NATURAL BACKGROUND LEVELS FOR GROUNDWATER IN THE UPPER RHINE VALLEY

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<u>Content:</u>

- ➢ *EU – Groundwater directive*
- ➢ *EU project – BRIDGE*
- ➢ *Derivation of Natural Background Levels (NLB)*
- ➢ *Results*
- ➢ *Conclusions*

Groundwater directive (GWD):
Environmental objectives

Groundwater

Good status

Good quantitative status

+

Good quality status
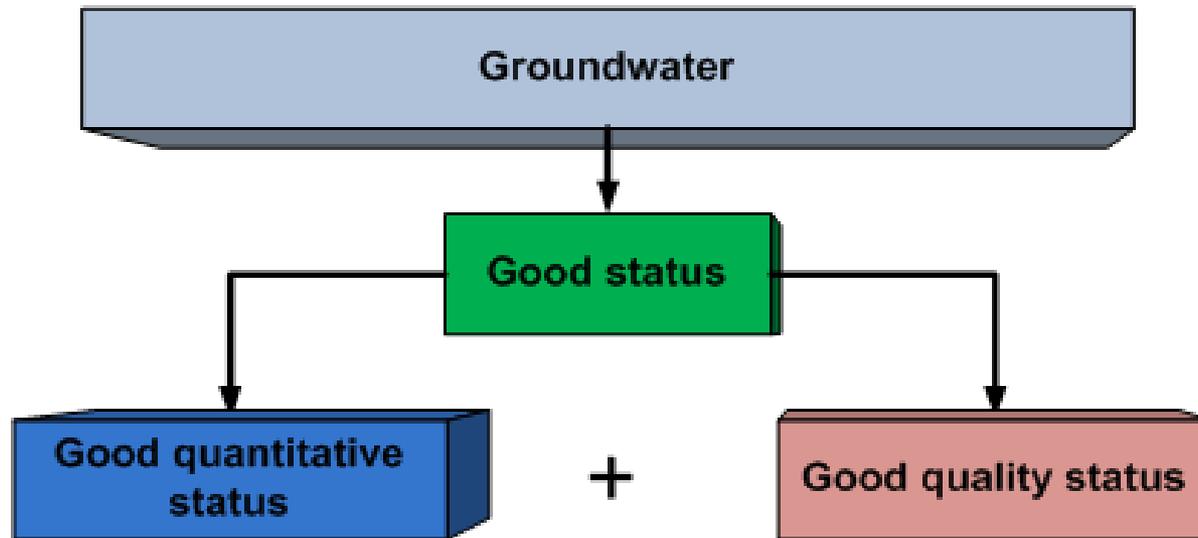
abstraction <
natural recharge

- no upward trends

- no saline or other intrusions

- compliance with quality standards:

  ➤ *EU-wide Standards (NO_3 and Pesticides)*

  ➤ *Threshold Values for pollutants + indicators: Heavy metals (Cd, Pb, Hg, ...), NH_4, As, SO_4, Cl, B, ...*

Good status has to be achieved on the level of groundwater bodies

Groundwater body:

Distinct volume of water in aquifer(s) = management unit

National and International River Basin Districts

National river basin districts

International river basin districts
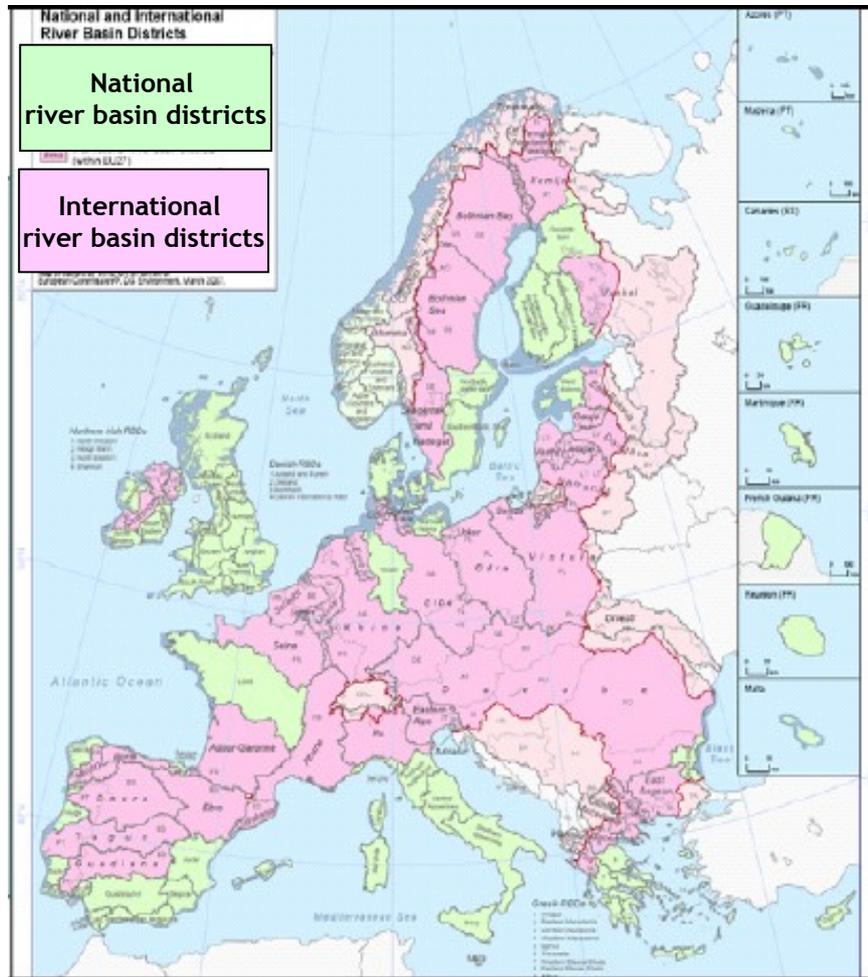
Transboundary groundwater bodies: member States sharing groundwater bodies have to **COORDINATE and HARMONIZE** their activities in respect of:

- *Delineation*
- *Characterization*
- *Monitoring*
- *Establishing threshold values for the groundwater*
- *Implementation of programs of*

  measures

EU- STREPS project BRIDGE

➢ **BRIDGE: Background criteria for the identification of Groundwater Thresholds**

➢ **Targets:**

  ✦ developing a plausible and general applicable approach to derive natural background levels (NBL) and threshold values (TV)

  ✦ Checking the applicability and validity of the approach in case study areas at the level of groundwater bodies throughout Europe

➢ **27 partners from 19 countries involved**

➢ **14 case studies (1 transboundary case study)**
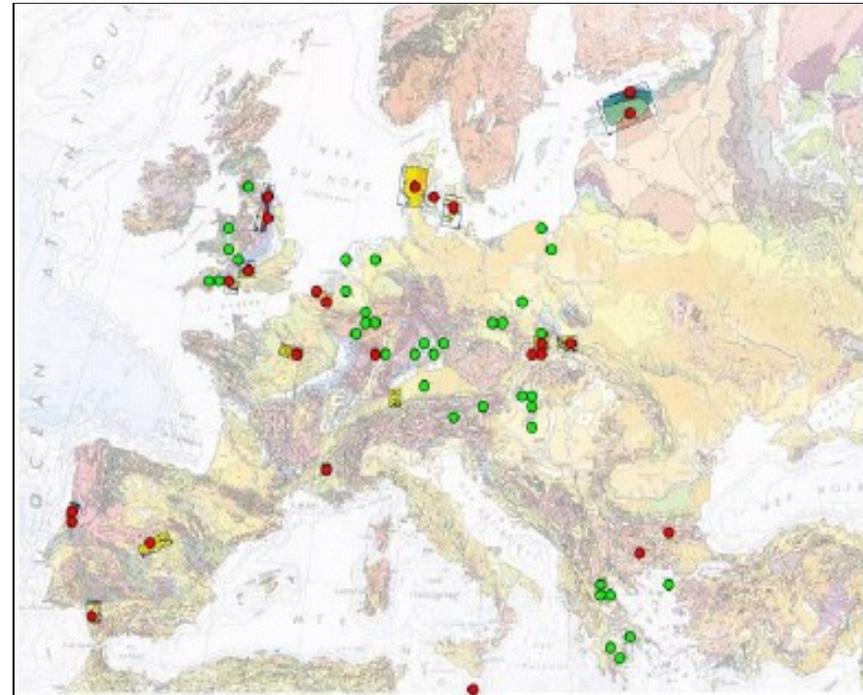
Case study area Upper Rhine Valley
(Switzerland, France, Germany)

Upper Rhine basin

- Pasture
- Arable Land
- Forest
- Other Areas
- Urban areas

0 5 10 20 30 40 50
Kilometers
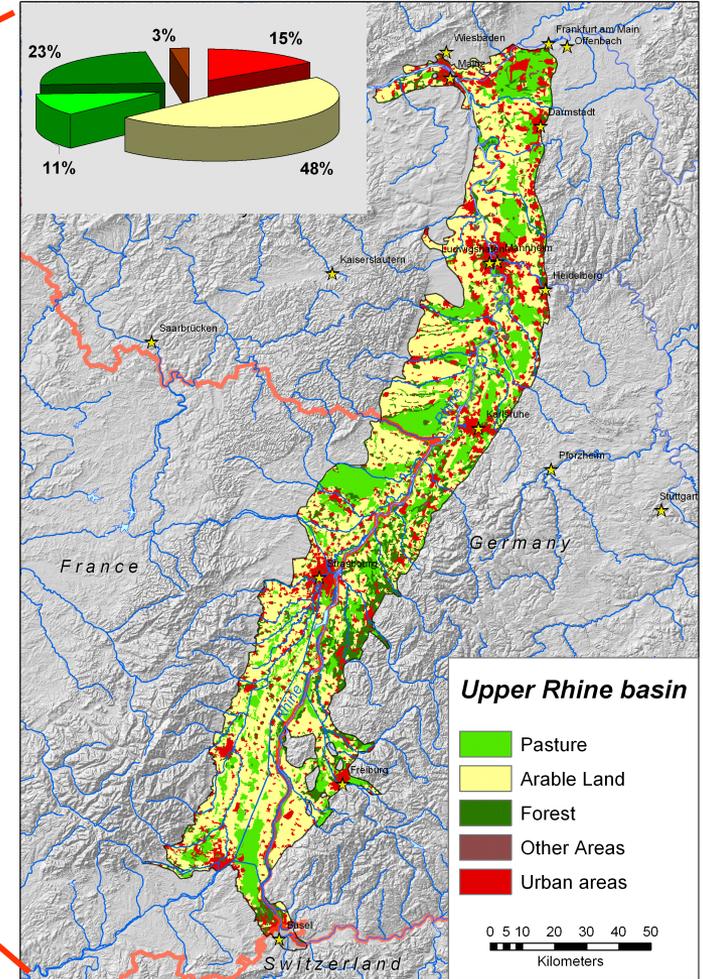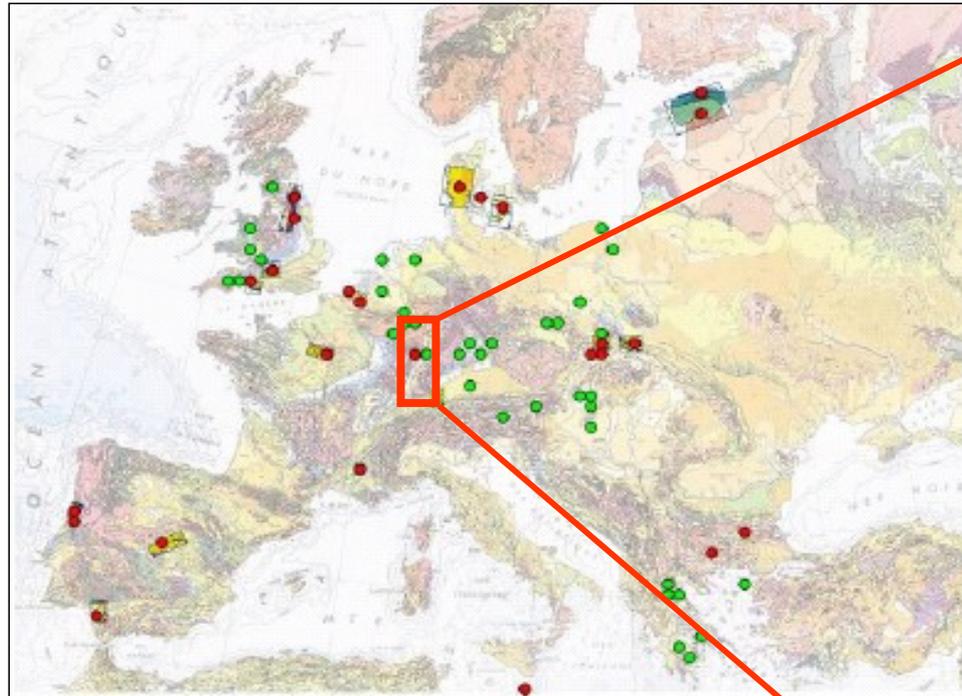
Characteristics:

- Total area: 9290 km^2
- Geology: quaternary sands and gravels
- Supraregional drinking water supply
- Densely populated
- Anthropogenic impacts on groundwater quality: agriculture and industry

Joining data from different data bases

1722 groundwater samples from monitoring networks (2002-2003)

- 67 samples from Switzerland

- 734 samples from France

- 910 samples from Germany
  - 535 from Baden-Württemberg
  - 209 from Rheinland-Pfalz
  - 166 from Hessen

One sample for each monitoring station containing up to 30 parameters:

- el. Conductivity, O2, pH, temperature, DOC, TAC, hardness, B, Ba, Ca, Fe, Mg, Mn, Na, K, Cl, SO4, HCO3, As, NH4, NO3, NO2, PO4, …

Nitrate concentration in groundwater
- <= 10 mg/l
- 10 - 25 mg/l
- 25 - 50 mg/l
- > 50 mg/l

Lakes
Upper Rhine basin
Rivers
national boundary
state boundary
Cities

0 5 10 20   30   40   50
Kilometers
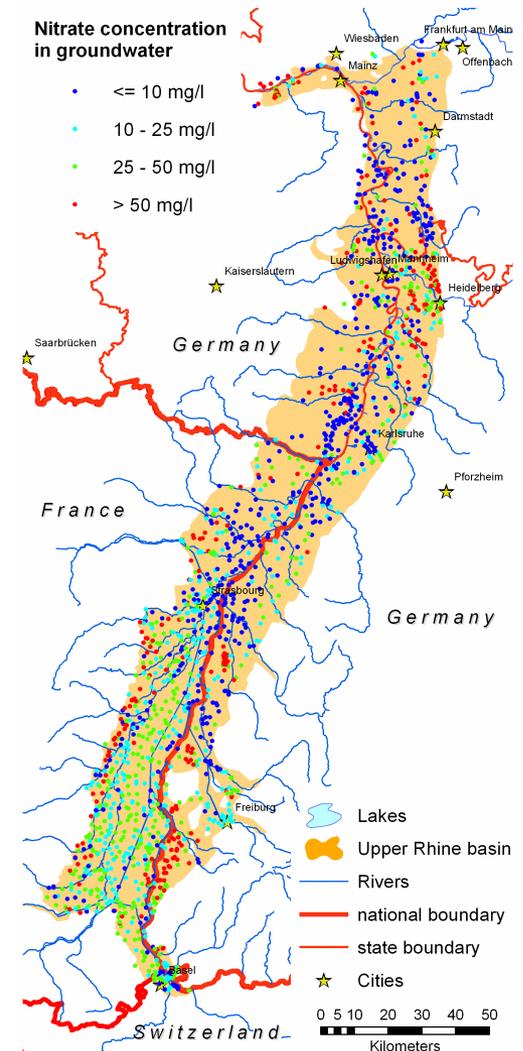
Natural groundwater composition

→ *does hardly occur (human impact almost everywhere)*

→ *must be derived using appropriate methodologies*
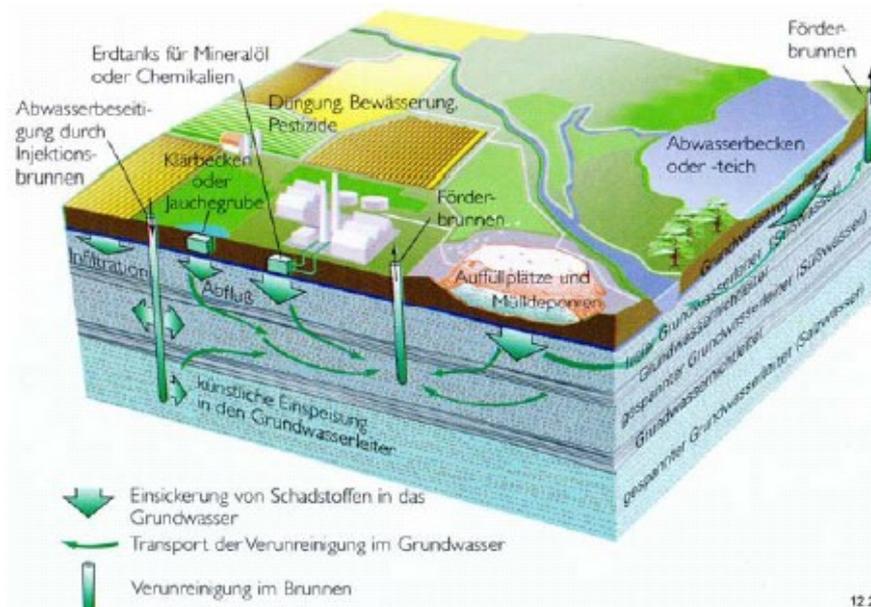
Two approaches used for NBL derivation : 1. component separation
2. data preselection

Derivation of natural background levels (NBL) :
Component separation methodology
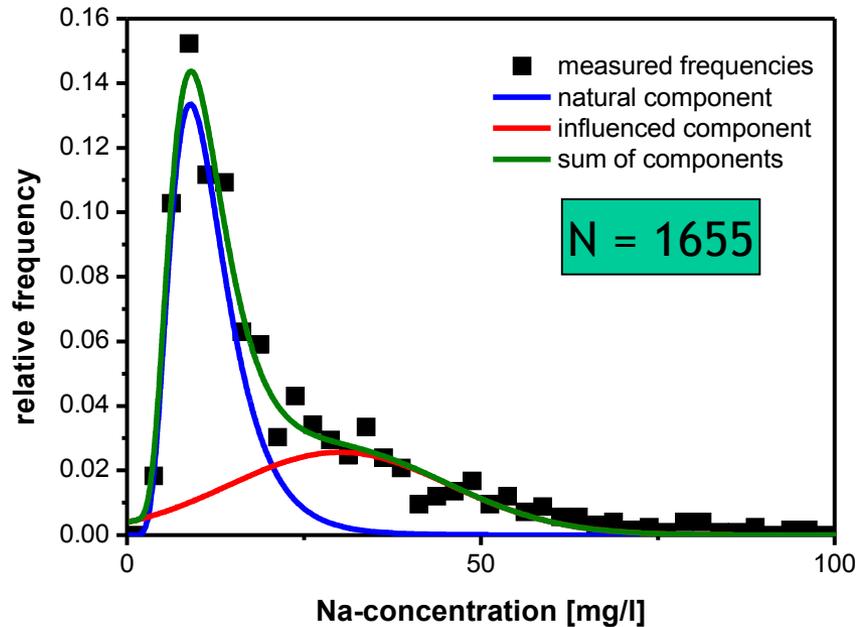
One natural component

- < 25 mg Na/l

One influenced component

- Here: effects of salt mining in Upper Rhine Valley

➢ *Prototype distribution pattern*
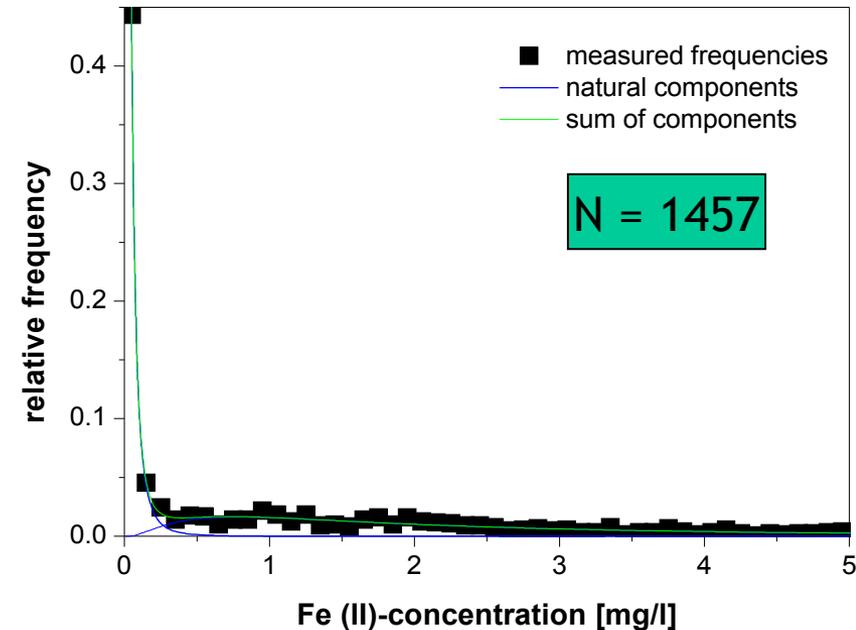
Two natural component

- indicates redox-stratification
- oxidized groundwater zone
- reduced groundwater zone

➢ *Distribution pattern for redox – sensitive parameters*

Derived NBLs (Upper Rhine Valley)

Parameter		Component separation		
		N	P10	P90
Na	mg/l	1655	6.2	18.9
K	mg/l	1552	1.1	4.7
Mg	mg/l	1658	7	33.1
Ca	mg/l	1553	74	197
Fe	mg/l	1457	0.005	3.3
Mn	mg/l	1572	0.01	0.6
HCO_3	mg/l	1589	277	438
SO_4	mg/l	1563	16.7	249
Cl	mg/l	1678	9.8	99
NH_4	mg/l	1636	0.0025	0.04
NO_3	mg/l	1678	0.05	1.2
PO_4	mg/l	1619	0.01	0.2
DOC	mg/l	1563	0.7	3.7
LF	mg/l	1678	450	1296
O_2	mg/l	1669	0.2	8.2
H	mg/l	1673	0.04	0.1
Al	mg/l	1039	0.2	3.6
B	mg/l	1572	0.02	0.04

Concentration at P 90 of natural component designates the upper limit for "natural" groundwater conditions

"natural" groundwater concentrations ∠= *good qualitative status*

Final conclusion

➢ **Natural background values define the regional background of a certain groundwater parameter, which would be present hypothetically without anthropogenic intakes**

➢ **Derivation of natural background levels (NBLs) in the case study area Upper Rhine Valley**

- based on available groundwater monitoring data from different monitoring networks

- results have been approved by German and French stakeholders

➢ **NBLs have been used as starting points to derive (receptor based) threshold values for the groundwater in the Upper Rhine Valley**
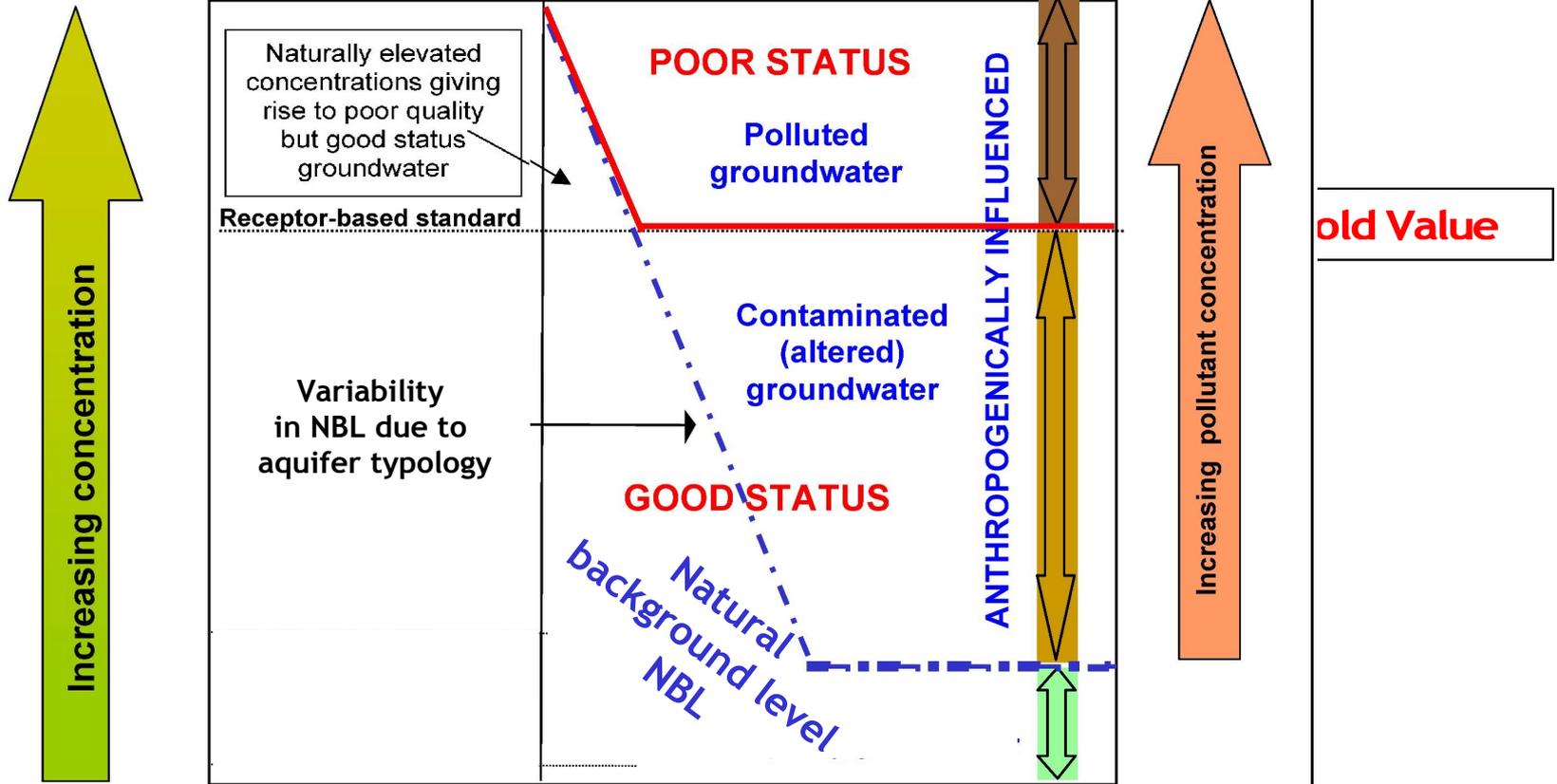
Schematic representation of the relationships as a starting point for the assessment of threshold values

Proposed method for TV derivation
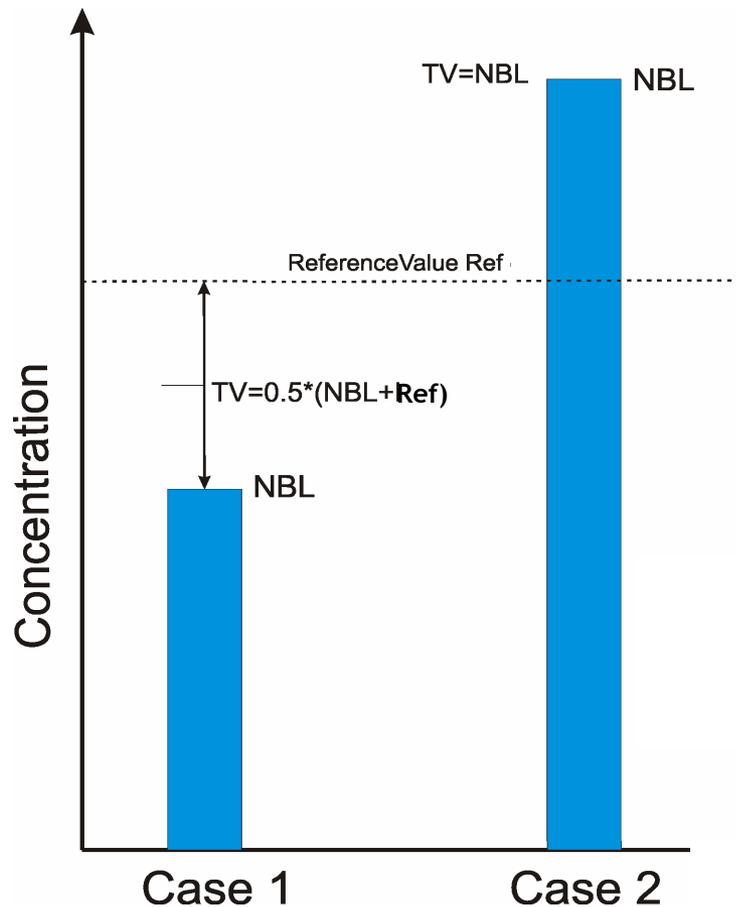
Examples for REF-values
(source: Directive 80/778/EWG about the quality of water for drinking purposes)

B	1	mg/l
Cl	250	mg/l
Fe	0.2	mg/l
K	10	mg/l
Mg	50	mg/l
Mn	0.05	mg/l
Na	200	mg/l
SO_4	250	mg/l
As	10	µg/l
Ni	20	µg/l
NH_4	0.5	mg/l
NO_2	0.5	mg/l
NO_3	50	mg/l
Pb	10	µg/l
PO_4	6.7	mg/l

- Different reference (REF) values can be used (e.g. DWS, EQS …)
- REF-values can be chosen according to the receptor of groundwater
- For groundwater DWS are unifrom across the EU

NBLs and related TVs in the case study area Upper Rhine Valley

Parameter	Unit	P_{90}	Ref	TV1
B	mg/l	0.1	1	0.5
Cl	mg/l	84	250	167
Fe (II)	mg/l	3.6	0.2	3.6
K	mg/l	7.2	10	8.6
Mg	mg/l	25	50	37
Mn (II)	mg/l	0.82	0.05	0.8
Na	mg/l	41	200	120
SO_4	mg/l	173	250	211
LF	µS/cm	951	2500	1726
As	µg/l	4	10	7
NH_4	mg/l	0.39	0.5	0.45
NO_2	mg/l	0.04	0.5	0.08
NO_3	mg/l	8.2	50	29.1

Practical relvance of background and threshold values

➢ **The natural background values define the regional background of a certain groundwater parameter, which would be present hypothetically without anthropogenic intakes**

➢ **For 2% to 5% of the samples the TV is exceeded. There the "good chemical status" of groundwater is <u>not</u> guaranteed.**

➢ **Threshold values define a concentration level, which requires further investigations or even measures, if it is exceeded:**

 ✦ As long as the threshold value is not exceeded, groundwater is in „good status" according to WFD. The requirements of the drinking water directive or other derived values are achieved.

 ✦ If a threshold value is exceeded, the reasons need to be investigated

 • In case the exceedance is due to natural resons (e.g. dykes, upwelling of mineralzed water etc.), the good groundwater status according to WFD is still ensured, even if the groundwater may have „bad quality".

 • Only in case the exceedance is due to to anthropogenic influences, the good groundwater status is not achieved. In this case measures to improve groundwater quality are required.

Groundwater directive (GWD):
Environmental objectives

Groundwater

Good status

Good quantitative status + **Good quality status**

+ **Prohibition to deteriorate**

+ **Trend reversal**
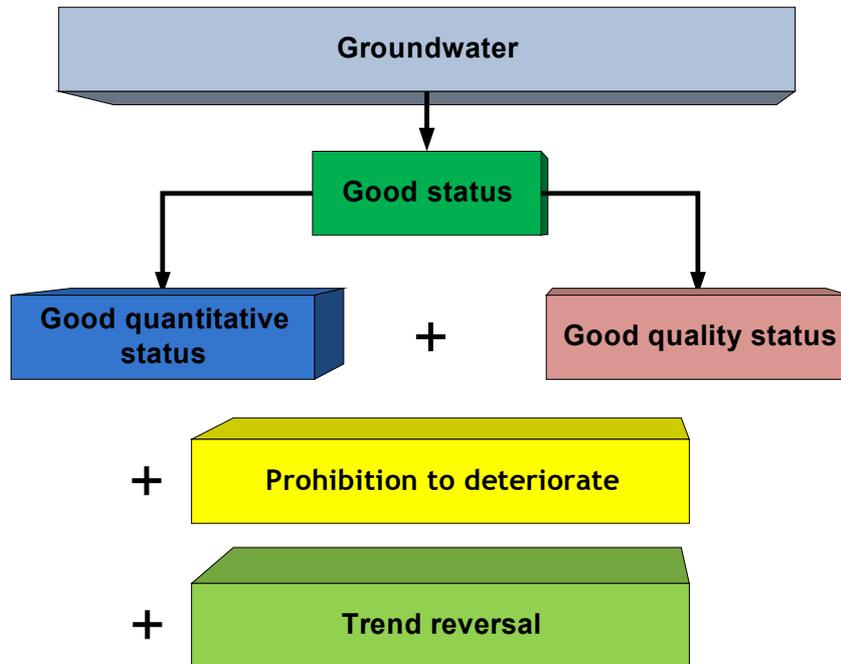
'Good Status' - for groundwater bodies in terms of

Quantity (balance between natural recharge and abstraction)

Quality (compliance with numerical quality standards; no upward trends; no saline or other intrusions)

→ **EU-wide Quality Standards for Nitrate and Pesticides**

→ **Threshold Values for parameters at risk**

'Prevent and limit' - for protection of groundwater

Prevention of inputs of hazardous substances

Limitation of inputs of non-hazardous substance

Groundwater Directive Annex II

Threshold values for groundwater pollutants and indicators

Good quality status of groundwater

Threshold values
(to be derived on national/regional level)

Quality standards for nitrates, plant protection products and biocides

(EU-wide)

- 0.1 µg/l pesticides
- 50 mg/l nitrates

Geogenic/ anthropogenic substances

- Ammonia
- Arsenic
- Cadmium
- Chloride
- Lead
- Mercury
- Sulphate

Synthetic substances

- trichloroethene
- tetrachloroethane

Saline or other intrusions

- El. Conductivity
- Sulphate
- Chloride

Case study area Upper Rhine Valley

NBL derivation: preselection method (quick and dirty)

➢ **Exclusion of samples:**

  ✦ containing purely anthropogenic substances (e.g. pesticides)

  ✦ containing nitrate and ammonia as indicator substances for anthropogenic inputs:

  ● NO_3 > 10 mg/l (oxidized groundwaters)

  ● NH_4 > 0.5 mg/l or NO_3 > 10 mg/l (reduced groundwaters)

  ● oxidized and reduced conditions are defined by the oxygen content of groundwater
($\leq$1 O_2 mg/l or >1 mg O_2/l)

➢ **In total 609 samples (from 1678) were available for further evaluation after preselection**

➢ **Definition of NBLs by the concentration range between the 10% and 90% percentile of the distributions of the remaining groundwater samples**

Statistical evaluation and comparison of derived NBL (Upper Rhine Valley)

Parameter		Component separation			Data preselection		
		N	P10	P90	N	P10	P90
Na	mg/l	1655	6.2	18.9	606	6.3	43
K	mg/l	1552	1.1	4.7	547	1.2	7.4
Mg	mg/l	1658	7	33.1	606	5.7	25
Ca	mg/l	1553	74	197	547	53	175
Fe	mg/l	1457	0.005	3.3	490	0.01	4.8
Mn	mg/l	1572	0.01	0.6	552	0.003	0.9
HCO_3	mg/l	1589	277	438	566	157	440
SO_4	mg/l	1563	16.7	249	544	21	186
Cl	mg/l	1678	9.8	99	609	8.6	84
NH_4	mg/l	1636	0.0025	0.04	573	0.01	0.51
NO_3	mg/l	1678	0.05	1.2	609	0.27	8.1
PO_4	mg/l	1619	0.01	0.2	564	0.01	0.18
DOC	mg/l	1563	0.7	3.7	533	0.45	4.1
LF	mg/l	1678	450	1296	609	305	963
O_2	mg/l	1669	0.2	8.2	605	0.16	6.7
H	mg/l	1673	0.04	0.1	607	0.03	0.2
Al	mg/l	1039	0.2	3.6	355	0.67	4.4
B	mg/l	1572	0.02	0.04	545	0.02	0.1

Results are slightly different, but derived NBLs are comparable:

both preselection and component separation can be used

Results for the Upper Rhine Valley

➢ **Preselection to remove anthropogenic influenced samples leads to reasonable results**

➢ **90% – percentiles useful in order to identify (exclude) extreme values**

➢ **Comparison of NBLs from preselection and component separation:**

  ✦ Slightly different but very comparable

  ✦ Both preselection and component separation to derive NBLs can be used in practice

➢ **NBLs are used as starting points for threshold value (TV) derivation**