

New methods for 3rd generation RBM plans under the WFD assessment to be made on the impact of groundwater on surface waters



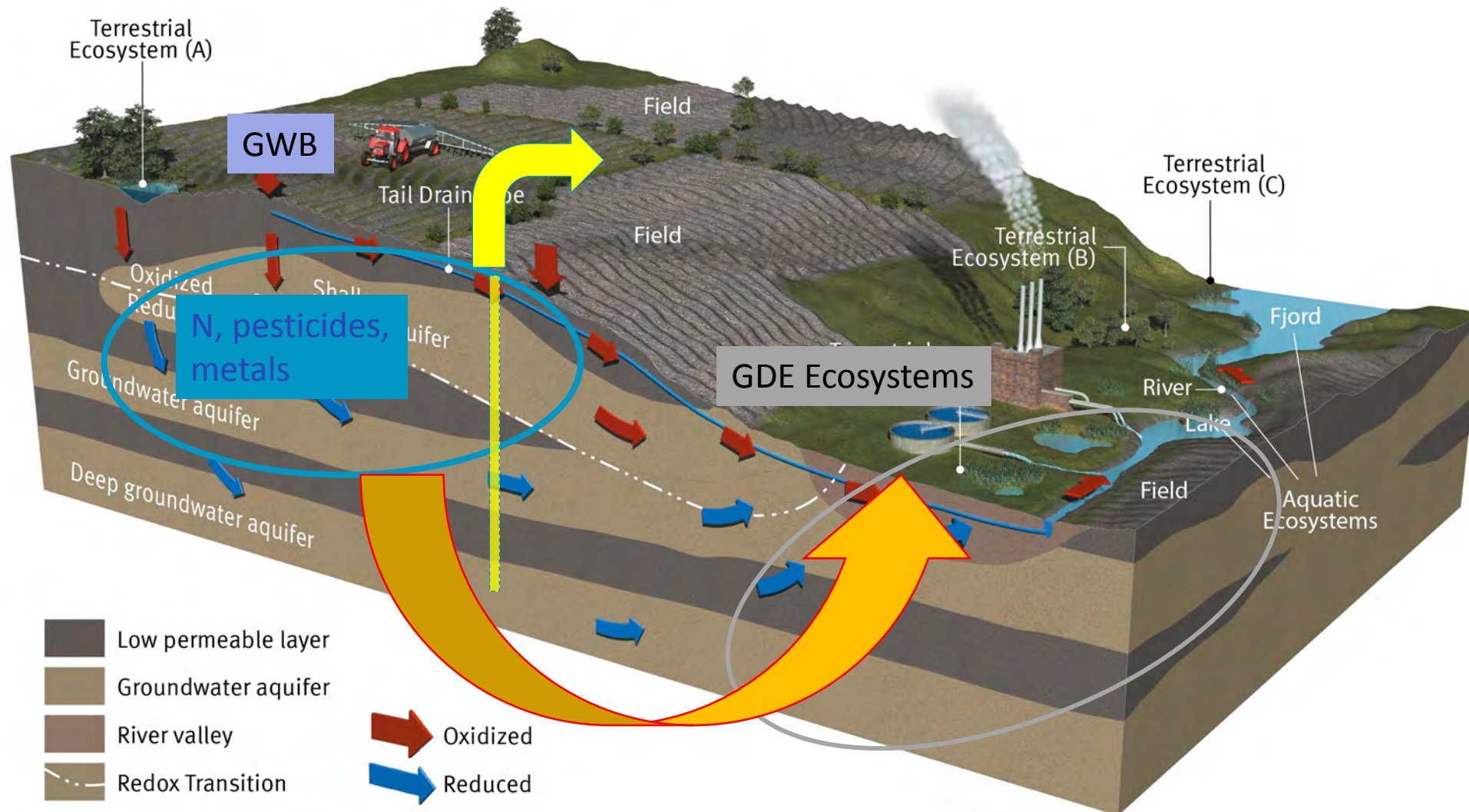
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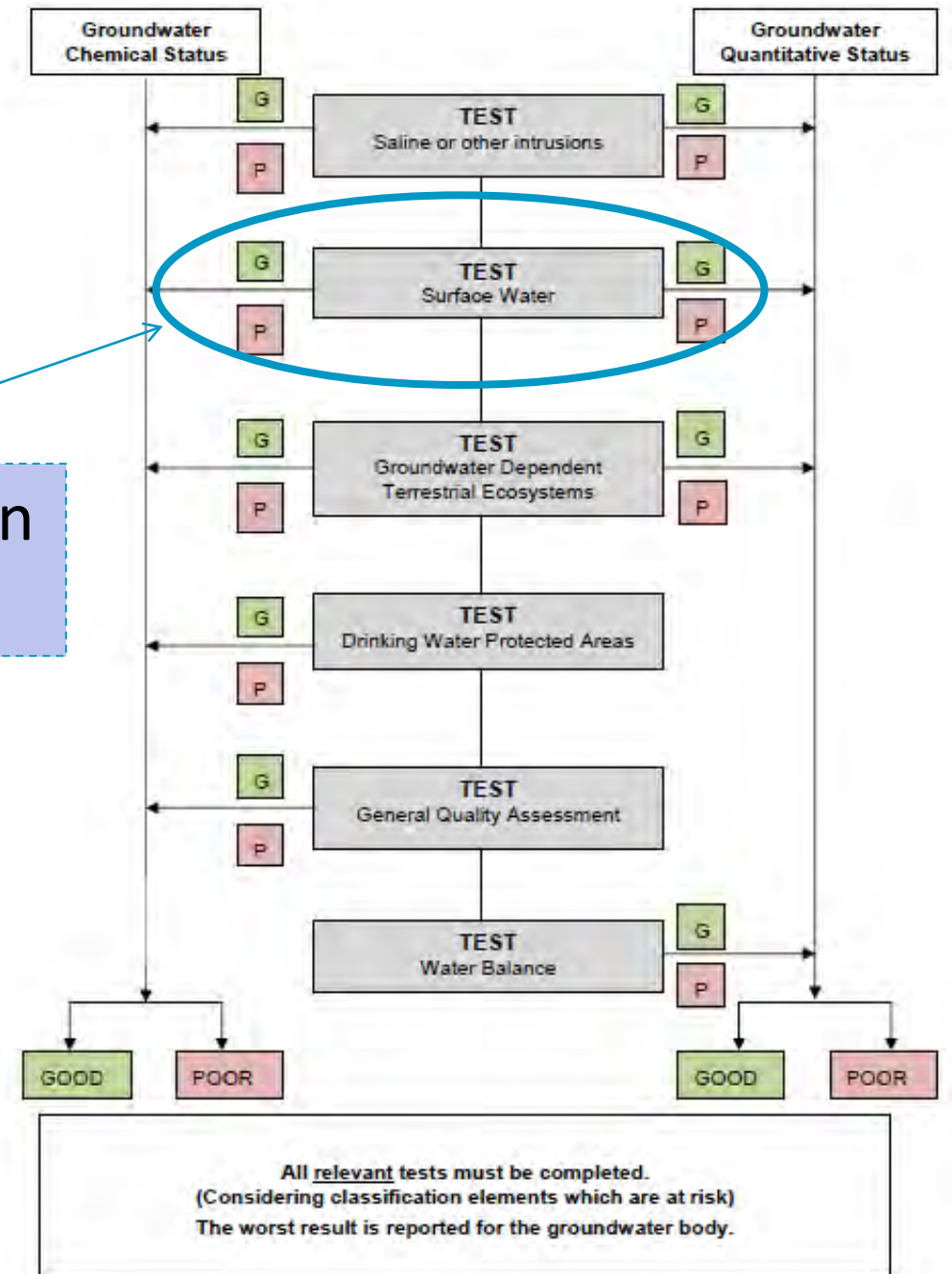
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Groundwater-Surface water interaction (WFD/GD)



Classification tests – groundwater status

Quantitative and hydrochemical interaction between groundwater and lakes



Guidance no. 18.
Groundwater status and
trends. CIS/WFD
guidance, EC techn.
Report 2009-26.

Focus in this presentation

Quantitative
impact of
groundwater
on lakes



Groundwater inflow is very heterogen in space and time





Focused groundwater discharge of phosphorus to a eutrophic seepage lake (Lake Væng, Denmark): implications for lake ecological state and restoration

Jacob Kidmose · Bertel Nilsson · Peter Engesgaard ·
Mette Frandsen · Sachin Karan · Frank Landkildehus ·
Martin Søndergaard · Erik Jeppesen

WATER RESOURCES RESEARCH, VOL. 49, 1–14, doi:10.1002/wrcr.20436, 2013

High-resolution distributed temperature sensing to detect seasonal groundwater discharge into Lake Væng, Denmark

E. Sebok,¹ C. Duque,^{1,2} J. Kazmierczak,¹ P. Engesgaard,¹ B. Nilsson,³ S. Karan,¹ and M. Frandsen^{3,4}

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Water Resources Research

RESEARCH ARTICLE

10.1002/2016WR019326

Groundwater flow and heterogeneous discharge into a seepage lake: Combined use of physical methods and hydrochemical tracers

J. Kazmierczak^{1,2}, S. Müller¹, B. Nilsson², D. Postma², J. Czekaj³, E. Sebok¹, S. Jessen¹, S. Karan⁴,
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Sosnowiec, Poland, ⁴COWI, Kongens Lyngby, Denmark

Key Points:

- Seepage lake interacting with aquifer under seemingly steady state conditions shows high spatial and temporal heterogeneity in discharge
- Groundwater discharge to the lake is focused at the adjacent wetlands and in high discharge zone occupying ~1% of the lake bottom

Most process studies on small scale

Very few whole lake studies

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Flow reversals in groundwater–lake interactions: A natural tracer study using $\delta^{18}\text{O}$

Mithra-Christin Hajati^{a,c}, Mette Frandsen^{b,c}, Ole Pedersen^b, Bertel Nilsson^c, Carlos Duque^{d,e},
Peter Engesgaard^d

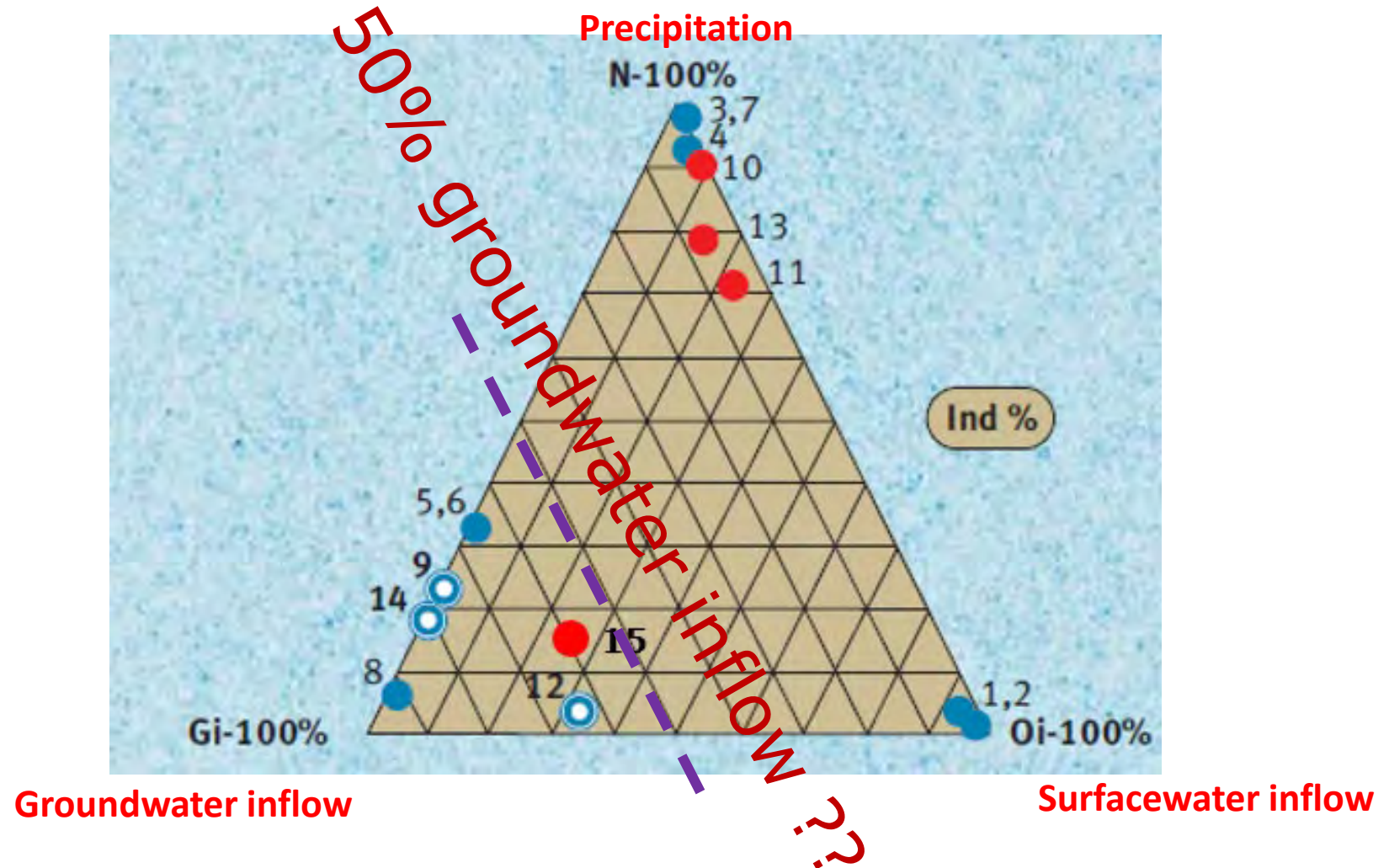


Groundwater

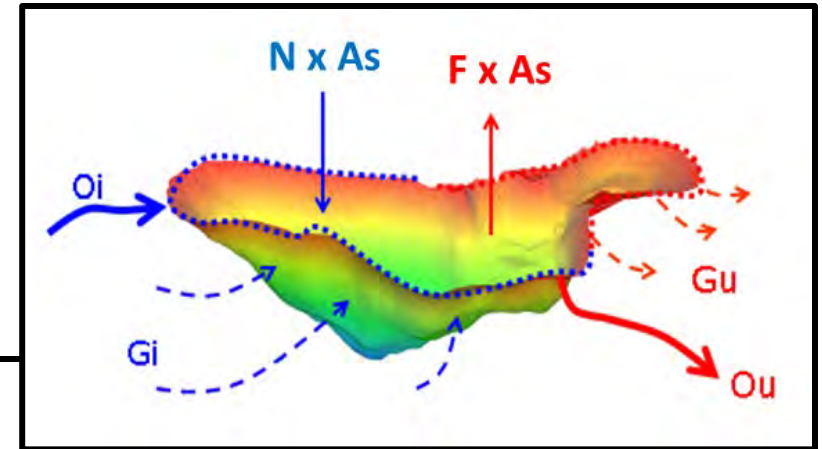
The Role of Groundwater for Lake–Water Quality and Quantification of N Seepage

by Jacob Kidmose^{1,2}, Peter Engesgaard¹, Daniela A. Oliveira Ommen³, Bertel Nilsson⁴, Mogens R. Flindt³, and Frede Ø. Andersen³

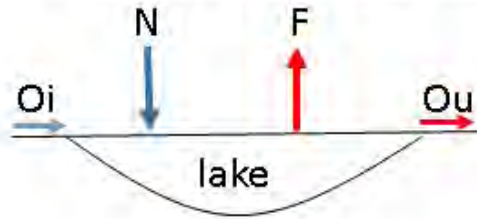
How much is "significant quantitative impact" ?



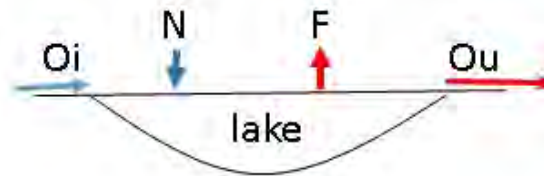
Whole lake water balance



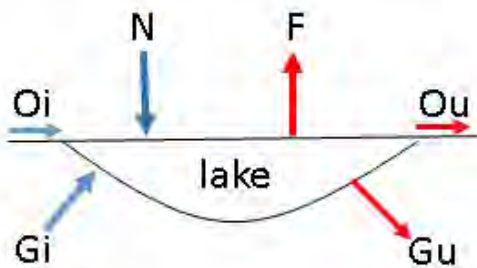
A. Climate Dominated Lake



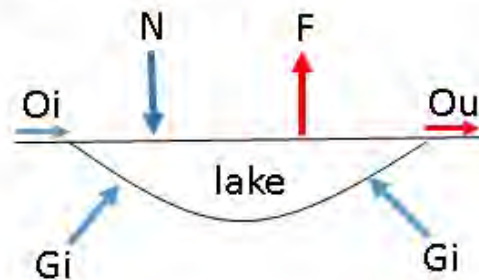
B. River Dominated Lake



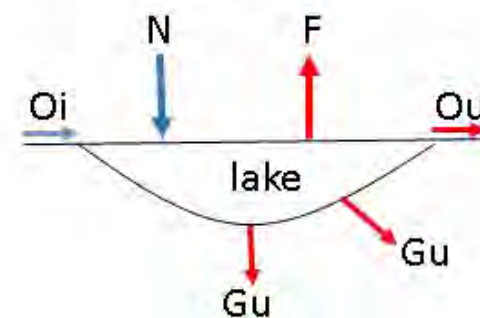
C. Flow Through Lake



D. Groundwater Fed Lakes



E. Drainage Lake



**Conceptual
models**

National monitoring data (NOVANA), other lake specific data and groundwater data (in 500m buffer)

Lake area	Method to determine the potential groundwater-lake contact	# lakes	Data sources (databases, national models, lake specific data)
> 100 ha	DK-model	89 (100%)	DK-model, DEM
	Water balance method	89 (100%)	DK Met data, HYMER, VandWeb, DK-model
< 100 ha	Segment approach (USGS method)	431 (56%)	JUPITER borehole database, DK-model, DEM
	EC in lake water and groundwater	256 (33%)	NOVANA, JUPITER
	Water Balance Approach	?	DK Met data, HYMER, VandWeb, DK-model
	Lake stage water level	(114)	NOVANA, DEM

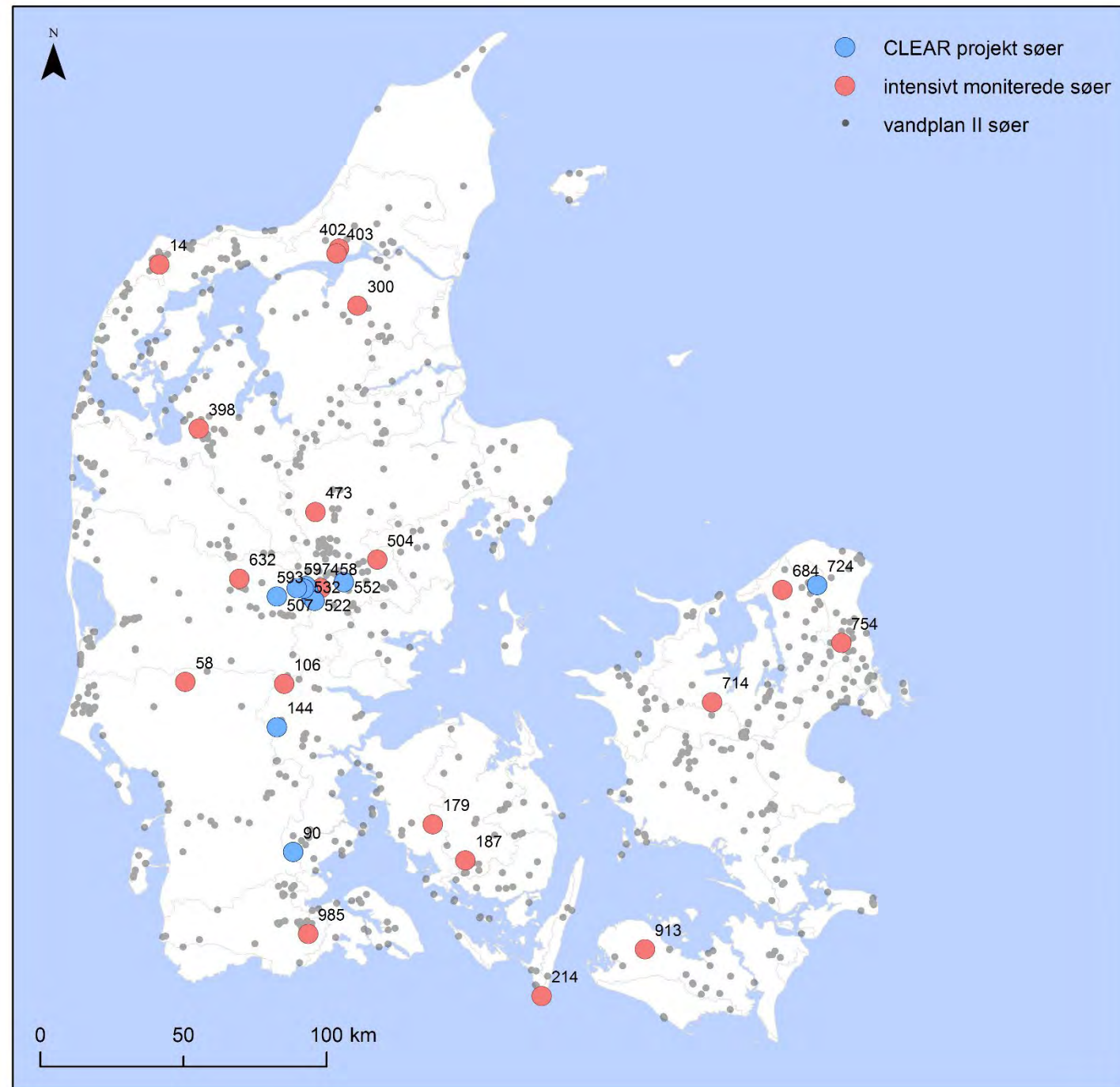
Number of lakes



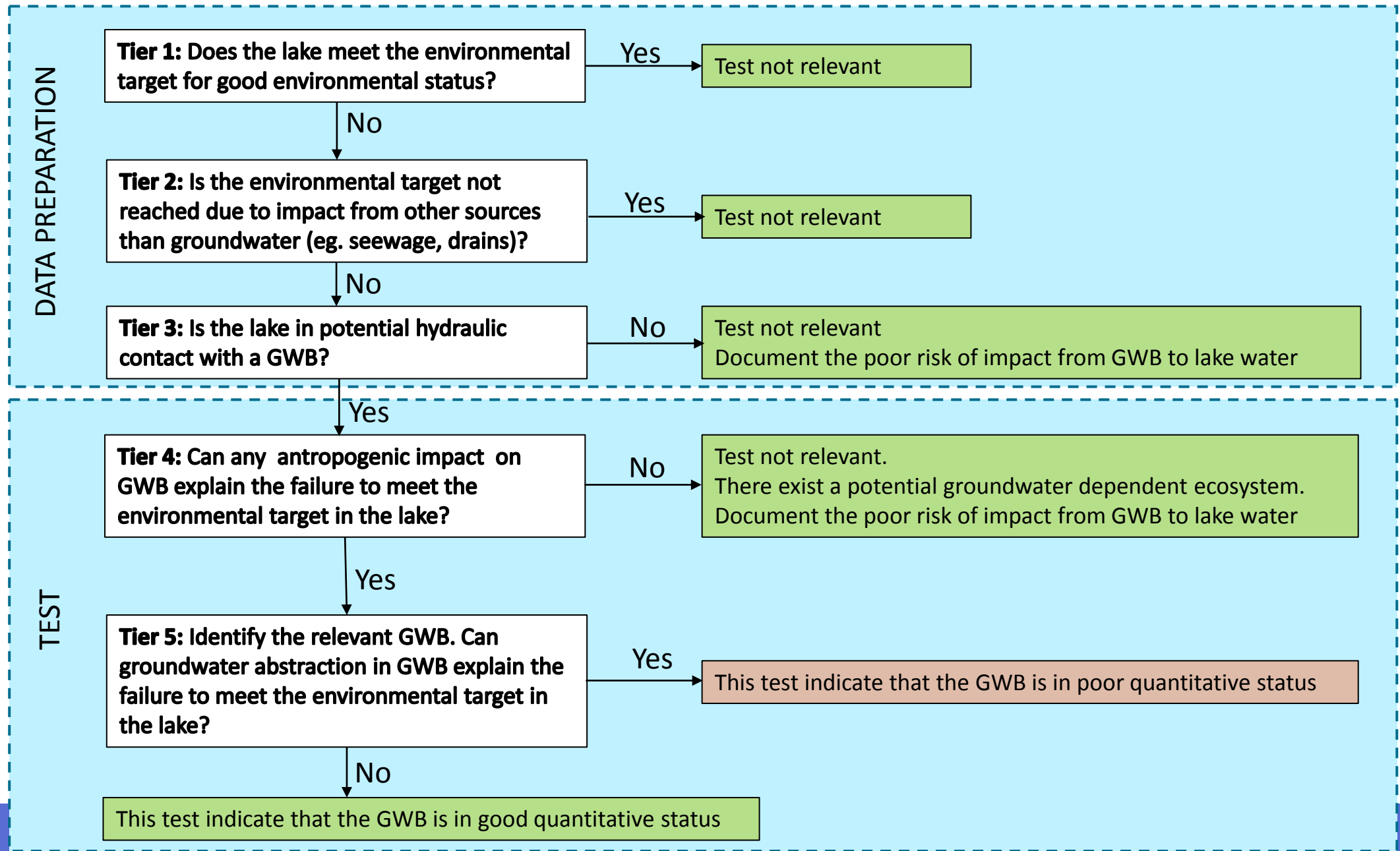
Total 857 NOVANA lakes
(environmental targeted)

Validation lakes

- 12 CLEAR research lakes (blue)
- 18 Intensive monitored lakes (red)
- 857 National monitored (NOVANA) lakes (grey)



The 5-Tier Method: Groundwater Quantitative Status



To summarize

- The suggested 5-tier method was found to be useful, however due to missing data made it impossible to complete some of the proposed tiers
- The current national monitoring programme (NOVANA) is only to a lesser extent sufficiently coherent and comprehensive to enable interdisciplinary qualitative and quantitative risk assessments to be made on the impact of groundwater on lakes

Acknowledgements

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