NATIONAL DEVELOPMENT PLAN

Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government

western river basin district

Water Framework Directive

Draft River Basin Management Plans

Adapting the Plans to Climate Change Final Report

ESB International

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Draft River Basin Management Plans
Adapting the Plans
to Climate Change

Contents

SUMMARY

A 'climate-check' has been completed of the River Basin Management Plan. The climate-check was achieved by:

- Assessing risk, due to climate change, of not achieving good water status or no-deterioration in water status as a consequence of the identified pressures, such as abstraction.
- Integrating the impacts of climate change when identifying and appraising the Programme of Measures and proposing appropriate adaptation of actions where necessary.
- looking for opportunities in the monitoring programme to improve our understanding of climate change trends.

Considerable effort is underway to improve our understanding of present changes in climate and of likely changes in the future. Notwithstanding the high levels of uncertainty involved, predictions have been made that allow broad ranges of impacts to be considered. Changes in the next twenty to forty years are more readily identified than longer-term changes that depend on many social and political assumptions.

Current predictions for Ireland indicate that climate issues may be relatively significant for measures related to:

- protected areas and high-status sites,
- abstractions, and
- physical modifications to river and marine morphology.

Considerations also arise for point-source discharges and diffuse landuse pressures such as agriculture, forestry and unsewered systems. Sensitivity for dangerous substances pressure is likely to be low.

The study identified that the Programme of Measures can be flexible and adaptable to potential future climate change, in terms of temperature, storm surge, floods and droughts. In fact, many contribute to national adaptation strategies.

The analysis highlights the advantages of an integrated catchment-based approach to water management. It contributes to adaptation strategy and strengthens future science/policy link on climate change and water by identifying research needs, communicating them to the research community and making best use of available research results.

1 INTRODUCTION

River Basin Characterisation Reports were prepared in 2004 and these addressed variations in water-dependent ecosystems throughout rivers, lakes, estuaries and coastal areas and linked them to topography, soils, geology and climate. The link with climate is discussed further in this report.

Climate is changing across the globe. In the past, the water environment has demonstrated its resilience as it responded to changes in climate. Water ecosystems may change during the planned six-year cycles of river basin management; hence this response must be factored into the present River Basin Management Plan, so that actions are consistent and adaptable.

The objective is to integrate the results of recent climate research in Ireland into the risk reduction strategies of the River Basin Management Plan.

The Programme of Measures has been checked for its resilience and flexibility in the context of predicted climate change. Priority is given to win-win situations, that is, measures that are robust and flexible enough to cope with changing climate conditions. Irreversible actions are avoided.

This check takes account of significant uncertainty involved in climate change assessment, uncertainty that arises at many levels, from:

- complex climate models at a global level,
- downscaling to the regional level
- hydrodynamic modelling at river basin district level
- social and political inputs and assumptions made over the forecast period.

Notwithstanding this uncertainty, the efficiency and effectiveness of investment decisions can benefit from this climate-check. The measures are said to be ‘climate checked’ rather than ‘climate-proofed’, because of the level of uncertainty involved. Furthermore, in this first cycle, water body typologies, reference conditions and default objectives (including standards) are based on current climate, as a baseline assessment. This approach is in accordance with recommendations agreed at EU level.

It is not intended to report here on the impact of the Programme of Measures on greenhouse gas emissions and mitigation. These aspects have been addressed during the preparation of the plan; however they are reported separately in the strategic environmental assessment (SEA) report.

Continuous monitoring of resources and procedures will be required to achieve the objectives of this River Basin Management Plan. This will need to take account of additional climate monitoring and research results as they become available.

Subsequent river basin management cycles will address this topic in more detail, including:

- More focussed monitoring,
- Target water body 'type' and ecological status reference conditions for certain water bodies might need to be reconsidered,
- It may be possible to 'climate-proofed' the Programme of Measures, and
- Contributions may be considered that contribute to global mitigation.

Climate issues affect all habitats, all components of the hydrological cycle - precipitation, infiltration, runoff, evaporation, and transpiration, and all components of the marine environment. This must be taken into account when implementing these measures. Examples have been illustrated by Wilby *et al.*, 2006, reproduced here in Table 2.1.

Table 2.1 Potential climate change impacts on ecological status

Parameters	Examples of impacts
Physico-chemical	Changes in water temperature and dissolved oxygen Decreased dilution capacity of receiving waters Increased erosion and diffuse pollution More frequent flushing of combined sewer outflows Photoactivation of toxicants Exceedence of water quality standards
Biological	Changing metabolic rates of organisms Changing ecosystem productivity and biodiversity Climate space of plant and animal distributions Fish migration patterns and dispersal corridors Increased eutrophication and prevalence of algal blooms Changes in aquatic fauna and flora at reference sites Changes in species assemblages in designated areas
Hydro-morphological	Changing river flows and sea levels lead to coastal erosion Indirect impacts from land-use practices and agriculture Hydrological connectivity of slopes, channels, and coastal zones Diffuse and point sources of sediment Long-term bed-load and channel change Geomorphological processes creating dynamic/diverse habitats

Source: Wilby *et al.*, 2006b.

2 CLIMATE CHANGE IN IRELAND

Many investigations have been undertaken on Climate Change in Ireland, most notably by universities and research institutes.

Contributions have been made by a wide range of organisations to three recent reports and these have been chosen as particularly relevant for river basin management under climate change:

1. EPA, Climate Change Research Observational Needs, 28th May 2008
2. EPA, Climate Change Research Adaptation, 17th June 2008
3. Met Eireann / UCD Research Report: "Ireland in a Warmer World", www.c4i.ie/docs/IrelandinaWarmerWorld.pdf , June 2008.

The third of these reports has been funded by EPA, SEI, HEA and undertaken by a consortium 'Cummunity Climate Change for Ireland' (c4i), led by Met Eireann and University College Dublin. Most of the simulation results have been posted on http://www.c4i.ie, where the user can access a wide range of weather parameters and view the expected changes in the coming decades. Here we focus on the main water-related elements, quoting directly from the report.

Temperatures
The climate is warming, particularly in the summer and autumn (1.2-1.4°C in mid century, increasing up to 3.4°C towards the end of the century). The warming is greatest in the south and east of the country.

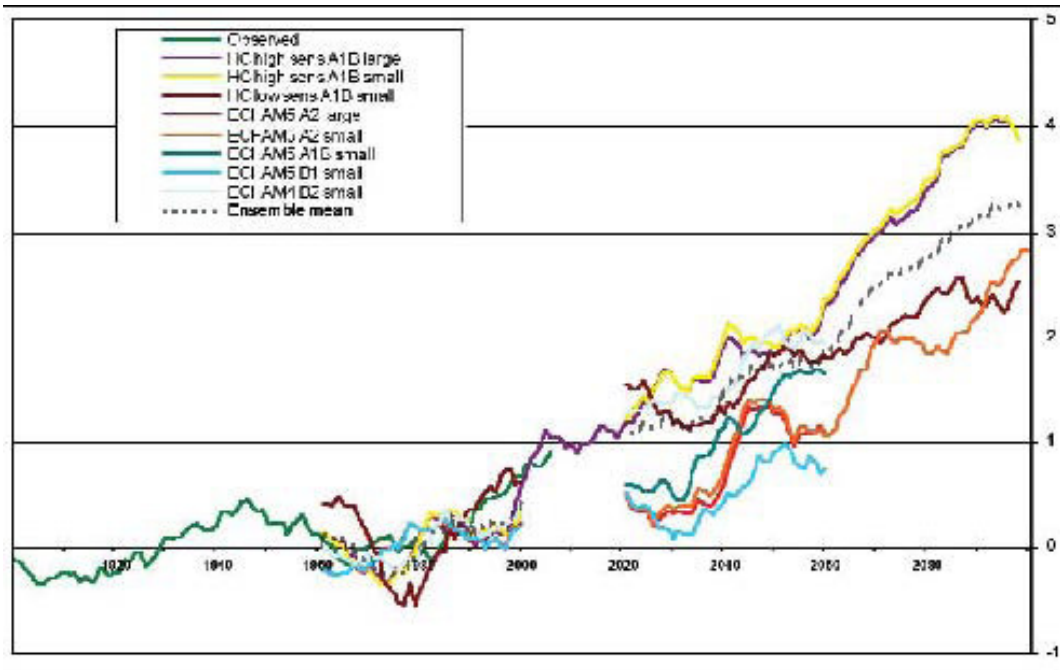

Figure 2-1. Observed and Model Predictions of Temperature (from www.c4i.ie)

Precipitation
Autumn and winter are becoming wetter: 5-10% increase in mid century, increasing 15-25% towards the end of the century. Summers are drier: 5-10% decrease for 2021-2060; 10-18% decrease towards the end of the century.

Wind speeds
The ensemble set shows slight increases in winter wind speeds (1-2%) and decreases in summer (2-3%) for 2021-2060. However, towards the end of the century there is an overall decline in speeds, particularly in summer (4-5%).

The latter is consistent with the predicted movement of storm tracks towards polar areas (IPCC, 2007); fewer storms may affect Ireland, although the influence of rising sea surface temperatures is likely to lead to more extreme storms.

It should be noted that the Irish observational records indicate that average annual wind speeds decreased in the 1990s, with this trend continuing in the early years of the 21st century.

Sunshine/cloudiness
No significant trends. However, these elements are particularly difficult to model.

Relative humidity
No significant trends.

Weather extremes
Modelling the sensitivity of the climate system to Atlantic sea surface temperatures suggests that there will be an increase in the frequency of the very intense cyclones with maximum wind speeds of more than 30 m/s; and
increases in the extreme values of wind and precipitation associated with the cyclones. This will translate into an increased risk of storm damage and flooding.

The consensus among different modelling approaches is that extreme rainfall events are likely to increase in frequency in autumn and winter. However, there is still considerable uncertainty in these projections and further research is required.

Sea temperatures
Sea temperature and sea level around Irish coastlines have been rising slowly in recent decades. Since the 1980s satellite and in situ observations show a general warming trend of 0.3-0.4°C per decade in Irish waters, mirroring temperature trends over land. However, over the Irish Sea the satellite measurements suggest a more rapid warming rate (0.6-0.7°C per decade). The trends are consistent with what has been observed globally and are predicted to continue over the coming decades with possibly large impacts on marine ecology.

Sea level rise
Rising sea levels in recent decades are primarily linked to the warming of the oceans and resulting thermal expansion of seawater, and the influx of water from melting land ice. Satellite measurements show that sea levels are rising on average about 3.5 cm per decade around Ireland, well in excess of the ongoing isostatic adjustment of the land. This sustained trend would lead to sea level rises that are consistent with the IPCC (2007) global projections for the end of the century, although these estimates are probably conservative as they do not include current uncertainties in ice
flow processes (melting glaciers, etc.).

Storm surges and waves
Ocean modelling results indicate an increase in the frequency of storm surge events around Irish coastal areas. There is also a significant increase in the height of extreme surges (in excess of 1 m) along the west coasts, with most of the extreme surges occurring in wintertime. The impacts on wave heights are seasonally dependent: there is some evidence of significant increases (up to 30 cm) in some months. Extreme wave heights (e.g. the 10-year return values) also show an increase - up to 10% around the northwest coast.

River catchment flooding
Modelling results suggest an amplification of the seasonal cycle across the country, with increased winter precipitation leading to a rise in winter stream flow (~10%), and the combination of increased temperature and decreased precipitation causing a reduction in summer stream flow (~30%). Change to the seasonal cycle will have an impact on water supply management and design. Increased winter flows, coupled with the predicted increase in extreme precipitation events lead to an elevated risk of flooding. This is particularly significant in the southwest of the country, and those catchments with fast response times. The decrease in summer stream flow will impact on water availability, water quality, fisheries and recreational water use.

Biodiversity and water dependent habitats and species
In terms of protected areas for water dependent habitats and species, and biodiversity in the wider national context, climate change, including changes in precipitation patterns, may result in significant changes and losses. Changes in species composition are predicted for many habitats, arising from a combination of temperature increase, changes in nutrient cycles and productivity, and soil moisture. These will lead to changes in the competitiveness of different plant species in salt marsh, semi-natural grasslands, woodlands, heath and peatland habitats. Some species may be vulnerable to range reduction or even extinction in Ireland in the longer term, for example alpine flora. New species of fauna are already being documented as ranges extend northwards from continental Europe, for example the little egret and Mediterranean gull (birds), and butterfly and dragonfly species.

Climate change induced drying of heaths and peatlands are likely to increase fire risk. Drying also increases the possibility of wind erosion, particularly on degraded sites, while extreme rainfall events also increase erosion risk and suspended solids loadings to downstream watercourses.

Habitats Directive Annex 1

With regard to Habitats Directive Annex 1 listed water dependent habitats, coastal transitional (saltmarsh habitats, coastal lagoons) and coastal onshore habitats (shingle banks, sand dunes and machair) are vulnerable to rising sea levels and coastal erosion, and to associated alterations in coastal geomorphological processes. Dune slack and machair wetlands may become more vulnerable to summer drought, particularly when abstractions are present. Saline intrusion may increase both from sea level rise and through abstraction pressures.

Peatland habitats (bogs and fens) are all highly susceptible as an increase in temperature and summer drying is likely to prove detrimental. A small lowering of the water table within these habitats will impact on vegetation structure and composition. More serious impacts arise when groundwater levels are impacted by existing pressures including abstraction and arterial drainage. For example, there is a direct groundwater contribution to the lagg (bog margin) portion of raised bogs, and the bog in general is supported by groundwater, so that if groundwater level is reduced under the bog, precipitation derived bog water will seep out of the bottom of the bog. Flush and poor fen habitats associated with blanket bog are also vulnerable to summer drought impacts on rainfall and groundwater levels, exacerbated by abstractions.

Wet heath also occurs in association with blanket bog, and may be replaced by dry heath or acid grassland with increasing climate change impacts. Both wet and dry heath may migrate upslope, potentially displacing montane heath species/habitat which is regarded as very vulnerable to climate change, and is at the lower altitude/southern edge of its distributional range in Ireland.

Cladium fen, alkaline fen, and petrifying springs with tufa formation are directly groundwater dependent, and existing pressures will be exacerbated by climate change impacts. Turloughs may be more robust, but susceptibility to climate change impacts may vary between sites and in relation to existing pressures.

Habitats Directive Annex 2

Habitats Directive Annex 2 listed species associated with dune slack, fen, bog and petrifying spring habitats are vulnerable to increased hydrological pressures associated with climate change, animal species such as the Annex 2 listed *Vertigo* species may be particularly vulnerable. Fresh water pearl mussel species *Margaritifera* populations in rivers may be more vulnerable to erosion and sedimentation pressures arising from extreme rainfall events.

Birds Directive SPAs

With regard to Special Protection Areas designated under the Birds Directive, rising sea levels may reduce the extent of intertidal and saltmarsh habitat availability for wintering waterfowl. Low islands and shingle banks used as nesting habitat by seabirds, particularly terns, are also vulnerable to rising sea levels and storm surges.

Summary of adaptation Issues

In Ireland, climate change is likely to result in increased competition for water resources during the summer months. Irrigation is likely to become necessary for some agricultural practices. Irrigation both increases competition for available resources as well as increasing the risk to water quality. Projected reductions in soil moisture will also have implications for agricultural practices.

Increased winter and spring precipitation as well as more frequent wetting and drying may affect the nutrient status of many soils. Reductions in groundwater levels are projected to occur. These will have significant implications for groundwater supplies. Therefore private wells and septic tanks are likely to become less viable. Pressures on groundwater dependent habitats and species are likely to increase.

The economy of Ireland is largely service-driven. Nevertheless, industrial activities that rely on a substantial supply of water may come under increasing pressures, for example the concrete industry. Likewise, many of the major cities and regional towns have developed along rivers, where increases in flooding are likely to cause significant damage to property and infrastructure. For coastal areas, sea level rise is likely to compound this problem.

3 PRESSURES, MEASURES AND CLIMATE CHANGE

The River Basin Plans consider risks of achieving objectives due to a wide range of pressures. The main measures identified are:

- Basic measures required by existing directives
- Other basic measures required by the Water Framework Directive
- Supplementary measures

Each of these pressures, associated measures and their significance in the context of climate change are assessed in turn in the next section.

The analysis is summarised here. As the climate changes, qualitative assessments can be made at this stage of the knock-on effect on the pressures and measures. The severity of this effect is difficult to state at present state of knowledge, but an attempt has been made in Table 3-1 below.

Table 3.1 Relative Severity of Climate Change on Pressures

Pressure	Relative severity of climate change
Protected Areas and High Status Sites	**Very High**
Unsewered Properties	**Medium**
Agriculture	**High**
Forestry	**High**
Point Source Discharges	**Medium**
Sources from Landfills, Quarries, Mines & Contaminated Lands	**Medium**
Dangerous substances	**Low**
Physical Modifications	**Very High**
Abstraction	**Very High**
Urban	**Medium**
Local Issues	**Low**

Certain measures have been categorised as win-win, no-regrets, regrets, and adaptation actions.

Win-Win Solutions are robust measures in the context of climate change. For example, some ecological improvements can increase water retention capacity of soil and help against increased flood risk.

Table 3.2 Win-Win Solutions

Measure	Contribution to adaptation to climate change
Altered abstraction timing	Protection of biodiversity
Create buffers around water bodies	Improved soil and subsoil water retention, reduced flood risk
Connection of unsewered wastewater discharges to municipal system in selected areas where assimilative capacity is available during low flow	Reduced spatial risk during severe droughts
Water conservation measures	Adaptation to droughts

No-Regret Solutions are measures that are robust and flexible enough to be viable under different climatic scenarios and thus will not be affected later by climate change. Measures to reduce diffuse nutrient pollution are examples.

Table 3.3 No-Regret Solutions

Measure	Benefit of measure under changing climate
Upgrade wastewater treatment	Robust
Buffer zones of agricultural land	Robust

Regret Solutions are measures that bear a high risk of being counter-productive regarding adaptation to climate change, because climate change reduces effectiveness, increases costs, reduces adaptive capacity of other sectors or ecosystems, etc.

Table 3.4 Regret Solutions

Measure	Potential problems under changing climate
Abandon existing forest crops in unsuitable areas	Unmanaged landscape - drainage issues, soil erosion, soil pH, invasive species
Siting critical infrastructure in floodplains	Continuity of supply

Adaptation solutions are measures specifically for adaptation to climate change.

Table 3.5 Adaptation Solutions

Measure	Contribution to adaptation to climate change
Sustainable Urban Drainage Systems	Integration of flood risk management into River Basin Management Plans
Water storage	Enhance environmental flows

The majority of the actions proposed within this draft River Basin Management Plan are identified as no regrets approaches.

Three areas that require particular attention are

- protected areas and high status sites,
- abstractions and
- physical modifications.

Monitoring systems in support of climate change are in line with those systems stated in the Water Framework Directive Monitoring Programme. Additional monitoring of evaporation, evapotranspiration and sedimentation in rivers would assist in climate assessment.

4 ASSESSMENT OF MEASURES

4.1 Basic Measures Required under Existing Directives

Table 4.1 Basic Measures Required under Existing Directives

Basic Measures under Existing Directives	Potential Climate Adaptation
The Bathing Water Directive (2006/7/EC)	
Undertake comprehensive monitoring programmes, identify pollution sources and draw up management plans to minimise risks to bathers.	Actions should allow for sea level rise and increasing storm surge, including potential washout of pollutants in coastal areas.
The Birds Directive (79/409/EEC)	
A major review of the SPA network is in progress, update Register of Protected Areas as changes are notified. On-going monitoring of bird species to inform conservation measures for Natura 2000 sites in management plans. Avoid adverse impacts in forward planning.	Actions may be required to replace habitat lost through sea level rise or increased flooding
The Drinking Water Directive (80/778/EEC) as amended by Directive (98/83/EC)	
Prepare Water Services Strategic Plans.	Plans should allow for reduced summer low flows and for increasing flood flows in source contribution zones.
The Major Accidents (Seveso) Directive (96/82/EC)	
Organise a system of inspections or other suitable control measures for relevant establishments. Internal and external emergency plans must be prepared by operators and by a nominated local competent authority.	Plans should allow for increasing temperatures.
The Environmental Impact Assessment Directive (85/337/EEC)	
Take account of the Water Framework Directive in regional planning guidelines, county development plans and local area plans during their review process to ensure that new projects will consider river basin management objectives.	Projects should assess impacts in the context of climate change.
The Sewage Sludge Directive (86/278/EEC)	
Prepare Sludge Management Plans in line with Code of Good Practice for the Use of Biosolids in Agriculture, maintain a register of sludge/biosolids movement and provide advance notification of spreading in accordance with a nutrient management plan.	Plans should consider potential climate change adaptation issues such as increasing temperature and rainstorms.

Basic Measures under Existing Directives	Potential Climate Adaptation
The Urban Waste-water Treatment Directive (91/271/EEC)	
Undertake monitoring at treatment plants and make provision for pre-treatment requirements for industrial wastewater entering the collection systems and treatment plants. Prepare Water Services Strategic Plans.	Consider potential for reduced assimilative capacity in rivers in summer and for changing estuarine flows.
The Plant Protection Products Directive (91/414/EEC)	
Authorise substances for use or marketing subject to rigid controls	None
The Nitrates Directive (91/676/EEC)	
Carry out monitoring surveys of water quality and agricultural practices, including studies of agricultural mini-catchments. Identify waters which are polluted or are liable to pollution and development and implement action programmes.	Actions should allow for potential washout of pollutants to surface waters during increasing rainstorms and for changes in groundwater contribution to surface waters.
The Integrated Pollution Prevention Control Directive (96/61/EC)	
Ensure operators of certain industrial installations must obtain an IPPC permit.	None
The Habitats Directive (92/43/EEC)	
Continued survey and monitoring to confirm location, conservation status and water status requirements of Annex listed habitats and species. Establish protect/restore measures in sub-basin plans with environmental quality standards appropriate to the most sensitive habitat or species receptor. Review and resolve unfavourable conservation status issues arising from abstractions and drainage pressures. Develop and implement management measures and codes of practice; monitor, audit, and adjust management and measures for individual Natura 2000 sites if necessary to achieve and maintain favourable conservation status. Update Register of Protected Areas, and implement administrative and database measures. Avoid adverse impacts in forward planning.	Monitor changes in hydrological pressures and review and adjust abstractions and other pressures which reduce groundwater levels in protected areas for groundwater dependent and/or supported habitats and species. Actions to reduce erosion and sedimentation pressures should be able to meet increased risk of extreme events. Consider potential for habitat creation in managed retreat from rising sea level

4.2 Other Basic Measures

Table 4.2 Other Basic Measures

Other Basic Measures	Potential Climate Adaptation
Cost recovery for water use and promotion of efficient and sustainable water use	
Member States must adopt a cost recovery system to ensure that water pricing polices act as incentives towards efficient water usage. The WFD also requires measures to promote efficient and sustainable water use.	Increasing efficiency of use of water will be a priority in the context of reducing river low flows in summer, supported by metering, leakage control and potential water harvesting.
Protection of drinking water sources	
Protect all ground and surface waters that are used, or may be used in the future, as a source of drinking water for more than 50 people, or where the rate of abstraction is above $10m^3$ per day.	Plans should allow for reduced summer low flows and for increasing flood flows in source contribution zones.
Abstraction and impoundment control	
Member States must have controls for significant surface water and groundwater abstractions and surface water impoundments.	Controls should allow for reduced summer low flows and for increased temperatures. Instream impoundments will need to allow for increasing flood flows.
Point source and diffuse source discharges control	
Prior regulation is required for point source discharges liable to cause pollution. For diffuse sources of pollution, measures to prevent or control pollutant input are also required. Controls may include: prohibition on the entry of pollutants into water; prior authorisation; or registration based on general binding rules, laying down pollutant emission controls.	Point source emission limits should allow for changes in temperature.
Controls on physical modifications to surface waters	
Member States must ensure that the physical condition of surface waters support required ecological standards. Controls can take the form of prior authorisation and/or registration based on general binding rules.	Authorisation system should require that modifications are adaptable to climate change.
Prevention or reduction of the impact of accidental pollution incidents	
Measures must be in place to prevent significant losses of pollutants from technical installations, and to prevent and/or to reduce the impact of accidental pollution incidents. These measures include systems to detect or give warning of events and in the case of accidents include all appropriate measures to reduce the risk to aquatic ecosystems.	Plans should allow for increasing temperatures and increasing rainstorms and flooding.

Other Basic Measures	Potential Climate Adaptation
Authorisation of discharges to groundwater	
Prior authorisation is required for reinjection of waters for a number of specific activities (such as dewatering for mining or construction, exploration for oils and injection for storage of gas). Construction or civil engineering works, which could influence the water table, also require authorisation and general binding rules.	Authorisation should allow for reduced summer low flows and for increasing flood flows. The range of water table levels may increase in the context of increased winter rainfall and reduced summer rainfall.
Priority substances control	
Measures are required to eliminate pollution of surface waters by 33 priority substances and 8 other pollutants and must aim to progressively reduce pollution from priority substances and cease or phase out emissions, discharges and losses of priority hazardous substances.	None
Controls on other activities impacting on water status	
Measures must be put in place to deal with any other identified significant adverse impacts on water status. Controls can include prior authorisation or registration based on general binding rules.	None

4.3 Supplementary Measures

Table 4.3 High Status Sites

Supplementary Measures	Potential Climate Adaptation
High Status Sites	
Review sites for habitats and species which are at favourable conservation status under the Habitats Directive, and which are not covered by a conservation designation currently; apply an appropriate conservation designation under EU and/or national legislation	Adaptation of measures relating to high-status sites and protected areas for water dependent habitats and species under the Habitats and Birds Directives will need to address: • Reduced habitat fragmentation and protect and restore areas of floodplains and wetlands • Changes to ground and surface water flow regime • Changes to erosion and sedimentation pressures • Changes to diffuse and point source nutrient loadings • Avoidance of adverse impacts in forward planning. Similar measures are likely where status is downgraded due to Freshwater Pearl Mussel, or other water dependent habitats and species, being at unfavourable conservation status under the Habitats Directive. Sub-basin plans should be adaptable to allow for climate change induced changes in pressures
Ensure that all water bodies under consideration for listing as High Status Sites under the Water Framework Directive are at favourable conservation status for any Habitats Directive Annex 1 water dependent habitats and/or Annex 2 species known to be associated with them	
Identify water bodies at high status, water bodies with WFD objective of restoring to high status catchment areas of monitoring sites at high status ((Q5 and Q4.5) in Regional, County and Local Development Plans	
Ensure that the appropriate high environmental quality standards are applied to all water bodies that would qualify for High Status under the Water Framework Directive, but where status has been down-graded to Moderate because an Annex 1 water dependent habitat or Annex 2 water dependent species is not at favourable conservation status under the Habitats Directive	
Ensure that the appropriate high environmental quality standards, as set out in the Draft Environmental Quality Objectives Regulations are applied to all high status water bodies and catchment areas of high status monitoring sites (Biological Quality rating Q4 and Q4.5)	
Prohibit point and diffuse source discharges liable to cause water pollution except where such discharges are subject to prior authorisation or general binding rules. Discharge authorisations must lay down emission limits that aim to achieve the environmental objectives/quality standards specified in the draft regulations	

Table 4.4 Unsewered Properties

Supplementary Measures	Potential Climate Adaptation
Unsewered Properties	
Amend Building Regulations - Code of Practice for single houses - Code of Practice for large systems - Certification of unsewered and percolation areas	Increasing rainstorm intensities may lead to washout of effluent to surface waters in poor soil conditions, while in highly permeable soils, the washout occurs to groundwater. Unsewered proprietary systems may need to account for increasing temperature.
Assess applications for new unsewered systems by applying risk mapping/decision support systems and codes of practice and require notice to planning authority immediately prior to construction	
Establish (a) certified expert panels for site investigation and certification of installed systems, (b) a second panel of hydrogeologists for clusters and large systems and (c) a national group for coordination of consistent approach in emerging and innovative technologies. Establish installation and maintenance training by FAS.	
Carry out an inspection programme in prioritised locations for existing systems and record results in an action tracking system	
Enforce requirements for de-sludging and implementation of codes of practice	
Consider connection to municipal systems	
Establish education and awareness programme on outline design, operation and maintenance of systems.	

Table 4.5 Agriculture

Supplementary Measures	Potential Climate Adaptation
Agriculture	
Creation of buffer strips around water bodies to prevent pollutant loss	Programmes must allow for increased contamination from nutrients during less frequent but intense rainfall events. Prolonged growing seasons may result in increased use of fertilisers. However this should be compensated by increased uptake by plants. The impact of nutrients from eutrophication may be worsened due to enhanced algal growth as a result of increased sunlight and water temperatures. This may be offset to some extent by increased functioning of microbes and increased denitrification within rivers.
Installation of fencing to prevent livestock access to watercourses	
Reduction of agricultural intensity, e.g. lower stocking density on land, land reclamation	
Require nutrient management planning	
Set aside of agricultural lands	
Increase participation in rural environmental protection schemes	
Upgrade farm management systems	
Removal by tanker in areas of nutrient surplus	
Treatment by digestors in areas of nutrient surplus	

Table 4.6 Forestry

Supplementary Measures	Potential Climate Adaptation
Forestry	
Implement management controls as they become available, e.g. new or improved guidance, new or revised legislation or regulations, codes of practice, ensuring regulations and guidance are cross referenced and revised to incorporate proposed measures	Climate change may lead to changing species of forestry in Ireland. Reduced rainfall and reduced river low flows in summer may lead to higher nutrient concentrations. Prolonged growing seasons may result in increased use of fertilisers. However this should be compensated by increased uptake by plants. The impact of nutrients from eutrophication may be worsened due to enhanced algal growth as a result of increased sunlight and water temperatures. This may be offset to some extent by increased functioning of microbes and increased denitrification within rivers. Acidification measures will limit the extent of acid washout during increased rainstorms.
Acidification - Avoid or limit (to below critical thresholds) afforestation on 1st and 2nd order stream catchments in acid sensitive catchments	
Acidification - Restructure existing forests to include open space and structural diversity through age classes and species mix, including broadleaves	
Acidification - Revise the Acidification Protocol to ensure actual minimum alkalinities are detected (that is ensure sampling under high flow conditions) and revise boundary conditions for afforestation in acid sensitive areas.	
Eutrophication and Sedimentation - Avoid or limit forest cover on peat sites	
Eutrophication and Sedimentation -Change the tree species mix (for example broadleaves) on replanting	
Eutrophication and Sedimentation - Limiting felling coup size	
Eutrophication and Sedimentation - Establish new forest structures on older plantation sites (including riparian zones, drainage layouts, species mix, open areas)	
Hydromorphology - Audit existing drainage networks in forest catchments	
Pesticide Use - Maintain registers of pesticide use	
Pesticide Use - Reduce pesticide usage	
Pesticide Use - Pre-dip trees in nurseries prior to planting out	
Acidification - Mitigate acid impacts symptomatically using basic material (e.g. limestone or sand liming)	
Acidification - Manage catchment drainage to increase residence times and soil wetting, including no drainage installation in some areas	
Acidification - Implement measures to increase stream production – for example with native woodland in riparian zones.	

Supplementary Measures	Potential Climate Adaptation
Forestry	
Eutrophication and Sedimentation - Establish riparian zone management prior to clearfelling	As above
Eutrophication and Sedimentation - Enhance sediment control	
Hydromorphology - Enhance drainage network management – minimise drainage in peat soils	
Pesticide Use - Develop biological control methods	

Table 4.7 Point Sources from Municipal Wastewater

Supplementary Measures	Potential Climate Adaptation
Point Sources from Municipal Wastewater	
Measures intended to reduce loading to the treatment plant: - Limit or cease the direct importation of polluting matter (e.g. liquid wastes, landfill leachate) - Investigate extent of use and impact of under-sink food waste disintegrators and take appropriate actions - Investigate fats/oils/grease influent concentrations and take actions to reduce FOG entering the collection system	Decrease in assimilative capacity is the main issue to be addressed. Increased storm events, especially in summer, could give more frequent incidences of combined sewer overflows discharging highly polluted waters into receiving water bodies, as well as rising sea levels affecting combined sewage outfalls. Higher temperatures can improve the effectiveness of treatment in sewage treatment.
Impose development controls where there is, or is likely to be in the future, insufficient capacity at treatment plants	
Initiate investigations into characteristics of treated wastewater for parameters not presently required to be monitored under the urban wastewater treatment directive	
Initiate research to verify risk assessment results and determine the impact of the discharge	
Use decision-making tools in point source discharge management	
Install secondary treatment at plants where this level of treatment is not required under the urban wastewater treatment directive	
Apply a higher standard of treatment (stricter emission controls) where necessary	
Upgrade the plant to remove specific substances known to impact on water quality status	
Relocate the point of discharge	

Table 4.8 Point Sources from Industry and Businesses

Supplementary Measures	Potential Climate Adaptation
Point Sources from Industry and Businesses	
Introduce Best Available Techniques (BAT) for industrial discharges	Decrease in assimilative capacity is the main issue to be addressed. Increased storm events, especially in summer, could give more frequent discharges of highly polluted waters into receiving water bodies. Higher temperatures can improve the effectiveness of treatment.
Relocate discharge point	

Table 4.9 Sources from Landfills, Quarries, Mines & Contaminated Lands

Supplementary Measures	Potential Climate Adaptation
Sources from Landfills, Quarries, Mines & Contaminated Lands	
Undertake remediation projects for prioritised landfills, quarries, mines and contaminated lands, e.g. pollution containment measures and monitoring requirements	Decrease in assimilative capacity is the main issue to be addressed. Increased storm events, especially in summer, could give more frequent discharges of highly polluted waters into receiving water bodies. Plans must allow for changes in surface water and groundwater regimes. Bypass flowpaths may develop during extreme events.

Table 4.10 Dangerous Substances

Supplementary Measures	Potential Climate Adaptation
Dangerous Substances	
Review of wastewater and industrial licences	Available dilution may decrease as a result of reduced precipitation and reduced summer flows, and chemical spikes may occur which could exceed set limits. Better storage and handling of toxic substances in industrial and commercial pressures reduce the risk of wash-in during high rainfall or flooding events.
Reduction of pollution by control of point sources through use of pollution reduction programmes	
Reduce discharges, losses and emissions from diffuse sources	
Relocate discharge point	

Table 4.11 Physical Modifications

Supplementary Measures	Potential Climate Adaptation
Physical Modifications	
Implement management controls as they become available, e.g. new or improved guidance, new or revised legislation or regulations, codes of practice These could include a code of practice for morphology	In addition to the 'soft' flood management systems that are planned under 'Catchment Flood Risk Management Plans', certain physical modifications may be required in order to manage extreme events, rising sea levels and storm surges. This could threaten achieving not only good status but also good potential in water bodies designated as heavily modified water bodies. Reduced available water resources in summer may result in measures to maintain compensation flows. This can contribute to fish migration within systems particularly around or across barriers such as weirs. This pressure is significant. Water capture during peak flows of extreme rainfall events, and off-channel storage (minimising hydrological change and introduction of barriers in existing channels) may become viable tools in reducing flood hazard and increasing storage infrastructure. Certain actions represent a win-win situation. For instance, OPW and Fisheries Board's River Enhancement Programmes improves river restoration and habitat conditions such that the biology is better able to cope and migrate with changing climatic conditions.
Support voluntary initiatives, such as wetlands and Integrated Coastal Zone Management schemes	
Channelisation investigation	
Chanelisation impact remediation schemes	
Over-grazing remediation	
Impassable barriers investigation	
Introduce impassable barriers remediation schemes	

Table 4.12 Abstractions

Supplementary Measures	Potential Climate Adaptation
Abstractions	
Modernisation of statutes and regulatory practices, e.g. assigning responsibility for compiling and maintaining a comprehensive, national register of abstractions	This pressure will be significantly affected as a result of rising temperatures and reduced low flows in summer. Agricultural irrigation use, for example, will increase and at the same time population increases are concentrated in certain areas. Available resources in the summer months will reduce, leading to difficulties for compensation flows and for fish migration. Therefore there is a potential significant increase in risk of not achieving Water Framework Directive objectives under this pressure - protected areas (particularly drinking water, and protected areas for water dependent habitats and species), status, no deterioration and groundwater level objectives. The proposed licensing action can be adapted in the future so that it will be capable of managing any increased risk from climate change. However, it may be worth considering at this time the need for additional storage infrastructure to compensate for seasonal impacts of climate change on river flows.
Support water conservation measures, e.g. rainwater harvesting schemes, awareness campaigns, introduce best practice guidance	
Address data limitations and additional monitoring needs, e.g. improve abstractions register, improve discharge register, validate and develop HSCs, improve hydrometric data, collect bathymetry data for lakes	
Examine compensation flow requirements on regulated rives and maintain minimum flow or flow variability, where applicable	
Develop water budgets	
Reduce abstraction demand, e.g. reduce leakage and unaccounted water, modify plumbing codes to support conservation, daily metering of abstracted volumes, implement small schemes with smaller demand	
Increase available water, e.g. promote infiltration of runoff, reuse of grey water or treated wastewater, identify and build infrastructure for alternate sources	
Water metering and charging programmes for residential users	
Reduce abstraction volumes	
Altered abstraction timing	
Conjunctive use	
Provision of additional storage	
Restrict development if abstraction already at capacity	

Table 4.13 Urban

Supplementary Measures	Potential Climate Adaptation
Urban	
Prepare urban asset management plans, which should include surveys, mapping, and research; codes of best practice or legislation; groundwater quality monitoring; improved infrastructure; and planning	The potential impacts on urban water quality will be largely driven by changes in short duration rainfall intensity overwhelming drainage systems. Plans must allow for changes in surface water and groundwater regimes.

Table 4.14 Supplementary Measures for Local Issues

Supplementary Measures	Potential Climate Adaptation
Aquaculture Propose national standards Develop Shellfish Management Plans Designate additional sites	Account for rising sea levels and increased storm surge.
Peat extraction Enforce licensing controls Implement rehabilitation plans	Allow for changes in winter and summer rainfall.
Cruising and boating Enforce pump out controls Enforce speed restrictions	Potential increase in sedimentation during high flows
Shared waters Increased transboundary coordination	

5 INTERACTION OF CLIMATE CHANGE AND MEASURES

Management action to address one pressure may increase the risk of not achieving Water Framework Directive objectives for another pressure. Climate change may increase this risk further.

For example, removing weirs to remove obstacles to the movement of native flora and fauna may increase the risk of allowing the spread of invasive species where the suitable habitat of these invasives is broadened because of climate change. A second example is that managed coastal retreat may reduce the risk from morphological pressures but increase the risk of saline intrusion, particularly where lower groundwater and surface water levels and flows are reduced as a consequence of climate change.

Because many of these risks are higher because of climate change the interaction of climate change and management action for different pressures needs to be considered. This highlights the need for integrated catchment thinking when managing different pressures under the Water Framework Directive.

The challenge will be to incorporate measures to cope with climate change as part of its implementation, starting with the first planning cycle for 2009. In particular, economic instruments and the user pays principle should be applied across all sectors, including households, transport, energy, agriculture, and tourism. This will provide strong incentives to reduce water consumption and increase efficiency of use.

The EU has prepared a communication on Water Scarcity and Droughts which is closely linked to climate change and adaptation. This should be applied in Ireland to link climate change with sustainable demand management and with water ecosystem protection. Applying efficient pricing policies, making water-saving a priority and improving efficiency in all sectors are already essential elements of the EU's approach.

Likewise, the link with assessment and management of floods will focus on prevention, protection and preparedness. Soft non-structural measures should be prioritised, i.e. using natural processes to the maximum to reduce flood risks e.g. working with wetlands, maximising retention capacities at source, sustainable land use and spatial planning limiting exposure and vulnerability. This will mitigate anthropogenic impacts including ecosystem protection. However, hard structural flood defences will continue to be important to cope with extreme flooding.

The marine aspects of climate change will affect transitional and coastal water ecosystems and morphology measures need to consider rising sea levels and increased storm surge.

References

Climate change literature review, 2007. North South Shared Water Resource Project, RPS Consulting

Department of Communications Marine and Natural Resources. 2007. Bioenergy action plan for Ireland.

Department of Environment Heritage and Local Government. 2000. National Climate Change Strategy.

Department of Environment Heritage and Local Government. 2002. Implementation of the National Climate Change Strategy. Progress Report. www.environ.ie

Department of Environment Heritage and Local Government. 2006. Ireland's Pathway to Kyoto compliance. Review of the National Climate Change Strategy.

Department of Environment, Heritage and Local Government. 2007. Ireland – National Climate Change Strategy 2007-2012.

Dunne, S., Lynch, P., McGrath, R., Semmler, T., Wang, S., Hanafin, J. and P. Nolan, 2008: The impacts of climate change on hydrology in Ireland. *Journal of Hydrology*, DOI:10.1016/j.hydrol.2008.03.025

Elsaesser, B., Bell, A.K., and Glasgow, G. RPS Consulting Engineers. 2006. Climate change scenarios and impact on catchment rainfall runoff response. In: Water Resources in Ireland and Climate Change. National Hydrology Seminar 2006.

Environment and Heritage Service. 2004. Climate change indicators for Northern Ireland.

European Environment Agency. 2006. Greenhouse gas emission trends and projections in Europe 2006. EEA, Copenhagen.

European Environment Agency. 2007. Climate Change and water adaptation issues. EEA Technical report, No. 2. EEA, Copenhagen.

Intergovernmental Panel on Climate Change. 2000. Special Report on Emission Scenarios. (www.ipcc.ch)

Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: The Physical Science Basis. Summary for Policymakers. IPCC WGI Fourth Assessment Report. (www.ipcc.ch)

Ireland in a Warming World, c4i consortium, June 2008. Met Eireann.

McElwain, L., and Sweeney, J. 2006. Implications of the EU Climate Protection Target for Ireland. Environmental Protection Agency, Wexford, Ireland.

McGrath, R., Gleixner, S., and Semmler T., Met Éireann. Climate Change at Local Level: Coping with Uncertainty. National Hydrology Seminar 2008. www.opw.ie/hydrology.

Murphy, C., and Charlton, R. ICARUS, NUI Maynooth. 2006. The impact of climate change on catchment hydrology and water resources for selected catchments in Ireland. In: Water Resources in Ireland and Climate Change. National Hydrology Seminar 2006.

Salway, A.G., Murrells, T.P., Milne, R., and Hidri, S. Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 – 2000. Department of the Environment, Food and Rural Affairs.

Semmler, T., Wang, S., McGrath, R., and Nolan, P. Met Éireann. 2006. Regional climate ensemble simulations for Ireland: impact of climate change on river flooding. In: Water Resources in Ireland and Climate Change. National Hydrology Seminar 2006.

SNIFFER. 2002. Implications of Climate Change for Northern Ireland: Informing Strategy Development.

SNIFFER. 2007. Preparing for a changing climate in Northern Ireland.

Sweeney, J., Brereton, T., Byrne, C., Charlton, R., Emblow, C., Fealy, R., Holden, N., Jones, M., Donnelly, A., Moore, S., Purser, P., Byrne, K., Farrell, E., Mayes, E., Minchin, D., Wilson, J., and Wilson, J. 2000. Climate Change: Scenarios and Impacts for Ireland (2000-LS-5.2.1-M1). Environmental Protection Agency, Wexford, Ireland.

Sweeney, J., Donnelly, A., McElwain, L., and Jones, M. 2002. Climate Change Indicators for Ireland (2000-LS-5.2.2-M1). Final Report. Environmental Protection Agency, Wexford, Ireland.

Sweeney, J., and Fealy, R. ICARUS, NUI Maynooth. 2006. Downscaling global climate models for Ireland: Providing future climate scenarios. In: Water Resources in Ireland and Climate Change. National Hydrology Seminar 2006.

UNFCCC. 2006. GHG Data 2006. Highlights from Greenhouse Gas (GHG) Emissions Data for 1990-2004 for Annex I Parties. (www.unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/ghg_booklet_06.pdf)

Wilby, R.L., Orr, H.G., Hedger, M., Forrow, D. and Blackmore, M. 2006. Risks posed by climate change to the delivery of the Water Framework objectives in the UK. *Environment International,* **32**, 1043-1055.