Influence of groundwater quality on rivers with a high baseflow component in Pandivere Upland, Estonia and its relevance for groundwater body status assessments

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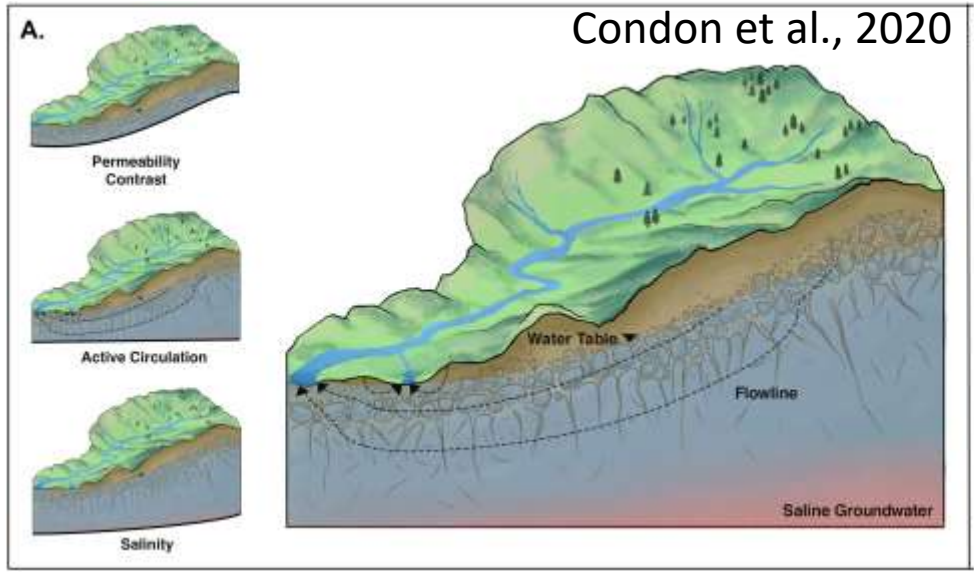
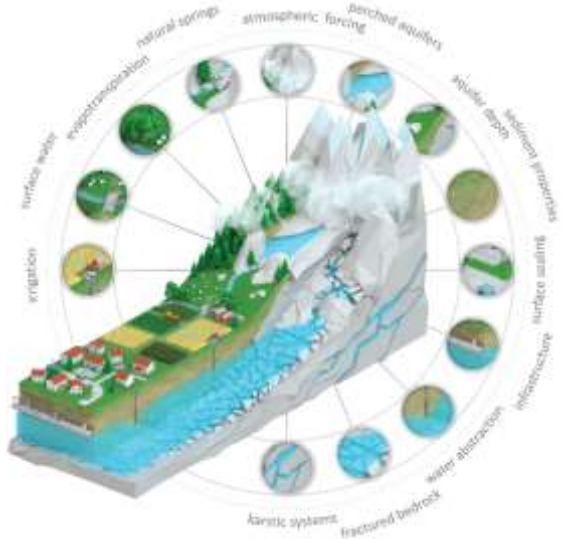
GW-SW interactions and systems approach behind WFD



Condon et al., 2020

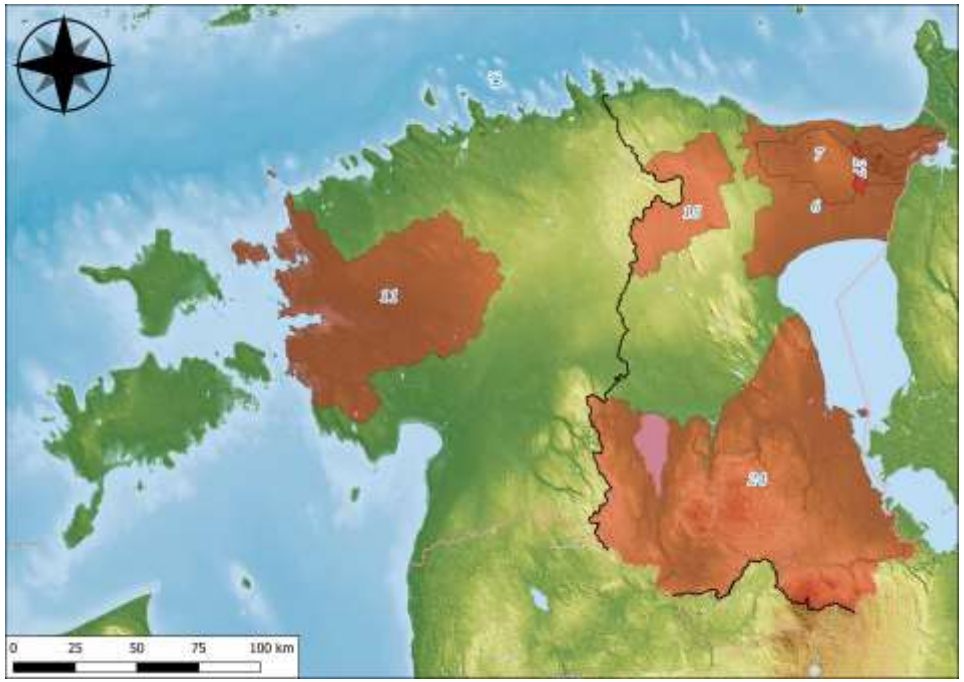

Ramgraber et al., 2021

- *„the absence of the paradigm shift towards the systems (integrated) thinking that the WFD was grounded on, is a fundamental problem with its implementation“* (Voulvoulis et al., 2017)
- **„Systems“ approach – catchment-based** approach; looking at land and water holistically as an integrated whole
- Need to understand the system of causes that could enable the evolution from current status to good status.

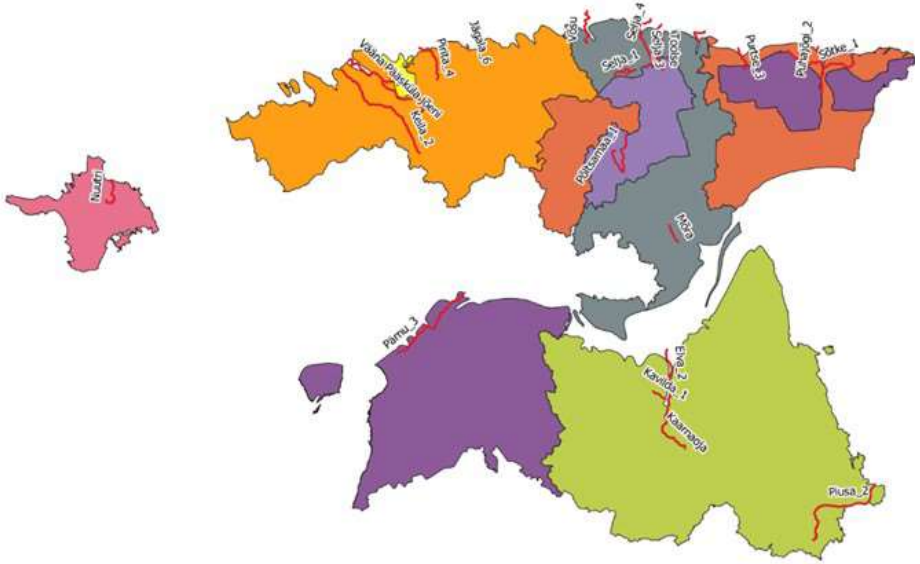
GW-SW interaction test in GWB status assessments. Estonian experience

- Latest groundwater body status (GWB) assessment completed in 2020 by the Geological Survey of Estonia (GSE, 2020)

GWB no.	Bad status	Indicator
6	chemical	phenols, NH_4-N, COD_{Mn} (*test no. 1*)
7	chemical/ quant.	SO4, COD_{Mn}, phenols (*test no. 1,5,7*)
11	chemical	COD_{Mn} (*test no. 1, 5*)
15	chemical	GW-SW (*test 3*); NO_3-N
24	chemical	NH_4-N, pesticides (*test no. 1*)
27	chemical/ quant.	SO4, NH_4-N, COD_{Mn} (*test no. 1, 3, 7*)
31	chemical	COD_{Mn} (*test no. 1*)



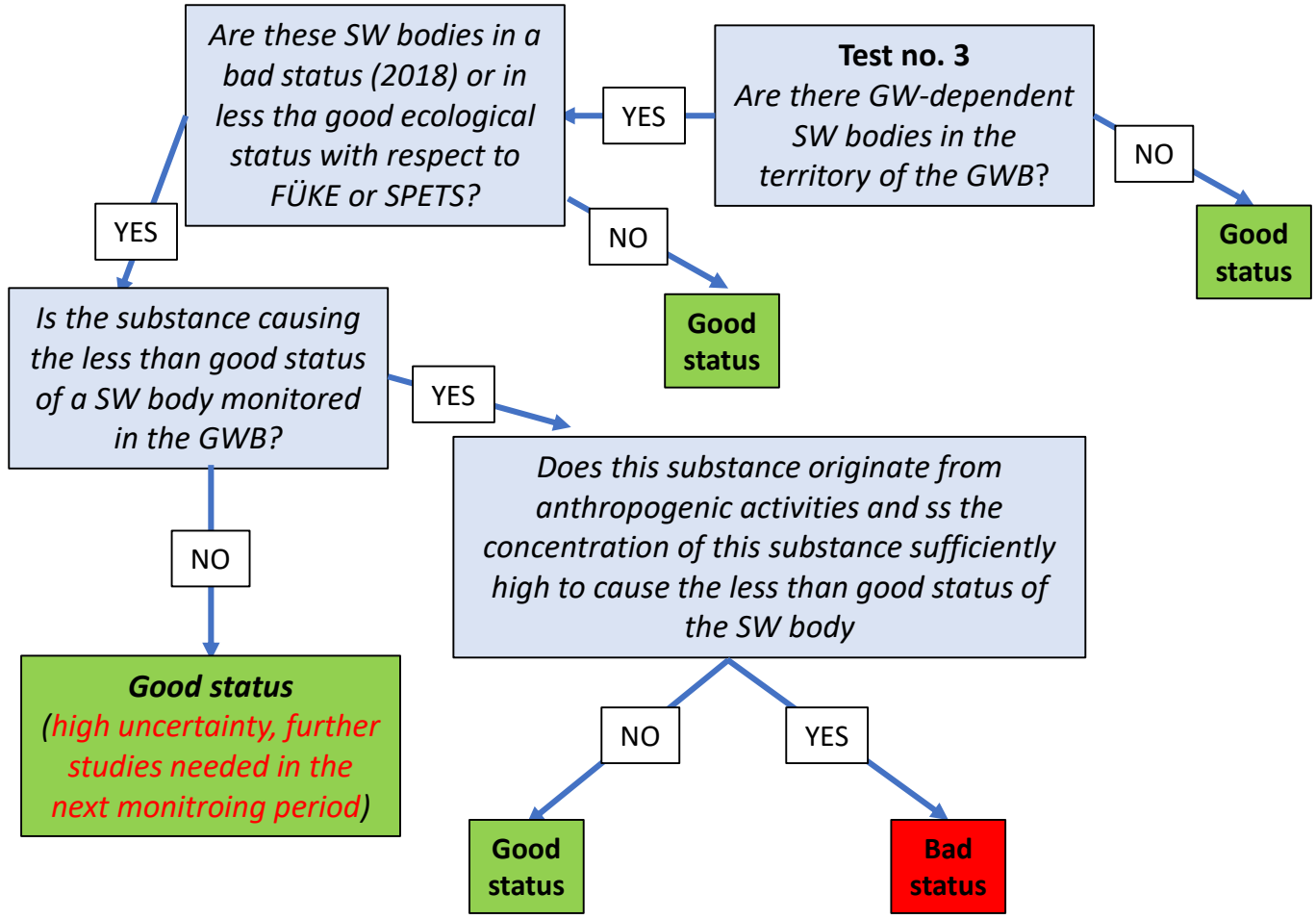
Shallow GWBs in bad status (GSE, 2020)



SWBs in less than good status and the related GWBs (GSE, 2020)

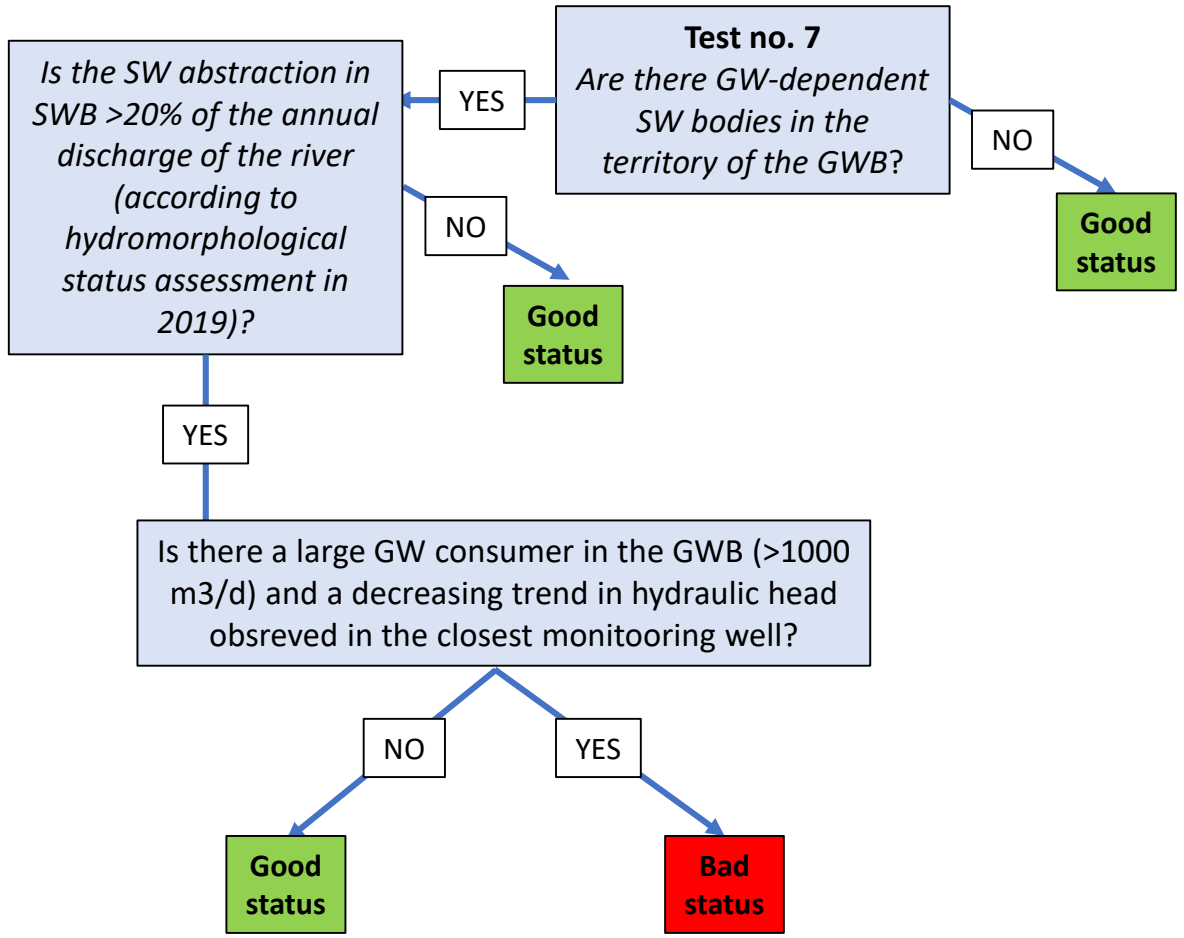
GW-SW interaction test in GWB status assessment. Estonian experience

- ✓ ***Test no. 3 Chemical status with respect to dependent surface water bodies:***
- ❑ SW bodies in bad general status or in less than good status with respect to FÜKE (physical-chemical indicators) & SPETS (water specific pollutants)?
- ❑ **is the substance causing the less than good status of GDE also monitored in GW?**
- ❑ Is the high concentration in GW monitoring point such that it can cause less than good status of GDE and **related to anthropogenic sources (Ba)**?
- ✓ **For all 21 shallow GWBs 12 results of test no. 3 had high uncertainty (57%); 2 GWBs in bad status according to test no. 3 (no. 15,**



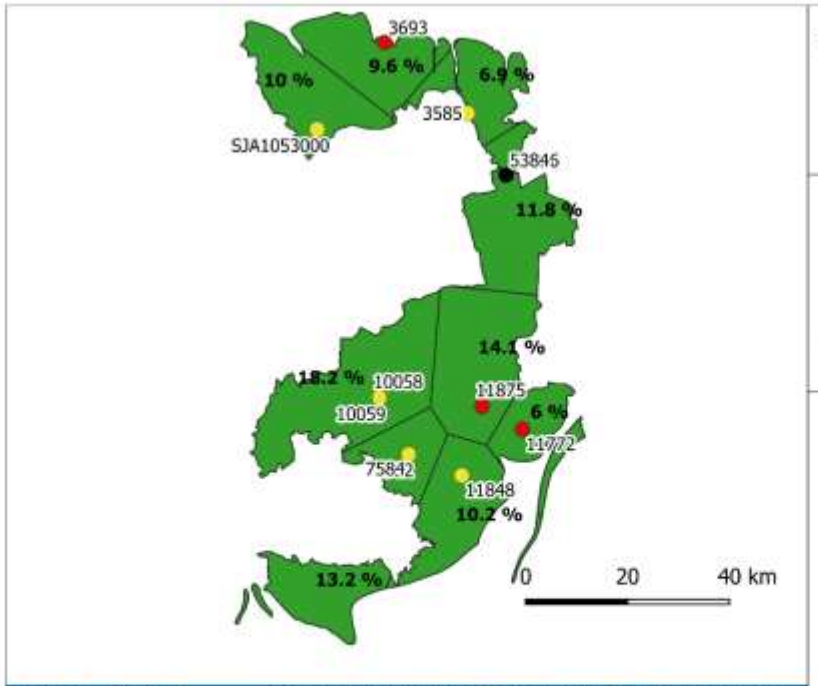
GW-SW interaction test in GWB status assessment. Estonian experience

- ✓ ***Test no. 7 Quantitative status of the GWB based on dependent GDEs:***
  - ❑ SW abstraction >20% of the annual river Q (hydromorphic status)?
  - ❑ Large water consumer in the vicinity (>1000 m^3/d) and decreasing trend in water levels in the GWB?
- ✓ **For all 21 shallow GWBs 2 results of test no. 7 had high uncertainty (10%); 1 GWB in bad status according to test no. 7 (Ordovician GWB in the Ida-Viru oil shale basin,**



GW-SW interaction test in GWB status assessments. Estonian experience

GWB no. 13



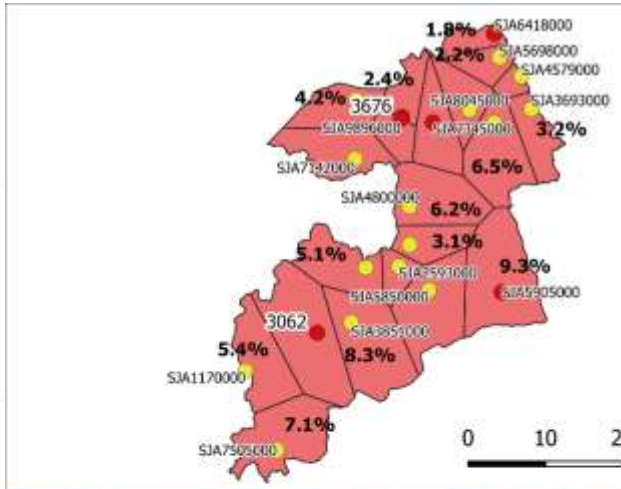
KKR kood	Näitaja	Lähtetase	Keskm	LV/PV	Ühik	p-väärtus	Trend	Kasvusuundumus
PRK0011875	Pestitsiidid summa	0.0032	0.463	0.1	µg/l	0.991	0.003	Üle PV
PRK0011772	NH4	0.45	0.534	0.5	mg/l	0.001	0.038	Üle PV
PRK0010056	SO4	1.65	4.23	Puudub	mg/l	0.044	2.125	püsiv
PRK0010056	NH4	0.035	0.095	0.5	mg/l	0.045	0.046	püsiv
PRK0003693	PAH summa	0.55	0.55	0.1	µg/l	0	0	Üle LV

Siluri–Ordoviitsiumi põhjaveekogum Ida-Eesti vesikonnas (nr 13):
keemiline seisund: hea
koguseline seisund: hea
koondusaldusväärsus: madal

- Üle lävi- või piirväärtuse
- Püsiv kasvusuundumus
- Puudub püsiv kasvusuundumus
- Seirepunkti mõjuulatus ja osakaal %

Marandi, A., Karro, E., Osjamets, M., Polikarpus, M., Hunt, M. 2020. Eesti põhjaveekogumite seisund perioodil 2014-2019. EGF Eesti Geoloogiateenistus, Rakvere

GWB no. 15



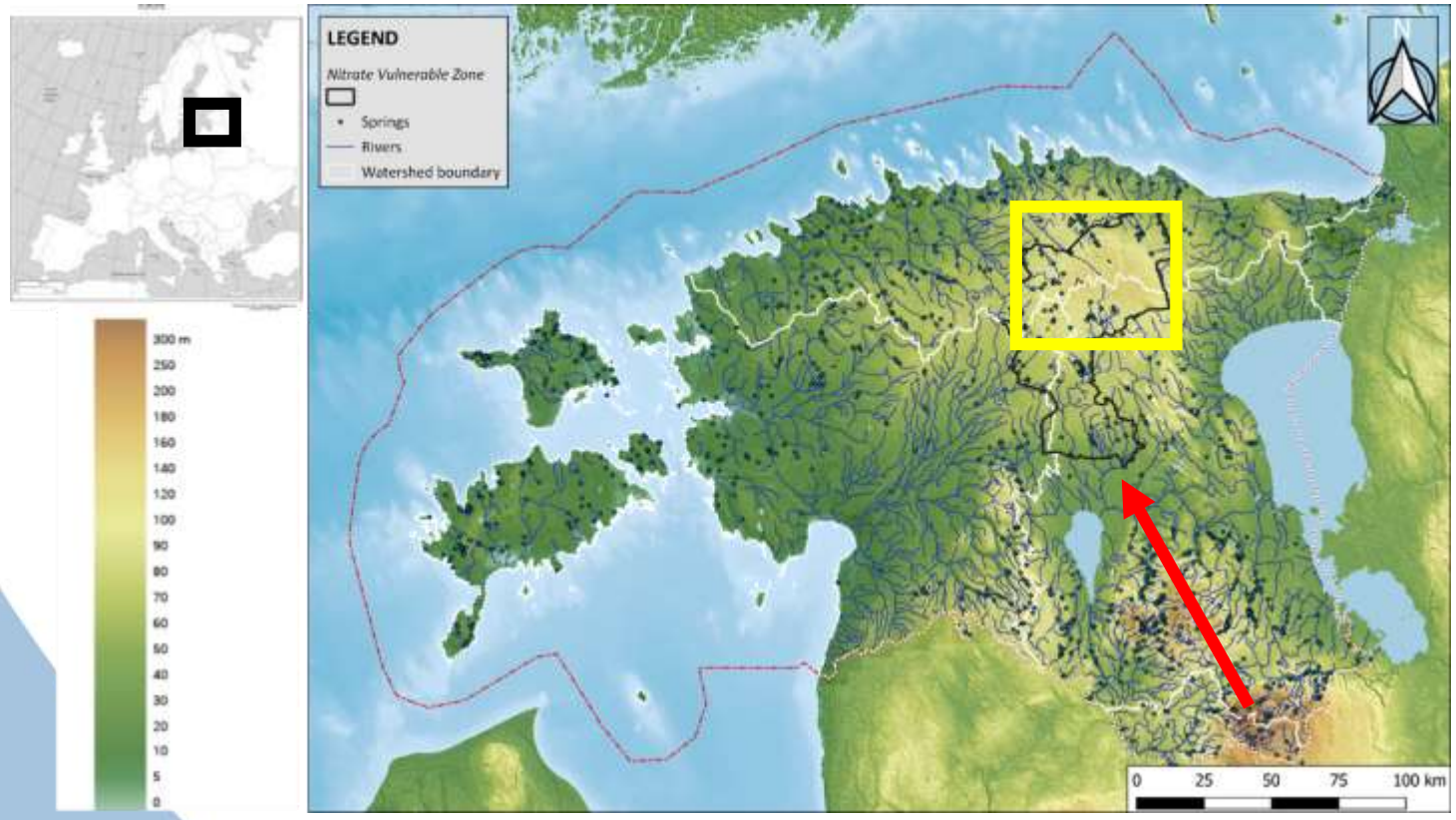
KKR kood	Näitaja	Lähtetase	Keskm	LV/PV	Ühik	p-väärtus	Trend	Kasvusuund.
SJA9896000	Pestitsiidid summa	0.13	0.13	0.1	µg/l	0	0	Üle PV
SJA7345000	Pestitsiidid summa	0.068	0.266	0.1	µg/l	0.911	-0.029	Üle PV
SJA6418000	Pestitsiidid summa	0.71	0.63	0.1	µg/l	0	-0.08	Üle PV
SJA6418000	O2	3.2	5.375	Puudub	mg/l	0.041	0.703	püsiv
SJA5905000	Pestitsiidid summa	0.66	0.83	0.1	µg/l	0	0.17	Üle PV
PRK0003677	PAH summa	0.25	0.11	0.1	µg/l	0.181	-0.05	Üle LV
PRK0003677	PHT(KHTMn)	1.2	2.467	5	mgO/l	0.002	0.423	püsiv
PRK0003677	Benseen	30	15.025	1	µg/l	0	-29.95	Üle LV
PRK0003676	SO4	3.3	33.983	Puudub	mg/l	0.001	4.123	püsiv
PRK0003675	PHT(KHTMn)	3.1	9.267	5	mgO/l	0.041	3.6	Üle PV
PRK0003675	Pestitsiidid summa	0.041	0.136	0.1	µg/l	0	0.189	Üle PV
PRK0003062	Pestitsiidid summa	0.0033	0.957	0.1	µg/l	0	0.953	Üle PV
PRK0003061	NO3	2.3	10.05	50	mg/l	0.015	1.262	püsiv

Siluri-Ordoviitsiumi Pandivere põhjaveekogum Ida-Eesti vesikonnas
(nr 15):
keemiline seisund: halb
koguseline seisund: hea
koondusaldusväärsus: madal

- Üle lävi- või piirväärtuse
- Püsiv kasvusuundumus
- Puudub püsiv kasvusuundumus
- Seirepunkti mõjuulatus ja osakaal %

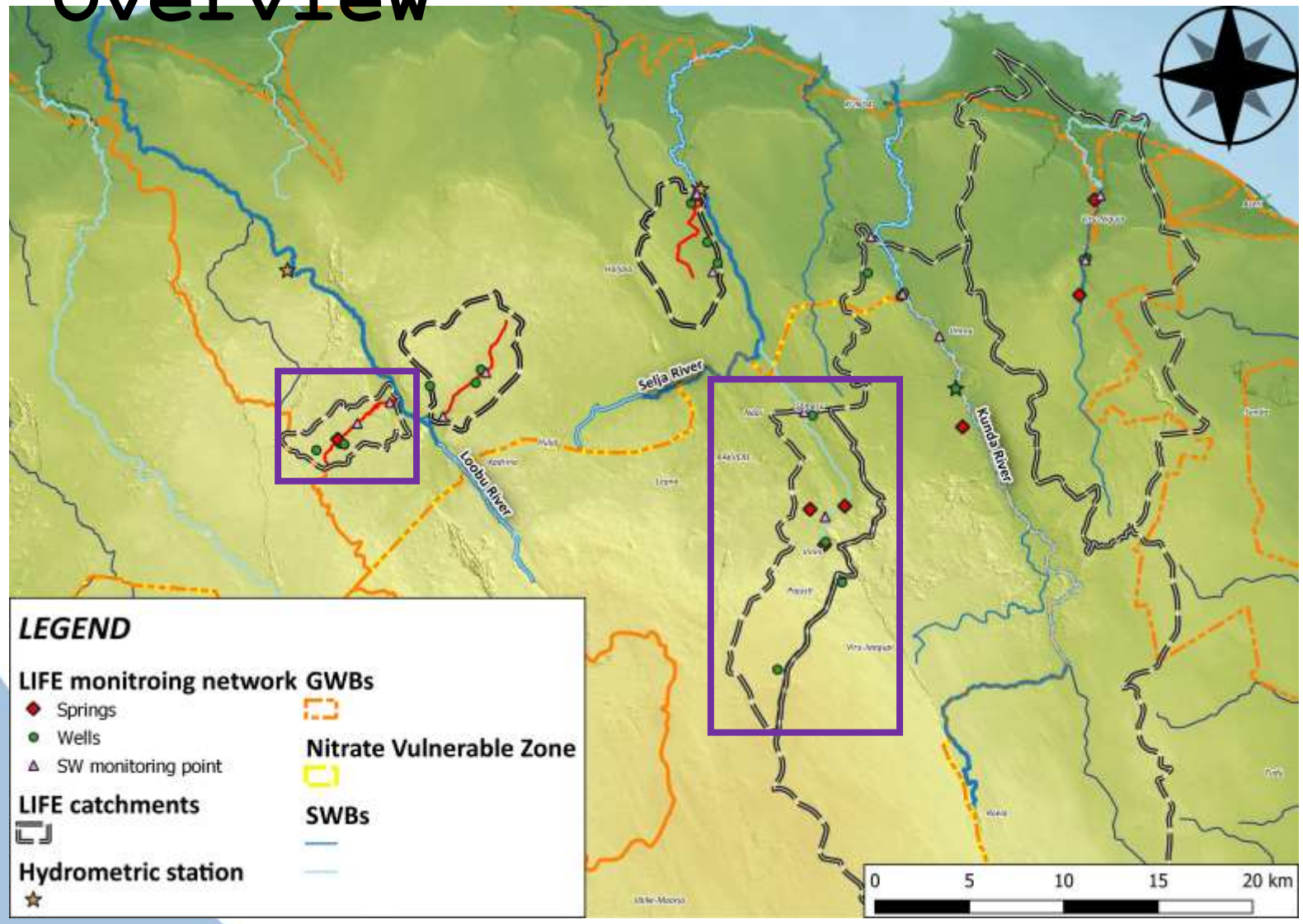
Marandi, A., Karro, E., Osjamets, M., Polikarpus, M., Hunt, M. 2020. Eesti põhjaveekogumite seisund perioodil 2014-2019. EGF Eesti Geoloogiateenistus, Rakvere

Pandivere Upland



- **Pandivere Upland** (80–166 m, asl; 1375 km^2) plateau of carbonate rock with thin sedimentary cover (<5 m);
- Important agricultural area – nitrate vulnerable zone (NVZ; black)
- No surface water network at the top of the upland (*diffuse groundwater recharge*);
- >200 springs on the slopes of the upland; large baseflow component

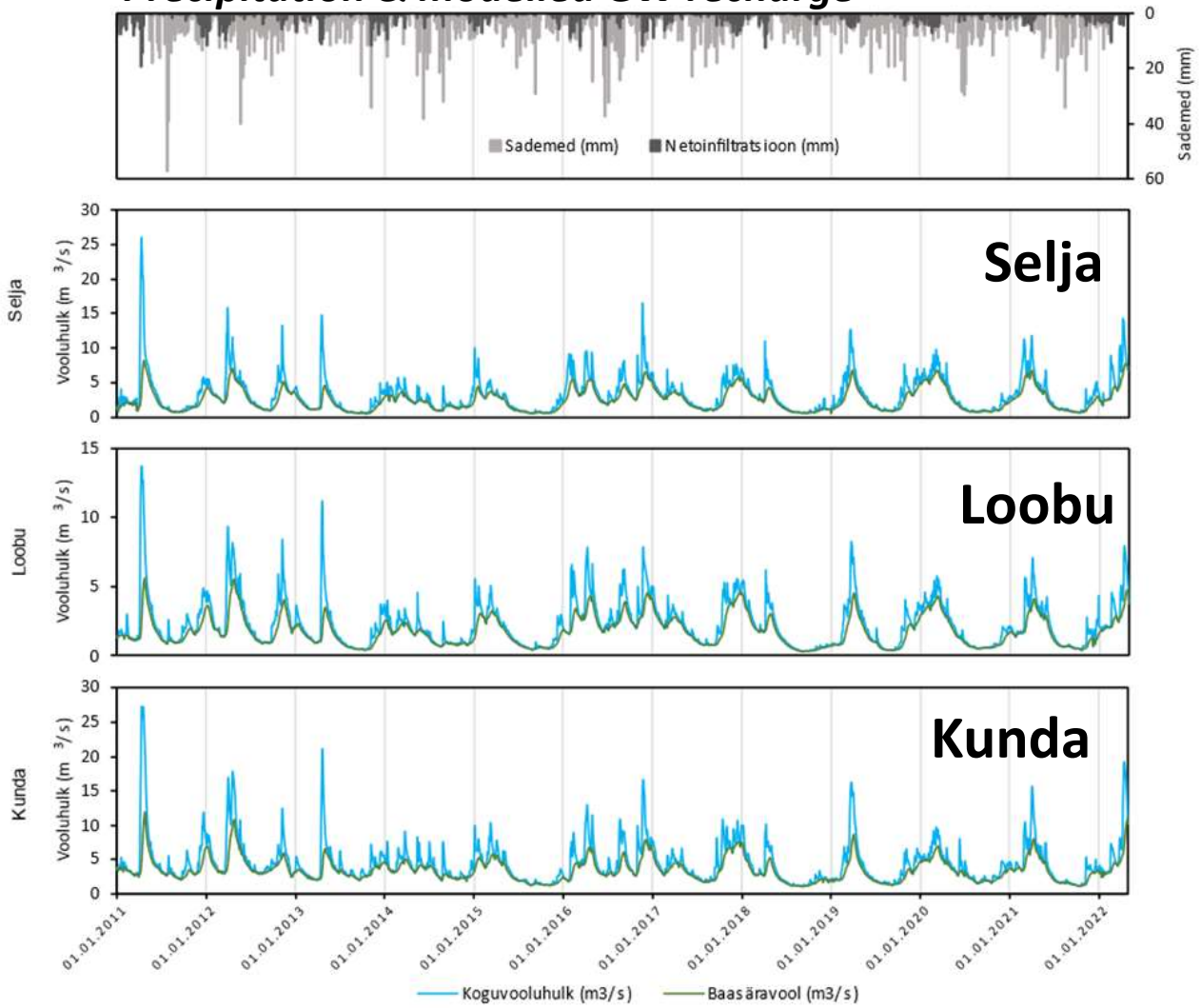
Results from LIFE IP CleanEst action C10.1. Overview



- **33 monitoring stations:**
- ✓ springs
- ✓ wells (depth 0-15 m)
- ✓ wells (depth 15-30 m)
- ✓ wells (depth 50-75 m)
- **Monitoring frequency:** 4 times/year, some springs 12 times/year
- **Monitoring period:** 09/2019 – 05/2022
- **Chemical composition:** NH4, NO3, NO2, Cl, SO4, HCO3, K, Na, Ca, Mg, Fe-total, pH, PHT, SiO2, vaba CO2, PO4, hardness, Fe(2+), F, Mn, N-total, P-total,
- **Isotopic composition:** $\delta^{18}O$, $\delta^{2}H$

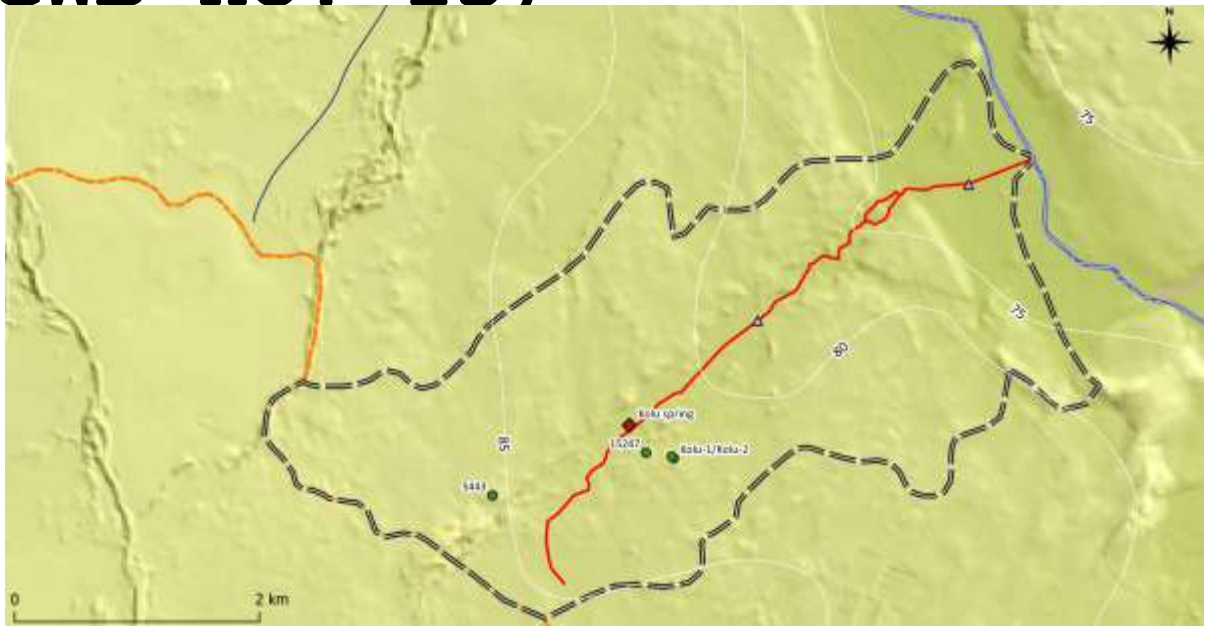
Results from LIFE IP CleanEst action C10.1. Baseflow

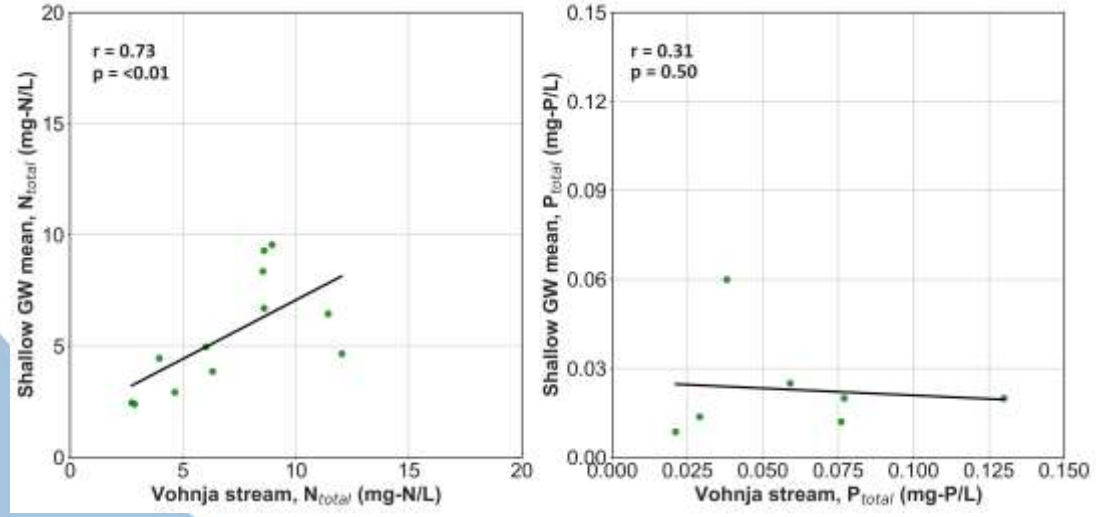
Precipitation & modelled GW recharge

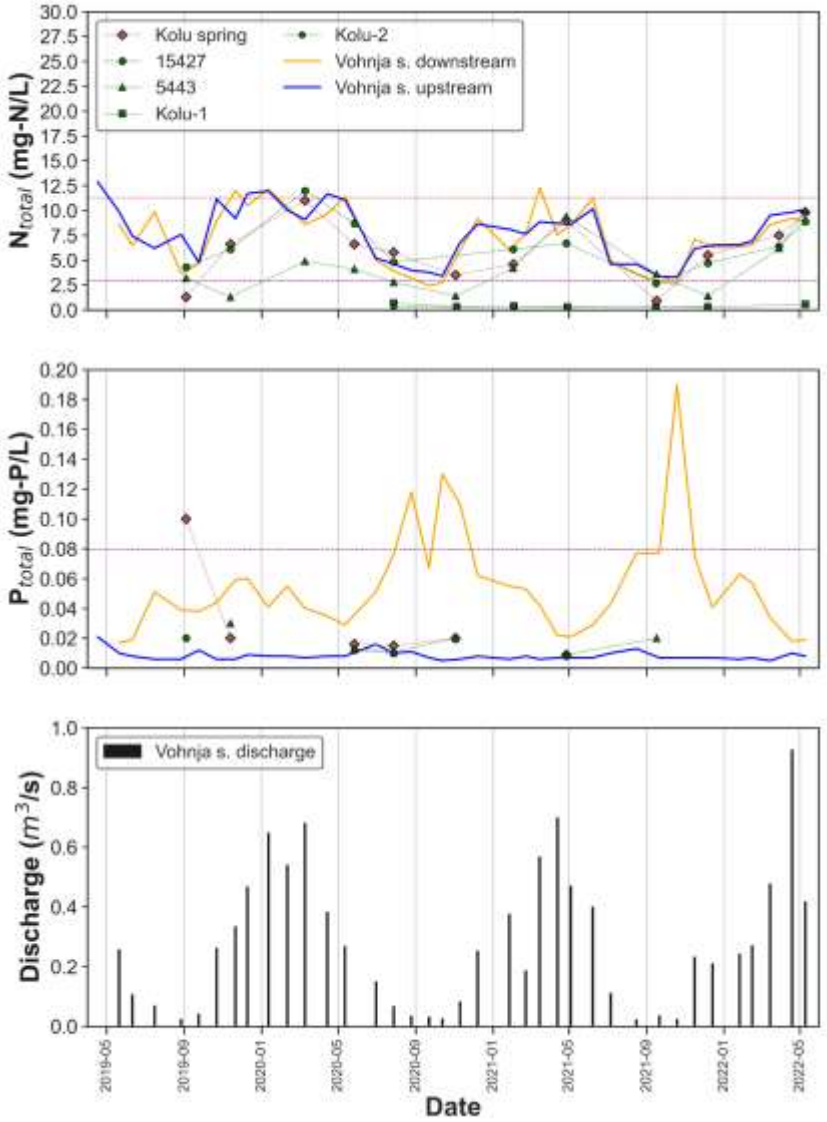


- Baseflow component for the period 2011-2022;
- 3 methods (Lyne ja Hollick (1979) filter method, HBV-Light, PRMS);
- Baseflow makes up on average 63-77% of total discharge in the 3 rivers;
- Lower values in the Loobu river and higher values in the Selja and Kunda rivers;
- Baseflow component was highest during the winter 2019/2020, when there was practically no snow cover.

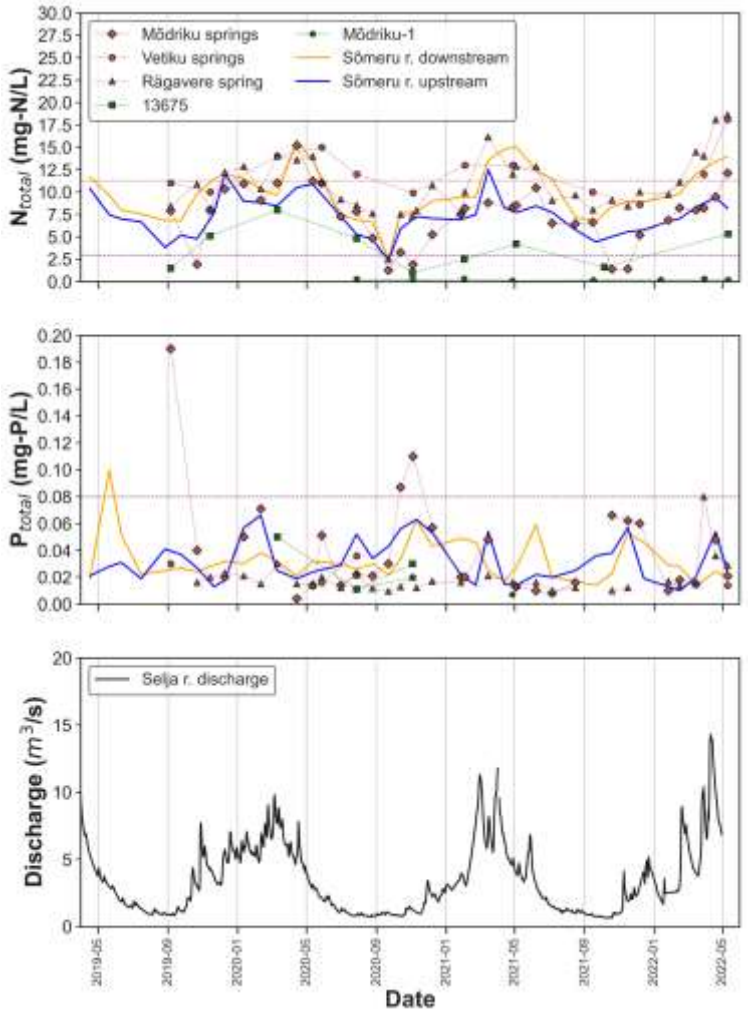
Results from LIFE IP CleanEst action C10.1. Vohnja catchment (GWB no. 13)

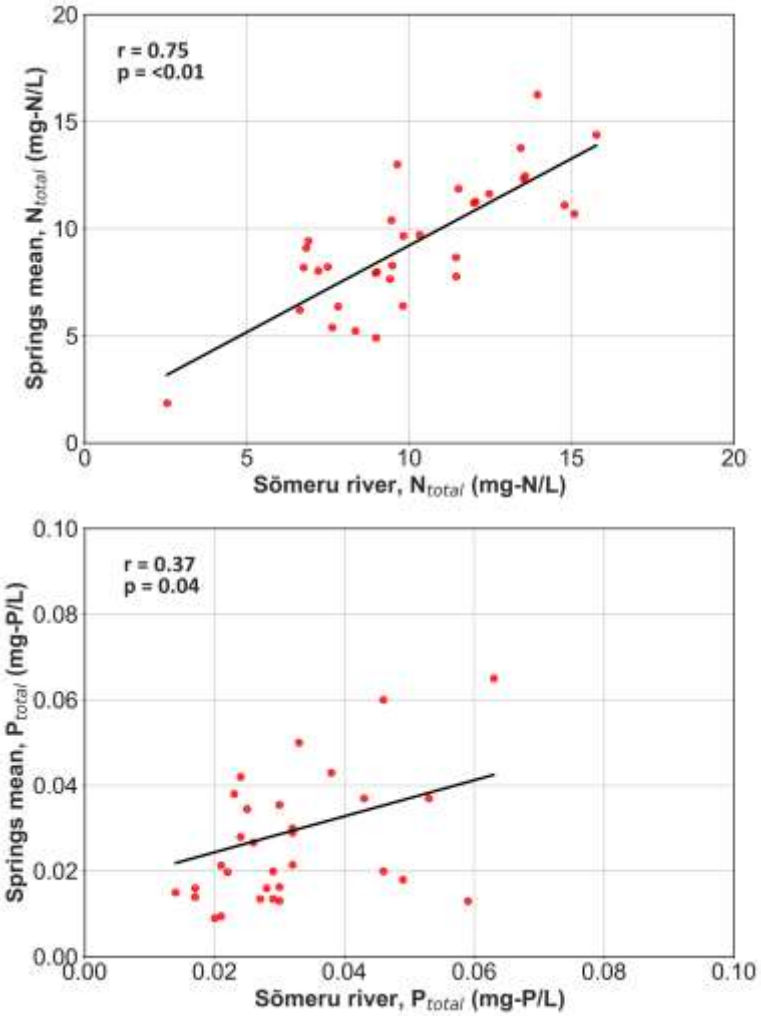






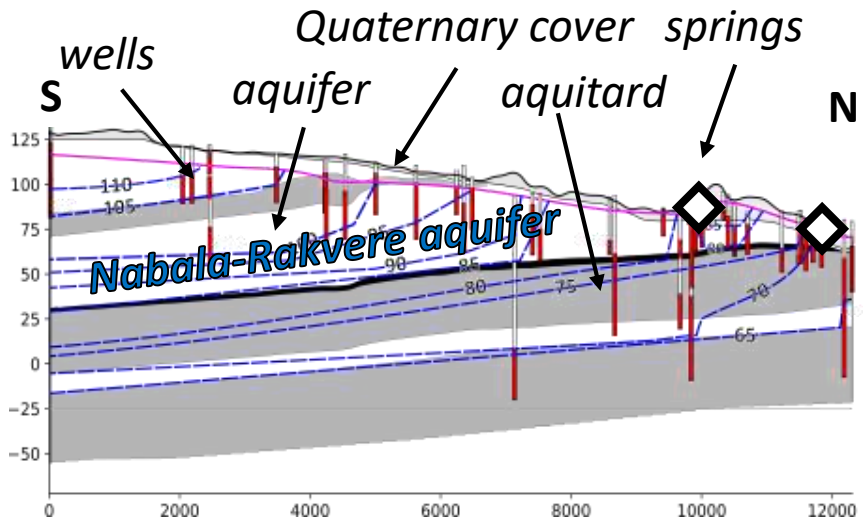
Results from LIFE IP CleanEst action C10.1. Sõmeru catchment (GWB no. 15)



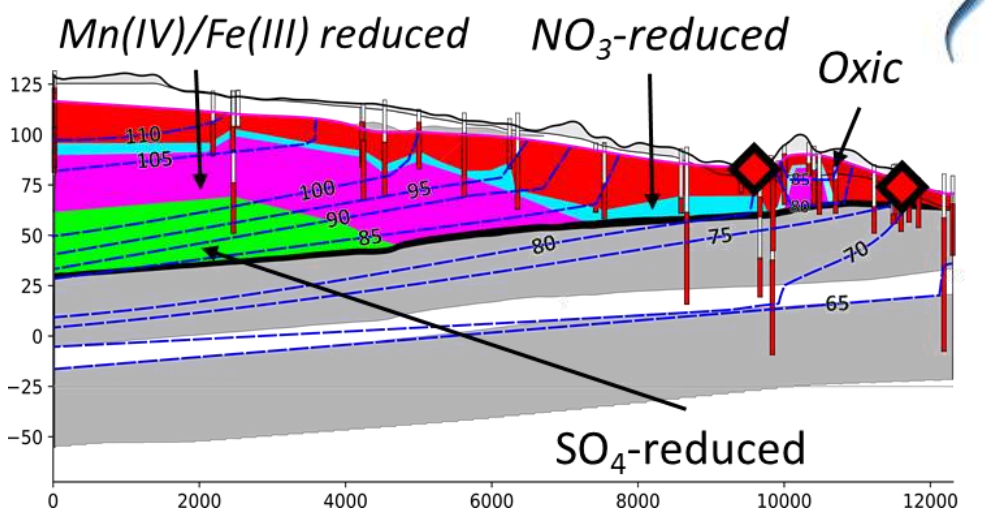


The groundwater system in the Sõmeru catchment

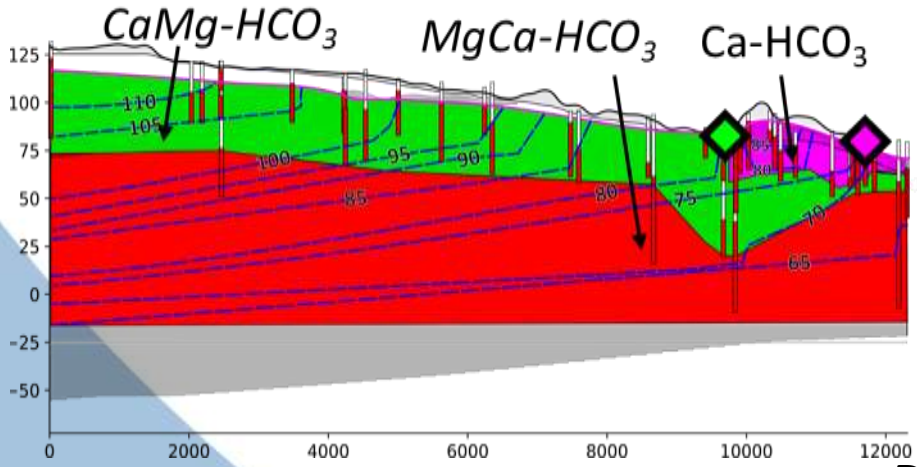
Hydrostratigraphy & hydraulic heads

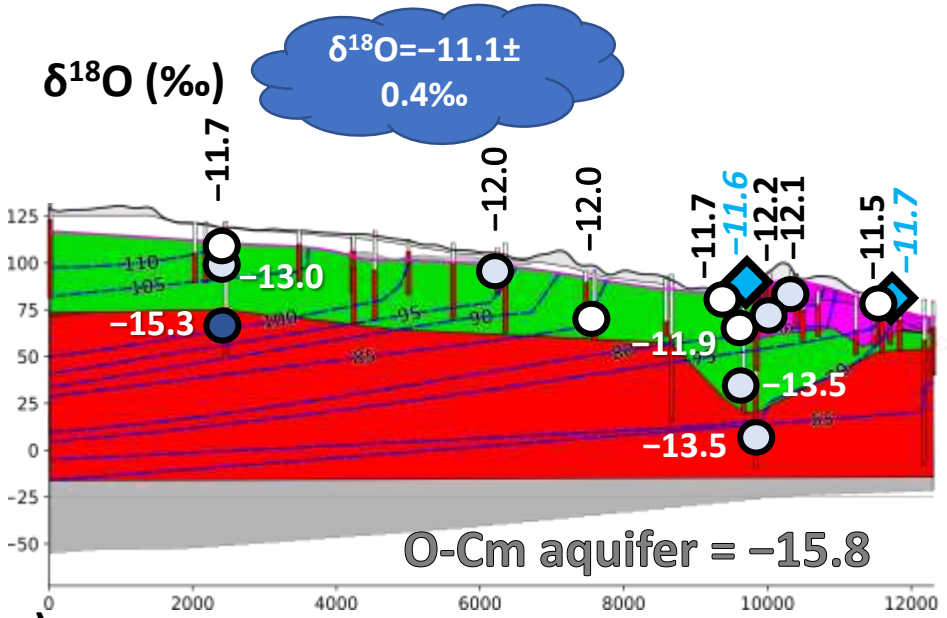


Redox conditions



Water types

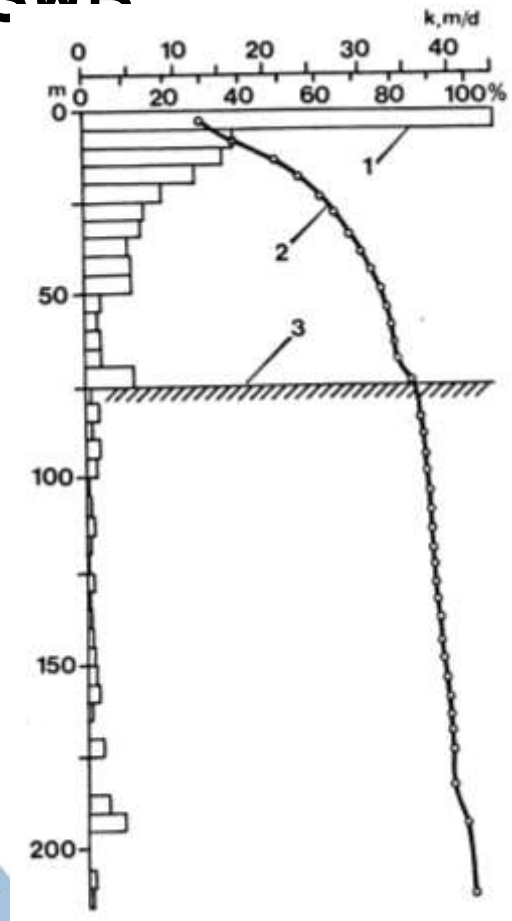




Depth (m, bgs)

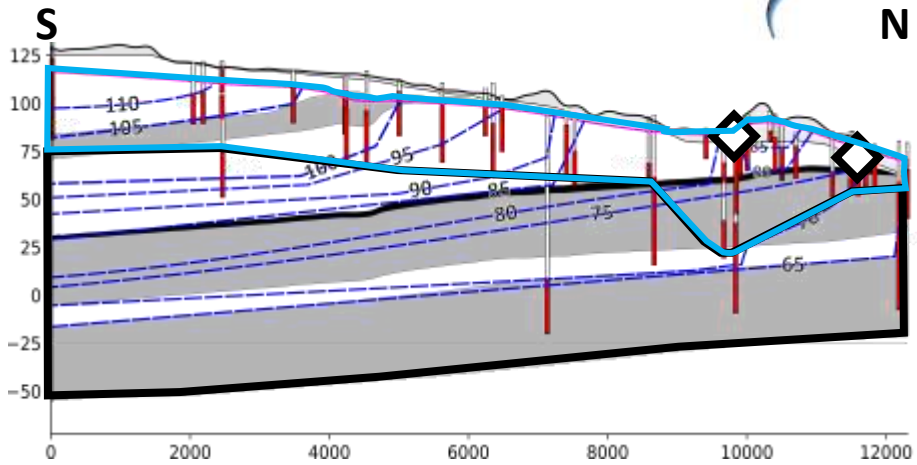
Distance (m)

Vertical extent of the GWB vs the extent of aquifers infulencing SWB

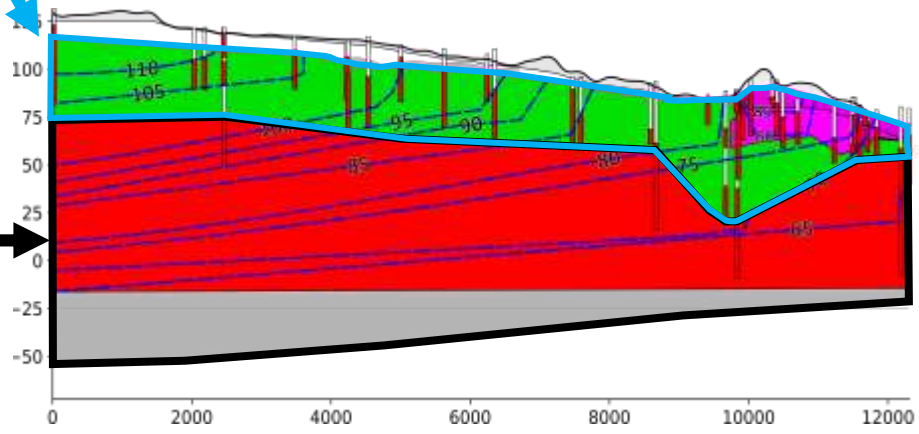


Impact of bedding depth on the hydraulic conductivity (m/d)
Perens & Vallner (1997)

Active water exchange zone (GW-SW interaction)



Delayed water exchange zone (no GW-SW interaction)



Conclusions and questions

- In and around the Pandivere Upland, GW quality can have an important effect on SW quality;
- GWB boundaries in Estonia are not always suitable to evaluate the effect of GWB status on SWB status:

✓Laterally (catchment boundaries);

✓Vertically (active and delayed water exchange zones)

- Should the GWB boundaries be changed to coincide better with SW catchments?
- How should the GWB monitoring network be modified to be able to see the effects of GW-SW interaction?
- What substances should be monitored from both GWBs

Thank you for your attention!

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