Relevance of sediment management in the context of river basin management planning

10th International SedNet Conference

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Diversity of uses, aspirations, pressures and impacts

Water is a cross-cutting issue

Diversity of river basins in Europe

Water is a transboundary issue!

Important role of sediments

- Development of the river bed and morphodynamics
- Habitats for aquatic species
- Connection to groundwater bodies and coastal zones
- River engineering, flood protection, hydropower, torrent control, restoration...
- Integral part of water ecosystem

Sediment management relevant for EU environmental legislation

- **Water Framework Directive 2000/60/EC**
- Floods Directive 2007/60/EC
- Nature Protection Directives: Habitats Directive 92/43/EEC and Birds Directive 2009/147/EC
- EIA Directive 2011/92/EU
- Marine Strategy Framework Directive 2008/56/EC
- ...

EU Water Framework Directive (WFD)

The River Basin concept

- **Holistic approach**: Protection and sustainable management of all surface and groundwater, including transitional and coastal waters
- Covering **all pressures and impacts**
- Water management at **river basin level**
- **River Basin Management Plans**: Basic instrument to implement WFD

WFD: The DPSIR approach: 6-years cycle

- **Economic act.**
- **Agriculture**
- **Urbanisation**
- **Energy**
- **Industrial dev.**

Driving Forces

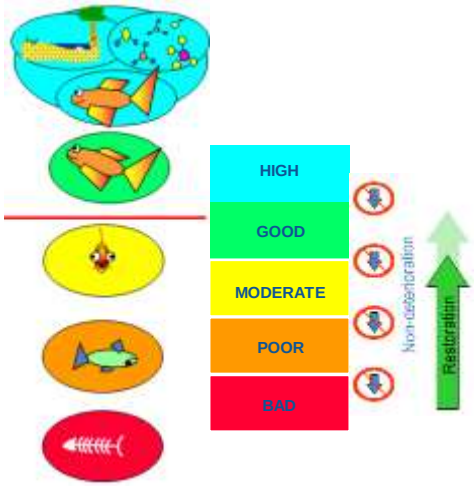
Responses

- **Urban Waste Water Treatment Directive**
- **Nitrates Directive**
- **Industrial Emissions Directive**
- **WFD basic measures (regulation of abstraction, discharge, modification)**
- **RBMP planning process**

Pressures

- Water abstraction
- Wastewater discharges
- Diffuse pollution
- Physical alteration of water bodies

State



Impacts

- **Organic enrichment**
- **Eutrophication**
- **Altered habitats**
- **Reduced connectivity**
- **Loss of ecosystem services**
- **Socio-economic impacts**

Slide partly curtesy of Peter Pollard, Scottish Environment Protection Agency

WFD objectives

Good surface water status/potential

Good **ecological** status / potential	Is an expression of the quality of the structure and functioning of aquatic ecosystems including: **biological, hydromorphological and chemical elements**	High/Maximum Good Moderate Poor Bad
Good **chemical** status	Means meeting all **environmental quality standards** for chemicals set at EU level in Directive 2008/105/EC (priority substances)	Good Failing to achieve good

Good groundwater status

Good **quantitative** status	Means ensuring a **long-term balance** between abstraction and recharge, protecting as well associated surface waters and ecosystems.	Good Poor
Good **chemical** status	Means meeting all standards for chemicals, either set at EU level (pesticides and nitrates) or at national level (threshold values)	Good Poor

Water Framework Directive

Sediment related criteria?

Sediments and the WFD:

- Linked to Environmental Quality Standards (EQS) and/or River Basin Specific Pollutants (RBSP), and therefore WFD link to **sediment quality management**

- Inherent determining element for hydro-morphology, aquatic habitats and hence biological quality elements, therefore WFD link to **sediment quantity management**

Water Framework Directive

Sediment quality

Chemical status:

- EQS Directive (2008/105/EC amended by 2013/39/EU) lists **priority substances** (PS) and defines EQSs in biota and/or water
- MSs can choose to **monitor** some of the priority substances **in sediments**
- If, then EQSs in sediment have to be derived by MSs – at least as protective as the ones from the EQS Directive

Trend assessment:

- Monitoring of some PSs in sediment and/or biota (listed in Art. 3.6 EQSD)

Ecological status:

- MSs can derive EQSs in any **relevant matrix** (water, biota, **sediment)** for the substances they identify as RBSPs

→ Activities changing **fluxes of sediment or leading to re-suspension** of contaminated particulates should be considered in **pressure-impact analysis**

→ Can **impact chemical and/or ecological status** (through RBSPs)

Sediment quantity - related criteria

Quality elements for classification of **ecological status** (WFD Annex V)

Example: Rivers

Biological elements
- Composition and abundance of aquatic flora
- Composition and abundance of benthic invertebrate fauna
- Composition, abundance and age structure of fish fauna

Hydromorphological elements supporting the biological elements
- Hydrological regime
  - quantity and dynamics of water flow
  - connection to groundwater bodies
- River continuity
- Morphological conditions
  - channel patterns, river depth and width variation
  - flow velocities, substrate conditions,
  - structure and condition of the riparian zone

...

WFD quality elements for ecological status "shaped" by sediment quantity

Relevance for characterisation of water body types (WFD Annex II and Annex V)

Establishment of type-specific reference conditions

- Type-specific hydromorphological reference conditions (flow, width and depth variation, structure, substrate, …)
- Type-specific physicochemical reference conditions (thermal, oxygen, salinity, acidification, nutrients, …)
- Type-specific biological reference conditions (aquatic flora, benthic invertebrate fauna, fish)

… description of undisturbed or nearly undisturbed conditions

Undisturbed or nearly undisturbed conditions = High Status

Sediment transport specifically mentioned in normative definitions for hydro-morphological quality elements (WFD Annex V)

Hydromorphological quality elements

Element	High status	Good status	Moderate status
Hydrological regime	The quantity and dynamics of flow, and the resultant connection to groundwaters, reflect totally, or nearly totally, undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
River continuity	The continuity of the river is not disturbed by anthropogenic activities and allows undisturbed migration of aquatic organisms and sediment transport.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Morphological conditions	Channel patterns, width and depth variations, flow velocities, substrate conditions and both the structure and condition of the riparian zones correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Normative definition for High Status (Reference Conditions)

Normative definitions for Good and Moderate Status

Water uses affecting sediments

European Commission

Specified Uses	Navi-gation	Flood protection	Hydro-power generation	Agri-culture/ Forestry/ Fishfarms	Water-supply	Recreation	Urbani-sation
Physical Alterations (pressures)							
Dams & weirs	X	X	X	X	X	X	
Channel maintenance/dredging/removing of material	X		X	X		X	
Shipping channels	X						
Channelisation/straightening	X	X	X	X	X		X
Bank reinforcement/fixation/ embankments	X	X	X		X		X
Land drainage				X			X
Land claim				X			X
Creation of back waters through embankments	X					X	X
Impacts on hydromorphology and biology							
Disruption in river continuum & sediment transport	X	X	X	X	X	X	
Change in river profile	X	X	X	X			X
Detachment of ox-bow lakes/wetlands	X	X	X	X	X		X
Restriction/Loss of flood plains		X	X				X
Low/reduced flows			X	X	X		
Direct mechanical damage to fauna/flora	X		X			X	
Artificial discharge regime		X	X	X	X		
Change in groundwater level			X	X			X
Soil erosion/silting	X		X	X			X


Hengl, 2004

(Source: CIS Guidance Document No. 4)

Development of Program of Measures

Data on sediments can be crucial for

- Assessment of reasons for failure to achieve WFD objectives (e.g. hydromorphological alterations and impacts on habitats)
- Assessment of required measures to achieve WFD objectives
- Calculation of related costs (most cost-effective Program of Measures)
- Whether measures are technically feasible
- Input for justification of exemptions
- …

Closing the first implementation cycle: WFD implementation report March 2015


EUROPEAN COMMISSION

Brussels, 9.3.2015
COM(2015) 120 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

The Water Framework Directive and the Floods Directive: Actions towards the 'good status' of EU water and to reduce flood risks

Changing the flow and physical shape of water bodies (**HYMO**)

- Due to land drainage channels, dams for irrigation or hydropower, impoundments to facilitate navigation, embankments or dykes for flood protection
- Among **main factors** preventing achievement of good status
- First PoMs proposed **insufficient actions** to counter this
- Measures often very general, no prioritisation and **no clear link** with the existing pressures or expected effects
- Water status assessment **methods often not sensitive** to hydromorphological changes

http://ec.europa.eu/environment/water/water-framework/pdf/4th_report/COM_2015_120_en.pdf

➔ **Need for improved understanding and measures**

Reports on Good Ecological Potential for HMWB and mitigation measures

Report on water storage and mitigation measures

Report on floods (draft)

Source: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC103830/kj-na-28413-en-n.pdf

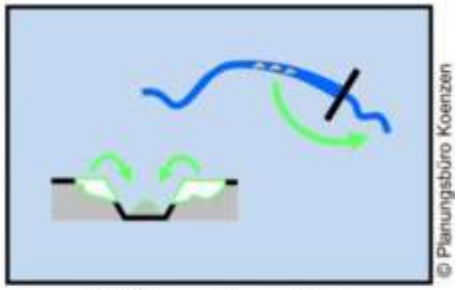
Example: Water Storage and Measures

European Commission

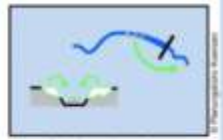
Table 5. Ranking of key types of mitigation for impacts from water storage for which measures are included in national libraries (based on responses from 23 European countries).

Mitigation for	Yes	No measure in library but impact identified/relevant	Not relevant	No answer	% yes
Upstream continuity for fish	21	0	2	0	91
Downstream continuity for fish	17	3	3	0	74
Low flow	16	2	5	0	70
Variable flow	14	4	5	0	61
Fish flow	13	1	9	0	57
Lake level alteration	13	3	7	0	57
Rapidly changing flows	12	3	8	0	52
Sediment alteration	10	5	8	0	43
Physico-chemical alteration	8	5	10	0	35
Ponded rivers (impoundments)	8	5	10	0	35

Example: Water Storage and Measures



Mitigation for sediment alteration

Hydromorphological alteration	Main ecological impact*	Mitigation for	Mitigation measures options	Mitigation measures in WFD reporting guidance 2016	Pictogram
River continuity for sediment disrupted or reduced leading to changes in substrate composition, disruption of morphodynamics in the ponded reaches (artificially stable river banks, disruption of lateral erosion processes)	Reduction in fish & invertebrate abundance & alterations in species composition Thermal changes Alteration or reduction in hyporheic species Alteration of self-purifying properties	**Sediment alteration**	Mechanical break-up of bed armouring Removal of sediment Re-introduce sediment (intake structures) Re-introduce sediment (reservoirs) Restore lateral erosion processes Introduce mobilising flows *(Fish stocking)*	Sediment management Removal of structures Restoration of bank structure Ecological flows Dredging minimisation Restoration of modified bed structure	 Mitigation for sediment alteration

Source: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC103830/kj-na-28413-en-n.pdf

Example: Water Storage and Measures

European Commission

Examples for mitigation measures on sediments

Mechanical break-up of bed armouring

Regulated flows can create an armoured substrate because of reduced flushing flows combined with fine sediment loads downstream of dams.

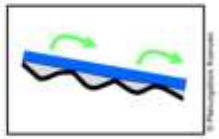
However, armoured beds are not necessarily created only due to fine sediment loads. An increase in fine sediment loads with reduced flushing flows leads to bed compaction. Armouring occurs due to the higher frequency of low magnitude events. Because of these constant low flow conditions, bed mobility involves smaller sediment fractions (i.e. sand-silt-clay). Therefore there is a high stability of surface bed material composed of coarser material, with the finer sediment trapped underneath.

This measure consists in mechanically breaking up the armoured river bed substrate to re-establish the lossed habitats. It should be noted that this measure should be considered together with flow alteration mitigation measures to increase its self-sustainability.

Removing bed fixation

Removal of sediment

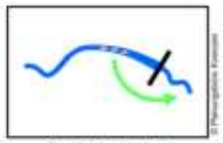
Mechanical removal of accumulations of sediment (eg to reform pools)



Removing accumulations of sediment

Re-introduce sediment (intake structures)

Re-introduce sediment downstream of river intake structures (eg through sluice gate; passively by weir design; by returning dredgings downstream)



Re-introducing sediment downstream of dam

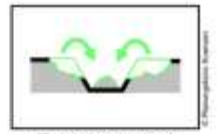
Re-introduce sediment (reservoirs)

Re-introduce sediment downstream of water storage reservoirs (including by actively introducing sediment or passively via a constructed bypass channel)

Re-introducing sediment downstream of reservoir

Restore lateral erosion processes

Restore lateral erosion processes in river (eg by removing engineering) to enhance local sediment supply

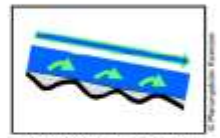


Enabling lateral erosion

Introduce mobilising flows

Introduce flows sufficient to mobilise sediment (flush fine sediment if colmation and/or mobilise coarse sediment)

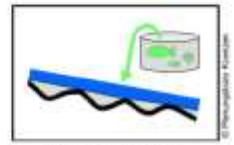
Flushing flows often are not feasible to improve type-specific sediment dynamic downstream of reservoirs. Instead of that, flushing flows from the bottom outlet of reservoirs cause high peaks with high loads of fine sediments in many cases, which is in many cases a critical alteration for river segments downstream.



Providing sufficient flows to mobilise sediment

Fish stocking

Fish stocking where interruption of sediment transport means bed characteristics are unsuitable for spawning and/or for juvenile fish. This measure can (to some extent) mitigate general hymo degradation (more than sediment alteration) for certain fish species but not all (e.g not eel).



Compensating habitat loss with fish stocking

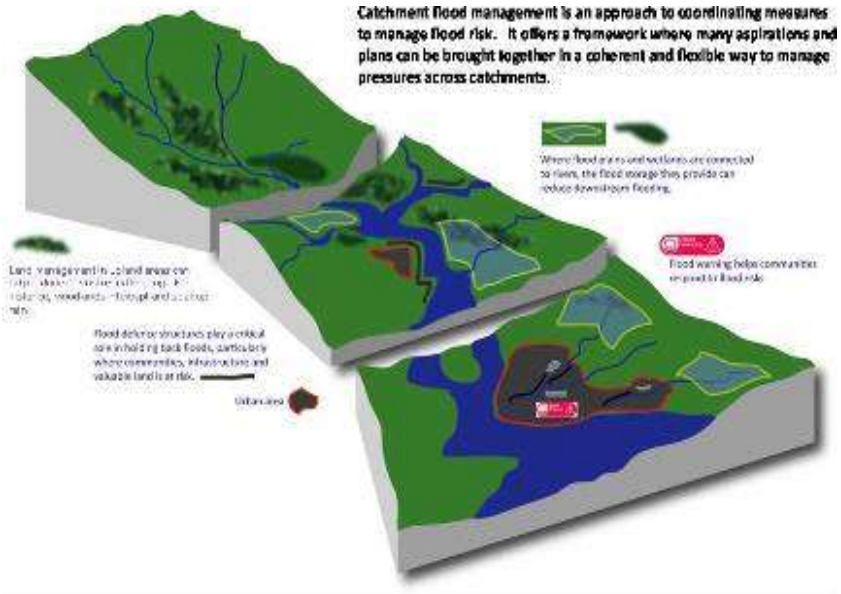
Source:
http://publications.jrc.ec.europa.eu/repository/bitstream/JRC103830/kj-na-28413-en-n.pdf

Brief excerpt: The Floods Directive

It creates a framework for the **assessment, mapping** and **management** of flood **risks,**

for **reducing** the adverse **consequences** for human health, economic activity, the environment, and cultural heritage.

Coordination across the river basin, including requirements for trans-boundary coordination!



Technical Report - 2014 – 078, Links between the Floods Directive and Water Framework Directive (adapted from Evers and Nyberg, 2013)

Conclusions

- **Sediments: Inherent role** for aquatic ecosystems and implementation of EU environmental legislation
- Relevance of **sediment quality and quantity**
  - Chemical and Ecological Status
  - Determining element for hydromorphology (sediment continuity…)
  - Habitats and biological quality elements (e.g. fish, macro-invertebrates, …)
- For **River Basin Management**: Strengthening abiotic indicators (next to biotic once) by **addressing also sediment regime**
- **Sediments addressed** at EU level and River Basins, however
- **Need for more targeted work**, e.g. improved monitoring, link to ecological impacts, measures to ensure sediment transport, role of infrastructure projects and for flood risk management, …

Further exchange welcome!

Thank you for your attention

Rhine river entering Lake Constance

Rhone river entering Lake Geneva

Web: http://water.europa.eu/policy