Water quality and Pollution

Chemical and Ecological status assessment

UN environment

GEMS Water

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Water quality pressures in Drin catchment

- The draft **Thematic report on Pollution** identifies the main pressures in the Drin catchment as principally:
  - **Point Sources**
    - Sewage systems
    - Small and medium enterprises
    - Industry
    - Waste disposal sites and dumpsites



  - **Diffuse sources**
    - Discharges not connected to the sewer network
    - Agriculture
    - Contaminated sites and mining


- Interestingly - no specific mention of **Forestry** as a potential pressure but perhaps this is not an issue due to topography / geology
- Thematic report identifies and recognizes a wide range of information gaps and data limitations


Water quality pressures in Drin catchment - Hydromorphology

Though not a chemical or biological pressure, per se, the increasing use of Balkan rivers for Hydro-electric power generation will surely result in many waterbodies now becoming classified as 'Heavily Modified Water Bodies' under WFD criteria and threatens much of their natural characteristics and biota. **The need for power needs to be balanced by the need for Nature!**

The previously undammed Vjosa River leaves vast gravel deposits along its banks in Albania as it winds its way to the Adriatic Sea. GREGOR ŠUBIC

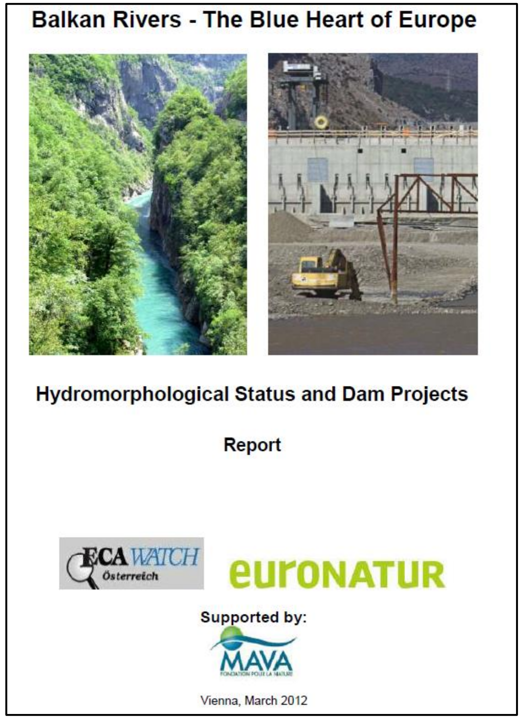
https://e360.yale.edu/features/a-balkan-dam-boom-imperils-europes-wildest-rivers

https://www.researchgate.net/publication/257318969_Chapter_11_Rivers_of_the_Balkans

"Balkan dam projects could result in loss of one in 10 European fish species" - The Guardian

https://www.theguardian.com/environment/2018/apr/18/balkan-dam-projects-could-result-in-loss-of-one-in-10-european-fish-species

The section of the Tara river in Montenegro that would be affected by dams on the Drina. Photograph: Riverwatch


Balkan Rivers - The Blue Heart of Europe

Hydromorphological Status and Dam Projects

Report

ECA WATCH Österreich

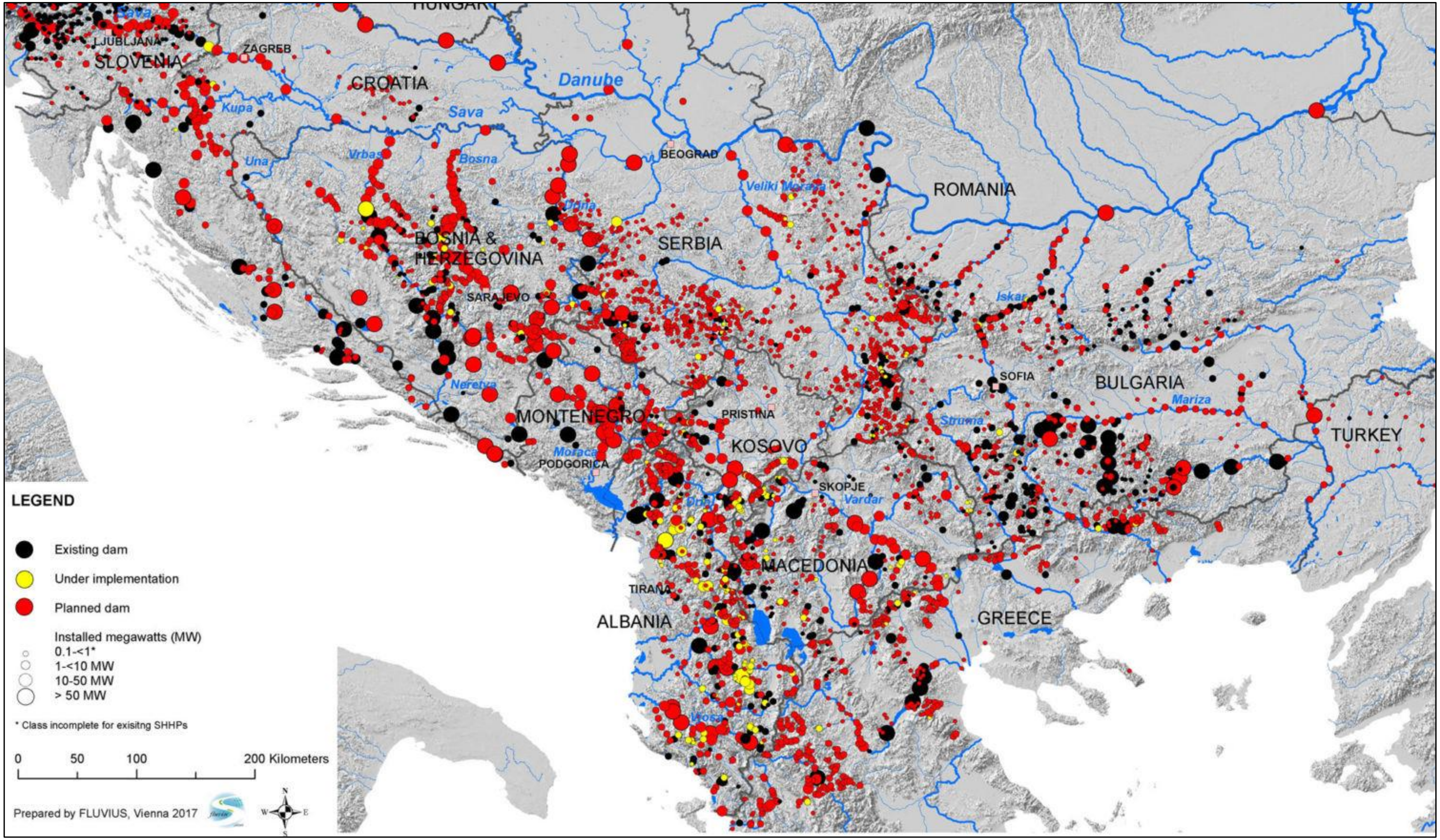
euroNATUR

Supported by:

MAVA

Vienna, March 2012

https://www.balkanrivers.net/sites/default/files/BalkanRiverAssessment29032012web.pdf



https://balkanrivers.net/ https://e360.yale.edu/features/a-balkan-dam-boom-imperils-europes-wildest-rivers

Water quality pressures in Drin catchment

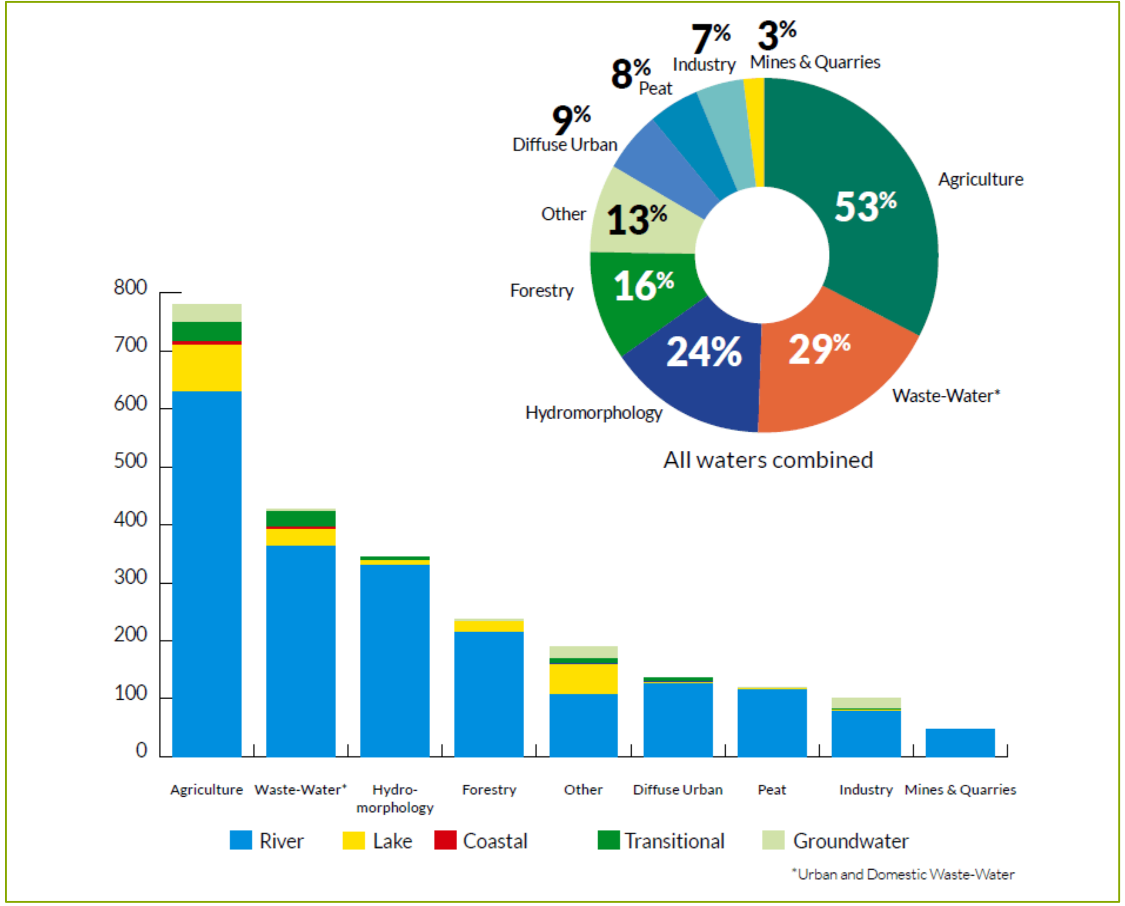
- Not all riparians are currently collecting, let alone reporting, pollution data to EU requirements making data harmonization a considerable challenge!
  - **This definitely needs to change to facilitate data harmonization and to comply with EU membership applications**
- There is currently no complete inventory of either point or diffuse pollution sources available
  - **Effort needs to be put in place to develop this inventory as soon as is practicable**
- Data interpolation has been based on expert judgement and limited national scale studies
- Wastewater management is generally poor (compared to UWWTD requirements) in most areas
  - Most WWTP are serving <2000 PE – may fall below UWWTD thresholds
  - **3 facilities account for 71% of organic loading … BUT**
  - **Smaller WWTP can have a more significant impact of water quality as treatment and dilution ratios may often be less effective**
  - **Need to assess water quality impacts of these lesser point sources**
- Arable lands are the primary sources of diffuse N and P loadings to the aquatic environment with livestock manures playing a key role
- Industrial impacts hampered by lack of a suitable IPPC based monitoring system – **this needs development**
- Municipal waste collection / segregation is severely limited in some regions – **point source pollution**?

Chemical pressures in Drin catchment

- **Major data limitations identified in the Thematic Report on Pollution include**:

- Chemical assessment based on 2006-2016 National monitoring program supported by specific monitoring campaigns in recent years – **data discontinuity is an issue**
- Just 60 stations for Surface waters, 40 for Groundwater, 7 TraCs and 11 sediments. Regional coverage was sporadic with not all parameters apparently monitored in each sub-basin – **needs a more structured approach to parameters**
- Threshold values for GW are based on its use as drinking water supply – a conservative approach
- Very limited number of stations monitored for metals – mainly Kosovo / FYROM – **greater coverage required**
- The White Drin sub-basin has the greatest proportion of monitoring sites failing to meet the WFD's objective of good status based on application of EU norms.
- Some exceedances for Cd / Pb but also a few stations failed for PBTs or synthetic priority substances.
- **Some parameters with analytical detection limits issues which needs resolution. For others LoQ seems very low**
- **Fails for DEHP could possibly be an analytical issue rather than indicative of a pollution problem. PAH fails are also typically linked to method deficiencies as EQS values are so low**
- **Phenol and Cyanide detects are a little surprising** (and also alarming) – could this also be a methodology problem?

WFD – Pressures in Ireland



Source: EPA Catchments

https://www.catchments.ie/understanding-our-catchments-water-framework-directive-characterisation/

The **Source-Pathway- Receptor** framework has been used in the characterisation process which is also the first step towards identifying the most appropriate measures e.g. measures can be targeted at the source, the pathway or the receptor:

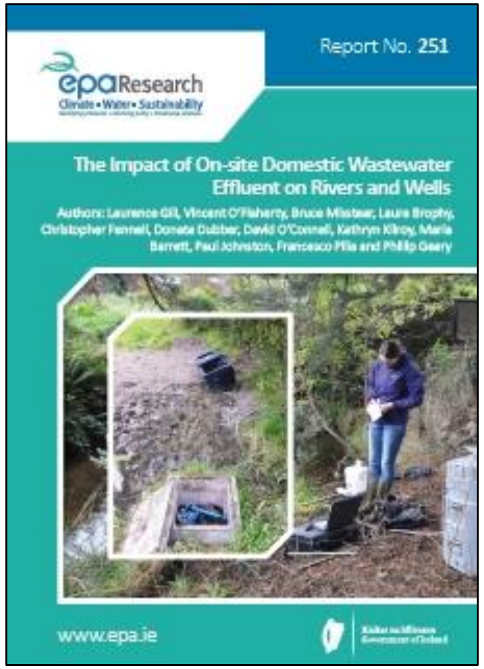
Source control: The most commonly applied measures in Ireland and elsewhere are applied at the source, as this is the point at which activities are carried out and regulated. This approach works well for large point sources, but is generally not sufficiently effective on its own for diffuse sources.

Repair the receptor: Restoration of receptors are most commonly used in Ireland for treating drinking waters to the required standard, or for restoring fish habitat after channel maintenance activities. However, these measures are often expensive, and focus on the symptoms in an impacted water body rather than the cause.

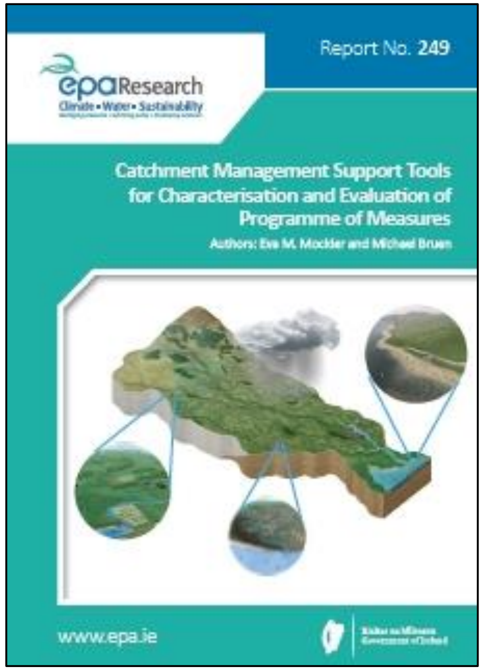
Break the pathway: For diffuse sources of contamination, particularly where contaminants are delivered to receptors via overland flow pathways, which are activated during rainfall events, it may be far more effective to intercept the transport pathway. This is especially useful where phosphorus is the issue because it takes a very, very small proportion of the amounts of phosphorus that are used in agricultural production to be lost to cause an ecological water quality problem. Relying only on source control in this instance is unlikely to be an effective solution.

WFD – Research to assist with Characterization / POMs

- Several research studies were needed and used to assist the characterization of water body pressures – in addition to expert and local knowledge



http://www.epa.ie/researchandeducation/research/researchpublications/researchreports/research251.html



http://www.epa.ie/researchandeducation/research/researchpublications/researchreports/research249.html

https://epaireland.sharefile.com/d-s0318915675b4162a

- Catchment guidance available in 5 parts to assist local authority staff to identify and implement agreed measures
- Effectiveness of the implementation of measures is assessed by EPA

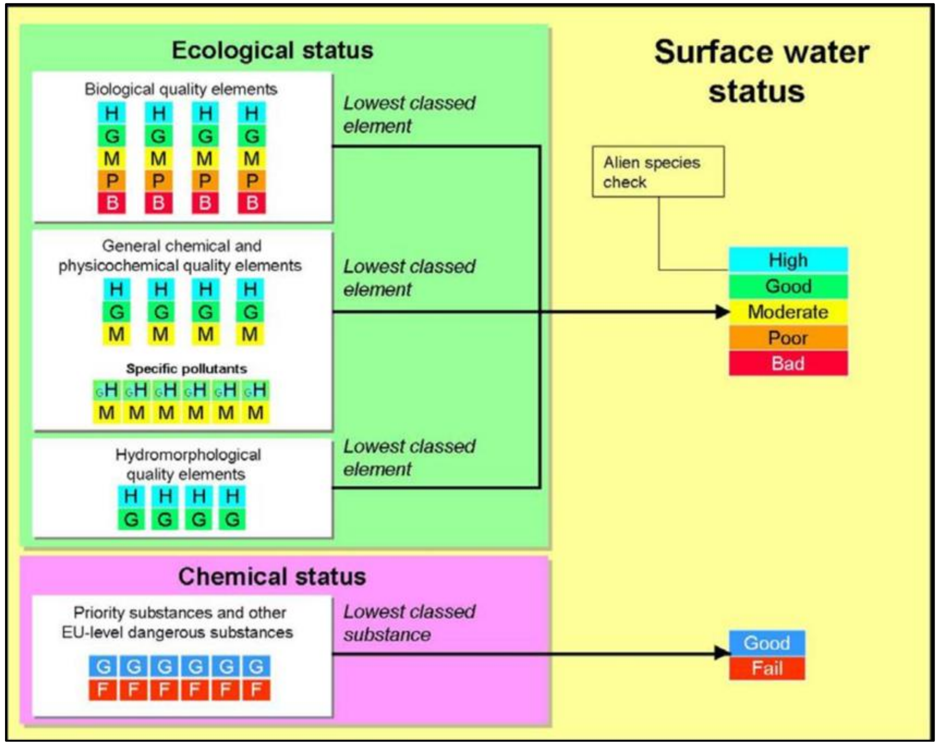
Estd. 490,000 single house wwtp in Ireland

WFD - Chemical and Ecological assessment

For WFD assessment Ecological and Chemical status are assessed independently of each other.

Ecological status assessment incorporates:

- General physico-chemical quality combined with biological quality comprising:
- Relevant national chemical contaminants
- Macro-invertebtrates (insects)
- Phytobenthos (microscopic plants and algae
- Macrophytes (aquatic plants)
- Fish
- Hydro-morphology and water quantity elements



Chemical status refers solely to compliance with relevant standards for both Specific Pollutants (SP), Priority (PS), and Priority Hazardous Substances as set Out in Directive 2013/39/EU

https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:226:0001:0017:EN:PDF

WFD – Biological assessment

High status' is defined as the biological, chemical and morphological conditions associated with no or very low human pressure. This is also called the 'reference condition' as it is the best status achievable - the benchmark. These reference conditions are type-specific, so they are different for different types of rivers, lakes or coastal waters so as to take into account the broad diversity of ecological regions in Europe.

Assessment of quality is based on the extent of deviation from these reference conditions, following the definitions in the Directive. 'Good status' means 'slight' deviation, 'moderate status' means 'moderate' deviation, and so on. The definition of ecological status takes into account specific aspects of the biological quality elements, for example "composition and abundance of aquatic flora" or "composition, abundance and age structure of fish fauna"

Problem 1. – **What are the reference conditions**? -> un-impacted waters but can be typology specific. Needs to be determined specifically for each country or region.

Problem 2. – **Now we have 'reference' sites how do we assess them**? – This requires the development of a national approach or use of a recognised international taxa index such as:

- BMWP (UK Biological Monitoring Working Party) Hawkes, H.A (1998). "Origin and development of the biological monitoring working party score system". *Water Research*. **32** (3): 964–968. doi:10.1016/S0043- 1354(97)00275-3
- ASPT (Average score per taxon) based on BMWP approach
- Shannon (proportion) or Simpson (dominance) index https://entnemdept.ifas.ufl.edu/hodges/ProtectUs/lp_webfolder/9_12_grade/Student_Handout_1A.pdf

- Information on methodology applied in several EU states is available at:
- https://www.eea.europa.eu/publications/92-9167-001-4/page021.html

- **Several biological classification system have been used in the Drin catchment assessment**

WFD – Biological assessment approaches

- UN/ECE have published a series of documents on water quality assessment. Their 2005 meeting in Georgia on transboundary rivers contains some excellent presentations. https://www.unece.org/index.php?id=5786 and https://www.unece.org/fileadmin/DAM/env/water/publications/documents/guidelinestransrivers2000.pdf

- UK Environment Agency published a reference document on approaches to lakes monitoring (2000) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/290270/stre110-e-e.pdf

- UK approaches to assessing indicators of pressures are available here: https://www.wfduk.org/sites/default/files/Media/Characterisation%20of%20the%20water%20environment/Biological%20Method%20Statements/Ecological%20Indicators%20of%20severe%20flow%20pressures%20UKTAG%20Method%20Statement.pdf

- A 2003 report on collaborative biological approaches in the Danube catchment are available here: https://iwlearn.net/resolveuid/6611813e7acc7e9ff5e661419c3b9019

UN/ECE Task Force on Monitoring & Assessment
under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992)

Work Programme 1997-2000

Guidelines on Monitoring and Assessment of Transboundary Rivers

First review of the 1996 Guidelines on Water-quality Monitoring and Assessment of Transboundary Rivers

March 2000

Biological Techniques of Still Water Quality Assessment

Phase 3. Method Development

R&D Technical Report E110

J Biggs, P Williams, M Whitfield, G Fox, P Nicolet

Research Contractor:
Pond Action

Further copies of this report are available from:
Environment Agency R&D Dissemination Centre
WRc, Frankland Road, Swindon, Wilts. SN5 8YF

WRc

UKTAG River Assessment Method

Ecological indicators of severe water resources pressures

by

Water Framework Directive – United Kingdom Technical Advisory Group (WFD-UKTAG)

wfd Water Framework Directive UK TAG

Danube Regional Project

UNDP/GEF DANUBE REGIONAL PROJECT
"STRENGTHENING THE IMPLEMENTATION CAPACITIES FOR NUTRIENT REDUCTION AND TRANSBOUNDARY COOPERATION IN THE DANUBE RIVER BASIN"

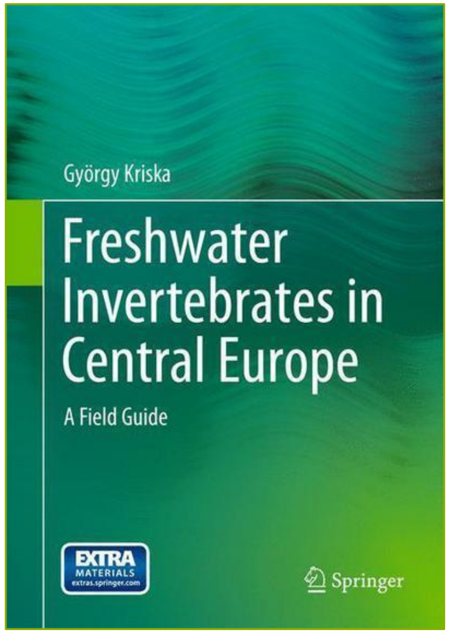
ACTIVITY 1.1.7 "IMPLEMENTING ECOLOGICAL STATUS ASSESSMENT IN LINE WITH REQUIREMENTS OF EU WATER FRAMEWORK DIRECTIVE USING SPECIFIC BIO-INDICATORS"

FINAL REPORT

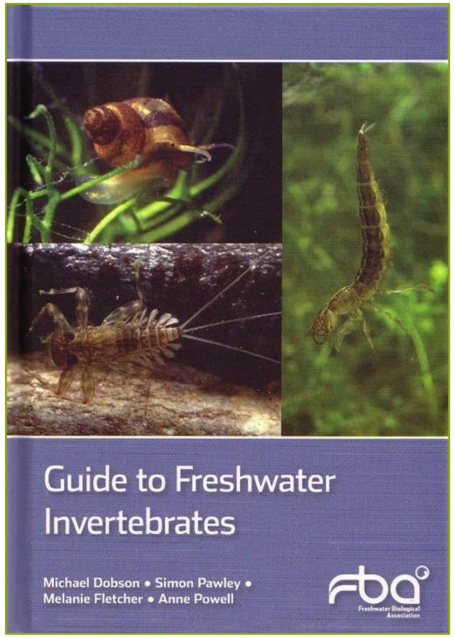
Standard macro-invertebrate sampling methods

Dec.Vermont.gov

pba-ecology.co.uk



ISBN 9783709115466
Springer Verlag



ISBN: 9780900386800
Freshwater Biological Association

- Kick-sampling across a defined are for typically 1-2 minutes capturing disturbed species in a fine mesh net
- Rinse net into a collection tray and examine in-situ or return to lab for species identification
- Based on species numbers and diversity assign the relevant biotic score / index.
- **ISO 10870: 2012** *Water quality -- Guidelines for the selection of sampling methods and devices for benthic macroinvertebrates in fresh waters*
- Irish Statute Book SI 277 of 2016 European Union Environmental Objectives (Standards for Monitoring of Quality Elements) Regulations 2016

http://www.irishstatutebook.ie/eli/2016/si/277/made/en/print

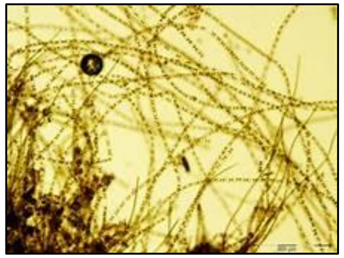
Standards for biological monitoring

Standards for Macrophyte and Phytobenthos:

EN 15460:2007 Water quality — Guidance standard for the surveying of macrophytes in lakes

EN 14184:2014 Water quality — Guidance for the surveying of aquatic macrophytes in running waters

EN 15708:2009 Water quality — Guidance standard for the surveying, sampling and laboratory analysis of phytobenthos in shallow running water



EN 13946:2014 Water quality — Guidance for the routine sampling and preparation of benthic diatoms from rivers and lakes

EN 14407:2014 Water quality — Guidance for the identification and enumeration of benthic diatom samples from rivers and lakes

Standards for benthic invertebrates:

EN ISO10870:2012 Water quality — Guidelines for the selection of sampling methods and devices for benthic macroinvertebrates in fresh waters

EN 15196:2006 Water quality — Guidance on sampling and processing of the pupal exuviae of Chironomidae (order Diptera) for ecological assessment

EN 16150:2012 Water quality — Guidance on pro rata multi-habitat sampling of benthic macro-invertebrates from wadeable rivers

EN ISO 19493:2007 Water quality — Guidance on marine biological surveys of hard-substrate communities

EN ISO 16665:2013 Water quality — Guidelines for quantitative sampling and sample processing of marine soft-bottom macro-fauna

Standards for biological monitoring continued:

Standards for fish:

EN 14962:2006 Water quality — Guidance on the scope and selection of fish sampling methods

EN 14011:2003 Water quality — Sampling of fish with electricity

EN 15910:2014 Water quality — Guidance on the estimation of fish abundance with mobile hydroacoustic methods

EN 14757:2005 Water quality — Sampling of fish with multi-mesh gillnets

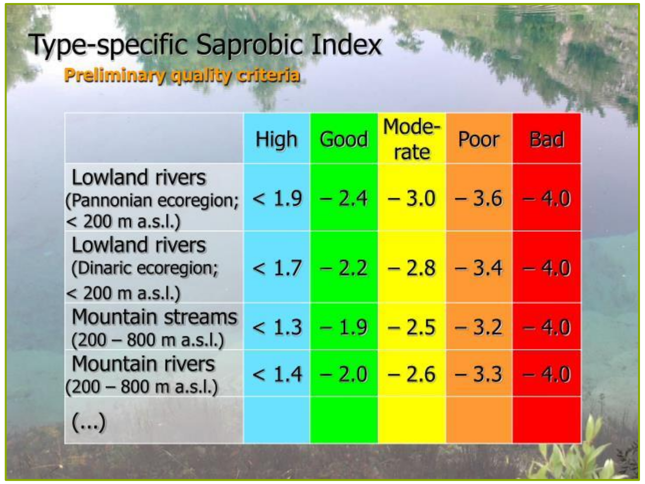
Standards for hydromorphological parameters:

EN 14614:2004 Water quality — Guidance standard for assessing the hydromorphological features of rivers

EN 16039:2011 Water quality — Guidance standard on assessing the hydromorphological features of lakes

Saprobic Index assessment

For larger rivers systems the use of diatoms to determine the oxygen influenced Saprobic Index may be more practical



Type-specific Saprobic Index

Preliminary quality criteria

	High	Good	Mode-rate	Poor	Bad
Lowland rivers (Pannonian ecoregion; < 200 m a.s.l.)	< 1.9	– 2.4	– 3.0	– 3.6	– 4.0
Lowland rivers (Dinaric ecoregion; < 200 m a.s.l.)	< 1.7	– 2.2	– 2.8	– 3.4	– 4.0
Mountain streams (200 – 800 m a.s.l.)	< 1.3	– 1.9	– 2.5	– 3.2	– 4.0
Mountain rivers (200 – 800 m a.s.l.)	< 1.4	– 2.0	– 2.6	– 3.3	– 4.0
(...)					

Zlatko Mihaljević, Ana Previšić, Igor Stanković Dept. of Biology, Faculty of Science, Univ. of Zagreb.
https://www.slideserve.com/abeni/development-of-biological-assessment-systems-for-rivers-and-lakes-benthic-macroinvertebrates

Source: www.labroots.com

Rolauffs, Peter & Stubauer, Ilse & Zahradkova, Svetlana & Brabec, K & Moog, Otto. (2004). Integration of the saprobic system into the European Union Water Framework Directive – Case studies in Austria, Germany and Czech Republic. Hydrobiologia. 516. 285-298. 10.1023/B:HYDR.0000025271.90133.4d.

https://www.researchgate.net/publication/226995296_Integration_of_the_saprobic_system_into_the_European_Union_Water_Framework_Directive_-_Case_studies_in_Austria_Germany_and_Czech_Republic

Water Quality Assessment using Benthic Macroinvertebrates in Wetlands and Ponds: Preliminary Study Case of Jijia and Miletin Ponds (ROSPA0042) DIANA GHEłEU1 , HARITON COSTIN2 1 Faculty of Biology, 'Al. I. Cuza' University from Iaşi Carol I Blvd., 20 A, Iaşi, ROMANIA 2 Faculty of Medical Bioingeneering, 'Gr. T. Popa' University of Medicine and Pharmacy, Iaşi ROMANIA dianagheteu@yahoo.com, hcostin@gmail.com

http://www.wseas.us/e-library/conferences/2011/Iasi/WEPRE/WEPRE-18.pdf

Assessing streams in Germany with benthic invertebrates: Development of a multimetric invertebrate based assessment system Jürgen Böhmer et al

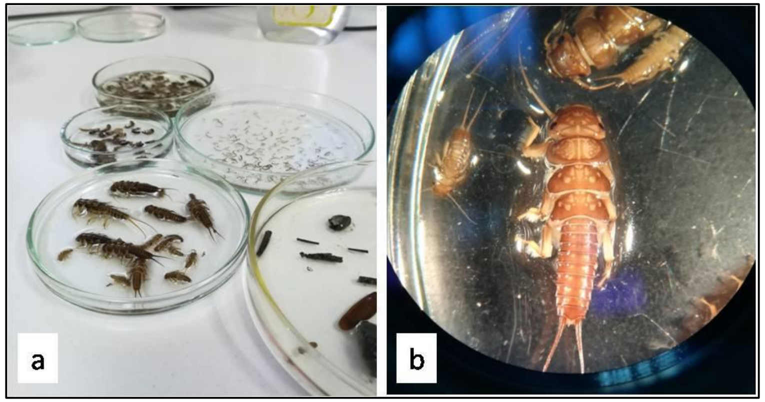
https://www.sciencedirect.com/science/article/pii/S0075951104800100

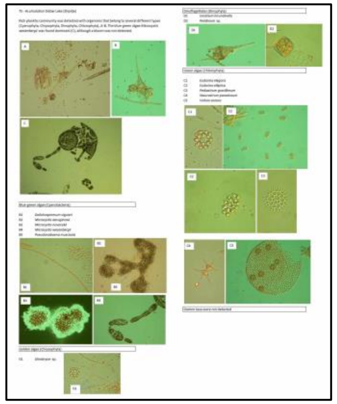
Water quality indices across Europe—a comparison of the good ecological status of five river basins Peter Carsten von der Ohe et al; J. Env. Mon, 9, 2007

https://pubs.rsc.org/en/content/articlelanding/2007/em/b704699p#!divAbstract

Biological assessment in the Drin catchment

- General lack of biological monitoring data in all riparian territories
- Annex III conclusions based largely on a single summer campaign in 2017 covering just 33 stations across the four territories – **this needs extended both spatially and temporally to provide more reliable data for ecological assessment**
- Assessment at some stations was compromised due to low flow / dry conditions
- Extensive evaluation of macroinvertebrates (insects), diatoms (micro-algae), and macrophytes (plants) by a team of trained biologists
- Wide range of standard Biotic Indices were calculated and summarised for each matrix - **possibility to streamline the approach to perhaps one or two BI to minimise post sampling workloads?**
- Need to match biological sampling to chemistry sites to get a more balanced perspective on water quality





Intercalibration

Most European countries have standardised procedures for biological monitoring but how can we be sure they all give similar outcomes – the answer is “Inter-calibration” whereby the approaches are compared in a similar environment

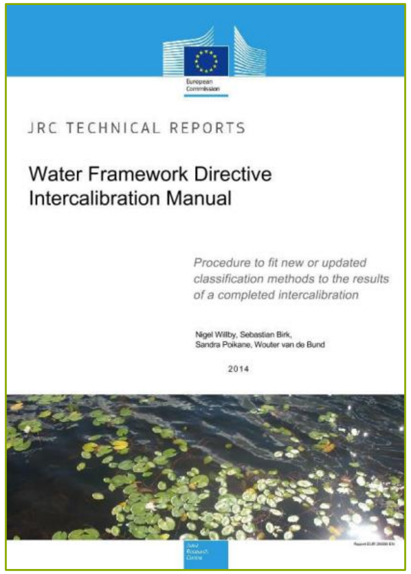
Through the JRC (Ispra) the Commission has facilitated intercalibration exercises and has assessed their outcomes based on the various Geographic Intercalibration Groupings.

EU Decision of 20th Sept 2013 (2013/480/EU) provides a summary of Work undertaken to compare several MS national classification systems for a range of metrics.

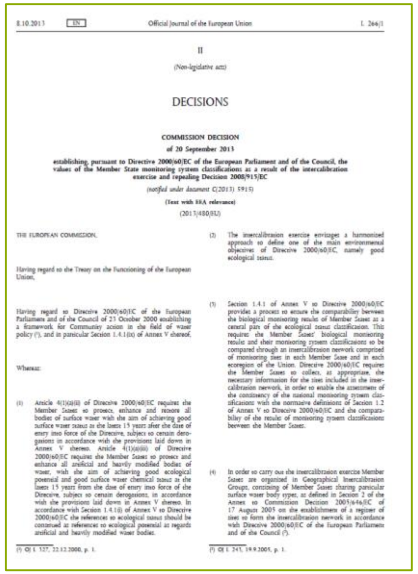
CIS Guidance documents 6 and 14 refer to the procedures for application and interpretation of Intercalibration exercises

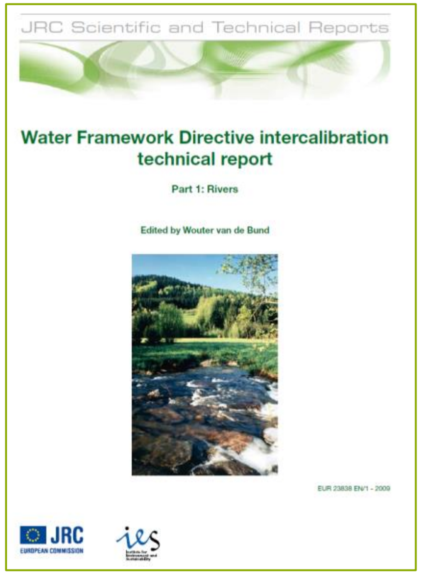
https://circabc.europa.eu/sd/a/a091506c-6fc8-45a8-a588-5c6397ed2aa4/Guidance%20No%206%20-%20intercalibration%20(WG%202.5).pdf

https://circabc.europa.eu/sd/a/366c3e9c-4780-4c9d-bb39-c47262915c45/Guidance%20No%2014%20-%20Intercalibration%20process.pdf



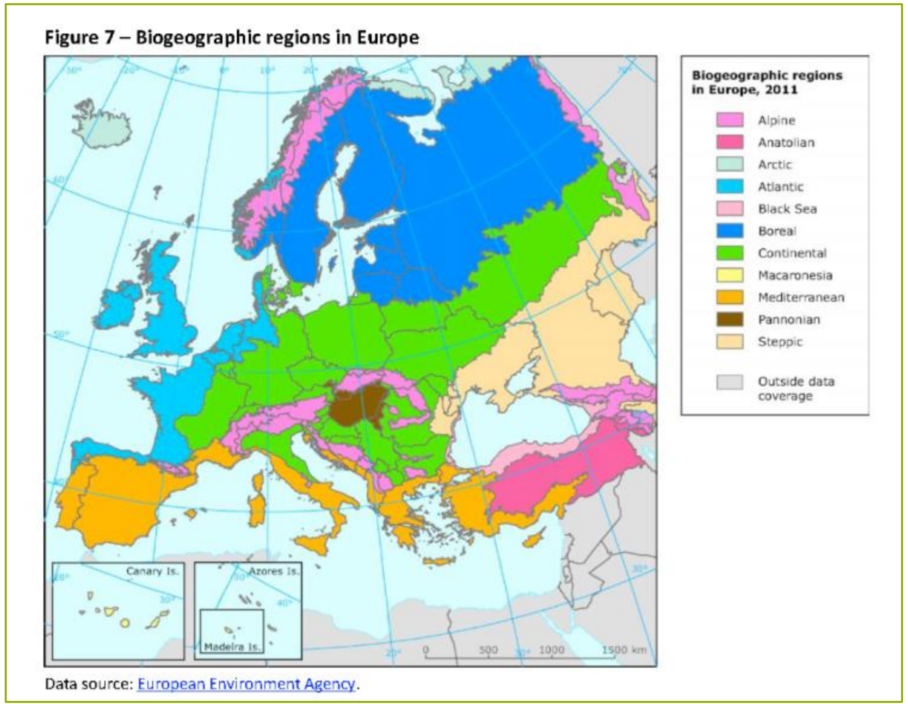
http://publications.jrc.ec.europa.eu/repository/bitstream/JRC89002/final%20report_march.pdf



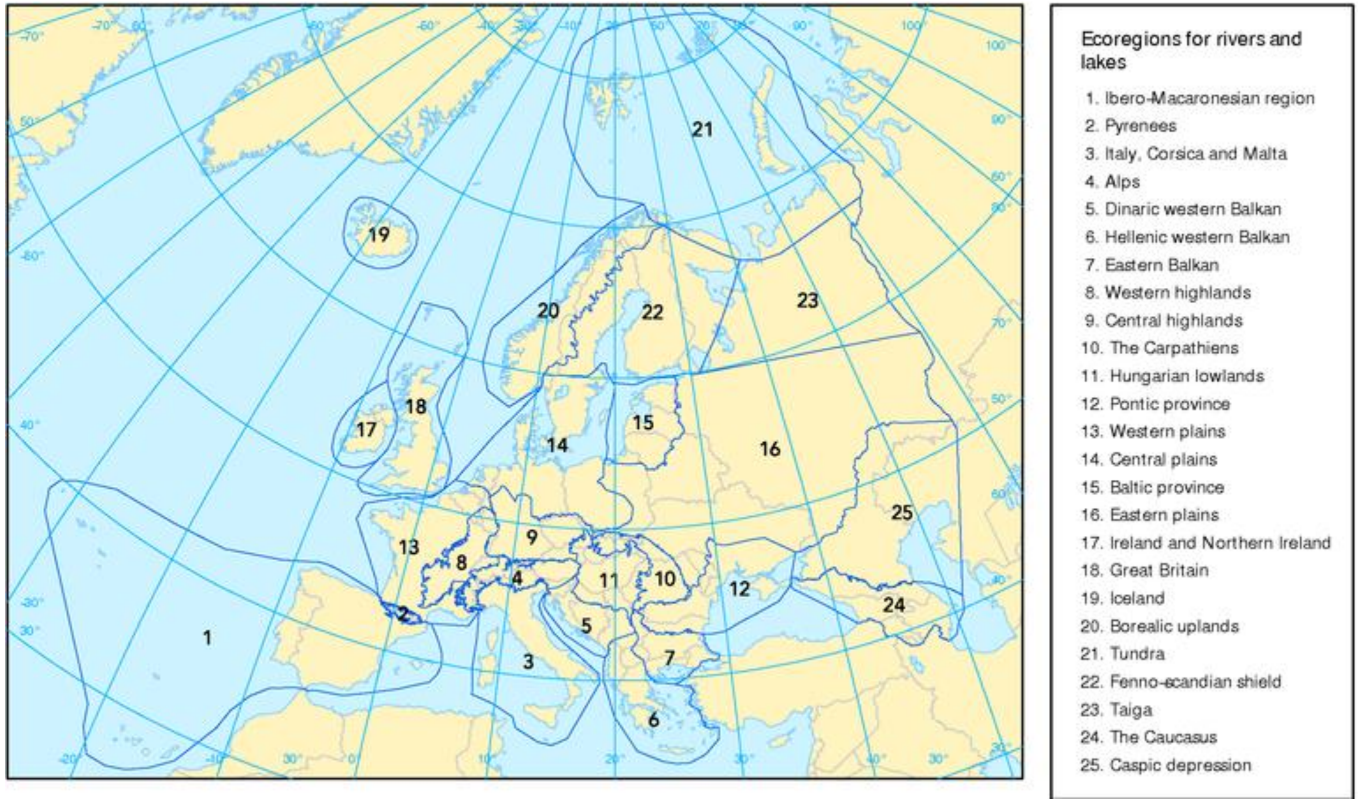


http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/294/1/reqno_jrc51339_3008_08-volumeriver_dec09.pdf

EU bioregions



Data source: European Environment Agency.



Montenegro / Albania grouped with other Mediterranean countries such as Italy, Greece, Spain for the purposes of biological comparability

Montenegro / Albania split between Ecoregions 5 and 6 – Dinaric / Hellenic Western Balkans

Published On April 16, 2015 in
Safeguarding Biological Diversity: EU Policy And International Agreements

WFD – GPC assessment - waters

- Which parameters to use?
- In which combination?
- What weighting (if any) to apply?
- Data transformation applied (Yes / No)?

In general there are 4 primary component groupings

- Acidity / Alkalinity (pH) / Hardness
- Oxygenation – BOD5, Dissolved Oxygen, (Ammonia), possibly COD
- Nutrients – Ortho P, Oxidized N / Nitrate , Ammonia
- Thermal conditions

What characteristic to apply?

- Face value assessment
- Mean / Range criteria
- Median / Mode
- Percentile – if so - 75%, 90%, 95% What level of statistical confidence ?

EU CIS Technical Guidance Note 19 – Guidance on Surface Water Chemical Monitoring under the WFD

https://circabc.europa.eu/sd/a/e54e8583-faf5-478f-9b11-41fda9e9c564/Guidance%20No%2019%20-%20Surface%20water%20chemical%20monitoring.pdf

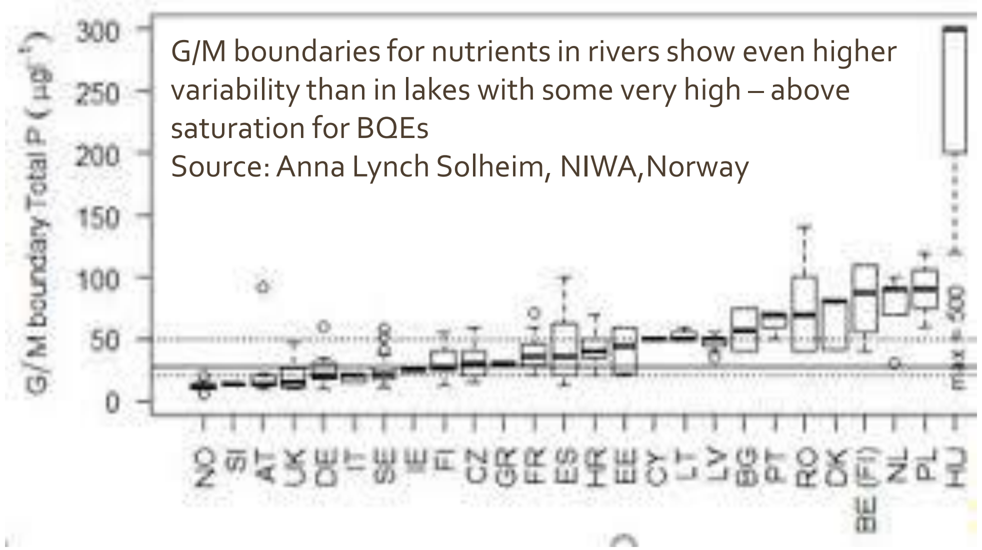
WFD – GPC assessment – What boundary values to set

Chemical quality classification for nutrients, salts and total parameters; comparison value: 90 percentile

Substance	Unit	Substance-based chemical water quality class						
		I	I - II	II	II - III	III	III - IV	IV
Total nitrogen	mg/l	≤1	≤ 1.5	≤ 3	≤ 6	≤ 12	≤ 24	> 24
Nitrate nitrogen	mg/l	≤ 1	≤ 1.5	≤ 2.5	≤ 5	≤ 10	≤ 20	> 20
Nitrite nitrogen	mg/l	≤ 0.01	≤ 0.05	≤ 0.1	≤ 0.2	≤ 0.4	≤ 0.8	> 0.8
Ammonium nitrogen	mg/l	≤ 0.04	≤ 0.1	≤ 0.3	≤ 0.6	≤ 1.2	≤ 2.4	> 2.4
Total phosphorus	mg/l	≤ 0.05	≤ 0.08	≤ 0.15	≤ 0.3	≤ 0.6	≤ 1.2	> 1.2
Orthophosphate Phosphorus	mg/l	≤ 0.02	≤ 0.04	≤ 0.1	≤ 0.2	≤ 0.4	≤ 0.8	> 0.8
Oxygen*	mg/l	> 8	> 8	> 6	> 5	> 4	> 2	≤ 2
Chloride	mg/l	≤ 25	≤ 50	≤ 100	≤ 200	≤ 400	≤ 800	> 800
Sulphate	mg/l	≤ 25	≤ 50	≤ 100	≤ 200	≤ 400	≤ 800	> 800
TOC	mg/l	≤ 2	≤ 3	≤ 5	≤ 10	≤ 20	≤ 40	> 40
AOX	µg/l	"0"	≤ 10	≤ 25	≤ 50	≤ 100	≤ 200	> 200

*comparison value: 10 percentile, alternatively minimum

Source: Federal Environment Agency, Bund/Länderarbeitsgemeinschaft Wasser (Working Group of the Federal States on Water Problems)



https://www.vannportalen.no/globalassets/nasjonalt/engelsk/harmonisation-and-implementation-of-the-wfd-in-the-northern-countries/8th-nordic-conference/presentations-day-1/anne-lyche-solheim-niva---harmonisation-of-nutrient-standards-in-europe.pdf

Nutrient Classification System (NCS) for not hydro-morphologically altered small/medium sized rivers based on annual average concentrations found in 36 sites scattered throughout Greece

		Quality classes				
		High	Good	Moderate	Poor	Bad
$N\text{-}NO_3^-$	mg/l	<0.22	0.22–0.60	0.61–1.30	1.31–1.80	>1.80
$N\text{-}NH_4^+$	mg/l	<0.024	0.024–0.060	0.061–0.20	0.21–0.50	>0.50
$N\text{-}NO_2^-$	μ g/l	<3.0	3.0–8.0	8.1–30.0	30.1–70.0	>70.0
$P\text{-}PO_4^{3-}$	μ g/l	<70	70–105	106–165	166–340	>3[illegible]
TP	μg/l	<125	125–165	166–220	221–405>	>405.13

Nikolaos Skoulikidis, Greece, 2006

http://twrm-med.net/southeastern-europe/regional-dialogue/activities/capacity-building-workshops/capacity-building-workshop-201cthe-implementation-of-the-water-framework-directive-wfd-as-a-means-to-enhanced-water-resources-management201d/Presentations/Presentation_B-Sc.pdf

UK Standards

http://www.legislation.gov.uk/uksi/2015/1623/pdfs/uksiod_20151623_en_auto.pdf

WFD – GPC assessment

- **Acidity** – generally straightforward to assess with no extreme values e.g. < 5, >8.5
- **Dissolved Oxygen** – typically 80 – 120% saturation is acceptable
  - Need to avoid inclusion of severe DO depletion or supersaturation – may need check on data integrity
  - May require establishing correlation between monitored mg/l and % saturation data to gain full use of data
- **BOD5** – can be difficult to obtain robust assessments especially if LoQ is poor e.g. "<2" as large numbers of qualified results can markedly influence calculations – and therefore the class assessments. For unpolluted rivers BOD5 AND carbonaceous BOD can generally be consider equivalent for practical purposes. COD values are generally to low in rivers to be of much practical use.
- **Ammonia and Phosphorus** – may be useful to examine e.g. log-transformed data vs. raw data as Ammonia data is generally left skewed and P data can show high variability
- **Oxidized Nitrogen / Nitrate** – Impacts from NO_2 are generally small (ca. 1% of TON) and seldom (but not always) insignificant so use a combined TON and Nitrate dataset for assessment purposes.
- **Hardness / Alkalinity** – may be necessary to establish a correlation especially where metals (Cu, Zn) EQS values may be hardness dependent
- **Ireland's legislation requires failure of <u>both</u> Mean and 95%ile EQS thresholds for any individual parameter failure and > 1 out of 3 for group failure of Nutrients or Oxygenation**

WFD – GPC assessment - Ireland

- Only stations with **10 or more results over a 3 year period** are assessed. Fewer than 10 samples necessitate the station to be manually reviewed (with caution in interpreting outcomes. <10 results are not summarised for EU reporting
- pH assessment is done at face value with Alkalinity / Hardness determining boundary conditions for Hard / Soft waters
- Dissolved Oxygen 95%ile value should be between 80 -120% - some 'anomalous' data may need reviewed before inclusion in calculations – typically as a result of misreported units values
- BOD, Ammonia, Phosphorus are all assessed using +1 log-transformed data (though other transformations may be suitable)
- TON / Nitrate is assessed on face value using a combined dataset (to ensure maximum coverage) as concentrations are sufficient for quantitation with very few < values
- For any of the nutrients to fail requires both the Mean and 95%ile EQS to fail at more than 99% confidence
  - **Though generally satisfactory for many stations if the 99% Confidence Interval is large then the station may appear to pass (statistically) but show a clear likelihood of actually being of lesser status. Expert review is necessary**
- Overall GP assessment is based on One Out – All out. If any grouping fails then GPC status is set to Moderate
- Chemistry data is matched with biological macroinvertebrate classifications. Any mismatches are individually reviewed (typically 10-15% of monitored sites)

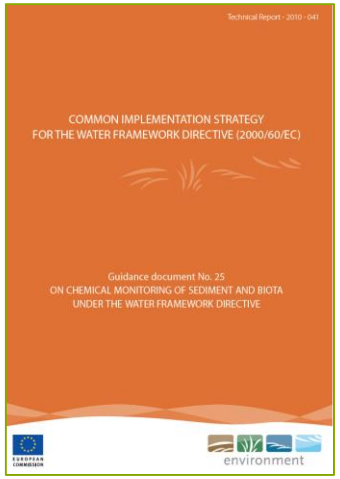
WFD – GPC assessment – Biota / Sediment

- **Biota assessments complicated by the choice of matrix and fraction examined – e.g. whole fish, liver, wet / dry weight etc.**

  - **Sediments**
  - **Molluscs**
  - **Fish**



- **Sediment assessments complicated by choice of sampling method, rate of sedimentation, location, Depth, No. samples etc.**
- **CIS Guidance document No. 25 (Chemical Monitoring of Sediment and Biota)**
- **CIS Guidance document No. 32 (Biota monitoring for determination of EQS biota)**
- **CIS Guidance document No. 33 (Analytical Methods for Biota monitoring)**



No. 25 https://circabc.europa.eu/sd/a/7f47ccd9-ce47-4f4a-b4f0-cc61db518b1c/Guidance%20No%2025%20-%20Chemical%20Monitoring%20of%20Sediment%20and%20Biota.pdf

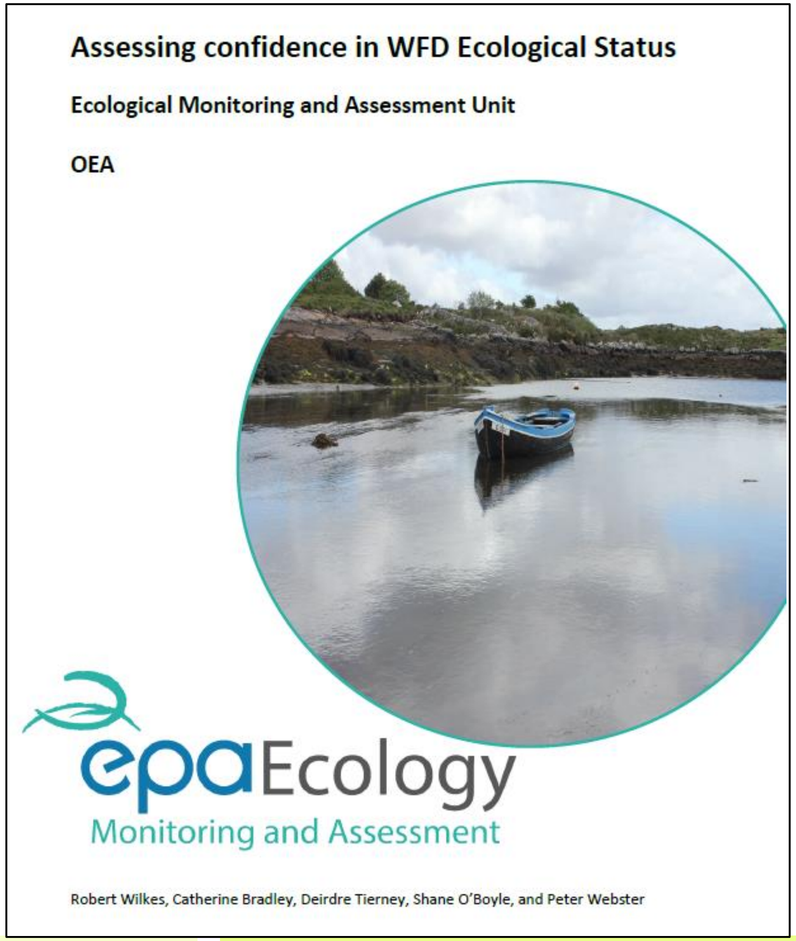
No. 32 https://circabc.europa.eu/sd/a/9cf535ba-14f2-4f0f-b75e-e334ad506caf/Guidance%20No%2033%20-%20Analytical%20Methods%20for%20Biota%20Monitoring.pdf

No. 33 https://circabc.europa.eu/sd/a/9cf535ba-14f2-4f0f-b75e-e334ad506caf/Guidance%20No%2033%20-%20Analytical%20Methods%20for%20Biota%20Monitoring.pdf


WFD – Assessing Ecological confidence

WFD reporting required the Irish EPA to collate and document (for the first time) each of the tools used to determine the contribution of each of the biological components.

It was necessary to come to a conclusion as to how the Confidence of status assessment could be determined


Assessing confidence in WFD Ecological Status

Ecological Monitoring and Assessment Unit

OEA

epaEcology

Monitoring and Assessment

Robert Wilkes, Catherine Bradley, Deirdre Tierney, Shane O'Boyle, and Peter Webster

Table 1. Confidence in classification for a status class.

Ecological Status	Confidence	Implication
Status Class	High (Scenario 1)	The waterbody is in a particular status. All elements agree with high confidence. We can be confident that measure can be applied to address issue for this water body (e.g. Improve or Maintain)
	Medium (Scenario 2)	The waterbody is in a particular status. One or more elements agree but with medium confidence. This implies that assessment is closer to a class boundary. Measure need to assess implications from risk of misclassification.
	Low (Scenario 3)	The waterbody is in a particular status. One or more elements agree but with low confidence. These elements are close to or at a class boundary, e.g. 'Moderate-low confidence' could be at the Good boundary implying that water body might be better than face value. Need to consider all elements, trends in status and other data. Or, it could be at Poor boundary and therefore definitely in need of measures to improve. There is a chance that this waterbody may be in a different class and measures/actions need to consider this.
	No Information	The waterbody is in a particular status. One or more elements agree but one may have no information, e.g. Hydromorphology. In such cases further analyses may be needed to calculate the confidence.

WFD – Ecological confidence explained

Physico-chemical elements

- Good status or better where there are no fails or high 'face value' anomalies = High confidence of correct status assigned – Level 3
- Stations "passing" but having high 'face value' averages or 95%ile values > EQS = Low confidence of correct status assigned - Level 1
- Moderate Status – where this is evident from more than 1 parameter failing = High confidence of correct status assigned - Level 3
- Moderate Status – in all other cases = Medium confidence – level 2

Invertebrates (Q-values)

The confidence in class for macroinvertebrates is based on the coefficient of variation for Q-Values which in turn is derived from the results of the formal WFD Intercalibration exercise[5, 9]. The coefficient of variation is around 10% or lower over the range High to Poor (Table 2).

Fish

Probability of being present in each status class is calculated by the fish tool for each site. Some further analyses of the fish data is needed to provide a final confidence in class or in more cases this has been reported as 0, no information.

Hydromorphology

The classification of hydromorphology does not include an assessment of confidence. In the absence of a calculated confidence a rating of 0, no information, is given. Work is ongoing to improve our knowledge and assessments for this element.

Similar approaches have been applied to Lakes, Transitional and Coastal waters using appropriate biometric tools e.g. seagrass distribution, rock shore algae etc.

Ecological confidence outcomes:

Scenario matrix outlining some of the potential implications for different confidence levels in status classes

Extrapolated status

Status in non-monitored water bodies is assigned based on extrapolation from other water bodies with similar physical characteristics and pressures. The status from the donor monitored water body is applied to the other members of the extrapolation group. Confidence is assigned one class lower than the monitored water body.

References:

EC, *The values of the Member State monitoring system classifications as a result of the intercalibration exercise (2008/915/EC)*. 2008, THE COMMISSION OF THE EUROPEAN COMMUNITIES: Official Journal of the European Union.

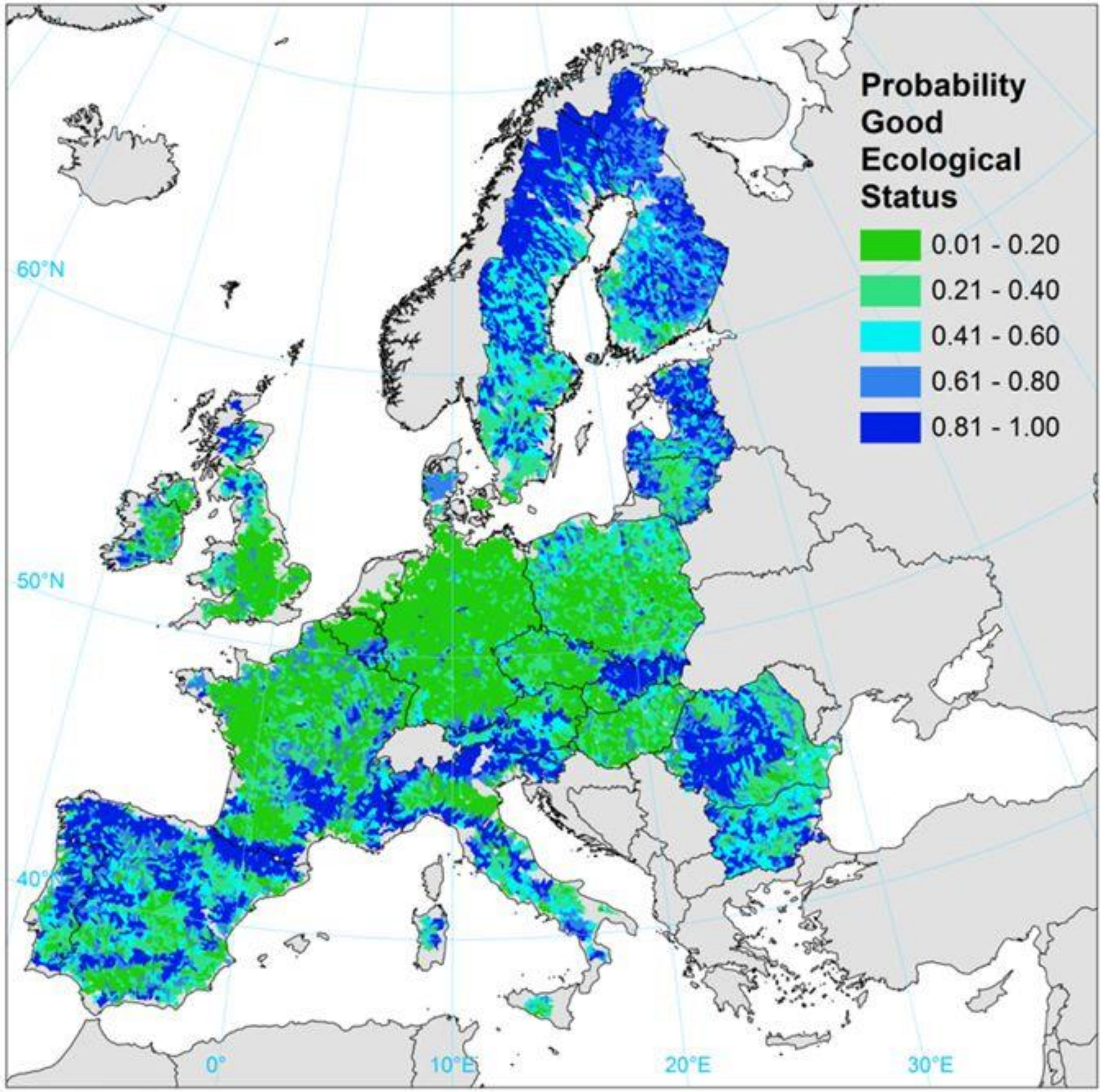
EC, *The values of the Member State monitoring system classifications as a result of the intercalibration exercise and repealing Decision 2008/915/EC*. 2013, THE COMMISSION OF THE EUROPEAN COMMUNITIES.

Commission, E., *WFD CIS Guidance Document No. 13. Overall Approach to the Classification of Ecological Status and Ecological Potential*, in *COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)*. 2003.

Buffagni, A. and M. Furse, *Intercalibration and comparison — major results and conclusions from the STAR project*, in *The Ecological Status of European Rivers: Evaluation and Intercalibration of Assessment Methods*, M.T. Furse, et al., Editors. 2006, Springer Netherlands: Dordrecht. p. 357-364.

Ecological Status	Confidence	Implication
High	High (Scenario 1)	The waterbody is in high status. All elements are in high status with high confidence. Measures are to maintain and prevent deterioration.
	Medium (Scenario 2)	The waterbody is in high status. One or more elements are in high status with medium confidence. This implies that assessment is closer to Good boundary. Waterbody is vulnerable to deterioration. Vulnerability can be measured by the number of elements at medium confidence. Measures are to maintain and prevent deterioration.
	Low (Scenario 3)	The waterbody is in high status. One or more elements are in high status with low confidence. These elements are close to or on the high/good boundary. Waterbody is very vulnerable to deterioration. Vulnerability can be measured by the number of elements at low confidence. Measures are to prevent deterioration. These water bodies could be a higher priority for action than water bodies with medium confidence.
Good	High (Scenario 4)	The waterbody is in good status. One or more elements are determining good status with high confidence. Some elements may be in high status. The element/s determining status are a generally in the middle of the class range. Measures are to maintain status.
	Medium (Scenario 5)	The waterbody is in good status. One or more elements are determining good status with medium confidence. Some elements may be in high status. Some elements are closer to class boundaries. If the elements are closer to the moderate boundary then this water body is more vulnerable.
	Low (Scenario 6)	The waterbody is in good status. One or more elements are determining good status with low confidence. Some elements may be in high status. Elements at boundary, particularly at G/M, require particular attention to prevent deterioration. Elements that have dropped to Good from High may be just below the H/G boundary and could need measures to restore.
Moderate	High (Scenario 7)	The waterbody is in moderate status. One or more elements are determining moderate status with high confidence. Some elements may be in high or good status. The element/s determining status are a generally in the middle half of moderate. Not vulnerable to further deterioration. Measures are to restore status.
	Medium (Scenario 8)	The waterbody is in moderate status. One or more elements are determining moderate status with medium confidence. Some elements may be in high or good status. Element is closer to the poor boundary may be at increased likelihood of further deterioration. Element may be closer to good boundary so measure to improve may be more immediately effective.
	Low	The waterbody is in moderate status. One or more elements are determining moderate status with low confidence. Some elements may be in high or good status. Elements may be closer to good boundary so measure to improve may be more immediately effective. Elements may be closer to the poor boundary. Measures may be more challenging to bring to Good.

The issue in Poor and Bad are less important as the element driving status will need comprehensive measures to bring it back to good. Confidence may indicate how close to the boundary the element is and may be an indication of tendency to improve/deteriorate.



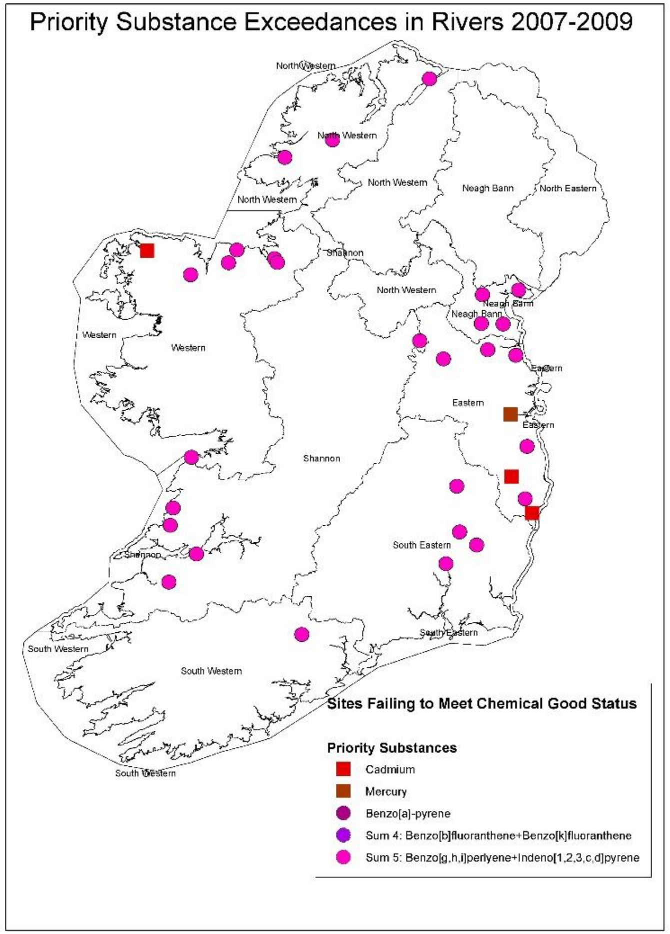
Human pressures and ecological status of European rivers
[B. Grizzetti](), [A. Pistocchi](), [C. Liquete](), [A. Udias](), [F. Bouraoui]() & [W. van de Bund]()

Scientific Reports **Volume 7**, Article number: 205 (2017)

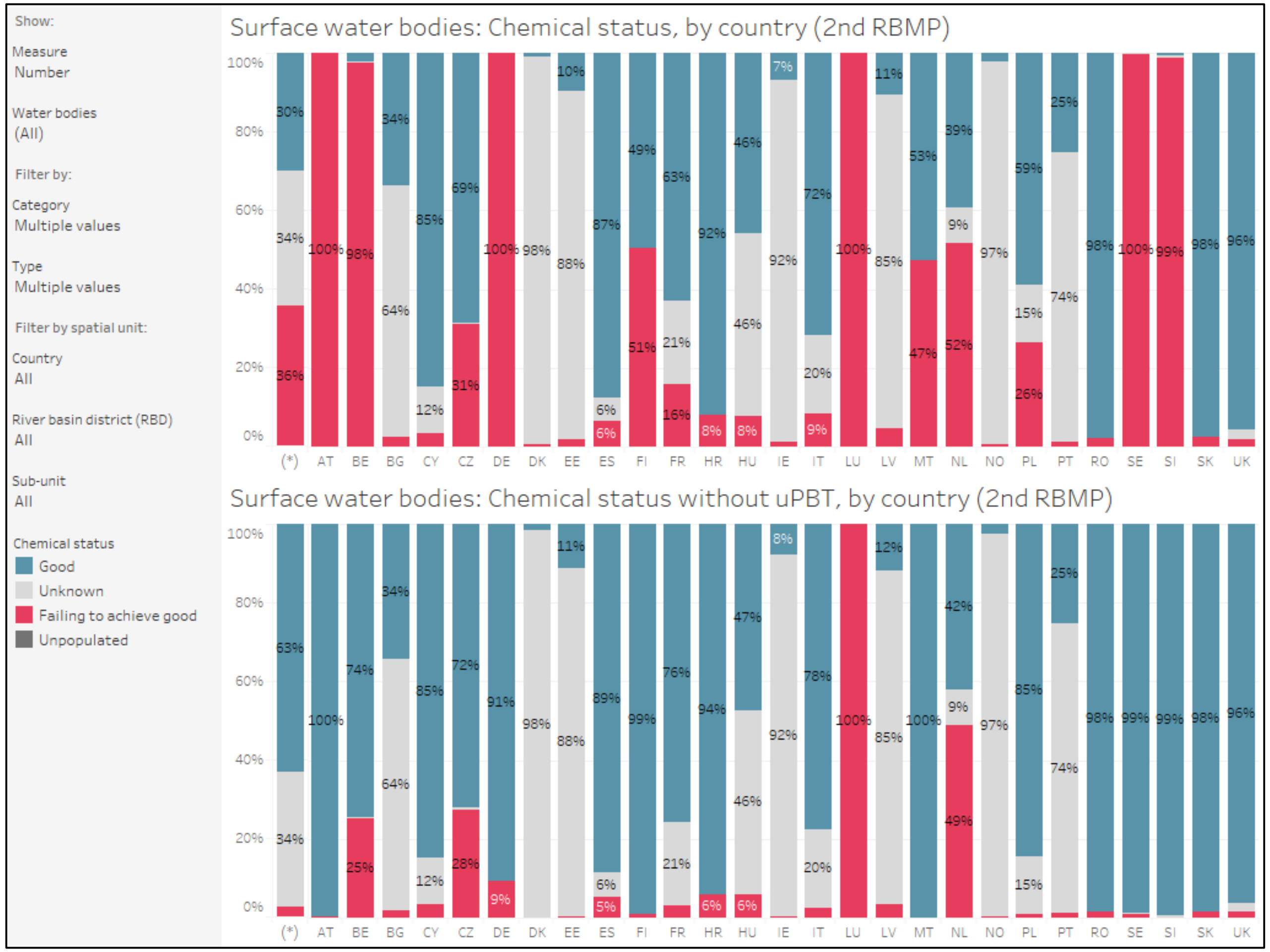
https://www.nature.com/articles/s41598-017-00324-3

WFD – Chemical status

- Chemical status is based solely on compliance with national / EU EQS values for PS / PHS parameters
- Ireland has 16 Specific (national) Pollutants – mostly metals and pesticides (Table 10)
- There are a further 35 substances (22 PS, 13 PHS) with EQS values in national legislation ([SI 272 of 2009]() – amended by SI 327 of 2012 and SI 386 of 2015). The 2015 amendment added 11 emerging substances such as Estrodiols and antibiotics as well as redefining PAHs EQS for Benzo-a-pyrene only.
- In 2006 a major survey of 26 locations (rivers / lakes / estuaries) was undertaken to determine the occurrence of substances listed in Directive 2000/60/EC. Many were not found to be present in the Irish environment so monitoring has focussed on the following groups of substances:
  - Volatile Organic Compounds e.g. Methylene Chloride, Trihalomethanes etc.
  - Metals (determined by ICP-MS)
  - PAHs
  - Pesticides / Herbicides
- Monitoring is undertaken monthly in one year of the 6 year WFD cycle (approx. 30 sites per year) for all parameters. 6 sites currently monitored for the 2015 added compounds
- Most results are (thankfully) reported as non-detected though some positive detects are observed from time to time – **this causes a major issue in evaluation of AA-EQS values**



WFD – Chemical status - EEA database



What this graphic clearly shows is that where countries have been ultra-conservative and classed all of their rivers as failing due (typically) to the presence of Hg, PAHs in fish there is a gross distortion

e.g. AT, BE, DE, LU, SE, SK all have virtual 100% failure

If however these ubiquitous PBTs are excluded the picture of Europe's surface waters looks very different

It also highlights differences in approaches to the classification of un-monitored rivers e.g. DK, IE,NO have high proportions (>90%) as unclassified => unmonitored

Source: EEA (2019)

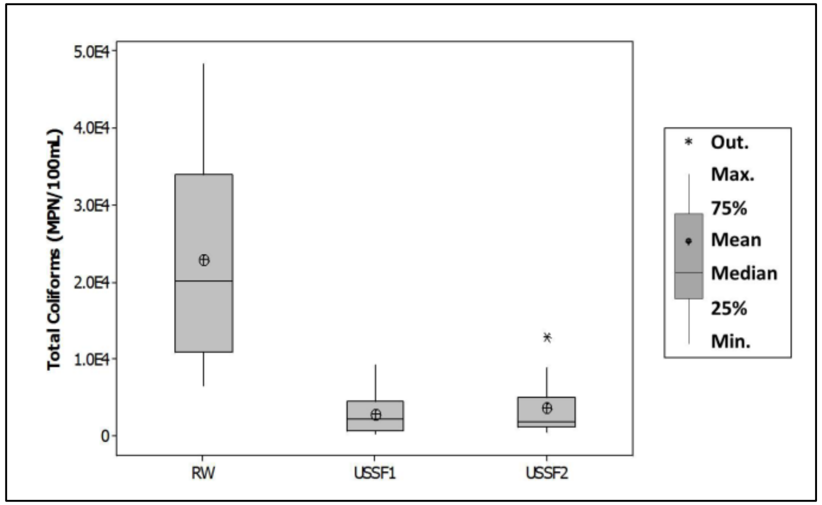
"River pollution by priority chemical substances under the Water Framework Directive: A provisional pan-European assessment"
AlbertoPistocchi[a]ChiaraDorati[b]AlbertoAloe[b]AntoniGinebreda[c]RafaelMarcé[d]
https://www.sciencedirect.com/science/article/pii/S0048969718352471

WFD – What to do with less than values

- Most EQS values are set as Annual Averages (AA-EQS) or as Maximum Allowable Concentration (MAC-EQS)

- This is fine providing all results are above the method LoQ (and this is less than the EQS) but often data is reported as <LoQ (e.g. <1 µg/l)

- Options for data transformation include:
  - Removing the censored data
  - Data substitution at 0.5*LoQ (s per Directive 2009/90/EC)
  - Use of 'face-value' assessment
  - Use of percentage (%) targets
  - Assessment by parametric (statistical methods) e.g. percentiles
  - Assessment using probability (non-parametric) methods



- Each one of these approaches has some limitation to its applicability as shown in the next slide …

WFD – What to do with less than values

Data option	Limitation
Remove censored data	Undesirable causes severe distortion of observations
Substitute < xx with 0.5*LoQ	Required by EU Directive but can result in serious bias when LoQ is high relative to EQS
Face value assessment	Does not consider spatial / temporal distribution and may be influenced by test method LoQ
Percentage targets	Based on achievement of an arbitrary target value (e.g. 20%) but is sample number dependent
Use of percentiles	Well suited to positive values e.g. nutrients but PS /PHS distributions are typically right skewed towards the lower boundary value. Generally requires larger sample numbers (typically >20) for robust assessment
Non-parametric methods e.g. "Look up tables"	Generally based on binomial probability at some confidence limit. Small sample sizes have a high chance of passing
Weighting of frequency / magnitude of exceedance supported by Regression on Ordered Statistics (RoS)	This is the approach adopted by Ireland following extensive consultation with stakeholder. It uses a matrix of frequency of detection / magnitude of exceedance to provide a weighted outcome. In the event of uncertainty this is also assessed using RoS

Application of RoS to real data: https://www.epa.gov/nps/nonpoint-source-monitoring-technical-notes

Reference: "*Statistics for Censored Environmental Data using Minitab and R*", Helsel D.R. ISBN 978-0-470- 47988-9 (Wiley publ.)

WFD – Ireland's approach – an outcome matrix

Frequency of exceedance

No. of EQS exceedences (from n=12 results)	Proportion (for other n)	Assignment	Frequency Weighting
None	None	NA	1
1	0 -10%	Very Low	2
2	10 -15%	Low	3
3	15-25%	Moderate	4
4	25-50%	High	5
5 or more	More than 50%	Very High	6

Magnitude of Exceedance of the EQS

Ratio to EQS	Assigned	Magnitude Weighting
< 2 x EQS	Very Low	1
2-3 x EQS	Low	2
3-5 x EQS	Moderate	3
5 -10 x EQS	High	4
> 10 x EQS	Very High	5

Assessment Outcome table

Confidence of Exceedence metric	Confidence of EQS exceedence	Assessment Outcome	Status to be assigned
LoQ > EQS	Unproven	Unable to determine compliance due to analytical performance issues	N/A
No detects	Extremely Low	Highly unlikely to be non-compliant	Pass
< 4	Very Low	Very unlikely to be non-compliant	Pass
4 - 9	Low	Compliance is more likely than not	Pass
10 -14	Moderate	Compliance not sufficiently proven. More data required for assessment	Fail
15 -20	High	Non-compliance is more likely than not	Fail
> 20	Very High	Non-compliance is very likely	Fail

Metric	Arithmetic	RoS	
No. detects > AA-EQS (0.002)	2 (Low)	2 (Low)	Overall the assessment of this locations was that it did not meet sufficient criteria to be considered as confidently failing the EQS
Mean	0.00686 µg/l	0.0054 µg/l	
Frequency weighting	2	2	
Margin of Exceedence	Moderate (3-5*EQS)	Low (2-3*EQS)	
Magnitude Weighting	3	2	
Confidence of Exceedence metric	2 x 3 = 6	2 x 2 = 4	
Likelihood of non-compliance	Low	Very Low	
Status	Pass	Pass	

Evaluation of marginal PAHs apparent failures by both conventional averaging and by use of RoS

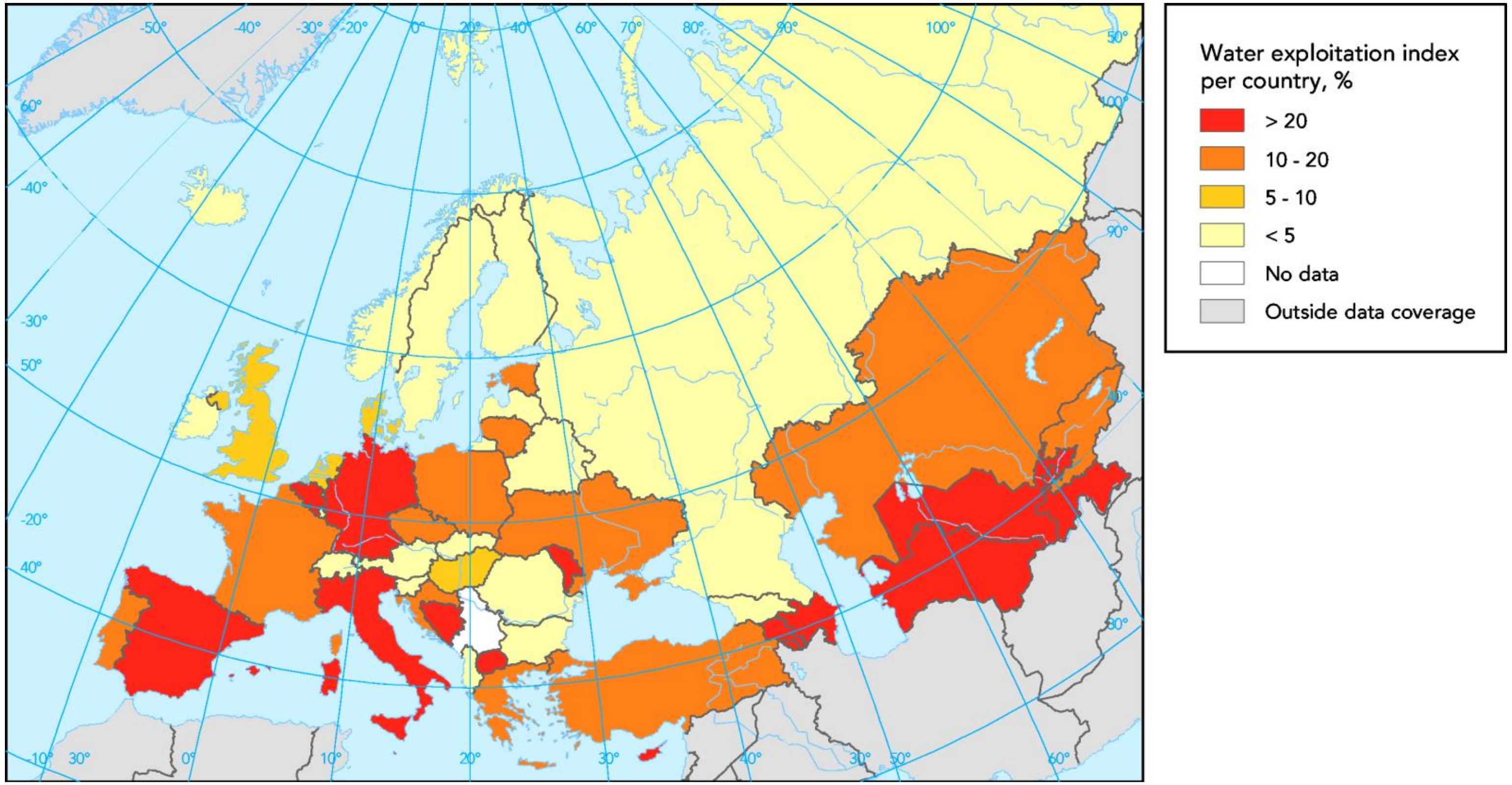
Water quantity

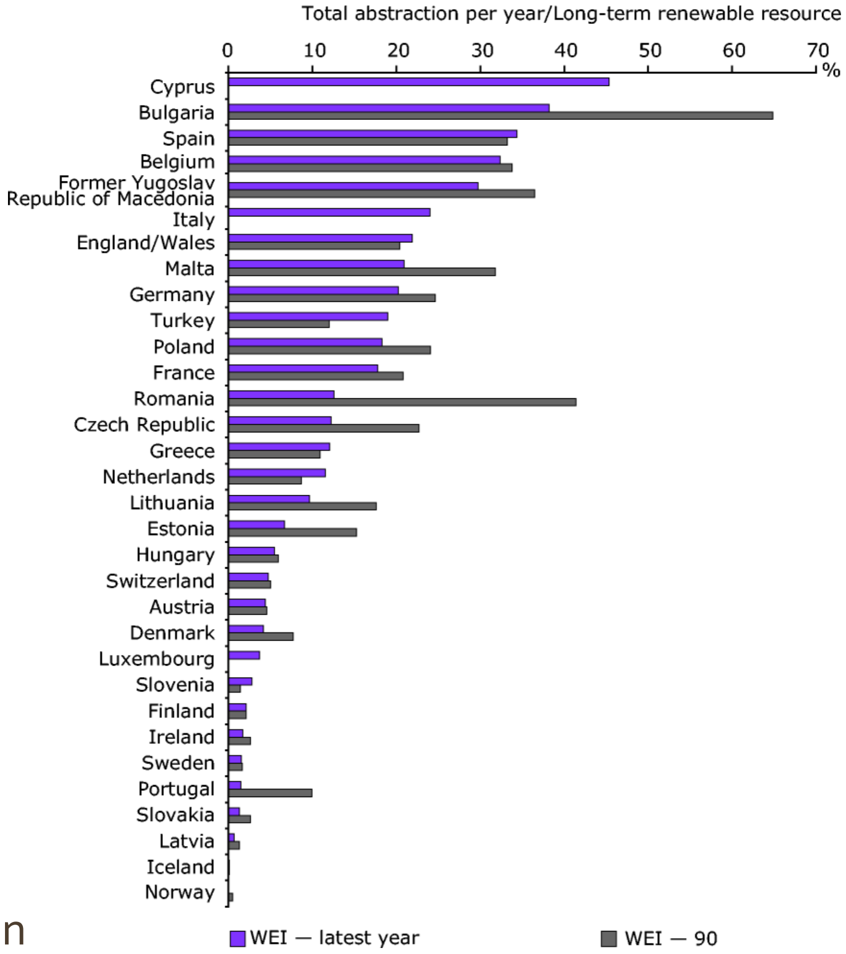
- WFD reporting also include provision of data on water quantity, abstractions, reuse, wastewater discharges
- The EEA Water Exploitation Index (WEI+) is geo-referenced and has been developed for use on a seasonal scale. It takes into account water abstraction (gross) and return (net abstraction) to reflect water uses etc.
- **WEI+ = (abstractions - returns)/renewable freshwater resources.**
  - Renewable freshwater resources are calculated as **'ExIn + P - Eta - ΔS'** for natural and semi-natural areas, and as 'outflow + (abstraction - return) - ΔS' for densely populated areas where: ExIn = external inflow, P = precipitation, ETa = actual evapotranspiration, ΔS = change in storage (lakes and reservoirs), outflow = outflow to downstream/sea.
  - UWWT data and Ecostat population data are used as a surrogate for the "return" value.
- It is assumed that there are no pristine or semi-natural river basin districts or sub-basins in Europe. Therefore, the formula 'outflow + (abstraction - return) - ΔS' is used to estimate renewable water resources.
- The EU's Roadmap to a Resource Efficient Europe (EC, 2011) also includes a milestone for 2020, namely that 'water abstraction should stay below 20 % of available renewable freshwater resources'
- In Southern Europe there has been a growing trend towards bottled water consumption
- **Agriculture accounts for ca. 46% of water usage in Europe with Southern Europe using ca. 90% of the total volume used for irrigation**

Water scarcity management: http://ec.europa.eu/environment/water/quantity/pdf/comm_droughts/8a_1.pdf

Water exploitation

- **Water exploitation index per country in % (2016)**

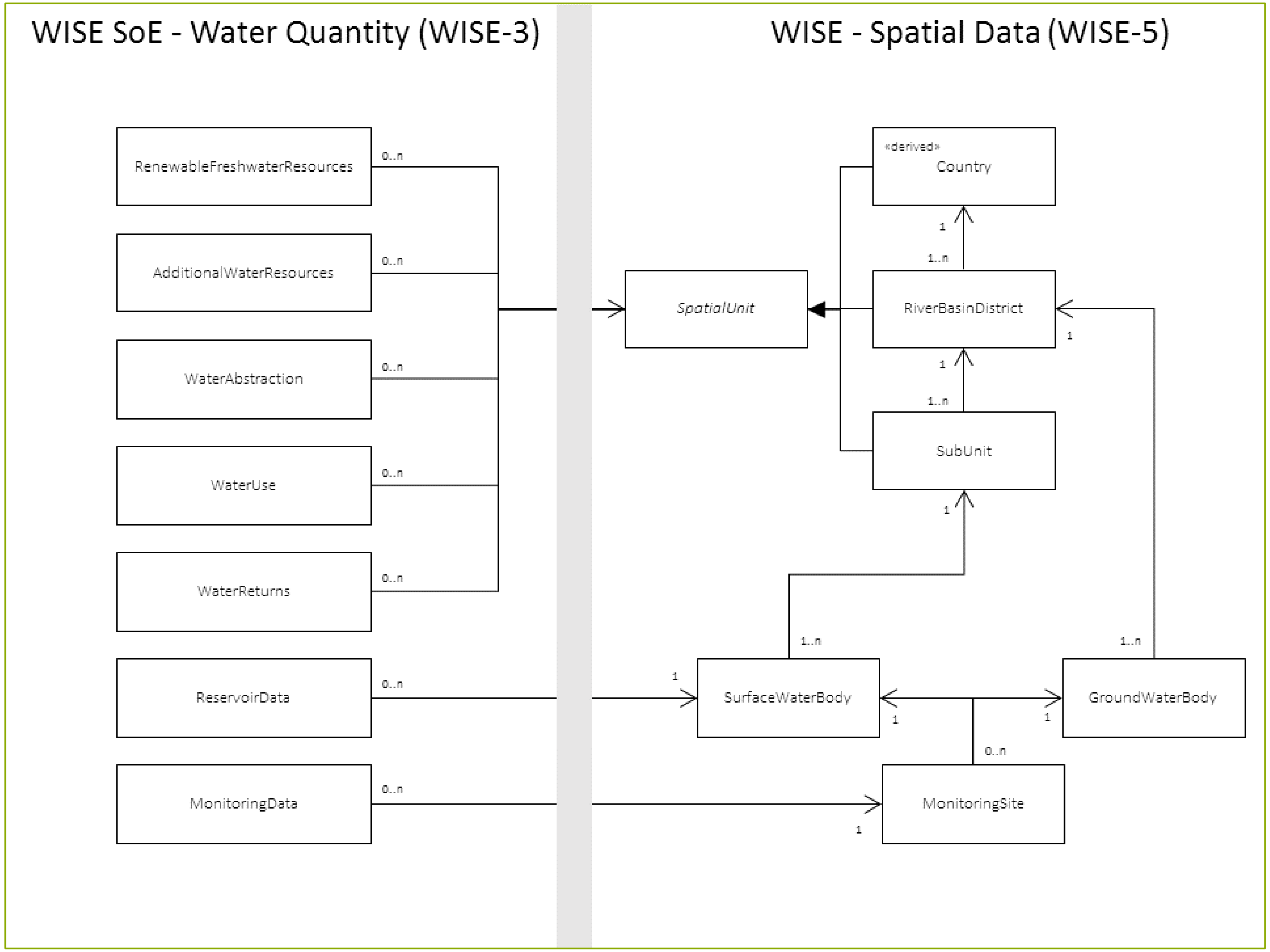




Despite reductions in overall water usage ca. 31% of Europe’s population live in areas with water stress where use exceeds renewable supply

Source: European Environment Agency
https://www.eea.europa.eu

Water quantity –WISE reporting



- Reporting via EEA EIONET WISE-3

  https://rod.eionet.europa.eu/obligations/184

  http://cdr.eionet.europa.eu/help/WFD/dir2000060ec/WISE_SoE/wise3

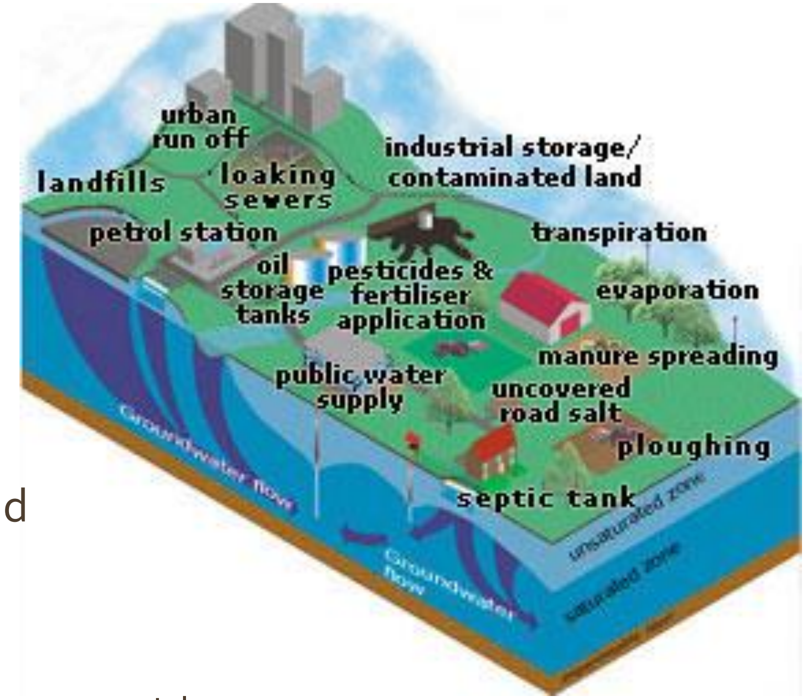
- Specific tables using WFD spatial information

G Copestake, Paul & P Goody, Nigel & Gosling, Richard & H Logan, Fiona & J Rodgers, Paul. (2019). The Water Framework Directive: a monitoring strategy for determining the quantity and dynamics of flow in Scotland

https://www.researchgate.net/publication/265248357

Groundwater

- Groundwater status consists of both quantitative (the amount of groundwater) and chemical (the quality of groundwater) components.
- Groundwater levels have been used as one of the measures of quantitative status, using a weight of evidence approach. To achieve good groundwater quantitative status, the available groundwater resource (i.e. the long-term average rate of overall groundwater recharge to the body less the long term annual rate of flow required to achieve the ecological quality objectives for associated surface waters) is not exceeded by the long-term annual average rate of abstraction.
- Groundwater abstraction must not also cause failure of good ecological status in dependent surface water bodies, significant damage of dependent wetlands (groundwater dependent terrestrial ecosystems) or saline or other intrusions.
- Groundwater chemical status is measured by concentrations of pollutants and changes in electrical conductivity in the groundwater body such that it:
  - does not exhibit effects of saline or other intrusions e.g. nitrate pollution;
  - does not exceed the Community quality standards;
  - would not result in failure to achieve the environmental objectives in associated surface waters or terrestrial ecosystems.



Sources of groundwater pollution © NERC 1998

Groundwater

- EPA Ireland GW methodology

METHODOLOGY FOR ESTABLISHING GROUNDWATER THRESHOLD VALUES AND THE ASSESSMENT OF CHEMICAL AND QUANTITATIVE STATUS OF GROUNDWATER, INCLUDING AN ASSESSMENT OF POLLUTION TRENDS AND TREND REVERSAL

epa Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

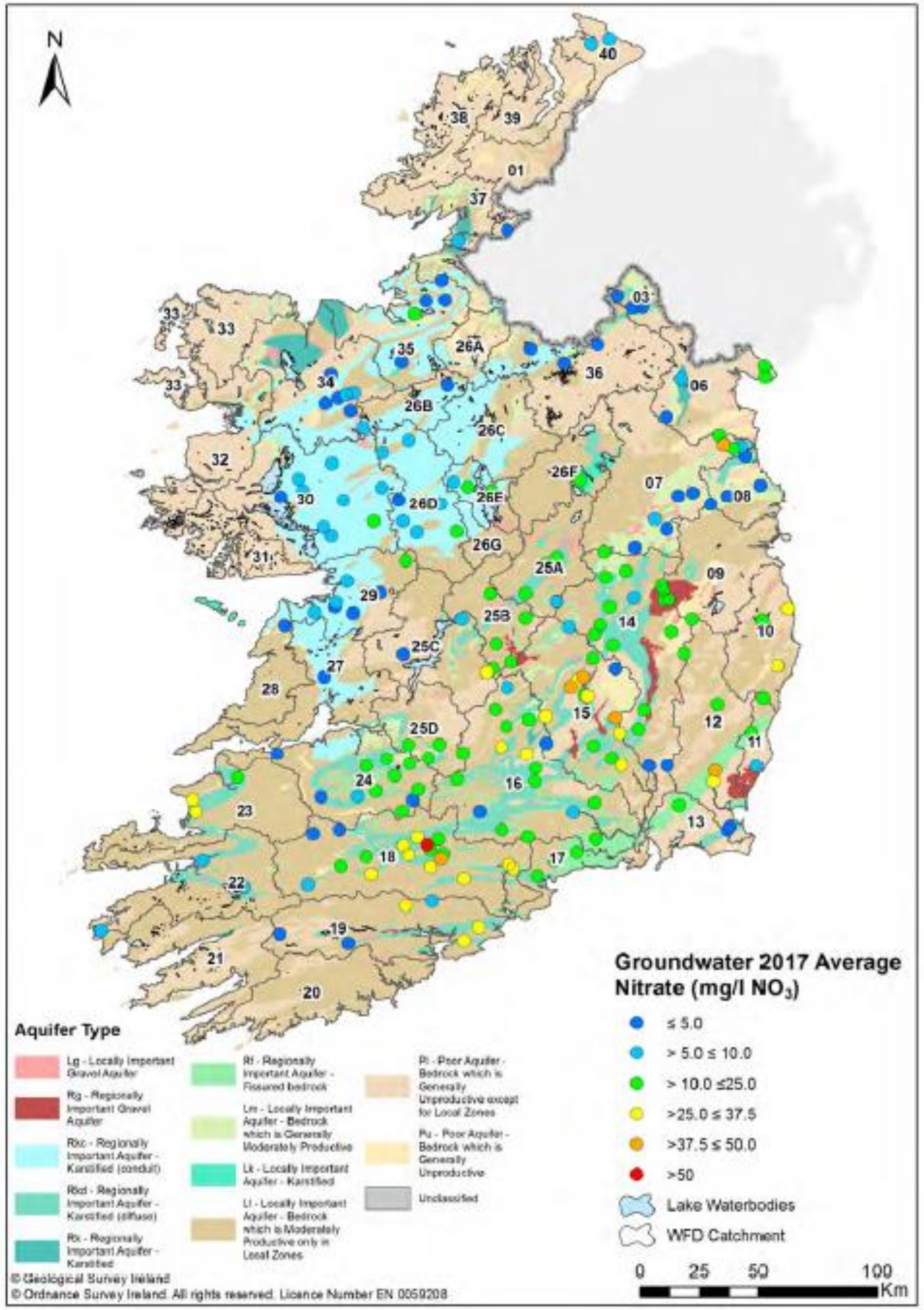
Hydrometric and Groundwater Section
Office of Environmental Assessment

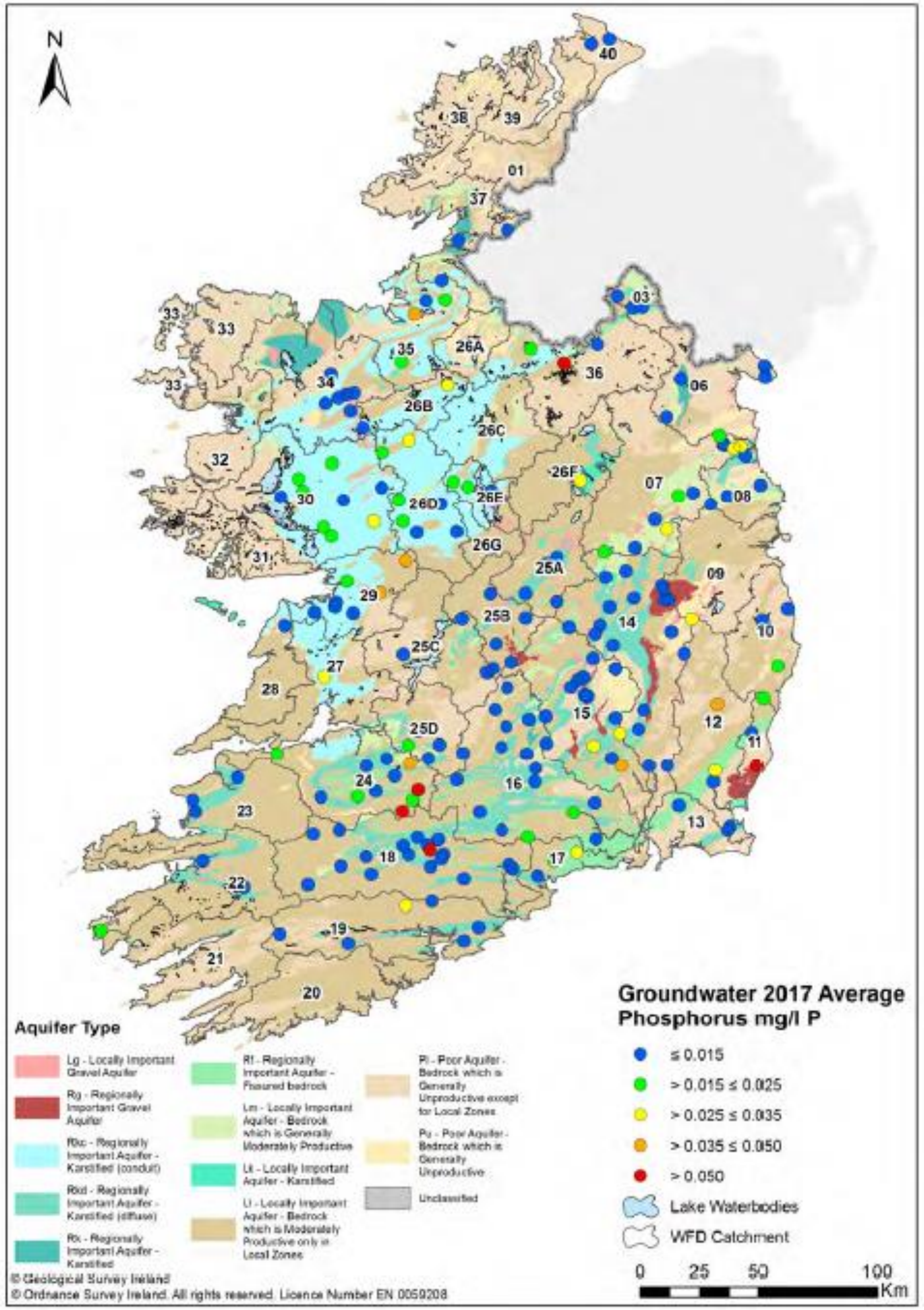
Version 1
December 2010

http://www.epa.ie/wfdstatus/groundwater/GW_Groundwater_Chemical_Quantitative_Status_Methology_TVs_and_Trends_June_10_Final_Dec10.pdf

Monitoring Suite	Determinands
Standard Suite	pH, Temperature, Conductivity, DO, Colour, Alkalinity, Total Hardness, Nitrate, Ammonium, Nitrite, Total Phosphate, Molybdate Reactive Phosphorus, Iron, Manganese, Sodium, Potassium, Chloride, Calcium, Sulphate, Cadmium, Arsenic, Zinc, Mercury, Lead, Magnesium, Copper, Boron, Aluminium, Nickel, Chromium, Total Organic Carbon, Fluoride, Barium, Molybdenum, Silver, Cobalt, Strontium, Beryllium, Antimony, Turbidity, Uranium
Additional determinands	E-Coli, Total & Faecal Coliforms, Pesticides (Atrazine, MCPA, 2,4-D, IPU, Mecoprop, Chlortoluron, Glyphosate, Bentazone, Cypermethrin, Dieldrin, DDT, Lindane and Diuron); selected VOC's & Hydrocarbons

195 monitoring stations monitored on a quarterly basis





Nutrients (2017)

NO_3- Stable or No trend detected in 83% of stations (2008-17). 10% of stations showing some signs of improvement

Phosphorus – Stable or No trend detected in almost all stations

Implementing measures

Monitoring can provide information to allow source apportionment between potential pollution sources but such programs need to be specifically thought through before commencement. **They will not solve the problem alone!**

It is essential that proposed POMs are reviewed for their cost effectiveness – and that expenditure is carefully recorded for future WFD reporting purposes

Existing measures such as the Nitrates Directive (2006) have had some impact on improving water quality but change is **VERY SLOW** and it may take up to 10-20 years to see improvements.

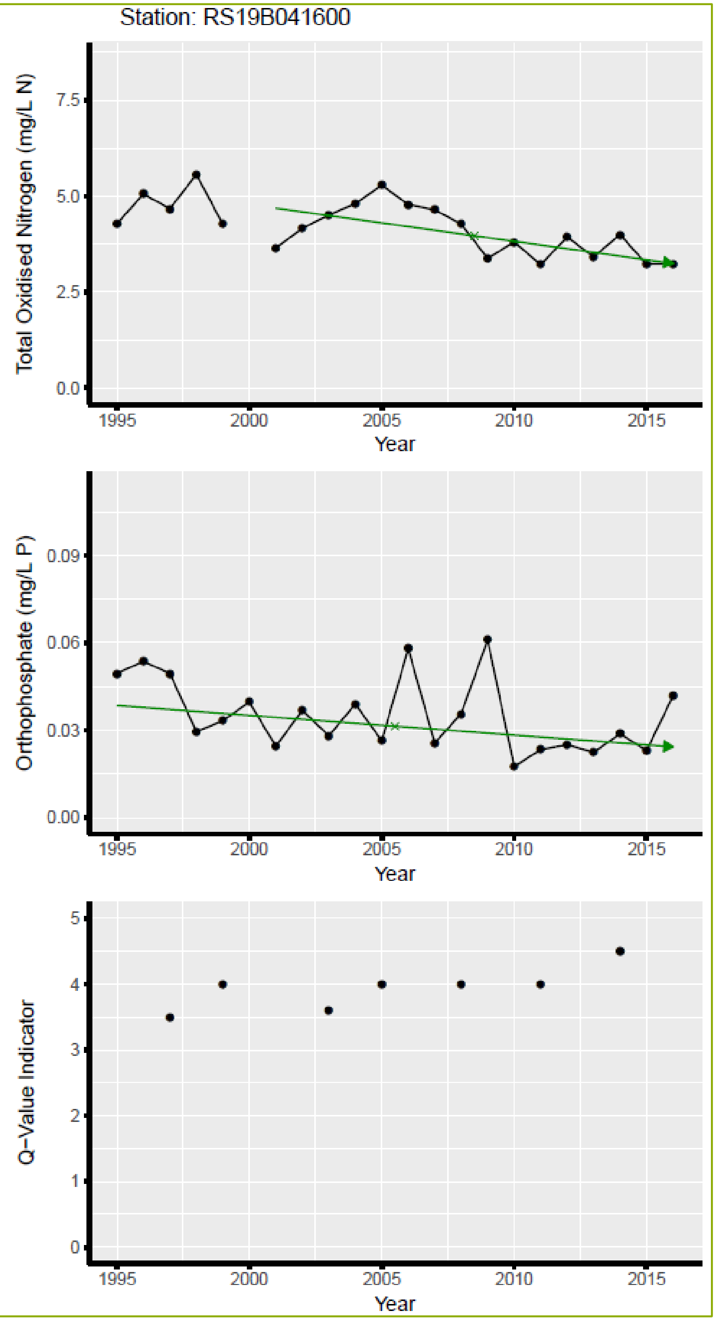
In several countries the UWWTD (91/271/EEC and amended by Directive 98/15/EC) has not been fully implemented

The type of WFD measures most commonly reported by Member States (MS) (beyond existing pre-WFD directives) are:

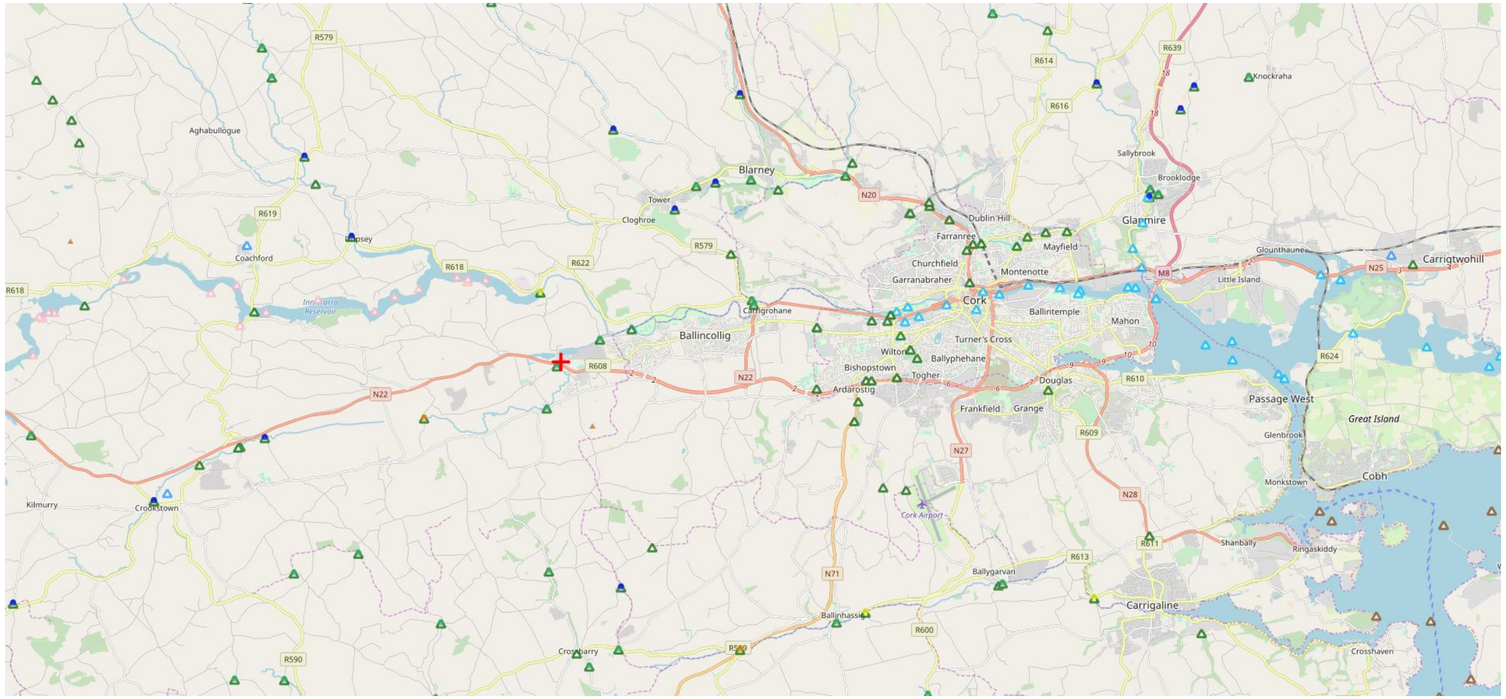
- Construction or upgrade of urban waste water treatment (19 MS)
- Reduce nutrient pollution in agriculture (16 MS)
- Improving river continuity and other hydro-morphological measures (16 MS)
- Research, improvement of knowledge base reducing uncertainty (15 MS)
- Drinking water protection measures (15 MS).

Latvia economic assessment of POMs http://gauja.balticrivers.eu/files/wp3_report_economic_evaluation_lvpdf

EC –DGEnv – Pre/Post WFD measures http://ec.europa.eu/environment/water/water-framework/economics/pdf/Defining%20pre-WFD%20and%20WFD%20measures.pdf



Year	TON	OP	Q
1995	4.283	0.0495	NA
1996	5.059	0.0536	NA
1997	4.676	0.0495	3.5
1998	5.569	0.0295	NA
1999	4.267	0.0332	4
2000	NA	0.0397	NA
2001	3.651	0.0245	NA
2002	4.163	0.0369	NA
2003	4.511	0.0281	3.6
2004	4.81	0.039	NA
2005	5.283	0.0264	4
2006	4.788	0.058	NA
2007	4.646	0.0256	NA
2008	4.275	0.0357	4
2009	3.378	0.061	NA
2010	3.809	0.0175	NA
2011	3.216	0.0233	4
2012	3.936	0.025	NA
2013	3.42	0.0224	NA
2014	4	0.0288	4.5
2015	3.225	0.023	NA
2016	3.24	0.0418	NA

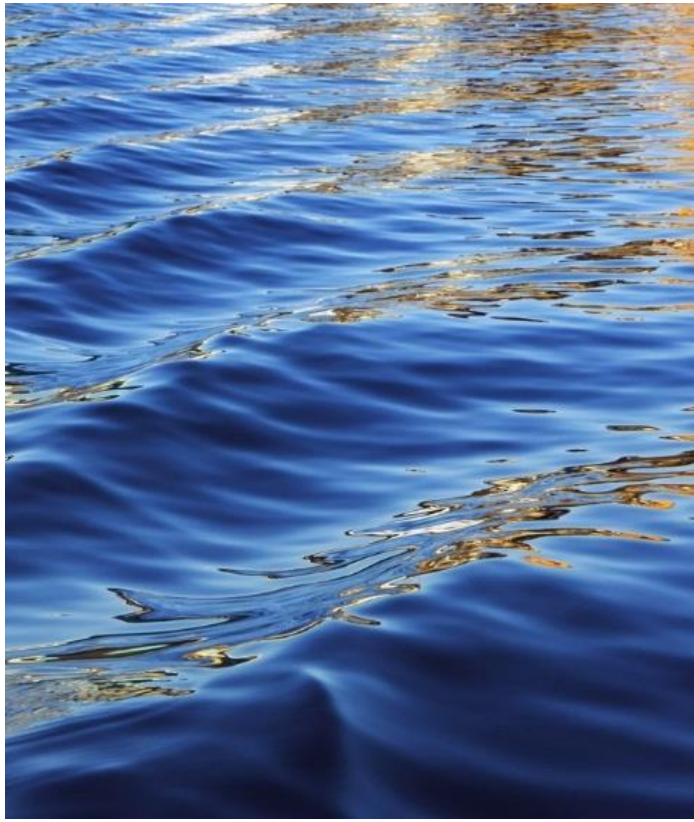


RS 19B041600 - River Bride just u/s of R. Lee confluence

Drains mainly dairy farming lands. Nutrient management plans in place for land-spreading of livestock manures

Biological quality has increased over 20 years from Q value 3.5 (EQR 0.7) up to 4.5 (EQR 0.9) with Nitrogen dropping from ca 5 mg/l N to ca 3 mg/l over **20 years** but now seems to have stabilised

Thank you



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