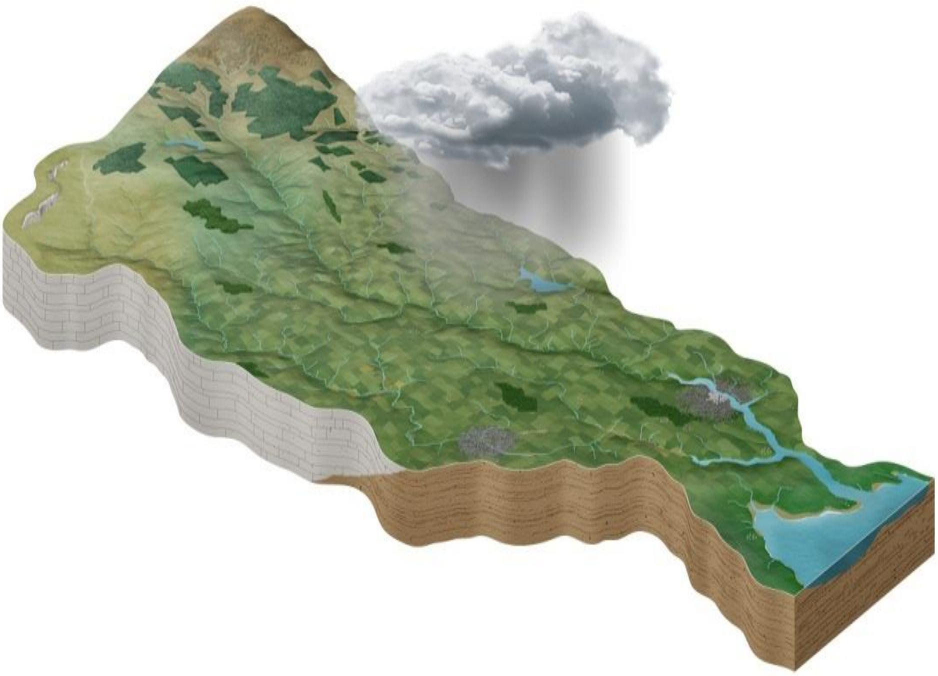
Review of Ireland's Heavily Modified Water Body Designations for the Third Cycle River Basin Management Plan



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Key Highlights

- Heavily modified waterbodies are waterbodies that have had their physical characteristics, or hydromorphological conditions, modified for the purposes of a specified use. Heavily modified waterbodies have different environmental objectives applied (Good Ecological Potential) which recognise that the modifications may prevent Good Ecological Status from being achieved. However, all Water Framework Directive standards for other elements such as nutrients and chemicals must still be met, and the modifications must be mitigated as far as possible.
- In the first and second river basin management plans, 33 waterbodies were designated as heavily modified. This was based on expert judgement and the best available technical information at that time. These included mainly lakes and rivers that were impounded for water storage for power generation and/or drinking water supply, estuarine waterbodies developed as ports or harbours, and waterbodies with their riparian zones reinforced or modified for flood protection purposes.
- A review of the designations has been undertaken for the third cycle, underpinned by an improved evidence base, improved technical assessment tools and new EU guidance developed since the first cycle.
- The designation process comprises three parts: identification of provisional heavily modified waterbodies based on their physical characteristics, i.e., characterisation; designation based on a series of tests on measures, alternative options, feasibility and costs; and classification of ecological potential.
- This report summarises the outcomes of the review. 466 waterbodies meet the criteria for designation and are being proposed as heavily modified waterbodies. This includes 433 rivers, 20 lakes and 13 estuarine and coastal waters. The significant increase is due to the availability of improved hydromorphological condition assessment tools and data and new EU guidance to support the designation process.
- An approach to establish the environmental objective (Ecological Potential) for each heavily modified water body has been developed and will be applied in due course to those waterbodies that are formally designated by the Minister in the third cycle river basin management plan.
- Where designated waterbodies do not meet at least Good Ecological Potential, a programme of measures must be developed to achieve those objectives.

Table of Contents

1 Background

Under the Water Framework Directive, waterbodies may be designated as heavily modified where their hydromorphological characteristics, or physical habitat conditions, have been modified for the purposes of a limited number of specified uses. Examples include waterbodies which have been dammed to store water for power generation and/or water supply, and waterbodies that have had their bed and banks reinforced for flood defence purposes.

Waterbodies that are designated as heavily modified have a different environmental objective applied which recognises that the physical habitat conditions have been modified for the purposes of the specified use, and that the extent of the modification may mean that Good Ecological Status cannot be achieved. For example, large dams associated with drinking water supplies may prevent the free passage of fish, which may impact on the structure and diversity of fish populations and therefore on fish status. Heavily modified waterbodies must nevertheless achieve good ecological condition for all the other status elements not affected by the modification (in this case the dam), such as nutrients, specific pollutants, priority substances and any other biological quality elements such as macrophytes (aquatic plants) or macroinvertebrates (aquatic insects). The impacts of the modification on ecological conditions must also be mitigated as far as possible, in this case for example by the installation of a fish pass.

For the first river basin management planning cycle, Ireland designated a relatively small number of surface water bodies as heavily modified based on the best available knowledge at that time. A conservative, expert opinion-based approach to the designation process was taken because the understanding of the interlinkages between hydromorphological pressures and good ecological condition, the availability of assessment tools, and an appropriate evidence base to carry out the assessment, were limited. The first cycle designations remained unchanged for the second cycle plans.

The River Basin Management Plan for 2018-2021 set out a National Hydromorphology Work Programme which outlines key tasks that need to be addressed, including the review of HMWB designations. The EPA is the technical lead for all three parts of the process, supported by representatives of state bodies represented on the national hydromorphology working group, the owners of the specified uses and Department of Housing, Local Government and Heritage (DHLGH). The following report outlines the results of this review and includes the following;

- The definition of a heavily modified waterbody and its implications;
- The heavily modified designation process;
- A summary of the waterbodies that were designated as heavily modified for the first and second cycles;
- A summary of the outcomes of the review which has identified a list of heavily modified waterbodies for the third cycle;
- A summary of the process to identify the ecological potential of these designated water bodies.

A period of public consultation on the process and its outcomes will run alongside the consultation period for the draft river basin management plan. Once completed, the EPA will review the outcomes of the consultation process and make a recommendation to the Minister for Housing, Local Government and Heritage on the waterbodies that meet the designation criteria. The Minister will consider the recommendation and make a decision on the designations which will then be published in the final river basin management plan.

2 What is a heavily modified waterbody?

The Water Framework Directive requires member states to assign surface waters into one of three waterbody categories:

1. **Natural water bodies** which include rivers, lakes, estuaries or coastal water bodies;
2. **Artificial waterbodies** which are surface water bodies which have been created in a location where no water body existed before, and which have not been created by the physical alteration, movement or realignment of an existing water body. Designation of artificial waterbodies is a separate process to the heavily modified waterbody designation. The majority of Ireland's artificial waterbodies are canals.
3. **Heavily modified waterbodies** which are bodies of surface water which have been substantially changed in their hydromorphological character for the purposes of a specified use. Heavily modified waterbodies are classified based on which of the natural waterbody types they most closely resemble. Examples might include rivers which have been dammed that now more closely resemble lakes.

Throughout Europe, the hydromorphological condition of water bodies has commonly been significantly modified for various specified uses, such as for land drainage, navigation and hydroelectric power generation. The heavily modified waterbody type is used to set objectives for these waterbodies that recognise that the extent of the modifications may not be consistent, in some circumstances, with the conditions required for Good Ecological Status, and that the impacts cannot be fully mitigated without impacting on the specified use.

The specified uses, and the criteria for designation, are set out in Article 4(3) of the Directive which states that a waterbody can be designated as a HMWB if:

(*a) the changes to the hydromorphological characteristics of that body which would be necessary for achieving Good Ecological Status would have significant adverse effects on:*

(i) the wider environment;

(ii) navigation, including port facilities, or recreation;

(iii) activities for the purposes of which water is stored, such as drinking-water supply, power generation or irrigation;

(iv) water regulation, flood protection, land drainage, or

(v) other equally important sustainable human development activities;

(b) the beneficial objectives served by the artificial or modified characteristics of the water body cannot, for reasons of technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option. Such designation and the reasons for it shall be specifically mentioned in the river basin management plans required under Article 13 and reviewed every six years.

Examples of typical types of modifications found in Ireland include instream weirs required for navigation, instream dams that store water for power generation or water supply, hard infrastructure for flood protection in urban settings, and arterial land drainage schemes to drain agricultural land to support production.

2.1 The implications of a heavily modified waterbody designation

Waterbodies that are designated as heavily modified have a WFD environmental objective of Good Ecological Potential rather than Good Ecological Status. The designation means that a realistic objective is set that acknowledges that the water body has been physically altered for a specified use that society needs to be continued. The physical modifications caused by the use need to be mitigated against as far as possible, whilst acknowledging that the specified use needs to be retained. For example, a fish pass designed to best practice standards might be required on an instream barrier to ensure fish passage. Any other impacts to the aquatic habitat and water quality (biological and physico-chemical quality elements from, for example nutrients or chemicals) must also be restored and/or maintained in good ecological condition. Heavily modified waterbodies that are not meeting their objectives must still therefore be included in the programme of measures and should not be mistaken for, or confused with, an exemption.

3 The heavily modified designation process

The process of designating waterbodies as heavily modified is set out in two comprehensive EU Common Implementation Strategy (CIS) Guidance documents, No. 4[1] and No. 37[2], supported by a third, No. 3, which addresses the assessment of pressures and impacts[3]. The designation process is described as a series of steps and it can be broadly divided into three parts (Figure 3-1):

(a) Identification of provisional heavily modified waterbodies (pHMWB);
(b) Application of a series of designation tests;
(c) Establishment of ecological potential.

3.1 Identification of provisional heavily modified waterbodies

The first part of the process is a six step, technical assessment, to identify a list of pHMWBs. This technical assessment describes the nature and extent of the hydromorphological modifications, and their impacts on ecological status, and it is part of the WFD characterisation process.

In Steps 1 and 2, candidate waterbodies are delineated, and artificial waterbodies are removed for consideration separately. In Steps 3 and 4, the waterbodies are assessed to determine if there are changes to their hydromorphological condition, and if so, whether those changes are significant. New hydromorphological assessment tools have been developed and/or evolved in Ireland since the first cycle that have been used to carry out these steps for the third cycle. These are the Morphological Quality Index (MQI) tool for rivers, the Lake-MimAS tool for lakes, and the TraC-MimAS tool for transitional and coastal waters. A brief description of these new tools is provided in Appendix 1.

In Step 5, member states must consider whether the waterbody has, or is likely to fail Good Ecological Status as a result of the hydromorphological changes. In some circumstances the candidate waterbodies may be impacted, but by a different environmental stressor, such as nutrients or chemicals for example. Step 5 is currently scientifically challenging because the linkages between hydromorphological pressures and ecological outcomes, i.e. the ecology-hydromorphology link, are often difficult to measure or quantify. For example, river embankments that disconnect a river from its flood plain will impact significantly on lateral connectivity, which is one of the criteria for good hydromorphological condition. In practice this means that the river can no longer naturally slow down

[1] https://circabc.europa.eu/sd/a/f9b057f4-4a91-46a3-b69a-e23b4cada8ef/Guidance%20No%204%20-%20heavily%20modified%20water%20bodies%20-%20HMWB%20(WG%202.2).pdf

[2] https://circabc.europa.eu/sd/a/d1d6c347-b528-4819-aa10-6819e6b80876/Guidance%20No%2037%20-%20Steps%20for%20defining%20and%20assessing%20ecological%20potential%20for%20improving%20comparability%20of%20Heavily%20Modified%20Water%20Bodies.pdf

[3] https://circabc.europa.eu/sd/a/7e01a7e0-9ccb-4f3d-8cec-aeef1335c2f7/Guidance%20No%203%20-%20pressures%20and%20impacts%20-%20IMPRESS%20(WG%202.1).pdf

its flood peaks and deposit its sediment load onto its flood plain, which may lead to further bank erosion and accumulation of sediment downstream, all of which impacts on the habitat condition for aquatic species. At present we do not have biological quality indicators that are directly and quantifiably sensitive to impacts to lateral connectivity. In some cases therefore, Step 5 must incorporate a degree of expert opinion as to the impacts of the hydromorphological change on ecological function.

Step 6 sets out a list of criteria that must be met before a waterbody can be identified as provisionally heavily modified. It must be substantially changed in character due to the physical alterations by human activity; these physical alterations should be permanent; the changes to the water body should be generally both hydrological and morphological and; the changes should be extensive, widespread or profound (CIS, 2003a). The guidance indicates that the assessment of 'substantial changes' can be determined using thresholds (e.g. percentage of channel irreversibly impacted) and this is the approach that has been taken in Ireland.

Waterbodies have been assessed on a case by case basis, or in the case of rivers, in groups that have been modified in similar ways for the same specified use. Waterbodies that proceed through all six steps are identified as pHMWBs and are brought forward to the second part of the process for consideration of the designation tests.

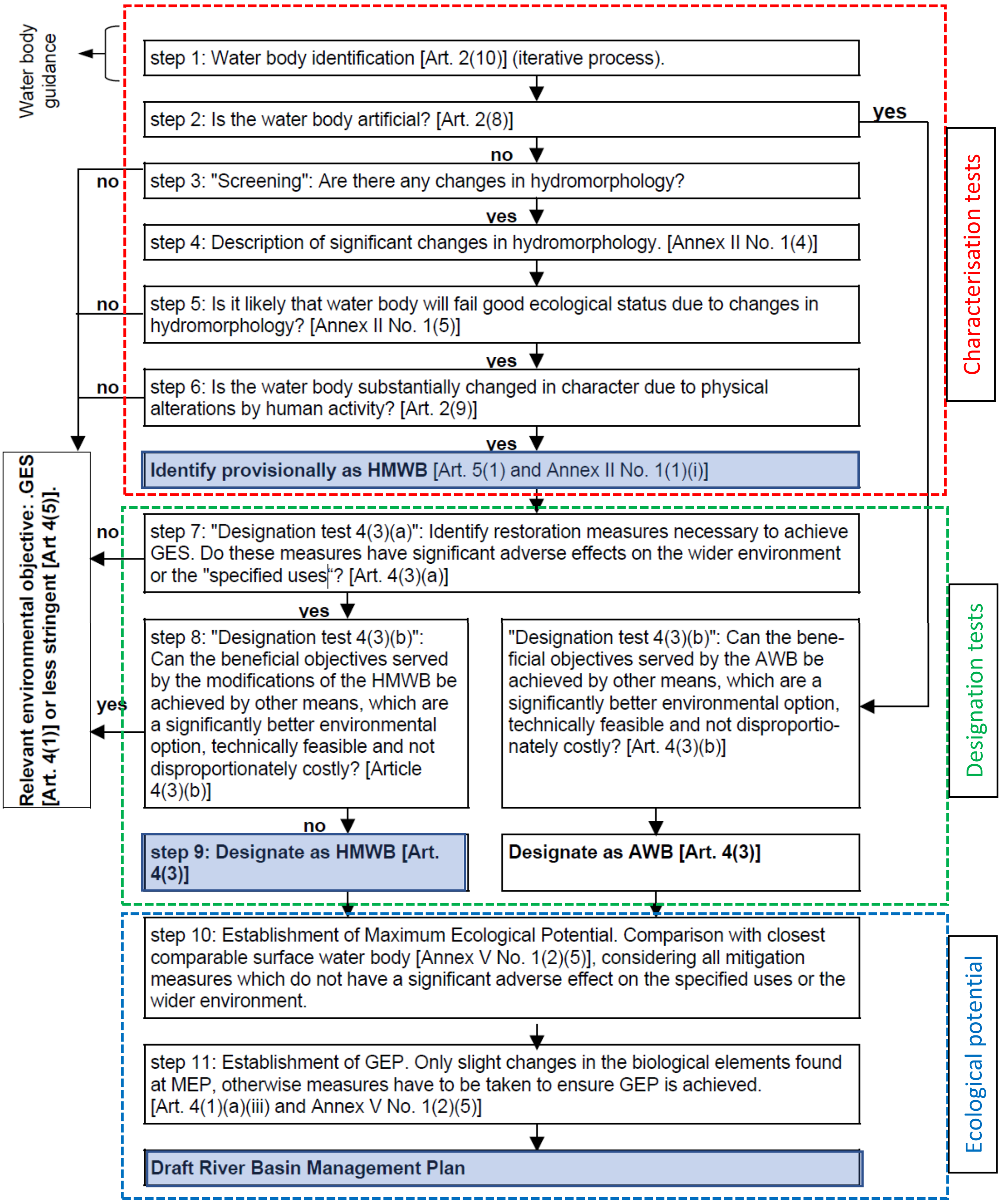

Figure 3-1. Explanation of the 11-step process which is carried out as part of the heavily modified waterbody designation process. The 11 steps can be broadly divided into three main parts: identification of provisional heavily modified waterbodies (pHMWB); application of a series of designation tests; and establishment of ecological potential. Adapted from CIS Guidance No. 4. Note although this flowchart was developed to support the first cycle river basin management planning cycle, the guidance indicated that it was envisaged that the same process would be followed for subsequent reviews.

3.2 Application of the designation tests

The second part of the process involves applying a series of designation tests to each of the pHMWBs to assess whether or not they meet the criteria for a formal designation. There are two designation test steps (Steps 7 and 8), each with a number of sub-questions, which lead to a formal designation in Step 9.

Step 7 identifies the restoration measures[4] that would be required to achieve Good Ecological Status and assesses whether they would have a significant adverse effect on (a) the specified use, or (b) the wider environment. This assessment can be considered at a range of scales. The significant adverse effects on use are based on the impacts to society rather than to an individual. The definition of wider environment is broad and includes the natural and human environments including archaeology, heritage, landscape and geomorphology. Waterbodies that cannot be restored to Good Ecological Status without impacting on the specified use progress to Step 8, otherwise the waterbody does not meet the criteria for a heavily modified designation. So for example, the restoration measure for a lake impounded for water storage for power generation might be to remove the impoundment, but this would not be feasible without ceasing power generation, so this lake would progress through to Step 8.

Step 8 assesses whether the specified use could be achieved by any other means that are a better environmental option, for example through an alternative drinking water or power supply, or a different navigation route. Where there are no other means, or there are other means but they are not technically feasible, or are disproportionately costly, then the waterbody may be designated under Step 9.

The guidance emphasises that not all waterbodies that have been identified as provisionally heavily modified based on their physical modifications, may meet the designation criteria, and therefore not all may necessarily be formally designated in Step 9. The designations should be reviewed every six years with the river basin management plan. A designation is not permanent – waterbodies can be de-designated, and new waterbodies can be designated with each cycle. Such situations may occur due to omission in the previous cycle, availability of new data (e.g. development of hydromorphologically sensitive biological quality elements, metrics or hydromorphological assessments), or based on monitoring data following the implementation of mitigation measures.

3.3 Establishment of ecological potential

The last part of the designation process involves the setting and assigning of the criteria for defining ecological potential. Ireland's proposed approach is set out in a separate document (Appendix 2).

In summary, there are two internationally recommended methodologies: a reference-based approach which is used where the ecology-hydromorphology links are well developed, and a mitigation measures-based approach used by many member states, also known as the Prague approach, which can be used as an alternative. Ireland is proposing to use an approach that is aligned with the Prague measured based approach, but incorporates, and is strengthened by, our national biological quality monitoring programme. The approach recognises that some biological quality elements may be sensitive to the hydromorphological modification, while others may not, and that not all biological quality elements are monitored at every site.

[4] The term 'restoration measures' is used to refer to measures that would remove the impacts of the modification such that Good Ecological Status could be restored. This is in contrast to 'mitigation measures' which are measures that will achieve the best possible environmental outcome given the modification. Mitigation measures are required to be in place to achieve Good Ecological Potential.

Using the 'one out, all out' WFD principle, a heavily modified waterbody is considered to be at Good Ecological Potential when it has:

- the relevant mitigation measures in place;
- achieved Good (or better) condition for the monitored biological quality elements (BQE) that are not sensitive to the hydromorphological modification;
- achieved the physico-chemical conditions equivalent to Good Ecological Status, except where parameters are impacted by the hydromorphological alteration caused by the specified use; and
- achieved the best state previously achieved since the modification for the monitored biological quality elements that are sensitive to the hydromorphological modification, where those data are available.

A full explanation of the methodology is provided in Appendix 2. Two case studies illustrating the application of the HMWB designation are provided in Appendix 3.

4 First and second cycle heavily modified waterbodies

There are currently 33 heavily modified waterbodies that were designated in the first cycle, all of which remained unchanged for the second cycle. The Southwestern River Basin District (RBD) led the assessment in 2008, on behalf of the national Programmes of Measures Coordination Group[5].

4.1 Heavily modified river waterbodies

Four river water bodies were designated nationally as heavily modified in the first and second cycle river basin management plans. The associated specified uses were drinking water supply (1), flood protection (2) and protection of the wider environment (localised dredging due to a contaminated substrate) (1). The number of designated waterbodies was very small because the tools used to determine hydromorphological impacts were still in development. This first iteration of the designations also did not consider land drainage as a specified use.

4.2 Heavily modified lake waterbodies

Sixteen lake water bodies were designated as heavily modified in the first and second cycle river basin management plans. The majority of these lakes are impounded rivers, associated with major drinking water supplies to urban areas and/or water storage for national power generation schemes.

4.3 Transitional and coastal Water Bodies

Eleven transitional and coastal (TraC) water bodies within ROI were designated as heavily modified in the first and second cycle river basin management plans[6]. These designations mainly related to urban ports, harbours and estuaries under the navigation/port specified use. One estuary was designated as it had a specified use associated with public transportation infrastructure.

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[5] SWRBD Heavily Modified Waterbodies and Artificial Waterbodies Programmes of Measures Study - Overall Summary Report, 2008. https://www.catchments.ie/download/heavily-modified-artificial-waterbodies-2009-2015/

[6]Note that two of the 33 HMWBs include Newry Estuary and Foyle and Faughan Estuaries. These are cross border HWMBs monitored by the Northern Ireland Environment Agency and therefore are not included in this review.

5 Heavily modified water body review process for the third cycle

The River Basin Management Plan for 2018-2021 set out a National Hydromorphology Work Programme which outlines key tasks that need to be addressed, including the review of HMWB designations. The EPA is the technical lead for all three parts of the designation process, supported by colleagues in state bodies represented on the national hydromorphology working group, the owners of the specified uses and DHLGH. The following sections outline in more detail the assessments for this process and provide a summary of the waterbodies that have been identified as heavily modified. A period of public consultation on the process and its outcomes will run alongside the consultation period for the draft river basin management plan. The EPA will then review the outcomes of the consultation process and make a recommendation to the Minister on the waterbodies that meet the designation criteria. The Minister will consider the recommendation and make a decision on the designations which will then be published in the final river basin management plan for 2022-2027.

The review is being carried out at waterbody scale and is considering the following specified uses:

- Water storage and regulation (*i.e.* major impounding structures such as dams and reservoirs);
- Flood protection;
- The urban environment;
- Arterial drainage;
- Navigation.

Waterbodies that were previously designated were also reviewed.

5.1 River waterbodies

There are 3208 number of river waterbodies in Ireland, only four of which were previously designated as heavily modified. River waterbodies are used for all five types of specified uses, and many may be used for more than one. A new hydromorphological assessment tool developed by the EPA, MQI-Ireland (Appendix 1), was the main tool used to assess the hydromorphological pressures and condition in each river waterbody.

As set out in the CIS guidance, for efficiency the review was carried out in groups of river waterbodies that have the same specified use and therefore the same sorts of modifications. The assessments of pressures and condition were carried out at a reach (sub-waterbody) scale in all river waterbodies, and then combined and assessed for significance at the waterbody scale.

The following sections describe the application of the 11 steps of the assessment for the river waterbodies in each of the specified use groups. In some cases, some of the steps are combined to help assess and describe the impacts of the modification in a coherent and efficient manner. For example, the criteria used in Step 3 to determine whether a hydromorphological change was significant, included an assessment of whether it was widespread which was then also used in Step 6.

5.1.1 Water storage and regulation

Large impoundments associated with water storages impact on ecological function by altering or regulating the river flow regime and the transport of sediment throughout the catchment, which in turn impacts on river function and aquatic habitat condition. Impoundments can prevent the free passage of fish species and may impact on important stages of their life cycles by for example, preventing access to spawning grounds and reducing flows that trigger spawning at the appropriate time of the year.

Step 1 – Water body identification – is a specified use present?

Three subgroups of waterbodies with large impoundments or structures used for water storage and regulation were included in the assessment:

a) River water bodies downstream of major ESB impoundments in the Lower Shannon, Claddy, Erne, Lee, and Liffey catchments. These impoundments were identified using EPA databases. This included 29 waterbodies in total.
b) River water bodies downstream of lakes or reservoirs that are used for significant drinking water supplies, where a significant dam is known to be present. These supplies were identified from the national abstractions register and from Irish Water databases and there were 29 in total.
c) River water bodies downstream of other major impoundments used for other purposes, such as industrial, private water supply or amenity use. These were identified using EPA databases and there were 31 in total.

Irish Water provided information on their water storages which was used to inform the assessment. The assessment was also informed by the outputs of the DHLGH Shannon Fish Passage Feasibility Study.

The waterbodies included in this assessment are known, on the basis of the currently available information, to have major impoundments that have resulted in substantial changes to the waterbody character, that are permanent, and are extensive, widespread or profound. Further information may become available through two new regulatory processes that are in development for controlling abstractions and other activities impacting on hydromorphological condition of waters. New information gathered through these processes can be considered in future reviews.

- ***A total of 89 river water bodies (RWB) were identified as having this specified use present***

Step 2 – Is the water body artificial?

No artificial water bodies were identified.

- ***89 RWBs remained after Step 2***

Step 3 Screening: Are there any changes in hydromorphology?

Screening for changes in hydromorphology was carried out primarily using the MQI-Ireland to first identify the reaches and the waterbodies that were impounded. Longitudinal connectivity was the key affected hydromorphological indicator. Hydromorphological impacts due to impacted flow conditions continue to occur for a distance downstream of impoundments until there is sufficient natural inflow from tributaries to restore a natural flow regime, even if that is somewhat diminished in size. As flow data are not generally available to measure hydrological change at this scale, a proxy method was used that compared the area of the catchment upstream of the impoundment, with the area of the total catchment for each reach under consideration downstream. Where the impounded catchment area was greater than 50% of the total catchment area, then the reach was deemed to be significantly impacted in terms of flow and sediment transport.

For dams which were not contained within the MQI database, the EPA QUBE hydrological assessment tool was used to identify waterbodies downstream of the impoundment which were at risk from impacts from abstraction. Where a waterbody downstream of an impoundment had an abstraction risk assessment of less than Good, then it was considered to be significantly hydromorphologically impacted. Subsequent downstream water bodies were not included.

- ***62 RWBs met the criteria for having a change in hydromorphology***

Steps 4 – 6 ***Step 4: Description of significant changes in hydromorphology?*** **Step 5:** ***Is it likely that water body will fail good ecological status due to changes in hydromorphology?*** **Step 6:** ***Is the water body substantially changed in character due to physical alterations by human activity***

Step 4
The criteria outlined in Step 3 for screening waterbodies with hydromorphological impacts were established to focus on impacts that are significant. The main impacts to hydromorphology associated with these major impoundments are associated with longitudinal connectivity and include impacts to flows and sediment transport as follows:

- *Impacts to flows*. Large dams which capture a large proportion of a catchments flow cause significant alteration of the natural flow regime. Compensation flows, while providing a benefit in terms of a minimum flow, may be constant and non-varying, and the total flow will be impacted by the abstraction. The intensity, timing and frequency of the downstream flow regime will be completely altered, often resulting in a decrease in the magnitude of small and medium sized flood peaks, and an increase in low flows. In some instances, operational procedures can result in rapid flow fluctuations that occur at non-natural rates. Over-abstraction of the upstream reservoir can also result in the downstream river drying out at certain periods of the year.
- *Impacts to sediment transport*. Major impoundments block the movement of sediment downstream and can cause a sediment build up on the upstream side. Sediment supply and transport are important elements of natural river function. They provide and maintain a variety of habitats and are fundamental for a healthy ecosystem.

Step 5
Large impoundments can directly affect the passage of multiple fish species upstream and downstream unless adequate fish structures are in place. Fish status is therefore considered to be the most sensitive biological quality element for assessing the impact of large impoundments on ecological status. The national fish monitoring programme is carried out at approximately 160 surveillance monitoring sites around the country, supplemented by some additional monitoring by Inland Fisheries Ireland (IFI) in catchments of interest. There are therefore not always waterbody-specific monitoring data available to directly assess the impact of particular dams on fish status.

While some of the larger dams for power generation do have fish passes in place, such as Ardnacrusha for example, their effectiveness for all species may not be adequate. Inland Fisheries Ireland is conducting a comprehensive national barriers assessment that will provide further information in the future to inform this assessment. In the meantime, based on expert judgement, it is considered that the large dams for power generation are having an impact on fish and therefore on ecological status.

For the remaining water bodies in this specified use group, fish passage, other impacts such as channel forming or ecological flows, and sediment transport, were used to make an expert judgement on the impact of the impoundment on ecological status.

Step 6

The waterbodies that have large impoundments that have been screened through all the previous assessment criteria to this step are considered to be substantially and permanently changed in character. The impoundments have affected significant hydrological and morphological change to the waterbodies they impact. To consider whether the changes were extensive, widespread or profound, the river reach assessment was combined back to water body level and a spatial scale threshold was applied. Where 15% or greater of the total waterbody length was impacted (with a minimum total length of 1 km), the scale of impact was deemed to meet these criteria. The 15% threshold is used in the abstraction risk assessment methodology and has precedence in other countries. Expert judgement was also applied in a limited number of circumstances where specific structures were well known.

- ***29 RWBs remained following Steps 4 -6 and are identified as provisional heavily modified waterbodies (pHMWB) for water storage and regulation***

Steps 7-9

Step 7 Designation test 4 (3)(a) (Restoration measures): Identify restoration measures necessary to achieve GES. Do these measures have significant adverse effects on the wider environment or the "specified uses"?

Step 8 Designation test 4(3)(b) (Alternative options): Can the beneficial objectives served by the modifications of the HMWB be achieved by other means, which are a significantly better environmental option, technically feasible and not disproportionately costly?

Step 9: ***Designate as HMWB***

Step 7

A list of restoration measures related to water storage and regulation were collated from the Mitigation Measures Library of the EU CIS Guidance No. 37, UKTAG WFD Cycle 1 measures library[7] and the Freshwater Morphology POMs Group Best Practice Toolkit[8]. Measures that were key to restore ecological status conditions to Good were identified by the EPA.

The key restoration measures related to water storage and reduction are the complete removal of, or reduction in height or storage of, an impounding structure. These measures could restore continuity along the river channel, in terms of flow and the movement of fish. Variable flow conditions could be re-established thus creating and maintaining habitat and furthermore, facilitating migration and spawning cues. The natural sediment regime could be restored as sediment would no longer trapped upstream of the impounding structure, further supporting the creation and maintenance of habitat and fish spawning beds. These key measures were further explored to identify whether they could be implemented without impacting water storage or regulation.

Based on the currently available information, including input from the specified use owners, it is considered that these restoration measures could not be implemented without significantly impacting

[7] https://www.catchments.ie/download/heavily-modified-artificial-waterbodies-2009-2015/

[8] https://www.catchments.ie/download/freshwater-morphology-2009-2015/

the specified use. This is because removing, or significantly reducing, an impounding structure and its associated storage would lead to a loss of energy production or water supply capacity and the State's hydropower and drinking water sources are dependent on these water supplies. Alterations to storage capacities and operating levels within impoundments also have dam safety implications for the integrity and stability of concrete and embankment dams and the management of large inflows safely through the dams. These storages are long established, and there has been infrastructure built downstream of many of them that would potentially be placed at risk, such as in Limerick downstream of Parteen Weir, the towns in Kildare and Wicklow on the Liffey below Pollaphuca Dam, and the greater Dublin area downstream of Leixlip Dam. There are also cultural and architectural heritage values associated with some storages, such as Ardnacrusha for example.

However, a number of mitigation measures were identified that may support Good Ecological Potential (Appendix 2 outlines the Prague, or mitigation measures approach). These include fish migration aids (i.e. fish pass, screen, ladders) to allow the movement of fish along the river channel, and the establishment of ecological flow regimes which would facilitate a range of ecological functions from minimum flows, to spawning trigger flows, to sediment transport flows and larger channel forming flows. As outlined in the draft River Basin Management Plan for the third cycle of the WFD, both measure types are currently being considered as part of the Shannon Fish Passage Study to mitigate the effects of the Ardnacrusha Hydroelectric scheme on the Lower Shannon. Inland Fisheries Ireland is currently conducting a nationwide survey to assess the nature of the barriers to fish and the extent to which they need to be mitigated. This work will further inform the mitigation measures.

Appendix 4 provides the full list of measures that were identified as either restoration measures (to restore to Good Ecological Status but with significant adverse impacts to the specified use) or mitigation measures (to support Good Ecological Potential).

Step 8

As there are no restoration measures available that will not impact on the specified use, alternative options for carrying out the specified use were also examined.

The dependence of many activities on the same hydropower infrastructure e.g. energy production, water supply, navigation, flood risk management and public safety, tourism, sport and public amenity makes the consideration of alternative options very complex.

ESB has indicated that from an energy generation perspective, the State is currently reducing its dependency on energy generated with fossil fuels to focus more on the use of renewables. The construction of sufficient renewables to end the use of fossil fuels remains decades away, assuming the technical challenges can be overcome. The use of hydro power supported by water retained in large storages provides a reliable and predictable source of potential energy that can be accessed on-demand, supporting the integration of other more intermittent forms of renewable energy. A reduction in hydro generation will be made up by a corresponding increase in energy from fossil fuel power stations. Hydropower therefore plays an important role in the State's renewable energy portfolio and also their Climate Action Plan. The State's energy security is also supported through having a diversity of energy sources, with hydropower reducing the dependence on imported fuels. The existing storages and their impoundments were designed and engineered at the time to maximise water availability, and that availability has been the basis for the current level of development. Many of these storages are also now being used for other specified uses, such as the provision of drinking water supply, or flood protection where it aligns with dam safety obligations and which depends on storage or diversion for the reduction of flood risk. There are no known alternative options at present for replacing these water storages.

Irish water is developing a national water resources plan which includes an assessment of existing sources and consideration of new and alternative supplies. The plan also considers options at a regional level which will facilitate a strategic transformation of the existing fragmented public supply system to a more resilient and sustainable interconnected supply. While the plan includes demand reduction measures such as leakage reduction and water conservation measures, due to the existing deficits across the public supply system, the majority of sources from impounding reservoirs will be required to be maintained along with new additional sources to ensure a safe and secure public supply.

Sources from impounding reservoirs are a resilient source of supply and due to the seasonal storage provided, are critical to the overall supply system. This will become increasingly important in the future in the context of climate change. The importance of impounding reservoirs to water supply is highlighted in the Water Quality and Water Services Infrastructure, Climate Change Sectoral Adaptation Plan[9]. Equivalent resilience supplies would only be available naturally from groundwater sources. Irish Water's existing impoundments are located in areas where equivalent groundwater yields are not available. Alternative surface water abstractions will not provide the same resilient supply without the provision of an impounding structure which would not provide better environmental outcomes.

On the basis of the currently available information, there are no alternative options for the current water supply storage network. The outcome and findings of the National Water Resources Plan, which is expected to be completed and adopted by 2023, will be incorporated into future reviews of the heavily modified waterbody designations.

- ***29 RWBs remained following Steps 7-8***

Step 9
As there are no measures available that can restore ecological status conditions without impacting water storage and regulation, and there are no alternative options, the 29 provisional candidates are recommended for designation as Heavily Modified Water Bodies.

A total of 29 river water bodies are identified as heavily modified waterbodies for water storage and regulation

5.1.2 Flood protection

Flood protection schemes typically comprise of a range of hard engineering measures or embankments designed to prevent a river from breaking its banks and flooding the surrounding area, improvements to channel conveyance and/or storage of excess flood waters upstream of the area at risk. This can result in the river being disconnected from sections of its flood plain. The flood plain connection is important ecologically so that high flows laden with fine sediment can deposit their loads, and flood peaks can be attenuated. This can reduce river bank erosion further downstream and affect aquatic habitat condition. Flood protection schemes can also include significant alterations to

[9] http://www.housing.old.gov.ie/water/water-quality/water-quality-and-water-services-infrastructure-climate-change-sectoral

the bed and banks of the channel, and the riparian vegetation, which can lead to a deterioration in habitat condition.

Step 1 – Water body identification – is a specified use present?

River water bodies with flood relief schemes and/or embankment schemes were considered as part of this step. This data was provided spatially by the Office of Public Works (OPW). OPW also provided insights and a number of case studies on which to base the assessment.

Waterbodies selected under this specified use are primarily flood schemes that have been in place since before the WFD. More recent, and new flood schemes currently in development, include an assessment of the impact of the scheme on ecological status, and consideration of alternative and mitigating options as part of the development process. In the future, there may be a requirement for a formal exemption (known as an Article 4.7 exemption) from achieving the objective under the WFD if the scheme is likely to result in a deterioration in status but can meet a number of sustainable development criteria. This is a separate process that is not under consideration as part of this review.

- ***A total of 189 river water bodies (1127 MQI reaches) were identified as having this specified use present***

Step 2 – Is the water body artificial?

No artificial water bodies were identified.

- ***A total of 189 river water bodies remained after Step 2.***

Step 3 – "Screening": Are there any changes in hydromorphology?

Screening was carried out primarily using the MQI-Ireland tool. Significant physical alteration has typically occurred within, and along the banks of river waterbodies that have been modified for flood protection schemes. The impacts are primarily to lateral connectivity which can be caused by bank protection with concrete walls, rock armour and embankments; and channel morphology due to changes to the river channel profile and its cross-section which are typically carried out to improve conveyance. Some examples include the Santry River in Dublin which has been channelised and culverted, and had its bed and banks replaced by uniform hard engineering to improve flood conveyance; and the Lower Fergus River in Clare which has had a major embankment scheme developed along its length adjacent to the town of Ennis.

- ***165 RWBs (814 MQI reaches) remained following Step 3***

Steps 4 – 6
Step 4: Description of significant changes in hydromorphology?
Step 5: ***Is it likely that water body will fail good ecological status due to changes in hydromorphology?***
Step 6: ***Is the water body substantially changed in character due to physical alterations by human activity***

Step 4

The main impacts to hydromorphology associated with major flood protection schemes were identified as follows:

- changes to channel morphology either though reprofiling, straightening, or a combination of both, results in a reduction of cross section variability. This reduction in channel sectional diversity negatively impacts natural river processes, which in turn impacts on habitat availability. Channel morphology is also impacted due to changes in bed and bank substrate usually associated with improving conveyance (e.g. concrete flood walls).
- changes to lateral connectivity by disconnecting the river from its floodplain. This occurs when flow is prevented from discharging onto the flood plain due to the presence of embankments, concrete walls and rock armour. These works can also result in a loss or impairment of riparian and marginal vegetation. Associated changes to the river's flow regime can also alter sediment composition and transport downstream. To minimise both the loss of attenuation and the cost of the works, the protection measures would typically have been set back as far from the river as possible and to protect only the urbanised areas. The area disconnected from the river is therefore minimised, would not benefit from the deposition of sediment and would potentially be a source of pollution into the waterbody if not disconnected.

Step 5

A number of the impacts associated with flood protection measures can affect the supporting conditions necessary to achieve good ecological condition in the key biological quality elements including macroinvertebrates, macrophytes and fish. For example, concrete channels and flood walls in place of a natural vegetated river bank can (a) reduce shade and increase water temperature in the summer months, which can deteriorate habitat conditions for insects and fish; (b) reduce food sources for aquatic species that fall in from overhanging riparian vegetation; and (c) create poor habitat condition for aquatic plants. However, the relationships between the hydromorphological changes and the biological elements can be difficult to quantify or measure at the waterbody scale as part of the national monitoring programme. Based on expert judgement it was determined that some or all of these elements are highly likely to be permanently impacted by flood protection works, even if they are not currently being quantified as part of the national monitoring programmes.

Step 6

In order to assess if the water body has been substantially changed in character, the river reach assessment was combined back to water body level and a spatial scale threshold was applied. Where 15% or greater of the total waterbody length was impacted (with a minimum total length of 1 km) the scale of the impact was considered to be widespread and profound.

- ***64 RWB remained following Steps 4 -6 and are identified as provisional heavily modified waterbodies (pHMWBs) for flood protection***

Steps 7-9

Step 7 Designation test 4 (3)(a) (Restoration measures): Identify restoration measures necessary to achieve GES. Do these measures have significant adverse effects on the wider environment or the ''specified uses''?

Step 8 Designation test 4(3)(b) (Alternative options): Can the beneficial objectives served by the modifications of the HMWB be achieved by other means, which are a significantly better environmental option, technically feasible and not disproportionately costly?

Step 9: ***Designate as HMWB***

Step 7

A list of restoration measures related to flood protection works were collated from the Mitigation Measures Library of the EU CIS Guidance No. 37, UKTAG WFD Cycle 1 measures library and the Freshwater Morphology POMs Group Best Practice Toolkit. This list was discussed with the relevant pressure owners (i.e. the OPW). Measures that were key to restore ecological status conditions to Good were identified.

Restoration measures for many of the existing flood protection schemes would include removing the hard engineering flood protection structures and bank rehabilitation (restoring the bank profile). Such measures would promote reconnection of the channel with its floodplain, allowing water and sediment to spill out over the banks, provide habitat and refuge and aid water retention. Furthermore, rehabilitation of riverbanks aids the establishment of riparian vegetation which allows for habitat, shade and a buffer to fine sediment/nutrient runoff, thereby providing multiple environmental outcomes. As channels are often straightened and deepened to aid flood conveyance, cessation of channel maintenance can be another restoration measure (this is further discussed in Section 5.1.5 on Arterial Drainage). This can allow the river to self-recover and reinstate variable flow conditions, which in turn will support the creation and maintenance of habitats and fish spawning grounds. However, removing or significantly altering these flood protection structures would lead to the standard of flood protection being compromised and an increased risk of flooding occurring. The areas that have been protected against flooding are generally comprised of developed, urban communities, and so removal of the flood protection works would place those developments and communities at significant risk.

Based on the currently available information, the implementation of restoration measures, ie removing the hard engineering works associated with existing flood protection schemes, would significantly impact on the delivery of the specified use, i.e., flood risk protection. However, a number of mitigation measures have been identified that can support Good Ecological Potential (Appendix 2 outlines the Prague, or mitigation measures, approach). Such mitigation measures include the use of sensitive channel maintenance strategies and techniques (i.e. the OPW Guidance: Drainage Maintenance and Construction[10]). These environmentally sensitive maintenance steps were developed in collaboration with IFI and include: restricting maintenance to the channel; selective vegetation removal; ensure one bank is left undisturbed while minimising disturbance to the opposite bank.

[10] https://www.floodinfo.ie/frs/media/filer_public/b0/5a/b05a1126-7de1-4921-bdb2-1c2579470171/environmental_guidance_-_drainage_maintenance_and_construction_2019_web_part-1.pdf

Appendix 4 provides a list of measures that were identified as either restoration measures (to restore to Good Ecological Status but with significant adverse impacts to the specified use) or mitigation measures (to support Good Ecological Potential).

Step 8

As there are no restoration measures available that will achieve Good Ecological Status while not impacting on the specified use, alternative options for carrying out the specified use were also examined.

As indicated by OPW, the design and development of the existing flood relief schemes included the consideration of alternative options. While such consideration included assessments of technical performance, cost-effectiveness and social acceptability, the implementation process was undertaken in line with environmental legislation, such as EIA, which required assessments of environmental impacts and alternatives. In some instances, no effective or viable alternative options would have been available.

The implementation of alternative approaches for at-risk communities, where potentially available, would in practice involve the development and construction of a new scheme for the area, in addition to the removal of the existing flood defence infrastructure. This would require very substantial cost, in addition to the social disruption, environmental impacts of new works and potential community vulnerability during the works period, which would be disproportionate to the scale of benefits achievable, noting that a flood relief scheme can cost in excess of €10m, and 50 schemes have been completed to date with many other schemes in development or construction at this time.

Future flood protection schemes being developed following publication of the Flood Risk Management Plans in 2018, include assessments of the impacts on WFD objectives, and also of nature-based catchment management solutions such as rewetting peatlands and slowing the flow upstream within catchments. The OPW, in collaboration with the EPA, has produced a guidance document on Nature Based Catchment Management Solutions (NbCMs) which reviews measures that can complement flood protection measures while also achieving wider catchment management benefits. Research internationally suggests that while these softer engineering measures can make a contribution towards reducing the smaller flood peaks in some catchments, on their own, they do not provide the necessary standard of protection against severe damage and potential loss of life during extreme, severe flood events that is achieved by a flood relief scheme. They can however play an important role in building additional resilience into a flood protection scheme as a climate adaptation measure, and support a multitude of co-benefits for biodiversity, water quality and climate change.

For existing schemes, the available evidence suggests that restoration measures to remove the hard engineering works would impact on the specified use, and that there are no viable alternative options available that would provide the same level of protection from flood risks, particularly in the context of climate change scenarios which forecast increasing rainfall intensities in winter. For new flood defence schemes, a wider range of alternative options are being considered as part of the project level planning, which is subject to Environmental Impact Assessment and Appropriate Assessment, where applicable. Based on information from the OPW, there are no (further) viable alternative options for existing flood relief schemes that can achieve the required level of flood risk protection for communities.

Step 9

As there are no measures available that can restore ecological status conditions without impacting flood protection, and there are no alternative options, the 64 provisional candidates are proposed for designation as Heavily Modified Water Bodies.

A total of 64 river water bodies are identified as heavily modified waterbodies flood protection

5.1.3 Urban

Rivers that flow through urban catchments are often channelised, straightened or culverted, and have had their bed and banks reinforced, or replaced with hard engineering to prevent flooding or to provide a foundation for adjacent buildings. There may be developments and/or roads in the flood plain and a network or drains delivering contaminated runoff from the paved areas during rainfall. These conditions constrain the river and impact on natural river processes. Habitats and food sources from riparian vegetation may be limited and/or absent, and instream habitat may be significantly impaired.

Step 1 – Water body identification – is a specified use present?

River water bodies flowing through urban areas (represented by CORINE 2018 urban data) were considered in the assessment. Representatives from a city council and a rural council also provided valuable insights and experience on the infrastructure, maintenance works and mitigation measures planned in their respective local authority areas. These insights were used to develop case studies on which to base the assessment.

- ***A total of 219 river water bodies (1217 MQI reaches) were identified as having this specified use present***

Step 2 – Is the water body artificial?

A number of river reaches within one artificial waterbody was removed from the assessment.

- ***218 river water bodies (1188 MQI reaches) remained after Step 2***

Step 3 – Screening: Are there any changes in hydromorphology?

Screening was carried out primarily using the MQI Ireland tool to identify river reaches with hydromorphological impact that is driven by this specified use. Impacts were primarily in the indicator groups relating to longitudinal and lateral connectivity, and channel morphology. These impacts are related to sediment availability and transport, and connectivity to the river corridor and floodplain, usually from the presence of bank protection (e.g. concrete) or embankments. These impacts were used to screen in river reaches which had changes in hydromorphology.

- ***217 RWBs (1160 MQI reaches) remained following Step 3***

Steps 4 – 6
Step 4: Description of significant changes in hydromorphology?
Step 5: ***Is it likely that water body will fail good ecological status due to changes in hydromorphology?***
Step 6: ***Is the water body substantially changed in character due to physical alterations by human activity***

Step 4
The main impact to hydromorphology associated with urbanisation were identified as follows:

- Changes to river morphology by substantial channel alteration including river cross-sectional profile and channel straightening, or both. Some river reaches may be completely culverted. Within urban settings, channel morphology is also impacted due to changes in bed and bank substrate, usually associated with improving conveyance (e.g. concrete flood walls) and culverting.
- Changes to lateral connectivity by disconnecting the river from its corridor and floodplain. This results from encroachment of urban development within the riparian zone and often up to the channel edge. Concrete bank and bed protection are often part of such historical modifications. The complete loss of riparian and marginal vegetation often occurs, with the exception of some green spaces in some places within urban areas. Associated changes to the river bank and bed, and the channel flow regime, can also alter sediment composition and transport downstream.
- Changes to the longitudinal connectivity may arise in reaches with urban weirs, or from the presence of other barriers such as river crossings.

Step 5
The multitude of types of hydromorphological modifications associated with rivers in urban environments, and their lateral extent, can result in significant permanent impacts to multiple aspects of their aquatic ecosystems. These can include impacts to all the supporting conditions including morphology, flow, physico-chemical parameters, chemicals and nutrients, which can in turn have negative impacts on habitats, water quality, and all the plants, animals and insects. It is therefore considered that these waterbodies are highly likely to fail Good Ecological Status due to changes in hydromorphology.

Step 6
One challenge with assessing the importance of the urban environment outside the major cities, in our rural towns and villages, is that the scale of the urbanised area can at times be a small proportion of the overall waterbody. The question then arises as to how significant the impact of a relatively small reach is within a larger system. There may also, at times, be difficulties in distinguishing impacts in these waterbodies from other stressors, such as nutrients and chemicals from point source discharges that are not related to the hydromorphological changes.

In order to assess if an urban waterbody has been substantially changed in character, the river reach assessment was combined back to water body level and a spatial scale threshold was applied that was different to other specified use groups. Where 25% or greater of the total waterbody length was impacted (with a minimum total length of 1 km) the impacts on that waterbody were deemed to be widespread and profound.

- ***23 RWB remained following Steps 4 -6 and are identified as <u>provisional</u> heavily modified waterbodies (pHMWBs) under the urban specified use***

Steps 7-9

Step 7 Designation test 4 (3)(a) (Restoration measures): Identify restoration measures necessary to achieve GES. Do these measures have significant adverse effects on the wider environment or the ''specified uses''?

Step 8 Designation test 4(3)(b) (Alternative options): Can the beneficial objectives served by the modifications of the HMWB be achieved by other means, which are a significantly better environmental option, technically feasible and not disproportionately costly?

Step 9: *Designate as HMWB*

Step 7

A list of restoration measures related to urban areas were collated from the Mitigation Measures Library of the EU CIS Guidance No. 37, UKTAG WFD Cycle 1 measures library and the Freshwater Morphology POMs Group Best Practice Toolkit. This list was discussed with the relevant pressure owners (*i.e.,* as mentioned above in Step 1, representatives from a city council (Dublin City Council) and a rural council (Offaly County Council)). Measures that were key to restore ecological status conditions to Good were identified.

Restoration measures associated with this specified use include removal and/or replacement of bank/bed protection, reopening of culverts and restoring natural variability of channel dimensions. Removal of bank protection aids the establishment of riparian vegetation allowing for multiple environmental outcomes such as habitat, shade, and a buffer to fine sediment/nutrient runoff. Removal of bed protection provides substrate for plants, insects and fish. Reopening of culverts restores natural flow and sediment conditions, returning the river to its channel, restoring riparian vegetation, and providing habitat for plants, animals and insects to re-establish. Restoring natural variability of the channel can involve narrowing, widening, or reconnecting meanders. These activities restore flow and sediment conditions and in turn, habitat.

Based on the information provided by both councils, these restoration measures cannot typically be implemented in full within the constraints of the existing built urban environment. Removing bank or bed protection can lead to potential slope stability issues thus impacting infrastructure (roads, buildings) due to an increase in the erosive effects of flows. Restoring the natural dimensions of a river channel requires space which is often limited in an urban setting. This measure also encourages floodplain reconnection which can at times be considered as a flood risk in the urban setting. Reopening culverts (often situated in private lands) and connecting the river channel to the surface requires urban space, while also impacting infrastructure and potentially increasing flood risk.

However, mitigation measures were identified that may support Good Ecological Potential (Appendix 2 outlines the Prague, or mitigation measures, approach). Nature based Sustainable Urban Drainage (SUDs) is an approach to surface water management in an urban setting that considers space for water. It involves natural water retention measures such as replacing impermeable areas, where possible, with permeable nature-based solutions and increasing water storage to alleviate flood risks. Nature based SUDS provides multiple benefits such as reducing flooding, urban run-off, 'greening' of urban areas and supporting biodiversity. This type of mitigation measure is currently being considered as an action in the draft River Basin Management Plan for the third cycle. As mentioned in Section 5.1.2, the recently developed Nature Based Catchment Management Solutions (NbCMs) guidance considers measures related to an urban setting, including SUDs.

Appendix 4 provides a list of measures that were identified as either restoration measures (to restore to Good Ecological Status but with significant adverse impacts to the specified use (when implemented at the necessary scale and within the indicated timeframe) or mitigation measures (to support Good Ecological Potential). With considered longer-term land use planning, there can be potential to introduce changes so that some urban specified use can be removed without significant adverse impacts. Provision can be made through policy and land use zoning decisions for the longer-term implementation of some of these measures in statutory plans and non-statutory plans by Planning Authorities. This is to be encouraged for multiple environmental, public health and amenity reasons. The scale at which measures are indicated and typical planning and development timelines can however present a challenge and the impact of such policies and interventions would need to be reviewed over time with respect to the achievement of Good Ecological Status. The implementation of measures may at times, for practical and logistical reasons, need to be opportunistically aligned with City/County Development Plans, Local Area Plans, etc. at a strategic level and also implemented through individual new planning applications, as and when they are received. For these reasons, such plans would require long-term support at several levels, from strategic high-level all the way through to individual site level.

Step 8

The available evidence would suggest that restoration measures in urban watercourses to remove the hard engineering works, without impacting on the specified use, are very challenging and are often not achievable because of the limitations of the extent of the existing built environment. In these cities, towns and villages, there are often limited, if any, alternative options without significantly impacting on the specified use. New urban developments, or redevelopments, however, can, and should, consider how best to integrate the WFD objectives into the planning process. The Department of Housing, Local Government and Heritage is currently developing planning guidance that will assist in this regard.

Step 9

In these urban settings, measures are typically not available to fully restore all the WFD elements to support Good Ecological Status condition, without impacting the urban environment, and there are no currently available alternative options, the 23 provisional candidates are recommended for designation as Heavily Modified Water Bodies.

A total of 23 river water bodies are designated as heavily modified water bodies under the Urban specified use

5.1.4 Navigation

Several waterways are used in Ireland for navigation, including for example, within the Shannon and the Barrow catchments. The types of hydromorphological pressures that may be present include permanent structures such as weirs and locks, and marinas and harbours. Channels may have been straightened and deepened, and there may be ongoing regular programmes of dredging and channel maintenance. All of these pressures in turn impact on habitat conditions and flows, which can result in unfavourable conditions for aquatic plants, insects and fish.

Step 1 – Water body identification – is a specified use present?

River water bodies with navigation schemes were considered for the assessment. The schemes that had available data included Barrow navigation, Erne system, Grand Canal, Royal Canal and Shannon navigation. These data were provided spatially by Waterways Ireland. Waterways Ireland also provided information and knowledge on the navigation infrastructure and their programme of maintenance works.

- ***A total of 107 river water bodies (479 MQI reaches) were identified as having this specified use present***

Step 2 – Is the water body artificial?

River reaches linked to the Royal Canal, Grand Canal and the canalised section of the Shannon-Erne Waterway between the Shannon and Erne systems were removed from the assessment as canals are considered to be artificial waterbodies in the WFD.

- ***37 river water bodies (302 MQI reaches) remained after Step 2***

Step 3 – Screening: Are there any changes in hydromorphology?

Screening was carried out primarily using the MQI Ireland tool to identify river reaches with hydromorphological impact that is driven by this specified use. Impacts were primarily in the indicator group relating to longitudinal connectivity. Longitudinal connectivity relates to the presence of weirs and locks. Morphological changes would have occurred historically when the works were carried out initially to improve navigation, but there are also typically on-going maintenance dredging works in limited stretches of the network. These impacts were assessed to determine which river reaches were screened in due to changes in hydromorphology.

- ***37 RWBs (200 MQI reaches) remained following Step 3***

Steps 4 – 6
Step 4: Description of significant changes in hydromorphology?
Step 5: ***Is it likely that water body will fail good ecological status due to changes in hydromorphology?***
Step 6: ***Is the water body substantially changed in character due to physical alterations by human activity***

Step 4
The main impact to hydromorphology associated with navigation schemes was identified as follows:

- changes to longitudinal connectivity – the presence of weirs and locks required for navigation disrupts or blocks the natural passage of fish and sediment along the river channel.

Step 5
The key biological indicator that is most sensitive to the permanent hydromorphological impacts associated with navigation is fish. The weirs and locks can directly affect the passage of multiple fish species upstream and downstream unless adequate fish pass structures are in place. The national fish monitoring programme is carried out at approximately 160 surveillance monitoring sites around the country, supplemented by some additional monitoring by Inland Fisheries Ireland (IFI) in catchments of interest. The Barrow catchment is one such catchment of interest. A catchment wide fish survey carried out in the Barrow in 2015 showed that good fish status was recorded in the upper catchment and in the faster flowing, non-navigable river sections downstream of the weirs, but fish were poor in the ponded areas upstream of weirs. Further work is being undertaken by IFI under the national barriers programme to assess the condition of and possible mitigation measures for the weirs.

Step 6
In order to assess if the water body has been substantially changed in character, the river reach assessment was combined back to water body level and a spatial scale threshold was applied. Where 15% or greater of the total waterbody length was impacted or a minimum total length of 1km, that waterbody was deemed to be significantly impacted.

- ***30 RWB remained following Steps 4 -6 and are identified as provisional heavily modified waterbodies (pHMWBs) under the navigation specified use***

Steps 7-9

Step 7 Designation test 4 (3)(a) (Restoration measures): Identify restoration measures necessary to achieve GES. Do these measures have significant adverse effects on the wider environment or the ''specified uses''?

Step 8 Designation test 4(3)(b) (Alternative options): Can the beneficial objectives served by the modifications of the HMWB be achieved by other means, which are a significantly better environmental option, technically feasible and not disproportionately costly?

Step 9: ***Designate as HMWB***

Step 7
A list of restoration measures related to navigation were collated from the Mitigation Measures Library of the EU CIS Guidance No. 37, UKTAG WFD Cycle 1 measures library and the Freshwater Morphology POMs Group Best Practice Toolkit. This list was discussed with the relevant pressure owners (*i.e.* Waterways Ireland). Measures that were key to restore ecological status conditions to Good were identified.

Such restoration measures can include removal of impounding structures (i.e. weirs, locks, sluices) which support ecological continuity (e.g. fish migration). It also allows for the re-establishment of natural flow and sediment regimes, which creates and maintains habitat. Based on the information provided by Waterways Ireland, these kinds of restoration measures could not be implemented in the key catchments without significantly impacting on navigation. Removal of impounding structures would impact the water depths, levels and flow conditions that are required for navigable waters.

There are, however, mitigation measures that may support Good Ecological Potential (Appendix 2 outlines the Prague, or mitigation measures, approach). Similar to water storage and regulation, one such measure includes fish migration aids (i.e. fish pass, screen, ladders) to allow the movement of fish along the river channel. Waterways Ireland are currently identifying opportunities for fish passage measures.

Appendix 4 provides a list of measures that were identified as either restoration measures (to restore to Good Ecological Status but with significant adverse impacts to the specified use) or mitigation measures (to support Good Ecological Potential).

Step 8

The River Barrow Navigation and Shannon Navigation are the results of major engineering works undertaken in the eighteenth and nineteenth centuries. The supply of water had to be maintained by the construction of several weirs and locks (with additional short sections of lateral canal necessary to bypass shallow or rapid waters on the River Barrow). They were a major undertaking at the time and are of significant cultural heritage value today, as well as being major tourist attractions in their regions.

As restoration measures are not available without significantly impacting on the navigation uses, alternative options were also considered. Alternative options could include the creation of parallel artificial channels to provide navigation for recreational purposes.

Significant land area would be required to create such new channels and the technical feasibility of their construction would be challenging given all the development that has taken place in these catchment areas since navigation commenced. Furthermore, these river systems lie within extensive Natura 2000 sites and new construction may not be viable in proximity to these sites. Therefore, on the basis of current information provided by Waterways Ireland, there are no alternative options for navigation that are technically feasible at the current time.

Step 9

As there are no measures available that can restore ecological status conditions without impacting navigation, and there are no alternative options, the 30 provisional candidates are designated as Heavily Modified Water Bodies.

A total of 30 river water bodies are identified as heavily modified water bodies for navigation

5.1.5 Arterial drainage

Arterial drainage schemes were established in the mid-20th century to deepen, widen and straighten river channels, in specific arterial drainage scheme areas, for the purposes of draining lands and reducing flooding for the benefit of agricultural lands. The channels have been regularly maintained since with the periodic removal of silt and vegetation build up to ensure conveyance of flood flows. The initial development of the schemes altered the channel structures and disconnected the rivers from their flood plains. The ongoing maintenance of these drainage schemes involves regular removal of bed material, instream vegetation and bank side riparian vegetation which can impact on habitat conditions, and water quality downstream.

Step 1 – Water body identification – is a specified use present?

River water bodies with an arterial drainage scheme as identified by the OPW were considered for HMWB designation. Other schemes such as the Local Authority led drainage district schemes were omitted from this current review as there is a lack of information available on which to assess them. For example, many schemes have been discontinued, maintenance regimes are irregular and are not consistent, and records of the works are poor. Local scale works carried out by individuals to drain their agricultural lands are also not included in the current assessment due to lack of data availability. Although the impacts of the latter may be more local in scale, they can be significant for water quality, especially in high status waters.

- ***A total of 672 river water bodies (15,831 MQI reaches) were identified as having this specified use present***

Step 2 – Is the water body artificial?

A number of river reaches were removed which were linked to artificial water bodies, but the number of waterbodies remained unchanged.

- ***672 river water bodies (15,794 MQI reaches) remained after Step 2***

Step 3 – Screening: Are there any changes in hydromorphology?

Screening was carried out primarily using the MQI Ireland tool to identify river reaches with hydromorphological impact that is driven by this specified use. Impacts were primarily in the indicator groups relating to channel morphology and lateral connectivity. Lateral connectivity related to disconnection of the river from its floodplain due to deepening or embankments. Channel morphology related to changes to the river channel profile including over deepening, widening, and cross-section changes. These changes occurred when the scheme works were carried out typically to improve conveyance. Ongoing maintenance works are typically planned on a 5-year rolling basis, but may not always be carried out where not deemed necessary.

- ***663 RWBs (9,902 MQI reaches) remained following Step 3***

Steps 4 – 6
Step 4: Description of significant changes in hydromorphology?
Step 5: ***Is it likely that water body will fail good ecological status due to changes in hydromorphology?***
Step 6: ***Is the water body substantially changed in character due to physical alterations by human activity***

Step 4

The main impact to hydromorphology associated with arterial drainage schemes were identified as follows:

- changes to river morphology – substantial channel alteration including river cross-sectional profile and channel straightening or both. Channel morphology is also impacted due to changes in bed and bank substrate often associated with improving conveyance. Excess sediment erosion from bare banks that have had their vegetation cleared, or as a result of more erosive fast flows, may impair habitat condition. Sediment composition and transport downstream may also be impacted. This in turn impacts channel form and function, and physical habitat conditions downstream.
- changes to lateral connectivity by disconnecting the river from its corridor and floodplain. This mainly results from over-deepening the channel after reprofiling to cease out of bank flooding and improve conveyance. The loss of riparian and marginal vegetation often occurs due to on-going maintenance. Large woody debris which provides important instream habitat diversity is also typically removed.

Step 5

A number of the impacts associated with this specified use are permanent and have a significant and profound impact on the supporting conditions necessary to achieve key biological processes. The biological impacts may be evident in places in macroinvertebrates and macrophytes reflecting the changes to channel morphology and habitat conditions caused by the dredging, and in fish reflecting the changes to overall habitat condition, excess sediment and changes to riparian vegetation.

A report produced by Inland Fisheries Ireland for the first cycle plan development indicated that surveys have shown little natural recovery in the morphology of many drained channels, up to 60 years after the drainage works took place. Natural biological recovery after channelisation is entirely dependent on morphological recovery, which in turn is dependent on the river gradient – high gradient rivers can achieve some recovery in as little as 2-3 years after channelisation, with full recovery in up to 7 years. Recent research being carried out by the Inland Fisheries Service in a tributary of the River Boyne has demonstrated significant natural recovery has occurred following cessation of channel maintenance. Low gradient rivers however, do not generate sufficient energy and can remain significantly affected in the long term and require ongoing, more frequent maintenance.

The guidance states that if a modified waterbody can achieve Good Ecological Status, it should not be further considered for a heavily modified designation. After consultation with key stakeholders, it was concluded that it is possible that Good Ecological Status can be achieved in some waterbodies within the arterial drainage schemes. This is because the ecology can recover after the historical over-deepening has occurred (albeit with the river still disconnected from its floodplain), if the channel is not maintained and/or it has a reasonable gradient that encourages natural restoration to occur. It is also known that parts of the channels were never historically maintained. Digital maintenance records are unfortunately not currently available to spatially identify these reaches. It must also be acknowledged that the most widely available biological monitoring data are for macroinvertebrates, which are more sensitive to organic and nutrient pollution than to hydromorphological impacts. This means that the true ecological impacts in dredged rivers, for example to fish, macrophytes or other biological indicators, may be being masked because of the lack of sensitive biological data.

For the purposes of the current review, a conservative approach has been taken to give the benefit of the doubt to waterbodies that have achieved Good Ecological Status (on the basis of the available data) in the recent past. A rule has been applied that any waterbody that has achieved Good Ecological Status within the previous three monitoring periods is excluded from further assessment as provisionally heavily modified, as it has already demonstrated that it can achieve good status. Waterbodies which have not achieved Good Ecological Status during those three monitoring periods were brought forward for further consideration. Over the course of the next cycle, further monitoring and assessment will be undertaken in these kinds of waterbodies to improve the understanding of the linkages between hydromorphological impacts associated with channel maintenance and ecological health. This new understanding can feed into the next review.

Step 6

In order to access if the waterbodies have been substantially changed in character, the river reach assessments were combined back to waterbody level, and a spatial scale threshold was applied. Where 15% or greater of the total waterbody length was impacted or a minimum total length of 1km, that waterbody was deemed to be significantly impacted.

- ***325 RWB remained following Steps 4 to 6 and are identified as provisional heavily modified waterbodies (pHMWBs) for arterial drainage***

Steps 7-9

Step 7 Designation test 4 (3)(a) (Restoration measures): Identify restoration measures necessary to achieve GES. Do these measures have significant adverse effects on the wider environment or the ''specified uses''?

Step 8 Designation test 4(3)(b) (Alternative options): Can the beneficial objectives served by the modifications of the HMWB be achieved by other means, which are a significantly better environmental option, technically feasible and not disproportionately costly?

Step 9: ***Designate as HMWB***

Step 7

A list of restoration measures related to arterial drainage were collated from the Mitigation Measures Library of the EU CIS Guidance No. 37, UKTAG WFD Cycle 1 measures library and the Freshwater Morphology POMs Group Best Practice Toolkit. This list was discussed with the relevant pressure owners (*i.e.* OPW).

Restoration measures that are key to restoring ecological status conditions to Good include raising the bed level back to its original state and reconnecting meanders. Such measures would allow the channel to be reconnected back to the floodplain, allowing water and sediment to spill out over the banks, provide habitat and refuge and aid water retention (i.e. slowing and reducing the flood peaks further downstream, reducing the erosive power of flows thus reducing fine sediment inputs within the channel). Furthermore, re-establishing the natural planform of a channel would support variable flow conditions, which in turn can create and maintain habitat. Another restoration measure involves cessation of channel maintenance, allowing the river to self-recover, preventing further disturbance to the riparian, bank and riverbed habitats. In this measure, the channel bed level would raise over time with silt and vegetation deposition and the channel flood capacity would reduce over time as the channel narrows due to vegetation encroachment, although research has found that self-recovery is more successful in rivers with sufficient gradient.

The key function of arterial drainage schemes is to improve land for agricultural production. They also serve as a flood protection measure and the maintenance of these schemes ensures these functions are protected. Based on the currently available information, the implementation of these kinds of restoration measures would rewet agricultural land thus impacting current farming practices and therefore the specified use. Infrastructure and development now also often exist on these drained floodplains, so measures to reconnect the channel to the floodplain can have significant socio-economic implications in places.

There are, however, mitigation measures that may support Good Ecological Potential (Appendix 2 outlines the Prague, or mitigation measures, approach). Such mitigation measures include the use of ecologically sensitive channel maintenance strategies and techniques. As mentioned in Section 5.1.2 (flood protection), the OPW Environmental Guidance: Drainage Maintenance and Construction is an example of a mitigation measure that currently exists and is mandatory for arterially drained rivers. Another mitigation measure that is currently being implemented is the IFI and OPW Environmental River Enhancement Programme (EREP)[11]. This involves rehabilitation of fish habitat within arterially drained rivers through such activities as importing spawning gravels, adding boulders or deflectors to improve flow variability. These measures enhance the habitat conditions and provide spawning habitat for fish albeit are only applicable for a portion of drained channels i.e. channels with a medium gradient which are suitable for salmonid fish species.

Appendix 4 provides a list of measures that were identified as either restoration measures (to restore to Good Ecological Status but with significant adverse impacts to the specified use) or mitigation measures (to support Good Ecological Potential).

Step 8

The specified use owner, in this case the OPW, has indicated that on the basis of the best available information, the required restoration measures could not be implemented without impacting on the specified use. It is not technically feasible to maintain these land uses without these schemes in place, so there are no technically feasible alternative options. The OPW are currently legally obliged to maintain these schemes under the Arterial Drainage Act.

Step 9

As there are no measures available that can restore ecological status conditions without impacting arterial drainage, and there are no alternative options, the 325 provisional candidates are designated as Heavily Modified Water Bodies.

A total of 325 river water bodies are identified as heavily modified water bodies for arterial drainage

5.1.6 Summary of heavily modified waterbody designation (Rivers)

Table 5.1 summarises the total number of designated heavily modified river waterbodies. Some waterbodies are affected by multiple specified uses, such as urban and flood protection for example, and these are separated out for clarity. One river water body (Bregagh (Kilkenny)_030), designated in the first cycle under 'wider environment' (contamination event that required localised dredging/introduction of artificial material), was de-designated for the third cycle as it no longer meets the criteria (i.e. localised and an one off event).

[11] https://www.fisheriesireland.ie/what-we-do/research/environmental-river-enhancement-programme-erep

Table 5-1: 3rd Cycle HMWB river waterbody designations

<table>
<tr><td rowspan="2">HMWB designations (rivers)</td><td rowspan="2">433</td><td>Single specified use</td><td>396</td></tr>
<tr><td>Multiple specified uses</td><td>37</td></tr>
<tr><td colspan="4">Breakdown of specified uses
(Note that multiple specified uses can exist in a river water body)</td></tr>
<tr><td>Specified use</td><td colspan="2">Single specified use</td><td>Multiple specified uses</td></tr>
<tr><td>Water storage & regulation</td><td colspan="2">27</td><td>2</td></tr>
<tr><td>Flood protection</td><td colspan="2">31</td><td>33</td></tr>
<tr><td>Urban</td><td colspan="2">13</td><td>10</td></tr>
<tr><td>Navigation</td><td colspan="2">28</td><td>2</td></tr>
<tr><td>Arterial drainage</td><td colspan="2">297</td><td>28</td></tr>
</table>

5.2 Lake waterbodies

There are 812 lakes designated for WFD monitoring and reporting purposes. For the first cycle of the WFD, 16 lakes were designated as HMWB. Water storage and regulation was the main specified use type associated with lake water bodies for water supply, flood protection and power generation. The ecological impacts of large impoundments associated with water storages has been discussed throughout Section 5.1. The assessments of hydromorphological pressures and modifications were carried out at a waterbody scale.

5.2.1 Water storage and regulation

Step 1 – Water body identification

The HMWB designation review for lakes followed the same process as rivers but was based on the outputs of the Lake MImAS tool. Review of lakes for the HMWB designation began with the existing list of 812 WFD lakes. These lakes met the criteria for identified lakes for the first WFD cycle, with some additions and re-delineations in subsequent cycles.

- ***A total of 812 lake water bodies (RWB) were identified***

Step 2 – Is the water body artificial?

One of the unmonitored lakes was designated as artificial in the first cycle. This is Sevenchurches, the lake created to service the ESB's pumped storage reservoir at Turlough Hill. It was screened out at this stage.

- ***811 RWBs remained after Step 2***

Step 3 – Screening: Are there any changes in hydromorphology?

Lakes were assessed in three main groups based on data availability:

1. Existing HMWBs designated in the first cycle of the WFD (16 lakes within ROI);
2. Monitored lakes for which more detailed monitoring data exists (215 lakes) and;
3. Unmonitored lakes (579 lakes).

Existing HMWBs were screened in based on known hydromorphological changes from the first cycle (16 lakes). Outputs from the lake hydromorphology condition assessment tool (Lake MImAS) was used to screen in monitored lakes. MImAS scoring works on the premise that lakes have a finite capacity for hydromorphological alteration and the greater the alteration, the greater the capacity used. This is measured as a percentage. The criteria for screening was based on a threshold of >5% capacity used within the lake system. At this capacity, a lake moves from high hydromorphological condition to good. This resulted in 132 lake being screened in. For unmonitored lakes, those deemed to be at risk from abstraction were screened in (40 lakes).

- ***188 LWBs met the criteria for having a change in hydromorphology***

Step 4 – Description of the significant changes in hydromorphology?

Existing HMWBs (lakes) were again screened in based on known hydromorphological changes from the first cycle. Outputs from MImAS were again used to identify significantly impacted monitored lakes. The criteria for inclusion was based on a threshold of >20% capacity used within the lake system. This was selected based on assessment of the scores for existing HMWBS, which all had greater than 23% capacity used. This resulted in 15 lakes being screened in. For unmonitored lakes, those deemed to be at risk from abstraction were cross referenced with information on the presence of impounding structures. These data were collected from the rivers hydromorphological assessment tool (MQI-Ireland) and data provided by Irish Water, which resulted in 11 lakes being screened in. Specified use owners were identified, including Irish Water, ESB Ireland, the OPW and Waterways Ireland. Additional data on management of the water bodies was requested for a number of these water bodies and incorporated into the review.

- ***42 LWBs remained after Step 4***

Step 5 – Is it likely that the water body will fail to achieve good ecological status due to changes in hydromorphology?

All status data (biological, chemical, hydromorphological) available for lakes that were still screened in were assessed. Expert judgement on fish status was discussed with IFI for lakes where this biological element is not surveyed. It was agreed that a water body with a large dam that prevents fish passage could not achieve good status. Status information and dam type and management were not available for all unmonitored lakes. Where evidence was not available, lakes were screened out. This resulted in 21 lakes being screened in.

- ***21 LWBs remained after Step 5***

Step 6 – Is the water body substantially changed?

All lakes screened in by the previous five steps were assessed individually using all available data, including remote sensing imagery and historical maps to validate that the hydromorphological change was substantial, extensive and permanent. Only one lake was screened out at this step, as it was identified as artificial during the investigation (St. Peter's Lough).

- ***20 LWB remained after Step 6 and are identified as provisional heavily modified waterbodies (pHMWBs) under the water storage and regulation specified use***

Step 7 Designation test 4 (3)(a) (Restoration measures): Identify restoration measures necessary to achieve GES. Do these measures have significant adverse effects on the wider environment or the ''specified uses''?

Step 8 Designation test 4(3)(b) (Alternative options): Can the beneficial objectives served by the modifications of the HMWB be achieved by other means, which are a significantly better environmental option, technically feasible and not disproportionately costly?

Step 9: Designate as HMWB

Step 7

As for the HMWB designation review for rivers, the list of restoration measures related to water storage and regulation were collated from the available measures libraries and toolkits. Measures that were key to restore ecological status conditions to Good included removal of the impoundments and other infrastructure associated with the water supplies. As outlined earlier, these restoration measures cannot typically be implemented without significantly impacting the specified use, but a number of mitigation measures supporting fish migration and ecological flows have been identified. These measures will be informed by the work of the IFI on barriers.

Appendix 4 provides the full list of measures that were identified as either restoration measures (to restore to Good Ecological Status but with significant adverse impacts to the specified use) or mitigation measures (to support Good Ecological Potential). Many of these measures are common to the lakes upstream of the dam and the rivers downstream of them, which is critical to managing the hydromorphological pressure at a catchment scale.

Step 8

As outlined in Section 5.1 regarding rivers, there are no restoration measures available without impacting on the specified use. Irish water is developing a national water resources plan which includes an assessment of existing sources and consideration of new and alternative supplies. Irish water has been conducting a drinking water supply rationalisation study and has advised that, based on the currently available information, there are no alternative options that are a significantly better environmental option or not disproportionately costly.

Step 9: Designate as HMWB

As there are no measures available that can restore ecological status conditions without impacting water storage and regulation, and there are no alternative options, the provisional candidates are recommended for designation as Heavily Modified Water Bodies.

A total of 20 lake water bodies are identified as heavily modified water bodies under the water storage and regulation specified use

5.2.2 Summary of heavily modified waterbody designation (Lakes)

As indicated, all lake water bodies identified for HMWB designation (Table 5.2) were all modified for water storage and regulation by an impounding structure. The proposed HMWBs were of three main types:

1. Water bodies that were historically rivers but have been modified by the creation of an impoundment and are now more functionally like a lake (i.e. reservoirs).
2. Water bodies that were historically lakes but have been modified by the creation of an impoundment (i.e. reservoirs).
3. Water bodies that have been identified as HMWB in the first cycle of RBMP planning and may have historically been rivers or lakes.

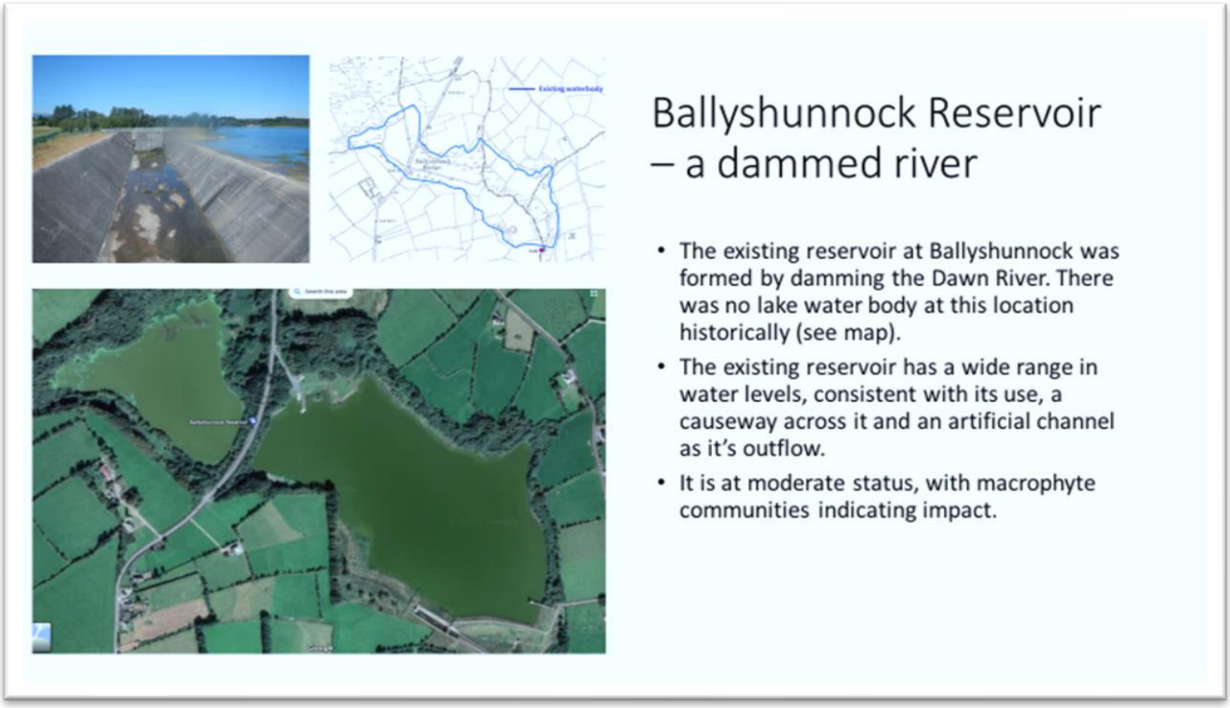
Case studies are provided for each of these example types below to highlight the type and magnitude of the modifications involved and the ongoing impacts of the modification.

Table 5-2: Third Cycle HMWB lake waterbody designations. Note that water supply and power generation fall under the specified use category 'Water storage and regulation'.

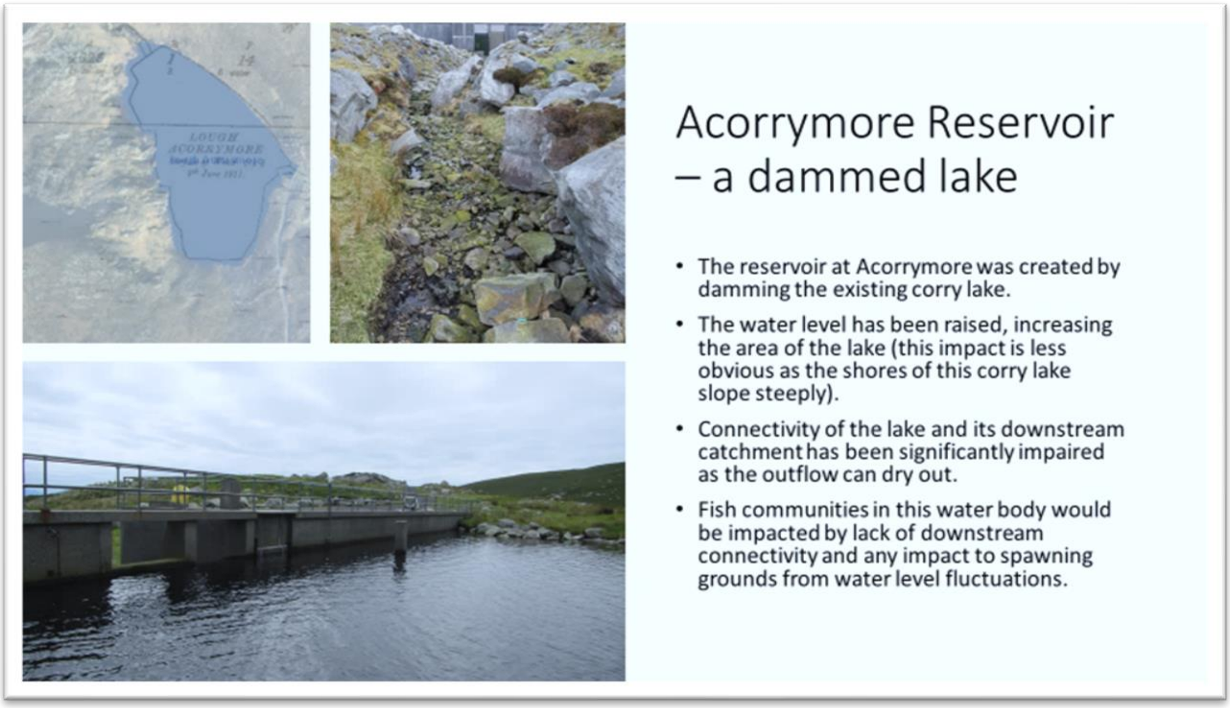
Name	**Previous Designation**	**Specified Use**	**Substantial change**	**Monitored**
Golden Falls	HMWB	Water supply; Power generation)	Dammed lake	0
Glenasmole Lower	HMWB	Water supply (& Flood protection from Cycle 1)	Dammed river - reservoir	1
Leixlip Reservoir	HMWB	Water supply; Power generation	Dammed river – reservoir	0
Glenasmole Upper	HMWB	Water supply	Dammed river - reservoir	1
Pollaphuca	HMWB	Water supply; Power generation	Dammed river - reservoir	1
Vartry Lower	HMWB	Water supply	Dammed river - reservoir	1
Vartry Upper	HMWB	Water supply	Dammed river - reservoir	0
Nahanagan	HMWB	Power generation	Pumped lake - reservoir	0
Assaroe	HMWB	Power generation	Dammed river - reservoir	0
Nacung Upper	HMWB	Power generation	Dammed lake	0
Salt	HMWB	Water supply	Dammed lake	1
Dunlewy	HMWB	Power generation	Dammed lake	0
Doo CE	HMWB	Water supply	Dammed lake	1
Inniscarra	HMWB	Water supply; Power generation	Dammed river – reservoir	1
Carrigdrohid	HMWB	Power generation	Dammed river - reservoir	1

Derg HMWB	HMWB	Power generation	Dammed lake	1
Kilsellagh	Lake	Water supply	Dammed river - reservoir	1
Ballyshunnock	Lake	Water supply	Dammed river - reservoir	1
Acorrymore	Lake	Water supply	Dammed lake	1
Greagh	Lake	Water supply	Dammed lake	0

Case study 1: Ballyshunnock Reservoir



Case study 2: Acorrymore Reservoir



Case study 3: Vartry Reservoir

5.3 Transitional and Coastal waterbodies

There are 304 transitional and coastal (TraC) water bodies in ROI, 11 of which were previously designated as heavily modified[12]. These HMWBs are Broadmeadow, Liffey Estuary Lower, Lower Suir Estuary, New Ross Port, Lee (Cork) Estuary Lower, Lough Mahon, Limerick Docks, Foynes Harbour, Rosslare Harbour, Cork Harbour and North Western Atlantic Ocean (Killybegs Harbour).

The assessments of hydromorphological pressures and modifications were carried out at a waterbody scale. The majority of hydromorphological modifications that were examined were associated with navigation and urban specified uses.

5.3.1 Navigation and urban

Navigation and urban are the main specified use associated with TraC water bodies in Ireland. Several TraC water bodies are used for navigation purposes around the Irish coast. Hydromorphological pressures associated with navigation structures and activities (e.g. dredging) impact on the functioning of the water body in various ways. Groynes, breakwaters and jetties change the habitat within their footprint and can cause scour or modify sediment transport. They also typically change wave exposure, creating sheltered environments in their lee. Vertical walls lead to direct and indirect loss of intertidal habitat and (depending on depth and wave exposure) changes in shallow water habitat/substrate type and associated connectivity. Dredging activities in ports can have profound effects on the environment. Dredging removes the original substrate including any species present, and possibly also changes the nature of substrate and/or of the intertidal area and associated connectivity. Maintenance dredging regularly removes or relocates the accumulated sediment and any species present, temporarily leading to increased suspended sediment levels. This increase in

[12] Note that an additional two HMWBs include Newry Estuary and Foyle and Faughan Estuaries. These are cross border HWMBs monitored by the Northern Ireland Environment Agency and therefore are not included in this review.

suspended matter both directly and indirectly affects macrophytes, benthic invertebrates, fish and phytoplankton communities.

TraC water bodies associated with urbanised catchments are often channelised and straightened and have their bed and banks reinforced with hard engineering to prevent flooding or provide a foundation for adjacent buildings. Subtidal and intertidal habitats are lost when land is claimed from the sea. Adjacent areas may also be affected and alongshore connectivity may be compromised. Revetments and other erosion control works affect the intertidal and shallow subtidal margins, directly and indirectly (e.g. as a result of connectivity loss) impacting on species, modifying sediment supply and transport, and preventing habitat evolution. Drains or drainage networks may deliver contaminated runoff from the paved areas during rainfall. Outfalls physically modify intertidal and shallow subtidal habitats in their vicinity.

The following section describes the application of the steps of the designation assessment for the TraC waterbodies.

Step 1 – Water body identification

All WFD water bodies (both monitored and unmonitored) from around the Irish coast were examined and 304 TraC water bodies were identified.

- ***A total of 304 TraC water bodies were identified***

Step 2 – Is the water body artificial?

No artificial water bodies were identified.

- ***304 water bodies remaining.***

Step 3 – Screening: Are there any changes in hydromorphology?

A screening process was used to identify water bodies which should not be considered for HMWB designation. All morphological alterations were considered in this step. Outputs from the TraC-MImAS tool were used to determine the percentage area and/or percentage shoreline length of a water body altered/impacted by alterations for a specified activity. Spatial data outputs from TraC-MImAS include land claims, dredging, use of dredged material, high voltage (HV) cables and pipelines, flow and sediment manipulation structures, shoreline reinforcement (hard/soft engineering), flood defence embankment, piled structures and other seabed uses (aquaculture, dredging and trawling fishing).

A threshold of greater than 5% area and/or length of shoreline impacted by pressures was applied. Water bodies with pressures less than 5% area and/or shoreline length impacted were screened out of the designation process.

- ***167 TraC water bodies met the criteria for having a change in hydromorphology***

Step 4 – Description of the significant changes in hydromorphology?

For waterbodies not screened out in Step 3, significant hydromorphological pressures were listed for each water body. The Ecological Status for each of the remaining water bodies was also taken into account. In the case of unassigned waterbodies, WFD Risk was used (risk is based on TRAC status extrapolation so considered suitable for this screening step). Water bodies with High or Good Ecological Status (considering the relevant sensitive BQEs) were screened out in accordance with the guidance. Unassigned water bodies were not screened out.

- ***121 TraC water bodies remained after Step 4***

Step 5 – Is it likely that the water body will fail to achieve good ecological status due to changes in hydromorphology?

Based on the information gathered in Step 4 and an assessment of the ecological status or risk (for unmonitored water bodies) of the water bodies, the likelihood of a water body failing to achieve Good Ecological Status due to hydromorphological pressures was assessed. For each water body, the quality elements that were less than Good status were identified. As introduced within Section 5.1, the Mitigation Measures Library (EU CIS Guidance No. 37) library was consulted for TraC water bodies to determine the likely effects of a particular pressure on the ecological conditions of a water body. This library outlines the impact of various specified uses (navigation, urban etc.) on the hydromorphology, physio-chemical conditions and BQEs of a water body and the associated measure to mitigate against this impact. For example, maintenance dredging which is carried out to maintain navigation as a specified use is deemed to have a strong or moderate impact on benthic invertebrates but a low likelihood of impacting phytoplankton. In a water body where the only significant hydromorphological pressure is dredging, and the invertebrates quality element is in the less then good category, failure to achieve good status is deemed to be a result of dredging pressures. In water bodies where hydromorphological pressures are not exerting a significant influence on biology, failure to achieve good status is caused by other pressures (e.g. nutrients). These water bodies were screened out.

- ***59 TraC water bodies remained after Step 5***

Step 6 – Is the water body substantially changed?

The purpose of this step is to select those water bodies where the changes in hydromorphology result in the water body being substantially changed in character. The remaining water bodies likely to fail Good Ecological Status, which are not substantially changed in character, will be identified as natural water bodies. Environmental objectives for such water bodies will be Good or High Ecological Status.

This is a subjective step and expert guidance was used to identify water bodies not substantially changed in character due to hydromorphological pressures.

After this step, eight water bodies remained and were identified as provisional HMWBs due to navigation and urban specified uses. In addition, four TraC water bodies previously listed as HMWBs in the first WFD cycle were also included. Due to the interconnected nature of the Lower Liffey Estuary, the Liffey Estuary Upper was also included to the list.

- ***13 TraC remained after Step 6 and are identified as provisional heavily modified waterbodies (pHMWBs) under the navigation and urban environment specified uses***

Step 7 Designation test 4 (3)(a) (Restoration measures): Identify restoration measures necessary to achieve GES. Do these measures have significant adverse effects on the wider environment or the ''specified uses''?

Step 8 Designation test 4(3)(b) (Alternative options): Can the beneficial objectives served by the modifications of the HMWB be achieved by other means, which are a significantly better environmental option, technically feasible and not disproportionately costly?

Step 9: Designate as HMWB

Step 7

The list of restoration measures for TraC waters to address impacts from navigation and urban specified uses were collated from the available measures libraries and toolkits as mentioned in Section 5.1. Measures that were key to restore ecological status conditions to Good were identified by the EPA. However, it was concluded that these key measures could not be implemented, without significantly impacting the urban environment or navigation.

Restoration measures for TraC water associated with the urban environment and navigation specified uses include the improvement of the morphological and/or habitat diversity of the seabed by the placement of rocks, artificial reefs etc. to form reef and/or other types of habitats. The addition of breakwaters, groynes or shore parallel islands introduces local variations in depth, exposure/shelter, etc. and create sheltered conditions to promote intertidal enhancement/development. Reprofiling of embankments and structures to a more natural profile to support habitat development or enhancement would provide benefits, as would restoration of sediment transport process by the removal of sediment from behind structures (breakwater, dam, jetty, terminal groyne etc.) and the serving of the roots of groynes. Modification and management of operation in ports by removing redundant structures, the introduction of a vessel management system, the reduction in vessel speed and seasonal tidal constraint on activities to protect spawning and migration of fish could be adopted. Working on flood or ebb tide to avoid impact on sensitive adjacent habitats and species and selecting dredging methods that retain sediment in a system or avoids raising suspended sediment levels may also provide benefits.

It is unlikely that restoration measures outlined here could be implemented without significantly impacting the specified use of the water body.

Step 8

As outlined in the rivers section, there are no alternative options available without impacting on the navigation and urban specified uses.

Step 9

As there are no restoration measures available that can restore ecological status conditions without impacting navigation and the urban environment, and there are no alternative options, the pHMWBs are identified as candidates for HMWB designation.

A total of 13 TraC water bodies are recommended as heavily modified water bodies under the navigation and urban specified uses

5.3.2 Summary of heavily modified waterbody designation (TraC)

A total of 13 TraC water bodies were identified as HMWBs based on the method outlined above (Table 5.3).

A case study is provided to highlight the type and magnitude of the modifications involved and the ongoing impacts of the modification.

Case study: Broadmeadow Water

Broadmeadow water is c. 3.6 km^2 and is largely cut off from the adjacent Malahide Estuary by a railway embankment. There is a short (180m) railway viaduct in the middle that allows water exchange from Broadmeadow Water to the Malahide estuary. There is extensive shoreline reinforcement throughout the bay. Land claim has been carried out primarily on the southern side of the railway embankment.

The ecological status of Broadmeadow is categorised as Poor. Status is driven by phytoplankton, oxygen and nutrients. With refence to the European Mitigation Library, the morphological alterations, caused by the near total impoundment of the Broadmeadow by the railway embankment, have the potential to adversely affect these three status drivers.

Table 5-3: Third Cycle HMWB TraC waterbody designations

Water body Name	Water body name	Previous Designation	Specified Use	Monitored
Broadmeadow Water	IE_EA_060_0100	HMWB	Urban*	Yes
Cork Harbour	IE_SW_060_0000	HMWB	Navigation/Port	Yes
Lee (Cork) Estuary Upper	E_SW_060_0950	TraC	Urban	Yes
Lee (Cork) Estuary Lower	IE_SW_060_0900	HMWB	Navigation/Port	Yes
Lough Mahon	IE_SW_060_0750	HMWB	Navigation/Port	Yes
New Ross Port	IE_SE_100_0200	HMWB	Navigation/Port	Yes
Rosslare Harbour	IE_SE_045_0000	HMWB	Navigation/Port	No
Foynes Harbour	IE_SH_060_0350	HMWB	Navigation/Port	No
Liffey Estuary Lower	IE_EA_090_0300	HMWB	Navigation/Port	Yes
Liffey Estuary Upper	IE_EA_090_0400	TraC	Urban, Navigation/Port	Yes
Limerick Docks	IE_SH_060_0900	HMWB	Navigation/Port	Yes
Lower Suir Estuary (Little Island-Cheekpoint)	IE_SE_100_0500	HMWB	Navigation/Port	Yes
North Western Atlantic Ocean (Killybegs Harbour)	IE_NW_085_0000	HMWB	Navigation/Port	Yes

**In the case of Broadmeadow, the specific use in the first cycle was identified as 'public transport infrastructure'. Urban environment is now considered the comparable specified use now.*

6 Conclusion

In summary, there were 433 river waterbodies, 20 lakes, and 13 transitional and coastal waterbodies identified as heavily modified waterbodies candidates on the basis of their physical characteristics.

The heavily modified water body designation review process is for the purposes of assigning environmental objectives for the third cycle in the context of current legislation and policy. It must be noted that as more evidence and data become available, designations can be reviewed again during the third cycle. It may be the case that additional water bodies are designated, and others are de-designated. As a greater understanding of the relationship between ecology and hydromorphology is developed, the link with ecological status will also be revisited.

It is important to reiterate that a HMWB designation is not an exemption or a derogation from the requirement to achieve the objectives of the WFD. Instead, a designation is used to acknowledge that there has been a modification for the purposes of a specified use, and that some different standards have been applied that are more appropriate to the modified physical condition of the water body. Furthermore, it allows for the environmental objective of Good Ecological Potential to be managed appropriately, considering the constraints due to the use of the waterbody. A Good Ecological Potential objective is only achieved when the relevant water quality standards have been met and the appropriate mitigation measures have been implemented.

Appendix 1: Summary of hydromorphological tools for the review of HMWB designations

MQI-Ireland

The Morphological Quality Index for Ireland (MQI-Ireland) morphological condition assessment tool has been developed and implemented nationally by the EPA to provide an overview of the hydromorphological condition of rivers. The tool was adapted to suit an Irish setting from the original Italian-derived method, which has been the official morphological assessment in Italy since 2010 and was recommended as a best practice method of morphological assessment in the EU funded FP7 REFORM project (www.reformrivers.eu). The assessment is carried out at the reach scale (c. 1-15 km) based on the OSI Prime 2 water line dataset. The tool is used to assess river processes (*e.g.* sediment production, water/sediment/wood flux, river channel adjustment), along with the features, or habitats, that these processes create.

The MQI-Ireland tool comprises of 15 hydromorphological condition indicators (MQI indicators) related to longitudinal connectivity, lateral connectivity, channel morphology and riparian vegetation condition. Each individual MQI indicator is given a percentage score for each reach which is banded into one of three impact categories (*i.e.* High, Medium or Low). All MQI Indicator scores are combined to generate an overall hydromorphological condition assessment score that is aligned with five hydromorphological quality classes, high, good, moderate, poor and bad. Scores range from 0% (poor quality) to 100% (high quality). These five classes are aligned with the five ecological status classes.

QUBE hydrological assessment tool

The flow modelling application 'Qube' is produced by Wallingford Hydro Solutions. This tool estimates naturalised (i.e. baseline) flow duration curves (FDCs) using a region-of-influence model. Artificially influenced flows are then estimated using abstraction data from the National Abstraction Register and discharge data from EPA and local authority licences and certifications. This model is now being used to determine the risk of impact of abstractions on flow conditions. While the model will provide an improved capability, some limitations in terms of accuracy will remain in karst and impounded catchments. The local accuracy of the model will be improved over time through targeted hydrometric data collection and hydrogeological investigations. The assessment methodology to establish the hydrological condition of lakes is currently under consideration.

Lake-MImAS

Lake MImAS (Morphological Impact Assessment System) is a hydromorphological classification and decision-support tool, developed to satisfy WFD requirements. Lake-MImAS is risk-assessment framework to assess the impact of hydromorphological pressures on ecologically relevant lake features and processes. The tool quantifies lost 'system capacity' (%) relative to pristine, or un-impacted condition and does so on a type-specific basis. High ecological status corresponds to less than 5% of capacity lost, while 15% corresponds to the Good/Moderate boundary. Lake MImAS has been used to assign hydromorphological status to Irish lakes since the 2007-2009 monitoring cycle.

TraC-MImAS

The TraC-MImAS (Transitional and Coastal Waters Morphological Impact Assessment System) is a risk based regulatory decision support tool which provides an assessment of the impact of physical structures and alterations (known as morphological alterations), upon the overall hydromorphological condition of transitional and coastal (TraC) waters. For this review, the TraC-MImAS tool was used to determine the footprint (area or length of shoreline) of morphological alterations within each water body.

Appendix 2: Approach to Defining Good Ecological Potential in Irish Heavily Modified Water Bodies for the third WFD Cycle

Background

Heavily Modified Water Bodies (HMWBs) are water bodies that have had their hydromorphology significantly altered to serve a specified use (e.g. a river may be dammed to become a heavily modified lake that serves as a reservoir). The significant alteration to their hydromorphological condition means that these water bodies cannot achieve Good Ecological Status (GES); instead they have to meet a different environmental objective of Good Ecological Potential (GEP). GEP is the closest that these water bodies can get to GES taking their significantly altered hydromorphology into account and whilst still providing the beneficial use (e.g. power generation). Before we can determine the ecological potential of a HWMB we need to define what that means.

In November 2019, the European Commission's ECOSTAT group published the Common Implementation Strategy (CIS) Guidance Document No. 37 entitled 'Steps for defining and assessing ecological potential for improving comparability of Heavily Modified Water Bodies'[13]. This guidance document outlines the steps required to set out a practical framework to define GEP for HMWBs.

Two possible approaches have been proposed, namely the Reference-based and Mitigation Measures (Prague) approaches. Both approaches prescribe the use of mitigation measures[14] or actions that need to be taken to improve the hydromorphological condition of the water body to support an improvement in the ecology whilst still retaining the beneficial specified use.

The details of both approaches are set out here and a recommendation is made on the most suitable approach to apply in defining GEP for Irish HMWBs.

Reference-based Approach

The Reference-based approach to defining GEP is supported by biological assessment methods that are known to have a link with hydromorphological condition. This is the main difference between this approach and the Mitigation Measures Approach. Knowledge of the relationship between hydromorphology and ecology is used to determine what the Maximum Ecological Potential (MEP) of a HMWB would be following the implementation of mitigation measures. MEP is somewhat comparable to High Ecological Status in natural water bodies although not at the same high ecological quality. The steps of the Reference-based Approach are:

- Identify all of the mitigation measures that do not have a significant adverse effect on the beneficial use of the HMWB.
- MEP is then defined by estimating the biological values that are expected to be achieved after implementation of these measures. This step is dependent on having sufficient information on the predicted effects of the selected mitigation measures.

[13] https://circabc.europa.eu/sd/a/d1d6c347-b528-4819-aa10-6819e6b80876/Guidance%20No%2037%20-%20Steps%20for%20defining%20and%20assessing%20ecological%20potential%20for%20improving%20comparability%20of%20Heavily%20Modified%20Water%20Bodies.pdf

[14] A European library of good practice mitigation measures has also been developed as part of this process and can be used to select measures to address the effects of hydromorphological alterations in each water category.

- GEP is then defined as a slight change from those biological values at MEP. The biological values used to define GEP are then used to select the possible mitigation measures needed to achieve GEP for that particular HMWB. At this step some of the measures for MEP can be removed.

Figure A2-1 is a simple schematic that outlines the approach[15].

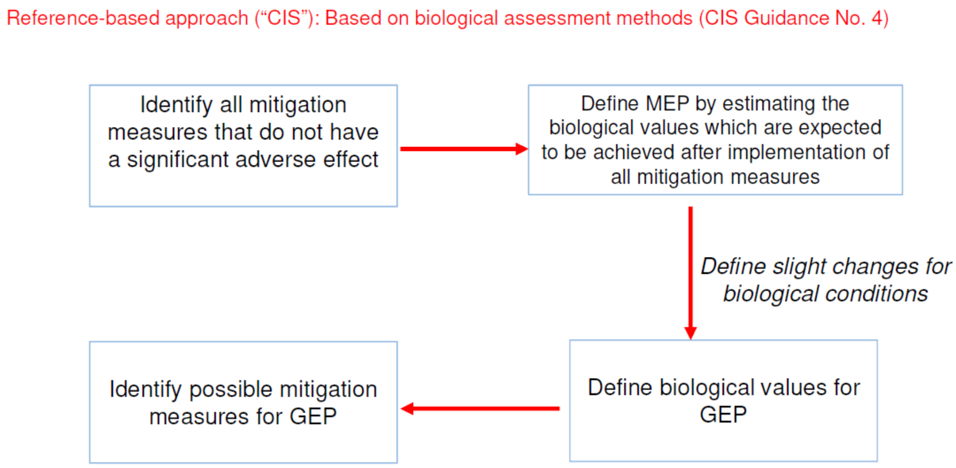


Figure A2-1: Basic outline of the suggested steps for the Reference-based approach to definition of GEP in HMWBs.

Mitigation Measures (Prague) Approach

This approach differs to the Reference-based approach because it is initially less reliant on an ecology-hydromorphology link and GEP is defined based on the implementation of mitigation measures.

- Firstly, all appropriate mitigation measures that do not have a significant adverse effect on the specified use are identified, and MEP is defined by estimating, using expert judgment, what biological values are to be expected following the implementation of the measures.
- Next the measures that are deemed to lead to only slight improvements in values of the Biological Quality Elements (BQEs) are removed.
- The remaining measures are then seen as the possible mitigation measures for GEP.

Ideally, the biological values for GEP are then defined once these measures have been put in place (Figure A2-2)[16]. The true biological values for GEP can only be derived, however, when links between hydromorphology and biology are known, in the absence of this knowledge, GEP is solely defined on the basis of the mitigation measures defined using this approach.

This is likely to be the case for some time to come given the lack of scientific knowledge linking the responses of BQEs to specific hydromorphology pressures. This gap has also been acknowledged in the current CIS guidance which notes:

'Increased efforts are needed in many countries to establish appropriate biological monitoring and develop and apply hydromorphology-sensitive biological assessment methods.'

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[15] Reproduced from presentation by Eleftheria Kampa, Ecologic Institute

[16] Reproduced from presentation by Eleftheria Kampa, Ecologic Institute.

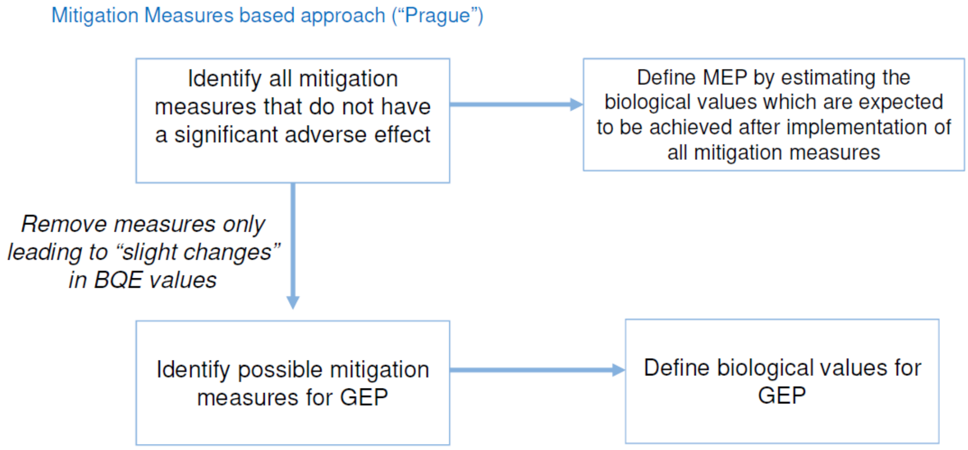

Figure A2-2: Basic outline of the suggested steps for the mitigation measures approach to definition of GEP in HMWBs.

Differences between the two approaches

The steps outlined above highlight the similarities but also the differences between the two approaches. Both should result in similar outcomes in ecological terms and both approaches have exactly the same concept for MEP (based on mitigation measures). The main difference lies in the derivation of GEP from MEP. In the Mitigation Measures approach, GEP is derived from the mitigation measures and in the Reference-based approach, GEP is derived from the biological quality element values at MEP.

This difference also has implications for the assessment of GEP. In the Reference-based approach, monitoring of hydromorphologically sensitive biological quality elements can be used to determine if GEP has been reached whereas under the Mitigation Measures approach GEP can only be reached when all identified mitigation measures are implemented. Furthermore, in the absence of suitable biological assessment methods the approach to the selection of mitigation measures will need to be more precautionary and more measures may need to be considered until there is sufficient evidence to exclude them from the definition of maximum and good ecological potential.

Proposed Approach for Ireland

As indicated above, Ireland, and indeed many of the other Member States, have not yet established the hydromorphology-ecology links with enough precision to allow us to use the Reference-based approach. Hence, the Mitigation Measures approach following the CIS guidance document is recommended. In time it is hoped that increased understanding will allow us to use the Reference-based approach which will allow a more targeted selection of mitigation measures and a more direct and precise determination of GEP.

In addition to addressing the impact of hydromorphological alterations on a HMWB, there still remains the requirement to ensure that those elements which are not sensitive to hydromorphological impacts but sensitive to other pressures such as nutrient or organic enrichment are considered. For example, for biological elements not sensitive to the hydromorphological alterations the same values for GES should be met. Values for EQSs for river basin specific pollutants and priority substances should also be consistent with achieving GES and good chemical status respectively. Also, in general, the same values for physico-chemical conditions should be met as for GES, except if the parameter is impacted by the hydromorphological alteration having led to HMWB designation (e.g. changed water temperature in water released from turbines used in hydro-power).

Finally, it is also important that the implementation of the necessary measures in the HMWBs is tracked as part of this approach but also that the effect of these measures on the biology and the wider environment is monitored.

The achievement of GEP by a HMWB may therefore be ascertained by looking at 3 main elements;

1. Are the mitigation measures for GEP in place? The recommendation here is to use the EU mitigation measures library for surface waters.
2. Are the BQEs/parameters not sensitive to the hydromorphological alteration at Good or higher (as per the standard WFD objectives for water bodies that are not HWMBs)?
3. Is the ecology/water quality related to the BQEs/parameters that are sensitive to the hydromorphological alteration at the best achievable state since the hydromorphological alteration was put in place? This is a precautionary step aimed at maintaining ecological functioning until we have a better understanding of how the ecology responds to hydromorphology.

Table A2-1 outlines the recommended modified Mitigation Measures approach for Ireland.

Table A2-1: Proposed approach to defining and classifying GEP in Irish HMWBs.

Hydromorphology (Mitigation Measures Approach)	BQEs/Parameters Not Sensitive to Hymo	BQEs/Parameters Sensitive to Hymo	Overall HMWB Classification
Measures in place	Good*	At best achieved since hymo alteration	Good Ecological Potential/higher
Measures in place	Good	Not at best achieved since hymo alteration	Moderate Ecological Potential/lower
Measures in place	Moderate/lower	At best achieved since hymo alteration	Moderate Ecological Potential/lower
Measures in place	Moderate/lower	Not at best achieved since hymo alteration	Moderate Ecological Potential/lower
Measures not in place	Good	At best achieved since hymo alteration	Moderate Ecological Potential/lower
Measures not in place	Good	Not at best achieved since hymo alteration	Moderate Ecological Potential/lower
Measures not in place	Moderate/lower	At best achieved since hymo alteration	Moderate Ecological Potential/lower
Measures not in place	Moderate/lower	Not at best achieved since hymo alteration	Moderate Ecological Potential/lower

*The objective for BQEs/Parameters not sensitive to hymo may be High status in some rarer cases.

Implications and future work

A smaller number of water bodies were designated as HMWBs in the first cycle and this remained the case in the second cycle. The assumption is that most of the HWMBs designated for the third cycle do not have mitigation measures in place that would help to achieve GEP. There is insufficient knowledge to support the use of the Reference-based approach, so this makes the Mitigation Measures approach a practical alternative until this knowledge gap improves. If Ireland was to apply this classification method to the current HWMBs they would likely come out as Moderate Ecological Potential or lower. Over time as the measures are implemented this situation would improve but initially there would be larger number of HMWBs failing to meet their ecological objectives.

It may happen in some HMWBs that the less sensitive BQEs/parameters are achieving their objectives but despite all of the GEP measures being implemented the sensitive BQEs/parameters are not at the best achievable state since the hydromorphological alteration was put in place. In these cases, a full examination of the prescribed measures should be undertaken to ensure their efficacy and/or an extended amount of time should be allowed for the measures to take effect.

There is a need now to invest time and resources to improve our understanding of how hydromorphological changes affect ecology, this will allow us to use the Reference-based approach and better protect the ecology of our HWMBs into the future.

Case Studies

Classification of hypothetical HMWB river with urban specified use

Table A2-2 outlines the implementation of the Mitigation Measures approach in classifying a hypothetical river that has been heavily modified in an urban setting. Rivers of this nature typically tend to have a range of hydromorphological impacts such as regular dredging, bank protection (e.g. rip rap) and/or culverting. In this case a suite of mitigation measures to achieve GEP has been prescribed and not all BQEs are monitored. The monitored sensitive BQEs are not in their best achievable state, GPC is achieving the environmental objective and not all of the measures identified for GEP have been implemented; therefore, the HMWB river is classified as being at Moderate Ecological Potential or lower and deemed to be failing its overall objective.

Table A2-2: Application of Mitigation Measures Approach to classification of a hypothetical HMWB riverwith an urban specified use.

Hydromorphology (Mitigation Measures Approach)	BQEs/Parameters Not Sensitive to Hymo	BQEs/Parameters Sensitive to Hymo	Overall HMWB Classification
Measures not in place	Good	Not at best achieved since hymo alteration	Moderate Ecological Potential/lower

Water Category	HMWB River
Specified Use	Urban
Extent of Hydromorphological Impairment (MQI result)	25% of channel impaired
All GEP measures in place	No
Q-value (at best achieved since hymo impairment)*	No
Macrophytes (at Good or higher)	Not monitored
Phytobenthos (at Good or higher)	Not monitored
Fish (at Good or higher)	Not monitored
GPC (at Good or higher)	Yes
Ecological Potential	Moderate or lower
GEP Measures	**Measure in place**
Sediment management	No
Improvement of in-channel diversity	No
Ecologically optimised maintenance	No
Increase habitat diversity; River depth and width variation improvement	No
Construction/technical measures to mitigate negative effects of hydropeaking	No
River bed rehabilitation	No
Modification or management of operations or structures (e.g. sluices)	No
Riparian habitat enhancement	Yes
Floodplains/off-channel/lateral connectivity improvement	No
Channel enhancement	Yes
Re-opening of sub-surface rivers (in pipes)	No
Vegetation management / rehabilitation	Yes
BQE	**Status**
Invertebrates Q-Value*	Not at best achievable
Macrophytes	Not monitored
Phytobenthos	Not monitored
Fish	Not monitored
GPC	**Status**
GPC Status	Good
*Sensitive to hydromorphology for this specified use	

Classification of hypothetical HMWB lake with power generation specified use

Table A2-3 outlines the implementation of the Mitigation Measures Approach in classifying a hypothetical HMWB lake with water supply as a specified use. Typically, these lakes have a dam or impounding structure associated with them and may have been originally a river. In this case the monitored BQEs and GPCs are all meeting the relevant environmental objective and all of the prescribed GEP measures have been put in place; meaning this HMWB lake can be classified as being at Good Ecological Potential or higher and is deemed to be meeting its overall environmental objectives.

Table A2-3: Application of Mitigation Measures Approach to classification of a hypothetical HMWB lake with a water supply as the specified use.

Hydromorphology (Mitigation Measures Approach)	BQEs/Parameters Not Sensitive to Hymo	BQEs/Parameters Sensitive to Hymo	Overall HMWB Classification
Measures in place	Good	At best achieved since hymo alteration	Good Ecological Potential/higher

Water Category	HMWB Lake
Specified Use	Water Supply
Extent of Hydromorphological Impairment (MImAS result)	20% cpacity used
All GEP measures in place	Yes
Invertebrates (at Good or higher)	Not Monitored
Macrophytes (at best achieved since hymo impairment)*	Yes
Phytobenthos (at Good or higher)	Yes
Fish (at Good or higher)	Not Monitored
GPC (at Good or higher)	Yes
Ecological Potential	Good or higher
GEP Measures	**Measure in place**
Enhancement of shore/shallow habitats (especially in the littoral zone)	Yes
Creation of secondary habitats	Yes
Removal/replacement of shore fixation	Yes
Management of reservoir/lake level	Yes
Management of sediments	Yes
Management of lake use / designation of protected areas	Yes
Ecologically optimised fisheries management	Yes
Fish migration aids /Improvement of connectivity to riverine habitats/tributaries/other lakes	Yes
Mitigation of effects on physico-chemical parameters in lake	Yes
BQE	**Status**
Invertebrates	Not Monitored
Macrophytes*	At best achievable
Phytobenthos	Good
Fish	Not Monitored
GPC	**Status**
GPC Status	Good
*Sensitive to hydromorphology for this specified use	

Appendix 3: Case studies to illustrate the Heavily Modified Waterbody designation process

This document presents two case studies that illustrate the application of the heavily modified waterbody designation process. The first case study looks at three heavily modified waterbodies in the Lower Shannon system that are impacted by three specified uses: power generation, water supply and navigation. The second is for three heavily modified waterbodies in the Moynalty River that have been modified for drainage of land for agricultural purposes as part of the Boyne arterial drainage scheme.

Case study 1: Lower River Shannon

Derg HMWB
Upstream of Parteen weir
Flooded river channel

Old River Shannon HMWB
Downstream of Parteen weir
Substantial flow diverted into the Ardnacrusha canal

Context

The Lower River Shannon downstream of Killaloe comprises three waterbodies, all of which are heavily modified by the effects of a weir known as the Parteen Weir: one, now a lake, upstream called Derg HMWB which was designated in the first cycle, and two rivers downstream of the weir, the Shannon (Lower)_050 and 060 that are being proposed through this review. There is also an Artificial Waterbody, the Ardnacrusha Canal. The weir was established to raise the level of what was the river upstream to create a water storage and divert the majority of its flow down the canal to the Ardnacrusha power station for hydropower generation. Seventeen kilometers of the Lower River Shannon is affected downstream of the Parteen weir until its confluence with the tailrace canal. The scheme was commissioned in the 1920s. The Ardnacrusha power station is a protected structure which has cultural heritage and tourism amenity values. Lough Derg and the Parteen Basin have significant long established social, sporting, tourism and amenity development facilitated by the ongoing management of water levels at Parteen Weir.

Characterisation tests

The Derg HMWB is a flooded river channel above the Parteen weir which now more closely resembles a lake. The lake is constrained by an artificial embankment and water levels are manipulated to maintain the water level within a narrow range for dam safety purposes. These modifications mean that the natural lake fluctuations are constrained and artificially altered, which in turn can impact on ecological condition. It is worth noting that new habitats have established since construction and any changes could impact on those habitats. The two lower Shannon river water bodies downstream of the weir have a significantly altered flow regime with substantial reductions in flow overall, and a largely fixed, minimum compensation flow down the old River Shannon. The weir acts as a barrier to fish, and although there is a fish pass structure in place, which was considered best practice at the time of construction, it has been assessed as needing significant improvement works by the consultants working on a DHLGH funded project to look at the feasibility of improving fish passage in the River Shannon. The weir is also a barrier to the movement of sediment down the river which has an impact on the formation of habitat conditions. The lack of regular medium to large size flows means that trigger flows for fish to spawn, and larger floods to move sediment accumulating further down the channel are limited. The river can also no longer interact with its floodplain and normal channel forming processes are much reduced, thus reducing the quality of habitat conditions and causing a build-up of sediment in the channel downstream. These waterbodies are substantially changed in character and the hydromorphological changes, that have been in place for close to a century, are permanent, extensive and profound.

Designation tests

Restoration of these three waterbodies to Good Ecological Status would require removal of the weir and a significant reduction in the proportion of the flow going down the Ardnacrusha canal. Based on the available information, and advice from ESB and Irish water, these measures would substantially impact on the specified uses of power generation and potential future water storage. They would also result in the potential for increased flooding in the Lower Shannon floodplain which has now been built upon with urban development on the outskirts of Limerick City. There would be a reduction in the capacity for renewable energy generation at Ardnacrusha, and potential impacts on navigation through the Ardnacrusha canal. The level of water in the upper Derg HMWB would be lowered which the ESB advises would pose a dam safety risk, compromise the integrity of the earthen embankment dams and pose a health and safety risk to residents adjacent to the lake under future flood conditions. The specified use owners, i.e., ESB, Waterways Ireland and Irish Water, have indicated that these restoration measures could not be implemented without impacting on the specified use and the wider environment, and that the specified uses cannot be achieved by other means that are a significantly better environmental option, technically feasible, and not disproportionately costly.

Ecological potential

In the Derg HMWB, the fish populations are not classified but are considered by expert judgement to be impacted on the basis of the available weight of evidence because of the presence of the Parteen Weir. All the other monitored quality elements are achieving at least Good status. In the Shannon (Lower) river, the biological water quality is impacted downstream of the weir, but nutrients and other water quality parameters are generally good.

The main mitigation measures for these waterbodies, which have been selected from the EU library of best practice measures, are new arrangements for ensuring the safe passage of multiple fish species up and down the regulated system, and a modern, best practice eflow regime. These measures would improve flow conditions, enhance aquatic habitats and improve the ecological health by facilitating the passage of multiple fish species. These measures have also been recommended by the consultants on the Shannon Fish Passage project as part of a high-level roadmap for a programme of measures to improve fish health in the Shannon system. The implementation of the roadmap will require holistic, catchment-specific assessments to determine the most favourable outcomes, given the presence of the natura sites downstream and all the other current dependencies in the system.

As these measures are not currently in place, all three heavily modified waterbodies would be classified as not meeting their Good Ecological Potential objectives. If these measures were to be implemented, a healthy (albeit modified), aquatic ecosystem could likely be achieved relatively quickly, given the otherwise generally good water quality.

Case study 2: Moynalty River, Co Cavan/Meath

Moynalty_020

Context

A number of river water bodies of the Moynalty river system (Moynalty_020, _030 and _040) are being proposed as HMWBs due to the physical modification of the river channel to faciliate an arterial drainage scheme (i.e. Boyne arterial drainage scheme). The initial drainage works led to an overdeepening of the channel, cutting the river off from its floodplain. This scheme falls under the Arterial Drainage Act of 1945 and 1995, with this act requiring OPW to maintain channels within this scheme to provide drainage for the benefit of agricultural lands. Maintenance can involve removal of bed material, bridge/culvert maintenance, in-channel, bank and riparian vegetation management, with such works impacting on habitat conditions.

Characterisation tests

The MQI-Ireland tool was used to assess the impact of the arterial drainage scheme on hydromorphological/physical conditions of these river water bodies. Drainage has adverse effects on MQI-Ireland indicators related to channel morphology due to straightening, over deepening, widening, and cross-section changes. The waterbodies are disconnected from their floodplain and in turn, flow and sediment regimes have been significantly altered, impacting habitat preferences for aquatic insects, plants, and fish. Regular maintenance creates continuous disturbance to the ecosystem. Due to the original arterial drainage scheme and the associated ongoing maintenance, these waterbodies are substantially changed in character and the hydromorphological changes are permanent, extensive, and profound.

Designation tests
Key restoration measures to achieve Good Ecological Status within these water bodies would involve restoring the bed level back to its original state so that it could interact with the floodplain, reconnecting meanders, and the cessation of channel maintenance[17]. Based on the available information and advice from OPW, these measures would have significant adverse impacts on the purpose and function of the arterial drainage scheme. Agricultural lands would be rewetted thus impacting on current farming practices. Infrastructure and development have also often been built on the drained floodplains of drained rivers such as these, so measures to reconnect the channel to the floodplain could have significant socio-economic implications. The specified use owner, in this case OPW, has indicated that on the basis of the best available information, the restoration measures could not be implemented without impacting on the specified use and the wider environment, and that the specified uses cannot be achieved by other means that are a significantly better environmental option, technically feasible, and not disproportionately costly. OPW are currently legally obliged to maintain these schemes under the Arterial Drainage Act.

Ecological Potential
The ecological condition of all three river water bodies is Poor due to biological conditions (invertebrates). The physico-chemical and nutrient water quality conditions are only monitored within Moynalty_030 and conditions there are Good.

The main applicable mitigation measures, which have been selected from the EU library of best practice measures, involve the use of appropriate environmentally sensitive channel maintenance strategies and techniques as set out in the OPW Environmental Guidance: Drainage Maintenance and Construction). This guidance is mandatory for all schemes and therefore this mitigation measure is in place in these waterbodies. Another mitigation measure that is currently being implemented in some rivers is the IFI and OPW Environmental River Enhancement Programme (EREP). This involves rehabilitation of fish habitat within arterially drained rivers through such activities as importing spawning gravels, adding boulders or deflectors to improve flow variability. These measures are only applicable to a portion of drained channels i.e. channels with a medium gradient which are suitable for salmonid fish species. EREP measures have not been implemented in the Moynalty River.

On the basis of the current ecological condition, which has deteriorated in recent years, and the mitigation measures currently being implemented, these water bodies require consideration if further mitigation measures are necessary for achieving their Good Ecological Potential objective. This will be addressed in the future through the new hydromorphology regulatory regime.

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[17] The EPA, with support from consultants RPS and CBEC, is currently developing a framework for river restoration measures which will, in time, provide further guidance on the types of river restoration measures that are appropriate in these and other waterbodies impacted by hydromorphological pressures.

Appendix 4: Restoration and mitigation measures to address specified uses

Water storage and regulation

Table A4-1: Restoration and mitigation measures associated with water storage and regulation. Measures addressing specific storage/regulation impacts are grouped together (denoted by thick black boxes). Restoration measures relate to measures that can help achieve Good Ecological Status. Mitigation measures are measures that will help achieve Good Ecological Potential. These measure types can only be implemented if they do not cause a significant impact on the specified use.

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	What is the effect of measure on Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
Water supply	**Artificial in-channel structures and impoundments** (e.g. Locks, weirs, culverts, sluices, dams)	Removal of structure	Loss of water/energy supply	Possible elimination of **wetlands/ recreation** that have developed due to water storage. **Flood risk.**	Restoration	No
		Reduce impoundment (e.g. reduce storage level, reduce height of structure)	Loss/reduce water/energy supply		Restoration	No
		Create by-pass channel	Reduce water/energy supply	Require land – impact to **recreation. Flood risk.**	Mitigation	Possibly
		Reconnect tributaries or side channels or by-pass channels, where appropriate	Reduce water/energy supply		Mitigation	Possibly
		Install by-pass valves (for damping sudden drop in discharge)	Limited effect	Limited effect	Mitigation	Possibly
		Structural modification (e.g. fish pass, ramp, fish screens, fish-friendly turbines)	Limited effect	Limited effect	Mitigation	Yes
		Adoption of operational protocols	Reduce water/energy supply	NA	Mitigation	Yes
		Ecological adapted operation mode	Reduce water/energy supply	NA	Mitigation	Yes

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	What is the effect of the measure on Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Provide additional flow/minimum flow components (e.g. low flow, base flow, peak flow, fish flow)	Reduce water/energy supply	NA	Mitigation	Yes
		Improve variable flow conditions (e.g. Passive/active flow variability, mobilising flows for sediment dynamics and/or residual flow turbines)	Reduce water/energy supply	NA	Mitigation	Yes
		Introduce or re-introduce sediment, where appropriate	Limited effect	Limited effect	Mitigation	Yes
		Improve sediment transport/dynamics (e.g. sediment by pass, restore lateral erosion processes, mobilise flows for sediment dynamics)	Reduce water/energy supply	NA	Mitigation	Possibly
		Catch, transport, release of aquatic species (e.g. fish, crayfish)	Limited effect	Limited effect	(Mitigation) Partial/Low effectiveness	Yes

Flood protection

*Table A4-2: Restoration and mitigation measures associated with flood protection. Measures addressing specific flood protection impacts are grouped together (denoted by black boxes in the Measures column). Restoration measures relate to measures that can help achieve Good Ecological Status. Mitigation measures are measures that will help achieve Good Ecological Potential. These measure types can only be implemented if they do not cause a significant impact on the specified use. (*Measures similar to current channel maintenance strategies (e.g. OPW Environmental Guidance: Drainage Maintenance and Construction))*

Benefit of use	**Associated pressures**	**Measures** ** Denote measures similar to current channel maintenance strategies*	**What is the effect of the measure on the specified Use?**	**What is the effect of the measure on Wider environment**	**Measure type**	**Can measure be implemented without significantly impacting specified use?**
Protect land from flooding	**Bank modification** (Bank related flood protection measures, hard bank protection (including hard bank protection in a state of disrepair), bank structures (e.g. groynes, jetties, moorings, pontoons))	Removal of flood defence structures (e.g. walls, embankments)	Removes purpose of scheme	NA	Restoration	No
		Re-alignment or re-location flood defence structures (e.g. walls, embankments)	This measure could impact on the hydraulic performance of a flood relief scheme (e.g., reduce conveyance / raise flood levels)	NA	Restoration - depending	Possibly
		Modify existing design or structures (e.g. set-back embankments)			Restoration - depending	Possibly
		Bank rehabilitation (e.g. reprofiling)			Restoration	No
		Improve water retention (e.g. Natural Water Retention Measures such as land use changes such as afforestation, restoration of rivers/floodplains, restoration of wetlands/moors, reduce impervious surfaces, create retention basins)	Require land to retain water	NA	Restoration – depending	Possibly
		Improve floodplain connectivity (e.g. reconnect floodplain and related habitats - connect backwaters, connect wetlands, set-bank embankments)	Typically no impact, but could reduce FP conveyance	Effect on Landowner	Mitigation	Possibly
		Re-establish floodplain habitats (e.g. create backwaters/ponds)				
		Awareness raising / information boards (invasive species - particularly plant species as impact hydromorphological condition) *	Limited effect - But may be unlikely to restore conditions	Limited effect	(Mitigation) Low effectiveness	Yes

Benefit of use	Associated pressures	Measures ** Denote measures similar to current channel maintenance strategies*	What is the effect of the measure on the specified Use?	What is the effect of the measure on Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Appropriate removal of invasive plant species*	Limited effect	Limited effect	(Mitigation) Low effectiveness	Yes
	Channel modification	Appropriate channel maintenance strategies and techniques	Limited effect	Limited effect	Mitigation	Yes
		Appropriate sediment management strategies			Mitigation	Yes
		Avoid the need to remove material/dredge	Reduce drainage efficiency/perceived flooding risk	May impact flow regime d/s/Flood risk	Mitigation	No
		Reduce impact of removing material/dredging (e.g. smaller area, shallower depth; dredger type) *			Mitigation	Possibly
		Reduce frequency of dredging*			Mitigation	Possibly
		Measures to facilitate natural recovery (e.g. cease man-made activities/interventions)	Reduce drainage efficiency/Reduce conveyance	May impact flow regime d/s/Flood risk?	Mitigation	No
		Site selection (e.g. avoid sensitive sites) *	Limited effect	Limited effect	Mitigation	Yes
		Re-meandering of straightened channels, where appropriate *	Loss of available land area/Reduce conveyance	Effect on Landowner	Mitigation	Possibly
		Alteration of the bed (e.g. re-construction of pools, where appropriate) *	Reduce drainage efficiency/Reduce conveyance	NA	(Mitigation) Low effectiveness	Possibly
		Raise riverbed level			Mitigation	No

Benefit of use	Associated pressures	Measures ** Denote measures similar to current channel maintenance strategies*	What is the effect of the measure on the specified Use?	What is the effect of the measure on Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Develop near-natural/optimised slope	Reduce drainage efficiency/ perceived flooding risk	May impact flow regime d/s/Flood risk.	Mitigation	No
		Restore natural variability of the cross section (i.e. narrowing (e.g. introducing wood), (re-) widening (e.g. remove bank protection)), increase width-depth variability)	Reduce drainage efficiency/Reduce conveyance	May impact flow regime d/s	Mitigation – still deepened	Possibly
		Increase in-channel morphological diversity (e.g. instream features where appropriate such as boulders, deflectors) *	Reduce drainage efficiency/Reduce conveyance	May impact flow regime d/s	(Mitigation) Low effectiveness	Possibly
		Introduce or avoid removing large wood ('woody debris') within the channel	Reduce drainage efficiency/Reduce conveyance	NA	Mitigation	Possibly
	Channel/ **Riparian modification**	Introduce or re-introduce sediment, where appropriate	Depends on size	NA	(Mitigation) Low effectiveness	Possibly
		Improve sediment transport/dynamics (e.g. sediment by pass, restore lateral erosion processes, mobilise flows for sediment dynamics)	Alteration to flow - Reduce drainage efficiency	NA	Medium – as still overdeepened	Possibly
		Reduce unnatural levels of fine sediment (e.g. reduce sediment input, mechanical breakup, interception measures such as trap/remove sediment, creation of farm ponds, interception of drains and ditches, two stage ditch channels (Also consider Natural Water Retention Measures))	Limited effect	Limited effect	Mitigation	Yes

Benefit of use	Associated pressures	**Measures** ** Denote measures similar to current channel maintenance strategies*	**What is the effect of the measure on the specified Use?**	**What is the effect of the measure on Wider environment**	**Measure type**	**Can measure be implemented without significantly impacting specified use?**
		Bank rehabilitation (e.g. reprofiling)	Reduce drainage efficiency/Reduce conveyance	Possible Flooding	Mitigation – as still over deepened	No
		Improve water retention (e.g. Natural Water Retention Measures such as land use changes such as afforestation, restoration of rivers/floodplains, restoration of wetlands/moors, reduce impervious surfaces, create retention basins)	Require land to retain water	NA	Mitigation	Possibly
		Indirect / offsite mitigation (e.g. off-setting such as creating compensation habitat such as spawning or rearing habitat for fish)	Limited effect	Limited effect	(Mitigation) Low effectiveness	Yes
		Reconnect tributaries or side channels or by-pass channels, where appropriate	Typically no impact, but could reduce FP conveyance	Effect on Landowner	Mitigation	Possibly
		Improve floodplain connectivity (e.g. reconnect floodplain and related habitats - connect backwaters, connect wetlands, set-bank embankments)			Mitigation – as still over deepened	Possibly
		Re-establish floodplain habitats (e.g. create backwaters/ponds)			Mitigation	Possibly
		Appropriate/selective vegetation control regime (e.g. (a) minimise disturbance to channel bed and margins, b) selective vegetation management for example only cutting from one	Limited effect – for other options, Reduce conveyance	Limited effect	Mitigation	Yes

Benefit of use	Associated pressures	**Measures** ** Denote measures similar to current channel maintenance strategies*	**What is the effect of the measure on the specified Use?**	**What is the effect of the measure on Wider environment**	**Measure type**	**Can measure be implemented without significantly impacting specified use?**
		side of the channel, c) providing/reducing shade, d) appropriate timing (e.g. seasonal maintenance)) *				
		Fencing programme to exclude livestock*	Limited effect	Limited effect	Mitigation	Yes
		Create buffer strips*			Mitigation	Yes
		Restore/establish riparian vegetation (e.g. plant trees)			Mitigation	Yes
		Protect and enhance ecological value of marginal aquatic habitat, banks and riparian zone*			Mitigation	Yes
		Create/re-establish floodplain forest/vegetation	Land required	NA	Mitigation	Possibly
		Orientated/ecologically optimised maintenance*	Limited effect	Limited effect	Mitigation	Yes

Urban

Table A4-3: Restoration and mitigation measures associated with urban areas as a specified use. Measures addressing specific urban impacts are grouped together (denoted by black boxes in the Measures column). Restoration measures relate to measures that can help achieve Good Ecological Status. Mitigation measures are measures that will help achieve Good Ecological Potential. These measure types can only be implemented if they do not cause a significant impact on the specified use.

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	What is the effect of the measure on Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
Infrastructure; Business; Homes	**Bank modification** (Bank related flood protection measures, hard bank protection (including hard bank protection in a state of disrepair), bank structures (e.g. groynes, jetties, moorings, pontoons))	Removal of hard bank reinforcement/revetment, or replacement with soft engineering solution	Potential for slope stability -issues for infrastructure on account of increased scour	Impact to infrastructure	Restoration	No
		Bank rehabilitation (e.g. reprofiling)	Land required – Reduce land for urban needs	Reduction of land for development/amenity. Flood risk.	Restoration	No
	Channel/River corridor/ Floodplain modification	Improve water retention (e.g. Natural Water Retention Measures such as land use changes such as afforestation, restoration of rivers/floodplains, restoration of wetlands/moors, reduce impervious surfaces, create retention basins)	Land required – Reduce land for urban needs	Reduction of land for development/amenity. Flood risk.	Mitigation	Potential impact -Case specific
		Reconnect tributaries or side channels or by-pass channels, where appropriate			Mitigation	Potential impact -Case specific

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	What is the effect of the measure on Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Improve floodplain connectivity (e.g. reconnect floodplain and related habitats - connect backwaters, connect wetlands, set-bank embankments)			Mitigation	Potential impact -Case specific
		Re-establish floodplain habitats (e.g. create backwaters/ponds)			Mitigation	Potential impact -Case specific
		Incorporation of SuDS processes			Mitigation	Potential impact -Case specific
		Restore/establish riparian vegetation (e.g. plant trees)	Require urban area; Increase in flood risk	Reduction of land for development/amenity	Mitigation	Potential impact -Case specific
		Create/re-establish floodplain forest/vegetation			Mitigation	Potential impact -Case specific
		Orientated/ecologically optimised maintenance	Land required – Reduce land for urban needs	Compatibility with other landuses	Mitigation	Potential impact -Case specific
		Protect and enhance ecological value of marginal aquatic habitat, banks and riparian zone			Mitigation	Potential impact -Case specific
		Appropriate/selective vegetation control regime (e.g. (a) minimise disturbance to channel bed and margins, b) selective vegetation management for example only cutting from one side of the channel, c) providing/reducing shade, d) appropriate timing (e.g. seasonal maintenance))	Limited effect	Limited effect	Mitigation	Yes

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	What is the effect of the measure on the Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
	Bed/Channel modification	Remove bed protection (e.g. in-channel rock armour, concrete)	Potential for slope stability -issues for infrastructure on account of increased scour	Impact to infrastructure	Restoration	Potential impact -Case specific
		Raise river bed level	Require urban area; Increase in flood risk	Flood risk to public	Restoration	No
		Develop near-natural/optimised slope	Require urban area	Reduction of land for development/amenity. Flood risk.	Restoration	No
		Restore natural variability of the cross section (i.e. narrowing (e.g. introducing wood), (re-)widening (e.g. remove bank protection)), increase width-depth variability)	Potential requirement for space	Public sense of safety and landuse planning restrictions	Restoration	Potential impact -Case specific
		Re-meandering of straightened channels, where appropriate	Land required – Reduce land for urban needs	Reduction of land for development	Mitigation	No

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	What is the effect of the measure on Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Measures to facilitate natural recovery (e.g. cease man-made activities/interventions)	Land required – Reduce land for urban needs	Compatibility with other land uses. Public safety or Flood risk.	Restoration	No
		Improve sediment transport/dynamics (e.g. sediment by pass, restore lateral erosion processes, mobilise flows for sediment dynamics)	Potential for slope stability -issues for infrastructure on account of increased scour	Impact to infrastructure	Restoration	Potential impact -Case specific
		Reduce unnatural levels of fine sediment (e.g. reduce sediment input, mechanical breakup, interception measures such as trap/remove sediment, creation of farm ponds , interception of drains and ditches, two stage ditch channels (Also consider Natural Water Retention Measures))	NA	NA	Mitigation	Yes
		Appropriate sediment management strategies	Limited effect	Limited effect	Mitigation	Yes
	Artificial in-channel structures and impoundments	Removal of structure	Require urban area; Increase in flood risk	Reduction of land for development/amenity. Flood risk.	Mitigation	Potential impact -Case specific

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	What is the effect of the measure on Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Reopening of culverts/pipes	Require urban area; Increase in flood risk	Reduction of land for development/amenity. Flood risk. Contaminated land.	Restoration	No
		Rehabilitate subsurface rivers from underground pipes	Require urban area; Increase in flood risk	Reduction of land for development/amenity. Flood risk. Contaminated land.	Restoration	No
		Reduce impoundment (e.g. reduce storage level, reduce height of structure)	Require urban area; Increase in flood risk	Reduction of land for development/amenity. Flood risk.	Mitigation	Potential impact -Case specific
		Create by-pass channel	Require urban area; Increase in flood risk	Reduction of land for development/amenity. Flood risk.	Mitigation	Potential impact -Case specific
		Reconnect tributaries or side channels or by-pass channels, where appropriate	Require urban area; Increase in flood risk	Reduction of land for development/amenity. Flood risk.	Mitigation	Potential impact -Case specific

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	What is the effect of the measure on Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Improve variable flow conditions (e.g. Passive/active flow variability, mobilising flows for sediment dynamics and/or residual flow turbines)	Potential for slope stability -issues for infrastructure on account of increased scour	Impact to infrastructure	Mitigation	Potential impact -Case specific
		Improve sediment transport/dynamics (e.g. sediment by pass, restore lateral erosion processes, mobilise flows for sediment dynamics)	Potential for slope stability -issues for infrastructure on account of increased scour	Impact to infrastructure	Restoration	Potential impact -Case specific
	Channel modification	Alteration of the bed (e.g. re-construction of pools, where appropriate)	Limited effect	Public sense of safety	Mitigation (Low effectiveness)	Yes
		Increase in-channel morphological diversity (e.g. instream features where appropriate such as boulders, deflectors)	Possible flood risk	Public sense of safety and land use planning restrictions	Mitigation (Low effectiveness)	Potential impact -Case specific
		Introduce or avoid removing large wood ('woody debris') within the channel	Possible flood risk	Public sense of safety and land use planning restrictions	Mitigation (Low effectiveness)	Potential impact -Case specific

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	What is the effect of the measure on the Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Introduce or re-introduce sediment, where appropriate	Possible flood risk	Public sense of safety and land use planning restrictions	Mitigation (Low effectiveness)	Potential impact -Case specific
		Indirect / offsite mitigation (e.g. off-setting such as creating compensation habitat such as spawning or rearing habitat for fish)	Land required – Reduce land for urban needs	Compatibility with other land uses	Mitigation (Low effectiveness)	Yes
		Awareness raising / information boards (invasive species - particularly plant species as impact hydromorphological condition)	No effect	No effect	Mitigation (Low effectiveness)	Yes
		Appropriate removal of invasive plant species	No effect	No effect	Mitigation (Low effectiveness)	Yes

Navigation

*Table A4-4: Restoration and mitigation measures associated with navigation. Measures addressing specific navigation impacts are grouped together (denoted by black boxes in the Measures column). Restoration measures relate to measures that can help achieve Good Ecological Status. Mitigation measures are measures that will help achieve Good Ecological Potential. These measure types can only be implemented if they do not cause a significant impact on the specified use. (*May support biological conditions (i.e. fish) but not hydromorphological conditions).*

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	Is there an impact from this measure on the Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
	Artificial in-channel structures and impoundments (e.g. Locks, weirs, culverts, sluices, dams)	Removal of structure	Impact water level for navigation	Potential	Restoration	No
		Reduce impoundment (e.g. reduce storage level, reduce height of structure)	Impact water level for navigation	Potential	Restoration	No
		Create by-pass channel	Impact water level for navigation	Potential	Restoration?*	Yes
		Reconnect tributaries or side channels or by-pass channels, where appropriate	Impact water level for navigation	Potential	Mitigation (Low effectiveness)	Possibly
		Install by-pass valves (for damping sudden drop in discharge)	Impact water level for navigation	Potential	Mitigation (Low effectiveness)	Possibly
		Structural modification (e.g. fish pass, ramp, fish screens, fish-friendly turbines)	Limited effect	No	Mitigation*	Yes
		Modification or management of operation of sluices, locks for agriculture and navigation	Possible	Potential	Mitigation	Yes

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	Is there an impact from this measure on the Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Adoption of operational protocols	Limited effect	No	Mitigation	Yes
		Ecological adapted operation mode	Impact water level for navigation	Potential	Restoration?*	Yes
		Provide additional flow/minimum flow components (e.g. low flow, base flow, peak flow, fish flow)			Restoration	Possibly
		Improve variable flow conditions (e.g. Passive/active flow variability, mobilising flows for sediment dynamics and/or residual flow turbines)			Restoration	Possibly
		Introduce or re-introduce sediment, where appropriate	Reduce depth required for navigation; Disrupt movement of vessel	No	Mitigation (Low effectiveness)	Possibly
		Improve sediment transport/dynamics (e.g. sediment by pass, restore lateral erosion processes, mobilise flows for sediment dynamics)		No	Mitigation	Possibly
		Catch, transport, release of aquatic species (e.g. fish, crayfish)	Limited effect	No	Mitigation?*	Yes
	Other: Other navigation structures Maintenance Areas / docks / dry docks /	Awareness raising / information boards (boat wash / sources of fine sediment)	No effect	NA	Mitigation (Low effectiveness)	Yes
			No effect	NA	Mitigation	Yes

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	Is there an impact from this measure on the Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
	marinas / slipways/ rowing steps	Awareness raising / information boards (invasive species - particularly plant species as impact hydromorphological condition)	- But may not restore conditions		(Low effectiveness)	
		Appropriate removal of invasive plant species	Limited effect	Limited effect	Mitigation (Low effectiveness)	Yes
	Other: Boat Movement Surface water disturbance and turbulence created by passage of hull (Also consider impacts associated with on-line moorings and sediment management)	Encourage reduction of boat wash impacts through traffic management in sensitive areas	Limited effect	NA	Mitigation (Low effectiveness)	Yes
		Encourage use of environmentally friendly vessel design	Limited effect	NA	Mitigation (Low effectiveness)	Possibly
		Removal of hard bank reinforcement/revetment, or replacement with soft engineering solution	May impact mooring of vessel		Mitigation (Low effectiveness)	Possibly
		Awareness raising / information boards (boat wash / sources of fine sediment)	No effect		Mitigation (Low effectiveness)	Yes
		Lateral zoning to concentrate boats within a central track	Limited effect	NA	Mitigation (Low effectiveness)	Possibly

Benefit of use	Associated pressures	Measures	What is the effect of the measure on the specified Use?	Is there an impact from this measure on the Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Awareness raising / information boards (invasive species - particularly plant species as impact hydromorphological condition)	No effect - But may not restore conditions		Mitigation (Low effectiveness)	Yes

Arterial Drainage

*Table A4-5: Restoration and mitigation measures associated with arterial drainage. Measures addressing specific drainage impacts are grouped together (denoted by black boxes in the Measures column). Restoration measures relate to measures that can help achieve Good Ecological Status. Mitigation measures are measures that will help achieve Good Ecological Potential. These measure types can only be implemented if they do not cause a significant impact on the specified use. (*Measures similar to current channel maintenance strategies (e.g. OPW Environmental Guidance: Drainage Maintenance and Construction))*

Benefit of use	**Associated pressures**	**Measures** ** Measures similar to current channel maintenance strategies*	**What is the effect of the measure on the specified Use?**	**What is the effect of the measure on Wider environment**	**Measure type**	**Can measure be implemented without significantly impacting specified use?**
Agricultural production	**Channel modification**	Appropriate channel maintenance strategies and techniques	Limited effect	Limited effect	Mitigation –as still deepened	Yes
		Appropriate sediment management strategies			Mitigation –as still deepened	Yes
		Avoid the need to remove material/dredge	Reduce drainage efficiency/perceived flooding risk	May impact flow regime d/s/Flood risk	Mitigation –as still deepened	No
		Reduce impact of removing material/dredging (e.g. smaller area, shallower depth; dredger type)*			Mitigation –as still deepened	Possibly
		Alter frequency to minimise impact of channel maintenance/dredging*			Mitigation –as still deepened	Possibly
		Measures to facilitate natural recovery (e.g. cease man-made activities/interventions)	Reduce drainage efficiency/Reduce conveyance	May impact flow regime d/s/Flood risk	Mitigation –as still deepened	No
		Site selection (e.g. manage activity within sensitive sites)*	Limited effect	Limited effect	Mitigation –as still deepened	Yes

Benefit of use	Associated pressures	Measures ** Measures similar to current channel maintenance strategies*	What is the effect of the measure on the specified Use?	What is the effect of the measure on the Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Re-meandering of straightened channels, where appropriate *	Loss of available land area/Reduce conveyance	Effect on Land owner	Mitigation –as still deepened	Possibly
		Alteration of the bed (e.g. re-construction of pools, where appropriate)*	Reduce drainage efficiency/Reduce conveyance		Mitigation (Low effectiveness)	Possibly
		Raise river bed level	Reduce drainage efficiency/ perceived flooding risk	May impact flow regime d/s/Flood risk	Restoration	No
		Develop near-natural/optimised slope			Mitigation	No
		Restore natural variability of the cross section (i.e. narrowing (e.g. introducing wood), (re-) widening (e.g. remove bank protection)), increase width-depth variability)	Reduce drainage efficiency/Reduce conveyance	May impact flow regime d/s	Restoration – if mitigate deepening	Possibly
		Increase in-channel morphological diversity (e.g. instream features where appropriate such as boulders, deflectors)*	Reduce drainage efficiency/Reduce conveyance	May impact flow regime d/s	Mitigation (Low effectiveness)	Possibly
		Introduce or avoid removing large wood ('woody debris') within the channel	Reduce drainage efficiency/Reduce conveyance	NA	Mitigation – channel still modified/deepened	Possibly
		Introduce or re-introduce sediment (e.g. coarse (gravels, cobbles, boulders)), where appropriate (i.e. river type/geology)	Depends on size	NA	Mitigation (Low effectiveness)	Possibly

Benefit of use	Associated pressures	Measures *** Measures similar to current channel maintenance strategies***	What is the effect of the measure on the specified Use?	What is the effect of the measure on the Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Improve sediment transport/dynamics (e.g. sediment by pass, restore lateral erosion processes, mobilise flows for sediment dynamics)	Alteration to flow - Reduce drainage efficiency	NA	Mitigation – as still overdeepened	Possibly
		Reduce unnatural levels of fine sediment (e.g. reduce sediment input, mechanical breakup, interception measures such as trap/remove sediment, creation of farm ponds , interception of drains and ditches, two stage ditch channels (Also consider 13 related to Natural Water Retention Measures))	Limited effect	Limited effect	Mitigation – as measures mainly outside channel. Difficult to mitigate within channel.	Y – if dealing with additional loads outside channel
		Bank rehabilitation (e.g. reprofiling (allow a more natural bank profile))	Reduce drainage efficiency/Reduce conveyance	Possible Flooding	Mitigation – as still overdeepened	N – if extensive and widespread
		Improve water retention (e.g. Natural Water Retention Measures such as land use changes such as afforestation, restoration of rivers/floodplains, restoration of wetlands/moors, reduce impervious surfaces, create retention basins)	Require land to retain water	Effect on Land owner/land use	Mitigation – as still overdeepened (depends on the measure type)	Possibly
		Indirect / offsite mitigation (e.g. off-setting such as creating compensation habitat such as spawning or rearing habitat for fish)	Limited effect	Limited effect	Mitigation (Low effectiveness)	Yes
		Reconnect tributaries or side channels back to main channel or by-pass channels, where appropriate	Require land/Reduce drainage	Effect on Land owner	Mitigation – as still overdeepened	Possibly

Benefit of use	Associated pressures	Measures * *Measures similar to current channel maintenance strategies*	What is the effect of the measure on the specified Use?	What is the effect of the measure on the Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
			efficiency/Reduce conveyance			
		Improve floodplain connectivity (e.g. reconnect floodplain and related habitats - connect backwaters, connect wetlands, set-bank embankments)	Loss of available land area/Require water retention on land	Effect on Land owner/land use	Mitigation – as still overdeepened	Possibly
		Re-establish floodplain habitats (e.g. create backwaters/ponds)			Mitigation – Not in-channel measure	Possibly
		Appropriate/selective vegetation control regime (e.g. (a) minimise disturbance to channel bed and margins, b) selective vegetation management for example only cutting from one side of the channel, c) providing/reducing shade, d) appropriate timing (e.g. seasonal maintenance))*	Limited effect	Limited effect	Mitigation	Yes
		Fencing programme to exclude livestock*			Mitigation	Yes
		Create buffer strips*			Mitigation	Yes
		Restore/establish riparian vegetation (e.g. plant trees)			Mitigation	Possibly – may impact future maintenance if extensive planting
		Maintain ecological value of marginal aquatic habitat, banks and riparian zone through management of activity*			Mitigation	Yes

Benefit of use	Associated pressures	Measures *** *Measures similar to current channel maintenance strategies***	What is the effect of the measure on the specified Use?	What is the effect of the measure on Wider environment	Measure type	Can measure be implemented without significantly impacting specified use?
		Create/re-establish floodplain forest/vegetation	Land required – but may reduce ponding	Effect on Land owner/land use	Mitigation	Yes – outside channel
		Orientated/ecologically optimised maintenance*	Limited effect	Limited effect	Mitigation	Yes
		Awareness raising / information boards (invasive species - particularly plant species as impact hydromorphological condition)* (could apply to staff carrying out channel maintenance or landowners etc.)	Limited effect - But may not restore conditions		Mitigation (Low effectiveness)	Yes
		Appropriate removal of invasive plant species*			Mitigation (Low effectiveness)	Yes