Comptroller and Auditor General

Report on Value for Money Examination

Office of Public Works

Arterial Drainage of the Boyle and Bonet Rivers

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Report of the Comptroller and Auditor General

Arterial Drainage of the Boyle and Bonet Rivers

I have, in accordance with the provisions of Section 9 of the Comptroller and Auditor General (Amendment) Act, 1993, undertaken a value for money examination of the arterial drainage schemes carried out by the Office of Public Works on the Boyle and Bonet rivers

I hereby submit my report of the above examination for presentation to Dáil Éireann pursuant to Section 11 of the said Act

John Purcell
Comptroller and Auditor General

31 December 1996

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Abbreviations

OPW	Office of Public Works
ha	hectares
CAP	Common Agricultural Policy
EU	European Union
FWS	Forest and Wildlife Service
ESRI	Economic and Social Research Institute

Summary of Findings

Arterial drainage work carried out on a river involves the artificial widening and deepening of the river channels to enable them to carry away a greater volume of water more quickly The principal objective of arterial drainage schemes carried out in Ireland by the Office of Public Works (OPW) was to bring about a long term improvement in agricultural incomes in river catchments The work carried out on schemes was designed to allow landholders to install field drainage which reduces waterlogging of land and enables it to carry more livestock or produce higher crop yields Schemes also have the effect of reducing both the incidence and duration of flooding.

An extensive programme of arterial drainage of Irish rivers has been carried out since the 1950s. The Boyle and Bonet drainage schemes commenced together in July 1982 It was planned that the schemes would be completed in five and three years, respectively, at a total cost of £17 million (constant 1982 prices).

An examination of the Boyle and Bonet schemes was carried out to establish

- the outturn on each of the schemes in terms of producing the specified outputs within time and budgetary targets
- whether programmes of maintenance for the schemes have been developed and are being implemented
- the adequacy of planning, specification and management of the schemes
- the economic and efficient use of resources in carrying out the schemes
- whether the effectiveness of the schemes has been adequately evaluated

Scheme Outturn

Both schemes continued over much longer periods than originally envisaged The Bonet scheme was carried out between July 1982 and January 1992 i e more than nine years, compared to the scheduled three years The Boyle scheme continued until December 1995 i e more than 13 years, compared to the scheduled five years

Progress on the schemes was slower than planned because annual funding for the schemes was much less than had been envisaged at the planning stage

At the time the schemes were halted, about 85% of the work originally planned had been carried out. The schemes were stopped because it was considered that the cost of the remaining scheduled work was greater than the potential economic benefit In addition, there were concerns that some of the remaining works on the Bonet would have encroached on environmentally sensitive fishing waters.

Quality of Work

Excavation and construction work on the two schemes was carried out to a high standard by OPW

Flood Protection

Arterial drainage schemes cannot eliminate the risk of flooding. Most of the schemes carried out by the OPW were intended to ensure that flooding of agricultural land from the main river channels is not likely to occur, on average, more than once in a three year period (This is called a 'three-year return period flood') The OPW estimated that this level of flood protection could not be achieved in the Boyle and Bonet catchments at a reasonable cost and opted for lower levels of protection The target adopted for the Boyle scheme was a two-year return period flood A one-year return period flood was adopted as the target for the Bonet.

Flooding problems in both catchments were reduced as a result of carrying out the arterial drainage schemes While the drained channels of the Boyle system meet the target two-year return period criterion, the drained channels of the Bonet system do not meet its target one-year return period

Field Drainage

Depending on soil type and the nature of the flooding problems, some land may improve directly as a result of carrying out arterial drainage work. In most cases, however, waterlogged land will only improve if field drainage is installed As a result, the extent to which field drainage is carried out by landholders is critical in determining the effectiveness of arterial drainage schemes

Projections of increased farm incomes as a result of carrying out the Boyle and Bonet schemes were based on the assumption that, soon after the arterial drainage work was completed, around 88% of the target damaged land would be improved to the extent that it could carry extra livestock. Based on a sample survey of the target damaged land, it is estimated that less than 25% of the target damaged land shows evidence of improvement This suggests that there was a very low incidence of installation of field drainage.

Maintenance

Without adequate maintenance, there is a considerable risk that drained channels may revert to their pre-drainage condition The OPW is required by law to maintain the schemes it carries out in proper repair and effective condition and spent an estimated £7.9 million on the maintenance of arterial drainage schemes in 1996

A decision was taken during the Boyle and Bonet schemes to postpone routine maintenance work during construction Given the long delays on the schemes, this has meant that channels drained early on were not maintained for many years and reverted some way towards their original state

The four-year maintenance programme adopted for the Bonet scheme in 1994 should be adequate to restore the channels to their post-scheme condition A five-year programme for maintenance of the Boyle started in 1996 but, given the progress to date, it appears that work on the main channels will need to be speeded up to ensure that the planned maintenance work can be completed within the target period

Expenditure on Schemes

Budgets for the Boyle and Bonet schemes prepared in March 1982 envisaged total expenditure of £14 5 million (in constant 1982 prices) on the work which was actually carried out Actual expenditure up to December 1995 was £31.6 million (in current prices)

About 30% of the expenditure overrun is related to inflation The remainder relates mainly to cost overruns on overheads and, to a lesser extent, on overruns on construction of structures, spoil rehabilitation and compensation payments

Inflation

The OPW was clearly aware that inflation would result in actual expenditure exceeding the budgeted amount but did not project what the impact might be Had work proceeded according to the original schedule, actual expenditure would have been an estimated £1.6 million higher than budgeted due to the inflation factor Because work was extended over a much longer time period, considerable further inflation (estimated at £3 5 million) was also incurred

Overheads

The OPW planned the Boyle and Bonet schemes on the basis of rates of work progress which would optimise the use of overheads e g. transport, machinery workshops, stores and supervisory and support staff Overheads were budgeted to be 54% of the cost of planned direct works but turned out to be 92% of the actual cost Extra spending on overheads accounted for more than half the entire cost overrun on the schemes mainly because the time required to carry out the schemes was extended so much

Before the Boyle and Bonet schemes started, the OPW pointed out to the Department of Finance that the Department's policy of restricting funds each year for on-going

drainage schemes was impeding work progress and that this had resulted in extensions of the work schedules, thereby leading to extra overheads and higher final costs for the schemes.

Construction of Structures

Structural work on the schemes mainly related to underpinning or replacement of bridges Actual expenditure on structures was considerably higher than budgeted mainly because the estimate of expenditure was based on the OPW's experience of the scheme carried out earlier on the Boyne river, where conditions were different, and because standards of construction higher than those planned were found to be necessary in many cases

Cost per Hectare of Target Land

The cost per hectare of agricultural land targeted for improvement on the Boyle scheme was not significantly different from the cost on other major schemes carried out in the 1970s and 1980s The cost per hectare on the Bonet scheme was much higher than the cost of other schemes carried out, with the exception of the Monaghan Blackwater where special circumstances applied It must, however, be borne in mind that the level of flood protection provided is lower for the Boyle and Bonet schemes than for all other schemes carried out

Project Management and Planning

The OPW's project management and planning procedures were appropriate for the scale and complexity of the schemes although some shortcomings were evident in budget preparation and monitoring of overall efficiency levels

Evaluation of Effectiveness

The OPW had a comprehensive methodology for evaluating the effectiveness of arterial drainage schemes. This was used in appraising the Boyle and Bonet schemes before they commenced The appraisal indicated that the benefits likely to be derived from carrying out the Bonet scheme were, at best, likely to be only marginally greater than the costs

The methodology used for appraising the schemes could have been used to reassess the argument for continuing with the schemes, particularly when it became clear that costs were likely to be higher than budgeted and that agricultural policies were moving away from schemes designed to increase agricultural production However, no re-appraisals of the Boyle or Bonet schemes were carried out during the course of their construction Despite the significant cost overruns which occurred and the low

incidence of installation of field drainage, the OPW has not carried out post-scheme evaluations of the effectiveness of the Boyle and Bonet schemes

The OPW does not propose to carry out any further arterial drainage schemes in the foreseeable future

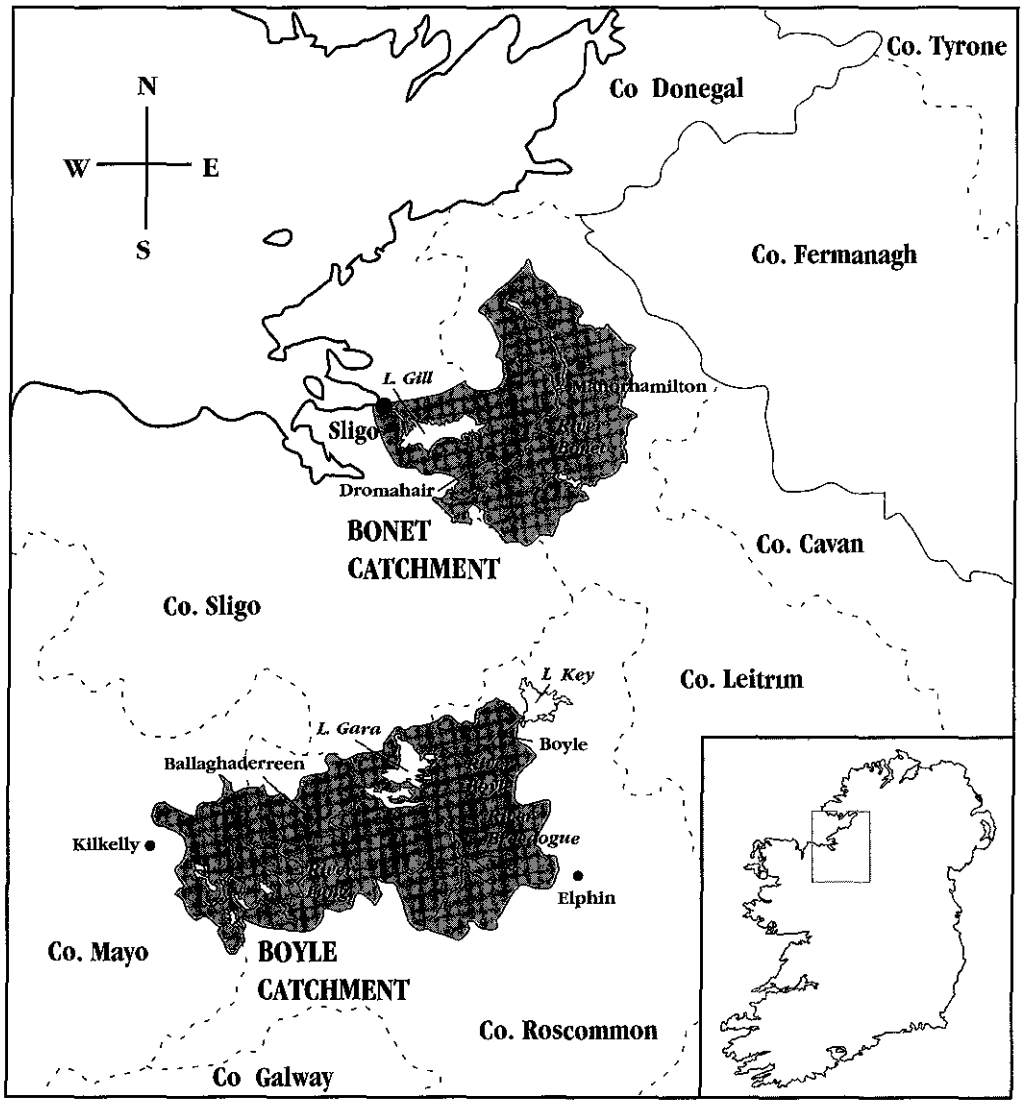
The Boyle and Bonet Drainage Schemes

1 Introduction

1.1 Arterial drainage of a river catchment involves the artificial widening and deepening of a river and its main tributaries in order to increase the volume of water carried per unit of time (called the 'discharge') The objective is to reduce both the incidence and duration of flooding and provide the opportunity for land-holders to improve the drainage of adjoining lands by installing field drainage

1 2 In 1982, the Office of Public Works (OPW) began arterial drainage schemes in the Boyle and Bonet river catchments. The catchment of the Boyle river and that of its two main tributaries, the Lung and Breedogue, spans an area of 54,900 hectares (ha) in north Roscommon, east Mayo and south Sligo The Bonet river catchment spans an area of 36,100 ha in north Leitrim and north Sligo

Figure 1.1
Boyle and Bonet river catchments



1 3 The amount of damaged land in the Boyle catchment which was expected to benefit from the arterial drainage works was almost 10,700 ha, comprising 6,200 ha of farmland and 4,500 ha of bog The amount of damaged land expected to benefit from the Bonet scheme was 1,400 ha, almost all of which was farmland

1 4 The Boyle and Bonet schemes were originally planned and costed on the basis that they would be completed in five years and three years respectively The associated total cost of the two schemes was estimated at £17 million (constant 1982 prices)

1 5 The two schemes started together in July 1982. Neither scheme was fully completed and work on both schemes has now ceased

- The Bonet scheme ceased in January 1992, when 84% of the originally scheduled work had been carried out
- When the Boyle scheme was stopped in December 1995, 85% of the originally scheduled work had been completed

1.6 Some of the scheduled work on the schemes was found to be unnecessary e g. replacement of footbridges no longer in use Such deletions from the schedule accounted for about 7% of the estimated cost of the direct works.

1 7 The schemes were stopped because it was considered that the cost of the remaining scheduled work was greater than the potential economic benefit. In addition, there were concerns that some of the remaining work on the Bonet would have encroached on environmentally sensitive fishing waters.

1 8 Over the period 1982 to 1995, a total of £31.6 million was spent on the two schemes

Scope of Value for Money Examination

1.9 The examination focused on

- the outturn on each of the schemes in terms of producing the specified outputs within time and budgetary targets
- whether programmes of maintenance for the schemes have been developed and are being implemented
- the adequacy of planning, specification and management of the schemes
- the economic and efficient use of resources in carrying out the schemes

- whether the effectiveness of the schemes has been adequately evaluated.

1 10 Chapter 2 outlines the nature of the arterial drainage programme under which the Boyle and Bonet schemes were carried out and the role of the OPW This is followed by an analysis of the engineering implementation (Chapter 3), costs (Chapter 4) and management (Chapter 5) of the Boyle and Bonet schemes.

1 11 The methodology used in carrying out this examination is outlined in Appendix A

2 The Arterial Drainage Programme

2 1 Many Irish rivers flow slowly through shallow channels over much of their courses because of the particular topography of the island Typically, rivers draining land in the relatively flat interior are constrained by higher land near the coastline to take long indirect routes to the sea This, when combined with relatively high rainfall levels, results in repeated flooding in certain areas and a considerable amount of land which is waterlogged for much of the year

2.2 Artificial widening and deepening of a river and its main tributaries enables the river channels to carry away a greater volume of water more quickly but, in most cases, does not significantly reduce waterlogging more than a few metres away from the channel Watertables can be effectively lowered by localised field drainage works, involving excavation of ditches or the installation of underground pipes or drainage courses Field drains require a lower river channel bed and water level – an outfall – into which excess water can flow Hence, making river channels deeper through arterial drainage work increases the amount of land which has the potential to be improved by field drainage

Objectives of Arterial Drainage

2 3 The principal objective of arterial drainage schemes carried out in Ireland in recent decades has been the long-term improvement of agricultural incomes in the river catchment affected

2 4 It was envisaged that this objective would be achieved through a sequence of events First, the river system would be arterially drained Next, the landholders would carry out the necessary field drainage works to ensure that the waterlogged or flood-prone land in the catchment would be successfully drained to the extent that it could support extra livestock or produce higher crop yields Finally, increased output would result in increased income for the landholder

2 5 The objective of increasing landholders' incomes by improving farm output in arterial drainage catchments was similar to the Common Agricultural Policy (CAP) approach adopted by the EU until 1984 when reform of the CAP commenced. The reforms are aimed at cutting back product surpluses, lowering prices to consumers and boosting the incomes of the poorest farmers by such means as

- direct farm income support schemes
- grant payments related to low stocking levels for livestock
- taking agricultural land out of production in return for 'set-aside' premiums
- encouraging long-term alternative land uses such as forestry
- developing and promoting alternative crops which are in short supply

2.6 Arterial drainage schemes also provide other, more immediate benefits, such as

- flood prevention and drainage of non-agricultural land e g built-up areas and public roads
- the provision of employment for the duration of the schemes and during their subsequent maintenance

Extent of Arterial Drainage

2.7 Arterial drainage work has been carried out on many Irish rivers over the past 150 years Schemes designed to improve the drainage of over 200,000 ha of agricultural land were carried out under a series of Arterial Drainage Acts from 1842 until 1933

2.8 A detailed review of river drainage was carried out over the period 1938-1940 by the Browne Drainage Commission. The report of the Drainage Commission formed the basis for the enactment of the Arterial Drainage Act, 1945 which prescribed the manner in which arterial drainage schemes would be designed, implemented and maintained in the future

2 9 Before 1945, flooding problems in river catchments were dealt with in a piecemeal fashion. This resulted in channels being deepened over short stretches of a river While this may have relieved localised flooding, it sometimes resulted in increased flooding further down the river system The 1945 Act specified that arterial drainage schemes should encompass all channels in the catchment in order to alleviate this displacement problem.

2 10 Thirty-nine arterial drainage schemes have been carried out under the provisions of the 1945 Act Of these, fourteen schemes were classed as being 'major' schemes (i e with catchments of 40,000 ha or more), five as 'minor' schemes (with catchments between 10,000 and 40,000 ha), fifteen as 'intermediate' schemes (with catchments less than 10,000 ha) and five 'embankment' schemes (the improvement of river banks). The total land targetted for improvement by these schemes is estimated at 262,000 ha, including 56,700 ha of bog Figure 2 1 indicates the catchments affected by the major, minor and intermediate schemes.

2 11 The Boyle scheme is classified as a major scheme while the Bonet is classified as a minor scheme.

2.12 In response to prolonged flooding in many areas, particularly in the winter of 1994/95, the Arterial Drainage (Amendment) Act, 1995 provided for localised flood alleviation schemes to be carried out

Figure 2.1
River Catchments drained under the Provisions of the Arterial Drainage Act, 1945

The Role of the Office of Public Works

2 13 The Drainage Commission report recommended that a central public agency should be given the authority to carry out all arterial drainage work because of the scale and cost of the work required for any scheme and because flooding and waterlogging of land were regarded as a 'national drainage problem', rather than as a collection of separate, localised drainage problems

2 14 Full responsibility for carrying out arterial drainage work was assigned to the OPW under the 1945 Act Its main functions under the Act are

- planning and design of schemes
- implementation of schemes
- maintenance of completed schemes

Planning and Design of Schemes

2 15 In 1945, the OPW drew up a list of 60 major and minor river catchments which it considered should be drained (see Appendix B) The schemes on this list were ranked in order of 'greatest need', defined in terms of the number of people suffering from large scale flooding problems Highest priority was given to schemes where there were no special technical or legal difficulties (e g river catchments which straddled the border) and/or where extensive high-cost works (e g. rock cutting work through built-up areas) were not required. The OPW also endeavoured to ensure that the highest priority schemes were not concentrated in specific counties but were distributed evenly throughout the country.

2 16 With the exception of the Bonet scheme, the 19 major and minor schemes which have been carried out to date are those which were generally given highest priority on this list.

2.17 Following a decision to proceed with a scheme, extensive surveying, designing and planning of the engineering works required are undertaken by the OPW In doing so, the OPW is obliged to consult with relevant government departments and local authorities. It is also required to exhibit publicly the scheme plans and to consider observations of interested bodies and members of the public

Implementation

2 18 The OPW has wide-ranging powers in the implementation of arterial drainage schemes. These powers include the right to purchase compulsorily any land, fisheries, water-rights, etc. deemed necessary to allow the work to be undertaken and to enter any lands to enable construction works to be carried out The OPW is obliged to

compensate any persons whose property is compulsorily purchased or who suffer loss or damage as a result of the carrying out of drainage works

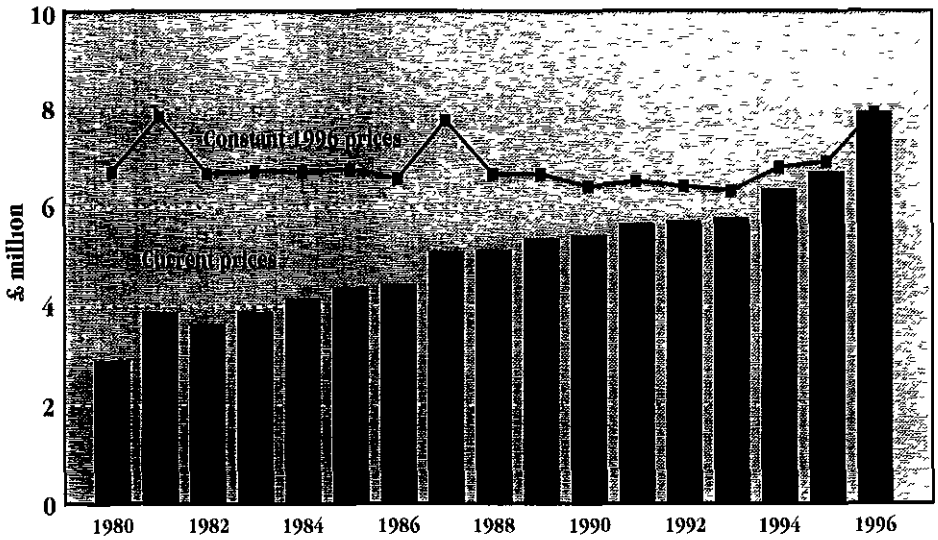
Maintenance

2 19 On termination of a scheme, the Minister for Finance issues a certificate of completion detailing the extent to which the scheduled works have been completed Subsequent to the issue of a completion certificate, the OPW is obliged to maintain the scheme 'in proper repair and effective condition'

2.20 After a certificate of completion has been issued, the OPW is required by law to lodge, in the High Court, maps and documents detailing what works were carried out The documents lodged are intended to serve as a benchmark detailing the standard of repair and condition to which the drainage works ought to be maintained. The OPW has not lodged such maps or documents relating to any of the drainage schemes carried out under the 1945 Act

2.21 The OPW spent an estimated £7 9 million on the maintenance of all arterial drainage schemes in 1996 (see Figure 2 2)

Figure 2.2
Expenditure by OPW on Maintenance of Arterial Drainage Schemes, 1980 to 1996 (at current and constant prices)



2 22 Local authorities are responsible for the maintenance of drainage schemes completed prior to 1945. The cost to local authorities of such maintenance is estimated at £700,000 in 1996 The OPW was given power under the 1945 Act to ensure that pre-1945 drainage schemes are maintained and may apply to the Minister for Finance for permission to assume the responsibility for the maintenance of the works Alternatively, the OPW can require the local authorities to carry out the necessary work, or can itself carry out the works and recoup the cost from the relevant local authorities

Environmental Impact Assessment

2.23 Arterial drainage work involves very significant intervention in the environment Since 1985, proposals for arterial drainage schemes are subject to full assessment of their likely environmental impacts, including the impacts on flora and fauna generally in the catchment, on sensitive habitats such as wetlands and on the condition and appearance of river banks and adjoining lands[1]

2.24 Prior to the introduction of the 1985 directive, the OPW consulted with fisheries interests when arterial drainage schemes were being planned and implemented. In addition, during planning, the OPW undertook short studies of the scientific and wildlife aspects of schemes

[1] *EU Directive 85/337/EC on environmental impact assessments*

3 Implementation of the Schemes

3.1 The Boyle and Bonet arterial drainage schemes were large scale civil engineering projects, having predetermined physical outputs which were planned to be delivered within given time and budgetary targets.

Time Targets

3 2 From an engineering point of view, the Boyle and Bonet arterial drainage schemes were two independent projects in separate catchment areas It was originally planned that the Boyle scheme, which was expected to take five years to complete, would commence first The Bonet scheme was to start about eighteen months later under the management of the same engineering staff and was expected to last three years. The schemes would thereafter run concurrently and finish around the same time.

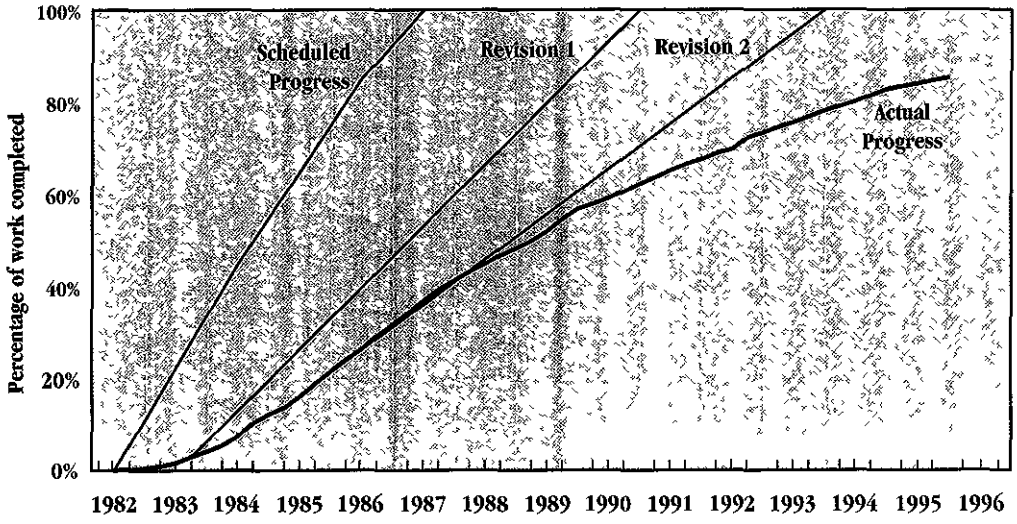
3 3 The OPW intended to commence the Boyle scheme around 1984 when the Corrib-Mask and Maigue schemes were due to wind down, making machinery and experienced staff available However, the Minister for Finance decided that both schemes should commence together in July 1982 On the basis of the original work plans for the schemes, the implied target completion dates were therefore mid-1985 for the Bonet scheme and mid-1987 for the Boyle scheme.

3 4 Figure 3 1 shows the scheduled and actual progress of work on the two schemes Work on each of the schemes proceeded more slowly than originally envisaged and neither scheme had been fully completed by the time it was halted. The schedule of works was revised twice – in September 1983 and in September 1985 – in the light of expected availability of funding and progress on the schemes up to then.

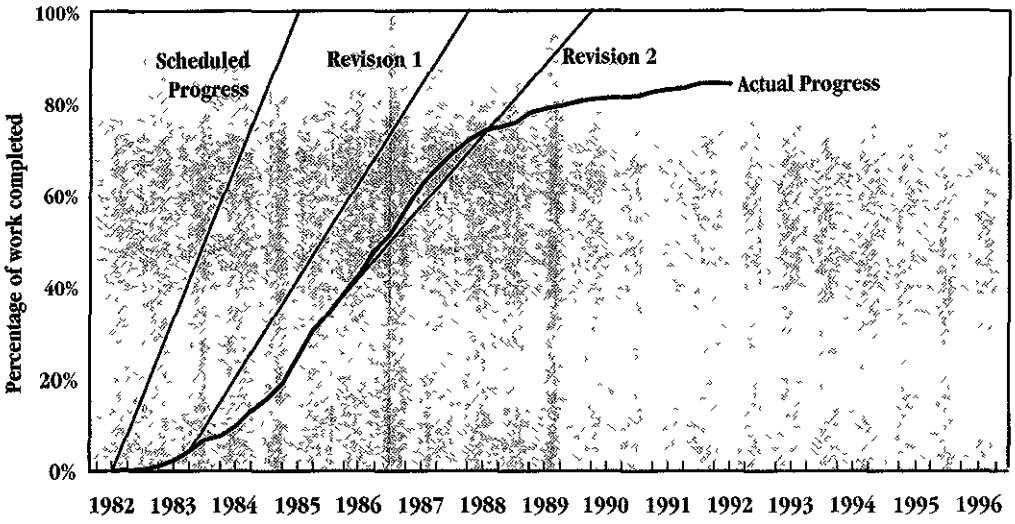
3 5 Progress was delayed by a number of factors including

- Annual funding levels for the schemes were much lower than had been envisaged at the planning stage
- Required machinery and staff were not available because of the early start.
- The start-up phase on both schemes was prolonged because the available management and planning resources as well as the machinery and staff had to be divided between the schemes from the outset
- The voluntary redundancy package for public service employees introduced in 1987 reduced the number of operatives available on the schemes These workers could not be replaced because of an embargo on recruitment which was in place at the same time As a result, there was an imbalance between supervisory/ support staff and operatives

Figure 3.1
Scheduled and Actual Progress of Work on the
Boyle and Bonet Arterial Drainage Schemes



Boyle Scheme



Bonet Scheme

3 6 In the course of this examination, the engineering aspects of a sample of stretches of river channels drained by the OPW were investigated The stretches examined are indicated in Appendix A Structures built by the OPW (mostly foot and road bridges) on these stretches of river were also examined

River Channels

Standard of Flood Protection

3 7 The OPW adopted lower than normal standards of flood protection for the Boyle and Bonet schemes.

3 8 Most arterial drainage schemes carried out by the OPW under the 1945 Act were intended to ensure that flooding from the main river channels in agricultural areas is not likely to occur, on average, more than once in a three year period This is referred to as 'a three-year return period flood' In some locations, where even occasional flooding could cause serious losses, a higher standard of flood immunity may be sought. For example, a twenty to twenty-five year return period may be applied in urban areas When areas are protected by embankments, the crest of the embankment is normally designed to cater for at least the ten year return period flood

3 9 In contrast to all previous arterial drainage schemes, the OPW's target for the Boyle arterial drainage scheme was to cater for a two-year return period flood while the Bonet scheme was intended to cater for a one-year return period flood The OPW estimated that the normal standard (i e to cater for a three-year return period flood) could not be achieved in the two catchments at a cost commensurate with the extra benefit it would confer

Channel Design

3 10 The engineering designs for channel capacity prepared by the OPW for the Boyle and Bonet schemes were not always consistent with the achievement of the target flood protection criteria specified

3 11 Hydrology – the study of natural water flows – is a relatively young science in which there have been substantial developments in the last twenty-five years and procedures for estimating design flows have been substantially improved

3 12 Most of the designs for the Boyle and Bonet schemes were prepared in the late 1960s and early 1970s Based on a retrospective analysis of water flow data at monitoring stations in the Boyle and Bonet catchments, it appears that the procedures adopted by the OPW in designing the schemes underestimated the design flow rates for both the

Boyle and Bonet by approximately 10% and 20% respectively However, this underestimation is within the generally accepted margin of error in hydrological design.

3 13 The ability of a river channel to carry a given discharge depends on factors such as channel slope, the cross-section shape and channel roughness While slope and cross-section shape are easily determined, the value of channel roughness is often a subjective evaluation unless extensive field calibration tests are carried out.

3 14 In the design of channels in the Boyle and Bonet schemes, the OPW used roughness values which would apply only to very regular and continuously cleaned channels As a result, the work planned on both schemes was unlikely to be sufficient to achieve the return period flood targets

Channel Performance

3.15 As part of this examination, a field survey was carried out at each of a number of locations in twelve sample stretches of channel to establish the cross-sections of the drained channels. The results of the field survey were plotted and compared with the intended channel cross-sections as designed by the OPW.

3 16 The majority of the channel sections were found to have been excavated to an acceptable tolerance with most of the channels being excavated to a greater depth than designed There was evidence of siltation subsequent to excavation in many of the channels In some cases, there was evidence of undermining of the river bank and river bank slippages Unforeseen rock excavation led to channel design variations at one location

3.17 One of the eight stretches examined in the Boyle catchment and three of the four stretches examined in the Bonet catchment were found to be inadequate in terms of their capability to transmit the design discharge.

3 18 Overall, there has been a reduction in flooding problems in both catchments While the Boyle drained channel system meets the target two-year return period flood criterion, the capacity of the Bonet drained channel system is insufficient to meet the target one-year return period flood.

Structures

3 19 The works carried out on bridges on the stretches of channel examined are broadly in compliance with what was originally proposed. The bridges do not impede the water flow at any of the sites In situations where constrictions might have occurred, the bridges were replaced.

3 20 In the sample examined, a new bridge was constructed at one location where the original bridge was found, during the course of work, to be in an unsatisfactory condition in order to allow the overall channel works to be carried out. The procedures for bridge underpinning were particularly successful under hazardous and difficult conditions of soft ground

Maintenance

3.21 Following arterial drainage, regular maintenance of river channels is required to ensure that they continue to convey the design flows The frequency and nature of channel maintenance work required will vary from channel to channel, but a maintenance cycle of five years is generally appropriate. Failure to undertake maintenance will facilitate the propagation of aquatic vegetation which impedes flow and causes silt to be deposited

3 22 Infrequent maintenance is not cost effective. Maintenance works carried out on a regular basis are likely to involve the cutting and removal of vegetation and some minor dredging The amount of silt deposited increases with time and major dredging works may again be required if channel maintenance works are delayed.

3 23 A decision was taken during the Boyle and Bonet schemes to postpone routine maintenance works during construction until the initial schemes were completed A programme of maintenance commenced on the Bonet in 1994 A limited amount of maintenance was carried out on part of the Boyle scheme during construction and a full programme of maintenance commenced in 1996

3 24 In general, the OPW's current approach to the maintenance of the Boyle and Bonet schemes is quite flexible with an outline maintenance programme being drawn up at the start of each year, taking account of the condition and maintenance needs of different channels. The programme is adjusted throughout the year to take account of localised problems identified by the maintenance engineers, demands from local farmers and political representations An annual maintenance budget is provided for each region and the regional engineer allocates funds to the various maintenance schemes.

3.25 Given the long delays on both schemes, postponement of maintenance during construction has meant that channels which were drained at the start of the schemes have not been maintained for many years and consequently have reverted some way towards their pre-drainage condition.

3 26 River channels in the Bonet catchment are steep and consequently, relatively high water velocities within the channels help to prevent siltation and the build up of

vegetation. The OPW have commenced a four-year programme of maintenance which should be adequate to restore the channels to their drained state

3.27 The Boyle catchment consists of a large number of low gradient channels which will quickly silt up unless there is regular maintenance. To keep the channels in their drained state, they will need to be maintained more regularly than those in the Bonet The first series of maintenance works on a drained channel is always the most onerous as initial bank settlements and silt movements occur In the case of the Boyle scheme, this is exacerbated by the fact that it is more than ten years since the primary drainage works were undertaken in many channels

3.28 The OPW commenced a five-year programme of maintenance on the Boyle in 1996, designed to restore the channels to their drained state. Very heavy maintenance requirements were encountered during 1996 making progress slow and requiring three or four machines working full-time throughout the year. Work on the main channels will need to be increased to ensure that the full maintenance programme can be completed within five years, as planned

Environmental Impacts

3.29 When the Boyle and Bonet schemes were being planned in the late 1970s, short studies of the birds, animals and plants in the catchments were undertaken by the Forest and Wildlife Service (FWS) of the Department of Agriculture The FWS pointed out in its report that its assessment was based on the sparse data already available and a three day survey of the catchments. This was insufficient to enable it to prepare comprehensive baseline data against which the potential environmental impacts of the schemes could be assessed.

3 30 Environmental considerations influenced the scheme design at a number of locations The original design of one channel was modified to prevent Cloonagh Lough in the Boyle catchment from being drained Similarly, the Bonet scheme was designed so as not to impact on Glenade Lough.

3.31 The EU agreed in 1983 to provide funding under the Western Drainage Package for the Boyle and Bonet schemes. It was a condition of the funding that the environmental impacts of the schemes would be monitored during the course of work and that impact evaluations would be carried out after the schemes ceased Apart from the monitoring of fisheries, the required monitoring and evaluations have not been carried out.

3 32 The OPW's current environmental practice for the construction of this type of drainage scheme differs from the practices adopted for the Boyle and Bonet schemes. In particular

- a full environmental impact assessment would be carried out for any proposed scheme
- channel excavation work would be carried out so as to minimise environmental damage

3 33 Because of the lack of baseline data gathered before the arterial drainage works started, only limited assessment of the post-scheme environmental impacts could be carried out In the course of this examination, impacts in the following areas were assessed

- spoil deposition and rehabilitation
- siltation
- impact on fisheries

Spoil Deposition and Rehabilitation

3 34 The general spoil rehabilitation policy operated by the OPW in carrying out the two schemes was to remove topsoil from adjacent land, spread the material excavated and re-cover with top soil The landowner was subsequently compensated for the cost of re-seeding the area. In two cases, major rock quantities excavated were taken off site Smaller rock volumes were piled on banks and farmers compensated for the loss of land

3.35 Post-project appraisal to assess the environmental effects of the spoil deposition practices is in this case difficult because of the lack of documented information about the pre-drainage status of the flora and fauna of the river banks and the adjacent land where spoil was buried.

3 36 The spoil disposal sites were for the most part located on marginal agricultural land. Along the twelve sample channel lengths inspected, the environmental effects of spoil deposition appeared limited However, in three cases, the rehabilitation carried out was unsatisfactory by reference to current standards In one location, rock was piled on land adjacent to the river channel In the other locations, channel slopes were very steep with limited vegetation

Siltation

3.37 In spite of increased channel capacities, the cleaning of the banks of a river and the more even grading of a river bed tend to result in faster velocities and increased silt loads which may be deposited downstream Maintenance works also cause a temporary increase in silt movements

3.38 Increased silt movement frequently results in severe disruption to the biology of the river and deterioration in water quality affecting plants and other aquatic life in the river.

3 39 The design criterion adopted by the OPW to cope with post-drainage siltation was to ensure that post-drainage velocities in the rivers were unchanged from the pre-drainage situation. It is unclear how it was intended to ensure that this would be achieved

3.40 There is some evidence of increased siltation in Lough Gara since implementation of arterial drainage works on the Boyle catchment was carried out However, because baseline studies of siltation patterns were not undertaken, it is not clear if this is a natural long-term process in the river system or if it has resulted mainly from the drainage work carried out.

3 41 River bed and bank protection measures were carried out on the Bonet River at locations particularly prone to erosion to reduce silt loads

3.42 Silt traps are areas purposely designed to slow down river flow temporarily and allow silt to settle without reducing the performance of the channel. A number of minor silt traps were installed on the Bonet river at points where water is taken out Installing such traps may reduce the degree of harmful siltation downstream

Fisheries

3 43 At the time arterial drainage of the Boyle river was being planned and carried out, the river was regarded as a relatively unimportant mixed fishery for brown trout and other coarse fish species In the early 1990s, the Central Fisheries Board was requested to carry out a study to assess the post-drainage status of channels with a view to drawing up a fisheries enhancement programme This assessment is ongoing

3 44 The Bonet is regarded as a relatively important salmon angling river. Prior to the arterial drainage scheme, the combined Bonet/Lough Gill salmon catch averaged around 200 fish a year During the drainage programme, catch levels fell to around 50 fish a year Studies of post-drainage catch levels in Lough Gill and on the Bonet were carried out in 1989 when the bulk of the work had been completed These

found that the Bonet had recovered as a fishery and that pre-drainage salmon catch levels were being achieved

3 45 Fishery rehabilitation programmes were carried out on both schemes in conjunction with the arterial drainage works. During the Bonet arterial drainage scheme, the OPW commissioned a fisheries rehabilitation programme on the river. This involved the execution of fisheries rehabilitation work in tandem with ongoing arterial drainage work

3 46 Arterial drainage maintenance schemes have the potential to impact on fisheries in a manner that can be even more damaging than the construction of the original scheme. The OPW commenced an experimental maintenance programme in 1990 in certain arterial drainage schemes to minimise the impacts of maintenance on fisheries and to incorporate improvements to fisheries. The experimental approach was extended in 1996 to the maintenance of the Boyle and Bonet schemes Regular contact is maintained between OPW staff and Regional Fisheries Board staff

Installation of Field Drainage

3.47 Field drainage of targeted damaged land is a critical factor in determining the effectiveness of arterial drainage schemes However, the installation of field drainage is not a function of the OPW

3.48 Depending on soil type and the nature of the flooding problems, some damaged land may improve directly as a result of carrying out arterial drainage work In most cases, damaged land will improve only if field drainage is installed

3 49 Cost-benefit analysis of the Boyle and Bonet schemes projected farm income increases on the basis that 10,650 ha (around 88%) of the target damaged land would be improved to the extent that it could carry extra livestock. Of this, 2,700 ha were expected to improve without recourse to field drainage.

3 50 Based on a sample survey of target damaged land, it is estimated that only around 15% to 25% of the land shows evidence of improvement. Assuming that the sample rate applies throughout the scheme catchments, the total amount of improved land is likely to be in the range of 1,700 to 2,800 ha. The expected improvement in land arising directly as a result of arterial drainage work suggests that the field drainage carried out so far has been on a very limited scale, and may be less than 500 ha in the two catchments.

3.51 EU-supported grant aid for field drainage was available only up to 1988 According to agricultural officers and advisers, there has been very little field drainage carried out in the Boyle and Bonet catchments since the grant aid ceased

4 The Cost of the Schemes

4 1 Expenditure on the Boyle and Bonet schemes can be looked at from a number of perspectives.

- Comparison of actual expenditure with the budget estimate of expenditure may provide indications of how accurate the budgeting exercise was, or how well project spending was controlled.

- Efficiency of work can be assessed by examining the costs of individual jobs undertaken.

- The cost of schemes per unit of land targeted for improvement is a means of comparing costs of the Boyle and Bonet schemes to costs of other arterial drainage schemes.

Expenditure Outturn

4 2 Budgets for the Boyle and Bonet schemes were prepared in March 1982. These envisaged total expenditure of £17 million (constant 1982 prices) on construction of the two schemes - £13 7 million for the Boyle and £3 3 million for the Bonet

4.3 The budget did not represent the full costs of the schemes By the time the budget was prepared, expenditure had already been incurred on extensive planning, surveying and design of the two schemes. These costs cannot now be identified Neither the budget nor recorded actual expenditure includes the costs of the OPW head-office administration of the schemes.

4 4 Because not all the planned work was undertaken, it is necessary to identify the budgeted cost of work actually carried out before estimation of variations on cost can be made. The budgeted cost of work carried out was £14.5 million (constant 1982 prices) Actual expenditure over the period 1982 to 1995 was £31 6 million (See Table 4.1, and Appendix C which shows year-by-year expenditure)

4 5 Of the total expenditure of £31 6 million, £5 1 million was provided by the EU under the Western Drainage Package between 1983 and 1986

4.6 Actual expenditure exceeded budgeted expenditure by £17.1 million. About 30% of this is related to inflation. The remainder relates mainly to cost overruns on budgeted expenditure for spoil rehabilitation, construction of structures, overheads and compensation payments.

Table 4.1
Expenditure on Boyle and Bonet Arterial Drainage Schemes - Budget and Actual, 1982 to 1995

	Boyle Scheme			Bonet Scheme		
	Budget[1] estimate £'000	Actual expenditure £'000	Variance +/(-)	Budget[a] estimate £'000	Actual expenditure £'000	Variance +/(-)
Direct works						
Channel excavation	3,297	4,133	25%	653	1,282	96%
Rock cutting	976	1,379	41%	366	540	48%
Spoil rehabilitation	692	1,703	146%	249	367	47%
Construction of structures	1,868	4,562	144%	376	1,311	249%
Special works	68	51	(25%)	79	56	(29%)
Maintenance	192	268	40%	6	16	167%
Contingency	308	-	-	82	-	-
All direct works	7,401	12,096	63%	1,811	3,572	97%
Overheads	4,039	11,210	178%	918	3,156	244%
Total direct cost of schemes	11,440	23,306	104%	2,729	6,728	147%
Compensation payments	239	855	258%	66	690	945%
Total cost of schemes	11,679	24,161	107%	2,795	7,418	165%

Source *Office of Public Works quarterly cost reports 1982 to 1995*
Note [a] *Budget estimate of cost of works actually carried out, at constant 1982 prices*

Inflation

4 7 It is standard practice for engineering firms to estimate the cost of inflation during the projected programme of work, thereby arriving at target outcomes for overall expenditure for the project and for planned expenditure each year The OPW was clearly conscious that price inflation would result in an increased level of spending, but the budget estimate for the Boyle and Bonet schemes did not provide for inflation during construction

4 8 Had the work done on the two schemes been carried out to the original schedule, inflation would have added £1 6 million (about 11%) to the budget estimate In fact, the extension of time in carrying out the work meant that considerable further inflation also occurred This further inflation effect is estimated at £3 5 million

Spoil Rehabilitation

4 9 Expenditure on spoil rehabilitation was significantly higher than the budgeted amount, particularly on the Boyle scheme Due to pressure from landowners for a higher standard of rehabilitation and the soft nature of the ground, the spoil being removed required more handling than was envisaged in the budget

Construction of Structures

4.10 Structures built on both schemes cost substantially more than the amounts budgeted.

4.11 A number of planned structures were not constructed where it was found during the course of the schemes that the original structures had been removed e g. small footbridges no longer in use. These deletions were offset by extra unplanned construction

4.12 Cost overruns on structures occurred because

- Budgeted expenditure on construction was based on the OPW's experience on the earlier Boyne arterial drainage scheme Actual expenditure was higher because access to construction sites was more difficult in the Boyle and Bonet catchments where the ground was softer and there were fewer on-farm roadways than in the Boyne catchment.

- Standards of construction higher than those planned were found to be necessary in many cases, particularly for roadbridges, due to increased volumes of traffic and weight of vehicles

- In a number of cases where underpinning of bridges had been planned, it was found to be necessary to replace the bridges entirely.

Contingency Provision

4 13 The budgets for the two schemes contained a provision for contingencies of around 5% of the budgeted cost of direct works The industry norm for this kind of work is at least 10%

Overheads

4.14 The cost overrun on overheads amounted to over £9 4 million (of which £1 8 million was due to inflation on the original planned overheads) This represented more than half of the entire cost overrun

4 15 A variety of back-up services and staffing are required in carrying out arterial drainage schemes. These include transport, machinery workshops, stores, engineering and supervisory/support staff The budgeted expenditure envisaged that overheads would represent 54% of the cost of direct works on the schemes Actual spending on overheads was 92% of the cost of the direct works undertaken

4 16 The OPW planned its drainage schemes on the basis of rates of work progress which would optimise the use of overheads, thereby ensuring the most economic cost of the schemes Before the Boyle and Bonet schemes were approved by the Minister for Finance, the OPW wrote to his Department to point out that insufficient annual funding for other schemes had resulted in extensions of the work schedules leading to extra overheads and higher final costs for the schemes As a result, the costs had begun to outstrip the benefits, thereby rendering the schemes uneconomic

4.17 The OPW stated that it could not have reduced overheads on the Boyle and Bonet schemes below the level incurred because

- the time required to carry out the schemes was considerably extended as a consequence of annual funding decisions
- a basic support infrastructure was still required if direct works were reduced below the planned optimum level
- reductions in supervisory/support staffing levels were not possible under the provisions of the Programme for National Recovery (1987-1989) and other agreements

Payment of Compensation

4 18 Compensation payments and associated costs totalled over £1.5 million for the Boyle and Bonet schemes. Such payments accounted for about 4% of the total expenditure on the Boyle scheme and over 9% on the Bonet scheme. Payments were made in respect of an estimated 514 compensation cases.

4 19 A small number of cases in each catchment involved large payments of compensation and costs. It is estimated that about 62% of the total amount of compensation and costs paid - about £950,000 - went to 20 individual claimants and their advisers

Occupational Injury Compensation

4.20 Almost 43% of the total amount paid in compensation on the Boyle scheme related to occupational injury claims made by workers on the scheme. To date, a total of £367,000 has been paid as compensation and costs associated with 16 occupational

injury claims. A further claim is due to be settled soon. No such claims were made by workers on the Bonet scheme

4.21 The budget estimate for compensation did not provide for any compensation in relation to occupational injury cases.

Fishery Related Compensation

4.22 In the Bonet catchment, substantial claims for compensation were made arising from alleged damages to fisheries and to angling-related business. Compensation and costs totalling over £300,000 were paid on foot of such claims over the period 1984 to 1992

Farm Related Compensation

4.23 The bulk of the compensation cases involved lower levels of compensation and costs, amounting to around £1,200 on average. These claims generally related to farm-based impacts of the drainage schemes, including

- rehabilitation of land used to bury spoil
- temporary loss of use of land while drainage work was being carried out
- permanent loss of land due to channel widening or dumping of rock
- erection of necessary fencing along the river bank.

4.24 Average payments were higher in Bonet cases (around £1,600 per case) than in Boyle cases (around £1,000 per case) Examination of a sample of compensation cases revealed that more than half of the difference in average payment levels relates to higher payments for costs in Bonet cases where most claimants employed advisers There is no evidence that higher rates of compensation for damages or losses were paid to claimants who retained advisers, or that compensation was paid for alleged intangible damages.

Efficiency Levels

4.25 The OPW did not adequately monitor efficiency levels for work carried out on the Boyle and Bonet schemes. Some measurement of actual quantities of physical work (e.g. cubic metres of rock or silt excavated) was carried out to calculate bonus payments to workers, but this was not used to produce measures of overall work efficiency actually achieved in carrying out the schemes

Excavation Work

4 26 Budget estimates for individual channel stretches were based on quantities of material for excavation which were identified (in the 1960s) in accordance with standard practice. Using conversion factors based on historic data from other OPW schemes, quantities were converted to 'machine hours'

4.27 Actual machine hours spent on each stretch of channel were recorded on cost record cards Some variation on estimated hours is to be expected However, the OPW's work records in relation to ten[2] of the channels surveyed in the course of this examination show that the actual machine hours varied from half the budgeted hours in one case to three and a half times the budgeted hours in another Actual hours were close to budgeted hours (i e within 20%) in only one case.

4.28 The survey of sample channels indicated that the quantities of material excavated did not vary significantly from the estimates Consequently, the very significant variations which occurred in actual machine hours must be due to other factors Possible factors which could explain the variations are

- the type of material excavated was significantly different from the estimates
- the efficiency with which work was carried out was very different from what was assumed in preparing the estimates

Unit Rates for Excavation Work

4 29 The 'unit rate' method for costing engineering work involves identifying the all-in cost for an item of work e g the cost of excavating one cubic metre of rock or soil. The rate is calculated to include direct costs, such as labour and machine time, as well as apportioned overheads Unit rate is the standard method used in budgeting and monitoring contract engineering work but is not used by the OPW.

4.30 Unit rates for the sample of channels surveyed were estimated on the assumption that the quantities of material excavated did not vary from the estimates. The estimated rates were then compared to civil engineering industry rates for carrying out similar work. In six cases, the estimated OPW unit rates were more than 40% higher than the prevailing industry rates In two cases, the estimated OPW rates were less than 60% of the prevailing rates

4.31 No conclusion can be drawn about the unit cost of work carried out by the OPW relative to prevailing industry rates However, the extreme pattern of variation in

[2] *Records for the other two channels surveyed are incomplete*

estimated rates underlines the need to collect data which would allow proper comparisons to be made

Construction Work

4 32 The OPW budgets for structures were based on estimates of labour hours, plant hours and materials derived from historical data from other OPW schemes.

4.33 The cost recording system in relation to structures cannot be relied on as a means of identifying how efficiently work was carried out.

- It is not clear whether all costs related to bridge construction have been recorded and allocated to the appropriate structure e g the cost of providing temporary accessways to bridges

- Monetary amounts in relation to plant and materials used are recorded on cost cards but quantities actually consumed are not.

- Labour hours recorded on cost cards are in most cases substantially less than budgeted but appear inconsistent with the level of expenditure on plant and materials

4.34 The OPW has not undertaken any analysis of the relationship between costs and quantities, or of overall efficiency in construction

Bonus Payments

4 35 A bonus payments system designed to increase productivity was operated on all work relating to excavation, ancillary work and structures on the Boyle and Bonet schemes Bonus payments are included in recorded job costs but are not distinguishable from other entries.

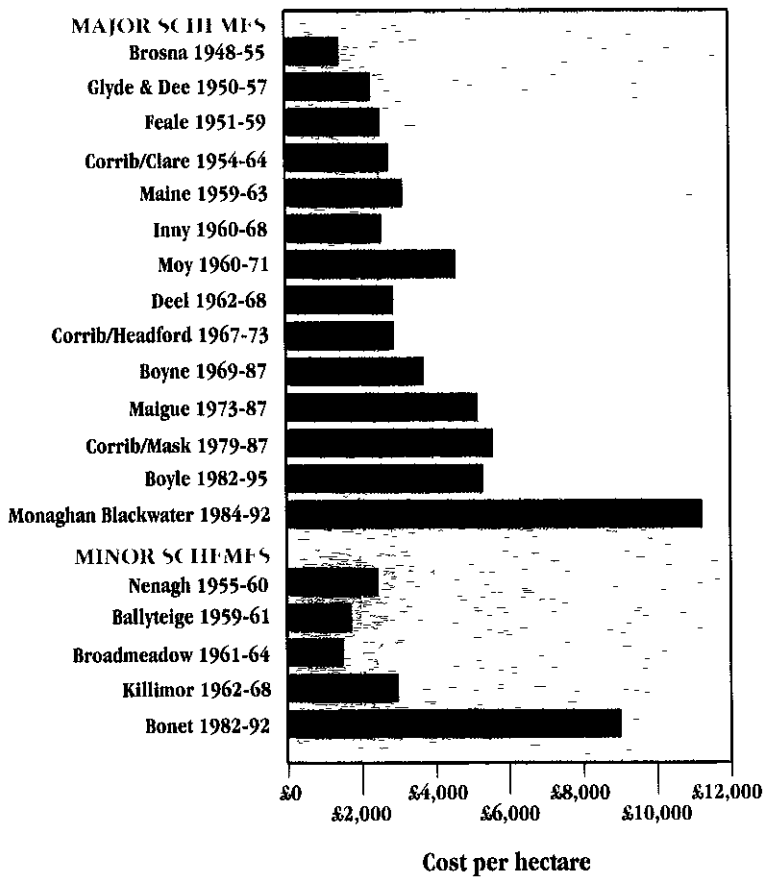
4 36 Target output rates for each section of channel or structure were set by a team of work study engineers by reference to previous OPW historical cost information and cost guidelines for similar work Targets were not directly linked to budget estimates

4 37 The OPW considers that bonus payments provided an effective incentive to complete work in as short a time as possible

Cost per Hectare of Target Land

4.38 The cost of carrying out arterial drainage schemes has increased substantially since work started under the terms of the 1945 Act. Figure 4 1 shows the construction cost (in 1996 prices) per hectare of agricultural land expected to benefit[3] for each scheme carried out under the Act The costs of planning, surveying and design of the schemes, together with the cost of administration of the schemes by OPW head office, are not included.

Figure 4.1
Cost per Hectare of Target Agricultural Land, by Drainage Scheme (1996 Prices)[4]



[3] *Bogland is excluded from the calculation of cost per hectare Under some schemes (including the Boyle), the target damaged land included significant amounts of bogland.*

[4] *Based on a methodology used in· Richard Bruton and Frank J Convery,* ***Land Drainage Policy in Ireland,*** *Dublin The Economic and Social Research Institute, Policy Research Series No. 4, July 1982*

4 39 The most expensive of the major schemes has been the Monaghan Blackwater scheme which cost almost £10,700 per hectare of target agricultural land. That scheme involved payment for some of the work carried out in Northern Ireland on the main river channels which provide the outfall for the catchment. There were also extra costs associated with security and co-ordination These factors increased the cost per hectare drained in the State

4.40 The cost per hectare of target agricultural land on the Boyle scheme – about £5,000 – is not significantly different from the cost of other major schemes carried out in the 1970s and 1980s. The cost per hectare on the Bonet scheme – about £8,700 – was much higher than the cost of any other minor or major drainage scheme, with the exception of the Monaghan Blackwater. The average market value of a hectare of agricultural land in Ireland in mid-1996 was around £4,300.

4 41 In comparing cost per hectare on schemes, it should be borne in mind that the levels of flood protection provided on the Boyle and Bonet are lower than on other schemes

4.42 There is a substantial difference in the estimated cost per hectare on schemes carried out in the 1950s and 1960s and those carried out in the 1970s and 1980s In a major review of the arterial drainage programme carried out in the period 1983-85, the OPW concluded that the cost base for schemes had changed significantly around 1970. The main changes identified by the review team were

- New methods of spoil rehabilitation (i.e. those used on the Boyle and Bonet schemes) were introduced in the 1970s The OPW estimated that the higher standard of treatment for spoil resulted in a 9.5% increase in the overall cost of schemes.

- Labour costs were estimated to be almost 25% higher in real terms in the early 1980s than they had been in the 1950s.

- The later schemes tended to be carried out less intensively because annual funding was lower than planned As a result, an estimated 7% was added to the cost of schemes in the form of additional overhead and maintenance costs

4.43 New standards for construction of bridges and other structures were introduced in the 1970s to cater for heavier traffic volumes and weights. While these added considerably to the construction cost of individual structures, they were estimated in the review to have added only 1% to the overall cost of the schemes carried out in the 1970s/1980s, compared to the cost of the schemes carried out earlier.

5 Management of the Schemes

5 1 Management of the Boyle and Bonet arterial drainage schemes can usefully be considered from two separate points of view

- direct project management of the individual schemes, including the technical planning of engineering work, budget preparation and cost control and monitoring
- pre and post scheme evaluation of the effectiveness of the schemes

Project Management and Planning

5 2 Elaborate systems and procedures required for major civil engineering projects may not be fully appropriate for arterial drainage schemes. Essentially, arterial drainage is a linear operation with many repetitive elements Consequently, some of the standard procedures can be simplified However, the total investment is substantial, so the design, construction and maintenance require careful planning and control In carrying out this examination, particular emphasis was placed on control systems for the management of variations to the original plan

5 3 The following project management criteria are considered to be central to the efficient management of arterial drainage schemes

- comprehensive definition of the scheme
- planning, scheduling and back-up strategies
- commitment of key agencies and local landowners
- scheme organisation and management
- project monitoring and control

Comprehensive Definition of the Scheme

5 4 The Boyle and Bonet schemes were defined in a comprehensive manner, as evidenced by the extensive engineering and land valuation surveys undertaken. Designs for channel excavation and bridge improvements were in accordance with best practice They were planned on a total catchment basis as required by the relevant legislation The reports prepared on the schemes at commencement highlighted most of the significant issues.

5.5 The schemes were exhibited for public consultation before final approval The consultation material was very detailed, based on drawings comprising the survey information and the designs for the schemes

Planning

5 6 The detailed planning for an arterial drainage scheme takes place when the approval of the scheme is imminent It was found that on the Boyle and Bonet schemes, the extent of work on channels, bridges and other special works was, in general, correctly identified

5.7 There were certain deficiencies in the preparation of detailed budgets for the two schemes.

- Important aspects of the programme and budget were based on the experience gained on a previous arterial drainage scheme on the Boyne catchment but they failed to account sufficiently for the specific difficulties associated with the Boyle and Bonet catchments In particular, no allowance was made for the very soft ground conditions on the Boyle

- Provision was made in the budget for contingencies, covering items such as repair of bank slippages and unforeseen conditions The amount provided was stated as a percentage of the cost of the scheduled direct work, but the percentage allowed was considerably less than is prudent on projects of this kind

- The most significant criticism of the cost estimate is the lack of an amount allocated for inflation during the works The projected programme of work extended over five years and hence there was effectively no target cash cost to completion. It has been the OPW's standard practice to provide for inflation in budget estimates since 1987

Commitment to the Project

5.8 The rate at which the budgeted funds were made available throughout the project was well below the planned rate of expenditure This led to significantly increased overheads and increased costs due to inflation during delayed works The rate at which funding was allocated may be indicative of a lack of commitment to the execution of the project

5 9 A joint Steering/Cost Control Committee for all arterial drainage schemes met regularly during the course of the schemes. The Committee consisted of representatives of the Department of Finance and the OPW. It dealt with all financial matters, with emphasis by the Department on the overall budget for all arterial drainage schemes The OPW had discretion on the allocation of funds to individual schemes, between the Boyle, the Bonet and three other schemes which were in progress at the time. On foot of agreements with the Northern Ireland authorities and

contractual commitments, priority was given to cross-border schemes where the OPW was working in partnership with a number of Northern Ireland government agencies.

5 10 The main objective of the Boyle and Bonet schemes was to increase agricultural incomes from the targeted land. This depended on follow-up field drainage being carried out by the landowners However, the extent of field drainage to date has been far short of the level projected

Scheme Organisation and Management

Project Manager

5.11 Ideally, a single project manager would have control and responsibility for budget, procurement of resources, design and construction for a major capital project.

5.12 In the OPW, there were separate management substructures for administration, engineering, cost accounting and land valuation, all dealing with their particular aspects of the schemes. The separate functions were co-ordinated only at the highest level in the organisation. During construction of the Boyle and Bonet schemes, these substructures were brought together, reporting to the new position of Director of Engineering Services and this led to a significant improvement in scheme co-ordination. However, the Director dealt with all OPW engineering projects, so the situation was still not ideal, since schemes of this magnitude would benefit from a full-time project manager

Organisation of Work

5.13 In general, work on the schemes was scheduled efficiently. The organisation of the work on-site was in accordance with best practice with regard to staffing and maintenance of plant

5.14 The original plan involved two separate site offices whereas only one was set up to service both schemes. This led to increased downtime for plant and difficulties in the supervision of the work because of the long distances between the working sites.

5 15 The execution of arterial drainage works by direct labour – as occurred on the Boyle and Bonet schemes – makes cost control difficult Contract work with its requirements of tendering and stated periods for completion may be more effective in controlling expenditure. In December 1986, the Government decided that contracts would be used on a trial basis on the schemes then in progress so that a yardstick would exist against which the cost effectiveness of carrying out drainage work by contract could be measured. None of the works on schemes underway at the time were carried out by contract

5 16 The OPW has stated that a section of work on another scheme was selected for contract work but no funding was provided To meet the cost, funds would have to have been diverted from direct labour operations thereby resulting in redundancies which was against Government policy and the terms of agreements between the Social Partners.

Monitoring and Control

5 17 Attention to quality assurance and constant monitoring of progress on delivery of the specified outputs against time and budgetary targets are central to successful civil engineering construction

Supervision of Work

5.18 On-site monitoring and supervision of the work carried out was completed to a high standard by the resident engineering and supervisory staff

Cost Control

5 19 Detailed cost recording was undertaken on a weekly basis Reports presented expenditure using measurement units of labour and machine hours. While these units are required for reporting actual expenditure, they provide no information on the progress of the work nor on the variations from budget

5.20 The only apparent measure of progress was a 'percentage complete' figure for each channel and structure, determined on a quarterly basis by the resident engineering staff An estimate of 'percentage of scheme complete' was calculated on the basis of the estimates for individual channels and structures

5 21 There is no evidence that cost overruns were systematically identified

Evaluation of the Effectiveness of Arterial Drainage Schemes

5.22 Evaluation of the effectiveness of arterial drainage schemes is a critical function, given the amount of resources which have been invested in such schemes and the need for ongoing maintenance Responsibility for carrying out effectiveness evaluations rests with the OPW. Forward-looking appraisals of proposed schemes are required, as well as retrospective evaluations of schemes which have been completed. The framework for evaluation of effectiveness can also be utilised in the event that a scheme has to be reviewed during its life.

Appraisal of Arterial Drainage Schemes

5 23 A comprehensive assessment of the likely economic benefits of all forms of public capital investment was carried out in the late 1960s A report on the assessment of arterial drainage[5] concluded that the cost of drainage carried out had exceeded the increase in the market value of the benefiting land. In some cases, the cost of drainage exceeded even the full post-drainage value of the land affected It was recommended that, in future, schemes should proceed only after comprehensive cost-benefit analysis of the proposed scheme had been carried out

5 24 Detailed analytic procedures for carrying out the required cost-benefit analyses were developed by a group of officials from the Departments of Finance and Agriculture, the OPW and An Foras Talúntais The methodology (as outlined in Figure 5 1) was applied in assessing eight arterial drainage schemes which were proposed after the procedures were adopted, including the Boyle and Bonet.

Figure 5.1
The OPW's Cost-Benefit Analysis Methodology for Arterial Drainage Schemes

In carrying out a cost-benefit analysis, the OPW included the direct costs of the arterial drainage scheme, the cost of installing follow-up field drainage and any on-farm investment in livestock and buildings associated with the projected increase in farm output In most cases, no direct estimate was made of environmental costs associated with scheme activity or habitat losses, other than in terms of compensation payments made and special works required to avoid environmental damage.

The OPW treated the increase in landholders' incomes as the primary benefit of drainage schemes. Employment during construction and on maintenance, was treated as a secondary benefit

Costs and benefits over a fifty-year time period were estimated and then discounted to take account of timing differences.

No decision criterion was fixed However, the lowest benefit:cost ratio of any scheme which proceeded was 1 1, implying that schemes could proceed if (primary) benefits were considered likely to exceed or match the cost of the scheme

[5] *Department of Finance (1969) Report on Arterial Drainage (unpublished).*

5 25 Cost-benefit analyses of the proposed Boyle and Bonet schemes were carried out in 1979 In the context of a 1983 application for EU funding for arterial drainage schemes, the analyses were revised It was estimated that the ratio of primary benefits to costs would be 1 6 1 for the Boyle and 1:1 for the Bonet When secondary benefits (mainly employment on the schemes during construction and maintenance) were taken into account, the benefit-to-cost ratios improved to 1.8 1 and 1 3 1, respectively

5 26 Different methodologies were used in estimating increases in farm incomes as a result of carrying out the Boyle and Bonet schemes In relation to the Bonet scheme, estimates were based on a methodology which the OPW had previously established gave more optimistic results (i e around 10% higher) than the alternative methodology used in relation to all other schemes including the Boyle and other schemes Had the usual method been used, the primary benefit cost ratio for the Bonet scheme would have fallen below the level of 1 1

Re-appraisal of Schemes

5.27 Detailed appraisals of capital projects provide a convenient framework for reviewing the justification for continuing the project at appropriate times, particularly if work is not proceeding to plan or budget or if external circumstances change

5.28 It was clear to the OPW early in the life of the Boyle and Bonet schemes that costs were likely to be higher than budgeted Combined with changing agricultural policies and the fact that the benefit cost ratio for the Bonet scheme was finely balanced, re-appraisal of the effectiveness of the schemes would have been appropriate during their lifetimes but was not carried out.

Post-Scheme Evaluation of Effectiveness

5 29 The OPW has not carried out post-scheme evaluations of the effectiveness of the Boyle and Bonet schemes although the significant cost overruns and the low incidence of installation of field drainage must have fundamentally altered the balance of benefits and costs

Review of Arterial Drainage Programme

5 30 The OPW carried out a detailed review of the arterial drainage programme in the period 1983-85 in response to issues raised in a comprehensive analysis of land drainage policy published by the Economic and Social Research Institute (ESRI) in July 1982

5 31 The report of the OPW review (completed in 1985) considered the policy recommendations made by the ESRI However, the discussion did not have the benefit of an evaluation of the impacts of any of the schemes carried out

5.32 The Government decided in December 1986 to change the operation of arterial drainage schemes and their maintenance, including the approach to evaluation The purpose of the changes was to improve efficiency and achieve better value for money The principal changes were

- Future proposals for arterial drainage schemes were to be carried out using a revised methodology to avoid undue optimism about returns on investment
- New criteria for schemes were to be set including minimum required rates of return on investment, strict control of expenditure on works and low on-going maintenance costs.
- On-going assessment should be undertaken of the effectiveness of carrying out maintenance work The same efficiency and effectiveness criteria were to apply to schemes and maintenance.

5.33 In February 1986, the OPW completed a study of the farmer response to arterial drainage schemes in the Corrib-Mask, Boyne and Maigue catchments which were all underway at the time The study examined changes in livestock levels on samples of holdings in each catchment during the implementation of the drainage works The report did not compare scheme outturns with scheme targets or re-estimate the benefit·cost ratios and so cannot be regarded as a re-appraisal of the effectiveness of the schemes In the event, all three schemes stopped in 1987.

5.34 Appraisals of a number of proposed arterial drainage schemes carried out since 1986 have concluded that the likely benefits did not exceed the scheme costs. The OPW do not propose carrying out any further arterial drainage schemes in the foreseeable future

Appendices

Appendix A

Examination Methodology

The study was carried out by staff of the Office of the Comptroller and Auditor General with the assistance of a technical adviser (Mr Paul Johnston of Trinity College Dublin) and an engineering consultancy firm (ESB International)

Technical Advice

The assistance provided by the technical adviser consisted of

- providing advice and briefing on the technical processes involved in arterial drainage
- advising on the tasks to be assigned to the engineering consultants and assisting in the selection of consultants
- reviewing the findings, conclusions and recommendations arising from the study

Engineering Assessments

The principal matters examined by the engineering consultants were

- overall design of the schemes
- construction of the schemes
- maintenance programmes and works
- certain environmental impacts
- field drainage installation
- management of the schemes.

Design

The Office of Public Works' (OPW) detailed engineering plans for the Boyle and Bonet schemes were examined and assessed. The likely hydrological performance of the channels, as designed, was established

Construction

A representative sample of river reaches of the drained channel systems were selected Cross-sectional and longitudinal drawings of each section within each reach were provided by the OPW. These were digitised and plotted. Between 26 August and 6 September 1996, surveys were carried out at each of the specified cross-sections in the sample reaches to establish the as-constructed profiles. The results of the surveys were plotted and compared with the design and original channel cross sections

An inspection was carried out on one bridge in each of the 12 sample reaches to assess compliance with the works originally proposed and with criteria for flood design

Mathematical models of the 12 sample reaches were developed to determine the ability of the 'as constructed' channel to convey the design flood and the overall capacity of the 'as constructed' channel

Maintenance

Maintenance programmes were identified and maintenance work carried out to date was examined

Environmental Impacts

The environmental effects of spoil deposition and rehabilitation were examined along the sample channel lengths inspected Siltation and fisheries were also examined

Field Drainage

A survey was carried out on a sample of the damaged lands in the two catchments Ten non-contiguous sample sites dispersed throughout the catchments were randomly chosen for the study, comprising approximately 10% of the target damaged lands A general assessment of the present quality of the land was made in conjunction with aerial photography of the region undertaken in 1995 Based on records of soil type an estimate was made of the amount of target land which showed evidence of having improved since arterial drainage was carried out. An estimate was also made of the proportion of land which has been afforested

Interviews

In the course of the study, interviews were carried out with relevant personnel in the OPW, the Department of Agriculture, Food and Forestry, Teagasc and the National Parks and Wildlife Service [1]

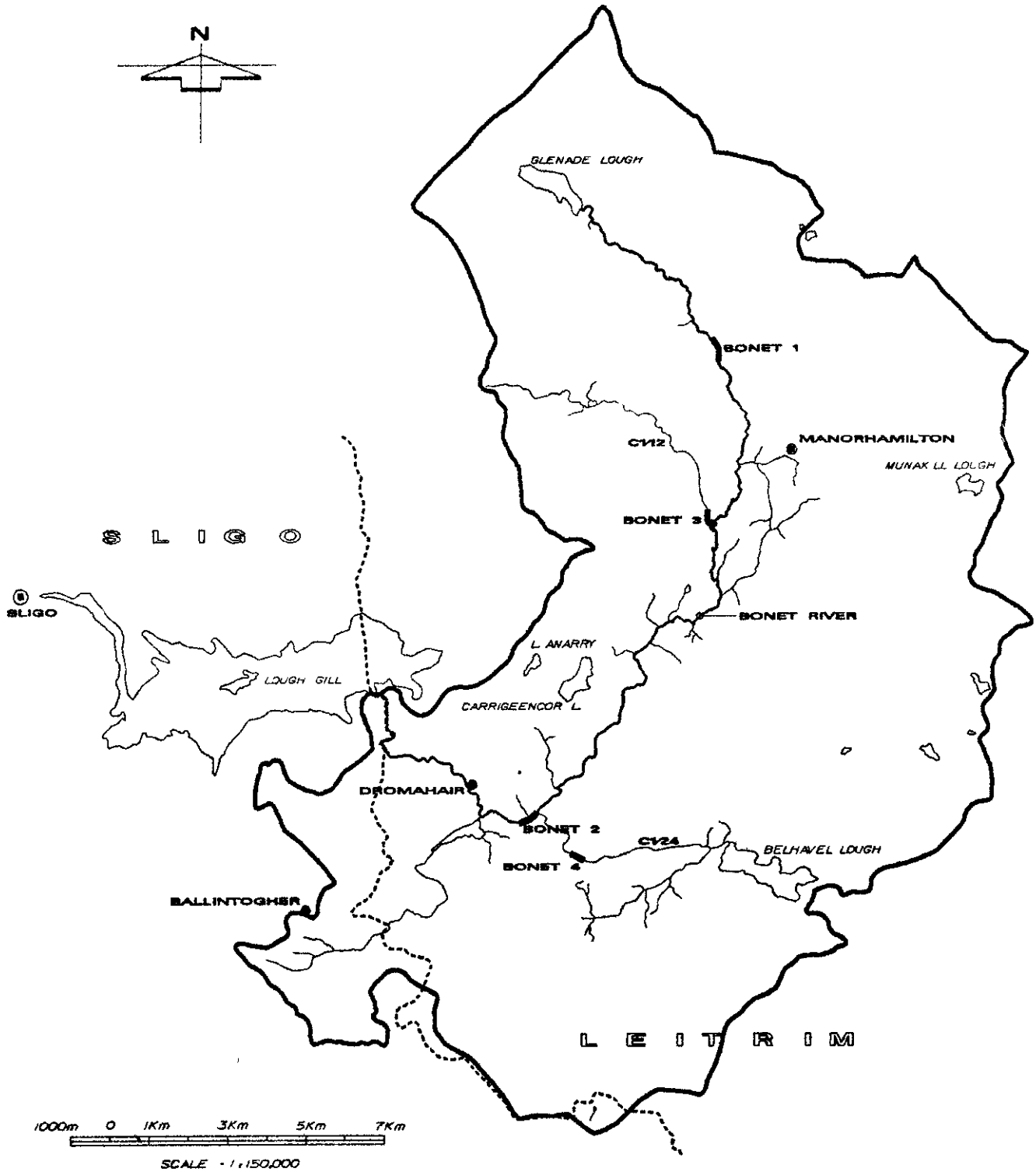
Examination of Compensation Payments

A random sample of 200 compensation claims against the Office of Public Works was examined A database of compensation claim and payment details was compiled to establish payment rates and patterns.

[1] *The National Parks and Wildlife Service took over responsibility for wildlife matters from what was formerly the Forest and Wildlife Service*

Map of River Channel Stretches Examined on the Boyle Scheme

Map of River Channel Stretches Examined on the Bonet Scheme



Appendix B

Programme of Arterial Drainage Schemes in Order of Priority

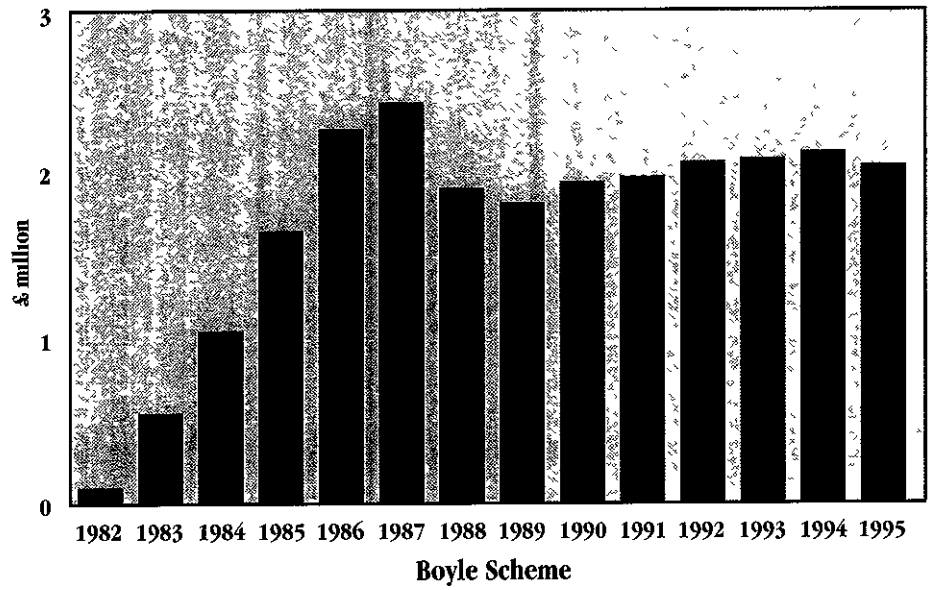
Major Catchments (40,000 hectares of land +)	Minor Catchments (10,000-40,000 hectares of land)
1 *Brosna*	1 *Nenagh*
2 *Glyde & Dee*	2 *Ballyteige*
3 *Feale*	3 Cahore
4 *Corrib-Clare*	4 *Broadmeadow*
5 *Corrib-Headford*	5 *Killimor*
6 *Corrib-Mask*	6 Quin
7 *Moy*	7 Owenkeagh
8 *Maine*	8. Eslin
9 *Inny*	9 Strokestown
10 Suck	10 Dunkellin
11 *Boyne*	11 Inagh
12 Erne	12. Scariff
13 Little Brosna	13 Rinn & Black
14 *Deel*	14. Nanny
15. *Boyle*	15 Longford
16 *Maigue*	16 Sow
17 Suir	17 Ballinhassig
18 Owenmore (Sligo)	18. Lavally
19. Mulkear	19 Lee (Kerry)
20. Nore	20 Fane
21 *Monaghan Blackwater*	21 Sixmilebridge
22. Fergus	22. Elphin
23. Liffey	23 *Bonet*
24 Blackwater (Cork)	24 Foyle
25 Barrow	25 Leannan
26 Lee (Cork)	26. Errif
27 Bandon	27. Tolka
28. Finn	28 Owenea
29 Laune	29 Owenmore (Mayo)
30. Slaney	30 Swilly

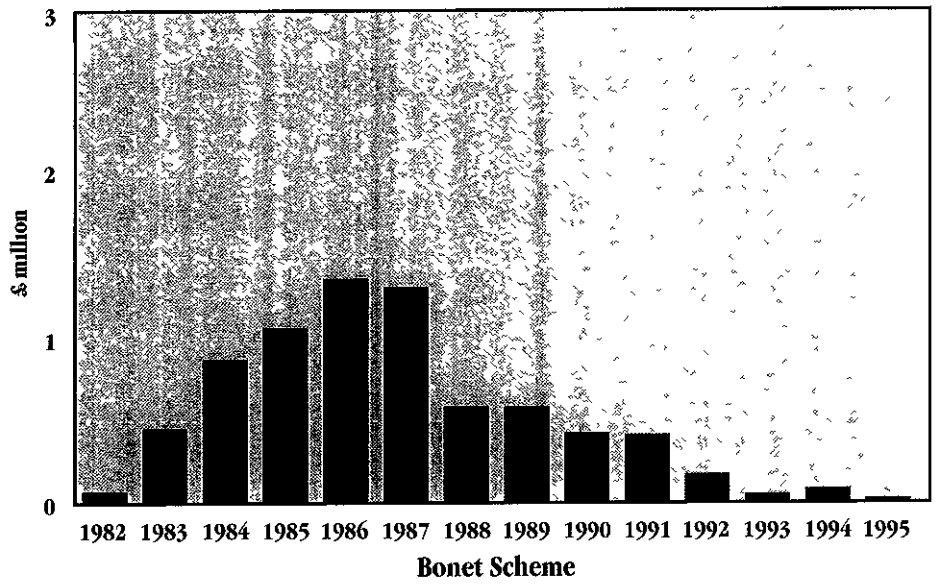
Notes 1 *Completed schemes are highlighted*

2 *The river Shannon has particular drainage problems which result in widespread and repeated flooding The Shannon catchment accounts for 17% of the area of the State so the drainage problem is on a much larger scale than other catchments. The Shannon itself is not included in the priority lists of catchments scheduled for drainage under the arterial drainage programme Fourteen of its sub catchments have been included in the lists These account for about 70% of the total Shannon catchment*

Appendix C

Annual Expenditure on the Boyle and Bonet Schemes, 1982 to 1995





Source. Office of Public Works quarterly cost reports 1982 to 1995