

FLUX measurements to design a nature-based barrier in an urban canal



resanat
Natuurlijk saneren we de bodem

14/10/2022
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RESANAT PROJECT

Remediation of Residual contamination with Nature Based Techniques

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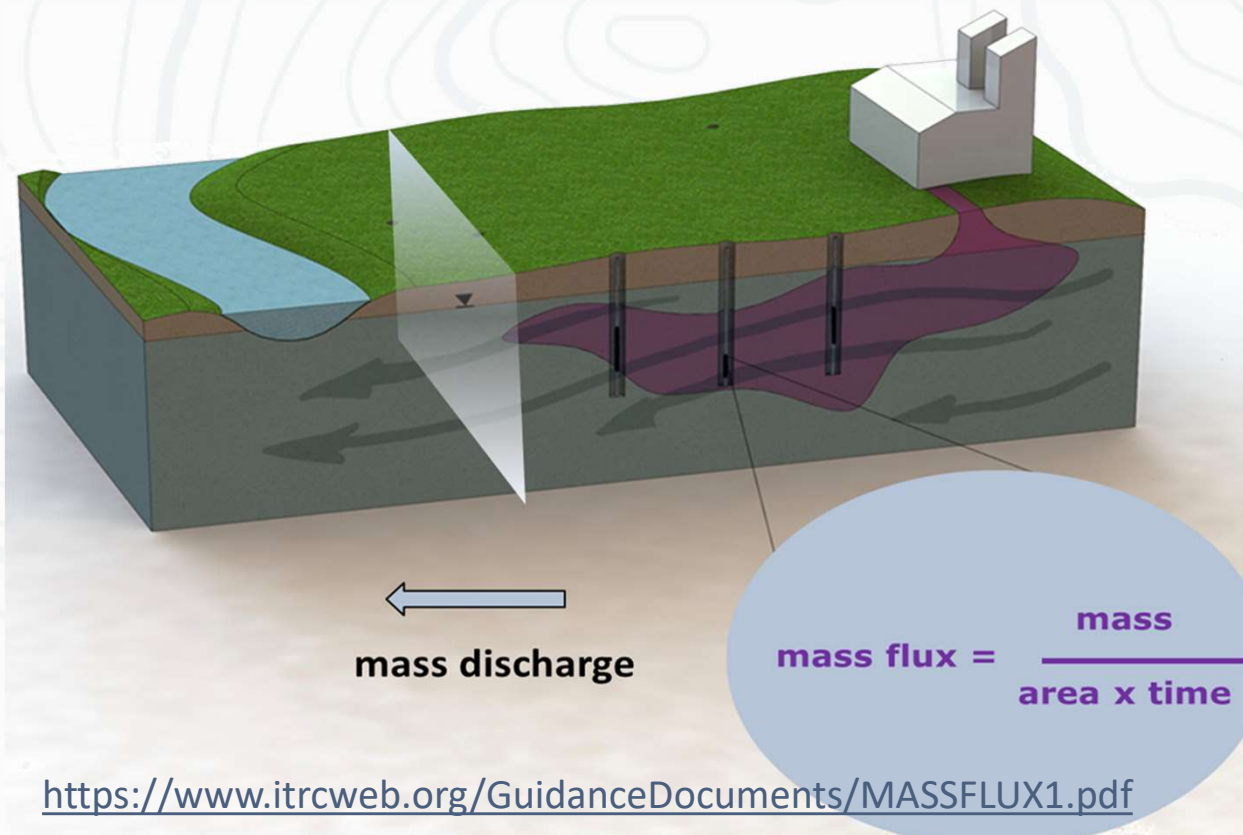
Witteveen + Bos



Deltares
Enabling Delta Life



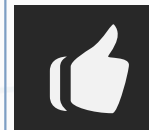
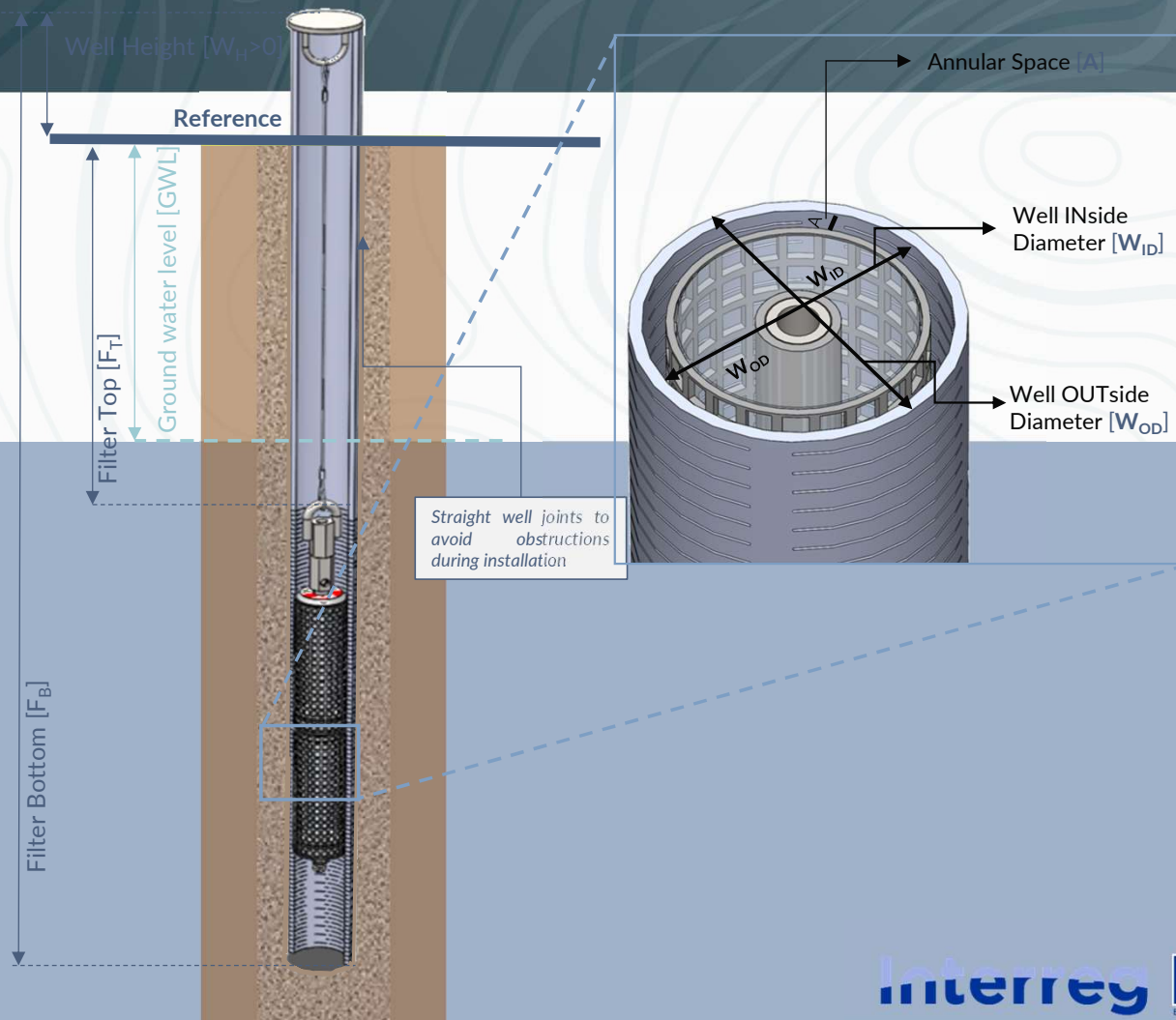
Groundwater & mass flux concept



Groundwater flux = Darcy velocity
 $q = Ki$

Mass flux =
Concentration x Darcy velocity
 $= C \times q$

iFLUX sampler: easy in use and reliable



Development well



Modular sampler adaptable to size of the well (1" - 6") and (multi)level



Optimal results:
Correction flow field distortion

Analytical packages : validated

WATERFLUX

Tracer alcohols

BTEX-N-S-MTBE

Benzene
Toluene
Ethylbenzene
O-Xylene
M-,p-Xylenes
Naphtalene
Styrene
MTBE

MINERAL OILS

Fraction C-10 – C-12
Fraction C-12 – C-20
Fraction C-20 – C-30
Fraction C-30 – C-40
Mineral oils (GC)

CHLORINATED SOLVENTS

Dichloromethane
1,1-Dichloroethane
1,2-Dichloroethane
Cis-1,2-dichloroethene
Trans-1,2-dichloroethene
Trichloromethane
Trichloroethene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Tetrachloromethane
Tetrachloroethene
Vinylchloride

CHLOROBENZENES

Monochlorobenzene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2,3-Trichlorobenzene
1,2,4-Trichlorobenzene
1,3,5-Trichlorobenzene

CHLOROTOLUENES

2-Chlorotoluene
4-Chlorotoluene

TRIMETHYLBENZENES

1,2,3-trimethylbenzene
1,2,4-trimethylbenzene
1,3,5-trimethylbenzene

POLYAROMATIC HYDROCARBONS

Naphtalene
Acenaphthylene
Acenaphthene
Fluorene
Fenanthrene
Anthracene
Fluoranthene
Pyrene
Benzo(a)anthracene
Chrysene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Dibenzo(ah)anthracene
Benzo(ghi)perylene
Indeno(123cd)pyrene

POLYCHLORINATED BIPHENYLS

PCB 28
PCB 52
PCB 101
PCB 118
PCB138
PCB153
PCB180

VOLATILE ORGANIC COMPOUNDS SPECIFIC

1,1,1,2-Tetrachloroethane
1,1,2-Trichloro-1,2,2-trifluoroethane
1,1-Dichloroethene
1,1-Dichloropropane
1,1-Dichloropropene
1,2,3-Trichloropropane
1,2-Dibromoethane
1,2-Dichloropropane
1,3-Dichloropropane
2,2-Dichloropropane
2,3-Dichloropropene
2-Chloro-1,3-butadiene
2-Ethyltoluene
3-Chloro-1-propene (allylchloride)
3-Ethyltoluene
4-Ethyltoluene
Bromobenzene
Bromochloromethane
Bromodichloromethane
Bromomethane
Chloroethane
cis-1,3-Dichloropropene
Cumene
Dibromochloromethane
Dibromomethane
Diisopropylether
ETBE (Ethyl tert-butyl ether)
Ethylether
Hexachlorobutadiene
Iodomethane
TAME (Tert-Amyl Methyl Ether)
trans-1,3-Dichloropropene
Tribromomethane (Bromoform)
Trichloromonofluoromethane

HEAVY METAL

Cadmium
Chromium
Copper
Lead
Nickel
Zinc

METAL SPECIFIC

Calcium
Iron
Potassium
Magnesium
Manganese
Sodium

NUTRIENT CATIONIC

Ammonium-N

HEAVY METAL SPECIFIC

Mercury
Arsenic

NUTRIENT ANIONIC

Nitrate-N
Sulfate

DIOXANE

1,4-Dioxane

PFAS

Perfluorohexanoic acid (PFHxA)
Perfluoroheptanoic acid (PFHpA)
Perfluorooctanoic acid (PFOA)
Perfluorononanoic acid (PFNA)
Perfluorodecanoic acid (PFDA)
Perfluoroundecanoic acid (PFUdA)
Perfluorododecanoic acid (PFDoA)
Perfluorobutanesulfonic acid (PFBS)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanesulfonamide (PFOSA)

REINTEGRATION OF URBAN CANAL

CONTAMINATED INDUSTRIAL SITE

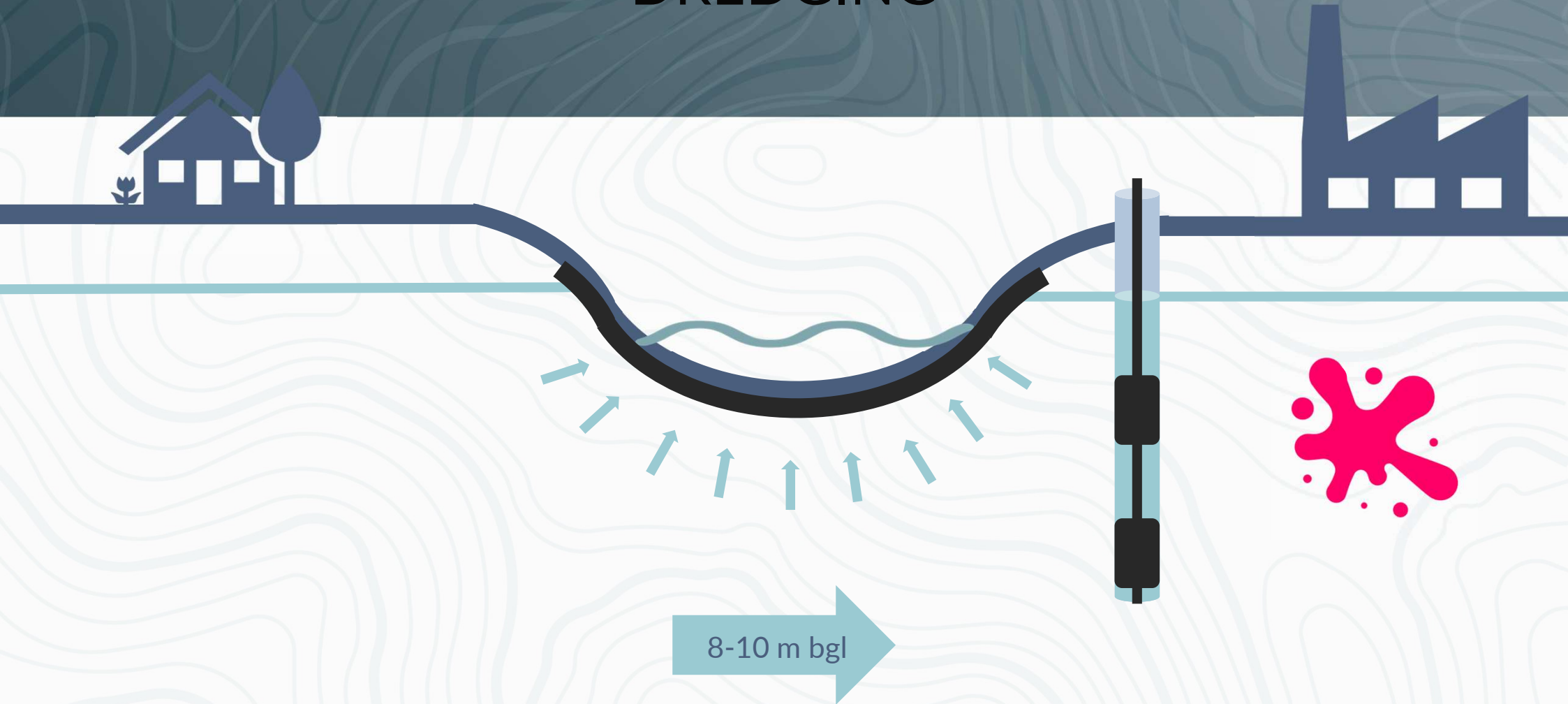


FLUX MEASUREMENTS BEFORE DREDGING

SHALLOW GROUNDWATER (3-6 m bgl)



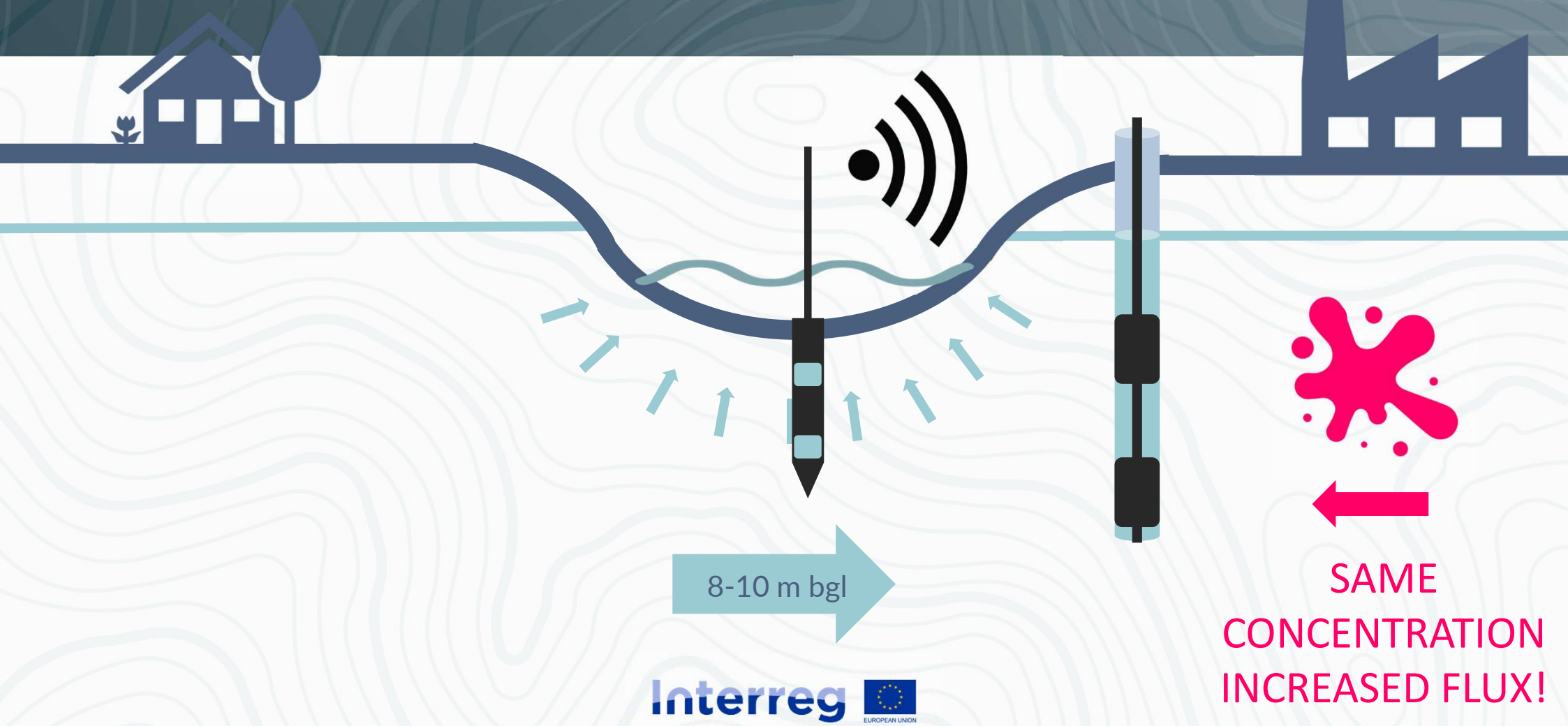
DREDGING



8-10 m bgl

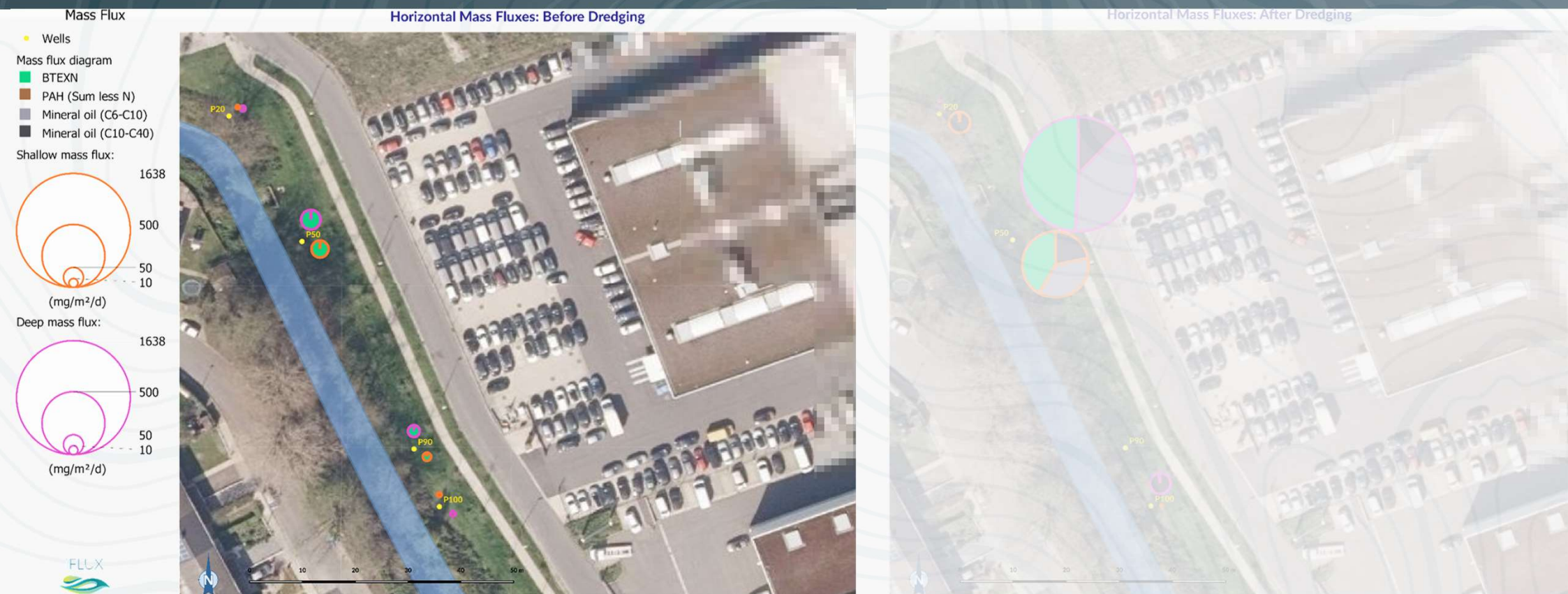
FLUX MEASUREMENTS AFTER DREDGING

EXCHANGE GROUNDWATER & SURFACE WATER



Horizontal flux samplers

DE LIEVE GHENT, BELGIUM



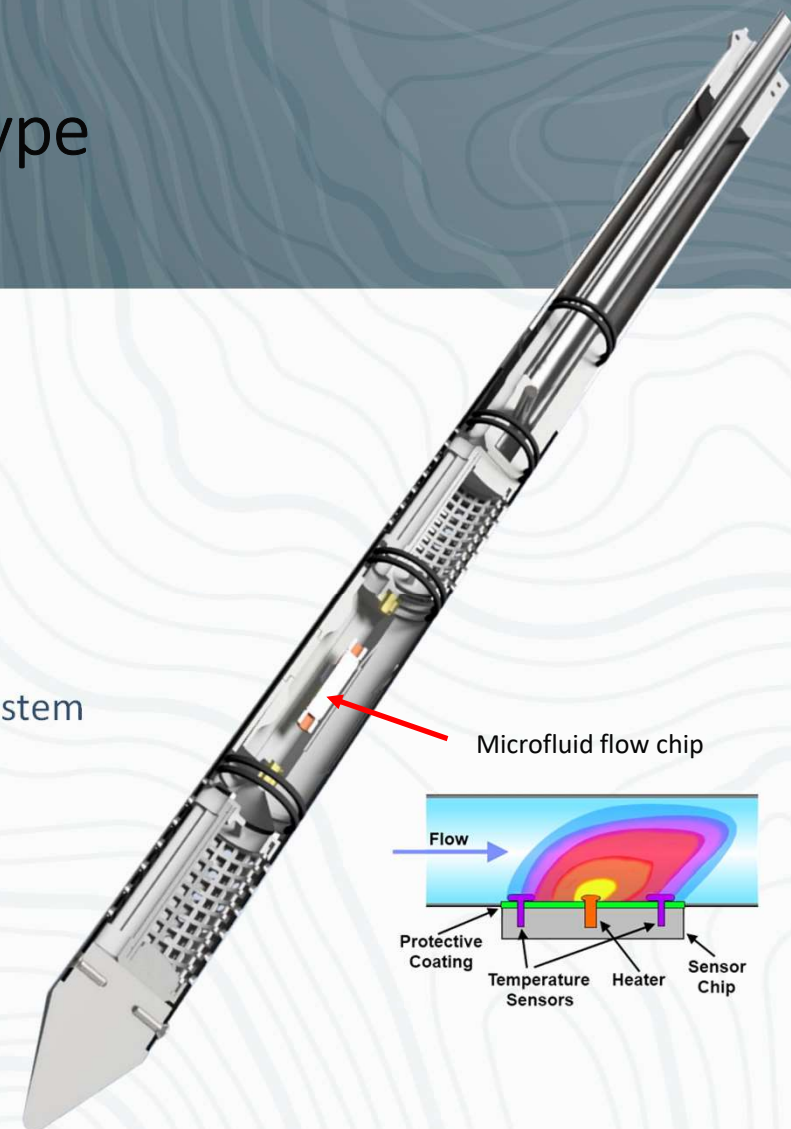
Horizontal flux samplers

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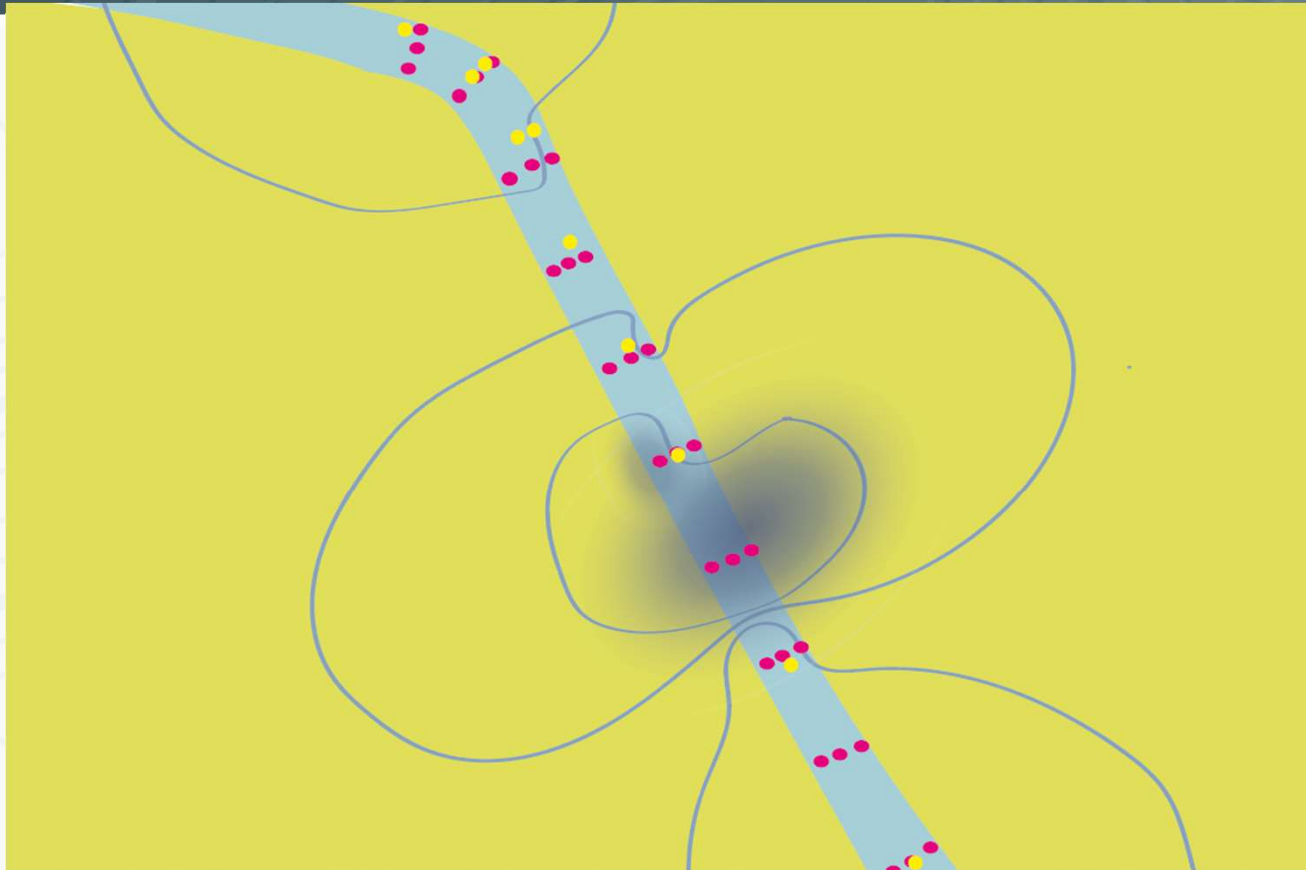
Digital iFLUX sensor – prototype

- Groundwater flow velocity and -direction
- Real time
- Horizontal & vertical groundwater flux probes
- Temperature based microfluid flow chip – closed system
- In-well or direct in soil/sediment



Results digital sensor

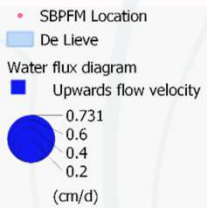
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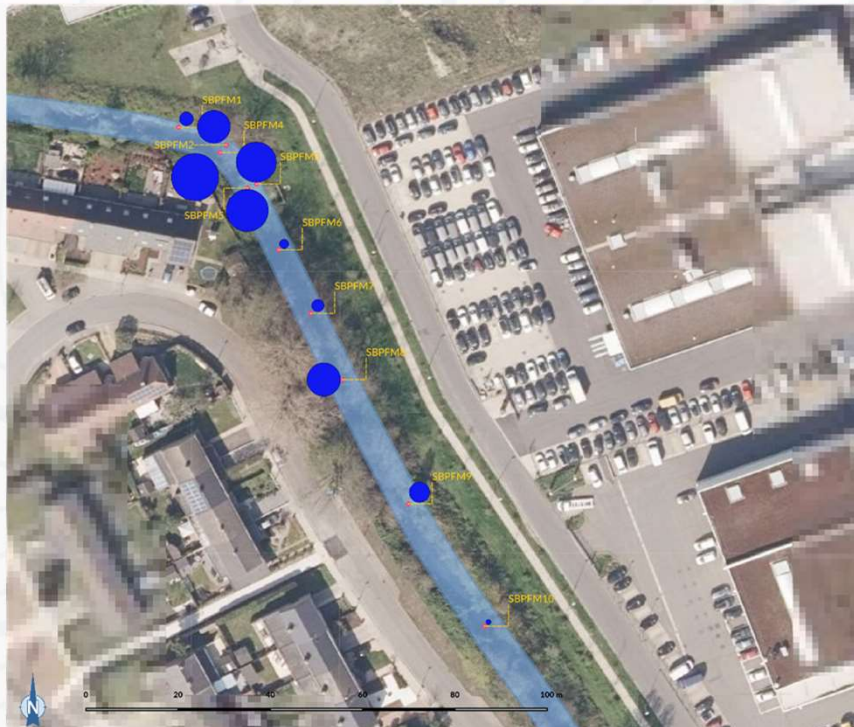
Vertical flux sampler

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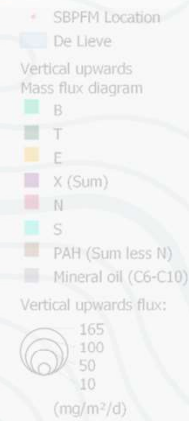
Water Flux



Vertical Upwards Flow Velocity: After Dredging



Mass Flux

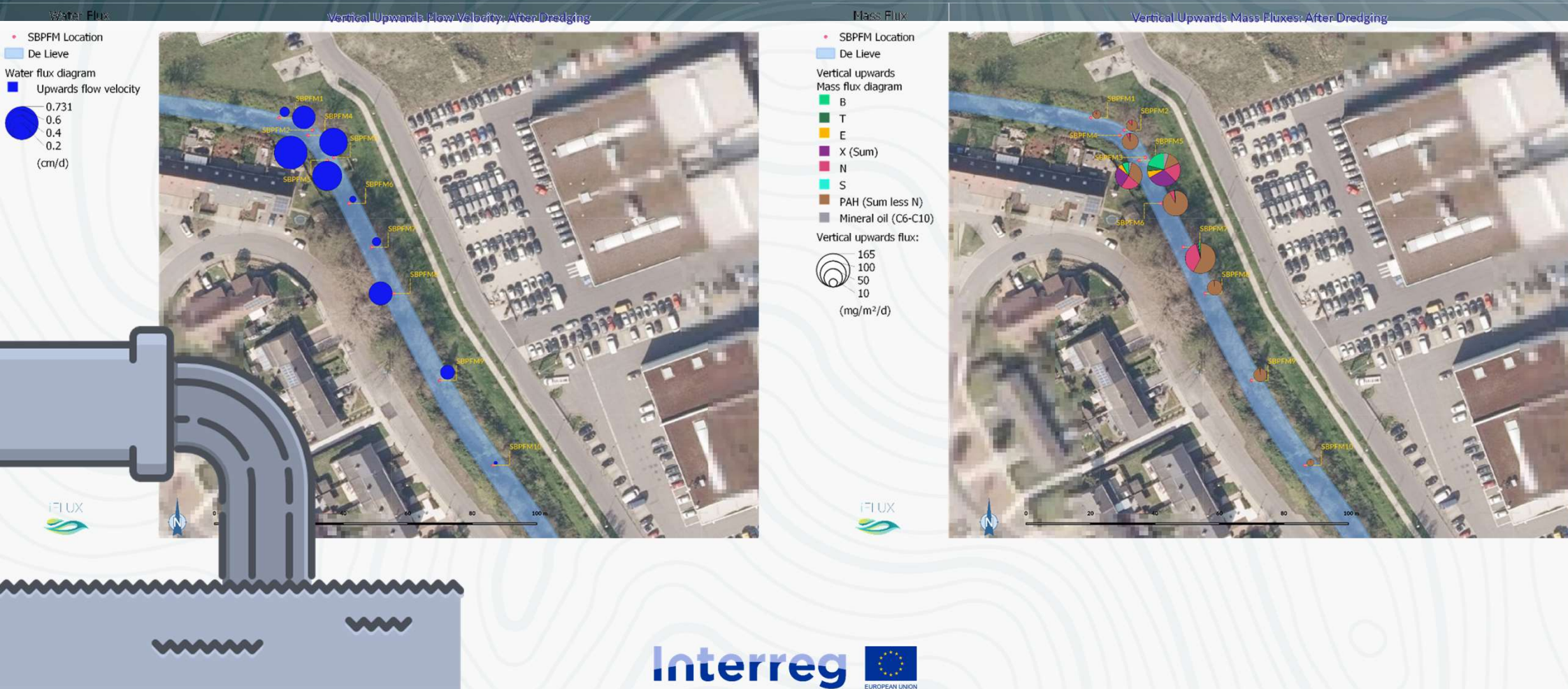


Vertical Upwards Mass Fluxes: After Dredging



Vertical flux sampler

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Results to Design barrier

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Monitoring efficiency barrier



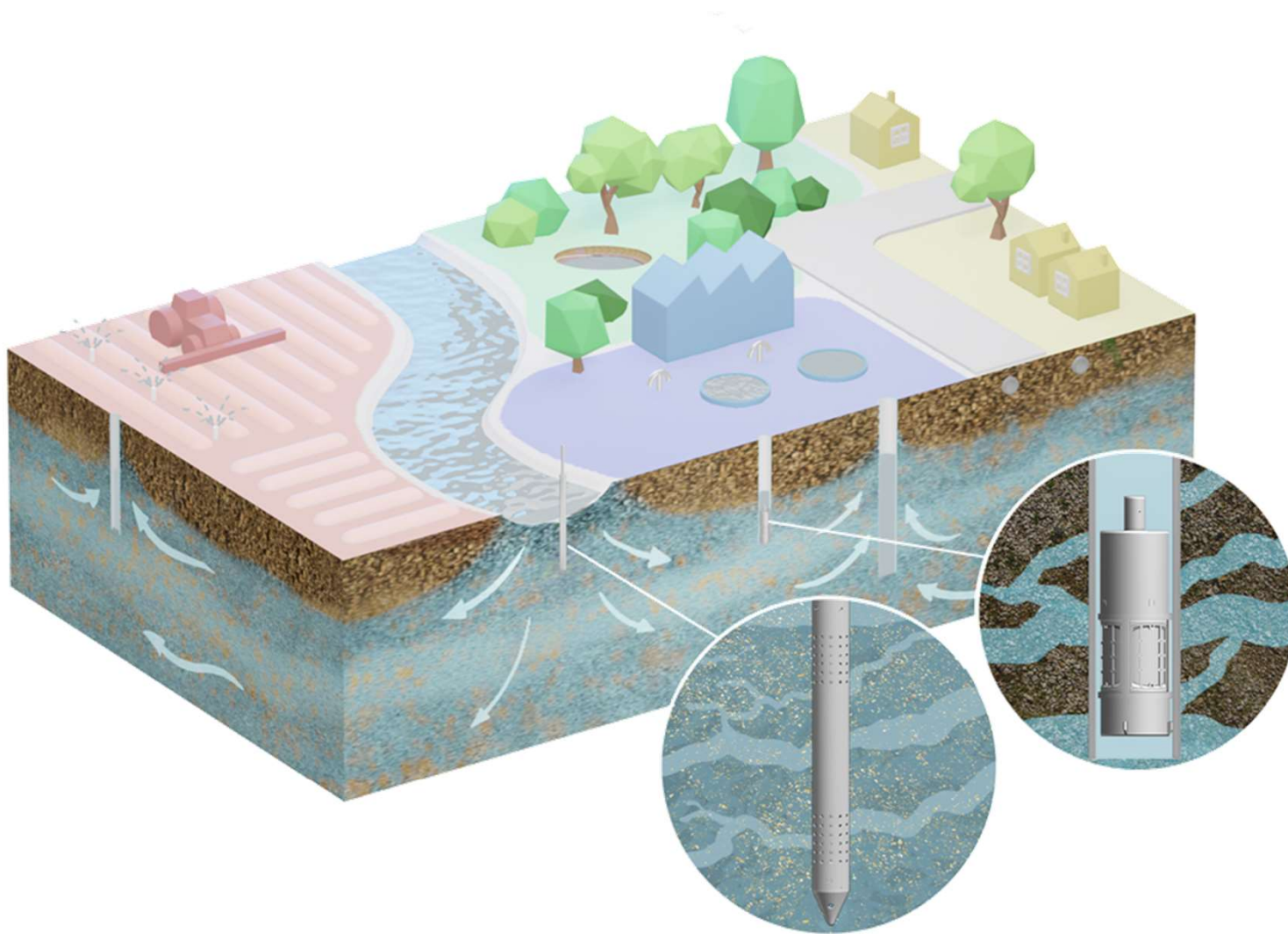
J (vertical):

Benzene

- Initial: 5-35 mg/m²/d
- MC1: 0-0,25 mg/m²/d

Benzene (toluene, naphtalene, acenaphtene)

- MC2: 0,6 mg/m²/d



Thank you!
Questions or remarks?

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