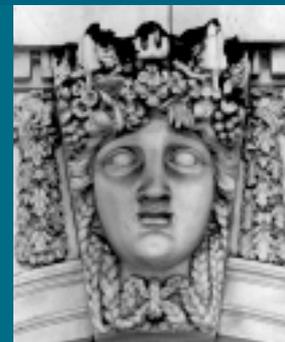
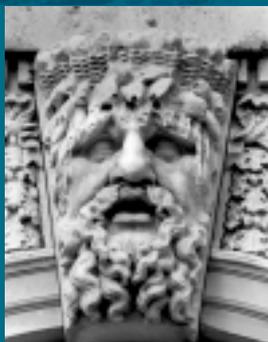


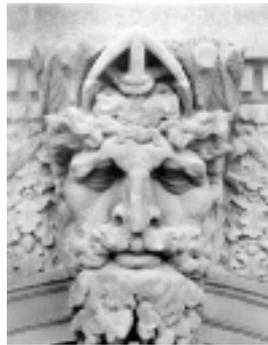
Report of the FLOOD POLICY REVIEW GROUP



OPW

*The Office of Public Works
Oifig na nOibreacha Poiblí*

report of the FLOOD POLICY REVIEW GROUP



The five sculptured heads illustrated above and on the front cover are a selection of “The Riverine Heads” carved by Edward Smyth, which are situated on the keystones on the ground floor of the Customs House, Dublin.

A total of fourteen Riverheads were carved, each representing one of the main rivers of Ireland and the Atlantic Ocean.

The heads on the front cover are (from left to right) Rivers Shannon, Blackwater, Lee (also cover inset), Barrow and Liffey.

Photographs are supplied courtesy of the Department of the Environment, Heritage and Local Government.

FLOOD POLICY REVIEW FINAL REPORT

TABLE OF CONTENTS

Foreword from Minister of State Mr Tom Parlon, TD	9
Introduction	10
Executive Summary	13
Recommendations	17
1. THE CAUSES, EXTENT AND IMPACTS OF THE FLOODING PROBLEM	22
1.1 Introduction	22
1.1.1 Definition of Flooding	22
1.1.2 Causes of Flooding	23
1.2 Flood Processes	25
1.2.1 Rainfall-Runoff Process	25
1.2.2 Flow Attenuation Process	26
1.2.3 Hydraulic Control Process	27
1.2.4 Coastal Flooding	29
1.2.5 Flooding Process	30
1.2.6 Summary of Causes	32
1.3 Irish Context	33
1.3.1 Rainfall-Runoff Process	33
1.3.2 Flow Attenuation Process	33
1.3.3 Hydraulic Control Process	33
1.3.4 Flooding Process	34
1.4 Extent of Flooding in Ireland³⁴	34
1.4.1 Historical Position	34
1.4.2 Impact of the 1945 Act	34
1.4.3 Records	35
1.4.3.1 Record Sources	36
1.4.3.2 Return Period.4.4 Risk Areas	36

1.4.5	Recent Extreme Events	37
1.4.6	Flood Defences	37
1.4.7	Deficiency of Risk Information	38
1.5	Impact of Flood Events	38
1.5.1	Tangible Impacts	39
1.5.2	Intangible Impacts	40
1.6	Financial Implications	40
1.6.1	OPW Studies	40
1.6.2	Humanitarian Aid	41
1.6.3	Costs of Local Authorities	42
1.6.4	Insurance Costs	42
1.6.5	Required Datasets	42
1.7	Conclusions	43

2.	CURRENT ROLES AND RESPONSIBILITIES OF THE MAIN STATE BODIES	45
2.1	The State	46
2.2	The Office of Public Works	47
2.2.1	The 1995 Act	47
2.2.2	Earlier Schemes	47
2.2.3	Principal Powers and Duties of the OPW	47
2.2.4	Current Activities	48
2.2.4.1	Maintenance	48
2.2.4.2	Flood Relief Schemes	48
2.2.4.3	Hydrological Data Collection	50
2.2.4.4	Humanitarian Aid Administration	50
2.3	Main Difficulties	51
2.3.1	Financial Resources	51
2.3.2	Human Resources	51
2.3.3	Environmental Considerations	52
2.3.4	Legislative Restrictions	52
2.3.5	Prioritisation of Scheme	53
2.4	Dept. of the Environment, Heritage & Local Government	53
2.4.1	Planning	53
2.4.2	Emergency Response	54

2.4.3	Water Framework Directive	54
2.4.4	National Parks & Wildlife Service	55
2.5	Dept of Agriculture & Food	56
2.5.1	The Role of the Dept of Agriculture & Food	56
2.5.2	The Irish Land Commission	56
2.6	Dept of Communications, Marine & Natural Resources	58
2.6.1	Coast Protection Act, 1963	58
2.6.2	Foreshore Acts, 1933 & 2003	58
2.6.3	National Coastal Protection Strategy Study	58
2.7	Local Authorities	59
2.7.1	Introduction	59
2.7.2	Local Authority Functions	59
2.7.3	Planning	60
2.7.4	Relief/Protection Works	61
2.7.5	Sewerage Works	61
2.7.6	Drainage Districts	62
2.7.7	Emergency Response	63
2.7.8	The 1948 Sanitary Services Act	63
2.7.9	Prioritisation of Local Authority Functions	63
2.8	Conclusions	64
2.8.1	Resources	64
2.8.2	Maintenance Responsibilities	64
2.8.3	Clarity of Roles	64
2.8.4	Prioritisation of Flood Relief Works (OPW)	64
2.8.5	Flood Relief Works-Environmental Considerations	65
2.8.6	Legislative Issues	65
2.8.7	Planning and Development	65
2.8.8	Humanitarian Aid	65
3.	INTERNATIONAL BEST PRACTICE	67
3.1	International Best Practice	68
3.1.1	Integrated River Basin Approach (River Basin Flood Risk Management)	70
3.1.2	Public Awareness, Public Participation and Insurance	71
3.1.2.1	Flood Hazard Mapping	72
3.1.2.2	Insurance	73

3.1.3	Research, Education & Exchange of Knowledge	74
3.1.4	Flood Relief Measures (Non-Structural & Structural)	75
3.1.4.1	Climate Change	77
3.1.5	Land Use, Zoning & Risk Assessment (Planning & Development Control)	78
3.1.6	Early Warning & Forecast Systems	80
3.1.7	Flood Emergency	81
3.1.8	Prevention of Pollution	81
3.2	The Water Framework Directive & Flood Management	82
3.3	Summary	82
4.	FUTURE POLICY PROPOSAL	87
4.1	Existing Position	88
4.2	Policy Consideration	89
4.3	Proposed Future Flood Relief Policy	91
4.4	Requirements for Policy Delivery	91
4.5	Proposed Framework for Policy Delivery	93
4.6	Information Requirements	94
4.6.1	Hydrological Information	96
4.6.2	Flood Risk Information	96
4.6.3	Environmental & Socio-economic Information	97
4.6.4	Planning & Development Control	99
4.6.5	Flood Relief Works	100
4.6.6	Channel & Defence Maintenance	101
4.6.7	Flood Awareness, Education & Preparedness	102
4.6.8	Flood Warning	103
4.6.9	Emergency Response	103
4.6.10	Humanitarian Aid & Insurance	104
5.	PROPOSALS FOR FUTURE ORGANISATIONAL STRUCTURES AND RESPONSIBILITIES	107
5.1	Future Organisational Models	109
5.1.1	Status Quo	109
5.1.2	Local Authorities as Lead Agency	109
5.1.3	Flood Management Executive Agency	110

5.1.4	Dept of Environment, Heritage & Local Government as Lead Agency	110
5.1.5	Office of Public Works as Lead Agency	111
5.2	Final Choice	112
5.3	Roles & Responsibilities of the Four Principal State Bodies Involved in Flood Management	113
5.3.1	The OPW will:	113
5.3.2	The DoEHLG will:	114
5.3.3	The Local Authorities will:	114
5.3.4	The DCMNR will:	115
6.	RESOURCE REQUIREMENTS	117
6.1	Introduction	118
6.2	Capital Works	119
6.3	Flood Warning	119
6.4	Flood Hazard Mapping	120
6.5	River Basin Flood risk Management Planning	121
6.5.1	Pilot Plan Development	121
6.5.2	RBFRMP Development	121
6.5.3	RBFRMP Maintenance	121
6.5.4	Development of Guidelines	121
6.6	Hydrological Research & Development	121
6.6.1	Update of Flood Studies Report	121
6.6.2	River Basin Modelling	121
6.6.3	Future Hydrological Research & Development ~ (R&D)	122
6.7	Table 5: Summary of Resource Requirements	121
6.8	Met Éireann	122
6.9	Economic Justification	122
	REFERENCES	124
	APPENDICES	129

FOREWORD FROM MINISTER OF STATE MR TOM PARLON, TD

Following my appointment as Minister of State in 2002 I became aware of a distinct lack of clarity about the State's response to flooding. My concern was heightened following the serious flooding that occurred in many parts of the country in October and November 2002.

On 27 November 2002 I announced that a review of national flood policy would be carried out and asked my officials in the OPW to establish a Group of relevant stakeholders and set the review in motion.

The Review Group completed its work in December 2003 and I am pleased that the Government has now approved its report. It sets out the policy, funding, structural and organisational difficulties that currently exist and makes recommendations to address these. It does not contain a detailed economic or engineering assessment of the issues as this was not deemed necessary for the purposes of the Review and indeed, would have delayed its completion.

The recommendations on policy, organisation and funding are key to a holistic and effective State response to flooding in the future. They represent a challenge to the OPW, to me as Minister of State, and to Government. I will work closely with my colleagues in Government to ensure that the recommendations are implemented.

Finally, I wish to record my thanks to the members of the Review Group and to the staff of the OPW for their work in completing this Report.

Tom Parlon, TD,
Minister of State at the Department of Finance
with special responsibility for the Office of Public Works

INTRODUCTION

The terms of reference for this Review are to:

- Report on the causes and extent of flooding
- Outline in general terms the impact of flooding on different sections of society e.g. households, businesses, insurance companies, farmers
- Draw up proposals to indicate how the State should respond to different categories of flooding and recommend which agencies should have responsibility in each case
- Recommend criteria for the prioritisation of expenditure between response programmes and within programmes where appropriate
- Identify the extent and adequacy of existing powers and processes and recommend any changes and any new or additional powers considered necessary
- Identify strategies to manage any increase in the present extent of areas at risk of flooding, with particular reference to current predictions regarding the effects of climate change
- Establish criteria for the initiation of any future humanitarian aid schemes.

The members of the Review Group are:

Mr. Tom Parlon, TD, Minister of State, Office of Public Works (OPW) (Chairman)

Mr. Sean Benton, Chairman, OPW

Ms. Clare McGrath, Commissioner, OPW

Mr. Tony Smyth, Director of Engineering Services, OPW

Mr. Jim Blighe, OPW

Mr. Donal Buckley, Irish Business & Employers Confederation (IBEC)

Mr. Matt Twomey, County & City Managers Association (Dublin City Council) (CCMA)

Mr. John Tiernan, County & City Managers Association (Roscommon County Council)

Dr. Gerard Farrell, Dept. of Communications, Marine & Natural Resources (DCMNR)

Mr. Michael Bergin, Irish Farmers Association (IFA)

Mr. Terry Allen, Dept. of Environment, Heritage & Local Government (DoEHLG)

Mr. Tom Walsh, DoEHLG

Mr. Jim Ryan, National Parks & Wildlife Service, DoEHLG

Mr. Matt Sinnott, Dept. of Agriculture and Food (DAF)

Mr. Eric Hartmann, Dept. of Finance (DF)

Mr. John Crimmins, OPW

The Group met on nine occasions. At its first meeting in January 2003 the Group agreed to a public consultation process. Submissions were invited from the public through advertisements in the media on 24 January 2003. All local authorities, a number of State agencies and voluntary agencies were approached directly and invited to make submissions to the Group. A total of 71 written submissions were received – a list of these is in Appendix 16. Following the closing date for receipt of submissions meetings were held with 14 agencies/groups.

It is important to note the scope of this Review. Given the background to its establishment and the requirement from Minister of State Parlon that the process be completed by autumn of 2003, the Review Group was careful to focus on the core issues. Essentially these revolved around clarifying, which State agency is responsible for responding to flooding and, more importantly, for planning to avoid, or at least reduce, damage from flooding in the future.

It was considered also that the situation where no State agency appeared to have legislative responsibility for flooding from certain watercourses was unsustainable from a public policy point of view. In these circumstances it seemed appropriate to the Group to focus primarily on the roles of the Department of the Environment, Heritage, and Local Government (DoEHLG), the Office of Public Works (OPW), the Department of Communications, Marine and Natural Resources (DCMNR), and local authorities, as these are the agencies most directly involved in flood management.

It is acknowledged that there are many non-governmental, communities, academic, private sector and representative associations and groups with an interest and expertise in this area. Their role is not discussed in detail in this Review as the focus has been on establishing the State's response. The Report, therefore, concentrates on the role of the main State agencies. The Review Group is confident that in the proposals for development of River Basin Flood Risk Management Plans it has provided a framework for participation by all sectors.

The Review focuses on fluvial (river) and tidal flooding and thus concentrates on the roles of the main State agencies in these areas. The Group has found that one of the features of this area is the lack of research and data. This has hampered its work. Nevertheless, it was considered important to complete the task assigned within the timescale set by the Minister of State. This precluded the commissioning of research or collection of data

specifically to inform the work of the Review.

The Report does not propose any change in existing responsibilities of other State agencies in related areas, which are not discussed in detail in the Report, e.g. stormwater and surface water run-off (local authorities), dams and other control structures (ESB, Waterways Ireland, some local authorities) and coastal protection (Department of Communications, Marine, and Natural Resources).

Together with the OPW, DoEHLG, DCMNR and local authorities, implementing the new policy set out in this Report will also require input from Met Éireann, Ordnance Survey Ireland, the Environmental Protection Agency and most likely the ESB and Waterways Ireland. Requirements will be discussed in detail as the process of implementing the Report's recommendations proceeds.

The Report contains a broad outline of resources required to implement the various work programmes arising from the new policy. This is an initial estimate of financial resources and will have to be reviewed by the relevant agencies as each work programme is specified in detail.

The Report consists of seven Sections (including a Reference Section), the titles of which are self-explanatory. There are seventeen Appendices, which contain more detailed discussion of topics raised in previous Sections.

Flood Policy Review Group

EXECUTIVE SUMMARY

Section 1 – Causes, Extent and Impacts of the Flooding Problem

Flooding is a natural phenomenon. The causes, extent and impacts of flooding are varied and complex. The unpredictability of rainfall and climate must always be borne in mind. Predictions about the impact of climate change add a further degree of uncertainty but must be taken into account in line with the 'Precautionary Principle'.

The flooding problem cannot be eliminated but can be managed so as to minimise its impact.

Human activity can cause an increase in the risk of damage from flooding.

Information on the extent of flooding, both historic and predictive, is not readily available.

There is a lack of information on the economic, social and environmental costs of flooding. Available evidence suggests these costs are substantial.

Section 2 – Current Roles and Responsibilities of the Main State Bodies

The current approach to flood management is largely reactive.

Existing responsibilities of State agencies have evolved in a piecemeal fashion without the benefit of an integrated policy on flooding.

Notwithstanding this, a lot of work, both historic and current, carried out by State agencies, particularly the OPW, local authorities and the ESB, makes a significant contribution to flood management.

There is a concentration on structural flood defence works to address problem areas with insufficient emphasis on non-structural methods of flood management.

It is acknowledged, however, that there are a considerable number of heavily populated urban centres that are currently at risk of flooding and where flood defence may be the only feasible solution.

There is a need to re-examine current expenditure on structural solutions (both maintenance of existing drainage schemes and construction of new flood defence schemes) to ensure that resources are prioritised to the areas of greatest need and that value for money is obtained.

There is uncertainty about responsibility for flood management in certain watercourses and in areas subject to tidal flooding. There are significant areas where no State agency currently has legislative responsibility for flood management.

The extent, condition and protection afforded by some existing man-made flood defences (many may be centuries old) throughout the country are not known. Neither is there a national inventory of the contribution of wetland eco-systems to flood attenuation.

There is a need to co-ordinate measures on flood management with the measures being taken to implement the Water Framework Directive.

Adequate funding must be allocated in the future to enable programme advancement in all aspects of flood management if a strategic approach, comparable to other EU States, is to be adopted.

In its assessment of new capital projects, the OPW should consider how it could provide for measurement of environmental costs and benefits in its Cost Benefit methodologies. The OPW should also, as a matter of course, have regard to the value of wetland ecosystems in flood management.

Section 3 – International Best Practice

Internationally, there is an increasing realisation that flooding is a natural phenomenon and that we must learn to live with flood events.

A change of emphasis is required, with a move away from engineering works that defend against floods to management of the flood risk and living with floods.

An integrated, holistic and river basin based approach to flood risk management is the way forward. This is consistent with and complements the Water Framework Directive.

Section 4 – Future Policy Proposals

The future policy is to minimise the national level of risk of loss of life and/or damage to property and personal well-being that might arise from flooding in a sustainable and cost-effective manner through the integrated, proactive and river basin based management of existing and potential future flood risk, and the mitigation of the impacts of flood events through non-structural, as well as structural, flood relief measures.

The proposed structure for delivering this policy is through a River Basin Flood Risk Management Planning framework.

Local Authorities will assist the OPW in the implementation of the new policy and particularly in their roles in relation to non-designated channels and flood warning systems.

A work programme is required to deliver on this which will include guidance and standards relating to planning; the adoption of non-structural flood mitigation measures; prioritisation criteria for expenditure; research and development.

Further information and study is required in a number of areas to determine the degree of socio-economic impact flooding has on various societal groups.

Completion of the Flood Hazard Mapping Programme and the Coastal Protection Strategy Study are essential for the implementation of this policy.

Section 5 – Proposals for Future Organisational Structures and Responsibilities

Following consideration of five organisational models, the Group decided the OPW as lead agency provides the most cost-effective and efficient option to implement future policy, given its existing structures and operational expertise in the area of flood management.

Locations solely at risk of tidal flooding will remain the responsibility of the Department of Communications, Marine & Natural Resources.

Section 6 – Resource Requirements and Strategic Programme

The success of the implementation of this Report depends upon the provision of sufficient resources to carry out its recommendations.

A current lack of accurate information and the further need to undertake various processes e.g. channel designation, prioritisation of capital works etc., make it difficult to quantify precisely at this time the full level of resources required.

The cost of implementing all schemes identified in both the OPW work programme and in a submission by local authorities is estimated to be in excess of €440 million.

Costs of approximately €26 million (spread over six years) – and not including any additional staff requirements – have been estimated for the development of the strategic, non-structural elements of the new policy.

RECOMMENDATIONS

POLICY

Future policy should seek to minimise the national level of exposure to flood damages through the identification and management of existing, and particularly potential future, flood risks in an integrated, proactive and river basin based manner:

The Office of Public Works is to be the lead agency in delivering this policy.

A two-pronged approach to flood management is to be pursued with a greater level of importance attributed to non-structural flood relief measures supported, where necessary, by traditional structural flood relief measures

All future expenditure in the area of flood relief will need to satisfy strict prioritisation criteria.

It is recommended that the option of administering future Programmes of Humanitarian Aid through established support networks under the aegis of the Department of Social and Family Affairs and/or Health Boards be examined.

OPERATIONAL

The OPW is to review immediately its current Flood Relief Work Programme to reassess the optimum balance between structural and non-structural measures.

Based on clear prioritisation criteria, rivers, channels and defence assets will be designated as priorities for maintenance and these will be the responsibility of the OPW. For all non-designated channels, without prejudice to the ongoing responsibilities of riparian owners or other interested bodies, local authorities will provide emergency relief under the provisions of the Local Government (Sanitary Services) Act, 1948 or the Local Authorities (Works) Act, 1949.

It is proposed that River Basin Flood Risk Management Plans (RBFMRPs) be developed.

The OPW will play an advisory role in the area of general planning and development control through the development of standards and guidelines in conjunction with DoEHLG and local authorities for inclusion in Development Plans.

It is recommended that comprehensive Flood Hazard Maps be developed and made available on the Internet.

It is recommended that, following completion of the first phase of the Flood Hazard Mapping Programme, all information be made immediately available to DoEHLG to inform future planning and development processes.

An asset register of flood defences is to be developed for the purposes of risk identification and the determination of maintenance priorities and programmes.

The application of flood warning systems is to be examined in conjunction with other non-structural flood impact mitigation measures.

The development and management of a general flood awareness campaign would be most appropriately coordinated at a national level by the OPW.

The OPW will assume responsibility for flood management at locations where tidal and fluvial influences interface. Locations solely at risk of tidal flooding will remain the responsibility of the Department of Communications, Marine & Natural Resources.

In its assessment of new capital projects the OPW should provide for measurement of environmental costs and benefits in its cost benefit methodologies. The OPW should also have regard to the value of wetland eco-systems in flood management.

The OPW, in conjunction with the EPA, to examine issues relating to the implementation of a strategic hydrometric monitoring programme

The OPW to examine possibility of developing high-resolution (possibly national) Digital Terrain Models (DTMs) for hydrological and hydraulic modelling

The OPW to examine possibility of developing Information Technology (IT) systems and structures, including Geographical Information Systems (GIS), telemetry systems, data protocols, management structures and systems, etc. for the management of flood-related data and information

RESOURCES

Additional funding will be required to implement the new policy. The figures below do not include costs of additional staff, which will be required primarily in the OPW.

OPW

€26 million	–	Non-Structural Costs (over 6-year period)
€440 million	–	Capital Works (over 10-15 year period)

Local Authorities

Not possible to quantify pending designation process.

Met Éireann

€1.05 million	–	Flood Warning
---------------	---	---------------

DCMNR

Awaiting completion of Phase I of the Coastal Protection Strategy Study

LEGISLATION

Current legislation under which the OPW and Local Authorities operate is restrictive and deficient in some aspects. The legislation should be reviewed to determine changes required in order to implement the new policy

RESEARCH

Programmes of necessary research have been identified in the following areas:

- Update of the Flood Studies Report and river basin (hydrological) modelling
- Analysis of the potential impacts of climate change on flood frequency and severity
- Meteorological forecasting techniques for flood warning systems
- Systematic collation of all information on flood damage in Ireland
- Socio-economic impact of flooding on Irish society
- The possible use of wetlands for attenuation purposes.

FLOOD POLICY REVIEW FINAL REPORT

1

THE CAUSES, EXTENT AND IMPACTS OF THE FLOODING PROBLEM

1. CAUSES OF FLOODING

1.1 Introduction

1.1.1 Definition of Flooding

For the purposes of clarity, it is important to define the term ‘flooding’, and the context within which the term will be used for the purposes of this Review.

A dictionary definition of a flood is a ‘great quantity of water, especially over land’ (Oxford English Dictionary, 1980). The ‘great quantity of water’ (in terms of river, or fluvial, flooding) is essentially caused by heavy rain that creates significant runoff into streams and generates a flow that exceeds the capacity of the river, causing water to flood out over the land, i.e., the floodplain. Flooding from estuaries or the sea is generated from sea levels (a combination of astronomical tides, surges, wind and waves) exceeding the level of, and hence spilling onto, the neighbouring land. These are natural processes. They do not represent a problem in themselves, and would not, in the absence of the damage that can be caused, necessitate any action.

Floods do, however, cause damage and disruption to property and infrastructure (i.e. economic or financial interests), personal well-being and other issues of human concern. While it is acknowledged that from an environmental perspective there may be positive aspects to flooding, this Review has been commissioned because of the damage caused by flooding, the rising costs of addressing this and of attempting to reduce the risk of exposure to such damage. It is in this context that the term ‘flood’ must therefore be used, i.e., an inundation of land that causes, or has the potential to cause, damage or disruption.

It must be emphasised here that flooding in this context means unusual or severe fluvial or tidal flooding. It does not include flooding arising from stormwater and surface water runoff, nor from roads, which are the responsibility of local authorities and/or the National Roads Authority (NRA) under the aegis of the Department of the Environment, Heritage, and Local Government. For practical, common sense reasons it must also be clear that flooding in the present context does not include small scale or short term localised events, which, although possibly causing inconvenience, do not pose a risk to persons or property.

1.1.2 Causes of Flooding

Although simplified above, the sources and natural processes through which a flood situation evolves are manifold and complex, and, in the majority of cases, cannot be controlled. Human settlement and land use practice can, however, have an impact on these processes, and increase or decrease the risk of flooding and flood damage. These human influences can be controlled, and focus must therefore be primarily directed towards these aspects and causes of flooding, rather than uncontrollable causes, such as heavy rainfall or extreme sea levels.

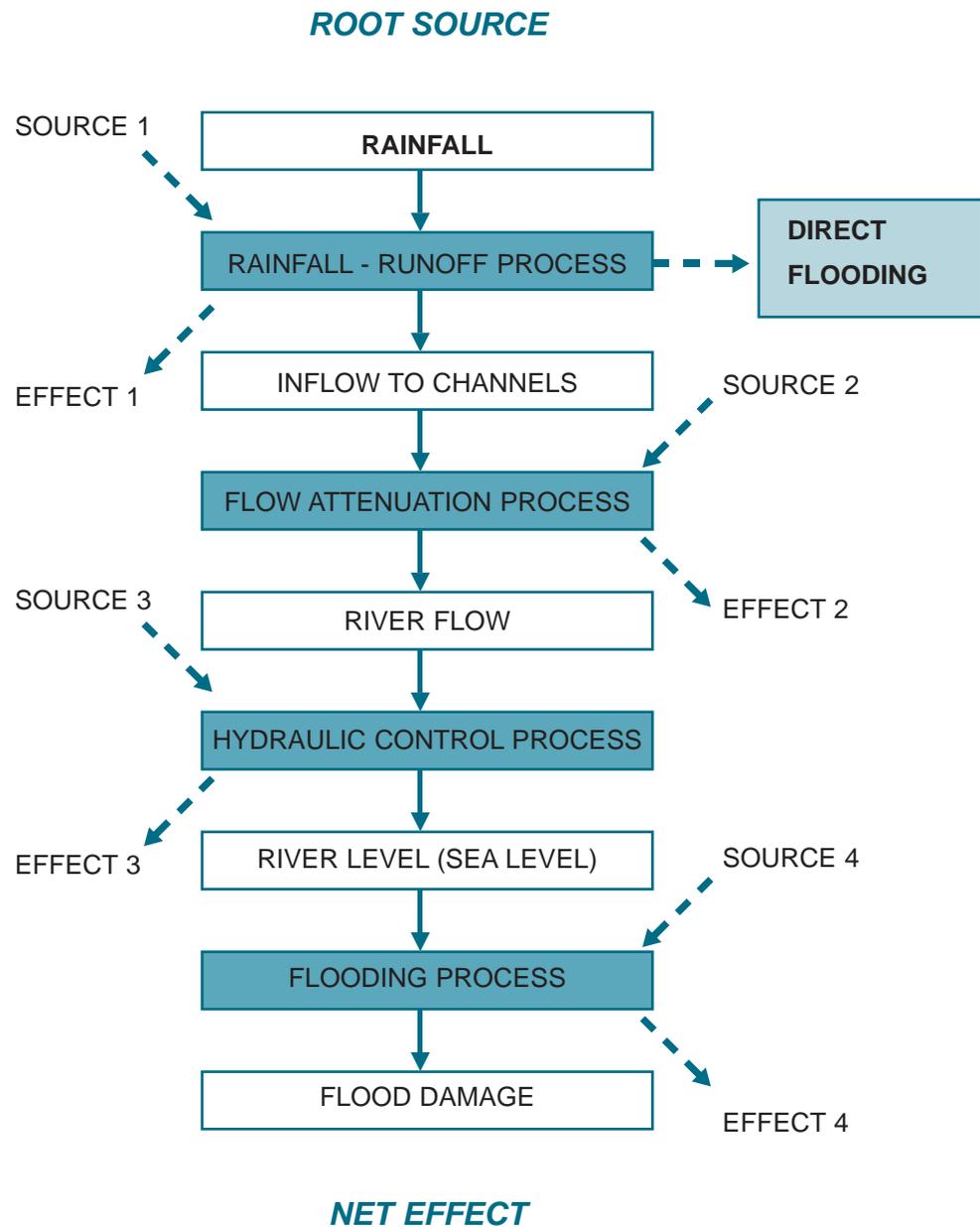
Furthermore, it should be noted that climate change is likely to increase both the magnitude and frequency of extreme weather events and lead to greater flooding. Some recent modelling of climate change impact suggests that in especially sensitive river basins what is now a one in 50-year flood could become a one in 20-year flood. The issue of climate change is addressed in more detail in Section 3.

A review of flood risk and flood risk management (ICE, 2001) made use of the 'Source-Pathway-Receptor' model of risk, which identifies, in the case of fluvial flooding, rainfall as the source, and the land and watercourses as the pathway by which the source makes its way to the receptor, i.e., people and property. In assessing the causes of flooding and human impact, a similar model or framework can be used, but with the middle step (i.e., the pathway) broken down into a chain of discrete processes or relationships (Figure 1) to facilitate analysis of how human activities influence the overall flooding process.

Figure 1 depicts the chain, and shows how the effect of one process is the source for the next. Any human intervention or influence on one of the processes that increases the effect of that process will, in turn, increase the source to the next process, and hence its effect, and so on through to the final process and effect. The causes of flooding will be identified and described as activities that can influence one of the processes and have consequential effects through the chain ultimately to increase flooding and flood damage.

It should be noted that the complete chain represents rain-based, or fluvial, flooding. As there is no control that can be exerted over sea levels, human interaction with tidal flooding can only be covered effectively under the fourth process, sea level to flood effects.

Figure 1: Causes of Flooding – Chain of Sources, Processes and Effects



The above process does not cover totally artificial flood pathways such as water supply or closed-system foul sewerage networks. These potential causes of flooding are beyond the scope of this Review and will therefore not be considered further at this time.

In the next four sub-sections, each process will be outlined and examined in terms of the role it plays in flooding, and more specifically, the principal influences and impact of human activities on each process. In this way, the human contributions, or controllable aspects, of the chain of events that result in flooding will be identified.

1.2 Flood Processes

1.2.1 Rainfall–Runoff Process

Rain is, in general, the primary cause of most flood events. Detailed analysis of rainfall patterns will improve our understanding of this cause to help manage the flood risk, and rainfall forecasts and warning systems can reduce flood impact, but the source itself is uncontrollable. The scope and requirements for managing the risk and introducing warning systems will be assessed in this Report.

Surface runoff, and the consequential rapid inflow to streams, drainage channels or rivers, is determined by the rainfall-runoff process. The ‘effect’ of this part of the chain (surface runoff) is reduced by the removal of water as it falls to the ground by a number of factors including:

- Interception (determined by vegetation type and coverage)
- Infiltration to the soil (and subsequent absorption and transpiration by vegetation, percolation down into aquifers, or delayed contribution to surface water discharges)
- Evaporation to the atmosphere (determined by atmospheric conditions).

Human activities that interfere with these sub-processes and reduce the short-term removal of water will increase the effect of this process with its consequential effects through the chain. Such activities include:

- *Removal of Vegetation:* This reduces interception, and has been seen to have severe effects, particularly in tropical areas.
- *Greenfield Development:* Paving over previously permeable areas for roads, housing, car parks, etc. can (if appropriate counter-measures are not taken)

significantly restrict the potential infiltration rate of the area covered. This activity might have a minor or negligible impact in large river basins (due to flood peak timing and proportion of area developed), but could substantially increase runoff in small river basins (i.e., by more than 100%).

- *Changes in Land Use or Land Use Practices:* Changes in the vegetation cover, the way in which land is used, or measures which impact negatively on natural flood retention areas (wetlands), can have impacts on both interception and infiltration.

As well as forming part of the chain, the rainfall-runoff process itself can also directly result in flooding. Property or infrastructure located in low points or hollows where surface runoff can accumulate, or in the path that surface runoff would naturally follow, can be at risk unless protective measures are taken. Certain causes of flooding can be identified from this direct route. These would include:

- *Inappropriate Location of Properties:* see above 'Greenfield Development'.
- *Infrastructural Cross-Drainage (Surface Waters):* Transport routes will often unavoidably cross natural surface runoff routes. Flooding of the infrastructure can, however, be prevented, reduced or controlled by directing or containing the cross-flow such as through drainage systems, culverts or specifically created fords.

1.2.2 Flow Attenuation Process

Once water has reached a watercourse through the rainfall-runoff process, it is incorporated with the existing flow in the channel from contributing areas upstream to produce the net flow at that point. The relationship of flow against time at a given point as the flood passes is described as a flood hydrograph. As a flood moves down the river it is subject to a series of influences that change the characteristics of the flood hydrograph, such as the timing and magnitude of the peak. In the absence of any additional inflows, the peak of the hydrograph will occur later due to the time taken for the flood to move downstream, and the magnitude of the flood peak will reduce due to temporary storage effects in the channel and floodplain. This process is known as attenuation.

The source (runoff from the contributing river basin) is hence attenuated to produce an effect, which is a flow at the particular point of interest. Any reduction in the attenuation of

the flood will increase the output (or 'effect') of this stage of the chain with a consequential increase in the net chain effect – flood damage. This process can be influenced in a number of ways by human activity:

- *Localised Drainage*: The process of deepening or widening a channel can increase the carrying capacity of a channel. This can reduce the risk of flooding in the immediate vicinity (see Section 1.2.3), but can also reduce the attenuation, increasing flows and hence flood risk downstream. The impact of this activity is normally only significant to locations immediately downstream of the drainage, or if undertaken on a large scale.
- *Channel Maintenance*: The process of removing vegetation from a channel can reduce the resistance to flow and hence increase the carrying capacity of the channel. This will have the same impact and scale of impacts as described above.
- *Floodplain Defence*: Preventing water from reaching the floodplain can reduce the natural storage capacity of the river system, and hence reduce the attenuation. As for the activities above, this impact would only be significant if floodwaters are prevented from reaching large storage areas. There could, however, be a significant impact on the integrity of environmentally sensitive areas (i.e. wetland eco-systems).

It might be noted at this point that man-made structures that deliberately impound water and hence increase the storage in the river system, such as dams, storage ponds, etc., could increase attenuation and therefore act as a flood relief or reduction measure. A similar result may be achieved by the creation of wetlands or the restoration of drained wetlands.

1.2.3 Hydraulic Control Process

Following the rainfall-runoff and attenuation processes, the effect of rainfall is to generate a flood flow at a point of interest where, for any given set of conditions, the hydraulic control determines the water level for a given flow.

There are numerous conditions that can influence this relationship between level and flow, such as the shape, slope, size and condition of the channel and floodplain, downstream

water levels, or the existence of restrictions to flow. Changes to these conditions can affect the hydraulic control and result in changes to the relationship, which would result in higher or lower water levels at the location for a given flow.

Many of the conditions, and hence the hydraulic control, can be significantly affected by human activities, with resultant increases (or decreases) in water, or flood, levels for a given flow. Such activities include:

- *Channel Restriction:* A restriction to an existing channel reduces the size of available flow area, and hence can shift the level / flow relationship causing flooding at, or upstream of, the restriction. A channel can be restricted in a number of ways, including:
 - encroachment by bank developments
 - construction of bridge piers in the channel
 - insertion of pipes in or across the channel
 - culverting of a channel.

- *Floodplain Restriction:* The floodplain can effectively form part of the channel in flood conditions, and therefore restrictions on, or across, the floodplain can have the same impact as constrictions in the normal channel. These might include:
 - embankments for infrastructure
 - development on the floodplain
 - protective embankments or walls around developments
 - walls or embankments that retain flow in the channel and prevent floodplain flow.

- *Blockages:* A channel or floodplain normally at an existing restriction can be further restricted by natural or human debris such as tree branches, plastic bags or shopping trolleys. This is most frequent at bridges with small arches / numerous piers, or at culverts, particularly if fitted with an inappropriately designed trash screen.

- *Lack of Maintenance:* An increase of vegetative growth can reduce the carrying capacity of a channel and influence the hydraulic control. A lack of channel maintenance where this is required to obtain a certain capacity can therefore cause flooding.

- *Siltation*: Human activities can lead to increased levels of particles / solids in a river and an increase in siltation, which in turn can reduce the available flow area or gradient of the channel and hence affect the hydraulic control.
- *Impoundment*: The construction of barrages across a channel, such as a weir or dam, are deliberate efforts to change the hydraulic control and raise water levels for a given flow. The design should, however, consider a full range of flows, including extremes, to ensure that the structure does not cause unintentional flooding.

It should be noted that not all of these activities noted above will change the hydraulic control at a location and cause flooding, but rather that they can if not fully assessed and designed appropriately.

1.2.4 Coastal Flooding

While river flooding is due entirely to rainfall, flooding of coastal areas is mainly caused by factors other than rainfall. These are: tides, surges and wave overtopping.

(i) Tides

Tides vary in a predictable manner over time. Higher than average tides occur every two weeks around the time of full and new moons when the gravitational pull of the moon and sun are aligned. These are known as spring tides and vary over time, with three or four particularly high tides occurring each year. Lower than average tides follow a similar two-week pattern when the sun and moon are at right angles and are referred to as neap tides. High spring tides can be over one metre higher than high neap tides.

Coastal morphology and coastal development have adapted themselves to this natural tidal rhythm with the result that tides on their own do not give rise to coastal flooding concerns.

(ii) Surges

Tide levels are rarely exactly as predicted. The difference between a higher than expected sea level and the predicted tide level is referred to as a surge. Surges can be up to one metre in height, or more in extreme cases. A surge occurs when high winds pile the water up on the coast or when an area of low barometric pressure causes the water level to rise. Surges of varying magnitudes occur frequently around our coasts and generally pass

unnoticed. Surges only come to attention in the infrequent event that they coincide with a high spring tide. This is what happened on the East coast in February 2002 when a large surge coincided with one of the highest spring tides of the year.

(iii) Wave Overtopping

Tides and surges on their own generate high still water levels and flood low lying areas by simply flowing onto them. Waves on the other hand, when driven by storms, can batter down coastal defences, erode beaches and dunes, run up sea walls and embankments and flood hinterland areas by overtopping. The effect of these storms is greatly magnified when they coincide with high spring tides and surges.

1.2.5 Flooding Process

Once a flood level has been determined for a particular location through the previous steps of the chain, or as might occur in a tidal area, the damage that results is variable, but can include loss of life, economic (direct and indirect), environmental, social and personal health and welfare costs. The damage costs of flooding are expanded upon later in this Section. The human influences on the magnitude or type of damage that occurs for a given flood level at a particular location would include the following:

- *Development:* Flooding of development such as property or infrastructure generally results in some damage. Development within a flood risk area therefore increases the potential damage when the flooding occurs. Such development can occur inadvertently due to lack of knowledge of flood risk. This can happen because of the long recurrence interval between severe flood events, making it tempting to develop in floodplains.
- *Inappropriate development:* The damage caused to flooded development is a variable in itself. It is recognised that development in a flood risk area is sometimes necessary for economic reasons, but the type of development permitted should be compatible with the existence of the risk. Inappropriate development involves property or contents that have a high potential for flood damage being located in a flood risk area. Inappropriate development might include:
 - high-density residential property (economic, social and personal welfare risk), or any residential property in areas subject to flash or deep flooding (risk to life)
 - manufacturing or storage property where the cost of flood damage to

contents (machinery/products) would be high (economic risk)

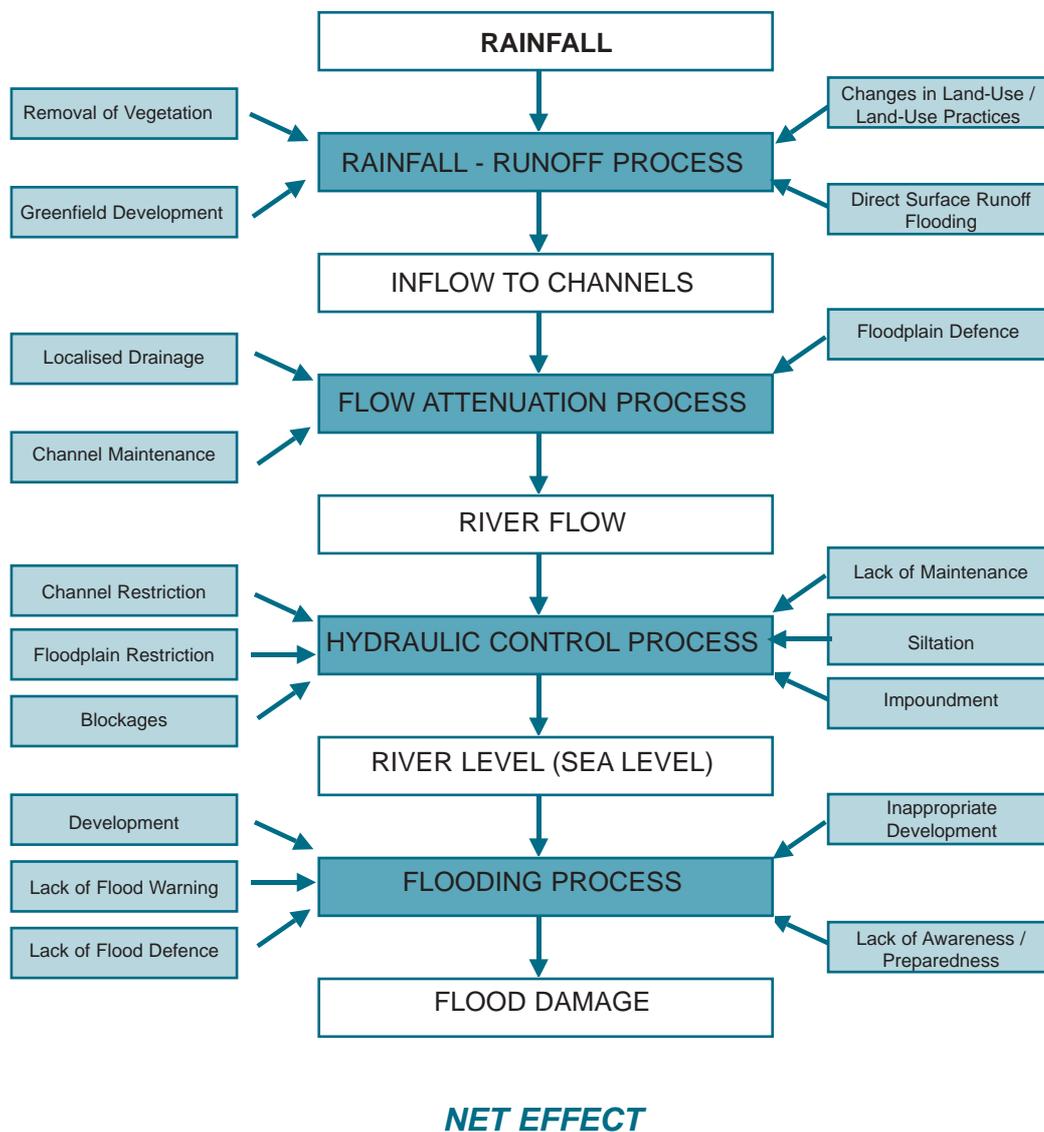
- industry or services where flooding could cause leakage of pollutants, such as chemical or sewage plants (risk to personal health and environment)
 - property or infrastructure with particular structural vulnerability to flooding (economic risk and risk to life)
 - key infrastructure for which, for example, disruption by flooding would cause significant delays to large numbers of people with consequent social and economic risk.
- *Lack of flood awareness or preparedness:* The damage caused by a flood can be reduced by awareness of the risk and preparations for actions to be taken in the event of a flood. The lack of this knowledge or preparedness will therefore increase the damage above the level that would otherwise have occurred, i.e., it causes unnecessary flood damage. Although this is a cause through inaction, it is valid nonetheless in the same way that failure to comply with a maintenance regime can also cause flooding.
- *Lack of flood warning and/or response:* In the same vein as noted above, a failure to provide adequate flood warning or to respond in an appropriate manner can increase damages above those that would occur if a flood warning had been issued and acted upon. Research (NOAA, 1997 p.19) indicates that, depending on the community and warning time involved, up to 40% of flood damages could be avoided through warning and response.
- *Inadequate, damaged or non-existent flood defences or protection:* Damage will increase during a flood for an area that is either unprotected, where defences are in place that fail (i.e., are overtopped, collapse, leak, etc.), or where defences have been damaged and are no longer effective. In such instances, floodwaters will reach extents or levels that would not otherwise have occurred. An example might be an embankment or wall that has been breached for temporary access purposes, allowing floodwaters through into a previously protected area.

An extension of this cause of flooding (failed defences) would be the breach of an impoundment structure such as a dam or canal embankment, which could result in serious flooding without warning.

1.2.6 Summary of Causes

Figure 2 below provides a graphical summary of the activities and influences on each process that can cause an increase in the net effect, i.e., flood damage.

Figure 2: Causes of Flooding – Human Impact on the Chain of Processes



1.3 Irish Context

Section 1.2 outlines human activities that can cause, or increase, the risk of flooding and associated damage. This Section discusses activities from among those identified above that are particularly relevant to Ireland.

1.3.1 Rainfall-Runoff Process

The significant majority of Irish land is now farmed or cultivated in some way. This might have increased flood flows over the last few decades, but there is now relatively limited scope for a major increase in the risk of flooding from extensive deforestation, or the cultivation and drainage of previously unused or wild land. However, the way in which land is used can have an impact on the runoff process and contribute to flooding.

The surge in the economy over the last decade has led to, or involved, a significant expansion in development, particularly of greenfield sites. As noted, this can increase runoff rates, particularly in small river basins, as well as introducing a direct risk of flooding from surface flow. Managed development at a river basin scale, with appropriate runoff compensation measures, such as stormwater management and sustainable urban drainage systems, can prevent an increase in flood damages and reduce the future need for flood relief schemes.

1.3.2 Flow Attenuation Process

For the same reasons described above, there is little scope for significant increases in flood risk arising from issues relating to flow attenuation, other than localised impact from drainage works and floodplain development. The issue of floodplain protection could, however, have serious impact if large areas of previously unprotected land that acts as flood storage become protected through the use of embankments or similar defences. This would have an additional undesirable impact on areas that are likely to be environmentally important e.g. wetland ecosystems.

1.3.3 Hydraulic Control Process

A further activity in Ireland that can have an impact on this step of the chain is again development-related. The restriction of channels, particularly due to floodplain development and the construction of under-sized bridges or cross-drainage culverts, is suspected of having been the cause of flooding at a number of locations. Impact analysis and better guidance and / or stricter controls in planning, design and construction can

prevent an increase in flood damages arising from these activities.

1.3.4 Flooding Process

This is the principal area where activity, or lack of activity, in Ireland could have probably the greatest impact in increasing the risk of flooding, through the inappropriate or inadequately designed development of property or infrastructure in flood risk areas (i.e. floodplains).

Ireland still enjoys a relatively low level of flood vulnerability, in comparison with other EU countries, as a result of its low population density. Development in floodplains driven by an expanding population and national wealth could, however, if allowed to continue, increase significantly the damage costs of flooding and the demand for expensive flood relief schemes in the future.

1.4 Extent of Flooding in Ireland

1.4.1 Historical Position

It is clear that flooding has been a major concern in this country for at least the past two centuries as reflected by the various Drainage Acts passed in, inter alia, 1842, 1867, 1925, 1928, 1945 and 1995.

The Browne Commission (Report of The Drainage Commission 1938-1940), which examined flooding and improvement of land through drainage, commenced its deliberations in 1938 and resulted in the development of the Arterial Drainage Act, 1945.

This commission recommended the establishment of a national drainage authority with a remit to embark on a national drainage programme with additional powers and responsibilities identified within the legislation.

1.4.2 Impact of the 1945 Act

Following the 1945 Act, a priority list of river basins was established and a programme of drainage work commenced. This programme continued until the early 1990s. The programme of works completed is identified in Map 1 (see Appendix 17). The implementation of this arterial drainage programme had the additional benefit of providing a level of flood protection to a number of urban areas and major infrastructure within the

scheme extents. Drainage schemes were designed for both flooding and drainage. The flood design criteria usually related to the 3-year flood event (i.e., a flood event that is expected to be equalled or exceeded on average once every 3 years) in rural and 20-year flood event in urban areas. An unmodified natural channel would be expected to break its banks in the event of a flood with a return period of approximately once every 2 years. The drainage design significantly increased the level of flood protection afforded by such schemes as the design level was lowered by several feet to provide an outfall for land drainage systems.

The emphasis of the 1945 Act was the improvement of agricultural land. This act was amended in 1995, when the emphasis changed to the protection of urban areas subject to flooding. This amendment arose after a number of urban areas suffered severe flooding in the mid to late 1980s and early 1990s. These floods caused extensive material damage and interruption to economic and social life. Analysis of the severity of these floods led to the conclusion that they were well within the normal range of expected floods with return periods in the range of 5 to 20 years, although some (e.g. Hurricane Charlie) had much higher return periods.

Several flood relief schemes have been completed by the OPW under the 1995 Amendment Act including Cappamore Co. Limerick; Sixmilebridge, Co. Clare; Duleek, Co Meath; Carrick on Suir, Co. Tipperary; Dunmanway, Co. Cork. A major scheme is currently on site in Kilkenny City.

1.4.3 Records

Records of flood events would ideally provide the information required to assess the risk of an occurrence and to design protective measures. Useful information includes:

- The date, time and duration of a flood
- The cause of the flood, i.e., the source of the water and any contributing events
- The path taken by floodwaters
- The level reached by the water and the depth of water at various locations
- Information on the probability of the flood (return period)
- The impact of the flood, including material damage and intangible effects
- The emergency response applied, and any lessons to be learned
- Remedial work carried out or required.

Existing records of floods contain some of the above information, but these do not conform

to a standard. The most useful data includes the dates of major floods in the past and some photographic evidence of the levels reached. No detailed analysis of the cost of flooding is possible without the detailed records described above. Often the immediate priority is, rightly, to protect and evacuate affected people and take measures to limit the damage suffered.

1.4.3.1 Record Sources

The preliminary research into extents of flooding in Ireland has been focused on the following record sources:

- OPW – Flood incidents identified from correspondence received in relation to flooding and flood relief and internally generated flood reports
- OPW – Middle and Upper Shannon flood envelope from January 2000
- Local Authority and Department of the Environment, Heritage and Local Government reports developed in relation to November 2000 flooding
- Ove Arup report commissioned by OPW in 1996 to identify priorities for flood relief
- Major flood events in February and November 2002 (see Map 5, Appendix 17). The main data available refers to the Tolka River Basin, where the flood envelope has been developed
- A submission received from the County & City Managers Association (CCMA) on behalf of local authorities (not all Authorities included in submission) has identified approximately 215 locations subject to flooding.
- South Galway Flooding Study

The information available and presented in Maps 1 to 5 (Appendix 17) reflects only those flood events for which information has been recorded and made available to the OPW in the recent past.

1.4.3.2 Return Periods

With the exception of Hurricane Charlie, the 2002 flood on the Tolka, and a small number of other events, the recent record does not include very many high return period events. The table below indicates typical events and the approximate return period.

Table 1: Typical Flood Events and the Approximate Return Period

Event	Return Period
Hurricane Charlie 1986	> 100 years
Tolka 2002	~ 100 years
Slaney 2000	~ 37 years
Suir (Clonmel) (1995 – 2000)	~ 5 to ~ 25 years

1.4.4 Risk Areas

On the basis of the information available (even though incomplete and limited in detail) it can be said with some confidence that there are in excess of 300 areas known to be at risk of, or subject to, periodic flooding. The effect of the flooding varies widely and includes damage to residential, commercial and industrial property, disruption to traffic, business, farms etc., sewerage treatment and other services. However, this information has not been catalogued in a systematic way, nor have any statistical estimates of the return period of the flood event been made.

The current OPW Flood Relief Work Programme is indicative of the extent of the problem (see Appendix 15). Many of the locations in the Programme are major urban centres where the risk of damage from flooding must be regarded as high. The Programme has been expanding in recent years with consistent representations from local authorities and property owners to include more areas.

1.4.5 Recent Extreme Events

A number of extreme events have occurred recently in both the UK and Europe (e.g., Easter floods 1998 and November 2000 floods, UK; flooding in August 2002 in central Europe; recent catastrophic flash flooding in Italy and France, etc.). A very small number of particularly extreme events have occurred in Ireland in the past 20 years, notably Hurricane Charlie, the East Coast tidal floods of February 2002 and the recent Tolka flooding in November 2002 (See Table 1).

1.4.6 Flood Defences

Flood defences exist in a large number of locations throughout Ireland. These date from several centuries ago to modern defences. They may be either natural features or man-made and they vary in scale from small stonewalls to extensive sand dune systems.

Flood defences may not be recognised for what they are until they fail or are interfered with. In many cases these defences have not been identified or centrally recorded.

1.4.7 Deficiency Of Risk Information

The above clearly identify some of the gaps in information on the risk of flooding at present. These gaps include information on areas at risk of flooding, the probability of flooding occurring, the probable damage which might be suffered, and the defences that are in place.

The records available at present may also be unreliable because of the following factors:

- Climate change may increase the probable floods
- New developments and infrastructure may increase the risk of flooding
- The hydraulic capacity of channels may be altered locally.

It should further be noted that in some cases remedial works might have been carried out to reduce the risk of flooding at locations identified in Maps 1 to 5 (Appendix 17). The flood incidents are, however, still identified in the maps.

1.5 Impacts of Flood Events

In order to quantify the negative impact of severe flood events, an objective method of assessment is required. Traditionally this is done by analysing tangible (i.e. direct economic) and intangible impacts.

Tangible impacts can be defined as those which are readily susceptible to measurement in monetary terms and, by and large, easily recognisable as being direct consequences of flooding.

Intangible impacts are those related impacts, which, despite their seriousness, are not always as readily measurable in monetary terms and may not be as clearly attributable to a flood event. This includes environmental damage.

Table 2: Potential Negative Flood Impacts (not in order of importance)

Tangible	Intangible
Damage to properties, commercial, residential, industrial, agricultural, institutional etc.	Immediate risks to life and health of residents
Damage to contents	Loss of memorabilia or pets
Clean-up costs	Disruption in services, transport etc.
Evacuation costs	Worry and stress at time of flooding (event worry and stress)
Alternative accommodation costs	Ongoing worry and stress caused by the fear of future flooding (post-event worry and stress)
Costs of restoring public services	Long-term health effects
Costs of providing emergency public services	Loss of public services
Disruption of commercial activity	Environmental damage e.g. habitats, archaeology etc.
Increased travel costs	Loss of amenities
Business losses and loss of income	Reduction in personal capacity
Loss of property values (including agricultural land).	

1.5.1 Tangible Impacts

In general terms tangible impacts on residential, commercial, industrial and agricultural properties and lands resulting from flooding are considered in financial terms. Flooding of properties can affect the buildings themselves or their contents. These impacts are usually valued by the costs of building repair and contents replacement. Contamination of floodwaters by sewage, chemicals, etc. and the presence of seawater can greatly increase the damage caused by flooding. Additionally, non-property related tangible impacts might also occur. Public utilities, such as electricity, communications and transport, may be directly affected through damage to infrastructure. Residents or visitors to flooded residences and road users generally may incur additional transport costs, if road flooding causes diversions. Finally, if commercial establishments are flooded, they may have to close temporarily, leading to loss of business, income and profit. By their nature, tangible effects are susceptible to measurement.

1.5.2 Intangible Impacts

Intangible impacts, by virtue of their subjective nature, are far more difficult to calculate, as they are often more personal to the victim, with the severity of the impact dependent upon the individual's specific relationship with the loss or damage resulting from the flood. Probably one of the more demonstrative examples of the varied nature of intangible impacts relates to trauma, stress, anxiety and their negative impacts on health. These can range from loss of life to post-event stress related problems. There can also be an economic impact on the community in terms of lack of investment or loss of morale.

Furthermore, intangible impacts can often be considered more detrimental to flood victims, as it is possible for them to continue developing over a considerably longer period of time. A typical example of this is the anxiety and stress that residents and property owners may experience in the post-flood period, because of the ongoing fear of further flooding events.

Because of the difficulties involved in assessing and calculating intangible impacts, the OPW has traditionally adopted a conservative approach by measuring these impacts as the equivalent of residential property damage.

There is little information readily available on the measurement of impacts of flood events on the environment.

1.6 Financial Implications

The economic cost of flooding in Ireland is difficult to quantify without a detailed economic analysis. This is not possible within the timescale set out for the Group to report. The following merely represents the readily available identified costs but is useful in establishing an order of magnitude for the financial implications of flooding.

1.6.1 OPW Studies

The estimated annual average damages for current studies lie in the range of approximately €250,000 to €2.6m, with a mean value of €1.1m. The locations that are currently subject to flood relief studies would, however, be expected to be those with greatest levels of risk. It is therefore assumed that a national average value for all flood risk locations of €250,000 would be reasonable.

In excess of 300 locations are known to be at risk from some degree of flooding, as noted in Section 1.4. It is likely that other locations are at risk from flooding but have not flooded in the recent past and as such have not been reported. It will, however, be assumed that only 300 locations are at risk.

The product of these figures (€250,000 multiplied by 300 locations) provides an estimated national annual average flood damage of €75m. Appendix 14 provides more detailed discussions of this issue.

1.6.2 Humanitarian Aid

The State's immediate response to recent flood events has been the provision of humanitarian aid. The cost of the programme to date is as follows:

Table 3: Humanitarian Aid Payments 1995 - 2002

Year	Amount Paid
2002	€13.5 million
2001	€2.25 million
2000	€1.78 million
1999	€2,500
1998	€0.16 million
1997	€0.22 million
1996	€0.71 million
1995	€0.95 million

The above figures include payments made under the separate Home Relocation Scheme (a scheme initiated in 1995 and which has resulted in expenditure of €1.05 million).

Furthermore, various state agencies would have incurred costs directly as a result of the flood events and in relation to remedial measures required. The Dept. of Communications, Marine & Natural Resources provided funding for the repair of coastal defences relating to tidal flooding in 2002.

1.6.3 Costs to Local Authorities

Comprehensive information on the costs incurred by local authorities for emergency response in the immediate aftermath of floods and the remedial measures required after the event are not available at this time. Dublin City Council has estimated its cost for 2002 flood events are €9 million. The Department of the Environment, Heritage, and Local Government has estimated that costs incurred by local authorities following the November 2000 floods amounted to €11.5 million.

1.6.4 Insurance Costs

The Irish Insurance Federation has estimated that the cumulative cost to the industry of the three serious flood events in recent years (November 2000, February 2002 and November 2002) was €138 million. This figure is likely to understate the true cost of these events, as it would not include the impact on infrastructure and transport systems and the consequent effects on commercial activity.

1.6.5 Required Datasets

In attempting to evaluate the existing or potential national economic impact of flooding arising from extreme meteorological events, the following datasets would be required:

- Establish the extents of area affected
- Identify all assets within the affected areas
- Identify the economic value (damage and loss values) attached to same
- Examine the current flood defence level provided.

In conjunction with the above datasets, a pragmatic methodology needs to be developed to quantify the damages, both tangible and intangible, arising from the flood events. This would be a major research undertaking and is outside the scope of this Review.

1.7 Conclusions

The causes, extents and impacts of flooding, or, more importantly, of real or potential flood damage, are manifold and complex, with human activity or inactivity often causing an increase in the risk of damage from flooding. Notwithstanding this fact, the fundamental issue regarding the unpredictability of the weather must always be borne in mind, and with that, the realisation that the 'flooding problem' can never be fully resolved, but merely managed in such a way as to minimise its impact on society. In looking to the future, the impact of climate change will be significant and requires research.

Management of flood risk requires the gaps in information identified in relation to flood extents to be addressed. Many areas that may flood in the future have not been identified to date as extreme events have not been recorded in living memory. Indicative flood risk models need to be developed to ensure that the appropriate prioritisation of risk is applied in using available resources. The development of a standard uniform database identifying the scale of flood risk on a national basis is important.

Research is required into the impact of flood events and associated costs and environmental impacts must be quantified in order to assist in the prioritisation of flood defence programmes and the development of appropriate emergency action plans. The research should also focus on the identification of mitigation measures at all levels, from individual members of the public to central government, to reduce the damage sustained in flood events.

FLOOD POLICY REVIEW FINAL REPORT

2

CURRENT ROLES AND RESPONSIBILITIES OF THE MAIN STATE BODIES

2. INTRODUCTION

The purpose of this Section is to outline the current roles and responsibilities of each of the main State stakeholders and to identify and outline some of the main difficulties or obstacles encountered by each of these stakeholders in their efforts to deal with the flooding problem. It also attempts to provide some insight into the organisational arrangements and methodologies currently employed and to identify inherent weaknesses. This process has helped to inform the recommendations of the Review Group in Sections 4,5, and 6 and to identify current practices which are no longer sustainable. It is not within the remit of the Review Group to review the role of non-statutory stakeholders. However, it will be seen later in this Report (Section 4) that the new policy and framework for its implementation provides for participation by all stakeholders.

2.1 The State

While property owners in general and riparian owners (i.e., property owners whose curtilage is either bordered or traversed by a watercourse) have particular responsibilities in relation to the prevention of flooding and protection of their own property, the State has traditionally played a major role both in dealing with the effects of flooding and taking action to minimise the risk of future flooding.

There is no statutory duty on any State or other authority to prevent flooding and, given that flooding is a naturally occurring phenomenon, it would be inappropriate to try to impose such a duty. There is, of course, a strong case for ensuring that adequate powers are available to allow State intervention in the most appropriate manner to reduce the risk of flooding.

The State has historically discharged its role through a number of Departments and Offices, in particular the Office of Public Works (OPW), the Department of the Environment, Heritage, and Local Government (DoEHLG), local authorities (L/A), the Department of Communications, Marine and Natural Resources (DCMNR) and the Department of Agriculture and Food (DAF). This Section gives a brief overview of the current roles of these organisations and identifies some perceived difficulties in relation to the effective discharge of those roles identified by the organisations themselves or in submissions from other parties to the Review Group.

2.2 The Office of Public Works

The current statutory authority and responsibility of the OPW in relation to arterial drainage and flood relief arises primarily from the Arterial Drainage Acts, 1925, 1945 and 1995.

2.2.1 The 1995 Act

The most recent change in the Commissioners' role was as a result of the Arterial Drainage (Amendment) Act 1995. This Act amended the 1945 Act and empowered the Commissioners to undertake works designed to relieve flooding in localised areas without having to undertake work throughout a river basin, as had been the position. This change recognised that urban flooding had become a significant problem and signalled a move away from land drainage. The Act does require, however, that in drawing up a scheme the Commissioners must have regard to the impact throughout the river basin.

2.2.2 Earlier Schemes

It is important to acknowledge that while the schemes undertaken under the provisions of the 1945 Act were designed primarily to provide adequate outfall for land drainage and thus were not specifically intended to provide urban flood relief they have in fact provided considerable protection to many urban areas in those river basins where they were executed.

2.2.3 Principal Powers and Duties of the OPW

- a) The OPW has power to design, and, subject to the approval of the Minister for Finance, to execute arterial drainage and flood relief schemes.
- b) The OPW is responsible for maintaining completed drainage and flood relief schemes which it has executed.
- c) The OPW has power in certain circumstances (Section 29 of the Arterial Drainage Act, 1945) to undertake maintenance of drainage districts, where they consider such maintenance is not being properly carried out by the responsible local authorities.
- d) The OPW's consent is required (Section 47 of the Arterial Drainage Act, 1945) for the erection, alteration or enlargement of a weir (other than by the ESB) except under specific conditions.
- e) The OPW has power (Section 48 of the Arterial Drainage Act, 1945) to require the

occupiers of land to restore, open up and generally put into proper repair and effective condition any watercourse on their land which discharges into an existing drainage district. If the occupier fails to act, the Commissioners have power to carry out the work and recoup the cost.

- f) The OPW's consent is required (Section 50 of the Arterial Drainage Act, 1945) for the construction, restoration or alteration of bridges (including culverts) by a local authority, railway company, canal company or any similar body and by any industrial concern.
- g) The OPW has power to remove bridges which have been altered, constructed or restored in contravention of Section 50.
- h) The OPW has power, subject to certain conditions being satisfied, to make compulsory drainage orders at the request of any Minister of State or local authority. The effect of a compulsory drainage order is to overcome the unreasonable withholding of consent to essential drainage works by an owner or occupier of land.
- i) The OPW now plays an active role in representing Ireland at EU level in discussions and initiatives relating to flooding. In addition, the OPW services the Irish National Committees of the International Hydrological Programme and the International Commission on Irrigation and Drainage.
- j) The OPW has power (Section 2.1 Commissioners of Public Works (Functions and Powers) Act, 1996) to make schemes or other arrangements for the provision of assistance, whether in the form of money, living accommodation, land or other property of any kind to persons who suffer hardship or personal injury or loss or damage to land or other property by reason of flooding. This Act also gives the OPW power to undertake development. These powers have so far not been invoked to facilitate Flood Relief works.

2.2.4 Current Activities

The current activities of the OPW are outlined here, concerning maintenance, Flood Relief Schemes, hydrological data collection and humanitarian aid.

2.2.4.1 Maintenance

The OPW is responsible for the maintenance of schemes completed under the 1945 Arterial Drainage Act and flood defence schemes completed under the 1995 (Amendment) Act. The Office currently maintains over 12,000km of channels and in excess of 700km of

flood defence embankments. Maintenance referred to under the 1945 Act includes:

- The maintenance of river channels in a condition that ensures they are free-flowing, thus reducing flood risk and providing adequate outfall for land drainage
- The maintenance of river and estuarine embankments in a condition that protects benefiting land, to the extent defined in the scheme, from risk of flooding
- The maintenance, repair and/or replacement of all structures forming part of a scheme, including accommodation bridges, weirs, sluice barrages, sluices, pumping stations and tidal flap gates.

Channels and embankments are maintained at design level. This affords considerable protection from waterlogging and flooding. It does not, however, provide full immunity from flooding in all circumstances. Wherever flood levels exceed the design conditions flooding may occur. However, the extent and duration of such flooding should be considerably less than would otherwise be the case.

2.2.4.2 Flood Relief Schemes

Where engineering works are deemed necessary to resolve a flooding problem, the OPW procure, either internally or through consultants, the necessary engineering, hydrological, environmental and other expert services needed to design an appropriate scheme and to take it through the statutory processes. Schemes must generally be cost-beneficial, based on an evaluation process agreed with the Department of Finance. They must also satisfy stringent environmental impact assessment criteria.

Engineering flood relief measures normally considered would include:

- Flood containment – construction of walls, embankments, etc. in order to keep the river in its channel or in a designated flood area. Sluices and pumping may be required for tidal risk and low-lying areas
- Increasing flow capacity – increasing the conveyance capacity of the channel and/or structures through the lining, deepening, widening, realignment or maintenance of channels, or the addition, removal or modification of channel structures
- Retention / storage upstream – development of an area where floodwaters can be stored
- Diversion – this measure involves either the diversion of part of the flood flow (flood relief channel, by-pass channel) or the redirection of the entire river (full channel

diversion).

Securing the maximum possible environmental benefit, while minimising any adverse environmental impact, is a central consideration in selecting the most appropriate option or combination of options when engineering works are being contemplated.

2.2.4.3 Hydrological Data Collection

The OPW has had an involvement with hydrometry (the measurement and recording of level and flow in watercourses) for well over 100 years in connection with its activities in the fields of arterial drainage and flood relief. It maintains the most comprehensive library of historic hydrometric data in the country. Data is presently collected at over 340 hydrometric gauging stations throughout the country.

Local authorities, the Electricity Supply Board and the Environmental Protection Agency also collect hydrometric data in connection with their own responsibilities. This data is made available to the OPW when required, in connection with the investigation and remediation of flooding problems.

2.2.4.4 Humanitarian Aid Administration

The OPW has been involved in recent years in the operation of two distinct types of humanitarian aid schemes, providing assistance to people who have suffered considerable hardship as a consequence of flooding.

- Home Relocation Scheme

As a once-off measure and in recognition of the devastation caused by the effects of flooding, particularly in the South Galway area, the Government by decision of 19 July, 1995, decided to establish a Home Relocation Scheme, for the most severely affected persons/families. The Office of Public Works devised and managed the scheme and all related activities.

- Grant Aid Scheme

The Government also decided on a number of occasions in recent years to establish a special Humanitarian Relief Fund to assist victims in the aftermath of major flooding events. These schemes were also funded through the OPW, which arranged for the

distribution of the funds by the Irish Red Cross Society, which has considerable national and international experience in this area. Expenditure on these Schemes is detailed in Section 1 (Para. 1.6.2).

2.3 Main Difficulties

2.3.1 Financial Resources

Table 4: Actual expenditure on flood relief activities 2000 -2003

YEAR	ACTUAL EXPENDITURE
2000	€5,405,000
2001	€10,867,000
2002	€17,616,000

As stated above, the OPW is aware that approximately 300 locations throughout the country are susceptible to flooding to an extent that may give rise to damage. An accurate estimate of the cost of addressing all of these areas is not available. However, the estimated capital cost of the limited number of projects currently in the OPW's Flood Relief Work Programme is approximately €300 million (See Appendix 15). This gives some indication of the potential size of the problem.

The provision for this work in the OPW's Vote for 2003 is €19.9 million. This allocation relates solely to capital expenditure and does not make any provision for other activities such as the administration of humanitarian aid schemes. Clearly, the annual provision, even if maintained at 2003 levels, means that the current programme will take a considerable number of years to implement.

2.3.2 Human Resources

Current capital expenditure and related commitments already stretch the human resources of the OPW. Any future increase in responsibilities or requirements resulting from this report, including flood hazard mapping or additional capital projects etc., will require increased human resources if they are to be implemented within a reasonable time.

2.3.3 Environmental Considerations

Early arterial drainage schemes are perceived as having caused significant environmental damage especially to fisheries and wetland eco-systems and their support functions for aquatic ecosystems. This perception is almost certainly correct. There has been considerable growth in general public awareness of the importance of environmental protection in recent years and the OPW has responded positively to this in its channel maintenance activities. For several years the OPW has sponsored and partnered with the Central Fisheries Board in the development of methodologies to protect, remediate and enhance fisheries. Likewise, it consults with DoEHLG and environmental groups as to the timing and extent of general maintenance activities. The OPW also consults fully with the appropriate environmental protection groups and the DoEHLG in the design of flood relief schemes. Full Environmental Impact Statements in relation to schemes are prepared and published where appropriate. Notwithstanding this, it is acknowledged that there is concern about the impact of flood relief schemes on the environment. This concern would tend to support a move away from intrusive civil engineering projects, where possible.

2.3.4 Legislative Restrictions

The OPW currently operates within a legislative framework, which imposes very detailed procedures in relation to design and exhibition of proposed Flood Relief Schemes, regardless of the size and nature of such schemes (see Appendix 8). The legislation as it stands effectively prohibits it from carrying out emergency works, which by their nature often do not allow time to first undertake a full design process. Innovative working arrangements with local authorities, described elsewhere in this Section, have overcome the problem in certain areas recently. The OPW considers, however, that while the existing legislation may be appropriate in the case of major schemes, it is desirable that there should be a legislative framework, which provides for it to act in its own right if necessary in urgent or emergency cases. This framework should also provide for a post-works environmental assessment where urgency has not made it possible to do so in advance.

There is currently no legislation in existence that would enable the OPW to undertake maintenance either on a once-off or ongoing basis, without having first executed a Flood Relief Scheme. In the UK the Environment Agency has the powers to undertake maintenance on this basis and it is recommended that this approach should be adopted in Ireland.

2.3.5 Prioritisation of Schemes

Prioritisation of schemes is fraught with difficulty. New flood events and recurrence of previous events constantly give rise to demands for immediate action. This makes it very difficult to maintain a set programme of works with finite financial and human resources. Public pressure and political imperatives make a consistent prioritisation methodology difficult to sustain, particularly immediately after flooding has occurred. There is a need for a clear strategic approach to the management of flood risk, which will be robust enough to respond to the type of reaction that invariably arises in the immediate aftermath of a flood event. The approach needs at the same time to be flexible enough to deal with genuine emergency situations.

The establishment of a clear methodology, which prioritises all response measures, can best meet these objectives. This will facilitate the openness and transparency that will help to build public confidence in and acceptance of the system.

2.4 Department of the Environment, Heritage and Local Government (DoEHLG)

The DoEHLG has a direct role in flood management through its work in promoting legislation on environmental protection and planning and development, funding of urban drainage under the Water Services Programme and providing policy guidance and funding to local authorities. However, there are no funds available to the Department to meet expenditure incurred by local authorities as a result of flooding.

2.4.1 Planning

The Planning and Development Act, 2000 provides that local authorities, through their Development Plans, can regulate development in areas at risk of flooding.

The DoEHLG, in cooperation with the OPW, is currently drafting Guidelines for Planning Authorities on Development Plans.

2.4.2 Emergency Response

The Department's primary concern is to ensure that when adverse conditions arise, local authorities (including the fire services) are able to respond promptly and effectively to help offset the worst effects in relation to those aspects for which they have direct responsibility. A circular is issued annually reminding local authorities of the need to revise and update, as necessary, their contingency plans for dealing with the consequences of severe weather conditions, bearing in mind certain aspects such as arrangements to take necessary action arising from early warning from Met Éireann, necessity to be pro-active as regards public relations and availability of equipment and stocks.

After the November 2000 flooding, during which a number of local authorities activated their Major Emergency Plans, an Inter-Departmental Committee (IDC) on major emergencies was established to review the response of the relevant organisations to the severe flooding and to identify any improvements which might be made for the future.

A questionnaire was issued to the main local authorities (City and County Councils) in February 2003 seeking information in relation to the plans and arrangements they had in place to deal with severe weather emergencies (e.g. flooding, snow, storms). From the replies received, the DoEHLG can confirm that all local authorities have plans in place for dealing with flooding and have worked to put the recommendations of the IDC into effect. This means that emergency response personnel have equipment and stocks, e.g. pumps, sandbags etc., available to assist local communities in flooding situations and that local authorities have arrangements in place for issuing accurate and timely information to the public.

2.4.3 Water Framework Directive

Several of the submissions received by the Review Group have urged that the flooding problem must be tackled in the context of the implementation of the EU Water Framework Directive (2000/60/EC). While the Directive is aspirational rather than prescriptive in relation to action on flooding, this approach to dealing with the problem is accepted in principle by the DoEHLG. This view is echoed by our EU partners and has resulted in the formulation of a Best Practice Document outlining the issue of flooding in a European context and in particular its role within the Water Framework Directive (see Section 3).

The DoEHLG chairs the Steering Group charged with implementation of the Water

Framework Directive in Ireland. The Department of Finance, the OPW, the Department of Agriculture & Food, the Department of Communication, Marine & Natural Resources and local authorities are among the organisations represented on the Steering Group. Each organisation retains full responsibility for work coming within its remit.

The Environmental Protection Agency chairs the Working Group on Hydrological aspects of the Directive.

2.4.4 National Parks and Wildlife Service (NPWS)

(i) Legislative Basis

In addition to the Wildlife Acts, 1976 and 2000, EU Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, together with EU Directive 79/409/EEC on the conservation of wild birds, obliges the Minister for the Environment & Local Government to ensure the maintenance of the favourable conservation status of habitats and species, particularly in designated areas. The NPWS of the Department of the Environment, Heritage & Local Government implements this obligation on the Minister's behalf.

(ii) Habitats

The main involvement for the NPWS is in monitoring habitats and species and securing their conservation either directly or through the provision of advice to other authorities or the public. Habitats include turloughs, fens (which are often very sensitive to water level fluctuations) as well as lakes, rivers, bogs, and important flood plain habitats such as the Shannon Callows. Among the species concerned are wetland birds, salmon and other species of fish and protected invertebrate species such as freshwater pearl mussel and crayfish.

(iii) Assessments

There is a need for all relevant authorities to ensure that appropriate environmental impact assessments are carried out of proposed developments that are liable to have an adverse impact and to consult the NPWS on such assessments. Projects can be approved if there is unlikely to be a significant negative impact on the ecological value of sites or on grounds of overriding public interest, particularly involving public health and safety. In assessing proposals for new Flood Relief Schemes there is need to include environmental issues in

any cost-benefit-analysis.

The contribution of wetland eco-systems to flood attenuation needs to be formally recognised. Likewise, attention should be given to the potential for creating or restoring wetland eco-systems damaged or lost through past activities, as a positive contribution to flood management.

2.5 The Department of Agriculture and Food (DAF)

2.5.1 The Role of the Department of Agriculture and Food

The Department of Agriculture and Food does not have any direct role in the prevention of flooding. The Department has from time to time at the request of Government allocated funds to alleviate difficulties arising from inclement weather and/or flooding which resulted in serious crop/livestock damage or loss; made saving of winter fodder impossible; repeated flooding of farmyards as in the Gort area of Galway. The total amount paid under this type of Government funding in the period 1985 –1999 was approximately €75 million.

2.5.2 The Irish Land Commission

There is a perception in some quarters that the Department of Agriculture and Food as successor to the former Irish Land Commission, has responsibility for the maintenance, repair or restoration of certain riverbanks, embankments, or other works to prevent flooding. This is not the case.

However, arising from the acquisition of certain estates, the former Irish Land Commission retained a portion of the purchase money due to the estate owner for the ongoing maintenance and upkeep of embankments on those estates. These retained funds were entrusted to the Public Trustee, who is now an officer of the Department of Agriculture and Food.

The Public Trustee has responsibility for the investment of these funds and the income earned may be applied for the specific purposes described in the trust deed for each estate. In the context of an ongoing or perpetual trust, it is established practice that the capital sum should not be used for general repairs except in very exceptional circumstances.

(i) Public Trustee Funds

The office of Public Trustee was set up by Section 52 of the Irish Land Act, 1903 and is governed by various Land Acts (Public Trustee Rules 1904, 1908, 1927, 1947, 1973). The Public Trustee is only responsible for the funds referred to above and only in respect of areas subject to a trust fund.

The Public Trustee is protected by the wording in the individual deed of trust governing the operation of the trust fund for each estate. The usual wording is:

It is hereby agreed and declared that nothing herein contained to the contrary shall render the Irish Land Commission or the Public Trustee liable for the misapplication or non application of the trust funds or the income thereof or of any part thereof or for any damage or loss which may occur directly or indirectly out of the trusts hereinbefore declared of and concerning the said trust funds or by reason of the state of any estate works or any flooding or other damage which may occur by reason thereof or impose any obligation on the Irish Land Commission or the said Public Trustee to see to the upkeep or maintenance of any of the said estate works hereinbefore provided for.

In many cases no Public Trustee trust funds were established. In the absence of an overall drainage policy, the Land Commission did from time to time provide financial assistance on an ex gratia basis in those cases when the repair work was beyond the competence and resources of the person involved. At that time Land Commission intervention was justified by their concern that security for advances under the Land Acts would not be jeopardised. Many of these advances have since been repaid, so that justification no longer exists.

The Land Commission/Minister for Agriculture and Food still has land awaiting allotment and it is possible that there are embankments on this land that they would still own. However, this is unlikely, as it is mostly bog land or other non-agricultural land.

In summary, the role of the Department of Agriculture and Food as successor to the Land Commission is to administer the trust funds. However the amount of such funds is generally small and wholly inadequate to maintain the various embankments.

2.6 Department of Communications, Marine and Natural Resources (DCMNR)

2.6.1 Coast Protection Act, 1963

The Department of Communications, Marine and Natural Resources is responsible for matters affecting the coastline. As part of its general remit for marine matters, the Department operates a coast protection scheme, with Exchequer funding provided via the annual Appropriation Act, in conjunction with local authorities who contribute towards the cost. Works undertaken under that scheme, some directly by the Department, have included protection of coastal areas from flooding (e.g. repair of tidal embankment in 2002 following collapse during high tides in February 2002). The Department has not operated the Coast Protection Act, 1963 (No 12), which is of limited scope and unsuited to present-day requirements.

2.6.2 Foreshore Acts, 1933 and 2003

The Department administers the Foreshore Acts 1933 to 2003 which specifically empower the Minister for Communications, Marine and Natural Resources to ban or otherwise restrict the removal of beach material or activities which would disturb the seashore (which includes the foreshore and every beach, bank and cliff contiguous thereto). Prohibitory Orders and Notices have been issued as required in order to protect important amenities. These Acts require the formal granting of permission to undertake works and activities on State-owned foreshore (the vast majority of foreshore) and for certain works on other foreshore, and for the deposit of material on any foreshore or seashore. Those Acts are being comprehensively reviewed in the context of new legislation being prepared for coastal zone management.

2.6.3 National Coastal Protection Strategy Study

In 2002, the Department began a fundamental review of coastal protection requirements with a view to adopting a more long-term strategic, structured approach to the issues involved. Consultants have been appointed to assist in this process. The review will examine policy options and set out a basis for effective decision making in regard to resource allocation. Fundamental to this will be preparation of a national database specifying the nature of the coast, its vulnerability to erosion or flooding and the nature of the hinterland in terms of economic, heritage and environmental assets.

2.7 Local Authorities

2.7.1 Introduction

Local authorities have a pivotal role in the response to flooding and are the organisation with the best overview of flooding at local level.

2.7.2 Local Authority Functions

There is a significant level of interdependency between the OPW and the local authorities. In more recent years, in fact, the OPW has adopted a policy of seeking to undertake flood relief schemes only where they are sponsored by the relevant local authorities. This has resulted in local authorities becoming more pro-active in the promotion of schemes and undertaking preliminary studies, in some cases availing of full or part funding from the OPW.

Other functions of local authorities, which impact, directly or indirectly in the areas of flood prevention, flood protection or flood relief are planning; relief/protection works; sewerage works; drainage and emergency response.

2.7.3 Planning

The Planning and Development Act, 2000, Section 10 (3), First Schedule, Part 1, Section 6, enables local authorities to provide in their Development Plans that development in areas at risk from flooding may be regulated, restricted or controlled.

It is normal practice for a planning authority to take measures to minimise the risk of flooding if a development is proposed in an area where it is aware that floods have occurred. For example, the authority can require that the finished floor levels of buildings in a development be above the storm water level, or ensure that the optimal storm water drainage layouts are put in place. Planning authorities would also liaise closely with the OPW in relation to the types of measures to be put in place.

Under the Planning and Development Act, 2000, a local authority can designate areas as flood-risk areas, and if development is proposed in these areas, the risk to the development of being flooded can be carefully evaluated and permission refused, if necessary. The new provision in the Act was included specifically because of the

possibility of increasing numbers and intensity of floods arising out of climate change. Both coastal and river flooding is included.

If permission for development is refused in areas at risk of flooding, that refusal will not attract compensation (whether or not the area is designated in the development plan).

2.7.4 Relief/Protection Works

The Local Authorities (Works) Act, 1949, Section 2, states: 'Where a local authority is of the opinion that land or structures have sustained, or are likely to sustain, damage from flooding, landslide, subsidence or similar occurrence, the authority is enabled to carry out relief or protective works'.

The extent to which local authorities have operated this provision is not clear. However, in the absence of a funding mechanism to support such works, and in view of the lack of a comprehensive range of ancillary provisions in the Act, e.g. acquisition and compensation mechanisms, it is unlikely to have been utilised to any significant extent.

Works covered by this Act include making drains, removal of obstructions in watercourses, widening/deepening of watercourses, making/repairing walls/embankments and diversion of water into watercourses.

In a number of recent instances, e.g. the Tolka River in Dublin City, County Meath and Fingal area, local authorities have undertaken urgent flood relief works availing of the powers in the Act. In a number of cases the OPW has provided the funds for the works and in some cases has carried out construction work on behalf of the relevant local authority. In order to provide a public consultation process in respect of these urgent flood relief works, the so-called Part 8 procedure in the Planning and Development Regulations 2002 has been used by the local authorities, thus allowing an opportunity for public comment without unduly delaying the works.

These arrangements have been found to work well where there is a general consensus about the need for the works and access to carry them out is not a contentious issue. Local authorities have been more reluctant to proceed in this way where some opposition is likely and the procedures (e.g. for acquisition of / interference with land, compensation, etc.) to deal with it, though present, are not fully developed in the Act

The provisions in the Act are generally considered operable only to deal with emergencies and where there is a general consensus about the need for a scheme.

A dedicated source of funding for such works might facilitate greater use of this procedure.

2.7.5 Sewerage Works

(i) Purpose

The Sanitary Services Acts and the Water Services Investment Programme are relevant here. Local authorities undertake public sewerage/drainage schemes. The Water Services Section of the Department of the Environment Heritage and Local Government (DoEHLG) grant-aids these schemes. They are not designed to provide direct flood relief measures, but only to cater for the run-off from development, streets and the surcharging of drainage networks in built-up areas.

(ii) Considerations

Where public sewerage/drainage schemes are being planned, consideration should be given to whether there is a need for flood relief works and the possibility of economic, environmental and other benefits if both were combined.

Public sewerage/drainage schemes should, where appropriate, build in sufficient spare capacity to cater for future development.

2.7.6 Drainage Districts

Many local authorities have a statutory responsibility for maintenance of Drainage Districts under the Arterial Drainage Act, 1925. A major difficulty for local authorities in fulfilling this obligation has been lack of adequate funding. Only minor investment has been possible and many Drainage Districts have fallen into disrepair.

2.7.7 Emergency Response

(i) Activities

The local authorities are generally the principal agency dealing with the immediate response to a flood event. The authorities have an excellent record in coping with these situations. The task of responding to a flood event is a multi-faceted one and the measures required vary from one situation to another. However the emergency response generally features some or all of the following activities:

- Provision of sandbags or other defensive equipment where floods are predicted
- Evacuation of people trapped in houses, etc.
- Co-ordination of medical services if required
- Provision of temporary accommodation for victims
- Control of traffic
- Emergency works to stabilise or replace walls, footpaths, bridges, or other structures
- Checking of electrical and gas systems before the ESB or Bord Gais will restore supply
- Health and safety issues
- Security issues
- Waste management issues
- Communications
- Overall control at the scene
- Clean-up when floods have receded

(ii) Other Agency Involvement

The involvement of other agencies with suitable equipment is a key issue in the response to floods. This has been done by activating the Major Emergency Plans, which brings agencies like the Army, the Health Boards, Irish Coast Guard, etc., into operation. It also enables a local authority to re-deploy staff from core statutory duties such as Waste Management, Road Maintenance, Housing Maintenance, to assist in the aftermath of a flooding incident. Formal debriefing after incidents occur has significantly improved performance following the recent flooding events.

(iii) Emergency Response Resources

As with all other bodies, the key issue for local authorities is ensuring the availability of adequate resources. Local authorities have indicated that, apart from the provision of emergency accommodation, the cost of which is recouped to them by the DoEHLG, all other costs incurred by them in providing an emergency response to flood events have to be met from their own resources and this puts pressure on their ability to provide their normal range of services.

2.7.8 The 1948 Sanitary Services Act

The 1948 Sanitary Services Act empowers, but does not oblige, a sanitary authority to remove any obstruction from rivers or watercourses to prevent injury to public health or amenities. Local authorities generally do not have the resources, equipment or expertise required to deal with this matter, particularly in the current tight financial situation. It is generally accepted that failure to put in place regular cleaning and maintenance of rivers and watercourses was a contributory factor in some recent flooding.

2.7.9 Prioritisation of Local Authority Functions

Local authority functions in relation to flooding are carried out in the context of their role as multifunctional agencies, taking into account the relevant statutory provisions and the need for reasonable balance between the various services for which they are responsible within the resources which are available. Section 69 of the Local Government Act, 2001, requires local authorities in performing their statutory functions to have regard to certain matters such as the availability and effective use of resources; maintenance of essential services; achievement of reasonable balance between functional programmes; Government or Ministerial policy; the need for co-operation, co-ordination or consultation with other public bodies; high environmental standards and sustainable development and the need to promote social inclusion.

2.8 Conclusions

2.8.1 Resources

There is a need to ensure that adequate funding is allocated in the future to enable programme advancement whether in relation to capital works, ongoing maintenance of completed flood defences or the provision/preparation of emergency response programmes. Whilst it is acknowledged that any demands for increased exchequer funding will be subject to intense scrutiny, it is regarded as being imperative if a strategic approach to flood management, comparable to that in other EU States, is to be adopted in Ireland.

2.8.2 Maintenance Responsibilities

There are a substantial number of watercourses for which no State authority currently has legislative responsibility from a flood management point of view, e.g. the River Shannon. There are also a substantial number of embankments providing protection from flooding, mainly from tidal inundation at river mouths. There are approximately 320 miles of so-called Land Commission embankments. While maintenance of many of these structures is unlikely to be justifiable on economic grounds, there are some where even a moderate degree of failure could result in damage to roads, buildings or businesses and considerable loss and hardship in local areas as well as environmental damage e.g. to habitats, sand dunes etc. There may be others, most likely only a few, where a more catastrophic failure could result in very substantial damage.

2.8.3 Clarity of Roles

Measures are required to ensure that there is no overlap between responsibilities of the OPW and the DCMNR in situations where flood management involves both tidal and fluvial elements.

2.8.4 Prioritisation of Flood Relief Works (OPW)

Given the extent of the OPW Flood Relief Programme and the availability of funding, there is a pressing need for the OPW to review its policy for these schemes. Options including small-scale structural works combined with non-structural measures could be given more weight. Some form of prioritisation criteria to target investment also seems appropriate.

2.8.5 Flood Relief Works – Environmental Considerations

In its assessment of new capital projects, the OPW should consider how it could provide for measurement of environmental costs and benefits in its Cost Benefit methodologies. The OPW should also, as a matter of course, have regard to the value of wetland ecosystems in flood management.

2.8.6 Legislative Issues

Current legislation under which the OPW operates is restrictive in that the Office is not empowered to carry out works or maintenance unless a Scheme has been developed in accordance with the legislation. This is a long and complex process.

The legislative basis under which local authorities carry out flood relief works needs to be strengthened.

2.8.7 Planning and Development

There is a clear need for greater recognition of flood management issues in the planning and development process.

2.8.8 Humanitarian Aid

The provision of humanitarian aid has developed in an ad hoc manner. Criteria are needed for initiation of schemes and distribution of aid.

FLOOD POLICY REVIEW FINAL REPORT

3

INTERNATIONAL BEST PRACTICE

3. INTRODUCTION

The approach to the management of flood risk varies significantly between different countries. The arrangements in a particular country would be expected to have evolved according to the national (or federal) and local government structures, and the development of semi-state agencies or authorities. It would not be appropriate to define a structure from another country as a model of best practice for Ireland, as each must fit within the wider institutional structure of its own country.

It is considered, therefore, more appropriate to examine the most recent developments at a strategic level in the area of flood risk management and what is currently recognised and accepted as international best practice. The implications of the Water Framework Directive on flood management are also examined.

3.1 International Best Practice

International best practice in flood prevention and mitigation is contained in two documents:

a) Guidelines on Sustainable Flood Prevention (2000) and b) Best Practices on Flood Prevention, Protection and Mitigation (2003).

- i) The Guidelines on Sustainable Flood Prevention were produced by the United Nations and the Economic Commission for Europe (UN/ECE) and were adopted by the Parties to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes in March 2000. The character of the Guidelines is strategic rather than technical; they aim to recommend measures and best practices to prevent, control and reduce the adverse effect of flood events on human health and safety, on valuable goods and property, and on the aquatic and terrestrial environment. The Guidelines are intended to assist the Parties to the Convention and other UN/ECE countries in developing and implementing sustainable measures and good management practices for flood prevention and protection that take account of economic, environmental and social considerations.
- ii) The second document has been produced as a result of a decision taken at an

informal meeting of the Water Directors of the European Union, Norway, Switzerland and Candidate Countries held in Copenhagen in November 2002 when they agreed to take an initiative on flood prediction, prevention and mitigation arising from the catastrophic flooding in Central Europe in August 2002.

A core group led by the Netherlands and France has prepared a best practices paper on flood prevention, protection and mitigation, which was presented to the most recent Water Directors meeting in Athens in June 2003. This document is an update of the UN/ECE Guidelines on Sustainable Flood Prevention.

The Water Directors agreed the following:

- The need for a reinforced political commitment to flood prevention and flood protection
- That integrated river basin management is the tool of choice to address flood prevention and flood protection
- That EU funding mechanisms could be powerful and effective instruments for promoting investments in flood prevention schemes. Funding of such schemes would be conditional upon the existence of integrated flood prevention plans at the level of the river basin.
- That it was desirable to improve and promote at EU level co-ordination and information exchange regarding floods
- That EU research programmes could make a significant contribution towards the prediction and prevention of floods
- EU action on flood prediction and prevention could take a variety of forms:
 - 1) Informal guidance documents
 - 2) Council conclusions/recommendations
 - 3) A Commission Communication with associated Council conclusions
 - 4) An EU action plan on flooding
 - 5) Legislative proposal (framework directive).

There was no consensus among the Water Directors as to the form of future EU action; however, it was recognised that while the form of EU action was an important issue, the content was the primary consideration.

The best practices paper aims to describe measures and best practices to prevent, protect and mitigate the adverse impact of flood events on human health and safety, on valuable

goods and property, and on the aquatic and terrestrial environment. The character of the best practice document is strategic rather than technical.

The key issues are discussed below:

3.1.1 Integrated River Basin Approach (River Basin Flood Risk Management)

Experience has shown that effective measures for flood prevention and protection have to be undertaken at river basin level and that it is necessary to take into account the cumulative effects of individual measures implemented along watercourses. The need for both a river basin and an integrated approach are very clearly spelled out in the best practices document:

It is absolutely necessary to organise the water management systems and improve forecasting, flood defence measures and crisis management on a river basin basis, cutting across regional boundaries and country borders.

For flood prevention and protection, a good mix of structural measures and preventive measures are necessary: building codes and legislation to relocate structures away from flood-prone areas, appropriate land-use, adequately designed floodplains and flood control structures, planning, mitigation, early warning systems, correct risk communication and preparedness of the populations how to act during flood.

The best practices paper recommends that all envisaged measures concerning flood prevention and protection should be compiled in an integrated and comprehensive action plan covering up to several decades.

An integrated river basin plan (developed for each river basin) is a tool which ensures permanent and integrated planning of functions and use of the river basin, and specifies principles for its organisation and co-ordinates investment activities and other activities affecting the river basin. Such a plan should:

- Draw long term conclusions for preventive action in water management, settlement policy and finance
- Define the scope of responsibilities in the flood protection system at levels of the

government and local administration, responsibilities of the public (individuals) and business companies.

The plan should cover all relevant aspects of water management, physical planning, land use, agriculture, transport and urban development, nature conservation at all levels (national, regional and local). In the development of a flood management plan, decision makers at all levels as well as stakeholders and civil society should be involved.

River basin flood management plans have been, or are being, developed in a number of countries both within and outside of the EU. International examples of application are given in Appendix 1 (Section 3).

3.1.2 Public Awareness, Public Participation and Insurance

It is clear that problems associated with floods are often not sufficiently recognised and acknowledged. It is essential, therefore, that all those in a potential flooded area are aware of the flood risk and take it into account. To be aware of a risk means to have recognised it, to know about it, not to forget or repress it, and to take it into account appropriately when acting.

The best practices document recommends that a communication plan to offer individuals an understanding of the nature and scope of the risks should be developed. The public should be actively involved in this process as it is recognised that all measures linked to public information and awareness raising are most effective when they involve public participation. The relevant authorities should ensure that the information concerning flood prevention and protection plans is transparent and easily accessible to the public. This can be achieved by:

- Developing flood hazard maps (see below) that are easily readable and show the different hazard levels, including the worst-case scenario. Information based on Geographical Information Systems (GIS) should be widely diffused and explained
- Keeping alive flood awareness through information and education
- Disseminating information early and actively, and not only on request.

The public should become aware that there is a need to restrict uses, such as for industrial, agricultural, tourist or private purposes, in areas at risk of flooding to reduce the

potential for damage. Information about restrictions on construction in flood areas should be easily accessible and easily understood. It is recommended also that the public should be encouraged to take their own flood prevention measures and be informed on what to do during flood events. This would be achieved by publishing and disseminating practical guides, maintaining regular training actions and a continuous information strategy.

3.1.2.1 Flood Hazard Mapping

Flood (extent) hazard maps have been widely developed and implemented throughout Europe and in other countries around the world. Such maps indicate the areas of land or property that have historically been flooded, or that are considered to be at risk from flooding. Flood hazard maps are used as the basis of consideration and determination in land use control and flood awareness and preparedness. Their importance in the area of flood risk management is illustrated by the following quotation from the best practices paper:

Flood hazard maps point out areas at risk and are necessary for planning. Maps must be easily readable and show the different hazard levels. They are necessary for the co-ordination of different actions. Flood maps should be used for the reduction of damage potential by integrating its outputs into spatial planning and emergency planning.

Flood hazard maps are presented in a range of formats (from restricted access hard copy to freely available digital format via the internet), with varying mechanisms for presenting risk areas (different colour coding, frequency description, etc.). Flood hazard maps include historic as well as potential future flood events of different probability, illustrating the intensity and magnitude of hazard at a selected scale.

Historic Flood Hazard Mapping

Due to its limited geographical coverage and variable event frequency, this is generally not used as an end product, other than as supplementary information to predictive maps.

Predictive Mapping – Single Frequency

This type of mapping is common, with maps produced that indicate the predicted extents of a single flood event frequency. The flood extents are predicted using a range of techniques, such as hydraulic modelling, and are generally indicative rather than definitive. Examples are the Section 105 maps in the UK (100-year fluvial event and 200-

year tidal event) or British Columbia, Canada (200-year).

Predictive Mapping – Multiple Frequency

This is similar to that described immediately above, but with two or more flood event frequencies indicated, i.e., showing a graduation of risk. Examples include Tasmania (20-50- and 100-year extents) or USA (100-and 500- year extents).

Predictive Mapping – Undefined Frequency

These maps define areas of risk in some format other than by event frequency or return period, such as 'high' or 'low', but are in fact generally derived from frequency-based maps, insofar as the term 'high risk' is generally associated with a flood frequency which has not been explicitly stated.

Non-Extent Hazard Mapping

Flood maps can be produced for flood hazards other than historic or predicted flood extents. Such hazards might include depth of flooding, flow velocities, health hazards, economic risk, etc. Flood hazard maps of this nature have been developed in Switzerland, where land has been zoned into areas of large, medium, low and residual danger degree of hazard (with associated planning restrictions) according to the level of risk from any of three different hazards (inundation extent, bank erosion and debris flow).

More information on flood hazard mapping is available in Appendix 3.

It should be noted that Flood Risk Mapping incorporates information on land usage and hence the potential damage that flooding could cause, as well as identifying flood hazard (normally extent) information (risk combines elements of probability and severity of damage, rather than hazard i.e., the cause of damage).

3.1.2.2 Insurance

In addition to public and individual measures, insurance can be an important factor in increasing the awareness and reducing the financial risk for individuals, businesses and even whole societies where natural hazards, such as flooding, are concerned.

A range of approaches to flood insurance has been adopted by different countries. They range from obligatory to completely voluntary coverage and from all-risk policies to flood-

only policies. There are advantages and disadvantages in all these concepts and none can be declared the best. In a study of different national approaches to flood insurance within the EU Dr. Jens Mehlhorn of Switzerland (The Future of Flood Insurance in Europe, (2003)) made the following points:

- Effective and sustainable flood cover is technically possible, but requires partnership between the state, the insurance industry and the individual, with each bearing certain responsibilities in relation to risk reduction.
- A large risk community (through, for example, compulsory insurance for all, or flood insurance incorporated as a standard part of property insurance with some risk differentiation) is preferable to a small community in terms of economic viability of the insurance scheme.
- Risk assessment (i.e., flood hazard information) is important for a sustainable insurance scheme.

The final point reinforces the requirement for flood hazard mapping by insurance companies when designing a premium structure. Flood risk zoning information is required also by re-insurers so that they can calculate the expected losses that the insurance industry might face as a result of an extreme event threatening a company's existence.

The best practices paper points out that insurance companies can make an important contribution towards loss reduction by raising the willingness of home and business owners to defend their property against flood damage. The motivation for the insured to take measures aimed at loss reduction would be reflected in adequately structured premiums.

It might be noted that in some countries flood damage arising from surface water runoff or inadequate or blocked storm water drainage systems exceeds that arising from fluvial and tidal inundation. Flood risk and insurance requirements are therefore not limited to river or seaside properties, but are relevant to most properties, and particularly those in urban areas.

3.1.3 Research, Education and Exchange of Knowledge

While much EC-funded research in recent years has addressed many issues of relevance to flood management, this research has been set mostly within the context of a broader

programme of science on understanding natural hazards and hydrogeological risks. It is widely acknowledged that more research on floods is necessary, particularly in the areas of modelling, data sharing and forecasting. An improved understanding of the climatological, hydrological, ecological and landscape context of floods is a prerequisite in flood management, and especially in developing flood mitigation strategies.

Research per se is of little value to the general public unless the knowledge and understanding gained is implemented in practice. The outcome of such research, therefore, should be the development and establishment of best practice measures. In addition, engineers, scientists, ecologists and others involved in flood management require continuing professional development and training, and opportunities for exchanging knowledge and experience gained through both national and international co-operation.

3.1.4 Flood Relief Measures (Non-Structural and Structural)

It is now internationally recognised that mitigation and non-structural measures have a greater role to play in flood management than formerly, when the emphasis has been on structural measures. Non-structural measures are considered to be potentially more efficient solutions and in the long term more sustainable, but structural measures (defence structures) will remain important elements in mitigating the effects of flooding.

The premise behind this shift in emphasis arises from the acknowledgement that rivers need space and that as far as possible human interference with the processes of nature should be prevented in the future. Rather than concentrating on defensive action, the current best practice approach is, where practicable, to live with floods through management of the risk. For example, it is recommended that human uses of floodplains should be adapted to the existing hazards, and appropriate instruments and measures should be developed to reduce the risk of flooding.

In addition, the best practices paper recommends that efforts for avoiding flood problems should be focused in urban areas where the greatest concentration of population and property are located. It is also recognised that there is a responsibility on the individual who may be at risk from the consequences of flood events to take, if possible, his/her own precautions. However, appropriate information and forecasting systems would need to be put in place by the competent authority.

This current thinking in relation to flood management measures is illustrated by the following international examples:

- a) In England, the Environment Agency (EA) is currently in the process of changing its flood defence policy from one of building flood defences to that of managing flood risk. Existing flood defence policy emphasised the development of flood warning systems and construction of urban and coastal flood defences. The EA's first priority will now lie with targeting investment at reducing risk to people and infrastructure identified in river basin plans. This will be closely followed by reducing flood impacts where they occur. Flood warning systems will continue to be developed, with a greater focus on accuracy and reliability.
- b) The Netherlands, following a series of serious flooding incidents in the early to mid 1990s, has introduced a number of policies and strategies including:
 - Space for the River' – a policy of permitting the river to utilise its natural winter floodplain area, and restricting development within such areas to river-dependent uses.
 - Repair, maintenance and possibly setback of embankments along the designated floodplain areas.
- c) In Germany, Federal Laender have developed a manual for, and promote the development of, Flood Action Plans. These plans set out measures required to minimise the risk of flood damage, reduce high water levels, strengthen the awareness of flooding and improve flood information. The plans are centred around a policy whereby floodplain management and sustainable planning and development have priority over flood protection works.
- d) A federal law passed in Switzerland in 1991 stated that 'protection of human lives and substantial economic values should be achieved in the first order by means of maintenance of river courses, second by land use management and in third order, if the above mentioned means are not sufficient, by structural protection measures'.
- e) The Russian Federation has a framework flood-protection programme (in stages up to 2015) that emphasises, inter alia, improvements to forecasting and warning systems.

3.1.4.1 Climate Change

One very important issue that needs to be considered when assessing future flood relief measures is the impact of climate change globally on sea levels due to thermal expansion and locally on future precipitation levels and river run-off.

Climate is the average of weather over a certain time span and area. It incorporates many different elements, including temperature, wind speed and direction, precipitation, cloudiness and many other quantities which describe the state of the atmosphere. Climate comprises both the mean values and the variability of these quantities over time. The time scales involved can be from weeks to millions of years. However, the World Meteorological Organisation (WMO) generally uses a 30-year averaging period. Climate changes with location and with time. Climate change is a statistically significant change in the mean state or variability of climate which lasts for a long time (decades or longer). Climate change may be due to internal processes, external forcings or due to man's activities or any combination of these.

The probability of increased extreme weather events leading to flooding is expected to increase, as global mean temperature increases as a result of global warming. The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001) predicted an increase in global mean temperature of between 1.5 and 4.5 degrees Celsius per decade. Based on this assumption, the sea is expected to rise by 9cm to 88cm by the year 2100. The precipitation pattern will also change. Humid areas will generally become more humid, and arid areas more arid. The amount of precipitation will also fluctuate more sharply, meaning, in general, a greater probability of flooding. The IPCC report suggests with high confidence that, if greenhouse gas emissions remain unchanged, there will be increased flood damage due to more intense precipitation events by 2025, a further increase by 2050 and flood damage several fold higher than 'no climate change' scenarios by 2080.

A range of international (IPCC, 2001) and national (Sweeney et al, 2003) research programmes has been initiated to consider the implications of climate change, with follow-up assessments of impacts on flood risk and flood defence works. In terms of best practice, it is more appropriate to consider policies for coping with potential change than examining the relative merits of different research programmes.

The issue of climate change and its implications for this country has been considered most

recently in a major report published by the Environmental Protection Agency (Sweeney et al, 2003). The report, 'Climate Change: Scenarios and Impacts for Ireland', was prepared for the EPA by NUI Maynooth as part of the Environmental Research Technological Development and Innovation Programme 2000-2006.

The research findings indicate that over the next half-century significant climate change can be anticipated in Ireland. While considerable uncertainty remains with respect to future climate conditions, the impacts of climate change are likely to be significant in certain key areas such as agriculture, water resources, coasts, marine and the natural environment. The report provides a perspective as to how changing climate may necessitate changes in current practices, and that forward planning is needed now for adaptation to climate change in Ireland.

A preliminary study of the impacts of climate change on flood risk in Ireland has recently been undertaken, on behalf of the OPW, and is presently being considered. The impact of climate change on the design of flood relief works is currently under development, and this is discussed in Appendix 8.

3.1.5 Land Use, Zoning and Risk Assessment (Planning and Development Control)

It is recognised internationally that inappropriate planning and development in a river basin may be a significant factor in adding to the flood risk. The more intensively and the less suitably a river basin is used, the greater the potential for damage when the flood occurs.

Water management policy and spatial planning efforts in the long run must concentrate on attaining a balance between economic development and urbanisation on the one hand and the need to allocate more space to water for flow retardation and water retention on the other hand. Best practice recommends that water must become a guiding principle in spatial planning. Specific key points in the best practices paper relating to preventive land use are:

- Immediate flood plains should be identified and designated by law as priority sites for flood retention or to restore mobility to waterways.
- Building development in the immediate areas at risk of floods, landslides or dam

failures should be stopped if unacceptable risks to human lives or material damage exist.

- All installations, works, construction work and hazardous or hazard-prone activities and uses in designated areas should be subject to administrative permits or authorisations. Restrictions and prohibitions should be based on risk assessments. Moreover, incorporation of an activity may not impede the retention, storage or drainage of water in the river basin area and should be guided by the underlying principle that water-related problems may not be passed downstream or from one part of the river basin to another.
- Vulnerability diagnoses should be generalised to existing industrial and commercial companies, real estate development managers, drinking water production or water treatment facilities, farms, etc. located in flood-prone areas. This is in order to assess the consequences of high-water incidences and to propose measures enabling their reduction, to produce flood emergency plans and to develop preparedness to the risk by training exercises.
- The most sensitive establishments, such as buildings, facilities and installations whose operation is fundamental to civil safety, defence or maintaining public order, or whose failure presents a high risk to humans or presenting the same risks due to their socio-economic importance, must be implemented on the nearest no-risk-prone areas. Only activities that are inextricably tied to the water management system or cannot be implemented elsewhere for reasons of important societal interest should be permitted.
- Existing constructions at risk of flooding should be made flood-compatible for all water-related problems. In some cases construction and reactive measures, with economic justification, can contribute more to damage reduction than other natural water retention measures and technical flood protection. In potential flood plains, the forward planning and approval stages of further construction work should take account of new and creative construction methods that incorporate the need to maintain space for water and address water-related problems.
- It is necessary to identify and reduce the vulnerability of existing infrastructures and all networks located in flood-prone areas (water supplies, energy systems, transportation and communication networks, public facilities, etc), and particularly transport network which may suffer massive interruptions or hinder the evacuation and the arrival of emergency services.

It might be noted in the context of the above that the United Kingdom has a well-developed policy in relation to planning and development in PPG25 that encourages development outside of flood risk areas, but is not prohibitive if no other appropriate site can be found.

Further information on the interaction between flood risk and planning and development control is given in Appendix 6.

3.1.6 Early Warning and Forecast Systems

Flood warning is an internationally proven non-structural method of reducing the impacts and damages caused by flooding. Key points in the best practices paper relating to early warning and forecast systems include:

- Flood forecasting can be effectively combined with other measures for flood prevention such as retention, land use and structural measures.
- A timely and reliable flood warning and forecasting system, depending upon consistent hydro-meteorological basins rather than on sectors, is one of the basic conditions for an improvement of the protection against floods.
- An effective early warning and forecasting system for extending the reaction time should be supported by meteorological information and the earliest possible warning of extreme weather conditions.
- Teams of forecasters should be, where possible, composed of meteorologists, hydrologists, hydraulicians and even crisis managers, capable of providing 24-hour a day, 365-day a year monitoring and forecasting.
- An effective and reliable system of flood forecasting and warning dissemination should be set up to inform flood authorities and citizens in threatened areas.
- Dissemination of information is a highly diversified activity that requires significant experience under local conditions.
- The possibility of climate change in decades to come further emphasises the need for early warning and flood forecasting.
- A compatible meteorological and hydrological information system and database, if possible with a fully automated data communication system, should be created for the entire river basin.

There are many specific flood forecasting and warning programmes in operation internationally. Flood warning is usually operated at a central government level through regional offices of a hydro-meteorological organisation. For instance, in the United

Kingdom, the EA has the lead responsibility in issuing flood warning, which is administered through central and regional offices. The Met. Office issues the various degrees of warning (flood 'watch', 'warning' and 'severe warning') during televised weather forecasts, while automated warnings are also issued to emergency response organisations, the media, nominated individuals, private individuals known to be at risk, and other relevant targets. In Australia, the Bureau of Meteorology, a national agency covering all six states, is responsible for issuing forecasts of heavy rainfall and for issuing flood warnings for non-flash flood river basins. The Bureau has offices in each state.

More information on flood warning is available in Appendix 12.

3.1.7 Flood Emergency

A well-structured emergency organisation is vital in order to be able to cope with flood emergencies. Evacuation and rescue services prevent casualties. The best practices paper recommends that comprehensive national and local contingency plans to respond to flood events should be properly prepared in due time and maintained in operational status. These plans should cover the crisis management before, during and after the flood event.

Among the recommendations are:

- The personnel of the organisation responsible for the maintenance and the operation of defences should establish, maintain and train an effective organisation for flood emergency operation.
- After a flood event, experienced feedback should be organised and a report produced including recommendations for improvements.
- Victim assistance and rescue should systematically include psychological support administered by operational skilled units, whose activity should extend for several months after the event.

3.1.8 Prevention of Pollution

There may be considerable environmental, health and financial consequences if floods affect water distribution and sewage systems. Preventive measures should therefore be taken to reduce possible adverse effects of flooding on these infrastructures. In flood-

prone areas, preventive measures should also be taken to reduce possible adverse effects of floods on aquatic and terrestrial ecosystems, such as water and soil pollution. For example, hazardous substances should be stocked outside the flood risk area or stored well above flood levels. The best practices paper recommends that an emergency plan should be in place to manage and operate against the harmful impacts of water pollution on ecosystems during floods.

3.2 The Water Framework Directive and Flood Management

Directive 2000/60/EC of the European Parliament and of the Council establishing a Framework for Community Action in the Field of Water Policy, known as the Water Framework Directive (WFD), came into force on 22 December 2000. It provides a new system for the protection and improvement of Europe's water environment – its rivers, lakes, estuaries, coastal waters and groundwaters. Its main innovation is the requirement that water be managed in an integrated way. The Directive has a wide scope and the provisions apply to all of the European Member States.

While the Directive is a complex document, comprising 26 Articles and 11 supporting Annexes, its central aim is clear – to ensure that the water environment across Europe is the subject of truly sustainable management. This is set out in Article 1 (Purpose), which states:

'The purpose of this Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwaters which:

- (a) Prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems
- (b) Promotes sustainable water use based on a long-term protection of available water resources
- (c) Aims at enhanced protection and improvement of the aquatic environment inter alia through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances
- (d) Ensures the progressive reduction of pollution of groundwater and prevents its

- further pollution, and
- (e) Contributes to mitigating the effects of floods and droughts’.

The implementation of the Directive is based on the idea of river basin management. At the heart of the Directive is the requirement to produce comprehensive river basin management plans that will help to deliver good water quality for each river basin, explaining how the objectives that have been set for the water bodies within the river basin are to be achieved. The plans must be based on a detailed analysis of the pressures on the water bodies within the river basin and an assessment of their impact. This allows a comprehensive programme of measures to be drawn up, tailored to the specific circumstances in the river basin and targeting improvements and monitoring effort on those water bodies which are most at risk of failing to meet their objectives.

Although one of the objectives of the WFD is to mitigate the effects of flooding, the Directive sets no prescriptive action in relation to flooding. The EU has confirmed that Member States have no firm obligations in relation to flood relief and that the Directive relates primarily to water quality issues.

It is widely recognised at European level (‘Precautionary Flood Protection in Europe’, International Workshop, Bonn, February 2003) that there is a need to clarify the role of the WFD in flood protection, which is currently not explicitly addressed in the Directive. The issue is, however, addressed indirectly, given that the Directive demands that there be no further deterioration of river systems. While a stated goal of the Directive is to reduce the impact of floods, precautionary flood protection measures are not specifically prescribed.

One of the outcomes of the Bonn Workshop was the opinion that the implementation of the WFD in Europe could be used as a ‘window of opportunity’ to strengthen ecologically oriented sustainable flood protection. The role of wetlands and floodplains in mitigating the effects of flooding is becoming increasingly recognised. This was highlighted in a number of the submissions received in response to this Review. The WFD provides the framework for the incorporation of flood management into river basin management plans, and these plans should be based on an integrated approach covering all relevant aspects of water management.

The Department of the Environment, Heritage and Local Government chairs the Steering Group charged with implementation of the WFD in Ireland. This group has representatives

from relevant Government Departments, their related technical agencies and local authorities. No new authorities will be set up to implement the Directive and there will be no transfer of functions between authorities. Each organisation retains full responsibility for work coming within its remit. Implementation will be based on co-ordination of the activities of existing authorities, with the assignment of new functions where necessary. Local authorities will have the primary role in promoting, establishing and implementing the arrangements required under the Directive, with one local authority taking the lead within each river basin district.

3.3 Summary

Flood events are a part of nature. They have always existed and will continue to exist. In addition to this certainty, the probability of flooding is expected to increase as a result of climate change. There is now an increasing realisation that we must learn to live with flood events. A change of paradigm is required, with a move from defensive action against the flood hazard to management of the flood risk and living with floods.

Important conclusions and recommendations regarding sustainable flood prevention, protection and mitigation included in the most recent best practices paper are:

- The focus in dealing with floods should be on management of the risk and living with floods rather than on defensive action against the hazard.
- Flood strategy should cover the entire river basin area and promote the co-ordinated development, management and conservation of actions regarding water, land and related resources.
- A river basin flood risk management plan should be based on an integrated approach covering all relevant aspects of water management, physical planning, land use, agriculture, transport and urban development, nature conservation, at all levels (national, regional and local).
- This holistic approach to flood risk management requires interdisciplinary co-operation regarding all phases of risk management: risk assessment, mitigation planning and implementation of measures.
- Human uses of floodplains should be adapted to the existing hazards.
- Mitigation and non-structural measures tend to be potentially more efficient and long term more sustainable solutions and should be enhanced, in particular to

reduce the vulnerability of human beings and goods exposed to flood risk.

- Structural measures (flood defence structures) will remain important elements and should primarily focus on the protection of human health and safety, and valuable goods and property.
- Efforts for avoiding flood problems should be focused on urban areas (where the major concentration of population and goods are located).
- Everyone who may suffer from the consequences of flood events should take (if possible) their own precautions. To this end, appropriate information and timely and reliable flood warning and forecasting systems should be established by the competent authority.
- A specific preparedness to alert, rescue and safety measures should be planned, implemented and maintained at all levels.
- In flood-prone areas, preventive measures should be taken to reduce possible adverse effects of floods on aquatic and terrestrial ecosystems, such as water and soil pollution.

This integrated, holistic, river basin based approach to flood risk management complements the Water Framework Directive.

FLOOD POLICY REVIEW FINAL REPORT

4

FUTURE POLICY PROPOSAL

4. FUTURE POLICY PROPOSAL

4.1 Existing Position

As discussed in Section 1, flooding is a natural phenomenon, influenced by human activities, that has caused widespread damage, both tangible and intangible, across Ireland, particularly in recent times. Given current predictions on the impact of climate change and continuing pressures for development, the frequency and severity of flooding, and consequently the damage caused, is likely to increase significantly.

Historically, flood relief in Ireland had concentrated on the improvement of the agricultural production potential of lands through arterial drainage. As discussed in Section 2, the cornerstone of current flood management policy (post-1995 amendment) is the reduction of existing flood risk to urban areas through the implementation of engineered or structural relief works, generally in response to major flood events. While reasonably effective to date, a number of problems and shortcomings in the current practice have been identified; these require attention to enable effective and sustainable flood risk management for the future. These issues, many of which were also identified in the submissions received by the Review Group, include:

- Structural works can be expensive and can have undesirable environmental consequences. Furthermore, as the degree and extent of risk increases, so will the demand for expenditure in this area. The continued heavy reliance on structural measures is therefore not sustainable for the future.
- Non-structural measures, which are not only more environmentally friendly but can also be effective in mitigating the impacts of flood damage as well as being economically advantageous, are considered for specific schemes, but are not being promoted at a national level.
- The implementation of works is localised and does not consider the river basin as a whole, leading to a loss of potential economies of scale, and the possible erosion of scheme benefits by activities in other parts of the river basin.
- The roles and responsibilities of different organisations, particularly in the area of channel maintenance, are not clearly defined, resulting in certain areas of activity not being addressed as well as they should be.

- There are instances where no State Agency appears to have responsibility for responding to flood events in particular locations.
- There are significant information deficits, particularly in relation to the extent and degree of flood risk, which create difficulties in informed decision making.
- There is an absence of guidance and standards with respect to the management of flood risk, particularly in relation to development and construction techniques in flood risk areas.
- Humanitarian aid helps reduce the suffering caused by flooding, but does not reduce future flood risks in any way, and may indeed undermine personal responsibility of individuals and businesses to protect and / or insure themselves against flood damage.
- The approach is retrospective, looking at defences for areas that have already flooded rather than attempting to address problems before they arise.
- The approach seeks only to ease the symptoms of the problem, i.e., reduce flood damage, rather than address the causes of flooding.
- The current approach is therefore not considered to be appropriate or sustainable for the future, and it is evident that a new policy is required.
- Best practice documents prepared by the EU (2003) and UN/ECE (2000) have been reviewed in Section 3. A strategic approach based on planning and managing risk through the assessment and control of human activity, rather than attempting to control the natural forces, has been widely accepted internationally as best practice.

4.2 Policy Considerations

The recognition that flood risk cannot be eliminated, but merely reduced, clearly identifies the need for a policy that manages the risk (current and future) in the most effective manner. Planning to minimise potential future increases in risk by addressing the causes of flooding would be an essential component of such a policy, while all available options (structural and non-structural) should be considered for managing the existing risk.

It is proposed that future policy should seek to minimise the national level of exposure to flood damages through the identification and management of existing, and particularly potential future, flood risks in an integrated, proactive and river basin based manner:

- An integrated approach is one through which all aspects of flood risk management are

brought together to facilitate the evaluation of flood risk, present and future. Issues such as local development control, regional development plans, social and environmental impacts and public education campaigns are all considered in parallel and in a systematic manner to enable the planning of long-term management strategies and holistic solutions to flood risk problems alongside the development of local flood relief measures.

- A proactive approach is forward looking rather than reacting to past floods. It involves evaluating existing risk, managing human activities to avoid damages arising from that risk, and simulating potential future scenarios (e.g., increased development, climate change) to predict, and hence permit, management of any potential additional or increased future risks. The approach promotes risk management and flood impact mitigation practices for risk areas in advance of floods (and flood damage) occurring, rather than implementing measures in reaction to a flood, i.e., after significant damage has been done.

- A river basin based approach looks at flood risk management throughout a river basin rather than concentrating on localised points. It promotes the evaluation of all aspects of the chain of events and conditions that give rise to flooding, components of which are often geographically remote from the location where the flood problem manifests itself. It also has the advantages of offering economies of scale, both in analysing and mitigating risk at possibly several flood-risk areas at the same time, and of lending itself to potentially economic solutions such as flood warning (which is intrinsically river basin based).

This approach is broadly in line with current international best practice, and follows recommendations provided by the European Union (EU, 2003) and the United Nations (UN/ECE 2000) as outlined previously in Section 3 and summarised above.

Similar considerations apply in the area of coastal flooding, where policy should seek to minimise the national level of exposure to flood and erosion damages through an integrated, proactive and coastal zone approach.

It is suggested that a river basin based policy is the one which can be most effectively and efficiently achieved in the long term by the implementation of non-structural measures, e.g. clear planning and development control guidelines to minimise additional future risks, flood awareness, education and preparedness, the use of flood warning systems, the identification of flood risk, appropriate research and development. Structural measures

would, however, continue to have a role in addressing existing problems where the above measures would not be effective and where certain prioritisation criteria are met.

4.3 Proposed Future Flood Relief Policy

Based on the considerations outlined in sections 4.1 and 4.2 above, it is recommended that the future flood relief policy should seek to minimise the national level of risk of loss of life and / or damage to property and personal well-being that might arise from flooding and to do this in a sustainable and cost-effective manner through the integrated, proactive and river basin based management of existing and potential future flood risk, and the mitigation of the impacts of flood events through non-structural, as well as structural, flood relief measures.

As stated at the outset in section 1.1.1 flooding in this context means unusual or severe fluvial or tidal flooding. It does not include flooding arising from stormwater and surface water runoff, nor from roads, which are the responsibility of local authorities and/or the National Roads Authority (NRA) under the aegis of the Department of the Environment, Heritage, and Local Government. For practical, common sense reasons it must also be clear that flooding in the present context does not include small scale or short term localised events, which, although possibly causing inconvenience, do not pose a risk to persons or property.

4.4 Requirements for Policy Delivery

Due to the existing shortcomings in the area of flood relief, most notably the information deficits and lack of clarity in roles and responsibilities, the above policy could not be implemented immediately, and considerable work is required to achieve a position whereby the policy could be delivered upon. The availability of appropriate resources for the implementing agencies will be a prerequisite for this.

By considering the information, organisational arrangements and functional capabilities necessary for the delivery of the new policy, it is possible to identify the current gaps and deficiencies. This, in turn, defines the work required to deliver on the new policy. The primary areas where such would be required are outlined below:

- The roles and responsibilities of all relevant organisations and stakeholders must be clearly defined to enable effective management of flood risk. This is likely to require the assignment of new responsibilities to existing organisations, and might involve the establishment of a new organisation and / or legislative change.
- The effective and integrated management of flood risk requires the consideration of all flood-related issues, and their relative impacts and sensitivities. Some form of planning framework will be required under which all issues may be addressed.
- In order to manage existing risk effectively and plan proactively for potential future risk, reliable information in relation to the following will be required:
 - a) Flood hydrology (e.g., expected flood flows and possible changes to the hydrological regime arising from climate change and / or further development, possibly through the development of river basin models)
 - b) The degree and extent of existing flood risk
 - c) The economic, social and environmental impacts of flooding.
 A development programme will have to be drawn up to deliver on these requirements.
- Guidelines and standards are required in relation to planning, development control and construction to ensure sustainable development practices in flood risk areas, and throughout a river basin, and hence avoid increased flood risk in the future. This would include possible land use guidelines relating to agricultural, forestry and peat extraction.
- Strategically planned non-structural flood impact mitigation measures, such as flood warning, awareness and preparedness, and appropriate emergency response must be promoted for the purposes of cost-effectiveness and sustainability.
- Prioritisation criteria need to be developed and applied to expenditure on structural and non-structural activities.
- Residual flood risk must be managed through an appropriate and sustainable balance of personal responsibility, insurance, and emergency (humanitarian) aid.

It is clear from the position outlined above that a planning framework is required to integrate all of the various aspects of flood risk management. Through this framework, the various roles and responsibilities of relevant organisations and specific functions, operational activities and work practices can be clearly defined and developed, and a strategy prepared that defines the range of work programmes required to fill the various information and capability gaps.

4.5 Proposed Framework for Policy Delivery

The policy and necessary capabilities outlined above can be delivered and achieved through an approach based on river basin flood risk management planning, a framework through which the various facets of flood risk management can be integrated and coordinated. This strategy, summarised below and discussed in more detail in Appendix 1, reflects current international best practice, as explicitly concluded by the EU ('For each river basin, a flood management plan should be developed' – EU, 2003), and the UN ('All envisaged measures concerning flood prevention and protection should be compiled in a comprehensive action plan.' – UN/ECE 2000). The approach is under development or has already been implemented in many other countries, including some outside of the EU.

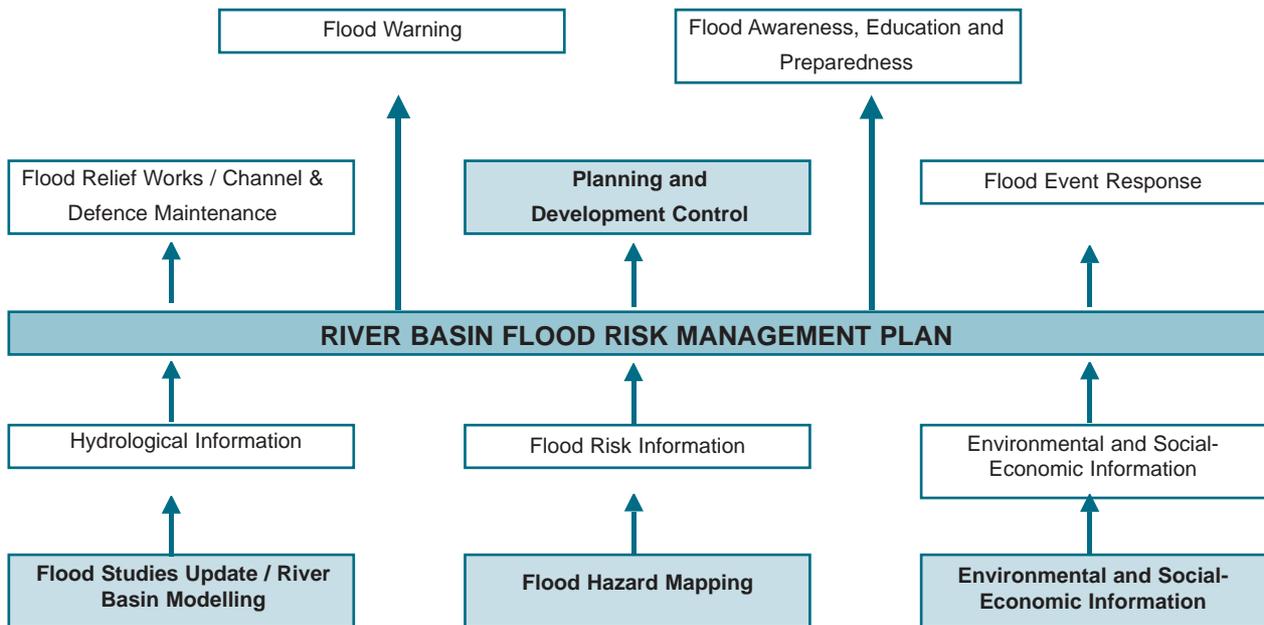
This approach is based on the development and implementation of River Basin Flood Risk Management Plans (RBFMRPs). These Plans would provide a baseline status report and risk assessment of the existing property and infrastructural development and of the economic, environmental and social conditions as they relate to flooding within the river basin. The Plans then set out for the river basin a range of strategies (derived from those set at national level) and operational measures for managing existing and future flood risks.

The primary objectives and advantages of the framework and plans include:

- The provision of a single focal point or management tool through which all aspects of flood risk management can be assessed and planned.
- The integration of all aspects of flood risk management at a river basin level.
- The development and documentation of the strategic management of future risk and planning of future measures.
- The involvement of the all relevant stakeholders (including the local authorities, communities, NGOs, etc.) through a plan review and approval process.

The diagram below (Figure 3) portrays the central role that the RBFMRPs would play in delivering a variety of solutions to meet the objectives set out in the proposed new policy, the principal information needs upon which the Plans are based, and the primary areas of activity in which they can form a key management tool.

Figure 3: The River Basin Flood Risk Management Planning Framework



4.6 Information Requirements

Effective implementation of the approach outlined above in Section 4.5 in Ireland would, however, require the development of adequate information bases and understanding upon which effective management practices can be built. The key areas where information gaps exist that require attention are:

4.6.1 Hydrological information

4.6.2 Flood risk information

4.6.3 Environmental and socio-economic information

Once the relevant information is available within the above areas, the present and future flood risk can be assessed, managed and planned for through the development and maintenance of the RBFMRPs, including works in the following areas:

4.6.4 Planning and development control

4.6.5 Flood relief works

4.6.6 Channel and defence maintenance

4.6.7 Flood awareness, education and preparedness

4.6.8 Flood warning

4.6.9 Emergency response

4.6.10 Humanitarian aid and insurance

The river basin flood risk approach concentrates on rainfall-linked fluvial flooding. The effects of coastal flooding are the same as those of fluvial flooding and the requirements for hazard mapping and flood risk information are the same, as is the need for development control and flood warnings. As pointed out above (section 1.2.4) coastal flooding arises, however, from entirely different, non- rain related, reasons to fluvial flooding. In addition, the issue of coastal flooding is intimately related to that of coastal erosion and protection, and both issues are part of the wider issue of coastal zone management. It is not clear how the issue of coastal flooding can be de-coupled from these other issues and linked to fluvial flooding under a general flooding heading.

Notwithstanding this fact, the Group is conscious that for the purpose of clarity it is important to determine which State Agency is responsible for flood management in all instances. For this reason it is felt that the OPW, given its responsibility for fluvial flooding, should also assume responsibility for flood management at locations where tidal and fluvial influences interface. However, locations solely at risk of tidal flooding will remain the responsibility of the Department of Communications, Marine & Natural Resources.

The Report proposes that, following completion of both the OPW's flood hazard mapping programme and the DCMNR's National Coastal Protection Strategy Study – scheduled to be completed in 2005 – that the OPW and the DCMNR will reassess the above allocation of responsibilities to determine if any changes are required at specific locations.

KEY ISSUES

The three key areas where information gaps exist are identified above (4.6). They are discussed here, with proposals as to how each issue might be addressed, and any associated work programmes required, to achieve the proposed policy.

The various issues will ultimately be managed at the river basin specific level, possibly through the Flood Risk Management Plans described above. However, it is appropriate and more efficient that they would, in most instances, be addressed initially at a national level, and then adapted or applied to local conditions.

4.6.1 Hydrological Information

Hydrological research and development (R & D) is required to fill existing and future information gaps, such as in the reliable estimation of flood flows and fuller understanding of river basin behaviour. This information is necessary to provide a platform from which the various components of the integrated and proactive approach for flood management can be effectively implemented, and to permit informed decision-making in a range of fields. Programmes of necessary research have been identified in the following areas:

- Update of the Flood Studies Report and river basin (hydrological) modelling,
- Analysis of the potential impacts of climate change on flood frequency and severity, and for the management of these risks
- Implementation of a strategic hydrometric monitoring programme
- Meteorological forecasting techniques for flood warning systems
- Development of high-resolution (possibly national) Digital Terrain Models (DTMs) for hydrological and hydraulic modelling
- Development of Information Technology (IT) systems and structures, including Geographical Information Systems (GIS), telemetry systems, data protocols, management structures and systems, etc. for the management of flood-related data and information

This issue is considered in more detail in Appendix 2, where some necessary work packages are also discussed.

4.6.2 Flood Risk Information

The effective delivery of a number of the key issues is dependent on a knowledge and understanding of the extent and degree of flood risk. It is indeed logical that the problem must be identified before it can be addressed. Assessing and mapping flood risk is a practice that was identified as a necessary step in flood risk management in many of the submissions received, and one that is advocated by both UN and EU documents on flood risk (e.g., 'Identification and mapping of ... risk areas should be integrated into land-use planning policies' – UN/ECE 2000).

This is, however, a new area of activity in Ireland, at least at a national scale, and one that would need to be developed under the proposed policy and strategies. To date, the OPW has developed an outline programme for the initiation of a National Flood Hazard Mapping

Programme (see Appendix 3), and has undertaken some preliminary work.

Phase 1 of this project involves the development of a GIS-database system to store and display digital maps displaying flood events and extents based on historic flood data and the associated supporting information. The estimated cost of implementing Phase 1, which should be delivered within two years of initiation, is approximately €2.5 million (depending on the volume of data available and collected).

Phase 2 involves the development of 'Predictive Mapping', covering both rivers and tidal risks. This dynamic information is compiled using national flood hazard datasets and also involves ongoing monitoring of flood events. Dependent on the extent of the mapping undertaken, the cost of compiling a reasonable coverage of predictive mapping is estimated to be between €5-10 million spread over a number of years. It is anticipated that the prioritisation within this phase would be aligned with National Spatial Strategy.

4.6.3 Environmental and Socio-Economic Information

Flood risk management entails a number of environmental aspects, all of which require to be considered to ensure effective protection of the environment. The following issues, discussed in more detail in Appendix 4, need to be considered:

- Land use management
- River basin management
- Biodiversity
- Heritage
- Environmental assessments
- Fisheries
- Protected habitats and species
- Liaison with statutory bodies
- Environmental work standards
- Education
- Legislative compliance

It might be noted that Environmental Impact Assessments (EIAs) are currently undertaken for all significant flood relief schemes. These require a detailed evaluation across a broad range of environmental aspects, varying from landscape, archeological and architectural

heritage, flora, fauna, site activities to pollutant emission controls. Finalisation of the scheme design takes cognisance of the environmental recommendations and mitigation measures are implemented at construction phase.

In recognition of the fact that maintenance works are of a smaller scale as compared to developments described in the First Schedule of the 1989 - 2000 EIA Regulations, it is not foreseen that they have a magnitude of impact to warrant an EIA. In the event of drainage maintenance works impinging on a protected area or species where the impact is deemed likely to be significant on the site's specific conservation aspect, then drainage maintenance works may be adapted to include mitigating measures following an Ecological Assessment.

The existing system for assessing and addressing the impacts of new flood relief schemes and maintenance operations is therefore considered to be generally adequate. There are unlikely to be significant environmental impacts arising from non-structural measures. Some research and river basin specific analysis will, however, be required to enhance the interaction of flood risk management and environmental protection / enhancement, and to permit the development of the RBFRRMPs. This might include:

- Optimisation of the balance of the extent of maintenance works (hydraulic capacity) and the opportunity for ecological sustainability and development
- Identification of existing or possible future flood-related environmental hazards (e.g., chemical or sewerage plants)
- Identification of areas of existing / potential environmental sensitivity to flooding / possible flood relief measures
- Assessment of the contribution of existing wetland ecosystems to flood management
- Potential for future environmental enhancement including the possible role of enhancements such as wetlands recreation and restoration for flood attenuation.

The understanding of the socio-economic impacts of flooding in Ireland is limited or not in the public domain. A programme of research, discussed in Appendix 5, is required to assess the following issues:

- Survey of public perception and awareness of flood risk
- Analysis of the direct economic damages of flooding in Ireland (including the

development of a system for estimating flood damages that is appropriate for Irish costs and circumstances)

- Review of the existing or potential socio-economic impacts of flooding (e.g., restricted development, property prices, insurance cover, impacts on rural communities)
- Analysis of the stress, health risks and other intangible damages potentially arising from flooding / flood risk
- Analysis of the potential economic benefits of flood warning.

4.6.4 Planning and Development Control

Planning and development control has been identified as a key tool in achieving sustainable flood risk management by addressing some of the primary potential causes and influences on the processes of flooding (see Section 1 and Appendix 6). This is a view that has been widely supported within the submissions received and that is recognised internationally.

Primary responsibility within this area of activity currently rests with the local authorities and it is not proposed that this position should change. It is, however, suggested that in the future the responsible body for flood management would play an advisory role in the area of general planning and development control through the development of standards and guidelines for development and planning. The OPW in conjunction with the DoEHLG are currently developing guidelines for inclusion in Development Plans. It is expected that a section within these guidelines will deal specifically with the issue of flood risk. It is foreseen that future guidelines and standards might include the following:

- Guidelines for consideration of flood risk in the preparation of development plans
- Guidelines for development control in flood risk areas
- Guidelines for consideration of flood risk in the assessment of planning applications
- Guidelines for flood proofing of development in flood risk areas
- Standards for stormwater management systems for new developments
- Standards for stormwater management systems for existing developments
- Standards for construction of development in flood risk areas
- Standards of design for construction in channels and flood risk areas (e.g., weirs, culverts, bridges and embankments)

Although responsibility for planning and development control would rest with individual local authorities, it is important under the proposed policy that these matters and potential impacts be considered at a river basin scale.

One approach to establishing an appropriate forum might be through Regional Flood Risk Management Groups (RFRMGs – possibly sub-committees of the Water Framework Directive River Basin District Management Groups). The Groups would provide a forum for the relevant local authorities (and other interested parties, such as the EPA, NPWS, Met Éireann, NGOs, etc.) to discuss and agree River Basin Flood Risk Management Plans, which would be presented for approval and adoption into the development plans of each local authority. This possibility and other stakeholder involvement issues are discussed further in Appendix 7.

Informed decision-making within planning and development control will be reliant to a significant degree on the proposed flood risk identification (flood hazard mapping) programme and hydrological research. It is therefore essential that these programmes be implemented.

4.6.5 Flood Relief Works

Flood relief works have traditionally formed the cornerstone of flood management in Ireland, and will, because effective, non-structural measures will not always be available as solutions, continue to have a role in mitigating the impacts of flooding (see Appendix 8). It is, however, important to stress two important issues to be considered in terms of future policy under this heading:

- (i) International experience points to the development of a two-pronged approach to flood management: the attributing of a far greater level of importance to non-structural flood relief measures, supported, where necessary, by traditional structural flood relief measures. This represents a significant change in emphasis from the current position, as discussed in Section 4.1. Given the imperative to make best use of available resources, it is recommended that the OPW immediately review its current Flood Relief Work Programme to reassess the optimum balance between structural and non-structural measures. Experiences gained from recent works on the River Tolka in Dublin City and County Meath and the Fingal area should also be taken into account.

- (ii) Given budgetary constraints, it is proper that all future expenditure in the area of flood relief will need to satisfy strict prioritisation criteria (this includes expenditure on maintenance of Arterial Drainage schemes and Drainage Districts). It is suggested that the main areas to be considered under this criteria will be risk to life, extent of people / properties affected, economic risk, and environmental implications. The prioritisation criteria will need to be developed in detail as part of the programme of work arising from this Report. However, care needs to be exercised to ensure that these criteria do not create a bias against non-urban areas. Flood events can affect rural areas quite extensively while not necessarily impacting on a significant number of properties. The criteria need to be flexible enough to measure the social and economic costs of this.

The design, implementation and maintenance of flood relief works is currently the responsibility of the OPW, although the local authorities are consulted extensively throughout the process and are empowered to undertake such works independently. In some instances local authorities have also agreed to manage schemes funded by the OPW. Funding for OPW schemes is derived from central government funding, although local authorities also fund smaller schemes if the necessary budgets are not available centrally and the local authorities consider that a problem needs to be addressed urgently. These arrangements are considered to be satisfactory and in line with the proposed policy, and should be maintained.

4.6.6 Channel and Defence Maintenance

The lack of maintenance of channels and defences, or of clearance of blockages from bridges, culverts, etc., has been identified as potential causes of flooding or influences on flood processes. Maintenance is therefore available as a flood relief measure, and is viewed as essential in high-risk areas (see Appendix 9).

Under the new policy it is proposed that a designation system will be introduced. Based on clear prioritisation criteria, rivers, channels and defence assets will be designated as priorities for maintenance and these will be the responsibility of the central State agency (i.e. OPW). It is likely that legislation will be required to give a legal basis to this process.

Rivers and defences that are not designated would remain the responsibility of the riparian

owner and/or other interested bodies, which includes the relevant local authority. Should the local authority consider that the prioritisation criteria have been met, it could seek to have the channel or defence designated.

An asset register of flood defences will need to be developed for the purposes of risk identification and the determination of maintenance priorities and programmes. This matter is discussed in more detail in Appendix 10.

4.6.7 Flood Awareness, Education and Preparedness

As already noted, emphasis in flood relief should shift from structural to non-structural approaches. The impacts of flooding can, depending on the period of warning received and the nature of the properties at risk, be significantly reduced if the emergency response authorities and flood victims are aware of the risk, educated in terms of appropriate action, and are prepared to take such action should a flood occur or warning be received. Programmes promoting awareness and preparedness have been undertaken internationally and found to be cost-effective in mitigating flood impacts, although these are normally dependent on, or linked with, the development and operation of flood warning systems (see section 4.6.8).

This is a new area of activity in Ireland that would need to be developed under the proposed policy and strategies. Discussion of the potential benefits of this activity and how it might be implemented is discussed in more detail in Appendix 11.

The development of material (e.g., public information brochures, guidelines and standards) and the management of a national general awareness campaign (incorporating television / radio / press advertising) would be most appropriately coordinated at a national level. Such material, which would be for public issue, might include:

- General flood awareness brochures and associated publicity material
- Guidelines for preparing for floods
- Guidelines for action in the event of flooding
- Guidelines for flood proofing properties
- Standards for flood protection / proofing products.

However, this functional area also has a strong local dimension involving consultation with the local community, the dissemination of site-specific advice, and the provision of

assistance with preparedness at a local level for individuals and businesses known to be at risk. This aspect of the campaign would require input from the local authorities. Information concerning major flooding incidents should be coordinated nationally and the response delivered locally.

4.6.8 Flood Warning

Flood warning, in association with awareness and preparedness (see above), is a non-structural flood impact mitigation measure. It is an internationally accepted method of reducing flood damages that has been found to be economically beneficial, if appropriately implemented and operated (see Appendix 12 for further detail).

With the exception of a small number of local, and often simple, applications, flood warning systems have not historically been used as a means of flood damage / impact mitigation by either the local authorities or central Government in Ireland. This must be considered as a new area of activity in Ireland that would need to be developed under the proposed new policy. The application of warning systems would however need to be assessed on technical and economic grounds for each site-specific application.

The development of flood warning systems requires specialised technical inputs in terms of rainfall or flow forecasting and the hydrological and hydraulic engineering involved in warning system development, calibration and installation. Less technical inputs are also required for system operation, the dissemination of warnings and initiation of the emergency response plan.

The development of flood warning systems requires an understanding of the risk in the target area, and the hydrology of its river basin area. As such, the implementation of the flood risk identification programme and certain aspects of the proposed hydrological research and development programme would facilitate the widespread establishment of warning schemes.

4.6.9 Emergency Response

Emergency response involves reacting to a flood warning to put in place defences and / or take appropriate action before, during and after the flood event to reduce damages and risk to health and life. As such, this area of activity may be viewed as a non-structural flood

risk management measure.

Local authorities currently share a responsibility with other agencies for emergency services and the development and activation of major emergency plans. In flooding situations, local authorities have generally made significant responses, and co-ordinated local relief efforts. Given the localised nature of this functional activity, it is recommended that the local authorities maintain this responsibility, although guidelines and advice could be provided by the OPW to ensure consistency and implementation of best practice.

Plans for dealing with flood events that might not necessitate activation of a 'Major Emergency Plan' would need to be prepared by the local authorities. These would incorporate consideration of issues such as response procedures to initial, interim and final flood warnings (if available), the deployment of resources to mitigate damage (according to previously identified properties at risk), the installation of temporary or demountable defences (if available), emergency housing availability, post-event clear up operations, etc.

It is noted that the establishment and operation of an effective emergency response plan is dependent to a considerable degree on the implementation of other programmes discussed most notably flood warning and flood risk identification; it is therefore essential that these programmes be implemented.

4.6.10 Humanitarian Aid and Insurance

Humanitarian Aid Schemes have been employed on a number of occasions to relieve hardship arising from flood events. These are currently administered through the OPW. The practice has been to delegate the operation of the Schemes to the Irish Red Cross. The demand for humanitarian aid has continued to rise as the figures quoted in Section 1 indicate.

The Programme was originally introduced in 1995 to alleviate extreme hardship caused by flooding. It is strictly limited in this way and does not extend to hardship caused by extreme weather events other than flooding. As discussed in Section 2, the Department of Agriculture and Food has in the past administered funds allocated by the Government to assist farmers with crop/animal losses arising from severe weather events. The administration of such funds should continue to operate as heretofore.

There is a need to examine a number of issues in relation to humanitarian aid, and the wider issues of insurance and personal responsibility, under a more strategic approach that would overcome the problems identified in previous programmes, including:

- Identification of risk
- Recurring and increasing cost of humanitarian aid programmes
- Criteria to be employed in determining humanitarian aid
- Failure to insure
- Insurance cost
- Uninsurable risk
- Education and personal responsibility for flood impact mitigation
- Emergency planning
- Identification of the role of local and state agencies.

The criteria for determining the allocation of humanitarian aid, and other issues such as the relationship between aid and personal responsibilities, are discussed in more detail in Appendix 13.

On the basis that some level of State aid will be provided in extreme circumstances, the question arises as to which is the most appropriate State agency to administer the Schemes. The administration of aid certainly does not fit well with the OPW's core functions. Following a review of submissions and subsequent discussions with relevant bodies, it is recommended that the option of administering future Programmes of Humanitarian Aid through established support networks under the aegis of the Department of Social and Family Affairs and/or Health Boards be examined. The Community Welfare Officer network could be considered in this context. Further discussion on this issue will be required and is beyond the scope of this Review.

SUMMARY

An integrated, proactive and river basin based approach is required for managing future flood risk. This approach is particularly important in managing development and construction works so as to minimise any adverse impacts. The flood management requirements, guidance and strategies identified or defined through the operation of this new approach can be set out through a River Basin Flood Risk Management Planning framework. Effective implementation of this approach in Ireland would, however, require the development of adequate information bases and understanding, such as improved flood flow estimation techniques, river basin models and flood hazard maps, from which such management could be undertaken effectively.

International experience has shown that the availability of information about the risk of flooding can alleviate some of the negative impacts by enabling people to take precautionary measures. The ready availability of information regarding areas where flooding had occurred in the past can also help avoid inappropriate development, or facilitate people in areas where such development had occurred to be more vigilant and thus avoid or reduce the worst consequences of the flooding. It is clear that the non-availability of flood mapping has severely hampered the provision of adequate flood relief measures in Ireland and added considerably to the negative impact of flooding on Irish society.

This approach is in line with international best practice recommendations, and similar policies, systems and frameworks are being developed, or have been developed in a number of other countries both within and outside of the EU. Within Ireland the implementation of this approach, particularly in relation to the development and maintenance of the River Basin Flood Risk Management Plans, requires clarification of the roles of relevant organisations and institutional and / or legislative change. These issues are discussed in Section 5, where proposals for future organisational structures and responsibilities are also presented.

FLOOD POLICY REVIEW FINAL REPORT

5

PROPOSALS FOR FUTURE ORGANISATIONAL STRUCTURES AND RESPONSIBILITIES

5. PROPOSALS FOR FUTURE ORGANISATIONAL ROLES AND RESPONSIBILITIES

5.1 Future Organisational Models

In considering the organisational arrangements for implementing the recommended new policy the Group examined a number of models. Following an initial study five were selected for closer scrutiny.

Each model was assessed on the basis of its suitability to implement effectively the new policy set out in this Report, i.e. to deliver an integrated, proactive and river basin based approach to flood risk management via non-structural and traditional engineering measures. In its assessment the Group was conscious that, in the short term (say 5 to 6 years), there would be a strong emphasis on the promotion of all non-structural aspects of the new policy. However, in the long term, flood management becomes predominantly an operational function. The Group also believes that, given the specialist skills and experience that are required in flood risk management, and the relative scarcity of these, there is value and synergy to be gained by retaining responsibility for structural and non-structural activities in the same organisation.

A summary of the main points discussed in relation to each option are set out below.

The five options considered were:

5.1.1 Status Quo

5.1.2 Local Authorities as Lead Agency

5.1.3 Flood Management Executive Agency

5.1.4 Department of Environment, Heritage and Local Government as Lead Agency

5.1.5 Office of Public Works as Lead Agency

5.1.1 Status Quo

A variety of organisations currently have responsibilities for different aspects of flood risk management: the OPW has functions under the Arterial Drainage Acts and has previously been identified as the lead agency in delivering flood relief (Government Decision (S.28507) 1995), DCMNR in coastal protection, and local authorities are responsible for planning and development control and emergency response under policy direction from DoEHLG, and are empowered to undertake maintenance and flood relief works.

A potential model for future roles and responsibilities would be to maintain the existing arrangements. However, the Group regarded this model as unsustainable given this review stemmed from dissatisfaction amongst key stakeholders and the public alike with the current position.

The main problems identified with the current position (set out in detail in Sections 2 & 4) can be summarised as follows:

- a) *Lack of Clarity:* Uncertainty regarding the roles and responsibilities of the various bodies involved in flood management in Ireland was one of the primary reasons for the initiation of the Review.
- b) *Reactive Approach:* Existing flood relief practices can be viewed as reactive as they are focused on providing remedial measures following a flood event, rather than trying to predict and minimise future damage through a range of preventive practices.
- c) *Isolated Decision-Making:* The dispersed nature of the various bodies involved in flood relief, their respective organisational priorities and the lack of systematic communication between these bodies have all prohibited the development of a more strategic and proactive approach to flood management in Ireland.

5.1.2 Local Authorities as Lead Agency

Under this model, responsibility for management, implementation and operation of the proposed flood risk management policy would rest with the local authorities. This role would include existing responsibilities, such as planning and development control and emergency response, and also responsibility for aspects such as design and management

of flood relief and flood warning schemes, channel maintenance, hydrometric monitoring, and all other operational functions. Funding for flood risk management matters would be derived from the local authority budgets. A small administrative central authority (or policy unit) would most likely be required within the DoEHLG to coordinate and develop national policy and guidelines.

Having considered this option, the Group were of the opinion that the strategic and logistical difficulties of coordinating local authorities on a river basin basis, the need for specific expertise in each local authority area and the potential lack of consistency of standards amongst local authorities would be problematic. Furthermore, it was not clear how the OPW's existing obligations under the Arterial Drainage Acts could be accommodated within this model. If the OPW were to retain its existing functions there would continue to be a lack of clarity in responsibilities vis a vis local authorities. On the other hand, devolution of the OPW's activities to local authorities would pose significant practical difficulties.

5.1.3 Flood Management Executive Agency

In this model a separate Flood Management Agency is created with funding and broad policy guidance from a 'parent' Department – DoEHLG or OPW.

In discussing this model the Group were cognisant of Government's reluctance to establish any further State agencies unless there is an overwhelming advantage in doing so. In addition, the Group were not convinced that a separate agency could successfully provide the integrated involvement of all stakeholders across a number of State bodies. Moreover, it was thought that a central authority – as part of a Government Department – could be equally objective in its operation, once clear and transparent decision-making processes were formulated.

5.1.4 DoEHLG as Lead Agency

Under this model, the primary responsibility for delivering on the proposed flood management policy, including policy implementation, operational and maintenance activities would rest with the DoEHLG. The relationship between the Department and local authorities in relation to planning and development control and emergency response would remain. Local authorities could also have delegated responsibility for certain

functions such as procurement and management of works contracts.

The DoEHLG is predominantly a policy-making department, with policy implemented through other bodies under the aegis of the Department e.g. local authorities, EPA etc. In a similar way the Group believes that the Department could also take full responsibility for the new flood management regime consisting of both structural and non-structural activities.

However, in view of the discussion at 5.1 above and in order to address the weaknesses outlined in 5.1.1, the Group believes that the OPW's current responsibilities should transfer to the DoEHLG in this model. While this is feasible, it was thought this would result in considerable disruption, and costs, inherent in the transfer of staff dispersed on a nationwide basis.

Another factor considered by the Group was the broad range of this Department's sphere of activity and the major public policy issues within its remit. By its unpredictable nature, flooding attracts an intermittent urgency that may have difficulty competing for priority with other important public policy issues within the Department's remit.

Some legislative change would also be required to transfer the OPW's responsibilities to the DoEHLG.

5.1.5 OPW as Lead Agency

Under this model, the primary responsibility for flood management in the future would rest with the OPW. Certain functions, such as non-designated channel maintenance, planning and development control and emergency response, would remain with the local authorities, who may also adopt delegated responsibility for certain localised works.

The Group noted the following:

- a)** *Operational Experience:* The OPW's operational involvement in flood relief dates back over 150 years. This experience and the accumulated expertise are crucial, given that future policy recommendations stemming from this Report are almost entirely operationally focused following an initial short-term focus on strategic, non-structural issues. The OPW, through existing organisational structures and

its established tradition of service delivery, is well placed to enable immediate implementation of future policy. In net terms, responsibility for non-structural aspects of the recommended future policy is being added to an existing operational sphere of activity.

- b)** *Minimal Legislative Change:* Various legislative instruments have conferred on the OPW significant powers in the area of flood relief.
- c)** *Single Focus:* The OPW would not have competing policy interests to the extent that a Government Department might have and as such is in a position to maintain consistent focus on the issue of flood management.
- d)** *Cost Effectiveness:* The costs involved in this option are minimal. Any additional costs arising from this Report would be solely associated with the implementation of its suggested recommendations and those additional resource requirements would arise regardless of which body was declared lead agency.

5.2 Final Choice

Having considered five models, the Group quickly focused on two options in particular, i.e. DoEHLG as Lead Agency and OPW as Lead Agency. The Group found drawbacks in the DoEHLG option, most notably DoEHLG's lack of service delivery experience and the difficulty – without considerable staffing, legislative and structural changes – in implementing the Recommendations of this report. Thus, when compared to the OPW's existing structures and operational expertise in the area of flood management, together with its established culture of service delivery and its immediate capability, subject to resources, to put into operation the recommended policy of the Report, the Group were strongly of the opinion that the OPW as the lead agency provides the most cost effective and efficient option.

Set out below are the proposed roles and responsibilities of the OPW, the DoEHLG, the Local Authorities and the Department of Communications, Marine and Natural Resources (DCMNR).

5.3 Roles and Responsibilities of the Four Principal State Bodies Involved in Flood Management

5.3.1 The OPW will:

1. Assume the lead role in relation to the management of flood risk and the implementation of flood relief works.
2. Manage and / or co-ordinate, as appropriate, the various work programmes required to achieve the necessary position in terms of information availability, including:
 - a) Hydrological research and development (section 4.6.1).
 - b) Development of flood risk information (section 4.6.2).
 - c) Development of environmental and socio-economic information (section 4.6.3).
3. Play an advisory role in the area of general planning and development control, including the provision of advice and assistance to the Department of Environment, Heritage, and Local Government in relation to the exercise of that Department's functions regarding development control (section 4.6.4).
4. Co-ordinate the identification and development of an appropriate management structure for the preparation, review and approval of the river basin flood risk management planning system (section 4.6.4).
5. Manage the flood relief programme, comprising non-structural as well as structural works (section 4.6.5).
6. Develop and implement prioritisation criteria for all flood relief works (section 4.6.5).
7. Develop designation criteria for high-risk channels (section 4.6.6).
8. Manage the maintenance of designated channels (section 4.6.6).
9. Co-ordinate the development of an asset register of flood defences (section 4.6.6).
10. Develop and implement a programme of flood risk education, including the preparation and dissemination of brochures, guidelines and standards (section 4.6.7).
11. Co-ordinate national aspects of flood warning, and provide assistance and support to local authorities in the establishment of flood warning schemes (section 4.6.8).
12. Provide advice and assistance, as required, in the preparation of flood-related aspects of emergency response plans (section 4.6.9).
13. Confirm institutional arrangements for the management of the humanitarian aid programme (section 4.6.10).

5.3.2 The DoEHLG will:

1. Develop and implement policy and guidelines on the consideration of flood risk in planning and development control (section 4.6.4.).
2. Assist with the identification and development of an appropriate management structure for the preparation, review and approval of the river basin flood risk management planning system (section 4.6.4.).

5.3.3 The Local Authorities will:

1. Assist the OPW in the implementation of the work programmes required to achieve the necessary position in terms of information availability, most notably in the preparation and provision of historic flood information (sections 4.6.1 to 4.6.3).
2. Apply policy and guidelines on the consideration of flood risk in the various areas of planning and development control as provided by the DoEHLG (section 4.6.4).
3. Assist with the identification and development of an appropriate management structure for the preparation, review and approval of the river basin flood risk management planning system (section 4.6.4).
4. Undertake flood relief works directly, where appropriate (section 4.6.5).
5. Support the implementation and operation of non-structural flood relief measures (section 4.6.5).
6. Apply for designation of channels as high-risk, following the designation procedures developed by the OPW (section 4.6.6).
7. For all non-designated channels, without prejudice to the ongoing responsibilities of riparian owners or other interested bodies, provide emergency relief under the provisions of the Local Government (Sanitary Services) Act, 1948 or the Local Authorities (Works) Act, 1949 (section 4.6.6).
8. Assist the OPW with the preparation of an asset register of all flood defences including floodplains, wetlands and coastal defences (section 4.6.6).
9. Assume responsibility for the local dimension of the flood risk education programme, including raising awareness of individuals and business interests considered to be at risk (section 4.6.7).
10. Assist individuals and business interests considered to be at risk with preparations for minimising damages in the event of a flood event (section 4.6.7).
11. Operate and maintain flood warning systems (section 4.6.8).
12. Develop flood-related aspects of emergency response plans (section 4.6.9).

5.3.4 The DCMNR will:

1. Continue its current role in relation to coastal erosion and coastal flooding as outlined previously in section 4.6.5.
2. Ensure completion of the National Coastal Protection Strategy Study.
3. Liaise with the OPW to ensure national consistency in relation to assessment of risks and hazards, standards of protection, flood warnings and planning and development guidelines.
4. Advise the DoEHLG and Local Authorities on impacts and sensitivity of erosion and flood risk in relation to planning and development, including the provision of assistance as required in the development of guidelines and standards.
5. Assist with the development of marine flood warning systems.

FLOOD POLICY REVIEW FINAL REPORT

6

RESOURCE REQUIREMENTS

6. RESOURCE REQUIREMENTS

6.1 Introduction

The Review Group felt that it was important to examine the level of resources required to implement its recommendations, to consider the financial implications and to propose a strategic programme. As previously outlined, the main responsibilities for implementing future flood management programmes will fall primarily on the OPW, supported by local authorities, and as such this section focuses mainly on their particular resource requirements.

It will take a number of years to complete the following projects: the designation process for channel maintenance; the review of existing flood relief schemes under newly revised prioritisation criteria; the compilation and analysis of flood and coastal zone mapping, and the development of River Basin Flood Risk Management Planning (RBFMP). It is therefore extremely difficult to quantify at present what the precise resource requirements of each agency will be. Nevertheless, it is possible to estimate the direct costs of certain aspects of the programme of work that will arise and these are set out below. There will also be a requirement for additional staff. Until work programmes are specified in more detail than is possible in this Report, these additional requirements cannot be quantified. It is clear, however, that the additional work arising cannot be undertaken without additional staff.

6.2 Capital Works

While this Report recommends a shift in emphasis from providing structural remedies alone to a mix of non-structural works coupled with engineering solutions, it is recognised that the need for structural works remains and will continue to do so in the future. As a guide to the potential costs of implementing these works, the Group notes the schemes currently in the OPW Work Programme (Appendix 15) and the number of schemes identified in the submission from the County & City Managers Association which total approximately €440 million. This is merely an indicative figure, not to be regarded as a firm estimate of cost.

As the maintenance liabilities for both the OPW and Local Authorities arising from the proposed designation process are currently unknown (Appendix 9), it is not possible to

gauge with any degree of accuracy potential maintenance requirements. However, examination of figures relating to previously completed OPW flood relief schemes suggest annual maintenance costs can be estimated to be approximately less than one percent of the total scheme completion cost.

The importance of non-structural flood management processes and the equal need to ensure their adequate resourcing in the future should be reiterated. In that context it has been possible to make reasonable assumptions as to the indicative cost of implementing the following recommendations of the Report.

6.3 Flood Warning

This work will involve the development of an OPW in-house flood warning capability, and the design and implementation of flood warning schemes, provision of assistance and support to local authorities, etc. Although already considered as a flood relief option, it is anticipated that flood warning would be pursued more proactively than as part of a flood relief scheme. Additional staff and funding will be required for this work in both the OPW and Met Éireann – details to be specified when a detailed work programme is developed.

6.4 Flood Hazard Mapping

This will require both staff and financial resources for the implementation of Phases I and II, and for the subsequent ongoing maintenance / update / development role. It must be stressed that the flood mapping must not be seen as a one-off project. river basin conditions change, floods occur, defences are erected, etc. and all of this requires an ongoing resource in updating the database. In addition, Phase II will target high priority areas only, and large areas of the country will require assessment beyond the scope of Phase II.

Phase I:

- a) Programme: years 1 - 2
- b) Cost: Estimated at €2.5m, although this will depend on the volume of historical data available (€1.5m yr 1, €1m yr 2)
- c) OPW responsibilities:
 - i) Specification, brief and contract development
 - ii) Technical and quality control of consultancy work

iii) Programme management

Phase II:

- a) Programme: years 2 - 6 (and ongoing at reduced level thereafter)
- b) Cost: €10m (€2m p.a., years 2 – 6, on the basis that 100 urban areas and environs will be mapped at an average of €100,000 per area)
- c) OPW responsibilities:
 - i) Development of standard specification, brief and contract documentation
 - ii) Technical and quality control of consultancy work
 - iii) Programme management
 - iv) In-house implementation

Flood Mapping Maintenance and Development

- a) Ongoing maintenance / update of information.
Ongoing staff costs to be determined.

6.5 River Basin Flood Risk Management Planning

River Basin Flood Risk Management Planning (RBFMP) needs to be developed and then pilot-tested, which can be done using in-house OPW staff with expert advice. This will develop the in-house expertise to manage the proposed national development of RBFMPs, and then maintain and develop on an ongoing basis thereafter. As noted under Flood Hazard Mapping, this must not be considered as a one-off project, but is rather an ongoing commitment due to changing circumstances and development requirements.

6.5.1 Pilot Plan Development

- a) Programme: years 1 -2
- b) Cost: estimated at €500,000 p.a. for consultancy / survey / etc. – years 1 - 2
- c) OPW responsibilities:
 - i) Review of international practice (at a detailed technical level)
 - ii) Hydrological model development
 - iii) Predictive flood risk identification (hydraulic modelling)
 - iv) Land use assessment and other associated work required for the development of pilot flood risk management plans.

6.5.2 RBFRRMP Development

- a) Programme: years 3 - 6
- b) Cost: estimated at €6m on the basis of €150,000 per river basin, although this can only be determined once the framework is fully developed – €1.5m p.a.
- c) OPW responsibilities:
 - i) Development of standard specification, brief and contract documentation
 - ii) Technical and quality control of consultancy work
 - iii) Programme management

6.5.3 RBFRRMP Maintenance (assuming steady workload undertaken in-house)

Ongoing update of information.

Staff costs to be determined.

6.5.4 Development of Guidelines (planning, flood awareness, preparedness, building standards, monitoring of international practice)

- a) Cost: estimated at €150,000 p.a. for advertising, publication of brochures, etc.

6.6 Hydrological Research and Development

6.6.1 Update of Flood Studies Report

- a) Programme: years 1 - 3
- b) Cost: €1.5m (€0.5m p.a.)
- c) OPW responsibilities:
 - i) Specification, brief and contract development
 - ii) Technical and quality control of research work
 - iii) Programme management

6.6.2 River Basin Modelling

- a) Programme: years 1 – 4
- b) Cost: €5m (€0.5m year 1, €1.5m years 2 - 4)
- c) OPW responsibilities:
 - i) Review of model availability / selection of model type
 - ii) Development of pilot model – Review of results
 - iii) Standard specification, brief and contract development
 - iv) Programme management, technical control of research work
 - v) In-house model development

6.6.3 Further Hydrological Research and Development (R&D)

- a) Ongoing model updates, etc.
Staff costs to be determined.

6.7 Table 5: Summary of Resource Requirements

SUMMARY OF COSTS		
COSTS	STAFF	CAPITAL
Year 1 - €3.0m	To be agreed as	OPW Work Programme
Year 2 - €5.5m	programmes develop	(€300 million)
Year 3 - €5.5m		Plus
Year 4 - €5.0m		CCMA Submission
Year 5 - €3.5m		
Year 6 - €3.5m		
TOTAL: €26 million		Total: €440 million (over 10-15 years)

6.8 Met Éireann

The effective operation of a flood warning system under the new policy will require significant input from Met Éireann. An immediate cost of approximately €50,000 is likely to arise in relation to IT infrastructure. If in the longer term a more sophisticated hydrological model were to be introduced, an enhanced weather radar network would be required with capital costs in the region of €1 million.

It must be emphasised that the above are capital costs only and additional staff resources will also be required.

6.9 Economic Justification

The following figures are a summary of the financial cost of flooding in recent years. The Review Group believes that in the long-term the new policy will reduce these costs considerably.

In the past eight years over €20 million (€20.57m) has been paid in Humanitarian Aid (this

figure includes the €1.05 million paid out under the Home Relocation Scheme).

Local authorities estimate the cost incurred by them arising predominantly from emergency response activities in the period 2000 – 2002 to be in excess of €20 million.

The Irish Insurance Federation has estimated that the cumulative cost to the industry of the three serious flood events in recent years (November 2000, February 2002 and November 2002) was €138 million. This figure is likely to understate the true cost of these events, as it would not include impact on infrastructure and transport systems, with consequent knock on effect on commercial activity.

At Section 1.6.1 an estimate of national annual average flood damage of €75 million is made, based on data from current OPW studies and the numbers of areas remain at risk.

In addition various state agencies would have incurred costs directly as a result of the flood events and in relation to remedial measures required. i.e. Dept. of Communications, Marine & Natural Resources provided funding for the repair of coastal defences relating to tidal flooding in 2002.

A more detailed discussion of costs and benefits can be found at Appendix 14.

FLOOD POLICY REVIEW FINAL REPORT

7

7. REFERENCES

Cargill, Dr. A. & Price, D. (2001), Comparison of FEH and FSR Estimates of Design Flood Magnitudes in Scotland, 37th Annual Conference of River and Coastal Engineers, DEFRA, UK

Cunanne, Prof. C. (2000), Flood Estimation Procedures – A Review in the Context of the New UK Flood Estimation Handbook, Institution of Engineers of Ireland, Dublin, Ireland

Department of Communications, Marine and Natural Resources (1998), Fisheries Guidelines for Local Authority Works.

Department of Communications, Marine and Natural Resources (2000), Forestry Services. Guidelines for Forestry and Water Quality

Department of Finance. Report of The Drainage Commission 1938 –1940 (Browne Commission) 1940, Ireland

EPA (1995), Advice Notes on Current Practice in the Preparation of Environmental Impact Statements, Environmental Protection Agency, Dublin, Ireland

EPA (2002), Guidelines on the Information to be Contained in Environmental Impact Statements, Environmental Protection Agency, Dublin, Ireland

ESSA (1970), Flood Warning Benefit Evaluation – Susquehanna River Basin (urban residences), ESSA (Weather Service) Technical Memorandum WBTM Hydro, March 1970

EU (2003): Best Practices on Flood Prevention, Protection and Mitigation, Water Directors of the European Union (EU). Draft presented in Athens, Greece, June 2003.

FHRC (1990), Flood Loss Assessment Information Report, Flood Hazard Research Centre, Middlesex Polytechnic, UK

FHRC (2003), Flood Loss Assessment Information Report', Flood Hazard Research Centre, Middlesex Polytechnic, UK

GBCMA (2002), Goulburn Broken Regional Floodplain Management Strategy, Goulburn Broken Catchment Management Authority, Victoria, Australia

Goodbody (2001), A Review of Cost Benefit Procedures for Flood Relief Schemes, Goodbody Economic Consultants, Dublin, Ireland

ICE (2001), Learning to Live with Rivers, Institution of Civil Engineers, London, UK

IoH (1999), Flood Estimation Handbook, Institute of Hydrology, Wallingford, UK

IPCC (2001). Climate Change 2001: The Scientific Basis. Contribution of Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, UK

Mehlhorn, Dr. Jens (2003). The Future of Flood Insurance in Europe. Presentation to the 6th National Seminar on Flood Risk and Insurance, Wallingford, UK (10 April 2003).

NERC (1975), Flood Studies Report, Natural Environment Research Council, London, UK

NOAA (1997), Automated Local Flood Warning Systems: Weather Service Hydrology Handbook No. 2. National Oceanic & Atmospheric Administration, US Department of Commerce, USA

Ogunyoye, F. (2002), Ensuring Safe and Effective Use of Temporary and Demountable Flood Protection Systems, 37th Annual Conference of River and Coastal Engineers, Department of Environment, Food and Rural Affairs (DEFRA)UK

OPW (2003), Flood Data Collection, The Office of Public Works, Ireland

PCP (2001), An Action Strategy for Integrated Catchment Management, The Parrett Catchment Project (prepared by Land Use Consultants with contributions and support from the Wise Use of Floodplains Project and the Levels and Moors Partnership), Somerset, UK

PWC (1999), Arterial Drainage Maintenance Programme – Report on Measurement of Return of Investment, Price Waterhouse Coopers & Ferguson McIlveen, Ireland

Spencer, P. & Walsh, P. (1999), The Flood Estimation Handbook: User's Perspectives from North West England, 34th Annual Conference of River and Coastal Engineers,

Ministry of Agriculture Fisheries and Forestry (MAFF) (now DEFRA), UK

Sweeney et al (2003). Climate Change – Scenarios and impacts for Ireland.
Environmental Protection Agency : Wexford, Ireland

UN/ECE (2000), Guidelines on Sustainable Flood Prevention, Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Economic Commission for Europe, United Nations, Geneva, Switzerland

FLOOD POLICY REVIEW FINAL REPORT

APPENDICES

APPENDIX 1	RIVER BASIN FLOOD RISK MANAGEMENT PLANNING	92
APPENDIX 2	HYDROLOGICAL INFORMATION	96
APPENDIX 3	NATIONAL FLOOD HAZARD MAPPING PROGRAMME	101
APPENDIX 4	ENVIRONMENTAL CONSIDERATIONS	109
APPENDIX 5	SOCIO-ECONOMIC INFORMATION	114
APPENDIX 6	PLANNING AND DEVELOPMENT CONTROL	116
APPENDIX 7	STAKEHOLDER INVOLVEMENT	120
APPENDIX 8	FLOOD RELIEF WORKS	122
APPENDIX 9	DESIGNATION OF HIGH-RISK CHANNELS	140
APPENDIX 10	FLOOD DEFENCE ASSET REGISTER	142
APPENDIX 11	FLOOD AWARENESS, EDUCATION AND PREPAREDNESS	144
APPENDIX 12	FLOOD WARNING	146
APPENDIX 13	HUMANITARIAN AID, INSURANCE AND PERSONAL RESPONSIBILITIES	151
APPENDIX 14	ECONOMIC JUSTIFICATION FOR PROPOSED FLOOD MANAGEMENT POLICY	152
APPENDIX 15	OPW WORK PROGRAMME	160
APPENDIX 16	SUBMISSIONS TO THE REVIEW GROUP	162
APPENDIX 17	MAPS	16

APPENDIX 1

RIVER BASIN FLOOD RISK MANAGEMENT PLANNING

1. INTRODUCTION

It has been widely recognised internationally as good practice that flood risk should be considered and managed in an integrated manner at a river basin level. River basin flood risk management planning is an approach or framework designed to achieve these objectives. The primary objectives and advantages of the framework and plans include:

- The provision of a single focal point or management tool through which all aspects of flood risk management can be assessed and planned
- The integration of all aspects of flood risk management at a river basin level
- The development and documentation of a strategic plan for the management of future risk and implementation of flood relief measures
- The involvement of all relevant stakeholders in flood risk management planning (including the local authorities, communities, NGOs, etc.) through a plan review and approval process.

This Appendix discusses in more detail the objective and content of the plans, the planning process, and then, with reference to international examples, outlines how the process might be implemented in Ireland. It should be noted at this point that further discussion and assessment will be required to determine the precise nature and management structure for development, review and approval of the system (see Appendix 7).

2. RIVER BASIN FLOOD RISK MANAGEMENT PLANS

2.1 Objective

The river basin is the primary hydrological unit, and points within a river basin are inter-related, with changes at one point potentially impacting on the hydrology or hydraulics at another. The potential impacts of works or development at one location must therefore be considered throughout a river basin to ensure that there will not be any detrimental effects

elsewhere. The purpose of planning the management of flood risk at a river basin level is hence to ensure that all relevant information is considered holistically within this unit.

The purpose of the proposed approach is not, however, limited to the concept of river basin based management. It has been recognised that flood risk management must also be integrated and proactive. The planning process described herein provides a framework for the integrated consideration of the wide range of issues related to flood risk, and the proactive planning to minimise risks in the future and to deal with potential future changes, such as climate change.

By bringing together the three key objectives of the proposed policy, the plans and planning process will form the central framework within which the various functional areas, such as planning and development control, and the implementation of flood relief works, can be managed effectively and with due consideration of their relationship with each other.

To provide an example, and using the two areas of activity noted above, the development of an individual property, or indeed of a large urban area, might previously have been constructed without full consideration of the relationship between development and flood risk (to the development itself and elsewhere). As a result, post-development flood relief works might later be required (due, for example, to further development upstream) that would need to be built within the constraints imposed by the development, a situation that would be likely to increase costs and / or reduce the range of viable options. Impact mitigation measures might also be required at other locations that have suffered from raised flood levels or increased flows caused by the development. By considering development proposals alongside flood risk issues, it will often be possible to integrate flood protection and impact mitigation measures into the design of the development without a significant cost implication, such as through specification of structural walls as flood defence walls, or the incorporation of flood paths into amenity features, hence reducing overall costs and impacts elsewhere.

By integrating the various aspects that relate to flooding, considering these aspects at the river basin level, and by planning for the future, potential conflicts of interest should be avoided providing for more sustainable development and flood risk management.

2.2 Format and Content

Based on a range of relevant information (see Section 4 in the main Report, and Appendices 2 to 5), the present and potential future flood risk can be assessed, managed and planned for. The existing conditions and the management strategy to deliver on the adopted management policy are generally set out in a report or plan, which can be described as river basin Flood Risk Management Plans. These plans would provide a baseline status report and risk assessment of the existing development, environmental and socio-economic conditions that relate to flood risk, and then make strategic and operational recommendations on the management of that risk. These might include:

- The need and potential for localised and / or river basin-wide structural or non-structural flood relief and impact reduction measures, i.e., solutions to existing problems
- The viability and requirements for flood warning options
- Plans or recommendations for co-ordinated emergency response
- The impacts of future development and possible climate change
- Areas where development would be particularly detrimental in terms of increasing flood risk
- Areas of flood risk where development might be controlled or restricted to appropriate (flood insensitive) development
- Location and details of environmental sensitivities or hazards, and the potential for environmental enhancement
- Community involvement, issues and interests, and public education needs / campaigns for flood awareness and preparedness, etc
- Land use and best practice (farming, forestry, etc.) in relation to runoff management

The plans, which would be live documents subject to regular review and update, would provide potential users (e.g., planners, developers, engineers) with documented information on flood risk and a strategy for risk management, upon which informed decision-making in a range of areas can be undertaken.

3. INTERNATIONAL EXAMPLES OF APPLICATION

3.1 Australia

Such plans have been, or are being developed in a number of countries. One of the world leaders in this field is Australia, where, in certain states, Catchment Management Authorities (CMA) have been established under the Water Act, 1989 and the Catchment and Land Protection Act, 1994. These authorities (semi-state bodies) have wide-ranging areas of interest and responsibility in connection with river basin management including floodplain management.

As an example, one of the authorities, the Goulburn Broken CMA, which has responsibility for a sub-river basin of almost 24,000 km² within the Murray-Darling basin, has recently published its Regional Floodplain Management Strategy (GBCMA, 2002). This strategy reviews relevant issues and the authorities achievements in the previous 5-year period, and then sets out its vision and strategy, and a series of implementation programmes, which cover:

- Asset management
- Flood studies and floodplain management plans
- Statutory land use planning
- Development assessment guidelines
- Control of works and activities
- Emergency response planning
- Flood monitoring action
- Information management systems
- Education, promotion and communication.

The Strategy defines priorities, and estimated benefits and capital and maintenance budgets, while within each programme benchmarks and performance measurement systems are established. It is interesting to note that a benefit-cost ratio of over 4:1 is estimated for the non-structural measures, although this figure would not necessarily be directly applicable to Ireland.

3.2 United Kingdom

Similar plans are under development in the UK. The Parrett Catchment Project, undertaken by a consortium including Environment Agency, Levels and Moors Partnership, Somerset County Council, and a large number of other stakeholders, and with support from the Wise Use of Floodplains Project, has developed a strategy for Integrated Catchment Management (PCP, 2001). The aim of the project was to ‘... develop a long term action strategy for land and water management and identify a new package of largely rural, agricultural and other land-based activities for the southern part of Somerset’.

The strategy, which stresses the importance of community and stakeholder participation, addresses a range of issues, but has a particular emphasis on flood management and reduction. It concludes by setting out a 50-year plan of initiatives including:

- Further development of technical understanding of flood management within the river basin involving the use of a GIS for decision-making
- Detailed analysis with a view to enhancing flood warning systems and physical defences
- Regulation of new development within the river basin to prevent any exacerbation of existing flooding
- Improving land and water management practices
- Enhancing existing nature reserves and developing more wetland habitats
- Establishment of a Parrett Catchment Forum.

4. SYSTEM MANAGEMENT

It is proposed that, given the recommendations of the Review group, the Office of Public Works would manage the development and maintenance of the plans. This work would, however, be undertaken in consultation with relevant stakeholders, most notably the local authorities. The plans would require review and approval by the relevant local authorities before adoption, which is discussed in Appendix 7.

5. FURTHER INFORMATION

The Catchment Management Authorities in Victoria, Australia, have published Management Plans, which are accessible via the Internet. The website address for the example used above is: www.gbcma.viv.gov.au

Some general discussion of river basin management policy and practice is provided within a publication entitled 'Learning to Live with Rivers' (ICE, 2001), which can be accessed at: www.ice.org.uk/rtpdf/iceflooding.pdf

APPENDIX 2

HYDROLOGICAL INFORMATION

1. INTRODUCTION

Hydrological information describes the natural water cycle. This would include information such as analysis of rainfall patterns, the rainfall-runoff response of a river basin, flood flows / volumes and frequencies, etc., and is hence of fundamental importance when attempting to address flood risk management.

An understanding and assessment of the hydrology, hydrological information (as described above) and the flood-generation characteristics of a river basin would be necessary for almost all aspects of the proposed policy and associated work practices, including:

- Establishing the frequency and severity of flood risk at a particular site
- Designing flood relief measures
- Design of appropriate or sustainable urban drainage systems
- Development of flood warning systems
- Assessment of the change in response of a river basin resulting from further development
- Assessing the possible impacts of climate change.

The absence of reliable and extensive hydrological information would cause considerable difficulties in implementing the proposed policy, and would severely undermine the reliability of any information or guidance produced.

The information, and the modelling programme in particular, would also be of wider benefit in relation to the design of bridges, culverts, etc., water resource management / water supply, the management of water quality, and implementation of the Water Framework Directive.

This Appendix describes the principal work programmes proposed to produce the

information required, and includes:

- Update of the Flood Studies Report
- River Basin Modelling Programme
- Strategic Review of the Hydrometric Monitoring Programme.

2. UPDATE OF THE FLOOD STUDIES REPORT

2.1 Current Flood Data Estimation Techniques

Flood estimation in Ireland has generally been undertaken in the last 25 to 30 years using the methodologies and data provided in the Flood Studies Report, or FSR (NERC, 1975) and from the various national hydrometric databases. The FSR resulted from an extensive UK – Irish research programme that is widely appreciated as having been a significant step forward in flood estimation. While other techniques are available, the FSR remains the standard methodology for use in Ireland.

2.2 Need for an Update

The FSR was developed using data, technology and techniques available up to and including 1969. A significantly greater volume of data is now available to extend the lengths of record, which are of particular importance in the estimation of extreme events. The data available now is also more contemporaneous than that used for the FSR, and would more accurately reflect current climatic and river basin conditions than the pre-1970 data. Technologies and techniques are also now available and well developed for improved analysis, presentation and usability of flood estimation packages. A programme of study for the development of new or recalibrated flood estimation methods in Ireland could therefore improve the quality and facility of flood estimation for the purposes of flood risk management.

It might be noted at this point that the FSR has already been superseded in the UK by the Flood Estimation Handbook, or FEH (IoH, 1999). The significant changes in approach adopted by the FEH from the FSR include the use of the median (rather than mean) annual flood as the index flood for growth curves, and the use of pooling groups based on river basin characteristics rather than geography for determining growth curves (Cunnane, 2000).

Research has shown mixed results in comparing flood flow estimates using the FEH pooling group methods as opposed to the FSR growth curves. In the North-West of England, the use of the FEH methods produced a slight increase in flow predictions for extreme events such as the 100-year flood (Spencer & Walsh, 1999). In Scotland however, the reverse has been found (Cargill and Price, 2001), with FEH estimates for 100-year flows in the order of 30% below those predicted using the FSR regionalised growth curve. While it is recognised that both results were derived from the analysis of a limited number of river basins, they do provide an indication of the uncertainty involved in using the FSR growth curves, and would support the need for a review of the FSR in Ireland.

2.3 Update of the Flood Studies Report

The Joint National Committee of the International Hydrological Programme and of the International Commission on Irrigation and Drainage passed a recommendation that a review and update of the FSR methodologies should be undertaken in Ireland.

A Management Committee (MC), comprising interested state, semi-state and other relevant organisations, was established to direct the programme and met in October 2000. A Technical Steering Group (TSG) was subsequently established to specify and manage the technical aspects of the program under the guidance and approval of the MC. The TSG met on 10 May 2001 and agreed a draft specification for the packages of work that would be required to deliver the objectives of the programme. Since this, there has been little activity, due to the lack of resources to initiate the programme.

A summary of the draft specification, as prepared by the TSG in 2001, listing the work packages that are considered necessary for the Irish Flood Studies Update Programme is outlined below (2.4). The work packages were only outlined in brief at the time of writing, and a more detailed review will be required, particularly in the light of the requirements of the proposed policy.

The cost of the update programme has been estimated to be in the order of €1.5m, with a programme period of 3 years, assuming that the majority of the work is undertaken as university research projects.

2.4 Proposed Packages of Work – TSG Specification 2001

1. METEOROLOGICAL DATA

- 1.1. Data Preparation
- 1.2. Intensity-Duration-Frequency Analysis
- 1.3. Estimation of Extreme Rainfall Depths

2. HYDROLOGICAL DATA

- 2.1. Hydrological Data Preparation
- 2.2. Hydrological Frequency Analysis
- 2.3. Determination of Index Flood in Ungauged River Basins

3. RAINFALL-RUNOFF METHODS

- 3.1. Single Event Analysis
- 3.2. Alternative Methodology Assessment
- 3.3. Alternative Methodology Analysis

4. URBAN FLOOD ISSUES

- 4.1. Scoping Study to Assess Requirements
- 4.2. Development Impact Analysis – Demonstrative Project
- 4.3. Assessment of Urban Floodwater Attenuation Measures

5. DEVELOPMENT OF INFORMATION SYSTEMS

- 5.1. Digitisation of River Basin Boundaries
- 5.2. Feasibility Study of Information System Applications
- 5.3. Development of GIS and Database Systems
- 5.4. Development of Digital Elevation Model (DEM)
- 5.5. Flood Attenuation Analysis using Digital Floodplain Storage Data

6. PUBLICATION OF WORK

3. RIVER BASIN MODELLING PROGRAMME

3.1 River Basin Modelling

River basin models simulate the hydrological behaviour of a river basin, and can take a variety of forms and structures. For the purposes of this Report, the models required would be computational (numeric) models based on measurable physical parameters, such as land use (e.g., degree of urbanisation), soil type, river basin area, slope and nature of the drainage network, so that parameters could be adjusted to assess future changes.

3.2 Need for a Modelling Programme

Once calibrated against recorded data, the models can be used for a variety of purposes such as:

- Estimation of floods of a specific frequency
- Determination of design flood flows at specific locations
- Determination of the impacts of hydrological flood relief works (e.g., storage reservoirs or changes in land use and / or management practices)
- Assessment of the impacts of possible future changes such as further development or increased rainfall resulting from climate change.

The models would be complementary to the update of the Flood Studies Report, which involves the derivation of flood estimation techniques and statistics, but would be site-specific and be required in their own right in terms of determining design / risk criteria at specified locations and the simulation of future changes. As noted above, this programme would have substantial wider benefits (including the reduction of design / implementation costs) in relation to the design of infrastructure, and management of water resources, supply and quality.

The modelling programme could be integrated with the update programme, with a shift away from generic flood estimation methodologies (as used in the FSR) to modelling-based estimation practices, such as is currently being investigated in the UK as the next evolution of the FEH. This matter would, however, require further investigation.

3.3 River Basin Modelling Programme

The objective of the programme is to develop and calibrate river basin models at a national level. The derived information would primarily be used for flood relief purposes, as discussed under paragraph 3.2 of this Appendix. It could however, subject to a review of liabilities and discussion and agreement with other authorities, also be made more widely available for other purposes.

The programme will initially require an assessment of available model types and packages to select that most appropriate for the intended use. Once selected, the programme, which is estimated will cost a minimum of €5m, can be implemented over a number of years on a priority basis (according to resource availability), using the calibration data currently available and design data as derived from the update of the Flood Studies Report. However, like all aspects of the river basin flood risk management framework, the modelling is not intended to be a series of inert, one-off projects, and will require review and updating to reflect changes within the river basin.

4. STRATEGIC REVIEW OF THE HYDROMETRIC MONITORING PROGRAMME

4.1 Existing Hydrometric Network

The OPW, Local Authorities/EPA, and the ESB operate the existing hydrometric network. While Ireland enjoys a reasonable density of hydrometric stations compared to other European countries, they form a network that has evolved primarily through historical, and often project-specific needs, rather than as a result of a strategic plan. Some stations also suffer from uncertainty in the flood flow range, a situation that exists in many countries. The data required therefore for the calibration of hydrological models or the direct estimation of flood flows might not be available or of sufficient reliability. A review and rectification of these issues could help to improve flood estimates, and hence more effective flood risk management.

4.2 Strategic Review

It is proposed that a strategic review of the network be undertaken to ensure that current and future needs will be met. The review would include consideration of the monitoring and data collection needs for a range of uses, but would concentrate on the following:

- Existing station quality (uncertainty in flood flow estimates, stability, etc.)
- General spatial coverage
- Infrastructural requirements (e.g., installation of telemetry systems)
- Organisational capabilities (e.g., development of mobile monitoring capabilities to meet short-term project needs)
- Integrated network coverage (relationship with rainfall / meteorological stations, local authority / ESB stations)
- Flood flows / levels in existing, or potential future, high-risk areas
- River basin model calibration
- Flood warning requirements
- General information requirements (based on assessment of requested information)
- Future flood research and development.

APPENDIX 3

NATIONAL FLOOD HAZARD MAPPING PROGRAMME

1. INTRODUCTION

Ireland has suffered a number of major flood events around the country during the last decade, and current understanding of climate change indicates that this problem is likely to become worse in the future. Concurrently, the country has enjoyed a period of unprecedented economic growth with an associated increase in development of infrastructure, commercial building and housing, which in turn is leading to mounting pressure for development on land that is increasingly at risk from flooding. These conflicting factors must be managed in a sustainable manner.

Flood risk or hazard maps are a widely used tool to assist with the management of development in floodplains and other areas at risk from tidal or surface water flooding, and the need for their development has been widely recognised and addressed in other developed countries.

This Appendix introduces some of the concepts involved in mapping flood hazard or risk, and outlines the steps currently proposed to develop and implement a flood mapping strategy and programme in Ireland.

2. FLOOD MAPPING

2.1 What are Flood Maps?

Flood Maps, often referred to as flood risk or hazard maps, present in a graphical format the areas of land or property that have historically been flooded, or that are considered to be at risk from flooding. The maps can display a range of parameters and different types of information, such as flows, water levels, depths, etc.

2.2 Why Undertake Flood Mapping?

Flood maps can provide useful information to planning authorities, a number of other bodies or organisations, and indeed the public, in the performance of a range of functions

or for information purposes, including:

- Land-use zoning for strategic development plans, i.e., promoting sustainable development by preventing flood-sensitive development in areas at significant risk from flooding
- Development control, i.e., the consideration of the risk of flooding when reviewing individual planning applications
- Planning of infrastructure, i.e., implementing appropriate design for bridges and embankments across rivers and floodplains
- Identification of property at risk and the needs for flood mitigation measures, i.e., the identification of flood-prone areas that would benefit from, and might justify the cost of, a flood relief scheme
- Planning and management of flood warning and response, i.e., identification of properties that should be warned of impending flooding and channelling of protective or remedial resources, such as the emergency services, to those properties
- Identification of available land suitable for development
- General awareness amongst the public of the risk to property, and possibly life.

While the maps can provide a great deal of useful information, they do have limitations and must be used in a manner appropriate to their type and standard of reliability. These are considered in paragraph 2.4.

2.3 Definition of Terms

Flood risk is a complex issue with a number of component parameters, and although words such as 'risk' or 'hazard' are often used in common speech as general terms for danger, in this area of work they have specific technical meanings. For the purposes of clarity the relevant terminology is defined below:

- A Hazard is an object, phenomenon or event that has the potential to cause damage. Under the theme of this report, the general hazard is flooding. It is possible to sub-divide the general hazard into 'sub-hazards' or specific dangers that could be encountered during flooding, e.g., flood extent or depth, water velocity, conveyance of sewage. It might also be noted that flood hazard can be defined into sub-groups according to cause or mechanism, such as heavy rainfall, high tide levels, blocked

bridges or culverts, surcharged sewers. Hazard maps of individual sub-hazards or sub-groups can be developed for specialist purposes, but it is more common to map the general hazard.

- Impact is the damage caused should a hazard be realised, often measured in financial terms. The impact of flooding can be loss of life, physical damage to property, infrastructure, crops or livestock, stress and disruption, etc.
- Probability is the likelihood of an event. In terms of flood risk, probability is often referred to as a return period, e.g., a 50-year flood event is a flow or tide level that is expected to be equalled or exceeded on average once every fifty years. The estimation of probability is prone to uncertainty due to the use of short periods of record or to changing conditions such as river basin urbanisation, channel maintenance or degradation and climate change.
- Risk is the probability of occurrence of the hazard combined with the degree or scale of the resultant impact. It is directly comparable to the calculation of the potential benefit of a flood alleviation scheme, and is generally measured in /year.

The choice of which parameter, or combination of parameters, is to be mapped will depend upon the objectives of the mapping exercise. Mapping or calculating flood risk, for example, is necessary for determining the potential benefits achievable from the implementation of a flood alleviation or mitigation scheme, but is cost-intensive and requires significant data input and would therefore be impractical to undertake on a regional or national scale. Flood hazard mapping on the other hand is less expensive, and yet, depending on type and level of detail, would still provide information of areas of land at risk from flooding and flood depths or levels.

In addition to different parameters, there are two principal generic types of mapping that are frequently used. These are defined below.

- i) *Predictive (Indicative) Flood Mapping* is the mapping of flood levels and extents that are predicted to occur for a given single or range of selected frequencies or return periods. The prediction for fluvial flood maps is often based on analysis in the following format:

- a) hydrological modelling to estimate design flows
- b) detailed channel and topographical floodplain survey
- c) hydraulic modelling, including calibration from recorded events, to predict flood levels
- d) mapping of extents according to predicted levels.

Predictive tidal flood extent mapping requires predicted tidal levels (based on tidal models and/or frequency analysis of recorded levels) for the selected return period and topographical data to determine areas below peak levels.

- ii) Historic Flood Mapping is the mapping of observed (as opposed to predicted) flood events and extents as recorded by survey, photography, video, the press, memory, etc. Data incorporated into historic flood maps could include recorded flood level, depth and flow as well as extent and incidence/occurrence, each of which can potentially be associated with a probability of occurrence or event return period. The data can be collected from a variety of sources, but requires interpretation and verification before use.

An example of an historic map, based on aerial photography taken during extensive flooding of the Shannon in 1999 / 2000, is provided in Figure 4 below.

The production process for indicative maps normally involves a greater degree of analysis than that required for historic maps, and as such is more costly to produce. Indicative maps are therefore generally only produced for areas of specific interest, which have often been identified through an examination of the historic flood data. On the other hand, the level of detail, potential area of coverage and degree of applicability of indicative maps are significantly greater than that generally available from historic maps.

The data that is collected and interpreted for historic mapping is often also necessary for the calibration of the hydrological and hydraulic modelling required for indicative mapping. The two types of mapping are not mutually exclusive, and the preferred methodology may incorporate both, with historic mapping undertaken as a precursor to indicative mapping.

Figure 4: Historic Flood Map – Athlone Town, Shannon Flooding, 9 January 2000



2.4 Limitations of Flood Maps

Historic flood maps developed in a rigorous manner are indisputable in that they convey recorded data, whereas predictive maps carry an inherent degree of uncertainty due to their dependence on the concepts of probability and inexact modelling techniques. The term 'indicative map' is indeed often used as a reflection of this uncertainty. In contrast however, the usefulness of historic maps can be limited unless a frequency or return period is associated to the mapped data, which again will incorporate a degree of uncertainty. The success of a flood mapping programme is dependent in part on the confidence placed in the maps by the end-users, and it is essential therefore that the degree of uncertainty is minimised as far as reasonably possible by rigorous verification of historic data and thorough calibration of any modelling.

Another limitation of the maps is derived from common misunderstanding of the concept of probability and uncertainty, and the consequent misuse of the maps (e.g., how can two separate ten or twenty year events occur in successive years?). The explanation of the relevant issues is an important factor that has a bearing particularly in the method of dissemination of the information.

Many of the determining factors in flood risk are prone to change. Variable river basin

characteristics such as land-use and the degree of urbanisation will have a significant impact on the rate and volume of runoff, while drainage and channel maintenance will impact on the attenuation of a flood event and on water levels for given flows. Climate change is another major factor that could significantly change the estimated design flows for predicted events or the return periods associated to historic events. The flood maps should take account of known past changes in an appropriate manner, such as highlighting any of the above changes that have occurred since an historic event, or allowances made for sea level rise or increasing frequencies in predictive levels or flows.

2.5 Choice of Mapped Parameter and Type

The choice of mapped parameter and type will depend upon the objectives of developing the maps, the resources available and the potential benefit achievable.

As indicated above, flood hazard maps (historical or indicative) define areas or locations at risk from flooding, incorporating, if available, the estimated frequency of occurrence in the form of a return period of the event causing the given flood extent, level, depth, etc. These maps are therefore of most use for planning functions associated with future development, for preliminary assessments of flood risk and for general information purposes.

Flood risk maps on the other hand indicate the associated economic, financial or social damage that the flooding would cause. This type of map is therefore suitable for the calculation of potential flood alleviation scheme benefits and the assessment of financial risk to existing developments or urban areas. They are often unsuitable however for large-scale (e.g., national) implementation due to the comparatively high cost of development.

2.6 Dissemination of Information

There is clearly little point in undertaking a flood mapping exercise without disseminating the information to the end-users. A number of issues should be considered in how to manage the dissemination process.

- a) The first issue is to identify the end-users, as this will have significant bearing on the methodology adopted. If the data is only to be provided to a limited number of users for whom document control will not be a problem then physical

dissemination in hardcopy or CD/DVD might be appropriate, whereas for a large number of users, this might cause problems as discussed below.

- b) As noted above in paragraph 2.4, flood data will change with time, new data will become available, and existing data may become incorrect following, for example, the construction of a flood mitigation scheme. The problems of revising the maps and disseminating updates to all end-users (i.e., document control) should be considered, particularly with reference to preventing the use of superseded information. Large-scale map revision and re-production will also have costs and resource implications.
- c) A third major consideration in the methodology for dissemination is the type of data to be made available. If the data to be supplied is limited, e.g., finished maps only or summary reports, then the issues above become less significant. If, on the other hand, support information such as copies of press reports or photographs is to be released, then the increased volume of data and media required can exacerbate the potential problems.
- d) A final consideration is the necessity for clear explanation on the appropriate use of the maps, particularly in relation to the degree of reliability/uncertainty and the concepts of frequencies and return periods. Appropriate interpretation, and hence correct use, of the information is essential to the success of a flood mapping programme.

3. A STRATEGY FOR IRELAND

3.1 Objectives of the Programme

The National Flood Hazard Mapping Programme was primarily initiated to provide relevant flood hazard information to the planning authorities to assist in the planning and development control functions. There are, however, a number of other stakeholders and potential beneficiaries of the Programme, including the Office of Public Works, other government departments and agencies, developers, engineering consultants and contractors, the insurance industry, and, of course, the general public.

For most of the above stakeholders, the primary parameters of interest are the areas of

land that are at risk from flooding, and the associated frequency and flood depth and/or level. The economic impact, or risk, would also be of interest to the Department of Finance and the insurance industry, but given the cost implications and difficulties associated with the development of this map type at a national scale, it is not considered viable to address this possibility, at least within the initial phases of the Programme.

The long-term objective of the Programme has hence been defined as 'the provision of comprehensive flood hazard maps for Ireland, and the efficient delivery of these maps in a clear and comprehensible manner to the stakeholders for their respective uses'.

3.2 Programme Development and Stakeholder Involvement

As discussed above, the success of the Programme depends on user uptake and acceptance of the maps and associated data. It is hence essential that the maps are developed in a way that will meet the needs of the end-users in terms of data provided, presentation, etc. To achieve this commitment it is important to involve the stakeholders in the development process.

The programme was initiated by the OPW a number of years ago but has not been progressed due to resource constraints. However, the OPW is currently carrying out preliminary work and has developed an outline implementation plan which covers the initial phase of the programme that will involve only historic flood mapping, the digitisation of existing indicative mapping and the development of an appropriate GIS-database system for data storage and access. The extension of the Programme to subsequent phases will be dependent upon the success of the initial phase, and the allocation of resources. The work tasks and deliverables proposed under the plan are summarised below.

3.3 Outline Plan – Phase I of the Programme

The objective of the initial phase is to make readily available to the end-users the existing indicative flood map data and as much reliable data on historic flood incidents and extents as may reasonably be collected. It is intended to disseminate this data via the Internet, and this is discussed in more detail in paragraph 3.4. Outlined below are the steps proposed for achieving the above objective.

- **Planning and Consultation:** It is essential that the primary stakeholders are fully committed to the programme, and the plan includes thorough consultation as discussed above so that their views and needs can be incorporated into the programme of work.
- **Data Identification and Collection:** A major step in the development of Historic Maps is the collection of historic flood data. This can include data held by local authorities, Government Departments, members of the public, press archives, and recorded hydrometric data. The data collection will be undertaken by appointed consultants, while the data identification process will include:
 - a) A preliminary questionnaire to organisations potentially in possession of relevant information
 - b) An extensive search of the press archive held by the National Library
 - c) Analysis of hydrometric records held by the Office of Public Works, the Environmental Protection Agency and Electricity Supply Board
 - d) A search through internal archives by the Office of Public Works (and other relevant departments)
 - e) **Data Interpretation:** After registration and filing, the data collected must be interpreted to extract relevant data or extents, which are then entered onto the database or plotted out in map format
 - f) **Data Verification:** Cross-referencing and verification of data is required to ensure a degree of reliability, and to determine supporting evidence for all flood locations or extents identified on the maps
 - g) Development of database, GIS and Internet access (see paragraph 3.4 below).
 - h) Identification of appropriate areas that could benefit from Indicative Mapping.

3.4 Internet Access

The programme deliverables will be in demand by the public as well as by local authorities and other stakeholder organisations, and will also be live data that will require frequent revision and updating. It is therefore logical that the objectives be delivered through an Internet accessible GIS and associated database. This would present the flood extents in graphical format over digital land maps, and would provide access to associated and

support information, such as information source, flood levels, event return periods, annual maxima at gauges, photographs and report summaries which would be stored in the GIS database. This methodology has the following advantages:

- A GIS will graphically allow easy access to the location where the flood extent information is required, and direct call-up of associated textual or numerical information.
- The information is digital (rather than hard-copy) and can therefore be updated and/or amended without the necessity of reprinting maps, reports, etc, including the addition of indicative flood risk information if and when this is available.
- The information is centrally managed and revisions or updates will therefore not need to be duplicated or repeated around the country.
- Placing the information on the Internet will minimise demands on resources in terms of data production and dissemination.

4. CONCLUSION

The Programme is expected to provide a central point of contact for information valuable to a range of organisations as well as the public. The Programme is, however, a long-term venture, and its direction, continuation and final outcome will be dependent on resources, stakeholder commitment, and technical developments.

APPENDIX 4

ENVIRONMENTAL CONSIDERATIONS

1. INTRODUCTION

Flood risk management entails a number of environmental aspects all of which require to be considered to ensure effective protection of the environment. The following issues are discussed in this Appendix:

- Climate Change
- Land Use Management
- River Basin Management
- Biodiversity
- Heritage
- Environmental Assessments
- Fisheries
- Protected Habitats and Species
- Liaison with Statutory Bodies
- Legislative Compliance

2. CLIMATE CHANGE

Climate change is now one of the most serious global environmental issues and the scientific consensus is that greenhouse gas emissions are the cause of man-made climate change. Developed countries agreed to legally binding targets to reduce global emissions of greenhouse gases by the period 2008-2012. Ireland's National Climate Change Strategy comprises a systematic programme towards meeting our greenhouse gas emissions target under the Kyoto Protocol (the text of the Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the third session of the Conference of the Parties to the UNFCCC in Kyoto, Japan, on 11 December 1997). Future flood relief designs and management strategies will have to consider the impacts of this phenomenon. Policy in relation to climate change and its impact on the design of flood relief works is currently under development within the OPW. More detailed

assessment of the climate change in general is ongoing in Ireland and globally, and would be investigated under the hydrological research programme of works.

3. LAND USE MANAGEMENT

Changes in land use can have a direct effect on flooding, typically by the reduction in attenuation capacity of the lands, leading to less storage and greater peak flows. Increased peak flood events can lead to erosion of river banks and destabilisation of river beds and spawning grounds. Conversely, increased rates of runoff leads to an extended duration of low flow, reducing effluent assimilation capacities and increasing eutrophication. In addition, extended low flows causes a reduction in the extent of wetted perimeters affecting fish passage, spawning and biomass productivity.

A number of land management practices require more detailed consideration within future assessments as follows:

- Extensive land drainage by agriculture and afforestation practices in upland and mid reach river areas resulting in increased runoff and associated increase in peak flows.
- Improvement by drainage of marginal lands, e.g. wetlands, peatlands, and buffer zones along watercourses with loss of their water attenuation capability. Indeed the potential benefit from a flood management perspective of restoring wetlands that have been degraded or lost should be assessed as a matter of course.
- Physical intrusions by development onto and reducing flood plains.
- Culverting of watercourses, causing a reduction in flood carrying capacity and difficulties for fish passage.
- Increase in urban surface water runoff e.g., increase in impermeable surface area.

3.1 Forestry

Forestry activities have the potential to interact both positively and negatively with aquatic resources. The Forestry Service's Forestry and Water Quality Guidelines sets out sound and practical measures that will mitigate against potential negative impacts while maximising the positive aspects of forestry, such as aquatic biodiversity enhancement and the creation of appropriate riparian ecosystems. The guidelines provide guidance on

buffer zones, ground preparation and drainage, construction of roads, bridges, culverts and fords and harvesting.

4. RIVER BASIN MANAGEMENT

The concept of future policy taking an integrated, proactive, river basin based approach will complement the Water Framework Directive. The Directive stipulates this broad-based approach and will strive to safeguard and upgrade the quality status of both freshwater and coastal waters on a river basin and river basin basis. Traditionally, aquatic quality was measured chemically and biologically but the Directive strives for a more holistic quality approach embracing hydrology, hydromorphology and the comparisons to reference conditions of pristine waters. In addition, the Directive demands consideration of the quality effects due to floods or droughts.

To comply with the Directive, future flood assessments will have to consider anthropogenic or flood effects on hydromorphology and take a broader view of the ecosystem within the aquatic and riparian zones.

5. BIODIVERSITY

Ireland became a signatory to the International Convention on Biological Diversity in 1992 and ratified the same in 1996. Accordingly, there is a binding requirement for Ireland to conserve biodiversity and to this effect, the National Biodiversity Plan was published in 2002.

This plan stipulates that each Government Department and State Agency has to draw up its own Biodiversity Action Plan. Furthermore, the National Plan targets a number of specific ecosystems and requires a number of associated actions to be taken for these ecosystems. However, guidelines for the production of sectoral Biodiversity Action Plans referred to in the National Biodiversity Plan are not yet available.

'Inland Water & Wetlands' is the ecosystem of most relevance to flood relief policy development with six associated actions specified. The following two actions are particularly relevant and will need to be addressed for future flood relief works:

- To ensure that all significant drainage, including both initial drainage and maintenance drainage, will require assessment of its implications for biodiversity, and particularly for wetlands.
- To produce guidelines for drainage and wildlife.

6. HERITAGE

The National Heritage Plan (NHP) was published in 2002 and is now Government policy. It is a 5-year strategy for the protection and enhancement of our heritage and addresses heritage from a number of aspects varying from increasing public awareness to promoting the accumulation of more knowledge on habitats and protected species.

Similar to the concept of Biodiversity Action Plans, the NHP calls for Local Heritage Plans and Local Authorities will be obliged to consider flood relief within the scope of these Heritage Plans. The NHP identifies multiple actions, about 160 in total, with a strong emphasis on the protection of inland waterway navigation and canals. In addition, this plan also requires a heritage assessment for flood relief works as quoted:

- Provide that all significant drainage, including both initial drainage and maintenance drainage, will require assessment of its implications for heritage, and particularly for wetlands.

All large flood relief works require an Environmental Impact Assessment (EIA) and as part of this process, heritage is assessed under architectural, archeological, flora, fauna, fisheries and cultural aspects. Complementing the same is the general obligation on all developments to avoid archeological deposits and, where this is not possible, to record the form and extent of the same under licensed excavations.

7. ENVIRONMENTAL ASSESSMENTS

Two components of legislation are relevant to the concept of EIAs for flood relief works. Firstly, the Environmental Impact Assessment Regulations 1989 – 2000 stipulate the classes of development that would require an EIA. The second component of relevant legislation is the Natural Habitats Regulations 1997. This stipulates that where an

operation or activity is likely to have a significant effect on a European site (i.e. an SAC or SPA), then an assessment should be carried out on the implications for that site in view of the site's conservation objectives. An EIA is deemed to be an appropriate form of assessment for the purpose of these regulations.

New flood relief schemes normally are of a sufficient magnitude to require an EIA under the First Schedule. These assessments demand a detailed evaluation across a broad range of environmental aspects varying from landscape, archeological heritage, flora, fauna, and site activities to pollutant emission controls. Finalisation of the scheme design takes cognisance of the environmental recommendations and avoidance or mitigation measures are implemented at construction phase. In light of the fact that this process is so thorough, it is clear that environmental issues in new flood relief schemes will continue to attain significant recognition.

In acknowledgment that maintenance works are of a smaller scale in comparison to developments described in the First Schedule of the 1989 - 2000 EIA Regulations, it is not foreseen that they have a magnitude of impact to warrant an EIA. In the event of drainage maintenance operations impinging on a protected region or species where the impact is deemed likely to be significant on the site's specific conservation aspect, then avoidance or mitigating measures are sought.

8. FISHERIES

Early arterial drainage schemes are perceived as having caused significant damage to fisheries. In recent years the OPW sponsored and partnered with the Central Fisheries Board the development of methodologies to protect, remediate and enhance fisheries during scheme execution and maintenance (see below). In addition, the Department of Communications, Marine and Natural Resources has published a guidance document for works in rivers outlining the fisheries' concerns.

8.1 ENVIRONMENTAL DRAINAGE MAINTENANCE PROGRAMME

The OPW in partnership with the Central and Regional Fisheries Boards has established an Environmental Drainage Maintenance (EDM) programme. This programme has been developed over the 1990s and is supported by the conclusions from studies on impacts of

various methodologies in channel maintenance. It has identified methods of operation, which are both environmentally sensitive and effective from a flood relief viewpoint.

Emanating from this EDM programme, alterations to work practices are being promoted. These range from leaving banks untouched where practicable, managing trees and vegetation, managing berms, tossing of spawning gravel (outside spawning season to remove entrapped silts) and enhancement works such as digging pools and placing of random boulders where deemed appropriate by the Fisheries Boards. Some of these methods have already been incorporated in routine maintenance operations.

9. PROTECTED HABITATS AND SPECIES

There are three primary classifications of environmentally protected regions, i.e., NHA, Special Areas of Conservation (SAC) and SPA, underpinned in Irish legislation by the Wildlife Act, 1976 – 2000 and the Natural Habitats Regulations, 1997. In addition, the Wildlife Act also protects particular species of flora and fauna. The National Parks and Wildlife Service (NPWS), part of the DoEHLG, is responsible for the implementation of this legislation. Accordingly, this Department is the best qualified to offer advice on avoiding or mitigating impacts both on protected habitats and species. In recognition of this resource, it is imperative that effective levels of communications are maintained with this Service.

Current communication protocols being developed in the OPW Drainage Maintenance require preparation of an Annual Maintenance Programme, with a copy of appropriate scheme maps where possible showing works that fall within National Heritage Areas (NHA), Special Area of Conservation (SCA) or Special Protection Area (SPA) sites. Follow up meetings are facilitated to discuss and tailor the programme of works. In tandem, the DoEHLG is notified of all individual maintenance works to be carried out in an NHA, SAC or SPA by forwarding the standard Notifiable Action Form. Observations or comments on what environmental impacts could occur and how to avoid or to mitigate these effects will be integrated within the maintenance works. It is essential that, in executing maintenance works, a proactive role is taken in communicating and minimising significant environmental impacts

When dealing with impacts on protected species that lie outside the zone of the environmentally protected regions, advice should be sought from the DoEHLG. Again, it is

desirable that a proactive role is taken in encouraging communications and in coaching staff at operational level to promote environmental protection.

10. LIAISON WITH STATUTORY BODIES

In light of the fact that flood relief works are predominantly within inland waters, the Fisheries Boards and the DoEHLG are seen as the primary stakeholders. In addition, local authorities are key stakeholders in respect of Drainage Districts although liaisons for these works tend to be more localised, i.e., focused on site-specific flooding issues.

The communication protocols presently in place allow for substantial positive interaction with the above two primary statutory stakeholders. The extension of these protocols to all future flood relief works is recommended.

11. LEGISLATIVE COMPLIANCE

The following is a non-exhaustive list of environmental legislation and policy, which must be complied with for flood relief works:

- Water Framework Directive
- Habitats Directive and Birds Directive as transposed to Irish law by the European Communities (Natural Habitats) Regulations, 1997
- Wildlife Acts, 1976 – 2000
- European Communities (Environmental Impact Assessment) Regulations, 1989 – 2001
- Arterial Drainage Acts, 1945 and 1995 (Environmental Impact Assessment) Regulations, 1990
- Planning and Development Act, 2000
- National Monuments Acts, 1930 – 1987
- Heritage Act, 1995
- Architectural Heritage and Historic Monuments Act, 1999
- Fisheries Acts, 1959 – 1997
- National Biodiversity Plan
- National Heritage Plan.

APPENDIX 5

SOCIO-ECONOMIC INFORMATION

1. INTRODUCTION

Socio-economic information in relation to flood risk refers to information on the social and economic impacts of flooding, such as the potential risk to health, undermining of local development, economic damages (direct and indirect). While hydrological and flood risk information is clearly necessary to evaluate the frequency and degree of flood risk and the design of flood relief measures, socio-economic information is necessary to assess the potential damages that could be caused by flooding, and hence target relief works and other measures to those areas potentially most seriously affected.

More specific examples of the type of information required, and hence why research in this area is necessary, are given below.

2. SOCIAL INFORMATION

2.1 Public Perceptions and Awareness of Risk

There is at present no comprehensive research available in Ireland in relation to the public perceptions and understanding of flood risk, and the awareness of individuals, businesses and local authorities of the level of risk that might affect them. This research would be of importance to the success of both a public awareness and preparedness campaign (see Appendix 11), and hence a flood warning programme, as it is difficult to target education without an understanding of the perceptions and knowledge of the intended audience.

It is proposed that a research programme be developed and undertaken to establish the parameters described above, and hence enable the development and implementation of an effective education campaign. It is anticipated that this research would comprise a review of comparable international research (if available), a series of interviews with focus groups, and subsequent analysis.

2.2 Stress and Ill-Health Caused by Flood Risk

The intangible damages caused by flooding are by definition difficult to quantify in economic terms for the inclusion in the assessment of flood damages. In co-operation with, or possibly as part of, the above research programme, an assessment (in a similar manner to that described above) is required of the stress, ill-health, and other intangible personal damages that can be caused by experiencing a flood event, or by living in fear that such an event might happen, with a view to establishing a realistic quantification of such damages.

3. ECONOMIC INFORMATION

3.1 Review of Flood Damage Estimation

Flood damages in Ireland have generally been calculated using the UK FLAIR Reports previously the 1990 report (FHRC, 1990) using an update methodology outlined in a report commissioned by the OPW (Goodbody, 2001), and more recently the 2003 report (FHRC, 2003). These methods have been accepted on the basis of the use of purchasing price power parities, and are used as a basis for the economic justification, or otherwise, of a flood relief scheme.

It is proposed that information on flood damages in Ireland is collated in a systematic manner wherever possible with a view to confirming the ongoing use of, and hence confidence in, these methods. This is likely to require the co-operation of the Irish insurance industry, and will require some form of agreement between the OPW and the industry on the use and privacy of any data received.

The review might include, as additional research, an assessment of the economic impacts of flood risk on issues such as property prices, development opportunities, agricultural loss and insurance costs.

3.2 Economic Benefits of Flood Warning

Flood warning schemes do not prevent flooding (unless linked to the installation of demountable / temporary defences), but rather rely on individuals, businesses and local authorities taking appropriate action to reduce the damages caused once the flood occurs. The economic benefits of a flood warning scheme are therefore determined not only by the value of property, but also by the mobility of such property, the awareness and

preparedness of warning recipients, the period (and reliability) of warning, etc and as such cannot be assessed by the standard methods.

The economic benefits of flood warning schemes have been reviewed in other countries, including the UK, but it cannot be stated with any certainty that the results are transferable, in particular given the awareness and preparedness conditions prevalent in Ireland. A research programme to address this information deficit is therefore required to establish methods and data for assessing the benefits of warning schemes in Ireland. By ensuring that only effective schemes are implemented limited resources would be used most efficiently. This programme would clearly be linked to all of those defined above (paragraphs 2.1 to 3.1)

APPENDIX 6

PLANNING AND DEVELOPMENT CONTROL

1. INTRODUCTION

Heavy rain or high sea levels can, through a series of processes, cause flooding. While the root causes (rainfall and sea levels) are essentially uncontrollable, the series of processes that transform these phenomena into flooding and flood damage are subject to influence by human activity. These activities, and the influence they can have, are controllable and can significantly increase or decrease the risk of flooding to property and infrastructure.

The activities that can impact on the processes that influence the flood regime are manifold, and include river maintenance, agricultural and forestry land-use practices, flood warning and defence. One activity that can potentially have a more significant impact than any other however, is development. Inappropriate development can not only place itself at risk, but can also increase flood risk many times over at other locations within a river basin. Appropriate sustainable development, however, will not be susceptible to significant damage and can have negligible impacts, or even reduce the risk, elsewhere.

Outlined below are a number of areas in which development and flood risk interact, followed by some points that might be considered during the preparation of development plans. Further sources of information are provided at the end of this Appendix.

2. FLOOD RISK AND DEVELOPMENT

2.1 Impact of Flood Risk on Development

Locating development in an area at risk from flooding can lead to property damage, human stress, hardship and ill-health, problems obtaining property insurance and consequential demands for the expenditure of local authority or central government resources on flood protection works. The construction of protection works at the time of the development, or at a later date, will incur significant additional costs and will not provide absolute immunity from the risk of flooding.

2.2 Impact of Development on Flood Risk Upstream

In times of flood, the river flows not only through its normal channel but also along the flood plains. Any constriction of the natural flow path can 'back-up' the river and lead to increased flood levels upstream. The construction of buildings or houses, and particularly embankments for infrastructure or protection, in or across a floodplain can therefore not only put the development itself at risk of flooding, but can also increase the flood risk for land and properties upstream.

The same is obviously true of any form of construction or encroachment in the normal river channel. Undersized culverts, or narrow openings between bridge piers, carry the additional risk of causing a blockage of floating debris during high flows.

2.3 Impact of Development of Flood Risk Downstream

Natural or agricultural land, such as forests, woodland, pastures, crop fields, and especially wetlands, is normally able to absorb and temporarily store a considerable proportion of any rainfall.

Covering such land with buildings, tarmac (such as for parking areas or roads), or other impermeable materials without the inclusion of designed attenuation facilities, where appropriate, can significantly reduce this ability to absorb rainfall, and will lead to increased land runoff. As a result large developments, including those away from major rivers, can increase river flows and the risk of flooding to land and property downstream. It might be noted that while the impact of an individual development can be minor, a series of smaller developments built up over a period of time can have a significant effect on flood risk in areas downstream.

Development that prevents floodwaters from accessing natural storage areas, such as can occur by constructing embankments around sections of a floodplain, reduces the attenuation of the river system. This in turn will increase flood flows and risk downstream.

2.4 Development Behind Flood Defences

Flood defences are built to a specific design standard. Should a flood occur that exceeds this standard then the defences will fail and the defended area will flood, i.e., the presence of a flood defence does not provide immunity from flooding, but rather reduces the frequency.

The design standard of flood defence can be reduced by changes in the river's flow regime. This might occur due to factors such as climate change or increased runoff from upstream development.

2.5 Development and Climate Change

Should climate change occur as currently predicted, the frequency and intensity of flood events will increase significantly, and so, with no influences from other sources (such as development), there will be an increase in flood damage. If, however, future development is not controlled and directed in an appropriate and sustainable manner, the risk of flood damage will increase exponentially.

For example, should climate change and development both increase flood flows by 20%, then what was a 100-year event would occur approximately every 10 years (i.e., frequency increases 10 times), and due to increased development, average annual flood damages might then increase by perhaps 20 to 30 times. This might be an extreme example, but indicates the compound nature of the problem.

2.6 Channel Maintenance

Many channels, particularly in urban areas, require maintenance to avoid a build up of debris and / or vegetation that could restrict flow and cause flooding. A provision for access to the channel for maintenance purposes is therefore essential.

2.7 Sections 50 (and 47) of the Arterial Drainage Act, 1945

Section 50 of the Arterial Drainage Act, 1945, states that 'No local authority, no railway company, canal company, or other similar body, and no industrial concern shall construct any new bridge or alter, reconstruct, or restore any existing bridge over any water course without the consent of the Commissioners.....' and that 'the word 'bridge' includes a culvert or other like structure'.

This requirement must be enforced to ensure that structures are not erected over or across rivers that could increase the risk of flooding. The OPW has developed a brochure and application proforma in relation to this matter. Section 47 incorporates a similar requirement for consent to Section 50, but refers to weirs or other similar structures.

3 FUTURE INFORMATION AND GUIDANCE

Flood risk information will be developed and produced under the National Flood Hazard Mapping Programme. This will identify areas at risk under existing conditions. The development of the River Basin Flood Risk Management Plans will identify and zone existing and future flood risk areas (with due consideration given to proposed flood relief measures), and identify areas where development could have a detrimental effect on flood risk.

The two programmes noted above will deliver information necessary for informed decision-making. It is proposed that detailed guidelines on various aspects of planning and development with respect to flood risk will be produced by DoEHLG, with assistance from the OPW as required. These would address the following issues:

- a) Flood risk and the related impacts of, or on, development should be considered during the preparation of development plans. This will facilitate sustainable development through the reduction of future flood damage and hence reduce demands for expenditure on flood protection works. Consideration should be long-term and evaluate the combined impact of all potential future developments, rather than assessing the impacts of individual developments. It should also evaluate development and flood risk throughout the whole river basin, rather than just in the immediate vicinity of zoned areas. It might be noted that river basins can include areas in other planning jurisdictions for which inter-authority co-operation would be required.
- b) Preventing flood-sensitive development (housing, industry, commerce, etc.) in flood risk areas will avoid increases in future flood damage (including human costs such as stress and ill-health) and the consequential demands for the expenditure of resources on flood protection.
- c) Permitting appropriately designed, flood-insensitive development (park areas, sports pitches, certain types of industry or warehousing, etc.) in flood risk areas might not significantly increase future flood damages, providing adequate drainage systems, safety measures and / or warning systems are put in place and the development does not restrict flow across floodplains.
- d) Development in, or across, a floodplain or normal river channel, particularly embankments and wide bridge piers, can restrict flow and lead to increased risk of flooding to property and land upstream, and should be avoided or designed to minimise any potential effects. It should be noted that there are statutory requirements under Sections 47 and 50 of the Arterial Drainage Act, 1945, requiring the consent of the

Commissioners of Public Works for the construction or alteration of any bridge, culvert, weir or similar structure. Consideration should also be given to providing access to the channel for maintenance purposes.

- e) Development anywhere within a river basin can reduce the absorption of rainfall by the soil, increase the rate of runoff and hence increase the flood risk to land and properties downstream. This impact can be reduced by using sustainable design practices, such as:

permeable or semi-permeable materials and/or designs for hard-surface areas such as car parks

- on-site storm water storage ponds to store and / or attenuate the additional runoff from development sites
- soak-aways or french drains to increase infiltration and minimise additional runoff.

4. FURTHER INFORMATION

The identification of flood risk areas is clearly important to the planning of development. At present, maps or information concerning flood risk are not widely available. Until such information is available, an examination of historic flood records or hydrometric data (available from the Environmental Protection Agency or Office of Public Works), and / or undertaking flood risk assessments and analysis can indicate areas at risk from both river and tidal flooding.

Information on stormwater management systems and measures to reduce or eliminate increase in runoff from developed areas is available from a variety of sources. Dublin City Council, for example, has produced a stormwater management policy for developers, while CIRIA (UK) have published information on their website (see below).

4.1 International Practice

Publications found at the following websites provide further information on development and flood risk management. The first describes guidance to planning authorities in the UK, while the second provides detailed discussion of the issues raised above and other related matters. The third provides outline information on stormwater management.

1. www.planning.odpm.gov.uk/ppg25
2. www.ice.org.uk/rtfpdf/iceflooding.pdf
3. www.ciria.org/suds

APPENDIX 7

STAKEHOLDER INVOLVEMENT

1. INTRODUCTION

The need for stakeholder involvement, particularly in the RBFMP framework, has been identified and a forum must be established whereby such involvement can be incorporated. This Appendix describes a proposal for this forum, but notes that this is a matter that will require further assessment and discussion before the most appropriate arrangements can be established.

2. STAKEHOLDER INVOLVEMENT

2.1 Local Authority Involvement

The local authorities have proposed roles in planning and development control, flood warning, emergency response, flood relief work implementation and / or operation, etc. In particular, the proposed flood risk management plans will need to be integrated into the development plan for the area under the jurisdiction of each local authority. The involvement of the local authorities in terms of developing, reviewing and approving the flood risk management plans is therefore critical to their success.

2.2 Public Involvement

The involvement of the public and local stakeholders in the development of management plans and the effective delivery of flood risk management initiatives is also essential at two levels.

2.2.1 The implementation of measures can rarely be directed from central or local government without the co-operation of the people potentially affected. The people who stand to benefit from an initiative must feel ownership of the scheme or programme, particularly if they are being asked to make sacrifices of some kind. People need to feel that their concerns are being addressed and that the initiative is theirs, rather than something that is being forced upon them. Without this participation, it is difficult to

engender confidence or the willingness to take any actions or make any changes necessary.

2.2.2 The people who have been flooded or observed flooding and the associated mechanisms often have invaluable information in terms of developing appropriate solutions or mitigation measures. Any initiative that is developed without their input might be ineffective or misdirected due to incomplete information. Alternatively, if an effective system has been developed but is contrary to popular approval and has not been discussed in detail with potential beneficiaries, there is a risk of lack of confidence and associated inaction.

2.3 Other Organisations

A range of other organisations will have statutory or non-statutory interests in the flood risk management planning process. These organisations might include national or regional bodies such as the DoEHLG, ESB, Fisheries Boards, representatives of the landowners or local interest groups, such as boating, angling clubs or environmental groups. The views of each of these organisations must also be taken on board during the development and review of the plans.

3. PROPOSED ORGANISATIONAL ARRANGEMENTS

It is proposed that the involvement of stakeholders in the process is secured at two levels:

- 3.1 Regional Management Groups:** High level forum for discussion and review for the plans with the primary stakeholders (e.g., local authorities, NPWS, ESB in controlled river basins, Waterways Ireland on navigable rivers, etc.)
- 3.2 Public Consultation:** Invitation of comments from all stakeholders (including the public) during the preparation of the plans, and presentation of the draft plans to public review before approval.

3.1 Regional Management Groups

River Basin District Management Groups (RBDMGs) have been (or are being) established under the Water Framework Directive in relation to the management of water quality and

other issues addressed in the Directive. This group has a wide range of interests and a broad scope of work, and might not be an appropriate forum for review of specific flood related issues. This structure, which has been developed on a river basin basis and brings together representatives of all local authorities with interests in specific river basins, would, however, form a useful basis for the required forum.

It is proposed that a sub-group of the RBDMGs should be established comprising the primary stakeholders. These groups would meet at regular intervals (perhaps once or twice per year) to review the river basin flood risk management plans, and discuss relevant matters, such as:

- Possible impacts throughout the river basin of amendments to development plans
- Agreements on limitations on development runoff rates
- Agreement on storage or floodable areas that could be of benefit in relation to flood risk in other jurisdictional areas
- Flood risk management and relief works strategy for the river basin
- Development of flood warning or other flood relief schemes that might be of benefit to a number of local authorities
- Designation of high-risk channels (see Appendix 9) that cross administrative boundaries
- Possible co-operation and co-ordination in emergency response.

Following review and public consultation, the Group would be responsible for formally approving the plans, which would then need to be integrated into the formal development plans of each local authority.

3.2 Public Consultation

Public consultation would provide members of the public and organisations that are not represented on the Regional Management Group with the opportunity to express comments or concerns that they might have, and to review the draft plans. It is proposed that the consultation process be administered by the local authorities in the same manner as that used for draft development plans.

APPENDIX 8

FLOOD RELIEF WORKS

1. INTRODUCTION

As noted in Section 4, flood relief schemes form the basis of the current flood risk management policy in Ireland. It might be noted that the term ‘flood relief scheme’ does not mean only engineered solutions and defences, but could also include flood warning systems, relocation packages, etc. Flood relief incorporates any measure that reduces the risk or impacts of flooding. This generally involves intervention at the hydraulic control or flooding process stages of the chain of causes described in Section 1.

This Appendix will be structured around the process of flood relief scheme implementation as followed within the OPW. It will, however, also incorporate discussion of all methodologies that are, or might be, incorporated into the reduction of potential damages from an existing flood risk. It might be noted at this point that although the term ‘scheme’ has particular legal significance in relation to OPW flood relief works, it will be used for the purposes of this Appendix (unless otherwise stated) to describe any package of flood relief measures.

The processes and methodologies described below are generalised and intended to cover only issues that might be expected to arise. However, it should be recognised that the range of issues covered is not exhaustive, and that every flood risk situation is unique and will have particular problems or issues that might not be covered below.

2. RELEVANT LEGISLATION

The primary legislation that governs the flood relief programme is the Arterial Drainage Act, 1945, and the subsequent Amendment Act, 1995. The former empowered the OPW to implement Arterial Drainage Schemes in any river basin area, following the process defined below, with the objective of preventing or substantially reducing periodic flooding in the area, or improving land quality throughout a river basin.

Following several serious flood events, and reflecting the changing economic circumstances in Ireland, the Amendment Act of 1995 permitted the OPW to undertake flood relief schemes at a localised level, i.e., concentrating on particular risk areas rather than entire river basins. It is at this localised level that OPW flood relief resources are currently directed.

2.1 OPW Scheme Process

Shown below in Figure 5 is a simplified flow chart of the OPW flood relief scheme implementation process. The process is generally initiated in response to a request from a local authority, although under a strategic system of flood risk management, the identification of the need for a scheme would evolve from the identification of existing flood risk, and would be incorporated into the River Basin Flood Risk Management Plan.

It might be noted that the progress of a scheme through this process is dependent on the availability of resources as well as the various decisions and assessments noted above.

The purpose of this Appendix is to highlight and discuss issues in flood risk management, rather than legislative procedure or construction processes. Therefore, while each stage of the process is outlined in the following Sections, only the feasibility / outline design stage will be covered in detail.

3. PRELIMINARY ASSESSMENT

The design and implementation of an OPW Scheme is a substantial undertaking and may not be appropriate where the cause of the flooding, or flood risk, is due to temporary factors or a lack of maintenance, or where the scale of the risk is small. In such cases, it might be more appropriate for a more simple, locally organised solution to be implemented, avoiding the time and costs involved in mobilising and fulfilling the OPW processes and requirements.

The objective of the Preliminary Assessment therefore is to review the cause and scale of the flood risk to determine whether the problem might merit OPW involvement, or whether it might be more appropriate and expeditious to handle the situation locally.

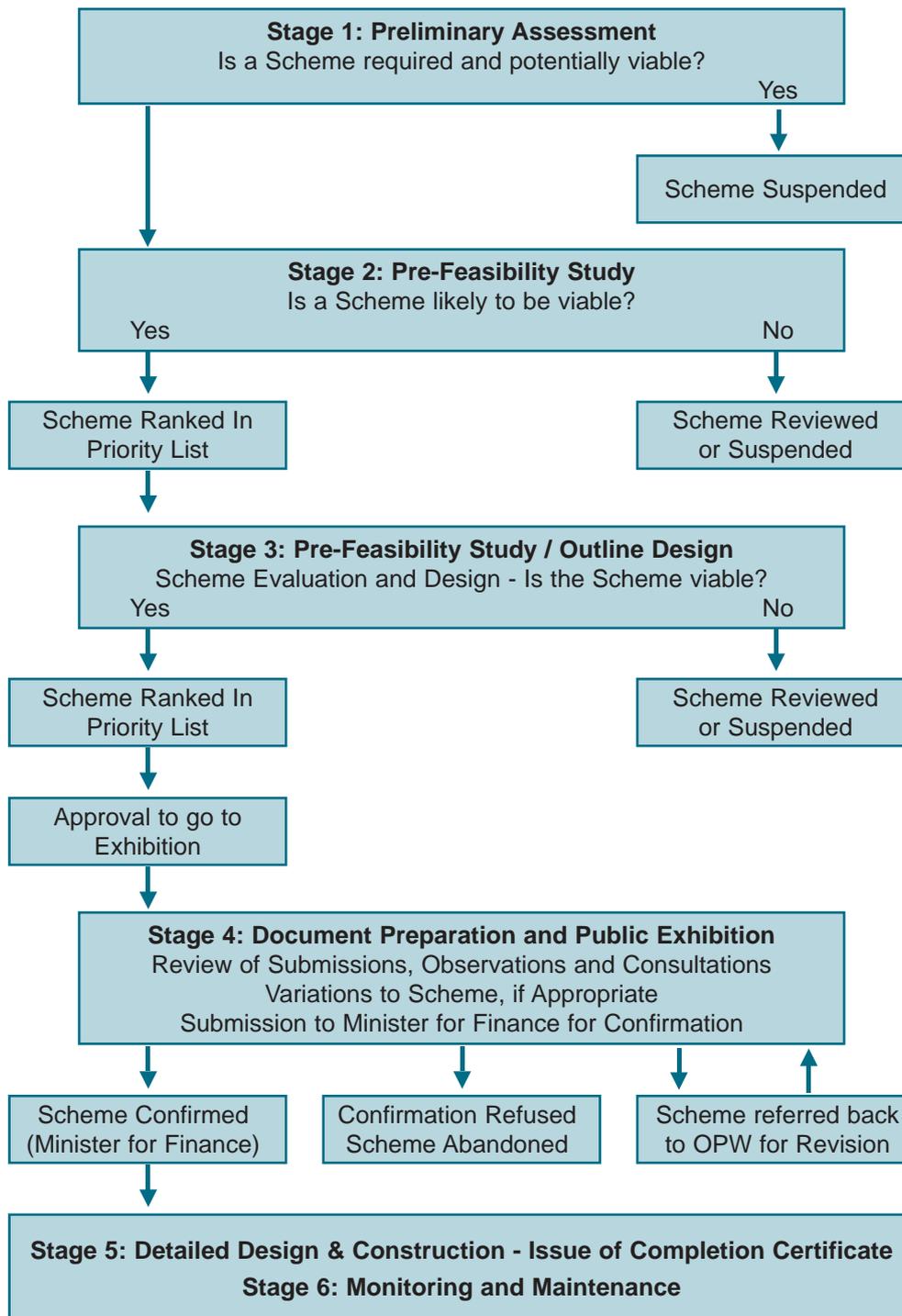
Examples of situations where an OPW Scheme might not be viable or offer the best

solution include:

- Culverts or bridge arches blocked by debris or silt, or temporary blockages in the channel
- Gaps in walls, including temporary breaches for construction purposes
- Undersized culverts or bridge arches that can be readily replaced
- Very few, or individual, properties or minor infrastructure only at risk
- Flooding is rare and only results in minor damage.

In the above situations, a simple localised solution is likely to be the most practical and economical. Suitable measures might include removal of debris and accumulated silt and the development of a channel maintenance programme, the construction of localised flood defences (minor walls or embankments) or flood proofing on a property-by-property basis.

Figure 5: OPW Flood Relief Scheme Implementation Process



A Preliminary Assessment will generally involve a site visit and discussion with local residents and local authority staff, followed by a recommendation for action. If the recommendation were that OPW involvement might be appropriate, or offer a solution, then a pre-feasibility study might be initiated. If not, then the local authority would be expected to assess the situation and possibly provide a solution.

4. PRE-FEASIBILITY STAGE

Having established during the Preliminary Assessment that the flood risk at a location is significant and permanent, the next stage in the design process is the identification and preliminary design of a Scheme that is viable in technical, economic, environmental and social terms. A full evaluation of this nature (the Feasibility Study / Outline Design) requires extensive surveys, analysis, etc. and can be expensive. To minimise the risk of performing such a study (and expending considerable resources), only to find that a viable solution is not possible, an intermediate stage, a pre-feasibility study, is undertaken.

The objective of a pre-feasibility study is to provide an indication as to the potential viability of a Scheme based on readily available information. The detail or accuracy of the study must be balanced against the cost, as it is not intended to determine whether or not a Scheme should be constructed, but rather only to justify whether or not the necessary resources should be committed to a full Feasibility Study. As such, the relevant issues are quantified as accurately as possible, but within a limited allocation of resources.

The issues that are generally examined are similar to those involved in a full feasibility study, but would include many more approximations and assumptions. The issues include:

- Collection of historic data
- Hydrological analysis (estimation of historic and design flood flows)
- Preliminary evaluation of existing degree of risk (development of estimated design flood profiles)
- Preliminary estimation of flood damages and potential scheme benefits
- Preliminary review of constraints (as derived through local authorities and local residents, groups, etc), and available information on environmentally sensitive areas
- Evaluation of outline options for flood relief (including estimation of costs).

The stage concludes with a report that includes a recommendation as to whether or not a scheme is likely to be viable, and hence whether the process should be taken to the next step.

5. FEASIBILITY AND OUTLINE DESIGN STAGE

As described above, a feasibility study is the identification, evaluation and outline design of a scheme that is viable in technical, economic, environmental and social terms. The pre-feasibility study will have indicated that such a scheme is likely to be possible, and will also have collected and prepared some of the base or raw data necessary. The feasibility study investigates the same topics as the pre-feasibility study, but in much greater depth, and will provide an outline design that can be taken forward to Exhibition (see below), if indeed the findings of the pre-feasibility stage are confirmed in that a Scheme is found to be viable. The work required as part of a feasibility study and outline design, and an indication of the level of detail required, is detailed below.

5.1 Data Collection / Surveys

The data collection process at this stage is extensive and will include all data necessary to make a full, accurate and thorough assessment of various aspects of the potential Scheme. The data collection and surveys required normally include the following:

5.5.1 Historic Flood Data

Any available data concerning historic floods, particularly levels and flooded areas, that can be used for calibration of the hydrological and hydraulic models is collected, including:

- a) Dates and relative magnitudes of historic events
- b) Depths, levels and duration of flooding
- c) Maps of flooded areas / extents
- d) Details of properties flooded and damage caused
- e) Flood mechanisms.

This data is most likely to be available from the OPW or local authorities as reports, press articles, photographs, etc., or can be collated through interviews with affected residents during a site visit. Survey is often required to establish a reported flood level in metres

above a datum, rather than as a level related to an object, e.g., top of a windowsill.

Historic data recorded in a non-definitive or non-technical manner (i.e., by verbal report rather than from a photograph or hydrometric records) can often be extremely useful, but does require some caution in that levels can be subject to deliberate or accidental exaggeration or understatement. However, by accumulating enough data from a range of sources, erroneous data can usually be identified. Care should also be taken in respect of the relative timing of the observation and the flood peak, and any changes in the channel or floodplain conditions since the historic event.

In Ireland, historic flood data can be difficult to collate and is often incomplete when compared to that ideally necessary for developing flood profiles and extent maps and calibrating models. There is a need for flood event data to be collated in a systematic manner. For this reason, the OPW produced a flood data collection brochure (OPW, 2002), targeted primarily at local authorities, which provides further discussion on the need for flood data and sets out the types of data required and methodologies for collection.

5.1.2 Hydrometric and Meteorological Data

Data is required from any relevant hydrometric or meteorological station in the same, or neighbouring river basins for the calibration of hydrological models and predictions, and the verification of historic flood data. Hydrometric data is now available in Ireland via the Internet (www.opw.ie/hydro/index.asp and www.epa.ie), while meteorological data is available from Met Éireann. There are a couple of particular points to note in relation to flood flow estimates from hydrometric records.

a) A number of hydrometric stations in Ireland are located upstream of bridges, often multi-arched. While these structures provide a constant control under most conditions, they can be prone to the build up of debris during flood conditions, which will artificially raise levels and lead to an over-estimation of flood flows. Discussion with hydrometric staff or local residents, or comparison with records from nearby stations can help identify when blockage has occurred.

b) Flood flow estimates in Ireland are generated from ratings (stage – discharge relationships) based on flow gaugings, and a recorded level. It is difficult at many stations to gauge flood flows, principally due to access problems in times of flood, but also

because it is not always possible to be at a station during flood conditions (due to lack of warning in flashy river basins, other priorities, etc.). As a result, many ratings do not have flood flow gaugings for calibration, and are therefore simply derived as an extrapolation of the highest calibrated rating. In many instances, and particularly where the highest gauged flows are in-bank, this will result in uncertainty of flood flow estimates, as floodplain flow (if applicable) will not have been accounted for. Again, discussion with hydrometric staff or local residents will help identify whether over-bank flow occurs. An improved, but not definitive, estimate can be achieved by hydraulically modelling the relevant river reach and calibrating the model as far as possible using the available flow gaugings. While this approach can improve flood flow estimates by simulating the physical and hydraulic characteristics of the reach above the gauged limit, it remains an estimate, due to the necessary assumptions such as roughness or structural head-loss parameters.

5.1.3 Channel Cross-Sections

Channel cross-sections are required at appropriate locations and spacing for construction of the hydraulic model. The selection of appropriate locations is important but site-specific and can not be discussed in further detail herein.

5.1.4 Floodplain Topographical Data

This data can be collected by the development of a digital terrain model (DTM) using Light Detection and Ranging (LiDAR) or similar technology, and / or topographical survey, and is required to allow modelling of floodplains, development of options and determination of property floor levels for assessment of potential flood damage. The use of LiDAR technology is becoming increasingly popular due to falling costs, improved resolution and accuracy (vertical Root Mean Square (RMS) error of 10-15cm can be achieved for average flight speed and height), and greater processing power of PCs. The DTM accuracy can be verified and indeed improved if accurate levels are available for large, flat locations (e.g., flat roof, car park, etc.).

5.1.5 Geo-technical Data

The soil and / or rock types under the floodplains and in the channel bed need to be identified to enable the design and costing of possible flood relief options.

5.2 Evaluation of Existing Degree of Risk

To develop relief solutions, it is first necessary to fully understand the existing problem, including the flow regime, frequency and extent of risk, and the mechanism by which the risk is realised. To determine these factors, the following tasks are normally undertaken:

5.2.1 Hydrological Analysis

Calculation of historic and design flows is required to associate frequencies with recorded flood extents and damages, and to derive inputs (flows) for the hydraulic analysis (see below). Design flow estimates should cover a range of expected frequencies up to and including the target scheme standard, but also for more extreme events to allow an analysis of, and planning for, failure scenarios. The calculation can be undertaken using a range of techniques. The FSR (NERC, 1975) remains the standard in Ireland for estimating flood flows, particularly where no recorded data is available. It is, however, recognised that uncalibrated estimates, particularly of the index flood, have a significant margin of uncertainty.

In estimating design flood flows from flood records, it is recommended that the record length should be at least half of the required design flood. Relief works are often designed to 100-year return period (Annual Probability of Occurrence (APO) 1%), but there are few reliable flood records in Ireland that exceed 50 years. A commonly used FSR-approach therefore is the use of an index flood (Mean Annual Flood) and the Irish Growth Curve. The Growth Curve was empirically derived from the pooled group of standardised Irish floods. While it is accepted that there is some scope for error, unpublished research by the OPW and NUI Galway has not identified significant improvements based on river basin characteristics or geography. The FSR Growth Curve is therefore generally accepted in the absence of any compelling evidence to the contrary.

Flood relief studies recently commissioned by the OPW have made use of the FEH catchment-characteristic based pooling group methodology, which produced 100-year growth factors within the range anticipated from the FSR work. Some care should, however, be used with this approach, due to possible underestimation of flood flows caused by rating extrapolation (paragraph 5.1), and the flood attenuation caused by lakes or significant floodplain storage that affects the pooled records but might not be applicable to the target site.

The two points immediately above refer to estimates of peak flow. The full hydrograph and river basin response may also be required, in particular if storage or flood warning are likely to be viable options, which require information on flood volumes and river basin response times respectively. This type of information can be achieved through simple calculations, such as the FSR Unit Hydrograph, or can be derived from more sophisticated models, such as rainfall-runoff-routing or continuous simulation models.

In developing design flows, allowances are generally made for increased runoff or flood flows resulting from increased development (based on local development plans) and for climate change. The former has been discussed in detail in earlier sections, while the latter will be reviewed in relation to its impact on flood relief design in paragraph 5.7 below.

5.2.2 Hydraulic Analysis

This involves the determination of the hydraulic characteristics of the river and floodplain through detailed hydraulic modeling, including model calibration and verification to historic data. In particularly complex situations, or where there is a dearth of data, physical model might be required

5.2.3 Flood Risk Assessment

Based on the above analysis, data and maps of the existing risk can be determined using models run with design flows and topographical and / or DTM data

5.3 Evaluation of Potential Flood Damages

The progress of the Scheme will depend upon its economic justification. To establish the baseline condition, a full potential damage assessment for the design flood scenarios is required to determine a value of the expected Average Annual Damage (sum of the product of event damages and annual probabilities of occurrence) for the control (or 'Do Nothing') option. This is undertaken using the surveyed property levels and types, the design flood levels and the FLAIR reports (FHRC, 1990 / 2003), or through a detailed survey by a loss adjuster. This damage calculation includes direct economic damages (e.g., to property, goods, lands etc.), but also indirect damages (costs to emergency services, traffic disruption, etc.) and intangible damages (stress to flood victims, personal disruption, etc.). Intangible damages are currently set as equivalent to the residential property damage.

The FLAIR report was developed in the UK in 1990, and as such costs need to be converted to equivalent rates in Ireland at that time, converted to punts, updated to the current date and then converted into Euro. There are two points, highlighted in a recent study of the cost benefit procedures for flood relief schemes (Goodbody, 2001), that should be noted here in relation to the conversion process for estimating damages.

- a) The conversion from 1990 UK costs to 1990 Irish costs is not simply a matter of currency rates, but also reflects the relative price differences (purchasing power parity) at that time.
- b) It is noted that the national Consumer Price Index (CPI) for inflation between 1990 and the current time underestimates the increase in costs related to flood damage. The repair, maintenance and improvement index rose by almost 89% between 1990 and 1999, as opposed to a CPI value of less than 22% cost. Over the same period, the increase in a composite index weighted to account for the property and goods typically damaged by flooding and the repair work involved (for a post-war bungalow with flooding duration less than 12 hours), was estimated at 36%.

The benefit and cost calculations for a scheme will be discussed under paragraph 5.6. Note that the 2003 report is now being adopted for use in Ireland by the OPW.

5.4 Review of Constraints

Boundaries and limitations must be set within which a Scheme can be designed. These constraints are determined in detail in close consultation with the relevant local authority and other stakeholders, and would normally include the following:

- Environmental and River Corridor Baseline Study: Establishment of a baseline study against which an Environmental Impact Assessment can be undertaken
- Fisheries: Constraints on works to ensure that fisheries, access and conditions for angling, etc., are not damaged. Note that this constraint often requires any in-channel construction works to be limited to the summer period.

- **Aesthetic and Amenity Constraints:** Determination of issues such as maximum acceptable wall heights, areas that must be preserved, e.g. important parklands, or particular issues in relation to the visual impact of the scheme. These constraints would often be identified through the local authority and public consultation meetings, letters, questionnaires, etc.
- **Archaeology:** Assessment of constraints in relation to protected buildings or structures, and requirements for archeological survey, etc.
- **Geo-technical:** Assessment of ground conditions with respect to the suitability of water retention measures and their impact on the design of foundations and the costs of excavation of material from channel bed, etc.
- **Spatial Constraints:** Determination of boundaries to possible works as set by other constraints, development plans and existing structures.
- **Other Local Interest Issues:** Issues of importance to local residents or interest groups, e.g. navigation, rowing / canoeing clubs, development plans. Again, these constraints are generally identified through public consultation.

It is important to establish the constraints so that the Scheme does not cause problems or damage local assets. A Scheme should not, however, just be seen to have potentially negative impacts, it can also be an opportunity for enhancement. For example, works in the river could introduce riffles and pools to encourage the presence of fish, could introduce lakes in townland areas for amenity value, or could develop wetland areas along the berms of split-channels or in designated floodplains or storage areas.

A very good example of incorporating enhancement measures into a flood relief scheme is the recently opened Jubilee Channel, which is a £90m (gross costs) relief channel for the Thames that provides flood relief for some 5,500 properties in Maidenhead, Windsor and Eton. Angling, bird-watching and other recreational facilities were incorporated into the design of the channel, along with an ecological study area including fisheries spawning areas and a range of habitats such as islands and reedbeds.

5.5 Environmental Assessment

The environmental assessment is undertaken in three stages.

- a) **Baseline Assessment:** This is undertaken early in the study period to examine the river corridor and identify any environmental constraints that will help derive the list of viable relief options. This stage of the assessment would often include preliminary public consultation as well as environmental inspection and research.
- b) **Assessment of Options:** This stage involves a review of options that have been found to be technically, economically and environmentally viable. The review will form part of the decision making process to select the preferred option.
- c) **Environmental Impact Assessment (EIA):** Once the preferred scheme has been identified and outline design is underway, a full EIA is undertaken, if required. The details of an EIA are beyond the scope of this paper, but the requirements for, and content of, an Environmental Impact Assessment are detailed in relevant EU legislation and directives, the Planning and Development Regulations (2001), and guidelines and advice notes produced by the Environmental Protection Agency (EPA, 2002 and 1995).

5.6 Evaluation of Options

Having identified the risk areas, flood mechanisms and constraints, the potential flood relief measures are considered and evaluated. Measures considered normally include:

(i) Flood Containment (walls, embankments, etc.)

This option, which intervenes in the flooding process stage of the chain of causes, involves keeping the river in its channel or in a designated flood area, and hence out of the protected areas. It is generally most suitable where there is limited space available for more extensive relief works, such as in a dense urban area, or for tidal defences, where containment is the only structural option. This form of defence is often used in conjunction with other measures to form an overall scheme, but does however have some associated risks:

- It can raise flood levels upstream
- It can reduce attenuation (only significant if large areas defended)
- It has potentially catastrophic and life-threatening failure mechanism
- It can be visually intrusive if inappropriately designed, or too high.

The last of these problems can be overcome. Where high defences are required at a location where river access and views are important to the community, a range of demountable or similar defences are now available. These include:

- Demountable Rigid Defences:** These are barriers or walls that are erected on fixed ground points only when a flood warning has been issued. This type of defence has been installed in Bewdley, UK, along the River Severn. The receipt of adequate warning that a flood is arriving is however of paramount importance, and maintenance of fixed points, practice drills, etc. are required to minimise the risk of failure.
- Floating Defences:** These are hollow plastic barriers that sit in trenches below ground level under normal conditions. As river levels rise, waters flood the trench, and the hydrostatic pressure lifts the barrier up into position. Although the lifting force is substantial, and can reportedly dislodge a car, the mechanism could fail if the access holes connecting the river and trench become blocked, or if a large vehicle or other heavy obstruction is placed over the barrier. This type of defence has been implemented in Carrick-on-Suir to provide access to slipways through the permanent defence wall, as shown below in figures 6a and b.



Figure 6a: Floating Defence Lowered (Normal Condition)



Figure 6b: Floating Defence Raised (Flood Condition)

- c) Inflatable Defences: These are large plastic rolls that are put in position and filled with water or other fluid or granular material when a flood warning is received.
- d) Other: There are a substantial range of other temporary or demountable defences, including the use of pallets and plastic to form walls, and a cantilevered walkway that rises through 90o to form a wall when river levels reach a certain point.

It should be noted that while the use of demountable defences is desirable in certain locations, they are not appropriate in all cases. In addition to the normal potential failure mechanisms for defence structures, there is also a real risk of a failure to close the defences due to inadequate warning, operational problems, obstructions, etc. A thorough analysis of site-specific conditions and risks is required before specifying such defences. Ogunyoye (2002) proposes a decision-making framework to guide the process including measures for minimising the risk of failure.

(ii) Increasing Flow Capacity:

This measure works by increasing the conveyance capacity of the channel and / or structures, through the lining, excavation, widening, realignment or maintenance of channels, or the addition, removal or modification of structures. The measure intervenes at the hydraulic control process of the chain of causes, and aims to reduce the water level at a location for a given flow. It is a low risk measure, in that it cannot be 'breached' or fail through lack of operation, but does maintain a residual risk of blockage in the same way that any river does. This is the principal flood relief mechanism being used in the Kilkenny

Flood Relief Scheme currently under construction.

It might be noted that increasing capacity can however increase flow velocities (a potential hazard), and channel excavation works can be environmentally damaging if not appropriately designed and implemented.

(iii) Retention / Storage Upstream

This measure, which intervenes at the attenuation process stage by increasing natural attenuation, involves structures, embankments, excavations, or other works to develop an area where flood waters can be stored. Such storage can be on-line (i.e., on the river itself such as a dam with a spillway or under-shot culvert) or off-line (i.e., a storage area in the floodplain which is flooded in a controlled way, often when river levels exceed a given point).

This measure is generally used for rivers with relatively small peak flows or for flashy river basins with short-duration flood hydrographs, as in both of these cases, the required storage volume is relatively low. However, the use of natural lakes or large flat floodplain areas can also be used to provide storage options for flood relief for larger rivers.

A further mechanism for this measure is available through distributed storage in the upper river basin. This can be achieved by allowing channels in the upper river basin to degrade and become overgrown, or by deliberately introducing constrictions to the channel that force waters into the floodplain and hence temporary storage. Although this mechanism can reduce flood flows downstream, it will obviously cause increased flooding in the upper river basin area, and is therefore only viable where this is acceptable.

(iv) Diversion

This measure involves either the diversion of part of the flood flow (flood relief channel, by-pass channel) or the redirection of the entire river (full channel diversion). It effectively removes a link in the chain (river flow), but re-establishes the chain at another location. The former sub-option (relief channel) is often preferred as a river forms a major focal point for a town and residents do not want it removed completely. The option can, however, involve substantial land-take and is generally only viable under certain conditions (relatively flat land, risk area on a meander, etc.).

While this measure can have environmental consequences if not appropriately designed,

it also offers opportunities for enhancement through the creation of a new waterway. Examples of the use of this option would include the Jubilee Channel, as discussed above, or the Cappamore Scheme in Tipperary.

(v) Sluices and Pumping

This option is generally only used in combination with protection / containment walls or embankments or raised drainage channels for tidal risk and low-lying areas respectively, and is not used widely due to the capital, running and maintenance costs of the pumps. Examples of the use of this option in the Ballyteige – Kilmore area of County Wexford, and the Fens or Polders in the UK and the Netherlands.

(vi) Flood Warning

This is the first of the non-structural flood relief measures. This option will not prevent the flooding occurring, but can reduce the damage caused. By providing adequate warning of an impending flood, residents and local authorities can take action to reduce the impacts of the flood, such as moving valuables to a safe place, distributing sand bags, erecting any mass or individual protection measures, closing off at-risk areas to prevent vehicle damage or risk to life, etc. The principal advantage of this option is the relatively low capital costs, although on-going resources are required for operation, monitoring and maintenance, and as noted, it does not prevent the flooding from occurring and carries a risk of failure.

The effectiveness of this measure depends upon a number of factors, including:

The reliability of rainfall forecasts (if forecast based)

The reliability of flood forecasts (i.e., of the flood prediction models or systems; a warning will not be heeded if it has previously been erroneous, the 'cry-wolf' syndrome)

- The warning time achievable (often a balance that must be made against the reliability)
- The effectiveness and reliability of the warning dissemination systems
- The awareness and preparedness of the population (which includes their ability to take action to reduce damages)
- The preparedness of the emergency response services (i.e., a response plan must have been previously developed, tested and rehearsed)
- Stakeholder / public commitment (confidence required to ensure appropriate action in the event of a warning).

(vii) Individual Property Protection

It is possible to protect individual properties through the use of flood barriers, plastic coverings / caps for vents, etc., and sandbags, as well as the traditional methods such as flood protection walls or embankments. The adoption of this approach is generally most appropriate for isolated properties in flood risk areas where prevention of flooding is not economically viable.

(viii) Runoff Reduction or Impediment

This flood relief measure is normally associated with new development, but can also be applied retrospectively. Although likely to be less expensive to include during the original development, the construction of attenuation ponds or french drains, the replacement of tarmac surfaces with semi-permeable surfaces can be incorporated into a development post-construction and therefore offers a potential flood relief measure.

(ix) Managed Retreat / Relocation

This measure involves allowing certain areas to flood, normally because it is not technically or economically viable to prevent flooding, but can also be used for environmental reasons. The managed retreat along floodplain areas to protect wetlands, etc., while also allowing additional flood flow area, for example, is now becoming increasingly popular. In some instances, this measure involves the relocation of at-risk properties, although this is only normally adopted for low density rural areas where residents are unable to cope with the existing risk, and as a measure of last resort. This measure was adopted for example in the South Galway (Gort) area.

(x) Do Nothing

This measure (not a flood relief option) is always considered as the 'control' option against which other measures are benchmarked in terms of benefit-cost ratio.

Flood relief scheme options are often formed using sub-options and / or combinations of the above measures. What must be stressed at this point is that there is a wide range of possible options for flood relief, and imaginative options, including or beyond the traditional engineered possibilities, must be looked at to develop schemes that will not just be a means to an end, but enhance local amenities and the environment. Where possible, the scheme should not just satisfy local residents, but also add value in other ways.

For each scheme the range of potential measures are reviewed against viability criteria to

determine viable options. The range of criteria against which measures are assessed include:

- a) Compliance with constraints, as identified above, including environmental impacts
- b) Technical viability and impacts, which would normally include the following:
 - i) Suitability under local physical conditions,
 - ii) Predictions of post-works design flood water levels and extents over the range of design flows (determined using hydraulic model)
 - iii) Assessment of mechanisms and impact of failure, and drainage of waters after failure
 - iv) Structural implications for existing bridges, walls, etc.
 - v) Assessment of likely construction problems
 - vi) Nature and extent of upstream and downstream impacts of scheme
- c) Health and safety risks and implications (as required for the Design Stage under the Safety, Health and Welfare at Work (Construction) Regulations, 1995)
- d) Impacts on landowners, the local community and other stakeholders, and other local issues and concerns
- e) Implications for the local surface water drainage systems
- f) Economic viability. This is determined by comparing estimated scheme benefits against costs. The estimated costs of the option are all costs directly attributable to the scheme and include design fees, construction costs, site supervision, contingency, post-works landscaping, maintenance. The benefit of the scheme is the predicted Net Present Value of the reduction in flood damage that the scheme option would achieve if implemented.

A recent study (Goodbody, 2001) highlighted a number of points in relation to the cost-benefit procedures for flood relief schemes, including recommendations to exclude VAT from the cost calculations, the use of a 3% discount rate for sensitivity, the use of a 50-year project time horizon, and the exclusion of the costs of environmental and / or amenity enhancement works.

As the evaluation progresses, some options might be rejected without consideration under all criteria due to their failure to meet particular requirements. For example, options might be rejected because they have unacceptable impacts on fisheries or the local environment, they do not deliver significant reductions in flood risk, they require land that is not available, or are significantly more expensive with lower benefits than other options.

On the basis of the above evaluation, a preferred option is selected for which a full Environmental Impact Statement (EIS) is developed, if required, based on the EIA. A series of sensitivity analyses are also run to examine the potential impact of uncertainty, such as the estimation of hydraulic parameters (Manning's 'n', head loss coefficients at structures, etc.), blockage of structures by floating debris, etc.

5.7 Climate Change

Changes in climatic parameters such as sea level and rainfall depths and intensities could have significant implications for flood risk to Ireland, and for the design of flood relief schemes. If, for example, flood flows were to increase by 20%, defences with an existing standard of protection of 100 years would be reduced to approximately 30 years. To avoid this potential reduction in design standard, it might therefore be considered sensible to design current flood relief schemes for the increased flows and associated levels.

It must, however, also be remembered that the predicted changes are not guaranteed to occur to the specified degree, or indeed, at all. It may not therefore be financially prudent to incorporate expensive additional protection that might prove to be unnecessary. The appropriate design policy should therefore strike a balance, taking account of the potential increase in risk from the predicted climate change, while also ensuring that resources are not wasted.

There are a number of design policy options available in relation to this issue, ranging from the assumption that the predicted climate change will occur through designing in scope for enhancement of defences that will be implemented should the changes occur, to assuming that the changes will not occur. On the basis of the Precautionary Principle, the first of these possibilities would be adopted. The last would tend to be rejected as short sighted.

The rate of increase of construction costs for a flood relief scheme tends to fall with rising

standards of protection (due to inversely proportional design and supervision costs and significant initial or fixed costs such as ground preparation, construction of foundations, establishment of site compounds and plant, etc), whereas the rate of increase of flood damages normally rises with increasing severity. These observations would suggest that schemes are likely to become more cost-beneficial by incorporating the predicted impacts of climate change into the design flow.

However, there will be exceptions to this expectation, and in these instances, as well as those where designing for the increased capacity has unacceptable environmental or visual impacts, a scheme might become unviable by incorporating the predicted impacts. This would raise the question as to whether it is better to pursue a design using current design estimates than to provide no protection at all.

A single, rigid policy for the design of all flood relief schemes, with respect to the impacts of potential changes in the climate, has therefore not as yet been adopted by the OPW. A provisional policy is, however, in place, whereby the predicted increases in flows and / or water levels are to be included where possible, but this position is open to review should the associated increase in costs, wall heights, land-take, or dependent factors exclude the progression of a scheme.

Work to determine appropriate design allowances within Ireland is currently underway.

5.8 Outline Design

Once a preferred option has been selected, drawings and plans are developed that will include locations, general dimensions (crest levels / widths, embankment slopes, culvert sizes, bridge inverts and soffits, excavation volumes, etc.), preferred materials, landscaping, etc. These are required for the Public Exhibition Stage (see paragraph 6 below).

5.9 Feasibility Report

The report, which is circulated to relevant stakeholders, and the local authority in particular, concludes with a recommendation for a proposed Scheme with justification and relevant comments or concerns. Other issues might also be reported upon, such as:

- Recommended measures for short-term flood risk reduction, e.g., maintenance or repair
- The installation of additional hydrometric monitoring for further model calibration
- Impacts of further development within the river basin or flood risk area
- Any further study necessary to clarify uncertainties that are specialist by nature or not directly related to the Scheme.

5.10 Feasibility and Outline Design Stage

A Feasibility Study, which is typically undertaken over the period of approximately a year, is a detailed assessment of flood relief options culminating in the selection, with justification, and outline design of a recommended flood relief scheme.

6. DOCUMENT PREPARATION AND PUBLIC EXHIBITION

The objectives of this stage of the process are three-fold:

- 6.1 To prepare the documentation required for Exhibition and the dissemination of notices
- 6.2 To conduct the Exhibition and Notification processes
- 6.3 To review observations, assess submissions, make revisions if necessary, and submit the Scheme for Confirmation.

Sections 4 to 7 of the Arterial Drainage Act of 1945 specify the required documents, exhibition processes and periods, notices to be served, etc. for an Arterial Drainage Scheme, while the relevant amendments specific to a localised Flood Relief Scheme are detailed in Section 5 of the Amendment of 1995. A summary of the requirements is given below in paragraph 6.1.

6.1 Document Preparation

The objective of the Scheme Documentation is to inform all interested parties of the nature of the Scheme by describing in detail the works proposed to be carried out. The documentation must enable the general public to clearly comprehend the works proposed under the Scheme, and more particularly insofar as these works affect individual landowners and the local community. The documents exhibited are of utmost importance as the statutory authority to execute the Scheme is based on these documents. The documents comprise:

- Schedules: Written Scheme details and benefits, including the names of the proprietors, owners and occupiers of the lands with which the proposed scheme will interfere
- Maps: Graphical details of the Scheme, including watercourses, lands and properties that are to be affected, interfered with or compulsorily acquired
- Drawings/Plans/Sections: Technical details of the Scheme
- EIS: if required
- Interference Notices: Documents issued to each affected proprietor, owner and occupier detailing the extent of works proposed on their respective lands or property, and any proposed compulsory interference with, or acquisition of, these lands or property.

6.2 Exhibition and Notification

All of the Scheme Documents are forwarded to the relevant local authority. They are also placed on Public Exhibition in a public building (local authority offices and other public buildings such as libraries, Garda stations etc.). These are notified in the local media. The Exhibition, which is intended to solicit observations, comments and, if applicable, objections, typically runs for a period of four weeks (although this is in excess of statutory requirements), during which representatives from the OPW (and / or staff of a consultancy firm if employed) will be present to respond to queries. The Interference Notices are also forwarded to affected proprietors, owners, etc. in advance of the Exhibition period.

6.3 Review of Observations and Scheme Submission

All observations received from the local authority, Government departments, affected property owners, the general public, etc., in relation to the Scheme are given due consideration and are responded to. As a result of the observations it is sometimes necessary to revise the Scheme, and possibly the associated cost-benefit analysis and EIS.

Once satisfied that all concerns have been appropriately addressed, the Scheme (with revisions if required) is submitted to the Minister for Finance for statutory confirmation of the Scheme. If confirmed, the OPW are empowered to implement the Scheme, and the process moves to the Detailed Design and Construction phase.

7. DETAILED DESIGN AND CONSTRUCTION PHASE

At present, the OPW normally appoints a firm of consulting engineers to act as the Engineer (design, construction supervision, etc.) and a firm of engineering contractors for the implementation of the Scheme, although for some Schemes the OPW will undertake the work itself by direct labour. The detailed design and construction of a Scheme is handled in a similar manner to many civil engineering projects, and is therefore not discussed further.

When all works have been completed on a scheme, a Completion Certificate is required to be issued. This is done through the Department of Finance who advertise the Minister for Finance's intention to issue a Certificate in the *Iris Oifigiúil* and other newspapers and invite any objections to be submitted within a set time frame. If objections are received they must be dealt with before submitting the completion certificate to the Department of Finance for signing and sealing.

8. MONITORING AND MAINTENANCE

The OPW often installs hydrometric stations during the pre-feasibility or feasibility stages to collect relevant data for Scheme design. These stations are normally maintained post-works to monitor the performance of the Scheme. The OPW assumes responsibility for the maintenance of its schemes.

9. TIDAL AND ESTUARINE FLOOD RELIEF

The process for the evaluation, design and implementation of Flood Relief Schemes in locations that are at risk from tidal flooding, or from the combined effect of high tides and river flow, are dealt with through the same process as those dealing solely with fluvial (river) flooding. The evaluation of risk is, however, assessed using slightly different methodologies, and the options available for defence are more limited.

For locations at risk only from tidal inundation, the principal hazard is high sea levels. The frequency of design sea levels can be determined from statistical analysis of recorded data where sufficient records are available. Where this is not available, an anecdotal

assessment is required at a pre-feasibility stage (based on the flooding history), while two-dimensional (or similar) hydraulic modelling is normally required for a Feasibility Study.

The situation is more complicated where the flood hazard can be either fluvial, tidal, or a combination of both. In this instance, a joint-probability analysis is required to determine design water levels (and flows) with a given APO (Annual Probability of Occurrence). It might be the case that there is an inter-dependency of rainfall and low-pressure systems (which cause tidal surge), which complicates the joint-probability analysis, as a simple analysis based on independence would no longer be valid. Preliminary investigations of inter-dependence suggest that any such link, if present, is not significant, although this is an issue that might be studied at a detailed level.

In terms of possible options for flood relief, containment is generally the only viable structural solution against tidal flooding, which may take the form of walls, embankments, sluices / flap-valves (for drainage channels and sewers) or barrages. The non-structural measures are also applicable however, such as flood warning systems, individual property protection, etc. For undeveloped areas, raising ground levels might also be an option.

For combined hazard situations (tidal and fluvial flood risk), the limitations on options with respect to the tidal hazard continue to apply in relation to the tidal component of the hazard, but the full range of measures are available to combat the risk from the fluvial component.

APPENDIX 9

DESIGNATION OF HIGH-RISK CHANNELS

1. INTRODUCTION

The lack of clarity in relation to roles and responsibilities for maintenance of channels has been identified as a major problem under the existing flood relief arrangements. The proposal is to designate high-risk channels and give permissive powers of maintenance to the central authority (OPW). It is intended that this approach will ensure that those channels where a lack of maintenance could cause significant flood risk are not left to degrade.

2. PURPOSE OF DESIGNATION

2.1 General Objectives

As outlined above, the general objective of designation is to ensure that potentially high-risk channels or defences are maintained to reduce the flood risk that may otherwise arise. This system is intended however only to be applicable to channels or defences that pose a potentially significant risk, or that are of strategic importance.

To ensure that these objectives are met, applications for designation must follow a prescribed system and meet certain criteria, as described in paragraph 3 below.

2.2 Associated Responsibilities

Upon designation, the OPW will be empowered to undertake maintenance of the designated channel or defence. The award of permissive powers of entry will require amendment to legislation. The designation of a channel does not guarantee that subsequent flooding will not occur or that maintenance will be undertaken at a certain interval. It rather empowers the OPW to undertake maintenance as required and as resources permit, in accordance with the prioritised maintenance programme.

3. DESIGNATION PROCESS

3.1 Designation Principles

As noted above, the designation of a channel or defence is intended to be applicable to certain high-risk cases. The potential commitment of resources to a maintenance programme for the channel or defence needs to be justified and hence be subjected to prioritisation criteria as will be the case for capital works schemes.

In addition to the standard approach above, strategically important channels or instances where flooding may cause losses of particular significance to a specific location/community, may require to be designated independently of standard criteria. This situation is considered in paragraph 3.2 below.

3.2 Designation Applications

It is proposed that the local authorities should be responsible for the application for designation on an economic / key criteria basis, in the same way that justification for assigning resources to the investigation or undertaking of a flood relief scheme would require a request and assessment from the local authority. A submission would be required to demonstrate that the application meets the criteria outlined below, which would then be subject to review by the OPW and subsequent acceptance, rejection or referral for further assessment.

It is also suggested that the OPW may propose the designation of channels or defences of strategic importance. This may be for reasons other than economic, and hence would not require an assessment against the criteria outlined below. Such reasons might include the protection of major national infrastructure, to ensure ongoing operation of a flood relief scheme, risk reduction for a proposed development area identified as being of significant importance in the National Spatial Strategy, or where there are risks of particular significance to a specific area/community. This form of proposal would however still need to be formally approved and authorised by the OPW.

3.3 Designation Criteria

It is proposed that the same key criteria be adopted in determining the acceptance or otherwise of a designation application as those used for flood relief schemes. These are:

- Risk to life
- Environmental impact
- Extent of properties affected
- Economic benefit

To submit an application, a flood risk assessment will need to be undertaken, based on historical or predictive analysis (e.g., historic flood records, computational modelling) to a level of detail that would normally be associated with a pre-feasibility flood relief study. It is noted that this might require the employment of specialist consultants, but this is considered to be appropriate given the anticipated frequency with which applications may be made, and the potential commitment to expenditure of resources that could arise.

Guidance will be required on the preparation of designation applications and certain assumptions that can be made in assessments, such as the loss of capacity if no maintenance is undertaken. These will be developed should the proposed designation system and approach be adopted.

Proposals that are cost-beneficial, and that meet a pre-set threshold priority score (to be set and reviewed regularly by the OPW) will be accepted for formal authorisation.

APPENDIX 10

FLOOD DEFENCE ASSET REGISTER

1. FLOOD DEFENCES DATA

The risk of flooding is reduced by the existence of flood defences. These flood defences may be natural features, they may have been constructed as flood defences, or flood defence may be a by-product of another development. These include sand dunes, walls, embankments, watertight gates, ramps, attenuation areas including wetlands, natural ponds, swamps and man made facilities. Other structures, such as impoundments, overflows, sluices, are also associated with flood defence.

There is currently no central definitive database of these structures available. There is evidence that defence assets such as those outlined above have been removed or altered, inadvertently placing areas at risk of flooding.

There may be a significant amount of information on these assets in existence. However it is not accessible to interested parties, planners etc. due to the format of the data. The technology now exists to collect this information, validate it and disseminate it, and it is proposed to do this as part of the central authority (OPW) role.

2. SOURCES OF DATA

- a) Among the sources of data are the various drainage schemes completed under drainage legislation dating back to the 1840s. The OPW have engaged in the digitisation of all mapped records relating to these schemes. The record includes all channels completed, embankments, protected and improved lands, and various other structures. The digitised data will allow planning authorities to identify drainage channels, embankments, structures, etc. and provide for their protection and maintenance under guidelines developed by the OPW. Some of these schemes are now maintained by the OPW, however those predating 1945 are maintained by local authorities. Data on these drainage districts has also

been digitised in the same format.

- b) In the 1940s the OPW examined and recorded Land Commission embankments and prepared maps that identified embankments, sluices, etc. and defended land. These too are now in the process of being digitised and will soon be available in digital format.
- c) Local authorities, through their emergency response, maintenance and other functions, have some information on defences. This information may be difficult to identify, in many cases it is probably held locally by overseers. In other cases the information may relate to very old or seemingly insignificant structures. The planning and engineering sections in each area may also have information on impoundments, tailing ponds etc. which may be of relevance. Information may have been gathered previously in the preparation of designs for water schemes and other similar projects.
- d) The Department of Communications, Marine and Natural Resources has a substantial amount of information on marine and coastal structures and the coastal zone generally. This information may identify a number of structures which provide a level of defence against tidal or estuarine floods.
- e) Waterways Ireland is the body responsible for navigation in relation to certain inland navigable channels such as the Shannon and canal systems. In a number of areas the water is impounded and the defence structure should be identified.
- f) The ESB would have a database of structures including embankment, attenuation and sluice arrangements which form part of their role in hydro-electric power generation.
- g) Certain other databases may exist within technical reports and other documents relating to infrastructure development, development plans etc. which should be identified within the scope of this project.
- h) The DoEHLG NGOs, and community/voluntary groups will have information on natural assets, i.e. existing wetlands and, possibly, specific information on those that have been degraded or lost through past activities. As part of the

implementation of the WFD information on wetlands of conservation interest will be listed in a Register of Protected Areas and on GIS systems.

3. DATA COLLECTION AND DISSEMINATION

The collection of this data from all of the above sources would form stage one of the process. Stage two would involve an examination of the assets identified in relation to:

- The extent of the flood defence structure or natural feature
- Its condition
- The standard of defence afforded
- Responsibility for the asset; powers and funding available for maintenance/preservation
- The economic value of the properties that benefit.

The third stage of the process would involve collation of the results from stage two, production of a database of the assets in digital format and dissemination to all interested parties. The identification of resource requirements and establishment of priorities for future maintenance, preservation, or capital investment would also occur at this stage.

Critical flood defence assets could be protected in the same fashion as protected structures under the Planning Acts. This would require legislative change.

APPENDIX 11

FLOOD AWARENESS, EDUCATION AND PREPAREDNESS

1. INTRODUCTION

To highlight the need for a campaign in relation to flood awareness, preparedness and education, it is first necessary to define what is meant by these terms (within the scope of this subject), and what such a campaign could achieve.

1.1 Definitions of Terms

Flood awareness is the understanding of a range of issues related to flooding and potential damages, including:

- The degree and nature (frequency, severity, etc.) of flood risk that might affect an individual, business, or community
- Actions which might be undertaken to reduce the likelihood of possible future flooding or flood damages
- Which actions are, or are not, appropriate to take immediately before (following a flood warning), during, or after a flood event to reduce the likelihood of flooding or flood damages,
- Which actions are, or are not, appropriate for individuals, developers and local authorities to take in relation to the planning and construction of property in a potential flood risk area, or of any property in relation to the potential flood risk impact elsewhere in the river basin.

For the purposes of this subject, the discussion will hereafter be confined to the first three of these issues, as the fourth is dealt with under the topic of planning and development (see Section 4 and Appendix 6).

Flood preparedness is the awareness and state of readiness of individuals, businesses and communities (including local and national authorities) in relation to the actions required to reduce the likelihood of flooding or flood damages should a flood event become imminent or occur.

Flood education is the mechanism for transferring the understanding of awareness and

preparedness from the source (the central authority / OPW) to the relevant audience, i.e., the public, business community, and local and national authorities.

1.2 Objectives

It has been noted in Section 1 that a potential cause of flood damages is a lack of awareness of flood risk and of both awareness and preparedness for the appropriate actions to take to reduce the potential damages arising from a flood event. Awareness and action taken in this regard, as outlined under paragraph 1.1. above, are therefore potential mechanisms for reducing flood damages. The successful implementation of a campaign (with appropriate follow-up action) in this area is hence to be viewed as a non-structural flood relief measure, as promoted under the new policy set out in this Report.

Similar policies and campaigns have been applied internationally (for example, the 'Floodline' campaign in the UK), and are now widely recognised as being a cost-efficient method of flood impact mitigation.

Outlined briefly below are some of the key aspects of a proposed flood education campaign in Ireland, although it should be noted that further research and development of the programme is required before finalisation and implementation.

2. PROPOSED PROGRAMME OF WORKS

2.1 Preparatory Research and Programme Development

As noted above, additional work is required to research best practice in this area, probably through international practice review and analysis of Irish communication channels, and then to develop an appropriate education campaign for Ireland.

2.2 Programme Delivery

The structure and form of the programme will depend to a significant degree on the findings of the social research as outlined in Appendix 5, but is anticipated to include:

- Preparation and dissemination of public information brochures on flood risk and related topics including preparation for flood events and actions to take immediately before, during and after a flood.
- Similar brochures to those described above would also be prepared independently

for business community and for local authorities.

- Preparation and delivery of a series of information seminars for local authorities in relation to awareness and preparedness of their own organisations, but also for the provision of advice and assistance to communities they represent.
- Preparation and dissemination of a media campaign (including press, TV, radio). This will evolve as the overall programme of works associated with the proposed policy progresses, e.g., the development of flood risk information (hazard maps), the development of flood warning systems, etc.
- Possible establishment of a helpline / advisory website.

APPENDIX 12

FLOOD WARNING

1. INTRODUCTION

Flood warning is a non-structural measure to reduce the impacts and damages caused by flood events. The warning is issued following the prediction of flooding on the basis of predicted or recorded rainfall, or recorded river levels upstream of the location at risk. This involves hydrological and hydraulic assessment of the river basin and the risk area, and the development of a predictive tool based on one or more of the inputs described above.

The reduction of impacts and damages is achieved on the basis that a warning is given in advance of the flooding occurring permitting individuals, businesses and emergency response teams adequate time to take appropriate actions that will either prevent an area from flooding, or reduce the damage caused by the predicted flooding. Such actions might include:

- Erection of demountable flood defences
- Distribution of sand-bags or other temporary defence measures
- Evacuation of people from properties predicted to be subject to a significant depth of flooding, high-velocity or polluted flood waters, etc.
- Closing off infrastructure at appropriate locations to prevent people from entering risk areas
- Preparing and mobilising teams for post-event damage reduction, e.g., through pumping
- Removal of high-value (economic and personal) items from risk areas
- Preparative safety work for inundation, e.g., switching off gas and electricity supplies.

Awareness of the risk and appropriate actions to take, and the willingness to take such actions, are essential components of a successful flood warning system, highlighting the need for the proposed programme of flood education (Section 4 and Appendix 11). The other critical factors in flood warning are the reliability of the warning, and the warning period available before the flooding occurs.

2. FLOOD PREDICTION METHODS

2.1 Flood Routing Models

Effective warning systems can be established based on routing models of some format, with inputs from upstream gauging stations. This type of model involves routing or translating river level / flow data recorded at an upstream location down to the risk location. They may involve simple methods such as regression to establish the relationship between the two points, or involve more complex systems such as hydraulic models.

This type of system would generally be more reliable than a system based on a hydrological model using recorded or forecast rainfall, due to the lower level of uncertainty, and would hence be the system of choice. They are, however, only appropriate where the time taken for a flood peak to travel between the two points is adequate, such as in the lower reaches of medium to large river basins.

2.2 Hydrological Models

Where the travel time required is not available for a routing-based structure, warning systems based on hydrological models can be developed with inputs from either recorded or forecast rainfall. Flows or levels are predicted at the risk location by using a hydrological, or rainfall-runoff, model. The model type can again range from a simple regression-based 'black box' type prediction method, to more complex deterministic systems based on, for example, unit hydrographs or river basin water balance models.

Models based on recorded rainfall would generally be less reliable than those using routing-methods, due to the introduction of additional uncertainty in terms of the rainfall-runoff process and spatial rainfall variability. They would be used where the flood peak travel time is inadequate for a routing based model, such as in small river basins or the upper part of larger river basins, but are not suitable for river basins with rapid rainfall-runoff responses.

The uncertainties associated with rainfall forecasting are greater still, and the use of forecast-based systems would generally be the least reliable of the three in terms of accuracy. Forecast-based systems would therefore only be used where the two alternative models described above would not be applicable or effective, e.g., small and flashy mountainous river basins.

2.3 Tide, Surge and Wave Models

A range of models of varying complexity are available for modelling tides, surges and waves. The more sophisticated models are based on numerical solutions of the hydrodynamic equations with input from meteorological conditions. The simpler models, which are more effective in many local cases, are based on empirical correlations with observed data.

3. FLOOD WARNING STRUCTURES AND REQUIREMENTS

3.1 System Structure

As noted above, a warning system involves the prediction of a flood event based on recorded water levels upstream and / or recorded or predicted rainfall. While the method of predicting the flood will vary between each system, they generally require an understanding of the channel capacity at the risk location (derived from a stage-discharge relationship or hydraulic model) and the nature of flooding that can occur, to enable the operating authority to make an estimate of the likely severity (e.g., depths, extents, velocities) of the predicted flood event and hence the action appropriate on that occasion.

The infrastructural requirements of the routing-based system would be telemetered level or flow gauges with regular readings being sent to the system operational centre, and a method of translating the recorded data to a risk at the target location (as described above). Alarm and dissemination systems are also required, although these are discussed later.

Systems using recorded rainfall data would not differ significantly in terms of infrastructural requirements from routing-based systems, other than the need for telemetered rain gauges. Warning systems using predicted rainfall, however, require a specialised meteorological input, e.g. from a national weather service, and access to significant infrastructure such as weather radar, regional circulation models.

3.2 Alarm and Warning Dissemination

All flood warning systems also require alarm and warning dissemination systems. The alarm systems are often based on automated phone or text calls, fax, or email transmissions that are triggered by pre-set conditions (e.g., a certain depth of rain is

predicted to fall or a certain level is reached at an upstream station). Warning dissemination systems can also take the form of automated messaging, although manual systems (i.e., door-to-door visits by operational staff) might be viable for smaller communities.

The alarm and warning dissemination systems are generally staged, and might take the following format:

- a) 'heads up' warning would be issued to the emergency response team co-ordinator and other key staff once there is an indication that a flood event might occur.
- b) A 'mobilisation' warning would be issued to the emergency response team once there is a reasonable degree of confidence that a flood will occur.
- c) A flood warning would be issued to the public once there is a high degree of confidence that a flood will occur. By this stage, the local authorities / emergency response teams would already be mobilised and implementing defence / impact mitigation measures.

This approach maximises the warning time available for preparation while also minimising the risk of widespread dissemination of false alarms.

3.3 Warning Period

The effective operation of a warning system requires an adequate period of warning to be given to permit effective action by authorities and individuals as described above. The potential reduction in economic damages achievable through flood warning is related to warning time available, with one study (ESSA, 1970) estimating that approximately 10% and 25% of damages can be avoided if warnings are received 4 and 15 hours ahead respectively (although these figures might vary significantly between locations). The warning time should therefore be as long as possible, and this will generally define the type of warning system that is appropriate for a specific situation, while issues concerning reliability must be addressed once the system type has been defined.

It might be noted that it is not appropriate to determine a minimum warning period. The period required for a well-prepared small community might be very short, while that required for significant benefit in a major urban area that relies for its protection on the erection of long reaches of demountable defences might be much longer.

3.4 Reliability

As well as providing as long a warning period as possible, a flood warning system must also be reliable. An effective system requires an action to be taken in response to a warning, and such a response will only occur where the recipient has faith in the accuracy of the warning. A lack of warning, or false warnings, would undermine this faith and hence the system itself (the 'cry wolf' syndrome). Unfortunately, the reliability of a system will generally be inversely related to the length of warning it provides. A balance must therefore be established whereby a system should be as reliable as possible while still providing adequate warning time.

3.5 Existing Flood Warning in Ireland

With the exception of a small number of local, and often simple, applications, flood warning systems have not historically been used as a means of flood damage / impact mitigation by either the local authorities or central government in Ireland. In more recent times, the need for non-structural flood relief measures has been recognised, and the installation of flood warning systems are now considered as one of the options available when assessing a flood risk problem.

There has in the past been a lack of clarity in relation to the assignment of responsibility for installation, operation and maintenance of the system, as such a role does not fall clearly into the remit of either central government (OPW) or the local authorities, which has impeded the development of systems. The general lack of historical experience has led, again with certain exceptions, to a deficit of understanding and / or knowledge in developing flood warning systems within these organisations.

Flood warning has however been internationally recognised as a viable, sustainable and economically beneficial measure for managing flood risk and reducing impacts and damages.

4. FUTURE APPLICATION IN IRELAND

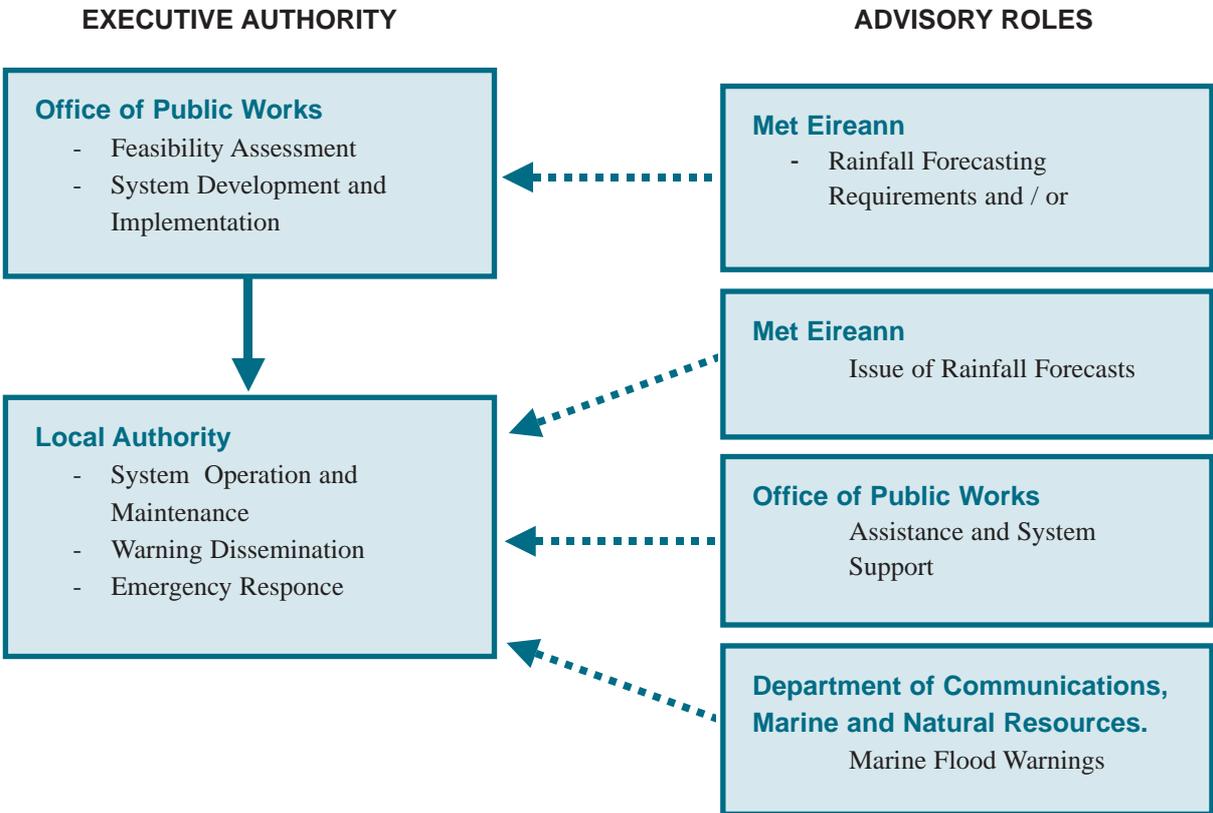
In accordance with the proposed policy set out in this Report it is intended that flood warning, as a non-structural flood relief measure, will have widespread application in Ireland. Development and implementation of systems will be undertaken primarily by the OPW following the same process as that followed for other flood relief works (see

Appendix 8). However, due to the ongoing local demands in terms of resources required for operation and maintenance, it is proposed that the local authorities will assume responsibility for these aspects once the system is in place. Met. Eireann will also become involved in system design and operation where rainfall prediction (and possibly rainfall recording) is required. The Department of Communications, Marine & Natural Resources will assist with the development of marine flood warning systems.

If this policy is to be successful these agencies will need to be provided with the necessary resources.

The diagram below outlines the proposed roles and responsibilities.

Figure 7: Flood Warning – Organisations’ Roles and Responsibilities



5. POTENTIAL INTERIM MEASURES

The above sets out the long-term position in relation to the establishment of warning systems around the country. Low-cost short to medium-term measures should also be considered for application to provide some interim cover for currently unprotected locations. Such measures could take a variety of forms and would need to be discussed with the relevant stakeholders, but could involve the issue of general heavy rainfall warnings issued directly to local authorities on the basis of trigger levels derived from historic flood events.

6. FURTHER INFORMATION

Further information on flood warning systems can be obtained from the following references:

'Automated Local Flood Warning Systems Handbook – Weather Service Hydrology Handbook No. 2'; U.S.Dept. of Commerce, National Weather Service, Office of Hydrology, February 1997

Various projects have been initiated in relation to flood warning including the MITCH Project, the EFWS Project and the Carpe Diem Project..

APPENDIX 13

HUMANITARIAN AID, INSURANCE AND PERSONAL RESPONSIBILITIES

This Appendix is intended to stimulate discussion on this matter in the context of the Review Group's recommendation at Section 4.6.10.

Humanitarian Aid, in the context of this policy proposal, means financial assistance provided to parties affected by a catastrophic flood event outside of their control and in respect of which the normal safety nets that protect against risk are either inoperable or inadequate.

Humanitarian Aid should not be provided automatically in the event of flooding. Provision of such aid will only be considered where it is clear that the normal risk protection mechanisms are inadequate and hardship is suffered on an extensive scale.

Whenever it is considered that a humanitarian aid scheme is necessary, the nature and extent of the scheme and the conditions attaching to it will have to be determined on a case by case basis having regard to the nature of the particular catastrophic event giving rise to it. Some general criteria can, however, be identified:

- Aid is not an insurance payment and should not be expected to put victims in the position they were in before the catastrophic event. It should rather be seen as alleviating extreme hardship.
- Aid should not cover risks that a reasonably prudent person would have provided against e.g. by insurance.
- In exceptional cases aid may be provided to assist people to deal with 'insurance type' damage, where it could be established that for substantial reasons no insurance was in place. Such circumstances might include households entitled to a medical card and/or in receipt of a Social Welfare payment, persons over age 70 and living alone.
- Trauma, as distinct from medical expenses incurred, should not be taken into account in determining the amount of aid or, if it is, the amount payable in respect of it should be fairly nominal.

- Commercial and industrial undertakings should not qualify for aid.
- Aid should normally be confined to defined areas where a catastrophic event has occurred
- While the distribution of aid will occur by definition in circumstances of hardship, and the administration of it should therefore have a minimum of bureaucracy, reasonable proof of loss or damage sustained should nevertheless be required.
- Applicants for assistance should be required to consent to reasonable enquiries being made to corroborate the existence or lack of insurance cover.
- The imposition of a simple means test should be considered where aid amounting to more than €4000 is being proposed.
- Aid may be provided for relocation where the degree of risk is considered to be high and ongoing payments / repairs are not considered to be sustainable. Refusal to relocate in these circumstances will render the potential recipient ineligible for aid.
- Criteria for aid (where conditions outlined above are met) should be developed, based on readily measurable parameters such as depth and / or duration of flooding.

APPENDIX 14

ECONOMIC JUSTIFICATION FOR PROPOSED FLOOD MANAGEMENT POLICY

1. INTRODUCTION

1.1 Need for Justification

While the proposed policy and associated strategies and programmes are in line with international best practice, have a sound logic and technical basis and recognise public concerns, they must also be justified on an economic basis. The total additional costs involved (see paragraph 2 below) are relatively small, and would be similar to the cost of a single major flood relief scheme, or the government spending on humanitarian aid over the last three years. They must, however, be justified to compete with other demands for public expenditure.

1.2 Assumptions and Uncertainty

The process of economic justification of a project (or programme) is information intensive. Unfortunately, and demonstrating to some degree the need for change, there is very little collated, analysed or centralised information in relation to flood damages, which would be required to form a reliable estimate of potential benefits. In addition, the benefits are related to future conditions, such as rates of development, which are not known with any certainty.

A number of assumptions must therefore be made to permit an estimate of the benefits of the proposed policy, strategies and programmes. It is recognised that the use of such assumptions introduces considerable uncertainty into the justification process. However, within the time scale available, the collection of more accurate data would not be possible. It might however be appropriate to investigate this matter further during the early stages of implementation (if adopted) before the full resource requirements are committed.

All of the strategies and programmes associated with the implementation of the policy are treated as a whole, rather than assessed individually. This is necessary as the programmes are heavily inter-dependent and mutually supportive. Partial implementation

would be likely to increase costs of those programmes implemented and/or reduce effectiveness.

1.3 Definition of Costs and Benefits

It should be stressed at this point that the costs, and indeed benefits, discussed are those that are incurred or derived through changes to policy, and do not include those that would otherwise have been incurred. As such, the normal benefits derived through the implementation of a flood relief scheme have been excluded from the analysis, as it is assumed that these would have been accrued through the execution of the existing programme and policy.

2. COST OF IMPLEMENTATION

2.1 Direct Financial Costs

The direct financial costs of implementation of the strategies and programmes have been discussed previously in Section 6. These are summarised below for reference.

Table 6: Direct Financial Costs of Non-Structural Policy Implementation

Year	Costs
Year 1	€3.0 million
Year 2	€5.5 million
Year 3	€5.5 million
Year 4	€5.0 million
Year 5	€3.5 million
Year 6	€3.5 million
Total	€26 million

3. DIRECT BENEFITS

Direct benefits are taken as those that would either directly reduce the risk of flooding (and hence reduce flood damages) or reduce the costs associated with the implementation of flood relief or similar works.

3.1 Reduction of Existing Flood Risk

The existing flood relief programme is relatively effective in reducing the existing risk of flooding within the allocated budget. Assuming that the budget is not increased (or indeed reduced to reassign resources to the proposed strategic aspects), the proposed policy will not directly reduce damages.

The proposed policy is expected to significantly reduce flood risk (and hence damages) in the medium to long term future, while programmes and strategies to deliver on the policy are expected to return benefits in the short to medium term (e.g., optimisation of return on investment through the prioritisation of schemes and increased cost-effectiveness through the emphasis on non-structural works). These aspects are however more related to cost-effectiveness, and do not however directly reduce existing flood risks which it can be said with certainty would not otherwise have been addressed under the existing policy, and are hence considered to be indirect benefits, (see paragraph 4 below). It is therefore assumed that no direct benefits will accrue in relation to the reduction of existing flood damages.

3.2 Development of Flood Warning Systems

The development of river basin models would significantly facilitate the development of flood warning systems, which as previously stated offer a low-cost and effective method of flood impact mitigation. The proposed modelling programme might therefore be considered to have a direct benefit in reducing the costs of developing flood warning systems. However, the number of systems to be developed is unknown, and would generally be integrated with the flood relief studies referred to in paragraph 3.3 below. It is therefore assumed that no benefits would accrue under this issue.

3.3 Hydrological Analysis / Modelling

At present, detailed hydrological analyses are required on a case-by-case basis for the design of each flood relief scheme, as well as for the design of bridges, culverts, etc. These analyses generally require expenditure on studies to determine flood flows and frequencies, which can cost in the order of €2,000 to €20,000 or more for low-level studies for individual, low-risk items of infrastructure, and can rise up to €50,000 for flood relief schemes.

The implementation of the recommended hydrological research programme, and most notably the update of the Flood Studies Report and the River Basin Modelling Programme, will provide a significantly increased understanding of the flood hydrology of Ireland, and

will also provide site-specific data on flood flows and frequency in every river basin. This will significantly reduce the work required to undertake hydrological analyses on case-by-case basis as referred to above.

3.3.1 Quantification – Low-level Studies

A low-level hydrological study will be assumed to cost €7,500 on the basis of 10 person-days at €750 per day. This is considered to be conservative (i.e., an under-estimate) for most studies, such as road bridge design. For the purposes of conservatism, it will also be assumed that these costs are actually reduced to only €3,500 should the proposed programmes proceed on the basis that some localised investigation or recalibration of hydrological models might be required.

It will be assumed that 25 such studies are required per year. Again, this assumption is considered to be conservative.

The average annual cost-reduction for low-level hydrological studies arising from the national hydrological analysis and modelling programmes is therefore estimated to be €100,000 (25 studies * cost saving of €4,000 per study).

Arising from the information derived from the hydrological analysis and modelling programmes, a reduction in the costs associated with over or under-design of infrastructure (i.e., over-specification for construction or the risk of failure respectively for bridges, culverts, etc.) could be expected. This benefit cannot be quantified, however, and hence will not be included in this analysis.

3.3.2 Quantification – Detailed Studies

A detailed study for a flood relief scheme will be assumed to cost €35,000 based on the relevant figures for recent OPW-funded flood relief schemes. For the purposes of conservatism, it will be assumed that only €25,000 of these costs would actually be eliminated on the basis that some recalibration might be required (i.e., a residual cost of €10,000 would remain).

It will be assumed that 6 detailed studies will be undertaken per year, based on the number of studies that have been commissioned by the OPW in recent years and the number of studies submitted to the OPW in support of applications for funding of flood relief schemes. It is likely that there are other studies that are, or would be, undertaken by

local authorities that would also benefit in the same way, although as information is not centrally available in relation to such studies, they will not be included in this analysis.

The average annual cost-reduction for detailed hydrological studies arising from the national hydrological analysis and modelling programmes is therefore estimated to be €150,000 (6 studies * cost saving of €25,000 per study).

3.4 Hydraulic Analysis / Modelling

Direct benefits would arise through the implementation of the National Flood Hazard Mapping Programme, as historical flood data collection and hydraulic modelling will be undertaken as part of the programme which would otherwise have been required to undertake the design of a flood relief scheme. It should be noted that such studies are required for the implementation of non-structural works such as flood warning schemes as well as structural schemes.

3.4.1 Phase I mapping

Following implementation of Phase I of the Programme, there would be a reduction in the costs of historical data searches for detailed studies such as for flood relief works. The reduction in costs (benefits) that would accrue is estimated to be €7,500 per study (based on 10 person-days per study), with 6 such studies undertaken per year as estimated under paragraph 3.3 above.

The average annual cost-reduction arising from Phase I of the National Flood Mapping Programme is therefore estimated to be €45,000 (6 studies * cost saving of €7,500 per study).

3.4.2 Phase II mapping

Following implementation of Phase II of the Programme, there would be a reduction in costs for hydraulic modelling and mapping normally required for flood risk assessment or relief studies. The reduction in costs arising could logically be assumed to be 100% of the cost of the modelling works for 100 schemes, as Phase II of the Programme would concentrate on urban areas considered to be at risk, and which therefore would otherwise have required detailed hydraulic analyses for flood relief design.

The typical cost of a hydraulic modelling and mapping study has been assumed to be €100,000 (for the purposes of developing cost estimates). It is assumed again that studies

would have been undertaken at a rate of 6 per year. For the purposes of conservatism, it will be assumed that only 75% of these costs are actually avoided on the basis that some recalibration might be required to allow for a potential time lapse after the mapping study has been completed, for channel / floodplain changes that might have occurred or for additional flood data that might have been gathered. Again, this reduction is considered to err on the conservative side. It might be noted that assumed number of studies per year for the calculation of the benefits of Phase II differs from that for Phase I, which arises from the non site-specific nature of Phase I, as opposed to Phase II, which concentrates on specific areas.

The average annual cost-reduction arising from Phase II of the National Flood Mapping Programme is therefore estimated to be €450,000 (6 studies * cost saving of €75,000 per study).

4. INDIRECT BENEFITS

Indirect benefits are taken as those that would reduce the risk of flooding (and hence reduce flood damages), or reduce the costs associated with the implementation of flood relief or similar works, through secondary, or indirect, actions resulting from, or permitted by, the implementation of the proposed policy and programmes, such as might arise following the widespread provision of information on flood risk or damage prevention measures.

4.1 Reduced Risk Exposure

The most significant benefit that would arise from implementation of the strategies and programmes is the elimination of inappropriate development in flood risk areas, which would lead to a reduction in the damages caused by floods. The National Flood Hazard Mapping Programme would be the principal source of benefit, although this Programme relies on the hydrological programmes for flood flow data.

The financial benefits that might arise through the reduction of risk exposure are related to the rate of development that would otherwise have occurred in risk areas if the relevant programme and strategies were not implemented. The rate of development that will occur, the location of the development, and the value of flood damages that currently, and will, occur are unknown. Assumptions must therefore be made to estimate the benefits arising. These are: The increase in development will occur at a rate of 2% per year

- In the absence of information on flood risk extent, future development would occur equally in risk and non-risk areas
- Current flood damages are €75m per year.

Assumption 3 is based on typical annual average damage figures derived from current flood relief studies, and the number of flood risk sites.

The estimated annual average damages for current studies lie in the range of approximately €250,000 to €2.6m, with a mean value of €1.1m. The locations that are currently subject to flood relief studies would, however, be expected to be those with greatest levels of risk. It is therefore assumed that a national average value for all flood risk locations of €250,000 would be reasonable.

In excess of 300 locations are known to be at risk from some degree of flooding, as noted in Section 1 of the main report). It is likely that some locations are at risk from flooding but have not flooded in the recent past and as such have not been reported. It will however be assumed that only 300 locations are at risk.

The product of these figures (250,000 * 300 locations) provides an estimated national annual average flood damage of €75m. Preliminary studies would however be required of all flood risk locations, or analysis undertaken of insurance industry figures (which are not currently available) to verify these figures.

The above assumptions are considered to be reasonable, if not conservative. The assumptions might be reviewed following implementation of the socio-economic research and development programmes (see Section 4.1.8 and Technical Appendix 5). Based on these assumptions, it may be concluded that the avoidance of damages arising from informed planning decisions and appropriate development would be €1.5m per year.

4.2 Reduced Runoff from Developments

Flood damages to existing and future development is likely to increase in the future unless sustainable urban drainage systems (e.g., on-site attenuation of floods) are implemented. While the various programmes would assist with the development and refinement of such systems, policies are already in place in relation to this matter. As such, it will be assumed that no additional benefits would accrue from the implementation of the proposed policy under this issue.

4.3 Prioritisation of Works

Indirect benefits would accrue through the prioritisation of flood relief schemes that is proposed, and which would be enabled through the collection and/or generation of relevant information such as the National Flood Mapping Programme. The benefits would arise by prioritising those schemes, which would be most beneficial (i.e., provide the greatest reduction of risk for the lowest cost). However, with the information available it is not possible to quantify this benefit, and as such it will not be included in this analysis.

4.4 Personal Risk Reduction

The education, awareness and preparedness programmes will empower people to take responsibility for minimising damages when a flood occurs through education in relation to the flood risk that exists, and awareness and preparedness of the appropriate actions that should be taken in advance of, during and after a flood.

In the absence of available information in relation to possible benefits, it will be assumed that the reduction in damages that would be made possible through the above programme would be 2% of total average annual flood damages. This figure is based on a reduction of 20% of the residential contents damage, which might typically constitute 10 to 30% of total potential damages (note that the 10% value is assumed for the purposes of conservatism). On the basis of the national annual average flood damages assumed above (€75m – see Section 4.1), the benefits accrued as a result of this programme would therefore be €1.5m per year.

Significant further benefits will be accrued in relation to the above programme if flood-warning systems are implemented. However, such benefits must be considered as those arising from the implementation of a (non-structural) flood relief scheme, which might have been implemented without adoption of the proposed policy. These benefits will therefore not be included in this analysis.

5. INTANGIBLE BENEFITS

In addition to the tangible economic benefits of the proposed policy, there are intangible benefits that must be considered. These would include a reduction in stress through reduced risk exposure and flood damage susceptibility, peace of mind of residents that would arise through the use of flood warning systems, the empowerment people might feel

to take action to reduce risk and / or potential damages that could arise through the awareness of risk and appropriate actions, etc.

The quantification of intangible benefits for specific schemes is based on assumptions and is subject to significant uncertainty. Current practice in Ireland is to set the intangible benefits equal to the residential (and owner-occupier small business) property damages. The report providing the flood damage data and standard methodology used for calculating flood damages (FHRC 2003) however suggests that the intangible damages might be equal to, or even double, the total tangible damages.

Based on the estimate of tangible national annual average flood damage noted above (75m), and assuming that even a small percentage of the associated intangible damages could be alleviated through the strategic elements of the policy (Flood Hazard Mapping Programme, the Awareness and Preparedness Programme, etc.), then the Present Value of the intangible benefits of the proposed policy could be in the order of tens of millions of Euro. However, given the high degree of uncertainty associated with all aspects of such an estimate, the intangible benefits will not be included in the above analysis.

6. PRESENT VALUES

The present values are calculated at a discount rate of 5%, which is the accepted standard in the area of flood relief. The values are calculated over a time horizon of 30 years, which is considered to be the reasonable period of time before the expiry of the validity of the data and information (subject to ongoing maintenance), and before a major renovation of any works undertaken is required.

Costs are allocated at the time they are currently anticipated. An additional capital (as opposed to staff resource) expenditure of €500,000 per annum has been assumed for maintenance and / or upgrade of the programmes and their outputs from year 6 to 30 (although this may not be necessary).

Benefits are considered to accrue starting in year 6, and will therefore only be applicable over 25 years of the 30 year time horizon. Some benefits may be accrued in advance of this but will be offset by others that might only be available after this time.

6.1 Net Present Costs

The programme of costs arising from the implementation of the strategies and programmes is provided in Section 6 and above in paragraph 2.1. With the maintenance / upgrade allowance, the Present Value cost of the strategies and programmes is estimated to be €28m.

6.2 Net Present Benefits

A summary of the quantifiable benefits estimated above is provided in the table below.

Table 7: Summary of Quantifiable Tangible Benefits

Aspect of Benefit	Estimated Average Annual Benefits
Hydrological Analysis / Modelling – Low-Level Studies	100,000
Hydrological Analysis / Modelling – Detailed Studies	150,000
Hydraulic Analysis / Modelling – Phase I	45,000
Hydraulic Analysis / Modelling – Phase II	450,000
Reduced Risk Exposure	1,500,000
Personal Risk Reduction	1,500,000
Total	3,745,000

For an annual average benefit of €3.745m per year, a Present Value of the potential benefit is estimated to be €42m.

7. BENEFIT – COST ANALYSIS

A comparison of the Present Values of the estimated costs and benefits provides a benefit – cost ratio of 1.5:1.

This figure is reasonably robust, and it must be remembered that a number of benefits have not been quantified, and that the estimates and assumptions made are generally considered to be conservative. It must also however be remembered that the analysis is a first order, or ‘ball-park’ estimate only, and should be subject to more rigorous examination.

8. CONCLUSIONS AND SUMMARY

8.1 Conclusions of Economic Assessment

The benefit – cost ratio of the proposed policy has been estimated to be in the order of 1.5:1. This indicates a marginal benefit. However, it must be remembered that:

- The analysis has been substantially based on a number of coarse assumptions, and must therefore be considered as no more than an indicative, first-order, or ‘ball-park’ estimate.
- Assumptions are considered to generally err on the conservative side, i.e., to underestimate the potential benefits
- A number of potential tangible benefits have not been included
- It might be anticipated that significant intangible benefits could arise from the implementation of the proposed policy and associated programmes. These however could not reasonably be quantified at this time, and have therefore not been included in the analysis.

8.2 Summary

On the basis of the above, it is considered likely that if a detailed assessment of the economic viability of the proposed policy and associated programmes of work were undertaken, a positive benefit – cost ratio would arise.

The analysis has considered only the strategic elements of the proposed policies. Neither costs resulting from the requirement for any additional staff nor costs and benefits arising from the implementation of any works and / or maintenance have been included. Any such works or maintenance for specific locations would be assessed for economic viability on their individual merits. In relation to additional staffing requirements this issue will be addressed as programmes develop.

While the analysis has indicated that implementation of the proposed policy is likely to be economically beneficial, it must be remembered that there are also, as previously indicated, other factors which support the policy including widespread demand from a range of public and private sources, and the accepted need for a strategic approach to managing flood risk. These criteria might be considered equally as important as the economic benefits, if not more, in justifying the adoption of the policy.

APPENDIX 15

OPW WORK PROGRAMME (DECEMBER 2003)

Project Title/ Description	Current Status
Kilkenny City	On Site
St. John's River, Waterford	Scheme Exhibited – awaiting confirmation
Clonmel	Exhibited – awaiting confirmation
Carlow	Exhibited – awaiting confirmation
Cregaclare, Co. Galway	Exhibited – under review
Mallow, Co. Cork	Preliminary report nearing completion. EIS in progress
Fermoy, Co. Cork	Preliminary report nearing completion. EIS in progress
Tolka River, Dublin (flooding in Drumcondra)	Feasibility report nearing completion. Interim works being progressed
Tolka River, Meath (flooding in Dunboyne, Clonee)	Feasibility report nearing completion. Interim works being progressed
Tolka River, Fingal (flooding in Littlepace, Mulhuddart)	Feasibility report nearing completion. Interim works being progressed
Morrell River, Straffan, Clane	On Site
Ennis, Co. Clare	Full Feasibility report to be commissioned
Enniscorthy, Co. Wexford	In-house Feasibility Study. EIS in progress
Templemore, Co. Tipperary	Pre-feasibility study with Local Authority for comments
Mornington River, Co. Meath	Feasibility Study nearing completion
Arklow, Co. Wicklow	Flood Study submitted to OPW. Under review
Tullow, Co. Carlow	Pre-Feasibility Study with Local Authority for comments
River Shannon	Limited pre-Feasibility Study in progress
Scotch Quay, Waterford	On Site
Freemount, Co. Cork	On Site
Mullinahone, Co. Tipperary	On Site
Al River, Athlone	Programme of works being agreed with Westmeath County Council
Limerick City	Brief being clarified with Limerick City Council
Ardclough, Co. Kildare	Kildare County Council preliminary report under review.

APPENDIX 16

SUBMISSIONS TO THE REVIEW GROUP

NUMBER	NAME
1	Michael Hurley, Dublin
2	Louise Weir, University College Dublin
3	Michael Burke, Co. Clare
4	Sr. Aileen Fenton, Co. Tipperary
5	Joe F Jones, Co. Meath
6	Noel Phelan
7	Dr. Michael Bruen, University College Dublin
8	Sandymount & Merrion Residents Association (Hon. Sec), Dublin
9	Ennis Chamber of Commerce, Co. Clare
10	Sandymount & Merrion Residents Association (Environmental Officer), Dublin
11	Aidan O'Shea, Cork
12	Revive Rush Tidy Towns, Co. Dublin
13	Geological Survey of Ireland
14	Patrick William Guinan, Co. Offaly
15	Ordnance Survey Ireland
16	Environmental Protection Agency
17	Mayo County Council
18	Residents of Stella Gardens, Irishtown, Dublin 4
19.	Galway County Council
20.	Offaly County Council
21.	North Strand Community Action Group, Dublin
22.	Waterford County Council
23.	Met Éireann
24.	Cork County Council
25.	Cork City Council
26.	William Dunn, Dublin
27.	Kilkenny County Council
28.	Cavan County Council
29	Jeremy Buckley, Cork
30	Comhar
31	Wm Merivale-Cheveley Johnston, Cork

32	Grian
33	Kinvara Area Residents Association, Dublin
34	Dermot Stokes, Dublin
35	Bath Avenue & District Associations, Dublin
36	Kildare County Council
37	Meath County Council
38	Leitrim County Council
39	Dun Laoghaire-Rathdown County Council
40	Royal Haskoning, UK
41	Dublin City Council
42	Fingal County Council
43	Mary & Alfie Mahon, Co. Sligo
44	Clare County Council
45	Irish National Committee of the International Hydrological Programme
46	Prof. J. Philip O'Kane, University College Cork
47	Professor Conleth Cunnane, NUI, Galway
48	Westmeath County Council
49	Irish Insurance Federation
50	Sligo County Council
51	Wicklow County Council
52	Irish Farmers Association
53	Longford County Council
54	Waterways Ireland
55	Iarnród Eireann
56	Bird Watch Ireland
57	Irish Red Cross
58	Central Fisheries Board
59	Gerry Bird & John Geraghty, Co. Meath
60	Limerick County Council
61	Cllr S Farrell & Cllr B Lynch, Co. Longford
62	Anonymous, Co. Roscommon
63	Hydrology Group- Sub-group of WFD National Co-ordination Group
64	IMPACT
65	Galway City Council

66	ESB
67	Louth County Council
68	Senator James Bannon, Co. Longford
69	Tolka River Residents Alliance, Dublin
70	Inland Waterways Association of Ireland
71	An Taisce

APPENDIX 17

MAPS

Map 1 – OPW Drainage Schemes

Map 2 – OPW Records of Areas at Risk of Flooding & Shannon Flood Envelope, Jan 2000

Map 3 – Floods of November 2000 as reported by Local Authorities

Map 4 – Areas at Risk of Flooding Identified by Ove Arup Consultants, 1996

Map 5 – Floods of February 2002 and November 2002

Map 1 – OPW Drainage Schemes



Scale 1 : 150,000

Map 2 – OPW Records of Areas at Risk of Flooding & Shannon Flood Envelope, Jan 2000



Scale 1 : 150,000

Map 3 – Floods of November 2000 as reported by Local Authorities



Scale 1 : 150,000

Map 4 – Areas at Risk of Flooding Identified by Ove Arup Consultants, 1996



Scale 1 : 150,000

Map 5 – Floods of February 2002 and November 2002



Scale 1 : 1,500,000

Scale 1 : 150,000