Pilot site in Iceland-

Challenges and lesson learned

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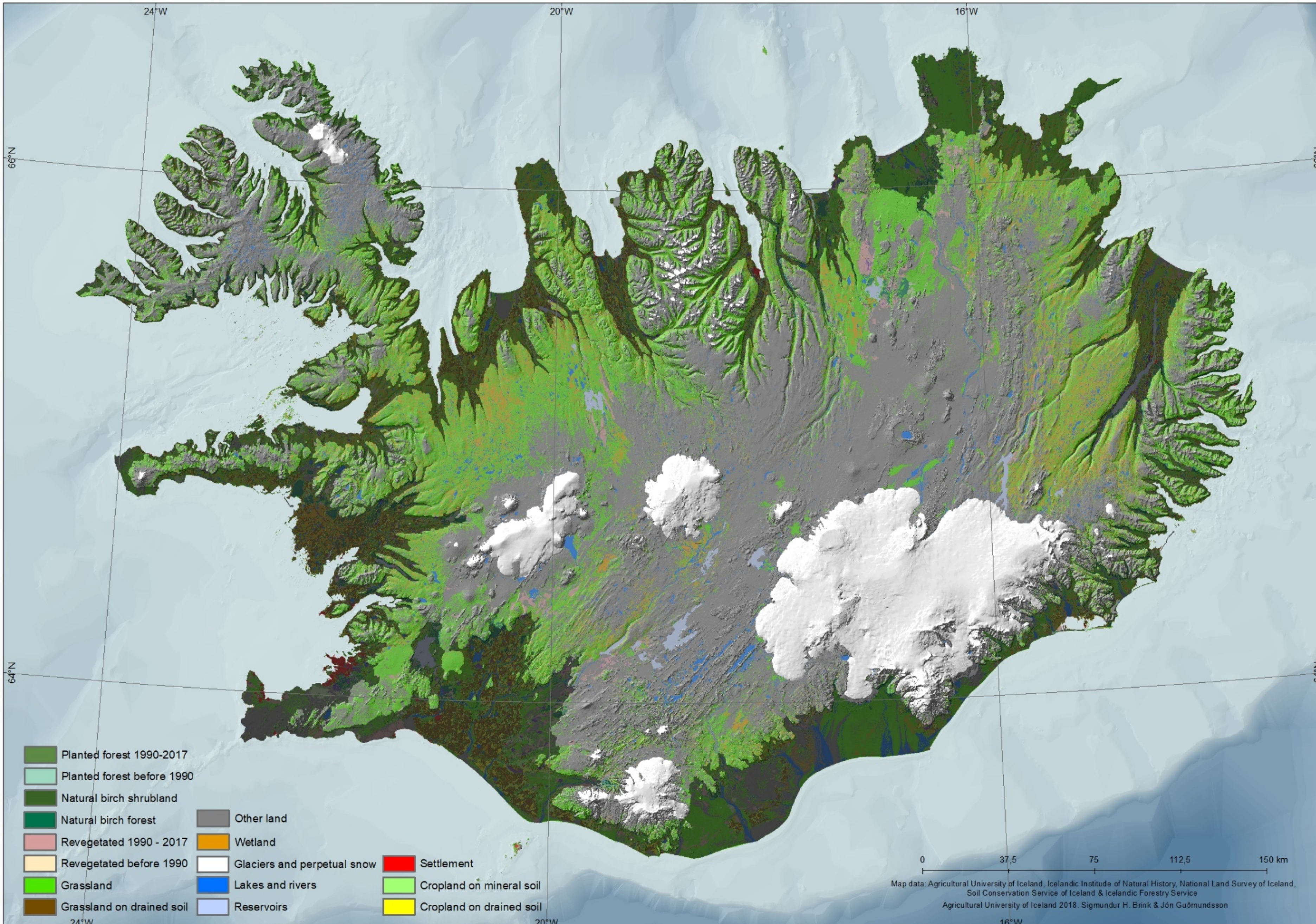
Overview of presentation

- Background on agriculture intensity and nutrients in lakes and rivers in Iceland
- Pilote site setup and equipments
- Some results
- Conclusions and the way forward


24°W
20°W
16°W
66°N
64°N
Planted forest 1990-2017
Planted forest before 1990
Natural birch shrubland
Natural birch forest
Revegetated 1990 - 2017
Revegetated before 1990
Grassland
Grassland on drained soil
Other land
Wetland
Glaciers and perpetual snow
Lakes and rivers
Reservoirs
Settlement
Cropland on mineral soil
Cropland on drained soil
0
37,5
75
112,5
150 km
Map data: Agricultural University of Iceland, Icelandic Institute of Natural History, National Land Survey of Iceland, Soil Conservation Service of Iceland & Icelandic Forestry Service
Agricultural University of Iceland 2018. Sigmundur H. Brink & Jón Guðmundsson

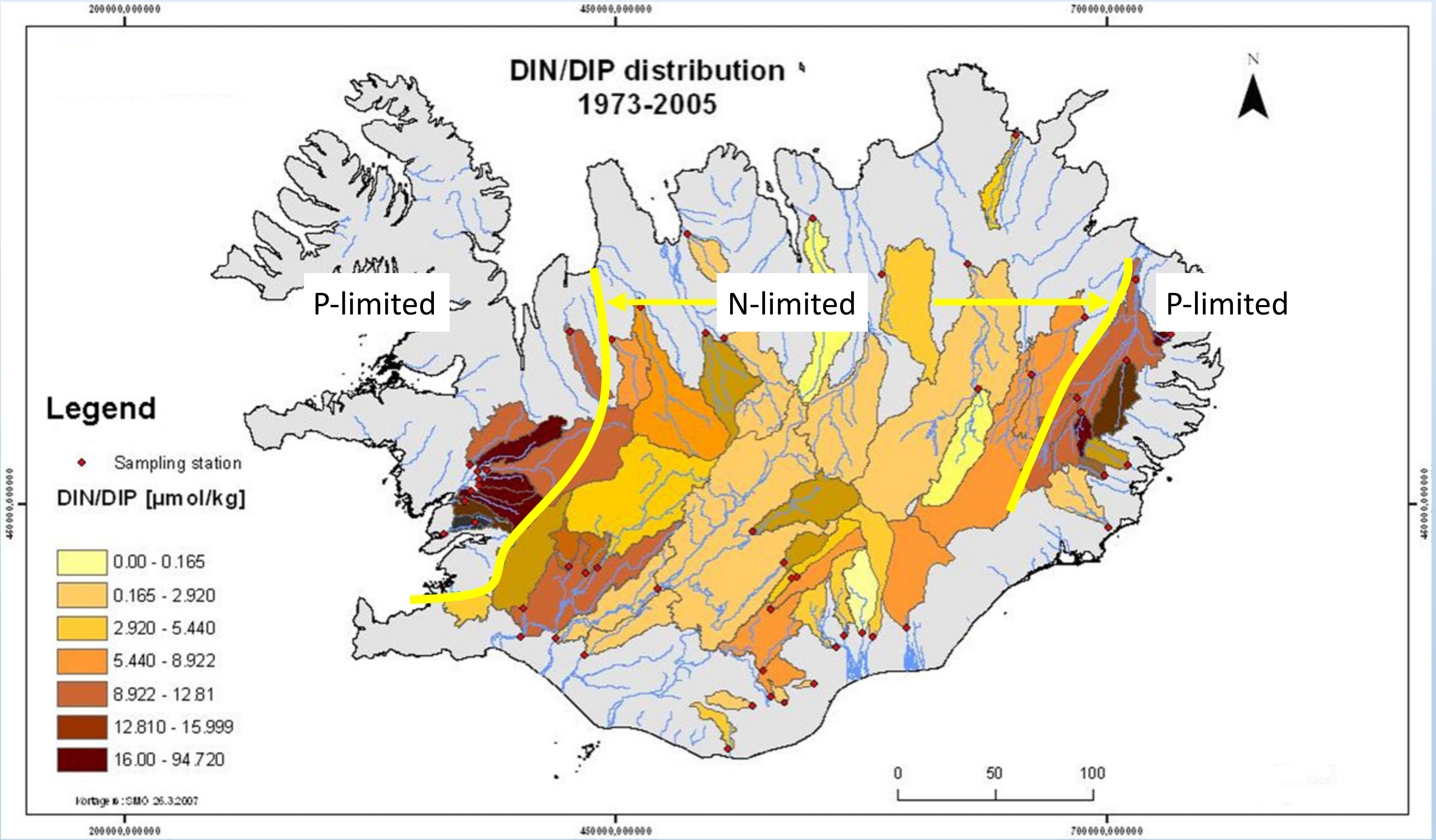
Intensity of cultivation

- Total cultivated area 1,800 km^2
  - all land cultivated at any time
  - in use 1,000 km^2 (1% of total area)
- Most (95-99%) below 200 m a.s.l.
  - 24,000 km^2 total –cultivated 4%
- In general residence time of water in rivers is short
- Eutrophication is generally not considered a problem

Then why worry?

- WaterPro project emphasizes two perspectives regarding nutrient losses from agriculture
  - Environmental
  - Economical
- Economical reasons to limit -recapture nutrients losses
  - nutrients cost
  - Resources for P are becoming scarce
    - Cd contaminated
  - Production of N fertilizers energy demanding
  - On farm nutrients are valuable assets in farming should not be thrown away

Slide borrowed from Eydís S. Eiríksdóttir



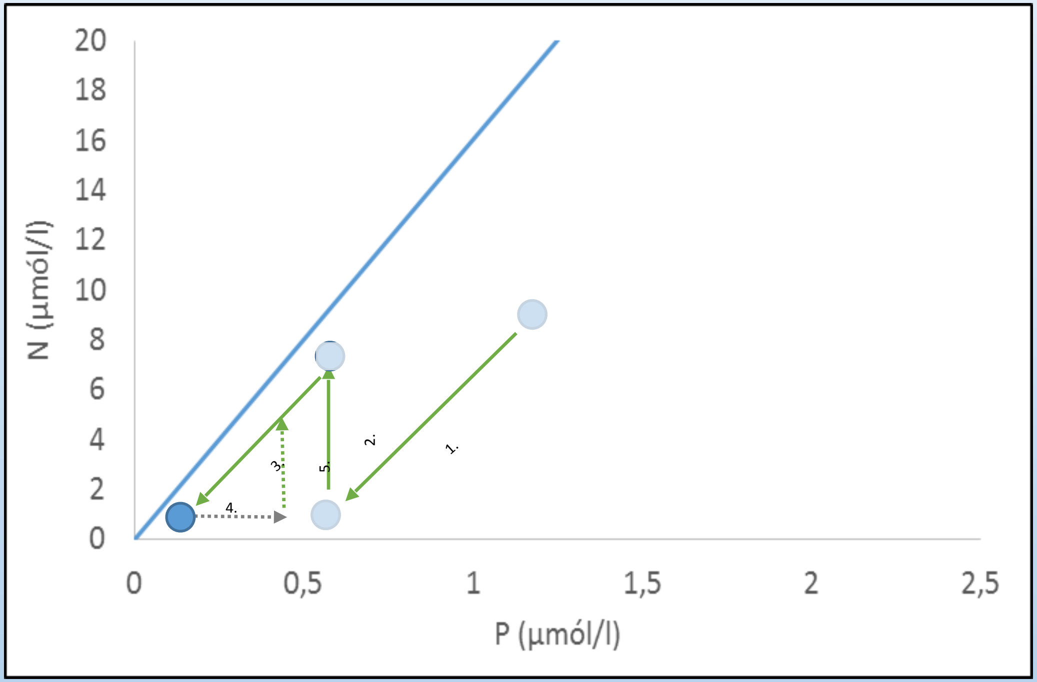
Ref: Oskarsdottir et al., 2011. J. Hydrology 397, 175 - 190

Importance of blue green algae and particulate P

- Blue green algae e.g. Anabaena stimulated by available P
  - Nitrogen fixing
- Additional N can cause P release from sediment
- Loop potential of ending in eutrophication

Slide borrowed from Eydís S. Eiríksdóttir

Model showing a possible nutrient cycle in a lake similar to Lake Mývatn



1. Photosynthesis
2. N-fixation by bluegreen algae
3. Photosynthesis
4. P influx from bottom sediment
5. N-fixation by bluegreen algae

4+5 in a loop while light permits

So – particulate P can participate in the nutrient circulation
and can enhance eutrophication (Lukkari, 2008; Yli-Hemminki et al., 2016; Eiriksdóttir et al., 2017)

Additional comment in the style of old Cato

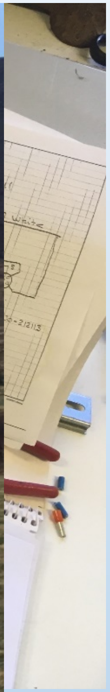
- It is not all about eutrophication
- Nutrient poor ecosystems are also valuable
- Small amounts of nutrients can change those ecosystems drastically

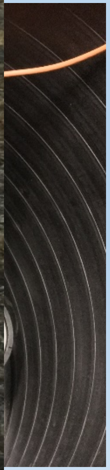
„Praeterea censeo Carthaginem esse delendam“

Runoff monitoring lacking in Iceland

- Challenges (before hand)
- Iceland condition
  - Frequent freeze- thawing cycles
    - Monitoring surface runoff more difficult
  - Manure spreading outside growing season
    - More important to operate in winter time
- Arctic – WaterPro prerequisites
  - Low agricultural density
  - Limited unreliable power supply
  - Remoteness -Minimum attendance
  - Need to compromise automation and power security
  - Relatively low budget

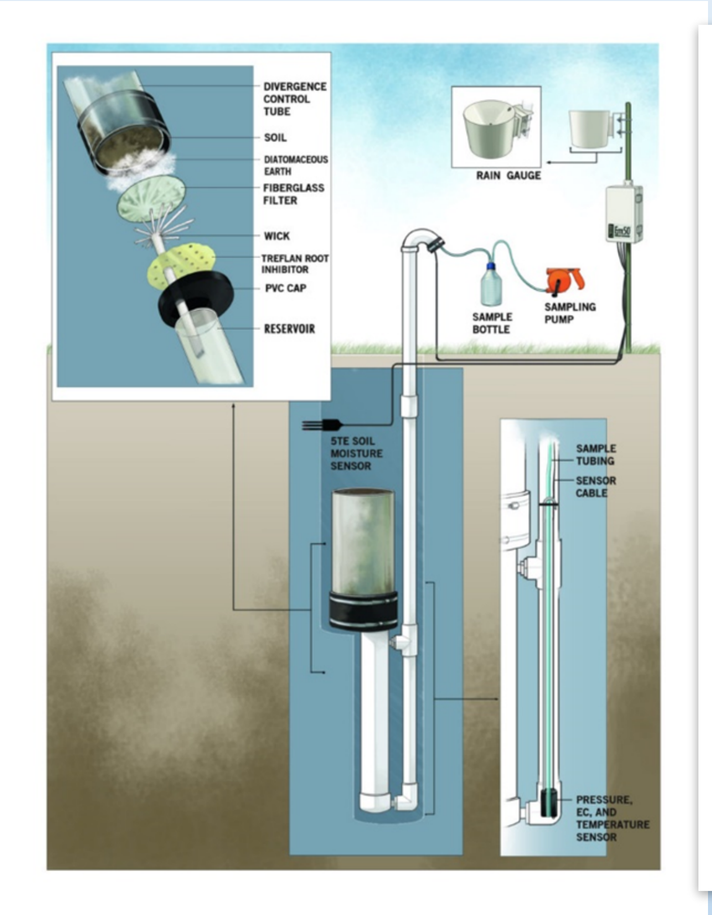
Setup-macro to micro



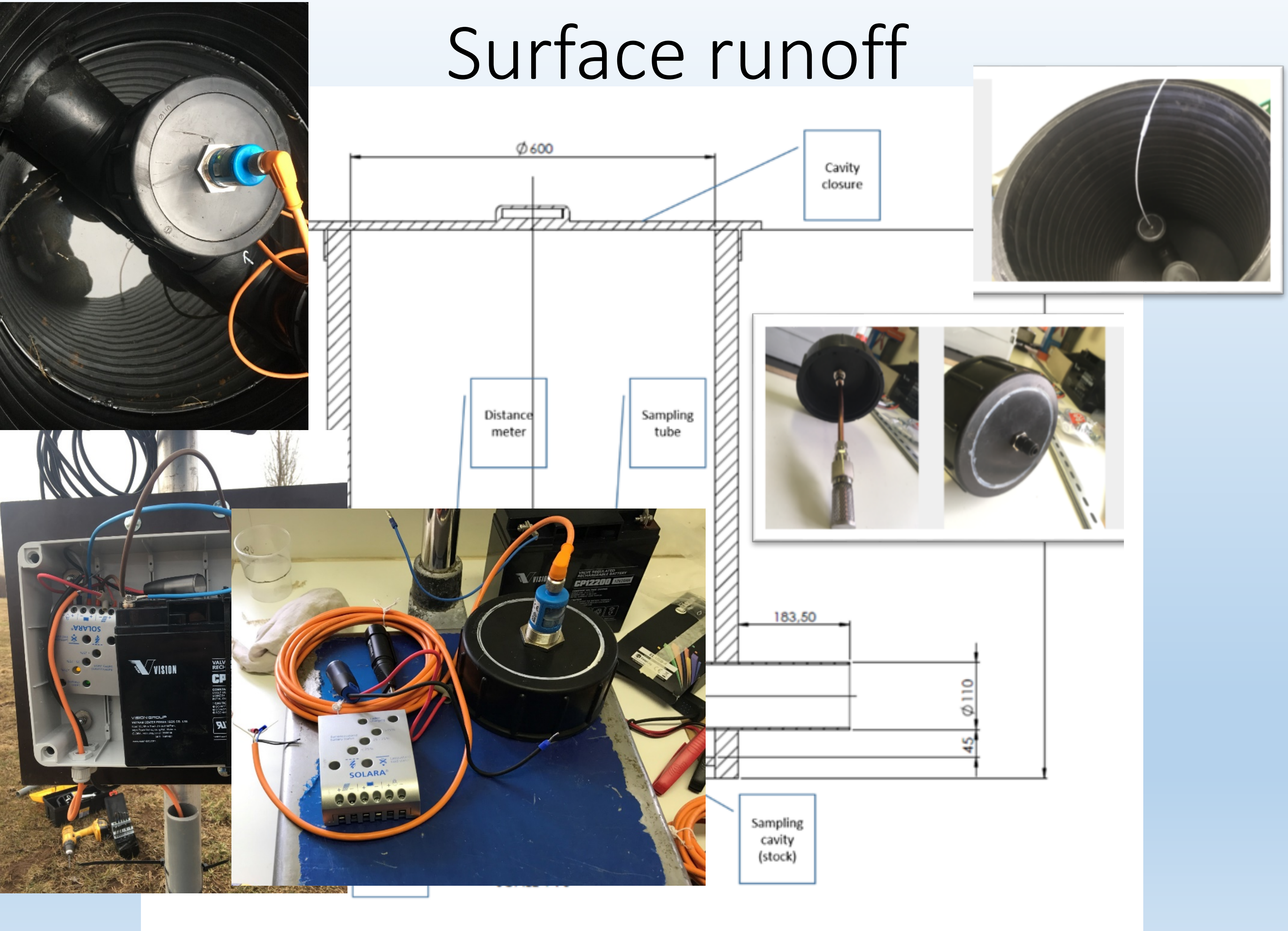


Deep drainage

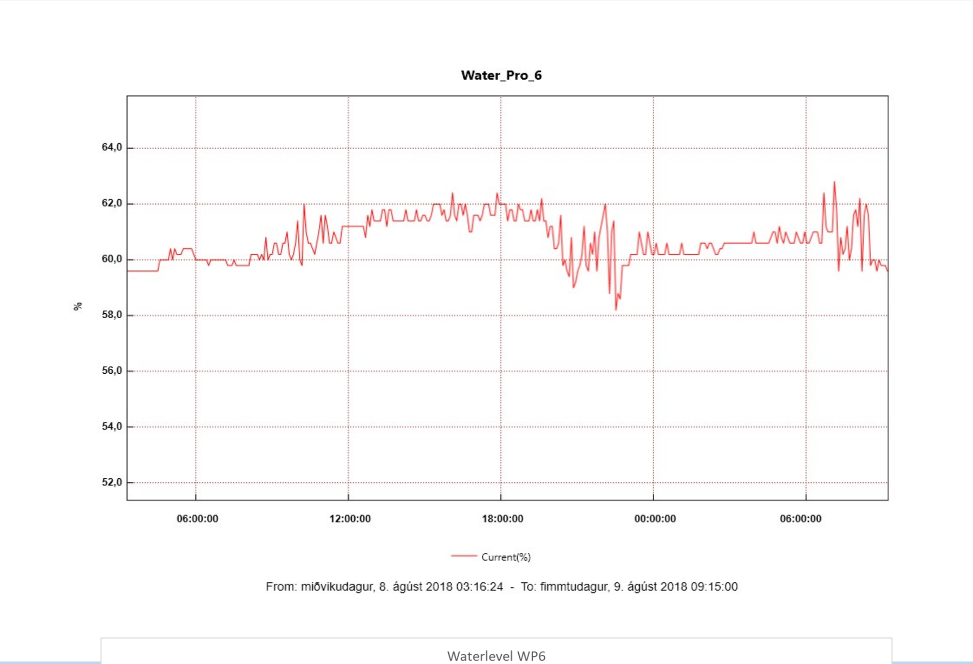
Passive capillary lysimeter 3G drain gauge from Decagon Devices Inc.



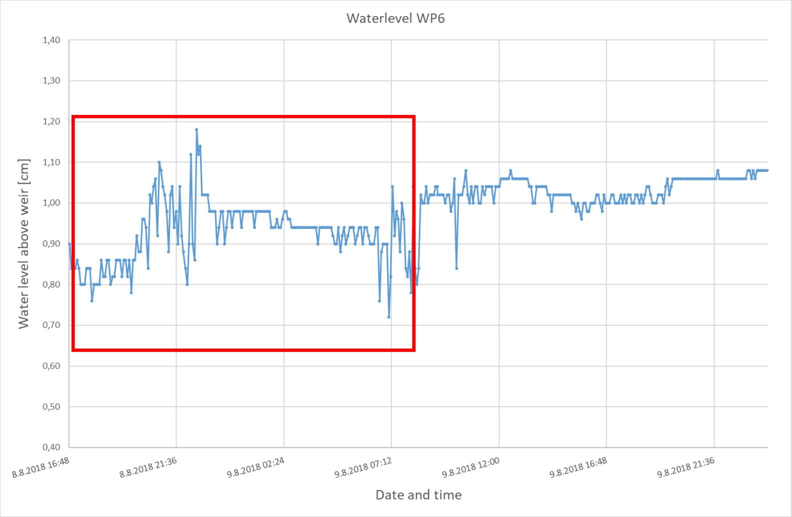
Surface runoff



Results- surface flow recording



Raw data % of max distance to water level



Converted to water level above weir [cm]

Flow calculations

The flow estimate is obtained by (Equation 1) (LMNO_Engineering 2019), calculating flow height of water over the weir lowest point, h is reflected by measured distance to water surface in the pipe.

$$Q = 4{,}28 * C * \tan\left(\frac{\theta}{2}\right) * (h + k)^{5/2}$$

Equation 1: Equation used for calculating surface run of discharge from measurements of distance to water surface above V-notch weir. Where Q: Discharge (in cubic feet's per second (cfs)) C: Discharge coefficient θ: Notch Angle h: Head (ft) k: Head Correction factor (ft)

The estimate of discharge coefficient (C) and head correction factor (k) is according to curve fitting to the notch angle (LMNO_Engineering 2019) . The equations of best fit are

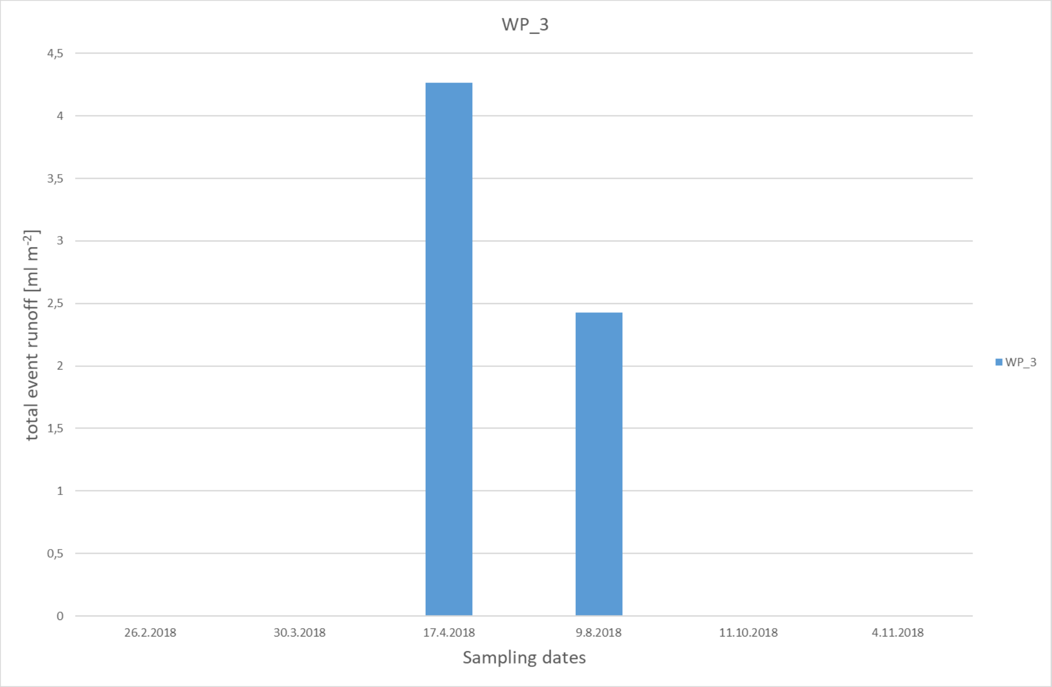
$$C = 0{,}607165052 - 0{,}000874466963 * \theta + 6{,}10393334 * 10^{-6} * \theta^2$$

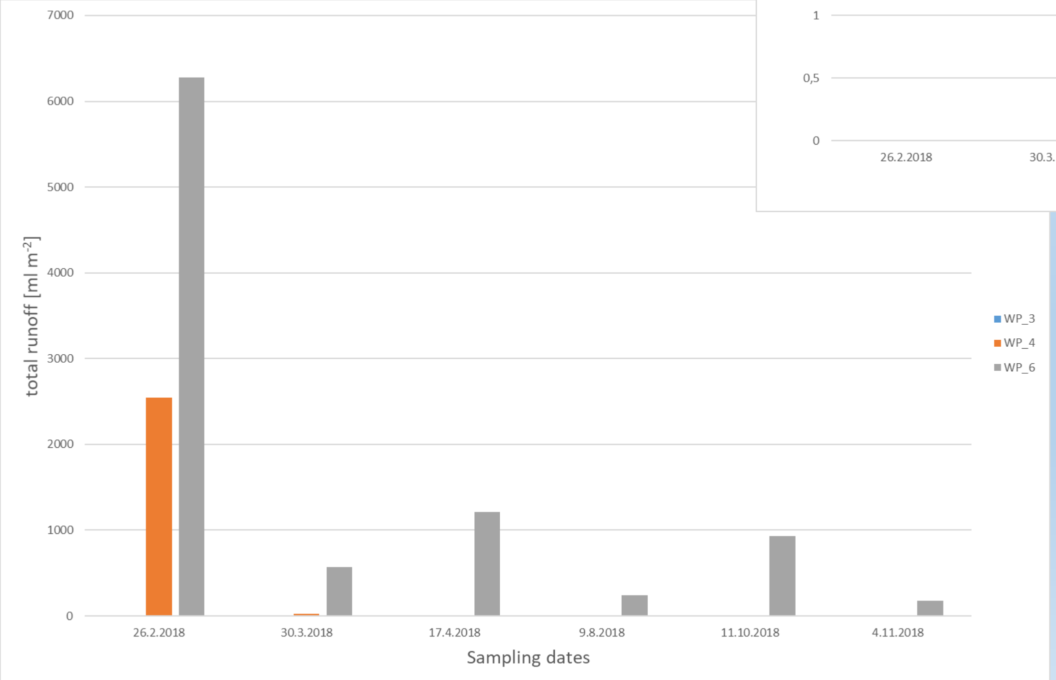
$$k(ft) = 0{,}0144902648 - 0{,}00033955535 * \theta + 3{,}29819003 * 10^{-6} * \theta^2 - 1{,}06215442 * 10^{-8} * \theta^3$$

Limitations and caution

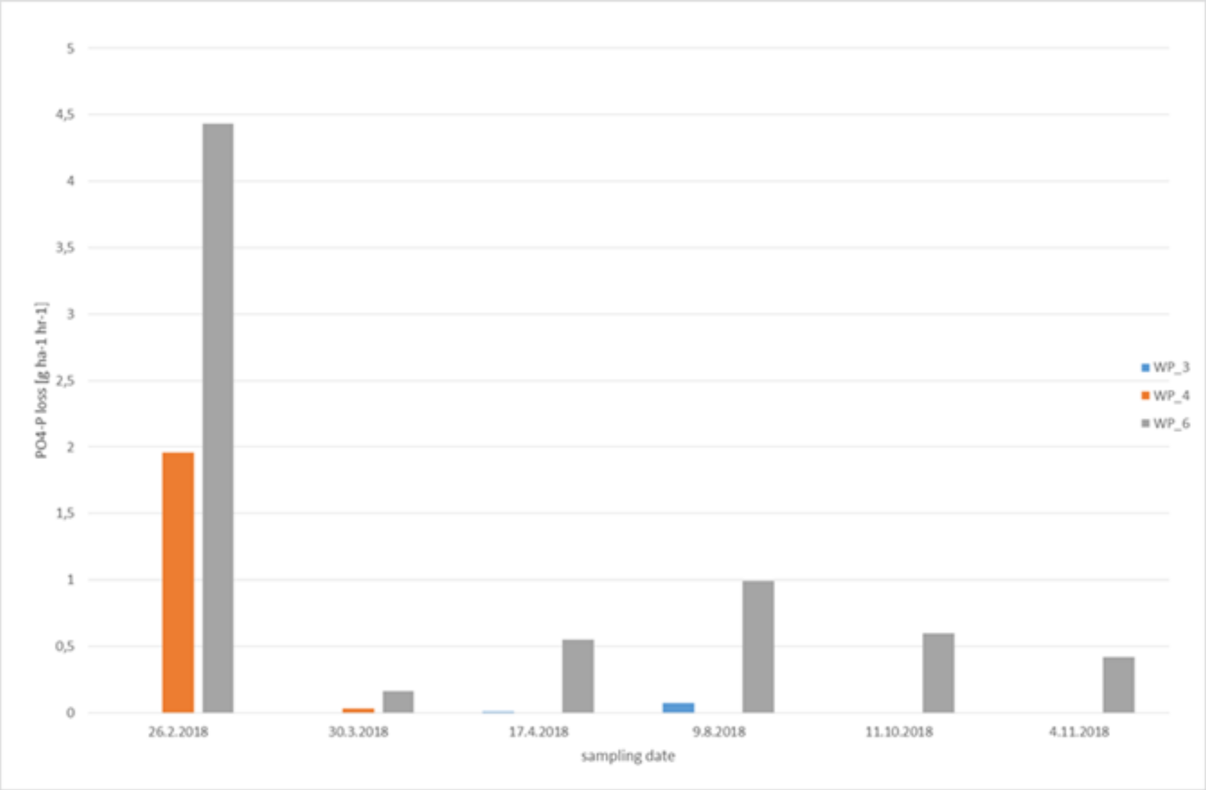
- The results from this equation is a rough estimate of the actual flow, as several stated pre-conditions are not met, in high flow pulses.
- For better estimate, calibration of the flow is necessary.
- Baseline distance to water level of each measurement point is needed.

Sampling associated flows





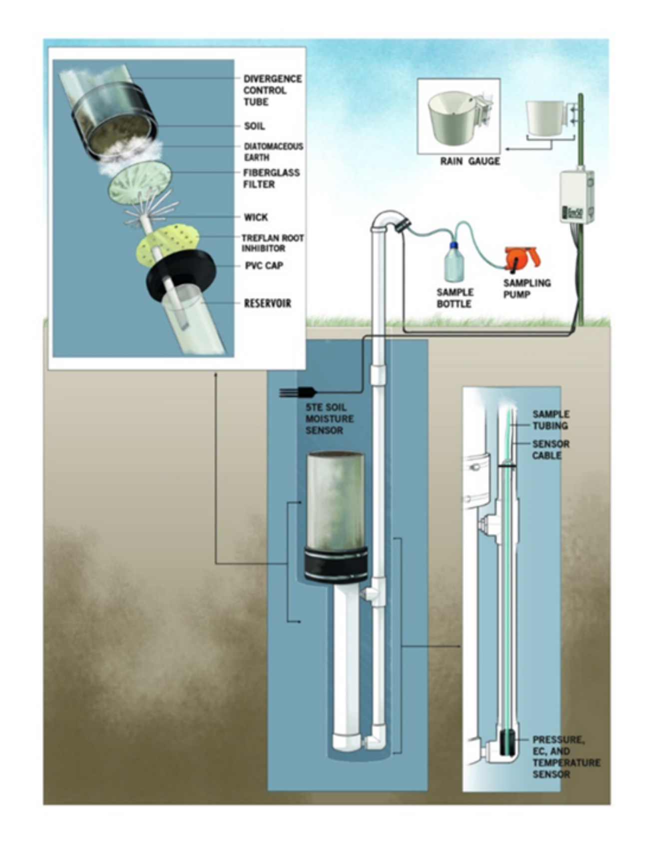
Losses associated to surface flow events



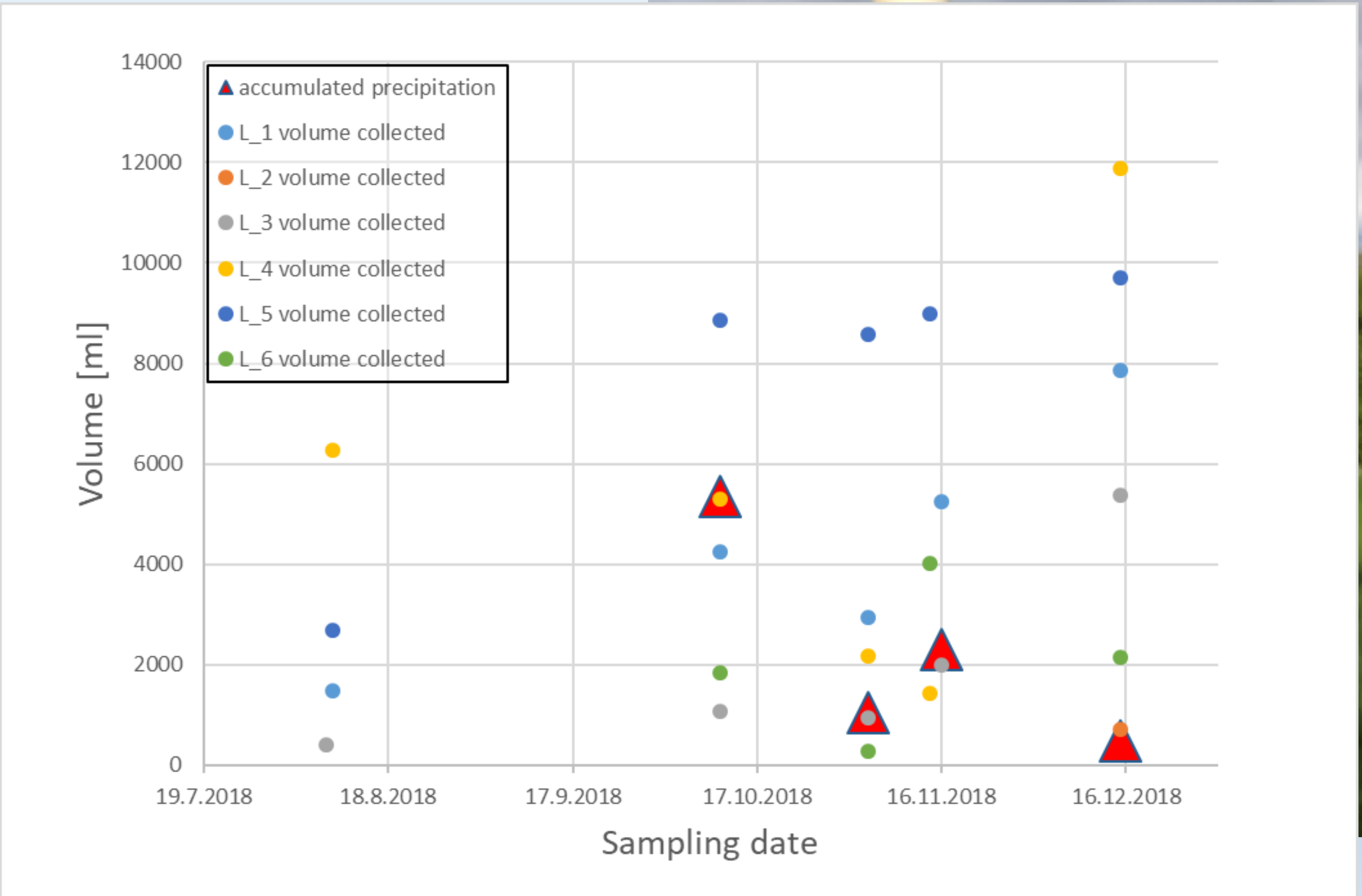
Calculated losses on hourly basis range from almost zero to 4.4 g PO4-P ha^{-1} hr^{-1}, on average the loss was 0.92 ±0.43 (SE). In most cases, loss detected was less than 1 g PO4-P ha^{-1} hr^{-1}. Because of discontinuity in flow recording in the testing period total runoff on annual basis can`t be estimated.

Deep drainage losses

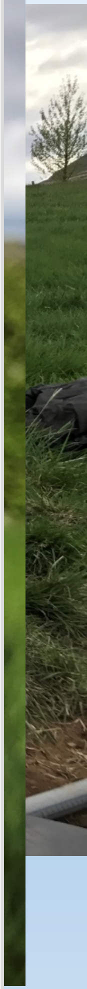
- G3 drain gauge Lysimeter collect water applying 11 kPa at top of the DCT (divergent control tube)
- Accumulated volume between sampling
  - Volume collected is the deep drainage since last sampling
  - Part of the precipitation that is not accounted for as evapotranspiration or surface runoff



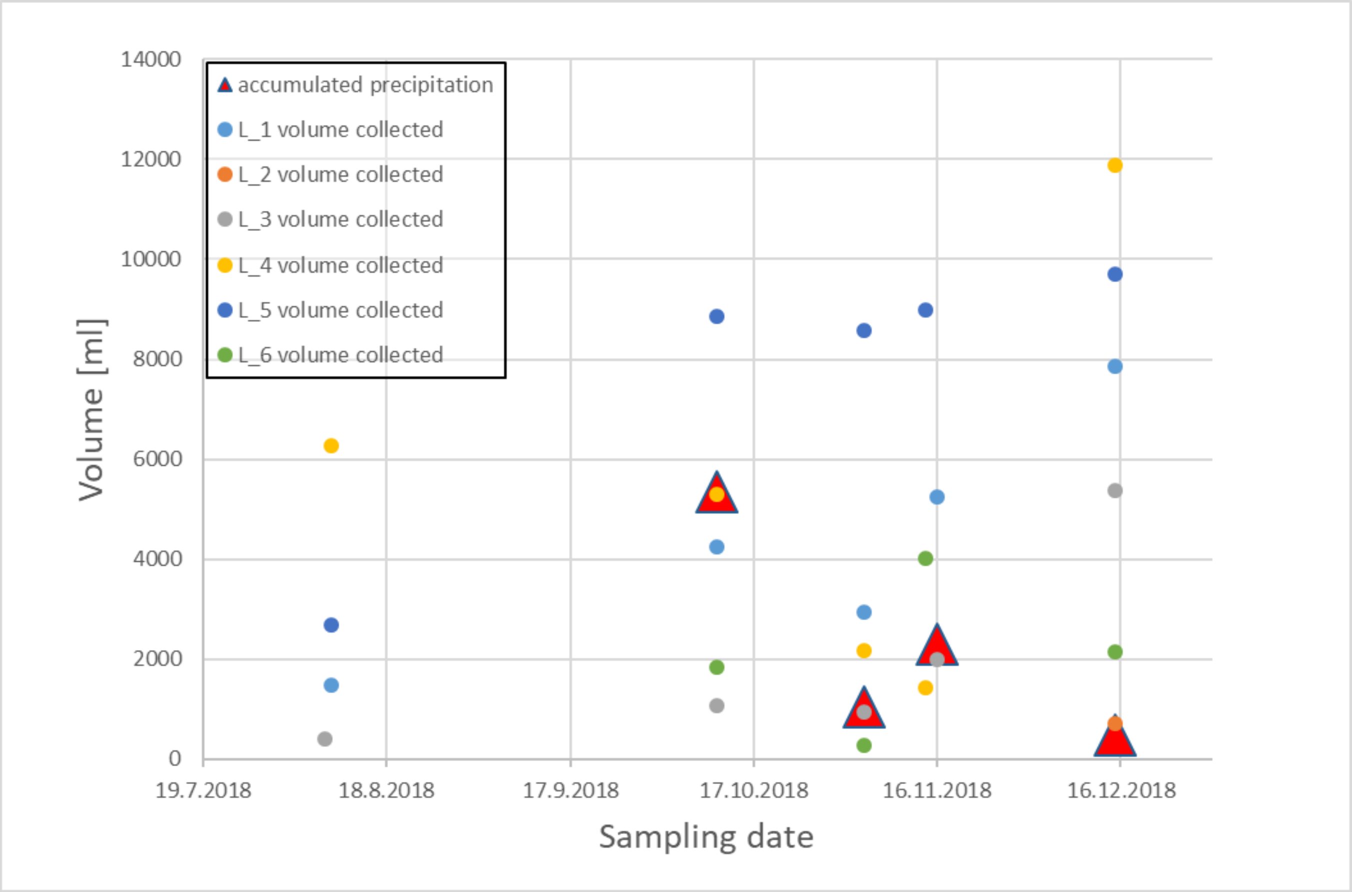
Volume



14000
12000
10000
8000
6000
4000
2000
0
Volume [ml]
accumulated precipitation
L_1 volume collected
L_2 volume collected
L_3 volume collected
L_4 volume collected
L_5 volume collected
L_6 volume collected
19.7.2018
18.8.2018
17.9.2018
17.10.2018
16.11.2018
16.12.2018
Sampling date



Outside our comfort zone?

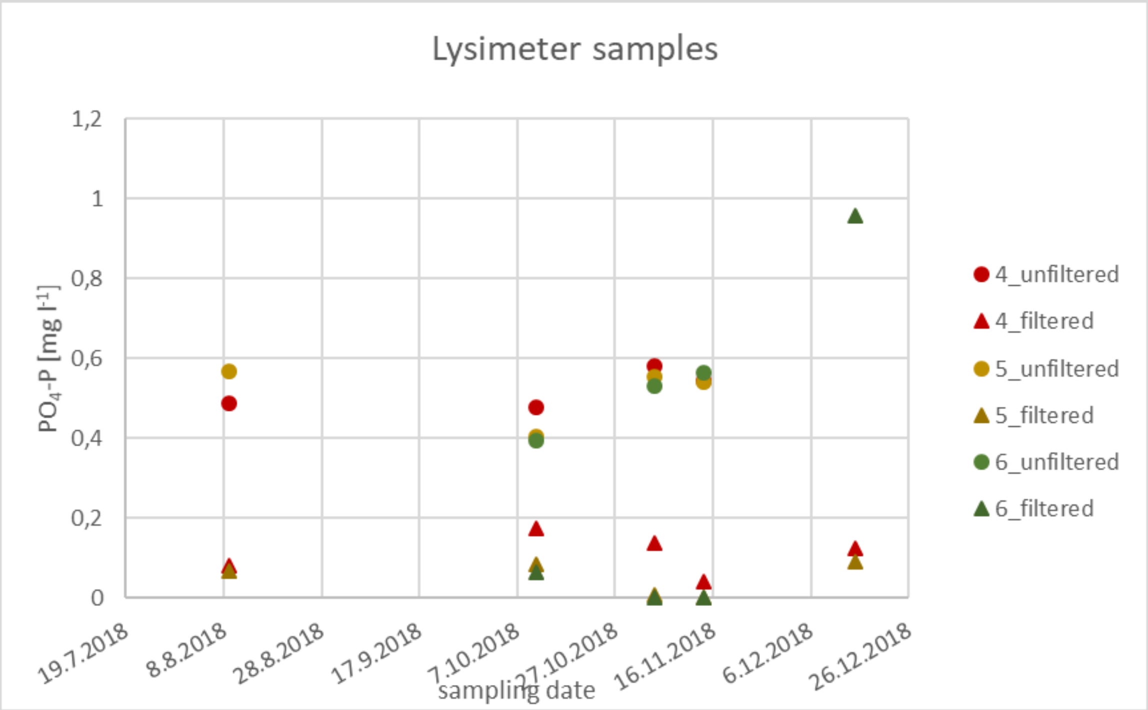


Why is collected amount more than accumulated precipitation?

- Possible explanations
  - Three types of events can cause gravitational water to rise above the DCT, which was set at approximately 60 cm below soil surface
  - One is intensive rain events, where infiltration is faster, than absorbed by the soil, or captured by plants or evaporated directly from surface
  - Second is fast snow melting, causing high infiltration rate.
  - Third is increased lateral inflow of soil water, causing water level to rise upstream to areas where lateral hydraulic conductivity is less than in adjacent areas.
  - These events do not exclude each other, and more than one can occur at the same time.

- Two more sources of water entering the lysimeters are possible, i.e.
  - drifting snow accumulating in the fields/plots and surface runoff passing or accumulating over the lysimeter.
  - Accumulation of snow or water over the lysimeter is affected by the micro-landscape on the fields with or without snow

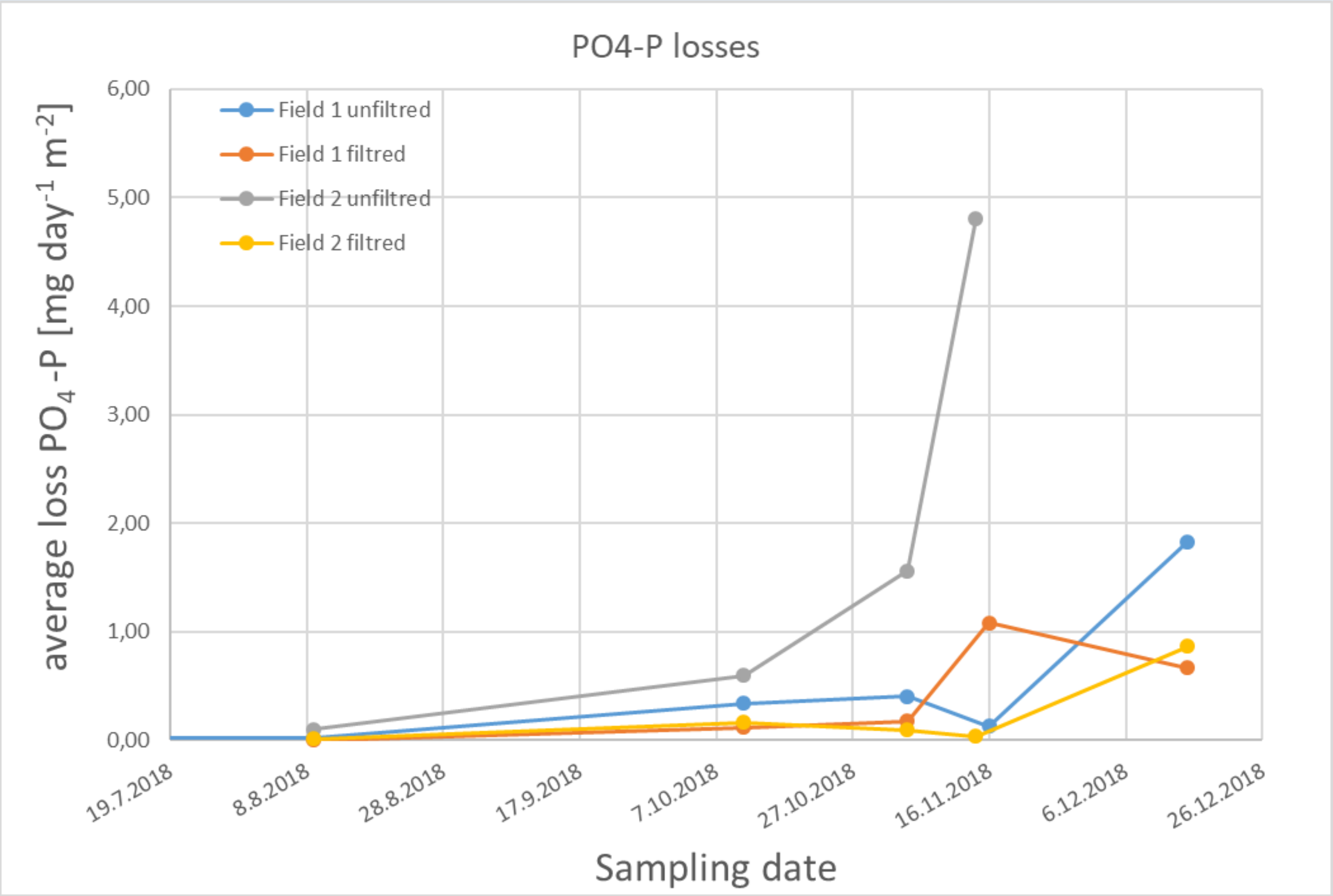
Nutrients in “deep drainage”



PO4-P CONCENTRATION IN LYSIMETER SAMPLES ON FIELD 2 (LYSIMETERS 4, 5, 6) FILTERED AND UNFILTERED SAMPLES

- Unfiltered samples higher in PO4-P
- Particulate P included in samples
- Changes in oxidation state – anoxic water entering Lysometer reservoir P disolved

Estimated P losses for each field



Lessons and conclusions

- Technical modifications needed
  - Flow rate measurements
  - Power supply and data storing
  - Additional environmental variables
- Methodological improvements
  - Calibration of flow measurements
  - Solve problem of debris in surface runoff and effects on water level behind weir
  - Sampling considering changes in oxidation stage of sample in lysimeters
- Hydrological problems
  - What is sampled by the lysimeters

Lesson and conclusions

- There are losses both assigned to surface runoff and deep drainage
- Recorded losses in surface runoff events is up to 4.4 g PO_4-P ha^{-1} hr^{-1}
- Average losses of PO_4-P captured by lysimeters over three months in autumn 2018 estimated as 1.4 kg ha^{-1} at both fields
- Results on N still pending


Thanks for listening and
WaterPro partners for the
company and co-operation