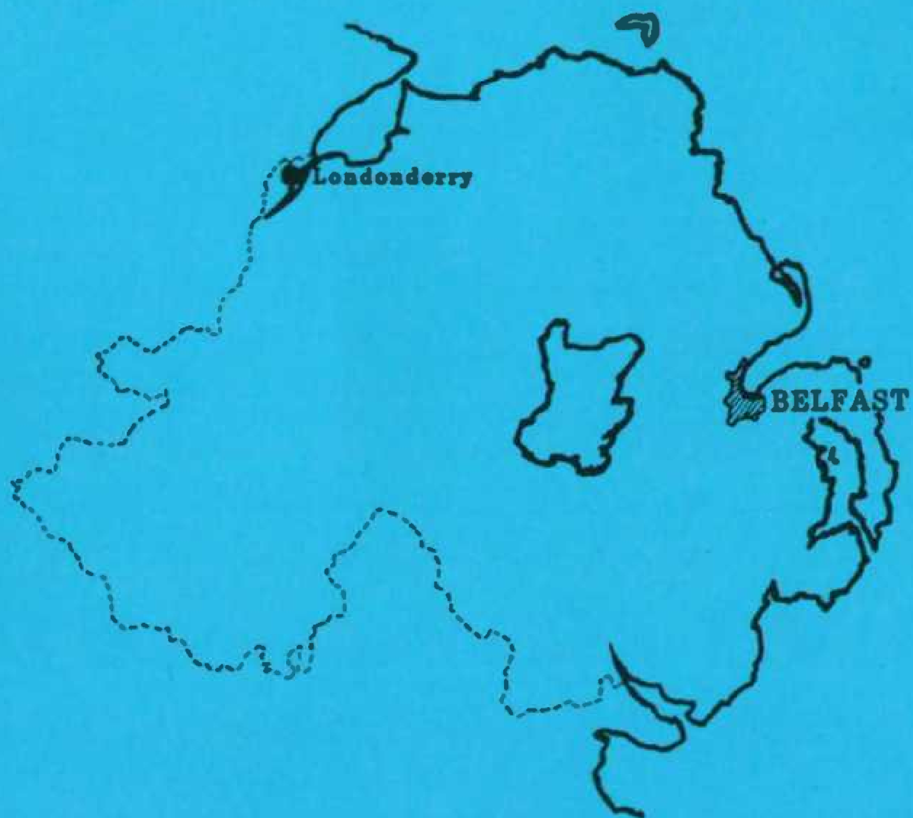
Department of the Environment for Northern Ireland

STUDY OF WATER DEMAND AND SUPPLY IN NORTHERN IRELAND

Volume 1
Main Report
August 1984



SIR ALEXANDER GIBB & PARTNERS
in association with
DELOITTE, HASKINS & SELLS MANAGEMENT CONSULTANTS

Department of the Environment for Northern Ireland

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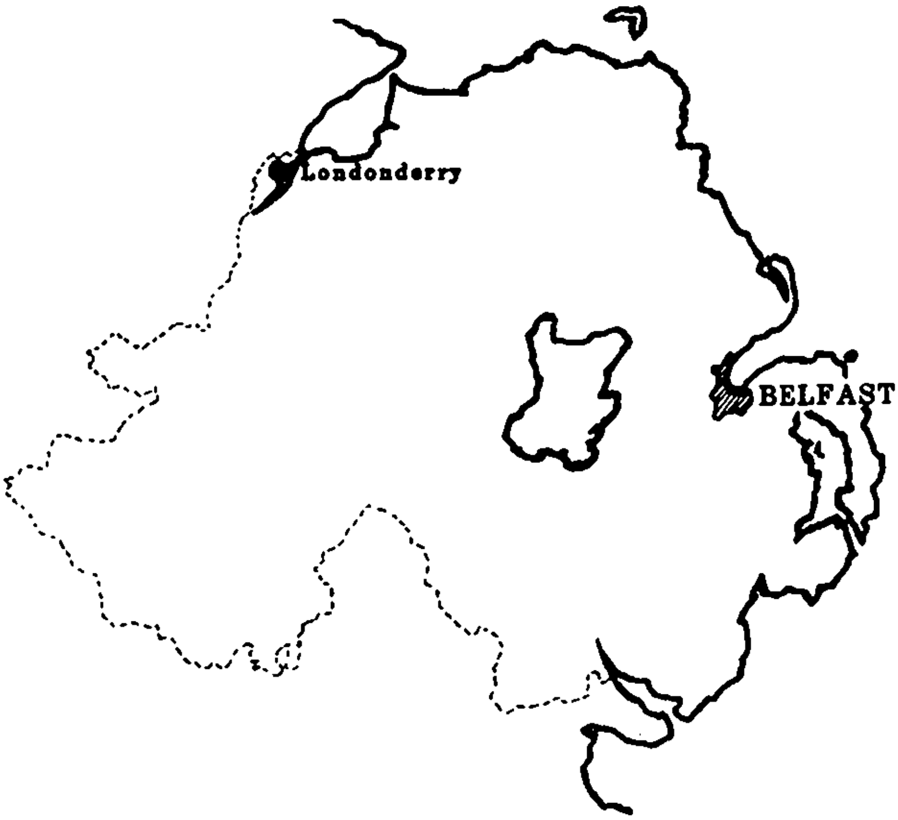

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in association with
DELOITTE, HASKINS & SELLS MANAGEMENT CONSULTANTS

SIR ALEXANDER GIBB & PARTNERS
CONSULTING ENGINEERS

EARLEY HOUSE
427 LONDON ROAD
EARLEY
READING RG6 IBL
TELEPHONE READING 61061 (21 LINES)
TELEGRAMS GIBBOSORUM READING
TELEX 848061

Deloitte Haskins+Sells Management Consultants

P O Box 207
128 Queen Victoria Street.
London EC4P 4JX
Telephone 01-248 3913
Telex 887880

Ref. 48a/83450A

August 1984

The Department of the Environment for Northern Ireland,
Northern Ireland Water Service,
Stormont,
Belfast,
BT4 3SS.

Dear Sirs,

STUDY OF WATER DEMAND AND SUPPLY
IN NORTHERN IRELAND

Following completion of our work on this study we have pleasure in presenting our report. Drafts of this report have been discussed with your staff and account has been taken of the comments raised at these discussions.

The report is in two volumes.

Volume 1	Main Report
Volume 2	Supporting Studies

Volume 1 commences with a statement of our conclusions and recommendations and presents a summary of the contents of the report.

We would like to record our appreciation of the co-operation and valuable assistance which we have received during the course of the study from members of staff of the Department of the Environment and of the Department of Finance and Personnel.

Yours faithfully,
for SIR ALEXANDER GIBB & PARTNERS and
DELOITTE HASKINS + SELLS

DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND

STUDY OF WATER DEMAND AND SUPPLY IN NORTHERN IRELAND

VOLUME 1

MAIN REPORT

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CONCLUSIONS AND RECOMMENDATIONS

The main findings arising from this study are as follows:-

The differences between yields of currently available sources of water and current treated water production are low, and this is a cause for concern. In Eastern Division these differences are less than 5% and in Northern and Southern Divisions they are less than 10%.

Recorded water production between 1973 and 1983 has been increasing on a Divisional basis at between 2.6% and 3.9% per annum.

Identified water consumption is rising and the range of long run forecast annual increase is between 0.7% and 2.2% per annum.

Unaccounted for Water (UFW) being the difference between production and identified consumption, is a very high proportion of production. UFW includes identified leakage, unidentified leakage (including that from trunk mains) and unidentified consumption.

With rising total demand, including UFW, it is essential that leakage should be reduced as, particularly in the Eastern Division, this is the only course which will meet increasing needs of consumers over the next few years. Development of major new sources could not be completed in time to meet these needs.

It is clearly economically beneficial to reduce identified leakage in distribution systems to realistic target levels and it is essential that adequate resources should be made available as soon as possible for effective leakage reduction and control programmes.

Preparations for introducing new source developments for the Eastern Area should be initiated now but should take account of the potential which exists for leakage reduction. These preparations should include source identification, outline design and the documentation required for public inquiry.

If the resources needed for effective leakage reduction are not made available, the development of a new major source for the Eastern Area is the only possible course if future demands are to be met. In these circumstances it will be essential to proceed without delay to public inquiry and the ensuing stages of detailed design and construction.

Final decisions to commit major financial expenditure on new source development cannot wait on the results of leakage reduction work for more than two or three years and failure to make progress with the earlier stages of promotion during that period will leave no opportunity for making up the lost time if leakage reduction work proves to be less effective than anticipated. In that event it would be necessary to contemplate the introduction of water restrictions over a sustained period until a new source had both been approved and constructed. The costs of promotional work prior to construction will not be wasted whatever the outcome of the leakage reduction programme, although they might be incurred ahead of the time when they were actually required.

10. For the Eastern Area, high pumping costs mean that the Tunny Point Scheme is not the most favourable. The most attractive large schemes for the Eastern Area are further development of the Lough Neagh source at Castor Bay and a new upland source at Glenwhirry, the economic differences being marginal. Secondary factors tend to favour Castor Bay, but only if the problem of dealing with the effects of algal blooms in Lough Neagh can be overcome at reasonable cost.

Information systems for planning and operation management require improvement, and it is essential that this should be addressed so that the balance of demand and supply can be kept under regular review.

SUMMARY

SCOPE OF THE STUDY

The Study of Water Demand and Supply in Northern Ireland commenced in September 1983 and this Final Report presents its conclusions and recommendations. The objective of the study is to determine the water supply needs in Northern Ireland, particularly in the Eastern Area, to examine the data on which water supplies are planned and to suggest improvements where appropriate. The study involves the following.

The assessment of the yields from available sources and the comparison of these yields with current water production requirements.

The analysis of water consumption requirements both as to categories of utilization and location of demand, and the preparation of projections of demand to the year 2000.

Identification of levels of unaccounted for water (UFW), including leakage and analysis of the cost effectiveness of further UFW reduction.

Assessing the needs for major new sources and development of criteria for taking decisions for the development of new sources.

Making recommendations for the main features for the management of the water supply/demand balance.

A review of the information needed for the monitoring of supply and demand.

The study has been carried out using water service sub-divisions as the basic geographical units. The base year for water consumption analysis is taken as 1981, for which the most recent census data are available. Costs have been taken at mid-1983 prices.

The contents of the report are summarized in the following pages.

OUTPUT FROM SOURCES

Concern regarding the ability of currently available sources to meet rising demands for water has increased in recent years and is one of the reasons for the present study. Thus a primary step is to assess the yields from the available sources and to compare them with current and projected water requirements, as described below.

Surface water is the most important source of water in Northern Ireland, although groundwater is also used. For upland sources regional relationships have been developed between reservoir storage volumes and yields, using available hydrological and meteorological data. These relationships have been used to establish yields at frequencies of reservoir failure of once in 20 years and once in 50 years for all existing sources and likely new sources. Estimates have also been made for direct river abstraction. There is effectively no hydrological limitation on use of Lough Neagh for water supply. For groundwater, operating records are used as the basis for capacities, although Water Service assessments for the ultimate outputs of the current borehole projects have been adopted.

In assessing available yields 1 in 50 year failure levels have been used and account has been taken of prescribed flows, process water requirements and system capacities as appropriate. The total available yields are summarized in the table below for each Division. The table also gives the water production levels for 1983 and the growth rates of water production over the past 10 years. (Allowance has been made for the closure of the Courtaulds factory in the growth figures for the Eastern Division).

OUTPUT FROM WATER SOURCES

Division	Current Source Capacity Ml/d	Average Production 1983 Ml/d	Annual Compound Growth Rates in Average Production 1973-83	
			Overall 1973-1983	Underlying Trend (1)
Eastern	350.0	334.7	2.6 %	2.0%
Northern	147.0	118.5	3.1 %	3.5%
Southern	132.1	123.0	3.9 %	3.7%
Western	116.8	110.9	3.5 %	3.7%

(1) Least squares analysis

These figures illustrate the limited margins between current source capacities and production levels at Divisional level.

Seasonal production peaks have occurred principally in the winter, probably due to burst mains. However, in milder years significant summer peaks are evident.

WATER CONSUMPTION

3.1 Base Year Consumption

Most domestic premises are not metered and water charges are recovered through the domestic rates. Non-domestic consumers are generally metered and charges are made on the basis of water consumed. Thus direct evidence of consumption is available for only non-domestic consumers.

For domestic premises, water consumption estimates have been derived from the results of a district metering exercise carried out by the Water Service. A total of 73 representative districts generally of about 30 houses each were used, in which waste levels were low. New meters were installed and readings taken in three separate periods between November 1983 and June 1984. After making corrections for legitimate night use and allowing for the occupancy ratio of the districts surveyed, an average daily consumption of 125 litres per head was derived for use in this study. This figure has been used to estimate total domestic consumption for each sub-division on the basis of the 1981 census, corrected for non-enumerated population.

For non-domestic consumers estimates were based on metered data provided from water charging records. The data have been adjusted for non-metered consumers and also for apparent errors in meter accuracy based on tests carried out by the Water Service. The results are broken down by consumer category and sub-district.

The estimated average consumption in the base year for each Division is shown in the table in the next section.

3.2. Consumption Forecasts

Forecasts of domestic consumption to the year 2000 have been made on the basis of forecast increases in population, with adjustments for improved living standards and falling household size. Population increases have been based on current Government planning projections. Living standard changes have been assessed on the basis of data on water using appliances, including a survey of about 2500 households carried out during the course of this study. Growth rates, derived from surveys in Great Britain, were used to obtain factors for future trends in appliance ownership in Northern Ireland. Household size changes have been based on recorded trends. To allow for uncertainty a range of growth bands has been used in each component for planning purposes.

For non-domestic consumption, forecasts have been based on projected changes in appropriate activity indicators for five principal sectors, agriculture, industry, commerce, construction and other (mainly public services).

An allowance of 3% of total production has been made for operational usage.

Overall base year and forecast consumption levels are as follows for each Division:-

Division		Base Year Consumption Ml/d	Forecast Consumption in 1990 Ml/d	2000 Ml/d
Eastern	High	167	206	250
	Low		179	187
Northern	High	74	89	111
	Low		79	85
Southern	High	73	86	109
	Low		76	84
Western	High	60	73	92
	Low		64	70
Northern Ireland	High	374	455	562
	Low		398	426

The forecasts represent annual increases of about 2.2%, and 0.7% for the high and low projections respectively.

3.3 Elasticity of Consumption

There is no firm evidence concerning the elasticity of water consumption with respect to price or income in Northern Ireland. Evidence from industrialized countries suggests that domestic demand is not sensitive to changes in price but is affected by levels of income. Research in England indicates that non-domestic consumption is affected by price and, to a greater extent, by industrial output.

UNACCOUNTED FOR WATER (UFW)

UFW comprises the difference between measured water production and identified consumption. Its chief component is leakage from the pipe network. Figures for production are available from Water Service records and estimates of base year consumption are referred to in Section 3.

4.1 Leakage from Supply Systems

Minimum night flow data from either district meters or waste water meters have been used to assess leakage rates in distribution networks for all sub-divisions, with allowances being made for legitimate night flows through trade meters and domestic households. In the absence of firm evidence only approximate estimates can been made for trunk mains, based on the results of Water Research Centre (WRC) studies.

4.2 Water Balances

Ideally the sum of estimated water consumption and measured leakage should equal water production, but in practice this is not so. The difference, or balance, is an indication of the uncertainty of estimates and measurements as well as of undetected consumption and leakage. The available information results in the following figures for each Division for the base year.

Division	Production	Estimated Consumption	Identified Leakage	Balance
	Ml/d	Ml/d	Ml/d	Ml/d
Eastern	307	167	109	+ 32
Northern	114	74	47	- 8
Southern	118	73	44	+ 2
Western	107	60	50	- 4
Northern Ireland	646	374	250	+ 22

It is evident that further work is needed to obtain better understanding of the larger balances.

4.3 Future Levels of UFW

Trends in water production over recent years indicate that UFW has been rising along with consumption. Thus it must be assumed that unless positive measures are taken to reduce UFW it will continue to rise. For lack of other information it has been assumed that in the absence of more effective leakage control UFW will tend to rise at the same rate as identified consumption.

REDUCTION OF LEAKAGE

With the limited manpower available and with the assistance of consulting engineers the Water Service has for some time endeavoured to reduce leakage, but the results of this study show that UFW levels are higher than is desirable. Thus a determined effort involving considerable increases in manpower, working to a properly prepared programme is needed to bring UFW to a more reasonable level than at present.

5.1 Leakage Levels

Data from base year leakage estimates suggests that overall net night flows per property are in the range of 20 to 40 litres per hour. These are high figures and it should be possible to reduce them significantly. Following the methods recommended in NWC Report No. 26, and making adjustment for conditions in Northern Ireland, target leakage rates in the range 13 to 22 litres per property per hour should be achieved if active leakage control is extended using waste water meters.

Levels of trunk main leakage should also be identified and reduced to acceptable amounts.

5.2 Costs of Leakage

Savings arising from leakage reduction can be estimated on the basis of two components,

- reduction in operating costs
- deferment of capital expenditure.

Unit operating and capital costs have been calculated for each of the principal supply systems and the resulting total unit costs are in the range 3.9 to 7.7 pence per cubic meter. The larger figures arise in areas where pumping costs are relatively high, such as from Dunore Point Treatment Works into Belfast. By applying these figures to the existing and target leakage levels the relevant annual values of potential saving have been estimated.

5.3 Cost of Leakage Control

Effective leakage control requires that adequate financial and manpower resources are allocated to the work. The estimated total annual cost of leakage control is £614 000, requiring a total of 68 industrial and supervising staff working on leakage detection.

In addition, resources are required to repair the arrears of leakages as a result of more intensive leakage control, over and above normal allocations for this work. It is estimated that this would add a total of £315 000 per annum and also require some additional 25 staff during the first few years. The annual equivalent cost amortized over 20 years amounts to £88 000 per annum.

5.4 Annual Benefits

The annual benefits that can accrue from leakage control for each Division are as follows:

Division	Net Saving £	Saving of Water Ml/d
Eastern	1 182 000	51
Northern	327 000	23
Southern	467 000	21
Western	330 000	27
Northern Ireland	2 306 000	122

It is clear that significant benefits can arise both economically and in terms of water production from effective leakage control. It is therefore recommended that the required resources of manpower and finance should be made available so that the necessary leakage programmes can be planned and executed. The effectiveness of this work must of course be closely monitored.

PLANNING FOR WATER SUPPLY

A number of factors must be taken into account in preparing development plans for sources as discussed in this section.

6.1 Treated Water Requirement

Projections for treated water production have been prepared, which include both identified consumption and UFW. These include high, mid and low estimates. It is assumed that UFW will grow at the same rate as forecast consumption in the absence of effective leakage control.

6.2 Output from Sources

In assessing the requirements for source capacities a number of factors must be allowed for in addition to treated water production.

process water requirement
compensation water (i.e. prescribed flow)
operating margins at critical points in time

The first two depend on local conditions. The purpose of the minimum operating margin is to allow for short term fluctuations in demand, persistent climatic variation and emergency situations. Evidence from Eastern Division records shows that the maximum variation due to the closure of Courtaulds factory resulted in a variation from 6% above the general consumption trend to 6% below. This range is likely to be extreme. It is considered that an operating margin of 5% of total production (about 10% of consumption) should be allowed in determining the timing of implementation of a new source. However, in systems which are supplied from small reservoirs the effect of summer peak demands may require a greater margin.

6.3 Level of Service

While it is possible to impose restrictions on consumers it has been concluded that, as a basis of planning, restrictions should not be imposed more frequently than once in twenty years on average. This assumes that such action would effectively increase the yield from sources. However analysis of the Silent Valley system has shown that restrictions in output at this frequency would not increase the effective yield significantly above the 1 in 50 year failure level. In view of this and the uncertainty of the data it is considered that for planning purposes it would be best to adopt the conventional practice of providing sources for which significant reduction in supply would not be expected more than once in fifty years.

6.4 Leakage Control

While consumer demand is expected to increase, the total level of water demand in the next few years will depend largely on the success achieved in reduction of leakage. For planning purposes it is therefore necessary to consider the options of:

a. no reduction in leakage
b. the achievement of target leakage levels

The resultant levels of UFW should be superimposed on the range of consumption forecasts that have been described.

6.5 Development Programmes

It has been shown that leakage control, if successful, is highly cost effective. However, even if extra staff are provided to supplement the efforts already being applied to the suppression of waste, it has to be recognised that the defined target levels may well not be achieved within the short term. Unfortunately the lead time needed for the implementation of a new source means that progress with the necessary promotional work cannot be set aside to await the results of a leakage reduction programme. It is of paramount importance therefore that preparatory work leading to the inquiry stage on new source development for the Eastern Area should proceed immediately so as to provide for the contingency that leakage will not be significantly reduced within two or three years. In the event of a new source being required at an early date the preparatory work which can be accomplished during that period will be vital and, if that time is lost, sustained restrictions on water demand may have to be contemplated. If leakage reduction (and its continued suppression) is sufficient to delay the promotion of a new source, the preliminary work will not have been wasted as a new source will eventually be required.

In the event that the resources needed for leakage reduction and control are not forthcoming, leakage would continue to rise along with consumption, and would result in more frequent restrictions in supply. In these circumstances it will be essential for a new source to be developed for the Eastern Area without delay.

APPRAISAL OF PROJECTS

A number of possible schemes have been evaluated to meet future increases in production requirements, although, in view of the uncertainty regarding the effects of leakage reduction, the precise timing of such projects must remain open. Preferred schemes have been identified on economic grounds on the basis of discounted unit costs of water but other factors such as environmental, social, legal and water quality aspects and land costs are not within the scope of this report. The conclusions of these considerations are as follows:

7.1 Eastern Division

Of the possible major schemes there are only marginal differences between an extension to Lough Neagh abstraction at Castor Bay and the development of a new upland source at Glenwhirry. Taking account of secondary factors, including land acquisition and compensation water requirements at Glenwhirry, indicates that the former would be preferable but only if the problems arising from algal blooms in Lough Neagh can be solved at reasonable cost.

The proposed Tunny Point scheme is less economical on account of the high pumping costs.

The development of Lough Island Reavy to yield a further 17 Ml/d is attractive, but would depend upon the implementation of a programme of renovation of the Mourne Conduit.

7.2 Ballymena/Antrim/Larne

Construction of the Inver Dam and associated works.

7.3 Coleraine/Ballymoney/Moyle

Interconnection of Altnahinch and Ballinrees sources.

7.4 Southern Division

Development of the Camlough Source.

7.5 Strabane/Omagh

Interconnection of Lough Fingrean with River Derg has been considered but found not to be economic.

7.6 Fermanagh

Interconnection of Derrylin Borehole and Killyhevlin with Killyfole.

DEVELOPMENT PLANS

Outline plans have been made for each of the areas for which source development will eventually be required. The position regarding margins between available source capacities and current demand is reviewed, together with the likely effects of leakage reduction.

In all cases priority must be given to the reduction of leakage but as the success of this work cannot be forecast it is not possible for firm programmes to be made. However, priorities for planning can be established and these are as follows:-

8.1 Eastern Division

Small scale improvements at Dunore Point Treatment Works to increase output by about 5 Ml/d.

Development of the Lough Neagh source at Castor Bay to yield about 110 Ml/d, provided that treatment problems can be resolved at reasonable cost.

8.2 Ballymena/Antrim/Larne

Extension of pipeline from Dunore Point further northwards to improve the supply to Ballymena.

Development of Inver Dam and associated works to provide an extra 12 Ml/d.

8.3 Coleraine/Ballymoney/Moyle

Current sources should be adequate until the end of the century.

8.4 Magherafelt/Cookstown

Sources appear to be adequate for the foreseeable future.

8.5 Southern Division

Development at Lough Ross and Clay Lake, totalling 8 Ml/d and improved interconnection between Castor Bay and Spelga/Fofanny.

At a later stage, development of the Camlough source, which will yield 13 Ml/d.

8.6 Londonderry/Limavady

The principal problem is the condition of Altnaheglish Dam. If it is to be drawn down for repair some temporary alternative supplies will be needed. Otherwise it is unlikely that a new source would be required within the time horizon of this study.

8.7 Strabane/Omagh

With the currently planned development of Lough Bradan and Lough Fingrean, further new sources do not appear to be necessary.

8.8 Fermanagh

Connection of Derrylin Borehole to the Killyfole supply area to utilize a source of 2 Ml/d.

Duplication of Killyhevlin, producing 11 Ml/d with interconnection to Killyfole.

INFORMATION FOR PLANNING AND OPERATIONS MANAGEMENT

Consistent, accurate and regular information is required by Water Service management for effective planning and control. This part of the study is concerned with information needed for the monitoring of supply and demand but it is observed that improvements are required also in other areas. The principal matters that require attention are as follows:-

9.1 Water Supply

The collection and transmission of data are generally satisfactory but the extent to which this is effective requires examination. In particular, the gauging of additional upland catchments is desirable.

9.2 Water Consumption

Data on domestic consumption are scarce and it is recommended that the metered district exercise carried out for this study should be adopted as a basis for further monitoring work.

For non-domestic consumers the existing meter recording system is not satisfactory. The system at present is limited to meeting consumer billing requirements and does not readily allow the effective recording and processing of data for planning purposes. Points that cause particular concern include:

a. Classification of consumers
b. Meter installation data
c. Accuracy of meters and meter replacement policy
d. Meter sizing
e. Classification of consumption data
f. Handling of meter records
g. Data presentation.

Access to information from external sources is also required, and should include population and household characteristics, economic trends and local authority development planning.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

This Study of Water Demand and Supply in Northern Ireland has been carried out for the Department of the Environment for Northern Ireland by Sir Alexander Gibb & Partners jointly with Deloitte Haskins & Sells, Management Consultants. Work commenced on 5th September, 1983, and interim reports were submitted in October 1983 and January 1984 which reviewed work carried out up to those dates. This report presents the conclusions and recommendations of the Study.

1.2 TERMS OF REFERENCE

Terms of Reference for the Study were drawn up by the Water Service of the Department of the Environment for Northern Ireland in conjunction with the Economics Division of the Policy, Planning and Research Unit of the Department of Finance and Personnel and were issued with the letter of invitation from DOE/NI reference WS79/81 dated 3rd May, 1983. These terms set out the requirement for the study in detail, and give the objective as follows:-

"The aim of the Study is to determine water supply needs in Northern Ireland and in particular Water Service's Eastern Area; to examine the data on water demand and supply on which supplies for Northern Ireland are planned and to suggest improvements where appropriate".

Primary requirements are:

Assessment of present levels of water demand and supply and preparation of projections to the year 2000.

Analysis of demand both as to categories of utilization and spatial allocation.

Examination of the scope for increasing transfer of supplies both within and between supply areas.

Assessment of safe yields of existing sources.

Re-examination of Unaccounted For Water (UFW) levels, including waste, and determination of the cost effectiveness of further UFW reduction.

Review of the requirements for an effective data base for monitoring supply and demand.

Estimation, in so far as data allows, of the elasticity of water demand to price.

8. Assessment of the need for a major new water source and development of criteria for taking decisions regarding the development of a new source.

Recommendations for the main features of a strategy for cost effective management of the water supply/demand balance.

1.3 SCOPE OF REPORT

This report presents the conclusions of the work carried out for this study. It does not set out to respond to each of the above questions separately but the requirements of the Terms of Reference are dealt with in the relevant chapters. The report covers all aspects of the Terms of Reference but in some cases it is necessary to refer to Volume 2, Supporting Studies for matters of detail.

Conclusions regarding the yields of available sources are presented in summary and are compared with recent production levels. The results of the investigations into current water consumption are presented together with forecasts for future consumption. A review is made of unaccounted for water, based on consumption and leakage assessments. Leakage reduction is examined both as regards costs, possible financial benefits and resource requirements, and also the savings of water that may be expected.

Factors which affect the decisions to be taken in planning for future developments are discussed and appraisals are made of possible source development from which optimum schemes are identified for a range of demand forecasts. These are used as the basis for plans for each of the principal areas for which development is required.

Finally, the availability of data relating to water production and consumption for management purposes is also discussed, and recommendations made for improvements of data retrieval.

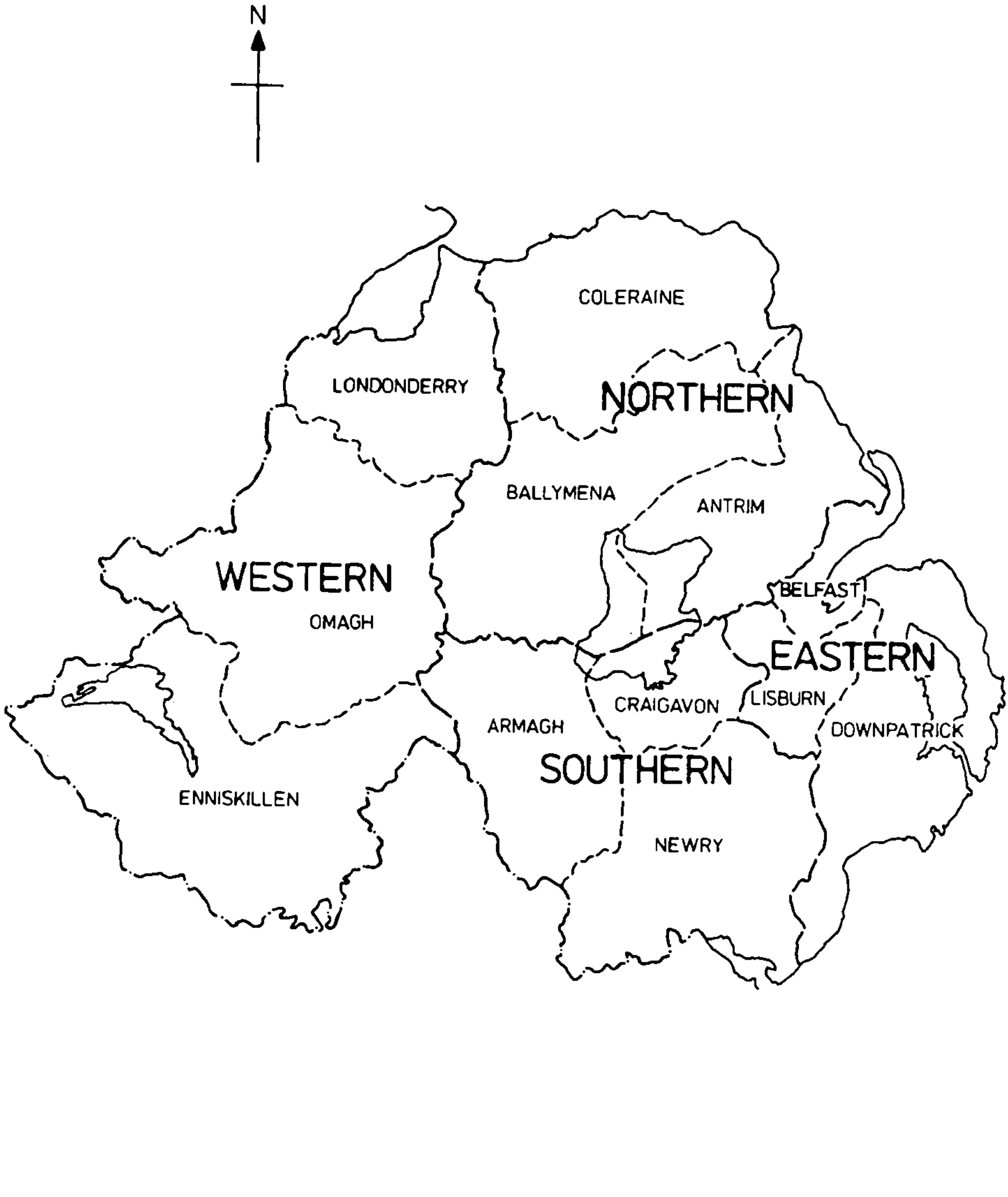
1.4 FRAMEWORK

The Northern Ireland Water Service is divided into four Divisions for operational purposes and each of these is further divided into three sub-divisions. In general each Division has independent water sources, but in many cases sources supply parts of more than one Division. The major demand centre is the urban area of Belfast, and the water supplied to the Eastern Division, which includes Belfast, is about 50% of the total used in Northern Ireland. The Divisional and sub divisional areas are shown on Figure 1.1.

There is some flexibility in the way that sources can be allocated and this can be of benefit when patterns of demand change as well as providing safeguards in conditions of emergency. However, the degree of interconnection of sources in the east of the Province, which supply Belfast and adjacent areas, means that for planning purposes a larger area than the Eastern Division has to be considered in this region.

It has been found that the most suitable geographical units for the purpose of this study are the Water Service sub-divisions, since much of the available data is already allocated in this way.

The base year for water consumption has been taken as 1981, as this is the latest year for which both census data and comprehensive consumption information are available. Mid-1983 prices have been used throughout for capital and operating costs, except where account has been taken of increasing energy costs.



NORTHERN IRELAND WATER SERVICE
DIVISIONAL AND SUB-DIVISIONAL AREAS
Figure 1 1

1.5 ACKNOWLEDGEMENTS

This Study has been undertaken with the assistance of

Ferguson & McIlveen, Consulting Engineers, Belfast
Institute of Hydrology, Wallingford
Mr. H. Speight, Water Management Consultant, Ferring, Sussex.

In carrying out the work the study team has been greatly assisted by members of the staff of the Water Service, both at Headquarters and at Divisional Offices, and the Economics Division and Social Research Division of the Policy Planning and Research Unit.

In addition, acknowledgement is given to assistance received from a number of other organizations whom we have consulted, as follows:-

Office of Public Works, Dublin
North West Water Authority, Warrington
South West Water Authority, Exeter

1.6 ABBREVIATIONS

A list of Abbreviations used in this report is given in Appendix 11.

CHAPTER 2

OUTPUTS FROM WATER SOURCES

2.1 INTRODUCTION

One of the reasons for this study is the concern that has arisen in recent years regarding the ability of available sources to meet the increasing demand for water. As a first step, therefore, it is necessary to consider the capacities of these sources in relation to the demands that have been put on them. This chapter discusses the assessments of reliable yields and the available production capacities of sources and relates them to the quantities of water that have been produced in recent years.

2.2 YIELDS OF SOURCES

2.2.1 Approach

The objective of this work has been to assess the reliable yields of existing and potential water sources. Surface water sources are the most important, particularly upland reservoirs and loughs, but attention has also been given to groundwater. The approach for upland sources has been to develop a regional storage/yield relationship for Northern Ireland, based on available river flow records augmented by meteorological records. This chapter summarises the conclusions of the work which is described in detail in Volume 2.

2.2.2 Yields from Reservoirs

Regional storage/yield relationships have been developed as a basis for the assessment of reliable yields for all of the relevant sources. Average runoff is calculated from standard annual average rainfall (SAAR) adjusted for evaporation and catchment area. For indirect catchments 80% of the catchment area is used, except for a few sites where more detailed information is available. The results are given in Volume 2 and the gross yields listed must be adjusted for compensation water where this is required. As well as existing works, the investigation included several proposed schemes which are considered in detail elsewhere in this report.

Yields from surface sources have been assessed on the basis of failure frequencies of 1 in 20 and 1 in 50 years. Consideration has been given to the effects of rationing which are discussed in Chapter 6 and Volume 2.

2.2.3 River Abstractions

The important sources involving direct abstraction are:

Eastern Division

River Annalong. This has been included in the assessment of the yield from the Silent Valley System.

Northern Division

River Bann at Castleroe. The yield of this source is limited primarily by the capacity of the intake.

Western Division

River Faughan at Carmoney. This has been reported on in detail by Binnie & Partners in December 1969. The output is limited by river conditions to 36 Ml/d.
River Derg at Tievenny. Work based on the Institute of Hydrology's Low Flow Study estimates reliable yields for 20 and 50 year return periods at 9.4 and 6.9 Ml/d respectively.

2.2.4 Lough Neagh

The conclusions of the Lough Neagh Working Group (1971) were that large quantities of water could be taken from the Lough with very little adverse effect. It is essential, however, that a solution to the algal problems should be found in the near future. For the practical purposes of the present study it is therefore concluded that all foreseeable demands for potable water on Lough Neagh can be met.

2.2.5 Groundwater

The complex geology of Northern Ireland results in aquifers of limited extent and yield. Recent groundwater development has increased total pumping capacity but is not wholly utilized. The quantities derived from groundwater sources in 1982 are given in Table 2.1.

TABLE 2.1

GROUNDWATER PRODUCTION IN 1982 (Ml/d)

Division		Boreholes	Springs & Wells
Eastern		12*	
Northern		1	13
Southern		11	1
Western		3	7
	Total	27	21

*Note: Groundwater supplies to the Eastern Division are being augmented by the completion of the Lagan Valley Boreholes which are expected to increase this figure by about 20 Ml/d.

In Northern Division, developments at Glarryford, Buckna and Drumbest are expected to add about 12 Ml/d.

2.3 AVAILABLE PRODUCTION CAPACITIES OF SOURCES

The reliable outputs which can be made available from those sources which are currently in use are listed in detail in Appendix 1 and summarised in Table 2.2. These are based on the foregoing sections, but account has been taken of the following, where appropriate.

(a) Yields from upland sources are based on 1 in 50 year failure criteria. (The question of the failure criteria to be used in resource planning is discussed later in this report).

(b) Constraints imposed by the capacities of water treatment plants, pumping stations, aqueducts and pipelines.

(c) Quantities used for treatment processes, such as in washing filters or in sand washing plants.

(d) Compensation water or prescribed flows.

(e) Groundwater includes springs, wells and boreholes.

TABLE 2.2

SUMMARY OF CURRENTLY AVAILABLE SOURCES

Eastern Division

		Ml/d	
Silent Valley System	112.8)	130.8	
Lough Island Reavy (3)	18.0)		
Woodburn Complex		44.1	(1)
Stonyford and Leathermstown		14.8	(1)(2)
Lough Neagh (Dunore) (3)		118.0	(1)
Magheraliskmisk		6.0	
Minor Sources		20.8	(1)
Groundwater (4)		15.5	
		350.0	

Notes. (1) Washwater deducted

(2) Prescribed flow deducted

(3) Proportion only

(4) Further development of Lagan Valley boreholes will add 16.5 Ml/d by 1987.

b. Northern Division

	Ml/d	
Killylane	13.0	(1)
Dungonnell	11.9	(1)
Quolie	5.0	(1)
Lough Fea	13.2	(1)
Ballinrees + River Bann	33.1	(1)
Altnahinch	10.7	(1) (2)
Lough Neagh (Dunore) (3)	18.0	
Moyola	13.0	
Minor Sources	10.8	(1)
Groundwater (4)	18.3	
	147.0	

Notes. (1) Washwater deducted

(2) Prescribed flow deducted

(3) Proportion only

Southern Division

	Ml/d	
Seagahan	14.5	(1) (2)
Spelga + Fofanny	24.1	(1) (2)
Lough Island Reavy (4)	1.2	
Lough Neagh (Castor Bay) (4)	63.7	(1) (3)
Minor Sources	18.1	(1)
Groundwater	10.5	
	132.1	

Notes. (1) Washwater deducted

(2) Prescribed flow deducted

(3) Rated output of treatment works

(4) Proportion only

d. Western Division

	Ml/d	
Altnaheglish + Glenedra	18.0	
Carmoney	34.8	(1)
Killyhevlin	10.9	(1)
Lough Fingrean/Macrory (2)	6.4	(1)
Lough Bradan (3)	3.6	
River Derg	13.0	
Minor Sources	19.6	
Groundwater	10.5	
	116.8	

Notes. (1) Washwater deducted

(2) To increase by 6.6 Ml/d

(3) To increase by 4.8 Ml/d

2.4 WATER PRODUCTION

2.4.1 Annual Average Production

The annual average rates of production of water are available from the Water Service records and these are summarised in Table 2.3 for each Division for the years 1973 to 1983 inclusive. The figures for the Eastern Division have been adjusted to allow for meter errors which were identified and corrected early in 1983.

These figures indicate that except in the Eastern Division the general trend of water production has been rising steadily over the last ten years although levelling off generally from 1979-1980. In Eastern Division production rose to a peak in 1979 and then fell sharply during 1980 and 1981. This was due to the closing of water consuming industries during that period, particularly the Courtaulds factory at Carrickfergus. Production has however continued to rise between 1981 and 1983. If the requirement of Courtaulds (about 25 Ml/d) is removed from the earlier years the underlying trend for the Eastern Division is also rising. The trend line growth has been analysed for each Division and is shown graphically in Figures 2.1 and 2.2.

TABLE 2.3

ANNUAL AVERAGE WATER PRODUCTION

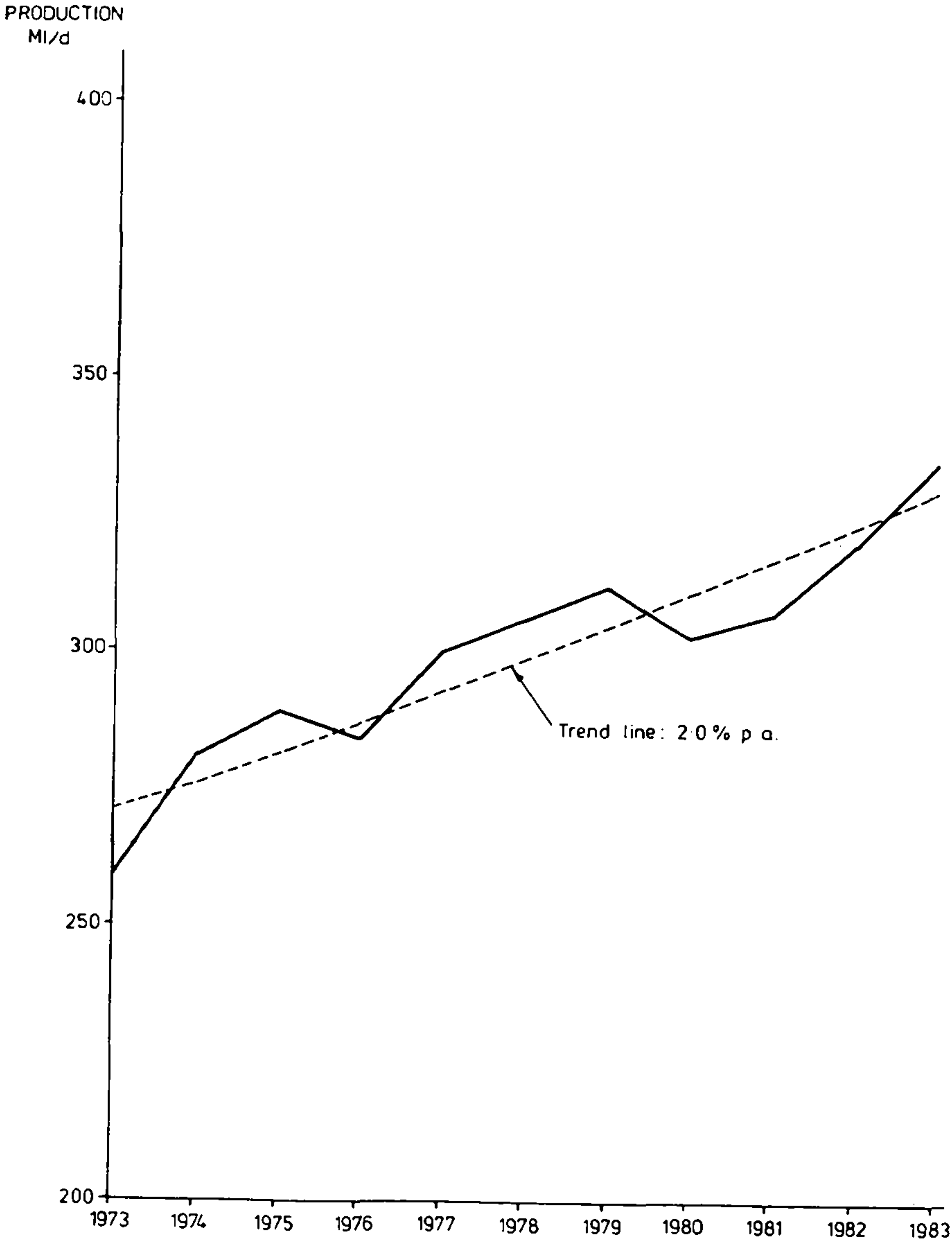
Ml/d

Year	Eastern	Northern	Southern	Western	Total
	DIVISION				
1973	284	87	84	79	534
1974	306	89	93	85	573
1975	314	90	91	81	576
1976	309	90	105	82	586
1977	325	101	107	92	625
1978	331	108	105	99	643
1979	339	106	120	98	663
1980	328	118	120	109	675
1981	307	114	118	107	646
1982	320	116	120	107	663
1983	335	118	123	111	687

The increases in water production for each Division over the ten years are:

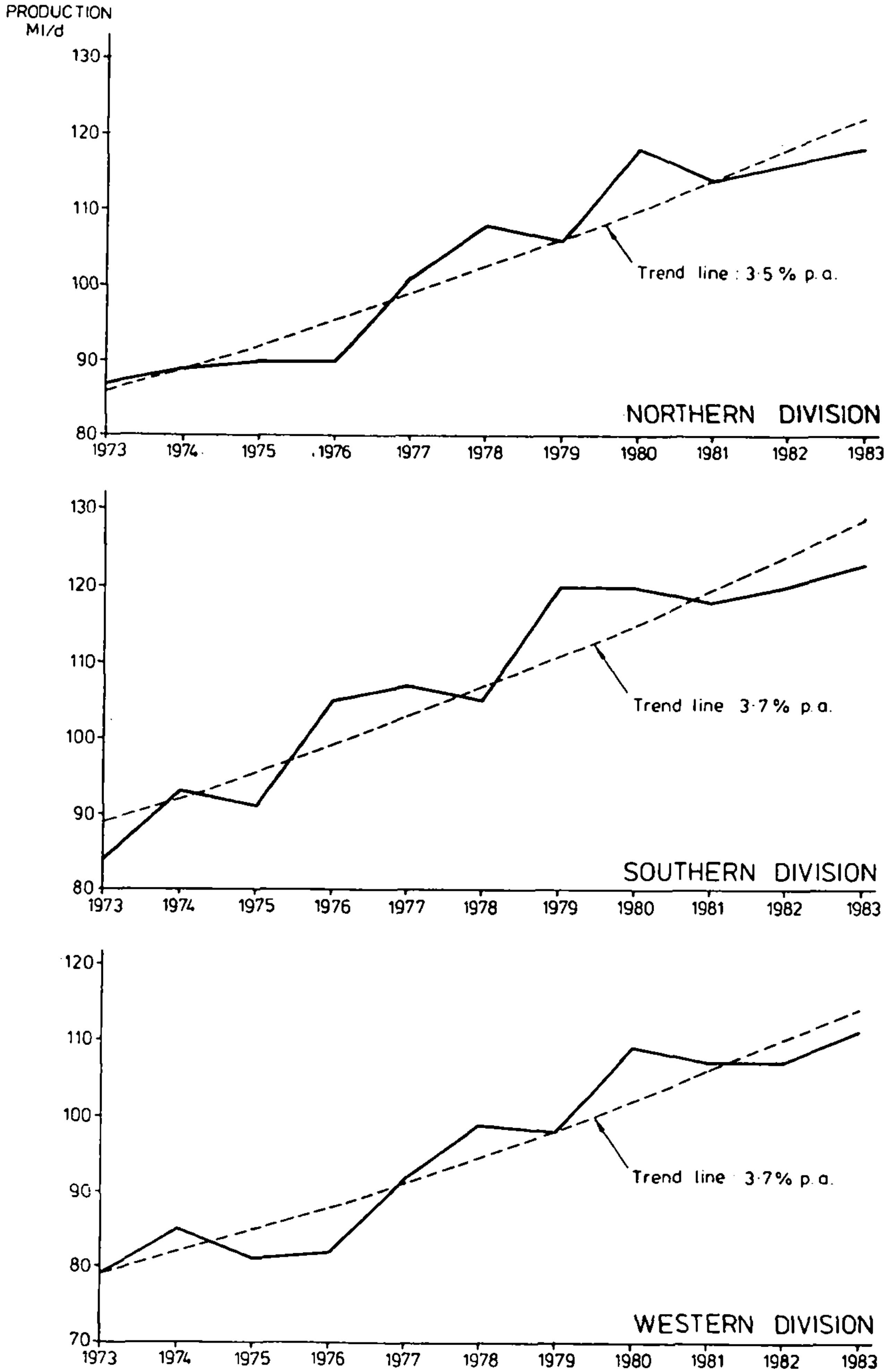
	Total increase	Annual compound growth 1973-1983	
		Overall	Based on trend analysis
Eastern	18%	1.7%	1.0%
(excluding Courtaulds)	29%	2.6%	2.0%
Northern	36%	3.1%	3.5%
Southern	46%	3.9%	3.7%
Western	41%	3.5%	3.7%

The lower trends for Eastern Division are in part due to the implementation since 1976 of more effective waste control.



NOTE: 1973 - 1979 exclude Courtaulds' consumption

ANNUAL AVERAGE WATER PRODUCTION
EASTERN DIVISION
Figure 2.1



ANNUAL AVERAGE WATER PRODUCTION
Figure 2.2

When comparing the water production in 1983 with the available production capacity given in Table 2.2 it is evident that currently the effective margins in most Divisions are not great although some additional source capacity is being developed. In some local areas the position is critical. If the past growth rates indicated above are maintained these margins will very soon be used up. Thus it is clear that the concern for the future position is fully justified.

2.4.2 Seasonal Variations

Of recent years, monthly water production has tended to reach a peak during the winter, and this is probably a reflection of the effect of burst pipes during very cold weather. These effects tend to obscure summer peaks but examination of monthly data for 1983 (a year for which winter peaks were less prominent) indicates that significant summer peaks can occur.

While meeting winter peaks may not present serious problems, summer peaks are more difficult to satisfy, particularly where reservoir storage capacities in small upland sources are limited. Thus the application of 1 in 50 year reliable yields for such sources must take account of the relevant seasonal demand fluctuations.

CHAPTER 3

WATER CONSUMPTION

BASE YEAR CONSUMPTION

3.1.1 Introduction

In accordance with general practice in the UK supplies to most domestic premises are not metered and the relevant water charges are recovered through domestic rates. Non-domestic consumers are generally metered and charges made on the basis of water consumed. As a consequence there is no direct measurement of domestic consumption but information for non-domestic consumers is available from meter records. It has therefore been necessary to adopt separate approaches to the assessment of domestic and non-domestic consumption for the base year (1981).

3.1.2 Domestic Consumption

1. Approach

Estimates of domestic water consumption have been derived from the results of a district metering exercise carried out by the Water Service for this sudy. This approach involved measuring the quantity of water used in a number of small well-defined residential areas and, by combining this with population and property data, obtaining estimates of average consumption per person. Total domestic water consumption for each water supply sub-division was then assessed using population estimates obtained from the 1981 Northern Ireland Census of population adjusted to take account of the impact of census non-enumeration in each sub-division.

2. Metered Districts Exercise

Districts were selected as far as possible to meet the following criteria:-

(a) small meterable area with known low waste levels where possible;

(b) approximately 30 residential properties with no non-domestic properties;

(c) properties of similar type (for example small terraced or large detached) within each individual district;

(d) representation of properties of different type across different areas.

New appropriately sized (generally 1") meters were installed in each district and weekly consumption volumes were measured during three separate periods;

(a) November/December 1983;

(b) February/March 1984;

(c) June 1984.

The June 1984 readings also included hourly nightflow information measured on two separate nights for each metered district. This information was not collected for the two earlier sets of readings. All results have been screened by the Water Service in order to exclude misleading information, for example where there was clear evidence of meters malfunctioning or of major water loss due to burst mains. It was further necessary to exclude a number of observations where there were information deficiencies, for example concerning the dates and times at which readings were taken. Table 3.1 summarises the coverage of the exercise.

Further data were collected for each district concerning numbers of properties and population. Of the 73 districts, roughly 50 were surveyed in full using the questionnaire developed for the main household survey (see Volume 2) while the remaining districts were surveyed for population only. Details of the districts included in the exercise are given in Volume 2.

TABLE 3.1

COVERAGE OF METERED DISTRICTS EXERCISE

	November/December 1983	February/March 1984	June 1984
No of districts	65	55	73
Hourly night readings taken	NO	NO	YES

Note: The 73 districts surveyed in June 1984 include all the districts which were surveyed in November/December 1983 and in February/March 1984.

Although districts were selected on the basis of known low waste levels, it is necessary to make a deduction to take account of waste in arriving at estimates of consumption. The maximum possible level of leakage in any district may be established by reference to the minimum night flow; the rate of leakage cannot exceed the lowest observed rate of flow. Some consumption may, however, take place at the point of minimum night flow either directly, due to night use of water-using appliances/ amenities, or indirectly, due to tank-filling following earlier activity. If leakage levels are calculated directly from the minimum night flow without taking account of this element of "legitimate night consumption" the estimates of domestic consumption will understate true water usage.

Data concerning legitimate night consumption were not collected for the metered districts exercise. This would have required major additional work which was not possible within the scope of this study. It was therefore necessary to estimate the extent of domestic night usage by reference to other studies.

DOE/NWC Report 26, 'Leakage Control Policy and Practice' recommends that a maximum deduction of 2 litres/property/hour (l/p/h) should be made from the observed minimum night flow rate (calculated from readings taken at 15 minute intervals) in order to assess total leakage. This method is, however, intended for application to relatively large areas with 1,500 or more properties.

Water Research Centre Report No. 154, 'The Results of the Experimental Programme on Leakage Control', upon which the NWC Report 26 procedure is based, indicates that the figure of 2 l/p/h was calculated on the basis of the average of flows taking place over a number of night hours. The level of legitimate consumption taking place during the minimum hour is likely to be somewhat lower than this average. This supports the argument that an average deduction from minimum night flow of 2 l/p/h may be excessive for the purpose of calculating leakage. In a number of areas the deduction of two litres from the minimum night flow would have resulted in a negative estimate of legitimate consumption.

In the very much smaller districts used for this exercise there is likely to be a closer correspondence between the minimum observed flow and the level of leakage. This is because the times of minimum nightflow vary significantly between different small groups of properties.

For the present study, the adjustment for domestic night consumption has been made dependent on the minimum night flow evident in each district. Whenever the observed minimum night flow exceeds 2 l/p/h a deduction of 2 l/p/h has been made. In those cases where the minimum night flow falls below 2 l/p/h all of this flow has been treated as consumption. The resulting average deduction made for legitimate night consumption amounts to 1.1 l/p/h.

Daily leakage figures have been calculated from the resultant estimate of night leakage rates using the recommended factor of 20 to make allowance for higher night pressures. The leakage figure calculated for each district based on the results of the June 1984 survey have been applied to the previous November/December 1983 and March 1984 survey results for these periods.

Table 3.2 summarises the results of the metered districts exercise, breaking down the results by Water Service Division. The figures shown in row (A) for each Division include all those observations where no specific problem is known to have occurred. The figures in row (B) exclude all observations for six districts where the results of the survey were considered to be suspect, either because of exceptionally great variation between the readings taken for different survey periods, or because they represented extreme (high or low) outliers when compared with the results for other districts.

The figures in Table 3.2 show marked variation between Divisions in net consumption per capita. Divisional results are however based on a relatively small sample of districts in each case and it is therefore not possible to ascertain whether this variation can be attributed to systematic differences (for example quality of housing stock, tenure patterns etc) between Divisions or to sample variation. Because of this, attention has been concentrated on the results for the Province taken as a whole.

Some information concerning the pattern of seasonal variation is evident from the figures shown in row (C) for each Division. These figures include only those forty districts for which observations were made for all three survey periods. The overall figures for the Province suggest that there may be seasonal variation between winter and summer consumption amounting to approximately 10% of average winter consumption.

In order to take account of seasonal variation equal weight has been given to the June readings and to the average of the two earlier readings as a means of adjusting for seasonal variation. This is shown below based firstly on all observations (rows (A) in Table 3.2) and secondly on all observations excluding outliers (rows (B) in Table 3.2).

(A) OVERALL AVERAGE CONSUMPTION = (0.5 x 127.7) + (0.25 x 120.9) + (0.25 x 126.8) = 125.8 litres/person/day

(B) OVERALL AVERAGE CONSUMPTION = (0.5 x 129.5) + (0.25 x 113.6) + (0.25 x 112.0) = 121.2 litres/person/day

TABLE 3.2

METERED DISTRICTS EXERCISE

SUMMARY OF RESULTS

		Gross Consumption[1] L/Household/Day			Gross Consumption[1] L/Person/Day			Net Consumption[1,2] per Person Adjusted for Leakage L/Person/Day		
		June 1984 Survey	Feb/March 1984 Survey	Nov/Dec 1983 Survey	June 1984 Survey	Feb/March 1984 Survey	Nov/Dec 1983 Survey	June 1984 Survey	Feb/March 1984 Survey	Nov/Dec 1983 Survey
EASTERN DIVISION	A)	431.8	441.8	398.3	142.4	142.0	133.4	127.1	121.0	122.6
	B)	447.6	430.9	371.8	143.9	125.3	121.8	129.4	105.4	110.2
	C)	462.3	449.6	421.2	132.8	129.3	121.4	115.1	111.6	103.7
NORTHERN DIVISION	A)	355.7	343.0	442.2	131.3	128.6	156.4	123.5	118.6	148.7
	B)	359.8	343.0	338.7	135.3	128.6	119.9	124.9	118.6	109.5
	C)	358.3	326.3	335.6	131.2	119.2	121.6	120.2	108.2	110.6
SOUTHERN DIVISION	A)	468.6	380.2	423.6	146.3	121.8	131.6	143.3	120.3	128.9
	B)	468.6	380.2	423.6	146.3	121.8	131.6	143.3	120.3	128.9
	C)	390.1	380.2	324.8	125.3	121.8	104.3	123.7	120.3	102.8
WESTERN DIVISION	A)	403.2	437.7	381.8	118.4	129.4	112.4	113.5	124.5	107.4
	B)	403.2	437.7	381.8	118.4	129.4	112.4	113.5	124.5	107.4
	C)	395.8	434.7	381.8	118.6	130.9	112.4	113.6	125.9	107.4
ALL NORTHERN IRELAND	A)	423.6	418.6	409.0	139.4	136.1	135.1	127.7	120.9	126.8
	B)	436.2	410.5	378.5	140.9	126.0	122.6	129.5	112.1	113.6
	C)	421.4	413.0	384.6	129.3	126.5	117.7	117.1	114.3	105.5

NOTE

(A) Contains all readings where no specific problem is known to have occurred (e.g. mains burst etc.)

(B) Certain readings have been excluded as noted below due to doubts concerning their validity, although no specific problem has been identified.

	District	Period[3]	Reason for Exclusion
EASTERN DIVISION	Broadway Parade	1, 3	High variation in readings
	Trigo Parade	1, 3	Exceptionally high readings, uncertainty re. position of decimal point
	Cawn Street	3	Exceptionally low reading
	Moonstone Street	1, 2	High variation in readings
	Maxwell Park	1, 3	High variation in readings
NORTHERN DIVISION	Cortal Lowry Park	1, 3	High variation in readings, possible meter problem
SOUTHERN DIVISION	None		
WESTERN DIVISION	None		

(C) Includes only districts where readings were taken for all survey periods (ie June 1984, Feb/March 1984, Nov/Dec 1983).

1 All consumption results are weighted by property numbers in each district. This approach eliminates the influence of correlation between household size and average per capita water consumption on estimated average consumption per person.

2 Domestic night consumption allowed for by deducting the lesser of the minimum night flow per property per hour and 2L per property per hour.

3 Period 1 = June 1984
Period 2 = February/March 1984
Period 3 = November/December 1983

The metered districts exercise thus indicates average 1983/84 per capita consumption levels between 121 and 126 litres/day. A figure of 125 litres/person/day has been used to derive base (1981) domestic consumption estimates for the present study. It is considered unlikely that the average per capita consumption in 1981 exceeded this figure for the following reasons:

(a) average consumption in 1981 is likely to have been somewhat lower than in 1983/84 (the survey period) due to consumption growth in the intervening years;

(b) the metered districts survey included a higher proportion of private housing than is evident from the NI Census; reweighting to take account of this would have resulted in an approximately 3% reduction in the average consumption estimate due to the typically higher than average consumption of households in private housing.

Set against these factors is the fact that the night flow figures used to calculate leakage rates were based on Saturday night readings which may be marginally higher than mid-week values. Given the inevitable uncertainty regarding average consumption, it was therefore considered inadvisable to make any deductions to take account of the factors noted above.

3. Estimates of Domestic Water Consumption by Sub-division

Estimates of domestic water consumption by sub-division have been obtained by combining the 125 litres/person/day consumption figure obtained from the metered districts exercise with population estimates obtained from the 1981 Census of Population. It has been assumed that there is no variation in per capita consumption throughout the Province.

It is known that a significant proportion of the Northern Ireland resident population was not enumerated in the 1981 Population Census. Table A2.1 in Appendix 2 gives estimates of non-enumerated population for major population centres in the Province as agreed by the inter-departmental working party established to examine this issue. The figure exceeds 10% in both Belfast and Londonderry local government districts. Table A2.2 shows estimates of non-enumerated population as a percentage of enumerated population for each sub-division.

Overall domestic consumption estimates for 1981 are shown by sub-division in Table 3.3 which also shows estimated population including the allowance for census non-enumeration.

3.1.3 Non-Domestic Consumption

Estimates of non-domestic consumption have been based on metered consumption data for 1981 provided from water charging records. A significant number of non-domestic consumers is known not to be metered and allowance was made for this based on a comparison of the number of meters for each major category of consumer together with comparable figures on the total number of establishments in that category based on the 1981 Census of Employment.

Non-domestic water consumption is highly concentrated in a very small proportion of consumers. The allowance made for consumption by non-metered non-domestic users has been based on the assumption that these did not include such very large consumers. This analysis is described in detail in Volume 2.

A sample survey of non-domestic water use was also carried out in order to investigate the relationships between employment (or other appropriate activity variables) and water consumption in individual establishments. However, the results of this analysis do not provide a reliable basis for water demand estimation due to the very small sample size which could be obtained and to the difficulty of associating individual meters with employment in individual establishments.

Evidence has been presented concerning systematic under-reading of certain trade meters. Tests carried out by Eastern Division in 1979 on 175 Frost meters showed that the 110 which were functioning were under-registering by an average of 5% at full flow conditions. A follow-up investigation carried out in February 1984 showed about 6% under-registration at both half and full flow levels. Under-registration at very low flow levels may be much higher. Tests on 25 Kent meters undertaken in Newry sub-division in 1977 showed an average under-recording of 46% at a flow rate of 6gph (27 l/h), reducing to 10% at 16gph (73 l/h) with negligible under-registration at full flow levels.

TABLE 3.3

BASE YEAR DOMESTIC CONSUMPTION AND POPULATION ESTIMATES BROKEN DOWN BY SUB-DIVISION

	BASE (1981) POPULATION ('000s)	BASE (1981) CONSUMPTION (Ml/d)
EASTERN DIVISION		
Belfast	448	55.95
Downpatrick	156	19.48
Lisburn	122	15.23
Total	725	90.66
NORTHERN DIVISION		
Antrim	86	10.78
Ballymena	118	14.72
Coleraine	83	10.39
Total	287	35.89
SOUTHERN DIVISION		
Armagh	80	9.98
Craigavon	78	9.72
Newry	108	13.47
Total	265	33.17
WESTERN DIVISION		
Enniskillen	58	7.22
Londonderry	117	14.62
Omagh	82	10.30
Total	257	32.13
NORTHERN IRELAND	1535	192.85

It is not possible to assess the full effect of this meter under-registration without additional information concerning:-

(a) the sizing of meters in relation to individual consumption flows;

(b) the proportion of metered consumption taking place at very low flows.

For the purposes of assessing total metered consumption for the present study an addition of 10% has been made to total metered demand estimates. This has been shown separately due to the considerable uncertainty concerning its value. It is recommended that further work be carried out on this question; first to assess the overall impact of under-registration on consumption estimates and second, to assist in the evaluation of meter replacement policies. Total revenue obtained from metered water consumption is of the order of £8 million per annum, suggesting that the loss of revenue may be as much as £800,000 per annum.

3.1.4 Overall Consumption Estimates

Overall estimated consumption for 1981 is shown in Table 3.4 for each sub-division broken down by broad consumer categories. Detailed figures are given in Appendix 4, Table A4.1.

TABLE 3.4

SUMMARY OF BASE YEAR (1981) CONSUMPTION ESTIMATES

SUB-DIVISION	DOMESTIC	NON-DOMESTIC[1]	TOTAL
Belfast	56.0	57.4	113.4
Downpatrick	19 5	12.7	32.2
Lisburn	15.2	5.9	21.1
EASTERN DIVISION	90.7	76.0	166.7
Antrim	10.8	9.3	20.0
Ballymena	14.7	14.2	28.9
Coleraine	10.4	14.8	24.8
NORTHERN DIVISION	35.9	38.3	74.2
Armagh	10.0	11.0	21.0
Craigavon	9.7	17.1	26.8
Newry	13.5	11.4	24.9
SOUTHERN DIVISION	33.2	39.4	72.6
Enniskillen	7.2	7.4	14.6
Londonderry	14.6	12.7	27.3
Omagh	10.3	8.1	18.4
WESTERN DIVISION	32.1	28.3	60.4
ALL NORTHERN IRELAND	191.9	182.2	373.9

Notes:

Includes operational/usage and addition of 10% to take account of estimated metering errors.

Some figures do not add due to rounding.

3.2 DOMESTIC CONSUMPTION FORECASTS

3.2.1 General

Forecasts of growth in domestic consumption have been based on projecting the impact of three key factors:-

(a) growth in population;

(b) improving standards of living;

(c) changing household size.

The latter two factors will tend to result in increases in average per capita consumption, whereas the former has a direct impact on numbers of consumers.

In the following paragraphs each of the above effects is assessed separately. They are then combined to provide indices of overall growth in domestic consumption.

3.2.2 Impact of Population Growth

Projections of population for local government districts have been obtained from DOE Planning. The total projected growth in NI population implied by these figures has been adjusted so as to agree with the range of projections in total population growth supplied by the Policy Planning and Research Unit (PPRU) of the Department of Finance and Personnel. The total of the locally based figures amounted, before adjustment, to some 2.1% less than the PPRU mid forecast for all NI in the year 2000.

The overall growth in population between 1981 and 2000 ranges from a low growth assumption of 4% to a high assumption of 18%. The range of growth assumptions for NI and for each Water Supply Division is shown in Table 3.5. Growth indices by sub-division are shown in Appendix 3.

TABLE 3.5

POPULATION PROJECTIONS BY DIVISION

		Estimated Population in Private Households[1] 1981 ('000s)	Growth Indices 1981	1985	1990	1995	2000
EASTERN DIVISION							
	High			1.028	1.076	1.127	1.127
	Mid	725.3	1.000	1.014	1.037	1.060	1.042
	Low			1.003	1.008	1.023	0.990
NORTHERN DIVISION							
	High			1.031	1.079	1.131	1.225
	Mid	287.1	1.000	1.017	1.039	1.066	1.131
	Low			1.006	1.010	1.025	1.074
SOUTHERN DIVISION							
	High			1.025	1.067	1.115	1.267
	Mid	265.4	1.000	1.011	1.028	1.052	1.170
	Low			1.000	1.000	1.011	1.111
WESTERN DIVISION							
	High			1.030	1.082	1.142	1.214
	Mid	257.0	1.000	1.016	1.042	1.078	1.121
	Low			1.005	1.013	1.035	1.065
ALL NORTHERN IRELAND							
	High			1.028	1.076	1.128	1.184
	Mid	1534.8	1.000	1.014	1.037	1.065	1.094
	Low			1.005	1.008	1.023	1.039

1981 NI Census of Population adjusted for estimated non-enumeration

3.2.3 Impact of Improving Living Standards

There is little direct evidence on the impact of a higher general standard of living on domestic water consumption in Northern Ireland. Increasing personal disposable income and the consequent increase in appliance ownership, combined with new housing development and the renovation of existing properties, can however be expected to lead to a greater use of water by Northern Ireland households.

Average water consumption per capita can be expected to grow in line with increased access to water using appliances and amenities. Projections of the increased ownership of these components of demand have therefore been used to form the basis of the forecast impact of standards of living on domestic consumption.

Table 3.6 shows ownership of water using appliances/amenities in Northern Ireland together with comparable figures for GB. A number of sources have been used to derive these figures namely:-

(a) the main survey of about 2,500 households carried out during the course of this study;
(b) the 1983 NI Continuous Household Survey;
(c) the 1981 NI Census of Population;
(d) the 1982 GB General Household Survey;
(e) studies by the English Water Authorities reported in National Water Council Occasional Technical Paper No. 6, June 1983.

There is a good correspondence between the results of the household survey carried out for this study and the evidence provided by the NI Continuous Household Survey (both 1983). The 1981 Census figures for baths/showers and internal WCs suggest that there has been some growth since 1981 in access to these amenities. Comparison with the General Household Survey however shows that NI households lag behind GB households in ownership of appliances/amenities (by approximately 10 years for baths/showers, 3 years for inside WCs and 8 years for washing machines). This pattern will be more marked in terms of ownership per capita because of the generally larger household size in the Province.

TABLE 3.6

OWNERSHIP OF WATER USING APPLIANCES/AMENITIES

	NI Household Survey (1983)							English RWA Studies			
	Owner Occupied	Public Rented	Other Tenures	NI Average (Weighted by 1981 Census Tenure Figures)	NI Continuous Household Survey (1983)	NI Census of Population (1981)	GB General Household Survey (1981)	South West (1976)	Severn Trent (1977)	Thames (1975)	Anglian (1976)
Percent of households with sole use of											
Bath	94.6	92.7	83.7	92.6	)			95	96	95	96
Shower	37.8	7.3	8.1	22.5	) 93	90.4	98	25	21	24	21
Internal WC	95.3	92.7	82.3	92.8	94	91.1	96	-	-	-	-
Washing Machine	85.7	71.4	41.6	75.1	75	-	79	72	79	61	76
Automatic	61.5	33.1	17.6	45.4			-	27	29	32	32
Other	24.2	38.3	24.0	29.7				45	50	29	44
Hose	-			35.8[1]				44	-	38	44
Sprinkler				4.7[1]				6	6	11	9

Unweighted result from household survey

Figure 3.1 shows the pattern of growth in ownership of water using appliances/amenities in GB evident from General Household Survey statistics. There has been steady growth in every category, although growth in access to baths/showers appears to have levelled off since 1980. It is not clear whether this is attributable to a "saturation effect" or to the impact of economic recession.

The average rate of growth in ownership of these appliances/amenities in GB over this period is summarised below:-

	% p.a. (not compound)
Baths/shower	0.7
Inside WC	1.0
Washing machine	1.3

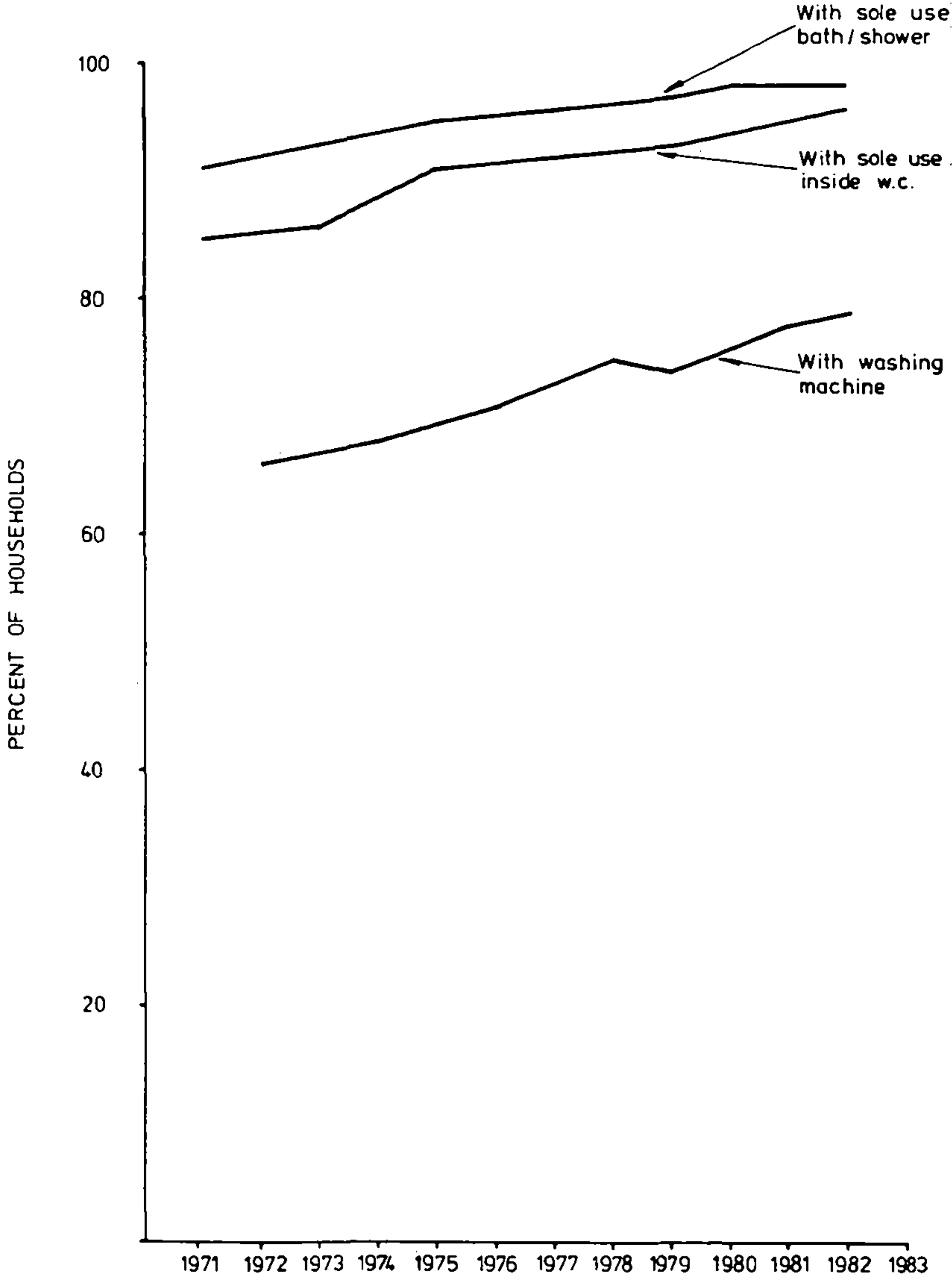
It is reasonable to assume that NI ownership of these items will grow in line with GB experience as standards of living improve. Rates of growth can be expected to decline however as penetration increases (the ownership percentages are defined in terms of the proportion of households with one or more of each item, so that 100% ownership is the maximum possible in every case). Table 3.7 shows assumed high and low projected levels of ownership in NI. (1981 levels have been projected backwards from 1983 data where necessary.)

TABLE 3.7

PROJECTIONS OF OWNERSHIP OF WATER USING APPLIANCES/AMENITIES

Proportion of NI Households Owning Appliance/Amenity (%)

	1981	1985		1990		1995		2000	
		High	Low	High	Low	High	Low	High	Low
Baths/showers	90.4	93	93	96	96	98	98	100	100
Inside WC	91.1	95	95	98	98	100	100	100	100
Washing machines	72.4	78	75	84	78	88	80	91	82
Sprinklers	3.5	6	5	9	6	12	8	15	9



SOURCE. GENERAL HOUSEHOLD SURVEY 1982.

TRENDS IN HOUSEHOLD OWNERSHIP
OF WATER-USING APPLIANCES
IN GREAT BRITAIN

Figure 3.1

In order to assess the impact of increasing appliance ownership on average domestic water consumption it is necessary to weight these figures by the proportion of water consumption attributable to each item. No NI evidence is available concerning this, but the Regional Water Authority studies provide an indication of the appropriate proportions as shown in Table 3.8.

TABLE 3.8

WATER USE BY COMPONENTS

	Average Consumption from RWA Studies (1976/77) l/person/day	Average Ownership[1] (1976/77) %
Baths	22	96
WC	37	92
Washing Machine	12	76
Outside use	3	7[2]
Miscellaneous	37	n/a
	111	

Source - RWA studies or General Household Survey where RWA figures not available.

Garden Sprinklers.

The combination of the high and low ownership projections shown in Table 3.7 with figures from Table 3.8 (used as weights) implies the mid and low average consumption growth indices shown below in Table 3.9. The high projection in this table is based on high growth in appliance ownership combined with the assumption that the rate of use will increase from 1981 to 2000 by 25% for baths/showers (due to greater frequency of use), by 10% for washing machines (due to increased ownership of automatic machines) and by 50% for sprinklers. Miscellaneous consumption has been assumed to grow in proportion to total consumption attributed to components in each case.

TABLE 3.9

IMPACT OF IMPROVING LIVING STANDARDS
(AVERAGE CONSUMPTION GROWTH INDICES)

	1981	1985	1990	1995	2000
High		1.095	1.190	1.276	1.343
Mid	1.000	1.067	1.124	1.171	1.200
Low		1.048	1.095	1.124	1.143

3.2.4 Impact of Falling Household Size

Household size affects water consumption due to economies of scale in water usage. The results of the RWA studies concerning this factor are summarised below in Table 3.10.

TABLE 3.10

DOMESTIC WATER CONSUMPTION FOR DIFFERENT HOUSEHOLD SIZE

	Litres/Person/Day			
Household Size	South West (1976)	Severn Trent (1976)	Thames (1980/81)	Average
1 person	125.9	116.1	136.0	126
2 persons	124.4	117.9	151.0	131
3 persons	118.1	109.0	123.0	117
4 persons	109.9	91.9	116.0	106
5 persons	102.9	96.3	103.0	101
6 persons	97.1	75.2	97.0	90
7+ persons	91.7	68.9	64.0	75

Reduced household size can therefore be expected to result in higher average consumption levels in NI.

There has been a distinct trend towards smaller household size in the Province. Table 3.11 shows movements in persons in each household size band between the 1971 and 1981 population censuses, together with comparative figures for England and Wales.

TABLE 3.11

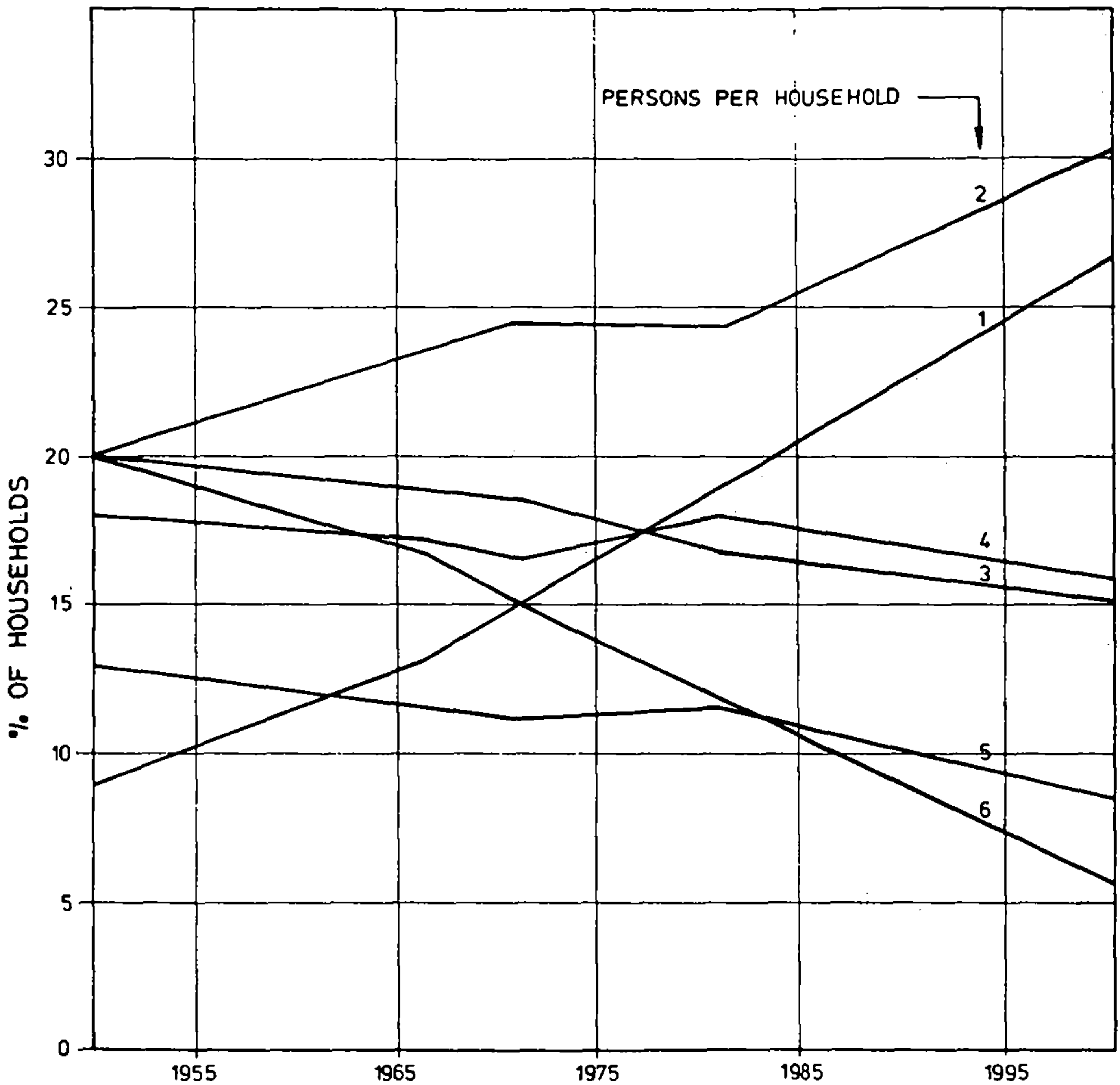
CHANGES IN HOUSEHOLD SIZE

Size Band (Persons)	Northern Ireland 1971 Census %	Northern Ireland 1981 Census %	England and Wales 1981 Census %
	4.3	5.8	8.0
2	14.2	15.6	23.7
3	15.7	15.6	18.8
4	19.1	22.1	26.6
5	15.6	17.1	13.4
6 +	31.1	23.9	9.5
	100	100	100
Overall average household size	3.4	3.2	2.7

It is likely that the size composition of households in Northern Ireland will become increasingly close to that in England and Wales although change will probably be gradual.

Projected household size composition in Northern Ireland has been based on the linear extrapolation of past trends in household size composition in the Province. This is shown diagramatically in Figure 3.2. A range of 25% above and below the central projection of change in household size composition has been assumed to allow for uncertainty. Table 3.12 shows projected household size composition for 1990 and 2000 together with corresponding values for persons by household size band.

The impact on average water consumption of changing household size composition weighted by average consumption by household size from Table 3.12 is shown in Table 3.13.



SOURCE: CENSUS OF POPULATION 1951, 1966, 1971, 1981.

CHANGE OF HOUSEHOLD SIZE
IN NORTHERN IRELAND

Figure 3.2

TABLE 3.12

FORECAST CHANGE IN HOUSEHOLD COMPOSITION

Household Size (Persons)	1981 Census[1]	1990 Low[2]	1990 Mid	1990 High[2]	2000 Low[2]	2000 Mid	2000 High[2]
Households by Household Size Band (%)							
1	18.7	21.3	22.2	26.6	24.3	26.2	28.1
2	24.9	26.8	22.4	28.0	28.9	30.2	31.4
3	16.6	15.8	15.4	15.1	14.8	14.1	13.5
4	17.7	16.8	16.6	16.4	15.9	15.3	14.9
5	10.9	10.1	9.8	9.6	9.2	8.6	8.1
6 +	11.2	9.2	8.5	7.8	6.9	5.5	4.0
Persons by Household Size Band (%)							
1	5.8	7.0	7.5	9.0	8.6	9.2	10.8
2	15.6	17.7	18.5	19.0	20.4	22.3	24.3
3	15.6	15.7	15.6	15.4	15.7	15.6	15.6
4	22.1	22.2	22.4	22.3	22.5	22.6	23.0
5	17.1	16.7	16.5	16.3	16.2	15.9	15.6
6 +	23.9	20.7	19.6	18.1	16.6	13.9	10.6
Implied mean number of persons/ household	3.20	3.03	2.97	2.95	2.83	2.71	2.59

Not adjusted for unenumerated households.

Low: average larger household size

High: average smaller household size.

TABLE 3.13

IMPACT OF CHANGING HOUSEHOLD SIZE COMPOSITION ON DOMESTIC WATER CONSUMPTION

		1981 (Base)	1990	2000
Impact of household	High		1.027	1.059
size (standard of	Mid	1.000	1.020	1.039
living held constant)	Low		1.014	1.033

3.2.5 Forecasts

Forecasts of Domestic Consumption broken down by Division are given in Appendix 4.

3.3 NON-DOMESTIC CONSUMPTION FORECASTS

3.3.1 General

Future non-domestic water consumption in the Province has been forecast in line with projected growth in appropriate activity variables. In all cases common assumptions have been employed for all water supply sub-divisions. The approach adopted for each category of consumer is outlined below. Further detail concerning underlying assumptions is contained in Appendix 5.

3.3.2 Agriculture

Forecast water consumption by agricultural consumers has been projected to grow in line with livestock numbers in the Province. The projected changes in livestock numbers have been weighted by estimates of water consumption based on design standards for agricultural buildings to provide overall water consumption projection factors (shown in Table 3.14).

TABLE 3.14

AGRICULTURE - OVERALL CONSUMPTION GROWTH FACTORS

	1981	1985	1990	1995	2000
High		1,023	1,052	1,081	1,111
Mid	1,000	1,009	1,020	1,030	1,040
Low		0,994	0,988	0,980	0,973

The impact of changes in techniques of farm husbandry has not been included in these forecasts and it is difficult to assess the direction of this effect. It is unlikely that this will have a significant impact on total agricultural demand.

3.3.3 Industrial Consumption

Industrial consumption has been projected to grow in direct proportion with industrial output. This implies an overall unit elasticity of water demand with respect to industrial output. As noted in Appendix 6 such evidence as exists concerning demand elasticities suggests that a lower figure might be appropriate. These projections should therefore be regarded as setting an upper bound for industrial consumption growth assuming the growth in output shown in Appendix 5.

The approach does not take account of differences between sector growth rates or of technological change both of which may have a significant impact on growth in water consumption. It has not proved possible to assess water consumption/activity relationships for individual industry sectors in the Province. This might be facilitated in future by the reclassification of industrial consumers by narrower categories in Water Charges Branch records.

A disaggregated approach, based on forecasting consumption by narrower industry sectors, would however require reliable forecasts of industry sector growth rates. Such forecasts are generally extremely uncertain beyond the short to medium term. In practice, therefore, the simpler approach adopted for the present study is a reasonable one for long-term forecasting.

Analysis of the sensitivity of consumption to different rates of industrial growth has been covered by means of a range of economic growth projections in these forecasts.

3.3.4 Commerce

Consumption in this sector has been projected to grow in direct proportion with forecast employment in private sector service industry. This is based on the view that employment rather than output is likely to determine consumption.

3.3.5 Construction

Consumption has been projected to grow in line with forecast output in this sector.

3.3.6 Other (Public Services)

On the same basis adopted for private sector services, other (mainly public services) consumption has been projected to grow in direct proportion with forecast employment in this sector.

3.3.7 Agricultural Domestic Usage

This has been projected in line with growth in average consumption per capita as indicated in Table 3.5 above. The growth in this category of usage is lower than growth in overall domestic consumption because it does not include the element of increase due to population growth. It has been assumed that there will be no growth in the total population in agricultural households.

3.3.8 Operational Usage

Operational usage has been estimated as approximately 3% of total production. For forecasting purposes it has been assumed that this will grow in line with the total of domestic and non-domestic demand.

3.3.9 Adjustment for Under-registration of Meters

This is shown in the projections as a constant 10% of total metered consumption. In practice it is hoped that improvements in meter accuracy should lead to a reduction in the unmetered quantity although this would not affect overall consumption levels.

3.4 OVERALL CONSUMPTION FORECASTS

Summary forecasts of consumption broken down by Division are shown in Table 3.15. A more detailed breakdown of the forecasts by Division and by category of consumption is given in Appendix 4 Table A4.2.

TABLE 3.15

SUMMARY WATER CONSUMPTION FORECASTS

		Base (1981)	1983	1985	1990	1995	2000
EASTERN DIVISION	High			181.7	205.6	231.1	250.2
	Mid	166.7	171.5	176.3	189.5	203.3	210.3
	Low			171.8	178.9	186.2	187.4
NORTHERN DIVISION	High			80.1	89.3	99.2	111.3
	Mid	74.2	76.1	78.0	82.7	87.7	93.9
	Low			76.3	78.6	81.1	84.7
SOUTHERN DIVISION	High			78.1	86.2	95.5	109.2
	Mid	72.6	74.3	75.9	80.2	85.1	93.1
	Low			74.2	75.9	78.4	83.7
WESTERN DIVISION	High			65.7	73.4	82.9	91.6
	Mid	60.4	62.0	63.8	67.9	72.7	77.3
	Low			62.2	64.4	67.0	69.7
ALL NORTHERN	High			405.6	454.5	508.7	562.3
IRELAND	Mid	373.9	384.0	394.0	420.3	448.7	474.6
	Low			384.5	397.8	412.9	425.5

3.4.1 Comments

Overall forecast consumption growth in the Province varies from 2.2% per annum on the high projection to 0.7% on the low projection with a mid projection of 1.3% per annum. The range of forecasts implies increases in total consumption by the year 2000 of between 14% and 50% of estimated total consumption in 1981.

Domestic consumption is the main component of growth, increasing from an estimated 51% of total base year consumption to 57% of total consumption in 2000 on the high projection. On the low projection domestic consumption growth is relatively more moderate, rising to 55% of the projected total by the year 2000.

The consumption growth rates projected for Northern Ireland may be compared with the growth in total production expected by the English Water Authorities as reported by the National Water Council.

	Water Authorities in England and Wales 1980 - 2000 % p.a. compound growth in production		Northern Ireland Projections 1981 - 2000 % p.a. compound growth in consumption
Highest regional increase	1.9	High projection	2.2
Average regional increase	1.2	Mid projection	1.3
Lowest regional increase	0.65	Low projection	0.7

There is evidently a fairly close correspondence between the Northern Ireland projections emanating from this study and the range of projections reported for the RWAs. However, it should be noted that the RWA figures refer to total production, whereas the NI figures are for consumption only and these are not entirely comparable.

3.5 ELASTICITY OF DEMAND

A discussion of the elasticity of water demand with respect to changes in price and income is contained in Appendix 6.

CHAPTER 4

UNACCOUNTED FOR WATER

4.1 GENERAL

Unaccounted For Water (UFW) comprises the difference between measured treated water production and identified consumption. Records of production are available and detailed assessments have been made of consumption for the base year as described in Chapter 3. Thus it is possible to estimate the total UFW on the basis of these data. The principal origin of UFW is leakage from the pipe network and the direct measurement of this using bulk meters and waste water meter installations has also been carried out. Not surprisingly the two approaches yield different results, partly on account of inaccuracy of meter readings but also because some elements of consumption and/or leakage cannot be correctly identified. Recent work has resulted in refinement of conclusions regarding consumption, as discussed in Chapter 3. This chapter summarizes the leakage assessments and presents balances for water production, consumption and leakage.

4.2 LEAKAGE IN SUPPLY SYSTEMS

Minimum night flows in distribution systems are available from either district meters or wastewater meters for over 80% of the Province by supply. For other areas it was necessary to estimate night flows from measured results for similar areas. Leakage rates have been calculated from minimum night flow data by deducting legitimate night flows based on trade meter readings and an allowance of 2 l/h per property. An equivalent day of 20 hours has been used to allow for diurnal pressure variations. Leakage in supply systems is discussed in detail in Volume 2.

Wastewater meters do not cover the larger pipelines particularly trunk mains in large urban areas. Thus it has been possible only to estimate losses from trunk mains, and the following factors, based on WRC Technical Report TR154, have been used:-

Newer mains	500 l/km/h
Older mains	750 l/km/h

The estimates of leakage rates are given in Table 4.1.

4.3 WATER BALANCES

As indicated above, data are available for

- treated water production
- estimated water consumption
- measured leakage
- estimated trunk main leakage

A summary of these data is presented in Table 4.2.

In view of the uncertainties in the estimates of trunk main leakage only the leakage rates in distribution systems have been used in the assessment of these balances. The table indicates that there are discrepancies between treated water production and the totals of consumptive use and leakage, and these discrepancies are indicated in Table 4.2 as balances. Positive balances indicate that either or both of consumption or leakage are under-estimated. Negative balances indicate the reverse.

These conclusions are, of course, subject to errors, one of which is meter error. Reviews of meter accuracy have been made recently in the Eastern Division from which it was concluded that

(a) Production meters are reasonably accurate (i.e. within a few per cent)

(b) Trade meters tend to under-record and allowance for this has been made in the assessment of metered consumption made in this study.

(c) Wastewater meters are of low accuracy, but without particular bias.

In addition, many of the consumption and leakage estimates are of necessity based on extrapolation from limited data, and are therefore not of a very high order of accuracy. Consequently the smaller balances should not be regarded as very much more than the results of the uncertainties in the estimation of the various components.

It is evident that further detailed work is needed to obtain a better understanding of the reasons for the larger balances.

4.4 NIGHT FLOWS IN BELFAST

In the course of the study, a five week sequence of hourly flows recorded by the Belfast telemetry system during May 1983, was studied in an attempt to measure the minimum night flows in relation to the average daily flow and the recorded wastewater meter flows in the relevant areas.

The minimum reservoir outflows (which did not occur simultaneously for all meters) totalled 135 Ml/d which was about 64% of the average daily flow for the area in 1983 of 211 Ml/d. The total of the relevant waste meter readings was 84 Ml/d.

The difference between the minimum reservoir outflows and the waste meter flows, gives an indication of the consumption by larger consumers with direct connection to the trunk mains plus a measure of trunk main leakage. Both factors should be taken into account when assigning priorities for searching for any trunk main leakage.

It is recommended that this exercise should be repeated at appropriate intervals making use of the latest additions to the telemetry system.

TABLE 4.1

LEAKAGE RATES

Sub-division	Distribution (1) System Ml/d	Trunk (2) Mains Ml/d	Total Ml/d
Belfast	65.2	4.7	69.9
Downpatrick	33.0	1.0	34.0
Lisburn	10.6	0.5	11.11
Eastern Division	108.8	6.2	115.0
Antrim	12.9	1.3	14.2
Ballymena	18.0	1.5	19.5
Coleraine	16.4	1.4	17.8
Northern Division	47.3	4.2	51.5
Armagh	15.0	1.4	16.4
Craigavon	11.3	1.7	13.0
Newry	12.3	1.8	19.1
Southern Division	43.6	4.9	48.5
Enniskillen	12.6	1.1	13.7
Londonderry	23.0	2.1	25.1
Omagh	14.7	1.1	15.8
Western Divison	50.3	4.3	54.6

(1) Based on metering

(2) Estimates only

TABLE 4.2

WATER BALANCES

Rates in Ml/d

Division	Sub Division (1)	(2) Total Production	(3) Estimated Consumption	(4) Leakage**	(5) Balance
EASTERN	Belfast	220.8 *	113.4	65.2	+42.2
	Downpatrick	59.8	32.2	33.0	-5.4
	Lisburn	26.6	21.1	10.6	-5.1
		307.1	166.7	108.8	+31.6
NORTHERN	Antrim	36.6	20.0	12.9	+3.7
	Ballymena	39.2	28.9	18.0	-7.7
	Coleraine	38.0	25.2	16.4	-3.6
		113.9	74.2	47.3	-7.6
SOUTHERN	Armagh	33.3	21.0	15.0	-2.7
	Craigavon	42.8	26.8	11.3	+4.7
	Newry	42.3	24.9	17.3	+0.1
		118.4	72.6	43.6	+2.2
WESTERN	Enniskillen	24.8	14.6	12.6	-2.4
	Londonderry	56.7	27.3	23.0	+6.4
	Omagh	25.1	18.4	14.7	-8.0
		106.5	60.4	50.3	-4.2
TOTAL		645.9	373.9	250.0	+22.0

* Corrected

** Distribution system leakage only - see Table 4.1.

Figures do not add due to rounding.

4.5 FUTURE LEVELS OF UFW

While it has been possible to quantify factors which can be used for projections of consumption it is more difficult to assess the likely changes in UFW. The most relevant data are the trends in water production over recent years. For the period 1973-1983 the trends of annual increases in average daily production for the Divisions are as follows:-

Eastern	2.0% (1)
Northern	3.5%
Southern	3.7%
Western	3.7%

Note (1) Effects of the closing of Courtaulds factory allowed for. The lower value for the Eastern Division is in part due to the implementation since 1976 of more effective waste control.

In view of the proportions of current UFW given earlier in this chapter and identified trends in consumption, it is evident that these changes were not due to increased consumption alone. Thus it must be expected that if UFW is unchecked it will continue to rise and will of course be influenced by the rate of occurrence of leaks, which is unlikely to diminish. For want of better data, it is reasonable to assume for planning purposes that the underlying rate of increase in UFW will be equal to the projected rate of increase in legitimate consumption in the absence of more effective measures for the leakage control.

CHAPTER 5

REDUCTION OF LEAKAGE

5.1 INTRODUCTION

One of the principal conclusions of this study is that the levels of unaccounted for water (UFW), including measured leakage, are higher than is desirable. While acknowledging that these assessments are not precise it is clear that a significant contribution to the efficiency of water supply systems in Northern Ireland would result from the reduction of leakage.

The problems of leakage have been subject to detailed investigation in the UK water industry, particularly in the past decade, and recommended control procedures have been established. These are described in the National Water Council Standing Technical Committee Report No. 26 (1980) to which extensive reference has been made in this report. The general approach, which is equally appropriate in North Ireland, is to follow a logical sequence, as follows:-

(i) measure the magnitude of leakage in the system.

(ii) assess the cost that can be attached to leakage.

(iii) estimate the resources needed and costs arising from relevant leakage control programmes.

(iv) evaluate the most economical plan for leakage control.

(v) provide the necessary resources and implement the leakage control plan in order to assess the magnitudes and locations of leaks.

(vi) repair leakages as necessary.

(vii) monitor performance at regular intervals.

The Department has already taken some action along these lines for Belfast and a report on the Belfast Sub-Division Waste Detection Scheme Leakage Analysis was prepared jointly by Kirk McClure and Morton, McAdam Design and Ferguson & McIlveen, in September 1983. A wider appraisal has been made in the present study, covering the whole of Northern Ireland. The current (1981) levels of measured leakage are discussed in detail in Volume 2, and are summarised in Chapter 4 of this report. The present chapter considers the extent to which measured leakage in distribution systems can be reduced, the associated costs and benefits and also indicates the resources required to ensure that the control of leakage is maintained.

In view of the magnitude of the other elements of UFW in Belfast (i.e. trunk main losses and 'balance') it is necessary that it should be investigated further. Preliminary work referred to in Section 4.4 suggested that a major component may be unidentified leakage and further work is needed to establish its real components. This work should be carried out in a similar manner to the leakage control referred to above, involving:

a. assessment of available information,
b. preliminary tests on trunk mains and/or reservoirs,
c. preparation of a programme of investigation,
d. assessment of the likely costs of such work and the benefits of the resulting UFW reduction,
e. provision of the necessary resources,
f. implementation of investigations to detect and locate leakages,
g. repair as necessary.

However, the initial approach should be to give priority to the reduction of identified leakage for which costs can be estimated.

5.2 LEAKAGE LEVELS

Report No. 26 gives a method for predicting reductions in likely net night flows for various methods of leakage control. The provision of waste metering throughout Northern Ireland is now being implemented and this method of leakage control has been assumed for assessing future net night flows. Leakage rates are assessed in terms of litres per property per hour and total leakage depends on the property counts in each area.

Attainable target leakage levels have been assessed broadly in accordance with the recommendations of Report No. 26, modified as appropriate in the light of local experience and knowledge. These levels are significantly greater than those which would be predicted strictly in accordance with that report, but represent attainable short term objectives.

Net night flows for the base year and target leakage levels for each of the major supply systems are set out in Table 5.1.

TABLE 5.1

NET NIGHT FLOWS

		Net Night Flow (l/prop/hr)	
	No. of Properties	1981	Target
Eastern Division	253 409	23	
Northern Division			
Coleraine/Ballymoney/Moyle	27 548	32	17
Magherafelt/Cookstown	16 858	30	17
Ballymena/Antrim/Larne	43 227	25	13
Southern Division	79 889	29	16
Western Division			
Londonderry/Limavady	30 670	40	17
Strabane/Omagh	21 715	36	19
Fermanagh	17 068	39	22

5.3 COSTS OF LEAKAGE

5.3.1 Method

The general approach is to assess the cost of leakage, and the savings brought about by its reduction, using unit costs of leakage based on two distinct elements,

(a) reduction in annual operating costs, and

(b) deferment of capital expenditure on schemes that would be required to increase water production.

5.3.2 Unit Operating Cost

The reduction in annual operating costs consists of two major elements, the reduction in electricity charges for pumping and the reduction in the quantities of chemicals used for treatment. The operating costs for the main sources have been obtained from each of the Divisions. It is assumed that the cheaper sources would be used as much as possible and the unit operating costs have therefore been taken as those of the most expensive sources.

Calculations of the unit operating costs of leakage for the major supply systems for the base year 1981 are included in Appendix 5.

5.3.3 Unit Capital Cost

The unit capital costs of leakage for the major supply systems are based on the deferment of capital expenditure on schemes which would be required to satisfy future demands. The estimated costs of the schemes have been discounted to the base year of 1981 at the current required rate of return of 5%. In certain of the supply systems the existing yields of the sources are adequate to meet the demands until the end of the century and the unit capital cost of leakage is therefore negligible.

The major systems for which capital costs of leakage have been assessed are described below.

Eastern Division	- Development of new upland sources.
Northern Division	
(a) Coleraine/Ballymoney/Moyle	- Interconnection of the Ballinrees and Altnahinch sources with a pipeline from Ballinrees Treatment Works to Glenlough Reservoir.
(b) Magherafelt/Cookstown	- The reliable yields of the sources should be adequate until at least the end of the century. Therefore, no new scheme is proposed.
(c) Ballymena/Antrim/Larne	- Construction of the Inver Dam and extension of the treatment plant.
Southern Division	- Development of the Camlough Source and extensions of distribution from Castor Bay.
Western Divison	
(a) Londonderry/Limavady	- Improvements to Altnaheglish Reservoir to achieve the original yield.
(b) Strabane/Omagh	- Following the completion of current extensions to sources, the reliable yields should be adequate until at least the end of the century. Therefore no new scheme is proposed.
(c) Fermanagh	- The extension of Killyhevlin Treatment Works.

Whilst the works described above may not necessarily be those works that are eventually carried out, it is expected that works of a similar nature, and having much the same discounted capital cost, would be required to meet future demands.

Calculations of unit capital costs of leakage for a rate of growth in demand of 1% are included in Appendix 7. This rate approximates to the mid level consumption forecasts (see Chapter 3).

5.3.4 Annual Costs of Leakage

The annual cost of leakage is calculated using the formula:-

$$\text{Annual Cost of Leakage } (\pounds/\text{property/year}) = \frac{NNF \times 20 \times 365 \times C}{100{,}000}$$

where NNF is the net night flow in litres per property per hour and C is the unit cost of leakage in pence per cubic metre (see Appendix 7). 20 hours each day are used in place of 24 hours to allow for the effect of pressure variation. This formula applies to both current and target leakage rates.

The resulting annual costs are set out in Table 5.2.

5.4 COST OF LEAKAGE CONTROL

The effort required to ensure effective leakage control is substantial, and it is essential that in future the necessary resources are continuously provided if target leakage levels are to be achieved and maintained.

By 1981 preliminary stages of active waste control had been implemented only in Eastern Division and the annual cost of leakage control in the other Divisions was effectively nil. The cost of leakage control in Eastern Division for that year can be calculated using information contained in the Division's 1981 annual report. From this the detection element of waste control for the Division is estimated to be £114 000.

TABLE 5.2

ANNUAL COSTS OF LEAKAGE

Supply System	No. of Properties	Unit Cost of Leakage	Current (1981) Levels		Target Levels	
			NNF	Total Annual Cost of Leakage	NNF	Total Annual Cost of Leakage
		p/m^3	l/p/h	£	l/p/h	£
Eastern Division	253,409	7.6	23	3,234,000	13	1,828,000
Coleraine/Ballymoney/Moyle	27,548	5.5	32	354,000	17	188,000
Ballymena/Antrim/Lorne	43,227	5.6	25	442,000	13	230,000
Magherafelt/Cookstown	16,858	4.7	30	174,000	17	98,000
Northern Division	87,633			970,000		516,000
Southern Division	79,889	7.7	29	1,302,000	16	718,000
Londonderry/Limavady	30,620	4.5	40	402,000	17	171,000
Strabane/Omagh	21,715	3.9	36	223,000	19	117,000
Fermanagh	17,068	5.3	39	258,000	22	145,000
Western Division	69,453			883,000		433,000

For the future, the practices recommended in NWC Report No. 26 should be followed and the costs of the required inspection, testing and monitoring work are discussed in detail in Appendix 8. The total annual costs of achieving the target leakage levels for each Division are summarised in Table 5.3.

TABLE 5.3

ANNUAL COSTS OF LEAKAGE CONTROL

Division	Annual Cost
	£
Eastern	298 000
Northern	111 000
Southern	101 000
Western	104 000
	614 000

5.5 COST OF REPAIRS

The rate of occurrence of new leaks in a pipe network will remain substantially constant, following the introduction of a new leakage control policy, since none of the factors affecting it will have changed. Thus the cost of repairing leaks, will also be substantially constant and can be ignored in comparative assessments, provided leakage is identified speedily. However, where there are arrears of repair work to be made up, which can only be carried out after more intensive leakage detection has been implemented; the cost of those arrears should be allowed for.

For the purpose of this study it has been assumed that the cost of repairing the arrears would be amortized using a payback period of 20 years at an interest rate of 5% per annum. It is not possible to make accurate estimates of total cost of these repairs, but the annual amounts are not great in relation to other costs.

The annual charges are estimated to be £40 000 for the Eastern Division and £16 000 for each of the other Divisions and have to be added to the cost of leakage control. They represent a total expenditure of about £1.1 million spread over a period of 3 to 4 years, i.e. about £315 000 per annum.

5.6 ANNUAL BENEFITS

The annual costs of leakage and leakage control for the base year and for the target leakage levels for each of the Divisions, together with the annual savings in cost are summarised in Table 5.4. This table also shows the annual savings in water which would result if the target levels were attained.

The conclusions to be drawn from this table are:

(a) The total net gain to the Department resulting from an active and effective leakage control policy would be of the order of £2.3 million annually.

(b) In order to achieve these savings the necessary resources must be increased requiring the total expenditure of an estimated £929,000 per annum. This amount covers the total resources required for leakage detection together with the staff employed on the repair of the backlog of leakages. Some of this expenditure is already being incurred by the Water Service in existing leakage reduction programmes.

(c) The potential total savings of water due to reduction of measured leakage in the distribution network is about 120 Ml/d.

5.7 PRACTICAL ASPECTS

In Northern Ireland present leakage levels are between 23 and 40 l/p/h. In England target leakage levels are generally fixed in accordance with NWC Report No. 26, but original leakage levels are much lower and in general property densities are higher than in Northern Ireland. To take account of these and other factors target levels for Northern Ireland have been assessed conservatively in the range 13 to 22 l/p/h. The target levels could well be improved upon as they represent practicable rather than ultimately obtainable figures in the Northern Ireland context.

5.8 RESOURCES FOR LEAKAGE CONTROL

Estimates have been made of the long-term resources required to provide effective active leakage control, based on manpower requirements, etc. that have been experienced in Northern Ireland in this work.

The resources required are the equivalent of 68 industrial and supervisory staff working on the monitoring and detection of leakage. In accordance with the recommendations of NWC Report No. 26, these allocations do not include the resources required to repair leaks. At present approximately 64 full time equivalent staff are employed on leakage detection and repair. About 42 of these are employed on leakage detection activities. Thus there is a requirement for an additional 26 permanent staff for leakage detection work over and above the present complement.

More intensive effort on leakage control would result in a temporary backlog of leakage repairs. Preliminary estimates indicate that an additional 25 staff would be required for a period of three or four years to reduce this backlog and the estimates of cost of the additional staff have been included in the costs of leakage control. Therefore, in the initial stages the total number of staff that would be directly involved on leakage control would be of the order of 93 persons, not including about 22 staff currently employed in leakage repair work.

In order for leakage control to be effective, it is essential that the further resources set out above are made available, both for the long term control programmes and in the shorter term to attend to the backlog of leakages.

In addition to the staff requirements outlined, the Water Service has identified a need for 10 extra staff, mainly for data collection work.

TABLE 5.4

ANNUAL BENEFITS

Division	Base Year (1981) Conditions: Annual Cost of Leakage	Base Year (1981) Conditions: Annual Cost of Leakage Control	Base Year (1981) Conditions: Total	Leakage Control Targets: Annual Cost of Leakage	Leakage Control Targets: Annual Cost* of Leakage Control	Leakage Control Targets: Total	Saving in Cost	Saving In Water
	£	£	£	£	£	£	£	Ml/d
Eastern	3,234,000	114,000	3,348,000	1,828,000	338,000	2,166,000	1,182,000	51
Northern	970,000		970,000	516,000	127,000	643,000	327,000	23
Southern	1,302,000		1,302,000	718,000	117,000	835,000	467,000	21
Western	883,000	0	883,000	433,000	120,000	553,000	330,000	27
TOTALS		114,000			702,000		2,306,000	122

* Includes an equivalent annual cost of £88,000 for staff required for the repair of backlog of leakages. The actual expenditure for such staff during the first 3 to 4 years will amount to about £315,000 per annum, giving a total of about £929,000 for each of those years.

5.9 RECOMMENDATIONS

In view of the conclusions regarding the benefits of leakage reduction it is clear that the necessary programmes should be prepared and executed. We therefore recommend that a determined and sustained drive to reduce leakage should be initiated and pursued as a matter of the highest priority and importance. To this end it is vital that,

(a) the necessary financial resources should be made available.

(b) staff working on leakage control should be reviewed, their numbers brought up to the levels required and suitable training provided.

(c) leakage control programmes as outlined in this report should be planned and executed.

(d) effective leakage control should form part of the regular routine of operational work in order to maintain satisfactory control.

(e) monitoring of leakage rates should be kept closely under review.

CHAPTER 6

PLANNING CRITERIA FOR WATER SUPPLY

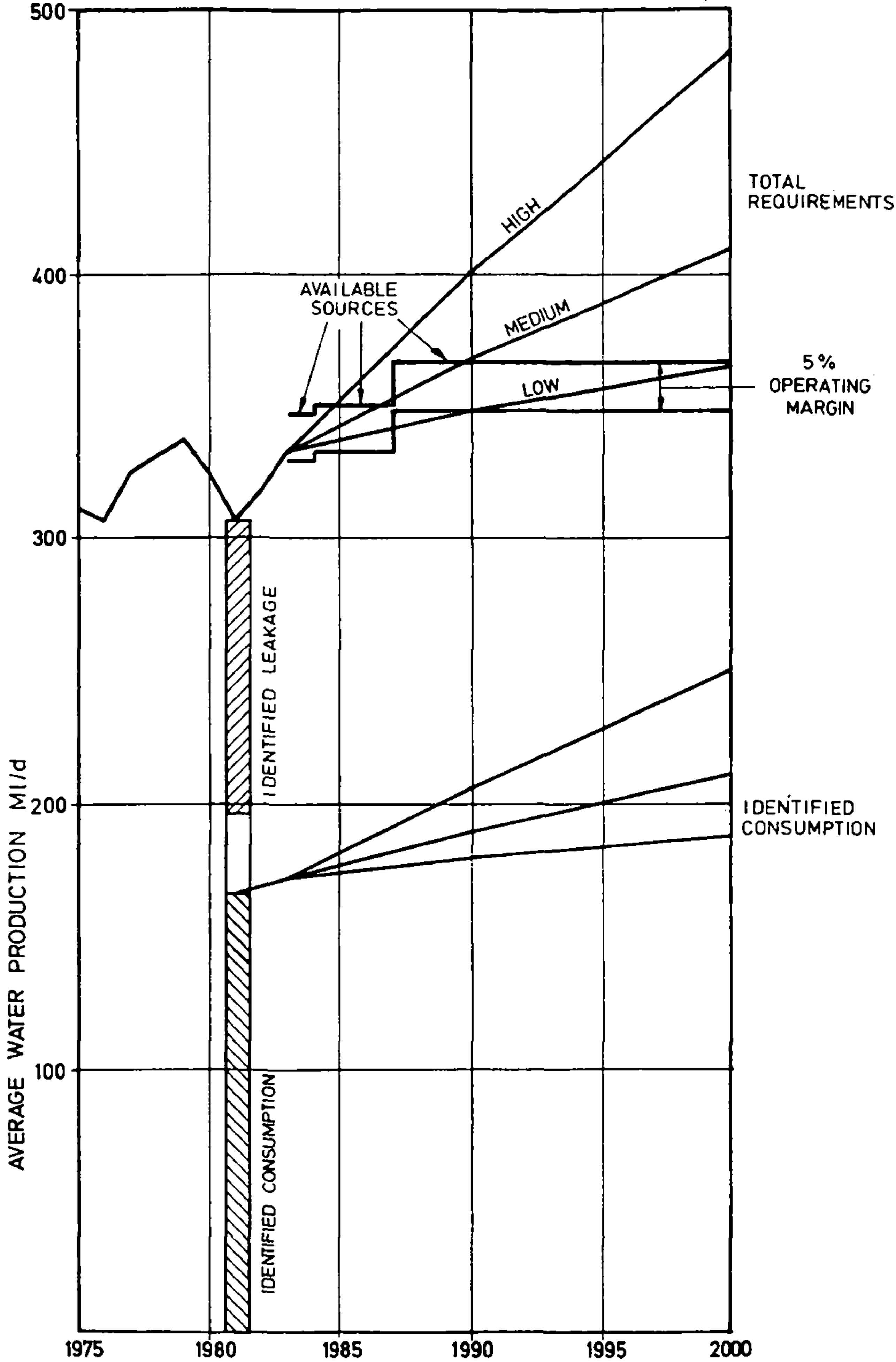
6.1 INTRODUCTION

The terms of reference for this study require that a strategy should be developed for cost effective management of the water supply/demand balance to the year 2000. They also call for conclusions to be drawn about the need for a new source to serve the Eastern Area of the Province. Thus a long term plan is required, covering the next 15 to 20 years which identifies water requirements during this period and offers an effective and economical approach to meeting them.

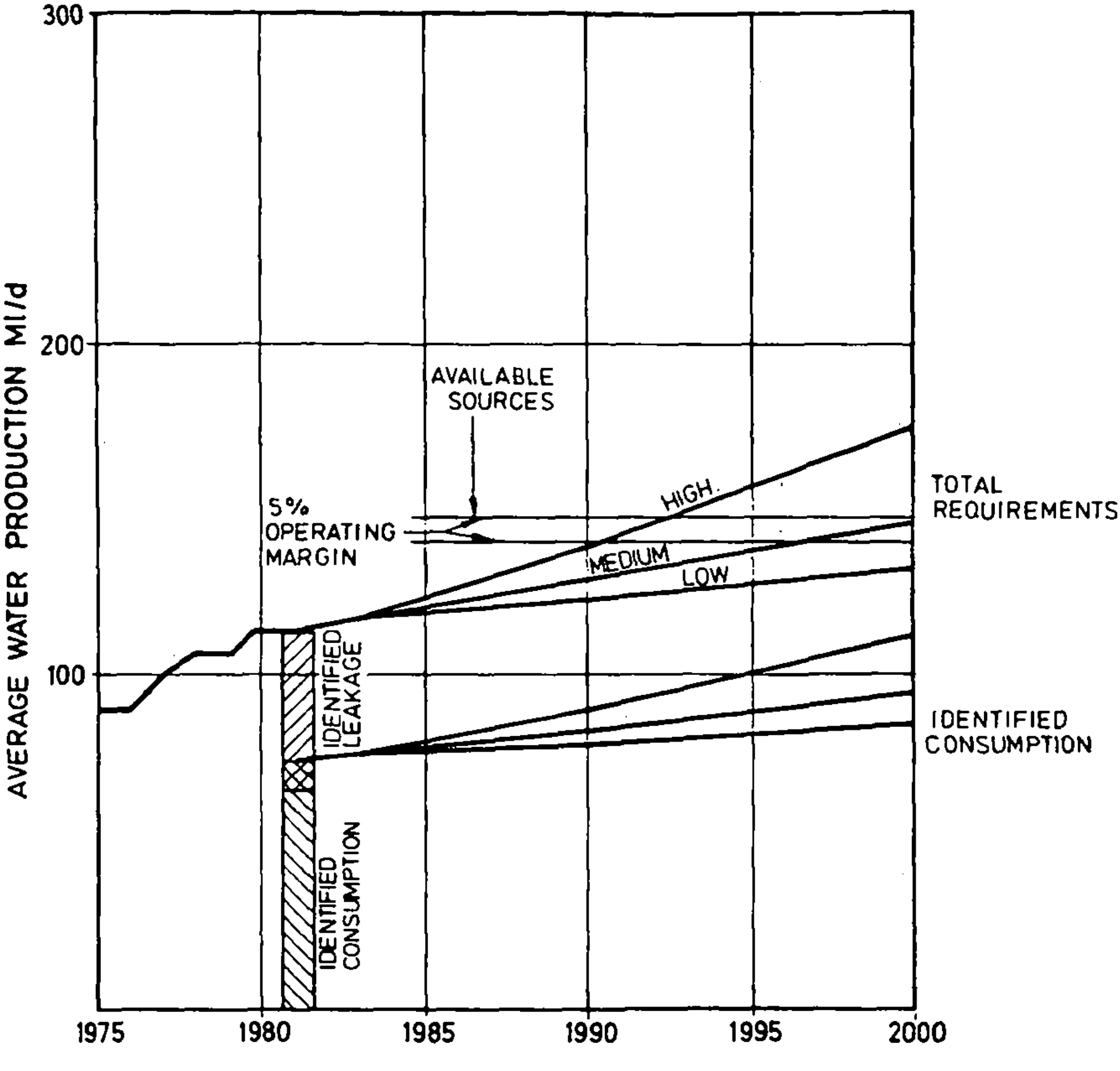
The timing of the introduction of new sources depends not only on the rate at which demand increases but also upon the success of demand management policies (leakage reduction, effects of water regulations, public awareness, etc.) and this chapter examines these and other factors which affect the planning of water supply developments.

6.2 TREATED WATER REQUIREMENTS

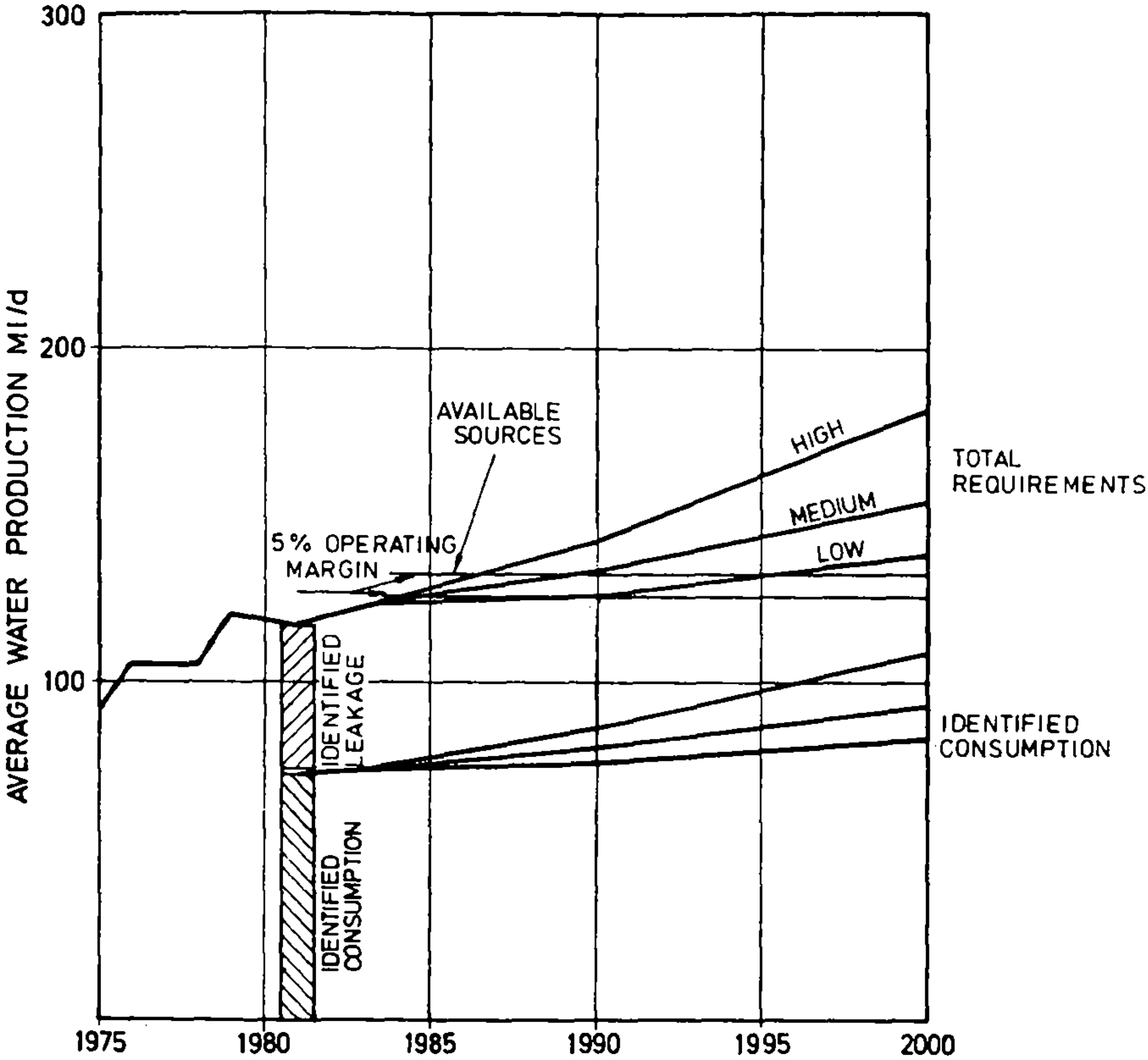
A basic objective of water supply planning is that, subject to certain considerations which are discussed later in this chapter, all future treated water requirements should be met. For this purpose forecasts have been made of future consumption levels as described in Chapter 3. However, the total requirements comprise both actual consumption and UFW. Unless UFW is controlled it will continue to grow and in Chapter 4 it was suggested that it was reasonable to expect that its uncontrolled growth rate would be similar to that for consumption. Thus forecasts of total treated water requirements including UFW to the year 2000 have been made on this basis for each Division, using the high, mid and low rates of growth discussed in Chapter 3. These are shown in Figures 6.1, 6.2, 6.3 and 6.4 on which the recorded production figures from 1975 to 1983 and the currently available water sources which were described in Section 2.3 are also plotted. These diagrams are based on the assumption



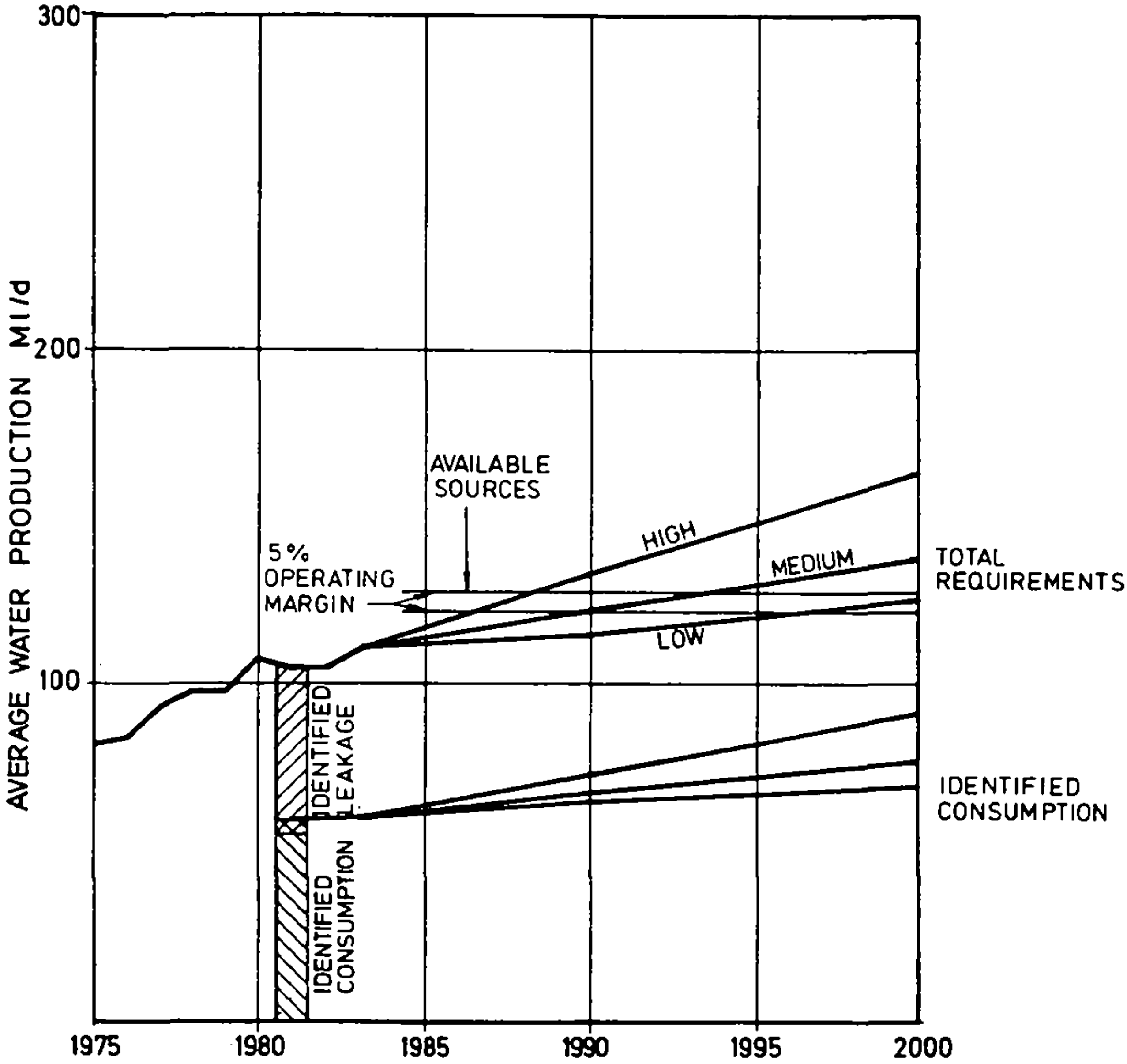
PRODUCTION FORECASTS WITHOUT LEAKAGE REDUCTION
EASTERN DIVISION
Figure 6.1



PRODUCTION FORECASTS WITHOUT LEAKAGE REDUCTION
NORTHERN DIVISION
Figure 6.2



PRODUCTION FORECASTS WITHOUT LEAKAGE REDUCTION
SOUTHERN DIVISION
Figure 6.3



PRODUCTION FORECASTS WITHOUT LEAKAGE REDUCTION
WESTERN DIVISION
Figure 6.4

that within each Division there are no restrictions in transferring supplies from all sources to consumers. However, owing to the limitations of the systems, this may not be possible in all cases.

6.3 OUTPUT FROM SOURCES

In assessing the effective capacities of sources it is necessary to make allowances for several requirements over and above treated water production. These needs are discussed below and are allowed for in assessing the limitations of existing and proposed new sources.

6.3.1 Process Water

Supplies are needed in treatment plants for washwater, sand washing, etc. which have to be provided from the source. For Lough Neagh plants this water is readily available, but for upland sources it must be deducted from reliable yields.

6.3.2 Compensation Water

In some catchments minimum compensation flows or prescribed flows must be maintained and these must also be deducted from the reliable yields. These quantities have been allowed for in the yields given in Section 2.3 of this report.

6.3.3 Operating Margins

This study is addressed to the timing at which new sources are needed, a matter influenced largely by the rate of increase of water demand. However it is necessary to introduce an operating margin into the equation between projected demand and the yields of available sources as a safety factor to allow for uncertainties, on the demand side of the equation, of the kinds discussed below.

(a) Short term fluctuations of demand. It is difficult to put a reliable estimate on such fluctuations, but it is possible to consider variations about the trend of total production in Eastern Division from available records. The general increase in the annual average rate of water supplied was about 1.5% per annum from 1974 to 1982 and within this period the maximum variations were about 6% above the general trend line in 1979 and about 6% below it in 1981. Events in this period included the closing of a large textile factory, Courtaulds, and these changes should therefore be regarded as extreme.

(b) Seasonal variation in water demand. These are significant in many UK water undertakings, where peak weekly averages commonly exceed annual averages by over 10%, usually in the summer. Available monthly figures for the Eastern Division for 1974 to 1982 show that monthly averages exceed annual averages by 3 to 6%. Peak months occur generally in the winter and are probably associated with the increased incidence of pipe bursts that commonly occur in cold weather. These particular peak variations are small and tend to arise when upland reservoirs are filling and are therefore unlikely to be important. However, in years when winter conditions are not so severe, summer peaks occur. These peaks are more evident at sub-divisional level and are particularly important where supplies are taken from upland catchments in which the reservoir capacities are limited. In such cases, if upland storage is allocated to meet peaks, there could be significant reductions in the volumes available for balancing stream flow and, consequently, in the reliable yields.

(c) Emergency situations involving loss of water downstream of source or treatment works. In general such situations are short lived and, although the water lost from the system has to be made good, the total quantities involved are likely to be relatively small.

Whilst matters of the kind referred to above need to be taken into account it would be unrealistic to expect a water undertaking to be able to meet all short term fluctuations in demand without regard to the costs involved. The critical period with which a study of this kind is concerned lies within the period of a few years when the basic projection of water demand lies close to the reliable yield of the then available resources. Fluctuations of demand above the basic projection could then present significant supply difficulties and it has been considered prudent to allow a minimum operating margin of 5% of water production (i.e. about 10% of identified current water consumption) to cover demand uncertainties in those critical years.

However, operating experience in particular circumstances, such as those described in (b) above for catchments having small reservoirs, may indicate that a rather larger margin should be adopted for some supply systems.

6.4 LEVEL OF SERVICE TO CONSUMERS

The imposition of rota cuts is the only practicable policy available to the Water Service in controlling consumption with virtually immediate effects. The acceptable frequency of such cuts should not, on average, be more often than once in twenty years.

In Volume 2 of this report the effects of imposing restrictions on the output of the Silent Valley source are discussed. These involve a 20% cut in source output when the reservoir level reached 25% full. The conclusions indicate that the imposition of rationing on the scale envisaged does not in fact allow a significant increase in effective reliable yield of this source above the more conventional 1 in 50 year failure level. Further, the order of accuracy of the figure is likely to exceed this increase and also the application of rationing rules would not be very precise. It must therefore be concluded that rationing of this nature offers no real advantage in resource planning for Northern Ireland and it is recommended that the slightly more conservative, and more conventional, reliable yields of sources based on 1 in 50 year failure should be adopted for planning purposes.

While the above conclusions are based on Silent Valley, where the reservoir capacity is 44% of ARV, the effects of rationing in catchments having proportionally much smaller reservoir capacities are likely to be more significant. However, in these catchments the yields are influenced to a greater extent by the physical characteristics of the catchment and the estimates of yields are thus less reliable, based as they are on regional yield/storage curves. Thus it is considered that the 1 in 50 year failure criterion should be used for all upland catchments.

Nevertheless, the use of rationing remains in the armoury of demand management as practised generally in the UK and is available for use in the more extreme drought conditions.

Thus the recommended level of service is that the consumer should receive reliable supplies within the current pattern of demand and that significant reductions in supply should not be expected at frequencies exceeding once in fifty years.

The current pattern of demand is, of course, influenced by the type and quality of water fittings which are in use and by the extent of ownership of appliances to those able to afford them. Future growth in the use of such appliances has been taken into account in preparing the estimates of water demand, but it has not been practicable to anticipate the effects which might be produced by a revision of the current Water Regulations. These correspond to the Water Byelaws in GB and it is likely that new Model Byelaws will become available during 1984. As currently drafted the Model looks to the more effective use of water in such apparatus as WCs, urinals and washing machines, but significant effects on water consumption could not be anticipated for many years. Nevertheless, the imminence of the new Model presents long term opportunities for influencing the growth in water users' legitimate demands.

6.5 LEAKAGE CONTROL

While consumer demand is expected to increase, the level of total water requirements in the next few years will depend to a large extent on the success achieved in leakage reduction. Thus for planning purposes it is necessary to consider a range of options, both for consumption forecasts and UFW reduction. For the latter the primary options are as follows:-

(a) In the worst case if the necessary resources to make significant reductions in the present levels of leakage are not provided to the Water Service, these will continue to increase in line with consumption.

(b) Leakage reduction programmes in wastewater meter districts (i.e. generally in distribution networks) will achieve their target of 13 l/p/h as discussed in Chapter 5. It is assumed that a period of ten years would be practicable for this work. Thereafter leakage would be controlled at the target leakage levels.

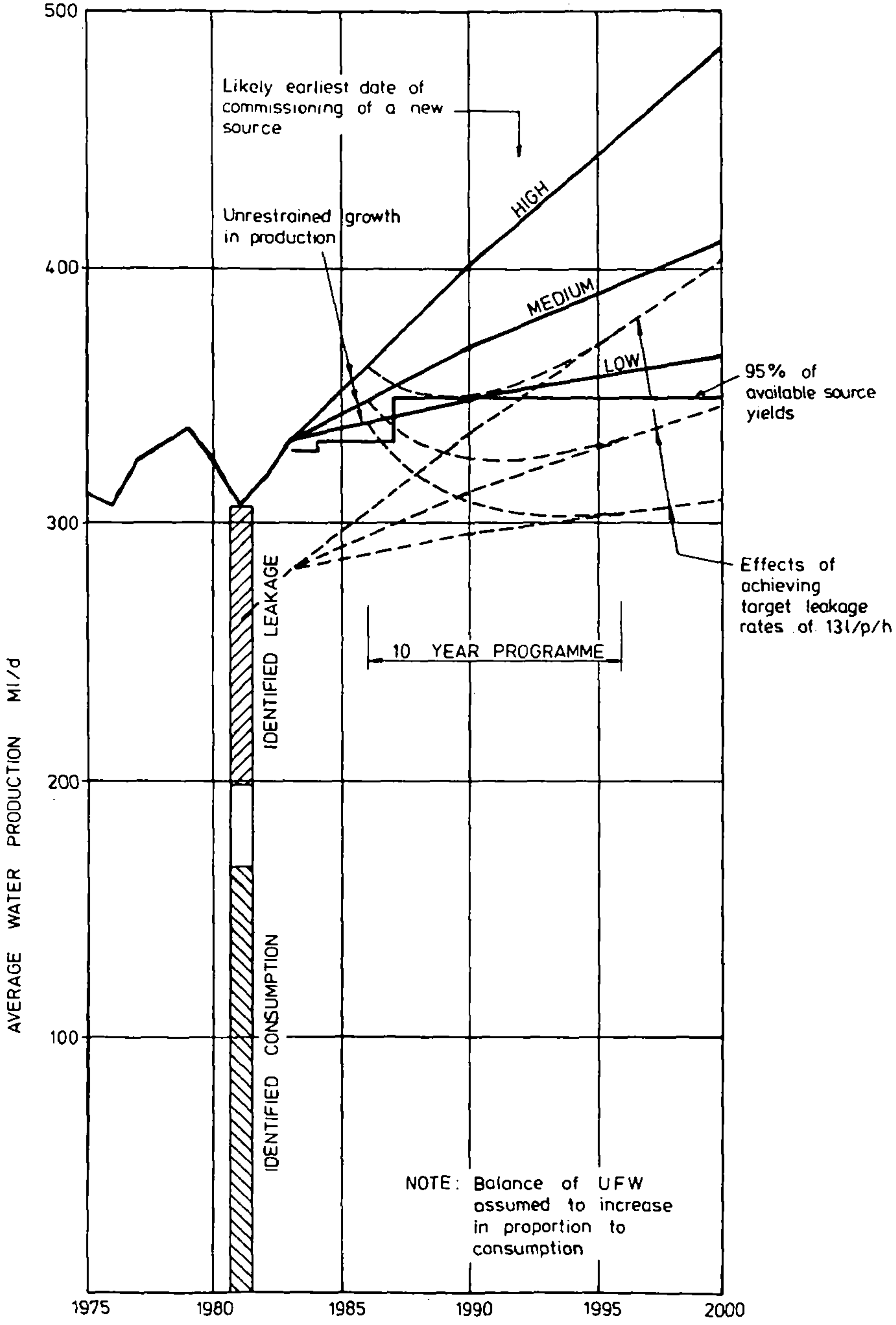
(c) Total UFW (where this exceeds measured leakage) is reduced to acceptable levels. For practical purposes, on the basis that this is largely leakage, a proportional reduction equal to that for (b) above would appear to be a reasonable first approximation.

The spectrum of total water requirements to be considered thus comprises a range of consumption forecasts superimposed on a range of UFW levels. This is illustrated in Fig. 6.5 which shows options (a) and (b) above for the whole of the Eastern Division, and, allowing time for the recruitment and training of the necessary staff, assumes that effective leakage control can be implemented in 1986. This diagram must be taken as illustrative only, as the results of leakage control work cannot be accurately forecast.

The benefits of pressure reduction have been demonstrated in the report on Leakage Analysis dated September 1983 which concluded that some 1.2 Ml/d could be saved in certain limited areas of Belfast. This may offer further significant contributions to UFW reduction in other areas where it is shown to be practicable.

6.6 DEVELOPMENT PROGRAMMES

The next chapter discusses the possibilities for development of further sources and the evaluation of the most economical options. As indicated in earlier sections of this chapter it is not possible to forecast with precision the dates when new sources will be needed,



POSSIBLE EFFECTS OF LEAKAGE REDUCTION PROGRAMMES
EASTERN DIVISION
Figure 6.5

primarily due to uncertainty regarding the implementation of effective UFW reduction programmes. To overcome this problem, particularly for the Eastern Area, the approach adopted has been to determine optimum strategies for a range of demand growth patterns. This is described in more detail in Chapter 7.

In planning for development a most important factor which must be borne in mind is the long lead time required to bring in a new source. Experience has shown that it takes about seven to eight years to deal with the various stages of investigation, design, public inquiry, tendering, construction, etc.

It has been demonstrated that, given adequate resources, there is good reason to anticipate that significant leakage reduction can be achieved. If such reductions can, in fact, be secured they would be highly cost effective and would defer the need to introduce new sources for several years. It must be recognised, however, that leakage reductions may not be achieved either in the time scale, or in the physical quantities, necessary to enable the introduction of new sources to be deferred. It is essential therefore that there should be an alternative, other than the introduction of water restrictions over a period of several years, which can be taken up if leakage reduction is inadequate.

It is recommended that preparations should proceed immediately, so as to be concurrent with the leakage reduction measures, for the identification, design, and promotion of new sources. Only by the early and vigorous implementation of the conclusions of the September 1983 report on Leakage Analysis in Belfast will the opportunity arise for securing, in the next two or three years, sufficient results to give reasonably reliable guidance on the further improvements that could be achieved and sustained in the longer term. During that two or three years preparatory work on the optimum source development for the Eastern Area ought to proceed to the maximum extent possible and this would include outline design of the preferred scheme and preparation of the documentation needed for a public inquiry. Otherwise, in the event of it being shown that leakage cannot be brought under adequate control in practice, consumers will be exposed to the effects arising from vital work preliminary to the promotion of a new source not having been completed. In that event the introduction of sustained water restrictions will need to be contemplated in the period before a new source can be approved and constructed.

It is also necessary to consider the possibility that adequate resources for effective leakage reduction will not become available. In that case not only would consumer demand increase but leakage levels would also continue to rise. The rate of growth of total production requirements is difficult to assess but it is unlikely to be less than that for identified consumption alone. In these circumstances it would be essential for the necessary steps to be taken without delay for the early development of a new source for the Eastern Area in order to minimise the occurrence of lengthy periods of restrictions of supplies. In addition to the preliminary work referred to earlier, it would be necessary to proceed to public inquiry, detailed design and construction of the required works.

CHAPTER 7

APPRAISAL OF PROJECTS

7.1 INTRODUCTION

The intention of this aspect of the report is to identify the best new source of water for the Eastern Area and to study the cost effectiveness of interconnection of existing sources to provide savings in operating and capital costs for the whole of Northern Ireland. Outside Eastern Area, the identification of new sources is not part of this report but nevertheless the alternative to interconnection of existing sources is usually the development of a new source (or augmentation of an existing one). In general such new sources have already been identified by the Water Service and their consultants, in various feasibility studies and reports.

The conclusions of such studies and reports have been taken as valid. Where these conclusions have been varied, it has generally been in the matter of scale rather than philosophy.

The projects appropriate for consideration in this report have previously been identified and are discussed further in the following sections:-

- 7.2 Eastern Division - New source
- 7.3 Ballymena/Antrim/Larne - New source
- 7.4 Coleraine/Ballymoney/Moyle - Interconnection of Altnahinch and Ballinrees
- 7.5 South Division - New source
- 7.6 Strabane/Omagh - Interconnection of Lough Fingrean with River Derg.
- 7.7 Fermanagh - Interconnection of Killyhevlin with Altaveedan.

Work is undoubtedly required in the Londonderry/Limavady area, to cope with the deterioration of Altnaheglish dam, and is under consideration by other consultants: pending their report, further comment cannot usefully be made. Likewise an interconnection pipeline in the Magherafelt/Cookstown area has already been defined and programmed.

The technique used for the comparison of options has, in the first instance, been the derivation of a long-term unit cost of water, expressed in pence/m^3. This takes into account capital and operating costs of the new scheme and any savings to be made in not operating more expensive existing sources, when overall surplus capacity permits.

It should be noted that the appraisal of projects is on the basis of engineering economics only. Other factors, such as environmental, social, legal, and water quality aspects, and land costs are not within the scope of this report.

It has been taken that costs will remain constant in real terms at mid 1983 levels, except for electricity which is assumed to increase by 1.9 per cent per year in real terms. The unit cost of water is sensitive to the following factors:

(i) rate of increase in demand;
(ii) discount rate used;
(iii) time of introduction of the new source (reflecting real increases in the cost of electricity).

Uncertainty over the effectiveness of leakage reduction programmes prevents accurate estimation of the timing of introduction of new sources until such programmes have been established and operating for some time. Consequently for the purpose of identifying the next source to be developed, it has been assumed that the next source will be required when the call on sources made up of identified demand plus an operating margin plus an economically attainable quantity of leakage equals the reliable yield of existing sources. Thereafter the call on sources is assumed to increase by a fixed percentage per year from a base of the current reliable yield.

The effect of the rate of increase of production requirements after introduction of the new source has been studied by using rates of 0.5, 1.0 and 1.5 per cent per year. Within this range the choice of new source can vary; for higher growth rates, checks have been made to show that whilst larger capacities may be indicated, the source for the first-in scheme remains the same. The band of growth is consistent with the forecasts discussed earlier in this report.

Where the new source is small in relation to the demand which it is supplying, analysis has concentrated on 1.0 per cent annual growth. For larger schemes the unit cost is calculated for the three rates of growth. Particular note is taken of those schemes whose sensitivity to growth rates is small.

7.2 EASTERN DIVISION

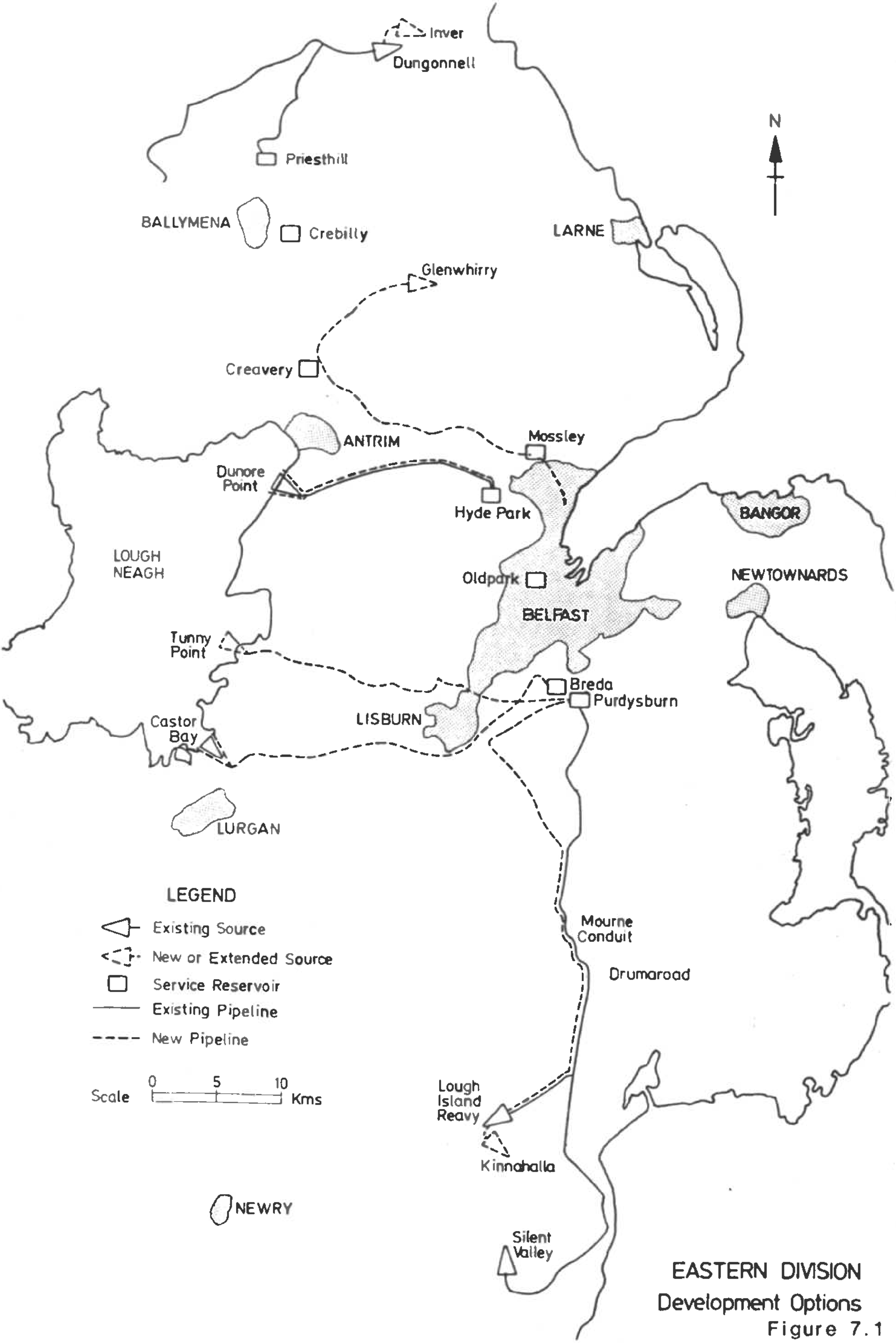
7.2.1 Alternative Schemes

Four major schemes have been considered for the next major source for Belfast: their locations are shown in Fig. 7.1. The first two schemes outlined below have been derived by re-examination of earlier proposals by others and the latter two have been developed in the course of this study.

The comparison of schemes was initially confined to the costs associated with producing and delivering water to the existing reservoirs and trunk mains around Belfast, taking into account a proposed Cross Town Main previously identified by the Water Service as necessary for north-south transfers. Because this approach tended to favour unduly those schemes situated to the north of Belfast, more detailed consideration has been given to the sizing of all the new major trunk mains in order to provide water at the locations where it is most likely to be required in the future. These considerations have been allowed for in the following review of schemes.

Glenwhirry (GW)

This proposed upland reservoir to the north of Belfast would entail a dam of up to 30 m height, would flood an area of up to 400 ha and, by development of a number of catchwaters, yield up to 180 Ml/d. Full treatment works would be provided in the vicinity of the dam from which a 30 km pipeline would deliver supplies to a new reservoir at Mossley at an elevation of 122 m, just north of Belfast. From Mossley a pipeline would lead down to Old Park initially and thereafter on to Breda Reservoir. Ferguson and McIlveen's report on this source proposed that reservoirs of 40,000 Ml and 44,000 Ml with capacities of 140 Ml/d and 175 Ml/d respectively could be built.



EASTERN DIVISION
Development Options
Figure 7.1

In this report, by utilisation of slightly smaller reservoirs and by postponement of any decision to utilise the more expensive catchwaters, slightly smaller yields have been considered, namely 110 Ml/d and 140 Ml/d.

The capital cost of these two developments have been calculated as follows:-

For 110 Ml/d: £ 28,723,000

For 140 Ml/d: £ 34,822,000

For the larger size of reservoir some eight properties would be inundated along with 400 ha of land which is predominantly upland bog and rough grassland much of which is already liable to frequent flooding. Further detailed consideration of this site is likely to confirm the view that an even smaller reservoir of around 17,000 Ml, flooding 260 ha and only three properties could yield around 85 Ml/d without significant increase in the unit cost of water; however a good gravity supply would have been underdeveloped.

Ferguson and McIlven's preliminary report identified compensation water requirements of 21.5 Ml/d. If there were a requirement for this to be, say, doubled, it could be achieved by increasing the height of the dam, for the smaller schemes, by about 2 to 3m at a cost of up to £1.5 million, which would effectively increase the unit cost of water by about 4%.

Tunny Point

This new proposed source has been sited to abstract Lough Neagh water at a point where the water is likely to give least treatment problems and to deliver it after treatment to Purdysburn Reservoir (elevation 96.0 m) to the south of Belfast. A land take of 40 ha of good agricultural land beside Lough Neagh would be required. Accordingly, previous studies have also looked at siting the treatment works on land already owned by the Water Service at Stonyford but with the same abstraction and ultimate delivery point. This second scheme was shown to be less expensive than the first, but the difference was predominantly attributable to the lower cost of service reservoir storage, an item which has not been considered in the current economic comparisons because it is common to all schemes. Accordingly the original scheme for treatment by the lough is the one considered in this study.

Dunore Point

Augmentation of the existing abstraction, treatment and distribution facilities at this Lough Neagh site would make use of many facilities already available at this site and hence reduce capital and operating costs. Duplication of the pipeline with cross connections to the existing pipeline would give a significant security benefit and permit repairs whilst maintaining a high proportion of the output. The drawback of this scheme is that it delivers by pumping to the comparatively high elevation of 135.6 m at Hyde Park Reservoir. In addition there are now only restricted routes for major trunk mains into the city from Hyde Park. This latter point would have to be considered in great detail before recommending implementation of this scheme.

Castor Bay

Castor Bay is currently the third largest water supply in Northern Ireland and predominantly supplies the Southern Division. A scheme has been proposed which takes advantage of existing facilities. This scheme involves extension to the existing treatment works and delivers to the south of the city, where further water is most likely to be required, at the comparatively low elevation of Breda Reservoir (elev. 67.0 m), but with a connection to Old Park Reservoir (elev. 58,2 m) in the centre of the city, as the initial point of delivery. The water requirements at this elevation which are not already provided by Woodburn are approximately 110 Ml/d. If greater quantities are provided from this new source, they would have to be repumped to higher elevation.

The capacity of the existing treatment works at Castor Bay is known to be adversely affected by algal bloom, far more so than at Dunore Point. No major scheme can be recommended for this site until a solution to this problem is found. Either the plant must be down rated, the method of treatment varied or the intake moved to a better site, and the relevant costs taken into account.

A further option, based on an alternative intake, would involve locating a new treatment works closer to the intake. Such a scheme would require a longer delivery pipeline, the advantages of flexibility between Southern and Eastern Divisions would be lost and administration costs would increase.

7.2.2 Capital Costs of Schemes

For the gravity schemes the yield usually defines the capacity of all components of the scheme including the size of pipeline. By contrast in a pumped supply, the choice of pipeline diameter will depend also on the capital and operating costs.

For the three pumped schemes analysis of the economical capacity of the pipelines has been carried out for each scheme using the expected electricity prices. This indicated that the economic velocity of water at full capacity is much lower than in most of the existing major schemes. This is of particular significance for Dunore where a second pipeline would allow sharing of the combined output.

The costs of the four major schemes at differing capacities is given in Table 7.1, and more details are tabulated in Appendix 9.

TABLE 7.1

COSTS AND YIELDS OF POSSIBLE NEW MAJOR SOURCES

Scheme		Yield (Ml/d)	Capital Cost £ x 10^3	Annual Operating Cost at full Capacity £/Ml/d
Glenwhirry	GW	110	28,723	5,995
	GW	140	34,822	5,879
Tunny Point	TP	65	18,366	10,847
	TP	110	26,987	10,178
	TP	140	32,359	9,924
Dunore Point	DP	40	15,197	9,155
	DP	65	21,042	9,017
	DP	110	28,729	9,083
Castor Bay	CB	65	19,289	6,238
	CB	110	28,708	5,216
	CB	140	34,530	5,117

7.2.3 Operating Costs

For schemes requiring a new treatment works, a fixed annual charge has been allowed to cover attendance and management. Other costs vary in proportion to production. For the upland sources these costs are mainly purchase of chemicals for treatment plants. For the Lough Neagh sources, where slow sand filters are used electricity for pumping is by far the most significant variable cost.

Because of the high pumping head and high power costs of the existing Dunore Scheme, any other proposed scheme should be operated at full capacity from the start of its life, with the output of Dunore cut back to the minimum necessary to meet demand. This will result in the maximum reduction in operating costs.

Consideration has been given to the possibility of introducing a new source solely to reduce electricity costs at Dunore. In a typical case of introducing a Glenwhirry scheme one year earlier than needed, the effect is as follows:-

	£
Increase in net present value (NPV) of capital costs	+1,273,000
NPV of net increase in non-electrical operating costs for one extra year	+396,000
NPV of net savings in electrical costs for one extra year	-876,000
Total Increase in NPV of costs	+793,000

It is concluded that currently it is uneconomic to introduce a new scheme solely to reduce operating costs of the most expensive existing scheme. However, if electricity prices continue to rise at 1.9 percent annually, in real terms, in 35 years time this will no longer be the case.

Consideration has also been given to the effects of the phased introduction of treatment works and pumping plant and it can be shown that there is no advantage in such phasing for any new scheme since the costs are more than offset by savings at Dunore. This conclusion introduces the possibility of providing enough water to permit the Mourne Conduit to be closed for repairs and provides an alternative to the complete replacement of that conduit.

7.2.4 Mourne Conduit

The Mourne Conduit is now over 90 years old and the possibility of its refurbishment must be considered in conjunction with the introduction of a new source. Already the replacement of the first third of the conduit has been undertaken on the grounds that structural strength, reduction in capacity and leakage had approached unacceptable levels and the conditions in the remaining two thirds are likely to be similar. Such work has assumed that the conduit's two tunnel sections at Donard and Carryduff, which would be difficult to replace, are in satisfactory condition and need no significant work.

The need to refurbish the triplicated pipeline sections of the conduit provides little choice of method since there would appear to be no viable long term alternative to replacing the oldest pipeline. This can be done by laying a new pipeline (1000 mm diameter) alongside the old, rapidly cross-connecting them and then abandoning the oldest pipeline.

For the open channel sections of the conduit, there is the possibility of working inside the conduit to effect its repair or relining, the latter being a longer term solution. Relining, incorporating an increase in the structural strength of the conduit, would be likely to reduce its capacity by up to one third (some 40-50 M/ld). This loss would have to be recovered by a new pipeline (minimum diameter 900 mm): however complete replacement (1400 mm) would appear cheaper than relining plus the smaller pipeline, (£313/m against £200 + £170/m).

The temporary works required to maintain supplies along the route of the conduit, whilst working inside the conduit, would add significant costs to those of the permanent works in some cases.

Three possible solutions are available for the section of conduit from between Donard and Carryduff tunnels and preliminary estimates are:

A Permanent Replacement. (£ 8,524,000)

B Temporary Bypass and Repair (£ 5,681,000) with later Replacement (£ 8,524,000)

C Temporary Alternative Supplies and Repair (£ 7,326,000), with later Replacement (£ 8,524,000)

Solutions B and C would involve purchase of pipe for the pipeline sections, but laid initially in parallel with the open channel sections whilst repair work was carried out inside: upon completion the pipeline would be relaid in parallel with the pipeline section. Solution B requires the installation of in-line booster pumps to maintain the full output from Silent Valley. Solution C requires relatively small quantities for supplies on the route of the conduit, and alternative supplies from a large new source with pumps and pipeline to provide water from Breda Reservoir to Purdysburn Reservoir and associated operating costs.

It can be seen that Solution A is the most economical unless the repair work, which would be confined to the inside of the conduit, can postpone the necessity for carrying out the structural strengthening for at least 20 years.

In view of the limited knowledge of the remaining useful life of the conduit, it is considered prudent to accept that the permanent replacement (Solution A) is the preferred method of securing supplies from the Silent Valley. This decision makes possible the further development of the Lough Island Reavy source at the earliest time because it is possible to build in capacity for the extra supplies. The decision also means that any major new source does not have to be large enough to supply the equivalent yield of Silent Valley whilst the conduit is closed down.

7.2.5 Lough Island Reavy

At a smaller scale than the foregoing major schemes, Lough Island Reavy offers an attractive possibility. The current yield of the existing reservoir, quoted as 18 Ml/d, could be increased by three alternative developments:-

L(A): development of a dam and a reservoir on the Spelga River and of further catchwaters to supply both the new and existing Lough Island Reavy Reservoirs, to give an extra yield of 65 Ml/d;

L(B): development of all the same catchwaters as in L(A) but without the new reservoir, to give an extra yield of 40 Ml/d;

L(C): development of further catchwaters adjacent to Lough Island Reavy, to give an extra yield of 17 Ml/d.

All three developments have been costed on the basis that full treatment works would be provided for the indicated capacity, but no allowance has been made for the costs of providing similar treatment facilities for the existing 18 Ml/d of yield. The location of such treatment works can either be beside Lough Island Reavy or at Drumaroad at the north end of the Newcastle Syphons, as discussed in more detail in the report, Siting of Water Treatment Works, January 1980, by Messrs. Ferguson & McIlveen. In either case, the capital costs for delivery of treated water at Drumaroad are considered to be the same and for the three schemes are as follows:

L(A)	£ 17,426,000
L(B)	£ 9,678,000
L(C)	£ 3,371,000

For further details of capital and operation costs, see Appendix 9.

For delivery of this increased yield to Belfast, it can be shown that a separate pipeline is uneconomical and that advantage should be taken of the need to carry out refurbishment of the Mourne Conduit, as considered in more detail in Section 7.2.4, by combining the two projects. It has been assumed that for the smallest scheme the yield can be accommodated in a slightly larger diameter replacement of the Mourne Conduit in the 20 km section from Drumaroad to the Carryduff Tunnel at the time when it is required to be replaced. For the two larger capacities it has been assumed that the Carryduff Tunnel would have insufficient capacity to transfer all water to the terminal reservoir at Purdysburn and an additional pipeline would be needed. On the basis that the replacement of the Mourne Conduit between Drumaroad and Carryduff Tunnel to maintain existing yields is necessary and would cost £6,196,000, the capital cost of transfer of the increased yield to Purdysburn is estimated to be as follows:

Total Cost of transmission system		Cost of Replacement Section		Effective Cost
L(A) £ 10,805,000	-	£ 6,196,000	=	£ 4,609,000
L(B) £ 9,983,000	-	£ 6,196,000	=	£ 3,787,000
L(C) £ 6,579,000	-	£ 6,196,000	=	£ 383,000

The costs of this scheme are given in Table 7.2.

TABLE 7.2

COSTS AND YIELDS OF LOUGH ISLAND REAVY EXPANSION

Scheme	Yield	Capital Costs £ x 10^3	Annual Operating Costs at full Capacity £/Ml/d
L(A)	65	22,035	4,833
L(B)	40	13,465	5,370
L(C)	17	3,753	5,458

Sequential development can be carried out from L(C) to L(B) to L(A), but this would result in slight increases in costs.

The economical development of this source is entirely dependent upon action being taken to carry out permanent refurbishment of the Mourne Conduit. If this policy is not adopted the development of the Lough Island Reavy source is no longer attractive.

7.2.6 Comparison of Schemes

A comparison has been made of all of the foregoing schemes sized on the basis of the yields of the available gravity sources.

To find an initial ranking of schemes of each capacity, the average cost of water produced at the full capacity of each was calculated and ranked accordingly in Table 7.3.

TABLE 7.3

RANKING OF EASTERN AREA SCHEMES
(assuming real increase in cost of electricity)
(p/m^3 of new water produced at full capacity)

Capacity Ml/d:-	17	40	65	110	140
Rank					
1	L(C) 5.1	L(B) 6.9	L(A) 6.5	GW 5.8	GW 5.5
2		CB 7.9	CB 6.8	CB 5.9	CB 5.9
3		DP 8.6	DP 7.4	DP 6.8	TP 7.0
4			TP 8.4	TP 7.4	

where L(A), L(B). and L(C) = Lough Island Reavy

GW = Glenwhirry

CB = Castor Bay

DP = Dunore Point

TP = Tunny Point

In view of the above rankings, further consideration of the Tunny Point and Dunore Point schemes was considered to be unnecessary.

As the above figures are for continuous operation at the rated capacities of the schemes, they do not take account of the under-utilization that will occur during the earlier years following commissioning. Sequences of development options were therefore developed to cater for 20 years of growth at 0.5, 1.0 and 1.5 percent per year increase in production and the resulting unit costs of new supplies of water were calculated and are as shown in Appendix 10. Table A.10.1 and A.10.2 give the unit costs for the first scheme commencing operation in 1992 and 2002 respectively.

Of the major schemes, the most economical would be the development of Glenwhirry at a capacity around 110 Ml/d, which becomes more attractive with increase of electrical costs. However, the advantage of this scheme over one of similar capacity at Castor Bay is very small particularly at the higher rates of growth. As a consequence secondary factors have to be considered. These include:

a. land acquisition
b. compensation water requirements at Glenwhirry
c. the problems due to algal bloom which affect the output of treatment works using Lough Neagh as a source.

In this last case the difficulties of treating Castor Bay water have to be fully investigated. Possible solutions could include moving the intake and treatment works to a more favourable location, whilst retaining the same concept of a pipeline to the low level reservoirs in Belfast. Against this solution are the following factors:-

(i) the delivery pipeline would be longer;
(ii) further common facilities would have to be provided;
(iii) supervision and management costs would have to be duplicated;
(iv) the benefits of a single source to cater for the growth in demand of both Eastern and Southern Divisions would be lost;
(v) there might be other water quality problems on the east side of Lough Neagh if quarrying were to develop in that area.

It is therefore necessary that the solution of treatment problems must be overcome on the Castor Bay site and it should be noted that similar problems have been reduced at Dunore Point. Action is being taken to reduce the output of nutrients into Lough Neagh from sewage treatment plants, to limit algal growths and this is expected to be effective. If treatment problems can be proved to be manageable at reasonable cost, then the effect of the two other major factors of land acquisition and compensation water (which tend to raise the cost of the impounding scheme) will be such as to make the Castor Bay scheme more attractive than the Glenwhirry scheme.

At a smaller scale, provided that funds are allocated for the renovation of the Mourne Conduit, the additional capital costs needed to provide for a further 17 Ml/d from Lough Island Reavy (L(C)) are proportionally small. This is therefore an attractive scheme. The larger Lough Island Reavy schemes (L(A) and L(B)) would require new routes for pipelines to Belfast and would therefore be much less economical. However further tests are currently being conducted on the capacity of the Mourne Conduit which may reveal that the extra yield from some of the additional catchwaters considered for the intermediate development (L(B)) can be carried in the replacement pipeline along the existing route of the conduit.

7.2.6 Sensitivity to the Cost of Electricity

As a test of the sensitivity of the unit cost of water to the cost of electricity, the whole of the above exercise has been repeated using constant electricity prices. The ranking of individual schemes is given in Table 7.4 and the rankings of various sequences of schemes are given in Appendix 10, Table A.10.3.

TABLE 7.4

RANKING OF EASTERN AREA SCHEMES
(constant electricity costs)
(p/m^3 of new water produced at full capacity)

	Scheme Capacity (Ml/d)				
Rank	17	40	65	110	140
	L(C) 4.9	L(B) 6.7	CB 6.2	CB 5.6	CB 5.3
2		DP 7.6	L(A) 6.5	GW 5.7	GW 5.5
3			DP 6.9	DP 6.4	TP 6.3
4			TP 7.8	TP 6.6	

These tables indicate that with constant electricity costs Castor Bay is slightly more economical than Glenwhirry, although the small development at Lough Island Reavy remains the most attractive economically.

7.2.7 Bangor Reservoirs

The six Bangor reservoirs in the north of the Downpatrick sub-division lie between Bangor and Newtonards in close proximity and involve five separate water treatment plants, some of which are in need of renewal. These sources have in recent years provided outputs of 10-11 Ml/d, well in excess of their reliable yields, because these sources have alternative supplies available from the Mourne Conduit in times of emergency. Rationalisation of these sources has to be considered along one of the following lines:-

Abandonment of these sources and reliance on the Mourne Conduit for all supplies.

b. Collection of the raw water from all the reservoirs at one or two sites for treatment in renovated works.

Renovation of the existing works in their present mode.

Solution a, which could in practice only be implemented after the provision of a major new source for Belfast, would place an additional call on the new source and bring forward the date of yet another new source. The analysis for the Eastern Area as a whole has suggested that most of the extra water which can economically be developed at Lough Island Reavy can be transmitted into Belfast provided that the replacement of the Mourne Conduit up to the Carryduff Tunnel is provided with adequate capacity. There is therefore little water that can specifically be reserved for Downpatrick sub-division; such quantities as are available can better be utilised further south in support of even smaller sources at such places as Killough, Tannaghmore and Lough Money. Therefore it is advisable to preserve all existing sources if at all possible, whilst minimising further capital and operational expenditure.

Solution b would call for the delivery by gravity of the raw water output of Holywood Reservoir to Creightons Green Reservoir and the combined output to Ballysallagh Upper Reservoir; the output of Conlig Upper and Lower Reservoirs would be pumped to Ballysallagh Lower Reservoir. The two adjacent treatment works at Ballysallagh could then be renovated and expanded to cope with the yields. Increased distribution mains would then be required to distribute the water.

Solution c implies an acceptance of the existing situation with persistence of extensive fixed operating costs and the extra capital costs of at least four of the treatment works.

In considering the relative merits of these three solutions it would appear uneconomical to discard such a significant source of 10 Ml/d capacity in an area which is likely to continue to experience above average rates of growth. Hence Solution a is considered to be unrealistic. For a comparison between Solutions b and c the cost of diversion pipelines, (approx £500,000), is less than the extra costs of renovation of treatment works at several sites and the higher operation charges. However the costs of developing alternative supplies of treated water to reservoirs directly supplied from the diverted sources requires further investigation and is considered to be beyond the scope of the present study. However it appears that such a investigation would be worthwhile.

7.3 BALLYMENA/ANTRIM/LARNE

Although interconnected with Eastern Division by virtue of its common source at Dunore Point, this area, shown in Figure 7.1, can in part be considered separately. Owing to their low storage ratios, difficulty has been experienced in operating the Dungonnell, Quolie and Killylane reservoirs close to their theoretical yields. Consideration has been given to increasing the storage at Dungonnell and alternatively the extension of the pipeline bringing Lough Neagh water from outside Antrim to outside Ballymena.

Ferguson & McIlveen (June 1982) reported on the Dungonnell - Inver Augmentation, and compared the costs of raising the existing dam with the costs of constructing a second dam on the adjacent Inver River which already feeds the existing reservoir through catchwaters. From the report it can be inferred that for optimum utilisation of resources the second dam is a more economical solution. The original scheme was built with this possibility in mind and the outlet pipeline from the treatment works was sized accordingly at a stated 21.5 Ml/d. In addition there is a pumped outlet of 2.5 Ml/d delivering to the north-east coastal strip. Anticipated yields and unit costs of water are shown in Table 7.5, for various sizes of new reservoir. Being a small source serving a large area, different rates of growth make negligible difference to the unit cost of water.

The unit cost of water for increasing sizes of reservoir is shown to be decreasing. However the cost of extra distribution pipework in excess of that already installed, would render the larger schemes less economical. Subject to hydraulic check of the main outlet pipeline, it would appear that the optimum scheme is one fully utilising all existing outlet pipelines i.e. with an increased yield of some 11.4 Ml/d from a reservoir of 1660 Ml net capacity, costing an estimated £3.2 million.

TABLE 7.5

COST OF WATER FROM INVER DAM

Reservoirs		Net Reliable Yield [1] (Ml/d)	Unit Cost of New Water (p/m^3) at Works
Dungonnell (Ml)	Inver (Ml)		
950	-	12.6	N/A
950	500	17.7	6.56
950	1 000	20.6	5.74
950	1 500	23.2	5.39
950	2 000	25.5	5.21
950	2,500	27.4	5.09
950	3,000	29.1	5.02
950	3,500	30.4	4.99

[1] Net of 3% washwater.

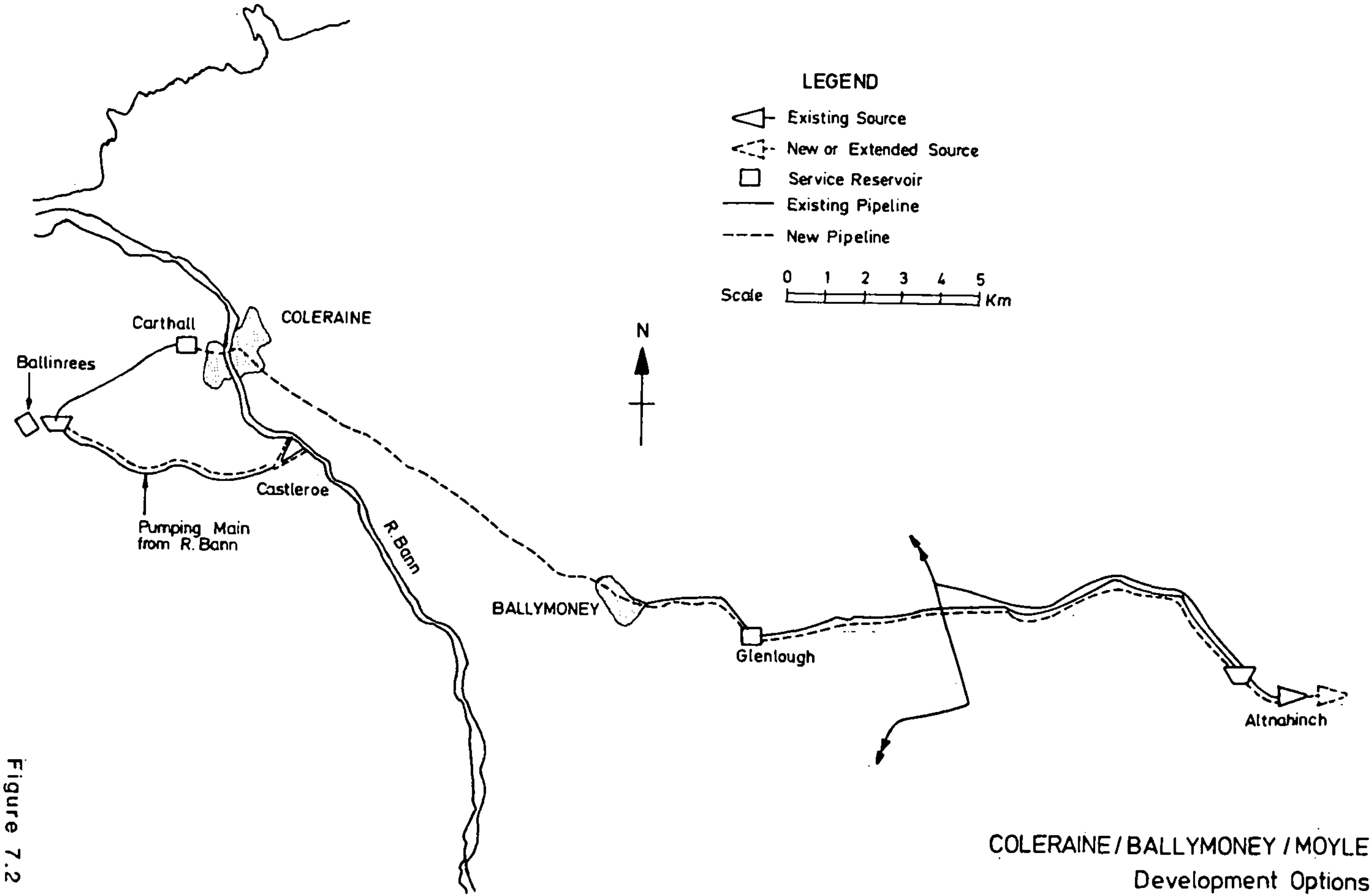
Consideration has also to be given to the utilisation of this enhanced production. Currently the interconnection of Ballymena to Antrim and hence to the Eastern Division is limited. In the past consideration has been given to extending the Dunore supplies to the north to provide additional water to Ballymena, by building a pipeline from close to Creavery Reservoir to Crebilly Reservoir outside Ballymena. This solution was considered to be cheaper than extending the Dungonnell reservoir and its treatment works, but it fails to provide extra resources. However if the pipeline is seen in a dual capacity of firstly providing supplies northwards and thereafter supplying the excess resources of Dungonnell/Inver southwards, its construction can be justified and add little to the unit costs of water. A 400 mm diameter pipeline to carry up to 10 Ml/d is considered to be appropriate and will cost £600,000 initially and a further £300,000 for extension when the dam is completed.

This scheme has a lower unit cost than any of the equivalent schemes in the Belfast Area. Its construction would permit a temporary allocation of more of the Dunore resource to Belfast. It is therefore considered to be the most favourable new source in the Eastern Area, and should be first in any development programme, even though of small size. It has been noted that work is being carried out to permit water available at Lough Mourne in Eastern Division to be pumped to Larne in the east of this area.

This development of Inver dam and its pipeline should be able to assist Belfast to the extent of around 2 years increase in demand based on past experience, but account would have to be taken of the time needed for its promotion and construction.

7.4 COLERAINE/BALLYMONEY/MOYLE

In this area, shown on Figure 7.2, the Altnahinch reservoir suffers from a low storage ratio and consequently difficulty is experienced in operating this source close to its theoretical reliable yield. However for some months of most years additional water is available, but would require the construction of further treatment works and a new pipeline down to Ballymoney and onwards to Coleraine in order to utilise the water.



COLERAINE / BALLYMONEY / MOYLE
Development Options

Figure 7.2

This proposal would not improve the reliable yield of the source, but would reduce the pumping currently required to supply Coleraine. It is understood that a proposal has been made to build a second dam upstream of the Altnahinch dam, but unfortunately details of such a dam are not available. It has been assumed that it is worthy of future further consideration as a source.

At Coleraine some relatively minor expenditure on raw water pumping plant and later on treatment works would provide all the components of that scheme with similar capacity.

Investigations to find the optimum development pattern reveals the following:

(i) construction of an interconnecting pipeline between Altnahinch and Ballinrees sources cannot be justified on the grounds of savings in operational costs alone;

(ii) when the Altnahinch supply needs augmentation, the most economical solution so far identified is to connect it to the Ballinrees system by a pipeline from Ballinrees treatment works via Carthall Reservoir in Coleraine to Glenlough Reservoir outside Ballymoney.

(iii) Augmentation of the Ballinrees works to the extent of matching the pumping and treatment capacity to that of the pipeline is more economical than extending the Altnahinch supply.

(iv) When further resources are needed, it is likely that upland sources will be more economical than river abstraction. The construction of a second dam at Altnahinch would provide the most economical source of this type so far identified. Prior construction of its treatment works and outlet pipeline would be economical but not essential. The extent of spare capacity in the Altnahinch treatment works and outlet pipeline is not known precisely and would have to be checked before sizing the augmentation of these two items.

From the Regional Storage/Yield relationship, the reliable yield of Altnahinch after allowance for compensation water (3.21 Ml/d) and washwater (0.3 Ml/d) is 11.0 Ml/d. Additional storage of 1360 ml, would increase this yield to 17.6 Ml/d. Prior to construction, optimum sizing would have to be undertaken. In order to allow for optimum utilization of wet weather flow, the treatment works and outlet pipeline should be designed for capacities of 23 Ml/d and 22.4 Ml/d respectively, at which rate it should be able to operate for 4 years out of 5.

The programme of development is therefore likely to be:

(i) extend raw water pumphouse and plant for Ballinrees to provide adequate standby facilities. (£300,000).

(ii) when Altnahinch is fully committed, connect Ballinrees to Glenlough Service Reservoir (£1,150,000).

(iii) when Ballinrees is fully committed, extend raw water pumping plant and treatment works by 7 Ml/d to match the capacity of the raw water pumping main (£700,000).

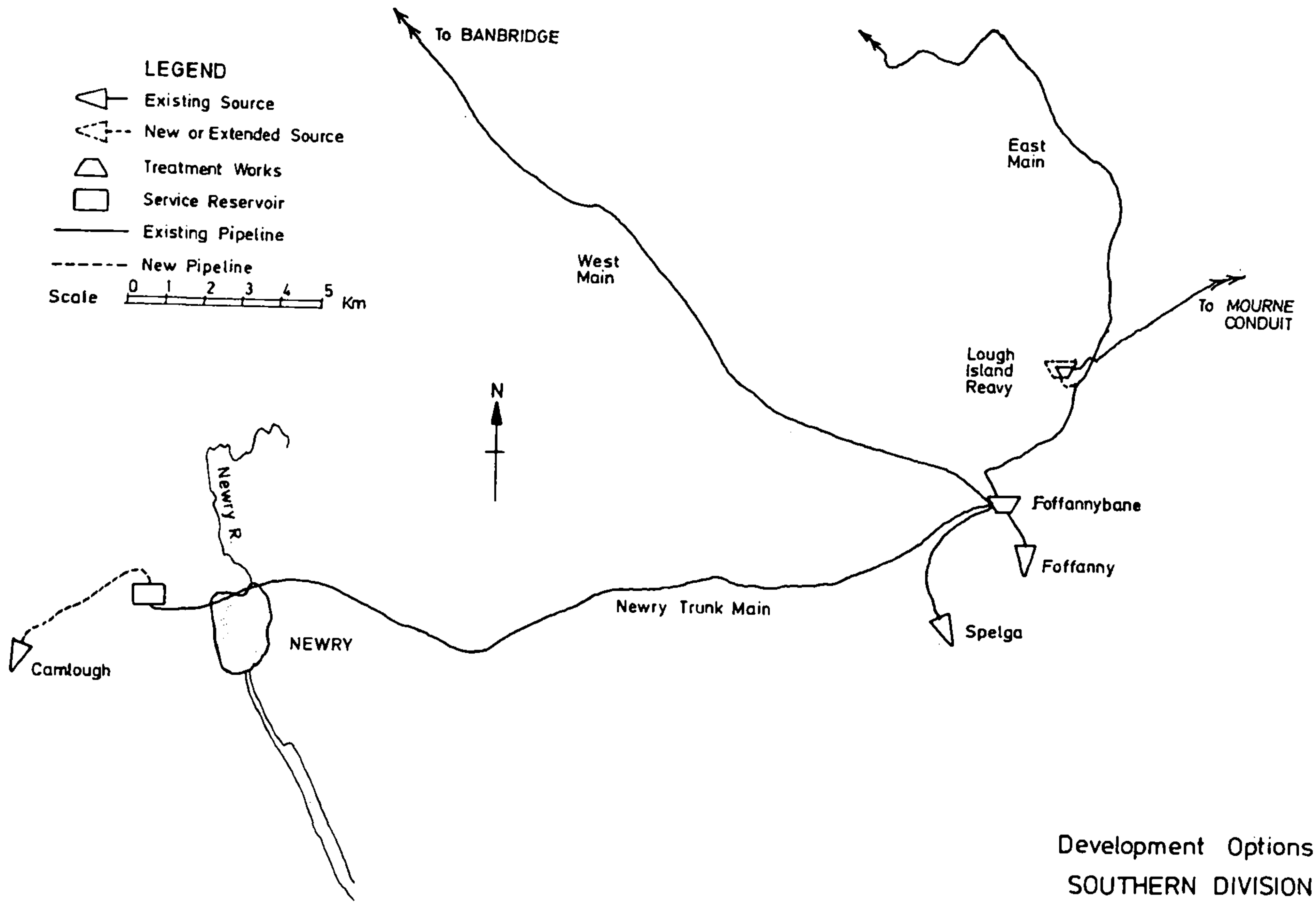
(iv) when Ballinrees raw water pumping main is fully committed, build the second Altnahinch dam (of the order of £4 to £6 million).

7.5 SOUTHERN DIVISION

In the Southern Division, Figure 7.3, plans for taking further supplies of water from Camlough to supply Newry are well advanced. It is understood that implementation has been delayed by conflict of interests with the current owners of the water rights. Consideration has to be given to the alternative sources of supply if this problem cannot be resolved.

The immediately apparent alternative is to make permanent use of Lough Island Reavy, which would entail either:

(a) a treatment works beside Lough Island Reavy with pumps to deliver water into the existing East Main out of Fofannybane Treatment Works



Development Options
SOUTHERN DIVISION

Figure 7.3

or (b) pumping raw water to Fofannybane and constructing an extension to the treatment works at that location.

The former alternative eliminates the need for a new pumping main and allows the treatment works to be used for Eastern Division. This alternative is therefore considered further.

The capacity of the distribution mains out of Fofannybane Treatment Works is adequate to cater for the increases in pumping out of Lough Island Reavy. By contrast, if the Camlough source is developed and immediate utilisation of all its capacity is required to make use of this gravity source, then a major increase in the distribution mains out of Fofannybane will be required. Typically the existing 250 mm West Distribution main would be replaced (due to age as well as low capacity) by a main up to 400 mm diameter to give adequate connection to the Castor Bay supply.

Three possibilities have been reviewed, and the cost of water derived for each.

		p/m^3
(i)	Camlough with interconnection to Castor Bay	11.46
(ii)	Camlough without interconnection to Castor Bay	10.86
(iii)	Lough Island Reavy	14.35

From these figures it can be concluded that utilisation of Lough Island Reavy is one third more expensive than using Camlough. Furthermore there is no economic advantage in providing further major interconnection with the Castor Bay system (in a northerly direction), until such time as any excess capacity at Camlough can be made available to Castor Bay supply area to postpone capital development at that site. Precise sizing of that further interconnection will depend on the relative rates of growth of the two areas.

Priority for Development in Southern Division

The Spelga/Fofanny source is currently over extended and is being assisted by small contributions from Lough Island Reavy and increasingly by Castor Bay. Increasing demand will require a new pipeline from Ballyduggan Reservoir down to Banvale Junction at an estimated cost of £300,000. This method of supply can continue for some years provided that there is surplus capacity at Castor Bay at all times of the year. This assumes that a permanent solution to the difficulties created by algal bloom can be found, either by permanent down rating of the plant or by the addition of a further stage of treatment for use at difficult times.

Thereafter the Camlough scheme should be brought in at an estimated cost of £3.1 million. At the same time a further pipeline from Fofannybane will be required to replace and increase the capacity of the West Trunk Main at a cost of £1.15 million.

7.6 STRABANE/OMAGH

Recent development of further catchwaters to replenish the reservoirs at Loughs Fingrean/Macrory and Bradan has reduced their storage/yield ratios. Consequently at these reservoirs and at Glencordial, there is plenty of water available during several months of many years. At Lough Bradan interconnection with the pumped source at Killyhevlin already exists and connection with the River Derg supply area is continuing to be developed. These connections permit some operational savings. For Lough Fingrean/Macrory and Glencordial consideration has been given to interconnecting these sources with the pumped source at Derg, in an attempt to reduce operational costs. However it has been found that such interconnection at this time is not economical.

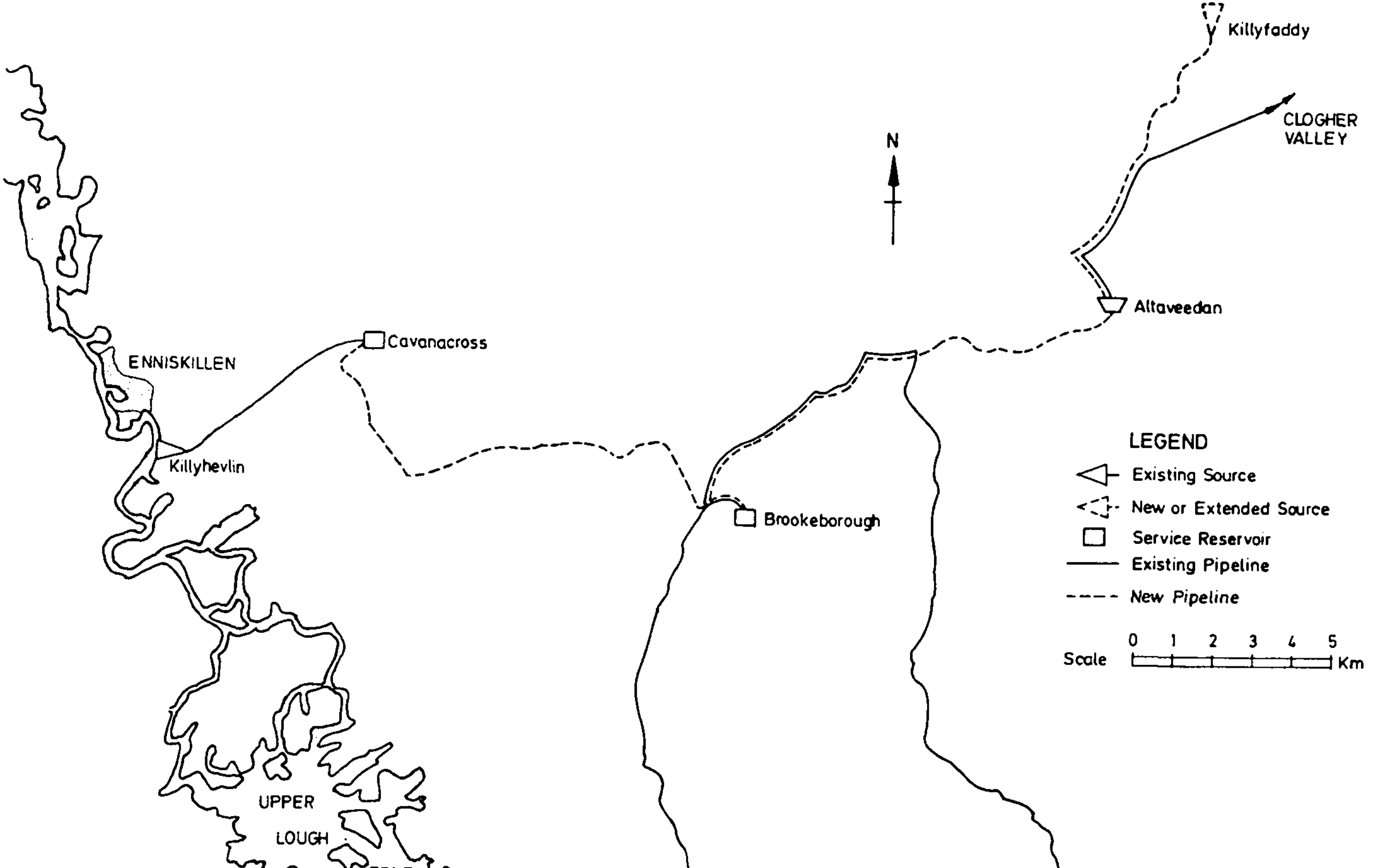
After the construction of the various catchwaters, the sources in this area will be able to meet demand for several years to come, and most probably till the end of the century.

There are therefore no economic grounds for further interconnection of sources to postpone major capital expenditure. When the next source is being considered, attention should be paid to the groundwater potential along the banks of the Strule as well as to the upland reservoir sites.

7.7 FERMANAGH

In this area of low population density and few gravity sources, small quantities of water have to traverse long distances and are therefore relatively expensive to provide. Rationalisation needs to be continued and predominantly this means extending the area of supply of the largest source, namely Killyhevlin outside Enniskillen, by interconnecting it with other sources, when such sources reach the limits of their capacity. Two such sources lie to the south west and west of Killyhevlin and are shown in Fig. 7.4. The first, the Killyfole supply, is currently overloaded, but its initial relief can more economically be provided by a pipeline connection with the Derrylin borehole which is under utilised. The second, the Altaveedan supply to the Clogher valley, suffers from a shortage of water in dry weather and has two boreholes available of lower quality water to act in support. For Altaveedan the possibility exists to pipe the output of a new borehole at Killyfaddy to the Altaveedan Works to improve its quality and mix it with the existing supplies.

To determine whether this possibility is more economical, a comparison has been made between the costs of a pipeline from the Killyhevlin supply past the Brookeborough reservoir in the Killyfole supply to Altaveedan and the costs of separate pipelines from Killyfaddy to Altaveedan and from Killyhevlin to Brookeborough. For quantities of 1.5 Ml/d provided to Altaveedan and 2.0 Ml/d provided to Killyfole, the operating costs are very similar but the capital costs show a significant saving by utilising the Killyfaddy borehole (£1.24 million against £0.93 million). The laying of a pipeline from Killyfaddy borehole to Altaveedan Works is therefore more economical.



FERMANAGH
Development Options

Figure 7.4

CHAPTER 8

DEVELOPMENT PLANS

8.1 INTRODUCTION

The previous chapter has dealt with the economic comparisons of various schemes without consideration of the timing of such developments. This chapter brings together all the aspects involved in decision-making in order to derive outline programmes of development and budgetary requirements at 1983 prices. Precise estimation of the timing of such developments will depend on regular reviews of the leakage reduction programme.

As discussed in Chapter 6 the timing of the decision to proceed with the construction of a new scheme is dependent primarily on four factors:-

(i) lead time required for introduction of new source;
(ii) current surplus capacity in system;
(iii) rates of growth of demand;
(iv) reduction of leakage achieved.

For the purpose of developing a programme on the basis of current information, it is necessary to make certain assumptions and then to monitor the available indicators to see whether the correct assumptions have been made.

8.1.1 Lead Time

The lead time for the construction of a new major source has been taken to be approximately seven years, consisting of two years for identification, preliminary design, and public enquiry two years for detailed design and land purchase and three years for construction. This time scale can be shortened in some of its details particularly for smaller schemes, but it is considered imprudent to plan on a much shorter overall period unless particular circumstances indicate otherwise.

8.1.2 Current Surplus Capacity

Table 8.1 shows the capacity of existing sources in each of the eight system areas, including allowance for capacity to be commissioned by 1987. The strategic capacity is defined as 95% of reliable capacity, allowing for an operating margin as discussed in Section 6.3.3.

TABLE 8.1

SURPLUS CAPACITY IN SYSTEM AREAS

(Ml/d)

	Eastern	Ballymena/ Antrim/ Larne	Coleraine/ Ballymoney/ Moyle	Magherafelt/ Cookstown
Reliable Capacity	350[1]	63[2]	53	31
Strategic Capacity	333	60	50	29
Production in 1983	335	52	42	24
Surplus Capacity Identified	2	8	8	5
Reducible Leakage	51	10	[illegible]	[illegible]

	Southern	Londonderry/ Limavady	Strabane/ Omagh	Fermanagh
Reliable Capacity	132	58	41[2]	29
Strategic Capacity	125	55	39	28
Production in 1983	123	54	29	28
Surplus Capacity in 1983 Identified	2	1	10	0
Reducible Leakage	21	14		

1 includes works completed in 1984 and 6 Ml/d from Southern Division

2 includes works to be completed in 1984/85

8.1.3 Rate of Growth of Demand

Overall historical growth and forecast water production requirement have been given in Chapter 6. In planning the timing of the introduction of new sources it is necessary to take account of the whole range of demand projections. In the current situation where historical rates of increase in production are greater than forecast rates of increase, it is important that contingency planning should allow for the high forecast growth rate. For each of the Divisions this rate exceeds two per cent per year for the next decade in which most decisions have to be taken.

8.1.4 Reduction of Leakage

The identified reducible leakage in each system is given in Table 8.1. In Chapter 6 a ten year period has been suggested for reducing leakage to an acceptable level. The effectiveness of leakage programmes cannot be forecast with precision, but it is evident that with sufficient resources devoted to leakage control it should be possible for the total water requirement to be met without major source development during this period. In view of the limited margins currently available leakage reduction schemes are essential in nearly all areas and, in parallel with this, initiation of the development plans for new sources as discussed in this chapter must be put in hand immediately.

If the rate of reduction in leakage exceeds the targets suggested, it may be possible to further postpone capital expenditure. If other elements of UFW, such as trunk main leakage, can also be reduced, this will further improve the position.

In the absence of significant success in leakage reduction the planned projects would have to be brought forward.

8.2 EASTERN DIVISION

Planning for the development of further water supplies should be based on the following:

Marginal development of existing sources, primarily two possibilities at Dunore Point:

In the short term, the utilization of primary filtrate for filter and sand washing, and recovery of filter and sand wash water after settlement, giving an extra 5Ml/d (cost £120,000). It is anticipated that this work could be operational for use in 1986.

b. Temporary reduction of supplies to Northern Division, made possible by the plans for that area (see para. 8.3 below), amounting to perhaps 8 Ml/d. It is unlikely that this could be implemented before 1988/89.

These marginal developments would allow additional time for the assessment of the effectiveness of leakage reduction programmes and a small measure of additional capacity if such programmes are only partially successful.

Development at Glenwhirry or Castor Bay with a capacity of around 110 Ml/d. The capital costs of the first stages of these two schemes involving only half the ultimate treatment works capacity, and delivery only as far as Old Park Reservoir, are as follows:-

For Glenwhirry	£22,893,000
For Castor Bay	£22,656,000

As stated in Chapter 7, if the treatment problems at Castor Bay can be shown to be manageable at reasonable cost, then secondary factors indicate that the Castor Bay solution is more attractive than the Glenwhirry scheme at this time.

Small scale source development at Lough Island Reavy is attractive, provided that the Mourne Conduit is to be renovated. Depending on a detailed study of the future demands on the route of the conduit, and hence the number of catchwaters which would be developed, this scheme would yield more than 17 Ml/d at a minimum cost of £15.7 million.

Of these total costs only 24% are attributable to the increased supplies from Lough Island Reavy and the remainder to improved security and quality of existing supplies. Consideration must be given to the necessity and timing of the renovation of the Mourne Conduit.

Other conclusions have also been reached:-

The Water Service is currently considering a proposal to isolate the Dunore supplies to the Northern Division from those to Eastern Division, by constructing a separate pipeline from the treatment works to connect to the existing offtake. Such expenditure would not of itself provide greater water resources and would require also further treatment facilities and probably a new intake. All plans for the Eastern Division point to the minimum possible utilization of Dunore and therefore further marginal development at this source for short term utilization is considered to be uneconomic.

The Water Service is currently proposing to lay a pipeline joining McVeighs Well, (the junction of the Dunore and Woodburn sources) in the North of the city and the Mourne-Stonyford Interconnector in the South, with a connection to Old Park Reservoir capable of being fed from either direction. It is understood that the primary purpose of the northern part would be to replace the pipeline known as Gravity II, which is of doubtful reliability. However it has become apparent in the course of this study that the circumstances requiring north-south transfers in excess of current levels are less frequent than originally thought.

8.3 BALLYMENA/ANTRIM/LARNE

Planning should be based on:

Extending the pipeline from Dunore further north from Creavery Reservoir to supply Ballymena through Crebilly Reservoir. This would not increase source capacity but would improve distribution in the Northern Area and in the longer term carry water southwards from Dungonnell Reservoir. This development costing £600,000 could be operational in 1986.

Development of the Inver Dam and 1700 Ml Reservoir on the catchment adjacent to the Dungonnell Reservoir together with the further development of their common treatment works and outlet pipeline to Crebilly Reservoir. The development of some extra 12 Ml/d would cost £ 3.5 million.

This development would satisfy demand until the end of the century if leakage reduction measures are successful. However in the early years by operating at full capacity it would serve to reduce the requirement for pumping from Dunore to Antrim and make more water available to Belfast to the extent of perhaps 8 Ml/d.

8.4 COLERAINE/BALLYMONEY/MOYLE

This area is currently supplied by two separate systems. The major scheme at Ballinrees outside Coleraine requires expenditure of some £300,000 to make the current capacity more secure by adding additional pumping plant at the Bann intake for Ballinrees. This source would then be adequate until at least the end of the century.

The other scheme, of which Altnahinch is the largest part and which includes a number of new ground water sources, serves Ballymoney and Moyle and its sources should be adequate until the end of the century. When required, the interconnection of Ballymoney and Coleraine with a 22 km pipeline, costing £1.1 million, currently appears to be the next most economical mode of development when the sources around Ballymoney are fully committed. Consideration should also be given at that time to construction of a second dam at Altnahinch.

8.5 MAGHERAFELT/COOKSTOWN

The reliable yield of the existing sources within this area is 38 Ml/d. With a 5 per cent operating margin, a new source would require to be operating when demand reaches 36 Ml/d. Demand in 1983 was 24 Ml/d and therefore this surplus capacity together with 4 Ml/d of reducible leakage will cater for many years of increased demand.

It is understood that major pollution of the River Moyola intake occurs not infrequently and that this can be overcome by providing an alternative intake from Lough Neagh. This would appear to be a sensible precaution.

8.6 SOUTHERN DIVISION

In recent years demand has required full utilisation of most of the sources other than Castor Bay which has neither produced nor been required to produce its full rated output. Sufficient evidence exists that the plant at Castor Bay will experience difficulty in maintaining the stated capacity of 68 Ml/d, unless further time and expenditure are allocated to finding the best ways to deal with problems of algal growth.

Further development of treatment capacity and associated works is recommended at Lough Ross (extra 3 Ml/d) and Clay Lake (extra 5 Ml/d) at estimated costs of £600,000 each. Improved interconnection of sources between Castor Bay and Spelga/Foffany is also needed at an estimated cost of £300,000.

In the longer term, the Camlough Source costing some £3.1 million with a yield of 13 Ml/d may not be required to be operating until about 1995. At that time 20 km of the West Trunk Main will require replacement at a cost of £1.2 million to permit more of the Spelga/Foffany source to be used towards Bannbridge.

8.7 LONDONDERRY/LIMAVADY

Examination of the condition of Altnaheglish Dam is currently being carried out by consultants. The effect of leakage reduction on the three remedial programmes which are under consideration should not be overlooked.

(i) If remedial work is to be carried out to the dam without drawing down the reservoir, this should be done as soon as possible for safety reasons;

(ii) If remedial work is to be carried out and requires drawdown of the reservoir, leakage reduction would limit water demand and temporary alternative supplies would be minimised;

(iii) If it is decided to provide a major new source it is unlikely that the additional yield will be required until the end of the century.

8.8 STRABANE/OMAGH

The capacity of the existing sources within this area is currently 29 Ml/d with approval given for the increase of Lough Bradan by 5 Ml/d and Lough Fingrean by 6 Ml/d to give a total of 40 Ml/d. With a 5% operating margin, a new source should be operating when demand reaches 38 Ml/d. Demand in 1983 was 29 Ml/d, so that there is an adequate margin provided that the two above developments are completed.

8.9 FERMANAGH

The interconnection of the Derrylin borehole to the Killyfole supply area to utilize an extra 2 Ml/d is of great importance and would cost some £400,000.

The duplication of Killyhevlin should be commenced in the near future. Interconnection of the Killyhevlin and Killyfole supply areas by a pipeline from Cavanacross Reservoir to Brookeborough Reservoir would await such duplication.

If detailed study of the leakage in Clogher Valley revealed little potential reduction, the development of the Killyfaddy pipeline to Altaveedan would be required in the immediate future.

8.10 PRIORITY AREA FOR LEAKAGE REDUCTION

In the preceding eight sections it has been shown that leakage reduction is urgently required in nearly every area if major capital expenditure is to be significantly postponed. The anticipated leakage reduction requires a defined degree of manpower as outlined in Chapter 5. If only limited manpower is available to carry out leakage reduction, it would be more economical to concentrate on the higher priority systems rather than disperse the resources throughout the Province.

CHAPTER 9

INFORMATION FOR MONITORING SUPPLY AND DEMAND

9.1 INTRODUCTION

This chapter sets out a number of observations concerning the information requirements of Water Service management and the ability of existing systems to deliver this information. It presents conclusions concerning possible improvements in the provision of management information and considers an outline structure for a system which can effectively handle the data. The analysis has been based on evidence obtained during the course of assessing the water supply and demand position in Northern Ireland, supplemented by a short programme of interviews with information users within the Water Service.

The investigations which have been carried out have been limited in scope. Only information requirements related to operations and water resource planning activities have been considered. Other information requirements, notably for financial management purposes have not been included. Because of the inter-relationship between data requirements for a variety of management and planning purposes, it is not strictly appropriate to consider management information for operations and water resource planning in isolation from these broader needs. Detailed review of information needs and provisions for these purposes would itself require a considerably more extensive programme of work than has been undertaken for this study. Due to these limitations of scope and depth, the present analysis should therefore be regarded as a basis for discussion.

9.2 MANAGEMENT INFORMATION REQUIREMENTS

Within the limits described above, consistent, reasonably accurate and regularly produced information is required by Water Services Management. These would include:-

In the short term

- control of water production
- waste control
- repair and maintenance programmes
- status and allocation of water resources
- monitoring performance against targets

In the longer term

- level of service to the consumer
- cost effectiveness of water supply
- resource planning
- agreements on appropriate objectives and targets.

The frequencies of making observations and collecting data will depend upon the particular management requirements.

9.3 WATER SOURCES

Substantial manually processed data are already available about each main source to assist both operational and planning needs and such data enable safe yields to be kept under review.

Information from each major source about reservoir level and output, indicating currently available storage and average daily draw off is transmitted in full or summary form to all relevant levels of management within the Province, and the frequency of forms returned to Headquarters is varied from monthly to weekly or daily basis according to the time of year and occurrence of drought conditions. Long run historic data essential for forecasting purposes is available for the larger sources.

It has, however, been noted that there is an absence of high quality flow data from small upland catchments, although the main reservoirs have gauged output. It is therefore recommended that the accuracy of resource assessments should be improved firstly by gauging two or three additional small upland catchments, and secondly by the review of existing measurement of reservoir level, draw off and spill for the major reservoirs.

Rainfall data at various locations throughout the Province are collected by the Metereological Office for use by the Water Service and are generally regarded as acceptable for estimating purposes. Adequate long run data are available.

Extensive data on water supply are transmitted from local through sub-divisional and Divisional levels to Headquarters. The extent to which the receipt of such data is either on the basis of "need-to-know" or forms the basis for individual responsibility for action has not been fully examined. A full assessment of this question would require a detailed examination of the functional responsibilities of each recipient, however, and would need to form part of a more extensive review.

A microcomputer is to be acquired by Water Resources Branch at Headquarters and is hoped to have the capacity to hold data and calculate figures for water storage, weekly draw off and other information currently calculated and graphed manually. This should release a substantial portion of the time currently spent on these activities by scarce professional manpower resources and it is hoped that the relevant equipment will be made available as soon as possible. While a microcomputer would ease the present burden of calculation, it is recommended that the overall system of collection and transmission of water supply data should be reviewed to avoid the risk of only piecemeal improvement to the existing management information system.

Consideration of water quality does not lie within the scope of this study but major problems such as those due to algal blooms in Lough Neagh and those arising from river water quality standards do occur and it is recommended that the collection of data on these aspects and their possible integration within a database be reviewed at the same time as any more extensive review of information systems.

9.4 WATER CONSUMPTION

In contrast with the extensive information available on the production and supply of water, a marked lack of systematic information is evident both at Headquarters and elsewhere on current water consumption and on factors likely to influence future demand.

9.4.1 Unmetered Consumption

Domestic water consumption accounts for approximately one half of identified water consumption in Northern Ireland. Because household consumption is unmetered, it is most important that efforts continue to be made to update and improve estimates of domestic water usage. The work carried out during the course of the present study on metered districts provides a basis upon which such efforts can proceed.

Survey of Metered Districts

The survey of metered districts provides a relatively low cost means of establishing estimates of average per capita domestic consumption. It has the further advantage of being easily repeatable and therefore offers a good basis for monitoring changes in domestic consumption and for assessing the factors which have brought these about. The continuation of this exercise with meter readings on at least an annual basis is recommended.

The metered district surveys for the present study were undertaken under some pressure of time. By establishing a more fully researched framework for future metered district surveys, it will be possible substantially to improve the quality of data in future. The selection of a wider variety of districts and inclusion of a greater number with a more representative proportion of public sector housing is particularly desirable.

In order to expedite the exercise a simplified form of the household questionnaire used for the present study should be developed to be used when a district is initially set up and from time to time thereafter (say every four to five years). In intervening years it will be adequate to update only household and population figures, possibly using forms for self-completion by householders. Because individual households will be surveyed on a regular and repeated basis, it may be appropriate to offer a small consideration to householders for taking part.

It is suggested that consumption metering in metered districts should be carried out more frequently than the household survey. This would provide additional information concerning, for example, seasonal variations in domestic demand and the impact of water rationing measures during periods of shortage.

Full Household Survey

More extensive information concerning changing patterns of ownership and use of domestic water-using appliances may be obtained by the occasional repetition of the full household survey undertaken for the present study. Repetition of this exercise on a five-yearly basis is suggested, although the actual frequency should be dependent on a range of factors including the results evident from the metered districts exercise and the prevailing balance of supply and demand.

Up-to-date estimates of domestic water consumption may be obtained by combining the results of the metered districts exercise with updated census information concerning such factors as population, household numbers and household size composition. It is suggested that such estimates should be calculated at least annually for each sub-division.

9.4.2 Metered Consumption

Data handling

At present all non-domestic consumers considered likely to consume over 100,000 litres in a six monthly period have a meter installed and the total expected revenue in 1983/84 is £8.8m. Meter readings obtained on a six monthly cycle are used to calculate water charges and are potentially a substantial source of reliable consumption data for planning decisions at Headquarters and Divisional level. However, because the present meter data feed a system designed solely for accounting and billing purposes, both the details from the records and the analysis of the data are inadequate for monitoring current consumption patterns and forecasting future demand. The quality of data records, their accessibility and their usefulness for operational and planning purposes represent a cause for concern.

A more fundamental problem is that a full register of meter holders does not exist and there appears to be no systematic means of keeping such a list up to date. While there has been a substantial increase in the number of metered consumers (from 47,000 in 1973 to 64,000 ten years later), there appear to be potential gaps in the transmission of information about new consumers. For example, though planning applications contain details on new developments, information may not be passed from Divisional level to the meter inspectorate. Similarly, notification of disconnection is left to the individual meter inspector, as is the identification of non-registered large-scale water users. This situation must also raise questions about the effectiveness of revenue estimation and collection.

Evidence provided during the course of this study indicated that there is significant under-registration of consumption by a proportion of trade meters, particularly at low 'trickle' flow levels. It is not possible to assess satisfactorily the overall volume of unrecorded consumption due to this cause without further information concerning sizing of meters and patterns of consumption by metered users (in terms of the proportion of consumption taking place at low flow levels). It is suggested that this subject should receive further attention with a view to developing the most economical meter replacement policy and to obtaining more reliable consumption figures. Improvements in this area should also have a direct impact on revenue, possibly amounting to a total of £800,000 per annum, and would therefore be self financing.

The method of data collection adopted in the Region appears unnecessarily complicated. The twice-yearly "merry go round" of consumer index cards from Water Charges Branch, who handle the data, to local level for completion and back again must involve a high risk of loss or mislaying of records.

The index cards themselves are the sole source of vital trend data in consumption often going back over ten years. Such data are not held on the bureau's computer files beyond 18 months or 2 years and consequently information on consumption patterns can only be established by lengthy examination of the manually collected meter cards. This assumes they can first be found and then abstracted from the system without disruption to the revenue generation procedures. Maintenance of these records on archive computer files should involve a negligible additional expense which would repay itself by providing a much needed data source for feasibility engineers at both Divisional and Headquarters levels.

One approach to the calculation of current water consumption adopted in this study was to estimate the consumption patterns of a selected sample of metered consumers. In attempting this it was found that the meter cards were often inadequately referenced and that they are catalogued by Water Charges Branch on a basis which bears little or no relation to the rounds of the inspectors. This results in unnecessary clerical effort to resort and reclassify.

Given the unavoidable difficulties with handling manual records, and the desirability of removing unnecessary clerical inputs, it is suggested that the following should be considered:-

(a) the use of self-completion forms by the consumer, perhaps on a more frequent basis than 6 monthly; or

(b) in the longer term the introduction of computerised integrated instantaneous meter reading-billing systems.

Data classification

The above paragraphs describe the operational problems with data capture. Major problems on the classification material used on the cards were also identified which limit their use for planning purposes. For example, while there is a very broad indication of the type of consumer such as agricultural, industrial or service sector, the classification does not allow demand to be analysed by more detailed industry groups and as a result examination of trends in the pattern of water use by, for example, the engineering or textile sub-sector is impracticable.

The geographical or locational information is also very limited. Cards are stored according to metering districts (which do not match the rounds of meter readers) and only addresses are stored on the computer file with no allocative process, so that analysis of consumption by area is impossible. This is known to have caused considerable difficulties in carrying out waste metering exercises.

At present the full potential usefulness of meter records for operational and planning purposes is not being realised. The type of managerial planning information which is required would cover for example:-

(a) historical consumption by industrial sector;

(b) geographical analysis of consumption by sector.

This could be achieved by:-

(i) The use of more extensive and accurate coding of the industry of the consumer. Standard Industrial Classification is recommended and some training for those completing cards would be essential to ensure consistency of material.

(ii) The use of smaller geographical areas, which would enable engineers to identify metered users and customers in individual waste metering districts.

(iii) Retention of data on computer file beyond two years to permit trends to be calculated.

Additional uses of data

The potential operational uses of the data could also be expanded in the following ways:-

(a) Although the computer based record contains details of the meter type, number and its age, this information is not used in the programme of planned maintenance of meters. Given that there is a five year rolling programme of replacement of meters, then the database should be used as a basic management tool. This is especially important given the likely under-recording of a large number of existing older meters and the consequent loss of revenue.

(b) If the individual users could be defined in relation to their position in the distribution network as well as being known by their geographical location, it would permit easy identification of consumers who would be affected by maintenance work.

In the course of the survey of management information needs, it emerged that some expenditure was likely on new developments in the software for calculation of water charges. It is understood that this would be designed to improve credit control, speed up queries, increase storage capacity, and give more flexibility in outputs. While this would certainly bring an improvement to the present situation it is suggested that more thought be given to improvements in the coverage and quality of the basic database and to the system of collection of data. Improvements in the presentation of data, when the data are incomplete or not useful, to major parts of the organisation would not, in fact, bring a net gain to the Water Service.

The overall requirement is therefore for a system which is oriented towards the timely provision of information for operational and planning needs as well as accounting requirements. It is likely this can be achieved only if there is some integration of engineering management, water charging and financial information arrangements.

9.4.3 Use of external information sources

Where regular information is available from elsewhere such as from the Census or the Continuous Household Survey or other economic and social statistical sources, there have been no regular arrangements made to analyse factors of particular relevance to the water industry.

Starting from the most aggregated form of information gathering to provide estimates of future demand, it is suggested that a reliable database of broad regional economic and social information be established and up-dated at regular intervals by Water Services Headquarters. An extensive list of the type of data necessary for such strategic planning purposes is set out in Table 9.1. As a minimum, updated census records of population and household characteristics (including analysis at sub-division level), records of trends in employment, industrial patterns and agricultural activities should be collated and reviewed regularly. The Water Service does not at present have enough of the specialist skills necessary to establish, maintain and interpret such data records. If success is to be achieved, it will be necessary for these skills to be obtained, either by recruitment or by outside assistance, possibly from the specialist resources available elsewhere in the Northern Ireland Civil Service.

On a more local level, it is suggested that further consideration should be given to the way in which local authority development planning information (affecting both domestic and non-domestic use) is transmitted to the Water Service at Divisional level and beyond. While drainage and sewerage services may present bigger problems at present than provision of water supply to new developments, there appears to be no formal mechanism to collect and collate data on forthcoming changes to help make judgements on the balance between available supply and new development demands.

9.5 UNACCOUNTED FOR WATER/LEAKAGE CONTROL

Substantial effort has been put in by all Divisions on wastewater monitoring programmes in the various waste districts. Considerable information is manually collated and transmitted throughout the system. However, partly because of a lack of resources, continuous waste control programmes have not yet been established. There is also considerable variation in the extent of waste measurement among the Divisions.

Some particular aspects were highlighted in the course of this study:-

(a) the frequency of monitoring of waste meters varies and the range of information collected such as minimum night flow and 24 hour flows seems to vary;

(b) the quality of trunk main metering requires improvement.

(c) waste management must be accorded a higher priority for action in all areas.

9.6 COMPUTER FACILITIES

Some of the issues raised in this Chapter are closely related to the importance of improved communications and more extensive use of computing facilities. The lack of such facilities in the Water Service at Headquarters and Divisional level is evident as is the possibly more crucial absence of staff with experience of use of such facilities. It is likely that a substantial learning period and training input would be required to enhance the staff capabilities.

There are particular problems arising from the lack of computer facilities directly accessible to Water Services Headquarters:-

(a) Operational models cannot be directly used by Water Service staff. This considerably reduces their ability to experiment with different operating strategies or to extend and develop models as required. There are also cost disadvantages.

(b) There is no facility for the Water Services to develop computer models needed for demand estimation and forecasting.

(c) The Water Service does not have access to an adequate database system.

There is, therefore, a strong prima facie case for the acquisition of computer facilities in the context of a more extensive review of information. Careful consideration is needed, however, before any particular option is selected. It will also be important to review existing management information systems and to make sure that any computerised system does not simply replicate the inadequacies of the existing manual clerical system in a more technically sophisticated way.

9.7 SUMMARY

In contrast with the Regional Water Authorities, there has been relatively little pressure on the NI Water Service to produce a corporate plan, to meet financial and cost performance targets or to produce annual reports and accounts, all of which require extensive non-financial as well as financial databases for management information. Development of performance indicators for various aspects of the service is not apparent and there have perhaps not been the equivalent discussions on target levels of service for the consumer.

Recent work on manpower, productivity and the relative costs of outputs undertaken for the Water Service has shown the usefulness of more extensive and integrated financial and non-financial data.

All this points to a greater need:-

(a) to clarify management information requirements;

(b) to provide a more detailed breakdown of information wherever possible;

(c) to improve accuracy of data collection;

(d) to ensure systematic transmission of information to those who need to know and are required to take action on the basis of the information;

(e) to provide appropriate computer facilities.

TABLE 9.1

SOCIAL AND ECONOMIC STATISTICAL REQUIREMENTS

(a) For domestic consumption estimation/forecasting

Item	Source
Household characteristics	Censuses of population and updates
- household numbers	"
household population	"
- household size distribution	"
- household tenure distribution	"
- rooms per household	"
- household income	Household surveys, General Household Survey, Family Expenditure Survey
Household amenities	
baths/showers	Household surveys
- inside W.C.	plus census of
- outside W.C.	population where
connection to public supply	applicable
- washing machines, dishwashers, garden hose, etc.	Household surveys

(b) For non-domestic consumption estimation/forecasting

Item	Source
Agriculture	
- number of farm establishments	Agricultural
livestock numbers	Census
Industry, Commerce, Other	
- number of establishments by sector	Census of Employment
- employment by sector	
size distribution of establishments by sector	
output by industry sector (regional)	Census of Production, National Income Statistics

TABLE A1.1

APPENDIX 1

EASTERN DIVISION

CURRENT CAPACITIES OF SOURCES

Ml/d

	Type	Basic Yield	Prescribed Flow	Process Water	Losses		Effective Yield	Notes
Dunore Point	L	136.0					118.0	18.0 to Northern
Woodburn System	I	45.9		1.8			44.1	
Silent Valley System	I	112.8					112.8	
Lough Island Reavy	I	30.1	15.9 (Max)				18.0	
Lough Cowey	L	4.1		0.2			3.2	(1)
Ballysallagh/Conlig	I	9.9	0.6	0.4			8.8	(1)
Holywood Reservoirs	I	3.4	0.1	0.2			3.1	
Portavoe	I	2.9		0.1		2.0)		
Lough Money/Tannaghmore	L	1.35				1.35)	4.0	(1)
Killough	I	0.7				0.7)		
Boomers	L	1.8		0.1			1.7	
Stoneyford/Leathermstown	I	25.5	5.7	1.0	1.8		14.8	(1)
Castor Bay (Magheraliskmisk)	L						6.0	From Southern
Whitehead	B	0.24						
Ballycullen/Comber	B	11.40				)		
Lisburn Borewells	B	2.03				)		
Derryaghy	B	1.12					12.0	1982 Production
Lagan Valley Boreholes	B						20.0	Expected Production by 1987
							366.5	

Note (1) Capacity limitations

TABLE A1.2

NORTHERN DIVISION

CURRENT CAPACITIES OF SOURCES

Ml/d

	Type	Basic Yield	Prescribed Flow	Process Water	Losses	Effective Yield	Notes
Dunore Point	L					18.0	From Eastern
Killylane	I	14.6		0.6	-1.0*	13.0	*Afforested Catchment
Dungonnell	I	13.0	0.5	0.6		11.9	
Quolie	I	5.2		0.2		5.0	
Lough Fea	L	13.8		0.6		13.2	
Ballinrees and River Bann	R	33.5		1.4		33.1	(1)
Altnahinch	I	14.5	3.2	0.6		10.7	
Moyola	R					13.0	Alternative inlet required
Sallagh Springs	S	1.27					
Glebe (Glenarm)	S	0.18			)		
Bonnytober	S	0.23			)		
Straidkilly	S	0.90			)		
Garron Point	S	0.18			)		
St. Cunning	S	0.30			)		
Toberterin	S	0.68			)		
Pomeroy	S	0.35			)		
Montober	S	1.86			)		
Knocklayd	S	1.10			)		
Foriff	S	0.28			)		
Ballyemon	S	0.30			)		
Waterfoot	S	0.13			)		
Farrantemple	S	1.00			)		
Moydamlaght	S	2.04			)	10.8	Current yields
Glarryford Boreholes	B	8.45			)		
Buckna Boreholes	B	2.40			)		
Drumbest Borehole	B	4.40			)		
Alcrossagh Borehole	B	2.05			)		
Dromain Borehole	B	1.00			)	18.3	Current dry weather yields
						147.0	

Note (1) Capacity limitations

TABLE A1.3

SOUTHERN DIVISION

CURRENT CAPACITIES OF SOURCES

Ml/d

	Type	Basic Yield	Prescribed Flow	Process Water	Losses	Effective Yield	Notes
Seagahan	I	16.3	1.2	0.6		14.5	
Altmore	I	3.6		0.2		3.4	
Clay Lake	L	10.3	9.3 (Max)			2.0	(1)
Ballylane Lake	L	1.2				0.9	(1)
Washing Bay	L	0.9				0.9	
Castor Bay	L	72.6		2.9		63.7	6.0 to Eastern
Spelga/Fofanny	I	28.0	2.8	1.1		24.1	
Lough Ross	L					4.1	(1)
Lough Island Reavy	L					1.2	
Camlough	L	2.2					
Ballintemple	I					3.2	(1)
Cloghinny	R	1.0					
Clontygora							
Leitrim	R					-	
Crotlieve/Yellow Water	R					1.0	(1)
Kilfeaghan	R	1.4				1.4	Min. River Flow
Attical	R					1.2	
Tullyard	B	2.39					Not used
Shanmoy	B	5.20					
Gortlenaghan	B	1.94					
Dickson's Mill	B	0.38					
Cabragh	B	1.73				9.2	1982 Production
Glenorn	W	1.32				1.3	
						132.1	

Note (1) Capacity limitations

TABLE A1.4

WESTERN DIVISION

CURRENT CAPACITIES OF SOURCES

Ml/d

	Type	Basic Yield	Prescribed Flow	Process Water	Losses	Effective Yield	Notes
Killyfole	L	7.3				4.5	(1)
Ballydoolagh Lough	L					2.3	(1)
Doagh Lough	L					0.2	
Killyhevlin	L	11.4		0.5		10.9	(1)
Muckros	L					1.6	To be abondoned
Altnaheglish/River Glenedra	I	(15.4 + 7.3)				18.0	
Killea	I	1.1				1.1	
Lough Fingrean/Lough Macrory	L					13.0	) Including current
Lough Bradan	L					8.4	) extensionds
Glencordial + R. Camowen	I	4.5		0.2		4.3	(1)
Evish/Knockhavoe	I					2.0	
Belleek	R	2.2				0.9	Demand limited
Altaveedan	R					2.7	(1)
Cloghole (Carmoney)	R	34.8				34.8	
River Derg	R					13.0	(1)
Larganacarron	B	0.18			)		
Augher	B	0.22			)		
Favour Royal	B	0.84			)		
Ummera	B	0.61			)		Demand limited
Brishey	B	1.04			)		
Culmore	B	0.13			)	3.4	1982 Production
Marble Arch	S	3.75			)		
Wellglass/Gortcorbies	S	2.51			)		
Altamooskan	S	0.10			)		
Sixmilecross	S	0.04			)		
Lenamore	S	0.33			)		
Newtownstewart	S	0.21			)		
Dunnamanagh	S	0.15			)	7.1	1982 Production
						128.2	

NOTE L = Lough; I = Impounding Reservoir; R = River; B = Borehole; W = Well; S = Spring; (1) Capacity limitations

APPENDIX 2

NON-ENUMERATED POPULATION

TABLE A2.1

1981 CENSUS NON-ENUMERATED POPULATION

Local Government District	Estimated Total Population	Census Enumerated Population	Implied Non-enumerated Population	Non-enumerated Population as % of Enumerated Population
Belfast	327 200	295 223	31 977	10.8
Cookstown	29 600	26 624	2 976	11.2
Dungannon	45 600	41 073	4 527	11.0
Londonderry	92 700	83 384	9 316	11.2
Magherafelt	33 800	30 825	2 975	9.7
Newry & Mourne	78 700	72 243	6 457	8.9
Omagh	46 300	41 159	5 141	12.5
Strabane	37 000	35 028	1 972	5.6
Other	871 300	862 518	8 782	1.0
Northern Ireland	1 562 200	1 488 077	74 123	5.0

TABLE A2.2

NON-ENUMERATED POPULATION BY SUBDIVISION

Subdivision	Estimated Non-enumerated Population as % of Enumerated Population
Antrim	1.0
Ballymena	5.8
Coleraine	1.0
NORTHERN	2.9
Armagh	6.5
Craigavon	1.0
Newry	6.7
SOUTHERN	4.9
Belfast	8.0
Downpatrick	1.0
Lisburn	1.0
EASTERN	5.2
Enniskillen	1.0
Londonderry	8.9
Omagh	9.4
WESTERN	7.2
NORTHERN IRELAND	5.0

APPENDIX 3

POPULATION GROWTH

TABLE A3.1

POPULATION PROJECTION BY SUBDIVISION (HIGH GROWTH)

	Population in [1] Private Housholds 1981 '000s	Growth Factor				
		1981	1985	1990	1995	2000
Eastern Division						
Belfast	447.6	1.000	1.007	1.029	1.055	0.965
Downpatrick	155.9	1.000	1.058	1.146	1.245	1.386
Lisburn	121.8	1.000	1.073	1.172	1.245	1.411
	725.3					
Northern Division						
Antrim	86.2	1.000	1.026	1.071	1.122	1.216
Balymena	117.8	1.000	1.043	1.101	1.162	1.304
Coleraine	83.1	1.000	1.022	1.058	1.097	1.126
	287.1					
Southern Division						
Armagh	79.9	1.000	1.027	1.069	1.115	1.226
Craigavon	77.8	1.000	1.048	1.093	1.130	1.229
Newry	107.7	1.000	1.022	1.064	1.113	1.298
	265.4					
Western Division						
Enniskillen	57.7	1.000	1.027	1.073	1.126	1.229
Londonderry	116.9	1.000	1.026	1.069	1.117	1.102
Omagh	82.4	1.000	1.037	1.107	1.190	1.302
	257.0					

1981 NI Census Figures Adjusted for estimated non-enumeration.

APPENDIX 3

POPULATION GROWTH

TABLE A3.1

POPULATION PROJECTION BY SUBDIVISION (HIGH GROWTH)

	Population in [1] Private Housholds 1981 '000s	Growth Factor				
		1981	1985	1990	1995	2000
Eastern Division						
Belfast	447.6	1.000	1.007	1.029	1.055	0.965
Downpatrick	155.9	1.000	1.058	1.146	1.245	1.386
Lisburn	121.8	1.000	1.073	1.172	1.245	1.411
	725.3					
Northern Division						
Antrim	86.2	1.000	1.026	1.071	1.122	1.216
Balymena	117.8	1.000	1.043	1.101	1.162	1.304
Coleraine	83.1	1.000	1.022	1.058	1.097	1.126
	287.1					
Southern Division						
Armagh	79.9	1.000	1.027	1.069	1.115	1.226
Craigavon	77.8	1.000	1.048	1.093	1.130	1.229
Newry	107.7	1.000	1.022	1.064	1.113	1.298
	265.4					
Western Division						
Enniskillen	57.7	1.000	1.027	1.073	1.126	1.229
Londonderry	116.9	1.000	1.026	1.069	1.117	1.102
Omagh	82.4	1.000	1.037	1.107	1.190	1.302
	257.0					

1981 NI Census Figures Adjusted for estimated non-enumeration.

TABLE A3.2

POPULATION PROJECTION BY SUBDIVISION (MID GROWTH)

	Population in[1] Private Housholds 1981 '000s	Growth Factor				
		1981	1985	1990	1995	2000
Eastern Division						
Belfast	447.6	1.000	0.993	0.991	0.995	0.891
Downpatrick	155.9	1.000	1.043	1.104	1.175	1.291
Lisburn	121.8	1.000	1.059	1.129	1.188	1.303
	725.3					
Northern Division						
Antrim	86.2	1.000	1.012	1.031	1.058	1.123
Balymena	117.8	1.000	1.029	1.061	1.096	1.205
Coleraine	83.1	1.000	1.008	1.019	1.035	1.041
	287.1					
Southern Division						
Armagh	79.9	1.000	1.013	1.029	1.052	1.132
Craigavon	77.8	1.000	1.034	1.052	1.071	1.135
Newry	107.7	1.000	1.008	1.025	1.050	1.199
	265.4					
Western Division						
Enniskillen	57.7	1.000	1.013	1.033	1.063	1.200
Londonderry	116.9	1.000	1.012	1.029	1.054	1.019
Omagh	82.4	1.000	1.023	1.067	1.123	1.203
	257.0					

1981 NI Census figures adjusted for estimated non-enumeration.

TABLE A3.3

POPULATION PROJECTION BY SUBDIVISION (LOW GROWTH)

	Population in Private Housholds 1981 '000s [1]	Growth Factor				
		1981	1985	1990	1995	2000
Eastern Division						
Belfast	447.6	1.000	0.982	0.964	0.956	0.846
Downpatrick	155.9	1.000	1.032	1.073	1.127	1.216
Lisburn	121.8	1.000	1.048	1.098	1.140	1.238
	725.3					
Northern Division						
Antrim	86.2	1.000	1.001	1.003	1.017	1.067
Balymena	117.8	1.000	1.018	1.031	1.053	1.144
Coleraine	83.1	1.000	.997	0.991	0.994	0.989
	287.1					
Southern Division						
Armagh	79.9	1.000	1.002	1.001	1.011	1.075
Craigavon	77.8	1.000	1.023	1.023	1.028	1.078
Newry	107.7	1.000	0.997	0.997	1.008	1.139
	265.4					
Western Division						
Enniskillen	57.7	1.000	1.002	1.005	1.021	1.140
Londonderry	116.9	1.000	1.001	1.001	1.013	1.967
Omagh	82.4	1.000	1.012	1.037	1.077	1.142
	257.0					

1981 NI Census figures adjusted for estimated non-enumeration.

APPENDIX 4

WATER CONSUMPTION

TABLE A4.1

BASE YEAR (1981) WATER CONSUMPTION BY CONSUMER CATEGORY Ml/d

Sub-Division	Domestic	Agriculture	Industry	Commerce	Construction	Other	Agr. Household	Operations	Meter Error	Total
Belfast	56.0	0.6	22.4	6.6	0.1	17.1	- 0.1	5.8	4.7	113.4
Downpatrick	19.5	6.2	1.7	1.1	-	2.4	- 1.4	1.7	1.1	32.2
Lisburn	15.2	1.8	1.1	0.4	-	1.6	- 0.5	1.1	0.5	21.1
EASTERN DIVISION	90.7	8.6	25.3	8.0	0.1	21.0	- 2.0	8.7	6.3	166.7
Antrim	10.8	8.0	1.3	1.1		2.5	- 0.5	1.1	0.8	20.0
Ballymena	14.7	7.3	1.7	2.6		1.9	- 1.8	1.2	1.4	28.9
Coleraine	10.4	5.7	2.4	1.8	-	2.3	- 1.1	1.3	1.3	25.2
NORTHERN DIVISION	35.9	16.1	6.5	5.4	0.1	6.7	- 3.4	3.5	3.5	74.2
Armagh	10.0	5.9	1.5	0.6		2.3	- 1.5	1.1	1.0	21.0
Craigavon	9.7	2.9	8.0	1.5	-	2.3	- 0.5	1.5	1.5	26.8
Newry	13.5	7.2	1.1	0.4	0.1	2.2	- 2.0	1.3	1.1	24.9
SOUTHERN DIVISION	33.2	15.9	10.6	2.6	0.1	6.8	- 4.1	3.7	3.6	72.6
Enniskillen	7.2	4.7	1.4	0.4	0.2	0.7	- 1.5	0.8	0.7	14.6
Londonderry	14.6	1.6	4.3	0.8	0.6	3.4	- 0.4	1.3	1.1	27.3
Omagh	10.3	4.6	1.0	0.4	-	1.5	- 1.1	0.9	0.8	18.4
WESTERN DIVISION	32.1	10.9	6.7	1.6	0.9	5.6	- 2.9	3.0	2.6	60.4
ALL NORTHERN IRELAND	191.9	51.5	49.0	17.6	1.2	40.2	- 12.3	18.9	16.0	373.9

NOTE: Errors in additions due to rounding.

APPENDIX 4

WATER CONSUMPTION PROJECTIONS

TABLE A4.2

WATER CONSUMPTION PROJECTIONS BY DIVISION AND BY CONSUMPTION CATEGORY (Ml/D)

		Base (1981)	1983	1985	1990	1995	2000
EASTERN DIVISION							
Domestic	High			103.7	119.5	136.3	145.8
	Mid	90.7	95.0	99.2	107.9	116.5	118.0
	Low			96.0	101.7	106.8	106.2
Agriculture	High			8.8	9.1	9.3	9.6
	Mid	8.6	8.7	8.7	8.8	8.9	9.0
	Low			8.6	8.5	8.5	8.4
Industry	High			25.7	27.9	30.5	33.5
	Mid	25.3	25.1	25.1	26.7	28.6	30.8
	Low			24.6	25.5	26.7	28.1
Commerce	High			8.0	8.9	9.8	10.8
	Mid	8.0	8.0	8.0	8.3	8.6	9.0
	Low			7.8	7.6	7.4	7.2
Construction	High			0.2	0.2	0.2	0.2
	Mid	0.1	0.1	0.2	0.2	0.2	0.2
	Low			0.1	0.1	0.1	0.1
Other	High			21.7	24.6	27.8	31.5
	Mid	21.0	21.0	21.6	23.4	25.2	27.2
	Low			21.5	22.1	22.6	23.2
Agricultural	High			-2.2	-2.4	-2.6	-2.8
Household	Mid	-2.0	-2.0	-2.0	-2.3	-2.4	-2.5
Usage	Low			-2.0	-2.2	-2.2	-2.2
Operational	High			9.5	10.7	12.1	13.1
Usage	Mid	8.7	9.0	9.2	9.9	10.6	11.0
	Low			9.0	9.3	9.7	9.8
Adjustment for	High			6.4	7.1	7.8	8.6
meter errors	Mid	6.3	6.3	6.4	6.7	7.2	7.6
	Low			6.3	6.4	6.5	6.7
TOTAL	High			181.7	205.6	231.1	250.2
	Mid	166.7	171.5	176.3	189.5	203.3	210.3
	Low			171.8	178.9	186.2	187.4

WATER CONSUMPTION PROJECTIONS

TABLE A4.2 (cont)

WATER CONSUMPTION PROJECTIONS BY DIVISION AND BY CONSUMPTION CATEGORY (Ml/D)

		Base (1981)	1983	1985	1990	1995	2000
NORTHERN DIVISION							
Domestic	High			41.2	47.4	54.1	62.6
	Mid	35.9	37.7	39.4	42.8	46.1	50.7
	Low			38.1	40.3	42.4	45.6
Agriculture	High			16.4	16.9	17.4	17.8
	Mid	16.1	16.1	16.2	16.4	16.5	16.7
	Low			16.0	15.9	15.7	15.6
Industry	High			6.6	7.2	7.8	8.6
	Mid	6.5	6.5	6.4	6.8	7.3	7.9
	Low			6.3	6.5	6.9	7.2
Commerce	High			5.5	6.0	6.6	7.3
	Mid	5.4	5.4	5.4	5.6	5.9	6.1
	Low			5.3	5.2	5.1	4.9
Construction	High			0.1	0.1	0.1	0.1
	Mid	0.1	0.1	0.1	0.1	0.1	0.1
	Low			0.1	0.1	0.1	0.1
Other	High			6.9	7.9	8.9	10.1
	Mid	6.7	6.7	6.9	7.5	8.1	8.2
	Low			6.9	7.1	7.2	7.4
Agricultural Household Usage	High			-3.8	-4.2	-4.5	-4.8
	Mid	-3.4	-3.5	-3.6	-4.0	-4.2	-4.3
	Low			-3.5	-3.8	-3.8	-3.9
Operational Usage	High			3.8	4.2	4.7	5.3
	Mid	3.5	3.6	3.7	3.9	4.1	4.4
	Low			3.6	3.7	3.8	4.0
Adjustment for meter errors	High			3.6	3.8	4.1	4.4
	Mid	3.5	3.5	3.5	3.6	3.8	4.0
	Low			3.5	3.5	3.5	3.5
TOTAL	High			80.1	89.3	99.2	111.3
	Mid	74.2	76.1	78.0	82.7	87.7	93.9
	Low			76.3	78.6	81.8	84.7

WATER CONSUMPTION PROJECTIONS

TABLE A4.2 (cont)

WATER CONSUMPTION PROJECTIONS BY DIVISION AND BY CONSUMPTION CATEGORY (Ml/D)

		Base (1981)	1983	1985	1990	1995	2000
SOUTHERN DIVISION							
Domestic	High			38.0	43.5	49.5	59.3
	Mid	33.2	34.8	86.4	31.3	42.2	48.0
	Low			35.2	37.0	38.7	43.2
Agriculture	High			16.3	16.8	17.2	17.7
	Mid	15.9	16.0	16.1	16.3	16.4	16.6
	Low			15.8	15.7	15.6	15.5
Industry	High			10.7	11.7	12.7	14.0
	Mid	10.6	10.5	10.5	11.2	12.0	12.9
	Low			10.3	10.6	11.2	11.8
Commerce	High			2.6	2.8	3.1	3.5
	Mid	2.6	2.6	2.6	2.7	2.8	2.9
	Low			2.5	2.4	2.4	2.3
Construction	High			0.2	0.2	0.2	0.2
	Mid	10.1	0.1	0.1	0.1	0.1	0.1
	Low			0.1	0.1	0.1	0.1
Other	High			7.0	7.9	9.0	10.1
	Mid	6.8	6.8	7.0	7.5	8.1	8.8
	Low			6.9	7.1	7.3	7.5
Agricultural Household Usage	High			-4.4	-5.0	-5.3	-5.7
	Mid	-4.0	-4.1	-4.3	-4.7	-4.9	-5.1
	Low			-4.0	-4.5	-4.5	-4.6
Operational Usage	High			4.0	4.4	4.9	5.6
	Mid	3.7	3.8	3.9	4.1	4.3	4.8
	Low			3.8	3.9	4.0	4.3
Adjustment for meter errors	High			3.7	3.9	4.3	4.6
	Mid	3.6	3.6	3.6	3.8	3.9	4.1
	Low			3.6	3.6	3.7	3.7
TOTAL	High			78.1	86.2	95.5	109.2
	Mid	72.6	74.3	75.9	80.2	85.1	93.1
	Low			74.2	75.9	78.4	83.7

TABLE A4.2 (cont)

WATER CONSUMPTION PROJECTIONS BY DIVISION AND BY CONSUMPTION CATEGORY (Ml/D)

		Base (1981)	1983	1985	1990	1995	2000
WESTERN DIVISION							
Domestic	High			36.8	42.5	49.0	55.3
	Mid	32.1	33.7	35.2	38.4	41.7	44.8
	Low			34.0	36.2	38.3	40.3
Agriculture	High			11.1	11.4	11.8	12.1
	Mid	10.9	10.9	11.0	11.1	11.2	11.3
	Low			10.8	10.7	10.7	10.6
Industry	High			6.8	7.4	8.1	8.9
	Mid	6.7	6.7	6.7	7.1	7.6	8.2
	Low			6.5	6.8	7.1	7.5
Commerce	High			1.6	1.7	1.9	2.1
	Mid	1.6	1.6	1.6	1.6	1.7	1.7
	Low			1.5	1.5	1.5	1.4
Construction	High			0.9	1.0	1.0	1.1
	Mid	0.9	0.9	0.9	0.9	0.9	0.9
	Low			0.9	0.8	0.8	0.8
Other	High			5.8	6.6	7.9	8.4
	Mid	5.6	5.6	5.8	6.2	6.7	7.3
	Low			5.7	5.9	6.0	6.2
Agricultural	High			-3.2	-3.6	-3.9	-4.1
Household	Mid	-2.9	-3.0	-3.1	-3.5	-3.6	-3.7
Usage	Low			-2.9	-3.3	-3.3	-3.3
Operational	High			3.3	3.7	4.1	4.6
Usage	Mid	3.0	3.1	3.2	3.4	3.6	3.8
	Low			3.1	3.2	3.3	3.5
Adjustment for	High			2.6	2.8	3.0	3.3
meter errors	Mid	2.6	2.6	2.6	2.7	2.8	2.9
	Low			2.5	2.6	2.6	2.7
TOTAL	High			65.7	73.4	82.9	91.6
	Mid	60.4	62.0	63.8	67.9	72.7	77.3
	Low			62.2	64.4	67.0	69.7

WATER CONSUMPTION PROJECTIONS

TABLE A4.2 (cont)

WATER CONSUMPTION PROJECTIONS BY DIVISION AND BY CONSUMPTION CATEGORY (Ml/D)

		Base (1981)	1983	1985	1990	1995	2000
NORTHERN IRELAND							
Domestic	High			219.6	252.8	289.6	322.9
	Mid	191.9	201.0	210.1	228.4	246.6	261.5
	Low			203.3	215.2	226.2	235.2
Agriculture	High			52.7	54.2	55.7	57.2
	Mid	51.5	51.8	52.0	52.5	53.1	53.6
	Low			51.2	51.0	50.5	50.1
Industry	High			49.7	54.1	59.1	65.0
	Mid	49.0	48.8	48.7	51.8	55.5	59.8
	Low			47.7	49.4	51.9	54.6
Commerce	High			17.7	19.5	21.5	23.7
	Mid	17.6	17.5	17.5	18.2	18.9	19.7
	Low			17.2	16.7	16.3	15.9
Construction	High			1.3	1.4	1.4	1.5
	Mid	1.2	1.2	1.3	1.3	1.3	1.3
	Low			1.2	1.2	1.1	1.1
Other	High			41.5	46.9	53.1	60.1
	Mid	40.2	40.0	41.3	44.6	48.2	52.0
	Low			41.1	42.1	43.1	44.2
Agricultural	High			-13.7	-15.1	-16.3	-17.4
Household	Mid	-12.3	-12.9	-13.0	-14.5	-15.1	-15.6
Usage	Low			-12.5	-13.8	-13.9	-14.0
Operational	High			20.5	23.0	25.7	28.4
Usage	Mid	18.9	19.4	19.9	21.3	22.7	24.0
	Low			19.4	20.1	20.9	21.5
Adjustment for	High			16.3	17.6	19.1	20.8
meter errors	Mid	16.0	15.9	16.1	16.8	17.7	18.6
	Low			15.8	16.0	16.3	16.6
TOTAL	High			405.6	454.5	508.7	562.3
	Mid	373.9	384.0	394.0	420.3	448.7	474.6
	Low			384.5	397.8	412.9	425.5

APPENDIX 5

ECONOMIC ACTIVITY PROJECTIONS

5.1 INDUSTRY AND COMMERCE

Forecasts of non-domestic water consumption have been based on projected movements in appropriate activity indicators. Table A5.1 shows the central assumptions which have been made for the path of growth of the Northern Ireland Economy from 1983 to the turn of the century. Also shown are official estimates of changes between 1981 (the base-year for this study) and 1983.

TABLE A5.1

KEY NI ECONOMIC VARIABLE - ANNUAL PERCENTAGE GROWTH

	1981-83	1983-85	1986-90	1991-95	1996-2000
Industrial Output	-0.3	2.6	1.2	1.8	1.9
Commercial (Private Services) Sector Employment	-0.3	0.0	0.8	0.8	0.8
Other (Public Services) Sector Employment	0.0	1.3	1.5	1.5	1.5
Construction Output	0.0	1.9	0.1	0.1	0.1

In order to take account of uncertainty, a range of values has been assumed about the central projection shown in Table A5.1. Table A5.2 shows the range expressed in terms of total percentage growth from 1983 to 2000.

TABLE A5.2

RANGE OF GROWTH PROJECTIONS OF N.I. ECONOMIC VARIABLES

	Total Percentage Increase (Decrease) 1983-2000		
	High	Mid	Low
Industrial Output	40	29	18
Private (Commercial Services) Sector Employment	35	12	(9)
Other (Public Services) Sector Employment	49	29	10
Construction Output	26		(13)

These economic assumptions have been made in the light of expectations concerning the long term development of the UK economy taken as a whole. The following assumptions have been made for the path of growth of the UK economy:-

TABLE A5.3

MAJOR NATIONAL ECONOMIC VARIABLE - ANNUAL PERCENTAGE GROWTH

1983/84 to 2000/01

	1983-85	1986-90	1991-95	1996-2000
Gross Domestic Product	2.0	1.8	1.9	1.9
Personal Disposable Income	1.4	1.2	1.6	1.6
Industrial Output	3.6	1.7	1.8	1.9
Non Marketing (Service Sector) Output	1.3	2.3	2.3	2.3

5.2 AGRICULTURE

Crop irrigation from public supplies is insignificant in the Province and not expected to increase. The main determinants of farm water consumption (excluding farm domestic use) are therefore the volume and mix of livestock together with techniques adopted for husbandry.

The assumptions which have been made concerning growth in livestock numbers are shown in Table A5.4. The mid and low growth paths in relation to the numbers of pigs reflect the likelihood of increasing foreign competition in this market. With the level of financial support for the CAP under review the growth projections shown in Table A5.4 may be optimistic.

TABLE A5.4

GROWTH IN LIVESTOCK NUMBERS IN NORTHERN IRELAND 1981-2000

	(No. of Livestock in 1981 [1]) '000s	Total Percentage Growth Projection to 2000		
		High	Med	Low
Dairy Cattle	325.8	21	8	0
Beef Cattle	1,102.7	5	0	-5
Pigs	634.6	5	-2	-9
Sheep	1,149.8	5	0	2

[1] Source 1981 Agricultural Census.

APPENDIX 6

ELASTICITY OF DEMAND

6.1 GENERAL

Information concerning the sensitivity of water consumption demand to changes in prices or to changes in income/output is desirable both for forecasting purposes and to assess the impact of policy measures on consumption. Very little evidence is available on this subject, however. The quality of consumption data collected in Northern Ireland is not adequate to permit the impact either of prices or of income/output to be properly assessed.

Data available from sources outside the Province could provide an alternative basis for estimating demand elasticities. In general this information too is of limited use, however, since detailed consumption figures for the domestic and non-domestic sectors have only recently become available so that it is not possible to calculate long-run elasticities. The poor quality of available data makes it very difficult to separate income and price effects from the impact of climatic variation, technological development or improvements in standards of hygiene.

Evidence available from other studies suggests that there are marked differences between the domestic and the non-domestic sectors. Where water is charged for according to use in the domestic sector, consumption appears to be relatively insensitive to price variations. Non-domestic demand (in particular industrial consumption) appears to vary considerably both with output and with price.

6.2 DOMESTIC WATER DEMAND

6.2.1 Price Elasticity

UK households are not charged directly for their water consumption so that it is not possible to estimate any price elasticities. Rises in water rates levied by the Water Authorities are generally deemed to have no noticeable effect on domestic water consumption. This is to be expected, since the amount consumed by an individual household has no direct impact on expenditure irrespective of the level of water rate.

Experience in countries where domestic demand is metered suggests that, despite short term reductions immediately after the imposition of price increases, the long term demand is almost price insensitive and that only minor reductions in water demand (particularly in the use of sprinklers, and garden hoses) could be achieved through price increases (Gundermann 1983).*

(* References at the end of this Appendix).

6.2.2 Income Elasticity

Income changes affect water demand indirectly through their effect on housing stock, availability of amenities, appliance ownership and social structure. Since these changes take place very slowly and reliable estimates of the domestic water consumption in the UK are only available for recent years, there is very little information on the long-term effects of increased household income on water demand. In Germany, where domestic consumption has been metered for a longer period, the long run income elasticity between 1960 and 1980 (measured against GDP) has been about 0.7 (implying that each 1% increase in GDP will lead to an increase in domestic demand of 0.7%). Due to national differences this figure, however, cannot be applied with confidence to Northern Ireland.

6.3 NON-DOMESTIC WATER DEMAND

6.3.1 Price Elasticity

All studies on industrial water demand agree on the existence of a small negative price elasticity of demand by non-domestic water consumers. Thackray and Archibald (1981) estimated a price elasticity of about -0.3 while Hanke (1979) found indications of slightly higher elasticity centering around -0.4. Thus a 1% increase in the water price would reduce industrial demand by between 0.3% and 0.4%. However, it is important to note that the elasticity is likely to be lower in Northern Ireland since a large proportion of the firms surveyed for these studies belong to water intensive sectors with considerable scope for water conservation. Such firms are uncommon in Northern Ireland.

Most industrial water users interviewed by Thackray and Archibald, particularly those for whom water charges are a substantial part of their production costs, indicated that they had already implemented water saving programmes in response to increased water charges or had been planning to do so in the future.

Thackray and Archibald's findings are supported by the fact that industrial metered demand in the East and West Midlands, where the study was carried out, fell by 14% between 1973 and 1979 while water charges rose by 20% in real terms and output fell by only 5%. Similarly in Germany where water charges have been increased considerably over the last decade, water consumption by the industrial sector has (despite substantial growth in output) been reduced by 17% between 1970 and 1980.

6.3.2 Output Elasticity

Industrial and commercial water consumption can be broken down into a 'domestic' component which is directly related to staff numbers and an 'industrial'component which is a result of the actual production process. While the 'industrial' component varies directly with the units of output, the 'domestic' component reacts much more slowly to output changes since firms are generally reluctant to take on or shed labour in response to fluctuations in the demand for their goods. Thus, the short run output elasticities for different industrial sectors depends on the relative size of the 'domestic' and 'industrial' components of their water demand.

Thackray and Archibald reported output elasticities between 1.0 and 0.3 for the different sectors with a mean of 0.5. Since their study included many firms from the mining and steel making industries which do not exist in Northern Ireland and have very low output elasticities, the average output elasticity for Northern Ireland is likely to be substantially higher. A value in the broad region of 0.7 is suggested by this analysis.

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APPENDIX 7

UNIT COSTS OF LEAKAGE

7.1 GENERAL

The unit costs of leakage depend upon two principal elements.

(a) The Unit Capital Cost.
This is calculated from the deferment of capital expenditure that would be required to increase water production. In making the assessment of the necessary capital works a growth in overall demand of 1% per annum has been used.

Costs of capital works are based on current planning. These costs are discounted to the base year (1981) using a rate of 5%. The discounted capital cost is converted to a unit capital cost by calculating the change in the capital cost brought about by a unit change in supply. The relevant formula is

$$\frac{(\text{capital cost}) \times (0.05)^2 \times 100}{1.05 \times (\text{annual increase in supply})} \quad \text{pence per cubic metre}$$

As indicated above the annual increase in supply is taken as 1% of the current production.

All costs are at 1983 levels.

(b) The Unit Operating Cost.
This comprises the current costs per cubic meter for electricity, chemicals and operating plant, plus relevant labour costs.

Where several sources supply a system the unit operating costs of the most expensive are used, on the basis that this is the most economical course to follow.

Estimates of the costs of leakage have been made for each of the principal supply systems on the basis of the foregoing and are presented below. These do not make allowances for all relevant factors (e.g. trunk main extensions) but the results are sufficiently accurate for the present purposes.

7.2 EASTERN DIVISION

(a) Unit Capital Cost

Annual increase in production m^3/d		4 000
Capital cost of new works (1)		£40 x 10^6
Effective construction date		1986
Discounted Capital Cost		£31.3 x 10^6
Unit Capital Cost	p/m^3	5.1

(b) Unit Operating Cost (Dunore) p/m^3 2.5

(c) Total Unit Cost of Leakage p/m^3 7.6 p/m^3

Note

(1)	Estimated Cost of New Works	£25 x 10^6
	Estimated Fixed Annual Operating Costs	£14 x 10^6
	TOTAL	£40 x 10^6

7.3 NORTHERN DIVISION

System		Coleraine/ Ballymoney/ Moyle	Ballymena/ Antrim/ Larne	Magharafelt/ Cookstown
(a) Unit Capital Cost				
Annual increase in production m^3/d		370	530	230
Capital Cost	£	1.3×10^6	3.6×10^6	Nil
		(1)	(2)	(3)
Effective construction date		1986	1988	
Discounted Capital Cost	£	1.00×10^6	2.56×10^6	Nil
Unit Capital Cost	p/m^3	1.8	3.1	NIL
(b) Unit Operating Cost	p/m^3	3.7	2.5	4.7
		(Ballinrees)	(Dunore)	(Moyola)
(c) Total Unit Cost of Leakage	p/m^3	5.5	5.6	4.7

Note

Existing sources should be adequate until the end of the century, if a pipeline is laid from Ballinrees Treatment Works to Glenlough Reservoir to suplement the Altnahinch Source in dry years.

A new source will be needed by 1990 for which Inver Dam and Treatment Works are envisaged.

Estimated Capital Cost	£2,600,000
Estimated Fixed Operating Cost	£ 976,000
TOTAL	£3,576,000

Current sources are adequate to the end of the century without significant capital expenditure.

7.4 SOUTHERN DIVISION

(a) Unit Capital Cost

Annual increase in production m^3/d		1 200
Capital cost of new works (1)		£4.8 x 10^6
Effective construction date		1988
Discounted Capital Cost		£8.87 x 10^6
Unit Capital Cost	p/m^3	4.8

(b) Unit Operating Cost (Castor Bay)	p/m^3	2.9
(c) Total Unit Cost of Leakage	p/m^3	7.7

Note

(1) Camlough Source (13 Ml/d)

Estimated Capital Cost		£3,000,000
Estimated Fixed Running Cost		£1,820,000
	TOTAL	£4,820,000

At the stated growth rate a further new source will be needed after about 10 years. Thus a capacity multiplier of 2.6 is used in discounting the capital cost (Report No. 26, Fig. B2)

7.5 WESTERN DIVISION

System		Londonderry/ Limavady	Strabane/ Omagh	Fermanagh
(a) Unit Capital Cost				
Annual increase in production m^3/d		570	270	250
Capital Cost	£	750,000 (1)	Nil (2)	870,000 (4)
Effective construction date		1987	-	1990
Discounted Capital Cost	£	1.68×10^6 (1)	Nil	561,000
Unit Capital Cost	p/m^3	1.9	NIL	1.5
(b) Unit Operating Cost	p/m^3	2.6 (Carmoney)	3.9 (3)	3.8 (Killyhevlin/ Killyfoyle)
(c) Total Unit Cost of Leakage	p/m^3	4.5	3.9	5.3

Notes

(1) Capital cost of improvement to Altnaheglish, which would satisfy only 8 further years increase in demand. Thus further works will be needed later and to allow for this a capacity multiplier of 3 is used in discounting the capital cost.

(2) Extensions to Lough Macrory/Stradowan and Lough Bradan are under construction and therefore capital costs of these projects cannot be deferred. Following completion of these schemes the resources will be adequate to at least the year 2001.

(3) Proportioned between Derg, Bradan and Fingrean.

(4) Extension of Killyhevlin required in 1992.

Estimated Capital Cost	£500 000
Estimated Fixed Operating Cost	£370,000
TOTAL	£870,000

APPENDIX 8

COST OF LEAKAGE CONTROL

8.1 LEAKAGE CONTROL ACTIVITIES

Report No. 26 outlines a range of frequencies for the various leakage control activities associated with an active waste control policy. The recommended frequencies are dependent on the unit costs of leakage for individual supply areas and on the size of waste meter districts within those areas.

Throughout Northern Ireland the Unit Cost of Leakage is relatively high and, accordingly, frequencies recommended are generally at the high end of the range. However, in rural areas with low population densities, waste districts contain very low numbers of properties and it is considered more appropriate in these areas that monitoring and inspection should be carried out less frequently.

Recommended frequencies are summarised and extended in Table A8.1. Whilst the recommended frequencies do not imply a fixed frequency for each waste district, they do, however, indicate the level of activity required within each supply area.

When implementing an active waste detection programme it is important that the correct balance between monitoring and inspection is obtained. Whilst the collection of records of night flows will not in itself reduce the level of leakage, it will enable resources to be directed to those areas where the greatest benefits, economic and otherwise, can be obtained.

8.2 MANPOWER REQUIREMENTS

Productivity figures obtained from the Belfast sub-division, increased as appropriate to make allowance for holidays and illness, have been used to estimate the number of industrial manhours required to carry out each of the various leakage control activities. These estimates have been used in Table A.8.2 to calculate the number of manhours which should be apportioned to waste detection in each supply area in order that the target levels of net night flow might be obtained.

The operational resources necessary to maintain the required level of activity will vary for each supply area. Approximately fifty-seven per cent of the total envisaged are for step-testing and night sounding. In areas other than the Belfast sub-division this would involve between twelve and twenty nights work per year in each linesman's district and the work could reasonably by carried out as overtime. In the Belfast sub-division it is considered that shift work will be necessary.

The balance of the waste detection programme involves work during the day and, considering the geographical problems involved with working right across the existing supply areas, it is probable that staff will be organised within the existing sub-division and linesman's districts. It is likely therefore that in areas other than the Belfast sub-division, where waste squads as such could operate, waste detection will be absorbed as additional work within existing structures. The impact of the additional work on existing duties would have to be assessed and staffing levels re-examined if necessary.

In the leakage analysis report dated September 1983 recommendations were made regarding appropriate operational resources for the Belfast sub-division. An examination of existing resources in the other sub-divisions would be necessary to determine how best the required level of activity can be achieved using existing or additional manpower.

8.3 COST OF LEAKAGE CONTROL FOR TARGET LEAKAGE LEVELS

Manpower requirements together with costs relating to transport and supervision can be used to calculate cost for each of the leakage control activities constituting an active leakage control policy.

These costs have been estimated as follows:-

Step Testing	£ 125.00
M.N.F. Recording	£ 12.50
Night Sounding	£ 110.00
Follow Up Investigations	£ 120.00

Table A.8.3 below extends these costs to estimate the target annual cost of leakage control for each supply area.

TABLE A.8.1

RECOMMENDED FREQUENCIES FOR LEAKAGE CONTROL ACTIVITIES

	No. of Properties	Proposed No. of Waste Districts	Average No. of Properties/ District	Recommended Frequencies (No./Year) Monitoring	Inspection	Total No. Per Year Step Tests	M.N.F. Recording	Night Sounding/ Follow up
EASTERN DIVISION	253409	381	665			760	2285	760
Coleraine/Balleymoney/Moyle	27548	60	459	4	1.5	90	240	90
Magherafelt/Cookstown	16858	35	482	4	1.5	55	140	55
Ballymena/Antrim/Larne	43227	70	618	6	2	140	420	140
NORTHERN DIVISION	87633	165				285	800	285
SOUTHERN DIVISION	79889	173	562		1.5	260	690	260
Londonderry/Limavady	30670	50	613	6	2	100	300	100
Strabane/Omagh	21715	100	217	4	1	100	400	100
Fermanagh	17068	60	284	4	1	60	240	60
WESTERN DIVISION	69453	210	462	(4)	(1.5)	260	690	260

TABLE A.8.2

MANPOWER REQUIREMENTS FOR ACTIVE LEAKAGE CONTROL

	Proposed No. of Waste Districts		Step Testing	M.N.F. Recording	Night Sounding	Follow Up Investigations	Total Man Hours Per Year
EASTERN DIVISION	381	No. required per year	760	2285	760	760	
		Man hours per activity	11.00	1.50	13.00	13.50	
		Total man hrs per year	8360	3428	9880	10260	31 928
NORTHERN DIVISION	165	No. required per year	285	800	285	285	
		Man hours per activity	11.00	1.50	13.00	13.50	
		Total man hrs per year	3135	1200	3705	3848	11 888
SOUTHERN DIVISION	173	No. required per year	260	690	260	260	
		Man hours per activity	11.00	1.50	13.00	13.50	
		Total man hrs per year	2860	1035	3380	3510	10 785
WESTERN DIVISION	210	No. required per year	260	940	260	260	
		Man hours per activity	11.00	1.50	13.00	13.50	
		Total man hrs per year	2860	1410	3380	3510	11 160

TABLE A.8.3

COST OF LEAKAGE CONTROL

	Proposed No. of Waste Districts	Step-Testing Total		M.N.F. Recording Total		Night Sounding/Follow Up Investigations Total		Total Annual Cost
		No/ Year	Average Cost	No/ Year	Average Cost	No/ Year	Average Cost	
EASTERN DIVISION	381	760	£ 125	2285	£ 12.50	760	£ 230	£ 298 00
SOUTHERN DIVISION	173	260	£ 125	690	£ 12.50	260	£ 230	£ 101 000
NORTHERN DIVISION	165	285	£ 125	800	£ 12.50	285	£ 230	£ 111 000
WESTERN DIVISION	210	260	£ 125	940	£ 12.50	260	£ 230	£ 104 000

APPENDIX 9

COMPARISON OF CAPITAL COSTS FOR MAJOR SCHEMES AROUND BELFAST ($£ \times 10^3$)

	GLENWHIRRY		TUNNY POINT			DUNORE POINT			CASTOR BAY			LOUGH ISLAND REAVY*		
Capacity (Ml/d)	110	140	65	110	140	40	65	110	65	110	140	17	40	65
Main Pipeline diameter	1300/1100	1400/1200	1000	1400	1600	1000	1400	1600	1000	1400	1600			
Site Investigation Intake & Pumps	Included with Dam		1603	2440	2959	1086	1600	2439	1512	2304	2797	1576	5587	4250
Pumping Station			308	467	565	187	274	415	274	415	502	49	111	49
Treatment Works	10800	13200	11000	15500	18500	8000	10500	15000	10500	15000	18000	1360	3200	5360
Dam & Catchwaters	6650	8800												6640
Reservoir			500	500	500									
Gravity Pipeline			2278	2961	3377							386	780	1127
Main or Pump Pipeline	7515	8470	2677	4319	5258	3647	5884	7163	5626	9077	11049			
Trunk Main	3758	4352		800	1200	2277	2784	3712	1377	1912	2182			
	28723	34822	18366	26987	32359	15197	21042	28729	19289	28708	34530	3371	9678	17426
Extra Conduit												383	3787	4609
												3754	13465	22035
Treatment Costs	£5150 per Ml/d p.a.		£1530 per Ml/d per annum									£3570 per Ml/d p.a		
Marginal Fixed Operating Costs	£60,000 p.a.		£80,000 p.a.			Nil			Nil			£ 10,000 p.a.	£20,000 p.a.	£30,000 p.a.

* Costings for treatment works and for larger schemes for Lough Island Reavy are marginal costings.

N.B. Costs based on previous studies, updated and modified in accordance with WEC publication TR61, Cost Information for Water Supply & Sewage Disposal.

APPENDIX 10

EFFECTS OF POSSIBLE SEQUENCES OF DEVELOPMENT FOR EASTERN AREA SCHEMES

TABLE A.10.1

1.9% Annual Increase in Electricity Costs -First Scheme Operational in 1992

Unit Cost of Water - p/m^3

Sequence of Schemes		GROWTH RATE					
		0.5%		1.0%		1.5%	
Sizes (Ml/d)	Sites	Unit Cost	Rank	Unit Cost	Rank	Unit Cost	Rank
17-40-110	L(C)-CB-GW	8.4		7.5	6	7.3	15
17-65-110	L(C)-CB-GW	8.0	6	7.4	4	7.2	4
17-110-110	L(C)-GW-CB	6.8	1	7.1	1	7.0	3
17-110-110	L(C)-CB-GW	7.9	4	7.7	10	7.0	2
17-140	L(C)-GW	6.9	2	7.1	2	6.8	1
40-65-110	L(B)-CB-GW	9.5	17	8.6	23	7.6	22
40-110	L(B)-GW	8.0	6	7.6	9	7.3	14
40-140	L(B)-GW	7.8	3	7.6	7	7.2	9
65-65-110	L(A)-CB-GW	8.9	8	8.5	22	7.6	21
65-110	L(A)-GW	8.9	8	7.6	8	7.3	12
65-140	L(A)-GW	8.9	8	7.5	5	7.2	7
65-17-110	CB-L(C)-GW	9.8	19	7.2	3	7.3	13
65-40-110	CB-L(B)-GW	9.8	19	8.7	24	7.6	23
65-65-110	CB-L(A)-GW	9.8	19	8.5	21	8.0	24
110-17-65	GW-L(C)-CB	9.0	11	7.8	12	7.4	18
110-17-110	GW-L(C)-CB	9.0	11	7.8	12	7.2	6
110-40	GW-L(B)	9.0	11	7.8	12	7.4	16
110-65	GW-L(A)	9.0	11	7.8	12	7.3	10
110-65	GW-CB	9.0	11	7.8	12	7.5	20
110-110	GW-CB	9.0	11	7.8	12	7.3	11
110-110	CB-GW	10.0	24	8.4	20	7.2	5
140	GW	9.7	18	7.9	19	7.2	8
65-110	CB-GW	9.8	19	7.9	18	7.5	19
65-140	CB-GW	9.8	19	7.8	11	7.4	17

Key to Sites
CB = Castor Bay
GW = Glenwhirry
L(A), L(B), L(C) = Lough Island Reavy

TABLE A.10.2

1.9% Annual Increase in Electricity Costs -First Scheme Operational in 2002

Unit Cost of Water - p/m^3

Sequence of Schemes Sizes (Ml/d)	Sites	GROWTH RATE 0.5% Unit Cost	0.5% Rank	1.0% Unit Cost	1.0% Rank	1.5% Unit Cost	1.5% Rank
17-40-110	L(C)-CB-GW	8.4	17	7.4	16	7.3	16
17-65-110	L(C)-CB-GW	8.0	13	7.3	15	7.2	14
17-110-110	L(C)-GW-CB	5.7	2	6.6	2	6.9	3
17-110-110	L(C)-CB-GW	7.4	12	7.7	18	7.0	7
17-140	L(C)-GW	5.3	1	6.5	1	6.5	1
40-65-110	L(B)-CB-GW	9.3	18	8.7	23	7.6	22
40-110	L(B)-GW	7.0	4	7.3	14	7.1	11
40-140	L(B)-GW	6.4	3	7.1	4	7.0	5
65-65-110	L(A)-CB-GW	8.1	14	8.4	20	7.5	21
65-110	L(A)-GW	8.1	14	7.2	7	7.1	8
65-140	L(A)-GW	8.1	14	7.0	3	6.9	3
65-17-110	CB-L(C)-GW	9.8	20	7.1	5	7.3	18
65-40-110	CB-L(B)-GW	9.8	20	8.9	24	7.6	23
65-65-110	CB-L(A)-GW	9.8	20	8.5	22	8.0	24
110-17-65	GW-L(C)-CB	7.4	5	7.2	8	7.2	15
110-17-110	GW-L(C)-CB	7.4	5	7.2	8	7.1	9
110-40	GW-L(B)	7.4	5	7.2	8	7.1	10
110-65	GW-L(A)	7.4	5	7.2	8	7.0	6
110-65	GW-CB	7.4	5	7.2	8	7.4	19
110-110	GW-CB	7.4	5	7.2	8	7.2	12
110-110	CB-GW	9.4	19	8.4	21	7.2	13
140	GW	7.4	11	7.1	6	6.8	2
65-110	CB-GW	9.8	20	7.8	19	7.5	20
65-140	CB-GW	9.8	20	7.6	17	7.3	17

Key to Sites

CB = Castor Bay
GW = Glenwhirry
L(A), L(B), L(C) = Lough Island Reavy

TABLE A.10.3

No increase in electricity prices

Unit Cost of Water - p/m^3

Sequence of Schemes Sizes (Ml/d)	Sites	GROWTH RATE 0.5% Unit Cost	Rank	1.0% Unit Cost	Rank	1.5% Unit Cost	Rank
17-40-65	L(C)-DP-CB	8.8	3	8.1	13	7.7	17
17-40-110	L(C)-DP-CB	8.8	3	8.0	12	7.4	15
17-65-65	L(C)-CB-DP	8.2	1	7.7	6	7.3	14
17-65-110	L(C)-CB-GW	8.2	1	7.4	3	6.9	3
17-110-65	L(C)-CB-DP	9.1	5	7.3	1	7.0	5
17-110-110	L(C)-CB-GW	9.1	5	7.3	1	6.7	1
17-140	L(C)-CB	10.0	7	7.5	4	6.8	2
65-17-65	CB-L(C)-DP	10.1	8	9.1	17	7.4	16
65-17-110	CB-L(C)-GW	10.1	8	7.6	5	7.0	6
65-110	CB-GW	10.1	8	7.9	7	7.2	10
65-140	CB-GW	10.1	8	8.2	14	7.3	13
110-17-40	CB-L(C)-DP	11.5	12	8.0	8	7.2	12
110-17-110	CB-L(C)-GW	11.5	12	8.0	8	6.9	4
110-40	CB-L(B)	11.5	12	8.0	8	7.2	11
110-110	CB-GW	11.5	12	8.0	8	7.1	7
110-110	GW-CB	12.5	16	8.2	15	7.2	9
140	CB	13.0	17	8.2	16	7.1	8

Key to Sites

CB = Castor Bay
DP = Dunore Point
GW = Glenwhirry
L(A), L(B), L(C) = Lough Is land Reavy

APPENDIX 11

ABBREVIATIONS

The following abbreviations are used in this Report:-

Organizations

DOE/NI	Department of the Environment for Northern Ireland
NWC	National Water Council
RWA	Regional Water Authority
WRC	Water Research Centre
IH	Institute of Hydrology, Wallingford

Geographical

GB	Great Britain
NI	Northern Ireland
UK	United Kingdom

Units - Metric

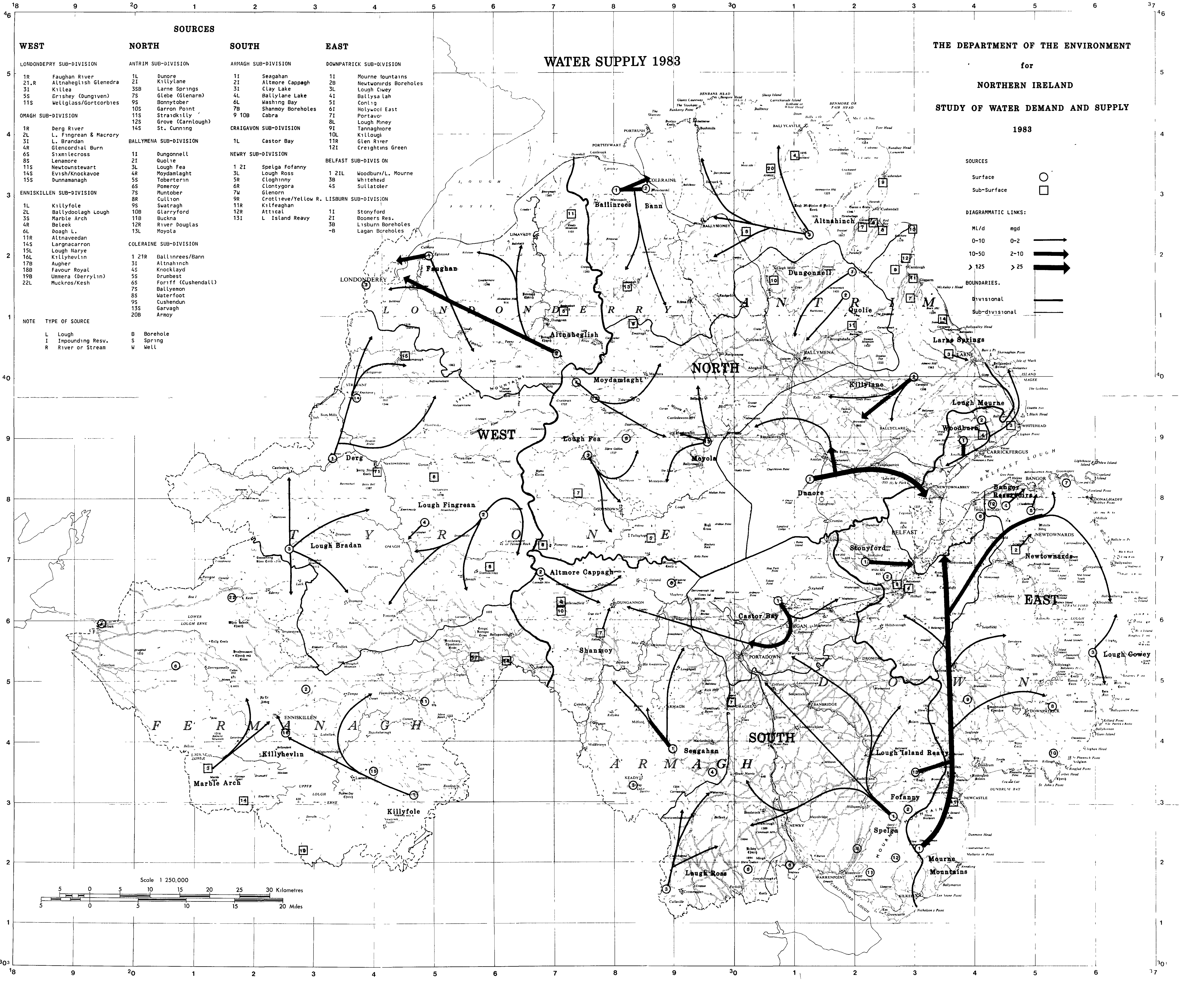
Ml	Megalitres (1 million litres)
Ml/d	Megalitres per day
l/h	litres per hour
l/p/h	litres per property per hour
l/km/h	litres per kilometre per hour
m^3/d	cubic metres per day
p/m^3	pence per cubic metre

Units - Imperial

mgd	million gallons per day
gph	gallons per hour

Technical

ARV	Annual Runoff Value
ADF	Average Daily Flow
BFI	Base Flow Index
CAP	Common Agricultural Policy
GDP	Gross Domestic Product
MNF	Minimum Night Flow
NNF	Net Night Flow
UFW	Unaccounted for Water
SAAR	Standard Annual Average Rainfall
%pa	Percent per annum


WATER SUPPLY 1983
THE DEPARTMENT OF THE ENVIRONMENT
for
NORTHERN IRELAND
STUDY OF WATER DEMAND AND SUPPLY
1983
SOURCES
WEST
LONDONDERRY SUB-DIVISION
1R Faughan River
21.R Altnaheglish Glenedra
3I Killea
5S Brishey (Dungiven)
11S Wellglass/Gortcorbies
OMAGH SUB-DIVISION
1R Derg River
2L L. Fingrean & Macrory
3I L. Brandan
4R Glencordial Burn
6S Sixmilecross
8S Lenamore
11S Newtownstewart
14S Evish/Knockavoe
15S Dunnamanagh
ENNISKILLEN SUB-DIVISION
1L Killyfole
2L Ballydoolagh Lough
3S Marble Arch
4R Beleek
6L Doagh L.
11R Altnaveedan
14S Largnacarron
15L Lough Narye
16L Killyhevlin
17B Augher
18B Favour Royal
19B Ummera (Derrylin)
22L Muckros/Kesh
NORTH
ANTRIM SUB-DIVISION
1L Dunore
2I Killylane
3SB Larne Springs
7S Glebe (Glenarm)
9S Bonnytober
10S Garron Point
11S Straidkilly
12S Grove (Carnlough)
14S St. Cunning
BALLYMENA SUB-DIVISION
1I Dungonnell
2I Quolie
3L Lough Fea
4R Moydamlaght
5S Toberterin
6S Pomeroy
7S Muntober
8R Cullion
9S Swatragh
10B Glarryford
11B Buckna
12R River Douglas
13L Moyola
COLERAINE SUB-DIVISION
1 21R Ballinrees/Bann
3I Altnahinch
4S Knocklayd
5S Drumbest
6S Foriff (Cushendall)
7S Ballyemon
8S Waterfoot
9S Cushendun
13S Garvagh
20B Armoy
SOUTH
ARMAGH SUB-DIVISION
1I Seagahan
2I Altmore Cappagh
3I Clay Lake
4L Ballylane Lake
6L Washing Bay
7B Shanmoy Boreholes
9 10B Cabra
CRAIGAVON SUB-DIVISION
1L Castor Bay
NEWRY SUB-DIVISION
1 2I Spelga Fofanny
3L Lough Ross
5R Cloghinny
6R Clontygora
7W Glenorn
9R Crotlieve/Yellow R.
11R Kilfeaghan
12R Attical
13I L. Island Reavy
EAST
DOWNPATRICK SUB-DIVISION
1I Mourne Mountains
2B Newtownards Boreholes
3L Lough Cowey
4I Ballysallah
5I Conlig
6I Holywood East
7I Portavo
8L Lough Money
9I Tannaghmore
10L Killough
11R Glen River
12I Creightons Green
BELFAST SUB-DIVISION
1 2IL Woodburn/L. Mourne
3B Whitehead
4S Sullatober
LISBURN SUB-DIVISION
1I Stonyford
2I Boomers Res.
3B Lisburn Boreholes
-B Lagan Boreholes
NOTE TYPE OF SOURCE
L Lough
I Impounding Resv.
R River or Stream
B Borehole
S Spring
W Well
SOURCES
Surface
Sub-Surface
DIAGRAMMATIC LINKS:
Ml/d mgd
0-10 0-2
10-50 2-10
> 125 > 25
BOUNDARIES.
Divisional
Sub-divisional
WEST
NORTH
SOUTH
EAST
LONDONDERRY
ANTRIM
TYRONE
FERMANAGH
ARMAGH
DOWN
Scale 1 250,000
Kilometres
Miles