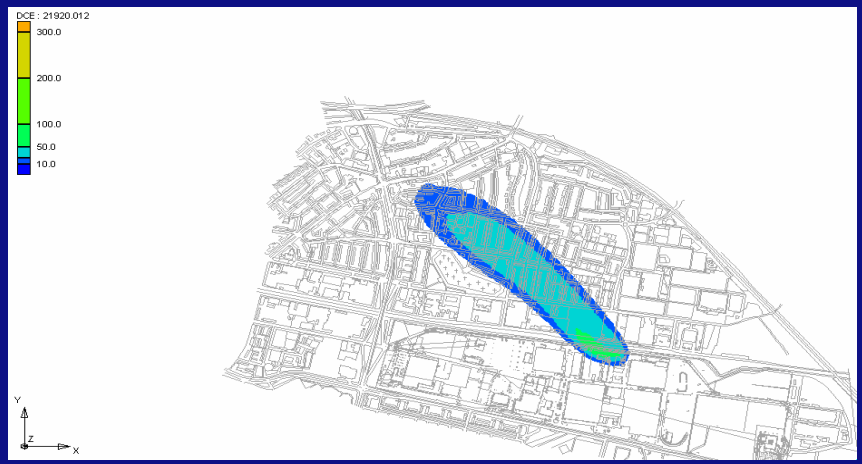


Hydrogen: very suitable for quick adjustments in injection regime of electron donor



Modelling effectiveness of bioscreen on vinyl chloride in plume

Stop of source flux with barrier will lead to disappearance of plume in no less than 60 years



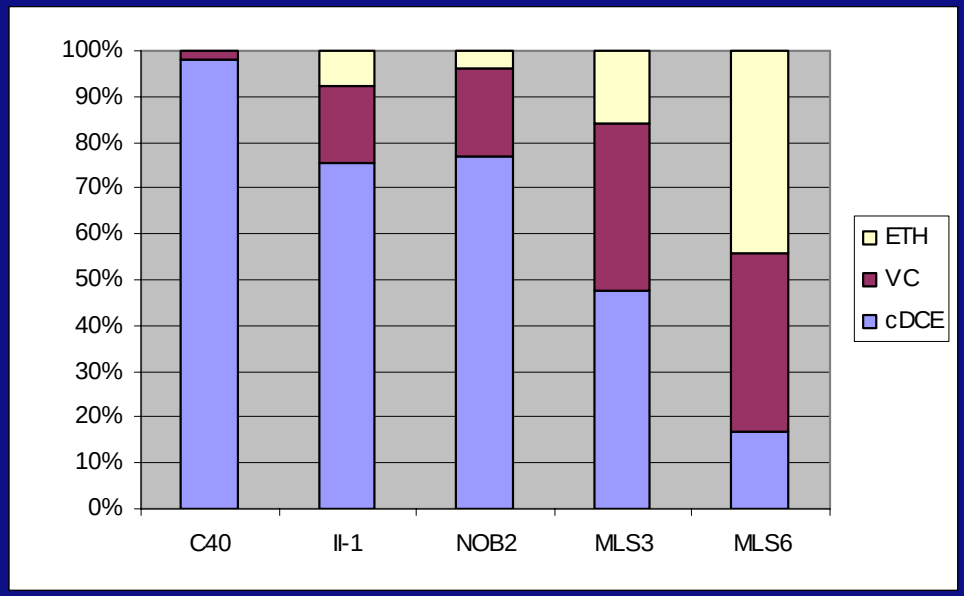
No source measures

Stop source flux

Evidence for natural biodegradation in aquifer?

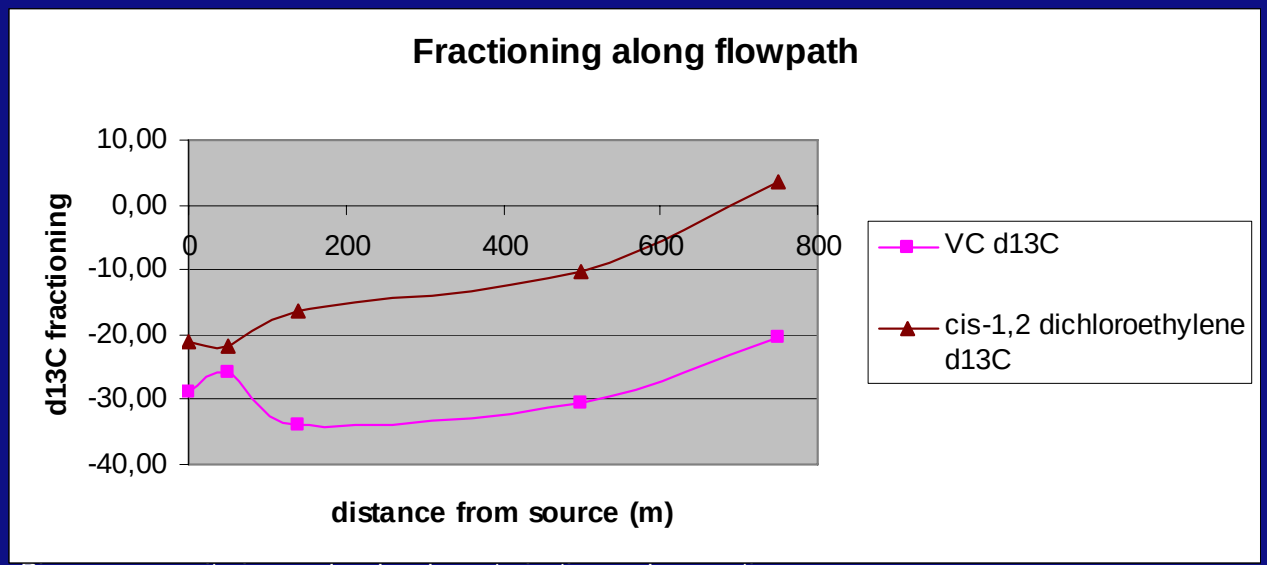
1. High resolution (multi level) sampling on heterogeneity redox zones: **no proof**
2. Modeling: current plume can be fitted assuming **no degradation**
3. Micro-cosm experiments: **no significant oxidative or reductive degradation**
4. Molecular analyses: **no specific dechlorinating bacteria** present (*Dehalococcoides – Dehalobacter – Desulfitobacterium)*
5. Flow path analysis:
   - Transport or degradation?
   - Stable isotopes

Degradation along flowpath?



Degradation products:

Strong change in ratio



Stable isotopes: Significant shift can only be explained by degradation

d13C cisDCE:
-20 to +4

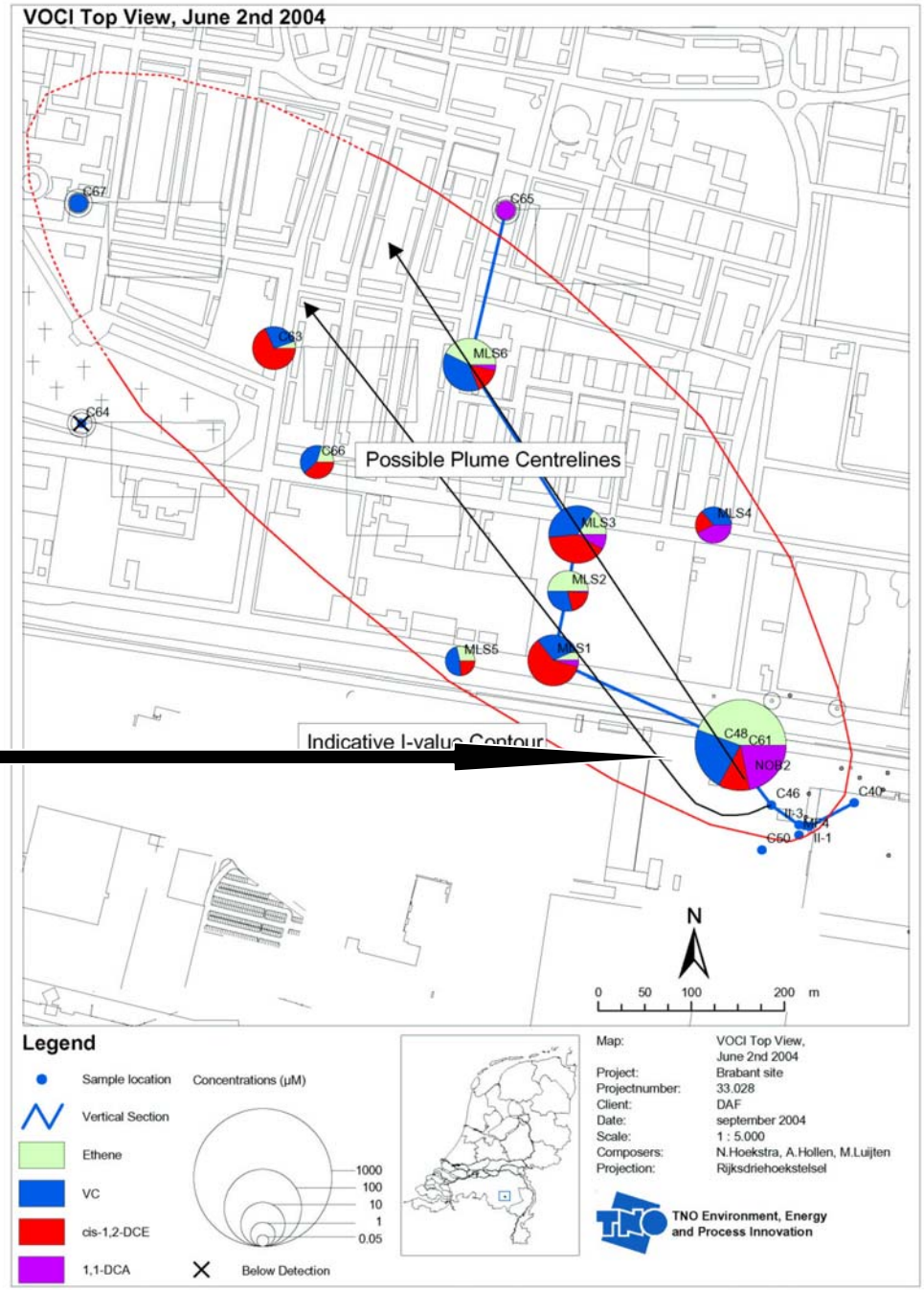
d13C VC:
-30 to -20

Top view plume(s)

Progressive degradation at origin of plume in well C48

Between 2000 and 2004:

Decrease of cisDCE and VC and increase in ethene

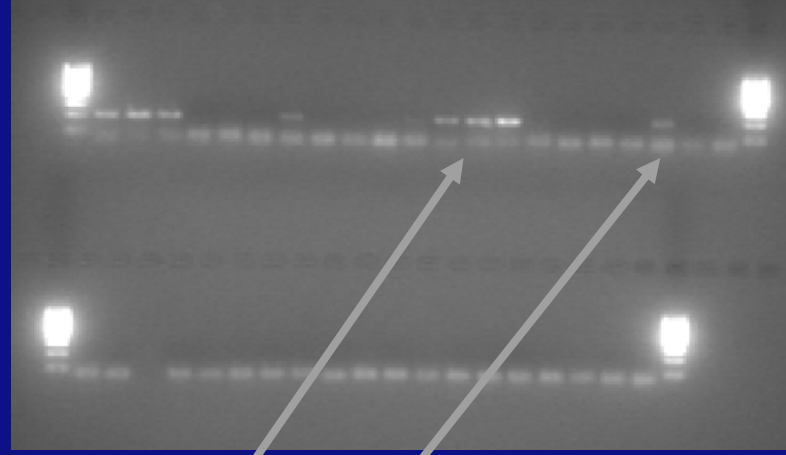


Well C48 in 2000 and in 2004 (bioscreen started in 2001)

	TCE	cisDCE	VC	ethene
2000	9.9	11,800	3,200	170
2004	<<	2,500	2,500	2,300

Is sudden increase in dechlorination a result of growing microbial activity?

Specific degraders in groundwater



In 48 filters of multi-level-samplers:
no *Dehalococcoides*

Dehalococcoides present in bioscreen
AND in well C48 downstream of bioscreen
(located halfway between bioscreen and plume MLS's)

Hence: emanation of bioscreen activity into plume!

Conclusions

- A bioscreen is a very cost effective solution when operations are based on elaborate monitoring (including hydrogen measurements)
- A bioscreen can expand into contaminant plume, leading to much shorter plume life compared to other containment measures
- Innovative analyses (DNA-identification and stable isotope numbers) provide ample proof for an inexpensive soil remediation strategy based on Natural Attenuation

Statement

Don’t be penny wise and pound foolish
but use your entrepreneurial skills
also for environmental issues:

An extra
EUR 10.000,-
for site characterization and sufficient monitoring
can save
EUR 100.(0?)000,-
in soil remediation costs