Sustainable Development Evaluation of Road Infrastructure Programmes and Projects

Section 1 and 2

A Study of the Hydrological Sustainability of the Roads Programme in Ireland

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SOCIO ECONOMICS

The Socio Economics Section of the Environmental RTDI Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in this area. The reports in this series are intended as contributions to the necessary debate on Socio Economics and the environment.

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Summary

This work is a study of the Hydrological Sustainability of Road Development in Ireland and was undertaken in association with FEASTA (Foundation for Economic Sustainability), as part of a larger project on the overall sustainability of road development in this country.

The focus of this work is an analysis of the effectiveness of the environmental impact assessment process and its under-lying legislation in protecting the aquatic environment and its dependent ecosystems. In addition to this the overall requirements of the national road development programme in ensuring environmental sustainability, was considered.

The main finding and recommendations of this thesis are:

Flooding issues have historically not been given sufficient, documented consideration in EISs. Flooding risk analysis should be carried out on all major proposed roads, especially if sub-surface drainage is a significant factor.

Commonly used pollution control BMPs are insufficient in retaining soluble pollutants. Soluble fraction of major runoff pollutants, such as heavy metals can be significant. As well as this the problem of sustainable methods for disposing of sediment and soil that has been contaminated by insoluble pollutants, remains largely unsolved.

From the EISs studied it would appear that groundwater disturbance investigations are usually inadequate and mitigation measures proposed to deal with the effects of the disturbances are largely unsubstantiated. In areas of ecological importance mitigation by avoidance would appear to be the only sustainable approach to groundwater disturbance issues.
Monitoring requirements and associated standards and conditions need to be formalised. Results should be published to ensure openness and transparency.

To significantly improve the environmental impact of road development, policy needs to be focussed on issues that contribute to transport growth, with the specific aim of reducing transport demand. These issues include land-use planning and modes of operation of industrial and commercial businesses.
# Table of Contents

<table>
<thead>
<tr>
<th>Declaration</th>
<th>i</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary</td>
<td>ii</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>iv</td>
</tr>
<tr>
<td>Lists of Figures &amp; Tables</td>
<td>vii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>viii</td>
</tr>
<tr>
<td>Glossary of Terms</td>
<td>ix</td>
</tr>
</tbody>
</table>

## Section 1: Introduction

1.0 Introduction

1.1 Objectives
   - 1.1.1 EIS Study
   - 1.1.2 Directives and Guidelines Study
   - 1.1.3 Sustainability Study

## Section 2: Kildare Town Bypass EIS Review

2.0 Kildare Town Bypass EIS Review

2.1 Background

2.2 Pollardstown Fen

2.3 Relevant Legislation and Guidelines

2.4 Adherence of the Original Kildare Town Bypass EIS to the requirements of the EIA Directive 85/337/EEC
   - 2.4.1 Requirement for an EIS for a motorway development, without exception, under Annex I of the directive.
   - 2.4.2 Provision of data to identify and assess the effects of the proposed project, and description of impacts
     - (i) Effect on receiving waters of runoff removal from road surface
     - (ii) Effect on receiving waters of water drainage from Kildare Town
     - (iii) Effect on receiving waters of water drainage from Curragh Aquifer
     - (iv) Effect of the Curragh Aquifer drainage on the supply of water from the aquifer to the various wells, springs and rivers
   - 2.4.3 Estimate by type and quantity, the emissions into air, soil and water from the operation of the proposed project
   - 2.4.4 Description of forecasting methods used to assess the effects on the environment
   - 2.4.5 Description of mitigation measures proposed
     - (i) Potential effects with NO proposed mitigation measures
     - (ii) Effects with proposed mitigation measures

## Conclusions

## Section 3: Second Liffey Valley Bridge Motorway Scheme EIS Review

3.0 Second Liffey Valley Bridge Motorway Scheme EIS Review

3.1 Background

3.2 Relevant Legislation and Guidelines

3.3 Adherence of the M50 Second Liffey Valley Bridge EIS to the requirements of the EIA Directive 85/337/EEC
   - 3.3.1 Requirement for an EIS for a motorway development, without exception, under Annex I of the directive
   - 3.3.2 Provision of data to identify and assess the effects of the proposed project, and description of impacts
     - (i) Effect on receiving waters of road runoff
     - (ii) Effect of support pillars on groundwater hydrology
   - 3.3.3 Estimate by type and quantity the emissions into air, soil and water from the operation of the proposed project
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>N3 Butler’s Bridge to Belturbet Road Improvement Scheme EIS Review</td>
<td>35</td>
</tr>
<tr>
<td>4.1</td>
<td>Background</td>
<td>35</td>
</tr>
<tr>
<td>4.2</td>
<td>Legislation and Guidelines</td>
<td>35</td>
</tr>
<tr>
<td>4.3</td>
<td>Adherence of EIS to Relevant Legislation</td>
<td>36</td>
</tr>
<tr>
<td>4.3.1</td>
<td>Requirement for an EIS</td>
<td>36</td>
</tr>
<tr>
<td>4.3.2</td>
<td>Provision of data to identify and assess the effects of the proposed project, and description of impacts</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Effect on receiving watercourses of road drainage</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Effect of road subsurface drainage (due to cuts) on the local hydrology</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>Effect on hydrology of using fill materials</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Effect of other cuts and fills northwest of the priority habitat</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Effects of bridge construction over the River Erne</td>
<td>44</td>
</tr>
<tr>
<td>4.3.3</td>
<td>Estimate by type and quantity, the emissions into air, soil and water from the operation of the proposed project</td>
<td>45</td>
</tr>
<tr>
<td>4.3.4</td>
<td>Description of forecasting methods used to assess the effects on the environment</td>
<td>45</td>
</tr>
<tr>
<td>4.3.5</td>
<td>Description of mitigation measures proposed</td>
<td>45</td>
</tr>
<tr>
<td>4.4.1</td>
<td>Description of the Proposed Development</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>(i) Construction</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>(ii) Commissioning</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>(iii) Operation</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>(iv) Anticipated Changes</td>
<td>50</td>
</tr>
<tr>
<td>4.4.2</td>
<td>Description of the Existing Environment</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Description of Impacts</td>
<td>52</td>
</tr>
<tr>
<td>4.4.4</td>
<td>Monitoring and Conditions</td>
<td>53</td>
</tr>
<tr>
<td>4.5</td>
<td>Reference of EIS to the UK Design Manual for Roads and Bridges (UK Highway Agency, 1999)</td>
<td>54</td>
</tr>
<tr>
<td>4.6</td>
<td>Conclusions</td>
<td>54</td>
</tr>
</tbody>
</table>

### Section 5: Legislation and Guidelines

| 5.0     | Legislation and Guidelines                                          | 57   |
| 5.1     | Introduction                                                        | 57   |
| 5.2     | Background                                                          | 58   |
| 5.3     | The requirements of the original 1985 EIA directive and its enabling legislation | 59   |
| 5.4     | The requirements and contents of the Roads Act, 1993 and the 1995 EPA advisory documents | 61   |
| 5.5     | The requirements and contents of the Amended EIA Directive 1997, the updated 2002/2003 EPA advisory documents and the 1999 UK Design Manual for Roads and Bridges (Volume 11 – Environmental Assessment) | 64   |
### Section 6: Sustainability of the Roads Programme

6.0 Sustainability of the Roads Programme  
6.1 Introduction  
6.2 Sustainability of Road Building (Construction, Operation)  
   6.2.1 Construction  
   6.2.2 Operation  
      (i) Runoff Contaminants  
      (ii) Flooding  
6.2.3 Conclusions  
6.3 Sustainability of Road Development Policy  
   6.3.1 Review of ‘Sustainable Development – A Strategy for Ireland’ (DOE, 1997)  
   6.3.2 Development of Public Transport  
   6.3.3 Land-use planning  
   6.3.4 Strategic Environmental Assessment (SEA)  
   6.3.5 Conclusions  

### Section 7: Final Conclusions and Recommendations

97

### Section 8: References

99

### Appendix 1

104
Lists of Figures and Tables

**Figures**
Fig 2.1: Proposed Kildare Bypass in relation to Newbridge and Kildare Towns, and Pollardstown Fen (IWAI, 2005)
Fig 2.2: Pollardsown Fen (IWAI, 2005)

Fig 3.1: Both bridges spanning the Liffey (outfall drain can be seen in bottom left corner)
Fig 3.2: Culverted Mill Race with drainage outfall

**Tables**
Table 2.1: Data needed to estimate flooding risk due to road runoff
Table 2.2: Data needed to estimate surface water pollution risk due to road runoff
Table 2.3: Data needed to estimate flooding and quality risk due to storm water runoff from Kildare Town
Table 2.4: Data needed to estimate the flooding and quality risk due to drainage of the aquifer

Table 5.1: Explanation of WFD-specific terms
Table 5.2: Proposed WQSs for Benzo(a)pyrene
Table 5.3: Proposed WQSs for Benzo(k)fluoranthene
Table 5.4: Proposed WQSs for Cadmium and its compounds

Table 6.1: Metals in Road Runoff and their Sources
Table 6.2: Metal concentrations found in road runoff and receiving waters
Table 6.3: Concentrations of Hydrocarbons and PAHs found in road runoff and freshwater sediment
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Glossary of Terms

Al.  Aluminium
BATNEEC  Best Available Technology Not Entailing Excessive Costs
bgl  below ground level
BMP  Best Management Practice
CCC  Cavan County Council
Cd  Cadmium
COD  Chemical Oxygen Demand
Cr  Chromium
cSAC  candidate Special Area of Conservation
Cu  Copper
DMRB  Design Manual for Roads and Bridges
DOE  Department of the Environment
DTO  Dublin Transportation Office
EC  European Commission
EIA  Environmental Impact Assessment
EIS  Environmental Impact Statement
EPA  Environmental Protection Agency
EQS  Environmental Quality Standards
FCC  Fingal County Council
Fe  Iron
FEASTA  Foundation for Economic Sustainability
HC  Hydrocarbons
KCC  Kildare County Council
MEL  Minerex Environmental Limited
Mn  Manganese
NGO  Non-Governmental Organisation
NHA  Natural Heritage Area
Ni  Nickel
OPW  Office of Public Works
PAH  Polycyclic Aromatic Hydrocarbons
Pb  Lead
pNHA  proposed Natural Heritage Area
Pt  Platinum
SAAO  Special Amenity Area Order
SEA  Strategic Environmental Assessment
SEPA  Scottish Environmental Protection Agency
SUDS  Sustainable Urban Drainage Systems
UI  University of Idaho
WFD  Water Framework Directive
WQS  Water Quality Standards
Zn  Zinc
1.0 Introduction

Sustainable development literally means progress or growth which can be maintained indefinitely. It is also defined by the Brundtland Commission as development which ‘meets the needs of the present without compromising the ability of future generations to meet their own needs’ (United Nations, 1987). Strictly speaking, no development is truly sustainable unless it is carried out without using any non-renewable resources or energy derived from non-renewable resources. Consequently it is clear that the Roads Programme in Ireland as a whole is far from sustainable. However, the scope of this thesis only encompasses the hydrological effects of road development (although there is some discussion in Section 6 on the wider sustainability issues associated with road development). Water is not a resource that is consumed during the construction or operation of roads, but rather is an element of the environment that can be affected by these processes. Therefore, finding solutions to protect it from adverse effects should be easier than utilising renewable energy and construction materials.

This work was carried out in association with a larger project, co-ordinated by FEASTA (Foundation for Economic Sustainability), on the overall sustainability of road development in Ireland.

The environmental sustainability of the national roads programme, including hydrology, is heavily dependent on the Environmental Impact Assessment (EIA) process. It is the level of adherence to this process, and the sufficiency of the requirements of the legislation and guidelines behind it, that will determine whether or not environmental sustainability is achieved. Hence in investigating the hydrological sustainability of the roads programme in Ireland this thesis will examine the effectiveness of the EIA process and the adequacy of associated directives and guidelines. The final section will examine the general question of sustainability with respect to the roads programme - i.e. what does sustainability in this context mean, can it realistically be achieved and if so, how?
1.1 Objectives

1.1.1 EIS Study

The first objective of this thesis is to compare the information and recommendations provided in a range of Environmental Impact Statements (EISs) with the requirements and advice detailed in the relevant directives and guidelines. This is to examine the level of adherence of EISs for road projects to the legislative requirements. Three EISs of various road projects have been chosen for this purpose: the Kildare Town By-Pass (KCC, 1993), the Second M50 Liffey Valley Bridge (FCC, 1998), and the N3 Butlers Bridge to Belturbet Road Improvement Scheme (CCC, 2005).

1.1.2 Directives and Guidelines Study

The objective of this study is to examine directives and guidelines relevant to the EIA process, with a view to assessing their effectiveness in ensuring hydrological sustainability. The main directives of interest are: the original Environmental Impact Assessment Directive 85/337/EEC (CEC, 1985), the Amended Environmental Impact Assessment Directive 97/11/EC (CEC, 1997), the Water Framework Directive 2000/60/EC (CEC, 2000). The Irish guidelines available to those producing an EIS are the Draft Guidelines on the Information to be contained in Environmental Impact Statements (EPA, 1995a) and the Advice Notes on Current Practice (in preparation of Environmental Impact Statements) (EPA, 1995b). Both of these documents were published by the Environmental Protection Agency (EPA). Revised versions of these documents were published in 2002 and 2003, respectively.

1.1.3 Sustainability Study

The objective of this final section of the thesis is (1) to determine the requirements of road construction and operation to ensure the sustainability of these projects and (2) to determine the wider requirements of road building plans and policies to ensure their sustainability.
2.0 Kildare Town Bypass EIS Review

2.1 Background

The Kildare Town Bypass development was proposed in response to (a) the government’s commitment to providing a National Primary Route of at least dual carriageway standard between Dublin and the Southwest, and (b) the increasing traffic congestion problem in Kildare Town.

The original EIS for the Kildare Town Bypass was published in 1993 and the road was completed in 2003. During the intervening ten years there was an extremely long and protracted series of objections and revised studies. It is not possible in this thesis, nor is it an objective, to examine and assess the whole process. The scope of this work only includes an assessment of the original EIS and the subsequent inspector’s report.

The proposed motorway was approximately 13km in length, to be incut along approximately 4.5km. Drainage of this cutting would be required to maintain the groundwater water level below the level of the road. The effects of this drainage on the Curragh Aquifer and on all the hydrologically connected springs, streams and wells in the area, were of major concern and required significant attention during the EIA process. Pollardstown Fen, as a legally protected nature reserve, was the most important local feature at risk from the aquifer drainage.

2.2 Pollardstown Fen
Pollardstown Fen is an alkaline marsh situated on the northern margin of the Curragh approximately 3km north-west of Newbridge Town, Co. Kildare. It is a spring-fed, post-glacial fen the origins of which can be traced back to the end of the last Ice Age, about 12,000 years ago. Because of the uniqueness of the habitat and the number of rare plant and animal species, the site is rated as of international importance. Pollardstown Fen lies in a shallow depression and is maintained by groundwater which continuously flows into the fen from approximately 40 springs and seepage zones. Most of the springs arise around the margins of the depression above the level of the fen and carry groundwater from the Curragh Aquifer (IWAI, 2005).
It is stated in the EIS that the ecology of the Fen, which is located 3km from the proposed road cutting at the nearest point, is particularly sensitive to changes in water regime, and that the proposed road construction has the potential to affect the baseflow of water towards the Fen.

The importance of the Fen is well recognised. It is designated in Ireland as a Statutory Natural Reserve under the Wildlife Act, 1976 and fulfils the criteria required by EU legislation for its designation as a Site of International Ecological Importance under the Habitats Directive 92/43/EEC (CEC, 1992). The Fen is not just important in its own right but also because of its hydrological connection to the Grand Canal. The Miltown Feeder is the natural drainage point of Pollardstown Fen and from there it flows into the Grand Canal, for which it is the main source of water (IWAI, 2005).

At the Public Inquiry into the Kildare Bypass Motorway Scheme which was held in Kildare Town from 23rd – 29th November, 1993 (hereafter referred to as ‘the oral hearing’) (O’Connell & Connor, 1994), Mr. Gerry Wrynn of the Waterways Section of the Office of Public Works (OPW) gave evidence that the Grand Canal was being developed by the OPW as an amenity with £4 million of EC funding, plus additional government funding. He also stated that alternative sources of water for the Canal (other than from the Miltown Feeder) were investigated in 1993 without success.
Fig 2.2: Pollardsown Fen (IWAI, 2005)

2.3 Relevant Legislation and Guidelines

In 1993 the only legislation relevant to the EIA process was the original Environmental Impact Assessment Directive 85/337/EEC (CEC, 1985). There were no Irish guidelines available at that time and no international guidelines were referenced in the Kildare Bypass EIS.
2.4 Adherence of the Original Kildare Town Bypass EIS to the requirements of the EIA Directive 85/337/EEC

2.4.1 Requirement for an EIS for a motorway development, without exception, under Annex I of the directive

In accordance with this requirement an EIS was produced for the proposed Kildare Bypass in 1993 by Kildare County Council. Most of the information contained in the EIS, pertaining to hydrology and drainage, was based on the findings and recommendations contained in a report entitled ‘Investigation into the Requirements and the Impact of Dewatering a Portion of the Curragh Aquifer Necessitated by the Present Design Proposed for the Kildare Town Bypass.’ This report was commissioned by Kildare County Council and produced in June 1993 by Consulting Engineers, K. T. Cullen & Co. Ltd (hereafter referred to as ‘the K. T. Cullen report’).

2.4.2 Provision of data to identify and assess the effects of the proposed project, and description of impacts

In broad terms there are several possible effects of the project on the hydrology in the area. These are the effects of road runoff, Kildare Town drainage and Curragh Aquifer drainage on the quality and quantity of receiving waters, as well as the effect of the aquifer drainage on the supply of water from the aquifer to the various wells, springs and rivers. These possible effects, and how they are dealt with in the EIS, are discussed below.

   (i) Effect on receiving waters of runoff removal from road surface.

It is proposed in the EIS that runoff from the surface of the proposed road would be removed via piped French drains into Simpson’s Stream (a tributary of the River Barrow) and also directly into the Barrow. Existing streams and land drains crossing the route of the proposed road would also be discharged via this drainage system.
• Possible effects of road runoff on flooding
Redirecting surface water and streams away from the proposed road and into nearby rivers would increase the risk of flooding in those rivers. To ensure that this drainage solution is viable it is necessary to ascertain whether or not the increased flooding risk is significant. The following type of data is needed to assess this risk:

| - Annual maximum analysis of the receiving rivers |
| - Maximum capacity of the river channels |
| - Estimation/prediction of the increased volume in the rivers due to additional runoff based on rainfall data, surface area of proposed road and runoff coefficient. |
| - Current destination of and flows in land drains and streams that cross the route corridor of the proposed road. |
| - Estimation of erosion risk due to larger volumes of water flowing at higher velocities |

Table 2.1: Data needed to estimate flooding risk due to road runoff

None of this information is contained in the EIS. Road surface drainage was referred to in the EIS as follows:

‘Simpson’s Stream and the Barrow are proposed as the outfall drains from the motorway. Simpson’s Stream will carry all the road drainage between McGrath’s Bridge and the Curragh. Surface water from the section of road West of McGrath’s Bridge will discharge directly to the River Barrow through a new outfall pipe laid via Moore Abbey.’

‘Road drainage will be collected into a piped French Drain and discharged via pipes to the River Barrow. Existing streams and land drains will be intercepted where they cross the Motorway and discharged via the road drainage system.’

‘Outfall streams will be deepened or enlarged where appropriate.’

‘Because of quicker run-off from large impervious paved areas greater volumes of water will be dealt with in a shorter period of time. This effect will be attenuated as one moves away from the proposed motorway and will have almost disappeared when the River Barrow is reached. The Council has designed the outfall streams to cater for the quicker run-off mentioned above.’
It is unclear whether ‘outfall streams’ refer to the piped discharge system or the receiving streams. If it means the receiving streams, the effect on the ecosystems in and around the streams and on the water quality due to enlarging and deepening them is not considered. Neither is the EIS explicit as to how the volume and velocity of runoff would be attenuated on its way to Barrow. If the French drains are leaking into the subsoil and groundwater and thereby reducing flow, this will possibly have some effect on groundwater hydrology and quality, which has not been considered. None of these issues is explained or clarified in the EIS.

Possible effects of road runoff on water quality

It is well documented in the literature (see Section 6.2.2 (i)) that road runoff can contain a variety of pollutants such as suspended solids, hydrocarbons, metals, salts and herbicides. If land drains are also to be directed into receiving waters with road runoff then it is possible that this water will also contain fertilizer and animal waste leachate. Hence there is a possible risk to the quality of receiving waters from the road runoff that enters them. To assess the magnitude of this risk the following information is required.

- Annual maximum and minimum flow analysis on the receiving rivers.
- Estimation/prediction of the volume of road runoff entering the receiving waters at different times of the year based on rainfall data, surface area of proposed road and runoff coefficient.
- Estimation/prediction of pollutant load (soluble and insoluble) in the runoff at different times of the year, including risk of accidental spillages.
- Current water quality in receiving waters in terms of chemical and biological analysis and also flora and fauna that is currently supported by these watercourses.

Table 2.2: Data needed to estimate surface water pollution risk due to road runoff

This information would enable the assessment of whether the dilution and dispersion capacity of the receiving waters is sufficient to ensure that the risk to water quality is insignificant. None of this information is contained in the EIS. The possible effect on quality of receiving waters due to road runoff is referred to in the EIS as follows:
‘Reports produced on receiving waters for previous schemes show that the chemical and biological quality of the receiving waters will not be significantly affected by the discharge from the proposed Motorway.’

There is no explicit reference to the title or authors of these reports in the EIS or any justification given for applying their findings to this situation.

The issue was raised at the oral hearing where evidence was given by Mr. Gerry Creehan of the Environmental Section of Kildare County Council, that he carried out chemical testing on the receiving streams for the runoff from the Naas and Newbridge bypasses. Results showed that these streams were not polluted within the range of chemical parameters measured and at the times of sampling. No biological testing was carried out.

No information was given regarding the types of chemical parameters measured, the standards they were compared with, or when the samples were taken. It would be important to know if any samples were taken during low flow periods when dilution and dispersion capacities of the receiving streams would be reduced.

As part of this thesis, and to investigate the possible effect of road runoff on receiving water quality, some grab samples were collected from Simpson’s Stream on 23rd July 2005 and tested for a range of water quality indicators - see Appendix 1 for results.

(ii) Effect on receiving waters of water drainage from Kildare Town

The following reference is made in the EIS to water from Kildare Town entering the motorway drainage system:

‘Stormwater drainage from new development in Kildare Town and its environs should discharge to the proposed motorway drainage system.’

‘The pipes and channel sizes (of the motorway drainage system) have been chosen to allow surface water drainage from Kildare Town.’
From this it is inferred that potentially all stormwater that will result from any new development in the town will enter the motorway drainage system and ultimately enter Simpson’s Stream and/or the River Barrow.

To assess the effect of this stormwater drainage from the town entering the receiving waters, in terms of flooding and water quality, the following information in addition to that set out in Tables 2.1 & 2.2, is needed:

- Estimation/prediction of potential water volumes entering the receiving waters from the town at different times of the year.
- Estimation/prediction of water quality of this stormwater.

Table 2.3: Data needed to estimate flooding and quality risk due to storm water runoff from Kildare Town

No attempt was made during the EIS preparation to quantity the effect of the future drainage of stormwater from Kildare Town on the quality or quantity of water in the receiving streams.

(iii) Effect on receiving waters of water drainage from Curragh Aquifer

3.5 km of the proposed road is to be located in a cutting permanently below the water table. To maintain dry conditions along this stretch of motorway it is proposed in the EIS that groundwater from the underlying Curragh Aquifer is continuously drained.

To assess the effect of the drainage on the receiving waters the following information is required:

- Estimation of the amount of water to be drained from groundwater
- Chemical and bacteriological quality of the groundwater
- Discharge location of the drained groundwater.
- The volume, velocity and quality of the receiving water and the spare capacity of the river channel.

Table 2.4: Data needed to estimate the flooding and quality risk due to drainage of the aquifer

Some of this information is available in the EIS and the K. T. Cullen report:
The continuous drainage requirement was estimated at 0.292 m$^3$/sec using computer modelling. This is equivalent to approx. 25,230 m$^3$/day (approx. 5.5 million gals/day).

Some chemical and bacteriological tests were carried out on Curragh Aquifer groundwater samples and were documented in the K. T. Cullen report. The results indicated a typical calcium carbonate groundwater with a hardness in the range 400-500 mg/l CaCO$_3$ which meets drinking water standards. There was no coliform or E. coli present and the water was generally of excellent quality.

Even though the groundwater in the Curragh Aquifer is of high quality the issue of groundwater/surface water compatibility must be taken into account when there is a proposal to mix the two. The pH, temperature and chemical composition of the groundwater may not be suitable for the flora and fauna that are dependent on the receiving waters. This issue was not addressed.

As with the road runoff and the Kildare Town stormwater, no attempt was made to assess the effect of the discharging drained groundwater on the risk of flooding in the local receiving waters.

(iv) Effect of the Curragh Aquifer drainage on the supply of water from the aquifer to the various wells, springs and rivers.

Aquifer and groundwater investigations are the most difficult areas of hydrology for which to gather detailed, reliable information. Pathways in aquifers are usually very complex and therefore it is difficult to accurately determine parameters such as permeability, flow rates, flow directions and water table levels. To properly assess the effect of the aquifer drainage on the surrounding area it is necessary to undertake an in-depth study of the aquifer and these related parameters. It is also necessary to predict, using this information, the changes that will occur to flow directions and volumes, and water table levels as a result of the proposed drainage operation.
Exploratory work was carried out on the Curragh Aquifer by K. T. Cullen & Co. Ltd and documented in the K. T. Cullen report.

The main aims of this investigation were to determine the following:
1. Rate at which groundwater must be removed to maintain dry conditions in cutting.
2. Extent of impact of this dewatering requirement on the Curragh Aquifer and its associated discharges including those natural discharges located within Pollardstown Fen.
3. Impact of this dewatering requirement on the surface and groundwater regime in the area of the Japanese Gardens and Tully West.

The investigation and results were based on ground studies (water levels, permeabilities etc) between the road and the Fen, and a finite-element model that was used to mathematically describe the Curragh Aquifer and predict changes in it due to the proposed road cutting.

Any model is only as accurate and trustworthy as the underlying assumptions and data. Therefore in order to confidently rely on the predictions of the model used in this case it is necessary to decide whether or not the assumptions are well-founded and the data are sufficiently numerous and representative of the area of interest. As a follow up it is necessary to monitor the surrounding area in order to determine how closely the predicted results match the actual results and also to monitor whether or not mitigation measures are working effectively.

Significant Assumptions of the model:

The historical mining exploration borehole data provided only irregular coverage of the area of interest and therefore the vertical and horizontal stratigraphy of large blocks of the overburden had to be assumed.

In the model fixed boundary heads were inputted for the Tully Stream, the River Liffey, the full circumference of Pollardstown Fen and the Milltown Stream exiting the Fen. This is a major and unrealistic assumption. It is unclear how fluctuations in water table levels in these critical areas can be assessed if they are fixed at the start of the modelling process. Also the values of these fixed boundary heads are not specified in
the report nor are the data on which they were based. It is stated in the EIS that seasonal fluctuations in water table level can be up to 1.25m, therefore it should at least be noted which seasonal period the fixed boundary heads represent.

The whole aquifer was assumed to have a permeability value of 69m/day. Since a range of values between 24 & 95m/day were found experimentally during pumping tests it is obviously a gross approximation to use a single value to represent the whole aquifer. Permeability is perhaps the most important parameter needed to determine the flow regime in an aquifer and consequently must be as accurate as possible.

Enhanced recharge is predicted to reduce the impact of dewatering on the surrounding area by reducing the spread of the drawdown curve, but not to change the rate or amount of dewatering. Enhanced recharge is described as recharge of the main gravel aquifer from the overlying clay-dominated aquifer layer. This arises due to the piezometric head difference between them, which is created by the drainage of the lower layer. This recharge is estimated at 0.2-0.3mm/day based on literature research and the prevailing conditions in the Curragh Aquifer.

According to the report enhanced recharge will occur for a number of reasons:

1. Water presently exiting as runoff or near surface runoff will be drawn down due to cone of depression and extended unsaturated zone.

Based on the model prediction that significant flow losses will be experienced in the local streams due to aquifer drainage, it must be concluded that there is possibly a significant hydrological connection between these streams and the aquifer. Therefore it is possible that redirection of surface runoff from the streams to the aquifer will have little effect as it does not add any extra water to the system as a whole and the available water would equilibrate regardless of its point of entry into the system.

2. Effective rainfall will increase because evapotranspiration will be reduced due to extended unsaturated zone which is caused by the drainage.

This argument was indirectly disputed at the oral hearing by Mr. John Mulqueen, Teagasc Land and Water Management Unit. While giving evidence on the effect of drainage on soil moisture and plant and tree growth, he stated that lowering the water table would have no effect on soil moisture and tree growth. This would suggest that
evapotranspiration would not be significantly affected and therefore there would be no extra water available for enhanced recharge from increased effective rainfall.

3. Water held in storage in the aquifer layers above the main aquifer would be drawn down due to the piezometric head difference. This overlying layer is the clay-dominated glacial till layer. There is no information given in the K. T. Cullen report as to the storage capacity of this layer. It is also not clear what the permeability of this soil is but it is presumably low due to the fact that it predominately consists of clay. Even if the permeability and connectivity of the two layers were definitely conducive to yielding enhanced recharge from the upper to the lower layer, presumably extra recharge would be needed to maintain sufficient water volumes in the upper layer to ensure the sustainability of its increased recharge to the main aquifer. This is not considered.

The enhanced recharge is extremely important to the protection of Pollardstown Fen. It is expected to reduce the flow loss to the Fen from 26% to 1.5-4% and so reliance on it must be based on significant evidence. Despite this the literature review on which this prediction is based is not referenced in the K. T. Cullen Report. Even allowing for the fact that some enhanced recharge may occur there is again no firm evidence for the accuracy of the prediction that it will provide in the region of 0.2-0.3mm/day and lower values would have very serious effects on the hydrology in the surrounding area.

In summary, this hydrological investigation makes some very significant assumptions which do not appear to be wholly justifiable, especially the fixed head boundaries for the model and enhanced recharge. Also the lack of data on stratigraphy and water table levels significantly weakens the model. Therefore the results cannot be considered reliable.

Given the complexity of the system to be modelled, the lack of reliable input data and the significance of the area at risk from the proposed development, the residual risk to the area could not be considered insignificant. Mitigation measures are clearly needed and to ensure that they are suitable, reliable and sustainable, more reliable data are needed on the hydrology of the area.
2.4.3 Estimate by type and quantity, the emissions into air, soil and water from the operation of the proposed project

As has been shown in the previous section no analysis was undertaken during the environmental impact assessment to estimate the type and quantity of pollutants discharging into the hydrological environment. Results from other schemes were mentioned in the EIS (See Section 2.4.2 (i)) but these were not referenced or described in sufficient detail.

2.4.4 Description of forecasting methods used to assess the effects on the environment

The only documented forecasting method was the computer model used to forecast the effect of aquifer dewatering on the hydrological regime in the area. This is described briefly in the EIS document and in greater detail in the KT Cullen report.

Since it was not attempted by the authors of EIS to forecast the type or quantity of pollutants entering the hydrological environment, or their possible effects, there is no related description of forecasting methods.

2.4.5 Description of mitigation measures proposed

The purpose of this section is to examine systematically the proposed mitigation measures, or lack thereof, for the adverse environmental effects of the proposed project.

(i) Potential effects with NO proposed mitigation measures

There is a potential for flooding in receiving waters, namely Simspoon’s Stream and the River Barrow, due to diversion into these water courses of road runoff, stream and land drains that cross the proposed route corridor, sub-surface drainage from the aquifer and future stormwater drainage from new developments in Kildare Town.

There is a potential for deterioration of water quality in Simpson’s Stream and the River Barrow due to possible pollutant content of some of the drainage waters flowing into them as
a result of the proposed road project. The main sources of concern would be the surface runoff from the proposed road, stormwater from Kildare Town and the land drains. There is potential for effects of mixing drained groundwater with freshwater in the receiving streams. Although testing has indicated that the groundwater is of very high quality it is not certain that it is compatible with the fresh water in the receiving water courses. The addition of large quantities of groundwater to surface water streams could significantly change their characteristics and nature as habitats for various flora and fauna.

It was estimated by the computer model that the aquifer drainage would cause the following effects on streams, springs and wells:

A steady state flow reduction of 53% to the northern portion of the Tully Stream.
All streams in the area of the Japanese gardens would be lost.
A 6% reduction in discharge to the river Liffey from the aquifer
Wells within the radius of the cut would potentially have g/w level reductions but this issue would be limited to shallow wells.

It was mentioned at the oral hearing by Kevin Cullen of K T Cullen & Co. Ltd. that the losses to the Japanese Gardens and Tully’s Stream would be compensated in the same manner as Pollardstown Fen, using injection methods (see below), but this was not outlined explicitly in the EIS.
Effects with proposed mitigation measures

Streams and surface ponds used for cattle watering are predicted to dry up. Kildare County Council will undertake to provide water troughs fed by the mains water system to compensate for this. This mitigation measure should be sustainable in the long term if the artificial watering system requires little or no maintenance.

Any reduction of flow to Pollardstown can be compensated for by the provision of injection wells located at the groundwater divide. The amount of water required is unknown but estimated in the K. T. Cullen report at up to 9600 m$^3$/day.

This proposed mitigation measure is completely unsustainable. It would require the perpetual injection of very significant quantities of water into the Fen. There are no details given in the EIS of how this measure might be operated, such as source of injection water and pumping & monitoring costs.

This issue was raised by a number of interested parties at the oral hearing. Opinions expressed on this matter were as follows:

- John Mulqueen, Teagasc Land and Water Management Unit:
  Agreed with Mr. Ryan, OPW that water pumped from the aquifer would precipitate calcium carbonate due to the pressure difference between the aquifer and the surface. This would obviously alter the chemical composition of the water.

- Mr. Cullen, author of K. T. Cullen Report:
  The system for injecting water to compensate for drainage had not yet been designed but would use clean ground water. He agreed that water drained from the cut could be polluted, making it an insecure source. Therefore he agreed that the water may need to be treated before re-injection. Mr. Cullen’s only experience of injection was with small scale operations.

- Mr. Paul E. Johnson, Ove Arup & Partners:
  In his experience re-injection is experimental in nature. He also said that using polluted water for re-injection is the single biggest concern.

- Mr. David Ball, OPW:
He said that he felt it would be very difficult to inject water to simulate the water required by the Fen.

Re-injection of water into the aquifer in areas where water supply from it has been affected by drainage was the most important mitigation measure mentioned in the EIS. It was the only proposed solution to the very significant potential effects of drainage on the hydrology of the area. Despite this no effort was made to design this re-injection system or to seriously consider the major issues and difficulties involved. It was suggested that the water needed would come from the cutting drainage water but this water was due to enter a drainage system along with the road surface runoff, the contents of the land drains and potential stormwater from Kildare Town, therefore its quality would be severely compromised. There was also doubt cast on the level of development of this technology and its effectiveness, which was not contradicted by the proponents of the scheme. There was also the outstanding issue of the long-term costs involved, which was not addressed by anyone.
2.5 Conclusions

It is clear from this study of the effectiveness of the Kildare Town Bypass EIS that there are serious omissions with respect to hydrology.

- The risk of flooding was not considered – it is possible that this risk was unlikely and insignificant but this assumption should have been clearly explained and justified, especially with a possible 5.5 million gallons/day being pumped from the Curragh Aquifer.

- The risk of pollution was summarily dismissed, again with no sufficient explanation or justification.

- And most important, the protection of Pollardstown Fen was not guaranteed by unsubstantiated theories on enhanced recharge and under-developed plans for re-injection.

- The EIS clearly did not adhere to the requirements of the original EIA Directive (CEC, 1985) in terms of data to identify and assess effects such as flooding and pollution. Also, some proposed mitigation measures could not be considered reliable.
3.0 Second Liffey Valley Bridge Motorway Scheme EIS Review

3.1 Background

The M50 motorway is a ring road for Dublin city which crosses the Liffey at the Strawberry Beds between Palmerstown and Castleknock. The second M50 Liffey Valley Bridge is a replica of the original bridge, which was completed in 1990. The design of the original took into account the fact that increased capacity would be needed in the future and therefore enough land was purchased for both bridges. As the plans for the original bridge were drawn up in 1985, before the EIA Directive 85/337/EEC (CEC, 1985) came into effect, the report for that proposed project made only a passing reference to environmental issues. Hence this work will focus on the EIS for the second bridge which was published in 1998. The bridge was opened in 2003.

A large part of the lower valley of the Liffey is designated as a Natural Heritage Area (NHA), under the Wildlife Act, 1976. Included are the Mill Race and the Liffey itself – the destinations for the runoff from the construction area and the bridges. Also a Special Amenity Area Order (SAAO), under the Local Government (Planning and Development) Act, 1963, was conferred on the Liffey Valley between Lucan Bridge and Palmerstown in 1990. Stated in this order is the following:

‘It is the objective of the council that the water quality of the river be maintained and that existing outfalls to the river be reviewed and upgraded as necessary’

Therefore it is to be expected that the EIS for the second bridge would make particular reference for the need to control outfalls to the river.
Fig 3.1: Both bridges spanning the Liffey (outfall drain can be seen in bottom left corner)

3.2 Relevant Legislation and Guidelines

The Amended Environmental Impact Assessment Directive 97/11/EC (CEC, 1997) had not been brought into effect at the time that the EIS for the second bridge was being prepared, therefore as with the Kildare Town Bypass, it is based on the original EIA Directive 85/337/EEC. The 1995 advisory documents published by the EPA (EPA, 1995 a&b) were also referenced by the authors of the EIS.
3.3 Adherence of the M50 Second Liffey Valley Bridge EIS to the requirements of the EIA Directive 85/337/EEC

3.3.1 Requirement for an EIS for a motorway development, without exception, under Annex I of the directive

In accordance with this requirement an EIS was produced for the proposed Second Liffey Valley Bridge of the M50, for Fingal County Council by Ove Arup Consultants in 1998.

3.3.2 Provision of data to identify and assess the effects of the proposed project, and description of impacts

The effects of the construction of a bridge across the Liffey Valley may include pollution of receiving waters by road runoff, increased risk of flooding in receiving waters due to road runoff and alteration of groundwater flow due to construction of supporting pillars of the bridge. The treatment of these issues in the EIS is dealt with in the following paragraphs.

(i) Effect on receiving waters of road runoff

It is proposed in the EIS that road runoff would drain via interceptors into the River Liffey and the adjacent Mill Race.

Possible effects with respect to flooding
Redirecting runoff away from the proposed road and into nearby rivers will increase the risk of flooding in those rivers. To ensure that this drainage solution is viable it is necessary to ascertain whether or not the increased flooding risk is significant.

The data needed to assess this risk has been previously tabulated in Table 2.1, Section 2.4.2.
Neither the risk of flooding in the receiving waters (the Liffey and Mill Race) nor the possible impacts were considered and therefore no attempt was made to measure current flows and capacity of river channels or to predict future additional flow due to runoff.
Possible effects with respect to water quality
As is stated in the EIS runoff contains hydrocarbons, grit, and spillages from road accidents, and it poses a significant threat to the quality of the receiving water. Despite this there was no estimation of the quantity of these contaminants that would enter the runoff and consequently no estimation of the extent of the impact to be mitigated. There was also no consideration of other possible runoff pollutants such as heavy metals which also potentially cause environmental damage (see Section 6.2.2 (i)).

The data needed assess the magnitude of the risk to the quality of receiving waters from road runoff is tabulated in Table 2.2, Section 2.4.2.

Fig 3.2: Culverted Mill Race with drainage outfall
The only data gathered relevant to this section was the biological analysis of the Liffey and the Mill Race. An aquatic survey of the biological resources was undertaken. Surface water quality was determined by investigating the diversity and abundance of aquatic invertebrates. The results of this investigation indicated that species richness is relatively high in both the
Liffey and the Mill Race. The mill race is quite stagnant and contains species that indicate poor water quality and organic enrichment. The Liffey is an important salmon river. It was noted however, that the survey was carried out during winter flood conditions which are unsuitable for macro-invertebrate sampling and therefore the full species complement may not have been collected. The sampling technique used was also unlikely to capture the full range of organisms present. There was no chemical analysis carried out. Obviously some effort was made to quantify the current quality in the receiving waters but the results are inconclusive and of little use due to the inadequacy of the timing of the sampling, the techniques used and the complete lack of chemical analysis. It was concluded in this section of the EIS that nothing found in survey is considered of high nature conservation importance which is incomprehensible given that the Liffey is an important salmon river.

This analysis of flooding and pollution risk is extremely poor, especially considering the requirements of the SAAO.

(ii) Effect of support pillars on groundwater hydrology

There was no mention in the EIS for the second bridge of the effect of the pier foundations on the groundwater beneath the Liffey Valley, or vice versa. The type of foundations used were detailed but not the depth to which they are laid. Information on groundwater levels and flows, and depths to bedrock was also omitted.
A 1992 article on the original bridge in the Proceedings of the Institution of Civil Engineers - Structures and Buildings (Smyth et al., 1992) detailed the following regarding depth of foundations and water level:

The south abutment and Piers 1 & 2 have a pad foundation bearing on bedrock at depths of approx 7m. Pier 3 and north abutment have steel piles driven into deep clay and gravel up to depths of 15m. Excavation drainage was needed at Piers 3 & 4.

This shows that the original bridge’s foundations were driven to significant depths and encountered groundwater. Since the second bridge was built in very close proximity to the first, similar methods must have been employed in the foundation construction. Therefore some mention should have been made in the EIS for the second bridge of the interaction of the foundations with the groundwater and the resulting effects.

If the groundwater level is sufficiently high then some or all pier foundations would require drainage. If this is the case then it is important to state approximately how much water will be drained, where to, the effect of the drainage on the aquifer potential. If this is not necessary it should be stated for clarification. With respect to the effect of the foundations on groundwater, foundations which intercept groundwater may significantly affect groundwater flows and this water is susceptible to pollution during construction. These issues should be addressed, if only to emphasise no effects. The extent and importance of the aquifer should also be mentioned.

### 3.3.3 Estimate by type and quantity the emissions into air, soil and water from the operation of the proposed project

The main emissions to water produced during operation of a road are those that end up in road runoff and ultimately in receiving waters. They have been listed in the EIS as hydrocarbons, grit and spillages from road accidents but no attempt was made to generate a more comprehensive list or to quantify them. This is not sufficient. There are other potentially harmful constituents of road runoff such as de-icing agents and herbicides which are not considered or mitigated against. See Section 6.2.2 (i)) for a literature review of typical sources, quantities and effects of pollutants in road runoff.
3.3.4 Description of forecasting methods used to assess the effects on the environment

No technical forecasting methods were used to assess the environmental effects of the proposed development. There was little or no analysis of the hydrological environment underpinning the choice of mitigation measures (see Sections 3.3.2 and 3.3.3).

3.3.5 Description of mitigation measures proposed

Runoff Interceptors
Existing runoff from original bridge is currently draining into Liffey via small interceptors. New interceptors are proposed to deal with runoff from both bridges and to discharge into both the Liffey and the Mill Race.
The proposed interceptors are commercially available prefabricated units and are designed to retain grit, suspended solids and hydrocarbons. The interceptors will be desludged and degritted at regular intervals as part of a routine bridge maintenance programme.
No mention of testing or monitoring the effectiveness of the interceptors. To ensure they are working correctly and adequately it is essential to monitor the quality of the water exiting them.
The only reference to monitoring of the performance of the interceptors is as follows:

‘Discharge licences to control the outputs from these interceptors, if required by legislation current at that time, will be obtained prior to opening of the bridge.’

This mitigation measure will have no effect on soluble contaminants which will flow uncontrolled into the receiving waters.
Accidental Spillages

With respect to mitigation of accidental spillages it is stated that in the event of an accidental spillage the interceptors would be isolated by an outlet valve and that such action would form part of the Operator’s accident response programme. This does not constitute an adequate description of an accidental spillage mitigation measure. It is necessary to elaborate on how the contingency plan would work. For example, would toll booth operators be trained to isolate interceptors, how quickly would it be carried out and would the programme ensure the retention of most, if not all, of the spilt substances?

Septic Tank for toll bridge

‘Foul Drainage from Toll Plaza is disposed of to a septic tank located adjacent to the plaza’

This is the only reference to the management of foul drainage from the Toll Plaza. Monitoring of the septic tank to ensure it is working correctly should be included as part of the mitigation measure.
3.4 Adherence of the M50 Second Liffey Valley Bridge EIS to the requirements of the 1995 EPA advisory documents (EPA, 1995a&b)

3.4.1 Description of Project

The advisory documents require that the effects on the environment of construction, commissioning, operation, anticipated changes, and decommissioning should all be considered individually. These effects on hydrology were dealt with in the Second Liffey Valley Bridge EIS as follows:

(i) Construction

- Temporary Bridge – driving piles into river bed and subsequently removing them will cause temporary elevated levels of suspended solids downstream in the Liffey. This was not considered to be a significant source of pollution. Although disturbance of the riverbed is not ideal, construction of the temporary bridge should not introduce any foreign material or substances into the river environment and therefore it should recover completely when the structure is removed. The depth to which the supporting piles are driven is not mentioned. This should be established to rule out interference with groundwater flow and quality.

- Earthworks – will cause excess soil runoff into Liffey and Mill Race. This will be an issue particularly to the south in the slow moving mill race. Therefore a temporary earth lagoon will be provided to settle the soil and prevent it entering the mill race. The water will also be filtered through straw bales at outlet to the mill race.

‘Such an approach has been demonstrated to be effective at other construction sites’

Therefore there are no plans to monitor the effectiveness of this approach during the project. There is no exact reference to the other occasions and sites where this approach has proved
successful or data from other sites supporting the claim and proving that the suspended solids content in the outflow is sufficiently low.

In the north, due to topography, it is not possible to install sediment lagoons. Therefore runoff of suspended solids due to earthworks in this area will run into Liffey without mitigation. This was judged not to be an issue because the Liffey is considered to be reasonably fast flowing and sediment ‘would have significantly less potential to cause an adverse impact. Nonetheless care should be exercised at this location during periods of heavy rainfall when the erosion of exposed subsoils within construction areas is more likely’

This analysis is unsatisfactory. It was assumed that the Liffey could cope with runoff contained suspended solids from the earthworks without elucidating the river’s flow velocity or the anticipated amount of suspended solids it might have to deal with. Also there is no clear action plan for circumstances of heavy rainfall, or onus or obligation on anyone to take definite action.

• Oil and Fuel Storage
Fuels will be stored in bunds along embankment south of works.

• Construction Site Runoff
Runoff from construction area will be channelled into Liffey (not into Mill Race as it is more sensitive). It will first of all be directed into sediment ponds or tanks to reduce suspended solids levels in runoff. Oil interceptors will also be installed to ensure that any petroleum spillages at the construction site will not reach the receiving water. Portable chemical toilets will be provided on site for those working on the construction site. Therefore no foul water will be allowed to drain into receiving waters.

There is no mention of monitoring sediment or hydrocarbon levels entering the river to ensure that the mitigation measures are working correctly. Monitoring is particularly important as runoff from the construction site may contain pollutants such as cement liquors that would not be sufficiently controlled by the suggested mitigation measures.
(ii) Commissioning

This section is not particularly relevant to a road project as it relates to testing and commissioning of, for example, process equipment.

(iii) Operation

The treatment of this issue in the EIS, with respect to the EIA Directive (CEC, 1985) requirements, has been dealt with in Section 3.3.2. The EPA advisory documents (EPA 1995 a&b) also require a description of maintenance activities and their possible effects, which is not covered in this EIS.

(iv) Anticipated Changes

There are no major changes anticipated for this project but is considered in the EPA advisory documents (EPA 1995 a&b) that changes such as aging and deterioration which can cause decreasing effectiveness of mitigation measures should be anticipated and addressed. These issues were not considered in the EIS.

3.4.2 Description of existing environment

The EIA directive required data on the existing water but did not specify exact quality parameters. The EPA guidelines are far more specific:
- All water types in the vicinity of the project are to be considered: ground, surface, estuarine, marine
- The physical, chemical and biotic characteristics of the waters are to be described, as well as the beneficial uses.
- The context, character, significance and sensitivity of these water bodies are to be described.
- The natural seasonal or long-term changes in hydrological environment
The main water bodies of interest in this project EIS are the surface waters of the Liffey and the Mill Race (no attention is given to groundwater). As outlined in Section 3.3.2 (i) a poor study of the macro-invertebrates in these watercourses was carried out. No data was given for the physical (temperature, volume, velocity), or the chemical (nutrients, gases, contaminants, pH, trace elements, mineralization) characteristics. Very little context and no character or sensitivity information (as described in the EPA Advice Notes, EPA (1995b)) in relation to these rivers or the local groundwater, are given. With respect to natural hydrological changes no mention was made of the annual flow patterns in the watercourses and how the pollutants entering them may have a more significant effect during periods of low flow.

3.4.3 Description of Likely Significant Impacts

The EPA advisory documents (EPA, 1995 a&b) elaborate on the EIA directive (CEC, 1985) requirements for impact description and recommend a description of direct and indirect impacts in terms of magnitude, spatial extent and duration, as well as the environmental elements (e.g. water, air, soil) that are effected.

As outlined in Section 3.3.2 the description of impacts on water was sparse. A risk of flooding in the Liffey and Mill Race due to road runoff, and a risk of interference with the groundwater flow regime due to the foundations of the bridge’s support pillars, were not considered as potential impacts. Probable risk to the quality of the receiving water from sediment and hydrocarbons in the runoff was acknowledged and mitigated against but without any quantitative data on the magnitude of the impact or its spatial extent.
3.5 Conclusions

The EIS for Second Liffey Valley Bridge Motorway Scheme was not sufficient to ensure environmental protection of the local surface and groundwater and did not adhere to the relevant legislation and guidelines, for the following reasons:

- There was no consideration of the flooding risk due to road runoff.

- The selection of mitigation measure for road runoff contaminants, namely oil and sediment interceptors, was not based on an estimation of runoff volumes, velocities or quantification of its sediment or oil content. No consideration was given to other possible pollutants contained in the runoff.

- There was no consideration of the possible effect of the supporting pillars’ foundations on the quality and flow of the groundwater.

- The description of the physical environment was extremely poor with no physical or chemical data for the local waters and only a poor biotic study of the Liffey and Mill Race.

- There was not sufficient regard for the area and the receiving waters in particular, given their status with respect to the SAAO.

- No account was taken of the possible environmental effects of road maintenance.
4.0 N3 Butler’s Bridge to Belturbet Road Improvement Scheme EIS Review

4.1 Background

The proposed road is a 6.7km stretch of single carriageway from Butler’s Bridge to Belturbet Town in Co. Cavan. This is to replace the existing road, the horizontal alignment of which includes several dangerous bends. The proposed road passes through the Lough Oughter and Associated Loughs area and requires the construction of two bridges, both of which exceed 100m in length, and two significant cuttings. The Lough Oughter and Associated Loughs area is a candidate Special Area of Conservation (cSAC) which means it is recognised as a site of international ecological importance. This designation has a legal basis in the EU Habitats Directive 92/43/EEC (CEC, 1992) and has been assigned in order to protect two particular habitat types, namely Natural Eutrophic Lakes and Bog Woodland. The wetland complex in the same area has also been designated a proposed Natural Heritage Area (pNHA), under the Wildlife Act, 1976. The landscape consists of drumlins and interspersed lakes, bogs and wetlands and generally soft ground. The proposed route also lies within the catchment of the River Erne.

4.2 Legislation and Guidelines

The EIS for this scheme which was published in May 2005, was prepared in accordance with several requirements and guidelines: the European Communities Environmental Impact Assessment (Amendment) Regulations 1999 (ISB, 1999a) which brought into force the 1997 Amended EIA Directive (CEC, 1997), Roads Act 1993 Sections 50 & 51 (ISB, 1993), and the EPA revised EIS advisory documents 2002/2003 (EPA, 2002 & 2003). The EIS also makes reference to the UK Design Manual for Roads and Bridges (DMRB), Volume 11 in relation to scoping of environmental issues (UK Highway Agency, 1999).

4.3 Adherence of EIS to Relevant Legislation
The changes to legislation, made as a result of the 1997 Amended EIA Directive (CEC, 1997) (the main changes are detailed in Section 5.5), have little effect on the analysis of impacts on the hydrological environment, therefore the legislative requirements in this respect are very similar to the those governing the analysis of hydrology at the site of the Second Liffey Valley Bridge Motorway Scheme.

4.3.1 Requirement for an EIS

Although there is no automatic requirement to carry out an EIS for a standard single carriageway road under the 1997 Amended EIA Directive (CEC, 1997), the Irish legislation states the need for an EIS if the proposed road is to be located in a special area of conservation, or if construction of a proposed road would include a bridge of 100m or more in length (CCC, 2005). Both of these caveats apply to the N3 development in question.

4.3.2 Provision of data to identify and assess the effects of the proposed project, and description of impacts

As with the other road schemes studied there are several ways in which the proposed development could adversely affect the hydrological regime in the local area, such as increasing the risk of flooding, pollution and alteration of the groundwater regime. These issues are dealt with in the EIS as follows:

Effect on receiving watercourses of road drainage

- Risk of flooding
A preliminary drainage design has been carried out to identify suitable outfalls for surface water and sub-grade drainage which will be directed into existing watercourses. The design also included an estimation of discharge flows for each outfall. Annagh Lough and Putiaghan Lough will receive drainage water. Annagh Lough is used for water abstraction (not specified whether or not it is used for drinking purposes). Culverts are to be used where the road
crosses existing land drains and watercourses. A one in 100 year flood is the proposed design criterion for the culverts.

Issues:
- An estimation of the discharge flows for each outfall could not be found in the EIS (the fact that estimations were undertaken was mentioned in Sections 4.4.9.1 & 14.2 of the EIS but there was no reference given for the data in either section).
- It is stated that Annagh and Putiaghan Loughs will receive road runoff but the exact outfall locations of the drainage water were not given. Figs 14.1-14.8 of the EIS depict some, though not all, (see Fig 14.2 of the EIS) of the road drains but the ultimate destination of a significant proportion of the road drainage network is not made sufficiently clear on these diagrams. It would also appear from these diagrams that some runoff doesn’t pass through the attenuation ponds.
- There was no information given on the existing flow regimes or volumes in these destination watercourses.
- There is no data provided to determine the one in 100 year flood in any of the rivers or drains. Table 2.1 (Section 2.4.2) outlines the type of information needed to estimate flooding risk. None of this information is included in this EIS.

  • Risk of pollution
The data needed to assess the risk of pollution in the receiving water courses due to road surface and sub-grade drainage, are detailed in Tables 2.2 & 2.4 (Section 2.4.2). Of this data electrical conductivity, pH and temperature in the land drains and at some groundwater level monitoring points, are detailed. Also there is information detailed on the types of fish to be found in the main cSAC lakes and in the River Erne and some chemical analysis data on these waters (see Section 4.4.1).
Issues:
Important information that has been omitted is sensitivity/toxicity data for the important flora and fauna, especially the fish, and the physical assimilative capacity of the waters in terms of volumes and flowrates. This is particularly important in the lakes where fresh water inflow and mixing may be low.
In addition, no attempt is made to quantify potential pollutants or their effects. This process is bypassed and mitigation measures are proposed without it.

Effect of road subsurface drainage (due to cuts) on the local hydrology

Although the cSAC encompasses a very large area the Aghnaguig Bog woodlands and wetlands (167 hectares) are deemed to be the most important in terms of habitat and within that a 5 hectare section of birch woodland with sphagnum has been designated a priority habitat area. This has been the focus for protection and conservation during hydrological investigations.

There are several sections of the proposed road which are to be incut into drumlins. These cuttings would cause varying amounts of subsurface drainage which in turn has the potential to cause significant changes to the hydrological regime in the area. Water flows and volumes in the local surface and groundwaters are crucial to maintaining the wetlands and bogs in the cSAC.

Refer to Section 16.4.1, Volume 1 and the diagrams in Appendix A.15, Volume 2 of the EIS (CCC, 2005) for details of the cuts.

Cut 1:
The maximum interception of the water table at Cut 1 has been calculated at 2.3m. Due to the groundwater level gradient the post-construction water level will still be at least 11m higher than the water levels in Drains 1&6, which divide the cutting from the priority habitat area. Therefore it is suggested in the EIS that the drains form a no-flow boundary and that hence it is of no consequence if there is a reduced flow from the cut drumlin towards the drains, because all flow is intercepted by the drains and does not contribute to the priority habitat.
Consequently it is assumed that Cut 1 is not likely to have a significant direct impact on Aghnaguig Bog.

There are two issues in relation to this assumption. Firstly, there is a least 3,000m$^2$ of cSAC (southeast of the priority habitat area) between Cut 1 and Drain 6 that could be affected by reduced groundwater flow from Cut 1. Secondly, it is not conclusive that all groundwater levels on the northwest side of Drain 6 are at a higher elevation than the water level in the drain itself, therefore the premise that the drain acts as a complete no-flow boundary may be false. It is perhaps possible that some of the flow in Drain 6 seeps into the priority habitat basin before it reaches Drain 1.

Also, the calculation of the maximum interception of the water table and Cut 1 (2.3m) is misleading. This is based on the level of the road in the cut but the level of the road foundations is 1.5m lower. The 1.5m of sub-grade fill will have a higher permeability than the natural soil and could form a preferential pathway. Therefore the potential dewatering could be much more significant than if the possible interception was simply 2.3m.

**Cut 2:**

It is estimated that under worst case scenario conditions the groundwater level under Cut 2 will reach 58-59m OD. It is therefore concluded that Cut 2 with a minimum road level of 58.4m OD will barely intersect with the water table. As with Cut 1 this assumption fails to take account of the foundation depth (as low as 56.9m OD) and the overlying high permeability sub-grade fill which could significantly increase the drainage.

It is stated in the EIS that the existing N3 and its associated road drainage and high permeability foundations, which lies between Cut 2 and the cSAC, implies that it acts as a drain for water flowing down-gradient towards the cSAC from the direction of the cut. The cut, N3 and cSAC are depicted in Appendix A.18, App J, Transect 4 in Volume 2 of the EIS (CCC, 2005) and the modelled water table level when at 55.5m OD in the drumlin under Cut 2, does not intersect with the existing N3 drainage system. It is also stated in the EIS that water levels fluctuate more at the periphery of the wetlands than at the centre and therefore it is not conclusive that a water level rise to the bottom of the cut under the drumlin would necessarily mean that the water level under the existing N3 would rise sufficiently to intersect with its drainage system.
It is stated that Drain 11 will act as a no flow boundary between the cut and the priority habitat area because it is 8m below the maximum cut level but it would appear from the maps in Appendix A.15, Volume 2 of the EIS that most of the water draining from Cut 2 would not intersect with Drain 11. It would also appear as if Drain 11 drains into the centre of the cSAC, therefore a reduction in water flow to the drain would impact on the wetland. It is also considered in the EIS that Cut 2 may have a minor indirect impact on the cSAC as it may reduce the spring discharge and baseflow to the start of Drain 1.

Groundwater level contours in the drumlins and therefore the cuts, are estimated based on point measurements. The degree to which the water table intersects with the cut is also estimated and subject to constant change. This means that the amount of sub-surface drainage that will occur is very uncertain and no attempt has been made to quantify the discharge. However it is stated in Section 16.7.1, Volume 1 of the EIS that recently installed monitoring holes (prior to publication of EIS) will determine the actual position of the water table and seasonal fluctuations relative to depth of cuts and to the depth of the excavation of the fill foundations.

Apart from the effect of the sub-surface drainage on the groundwater flow regime there is also the issue of the effect of adding drained groundwater to the receiving watercourses and their ecosystems. No attempt to estimate the quantity of groundwater that would enter each surface watercourse or the possible effects of mixing different water types, has been documented. (The importance of this issue has been previously discussed in Section 2.4.2 (iii)).
Section 4: N3 Butler’s Bridge to Belturbet Road Improvement Scheme EIS Review

Effect on hydrology of infilling

Refer to Section 16.4.2, Volume 1 and the diagrams in Appendix A.15, Volume 2 of the EIS (CCC, 2005) for details of the fills.

It is stated in the EIS that infilling part of the road route can cause hydrological issues due to excavation of foundations for the fills/embankments and the change in below-ground materials. Excavations are typically made to a depth of 1-2m which can potentially cause dewatering. In addition, back fill materials are usually of higher permeability than the original soil and can therefore create preferential pathways for groundwater flow.

There are three major fill locations detailed in the EIS and all in close proximity to the priority habitat area.

**Fill 1:**

This fill section stretches for approximately 700m at the start of the new road adjacent to Annagh Lough on the east side. The EIS asserts that because Fill 1 occurs down-gradient of the main cSAC boundary it will not have a major dewatering or re-diversion impact on the wetland in this area. But it would appear that this could happen in two respects. Firstly that high permeability material used as fill under the road at this section could act as a preferential pathway and intercept groundwater before it reaches Drain 1 and therefore channel it along the road route southwards and away from Annagh Lough. And secondly, the quicker flow velocities through the fill material would also change the groundwater flows and levels in the local area and potentially change the location and height of the groundwater divide closer to the cSAC in the northwest and east.

Also, it is not explained how Drain 1 will be protected as it crosses under the road to Annagh Lough. It must already be culverted under the original road at this point but it is not clear if this will be disturbed during construction.

Fill 1 also intersects the southern tip of bog woodland priority habitat area (as described in Section 4.3.2 (ii)) and could again act as a preferential drainage pathway for this section of the cSAC and change the hydrological regime within it. This is considered by the EIS authors as a local negative impact and mitigation measures are suggested (see Section 4.3.5)
Fill 3:
Interpolated phreatic contours suggest that the water table occurs approximately 3 metres below the ground level where this fill is to be located and it is therefore suggested that the 1-2 metres excavation needed for the fill may seasonally interfere with some local groundwater, but the dewatering is not expected to be significant. It is not made clear for what time of the year the 3 metre below-ground-level (bgl) figure refers or what the highest winter water table level might be. There are similar outstanding issues with the intersection of Fill 3 with Drain 1, as with Drain 1. Fill 3 intersects with the start of Drain 1 and it is not made clear how the crossing will be dealt with. If the drain is culverted the flow into the section of it which passes under the road, would be affected. It would also seem possible that any high permeability material in Fill 3 could act as a preferential pathway and intercept groundwater away from Drain 1 and Aghnaguig Bog. These issues need to be clarified.

Fill 2:
Intercepts the south-western corner of the cSAC and is approximately 10m from the priority habitat area at its closest point (see Fig 3.2, Volume 1 of the EIS (CCC, 2005)). It consists of two fill embankments (2a in the southeast and 2b in the northwest), which are necessary to support a 100m bridge in between. Because of the unsuitability of the ground in this area for construction, the embankments need to be piled through the peat and underlying lacustrine clay to boulder clay beneath the wetland. It has been determined that the lacustrine clay is an important vertical boundary between the peat and the clay, gravels and bedrock below it. Therefore the lacustrine clay is a barrier between the shallow groundwater in the peat and the deeper groundwater with higher hydraulic pressure. If the lacustrine layer is pierced by the pilings this could produce a pathway between the two groundwater layers. As a result of this pathway cross-mixing of the regional and local groundwaters, and a decrease in the local hydraulic pressure gradient upwards would occur. The change in groundwater quality and hydraulic pressure would adversely affect the vegetation in the bog woodland habitat, especially the sphagnum moss (see mitigation measures Section 4.3.5).

The pilings are to be closely placed, with 2-4 metre spacings. This will occur between chainage 1+570 and 1+725 (see diagrams in Appendix A.15, Volume 2 of the EIS). The area
of the embankments outside these chainages will undergo dig and replace, or in-situ loading or replacement if the water table is high. The bridge between the two embankments will require two piers to be fixed into the boulder clay or bedrock beneath the wetland.

The fill areas are upstream of the priority habitat area. The piles under Fill 2b and the bridge piers could interfere with the groundwater movement downstream. Fill 2a is cut off from the priority habitat area by Drain 6 but it is not certain that this will be retained. Even if the drain is retained, Fill 2a still has the potential to affect groundwater flow to the cSAC to the southeast of Drain 6 if it intercepts the water table.

It is necessary to use a culvert for Drain 11 as it passes under Fill 2b. A significant portion (at least 25%) of the length of Drain 11 will lie within this embankment. It must be assumed that it will not be possible for groundwater to enter this drain through the culverted section. Drain 11, as stated previously (see Section 4.3.2 (ii)), appears to drain into the central basin very close to the priority habitat area therefore it is very possible that Fill 2b will cause the redirection of a significant portion of the water currently in Drain 11, away from the priority habitat. This issue is not addressed.

It is mentioned above that it is possible to use in-situ loading instead of dig and replace in areas of the Fill 2 embankments where the water table may be high. Presumably this solution should be considered for Fills 1&3, if at all possible, in order to significantly reduce the likelihood of dewatering.

Effect of other cuts and fills northwest of the priority habitat

The cuts and fills that are considered in the EIS are within the water catchment (see diagrams in Appendix A.15, Volume 2 of the EIS) of the Aghnaguig Bog woodland and wetlands. But there is no indication that groundwater levels have been measured outside this water catchment. Therefore it is not certain that this catchment does not extend further and encompass more of the proposed road route. If the water catchment area as outlined is correct it is still possible that works outside this area could affect the location and level of the groundwater divide. These possibilities are not considered.
Apart from the possibility that cuts and fills located outside the outlined water catchment, could affect the cSAC inside it, they could also adversely affect the other sections of cSAC along the proposed route (there are 7 sections altogether – see Chapter 17 of the EIS (CCC, 2005) for description). The most important of these with respect to hydrology are 200m of significant fill planned at Bessbrook through wet-willow alder woodland and approximately 150m of significant fill through cutover bog between chainages 5+100 and 5+800 (see Figs 4.1-4.6 & 17.0-17.4, Volume 1 of EIS (CCC, 2005)). There has been no investigation into the effects on hydrology of building the road through these areas. It is stated briefly in Section 17.4.1, Volume 1 of the EIS (CCC, 2005) that there would be a direct loss of 0.6ha of wet woodland in Bessbrook and an indirect impact on the hydrology of the whole ecological site at that location (see Fig 17.2 Volume 1 of EIS (CCC, 2005). As mitigation woodland of equivalent size to the area lost will be created adjacent to the site. This mitigation measure does not take sufficient account of the possible alterations to hydrology that may take place in this area. Cutover bog, currently covered in a conifer plantation is to be partly remediated to compensate for the loss of bog between chainages 5+100 and 5+800. Again the affect on hydrology in this area is not sufficiently dealt with.

Effects of bridge construction over the River Erne

The Erne has been identified as an important fishery and therefore must be protected as much as possible during the construction of the bridge crossing. There are no data given on the groundwater levels around the crossing or the possible effects of the fill embankments of the bridge on the local groundwater hydrology. It is recognised that siltation of the river during construction is a significant issue for the river as a flora and fauna habitat and this is to be mitigated against using siltation/retention ponds.

4.3.3 Estimate by type and quantity, the emissions into air, soil and water from the operation of the proposed project

Petrol/oil/hydrocarbons and sediment/grit have been mentioned in the EIS as potential polluters of the receiving watercourses but no attempt was made to estimate all types or any
quantities. The possibility of groundwater, from cut and fill drainage, as a potential polluter of the receiving watercourses due to its chemical nature, is not considered. The possibility of deep groundwater contaminating the groundwater above the lacustrine clay due to leakage around the piles of the embankments and bridge near the priority habitat area was considered (see Section 16.4.2, Volume 1 of the EIS (CCC, 2005) but the possible extent was not quantified.

4.3.4 Description of forecasting methods used to assess the effects on the environment

There was no documentation of flood forecasting or pollution forecasting in the receiving waters. Predictions of effects on the hydrology of the cSAC are based on soil, geology and groundwater level investigations. These are described in full in Appendices B.7 and A.12-A.18, Volume 2 of the EIS (CCC, 2005)).

4.3.5 Description of mitigation measures proposed

1. To mitigate against pollution and flooding risks in the receiving waters attenuation ponds, silt traps, bunds, and hydrocarbon and grit interceptors will be used. The attenuation ponds will be situated outside the cSAC boundaries and will be lined in areas of high aquifer vulnerability. There will be an overflow facility for storm events with a return period greater than 25 years. The containment area for accidental spillages will be 40m$^3$.

Issues with these mitigation proposals that need to be addressed:

- It is not stated specifically that interceptors will be capable of retaining sediment less than 63µm in size (this is the sediment particle size range that is most likely to contain insoluble road runoff pollutants (see Section 6.2.2 (i))).
- No mitigation measures are detailed for preventing soluble pollutants from entering receiving waters.
- Some of the road drainage does not appear to be routed through the attenuation ponds (see Figs 14.1-14.8, Volume 1 of the EIS (CCC, 2005))
- There is no mention of the residual impacts on receiving waters with respect to flooding and pollution due to the overflow facility.
- Confirmation is needed that the 40m$^3$ containment facility for accidental spillages is sufficient and conforms to standards in this area.

2. Provision of alternative water supply to replace wells affected by the proposed development.

3. An experienced geo-technical engineer on site during construction of the bridge over the wetland and a wetland specialist to visit site regularly during and after construction, particularly to monitor groundwater levels and chemistry.

4. Piling for bridge piers should be carried out at slow consistent speed through lacustrine clay to avoid damage. An inert eco-friendly sealant will be used to seal lacustrine layer and prevent leakage of groundwater up from below this layer.
   Issue: This mitigation measure would not appear to be sustainable. Clarification is needed on the durability of the sealant (how long it will remain effective) and the likelihood of successfully and completely sealing the lacustrine clay around the piles.

5. To mitigate against the limitation of groundwater flow under Fill 2 due to the high density piling the insertion of preferential flow structures into the design of the embankment will be considered.
   Issue: It may be possible to successfully create an artificial flowpath to simulate the natural flow conditions. However, no examples of previous projects where similar features have been included, or even basic design details, are documented. Further details would need to be provided to demonstrate the likelihood of success in designing flow structures to sufficiently imitate the original flow regime, before this could be considered an adequate mitigation measure.
6. To prevent preferential flow along the high-permeable fill material under the road at Fill 2b, vertical hydraulic barriers to be put in place. This mitigation measure should be considered for use at the other fill locations.

7. Construction of the embankments to take place Apr - Sept to avoid the high phreatic surface.
   Issue: This is a sensible precaution but will not solve the problem of the phreatic surface entering the high permeability fill material at wetter times of the year and using it as a preferential pathway.

8. To avoid excavation at Fill 3 it is intended that a geotextile membrane will be used instead of excavation to prevent interception and drainage of groundwater that could affect the water supply to Drain 1, which is needed to maintain the hydrological integrity of the wetland.
   Issue: It is necessary to clarify how the road is going to cross Drain 1 and how the geotextile membrane will be laid in relation to it. This mitigation measure could solve the issue of groundwater entering the embankment and using it as a preferential pathway.

9. To prevent the possibility of construction materials interfering with and changing the groundwater chemistry it is suggested that cement and bentonite should not be used for piles and piers. Alternative materials should be sourced or the cement/bentonite sections should be sleeved.
   Issue: No suitable alternatives are suggested.

10. Location of sumps downgradient of excavation areas and connected to attenuation ponds will control surface runoff and transport of suspended solids during construction.

11. An environmental management plan will be put in place for the construction phase including regular checks of bunds and machinery to ensure no leakage of site waste such as hydrocarbons and concrete liquors.
12. To avoid impacts on the River Erne from the road crossing, a single span bridge with no piers will be constructed (but as mentioned in Section 4.3.2 (v) the local hydrology could still be affected via the bridge embankments). The location of the piers for the temporary bridge which facilitates construction will depend on a study of fish habitats. There will be no in-river work done during spawning.

13. Sections of conifer plantation will be purchased and restored as wetland to compensate for adverse impacts on important habitats due to the road construction.

4.4.1 Description of the Proposed Development

(i) Construction

The construction of the proposed development in terms of effects on hydrology is covered with respect to the cuts and fills, the two major bridge crossings and the construction materials. These issues have been covered in the preceding sections. General housekeeping issues such as oil and fuel storage, sediments caused by earthworks and construction site runoff, are not dealt with in detail. It is stated in the EIS that during construction ‘All materials, which may cause contamination or pollution, shall be stored securely in a bunded compound to retain accidental spillages. In particular, measures shall be taken to protect watercourses and groundwater sources’.

The EIS should be more explicit about the measures to be taken to protect the local waters. Also monitoring should be carried out to ensure these measures are effective.

(ii) Commissioning

There is no information given under this heading – it applies more the start-up procedures of production facilities.

(iii) Operation

The impacts of the road operation on hydrology have been discussed in Section 4.3.2. The EPA advisory documents (EPA 2002 & 2003) also require a description of maintenance activities and their possible effects. The only reference made to maintenance is that there will be provision of access to the attenuation ponds for regular maintenance. No mention was
made of the possible effects of maintenance (e.g. resurfacing or herbicide spraying) of the road itself.

(iv) Anticipated Changes

There are no major changes anticipated for this project but is considered in the EPA advisory documents (EPA 2002 & 2003) that changes such as aging and deterioration which can cause decreasing effectiveness of mitigation measures should be anticipated and addressed. These issues were not considered in the EIS.

4.4.2 Description of the Existing Environment

The proposed development is to be located in the Lough Oughter and associated Loughs area which is a candidate Special Area for Conservation. The complete outline of the cSAC in the vicinity of the proposed road is not made clear in the figures and diagrams. The EIS states that the proposed road alignment crosses the cSAC boundary at seven points along the route (these are outlined in Chapter 17, Volume 1 of the EIS (CCC, 2005)) but only two of these are detailed on the diagram of the cSAC boundary near Aghnaguig Bog (see Appendix A.15, Volume 2 of the EIS (CCC, 2005). The cSAC is much more extensive than the section outlined on this diagram and covered by the hydrological study.

The cSAC designation for the area arises due to the location of bog woodland and natural eutrophic lakes within it. These two natural features are listed under Annex 1 of the EU Habitats Directive 92/43/EEC (CEC, 1992). Bog woodland is also designated as a priority habitat under the directive.

**Main Water Bodies:** River Erne and Annagh, Bun, Putiaghan and Tullyroane Loughs. These are all described in terms of water levels, the importance as fish habitats, and the following chemical parameters:

NH4-N, orthophosphate, Total Phosphorus, TOC, electrical conductivity and pH.
There are no results given for DO, or toxicity data for the relevant fish species – these parameters are particularly important for estimating the chemical assimilative capacity of these waters. There is also no information given on volumes or flowrates in these waters – again this is important for assessing their physical assimilative capacity.

**Bog Woodland:** From Fig 3.2, Volume 1 of the EIS (CCC, 2005) it would appear that there are three distinct areas of bog woodland close to the road alignment. They are all located within the cSAC boundary at Aghnaguig Bog and are also all within the Minerex Environmental Limited (MEL) hydrogeological study area (see Appendices A & E1 of Appendix B.7, Volume 2 of the EIS). The bog woodland in the central basin is the only one of the three which is considered a priority habitat in the EIS. The reason for this is unclear. The growth of sphagnum moss in the bog woodland is considered to be a significant factor in the importance of this habitat type (see Section 16.3.6, Volume 1 of the EIS) but the bog woodland in the south-eastern basin also contains sphagnum moss (there is no indication of the moss content of the third and most easterly area of bog woodland). Therefore all three areas of bog woodland should be treated as priority habitats or a clear explanation given as to why they are not.

**Geology:** soils and constituents of the drumlins, overburden and bedrock are all described.

**Aquifers and groundwater levels:** There are no quantitative data on aquifer permeability but temperature, pH and electrical conductivity of groundwater at various locations within the MEL study area were monitored. Groundwater levels were thoroughly examined but only within the MEL study area (see Appendix A.15, Volume 2 of the EIS (CCC, 2005)).

**Land Drains:** the extensive land drain network is described including electrical conductivity, pH and temperature measurements. Water levels in the drains are not detailed explicitly. All drainage water in the area currently ultimately enters Drain 1 which in turn flows into Annagh Lough – therefore the level of Annagh Lough controls the drainage.
Important springs are also described in terms of location, electrical conductivity, pH and temperature.

### 4.4.3 Description of Impacts

In accordance with the EPA advisory documents (EPA 2002 & 2003) the description of impacts should include various details under the headings character, magnitude, duration and consequence, including:

- The environmental elements are affected by significant positive or negative impact
- Quantification of magnitude of change of the environmental element due to impact
- Indication of the spatial extent of impact
- Duration of impact
- Highlight irreversible impacts and when consequences cannot be determined

Worst case scenario is also to be described where failure of project or mitigation measures would lead to destruction of unique habitat, contamination of significant aquifer. State the likelihood of such an occurrence.

With respect to these requirements this EIS has omitted:

A quantitative description of possible impacts such as the amount of pollution or volume of runoff entering the receiving waters, and the amount of road dewatering. The spatial extent of the impact of dewatering is not sufficiently addressed for the areas around the proposed road that do not lie within the outlined water catchment (see Appendix A.15, Volume 2 of the EIS (CCC, 2005).

There is also no description of worst case scenarios. This would be a particularly relevant inclusion with respect to some mitigation measures which have not been designed in detail – for example the use of geotextiles as barrier materials, the construction of artificial flow pathways in piled embankments and the containment facilities for accidental spillages.

### 4.4.4 Monitoring & Conditions
There are significant recommendations for monitoring in the EIS (see Section 16.7.1, Volume 1 of the EIS, (CCC, 2005). It is recommended that quarterly baseline monitoring of water levels and field hydrochemistry (presumably electrical conductivity, pH and temperature) should take place. Also annual analysis of key chemical parameters (they are not specified) would be appropriate. It is recommended that this monitoring regime should be continued during construction but that frequencies should be increased to monthly for water levels and field hydrochemistry, and to quarterly for laboratory chemical analysis.

Post construction monitoring is recommended to consist of 24 months monitoring the same parameters and at the same frequency as pre-construction.

As mentioned in Section 4.3.5 it has been recommended as a mitigation measure that a wetland hydrologist be present and conduct water level and chemical monitoring during the construction of the bridge over the wetland.

This is the first instance in this overall study of EISs, that the need for a significant monitoring programme has been documented and recommended. This programme will highlight any changes to groundwater levels and water chemistry in the area around the bog woodland habitat, which are the main factors that would affect that habitat and the flora in it. However the bog woodland in the area of Aghnaguig Bog is not the only important habitat or the only section of cSAC in the vicinity of the proposed road. At least, the Annagh, Bun and Putiaghan Loughs and the River Erne should all be subjects of water quality and biotic monitoring. They are important fisheries, some if not all will receive runoff, and in addition, Annagh Lough is a source of water abstraction.

Also the water leaving the attenuation ponds should be subject of at least spot checks, especially after severe storms events, to ensure that they are providing adequate attenuation and protection.

Although strongly recommended in the 2002 EPA Guidelines (see Section 5.5) there is no mention in the EIS of conditions or assurances in relation to monitoring impacts and effectiveness of mitigation measures.
4.5 Reference of EIS to the UK Design Manual for Roads and Bridges (UK Highway Agency, 1999)

It is stated in the EIS that the UK DMRB was used as a scoping tool. There is a lot of detailed information in the manual on methods for water assessment and analysis. Unfortunately it does not appear that any of these methods were used during the EIA.

4.6 Conclusions

The EIS for the N3 Butler’s Bridge to Belturbet Road Improvement Scheme is the most thorough of the three EISs studied but there are still several outstanding issues:

- Flooding – the risk of flooding in the receiving waters has been considered and is to be mitigated against using attenuation ponds. However, data for flood analysis such as estimated discharge and current flow regimes in the receiving waters has been omitted from the EIS.

- Drainage System – the exact location of most outfalls is unclear. Also it would appear from the diagrams of the system that some of the runoff would not pass through an attenuation/sedimentation pond.

- Pollutants – No attempt was made to quantify the possible pollutants in the road runoff. No mitigation measures were suggested for the soluble pollutants but it was suggested that attenuation facilities should be lined in areas of groundwater vulnerability, which is positive. It was mentioned that access would be available for cleaning and maintenance of the attenuation ponds but no consideration was given to the ultimate destination of the polluted sediment.

- MEL Hydrological Study Area – significant groundwater level monitoring and chemical analysis was undertaken in this area and a water catchment area was
delineated. However it would appear that the groundwater divide around this area was not located. Also the assumptions made about the possible effects of the cuts and fills in this area were unsatisfactory.

- **Outside MEL Study Area** – Areas within the cSAC and of ecological significance, but lying outside the study area, and the effect of the road on them, were not considered in any detail despite their importance. There are plans to replace equivalent areas of wet woodland and cutover bog that would be destroyed by the road alignment but account was not taken of the possible effect on the groundwater regime, of the cuts and fills in these areas.

- **Receiving Waters** – There was no estimation in the EIS of the amount of road runoff and sub-surface drainage that would enter the receiving waters. These rivers and lakes were assessed in terms of some chemical parameters (not including dissolved oxygen) and biotic content but not in terms of physical assimilative parameters such as volumes and flow velocities. This is of particular importance with respect to the slow-moving waters in lakes.

- **Mitigation Measures** – measures such as sealing the lacustrine clay layer and the creation of artificial groundwater flow pathways through embankment pilings would, at first glance, appear to be difficult measures to implement successfully. The suggestion of such measures should be backed up by evidence of their successful implementation in similar situations and of their long-term effectiveness.

- **Monitoring** – a major monitoring programme is to be implemented before, during and after construction, involving independent experts. This is extremely positive but fails to include post-construction monitoring of quantity and quality of the runoff, or of the water quality in the receiving waters. This is needed to demonstrate the adequacy of the pollution prevention measures.
• Conditions – As well as monitoring, which is not an end in itself, setting of standards that the monitored parameters must achieve is needed, and a detailed course of action agreed on for the instances where these standards are not met. This is not addressed in the EIS.
5.0 Legislation and Guidelines

5.1 Introduction

As mentioned in the main introduction the environmental sustainability of the national roads programme is dependent on the EIA process, and the effectiveness of this process in turn depends on the legislation that underpins it. If this legislation is inadequate then there is little hope that the EIA process will be successful in protecting the environment. Therefore it is important to evaluate the effectiveness of the legislation and guidelines that govern the EIA process, in order to determine whether or not it is far-reaching enough to ensure sustainability.

In the previous sections three EISs were analysed to determine whether or not they were carried out in full accordance with the legislation governing them. In many respects they were not. But it must be admitted, as will be seen in this section, that there is a lot of leeway for interpretation of the legislation and guidelines, and a lot of inclusions and omissions in an EIS are at the discretion of the developers and the competent authority. It must be acknowledged that there is a limit to the amount of testing and analysis that can be carried out during an EIA and decisions must be taken quite early on during the scoping process regarding priority areas for focus. Nevertheless it is the purpose of the EIA related legislation to protect the environment from the adverse effects of developments and it must be detailed and binding enough to ensure a thorough, comprehensive EIA is carried out for each proposed development, regardless of the various parties and bodies involved.
5.2 Background

As previously mentioned the original Environmental Impact Assessment Directive 85/337/EEC (CEC, 1985) was published in 1985 and it was stipulated that the requirements of the directive be transposed into the laws of Member States within three years. This was complied with for motorway projects via Statutory Instrument (S.I.) No. 221/1988 (ISB, 1988) which is the European Communities (Environmental Impact Assessment) (Motorways) Regulations, 1988. The legislation governing the EIA process in general was introduced in the following years by European Communities (Environmental Impact Assessment Regulations, 1989 (S.I. No. 349/1989) and Local Government (Planning and Development) Regulations, 1990 (S.I. No. 25/1990).

The EIS of the Kildare Town Bypass Motorway was published by Kildare County Council in July 1993 and is based on the requirements of the original directive.

In 1993 (presumably too late to affect the EIA process for the Kildare Town Bypass) the Roads Act (ISB, 1993) was brought into force. Sections 50 and 51 of the Act deal with the EIS and EIA of roads, respectively and S.I. 221/1988 was thereby revoked.


The EIS for the Second M50 Liffey Valley Bridge was published by Fingal County Council in December 1998 and was therefore governed by the legislative requirements of the Roads Act, 1993 and the 1995 EPA advisory documents.

In March 1997 the European Council published a second EIA Directive as an amendment to the original one (CEC, 1997). This was transposed into Irish law by the European Communities Environmental Impact Assessment (Amendment) Regulations, 1999 (ISB, 1999a) and the Local Government (Planning and Development) Regulations, 1999 (ISB 1999b).
In March 2002 the EPA published a revision of the 1995 Draft Guidelines document (EPA, 2002) and in 2003 it published a second edition of its Advice Notes document (EPA, 2003). Therefore the 2005 EIS for the N3 Butler’s Bridge to Belturbet Road Improvement Scheme (CCC, 2005) was based on the relevant sections of the Roads Act 1993, the 1999 Regulations relating to the 1997 EIA Amendment Directive, and the updated versions of the EPA advisory documents. The authors of this EIS also consulted the UK Design Manual for Roads and Bridges (UK Highway Agency, 1999), Volume 11, which deals with Environmental Assessment.

5.3 The requirements of the original 1985 EIA directive and its enabling legislation

Briefly, the main aims and requirements of the directive as relates to hydrology, these are:

- To identify describe and assess in an appropriate manner, the direct and indirect effects of a project on the following factors:
  Human beings, fauna and flora, soil, water, air, climate, landscape, the interaction of the foregoing factors, material assets and cultural heritage.
- Member States shall ensure that the project developer supplies the information specified in Annex III of the directive (CEC, 1985) where the Member States consider the information is relevant to the project type and pertains to environmental features likely to be affected.

The minimum information to be provided by the developer (related to hydrology):

- Data required to identify and assess the main effects which the project is likely to have on the environment
- Description of measures envisaged in order to avoid, reduce or, if possible, to remedy significant adverse effects

When this directive was transposed into Irish law (for motorways) through S.I. No. 221/1988 (ISB, 1988) the minimum requirements described above were all brought into effect with the addition of a requirement for an outline of the main alternative motorway alignments (if any)
studied and an indication of the main reasons for selecting the proposed alignment, taking into account the environmental effects.

Additional information as detailed in Annex III of the directive was not given any mention in this Statutory Instrument but was detailed in S.I. 349/1989 (the legislation governing the EIA process in general). It was prefixed by the following statement:

‘An environmental impact statement may include, by way of explanation or amplification of any specified information, further information on any of the following matters ..’

Issues:
• The requirements of the directive are too vague.
- Elements of the environment to be addressed (air, soil, water etc) are clearly listed (although not elaborated on) but likely, significant effects are very subjective unless clearly defined. No definition, explanation or interpretation of this type of effect is given.
- The assessment is to be carried out ‘in an appropriate manner’ but no other direction or guidance on the method of assessment such as time of year and type of testing, is given.
- Data required to identify and assess the main effects of the project must be given but no elaboration is made on the type or amount of data needed.
- More detailed potential requirements are listed in Annex III of the Directive but it is wholly at the discretion of the competent authorities in each Member State as to whether or not this information is requested. In the case of the Irish legislation, it would appear that the inclusion of any of the information in listed in Annex III is completely at the discretion of the EIS authors (see quote above). No circumstances requiring the inclusion of this information are stipulated.

• Any requirement for monitoring is completely omitted.
Monitoring of the environment during construction and operation is essential to determining whether or not impacts manifest themselves as predicted. This information is invaluable to the success of future EIAs. Monitoring is also vital for verifying the effectiveness of mitigation measures and identifying improvements (if any) that are needed. Therefore conditions are also necessary to ensure that developers take corrective action if monitoring
indicates that impacts are other than predicted or that mitigation measures are not operating correctly, or are insufficient.

5.4 The requirements and contents of the Roads Act, 1993 and the 1995 EPA advisory documents

By the time the EIS for the second M50 Liffey Valley Bridge was published in December 1998 Section 50 & 51 for the Roads Act 1993 (ISB, 1993) and the 1995 EPA advisory documents (EPA 1995 a&b) were the most up-to-date references for the authors of EISs. The transposition of the EIA/EIS legislation into the Roads Act 1993 made no significant difference to the content, therefore the issues with respect to the original legislation still apply. However the EPA Draft Guidelines and Advice Notes on Current Practice made the most significant contribution to the EIA process in Ireland since the original directive in 1985.

The following are the main contributions of the 1995 EPA documents:

- Explicitly details all stages of a development (construction, commissioning, operation, anticipated changes, decommissioning) and emphasises the need to assess possible environmental effects caused at all stages. Also included is the need to address the possible effects of secondary processes and activities such as maintenance (very considerable with respect to roads) and accidental spillages.

- Explicit about the need for a description of the existing environment which provides baseline data which are invaluable references for monitoring impacts of operation. Also takes into account seasonal or long-term natural changes in the environment that can make it more or less vulnerable at various times. Also particular emphasis must be placed on especially sensitive or significant areas such as wetlands and coastal zones.

- Scope of topics – a lot of detailed guidance is given on the topics to be covered when assessing the current state of, and the possible effects on, the ten environmental elements that are listed in the legislation.

In the case of water the various types to be considered are surface, ground, estuarine and marine, and the properties of water to be considered are physical, chemical, biotic and beneficial uses, all of which are elaborated on. In addition to this the Advice Notes
outline suggested topics for 32 different project types, again with respect to each of the ten different environmental elements.

- The description of impacts is elaborated on and should include various details under the headings character, magnitude, duration and consequence. Also indirect impacts are explicitly defined (as those caused by interactions of effects and associated developments).
- In the description of mitigation measures a hierarchy of mitigation is advised: mitigate by avoidance, reduction and then, if necessary, remedy. Residual impacts must also be detailed.

Issues:
- Sufficiency of data – it is stated in the Draft Guidelines that insufficiency of data can be tolerated if information is difficult to obtain (e.g. due to time of year), on condition that the design may be modified if anything of significance is encountered later. This is reasonable but not sufficiently far-reaching. It would need to be stipulated that the omitted data are deliberately looked for at a more appropriate time and the results followed up.
- Description of Impacts – it is attempted in the Draft Guidelines to guide EIS authors in determining likely significant impacts but again they are not sufficient in ensuring that all impacts of importance are covered.

Likely impacts: it is stated that all planned (e.g. earthmoving, emissions) and inevitable impacts must be assessed as well as possible effects resulting from accidents and failures. Forecasting methods may be used and must be explained and justified. In my opinion detailed guidance and requirements should be given on these issues. For example, with respect to accidental road spillages standards should be set as to the types and quantities of spillages that must be catered for.

Significant impacts: it is stated that significance should be described in terms of magnitude, intensity and duration (objective evaluation) and public concern regarding the effects (subjective evaluation) but there are no standards given that determine what levels of magnitude, intensity, duration or public concern make an impact significant. The whole issue of significance remains subjective unless limits and standards are applied where possible.
• In general there is a deficiency of limits and standards in these documents. As their titles suggest their purpose is to advise and not to impose conditions and requirements. Their contents are very comprehensive but it is emphasised at several points that not all topics described are likely to be of relevance to all projects. Therefore in my opinion there is an over-reliance on the expertise and judgement of EIS authors. For example in the case of water there should be definitive limits placed on the allowed changes in quality and quantity in all watercourses depending on their uses and the habitats and ecosystems they support.

• Monitoring and Conditions: Monitoring is mentioned briefly in two sections of the Draft Guidelines. Under ‘Description of Existing Environment’ it is stated that baseline data is a valuable reference for monitoring impacts of operation, and under ‘Description of Mitigation Measures’ it is stated that ‘this strategy (of impact reduction) seeks to intercept emissions, effects and wastes before they enter the environment. It monitors and controls them so that acceptable standards or not exceeded.’

These references are very frustrating as they almost imply that monitoring and control of impacts occurs as a matter of course without the need for detailed legislation to bind developers to undertake them. As discussed in Section 5.3 detailed monitoring procedures are essential to ensuring environmental protection. Also as discussed in Section 4.6 conditions attached to monitoring results are in turn essential to ensuring the success of any monitoring programme.

The 1995 EPA advisory documents are a vast improvement on what went before but still fall short of what is needed.

The amended EIA Directive (CEC, 1997) and its enabling legislation S.I. No. 93/1999 (ISB, 1999 a&b) make several changes to the original Directive and legislation. The main changes are as follows:

- The need to assess the interaction between the various environmental elements (air, soil, water etc.) now includes the interactions between material assets and cultural heritage and the other eight elements. The possible interactions of these two specific elements were previously omitted.

- A new Annex (III) was added which contains a set of selection criteria to be taken into account when determining whether or not projects listed in Annex II should be subjected to the EIA process.

This additional annex makes very little difference to the methods of determining which Annex II projects require EIAs. The decision still rests with the individual Member States. The ‘criteria’ set out in Annex III are only a set of project characteristics which Member States must consider when determining the need for an EIA. There are no thresholds or specific criteria governing the decision. Although the EU Directives are quite vague and non-committal in this respect, it must be stated that the original Irish enabling legislation S.I. No. 349/1989 (ISB, 1989) established very definite thresholds beyond which EIAs were required for Annex II type projects.

- It is necessary for the competent authority to advise the developer on EIS content. This is an important time-saving exercise and benefits all parties concerned. The EIA process is made quicker and more effective if the requirements of the competent authority are known before submission of the EIS. It is pointed out that the initial advice given by the competent authority does not preclude it from subsequently requiring further information.

- A requirement for monitoring was omitted from the amended EIA directive 97/11/EC even though is was recognised as an omission in the Commission of European Communities review of the original EIA Directive 85/337/EEC.
‘The commission is a strong advocate for the inclusion of a formal monitoring programme in an EIS but EU Member States are normally more defensive and reactive’ (Glasson, 1999).

- Notification to the public of granted development consent will now include a description of the main mitigation measures. This is an extremely important step in ensuring that the whole environmental protection process (not just the EIA) is open and transparent but it should be more far-reaching. A whole programme of measures including the monitoring of impacts and mitigation measures and attached conditions should be published. This should include the results of the monitoring programme and any action taken.

**EPA Advisory Documents**

There were few significant changes made in the 2003 edition of the EPA Advice Notes document (EPA, 2003) but the 2002 revised Guidelines document (EPA, 2002) includes a whole new section entitled ‘Principles and Practice’. The main elements are as follows:

- Pursue preventative action – avoid impacts (as opposed to reducing or remedying them) as much as possible.
- Maintain focus on environmental issues
- Include detailed descriptions of roles of all participants in the EIA process
- Scoping: much more emphasis is placed on this element than previously and methodology is given. The importance of consultation is emphasised as is the continuous review of the scope of the EIA as more information becomes available.
- The most significant element of the new section is the inclusion of guidelines on monitoring and conditions.

‘Monitoring of the effectiveness of mitigation measures put forward in the EIS, both by the competent authorities and the developer, is an integral part of the process. Monitoring of environmental media and indicators arise from undertakings or conditions. In either case it is important for all parties to be aware of the administrative, technical, legal and financial burdens that can accompany inflexible and unresponsive monitoring regimes. It is important to ensure that, where
monitoring is provided for, it is clearly related to thresholds, which if exceeded cause a clearly defined set of actions to be implemented.’

‘Conditions are principally used to ensure that undertakings to mitigate are secured by explicitly stating the location, quality, character, duration and timing of measures to be implemented. A secondary role of EIA related conditions is to ensure that resources e.g. bonds/insurances will be available and properly directed for mitigation, monitoring or remedial action, in the events that impacts exceed the prediction levels.’

Issue:
It should be explicitly required that monitoring is carried out not just on mitigation measures but also on the accuracy of impact predictions in general. Environmental elements where no measures are in place because impacts have been predicted to be insignificant, are probably more vulnerable than the rest if impact predictions prove to be incorrect. Also, as opined earlier in this section, monitoring results and consequent action should be published.

UK DMRB
The EIS for the N3 Butlers Bridge to Belturbet Road Improvement Scheme refers to the UK Design Manual for Roads and Bridges, Volume 11, (UK Highway Agency, 1999). The design manual is very extensive and therefore this review will only examine the section most relevant to hydrology which is Volume 11, Section 3, Part 10: Water Quality and Drainage.
The main points are:

- In the UK there are statutory water quality standards (WQSs) for different river classes (classification depends on use).

- WQSs for groundwater were not established at the time of publication but discharge of cadmium, hydrocarbons and minerals is prohibited as per the Groundwater Directive 80/68/EEC. Discharge of zinc and copper is limited. Long-term monitoring in the vicinity of discharge to groundwater may be required (but no detail is given of circumstances under which it would be required).

  Issue: Monitoring should be mandatory in areas of discharge to any bodies. It is only to be expected that this would be scaled back over time if results show no deterioration but as long as discharge occurs, at the very least spot checks for quality changes should be continued.

- Specific guidelines for the application of herbicides and de-icing agents are covered in the (UK) Highway Agency’s Maintenance Manual.

- Suspended solids form the largest part of contaminants in road runoff and dissolved contaminant concentrations are likely to be low. Therefore significant pollution is unlikely provided adequate measures are taken to deal with solids and there is sufficient dilution dispersion for the liquid element of the runoff. It is noted that fine sediments, of particle size <63µm, are the most important source of insoluble pollution. This means that sedimentation mitigation measures will only be effective if they can trap particles of very small size.

- Mitigation for road runoff – *mitigation is needed when there is insufficient dilution available or the risk of accidental spillage is unacceptably high. Mitigation to prevent pollution will not be required in every case although the need for mitigation should be assessed for every outfall individually.*

  There is very useful information on various mitigation measures in Annex II (of Volume 11, Section 3, Part 10 of UK DMRB).

- Methods for the following assessments are detailed:
  - Spillage risk and need for facilities to control them (Annex III)
  - Preliminary water quality assessment method for flowing receiving waters and groundwaters (Annex III)
- Detailed water quality assessment method (Annex IV)

This manual is superior to the Irish guidelines due to the level of detail supplied for assessing effects and responding to them. The development of WQSs for all surface waters is also an extremely significant factor in ensuring water quality. Water quality monitoring is also far more developed in Britain. Regulatory Authorities there track surface water quality over time to identify improvements or deterioration. They have also classified all rivers in terms of water quality and use.

5.6 Requirements of the Water Framework Directive (CEC, 2000)

The Water Framework Directive (WFD) is the most ambitious and comprehensive EU plan for water protection and conservation to date. Therefore it has inevitable consequences for any projects that propose to disturb or discharge to natural water bodies. The basis of the directive is the division of Member States into geographical river basin areas which are then individually managed to protect all natural water types within each.

Its main aims are:
- To achieve good status* in all water bodies at the latest 15 years after entry into force of the directive
- To eliminate priority hazardous substances*, progressively reduce all other hazardous substances* and with respect to groundwater reverse the upward trend in concentration of any pollutant
- To set emission limit values and environmental quality standards (EQSs) which are common across the EU
- To control abstraction and artificial recharge
- To identify pollutant sources and agree specific control measures
- To standardise monitoring, sampling and analysis methods
- To devise appropriate penalties for regulation breaches
- To integrate the protection and sustainable management of water into energy, transport, agriculture, fisheries, regional policy and tourism sectors
To protect aquatic ecosystems, and terrestrial ecosystems and wetlands directly dependent on them

( * See Table 5.1)

These aims are to be achieved by comprehensively analysing the water quality in all natural waters and taking measures to maintain or improve the quality as necessary.

**Table 5.1: Explanation of WFD-specific terms**

<table>
<thead>
<tr>
<th>Good water status</th>
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</thead>
<tbody>
<tr>
<td>- for surface water means good ecological status (classified in accordance with Annex V) and good chemical status (defined by EQSs in Annex IX and under Article 16(7))</td>
<td></td>
</tr>
<tr>
<td>- for groundwater means good quantitative status and good chemical status (both defined in Annex V)</td>
<td></td>
</tr>
</tbody>
</table>

**Priority hazardous substances** – 33 substances (listed in Annex X) are considered to be of particular harm in the aquatic environment

**Hazardous substances** – any substances or groups of substances that are toxic, persistent and likely to bio-accumulate

There is extensive information in the Annexes of the Directive on monitoring and assessing water quality but the EQSs governing good status are only being developed and agreed on an on-going basis. An EU Expert Group on Quality Standards has been set up and has already published proposed quality standards for some road runoff related pollutants such as poly-aromatic hydrocarbons (PAHs) and cadmium (see Tables 5.2, 5.3, 5.4 below).

Although the WFD was published in December 2000, no reference was made to it in the 2005 EIS for the N3 Butler’s Bridge to Belturbet Road Improvement Scheme. Admittedly implementation of the river basin management plans that are to achieve the aims of the directive, is long and protracted. A programme of measures for each basin to achieve the directive’s aims is not required until 2009. Also WQSs/EQSs are not yet finalised. But all road projects will eventually have to incorporate the comprehensive requirements of this directive into their interaction with the natural hydrological environment.
The following tables are examples of the quality standards for some road runoff related pollutants proposed by EU Expert Group on Quality Standards (WFD CIRCA, 2005).

Table 5.2: Proposed WQSs for Benzo(a)pyrene

<table>
<thead>
<tr>
<th></th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh water (µg/L)</td>
<td>0.05</td>
</tr>
<tr>
<td>Sea water (µg/L)</td>
<td>0.005</td>
</tr>
<tr>
<td>Sediment in Fresh water (µg/kg dry wt)</td>
<td>2497</td>
</tr>
<tr>
<td>Sediment in Sea water (µg/kg dry wt)</td>
<td>250</td>
</tr>
<tr>
<td>Drinking Water (µg/L)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Table 5.3: Proposed WQSs for Benzo(k)fluoranthene

<table>
<thead>
<tr>
<th></th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh water (µg/L)</td>
<td>0.0054</td>
</tr>
<tr>
<td>Sea water (µg/L)</td>
<td>0.00054</td>
</tr>
<tr>
<td>Sediment in Fresh water (µg/kg dry wt)</td>
<td>349</td>
</tr>
<tr>
<td>Sediment in Sea water (µg/kg dry wt)</td>
<td>35</td>
</tr>
<tr>
<td>Drinking Water (µg/L)</td>
<td>0.1 (total allowed concentration of 4 PAHs incl. Benzo(k)fluoranthene)</td>
</tr>
</tbody>
</table>
Table 5.4: Proposed WQSs for Cadmium and its compounds

<table>
<thead>
<tr>
<th></th>
<th>Hardness (mg CaCO$_3$/L)</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh water (µg Cd/L)</td>
<td>40-&lt;100</td>
<td>0.08</td>
</tr>
<tr>
<td>Fresh water (µg Cd/L)</td>
<td>100-&lt;200</td>
<td>0.15</td>
</tr>
<tr>
<td>Fresh water (µg Cd/L)</td>
<td>&gt;200</td>
<td>0.25</td>
</tr>
<tr>
<td>Sea water (µg Cd/L)</td>
<td>N/A</td>
<td>0.21</td>
</tr>
<tr>
<td>Sediment in Fresh water (mg Cd/kg dry wt)</td>
<td>N/A</td>
<td>2.3</td>
</tr>
<tr>
<td>Sediment in Sea water (µg Cd/kg dry wt)</td>
<td>N/A</td>
<td>Lack of toxicity data for marine benthic organisms</td>
</tr>
<tr>
<td>Drinking Water (µg/L)</td>
<td>N/A</td>
<td>5</td>
</tr>
</tbody>
</table>
5.7 Conclusions

As can be seen from Section 5, significant improvements have been made in the EIA-related legislation and advisory documents in the twenty years since the publication of the original EIA directive (CEC, 1985).

Despite this, as was observed in Section 4, currently-produced EISs are not comprehensive. This is mostly due to the fact that there are little or no detailed requirements or standards for pollution risk or groundwater disturbance, such as maximum allowable concentrations of pollutants allowed in various receiving water types, and limits on the maximum allowable interception of foundations with groundwater in vulnerable aquifers. Hopefully far higher standards in the area of pollutant control will be achieved with the full implementation of the WFD (initial steps can be seen in Tables 5.2-5.4).

In addition to tighter specifications and standards, the whole environmental protection process associated with roads (post-EIS) needs to be far more transparent. A huge emphasis is placed on consultation with the public and NGOs before and during the EIA process but the amount of available information falls dramatically once a road is built. Stakeholders and interested parties should have access to monitoring data and as part of ensuring the transparency of the whole process, details of monitoring parameters and frequencies, results, conditions and actions taken should be published electronically. This would ensure accountability and ultimately improve environmental standards.
6.0 Sustainability of the Roads Programme

6.1 Introduction

There are several definitions available for sustainable development:

- Development which ‘meets the needs of the present without compromising the ability of future generations to meet their own needs’ (United Nations, 1987).

- The need to enhance the environment, but at the same time protect it for the future – ‘capacity for continuance’ and Sustainable Transport: Ways and methods of travelling which do not have significant impact on the environment, often by definition, not including car use (University of Nottingham, 2005).

- Development which improves the quality of life while living within the carrying capacity of the supporting ecosystems (IUCN et al., 1991 cited Butler and Parkinson, 1997).

Despite, or maybe because of, the numerous efforts to define sustainable development ambiguity still exists when it comes to design and implementation of strategies to ensure the sustainability of human development. Most people would agree that environmentally sustainable activities are ones which do not produce any significantly adverse impact on the environment. But beyond that simple statement agreement is much more difficult. Opinions differ on a wide range of related issues, such as:

What constitutes significant?
Is it possible to determine with certainty the type, magnitude and duration of impacts on the environment from a proposed activity?
Are there agreed methods for these determinations?
Are there agreed mitigation measures for preventing impacts?
Is it sufficient to minimize impacts if complete prevention is not possible or should impacts be avoided despite economic consequences?

At the moment there is no commitment from governments or policy-makers to truly environmentally sustainable development. The 1999 figure for fossil fuel consumption in developed countries was 6.4 tons of oil equivalent per capita per year (United Nations, 2002) and pollution of air, water and soil is tolerated to a very large extent through, for example, land-filling, waste-water disposal and vehicle emissions. Many governments are committed to ensuring that developments are as environmentally-friendly as possible using techniques such as BATNEEC (Best Available Technology Not Entailing Excessive Cost) but residual impacts such as the effects of CO$_2$ production, which can be severe, are tolerated in order to achieve economic growth.

This is the main difficulty with sustainable development; the fact that in the short-to-medium term it is completely at odds with economic growth and development. In a study on the relationship of environmental and economic performance in the European paper manufacturing industry Wagner (2005) concluded that environmental performance has either a uniformly negative or an inversely U-shaped relationship with economic performance. Currently successful growth of an economy involves a huge array of environmentally detrimental activities such as consumption of enormous quantities of fossil fuels, clearance of vast areas of natural habitats and ecosystems and the production of toxic by-products from numerous production activities such as nuclear fission, petroleum refining and mining. There are few sustainable alternatives to these activities and those alternatives that are available are not as economically viable. The negative environmental impacts of these activities are either disputed or controlled to the extent that they are not significant in the short-term. Failure to grow economically has a more obvious, certain and immediate impact on our lifestyles than failure to ensure environmental sustainability and therefore the former takes overwhelming precedence.

In the very long-term our activities now will more than likely have a very adverse effect on our ability to grow economically due to a depletion of natural resources such as fuels and ores,
the contamination of water supplies and land, and the climatic effects of releasing greenhouse gases. But it is also more than likely that serious, comprehensive moves towards sustainable living and development will not occur until these environmental impacts on lifestyle are more tangible than economic ones.

Truly sustainable development will not be realized in the near future, if ever, due to severe economic pressures. But does that mean that in discussing the requirements of sustainable development, the meaning of sustainable should be softened, in order to make the requirements and objectives of sustainable development more attainable and compatible with current lifestyles and economic growth? I don’t believe so. The requirements of real sustainability may never be realized but it is important not to deceive ourselves that what we are currently doing or planning is really sustainable.

So, in terms of sustainability of road developments there are two main issues: the sustainability of the construction and operation of individual road projects and the sustainability of policies and plans for the wider road network.
6.2 **Sustainability of Road Building (Construction, Operation)**

6.2.1 **Construction**

- **Construction runoff**
  Runoff from road construction sites may include oil and fuel from machinery, concrete liquors, and metal from steel-working. These contaminants pose a threat to the environment (issues with hydrocarbons and metal pollution of water is discussed in more detail in Section 6.2.2 (i)).
  Mitigation measures are suggested for controlling these contaminants such as bunding, to protect the natural environment but the success of these measures needs to be monitored and proven to ensure their sustainability.

- **Earth-moving**
  All road projects require the disturbance of large quantities of soil. Local rivers and lakes are vulnerable to this activity due to the risk of introducing sediment to the aquatic environment, which reduces water quality and adversely affects it as a habitat. Where a river is crossed by a road it is particularly vulnerable as the river channel may have to be culverted or modified at this point. In general the risk of suspension of solid particles in surface waters is temporary and if controlled will not have a major impact. The biggest risk from the alteration of a river channel is the effect on fish migration. Free movement especially to spawning areas must be ensured, otherwise the modifications are completely unsustainable.

- **Disruption of groundwater flow**
  Groundwater is of major importance as a source of clean, uncontaminated water for human consumption and use, and as a source of water for all types of vegetation, for support of agricultural land, forests and wetlands, and for providing baseflow to rivers and lakes.
  Disruption of groundwater flow is the most complex issue relating to the management of resources during road construction. The groundwater flow can be disrupted in many ways.
- Drainage of groundwater from incut sections of roadway that intercept the water table
- Creation of preferential pathways for groundwater in permeable fill materials
- Disruption of groundwater flowpaths through the use of foundation pilings
- Puncturing by foundation pilings of horizontal geological strata which naturally divide deep groundwater from shallow perched aquifers

All these potential design aspects of roads can have very serious effects (as discussed in Sections 2-4) depending on the importance of the aquifers, the ecosystems they support and the pathways between them. Nevertheless some are potentially sustainable under certain conditions.

Aquifer drainage – is sustainable if the volumes removed do not cause
- a permanent reduction in the aquifer volume
- significant changes in groundwater levels or location of groundwater divide that would result in adverse effects on existing abstraction wells or local flora and fauna
- excess volumetric addition to receiving waters
- a change in the chemical composition of receiving waters such that associated flora and fauna are adversely affected

Creation of preferential pathways - can be sustainable if they can be successfully mitigated against using for example, impermeable barriers.

Disruption of flowpaths by closely spaced pilings – the solution suggested for this problem in the EIS for N3 Butler’s Bridge to Belturbet Road Improvement Scheme, is the construction of flowpaths to simulate the natural, pre-development conditions. The possible sustainability of this measure is discussed in Section 4.3.5.

Puncturing of important horizontal dividing strata – the solution suggested for this problem in the EIS for N3 Butler’s Bridge to Belturbet Road Improvement Scheme is the use of eco-friendly sealant to seal the gap between layers around the pilings. Again the possible sustainability of this measure is discussed in Section 4.3.5.
In conclusion, the sustainability of these effects and their associated mitigation measures with respect to groundwater, is not guaranteed. In order to achieve that level of certainty the following is required:

- An accurate and complete description of the sub-surface hydrological regime, including natural groundwater level fluctuations
- Accurate predictions of the temporal and spatial effects of the proposed road on this regime
- Accurate predictions of the effects of introducing proposed mitigation measures to this system

In addition, the compatibility, integrity and longevity of various components of the mitigation measures such as geomembranes, inert sleeves for sub-surface use of cement and bentonite, and lacustrine clay sealant must be ensured.

These are unrealistic requirements but are nevertheless necessary to *ensure* sustainability. Therefore in my opinion road developments can only be considered truly sustainable with respect to groundwater hydrology if serious environmental impacts on groundwater and dependent ecosystems are *avoided*, not mitigated against using complicated techniques. These techniques may be effective and can be used but it is important for all stakeholders to be aware and accept that they cannot guarantee sustainability.
6.2.2 Operation

The main impact of road operation is the production of road runoff which has the potential to create pollution and flooding issues.

(i) Runoff Contaminants

- Metals

Various researchers have analysed the metal content of road runoff (see Table 6.2). SEPA (2003) tested sediment from receiving streams as opposed to direct road runoff. The metals found in the streams were all associated with road runoff in particular from tyres and brake linings and combustion of lubricating oils, but these metals are also to be found in various industrial processes. The activities in the vicinity of each stream were not fully described therefore it was not possible to conclude that concentrations of metals found were entirely due to road runoff. However it was estimated that road runoff accounts for between 50% and 70% of heavy metal contamination in receiving streams (Ellis et al., 1986 cited SEPA, 2003). Other researchers analysed the contents of road runoff. Legret et al. (1999) determined that in samples tested the insoluble fractions of Pb, Cu, Cd and Zn were 90%, 45%, 47% and 35% respectively. For the insoluble fractions of the same metals Bulc and Slak (2003) observed somewhat lower results of 80%, 25%, 25% and 50% respectively. It can be concluded from these results that removal of sediment from road runoff only partly protects surface waters and groundwaters from metal contamination, since metals are not wholly insoluble. The soluble fraction is also more bio-available and therefore more harmful than the relatively easily removed insoluble fraction (Li et al., 2005).
### Table 6.1: Metals in Road Runoff and their Sources

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<thead>
<tr>
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<tr>
<td>Asphalt Paving</td>
<td></td>
<td></td>
<td>X_b</td>
</tr>
<tr>
<td>Atmosphere</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearing wear</td>
<td>X_b</td>
<td>X_b</td>
<td></td>
</tr>
<tr>
<td>Brake Linings</td>
<td>X_b</td>
<td>X_{a,b,c}</td>
<td>X_a</td>
</tr>
<tr>
<td>Corrosion of Galvanised</td>
<td></td>
<td></td>
<td>X_a</td>
</tr>
<tr>
<td>Barriers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deicing Agents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dirt on Vehicles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhaust Fume Particles</td>
<td>X_b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td>X_{a,b}</td>
<td></td>
<td>X_b</td>
</tr>
<tr>
<td>Fungicides/Insecticides</td>
<td>X_b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highways Structures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lubricating Oil &amp; Grease</td>
<td>X_b</td>
<td></td>
<td>X_b</td>
</tr>
<tr>
<td>Metal plating on vehicles</td>
<td>X_{b,c}</td>
<td>X_b</td>
<td>X_b</td>
</tr>
<tr>
<td>Pavement Wear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rust</td>
<td></td>
<td></td>
<td>X_b</td>
</tr>
<tr>
<td>Tyrewear</td>
<td>X_{b,c}</td>
<td>X_{a,b,c}</td>
<td>X_{b,c}</td>
</tr>
<tr>
<td>Catalytic Converters</td>
<td></td>
<td></td>
<td>X_c</td>
</tr>
</tbody>
</table>

All metals are elements and therefore non-biodegradable and persistent. Their concentrations in the environment will continually increase and they bio-accumulate in the food chain (Irish et al., 1995). Chronic exposure of fish to sub-lethal trace metal levels causes reduced swim speed and reduced growth and condition (Bervoets et al., 2005). Cadmium features on List I of the Dangerous Substances Directive, 76/464/EEC (CEC, 1976) due to its extreme persistence, toxicity and bio-accumulative nature. List II contains zinc, copper, chromium, lead and nickel and it is required that the concentration of all these substances be controlled due to the deleterious effect they have on the aquatic environment.
Section 6: Sustainability of Road Development

<table>
<thead>
<tr>
<th>Scope of Work</th>
<th>Pb (µg/l)</th>
<th>Cu (µg/l)</th>
<th>Cr (µg/l)</th>
<th>Cd (µg/l)</th>
<th>Zn (µg/l)</th>
<th>Al (µg/l)</th>
<th>Fe (µg/l)</th>
<th>Ni (µg/l)</th>
<th>Mn (µg/l)</th>
<th>Total Metal (mg/kg dry sediment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legret et al., 1999</td>
<td>Mean: 58</td>
<td>45</td>
<td>1</td>
<td>356</td>
<td>2102</td>
<td>14-188</td>
<td>11-148</td>
<td>0.2-4.2</td>
<td>104-1544</td>
<td>0.057</td>
</tr>
<tr>
<td>Shinya et al., 2000</td>
<td>To study runoff from a 1082m² section of elevated urban highway (75,000 ADT) in Osaka, Japan, adjacent to an area of commercial and high density residential land use, over 4 months (Aug - Nov '97, 4 events)</td>
<td>Mean: 35.2</td>
<td>55.2</td>
<td>4.6</td>
<td>1.5</td>
<td>561.3</td>
<td>1900</td>
<td>3200</td>
<td>5.2</td>
<td>68.1</td>
</tr>
<tr>
<td>Shinya et al., 2003</td>
<td>To study runoff from a 1082m² section of elevated urban highway (62,000 ADT), Osaka, Japan, adjacent to an area of commercial and high density residential land use, over 16 months (May '99 - Sept '00, 8 events).</td>
<td>Mean: 31</td>
<td>58.7</td>
<td>614</td>
<td>1240</td>
<td>2300</td>
<td>85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barrett et al., 1995 (Site 1)</td>
<td></td>
<td>Mean: 99</td>
<td>38</td>
<td>ND</td>
<td>237</td>
<td>3537</td>
<td>ND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barrett et al., 1995 (Site 2)</td>
<td>To study runoff from 3 different road sections of varying area, paving, adjacent land use and ADT in Austin, Texas. Each site was monitored for at least 15 months (93-95, no. events not given)</td>
<td>Mean: 41</td>
<td>10</td>
<td>ND</td>
<td>77</td>
<td>2437</td>
<td>ND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barrett et al., 1995 (Site 3)</td>
<td></td>
<td>Mean: 9</td>
<td>7</td>
<td>ND</td>
<td>19</td>
<td>442</td>
<td>ND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roe, 2003</td>
<td>To study runoff from 6 different rural highway sections of varying area, paving, ADT (min. 15,000) and existing runoff treatments. Each site was monitored for at least 1 year (97/’98, 10 events per site).</td>
<td>Mean: 23</td>
<td>41</td>
<td>6</td>
<td>0.49</td>
<td>140</td>
<td>1231</td>
<td>5.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEPA, 2003</td>
<td>To study sediment at nine freshwater sites in Scotland with varying proportions of residential, commercial, industrial and road runoff</td>
<td>Range</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6.2: Metal concentrations found in road runoff and receiving waters

ND: not detectable

a: sediment in road runoff
b: sediment in receiving stream

81
Mitigation measures
Due to the elemental nature and persistence of metals there are no mitigation measures that ensure sustainability once the metals are deposited on the road surface. Retention and sedimentation ponds can be used to prevent sediment from reaching the natural environment but these cannot be guaranteed to remove all particles sizes as most insoluble metal adsorbs to particulates that are less than 63µm in size (Roe, 2003). Bulc and Slak (2003) advise that particles of 10µm and less must be targeted in order to remove as much metal as possible. Apart from particle size retention issues, sedimentation systems will not have any effect on the soluble portion of metals in runoff. However, soluble pollutants may be removed to some extent in vegetated systems (for example, constructed wetlands, vegetated filter strips etc.) through uptake from soil water by rooted vegetation. This removal mechanism depends on a slow infiltration rate (Shortt, 2002).
Even if mitigation measures could be devised to remove all soluble and insoluble metal content from road runoff it still must be disposed of. Methods of disposal of sedimentation facility waste include land-spreading in low risk areas (SEPA, 2003) but alternative disposal routes may need to be considered for sediments from sustainable urban drainage systems (SUDS) that have received polluted urban runoff for many years (Wilson et al., 2003). These options are not sustainable as they only involve moving the contamination to another part of the natural environment.

- De-icing Salts
De-icing salts (mostly NaCl) are used to lower the freezing point of water and thereby reduce ice and accidents on road surfaces.

Godwin et al. (2003) investigated the long-term trends of sodium and chloride in the Mohawk River in New York. Although the practice of de-icing salt application is not as widespread or intensive in Ireland as in New York State this research shows that de-icing salts have definite impact on the Na⁺ and Cl⁻ levels in road runoff receiving waters. Concentrations of various ions in the Mohawk River in the 1950s, 1970s and 1990s, were compared. The mean, minimum and maximum concentrations of Na⁺ and Cl⁻ all rose significantly from each study.
period to the next. The equivalent concentrations of $K^+$, $Mg^+$, $Ca^{2+}$, and $SO_4^{2-}$ fluctuated or decreased over the study periods. Elevated concentrations of chloride were also found in groundwater wells and springs in the river catchment.

Norrström (2005) investigated the ability of de-icing salts to mobilize metals. De-icing salts can promote metal leaching by the formation of soluble compounds of metals and $Cl^-$, and by the exchange of metals with $Na^+$ at soil exchange sites. Also in soils with high $Na^+$ concentration soil aggregates break up and a subsequent supply of low salinity water causes dispersion and mobilization of colloids (sediment particles <10μm). These mechanisms could cause metals in soils to leach into groundwater and metals in sedimentation ponds to remain in solution and enter surface receiving waters.

Toxicity

Chronic inputs of NaCl into the environment are thought to negatively affect human health as well as flora and fauna (Godwin et al, 2003). Excess salt intake is linked to high blood pressure and other related health problems (CASH, 2005).

Mitigation Measures

Removal of salt from the environment is difficult because it is very water-soluble. Furthermore there is very little emphasis on it as a problem – most mitigation measures are focused on dealing with sediment, metal and hydrocarbon removal. But, as mentioned above, as well as being a pollutant in its own right, salt is considered by some researchers to be instrumental in mobilizing toxic metals.
• Hydrocarbons (including PAHs)
The release of hydrocarbons into the environment is due to leakage or incomplete combustion of fuel. Table 6.3 details research findings for hydrocarbons in road runoff and the natural environment. As with the metal concentrations detected by SEPA (2003) the hydrocarbon concentrations found in that study are not necessarily due entirely to road runoff. The high concentrations of hydrocarbons in runoff sediment found by Legret et al. (1999), suggest that they have a high affinity to the particulate phase. PAHs tend to become adsorbed to sediments although during disturbance they can be resuspended in water. Lower weight PAHs are most readily released from sediments into this suspended form (DEFRA, 2002 cited SEPA, 2003).

Toxicity
Certain low molecular weight PAHs are directly toxic to aquatic life and high molecular weight PAHs are highly carcinogenic to animals including humans (Law et al., 2002). Persistent mineral oils and hydrocarbons of petroleum origin are classified as List I substances under the Dangerous Substances Directive (CEC, 1976) due to their toxicity, persistence and bioaccumulation (SEPA, 2003).

Mitigation measures
Measures to deal with particle-attached hydrocarbons and associated issues are very similar to those for metals. Sedimentation facilities are used to remove insoluble hydrocarbons from runoff and must eventually be disposed of. The main difference between metals and hydrocarbons is that hydrocarbons are somewhat biodegradable and should eventually decompose. This process could be quite protracted depending on the type of compound and the environmental conditions so it should not be relied upon as a method of contaminant removal. Suspended hydrocarbons will contaminate surface waters and groundwaters but can be removed through the use of oil interceptors/separators. However, Roe (2003) found that nearly all oil separators studied performed poorly due to poor installation and/or design. This again reinforces the need for monitoring to ensure that mitigation measures are performing effectively.
### Table 6.3: Concentrations of Hydrocarbons and PAHs found in road runoff and freshwater sediment

<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>Scope of Work</th>
<th>HC (mg/l)</th>
<th>PAH (ng/l)</th>
<th>HC (mg/kg dry sediment)</th>
<th>PAH (mg/kg dry sediment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legret et al., 1999</td>
<td>To study runoff from a 3200m² section of asphalt surface, rural motorway (24,000 ADT) in Nantes, France over one year (Mar '95- Feb '96, 48 events).</td>
<td>Mean</td>
<td>1.2</td>
<td>96</td>
<td>865²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>0.14-4.2</td>
<td>11-474</td>
<td>250-1920²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annual Pollutant Loading (g/h/year)</td>
<td>0.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shinya et al., 2000</td>
<td>To study runoff from a 1082m² section of elevated urban highway (75,000 ADT) in Osaka, Japan, adjacent to an area of commercial and high density residential land use, over 4 months (Aug - Nov '97, 4 events)</td>
<td>Mean</td>
<td>1100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shinya et al., 2003</td>
<td>To study runoff from a 1082m² section of elevated urban highway (62,000 ADT), Osaka, Japan, adjacent to an area of commercial and high density residential land use, over 16 months (May '99 - Sept '00, 8 events)</td>
<td>Mean</td>
<td>723</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roe, 2003</td>
<td>To study runoff from 6 different rural highway sections of varying area, paving, ADT (min. 15,000) and existing runoff treatments. Each site was monitored for at least 1 year ('97-'02, 10 events per site)</td>
<td>Mean</td>
<td>1500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEPA, 2003</td>
<td>To study sediment at nine freshwater sites in Scotland with varying proportions of residential, commercial, industrial and road runoff</td>
<td>Range</td>
<td></td>
<td>20-3400³</td>
<td>0.02-52</td>
</tr>
</tbody>
</table>

Table 6.3: Concentrations of Hydrocarbons and PAHs found in road runoff and freshwater sediment
• Sediment
Dealing with sediment in road runoff is crucial because (1) it can increase water turbidity and (2) due to the affinity of toxic pollutants such as metals and hydrocarbons to it.

Sediment particles are probably the easiest water contaminants to remove as most of them will settle out of water if given enough time and space. Unfortunately the smallest particles that are least likely to settle out, would appear to contain most of the hydrocarbons and metals. It has been documented that it is the particles <63μm in size that contain the majority of the metal and hydrocarbon content of sediment (Roe, 2003). Li et al. (2005), in work done on sediment particle size in Los Angeles, found that of grab samples of road runoff collected at three sites, over 97% of the sediment particles were less than 30μm.

It is therefore extremely important that particle removal efficiencies of BMPs are adequate to deal with very small particle sizes. These efficiencies should be documented and monitored by road operators. Again as mentioned above, removing sediment from runoff does not constitute a completely sustainable solution to the problem, as the sediment must still be disposed of.

• Herbicides
Herbicides are used in the maintenance of roads and the associated landscaping. The University of Idaho Extension Forestry Information Series documentation (UI, 2005) provides the following information on the behaviour of herbicides in the natural environment.

- Herbicides tend to leach more and run off the surface less when applied to coarse-textured soils as opposed to relatively impervious clays.
- Herbicides adsorb readily onto soils with high organic content.
- Some herbicides are highly water-soluble but water-solubility varies with type.
- The persistence of herbicides depends not only on their chemical properties but also on soil aeration, organic content and pH, sunlight, temperature, and the level of microbial activity in the soil.
- High water tables and coarse soils make groundwater particularly vulnerable to contamination with herbicides.
In an article by Phyu et al. (2005) it is documented that atrazine, a widely used herbicide, persists particularly in anaerobic or denitrified soils. Triazine based herbicides such as atrazine are practically unaffected by microbial or hydrolytic processes and are therefore extremely persistent.

Roe (2003) detected five different types of herbicide in road runoff at various monitored and sites and demonstrated the persistence of Glyphosate in runoff from one site during the month following application of the herbicide.

Herbicides which are effectively poisons are toxic to aquatic fauna and humans. Atrazine is listed as a priority hazardous substance in Annex X of the Water Framework Directive (CEC, 2000), emissions of which must be ceased or phased out.

- **Accidental Spillages**

Hazardous liquid substances such as chemicals and fuels are transported overland by road and accidental spillages of these substances from transporters can occur and are liable to cause devastating environmental damage if not properly contained. Even non-hazardous liquids such as milk, in large quantities can severely affect receiving waters.

Wilson (1999) advocates that road authorities provide reliable and easy means of isolating part of the drainage system, information on the outfall catchment and the means of isolating containment facilities to protect the outfall. The containment facilities protecting sensitive receiving waters should be sized for a spillage event with a return period less than 1 in 100 years and less than 1 in 50 years in other cases. Design of containment facilities and routine pollution treatment systems should be considered together - sedimentation tanks and vegetative systems can provide spillage containment and pollution protection. There are inherent risks involved with accidental spillages regardless of the quality of the containment facility. The spillage may exceed the design capacity; the spillage may coincide with a severe storm event which would reduce the capacity of the attenuation facility to
receive the runoff; delays may occur that could significantly impede implementation of isolation procedures, especially if the spillage occurs at night. Therefore accidental spillage containment facilities cannot guarantee complete protection for the environment.

(ii) Flooding

Flooding in a catchment occurs when the amount of water flowing into a river section from (1) upstream, (2) direct land runoff, and (3) baseflow contribution from groundwater, exceeds the capacity of the river channel. The excess volume and velocity of the flood water can cause erosion and suspension of sediment and thereby destroy important flora and fauna habitats within and alongside the river channel. Apart from the effect on plants and wildlife, flooding can severely damage property and pose a significant safety risk to humans.

Roads can contribute to the severity of flooding in two ways. Firstly, road surfaces are predominantly, if not completely impervious and therefore the opportunity for rain falling on roads to infiltrate to soil and groundwater at that point is lost. This increases surface runoff volumes and therefore the amount of water receiving streams must cope with. Secondly, surface runoff from roads moves much more rapidly over the road and through its drainage system than surface runoff on undeveloped land. Roads are designed to remove runoff from the surface as quickly as possible. Therefore runoff from roads reaches receiving waters much more quickly than it otherwise would. As a result the stormwater created by a severe rainfall event must be dealt with by the streams and rivers within a catchment in a much shorter space of time than would otherwise be required.

The concept of flood attenuation is in itself quite sustainable. It involves channelling road runoff away from the road surface to an attenuation area, from where its release to the receiving environment can be slowed and controlled to prevent flooding, and where it can also be allowed to infiltrate to groundwater. Unfortunately the sustainability of this concept is complicated by the pollutant content of the water. This makes the infiltration aspect of flood
attenuation measures unsustainable because of the risk to groundwater of runoff contaminants, as outlined above.

Pollutants in the runoff also become a very significant factor in the unsustainability of flood attenuation when the stormwater volume exceeds the capacity of the attenuation facility. Attenuation facilities are sized to cope with floods with a predicted return of X no. of years (25 years in the case of the N3 Butler’s Bridge to Belturbet Road Improvement Scheme, see Section 4.3.5). Since roads have a long life cycle and the land under them is very seldom revegetated, it is probable that associated flood attenuation facilities will overflow on a few occasions. This would probably be accepted as having similar or less effect than a natural flood (i.e. if neither the road nor the attenuation facility were in place) if it was not for the pollutant content of the overflowing water. Stormwater overflowing an attenuation/sedimentation facility would undergo little or no pollution and sediment retention.
6.2.3 Conclusions

The most significant sustainability issues related to road construction and operation are: (1) the associated pollutants, especially those that are particularly toxic and/or persistent, and (2) alterations made to groundwater flow that can have very complicated, far-reaching effects on dependent ecosystems and water supplies for human consumption.

The removal of metals and hydrocarbons is largely reliant on sedimentation-based BMPs but as discussed in Section 6.2.2 (i) significant quantities of these pollutants remain in solution or suspended. Vegetated BMPs may remove some soluble pollutants through root uptake, depending on plant types and infiltration rates. However, most pollutant-removal BMPs are aimed at insoluble pollutant removal. Pollutant removal BMPs in general do not deal with or solve the issue of the ultimate destination of the removed pollutants.

Alterations to groundwater flow and the widespread consequences of this are extremely difficult to predict accurately, and to mitigate against. Mitigation measures for the groundwater flow issues in the EISs studied (see Sections 2-4) are complex and suggested without reference to instances of successful implementation. It must be concluded that the only sustainable mitigation measure for vulnerable groundwater and dependent ecosystems of ecological significance, is avoidance of alterations of the sub-surface flow regime.
6.3 **Sustainability of Road Development Policy**

6.3.1 **Review of ‘Sustainable Development – A Strategy for Ireland’ (DOE, 1997)**

In 1997 the Irish Department of the Environment (now the Department of the Environment, Heritage and Local Government) produced a strategy document entitled ‘Sustainable Development – A Strategy for Ireland’.

It outlines the following transport issues with respect to the environment:

- 96% of passenger transport and 89% of freight transport is by roads
- transport consumed 31% of energy used in Ireland in 1993 (22% industry, 28% residential, 15% commercial, 4% agriculture)
- Transport constitutes 17% of CO₂ emissions, 75% of which is due to road use
- The effect of road transport on aquatic systems is acknowledged in the report but not quantified

As part of the government’s overall transport policy it is stated in this strategy document that ‘government policy and investment for road transport will support necessary economic growth.’ But it is also stated that as part of government policy to develop sustainable transport, one of its aims is to minimize the potential growth in transport. These two goals do not appear to be compatible.

The reasons for growth in transport due to economic growth are detailed in the report as follows:

- Dispersal of industrial activities away from traditional urban locations
- Changing production and stock control methods requiring more frequent shipments of smaller quantities of goods
- Growth of the service sector involving multi-site businesses, and of the tourism sector
Section 6: Sustainability of Road Development

- Increased business and professional mobility
- Demand for year-round availability of seasonal foods and products

And it is recognized therefore that patterns of economic growth must change:

‘The challenge for sustainable transport is to encourage patterns of economic growth which can be achieved with maximum transport efficiency and the least possible environmental impact so that the economic growth does not generate unlimited growth in demand for transport, with adverse environment impacts.’

Despite this recognition of the inter-relationship of transport and economy it does not appear to be part of the government strategy to tackle these underlying economic causes of unsustainable transport growth. This can only be achieved through very strategic land-use planning and dialogue with major industries aimed at reducing their transport needs. Instead it would appear from this strategy document that efforts are to be aimed at:

- The sustainability of road construction, methods and materials, and upgrading existing roads and minimizing construction of new roads
- Vehicle testing to ensure emission standards
- Development of passenger rail transport especially in the greater Dublin area
- Supporting sustainable energy research (e.g. Teagasc’s biodiesel project)

**Development of Public Transport**

To achieve sustainability of the roads programme requires a dramatic decrease in the growth rate of road usage. Unfortunately between 1991 and 1997 person trips in private cars alone, at peak hour increased by 63% in Dublin, and a 95% increase peak hour person trips has been predicted between 1997 and 2016 (DTO, 2001). Public transport is key to ensuring that this doubling of demand within twenty years is not dominated by road use. In response to this demand the Dublin Transportation Office (DTO) plans to increase available peak-morning public transport trips from 70,000 in 2000 to 300,000 in 2016 through the extension of the
LUAS light rail network, construction of a METRO system, new rail lines to separate intercity and suburban services, and a much expanded bus network (DTO, 2001). This 430% planned increase in available public transport trips in 16 years is hugely ambitious and unfortunately was not accompanied by a breakdown of capacity increases or implementation timescales.

6.3.3 Land-use planning

This is an extremely important element of ensuring the sustainability of the road network as it has a direct impact on the quantity and duration of road trips in all areas.

It is recognised that higher residential densities lead to shorter trips and lower levels of car use, and higher employment density leads to greater public transport use (EC, 2003).

The government has also recognised the significant impact of land-use planning with respect to business and industry (see Section 6.3.1). The location of a business or industry in relation to its suppliers, customers and employees, has an enormous effect on its transport requirements. However, there is no indication in the government strategy document that these issues are to be addressed. Again economic concerns for employment and business growth are considered to be of over-riding importance.

Land-use planning should also be focussed on making residential areas as pedestrian-friendly as possible with adequate public transport to avoid short car trips. Facilities such as shops and schools should be placed in central, easily-accessible areas. Developments of large out-of-town leisure and shopping complexes with no public transport access, which encourages traffic, should be curtailed.
6.3.4 Strategic Environmental Assessment (SEA)

SEA is an environmental impact assessment that can be applied to plans, programmes and policies to assess their potential impact on the environment and which aids the decision making process. The European Council introduced the SEA Directive in 2001 (CEC, 2001) which aims to integrate ‘environmental considerations into the preparation and adoption of certain plans and programmes which are likely to have significant effects on the environment in the Member States, because it ensures that such effects of implementing plans and programmes are taken into account during their preparation and before their adoption’.

This directive is a significant step in ensuring that road authorities consider the environmental implications of overall road development plans, but as with environmental impact assessment directives (CEC, 1985 & 1997) the success of requirement for SEA, in its ultimate goal of protecting the environment, relies on thorough implementation.

Policies are notably omitted from the requirements of the directive probably due the restrictions it would place on governments and parties in formulating their political policies. Policy making is too closely connected with day-to-day political agenda to be readily made the subject of the SEA process.

Fischer (2003) analysed the implementation of SEA with respect to transport and land-use policies, plans and programmes in three major European cities between 1997 and 2002. His analysis was based on transport policy documentation, and interviews with decision-makers, planners and other stakeholders.

In Berlin the main focus of the City Development Plan (1994-1998) was the assessment of different policy scenarios and options in order to identify those measures that would lead to an achievement of overall policy goals. This assessment did not occur and in 2002 the main focus had shifted to the identification of concrete projects for improving transport infrastructure in Berlin, without previously assessing the impacts of different strategic policy options.
In Amsterdam change in government between 1997 and 2002 resulted in significant policy change with respect to transport in the city. A shift in policy away from managing transport demands and towards meeting perceived demands occurred.

In Liverpool plans for impact assessment on overall policy options had been abandoned by 2002 and less emphasis was being placed on the issues of traffic volume growth and CO₂ emissions than previously.

In all three cities there was a notable decrease in the emphasis on SEA between 1997 and 2002. This research does not bode well for the successful implementation of the SEA Directive.
6.3.5 Conclusions

To ensure the sustainability of road development in Ireland, the causes of traffic growth and the demand for additional, larger roads must be tackled. These causes are very well described in the government’s strategy document but unfortunately its objectives are focussed on mitigation by reduction of traffic impacts as opposed to avoidance of impacts by reduction in traffic growth. The exception to this is the highly ambitious plan for passenger traffic reduction in the greater Dublin area, providing huge increases in available public transport. However, the successful and timely implementation of this plan is far from certain.

Land use and urban planning are the most effective ways of limiting traffic growth. This must be focussed on integrated urban developments with good public transport systems, and away from isolated industrial and commercial developments that promote road use for people and goods.

To ensure that economic growth does not generate unlimited growth in transport demand (this is a requirement for achieving sustainable transport, as outlined in the government’s strategy document (DOE, 1997)), strict controls would need to be placed on the types of industries and commercial businesses (and their locations) that operate in this country. But, the political and economic consequences of a definite strategy in this direction would unfortunately be too severe, and so less effective sustainable transport strategies are implemented in order to protect economic growth.
7.0 Final Conclusions and Recommendations

- Increased flooding risks due to road runoff and sub-surface drainage have not been given sufficient consideration in EISs in the past but the plans for flood attenuation at the N3 Butler’s Bridge to Belturbet Road Scheme are a significant improvement. Increased flooding risks, especially in relation to roads with sub-surface drainage, must be given adequate consideration, as outlined in Section 2.

- Pollution of the aquatic environment due to road runoff pollutants can be somewhat reduced by BMPs but these measures cannot fully protect the environment (soluble pollutants are practically unaffected) and the problem of disposal of sediment that has been removed from runoff, remains unsolved. In the case of persistent, bio-accumulative pollutants especially, measures are needed to eliminate their release into the environment. This would involve finding less harmful, biodegradable alternatives to heavy metals in tyres, brake-linings etc, to herbicides and ultimately to fuel (e.g. electrically-powered vehicles).

- Groundwater disturbance due to roads can have far-reaching effects and interference with natural groundwater flow patterns needs to be more strictly controlled, and should be completely avoided in areas of ecological importance. Where interference does occur it must be ensured that any mitigation measures used have a proven track record for effectiveness and sustainability in similar situations.

- Monitoring and Conditions are vital elements of the EIA/EIS process in ensuring effective environmental protection. However, these important elements were not fully considered in any of the three EISs studied. Monitoring must focus on the runoff entering receiving waters and the overall quality in the receiving waters themselves. These include rivers, lakes and groundwater. Changes in groundwater levels and groundwater divide locations must also be monitored. All this information must feed back into an analysis of the accuracy of impact predictions and the effectiveness of
mitigation measures, if it is to be of use. Clear, documented standards and conditions must be met and defined actions taken if breaches occur.

I would further recommend that these conditions, standards and remedial action plans are published, together with the monitoring results. This is needed to ensure the continued openness and transparency of the environmental protection process. There is a significant emphasis on stakeholder participation and consultation during the EIA process but there is none at the post-development stage. Independent interested parties and NGOs should be kept informed of the effectiveness of environmental protection measures.

- Road development in Ireland needs considerable further study if it is to be sustainable in hydrological terms. Efforts are being made to minimise the hydrological impact of roads but far less is being done to reduce factors causing significant environmental impact such as traffic growth and the demand for road space. It appears that economic considerations continue to over-ride environmental ones when it comes to transport programmes and policies.
8.0 References


CASH (2005), Consensus Action on Salt and Health, Charity Registration No. 1098818 (accessed at, http://www.hyp.ac.uk/cash/information/salt_its_effecton.htm, 24/8/05)

CCC (2005) Environmental Impact Statement N3 Butler’s Bridge to Belturbet Road Improvement Scheme, Arup Consulting Engineers


KCC (1993) Kildare Town Bypass Environmental Impact Study, Kildare County Council Senior Engineer


O’Connell L, and Connor, B (1994) Inspector's Report, Summary of Evidence and Recommendations on Scheme for the Provision of a Motorway under Section 4 of the Local Government (Roads and Motorways) Act 1974, Kildare Town Bypass (based on evidence given at the public local inquiry held into the Kildare Bypass Motorway Scheme and associated EIS, objections and submissions, in the CYMS Hall, Kildare Town from 23rd to 29th Nov, 1993)


Appendix 1: Receiving Water Sampling Results

Grab sampling was carried out at Simpson’s Stream, one of the outfall locations for the Kildare Town Bypass. Sampling was carried out on the 23rd July 2005 during a heavy rainfall event. Water was sampled exiting the Simpson’s Stream culvert under the bypass and also at a point approximately one kilometre downstream. The samples were tested for Cl\(^-\), NO\(_3^\)-, PO\(_4^{3-}\), SO\(_4^{2-}\), pH and COD in the Environmental Laboratory in the Dept. of Civil Engineering, TCD and testing was conducted in duplicate. All ion tests were carried out using Merck test kits – details of procedures can be found at http://photometry.merck.de/servlet/PB/menu/1169840/index.html.

<table>
<thead>
<tr>
<th></th>
<th>At Culvert</th>
<th></th>
<th>Downstream</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test 1</td>
<td>Test 2</td>
<td>Test 1</td>
<td>Test 2</td>
</tr>
<tr>
<td>pH</td>
<td>6.87</td>
<td>N/A</td>
<td>7.23</td>
<td>N/A</td>
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<tr>
<td>COD</td>
<td>48</td>
<td>43</td>
<td>&lt;10</td>
<td>21</td>
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<tr>
<td>Cl(^-)</td>
<td>39</td>
<td>19</td>
<td>15</td>
<td>15.5</td>
</tr>
<tr>
<td>NO(_3^)-</td>
<td>3.2</td>
<td>4.2</td>
<td>5.3</td>
<td>3.9</td>
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<tr>
<td>PO(_4^{3-})</td>
<td>0.38</td>
<td>0.44</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>SO(_4^{2-})</td>
<td>43</td>
<td>52</td>
<td>154</td>
<td>108</td>
</tr>
</tbody>
</table>

All these results suggest that the water is clean and unpolluted by road runoff. The samples have also been sent to Alcontrol Laboratories for metal and PAH testing but results are not yet available. They will be included in the final draft.

It was also attempted to sample the runoff from the M50 Liffey Valley Bridges but was not possible due to the lack of rain this summer.