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Shannon International River Basin District Project

Freshwater Morphology POMS Study

Literature Review 2

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SHANNON INTERNATIONAL RIVER BASIN DISTRICT PROJECT

Freshwater Morphology POMS Study – Literature Review 2

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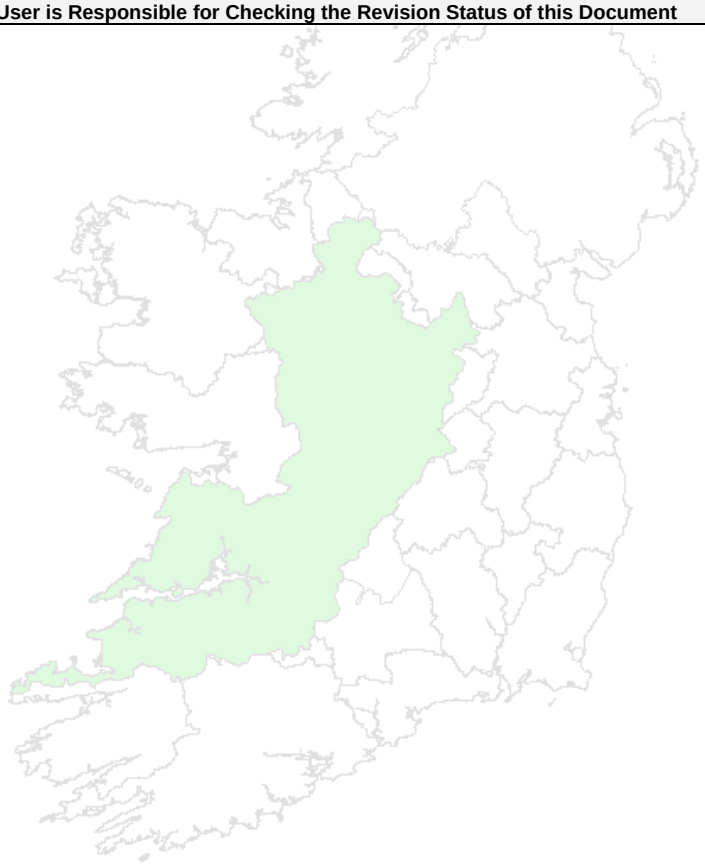

Contents

Glossary of Terms

AWB	Artificial Water Body (pAWB indicates provisional AWB)
CIS	Common Implementation Strategy
EHS	Environment and Heritage Service (NI)
EPA	Environmental Protection Agency (RoI)
ERBD	Eastern River Basin District
EU	European Union
GEP	Good Ecological Potential (for HMWB and AWBs)
GES	Good Ecological Status
HMWB	Heavily Modified Water Body (pHMWB indicates provisional HMWB)
IRBD	International River Basin District
LHS	Lakes Habitat Survey
MImAS	Morphological Impact Assessment System
Mitigation Measures	Measures taken on a waterbody to generate Good Ecological Potential
NS SHARE	North- South Shared Aquatic Resource Project
NBIRBD	Neagh Bann International River Basin District
NERBD	North Eastern River Basin District
NI	Northern Ireland
NWIRBD	North Western International River Basin District
OPW	Office of Public Works
P&I	Pressures and Impacts
PoM	Programme of Measures
POMS	Programmes of Measures and Standards
R.A.T	Rapid Assessment Technique
RBD	River Basin District
RBMP	River Basin Management Plan
Restoration Measures	Measures taken on a waterbody to reach Good Ecological Status only
RHS	River Habitat Survey
RoI	Republic of Ireland
SERBD	South Eastern River Basin District
SHIRBD	Shannon International River Basin District
SWRBD	South Western River Basin District
UK TAG	United Kingdom Technical Advisory Group
WFD	Water Framework Directive
WRBD	Western River Basin District

1.0 Introduction and Background

This literature review has been completed under Work Package 1 of the Shannon International River Basin District, Freshwater Morphology, Programmes of Measures and Standards (POMS) Study Terms of Reference as agreed in October 2005.

This report follows on from Literature Review 1 (DC060), September 2006 to provide an update on research documents previously reviewed, and to provide a synopsis of literature that has more recently become available, and is of relevance to the Freshwater Morphology POMS Study.

2.0 Freshwater Morphology POMS Study Objectives

A recap of the objectives of the Freshwater Morphology POMS Study, of which this report is a deliverable, is provided below.

2.1 Primary Objective

Specifically with regard to historical channelisation and dredging works and ongoing maintenance dredging in RoI there is uncertainty as to the long term impacts of these activities. Similarly, there is limited data within NI on the extent of morphological alterations to rivers and lakes. Techniques for describing and assessing the morphological condition of surface waters are currently being developed and are not widely applied. The overall approach to Article 5 risk assessment was precautionary because of the limited data available and the poor understanding of the relationships between morphology and ecology. This resulted in a significant amount of waterbodies being categorised as “1b -probably at risk” or “2a -probably not at risk”.

Therefore, the primary objective of the Freshwater Morphology POMS Study is to resolve the uncertainties identified in the Article 5 reports in relation to the two key freshwater morphology assessments (i.e. channelisation and intensive land use). Fieldwork and examination of pressure and impact relationships will refine the risk assessments and thresholds applied.

The revised thresholds will be reapplied on behalf of all RBDs to provide output for the first River Basin Management Plan (RBMP) in 2008 and will be developed where appropriate.

2.2 Secondary Objective

Both RoI and NI used the same principles in applying methods for the determination of risk in the morphological risk assessment. The methodology comprised of two stages:

* Stage 1: determination of risk magnitude;
* Stage 2: adjustment based on data confidence.

However, as illustrated in the Article 5 risk assessment methodologies and results, there were differences in the datasets used and the morphological activities assessed to define morphological alterations as an overall pressure. To this end, the achievement of harmonisation in risk assessments between NI and RoI will be addressed within the overall POMS Study as a secondary objective. The outcome of this will be presented in subsequent Work Package deliverables as they are progressed.

3.0 Literature Review 2: Objectives and Scope

Several documents have been collated for inclusion in Literature Review 2. The main objective is to identify the scope of relevant ongoing research and to draw upon significant findings with respect to research, monitoring, regulatory measures and decision support tools for regulators. Literature relating to Best Practice Measures will be reviewed in a separate report to facilitate the development of a framework of management measures

An indication of how the documents reviewed apply to the objectives of the Freshwater Morphology POMS study is provided within this report.

This report has been prepared so that the most current research and guidance publications can be reviewed and applied within the Freshwater Morphology POMS Study as appropriate.

4.0 Guidance Documents

Since the completion of Literature Review 1, further Guidance documents have become available. Table 1 lists the Guidance Documents that are reviewed in this report and provides an indication of related documents that were discussed in Literature Review 1.

Table 1: Guidance Documents Discussed in Literature Review 2

Document Number	Document	Author	Earlier Version Reviewed in Literature Review 1?
2.4.1	Draft Mandate for an Activity on "Water Framework Directive and Hydromorphological Pressures" Phase II: 2007-2009	CIS, 2006	WFD and Hydromorphology , European Workshop, Prague, Summary Report was reviewed which precedes Documents 2.41. and 2.4.2
2.4.2	WFD and Hydro-morphological pressures Policy Paper	CIS, 2006	
2.4.3	A Guidance Standard for Assessing the Hydromorphological Features of Rivers	CEN, 2002	NO
2.4.4	Water Quality – Guidance Standard on Assessing River Quality based on Hydromorphological Features (CEN/TC 230)	CEN, 2007	NO

Document 2.4.1 outlines the proposals of the Common Implementation Strategy with respect to WFD and Hydromorphological Pressures. The significance of hydromorphology pressures in Member States' Article 5 risk assessments warranted the set up of a CIS activity to address the issues surrounding it. The main aims of the activity are:

- To identify how the conflicts and synergisms between managing hydromorphology in River Basin Districts and the requirements of other policies (e.g. renewable energy, transport and flood management);
- To exchange information on approaches to the assessment and management of significant hydromorphological pressures and impacts so that expertise can be transferred across Member States and approaches can be developed in common;
- To exchange information on approaches and strategies for the protection and/or restoration from hydromorphological deteriorations;
- To identify available knowledge about the link between hydromorphological changes and ecological/biological impacts.

The CIS Activity on Hydromorphological Pressures and WFD is being jointly led by Germany and the UK. A Strategic Steering Group was established to assist. The activity is largely based on the use of workshops as a forum for transferring information instead of the production of several reports. However two key deliverables are:

- A technical document identifying best practice in relation to preventing deterioration, restoring hydromorphological condition and mitigation measures;
- A policy paper making recommendations on the integration of hydropower policy, transport policy and flood management policy with water policy (**Document 2.4.2**).

The best practice document will be discussed in a separate Best Practice Report under the Freshwater Morphology POMS Study.

Document 2.4.2 entitled **WFD and Hydro-morphological pressures Policy Paper** is a deliverable of the CIS Activity on Hydromorphological Pressures and the WFD. It is recognised that there is the potential for conflict or overlapping of WFD policy and other EU policies, particularly in relation to hydropower, navigation and flood protection. (A separate Strategic Steering Group has been set up to deal with "WFD and Agriculture"). Several policies exist regarding these hydromorphology pressures. The paper outlines the various levels at which integration is needed as follows:

<u>Policy Development Level</u>

Transparency in decision making is regarded as the key path of progress in ensuring better integration between different policies. This means transparency in data and procedures but also in economic assessments. It is considered that market based instruments supporting the

achievement of environmental objectives should be further developed. The assessment of cost versus benefit is fundamental in this process.

Planning and Programming Level

At this level, decisions are made for geographical areas or whole sectors. It is considered crucial that different sectoral areas are coordinated so that plans can be integrated with respect to hydromorphology issues. The Strategic Environmental Assessment (SEA) Directive is highlighted as a useful mechanism for developing common visions across different policy areas. It has been suggested that in RoI, the alignment of other management boundaries (e.g. fisheries) with River Basin District boundaries would help to achieve coordination between WFD freshwater morphology and fisheries measures implemented by Central and Regional Fisheries Boards.

Project Level

Recommendations on project level are focussed on the assessment of impacts and the needed mitigation measures. Technical solutions that do not cause deterioration in status should be promoted.

Dialogue and coordination between the different competent authorities, experts and stakeholders is are necessary at all of these levels and should take place with regard to the three WFD stages of prevention, restoration and mitigation.

The use of hydropower is a significant pressure across many Member States although it did not emerge as a significant factor in the Article 5 risk assessments in RoI. Whist hydropower schemes are not present in RoI at the same scale as in other Member States it is still a water use that has been raised as conflicting in terms of WFD policy and policies on renewable energy. **Document 2.4.2** recommends that in order to minimise the need for new sites, the development of hydropower capacities could be supported first by the modernisation and the upgrading of existing infrastructures. Planning policies should also identify areas where the construction of a hydropower scheme would conflict with WFD requirements.

Similarly, inland navigation and ports are not as large-scale pressures in RoI as they are in other Member States. However, where they do exist or are proposed, specific attention should be paid to the dynamic nature of the environment in achieving ecological objectives under WFD and those for water dependent Natura 2000 sites, achieving “favourable conservation status.”

Flood Risk Management is a topical issue across EU at present. The forthcoming EU Floods Directive also promotes a catchment based approach to managing flood risk. To this end, there is much scope for coordinating the Floods Directive and WFD. CIS regard the Defra

approach of "Making Space for Water" promising and recommends that land use planning policies are made in support of, and in combination with, agriculture and forestry policies.

The paper concludes that whilst the WFD may be an ambitious piece of legislation requiring reconsideration in the way users operate, the RBMP's also provide flexibility in terms of setting environmental objectives. In addition, the RBMP's can identify obsolete infrastructure or disconnection of a river's floodplain which can be respectively removed or restored. This approach can be applied in the removal of unused weirs from rivers which restores connectivity in terms of migratory species, for example. This is being investigated within the Freshwater Morphology POMS Study.

The South Western Regional Fisheries Board is aspiring towards the "No Net Loss" Principle being adopted within the Planning Framework. This principle is quoted in the policy paper as a possible mechanism for counterbalancing the environmental impact of a project by undertaking an equivalent environmental enhancement project. It cannot be applied in all cases and care must be taken to ensure it is not abused.

The "No Net Loss" Principle will be discussed in detail within the Best Practice report under the Freshwater Morphology POMS Study.

Document 2.4.3

A Guidance Standard for Assessing the Hydromorphological Features of Rivers (EN 14614)

The European Committee for Standardisation (CEN) was founded in 1961 by the national standards bodies in the European Economic Community and EFTA countries.

CEN contributes to the objectives of the European Union and European Economic Area with voluntary technical standards which promote free trade, the safety of workers and consumers, interoperability of networks, environmental protection, exploitation of research and development programmes, and public procurement. (http://www.cen.eu/cenorm/aboutus/index.asp).

In the case of Freshwater Morphology a guidance standard for assessment was developed in 2002 since it was recognised that many European countries historically monitored river "quality" simply in terms of the chemical or pollution status, not its physical condition.

The standard provides guidance on the features to be recorded when characterising and assessing the hydromorphology of rivers. It focuses on the structural features of rivers and on river continuity as opposed to hydrology and underlying geology. The underlying basis of the guidance is the measurement of deviation from reference condition.

Survey requirements are identified as:

- River Types
    - Enables results of surveys on rivers of similar types to be compared
    - Meets the WFD requirement of defining “high status”, type specific reference conditions in an ecologically meaningful way
    - Core type information can be derived from maps or catchment wide databases and can be refined using field data or through expert opinion
    - Factors used in defining type are recommended as size, gradient, geology, geographical location, altitude and hydrological regime

- Dividing Rivers into Reaches
    - Catchment needs to be divided into river types, then component reaches based on significant changes in geology, valley form, slope, discharge, land use and sediment transport

- Survey Strategy
    - Reaches can be characterised hydromorphologically using survey strategies
    - Surveying the whole reach can involve single surveys or contiguous surveys.
    - Alternatively sampling within a reach can be undertaken
    - Survey strategy should take account of the objectives of the work and reporting requirements

Figure 1 illustrates the different types of surveys that can be undertaken within a catchment.

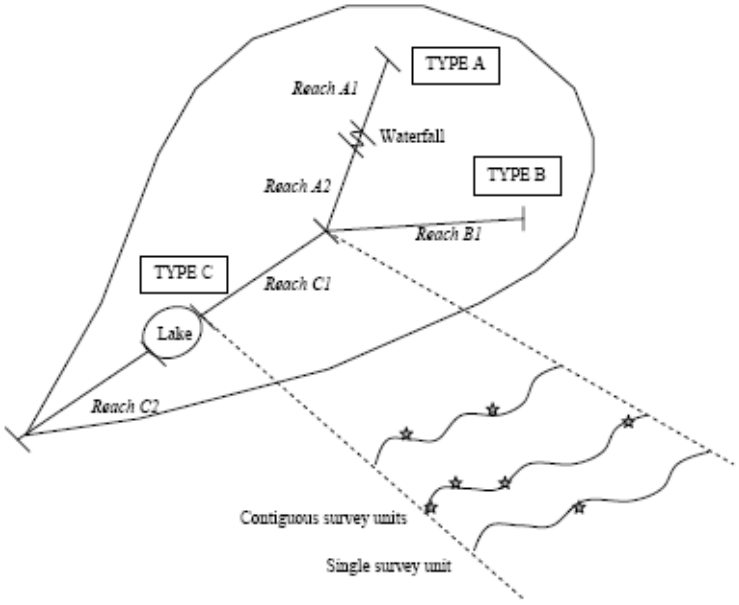

Figure 1: A hypothetical catchment showing the main types of approach to hydromorphological survey, set within the context of river scale ('type', 'reach', 'survey unit') (☆ = survey unit) *(CEN Guidance Document TC 230/WG 2/TG 5: N32)*

- Scale of Surveys and evaluations
  - Length of survey unit is dependent on purpose of the assessment and the size of the river
  - Where the main purpose of the survey is to assist in operational river management, more detailed collection of data on river features may be required
  - Lateral survey boundaries need to encompass all floodplain features that may be present. A standard distance of 50m on either side of the watercourse is recommended
  - Information should be gathered for the left and right banks, enabling assessments to be made for each bank separately or both together.

- Timing and frequency of field surveys
  - The key to timing is the ability to assess all features with confidence. This will usually be in times of low flow and where the vegetation type or structure within the channel, bank and riparian zone can be recorded accurately

- In order to track morphological change, surveys should be repeated every 5 - 10 years

- Reference conditions
  - This is an essential pre-requisite for assessing hydromorphological quality and is a specific requirement of WFD to enable classification of other status levels.
  - Reference conditions should be identified within each river type using the following criteria
    - Bed and bank character
    - Planform and river profile
    - Lateral connectivity and freedom of lateral movement
    - Free flow of water and sediment in the channel
    - Vegetation in the riparian zone

Table 2 illustrates the features for survey and assessment as outlined in the CEN guidance document. Those features identified as necessary for classification at high status are shown.

Table 2: Assessment categories, features and attributes comprising a standard hydromorphological assessment *(CEN Guidance Document TC 230/WG 2/TG 5: N32)*

No	Assessment Categories	Generic Features	Examples of Attributes Assessed	Classification at "high status"
	CHANNEL			
1	*Channel geometry*	Planform Longitudinal section Cross-section	Braiding, sinuosity Modification to natural planform Gradient, long section profiles Variations in cross-section shown by depth, width, bank profiles, etc.	✓
2	Substrates	 Artificial Natural substrate types Management/catchment impacts	Concrete, bed-fixing Embedded (non-movable boulders, bedrock, etc.) Large (boulders and cobbles) Coarse (pebble and gravel) Fine (sand) Binding (silt and clay) Organic (peat, etc.) Degree of siltation, compaction	✓
3	Channel vegetation & Organic debris	Structural form of macrophytes present Leafy and woody debris Vegetation management	Emergent, free-floating, broad-leaved submerged, bryophytes Type and size of feature/material Weed cutting	

4	Erosion/deposition character	Features in channel and at base of bank	Point bars, side bars, mid-channel bars and islands (vegetated or bare); Stable or eroding cliffs; slumped or terraced banks	
5	Flow	Flow patterns Flow features Discharge regime	Free-flow, rippled, smooth Effect of artificial structures (groynes, deflectors) Pools, riffles, glides, runs Off-takes, augmentation points, water transfers, releases from hydropower dams	✓
6	Longitudinal continuity as affected by artificial structures	Artificial barriers affecting continuity of flow, sediment transport and migration for biota	Weirs, sluices across bed, culverts	✓
	RIVER BANKS/ RIPARIAN ZONE			
7	Bank structure and modifications	Bank materials Types of revetment/bank protection Bank profiles	Gravel, sand, clay, artificial Sheet piling, stone walls, gabions Cliffs, berms, re-graded, trampled, eroding, depositing	✓
8	Vegetation type/ structure on banks and adjacent land	Structure of vegetation Vegetation management Types of land-use, extent and types of development	Vegetation types, stratification, continuity Bank mowing, tree felling Agriculture, urban development	✓
	FLOODPLAIN			
9	Adjacent land-use and associated features	Types of land-use, extent and types of development Types of open water/wetland features	Floodplain forest, agriculture, urban development Ancient fluvial/floodplain features (cut-off meanders, remnant channels, bog) Artificial water features (irrigation channels, fish ponds, gravel pits)	
10	Degree of (a) lateral connectivity of river and floodplain; (b) lateral movement of river channel	Degree of constraint to potential mobility of river channel and water flow across floodplain Continuity of floodplain	Embankments and levees (integrated with banks or set back from river), flood walls and other constraining features Any major artificial structures partitioning the floodplain	

Document 2.4.4

Water Quality – Guidance Standard on Assessing River Quality based on Hydromorphological Features (CEN/TC 230), CEN, 2007

The European Guidance on the assessment of hydromorphological features provided in **Document 2.4.3** was progressed under CEN/TC 230 "Water Analysis" to produce a CEN Standard in 2007. It sets out a simple scoring system and suggests suitable sources of information which may contribute to hydromorphological assessments. However the Standard is not linked directly to the assessments of ecological status made under WFD. Whilst the previous CEN guidance document outlines field assessment protocols, this CEN standard has been developed for assessing the degree of modification of river morphology to assist in more broad scale assessment, land use planning, strategic environmental assessment, river basin management and setting targets for river restoration work.

The document is a working document at present and is based on the hydromorphological features described in Table 2. The features have been divided into two groups as illustrated by Figure 2.

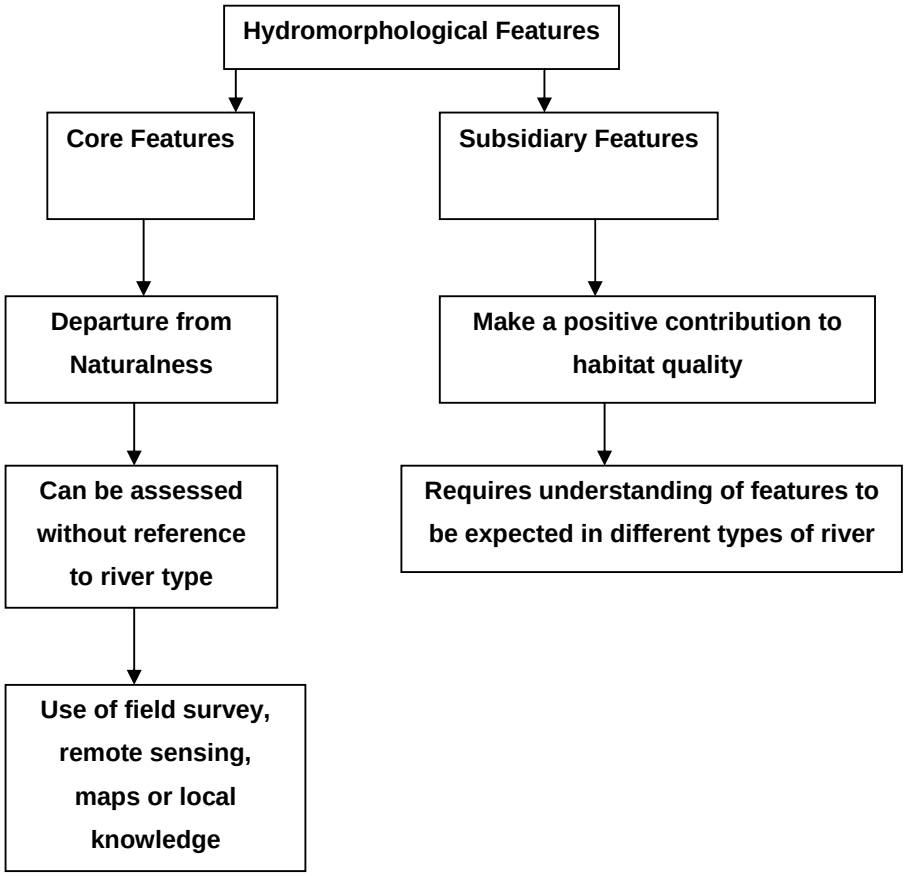

Figure 2: Core and Subsidiary Hydromorphology Features as described by CEN Standard.

Table 3 indicates which hydromorphological features are core and subsidiary.

Table 3: Categories of "core" and "subsidiary" features for quality assessment *(CEN Guidance Document TC 230/ No. 556))*

Category	Core	Subsidiary
2b 'Natural' substrate mix or character altered		
1a Planform	✓	
1b Channel section (long-section and cross-section)	✓	
2. Substrates		
2a Extent of artificial material	✓	
		✓
3. Channel vegetation and organic debris		
3a Aquatic vegetation structure		✓
3b Extent of woody debris if expected		✓
4. Erosion/deposition character		✓
5. Flow		
5a Impacts of artificial in-channel structures within the reach	✓	
5b Effects of catchment-wide modifications to natural flow character	✓	
6. Longitudinal continuity as affected by artificial structures	✓	
7. Bank structure and modifications	✓	
8. Vegetation type/structure on banks and adjacent land	✓	
9. Adjacent land-use and associated features	✓	
10a. Extent of floodplain not allowed to flood regularly due to engineering	✓	
10b. Constraint on lateral movement of river channel	✓	

Two procedures for scoring are outlined. Score Band 'A' uses qualitative data whereas Score Band 'B' uses quantitative data. Score Band A is a 3-point scale. Score B is a 5-point scale. The score band used reflects the degree of confidence in the assessment. The score bands are numbered as shown in Table 4.

Table 4: Scoring Systems used in CEN Standard

5 - Band	Name	3- Band	Name
1	Near- Natural	1	Near natural
2	Slightly altered	3	Slightly to moderately altered
3	Moderately altered		
4	Extensively altered	5	Extensively to severely altered
5	Severely altered		

A draft protocol for scoring river quality based on hydromorphological features using either the qualitative or quantitative scoring systems is outlined. The quantitative system includes thresholds for each score, 1 to 5, that can be assigned for each attribute. These thresholds are expressed as percentage ranges and in general are as follows:

- 1 = 0-5% of reach length modified
- 2 = >5-15% of reach length modified
- 3 = >15-35% of reach length modified
- 4 = >35-75% of reach length modified
- 5 = >75% of reach length modified.

Applicability to Freshwater Morphology Study:
The applicability of these thresholds in the context of Irish rivers will be assessed within the Freshwater Morphology POMS Study which aims to refine risk assessment thresholds based on field data.

The principal applications for the CEN standard are outlined as:

- Land-use planning and Strategic Environmental Assessment
- Site- or reach-based Environmental Impact Assessment
- Maintenance work on rivers
- Catchment appraisals for catchment management
- Management of Natural 2000 sites and other sites of conservation importance
- Protecting valuable fish habitat

Although relevant to the WFD, this standard is not principally designed for WFD assessments but for a wide range of reporting and management needs. ***(CEN Guidance Document TC 230/ No. 556).***

5.0 Research and Development of Morphological Assessment Applications

Under Article 11 of the WFD, by 2009, Member States need to develop a Programme of Measures (POMs) for each River Basin District (RBD) taking into consideration the results of both initial characterisation (Article 5) and further characterisation. A draft programme is to be prepared by 2008.

A Programme of Measures implemented at a national or local level within Member States may include wide-ranging actions such as:

- measures to manage specific pressures arising from: forestry, agriculture, urban development, etc;
- control regimes or environmental permitting systems;
- water demand management measures;
- economic instruments such as incentives, taxes on fertilizers, etc;
- river restoration strategies.

(Source: http://www.wfduk.org/tag_guidance/Article%20_11/)

Programmes of Measures (as specified in RBMP's) are required to be operational by 2012. Competent authorities (supported by UKTAG) are reviewing the requirements of the WFD in this area. UKTAG, via its Programme of Measures Task Team, is reviewing how the requirements of the WFD can be met within UK systems for:

- Environmental objectives under WFD;
- Classification schemes and environmental standards which aim to ensure UK regimes are WFD compliant;
- Managing the interaction of WFD with other European directives being implemented by the UK;
- Developing the framework for assessing cost-effective programme of measures.

With respect to freshwater morphology, research in these areas is still developing across Europe. At present research projects are ongoing both through the UKTAG and in RoI which have relevance to freshwater morphology. Table 6 indicates the freshwater morphology related research documents that are discussed in this report and identifies those documents that had related publications discussed in Literature Review 1 (September 2006).

Table 6: Morphology Research Documents included in Literature Review 2

Document Number	Document	Author	Earlier Version Reviewed in Literature Review 1
2.5.1	Using Science to Create a Better Place, Incorporating Climate Change in River Typologies: Results	Environment Agency, UK, Feb 2007	Freshwater Morphology Workshop – Research Needs, Lancaster University. This paper was discussed at the workshop and has since been published.
2.5.2	Linking organisms to natural and modified river hydromorphology by the analysis of existing data	Dr Ian Vaughan & Prof. Steve Ormerod, Cardiff University	Yes, proposal to UK TAG by Cardiff University was discussed. It has since been approved and research has commenced.
2.5.3	UK Environmental Standards and Conditions (Phase 1) –Final Report	UK TAG, Jan 2007	Yes, draft report reviewed.
2.5.4	Definition of the Spatial Scale of Environmental Impact Affecting Status of Waterbodies (Draft)	SEPA/UK TAG, Nov 2006	NO
2.5.5	UK Environmental Standards and Conditions (Phase 2) –SR1 – 2007, June 2007	UK TAG, June 2007	NO
2.5.6	WFD 49f (Extension to SNIFFER project WFD49a) "Development of a decision making framework for managing alterations to the morphology of lakes" – Draft Final Report	SNIFFER, Jan 2007	Yes, draft final report has now been published; the initial work was discussed previously.

5.1 Research

Document 2.5.1

Using Science to Create a Better Place, Incorporating Climate Change in River Typologies: Results

Lancaster University hosted a Freshwater Morphology workshop in June 2006 to discuss WFD research needs in the UK. Delegates from Government Authorities in England and Scotland, consultants and academics were in attendance. RPS Consulting Engineers attended on behalf of the Shannon River Basin District Project. The key research gaps identified were:

- The link between hydromorphological conditions and ecology is not well developed.

- The difficulty in establishing a link between hydromorphology and ecology is not fully appreciated.
- The effect of climate change on ecological quality of aquatic ecosystems is not well researched at present.

One report has been published since this workshop under the auspices of Environment Agency and led by Lancaster University entitled *"Using Science to Create a Better Place, Incorporating Climate Change in River Typologies: Results".*

The main aims of the project were to review existing approaches to channel typology which both incorporate climate change and support WFD; develop a typology on a test catchment; describe channel types using this typology and field data; consider the ecological significance of these channel types; apply hydraulic models driven by climate change scenarios and develop an archive of hydromorphological data.

The case study used was the River Eden in Cumbria. The Eden river network was rebuilt on GIS so that individual arc lengths were approximately 500m in length to make them more consistent with field survey data.

The research produced 11 different typologies using the following descriptors:

- Stream Order (1-5)
- Stream Power (as a measure of the river's power to transport sediment)
- Slope
- Floodplain extent

Catchment data such as solid and drift geology and land use were also described for each 500m reach; however these did not have a significant effect on the geomorphological types at this scale. It was considered that such variables are important in determining ecological relevance of typology classes as opposed to the classes themselves.

Fieldwork was conducted within the Eden catchment to test whether the expected channel types corresponded to observed geomorphological character in the field; to observe the variability of features and flow charts within each channel type; and to develop a field based database by which morphology/ecology interactions could be explored.

The comparison of the broad typology against field data worked well in some but not all cases. Future fieldwork is planned to address the under-representation of some of the 11 river types in this study and to look more closely at the comparisons made.

In general, the results obtained presented questions for further research, and closer investigation using available data for the Eden Catchment. The typology was developed on the basis that stream power is an indicator of likely channel response. Further validation work on this is required so as to ensure mis-interpretation does not occur. For example, comparing downstream stream power with field data can highlight erosion dominated areas, but whilst this could be a natural channel response, it could be due to localised artificial influences such as stock damage.

Channel types were defined in terms of their range of habitat features and the most likely way they may change in response to discharge variation under climate change.

Low Flows 2000 software was used to derive both natural flow estimates and influenced flow statistics for the Eden catchment. A physically-based hydrology model SHETRAN was also used to dive a detailed description in time and space of the flow and transport in a river basin and can be used for studying the environmental impacts of land erosion, changes in land use and climate, surface water and groundwater management. This model was used more extensively that Low Flows 2000 in the analysis as the latter only gives a flow estimate of up to the Q5 flow (i.e. the flow that is equalled or exceeded by the river 5% of the time). As stream power was the main indicator used, and this is based on bank full discharge, it was considered that a more accurate representation is the Q1 flow, which could only be predicted using SHETRAN. This model was run for various climate scenarios - both current and future.

It was found that 5% of the 500m reaches in the Eden catchment would experience changes in stream power significant enough to actually slot the reach into a different river type (using the 11 derived in this study). However, the modelling approach taken was not considered to have captured local response. The general findings made were:

- Most channel types are expected to have higher stream power which implies greater transfer of sediment in future climate change scenarios
- Some channels may also change from one type to another
- To maintain a 10cm flow depth over riffles by 2080, hands off flows would need to equal Q70 (currently Q95)
- Flow depth is important for salmon fry and results imply that preserving ecological status will mean less water for abstraction
- It is considered that current typology systems in WFD are large scale and simple, more detailed information on why a river type is present and how it may change is needed if climate change is to be incorporated
- There remains a need to understand how geomorphological, hydrological and ecological functions are linked at the catchment scale
- Geomorphological typologies should capture driving processes and allow for local variability to be compared with habitat and species population data.

The discussion within the report recommends that whilst large scale representation of waterbody status is useful for reporting for WFD, Programmes of Measures will require detail at smaller scales (10 – 100m). The combination of the developed typology and gathering of channel modification data can identify where semi natural or expected processes have been changed. This could be used to target reaches for restoration or remediation measures.

The report recommends that "characterisation of channel reaches based on stream power, slope and floodplain extent is an important first step in characterising hydromorphology for WFD. Development of channel modification databases should be part of this first step because restoring modified channels may be one of the measures used to improve ecological status. Further research is recommended to explore links between physical habitat and biological response using the 11 type typology to underpin other typologies based on water quality.

Applicability to Freshwater Morphology Study:

Environment Agency has advised that the 11 type typology described in this report was developed for research purposes only. EA are producing a 6 type, typology to support the MImAS tool for use in England and Wales. The reason for a lower number of types is that the risk of mis-classification increases with an increased number of types in a typology system. Under Work Package 6 of the POMS Study there will be a focus on the typologies used in MImAS and RAT with a view to application in Ireland. A GIS methodology for assigning channel type will be developed for application to Irish rivers.

Document 2.5.2

Linking Organisms to Natural and Modified River Hydromorphology by the Analysis of Existing Data, Cardiff University

As discussed in Literature Review 1, academics from Cardiff University are undertaking a research project with a primary objective of improving the understanding of the links between riverine ecology and hydromorphology, "*Linking organisms to natural and modified river hydromorphology by the analysis of existing data*". It is recognised that this is vital to delivering the WFD.

The research project is making use of existing Environment Agency data holdings - River Habitat Survey, water chemistry and biological data - to investigate the role that hydromorphology (as revealed by RHS) plays in the distribution/abundance of different organisms (predominantly invertebrates). Pilot studies using a few taxa and in a selection of catchments suggest that these datasets can provide useful information about this, despite the

limitations (e.g. invert data are only family, not species, level and the different data were not collected at exactly the same sites).

At present, the research team are finalising the dataset (containing thousands of sites) that will be used for the full analysis. When complete, this will enable a detailed investigation into overall links to natural and modified hydromorphology both across England and Wales, and across/within individual catchments. Useful outputs from this work are expected mid 2007 and the Freshwater Morphology POMS Study Team will be kept updated.

Cardiff University consider these analyses as a "first step in providing support for existing management, guiding the development of new management tools and helping to inform research strategies. In the medium to longer term, dedicated research aimed at understanding the *mechanisms* linking organisms and hydromorphology is essential for sustainable river management e.g. devising Programmes of Measures".

The expected timescale of this research project is two years.

Applicability to Freshwater Morphology Study:
The outputs of this study have significant relevance to the Freshwater Morphology POMS Study. More specifically, the evidence presented and the analyses in support of management tools such as MImAS provides valuable input and information on the viability of decision support tools for regulators. It is expected that classification and regulation tools in RoI will evolve and develop over time as research projects like this further our understanding of the links between freshwater morphology and ecology. The phased deliverables of this project will be closely monitored as the Freshwater Morphology POMS Study progresses.

5.2 Development of Morphological Assessment Applications for Rivers

Document 2.5.3 – UK Environmental Standards and Conditions (Phase 1) – Final Report

The UK Technical Advisory Group (UKTAG) has developed Environmental Standards and conditions to underpin implementation of the WFD. The first draft of this report was published in January 2006. The final draft was published in August 2006 following peer review of the standards proposed for the following elements:

- Water Quality Standards for rivers
- Water Quality Standards for lakes
- Standards for transitional and coastal waters

- Water Resources Standards
- Morphology of Rivers

As discussed in Literature Review 1, An Environmental Standard is an expression of a waterbody's ability to absorb change, or the level at which, if exceeded, will cause deterioration in status.

Environmental Standards are used to assist in a decision making framework when developing Programmes of Measures and in regulation of e.g. engineering activities on rivers. The Standards currently being developed for surface waters fall into three groups:

1. **Physico-Chemical** – Numeric values have been developed which have been matched to biology;
2. **Hydrological** – Numeric values supported by modelling have been developed, based upon the best available understanding of links to biology; and
3. **Morphological** – A decision framework using best available knowledge supported by numeric thresholds

A waterbody must meet all of these Environmental Standards in order to be classified as High Status.

In the draft report of January 2006, UK TAG recognised that development of evidence-based standards for river morphology is not yet possible. This is re-iterated in the final draft. It is stated that for now, the procedure will be to use assessment of impacts on morphological features and processes to identify proposals that pose a high risk to ecological status. This approach is to be supported by a decision support framework that was developed in consultation with expert geomorphologists and ecologists.

The Environmental Standards for river morphology developed by UK TAG, upon which the decision support framework is based, are indicated by Table 7.

Table 7: UKTAG Proposals for River Morphology – Conditions to Protect Ecological Status

Zone	**% of the capacity used**	
	High Status	**Good Status**
Channel	5	15
Bank and Riparian	5	15

The Environmental Standards for river morphology (previously called Morphological Condition Limits) are expressed as a percentage of the "capacity" that has been taken up i.e. a river's capacity to accept morphological change without changing its ecological status.

Using Environmental Standards in Regulation of Morphological Alterations

UKTAG has used a pragmatic approach to develop a decision support framework to help assess the risk to ecological status of a waterbody as a result of proposed alterations to morphology e.g. river engineering activities.

The concepts of the UK TAG decision support framework are:

(1) A waterbody has some capacity to accept morphological change without changing its ecological status

(2) Expert judgement can set acceptable limits for morphological change in conditions beyond which there would be concern about risk to ecological status

The assumptions of the UK TAG decision support framework are:

- There is a relationship between extent of morphological alteration and ecological status
- Response is predictable and depends on the sensitivity of the ecology of the river
- Response is predictable for a type of waterbody

The decision support tool within the framework is called the Morphological Impact Assessment Tool (MImAS), the details of which are discussed in Literature Review 1. MImAS uses the standards outlined in Table 6.4 to identify proposed river engineering activities that pose high risk to ecological status. The Scottish Environmental Protection Agency (SEPA) has adopted this tool as their decision support framework and has embedded it within Scotland's Controlled Activities Regulations (C.A.R). The Environment Agency (EA) for England and Wales has not yet adopted MImAS as their decision support tool.

Whilst SEPA has adopted MImAS for regulation, and EA have not yet, UK TAG recognises that a general approach for regulation will need to be adopted by both agencies that include the following criteria:

1. All proposals are expected to follow good practice guidelines
2. All proposals are expected to meet flood management requirements
3. Proposals affecting migratory movements of fish will be subject to a more detailed assessment
4. More detailed assessments will be required in special cases e.g. proposals causing loss of floodplain connectivity, or areas environmentally designated
5. If the implemented decision support tool (e.g. MImAS) identifies a high risk proposal, a more detailed assessment will be required, usually by the applicant.

UK TAG has not yet developed a standard protocol for a more detailed assessment. However a draft approach to classification has been produced and will be added to this review when the final report has been produced.

SEPA has produced a Guidance Document for its staff to aid the implementation of River Environmental Standards and MImAS when regulating engineering activities under C.A.R. A Stage 1 assessment is carried out on a 500m river stretch surrounding the proposed activity. If this assessment fails in terms of the amount of the river's capacity to accept physical change that is used up, then a Stage 2 assessment is carried out. This is termed a "Water Body Assessment" and is carried out over a 2500m stretch surrounding the proposed activity. In this assessment, if the proposed activity or activities use up > 20% capacity, then the Stage 2 test is failed.

The Stage 1 and 2 tests steer the regulators to appropriate guidance document for a certain activity and aids decision making, they do not produce the final decision in terms of applicant consent. The pass/fail mechanism indicates risk of deterioration in status. If the 500m (Stage 1) is failed, then a 2500m (Stage 2) is undertaken to determine the risk to overall waterbody status.

Applicability to Freshwater Morphology Study:

Under WFD Article 11, Member States are required to control physical change to rivers and lakes. The requirement for new primary legislation in RoI was investigated by DoEHLG and it has been concluded that regulatory control can be exercised through secondary legislation / statutory instruments that are already in existence. SEPA's Stage 2 Water Body assessment may have relevance in this respect.

Furthermore, waterbody classification / characterisation for river morphology is required for WFD compliance, at least at the high/good status class boundary.

Using Environmental Standards in Risk Assessment for Waterbodies

UK TAG considers that it may be possible to apply the decision support framework and the MImAS tool for assessing risk at a waterbody scale as part of classification/characterisation and EU reporting. Future requirements for developing the use of the MImAS tool for e.g. classification are:

- Creation of a scoring system for rivers with significantly modified hydrological and sediment regimes due to catchment wide activities

- Up-scaling of results to 10km stretches allowing decisions to be made at a waterbody scale.

Document 2.5.4

With respect to the upscaling of results to waterbody scale, ***"Definition of the Spatial Scale of Environmental Impact Affecting Status of Waterbodies (Draft)"*** was written by SEPA to provide guidance on the spatial component of UK TAG'S Environmental Standards, and to set out criteria for determining when the overall ecological status of a waterbody is threatened. The criteria are based on 2 sets of Environmental Standards:

1. Environmental Standards for morphological conditions (as discussed in Literature Review 1, and in this report)
2. Environmental Standards for water resources.

In addition consideration is given to:

- the length of river over which the standards are failed;
- the degree of disruption to the migration of fish resulting from any form of manmade impediment to migration.

Criteria are provided for the spatial extent over which an Environmental Standard would have to be failed for the associated adverse impacts to be enough to affect the status of the overall waterbody.

River Length Criteria

The following table is an extract from the document and stipulates the spatial scales of failure of Environmental Standards for both morphology and water resources resulting in a threat to the status of the overall waterbody. There are 2 rules which apply to river stretches with a catchment area greater than 10km^2.

Table 8: Spatial Scales of Failure of Environmental Standards

		Standard needed to protect HIGH Status	**Standard needed to protect GOOD Status**	**Standard needed to protect MODERATE status**	**Standard needed to protect POOR status**
Main stem and major tributaries of baseline waterbody with	**Rule 1**	Less than 0.5km of the contiguous river length has an ES worse than the HIGH/GOOD boundary	Less than 1.5km of the contiguous river length has an ES worse than the GOOD/MODERATE boundary	Less than 3km of the contiguous river length has an ES worse than the MODERATE/POOR boundary	Less than 4km of the contiguous river length has an ES worse than

					the POOR/BAD boundary
catchment area > 10km^2	**Rule 2**	Less than 5% of the total length has an ES worse than HIGH/GOOD boundary (unless 5% is < 0.5km)	Less than 15% of the total length has an ES worse than GOOD/MODERATE boundary (unless 15% is < 1.5km)	Less than 25% of the total length has an ES worse than MODERATE/POOR boundary (unless 25% is < 3km	Less than 35% of the total length has an ES worse than POOR/BAD boundary (unless 35% is < 4km

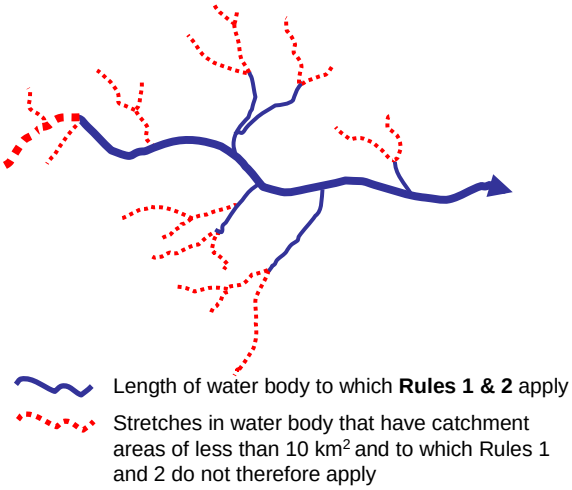

Figure 3: Schematic Diagram illustrating the river stretches where Rules 1 & 2 do and do not apply (Source Document 2.5.3)

A third rule exists for stretches in the waterbody that have catchment areas of less than 10km2.

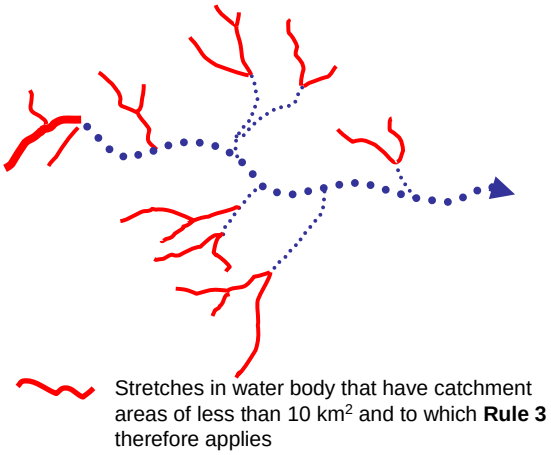

Figure 4: Schematic Diagram illustrating the river stretches where Rules 3 applies (Source Document 2.5.3)

Rule 3 is defined as follows:

"A proportion of the minor streams in the waterbody which are assessed by SEPA as being significant enough to affect the status of a waterbody, taking into account the characteristics of the streams, including the biological assemblages they are important in supporting and the number of streams serving similar roles in the River Basin."

Rule 3 only applies to stretches with a catchment area of less than 10km^2 measured at the nearest downstream confluence and providing the proportion identified has a catchment area of at least 15% of the total catchment area of minor streams in the waterbody.

Minor streams not conforming to these criteria are not considered significant enough to affect overall waterbody status.

Applicability to Freshwater Morphology Study:

This work is ongoing as part of further research into the upscaling of the MImAS tool from a 500m reach scale to a waterbody scale. Rules 1, 2 and 3 would improve the use of MImAS as a waterbody classification tool as opposed to a regulation tool for localised engineering activities. Implementation of Rules 1, 2 and 3 would be more readily carried out using remote sensing, for which a large database of pressure information is required. This will be reflected in the findings of the Freshwater Morphology POMS Study.

Impediments to Migration of Fish Species

SEPA's general rule applied to structures impeding fish migration is if more than 15% of the catchment is affected, there is a risk of deterioration in status from good to moderate. Figure 5 provides examples of how the location of an impeding structure can affect varying areas of the catchment.

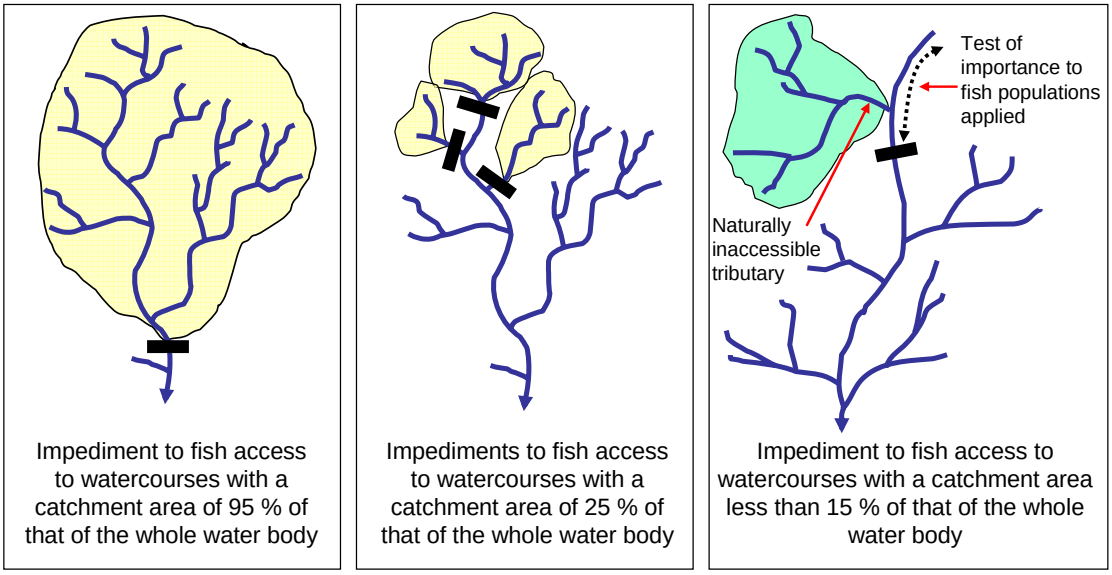

Figure 5: Impediments to Migration affecting access to different lengths of stream in a waterbody (Source: Document 2.5.3)

Table 9 provides the thresholds between status classes with respect to impediments to fish migration.

Table 9: Thresholds for % of fish failing to access a watercourse due to presence of an impeding structure (Derived from Document 2.5.3)

Status	% of fish failing to access watercourse that would be able to do so in absence of impediment
High	<5%
Good	5-15%
Moderate	15-35%
Poor	35-70%
Bad	70-100%

Applicability to Freshwater Morphology Study:

The thresholds applied by SEPA for assessing the spatial impact of in stream structures impeding fish migration will be considered within Work Package 7 of the Freshwater Morphology POMS Study. The current approach under development within the POMS Study is to assign a risk value to the structure itself in terms of impassibility, and then weight this risk according to the position of the structure within the catchment, and the natural occurrence of fish supporting habitat within the catchment.

5.3 Development of Morphological Assessment Applications for Lakes

Document 2.5.5

UK Environmental Standards and Conditions (Phase 2), sr1-2007, June 2007-07-12

The development of UK Environmental Standards and Conditions has so far taken place in 2 phases. Phase 1, which was published in draft in August 2006, makes recommendations to UK governments and is reviewed in Literature Review 1. The final draft **(Document 2.5.3)** was published in January 2007 and is reviewed in this report. The quality elements covered in Phase 1 were:

- Water Quality Standards for rivers
- Water Quality Standards for lakes
- Standards for transitional and coastal waters
- Water Resources Standards
- Morphology of Rivers

UK TAG expects to update the Phase 1 report in October 2007.

Phase 2 constitutes the UK TAG proposals for an additional and second set of Environmental Standards and Conditions. These are:

- Management approaches for temperature, nutrients, and suspended solids
- Flow in estuaries
- **Lakes Morphology**
- Transitional and Coastal Morphology

These Standards and Conditions are to be used to guide policy making decisions in each country, and to guide the first cycle of River Basin Management Plans. The UK TAG proposals for Lakes Morphology are based on the findings of a SNIFFER project WFD 49f (**Document 2.5.6**) which is discussed next. Within the WFD 49f project, a decision support tool entitled “Lakes- MImAS” was developed for application within a 2 stage screening process similar to that of rivers:

Stage 1 – Preliminary assessment – application of Lakes-MImAS at a local scale of 500m
Stage 2 – Larger scale assessment where the Environmental Standards and Conditions are exceeded in Stage 1. This assessment may draw on supplementary information from field surveys or existing Lakes Habitat Survey (LHS) data.

It is suggested that classification of lakes morphology status at the good/high boundary can be undertaken using the proposed Environmental Standards and Conditions (refer to Table 10).

Document 2.5.6 is an extension to WFD 49a to further develop the ALMS tool using the Morphological Impact Assessment System (MImAS) template that was developed for rivers. The finished product is entitled "Lakes – MImAS". A draft final report is has been published and is currently under review by UK TAG. This will be followed by a period of tool validation using existing LHS data.

The assumptions used in the Lakes –MImAS tool reflect those used in the Rivers -MImAS tool and uses the concept of "capacity to accept morphological change" as the basis for assessment.

The decision-support framework established is a pragmatic, risk-based approach which seeks to assess the risks to ecological status causes by proposed alterations to lake morphology. This framework uses best available knowledge to support consistent and transparent decisions, and is adaptive in the sense that it can be updated to incorporate new insights from WFD monitoring programmes and future advances in the science.

The framework is based on the following concepts:

- A water body has some capacity to accommodate morphological change without changing its ecological status.
- We can set, by expert judgement, limits for changes in *morphological conditions* beyond which we would be concerned that ecological status would be at risk, where *morphological conditions* refers to the list of attributes in Annex V of the Directive e.g., lake depth variation, quantity and structure of the substrate, the structure and condition of the lake shore zone. Because of the co-dependency between geomorphology and hydrology, the tool also sought to capture aspects of *hydrological regime* e.g., the quantity and dynamics of flow, level, residence time, and the resultant connection with groundwater.

This Lakes-MImAS method takes account of the biological and geomorphological sensitivity of different lake types and the extent, nature and impact of existing modifications to estimate how much of the existing capacity has been degraded. This can then be used to assess whether new proposals can be permitted or whether they should be subjected to further investigation, which is how the River-MImAS tool is implemented for regulatory purposes by SEPA in Scotland.

The Environmental Standards developed under WFD 49f are indicated by Table 10.

Table 10: Environmental Standards under WFD49f

	Capacity Used	
ZONE	High-Good	Good-Moderate
Pelagic / profundal	5%	15%
Shorezone	5%	15%

While rivers zones are split into channel and riparian zones, lakes are split into shore zones and profundal zones.

These are the Environmental Standards and Conditions that have been set for Lakes Morphology within **Document 2.5.5** by UK TAG.

Lake-MImAS, as with the other surface water MImAS tools has been developed primarily as a risk assessment to inform regulatory decision by non-expert staff. The development of this system has required a number of scientific concessions in the pursuit of a set of practicable management procedures.

The substantive issues that are recognised as limitations of the method are listed below, but these are subject to on-going iteration and will be rigorously assessed further during the testing and validation stage and ultimately as part of the public consultation and peer review process which will inform the final stages of the work.

- Reliance on expert judgement;
- Reliance on hybrid lake typology, restricted to large lakes, five 'geology' classes and two depth classes;
- Limited consideration of site specific characteristics;
- Lack of consideration of specific conservation interests;
- Limited consideration of hydrological regime management within the lake through active water level control (dams, sluices etc.);
- Limited consideration of scaling questions relating to the size of the lake waterbody;
- No consideration of synergistic responses to multiple pressures, instead the scoring system is simply summative;
- No consideration of seasonality or life stage.

(WFD 49f, Dundee University)

Applicability to Freshwater Morphology Study:

The Lakes MImAS approach replaces the ALMS approach originally developed for WFD purposes. A trialling period is the next stage of development. The tool may be trialled in RoI by selecting a specific case study and undertaking fieldwork. The MImAS tool does depend on a database of pressure information. The establishment of such a database would be the first stage of development in RoI.

6.0 Conclusion – Key Applications of Literature Review 2 to Freshwater Morphology POMS Study

This report provides a comprehensive review of literature documents relating to Freshwater Morphology between September 2006 and June 2007.

The discussion of **Guidance Documents** in Chapter 5.0 places the work undertaken at the Article 5 Characterisation stage of WFD implementation, particularly with respect to Freshwater Morphology Risk Assessment, into context. The uncertainties associated with the risk assessment and the differences in approach taken between RoI and NI identifies the need for closer investigation into freshwater morphology within the Further Characterisation phase of WFD implementation in Ireland.

The discussion of **Research and Development of Morphological Assessment Applications** Documents in Chapter 6.0 draws out their key points and identifies how they are applied to ongoing work packages within the Shannon RBD Freshwater Morphology POMS Study. The applications highlighted in Chapter 6.0 are summarised in Table 11 as follows:

Table 11: Applicability to freshwater Morphology POMS Study

Document Number	Document Name	Year Published	Applicability to Freshwater Morphology POMS Study
2.4.1	Draft Mandate for an Activity on "Water Framework Directive and Hydromorphological Pressures" Phase II: 2007-2009 -*CIS*	2007	The mandate for this CIS Activity outlines the deliverables and associated programme in terms of guidance documents and workshops. This will facilitate the transfer of information between RoI and other Member States with respect to findings in Freshwater Morphology.
2.4.2	WFD and Hydro-morphological pressures Policy Paper - *CIS*	2007	This is the first CIS deliverable from the Hydromorphology Activity and provides guidance on how different environmental policies such as WFD and renewable energy can be integrated to minimise conflicting issues between them. This will be of use in developing a framework of best practice within the RBMP's.
2.4.3	A Guidance Standard for Assessing the Hydromorphological Features of Rivers - *CEN*	2002	In the case of Freshwater Morphology a guidance standard for assessment was developed in 2002 since it was recognised that many European countries historically monitored river "quality" simply in terms of the chemical or pollution status, not its physical condition. The standard provides guidance on the features to be recorded when characterising and assessing the hydromorphology of rivers. It focuses on the structural features of rivers and on river continuity as opposed to hydrology and
2.4.4	Water Quality – Guidance Standard on Assessing River Quality based on Hydromorphological Features *(CEN/TC 230)*	2006	

			underlying geology. The underlying basis of the guidance is the measurement of deviation from reference condition. It is expected that each Member State will use the principles and key recommendations of the CEN standard and refine them in their own morphological assessment methods. A desk based trial using morphology data and the CEN scoring system will be undertaken through the NS SHARE project to ensure that the MImAS and RAT methods are generally CEN compliant.
2.5.1	Using Science to Create a Better Place, Incorporating Climate Change in River Typologies: Results – *EA and Lancaster University*	2007	Under Work Package 6 of the POMS Study there will be a focus on the typologies used in MImAS and RAT with a view to application in Ireland. A GIS methodology for assigning channel type will be developed for application to Irish rivers.
2.5.2	UK Environmental Standards and Conditions (Phase 1) –Final Report – *UK TAG*	2007	Under WFD Article 11, Member States are required to control physical change to rivers and lakes. The requirement for new primary legislation in RoI was investigated by DoEHLG and it has been concluded that regulatory control can be exercised through secondary legislation / statutory instruments that are already in existence. SEPA's Stage 2 Water Body assessment may have relevance in this respect. Furthermore, waterbody classification / characterisation for river morphology is required for WFD compliance, at least at the high/good status class boundary.
2.5.3	Definition of the Spatial Scale of Environmental Impact Affecting Status of Waterbodies (Draft)	2007	This work is ongoing as part of further research into the upscaling of the MImAS tool from a 500m reach scale to a waterbody scale. Rules 1, 2 and 3 would improve the use of MImAS as a waterbody classification tool as opposed to a regulation tool for localised engineering activities. Implementation of Rules 1, 2 and 3 would be more readily carried out using remote sensing, for which a large database of pressure information is required. This will be reflected in the findings of the Freshwater Morphology POMS Study. The thresholds applied by SEPA for assessing the spatial impact of in stream structures impeding fish migration will be considered within Work Package 7 of the Freshwater Morphology POMS Study. The current approach under development within the POMS Study is to assign a risk value to the structure itself in terms of impassibility, and then weight this risk according to the position of the structure within the catchment, and the natural occurrence of fish supporting habitat within the catchment.

2.5.4	Linking organisms to natural and modified river hydromorphology by the analysis of existing data – *SEPA/ UK TAG*	2007	The outputs of this study have significant relevance to the Freshwater Morphology POMS Study. More specifically, the evidence presented and the analyses in support of management tools such as MImAS provides valuable input and information on the viability of decision support tools for regulators. It is expected that classification and regulation tools in RoI will evolve and develop over time as research projects like this further our understanding of the links between freshwater morphology and ecology. The phased deliverables of this project will be closely monitored as the Freshwater Morphology POMS Study progresses.
2.5.5	UK Environmental Standards and Conditions (Phase 2) SR1-2007	2007	The Lakes MImAS approach replaces the ALMS approach originally developed for WFD purposes. A trialling period is the next stage of development. The tool may be trialled in RoI by selecting a specific case study and undertaking fieldwork. The MImAS tool does depend on a database of pressure information. The establishment of such a database would be the first stage of development in RoI.
2.5.5	WFD 49f (Extension to SNIFFER project WFD49a) "Development of a decision making framework for managing alterations to the morphology of lakes" – Draft Final Report	2007	

APPENDIX A

SUMMARY OF DOCUMENTS REVIEWED

Appendix 1

Documents Reviewed – Summaries

Document 2.4.1

Draft Mandate for an Activity on "Water Framework Directive and Hydromorphological Pressures" Phase II: 2007-2009 (CIS, 2009)

Document 2.4.1 outlines the proposals of the Common Implementation Strategy with respect to WFD and Hydromorphological Pressures. The significance of hydromorphology pressures in Member States' Article 5 risk assessments warranted the set up of a CIS activity to address the issues surrounding it. The main aims of the activity are:

- To identify how the conflicts and synergisms between managing hydromorphology in River Basin Districts and the requirements of other policies (e.g. renewable energy, transport and flood management);
- To exchange information on approaches to the assessment and management of significant hydromorphological pressures and impacts so that expertise can be transferred across Member States and approaches can be developed in common;
- To exchange information on approaches and strategies for the protection and/or restoration from hydromorphological deteriorations;
- To identify available knowledge about the link between hydromorphological changes and ecological/biological impacts.

The CIS Activity on Hydromorphological Pressures and WFD is being jointly led by Germany and the UK. A Strategic Steering Group was established to assist. The activity is largely based on the use of workshops as a forum for transferring information instead of the production of several reports. However two key deliverables are:

- A technical document identifying best practice in relation to preventing deterioration, restoring hydromorphological condition and mitigation measures;
- A policy paper making recommendations on the integration of hydropower policy, transport policy and flood management policy with water policy (**Document 2.4.2**).

Document 2.4.2

WFD and Hydro-morphological pressures Policy Paper (CIS, 2007)

Document 2.4.2 entitles WFD and Hydro-morphological pressure Policy Paper is a deliverable of the CIS Activity on Hydromorphological and the WFD. It is recognised that there is the potential for conflict or overlapping of WFD policy and other EU policies, particularly in relation to hydropower, navigation and flood protection. Several policies exist regarding these hydromorphology pressures. The paper outlines the various levels (policy development, planning and programming and project levels) at which integration is needed.

The paper concludes that whilst the WFD may be an ambitious piece of legislation requiring reconsideration in the way users operate, the RBMP's also provide flexibility in terms of setting environmental objectives. In addition, the RBMP's can identify obsolete infrastructure or disconnection of a river's floodplain which can be respectively removed or restored. This approach can be applied in the removal of unused weirs from rivers which restores connectivity in terms of migratory species, for example. This is being investigated within the Freshwater Morphology POMS Study.

Document 2.4.3

A Guidance Standard for Assessing the Hydromorphological Features of Rivers (CEN, 2002)

CEN contributes to the objectives of the European Union and European Economic Area with voluntary technical standards which promote free trade, the safety of workers and consumers, interoperability of networks, environmental protection, exploitation of research and development programmes, and public procurement

In the case of Freshwater Morphology a guidance standard for assessment was developed in 2002 since it was recognised that many European countries historically monitored river "quality" simply in terms of the chemical or pollution status, not its physical condition.

The standard provides guidance on the features to be recorded when characterising and assessing the hydromorphology of rivers. It focuses on the structural features of rivers and on river continuity as opposed to hydrology and underlying geology. The underlying basis of the guidance is the measurement of deviation from reference condition.

Survey requirements are identified as:

- River type
- Dividing Rivers into Reaches
- Survey Strategy
- Scale of surveys and evaluations
- Timing and frequency of field surveys
- Reference conditions

Document 2.4.4

Water Quality – Guidance Standard on Assessing River Quality based on Hydromorphological Features (CEN/TC 230, 2007)

The European Guidance on the assessment of hydromorphological features provided in Document 2.4.3 was progressed under CEN/TC 230 "Water Analysis" to produce a CEN Standard in 2007. It sets out a simple scoring system and suggests suitable sources of information which may contribute to hydromorphological assessments. However the Standard

is not linked directly to the assessments of ecological status made under WFD. Whilst the previous CEN guidance document outlines field assessment protocols, this CEN standard has been developed for assessing the degree of modification of river morphology to assist in more broad scale assessment, land use planning, strategic environmental assessment, river basin management and setting targets for river restoration work.

Document 2.5.1

Using Science to Create a Better Place, Incorporating Climate Change in River Typologies: Results (Environment Agency, 2007)

Lancaster University hosted a Freshwater Morphology in June 2006 to discuss WFD research needs in the UK. The key research gaps identified were:

- The link between hydromorphological conditions and ecology is not well developed.
- The difficulty in establishing a link between hydromorphology and ecology is not fully appreciated.
- The effect of climate change on ecological quality of aquatic ecosystems is not well researched at present.

The report "Using Science to Create Better Place, Incorporating Climate Change in River Typologies: Results has been published since this workshop.

The main aims of the project were to review existing approaches to channel typology which both incorporate climate change and support WFD; develop a typology on a test catchment; describe channel types using this typology and field data; consider the ecological significance of these channel types; apply hydraulic models driven by climate change scenarios and develop an archive of hydromorphological data.

The report recommends that "characterisation of channel reaches based on stream power, slope and floodplain extent is an important first step in characterising hydromorphology for WFD. Development of channel modification databases should be part of this first step because restoring modified channels may be one of the measures used to improve ecological status. Further research is recommended to explore links between physical habitat and biological response using the 11 type typology to underpin other typologies based on water quality.

Document 2.5.2

Linking organisms to natural and modified river hydromorphology by the analysis of existing data (Cardiff University, ongoing)

Cardiff University are undertaking a research project with a primary objective of improving the understanding the links between riverine ecology and hydromorphology, "*Linking organisms to natural and modified river hydromorphology by the analysis of existing data*".

The research project is making use of existing Environment Agency data holdings - River Habitat Survey, water chemistry and biological data - to investigate the role that hydromorphology (as revealed by RHS) plays in the distribution/abundance of different organisms (predominantly invertebrates). When complete, this will enable a detailed investigation into overall links to natural and modified hydromorphology both across England and Wales, and across/within individual catchments.
Cardiff University consider these analyses as a "first step in providing support for existing management, guiding the development of new management tools and helping to inform research strategies. In the medium to longer term, dedicated research aimed at understanding the *mechanisms* linking organisms and hydromorphology is essential for sustainable river management e.g. devising Programmes of Measures".

Document 2.5.3

UK Environmental Standards and Conditions (Phase 1) –Final Report (UK TAG Jan 2007)

The UK Technical Advisory Group (UKTAG) has developed Environmental Standards and conditions to underpin implementation of the WFD. The final draft was published in August 2006 following peer review of the standards proposed for the following elements:

- Water Quality Standards for rivers
- Water Quality Standards for lakes
- Standards for transitional and coastal waters
- Water Resources Standards
- Morphology of Rivers

Environmental Standards are used to assist in a decision making framework when developing Programmes of Measures and in regulation of e.g. engineering activities on rivers. The Standards currently being developed for surface waters fall into three groups:

- **Physico-Chemical** – Numeric values have been developed which have been matched to biology;
- **Hydrological** – Numeric values supported by modelling have been developed, based upon the best available understanding of links to biology; and

- **Morphological** – A decision framework using best available knowledge supported by numeric thresholds

A waterbody must meet all of these Environmental Standards in order to be classified as High Status. It is stated that for now, the procedure will be to use assessment of impacts on morphological features and processes to identify proposals that pose a high risk to ecological status. This approach is to be supported by a decision support framework that was developed in consultation with expert geomorphologists and ecologists.

Document 2.5.4

Definition of the Spatial Scale of Environmental Impact Affecting Status of Waterbodies (Draft) (SEPA, 2006)

With respect to the upscaling of results to waterbody scale, ***"Definition of the Spatial Scale of Environmental Impact Affecting Status of Waterbodies (Draft)"*** was written by SEPA to provide guidance on the spatial component of UK TAG'S Environmental Standards, and to set out criteria for determining when the overall ecological status of a waterbody is threatened. The criteria are based on 2 sets of Environmental Standards:

- Environmental Standards for morphological conditions (as discussed in Literature Review 1, and in this report)
- Environmental Standards for water resources.

In addition consideration is given to:

- the length of river over which the standards are failed;
- the degree of disruption to the migration of fish resulting from any form of manmade impediment to migration.

Document 2.5.5
UK Environmental Standards and Conditions (Phase 2), SR1-2007, June 2007

The development of UK Environmental Standards and Conditions has so far taken place in 2 phases. Phase 1, was published in draft in August 2006, makes recommendations to UK governments and is reviewed in Literature Review 1. The final draft **(Document 2.5.3)** was published in January 2007 and is reviewed in this report. The quality elements covered in Phase 1 were:

- Water Quality Standards for rivers
- Water Quality Standards for lakes
- Standards for transitional and coastal waters
- Water Resources Standards
- Morphology of Rivers

UK TAG expects to update the Phase 1 report in October 2007.

Phase 2 constitutes the UK TAG proposals for an additional and second set of Environmental Standards and Conditions. These are:

- Management approaches for temperature, nutrients, and suspended solids
- Flow in estuaries
- **Lakes Morphology**
- Transitional and Coastal Morphology

Document 2.5.6

WFD 49f (Extension to SNIFFER project WFD49a) "Development of a decision making framework for managing alterations to the morphology of lakes" – Draft Final Report (SNIFFER, 2007).

Document 2.5.5 is an extension to WFD 49a to further develop the ALMS tool using the Morphological Impact Assessment System (MImAS) template that was developed for rivers. The finished product is entitled "Lakes – MImAS". A draft final report is has been published and is currently under review by UK TAG.

The assumptions used in the Lakes –MImAS tool reflect those used in the Rivers -MImAS tool and uses the concept of "capacity to accept morphological change" as the basis for assessment.

The framework is based on the following concepts:

- A waterbody has some capacity to accommodate morphological change without changing its ecological status.
- We can set, by expert judgement, limits for changes in *morphological conditions* beyond which we would be concerned that ecological status would be at risk, where *morphological conditions* refers to the list of attributes in Annex V of the Directive. Because of the co-dependency between geomorphology and hydrology, the tool also sought to capture aspects of *hydrological regime* e.g., the quantity and dynamics of flow, level, residence time, and the resultant connection with groundwater.

This Lakes-MImAS method takes account of the biological and geomorphological sensitivity of different lake types and the extent, nature and impact of existing modifications to estimate how much of the existing capacity has been degraded. This can then be used to assess whether new proposals can be permitted or whether they should be subjected to further investigation, which is how the River-MImAS tool is implemented for regulatory purposes.