Methodologies developed for assessing the status of groundwater dependent ecosystems (GDEs) in Estonia

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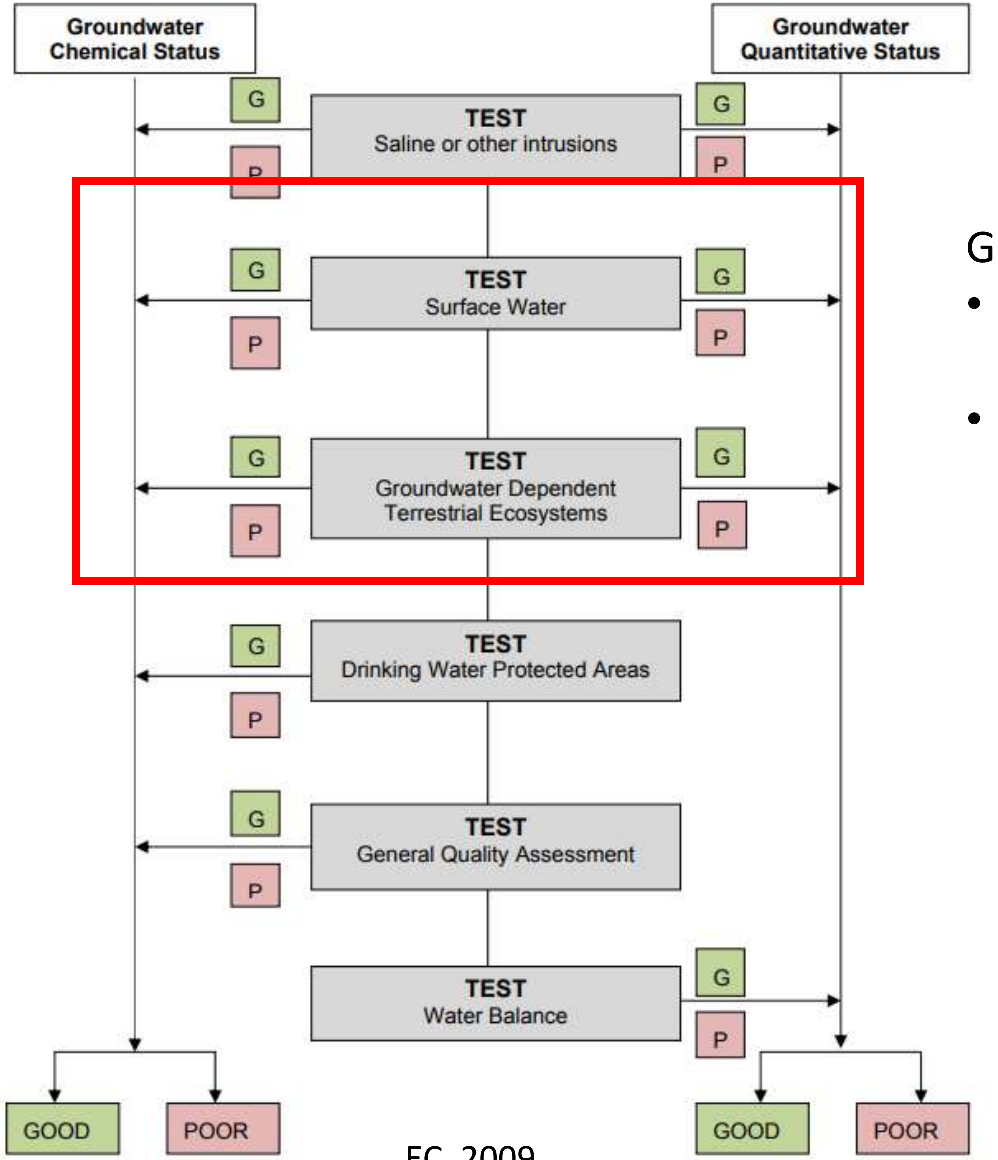
GDEs in the Water Framework Directive (2000/60/EC)

- Member States should aim to achieve the objective of **at least good water status** [...]. Where good water status already exists, it should be maintained.
- Definition of good quantitative status for groundwater:
  - The level of groundwater is not subject to anthropogenic alterations such as would result in: – failure to achieve the environmental objectives specified under Article 4 for **associates surface waters**; – any significant diminution in the status of such waters; – any significant damage to **terrestrial ecosystems** which **depend directly on the groundwater body** [...].
- Definition of good groundwater chemical status for groundwater:
  - The chemical composition of the groundwater body is such that the concentrations of pollutants: [...] – are not such as would result in failure to achieve the environmental objectives specified under Article 4 for **associated surface waters** nor any significant diminution of the ecological or chemical quality of such bodies nor in any significant damage to **terrestrial ecosystems** which **depend directly on the groundwater body**.

Groundwater body (GWB) status assessment



EC, 2009

Groundwater dependent ecosystem (GDE):

- Groundwater dependent terrestrial ecosystem (GDTE)
- Groundwater associated aquatic ecosystem (GAAE)

GDE identification and assessment in Estonia

- A project ordered by the Ministry of Environment and conducted in 2014 and 2015 by the Institute of Ecology at Tallinn University.
- To determine ecosystems depending on groundwater bodies (GWBs) and to develop methods to assess whether the groundwater bodies have a negative effect on the GDEs.
- Based on existing databases and previous studies, no new data was collected.
- Then there were 39 GWBs, including 13 Q only GWBs.
- Since 2019 there are 31 GWBs and just 4 of them are Q only.
- Altogether 197 significant groundwater associated permanent lakes, 26 karst lakes, 114 flowing water bodies and 70 dependent terrestrial ecosystems (mires) were identified.

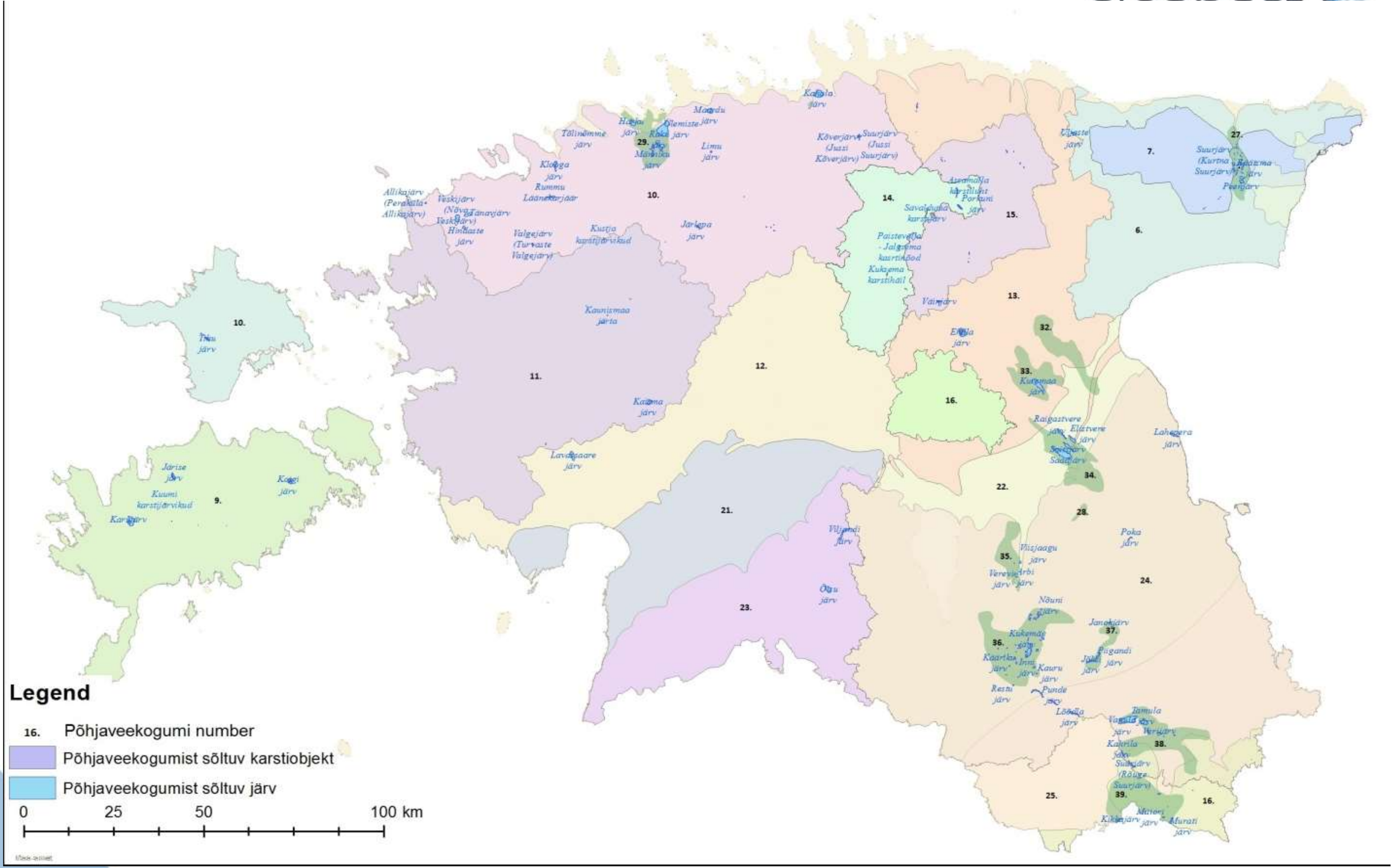
Identification of significant GAAEs (permanent and karst lakes) I

- Lakes where groundwater is the dominant source of water.
- Basically all lakes are groundwater associated, besides bog and coastal lakes and lakes with considerable surface water throughflow. The main question was how to distinguish between significant and nonsignificant lakes.
- Three groups of lakes were considered as significant:
  - Lakes in the Book of Primeval Nature – compiled in the 1980s and 1990s. According to its statute, only lakes connected to groundwater are included in it. Therefore all these lakes were considered to be significant GAAEs. Associating them with the correct GWB was occasionally problematic (whether Q or S, O, D).
  - Water bodies – Denominated as significant through the Water Framework Directive. Several lakes overlapped with the ones in the Book of Primeval Nature. For the others, the potential dependence on bedrock GWBs was estimated based on expert decision according to the water level depth of the GWBs around the lakes. Lakes with dark and soft water and coastal lakes were automatically considered not dependent.

Identification of significant GAAEs (permanent and karst lakes) II

- Lakes listed as habitats according to the Habitats Directive – only those were evaluated that were located on Quaternary GWBs or form protected lake districts. All habitat-lakes on Q GWBs were considered dependent on the Q GWB, except habitat type 3160 – *Natural dystrophic lakes and ponds*. In case of protected lake districts not on Q GWBs, the potential dependence on bedrock GWBs was evaluated according to GWB water level depth.
- 197 significant groundwater associated permanent lakes and 26 karstic lakes were identified.

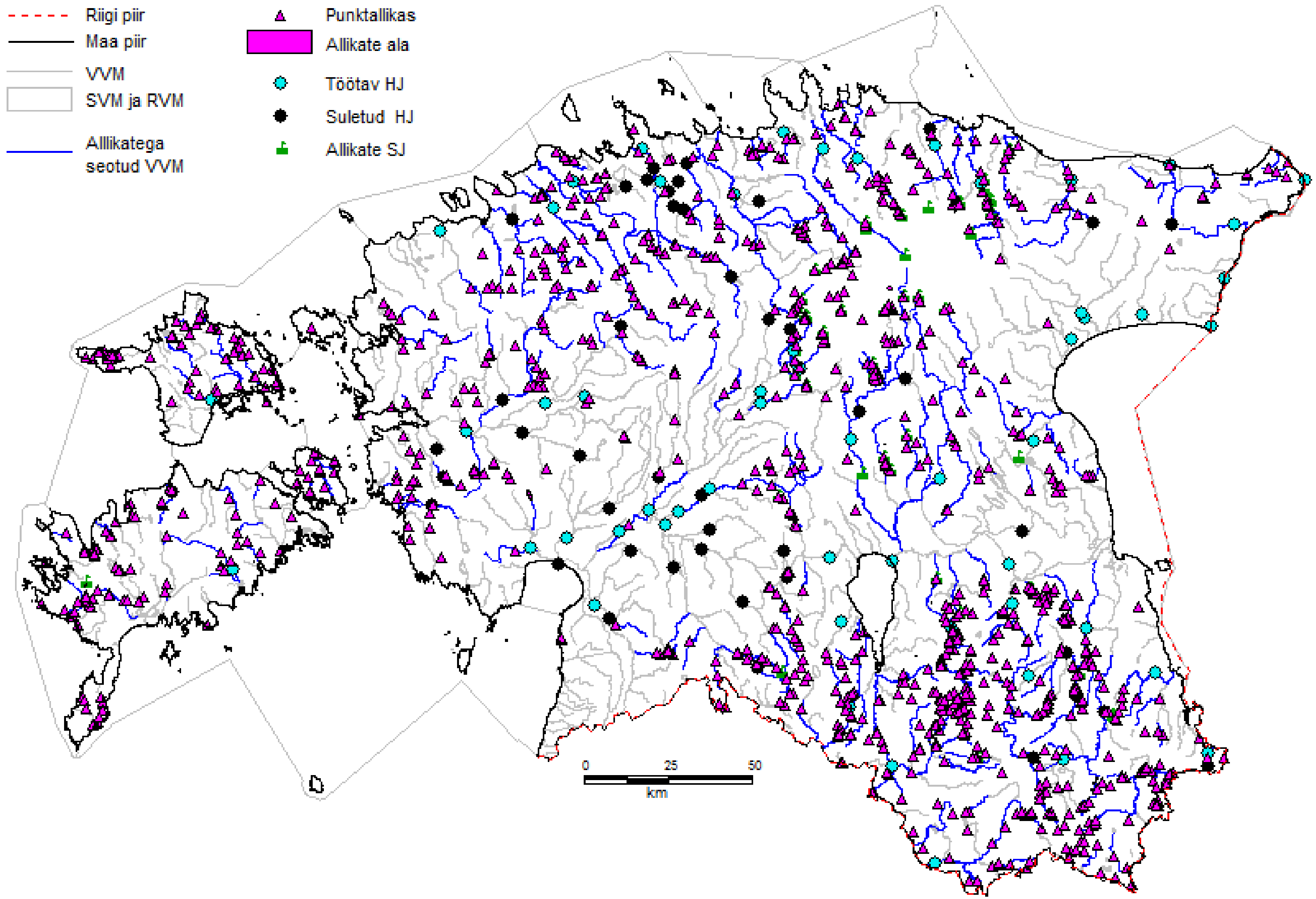
Significant GWB associated lakes in Estonia



Significant GAAE identification (flowing water bodies) III

- Flowing water bodies according to the Water Framework directive were taken as the initial list to choose from.
- Only flowing water bodies with clear water (with exceptions).
- There is information on the share of groundwater in annual discharge at selected locations for the largest rivers in Estonia, but the data is more than 50 years old. Therefore that could not be taken as the criteria for the selection.
- Dependence on groundwater was assumed if there were known springs present in a 1 km radius of the water bodies. Some water bodies were excluded afterwards, where, according to expert opinion, the groundwater contribution from the spring(s) was clearly insignificant.
- The resultant water bodies were associated with the topmost GWB beneath the water body.
- 114 significant flowing water bodies associated with GWBs were identified.
- According to EC Technical report no. 9 (2015), critical dependence on groundwater means that groundwater should be the dominant source of water (>50%). Therefore the Estonian list may be overestimated.

Significant GWB associated flowing water bodies in Estonia

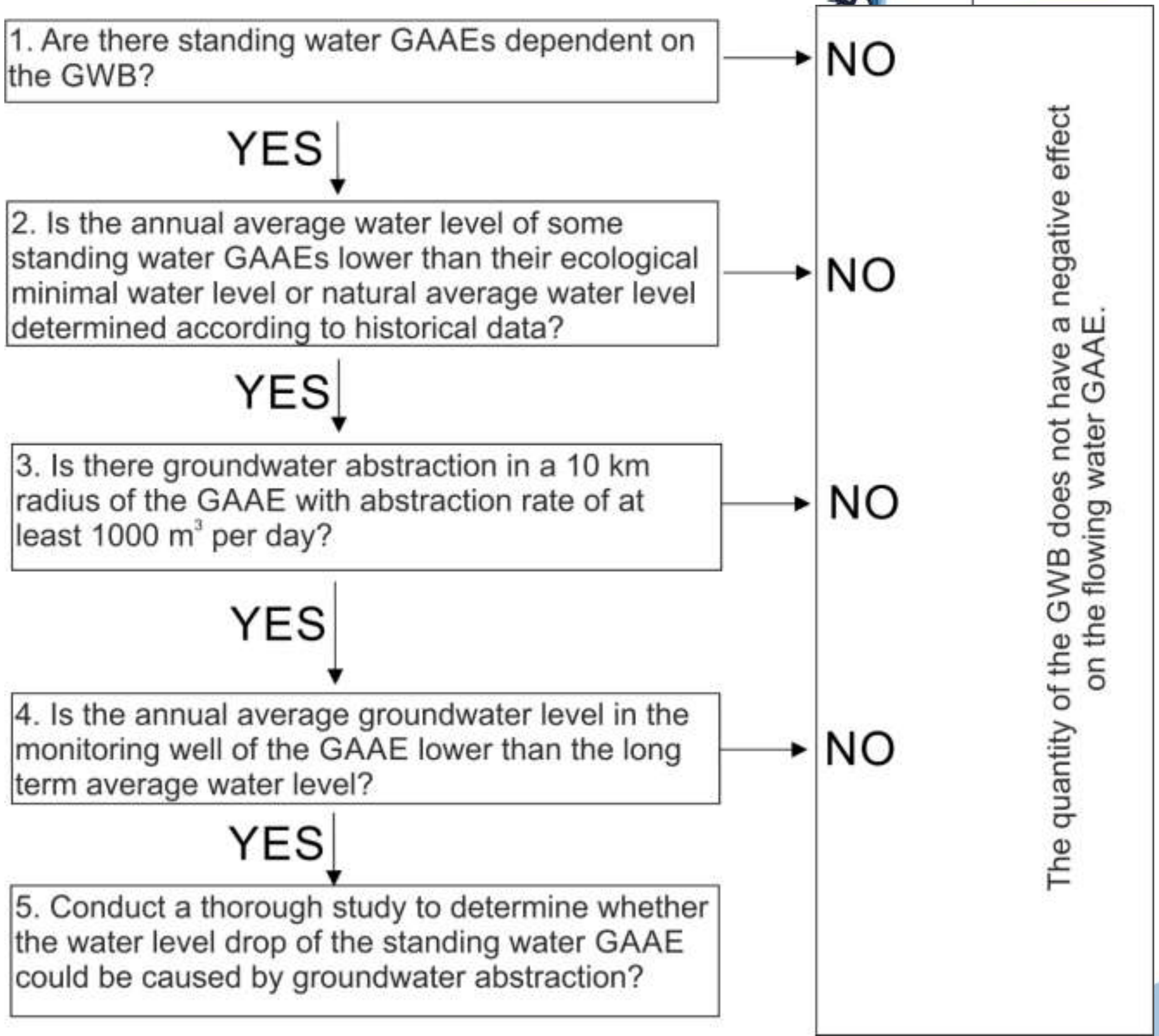


Effect of groundwater bodies on GAAEs

- According to the WFD, groundwater body can have a negative quantitative and/or qualitative effect on the GAAE.
- Quantitative effect – human influence has caused too low groundwater level that does not provide enough water to sustain the GAAE in its natural state.
- Qualitative effect – human influence has affected the groundwater body in a way that its chemical composition causes the deterioration of the ecological or chemical status of the GAAE.

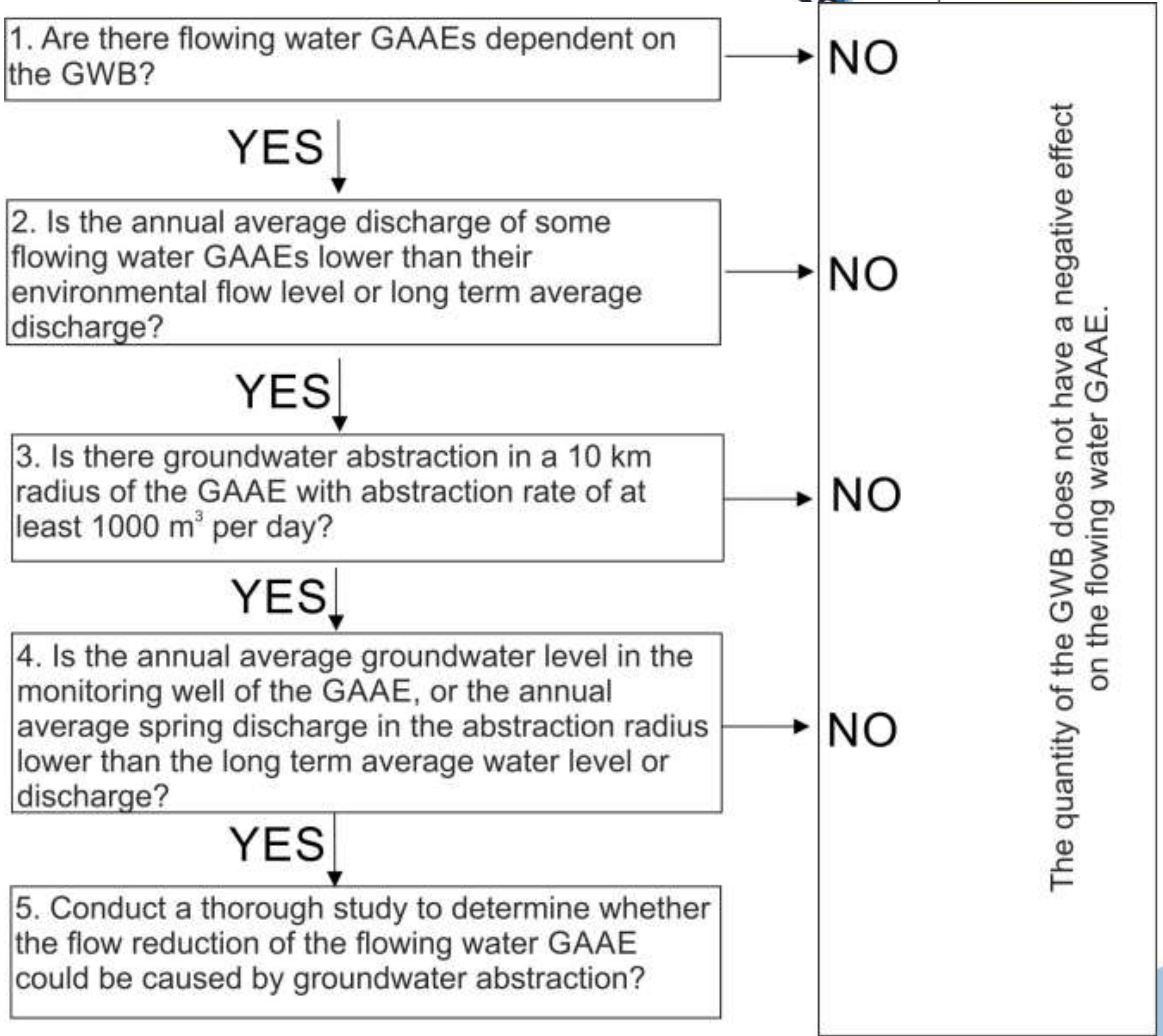
Assessment scheme of the quantitative effect on standing water GAAEs

- Requires knowledge of the GAAEs current and historical water level (may be estimated).
- In case of nearby groundwater abstraction, requires at least one groundwater level monitoring well (upstream of the GAAE) that has been verified to represent the same aquifer that feeds the GAAE.



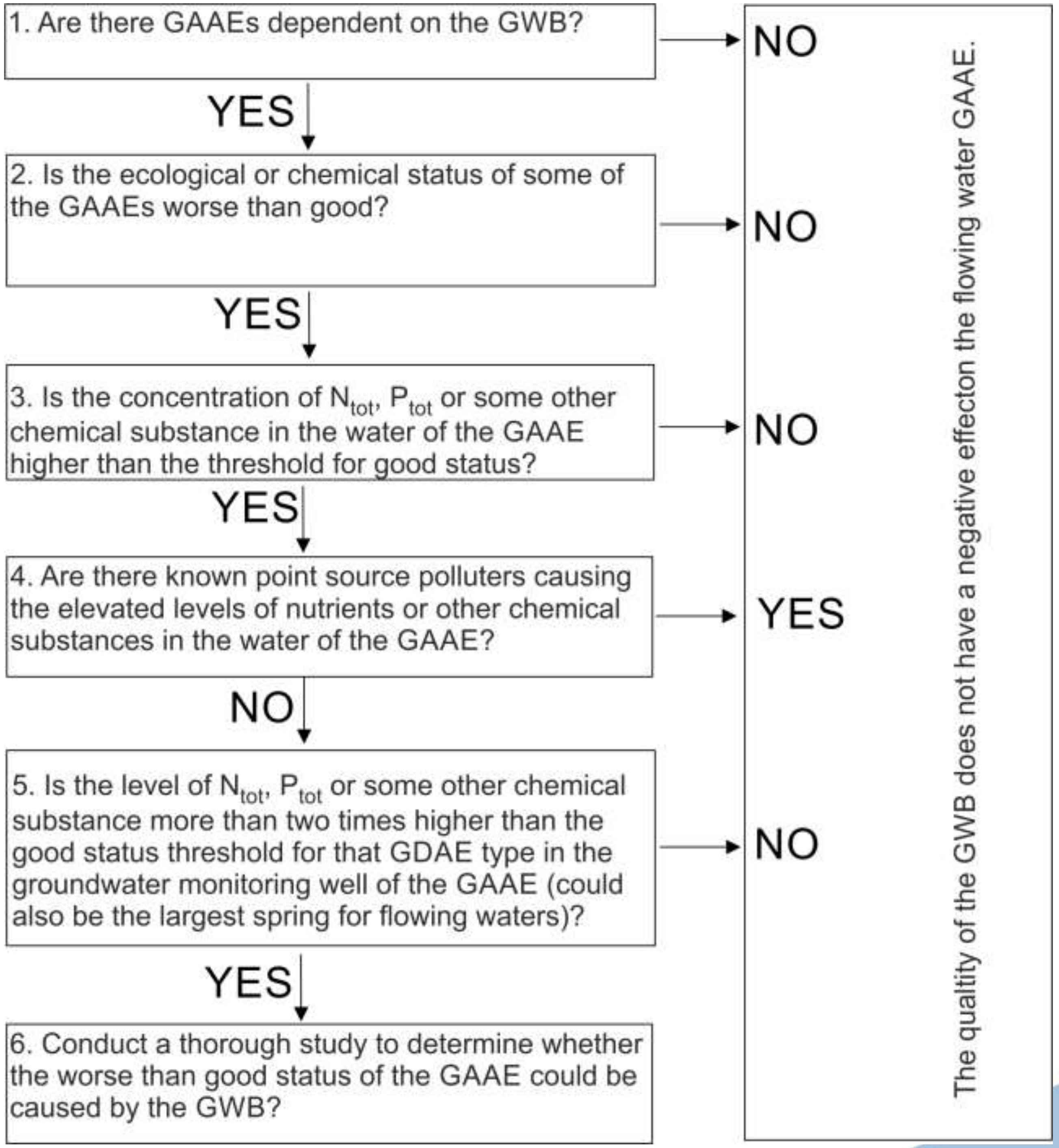
Assessment scheme of the quantitative effect on flowing water GAAEs

- Requires knowledge of the GAAEs current and historical discharge.
- In case of nearby groundwater abstraction, requires at least one groundwater level monitoring well (upstream of the GAAE) that has been verified to represent the same aquifer that feeds the GAAE, or monitoring of spring discharge.



Assessment scheme of the qualitative effect

- Requires knowledge of the ecological status of the GAAE.
- Requires at least one groundwater level monitoring well (upstream of the GAAE) that has been verified to represent the same groundwater body that feeds the GAAE, or a spring.
- Requires the measurement of matching substances from the GAAE and groundwater well/spring.



Problems with applying the schemes

- Not enough long term data on water levels and river discharges.
- Groundwater monitoring network has not been designed for monitoring its effect on water bodies.
- Different compounds are monitored in groundwater and surface water.
  - E.g. – TotN and TotP in surface water, but nitrates, nitrites, ammonia and phosphates (only in the NVZ) in groundwater.
- Good status thresholds for nutrients and toxic substances are different for surface water and groundwater.
  - Good status threshold for nitrates in groundwater is 50 mg/l (11,3 mgN/l). TotN in rivers 3 mgN/l, in lakes 0,5 – 2,5 mgN/l.
  - On the contrary – barium good status threshold 115 µg/l in surface water, 50 µg/l in groundwater, no threshold in drinking water.

Example assessments – quantitative effect

Quaternary Vasavere GWB

1. Are there standing water GAAEs dependent on the GWB?

39 lakes

2. Is the annual average water level of some standing water GAAEs lower than their ecological minimal water level or natural average water level determined according to historical data?

Lake level lower in 2014, than in 1960:
L. Jaala 43,0 – 42,8
L. Kirjakjärv 41,7 – 41,3
L. Nõmme 46,2 – 45,9
L. Ahnejärv 45,9 – 44,3
L. Liivjärv 45,8 – 42,7
L. Martiska 45,2 – 43,5

Lake level the same in 2014 and 1960:
L. Valgejärv 44,0 – 44,0
L. Aknajärv 42,2 – 42,2

No water level either from 2014 or from 1960:
31 lakes

3. Is there GW abstraction in a 10 km radius of the GAAE with abstraction rate of at least 1000 m^3/day?

Vasavere water intake (6100 m^3/day):
L. Jaala
L. Kirjakjärv
L. Nõmme
L. Ahnejärv
L. Liivjärv
L. Martiska

4. Is the annual average GW level in the monitoring well of the GAAE lower than the long term average WL?

GW level lower in 2014, than the the average level
L. Jaala – (well 5077) 43,16 vs. 43,77
L. Ahnejärv – (well 13733) 44,51 vs. 45,28
L. Martiska – (well 3282) 42,87 vs. 43,39

GW level same as average level:
L. Kirjakjärv – (well 3367) 41,85 vs. 41,89

No suitable GW monitoring well
L. Nõmme
L. Liivjärv

5. Conduct a thorough study to determine whether the water level drop of the standing water GAAE could be caused by groundwater abstraction?

L. Jaala
L. Ahnejärv
L. Martiska

Example assessments – qualitative effect

Silurian-Ordovician Pandivere GWB in East-Estonian RBD

1. Are there flowing water GAAEs dependent on the GWB?

20 water bodies

2. Is the ecological or chemical status of some of the GAAEs worse than good?

17 water bodies in a worse than good status in 2020

3. Is the concentration of TotN, TotP or some other chemical substance in the water of the GAAE higher than the threshold for good status?

Kunda_1 – dicofol, heptachlor, heptachlor epoxide
Kunda_2 – heptachlor
Loobu_1 – Zn, benzo(a)pyrene
Põltsamaa_1 – TotN, TotP
Selja_1 – TotN
Selja_2 – TotN
Selja_3 – TotN, benzo(a)pyrene
Selja_4 – TotN, heptachlor epoxide, cypermethrine
Sõmeru – TotN, dicofol, heptachlor, heptachlor epoxide

4. Are there known point source polluters causing the elevated levels of nutrients or other chemical substances in the water of the GAAE?

No

5. Is the level of TotN, TotP or some other chemical substance more than two times higher than the good status threshold for that GAAE type in the GW monitoring well (or the largest spring) of the GAAE?

Level at least 2x higher:
Põltsamaa_1 – (Kiltsi spring) nitrates 26,8 mg/l (6,1 mgN/l)
Sõmeru – (Rägavere spring) nitrates 39,8 mg/l (9,0 mgN/l).
Dicofol not measured. Heptachlor and heptachlor epoxide lower.

Level lower:
Kunda_2 – Iluski spring, Rahkla spring, Lavi spring

No suitable GW monitoring well nor monitored spring:
Kunda_1
Loobu_1
Selja_1, _2, _3, _4

5. Conduct a thorough study to determine whether the worse than good status of the GAAE could be caused by the GWB?

Põltsamaa_1
Sõmeru