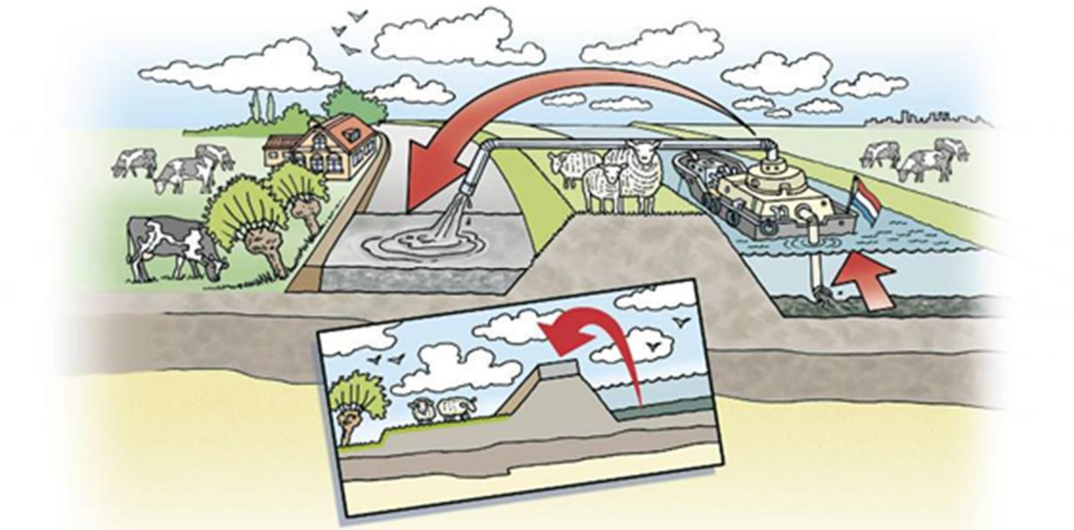
Lift up of lowlands

The reuse of sediments on peat meadows, looking at the physical, chemical and biochemical properties in relation to the local situation.

24-09-2015 / / 11.20-11.40 session

Arjan Wijdeveld, Leon van Paassen, Roderick Tollenaar

Lift up of Lowlands



Part of the STW program “Bio-Geo-Civil”

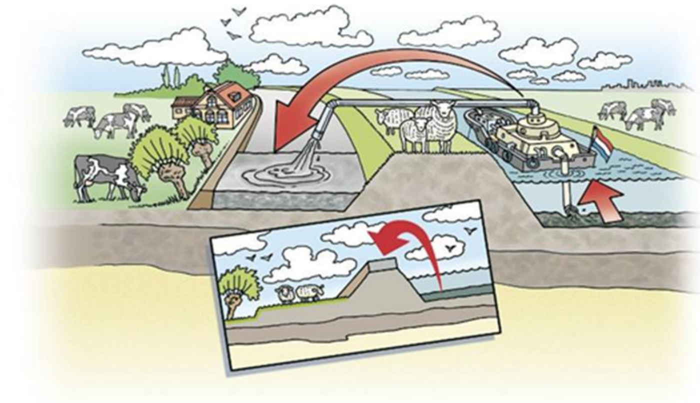
- PhD. Wageningen University: Bruna Figueiredo Oliveira
- PhD. TU Delft: Roderick Tollenaar

Pilot site for CEAMaS (Civil Engineering Applications for Marine Sediments), an INTERREG IV-b program

CEAMaS Civil Engineering Applications for Marine Sediments

Investing in Opportunities
This project has received European Regional Development Funding through INTERREG IV B.
nwe INTERREG IVB

Lift up of Lowlands



Goal of Lift up of Lowlands

Lift up of lowlands goes back to pre-historic sediment management, the reapplication of dredged sediments to compensate subsidence and to improve the lands fertility.

In this talk I will focus on compensation for subsidence in relation with the physical, chemical and biochemical properties of the sediment.

For more information on the improvement on the lands fertility, please visit the talk by Bruna:

- Friday 25-09, 10:00 – 10:20 Beneficial use of dredged material in agricultural land

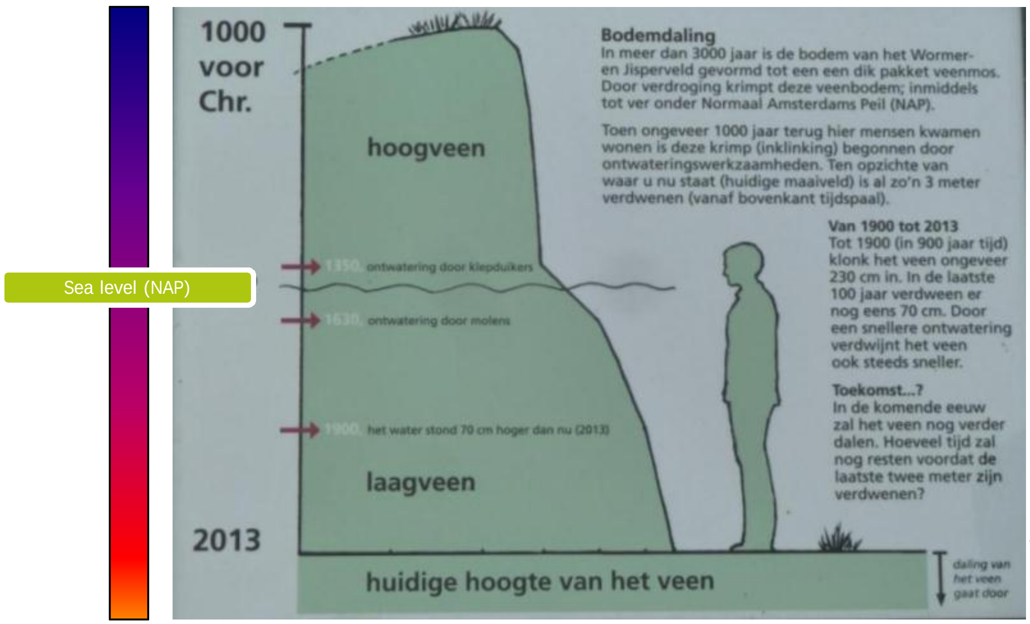
Lift up of Lowlands

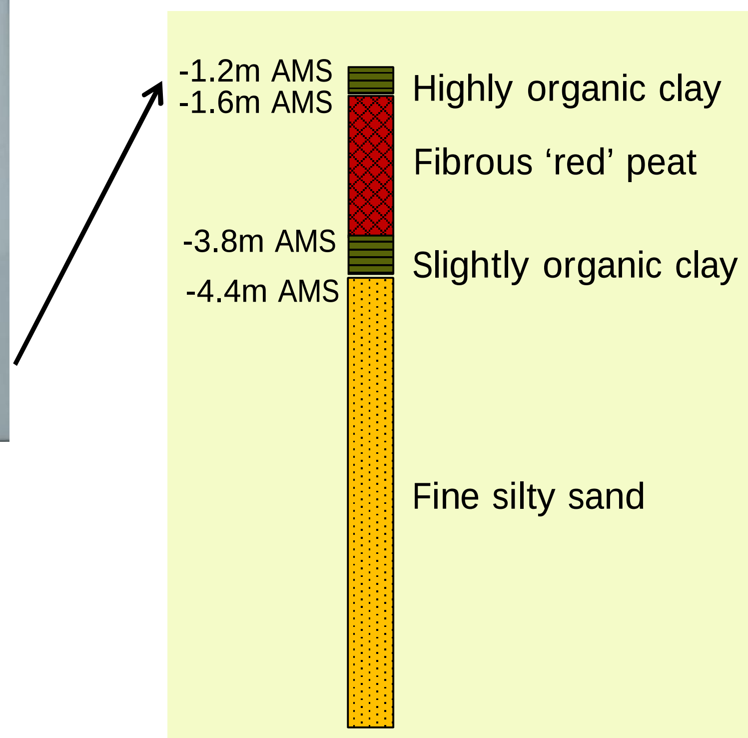
Location in The Netherlands, Wormer- and Jisperveld

Filling up of depot

Lift up of Lowlands

Wormer- and Jisperveld, a peat are.
What is the historical implication of dewatering?





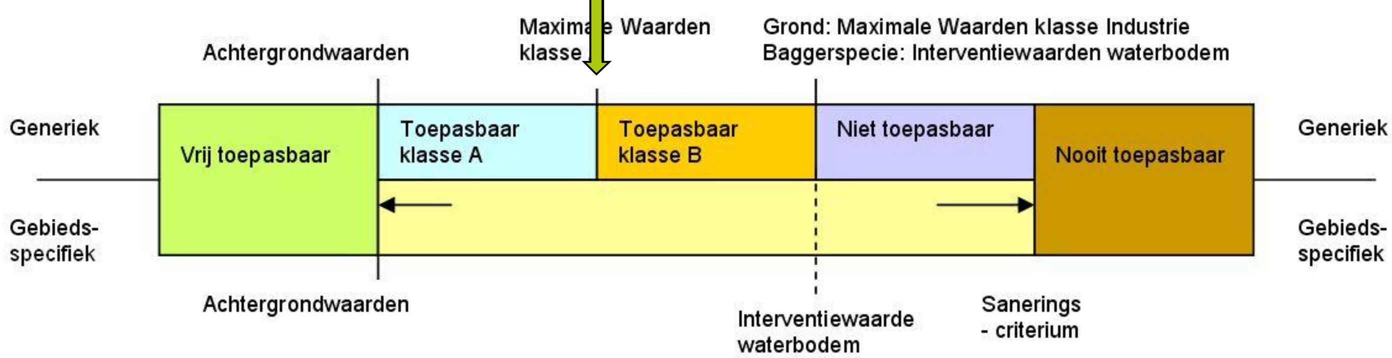
Lift up of Lowlands

With regard to subsidence, what are the main issues?

- What happens with the sub surface when sediments are used to increase the soil level?
- How quickly are sediments transformed to a stable soil? Dewatering
- What are the properties if this new soil, since the sediment itself is mostly peat.

Also, since the sediments are not 100% clean with regard to pollutants (due to historical industrial activity the classification is “class A/B”), what is the potential ecological impact of reuse on land?

Global reuse schematic for soils and sediments within the Dutch Soil Directive



Lift up of Lowlands

Topics for this presentation

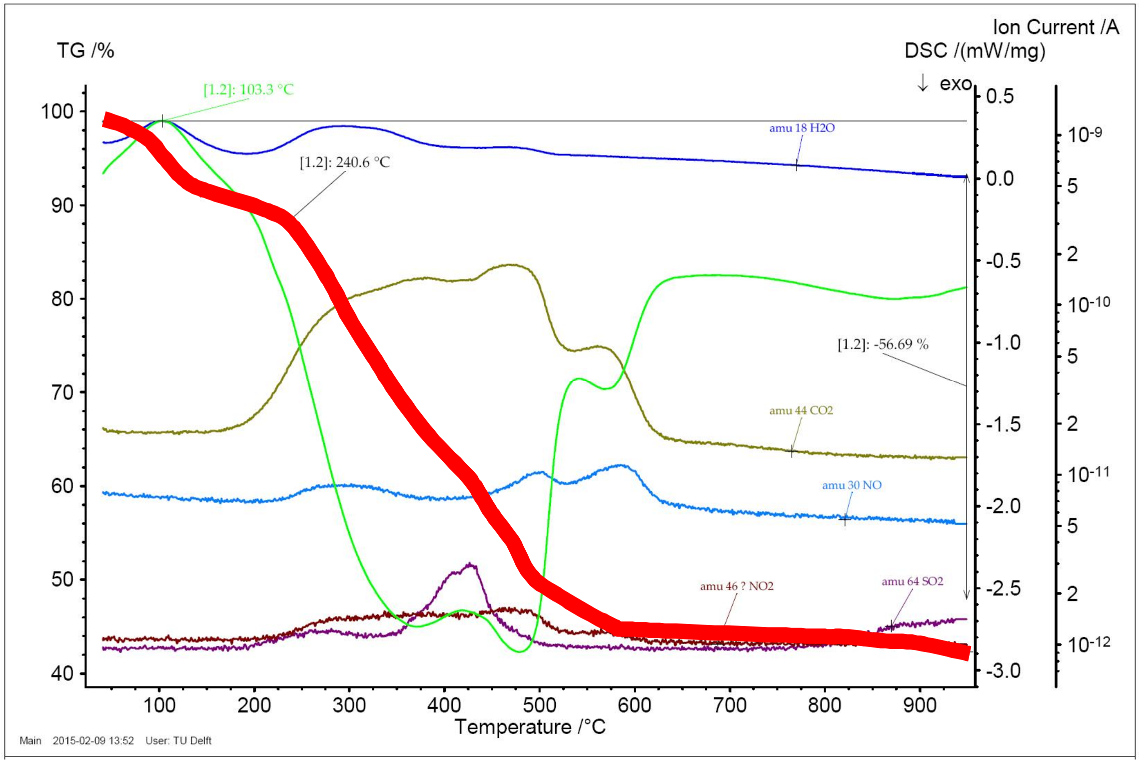
- Physical
  - Thermogravimetric Analyzer (TGA) (water content & indicative composition)
  - Pressure measurements (dewatering & permeability)
  - “Zakbaak” (subsurface compaction, soil level)
  - Oedemeter test (soil consolidation)
  - Hyprop test (crack formation)
  - Zeta potential measurements (flocculation)
  - Heat conductivity of the soil (local density)
  - SEM (peat fibre structure)

- Chemical
  - Total concentration & leaching test (metals)
  - ms-PAF (ecotoxicity)
  - Bio-available fraction (organic pollutants)

- Biochemical
  - Please visit the presentation of Bruna (Friday 25-09, 10:00 – 10:20 ...)

Lift up of Lowlands

Physical: TGA
60% mass loss for Lowlands sample during temperature ramping
Organic content: 70- 98% of solid phase
Mostly Peat



Lift up of Lowlands

Physical: Pressure measurements (dewatering & permeability)

datalogger

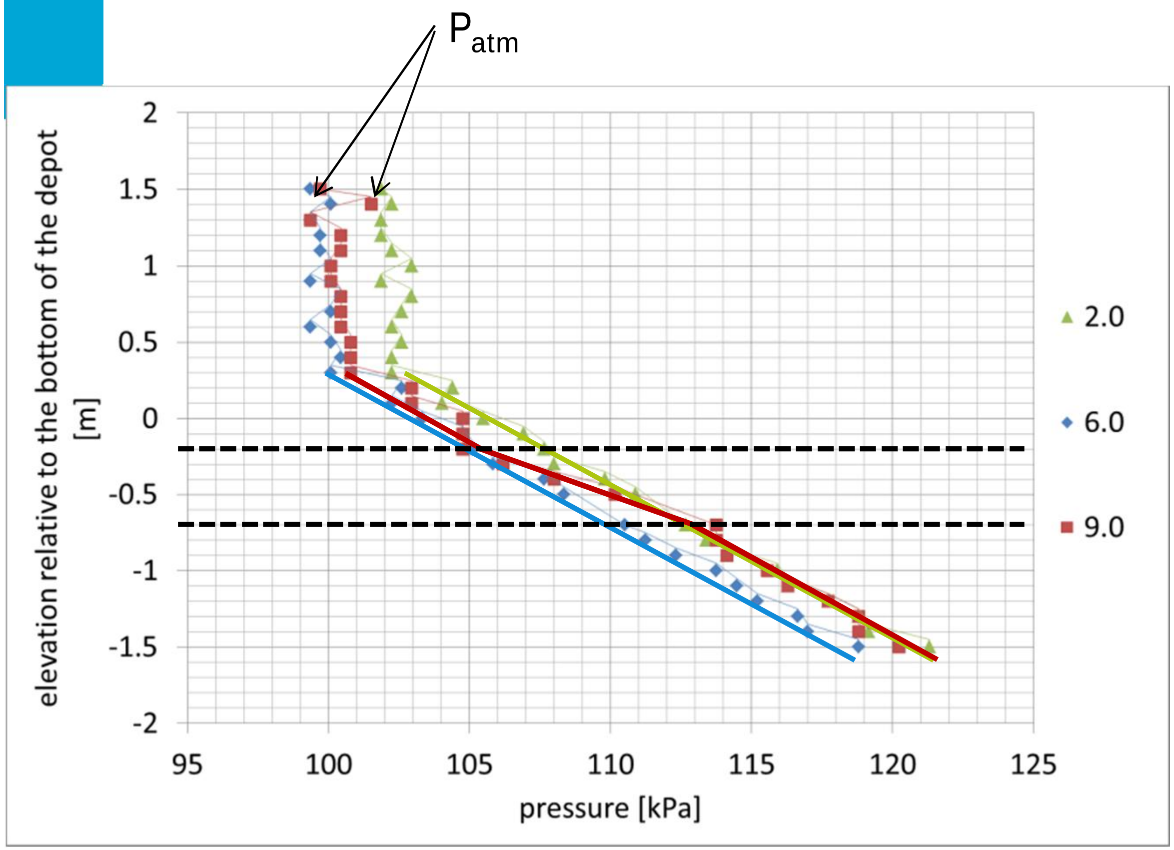
level gauge

pressure sensors

- every 10 cm
- from +1.5 m to -1.6 m relative to bottom empty depot
- range: 0 - 2000 kPa absolute pressure
- accuracy: 0.36 kPa (3.6 cm water pressure)

Lift up of Lowlands

Physical: Pressure measurements (dewatering & permeability)



Pressure profiles with depth:

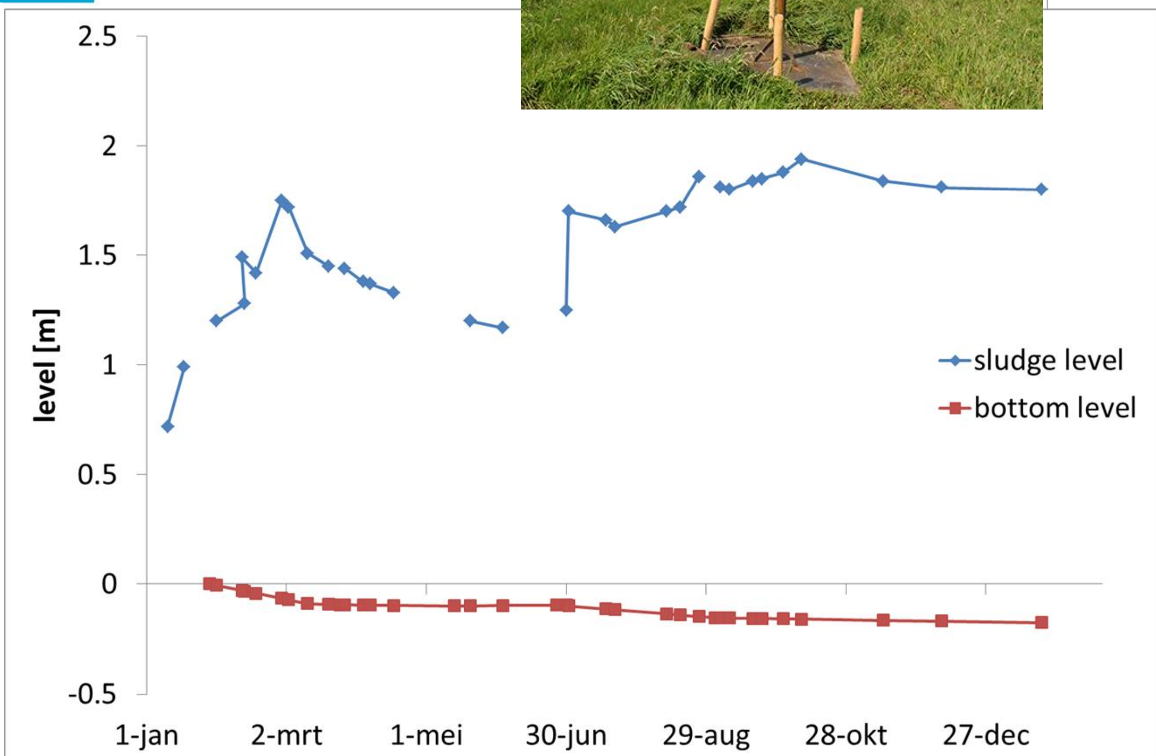
- At 2 days:
  - P_{atm} = 1020 mbar;
  - dP/dz = 10 kN/m^3 for z<0.3m
- At 6 days:
  - P_{atm} = 1000 mbar;
  - dP/dz = 10 kN/m^3 for z<0.3m
- At 9 days:
  - P_{atm} = 1000 mbar;
  - dP/dz = 10 kN/m^3 for z<-0.7m
  - dP/dz = 10 kN/m^3 for -0.2<z<0.3m
  - dP/dz = 15 kN/m^3 for -0.7<z<-0.1m

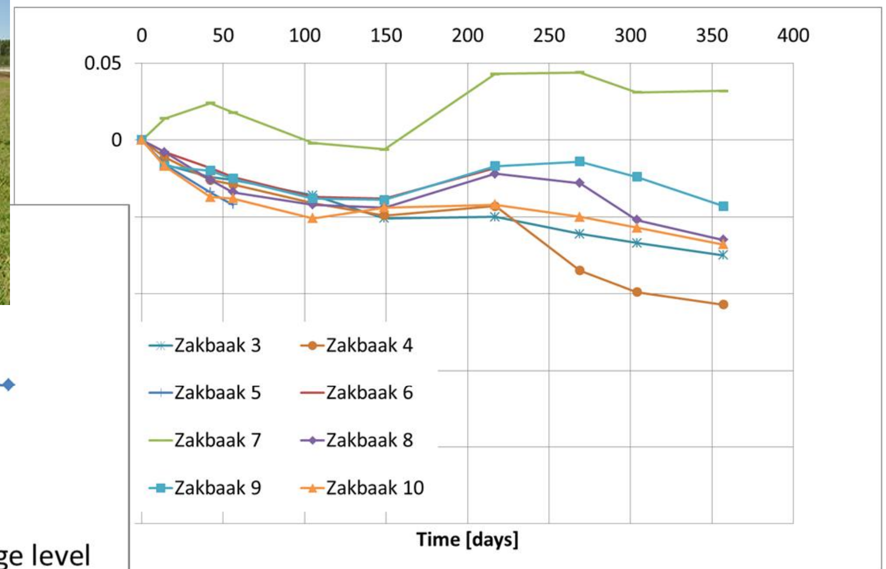
Hydrostatic gradient:
$dP = \gamma_w \cdot dz$ with γ_w = 10 kN/m^3

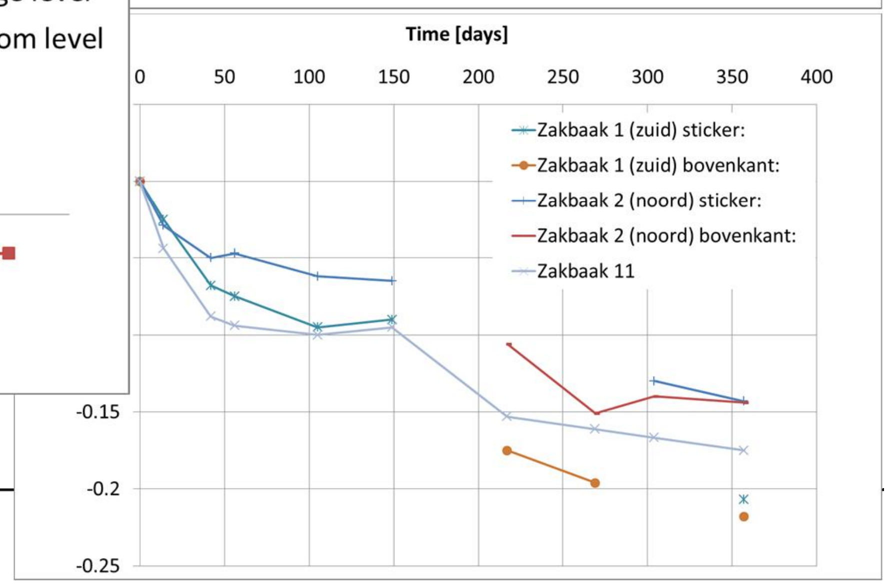
Hydraulic barrier between -0.7 and -0.2 m

Lift up of Lowlands

Physical: Zakbaak



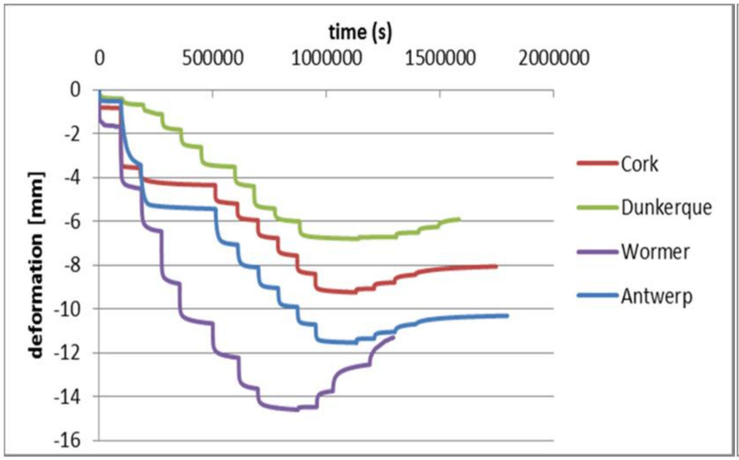


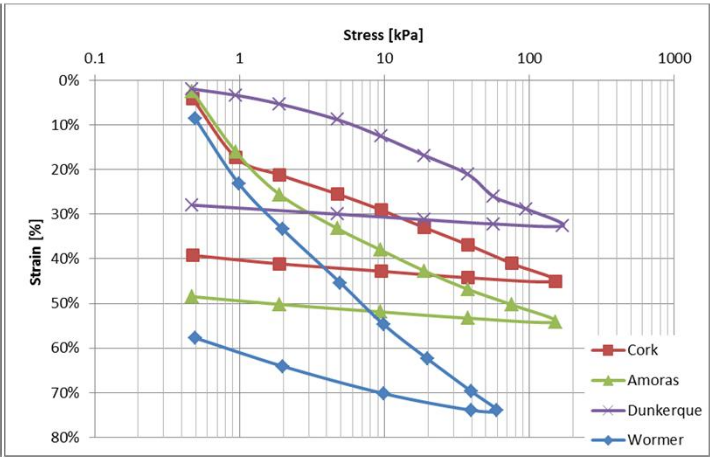


Lift up of Lowlands

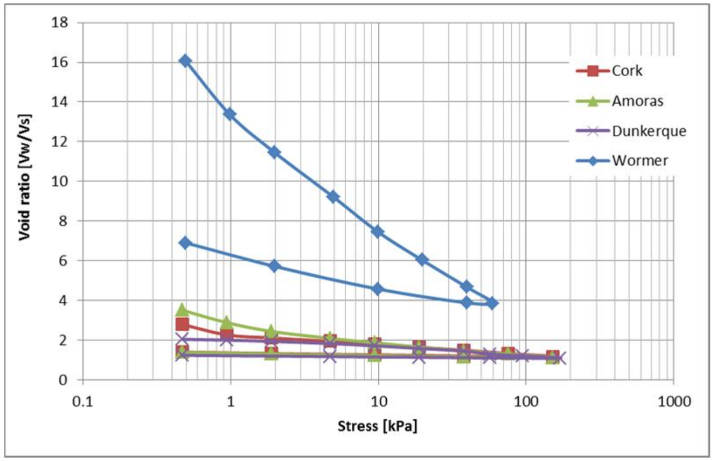
Physical: Oedemeter test
1-Dimensional consolidation

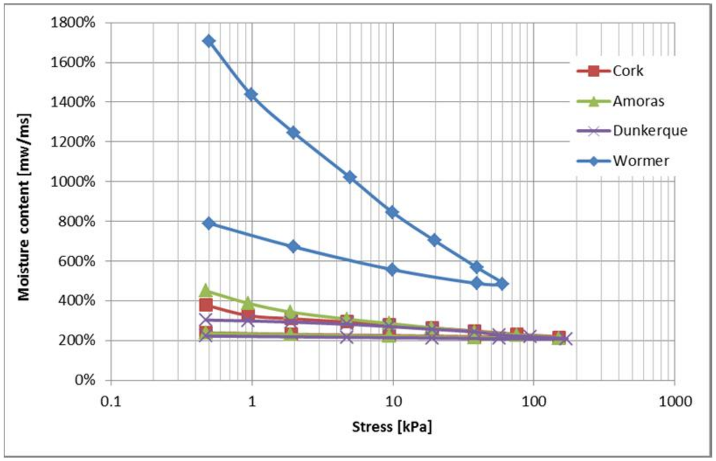
Measurements





Results

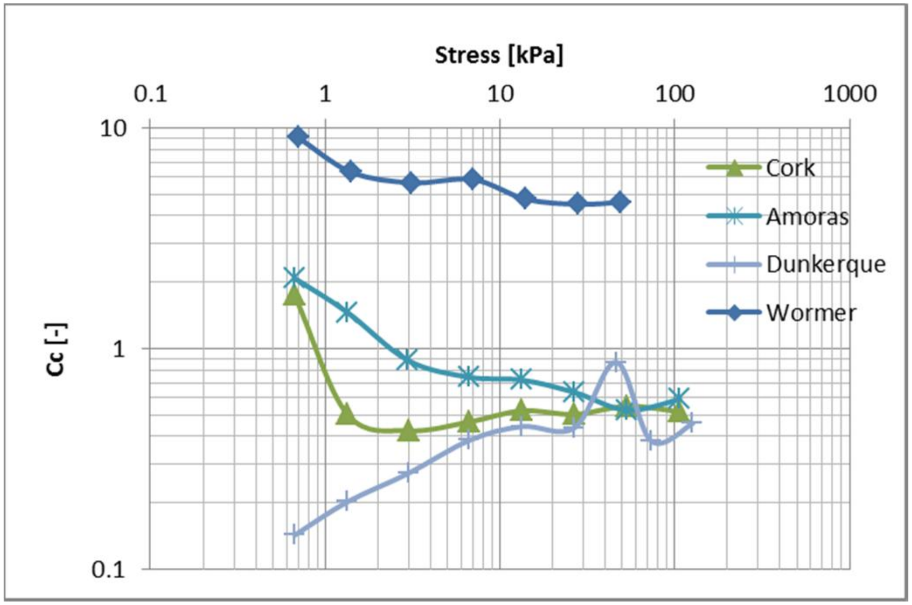




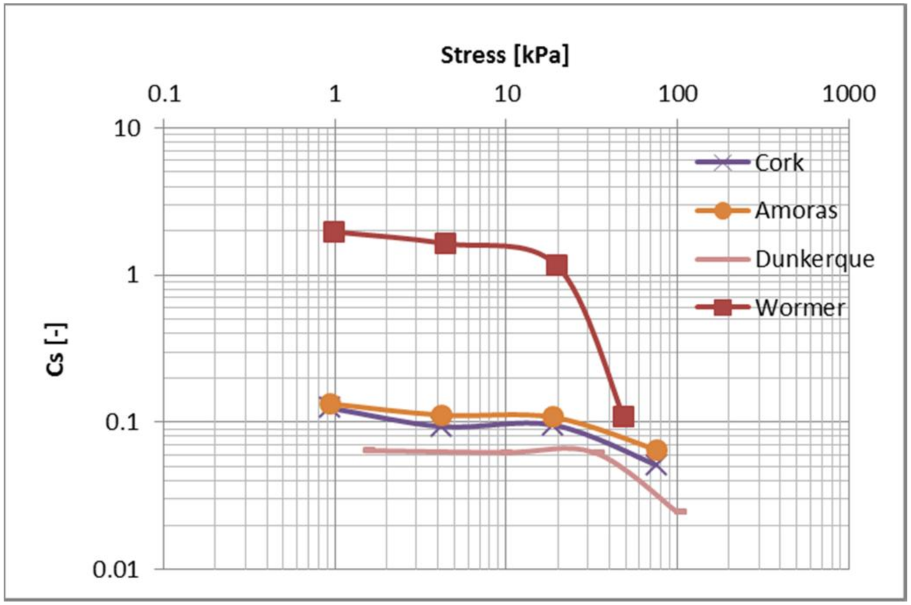
Lift up of Lowlands

Physical: Oedemeter test
1-Dimensional consolidation

Results



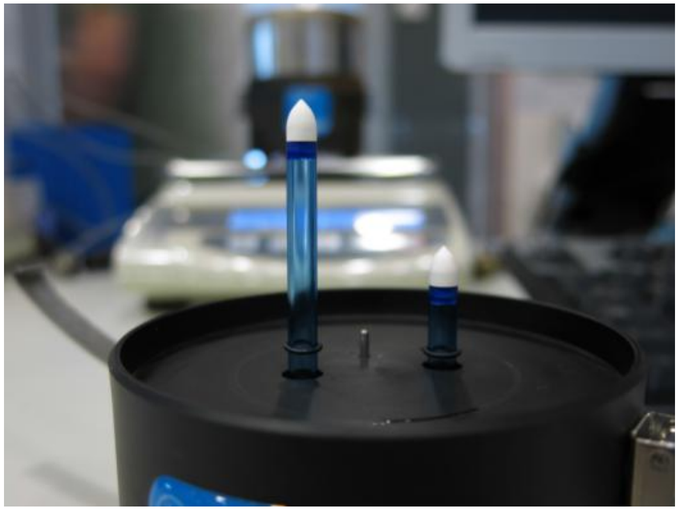
Compression index

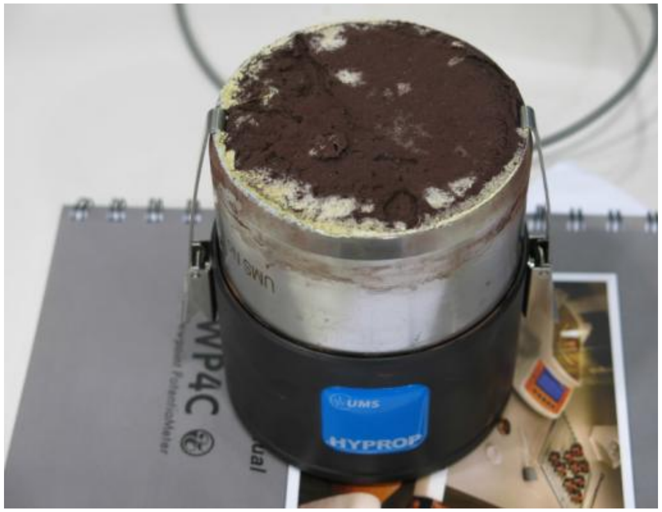


Swelling index

Lift up of Lowlands

Physical: Hyprop test
Soil water retention curve, determination of pF-curves and unsaturated conductivity.

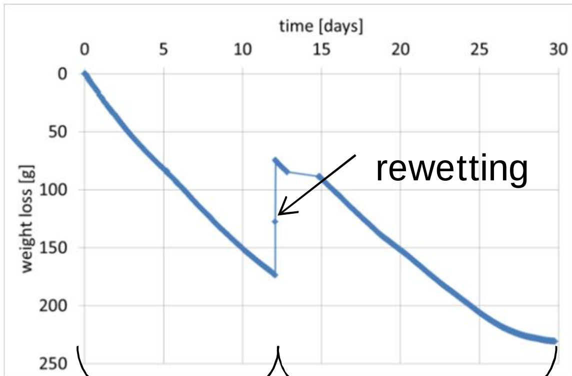




Lift up of Lowlands

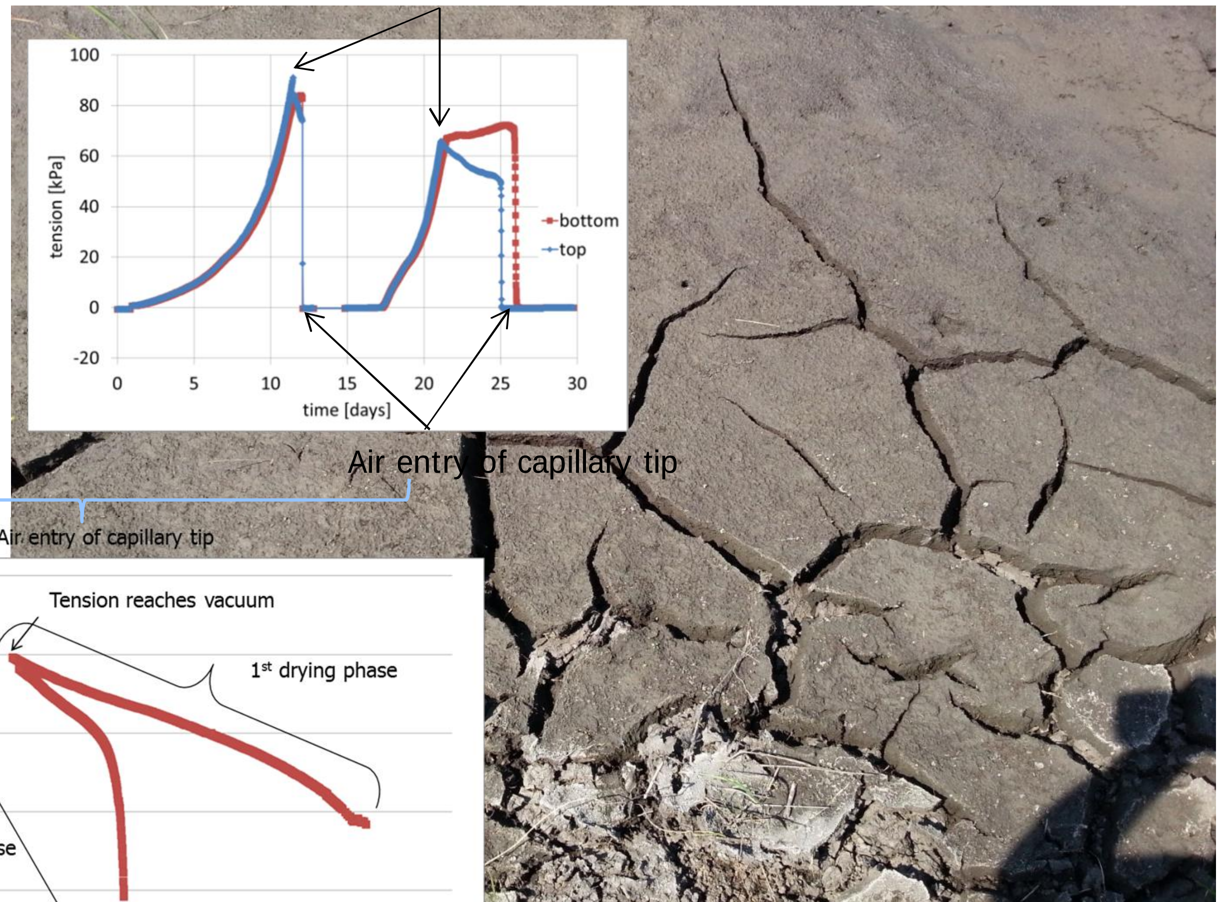
Physical: Hyprop test

We used the hyprop to determine the `tension needed to start crack formation.



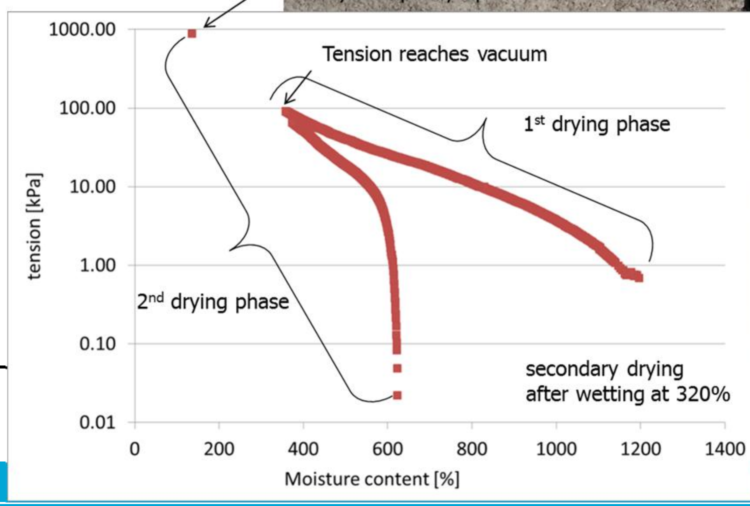
1st drying phase 2nd drying phase

tension reaches vacuum



Air entry of capillary tip

Soil water retention curve of drying peat

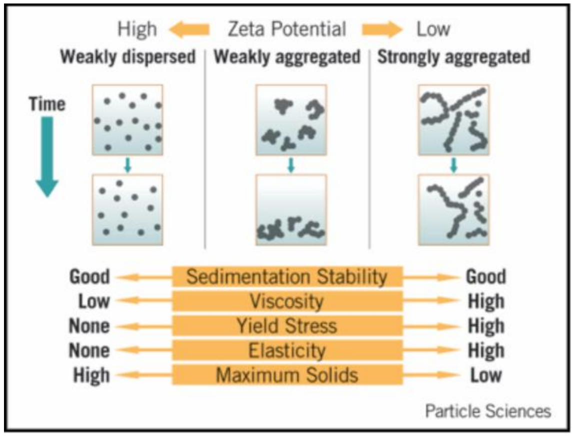


Lift up of Lowlands

Physical: Zeta potential measurements

Particles have a so-called interfacial 'double layer' of charges, the zeta potential. The zeta potential is caused by the net electrical charge contained within the region bounded by the slipping plane, and also depends on the location of that plane.

At low repulsive forces, the Van der Waals force dominates and clays start to aggregate.



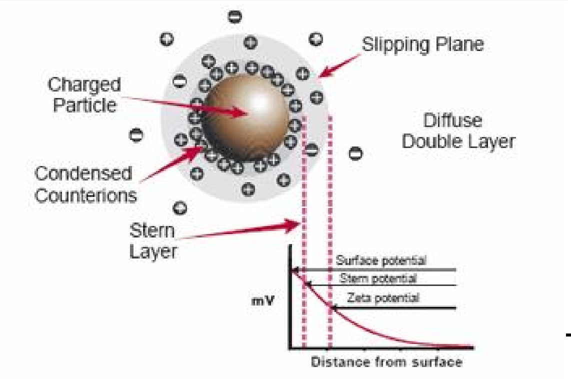
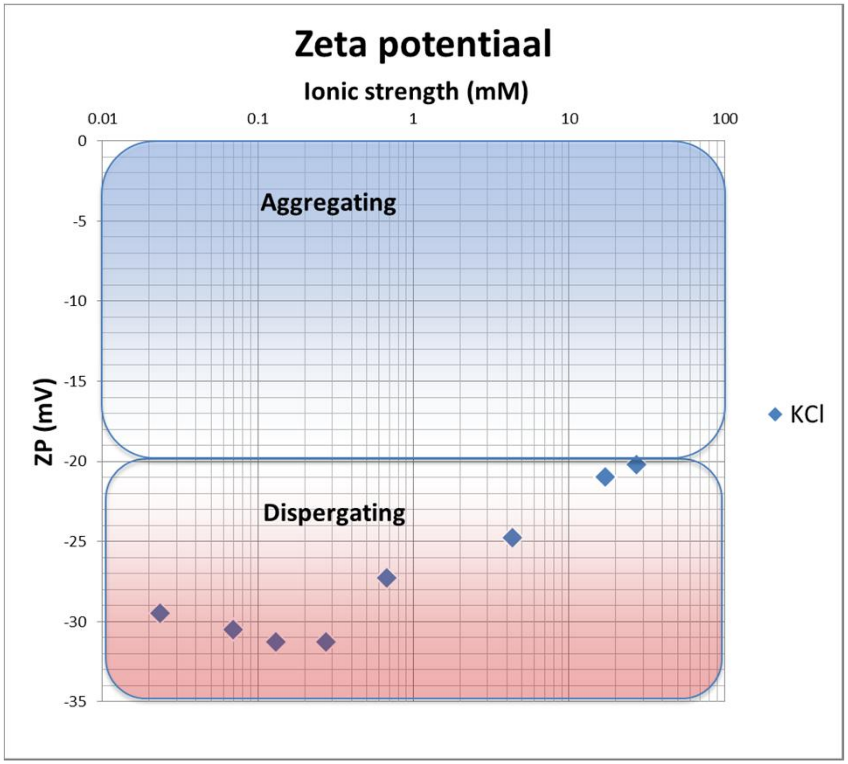
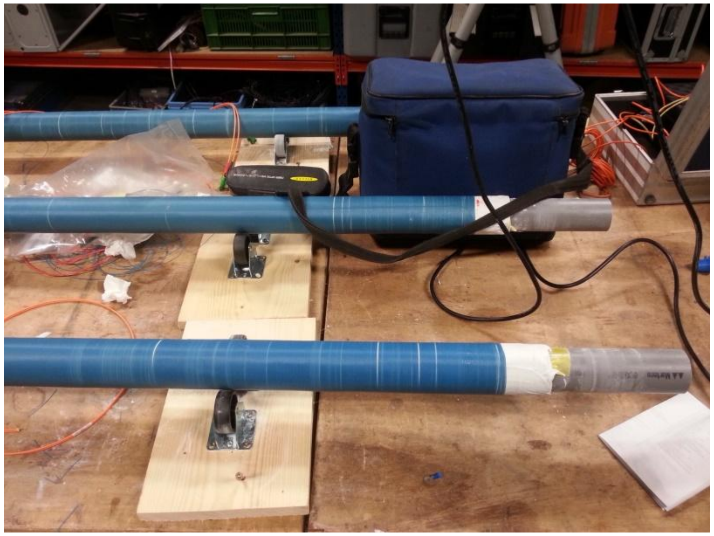


Figure 1: Schematic showing the distribution of ions around a charged particle.



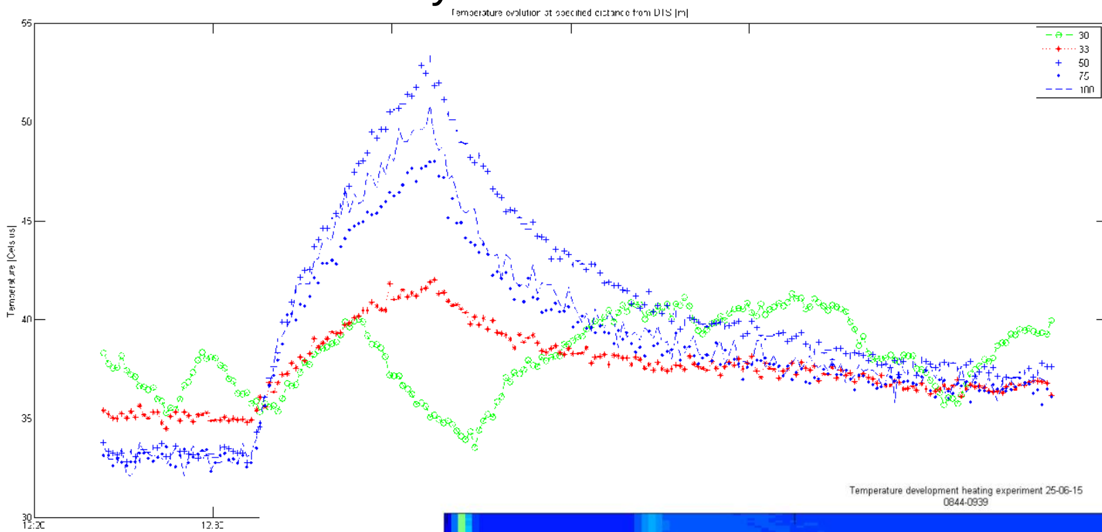
Lift up of Lowlands

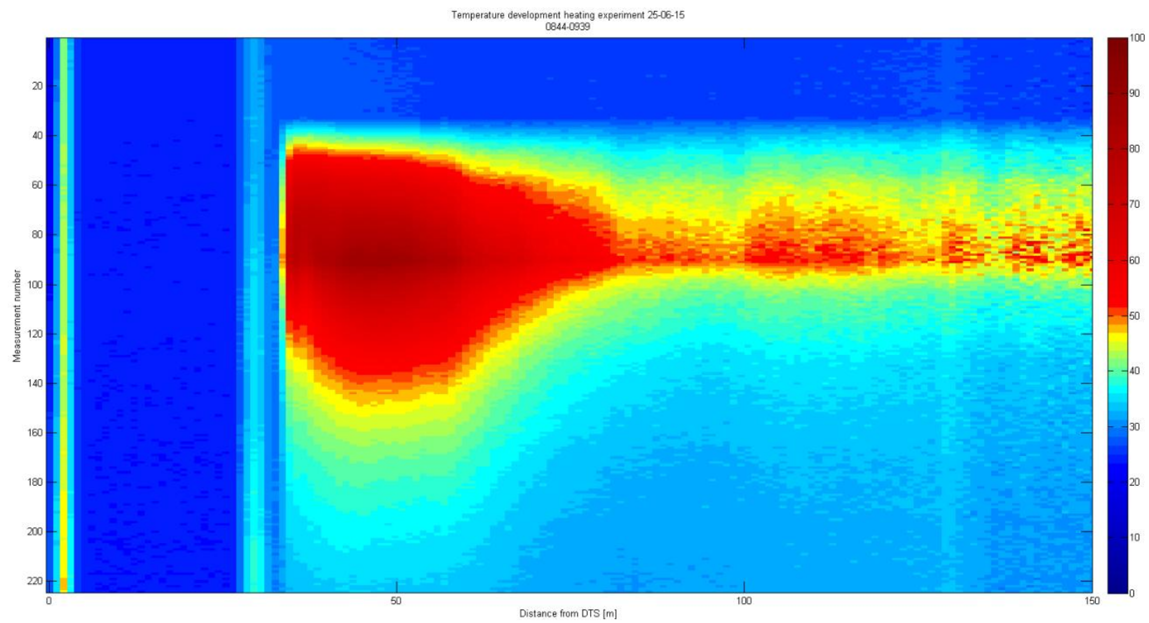
Physical: Heat conductivity



Lift up of Lowlands

Physical: Heat conductivity

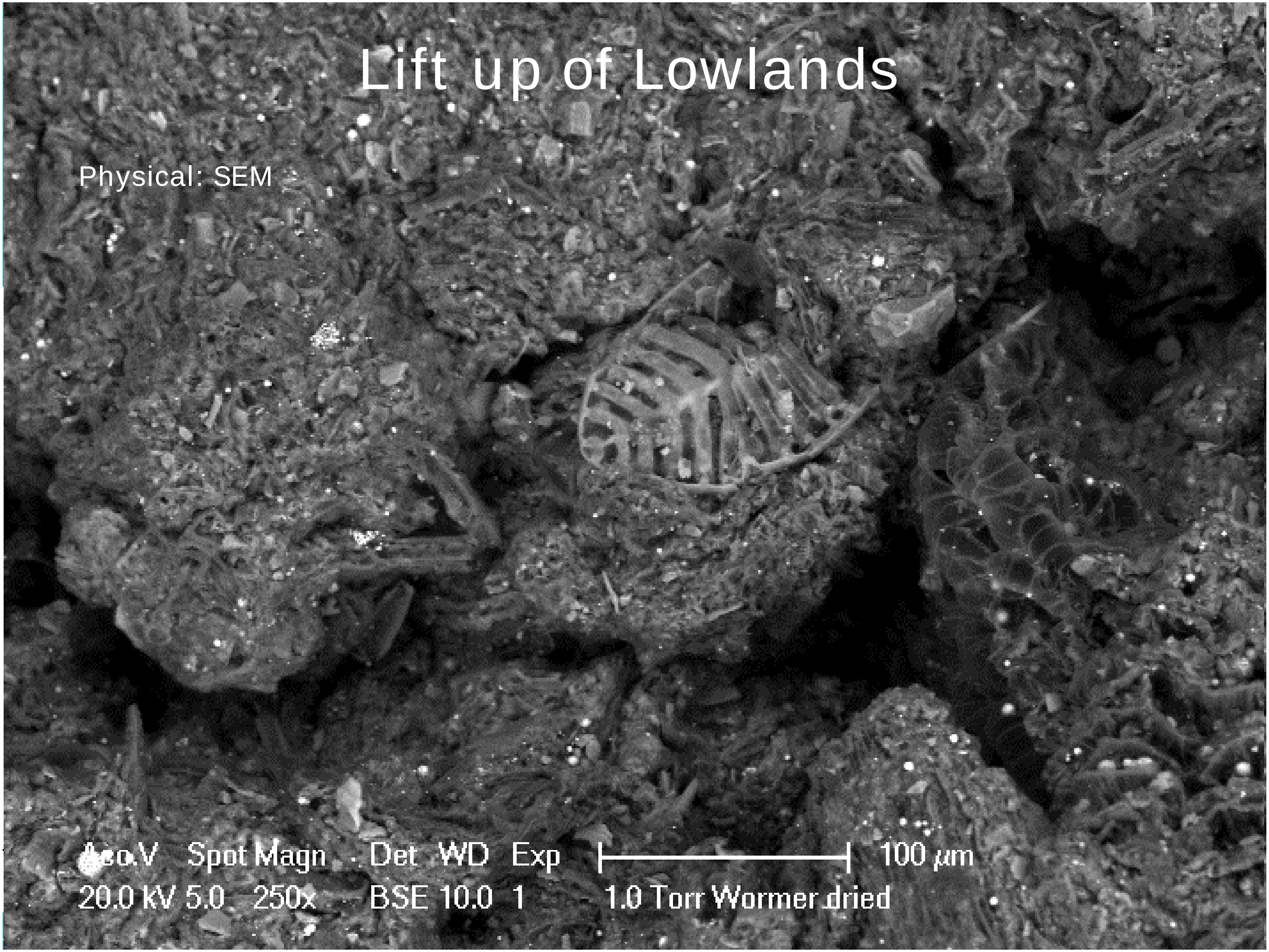




In potential a tool
to follow the consolidation
in the field during ripening.

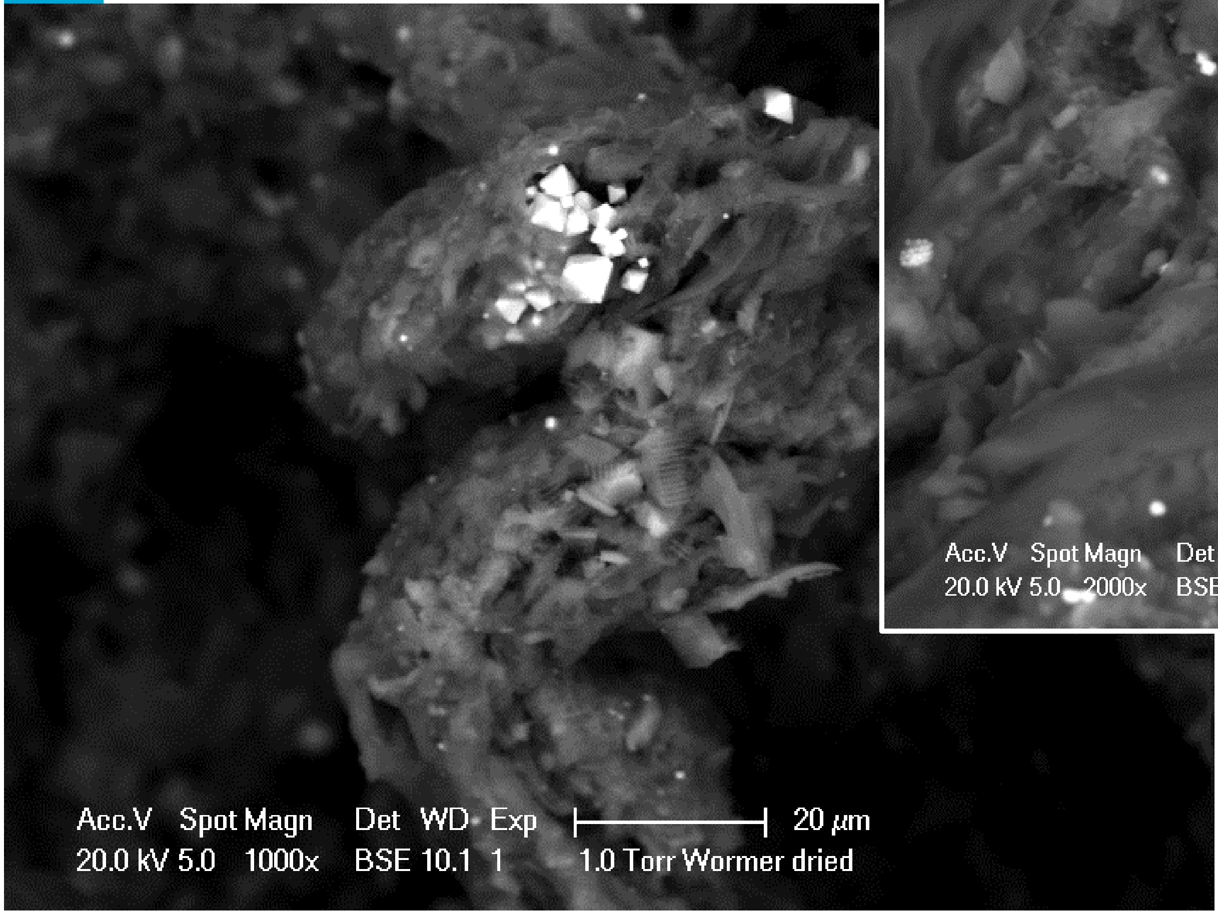
Lift up of Lowlands

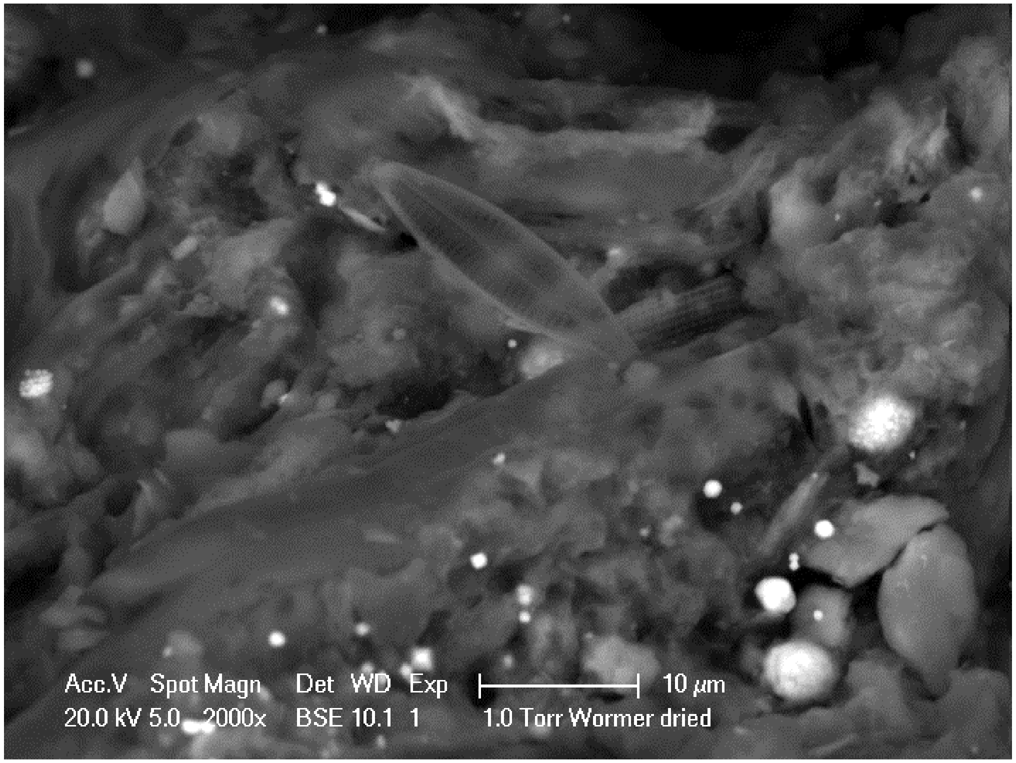
Physical: SEM

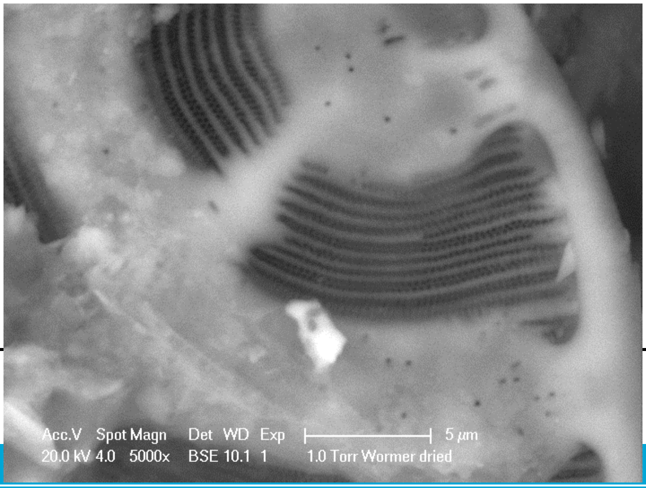


Lift up of Lowlands

Physical: SEM

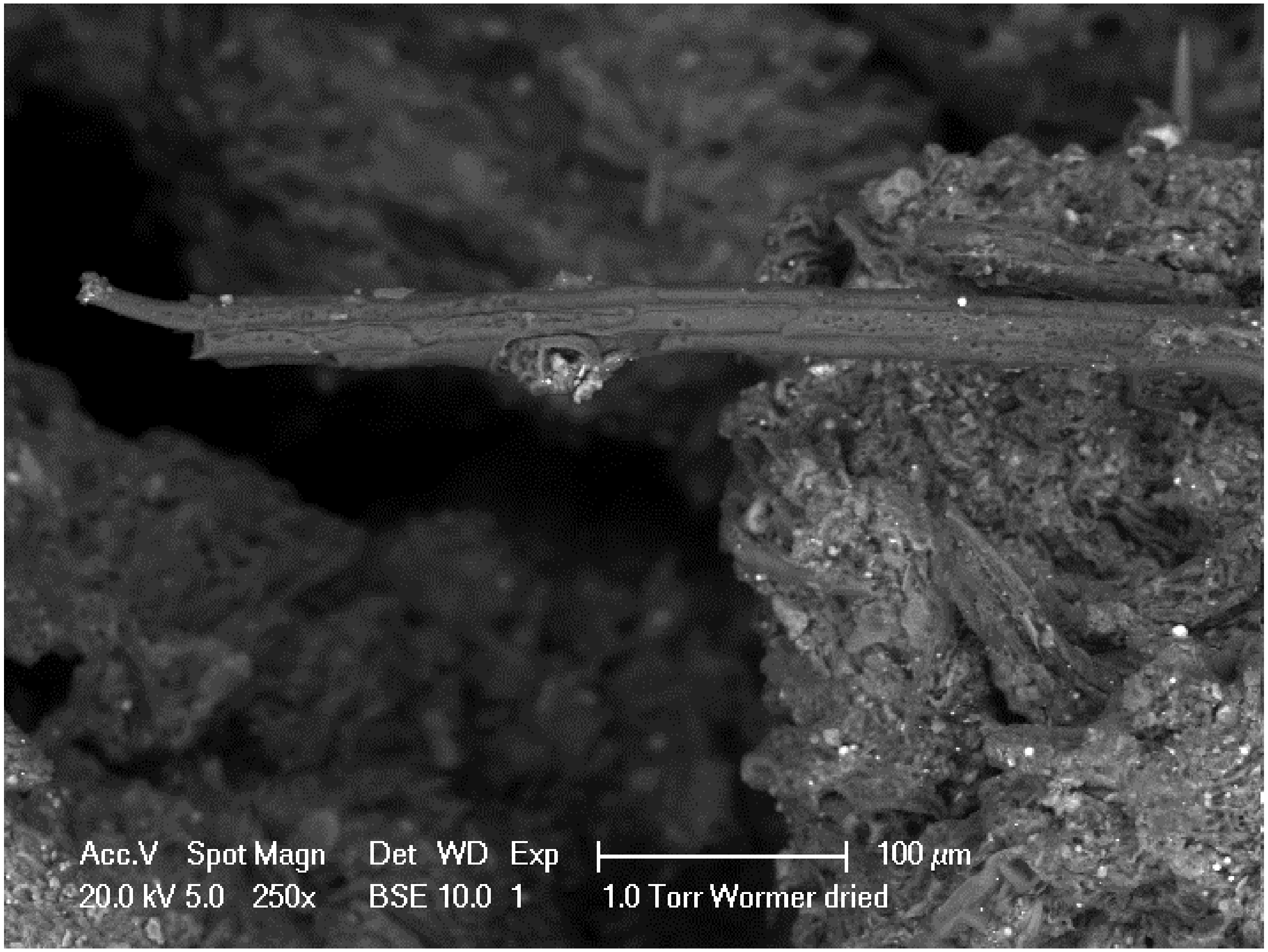






Lift up of Lowlands

Physical: SEM, the real question, how does ripening impact the fiber structure?



Lift up of Lowlands

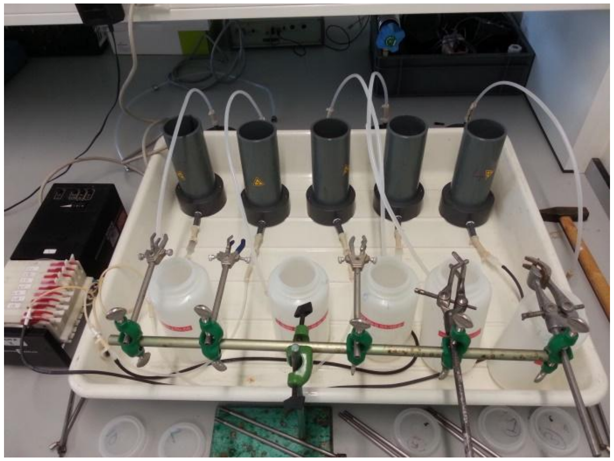
Chemical: Total concentration in (metals)

Classification according to different EU countries

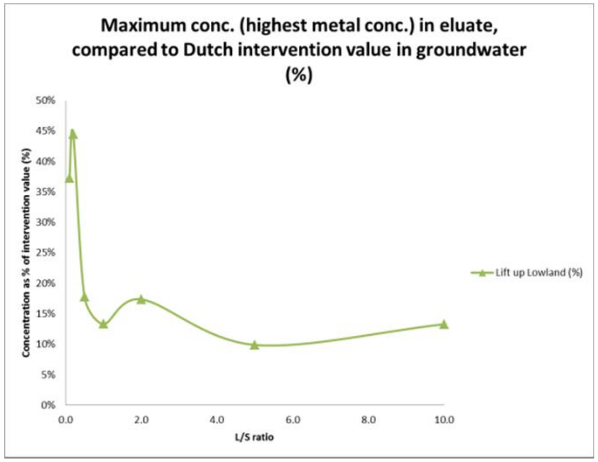
metals		Lift up Lowlar	Irish Lower level Lift up Lowland	 Upper level I Lift up Lowland	Flamish free use Lift up Lowland	 secondary re Lift up Lowland	French Level 1 (N1) Lift up Lowland	 Level 2 (N2) Lift up Lowland	Dutch class A Lift up Lowland	 class B Lift up Lowland
Antimone	Sb	0.8								5%
Arsenic	As	16.5	141%	18%	36%	5%	51%	25%	57%	19%
Barium	Ba	23.9							6%	4%
Cadmium	Cd	2.2	160%	27%	93%	11%	93%	47%	56%	16%
Chromium	Cr	15.5	43%	25%	33%	2%	33%	17%	13%	4%
Cobalt	Co	22.7							91%	9%
Copper	Cu	84.5	155%	57%	86%	17%	138%	69%	88%	44%
Lead	Pb	135.1	180%	49%	90%	9%	108%	54%	98%	23%
Molybdenum	Mo	1.6							31%	1%
Nickel	Ni	9.1	138%	48%	52%	12%	78%	39%	18%	4%
Selenium	Se	1.7								2%
Tin	Sn	0.9								0%
Vanadium	V	10.9								4%
Zinc	Zn	174.8	136%	53%	109%	17%	79%	39%	31%	9%
Classification			180%	57%	109%	17%	138%	69%	98%	44%

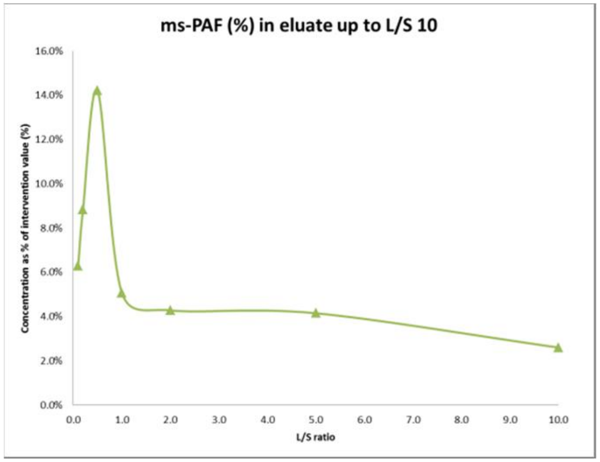
Lift up of Lowlands

Chemical: Leaching test & ms-PAF
Highest concentration of metals in eluate in comparison with the Dutch groundwater standard (intervention value).
Concentrations used to calculate the ms-PAF.



		Standard	ms-PAF
Timestep	L/S (sum)	Lift up Lowland (%)	Lift up Lowland (%)
k1	0.1	37%	6.3%
k2	0.2	44%	8.8%
k3	0.5	18%	14.2%
k4	1.0	13%	5.1%
k5	2.0	17%	4.3%
k6	5.0	10%	4.2%
k7	10.0	13%	2.6%

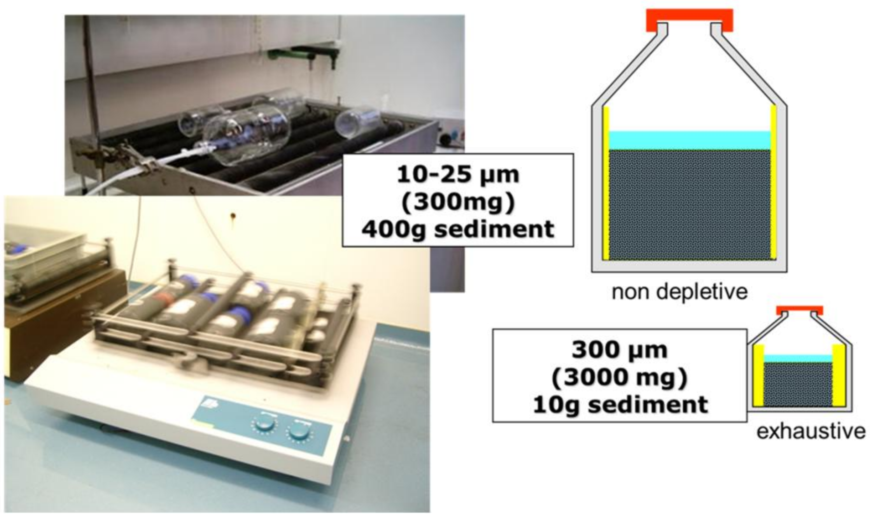


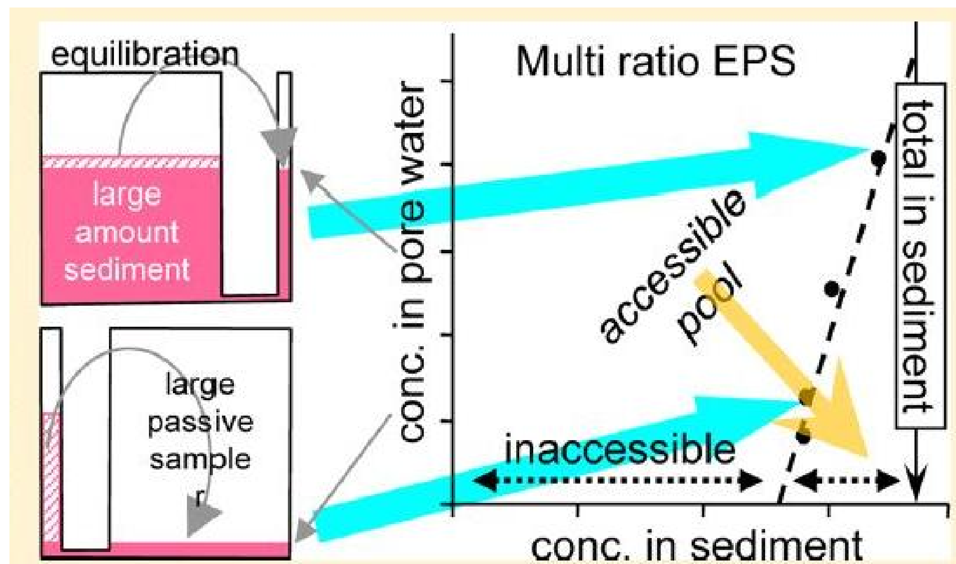


Lift up of Lowlands

Chemical: Bio-available fraction
Measured with passive sampling.

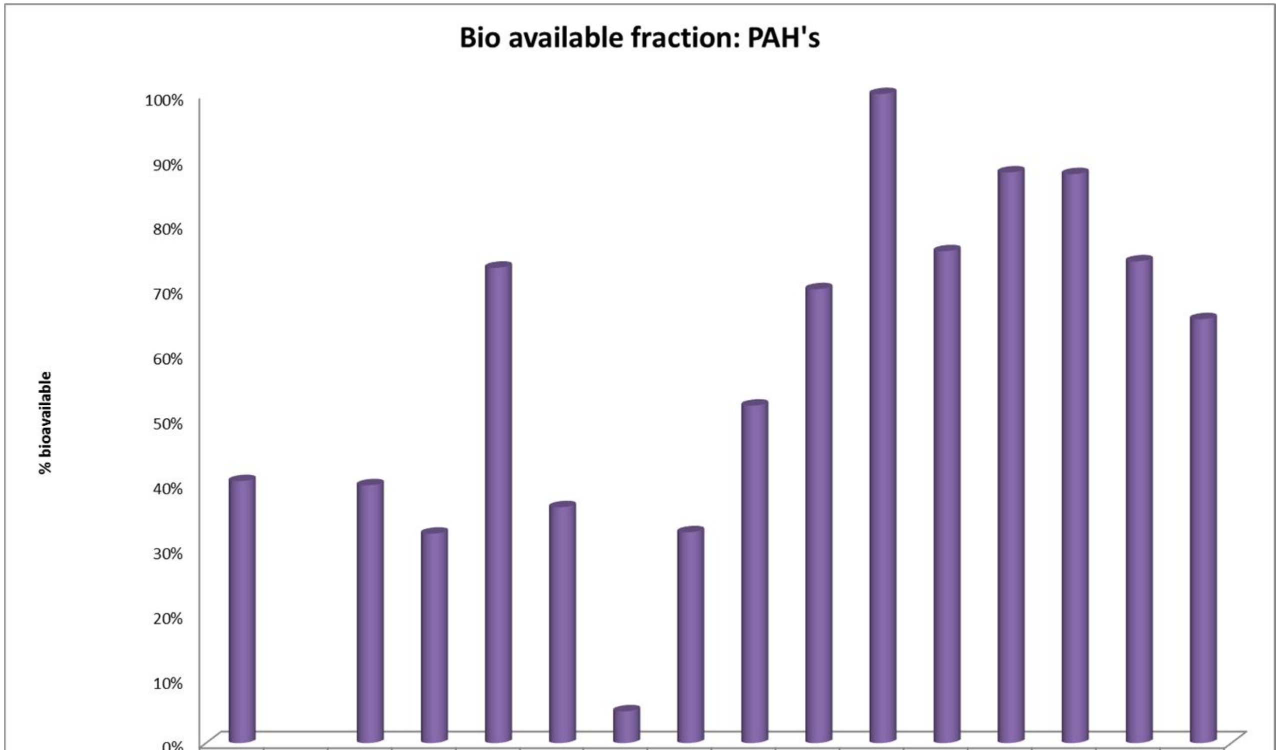
Silicone film and sediment in glass bottle



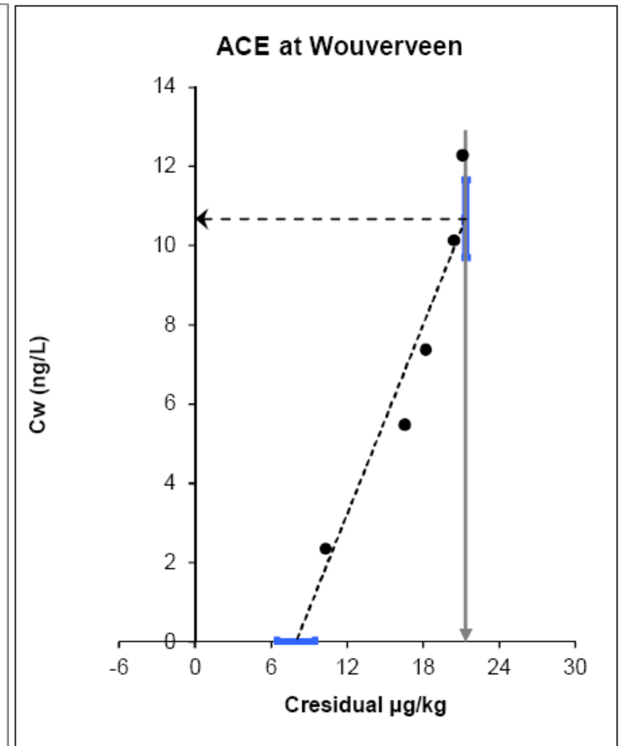


Lift up of Lowlands

Chemical: Bio-available fraction
Results.



	NAP	ACY	ACE	FLE	FEN	ANT	FLU	PYR	BAA	CHR	BBF	BkF	BAP	INP	DBAHA	BGHIPE
Lift up of Lowlands	40%		40%	32%	73%	36%	5%	32%	52%	70%	100%	76%	88%	88%	74%	65%



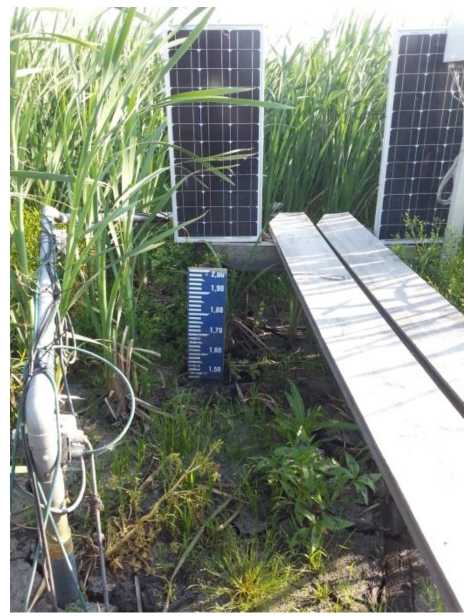
Lift up of Lowlands

Conclusions

The “Lift up of Lowlands” was successful with regard to compensating subsidence (+1.2 m) without causing an unacceptable impact on the emission of pollutants.

The (ongoing) measurements on the drying and compaction processes taking place during the transformation from wet sediment to dry soil help to define better models to predict the dewatering of peat rich sediments.

1 year later



Lift up of Lowlands

Alternative ways to use sediments at the Wormer-/Jisperveld location, the “baggerbuffer”

Lift up of Lowlands is one example to beneficially reuse sediments. Tauw has implemented a solution to protect against shore erosion by using locally dredged sediments.