JRC TECHNICAL REPORTS

WG ECOSTAT report on common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies

Part 2: Impacted by flood protection structures

Drafted by ad hoc GEP/Flood group for CIS WG ECOSTAT

- DRAFT VERSION -
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Contents

1 Introduction ............................................................................................................ 5
   1.1 Recent floodings in Europe ............................................................................ 5
   1.2 Relationship to Floods Directive ..................................................................... 5
   1.3 Relevant EC documents and sources ............................................................. 6

2 Key terms in this report ......................................................................................... 7
   2.1 What is a “flood”? .......................................................................................... 7
   2.2 What are flood defences? ................................................................................ 7
   2.3 HMWB designation due to floods ................................................................... 8

3 European questionnaires on Floods and GEP ...................................................... 10
   3.1 Exchange of information on HMWB designation due to flood protection and GEP definition ....................................................................................................... 10
   3.2 European Questionnaire on Floods and GEP ............................................... 10
      3.2.1 Aims of the questionnaire on Floods & GEP ........................................... 10
      3.2.2 Structure of the questionnaire on Floods & GEP ................................. 11
      3.2.3 General questions on HMWB designation ............................................. 12
      3.2.4 Specific questions on impact detection and mitigation measures .......... 13

4 Outcomes from the European questionnaire on Floods & GEP ......................... 14
   4.1 Responding countries ..................................................................................... 14
   4.2 Impact detection ............................................................................................. 14
      4.2.1 Ability of MS methodologies for hydromorphological assessment to detect hymo alteration .............................................................. 14
      4.2.2 Spatial extent of hymo impacts ................................................................. 14
      4.2.3 Relevance of the alteration for the achievement of legitimate use and effect on the ecological status ....................................................... 15
   4.3 Mitigation measures ....................................................................................... 16
      4.3.1 Types of mitigation measures ................................................................. 16
      4.3.2 WFD pressures and mitigation measures related to flood protection ........ 17
      4.3.3 Mitigation measures related to flood protection: presence in MS national libraries and/or consideration of impacts from flood defence .......................... 22
      4.3.4 MS assumed effectiveness of mitigation measures to improve hydromorphology and biological quality vs effect of measures on use ................................................................................. 23
   4.4 Reasons for ruling out mitigation measures to classify a HMWB as GEP .......... 25

5 Conclusions and recommendations for flood protection .................................... 26

6 References ............................................................................................................. 27

7 Annexes ............................................................................................................... 28
   7.1 Annex 1 –UK Specific Mitigation Measures .................................................. 28
List of Tables

Table 1. Flood defence structures/actions........................................................................................................... 8
Table 2. Measures for mitigating the impacts from Flood Defences (pressures).................................................. 17
Table 3. Overview of the main pressures and measures to mitigate flood defence impacts, related to pressures and mitigation measures in the CIS reporting guidance 2016. ..................................................... 18

List of Figures

Figure 2. Number of water bodies per water uses/drivers for which water bodies were designated as HMWB ........................................................................................................................................................................... 9
Figure 3. Water uses for which water bodies were designated as HMWB (Kling, 2015). .................................... 9
Figure 4. DPSIR schema for HMWB designation and definition of mitigation measures .............................. 11
Figure 5. The overall (intercalibration) process and the different stages explored through the questionnaire........................................................................................................................................................................... 12
Figure 6. Ability of MS hymo methods to detect hymo alteration per key flood defence structure/action .................................................................................................................................................................................... 14
Figure 7. Spatial extent of flood defence impacts in the MS (% MS).............................................................. 15
Figure 8. Value the alteration is providing to the benefit of the water use of flood protection (% MS). .................................................................................................................................................................................... 15
Figure 9. Relative importance of the alteration for reaching Good ecological status (% MS) ..................... 16
Figure 10. Types of measures considered by MS and/or included in national mitigation measures libraries........................................................................................................................................................................... 22
Figure 11. Assumed effectiveness of measures considered by MS and/or included in national mitigation measures libraries........................................................................................................................................................................... 23
Figure 12. Impacts of measures on use .................................................................................................................. 24
Figure 13. Reasons for ruling out mitigation measures necessary to classify a HMWB as GEP (% MS) ....... 25

Cover:

Rinaldi M. et al., 2010

Bottom right: Tiber embankments, Rome (http://www.archidiap.com/opera/muraglioni-del-tevere/)
1 Introduction

Along with storms, floods are the most relevant natural disaster in Europe, in terms of economic costs due to direct damage to infrastructure, property and agricultural land, and indirect losses (e.g. production losses caused by damaged transport or energy infrastructure). They have the potential to cause fatalities, displacement of people and damage to the environment, to severely compromise economic development and to undermine the economic activities of the European Community (EEA, 2012; WG Floods 2014)

In centuries, urbanization has been accompanied by the construction of flood control infrastructures (levees, retention basins, channel straightening, etc). In order to protect population and assets, such structures function by interrupting river continuity, i.e. by disconnecting channels from floodplains, in the case of unconfined rivers, or channels from hillslopes, in the confined ones. Flood control can also be exerted by management of vegetation and/or sediments (e.g. selective cuts, dredging, etc.). Such actions anyway alter the ecological dynamics.

Thus, flood protection structures and actions (such as vegetation and sediment removal and management) are among the main causes for hydromorphological alteration and ecological impairment. Moreover, mitigation measures options, in the case of HMWB for flood protection, are very limited. Any action for mitigation could in fact result into a weakening of flood protection, increasing risk for population and assets.

1.1 Recent floodings in Europe

More than 325 major river floods have been reported for Europe since 1980, among which more than 200 have been reported since 2000. The rise in the reported number of flood events can be explained by the increased vulnerability due to land use changes leading to soil sealing and the climate change impacts on precipitation and streamflow regimes, accompanied also by an increased reporting activity.

Although global warming is projected to intensify the hydrological cycle and increase the occurrence and frequency of flood events in large parts of Europe, estimates of changes in flood frequency and magnitude remain affected by high uncertainty. As an example, in regions with reduced snow accumulation during winter, the risk of early spring flooding would decrease. (EEA, 2012)

1.2 Relationship to Floods Directive

The EU Directive 2007/60 (Floods Directive - FD) aims at reducing and managing the risk of flood on human health, the environment, cultural heritage and economic activity, through the implementation of combinations of different measures envisaged by Flood Risk Management Plans (FRMP). According to art.9 FD, “Member States shall take appropriate steps to coordinate the application of FD and that of WFD focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits having regard to the environmental objectives laid down in Article 4 of Directive 2000/60/EC”.

In terms of measures, it means that priority should be given to the identification and implementation of those measures that can deliver on the objectives of both directives (win-win measures such as, for example, natural water retention measures or room for the river) or even more environmental policies (biodiversity, birds, habitat, etc.). However, in some cases, e.g. typically in highly urbanised areas, due to scarce or null availability of wide spaces for win-win measures, flood protection objectives often require new infrastructure that may deteriorate the status or prevent the achievement of good status in one or more water bodies, because there is no other feasible alternative. Such projects are allowed only if the conditions set in article 4(7) of the WFD are fulfilled.

In the case of existing flood protection schemes, the HMWB designation process has a built in obligation to consider alternatives which maintain the benefits for flood protection but are better
environmental options. Maintenance or rebuilding of existing infrastructure is only possible if there are no better environmental options which maintain the flood protection levels. This does not mean stasis, of course, because all practicable mitigation measures would need to be taken, considering the relevant site-specific circumstances, in particular the potential for ecological improvement.

1.3 Relevant EC documents and sources


The 2014 CIS Technical report identifies potential synergies in the implementation of both the WFD and FD and the requirements for coordination. It also sets out opportunities for synergies, promoting an integrating approach to maximise them, and possible conflict. The technical report takes into account the experience of Member States in implementing and coordinating the two Directives in parallel, and will be routinely revised to capture and build on experiences and good practice for future reference and application in the second and subsequent cycles.


The workshop aimed to facilitate the coordination between WFD and FD, through the presentation and discussion on methods, experiences and operational tools to integrated and coordinated implementation of both directives, keeping into account the indications highlighted in the Technical Report “Links between the Floods Directive (FD 2007/60/EC) and Water Framework Directive (WFD 2000/60/EC)”, with particular reference to the possibility of an interconnected development of measures for both related management plans.

Towards Better Environmental Options for Flood risk management (Note by DG Environment)

Note + annexes


Communication

Flood risks and environmental vulnerability — Exploring the synergies between floodplain restoration, water policies and thematic policies. EEA Report No 1/2016

Aimed top support the implementation of Floods Directive, the EEA report No. 1/2016 focuses on the role of floodplains in flood protection, water management, nature protection or agriculture and the impact of hydromorphological alterations on the ecosystem services that floodplains provide.


NWRRM
http://ec.europa.eu/environment/water/adaptation/ecosystemstorage.htm

Green infrastructures
2 Key terms in this report

2.1 What is a “flood”?

According to the FD, a flood is “the temporary covering by water of land not normally covered by water. This shall include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas, and may exclude floods from sewerage systems.” For the aim of this report, we refer only to pluvial\(^1\) or fluvial flood defences.

2.2 What are flood defences?

In the context of this report, flood defences refers to all the structures aimed at preventing or reducing the detrimental effects of floods, including actions on vegetation and sediments. Flood defences represent the hydromorphological pressures due to the use of flood protection.

Flood defences can be classified according to the main aspect of flood dynamics they are going to block or attenuate, as shown in the table below. Each of these effects is put in place through a structure or an action of management or their combination. Related specific and scientific definitions can be found in the relevant glossaries such as WMO, FloodSite, REFORM. In the appendix an illustrated glossary helps identifying those defences (to be added).

<table>
<thead>
<tr>
<th>Flood defence macropressures (category types of works/actions for flood attenuation)</th>
<th>Flood defence pressures (types of works/actions for flood attenuation)</th>
<th>Aspect of fluvial dynamics which is blocked/attenuated</th>
</tr>
</thead>
</table>
| Transversal | Retention Check Dams  
Dams  
Grade control structures | They alter flow and sediment discharges with complete (and permanent) interception of bedload.  
They reduce slope, decrease flow velocities inducing sediment deposition and energy losses. |
| Lateral | Bank reinforcements/protection  
Embankments  
Groynes | They prevent water and sediment lateral movement |
| Complex | Channel revetments  
Channel straightening  
Flood detention basins  
Flood deviation channels  
Flood drainage systems | They act on different aspects, reducing flood magnitude also modifying flood routing. |
| Management actions | Channel re-profiling  
Sediment and/or vegetation management | They are aimed to avoid channel conveyance impairment. |

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\(^1\) pluvial flooding: rapid rise in water level out of the draining network, due to ponding or to overland flow before reaching the draining network.
Table 1. Flood defence structures/actions.


2.3 HMWB designation due to floods

Flood defence seems to be one of the prevalent uses for designation of HMWB, followed by water storage for hydropower (Kampa et al., 2009; Kling 2015). Data reported in the context of the 1st draft RBMPs indicated that flood protection was the second reason to designate HMWB in Europe (above 30% of total HWMB), while 4 MS had the highest percentage of HMWB due to flood defence (above 72% of total HWMB). As already illustrated in par. 1.3, better environmental options to structural flood protection measures are quite difficult to be found and HMWB designation is almost straightforward.

The figure below shows the percentage of HMWB designated as such due to flood defence use in relation to total HMWB in the 1st (draft) RBMPs of the WFD.
Figure 2. Number of water bodies per water uses/drivers for which water bodies were designated as HMWB.

Source: Kampa E. 12/3/2009 – HMWB Workshop, Brussels

Note: 24 countries completed the HMWB questionnaire (comprising a total dataset of 35 questionnaires): AT, BE (3 questionnaires), BG, CY, CZ, DE (9 questionnaires summarised into 1), EE, ES, FI, FR, HU, IE, LT, LU, LV, NL, NO, PL, PT, RO, SE (questionnaires from 2 RBDs), SI, SK and UK

The following figure shows the updated situation following the questionnaire response:

Figure 3. Water uses for which water bodies were designated as HMWB (Kling, 2015).
3 European questionnaires on Floods and GEP

3.1 Exchange of information on HMWB designation due to flood protection and GEP definition

The exchange of information related to drainage and flood protection as drivers for HMWB designation, was initiated at a meeting in Gothenburg, SE, on March 2014. In February 2015, a core group was formed with representatives from IT, SE, NL, UK, HR and JRC at a meeting organized by IT at ISPRA in Rome. The purpose of the meeting was to prepare a detailed questionnaire regarding flood protection and drainage in conformity with a similar questionnaire developed for GEP of HMWB impacted by water storage.

A first draft of the questionnaire was provided by IT/SE before the meeting. During the meeting it was concluded that also information about the relationship between hydromorphology and ecological status as well as HMWB in general, should be included in the questionnaire.

The final version of the questionnaire was sent to Member States in May 2015.

3.2 European Questionnaire on Floods and GEP

3.2.1 Aims of the questionnaire on Floods & GEP

The purpose of the questionnaire was:

1) exchanging experience on good ecological potential (GEP) and hydrom alterations caused by flood protection structures,
2) finding suitable methods for assessing comparability (intercalibration),
3) learning from each other to ensure common understanding
4) sorting out good management practice and
5) possibly defining best available mitigation measures for heavily modified water bodies due to flood protection structures across Europe.

In order to reach that aim, the following related questions for rivers and lakes affected by flood protection schemes should be answered:

- Do we design Flood related HMWB in a similar or comparable way?
- Do we look at similar impacts, regarding type and scale?
- Do our national mitigation measure libraries contain similar measures for these impacts?
- Do we use comparable criteria to select/rule out mitigation measures?
3.2.2 Structure of the questionnaire on Floods & GEP

The questionnaire was formulated according to the DPSIR approach, and articulated in different sections inside a two-worksheet spreadsheet.

Flood protection and the DPSIR concept

In a DPSIR (driving forces, pressures, state, impacts, responses) context, which is the causal framework for describing the interactions between society and the environment (EEA), flood protection represents a societal need, a "driving force". This need is put in place through structures or flood defences, which represent the hydromorphological pressures altering river hydromorphology and so impacting on ecological status. Mitigation measures are the responses to those impacts aimed to enhance the status.

Figure 4. DPSIR schema for HMWB designation and definition of mitigation measures

In the first worksheet, information was requested on MS approaches to hydromorphological assessment and to the designation of HMWB.

The second worksheet focused on: 1) the ability of methods to detect the impacts of hydro morphological pressures; 2) pressure-impacts related mitigation measures and 3) how the measures are used (e.g. is there a formal process and clear criteria in place for not including the measure, or is it left to local discretion?).
3.2.3 General questions on HMWB designation

The first sheet of the questionnaire included questions related to HMWB designation process, in order to compare how MS assess hydromorphological alteration and whether standardized procedures are in place to verify that the designation test requirements are met, including definitions (e.g. significant effect on use, etc.).

<table>
<thead>
<tr>
<th>QUESTIONS ON HMWB IDENTIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have the waterbodies been changed (splitted up) due to HMWB designation?</td>
</tr>
<tr>
<td>Have you any guidance for splitting or merging former water bodies?</td>
</tr>
<tr>
<td>Have you got any criteria for assessing the significance of the hymo changes?</td>
</tr>
<tr>
<td>Has the hymo assessment method been based on the CEN standards for hydromorphological alteration or do the method comply with the standards?</td>
</tr>
<tr>
<td>What information is the biological assessment based on?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QUESTIONS ON HMWB DESIGNATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you have a definition of wider environment?</td>
</tr>
<tr>
<td>Do you have a definition of significant adverse effects on the wider environment?</td>
</tr>
<tr>
<td>Do you have a definition of “flood protection” (e.g protecting people and assets and/or protecting an area)?</td>
</tr>
<tr>
<td>Do you have a definition of significant adverse effects on flood protection?</td>
</tr>
<tr>
<td>Have you designated HMWB for “equally important sustainable human development activities”?</td>
</tr>
<tr>
<td>Do you have a definition of “equally important sustainable human development activities”?</td>
</tr>
</tbody>
</table>

It is very difficult to have implementation of CIS_guidance_no4, step 8: "Designation test 4(3)(b) in practice. Do you have guiding principles on how to define “other means, which are a significantly better environmental option, technically feasible and not disproportionately costly”?
3.2.4 Specific questions on impact detection and mitigation measures

The second sheet of the questionnaire contained more specific questions aimed to understand: the national methods ability to detect impacts from flood defence actions/structures; measures available to a country for mitigating ecological impacts from flood defences pressures; how these measures are used. Measures were grouped in key types according to the types of pressures leading to the impairment of the same hydromorphological function (e.g. loss of lateral continuity) and consequently to the impairment of related ecological functions (see Table 3).

For each of the key types of pressures and consequent impacts, national experts were asked to indicate which mitigation measures must be in place to achieve GEP, whether there can be exceptions, and if so, the common reasons for these.

<table>
<thead>
<tr>
<th>QUESTIONS ON IMPACT DETECTION AND THEIR EFFECT ON ECOLOGICAL FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the impact (alteration) picked up by the national classification for hydromorphological status?</td>
</tr>
<tr>
<td>Spatial extent of impact</td>
</tr>
<tr>
<td>What is the relative importance of the alteration for reaching Good ecological status?</td>
</tr>
<tr>
<td>What value is the alteration providing to the benefit of the water use?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QUESTIONS RELATED TO EACH TYPE OF MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you have this measure in your mitigation library for GEP?</td>
</tr>
<tr>
<td>What is the assumed effectiveness of the measure for improving hydromorphology and biological quality?</td>
</tr>
<tr>
<td>What is the relative magnitude of negative effect on water use?</td>
</tr>
<tr>
<td>Would mitigation measure be needed to classify a HMWB as GEP if reference conditions mean that the impact is not present (i.e. if ecological status is anyway good)?</td>
</tr>
<tr>
<td>Would mitigation measure be required to classify a HMWB as GEP if there was no technical solution by which the measures could be implemented?</td>
</tr>
<tr>
<td>Would mitigation measure be required to classify a HMWB as GEP if it would have a significant adverse impact on the water use?</td>
</tr>
<tr>
<td>Would mitigation measure be required to classify as GEP if it would have a significant adverse impact on the wider environment (e.g. protected buildings etc)</td>
</tr>
<tr>
<td>Would mitigation measure be required to classify a HMWB as GEP if it would be disproportionately expensive to put in place</td>
</tr>
<tr>
<td>Is mitigation measure required to classify a water body as GEP unless one of the reasons listed in the preceding columns? If you do not have a rule-based process for deciding which measures in your library must be applied (e.g. library use is optional and left to local discretion), you should answer “no”</td>
</tr>
</tbody>
</table>
4 Outcomes from the European questionnaire on Floods & GEP

4.1 Responding countries

In total, 17 European countries have replied to the questionnaire (UK, SK, PT, NO, NL, LU, LT, IT, IE, HR, FR, ES, DK, CZ, BG, AT, DE). Their responses are reported in the following paragraphs. The responses (questionnaires) are to be uploaded on CIRCA.

It is noted that although consistency and cross-checking analysis of MS data was carried out, MS answers may have been biased by the way the questions were formulated.

4.2 Impact detection

4.2.1 Ability of MS methodologies for hydromorphological assessment to detect hymo alteration

Although not all the MS have developed an "official" national hydromorphological assessment method, most of them answered that their assessment systems seem to detect the hydromorphological alteration caused by the flood defence structures and actions. There are some exceptions related to 30% of some specific types of measures (Vegetation and wood maintenance; groynes, etc.), probably because they are not commonly used in certain fluvial contexts in Europe.

![Figure 6. Ability of MS hymo methods to detect hymo alteration per key flood defence structure/action.](image)

4.2.2 Spatial extent of hymo impacts

MS were also asked to report on the average spatial extent of the impacts due to flood defence. In 30% of responding EU countries, such an extent is typically related to the presence and frequency of downstream tributaries, and/or channel morphology and/width and scales with them so it is not possible to quantify it as an average. In 12% of the MS, the spatial extent of the impact was not quantified at all. For 14% of the MS, it was possible to reply in terms of classes of fixed length (both % or km), with the class of length ranging from 0,1 km to 0,5 km prevailing (4%).
4.2.3 Relevance of the alteration for the achievement of legitimate use and effect on the ecological status

On the one hand, flood defences are needed in order to put in place the legitimate use of flood protection. The value flood defences provide to the benefit of flood protection depends on the type of flood defence structure and/or action.

Figure 8. Value the alteration is providing to the benefit of the water use of flood protection (% MS).
On the other hand, flood defences alter hydromorphological processes, and ecosystem impairment follows. The relative importance of flood defences for reaching GES is strongly linked to the type of structure/ action adopted. Therefore, a flood defence may be an insurmountable obstacle (high value or importance), as in the case of a dam, down to a negligible one (no value or importance) for reaching the good ecological status.

Figure 9. Relative importance of the alteration for reaching Good ecological status (% MS).

4.3 Mitigation measures

4.3.1 Types of mitigation measures

As already mentioned, each pressure (flood defence) triggers an alteration of the process it aims to block, in order to guarantee flood protection. In order to mitigate the impacts of that alteration on ecological processes, action has to be taken which would not lower the level of protection of the flood defence significantly, which is quite a particular possibility. In the case of already existing flood defences, few typologies of mitigation measures can be put in place.

Alternatively, a reconsideration of the type of measure (hard vs. soft engineering) and/or an option to substitute it with a non-structural one (removal of structures) could possibly lead to reaching the GES and so bring the HMWB back to a natural water body.

In the questionnaire on Floods & GEP, for each pressure, mitigation measures, linked to the particular type of process that has been impaired, were listed as defined answers. MS also added other more detailed types, as for Germany or UK.
<table>
<thead>
<tr>
<th>Pressures</th>
<th>Mitigation measures (full wording)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Dams</td>
<td>Fish passages/downstream sediment by-pass actions/e-flows</td>
</tr>
<tr>
<td>b Bank reinforcements/protection</td>
<td>replacement of hard structures with soft engineering ones; creation of natural-like irregularities (DE: removing reinforcements; initiating self-dynamic development)</td>
</tr>
<tr>
<td>c Grade-control structures</td>
<td>fish passages (DE: removing grade control structures; lengthening river channel to reach natural-like slope)</td>
</tr>
<tr>
<td>d Check-dams</td>
<td>Fish passages/openings (filtering action)/e-flows</td>
</tr>
<tr>
<td>e Channel straightening (including meander cut-offs)</td>
<td>Irregular shaping of the banks to favour morphological diversity and habitat etherogeneity (DE: reconnecting meander cut-offs; initiating self-dynamic lateral development; creating new river channel; reactivating floodplain dynamics (secondary floodplain or in combination with increased retention area))</td>
</tr>
<tr>
<td>f Channel re-profiling</td>
<td>Increase in-channel morphological diversity; create low-flow channel increasing diversity (DE: selective re-profiling due to real necessity)</td>
</tr>
<tr>
<td>g Vegetation and wood maintenance</td>
<td>Selective cuts (DE: remove woody debris only upstream of, or within, areas of urban flood risk)</td>
</tr>
<tr>
<td>h Embankments</td>
<td>creation of natural-like irregularities; set-back embankments (DE: building/reactivating retention area upstream)</td>
</tr>
<tr>
<td>i Channel revetment</td>
<td>increase of roughness elements (cobbles or boulders) (DE: removing revetment (in combination with self-dynamic lateral development))</td>
</tr>
<tr>
<td>j Flood detention basins</td>
<td>creation of natural-like diversity within the flood detention basin (DE: rebuilding detention basin without permanent impoundment (dam for flood attenuation); constructing bypass channel)</td>
</tr>
<tr>
<td>k Groynes</td>
<td>creation of natural-like irregularities; increase of roughness trough wood/rocks</td>
</tr>
<tr>
<td>l Flood Drainage systems (pipes, intakes, ditches, etc.)</td>
<td>Storage tanks at the delivery to attenuate discharge peaking (DE: building/reactivating retention area upstream)</td>
</tr>
<tr>
<td>m Flood Deviation channels</td>
<td>no real measure as impacts are temporary (DE: developing secondary (floodplain) habitats in deviation channels)</td>
</tr>
</tbody>
</table>

Table 2. Measures for mitigating the impacts from Flood Defences (pressures).

As in the table above, in order to be more concise, the listed measures can be identified by a letter in the following graphs.

4.3.2 WFD pressures and mitigation measures related to flood protection.

The following Table 3 maps the key types of pressures and related mitigation measures for flood defences along with the most comparable pressures & Key Types of Measures (KTM) in the 2016 WFD Reporting Guidance.
Table 3. Overview of the main pressures and measures to mitigate flood defence impacts, related to pressures and mitigation measures in the CIS reporting guidance 2016.

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Pressures in WFD reporting guidance 2016</th>
<th>Hydromorphological alteration</th>
<th>Ecological impact</th>
<th>Mitigation measures options</th>
<th>Relevant KTM in WFD reporting guidance 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transversal works</strong>&lt;br&gt;Dams for floods attenuation, Retention check dams*&lt;br&gt;4.2.2 Dams, barriers and locks -Flood protection</td>
<td>Loss of longitudinal continuity in sediments, water and biota; alteration of hydrological regime if multiple uses. Change to impounded stretch if combined with permanent storage</td>
<td>Loss of sediment/biological continuity - interference with fish population movements; alteration of flow regime and river morphology Alterations to plant &amp; animal species composition (e.g. favouring disturbance-tolerant species/still water species)</td>
<td>fish passages downstream sediment by-pass actions e-flows</td>
<td>5 Improving longitudinal continuity (e.g. fish passes, by-pass channels) 7 Improvements in flow regime and/or establishment of ecological flows</td>
<td></td>
</tr>
<tr>
<td><strong>Transversal works</strong>&lt;br&gt;Retention Check Dams&lt;br&gt;4.2.2 Dams, barriers and locks -Flood protection</td>
<td>Loss of longitudinal continuity in sediments, water and biota; alteration of hydrological regime if multiple uses</td>
<td>Impairment to sediment flux/loss of biological continuity - interference with fish population movements; alteration of flow regime and river morphology</td>
<td>fish passages openings (filtering action) for sediments E-flows</td>
<td>5 Improving longitudinal continuity (e.g. fish passes, by-pass channels) 7 Improvements in flow regime and/or establishment of ecological flows</td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
<td>Pressures in WFD reporting guidance 2016</td>
<td>Hydromorphological alteration</td>
<td>Ecological impact</td>
<td>Mitigation measures options</td>
<td>Relevant KTM in WFD reporting guidance 2016</td>
</tr>
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</tr>
<tr>
<td><strong>Transversal works</strong></td>
<td></td>
<td>Loss of longitudinal continuity in biota (sometimes in sediments, depending on the geometry and topographic characteristics of the reach upstream)</td>
<td>Loss of sediment/biological continuity - interference with fish population movements</td>
<td>fish passages</td>
<td>5 Improving longitudinal continuity (e.g. fish passes, by-pass channels)</td>
</tr>
<tr>
<td><strong>Grade control structures</strong></td>
<td>4.2.2 Dams, barriers and locks -Flood protection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lateral works</strong></td>
<td></td>
<td>Loss of lateral continuity (connectivity with floodplain/hillslopes)</td>
<td>Loss of riparian zone / marginal habitat / loss of lateral connectivity / loss of sediment input</td>
<td>replacement of hard structures with soft engineering ones; creation of natural-like irregularities</td>
<td>6 Improving hydromorphological conditions of water bodies other than longitudinal continuity</td>
</tr>
<tr>
<td><strong>Bank reinforcements/protection</strong></td>
<td>4.1.1 Physical alteration of channel/bed/riparian area/shore – Flood Protection</td>
<td>Loss of lateral continuity (connectivity with floodplain/hillslopes)</td>
<td>Loss of riparian zone / marginal habitat / loss of lateral connectivity / loss of sediment input</td>
<td>creation of natural-like irregularities; set-back embankments</td>
<td>6 Improving hydromorphological conditions of water bodies other than longitudinal continuity</td>
</tr>
<tr>
<td><strong>Lateral works</strong></td>
<td>4.1.1 Physical alteration of channel/bed/riparian area/shore – Flood Protection</td>
<td>Loss of lateral continuity (connectivity with floodplain/hillslopes)</td>
<td>Loss of riparian zone / marginal habitat / loss of lateral connectivity / loss of sediment input</td>
<td>creation of natural-like irregularities; increase of roughness trough wood/rocks</td>
<td>6 Improving hydromorphological conditions of water bodies other than longitudinal continuity</td>
</tr>
<tr>
<td><strong>Embankments</strong></td>
<td></td>
<td>Loss of lateral continuity (connectivity with floodplain/hillslopes)</td>
<td>Loss of riparian zone / marginal habitat / loss of lateral connectivity / loss of sediment input</td>
<td>creation of natural-like diversity within the flood detention basin</td>
<td>6 Improving hydromorphological conditions of water bodies other than longitudinal continuity</td>
</tr>
<tr>
<td><strong>Groynes</strong></td>
<td>4.1.1 Physical alteration of channel/bed/riparian area/shore – Flood Protection</td>
<td>Loss of lateral continuity (connectivity with floodplain/hillslopes)</td>
<td>Loss of riparian zone / marginal habitat / loss of lateral connectivity / loss of sediment input</td>
<td>creation of natural-like diversity within the flood detention basin</td>
<td>6 Improving hydromorphological conditions of water bodies other than longitudinal continuity</td>
</tr>
<tr>
<td><strong>Complex works</strong></td>
<td>4.1.1 Physical alteration of channel/bed/riparian area/shore – Flood Protection</td>
<td>Loss or reduction of lateral and longitudinal continuity of sediments, water and biota</td>
<td>Loss of riparian zone / marginal habitat / loss of lateral connectivity / loss of sediment input</td>
<td>creation of natural-like diversity within the flood detention basin</td>
<td>6 Improving hydromorphological conditions of water bodies other than longitudinal continuity</td>
</tr>
<tr>
<td>Pressure</td>
<td>Pressures in WFD reporting guidance 2016</td>
<td>Hydromorphological alteration</td>
<td>Ecological impact</td>
<td>Mitigation measures options</td>
<td>Relevant KTM in WFD reporting guidance 2016</td>
</tr>
<tr>
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<td>---------------------------------------------</td>
</tr>
<tr>
<td><strong>Complex works</strong>&lt;br&gt;Flood Deviation channels</td>
<td>3.7 Abstraction or flow diversion - Other</td>
<td>Temporary Loss of lateral and longitudinal continuity of sediments, water and biota</td>
<td>temporary Loss of riparian zone / marginal habitat / loss of lateral connectivity / loss of sediment input</td>
<td>no real measure as impacts are temporary</td>
<td></td>
</tr>
<tr>
<td><strong>Complex works</strong>&lt;br&gt;Flood Drainage systems (pipes, intakes, ditches, etc.)</td>
<td></td>
<td>Alteration of hydrological regime</td>
<td>Alterations of water inputs through artificial means</td>
<td>storage tanks at the delivery to attenuate discharge peaking</td>
<td></td>
</tr>
<tr>
<td><strong>Complex works</strong>&lt;br&gt;Channel straightening (including meander cut-offs)</td>
<td>4.1.1 Physical alteration of channel/bed/riparian area/shore – Flood Protection 4.4 Hydromorphological alteration - Physical loss of whole or part of the water body</td>
<td>Alteration of hydrodynamic and morphodynamic characteristics</td>
<td>Loss of morphological diversity and habitat</td>
<td>Irregular shaping of the banks to favour morphological diversity and habitat etherogeneity</td>
<td>6 Improving hydromorphological conditions of water bodies other than longitudinal continuity</td>
</tr>
<tr>
<td>Pressure</td>
<td>Pressures in WFD reporting guidance 2016</td>
<td>Hydromorphological alteration</td>
<td>Ecological impact</td>
<td>Mitigation measures options</td>
<td>Relevant KTM in WFD reporting guidance 2016</td>
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</tr>
<tr>
<td><strong>Complex works</strong>&lt;br&gt;Channel revetment</td>
<td>4.1.1 Physical alteration of channel/bed/riparian area/shore – Flood Protection 4.4 Hydromorphological alteration - Physical loss of whole or part of the water body</td>
<td>Loss or reduction of lateral and vertical continuity of sediments, water and biota; loss of natural substrate</td>
<td>Loss of riparian zone / marginal habitat / loss of lateral and vertical connectivity / loss of sediment input</td>
<td>Increase of roughness elements (cobbles or boulders)</td>
<td>6 Improving hydromorphological conditions of water bodies other than longitudinal continuity</td>
</tr>
<tr>
<td><strong>Management and maintainance</strong>&lt;br&gt;Channel re-profiling</td>
<td>4.1.1 Physical alteration of channel/bed/riparian area/shore – Flood Protection 4.4 Hydromorphological alteration - Physical loss of whole or part of the water body</td>
<td>Loss of morphological diversity</td>
<td>Loss of morphological diversity</td>
<td>Increase in-channel morphological diversity; create low-flow channel increasing diversity</td>
<td></td>
</tr>
<tr>
<td><strong>Management and maintainance</strong>&lt;br&gt;Vegetation management</td>
<td>4.1.1 Physical alteration of channel/bed/riparian area/shore – Flood Protection</td>
<td>Loss of morphological diversity, loss of organic matter input, loss of shading</td>
<td>Loss of morphological diversity, loss of organic matter input, loss of shading</td>
<td>Selective cuts</td>
<td></td>
</tr>
</tbody>
</table>

* For storage relevant aspects please also see Halleraker et al., WG ECOSTAT report on common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies. Part 1: Impacted by Water Storage
4.3.3 Mitigation measures related to flood protection: presence in MS national libraries and/or consideration of impacts from flood defence.

Few MS have already developed a national library. Even a national library for mitigation measures is present, MS may not have considered all the possible impacts from flood defences for different reasons, not least because they consider certain impacts as non-existing, as in the case of flood deviation channels, which work only in the occurrence of floods with a certain magnitude and return period.

There is a moderate number of negative answers, mainly due to the absence of a national mitigation measure library or on uncertainty on the impacts of flood defences.

The reasons for not identifying the need for certain types of mitigation is mainly linked to the fact that in some countries, (e.g. mainly lowland), some flood defences are not used, and therefore the related impacts and measures are not considered. Another reason may be that some countries are lacking an appropriate assessment system to detect some types of impact.

![Figure 10. Types of measures considered by MS and/or included in national mitigation measures libraries](image)

(a. Dams for floods attenuation: fish passages/downstream sediment by-pass actions/e-flows; b. Bank reinforcements/protection: replacement of hard structures with soft engineering ones; creation of natural-like irregularities; c. Grade control structures: fish passages; d. Retention check dams: fish passages/openings (filtering action)/e-flows; e. Channel straightening (including meander cut-offs: irregular shaping of the banks to favour morphological diversity and habitat etherogeneity; f. Channel re-profiling: increase in-channel morphological diversity; create low-flow channel increasing diversity; g. Vegetation and wood maintenance: selective cuts; h. Embankment: creation of natural-like irregularities; set-back embankments; i. Channel...
revetment: increase of roughness elements (cobbles or boulders); j. Flood detention basins: creation of natural-like diversity within the flood detention basin; k. Groynes: creation of natural-like irregularities; increase of roughness through wood/rocks; l. Flood drainage systems (pipes, intakes, ditches, etc.): storage tanks at the delivery to attenuate discharge peaking; m. Flood deviation channels: no real measure as impacts are temporary).

4.3.4 MS assumed effectiveness of mitigation measures to improve hydromorphology and biological quality vs effect of measures on use

Measures aimed at enhancing longitudinal connectivity for fish and sediments and e-flows are considered highly effective by the majority of MS and, at the same time, without an adverse effect on use.

On the contrary, measures linked to enhancing lateral continuity or heterogeneity of banks and channel are deemed to have an adverse effect on use, lowering the level of protection from floods.

Figure 11. Assumed effectiveness of measures considered by MS and/or included in national mitigation measures libraries

<table>
<thead>
<tr>
<th>Types of measures</th>
<th>Aa</th>
<th>No</th>
<th>Low</th>
<th>Some</th>
<th>High</th>
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<tbody>
<tr>
<td>a</td>
<td>19%</td>
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<td>6%</td>
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<tr>
<td>b</td>
<td>75%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
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<tr>
<td>c</td>
<td>69%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
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<td>13%</td>
<td>6%</td>
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<td>e</td>
<td>31%</td>
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<td>6%</td>
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<td>6%</td>
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<td>25%</td>
<td>6%</td>
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<td>g</td>
<td>19%</td>
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<td>k</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
</tr>
</tbody>
</table>
(filtering action)/e-flows; e. Channel straightening (including meander cut-offs: irregular shaping of the banks to favour morphological diversity and habitat heterogeneity; f. Channel re-profiling: increase in-channel morphological diversity; create low-flow channel increasing diversity; g. Vegetation and wood maintenance: selective cuts; h. Embankment: creation of natural-like irregularities; set-back embankments; i. Channel revetment: increase of roughness elements (cobbles or boulders); j. Flood detention basins: creation of natural-like diversity within the flood detention basin; k. Groynes: creation of natural-like irregularities; increase of roughness trough wood/rocks; l. Flood drainage systems (pipes, intakes, ditches, etc.): storage tanks at the delivery to attenuate discharge peaking; m. Flood deviation channels: no real measure as impacts are temporary.

Figure 12. Impacts of measures on use
(a. Fish passages/downstream, sediment by-pass actions/e-flows; b. Replacement of hard structures with soft engineering ones; creation of natural-like irregularities; c. Fish passages; d. Fish passages/openings (filtering action)/e-flows; e. Irregular shaping of the banks to favour morphological diversity and habitat heterogeneity; f. Increase in-channel morphological diversity; create low-flow channel increasing diversity; g. Selective cuts; h. Creation of natural-like irregularities; set-back embankments; i. Increase of roughness elements (cobbles or boulders); j. Creation of natural-like diversity within the flood detention basin; k. Creation of natural-like irregularities; increase of roughness trough wood/rocks; l. Storage tanks at the delivery to attenuate discharge peaking; m. No real measure as impacts are temporary.)
4.4 Reasons for ruling out mitigation measures to classify a HMWB as GEP

According to WFD rationale, the ruling out of mitigation measures for GEP definition can be allowed only if some conditions, explicit in the relevant CIS guidances (namely n° 4 and n° 20) are met. Detailed justifications, in the context of a scenario analysis, have anyway to be given in order to support the exclusion of such measures in order to apply the relevant exemptions. In particular, the process of GEP definition envisages the consideration of all the possible mitigation measures that have not a significant effect on use and/or on the wider environment.

Where national mitigation measure libraries are in place, all or some of the mitigation measures are considered necessary to be implemented in order to classify a HMWB as in good ecological potential, consistently with the WFD dictate for possible ruling out.

The most common reasons for ruling out mitigation measure options are significant effects on use or the wider environment.

Some MS seem to rule out mitigation measures due to technical infeasibility (32%) and/or disproportionate costs (23%).

In the peculiar case in which a MS designated a HMWB even if the GES seemed to be met due to high uncertainties on the BQ methods, they decided to precautionarily apply the mitigation measures (14%).

Meeting one or more of the aforementioned conditions can trigger the ruling out of the considered measure in 61% of MS.

<table>
<thead>
<tr>
<th>Condition</th>
<th>MS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. significant impact on use</td>
<td>100</td>
</tr>
<tr>
<td>2. significant impact on wider environment</td>
<td>100</td>
</tr>
<tr>
<td>3. no technical solutions to implement MM</td>
<td>100</td>
</tr>
<tr>
<td>4. Heavily modified but GES</td>
<td>100</td>
</tr>
<tr>
<td>5. disproportionate costs of MM</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 13. Reasons for ruling out mitigation measures necessary to classify a HMWB as GEP (% MS)
GREEN= YES; RED=NO; GREY=N.A.
5 Conclusions and recommendations for flood protection

Although not all Member States have developed a national hydromorphological assessment method, most of them answered that their systems can detect the hydromorphological impacts due to flood defence structures and actions. Regarding the scale of the impacts, it appears that in the case of flood defences, which work in longitudinal, lateral and vertical dimensions, a typical range of length of impacts cannot be found.

Some flood defence structures are not very common in some countries, which could explain why the assessment systems are not actually detecting them (e.g. grade control structures, groynes, etc.).

Regarding the mitigation measures, few MS have already developed a national library. In any case, fish passages and light bank protection structures seem to be considered as the most effective measures.

Overall, the majority of MS has not set up a national procedure for estimating GEP (only ca. half of the responding countries have done this), therefore the questions relevant to GEP have not been answered.

When going to the procedures to get to GEP, the most common reasons for ruling out mitigation measure options are significant effects on use or the wider environment. Some MS rule out mitigation measures that are technically infeasible and/or disproportionately costly.

A general preliminary conclusion is that there is a need for a common language in order to understand what flood structures and actions are and their impacts in terms of scales and magnitude, on fluvial hymo and biological processes. Further development of the use of HMWB in respect to flood protection is also needed, with a better understanding of the effects of mitigation measures on hymo and biota and of the potential adverse effects on use. This requires close cooperation with development within the Floods Directive implementers and again calls for the need of a common language and understanding.
6 References


REFORM wiki (http://wiki.reformrivers.eu/index.php/Main_Page)

WFD CIS (2003) CIS Guidance no 4. Identification and Designation of HMWB and AWB.


WFD CIS (2015) CIS Guidance n. 31. Ecological flows (Eflows) in the implementation of the WFD.

## 7.1 Annex 1 – UK Specific Mitigation Measures

<table>
<thead>
<tr>
<th>Flood protection specific measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM2: Remove obsolete structure</td>
</tr>
<tr>
<td>MM4: Removal of hard bank reinforcement / revetment, or replacement with soft engineering solution</td>
</tr>
<tr>
<td>MM5: Preserve and, where possible, restore historic aquatic habitats</td>
</tr>
<tr>
<td>MM6: Increase in-channel morphological diversity</td>
</tr>
<tr>
<td>MM8: Re-opening existing culverts</td>
</tr>
<tr>
<td>MM9: Alteration of channel bed (within culvert)</td>
</tr>
<tr>
<td>MM10: Flood bunds (earth banks) (in place of floodwalls)</td>
</tr>
<tr>
<td>MM11: Set-back embankments (a type of managed retreat)</td>
</tr>
<tr>
<td>MM12: Improve floodplain connectivity</td>
</tr>
<tr>
<td>MM16: Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works.</td>
</tr>
<tr>
<td>MM18: Management of the risk of fish entrainment in intakes for hydropower turbines or water resource purposes (or pumping stations) where there is downstream fish migration.</td>
</tr>
<tr>
<td>MM19: Preserve and where possible enhance ecological value of marginal aquatic habitat, banks and riparian zone</td>
</tr>
<tr>
<td>MM20: Operational and structural changes to locks, sluices, weirs, beach control, etc</td>
</tr>
<tr>
<td>MM34: Appropriate vegetation control technique</td>
</tr>
<tr>
<td>MM35: Appropriate timing (vegetation control)</td>
</tr>
<tr>
<td>MM36: Appropriate techniques (invasive species)</td>
</tr>
<tr>
<td>MM37: Retain marginal aquatic and riparian habitats (channel alteration)</td>
</tr>
<tr>
<td>MM38: Sediment management strategies (develop and revise) which could include a) substrate reinstatement, b) sediment traps, c) allow natural recovery minimising maintenance, d) riffle construction, e) reduce all bar necessary management in flood risk areas</td>
</tr>
<tr>
<td>MM39: Appropriate channel maintenance strategies and techniques e.g. minimise disturbance to channel bed and margins</td>
</tr>
<tr>
<td>MM40: Appropriate channel maintenance strategies and techniques e.g. remove woody debris only upstream of, or within, areas of urban flood risk</td>
</tr>
<tr>
<td>MM41: Appropriate water level management strategies, including timing and volume of water moved</td>
</tr>
<tr>
<td>MM47: Appropriate techniques to align and attenuate flow to limit detrimental effects of these features (drainage)</td>
</tr>
<tr>
<td>MM54: Educate landowners on sensitive management practices (urbanisation)</td>
</tr>
</tbody>
</table>

Flood protection specific measures
<table>
<thead>
<tr>
<th>Mitigation Measure number and name</th>
<th>Perth region（e.g. Butterworth)</th>
<th>Peel region（e.g. Mandurah）</th>
<th>Rockingham region</th>
<th>Mandurah region（e.g. Mandurah）</th>
<th>Mandurah region (e.g. Mandurah)</th>
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</tbody>
</table>

*Note: The table above represents the mitigation measures and their implementation status across different regions. The symbols (X) indicate the implementation or readiness status for each measure.*

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**March 2017**

**Page:** 29