



An Ghníomhaireacht um Chaomhnú Comhshaoil

# **An Assessment of the 1995 Drought**

*Including a comparison with other known drought years*

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## **Summary**

The flowrates measured towards the end of the 1976 drought are among the lowest flows on record and can be used as a benchmark drought against which other droughts can be compared. In this report, the climatic conditions and the drought flows that occurred in 1995 are examined at selected rainfall and hydrometric stations and the data compared with available data for 1976 and other drought years. It was found that low flows measured towards the end of the 1995 drought were, in some areas, comparable to the flowrates measured at the same stations towards the end of the drought in 1976.

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# **Table of Contents**

## **Page No.**

### **CHAPTER 1: DROUGHTS IN IRELAND**

1.1	Introduction	1
1.2	River Flow	1
1.3	Severity of Droughts	3
1.4	Classification of River Flows in Drought Conditions	4
1.5	Meteorological Classification of Droughts	4
	(i) Absolute Drought	4
	(ii) Partial Drought	4
	(iii) Dry Spell	4
1.6	Period of Insignificant Rainfall	5
1.7	Methods of Measurement and Recording River Flows	5
	(i) Development of a Station Calibration	5
	(ii) Continuous Recording of Water Level	6
1.8	Hydrograph of Flow of Rivers in Ireland	6
1.9	Methodology	6
1.10	Scope of this Report	7

### **CHAPTER 2: RAINFALL RECORDS**

2.1	Introduction	8
2.2	Rainfall Stations	8
2.3	Identification of Periods of Absolute Drought, Partial Drought and Dry Spell	8
2.4	Identification of Periods of Insignificant Rainfall	8
2.5	Rainfall Records for 1976	10
2.6	Rainfall Records for 1995	10
2.7	Commentary on Dry Periods in 1995	11
2.8	Examination of Rainfall Records in 1975, 1989, 1990 and 1991	12

### **CHAPTER 3: RIVER FLOWS**

3.1	Introduction	13
3.2	Gauging Station Network	13

3.3	Use of Hydrometric Records	14
3.4	Period Studied	14
3.5	River Flow Data	14
3.6	Hydrograph of Flow in 1976	17
3.7	Examination of Low Flow in 1976	17
3.8	Hydrograph of Flow in 1995	18
3.9	Examination of Low Flow in 1995	18
3.10	Examination of Low Flow in 1975, 1989, 1990 and 1991	19
	1975	19
	1989	19
	1990	19
	1991	19
3.11	Comment on 1975, 1989, 1990 and 1991 Low Flows	19
3.12	Comparison of Rainfall Pattern and Corresponding flows in 1995 and 1976	20
<b>SUMMARY AND CONCLUSIONS</b>		21
<b>REFERENCES</b>		22

## **TABLES**

TABLE 3-1	List of Hydrometric Stations used in this Report	15
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## **FIGURES**

Fig. 1	Hydrographs of daily mean flows for Station 12013 Rathvilly on the River Slaney for 1976 and 1995	2
Fig. 2	Selected Rainfall Stations	9

## **APPENDICES**

<b>APPENDIX 1</b>	<b>23</b>
TABLE A1-1 Periods of absolute drought, partial drought, dry spell and periods of insignificant rainfall in 1975, 1976, 1989, 1990, 1991 and 1995 at Clones, Mullingar, Dublin Airport, Casement Aerodrome, Kilkenny, Moorepark, Killarney, Shannon Airport, Birr, Claremorris, Glencolumbkille and Malin Head Rainfall Stations	25
Fig. A1-1 Periods of insignificant rainfall in 1976	31
Fig. A1-2 Periods of insignificant rainfall in 1995	32
Fig. A1-3 Periods of insignificant rainfall in 1975	33
Fig. A1-4 Periods of insignificant rainfall in 1989	34
Fig. A1-5 Periods of insignificant rainfall in 1990	35
Fig. A1-6 Periods of insignificant rainfall in 1991	36
<b>APPENDIX 2</b>	<b>37</b>
TABLE A2-1 Low flow recorded at selected gauging stations for the years indicated	39
<b>APPENDIX 3</b>	<b>47</b>
Hydrographs of daily mean flows for selected hydrometric stations	49
<b>APPENDIX 4</b>	<b>65</b>
List of abbreviations used in this report	67
User Comment Form	69

# **CHAPTER 1**

## **DROUGHTS IN IRELAND**

### **1.1 Introduction**

Information on flows in rivers and streams, and in particular on low flows, became a greater priority in the early 1970's based on the need to quantify our water resources, to protect them and to meet the data requirements of ongoing developmental needs<sup>1</sup>. Since then, a great deal of hydrometric information has been assembled. During the Summer of 1975 and 1976, extremely severe droughts were experienced. A large number of flow measurements and spot checks were carried out at hydrometric gauging stations around the country in these droughts. The measurements were important for providing information on the low flow at a large number of locations, the reliability of rating curves at gauging stations and for filling in gaps in chart records at times of low flow. The spot checks assisted in checking the reliability of the water level records. The low flows measured towards the end of the 1976 drought have become a standard against which to compare the severity of subsequent droughts. During the Summer of 1995 extremely low flows in rivers were experienced over large areas of the country.

This report examines the rainfall pattern and low river flows that were recorded at selected rainfall and hydrometric stations in 1995 and compares them to the rainfall pattern and low river flows that occurred in the drought year 1976.

Information on the rainfall pattern and low flows that occurred in each of the other dry years 1975, 1989, 1990 and 1991 is also included in this report.

Available data is used:

1. to examine the rainfall and river flow records for 1995 and other known drought years, especially 1976;
2. to compare the rainfall and low flows in 1995 with the rainfall and low flows that occurred in 1976;
3. to assess the relative severity of the 1995 drought.

### **1.2 River Flow**

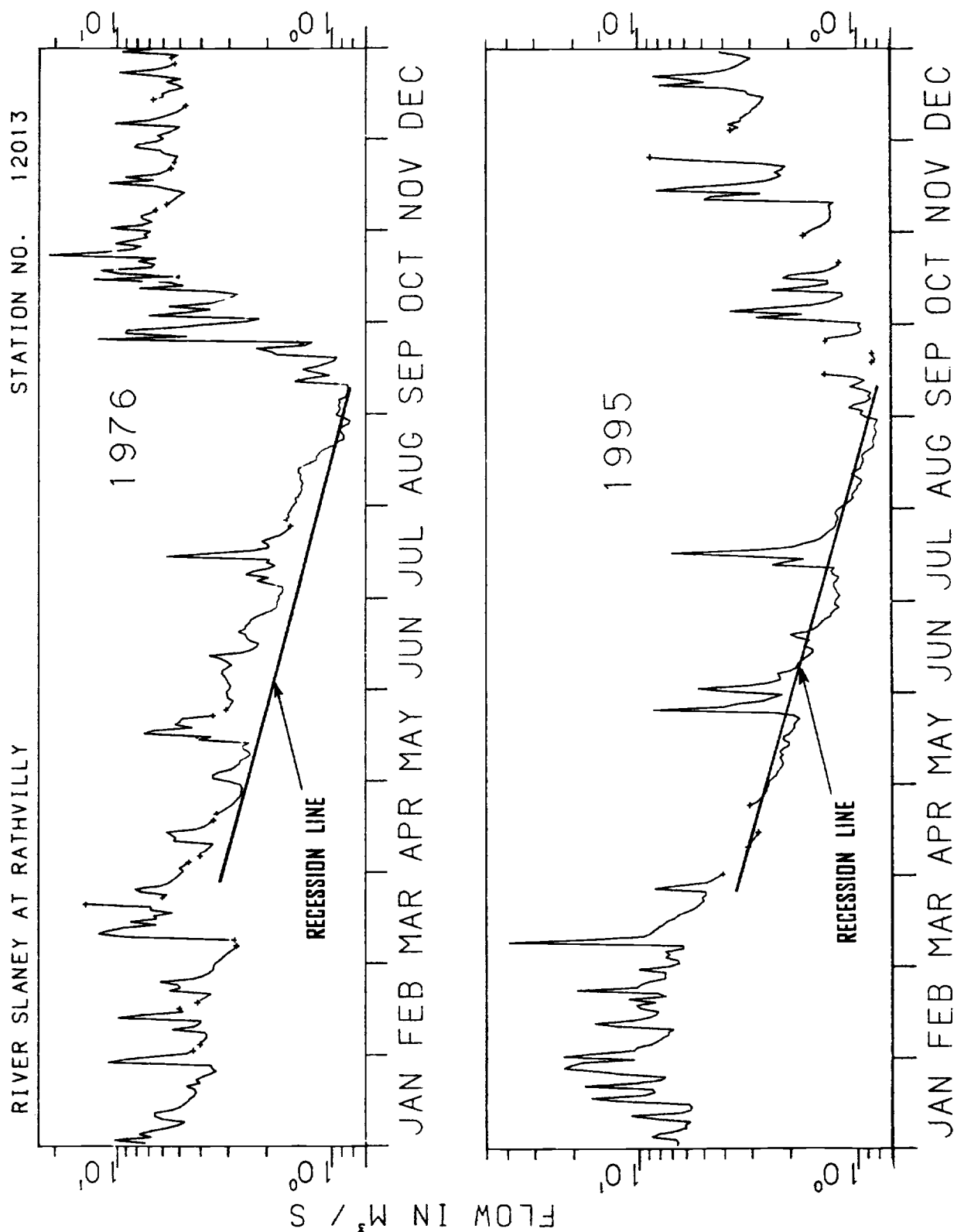
River flow can be divided into two main components:

- a) surface runoff from rainfall and
- b) baseflow recession from groundwater storage.

Surface runoff results from rainfall, resulting in an increase in river flow with rainfall and a reduction when rainfall ceases. When river flows are falling after a flood, the falling limb of the hydrograph is called the recession. The baseflow recession is that part of the river flow which comes from groundwater storage. In general there is a gradual decrease in groundwater discharge from late Spring and this decrease can be approximated by an



# HYDROGRAPHS OF DAILY MEAN FLOWS



**Fig. 1 HYDROGRAPHS OF DAILY MEAN FLOWS FOR STATION 12013 RATHVILLY ON THE RIVER SLANEY FOR 1976 AND 1995.**

exponential curve. When the recession is plotted on an arithmetic scale, it is shown as a master recession curve which is made up from a series of minor curves. On a semi-logarithmic scale, this recession curve is a straight line. An example of a simplified recession line is shown in the hydrograph for Station 12013 Rathvilly on the River Slaney for the calendar years 1976 and 1995 (Figure 1) where the vertical ordinates are drawn using a logarithmic scale.

During a period of drought, as flows decrease, the proportion of river flow arising from surface runoff becomes negligible. In the absence of rainfall, the magnitude of the baseflow component also continues to decrease with time, but at a diminishing rate.

Minimum river flows occur when a prolonged dry period coincides with a time of year when groundwater levels are at their lowest.

In the smaller catchments or in the upland areas of larger catchments, very low river flows can occur irrespective of the duration of a dry period. On the other hand, in large catchments, short periods with little or no rainfall will reduce the surface runoff component of river flow but may have only a negligible effect on baseflow, depending on the time of year when the shortage of rainfall occurs.

The main determinants of the low flow at a particular location on natural streams ( without lakes and unaffected by impoundments or abstractions) are:

- (1) the catchment area contributing to the flow at the location ( the greater the catchment area, the higher the flow per unit area);
- (2) lack of rainfall;
- (3) the variability in the geology and surface cover which can vary both within catchments as well as from catchment to catchment.

### **1.3 Severity of Droughts**

The severity of a drought is reflected in river flows and its effect on these flows can depend on a number of factors<sup>2</sup>:

- . the distribution, duration and time of year when the lack of rainfall occurs;
- . the size, topography, surface cover and geology of catchments;
- . antecedent groundwater (baseflow) conditions;
- . any lag in the response time to rainfall events;
- . soil moisture deficit.

The severity of a drought can only be assessed by comparing it with a known drought which is recognised as an extreme event. The drought which occurred in 1976 was such an event.

## **1.4 Classification of River Flows in Drought Conditions**

There is no standard classification of droughts in regard to river flows. In the preparation of Water Quality Management Plans, use has been made of the dry weather flow (which has been defined as a flow which has a 50 year return period) and the 95 percentile flow ( the flowrate which is equalled or exceeded 95 percent of the time).

## **1.5 Meteorological Classification of Droughts**

The following definitions of a drought have been used by the World Meteorological Organisation(WMO)<sup>3</sup>:

- (1) prolonged absence or poor distribution of precipitation;  
  
and
- (2) period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance.

The terms used by Met Éireann<sup>4</sup> to describe periods of little or no rain are absolute droughts, partial droughts and dry spell. These are defined as follows:

### **(i) Absolute Drought**

An absolute drought is a period of 15 or more consecutive days, on none of which 0.2 mm or more of rain fell.

### **(ii) Partial Drought**

A partial drought is a period of at least 29 consecutive days, the mean daily rainfall of which does not exceed 0.2 mm i.e. 5.8 mm in 29 days.

### **(iii) Dry Spell**

A dry spell is a period of 15 or more consecutive days, on none of which 1.0 mm or more of rain fell.

In practical terms, the Met Éireann definition is more useful and quantifiable for the conditions pertaining in Ireland than the WMO definition and is used in this report.

A difficulty which arises for hydrologists when using the meteorological classifications of a drought is that these definitions do not have regard to river flows or the effect of evapotranspiration.

From a meteorological perspective the order of dry spell/partial drought/absolute drought may be in the order of increasing severity. However, from a river flow point of view, the reverse order may be more significant. Small amounts of rainfall in a drought period may be lost in evapotranspiration and have little effect on the flow regime in natural streams.

## **1.6 Period of Insignificant Rainfall**

A small amount of rainfall, falling at the end of a drought, may break the formal definition of an absolute drought/partial drought/dry spell but may not be sufficient to cause surface runoff or may cause a small amount of surface runoff. In the latter case, the river levels will return very quickly to the pattern which pertained prior to the rainfall because the groundwater component has not increased.

For this reason, a term called "periods of insignificant rainfall" is defined and which will have regard to the runoff effects of small rainfall amounts in drought periods and is used in this report to assess the severity of droughts in conjunction with river flow records.

The application of this definition is subjective. A definition would be:

1. Any period of consecutive days commencing with a period of no rainfall;
2. The rainfall falling towards the end of the drought; when averaged over the full period of the drought, is about an average of 0.3 mm per day;
3. Individual rainfall amounts, of up to 6 mm, or other small amounts over a number of days, have been disregarded for the purpose of identifying these periods of insignificant rainfall;
4. Evidence from hydrographs of daily mean flows are used to identify the response of individual catchments to particular rainfall amounts in drought periods, to confirm that the decreases in flowrates are continuing.

## **1.7 Methods of Measurement and Recording River Flows**

The production of a continuous flow record at a gauging station requires (i) development of a station calibration and (ii) continuous recording of water levels and continuous checking and updating of station calibrations.

### **(i) Development of a Station Calibration**

The station calibration is developed by plotting the results of flow measurements which have been carried out at the gauging station at various water levels in the river and developing a relationship between water level and river flowrate.

The principal methods of flow measurement are: (i) velocity-area method, (ii) discharge measuring structures, (iii) dilution methods and (iv) electromagnetic and ultrasonic methods. The vast majority of the flow measurement stations in Ireland are calibrated with flow measurements carried out using the velocity-area method.

The velocity-area method of flow measurement consists of measuring the velocity of water (by current meter) and the cross sectional area<sup>5</sup>. The cross section is divided into a number of segments. The velocity is measured in each segment of the cross section. The flow in each segment is obtained by multiplying the segmental velocity by the cross sectional area

of that segment. The total flow in the cross section is obtained by adding the flow in each of the segments. The flowrate is given in cubic metres per second ( $\text{m}^3/\text{s}$ ).

Structures, in the form of notches and weirs, are also used, mainly for the measurement of discharges on small streams. On a number of large rivers, flat vee weirs have been constructed to stabilise the station calibration. Regular flow measurements are required at hydrometric stations to ensure credible ratings.

## **(ii) Continuous Recording of Water Levels**

Continuous water level records are obtained using autographic (chart) water level recorders. These chart records are digitised and processed, using the rating curve, to provide a continuous river flow record. In recent years a number of data loggers have been installed at hydrometric stations. The data from these loggers can be entered directly into a computer, overcoming the need to digitise water level records. The data are then verified by the processing authority using spot checks carried out from time to time. When verified, the data is processed, using the rating curve, to produce a continuous river flow record.

## **1.8 Hydrograph of Flow of Rivers in Ireland**

The pattern of river flow in Ireland reflects the rainfall pattern and, in general, there is a prompt response to rainfall although the rate of response varies from catchment to catchment. Some catchments have a very quick response to rainfall and are regarded as flashy catchments, with little or negligible storage. In other catchments, the rate of increase in runoff resulting from rainfall may not be as severe as water goes into storage and then contributes to river flow from storage.

The normal pattern of flow in rivers in Ireland is that the groundwater recession commences in the Spring and continues at a steady rate until the Autumn. Rainfall in the late Spring/Summer does not alter the trend of the recession once it is established, although such rainfall may lead to an increase in river flows.

Recovery of groundwater flow to normal winter levels depends on the rainfall pattern after the end of the low flow period.

The total river flow hydrograph may be important in circumstances where the total river flow in a summer period has implications for water resource management.

## **1.9 Methodology**

An examination was undertaken of the rainfall records at a selection of stations in the years 1975, 1976, 1989, 1990, 1991 and 1995. The periods of absolute drought, partial drought and dry spell in each year were identified. The periods of insignificant rainfall were also identified in these years. The results of this examination are presented in Table A1-1 (Appendix 1). The low flow in the same years at selected hydrometric stations was also established and are presented in Table A2-1 (Appendix 2). The hydrographs of daily mean flow at selected stations for 1976 and 1995 are presented in Appendix 3.

## **1.10 Scope of this Report**

This report deals with low river flows in natural river catchments (i.e. rivers not affected by lake storage or river regulation due to impoundments/small scale hydro electric stations) during the long dry periods in the years listed earlier when severe droughts are known to have occurred.

It does not deal with the particular problem of storage in impounding reservoirs<sup>6</sup>.

## **CHAPTER 2**

### **RAINFALL RECORDS**

#### **2.1 Introduction**

Daily rainfall data was obtained from Met Éireann for a selection of rainfall stations. The locations of these selected rainfall stations are shown in Figure 2. These stations were selected in order to have a good geographic spread of rainfall stations around the country.

Rainfall records have been used in this report as indicators of the drought duration and are used, in conjunction with stream flow records, to assess the severity of the drought.

#### **2.2 Rainfall Stations**

The following rainfall stations were used in this report:

Clones, Mullingar, Dublin Airport, Casement Aerodrome, Kilkenny, Moorepark (Fermoy), Killarney (BVM Park), Shannon Airport, Birr, Claremorris, Glencolumbkille and Malin Head.

Rainfall records for both Glencolumbkille and Killarney (BVM Park) stations were not available for 1975 and data for Glenties Hatchery and Muckcross House, respectively, were used as an alternative for each of these stations for that year. Similarly, where it was necessary to express the rainfall total for a month as a proportion of the average monthly rainfall but the average monthly (normal monthly) rainfall was not available for a station, the proportion of the monthly rainfall to the long average rainfall at a nearby station was taken as being applicable at the selected station.

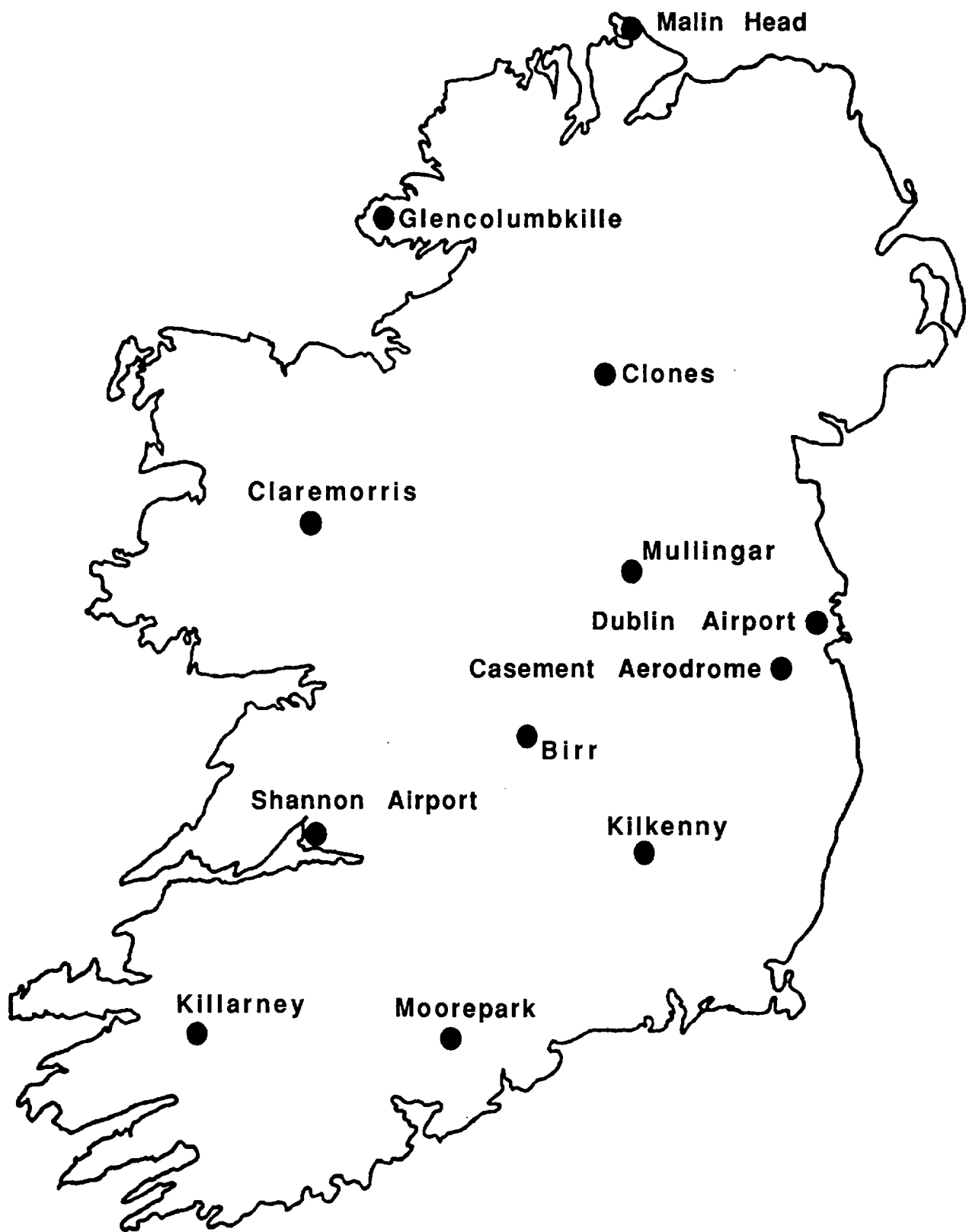
#### **2.3 Identification of Periods of Absolute Drought, Partial Drought, and Dry Spell**

The rainfall records in each of the years 1975, 1976, 1989, 1990, 1991 and 1995 were examined and the periods of absolute drought, partial drought and dry spells identified, based on the Met Éireann definition of these terms. The results of this examination are presented in Table A1-1, Appendix 1.

#### **2.4 Identification of Periods of Insignificant Rainfall**

The periods of insignificant rainfall in 1975, 1976, 1989, 1990, 1991 and 1995 were identified using the definition given in Chapter 1. These are also given in Table A1 and shown in Figure A1-1 (for the year 1976), Figure A1-2 (1995), Figure A1-3 (1975), Figure A1-4 (1989), Figure A1-5 (1990) and Figure A1-6 (1991). These figures are presented in Appendix 1.

**KEY**  
● **LOCATION OF RAINFALL STATIONS**



**Fig. 2 SELECTED RAINFALL STATIONS**



## **2.5 Rainfall Records for 1976**

The rainfall in January 1976 was around 90% of normal at most stations although at Clones and Malin Head stations it was around 130% of normal. In February, it was about 70% of normal and in March was about normal at most stations while in April, it was about 50% of normal at most stations.

In May, rainfall was generally about 120% of normal but was 186% of normal at Mullingar and 200% of normal at Malin Head station. In June, it was 50% of normal in most areas although it was around 80% of normal at both Killarney and Malin Head stations. In July, it ranged from 53% of normal at Mullingar to 119% of normal at Dublin Airport station.

In August, the rainfall total for the month was quite low and ranged from about 10% of normal at most stations to 23% of normal at Malin Head station. The rainfall total for the month of September was quite variable: at Dublin Airport and Casement Aerodrome stations, it was around 190% of normal but elsewhere on the east coast and in the south and south-east, it was around 110% of normal while on the west coast and in County Donegal it was around 70% of normal.

In October, the rainfall was about 140% of normal although there was a large variation at some stations: ranging from 105% of normal at Killarney to 224% of normal at Dublin Airport station. In November, the rainfall was about 70% of normal at most stations although it was about 120% of normal at Glencolumbkille and Malin Head stations. In December, the rainfall was about 70% of normal although the range was quite marked: ranging from 58% of normal at Mullingar station to 112% of normal at Killarney station.

The periods of absolute drought, partial drought and dry spell in the year 1976 are listed in Table A1-1 (Appendix 1) for the selected rainfall stations. The periods of insignificant rainfall are also listed in Table A1-1 and shown in Figure A1-1 for the year 1976 (Appendix 1).

In 1976 the duration of the drought ranged from 27 days at Glencolumbkille (ending on 7 September) to 66 days at Moorepark (ending on 18 September). At most stations the drought ended on 9 September.

The rainfall data indicates that the 1976 drought was virtually nationwide (Figure A1-1, Appendix 1).

## **2.6 Rainfall Records for 1995**

Rainfall at all the selected stations was considerably above normal for the months of January, February and March 1995: in January it was about 170% of normal, in February around 200% of normal and in March was about 140% of normal.

In April it was below normal at all selected stations, ranging from 26% of normal at Killarney to 75% of normal at Malin Head station; there was less than half the normal rainfall over most of the southern half of the country and the north-east; at Kilkenny it was the driest April since 1976 while at most other stations it was the driest April for seven to thirteen years.

In May, rainfall was around 70% of normal over most of the country but parts of the north-west and south-west had above normal amounts for May. The rainfall for the month was in the range 61% to 89% along the midlands and east coast while along the west coast it was in excess of 100% of normal and up to 200% of normal in Donegal.

June was a very dry month almost everywhere. Rainfall was below normal at all selected stations, ranging from around 21% of normal at Dublin Airport to 77% of normal at Kilkenny station.

Rainfall totals for the month of July varied widely, ranging from 72% of normal at Malin Head to 195% of normal at Shannon Airport. It was above normal at Clones, Mullingar, Kilkenny, Moorepark, Killarney, Glencolumbkille, Claremorris and Shannon Airport stations while it was below normal at Dublin Airport, Casement Aerodrome, Birr and Malin Head stations.

In August, there was less than half the normal rainfall at all selected stations but the eastern half of the country was particularly dry. The rainfall ranged from 4% of normal at Casement Aerodrome to 46% of normal at Birr. Except for Birr, the rainfall at all selected stations was under 20% of normal.

The rainfall for September was around 50% of normal at Casement Aerodrome, Kilkenny, Moorepark, Killarney, Shannon Airport and Birr stations. At the other selected stations, Clones, Mullingar, Dublin Airport, Claremorris, Glencolumbkille and Malin Head stations, rainfall ranged from 67% of normal at Claremorris to 110% of normal at Malin Head. Relatively large amounts of rain fell between 10 and 13 September and between 23 and 26 September.

In October, the rainfall for the month was in excess of 150% of normal at most stations although the rainfall in the Dublin area was 55-69% of normal. In November, the average rainfall for the month was about 120% of normal and ranged from 73% of normal at Malin Head station to around 200% of normal in the Dublin area. In December, the rainfall ranged from 33% of normal at Clones station to 104% of normal at Moorepark station and was in excess of 50% at most of the selected stations.

The periods of absolute drought/partial drought and dry spell in 1995 are listed in Table A1-1 (Appendix 1). The periods of insignificant rainfall for 1995 are also listed in Table A1-1 and shown in Figure A1-2 (Appendix 1).

## **2.7 Commentary on Dry Periods in 1995**

There was a dry spell in most areas in March/April and in June/July. On the east coast, the dry spell which began in June/July extended into August. In general, there was very little rain on the east coast and midlands from 4 June to around 5 July and on the west coast (excluding Claremorris) from 20 June to around 5 July. There was a recurrence of dry conditions from late July until early September. There were a number of single days in September with rainfall as follows: around 3 September (about 6 mm), 12 September (about 10 mm) and 23 September (about 10-20 mm).

In 1995 the duration of the second dry period ranged from 12 days at Glencolumbkille (ending on 12 August) to 45 days at Birr (ending on 11 September).

The rainfall records indicate that the lack of rainfall was most severe (1) south of a line drawn from Sligo to Dundalk and (2) east of a line from Cork to Galway (Figure A1-2, Appendix 1).

## **2.8 Examination of Rainfall Records in 1975, 1989, 1990 and 1991**

The periods of absolute drought, partial drought and dry spell in the years 1975, 1989, 1990 and 1991 are listed in Table A1-1 (Appendix 1) for the selected rainfall stations. The periods of insignificant rainfall for these stations for the same years are also listed in Table A1-1 and shown in Figures A1-3 for the year 1975, Figure A1-4 (1989), Figure A1-5 (1990) and Figure A1-6 (1991), all in Appendix 1.

An examination of Table A1-1 (Appendix 1) indicates that the duration of the drought in 1975 ranged from 23 days at Malin Head (ending on 12 July) to 67 days at Claremorris (ending on 8 July). In most areas the drought ended in the first week in July; South of a line from Dublin-Shannon-Moorepark there was a recurrence of drought conditions ending around 5-7 September 1975.

In 1989, the duration of the dry period ranged from 8 days at Glencolumbkille (ending on 8 July) to 38 days at Moorepark station (ending on 7 August);

In 1990, the duration of the drought ranged from 12 days at Glencolumbkille (ending on 27 July) to 38 days at Dublin Airport and Mullingar stations (ending on 13 August). On the east and south-east coast, the dry period recurred for about 20 days, ending around 15 September 1990.

In 1991, the duration of the first dry period ranged from 21 days at Glencolumbkille (ending on 2 June) to 39 days at Mullingar station (ending on 7 June). There was a second dry period ending between 12-14 September with the period of insignificant rainfall ranging from 18 days at Mullingar station to 45 days at Kilkenny station.

The above examination of the rainfall data indicates that the drought in 1975 was virtually nationwide and the period when there was negligible rainfall was about the same as that which occurred in 1976. In 1989, 1990 and 1991, the periods of negligible rainfall did not cover as extensive an area of the country and the number of days was about half the value noted at the same stations in 1976.

## CHAPTER 3

### RIVER FLOWS

#### 3.1 Introduction

Hydrometric data for low flow conditions has only been collected systematically since about the early 1970's. Prior to that, any hydrometric data collected related to particular projects<sup>7,8</sup>. In May 1922, Professor Purcell (University College Dublin) erected a recorder on the River Liffey at Burgage Bridge<sup>9</sup> for the Royal Dublin Society. Dublin Corporation erected staff gauges at Pollaphouca and at New Bridge (near Celbridge) on the same river also in the 1920's<sup>9</sup>.

In the 1930's, the Electricity Supply Board (ESB) erected recorders on rivers with a view to studying these rivers for the purposes of power generation. From the late 1940's, subsequent to the passage of the Arterial Drainage Act 1945, the Office of Public Works erected recorders at strategic locations on rivers and lakes in relation to arterial drainage and flood relief.

A major effort to carry out flow measurements at times of low river flow and to improve station calibrations began in the drought years 1975 and 1976<sup>10</sup>. Hydrographs of flow for the calendar years 1975, 1976 and 1977 were published in the Surface Water Year Book for 1975<sup>11</sup>, for 1976<sup>12</sup> and for 1977<sup>13</sup>.

With the passage of the Local Government (Water Pollution) Act 1977, the needs of Local Authorities for data in relation to effluent licences gave rise to the need for more hydrometric data. Local Authorities, assisted by AFF, erected hydrometric stations in relation to conservation, environmental protection and water resources development.

Under the Environmental Protection Agency Act 1992, the Agency must prepare a National Hydrometric Programme for the collection, analysis and publication of information on the levels, volumes and flows in rivers, lakes and groundwaters in the State.

#### 3.2 Gauging Station Network

The current hydrometric network comprises stations operated by the OPW, the ESB, Local Authorities and other bodies. The numbers of stations are as follows:

##### Number of stations operated by the Office of Public Works

	Rivers	Lakes	Tidal
Recorders	239	29	21
Staff gauges	8	5	0

##### Number of stations operated by Local Authorities

	Rivers	Lakes	Tidal
Recorders	133	44	0
Staff gauges	644	46	0

### **Number of stations operated by the ESB**

	Rivers	Lakes	Tidal
Recorders	24	8	4
Staff gauges	7	1	0

### **Number of stations operated by Other Bodies**

	Rivers	Lakes	Tidal
Recorders	6	0	13
Staff gauges	10	0	6

For the purposes of this study, a selection was made from these hydrometric stations to allow an assessment to be made of the effects of droughts on river flows. Stations on lakes and stations where the flow was affected by river regulation or major abstractions were omitted from the selection.

### **3.3 Use of Hydrometric Records**

Hydrographs or tables of daily mean flows were used for the purposes of this report to show the flow pattern throughout the year, to identify the groundwater recession, the date of the end of the drought as regards river flows and the recovery of river flows.

River flow measurements and records from hydrometric stations during long dry periods were used to assess the severity of the drought.

### **3.4 Period Studied**

The river flow records in the years 1976 and 1995 were examined at the selected hydrometric stations.

Information on the low flow at the end of the drought in 1975, 1989, 1990 and 1991 at selected hydrometric stations are also included (where available).

### **3.5 River Flow Data**

The hydrometric stations used in this report are listed in Table 3-1 giving the station number, registered name, the river on which it is located, a three letter code indicating the body responsible for the maintenance of the station, the national grid reference of the location of the station and the catchment area to the station (in km<sup>2</sup>). The list of abbreviations used in this report is given in Appendix 4.

These stations were chosen because they give a good geographical spread of stations throughout the country and low flow data was available from them for the years 1975 and/or 1976.

TABLE 3-1

## List of Hydrometric Stations used in this Report

STAT. No.	LOCATION	RIVER	BDS	NGR	Area (km <sup>2</sup> )
01043	BALLYBOFEY	FINN	OPW	H134946	319.0
03051	FAULKLAND	BLACKWATER	MON	H704379	126.0
06013	CHARLEVILLE	DEE	OPW	O044907	307.0
06014	TALLANSTOWN	GLYDE	OPW	N953978	270.0
07005	TRIM	BOYNE	OPW	N801569	1282.0
07009	NAVAN WEIR	BOYNE	OPW	N878667	1610.0
07012	SLANE CASTLE	BOYNE	OPW	N949739	2408.0
08002	NAUL	DELVIN	DUN	O132612	37.0
10002	RATHDRUM	AVONMORE	WIC	T197883	233.0
10003	LARAGH	AVONMORE	WIC	T146965	107.2
10004	LARAGH	GLENMACNASS	WIC	T143965	28.0
10028	KNOCKNAMOHILL	AUGHRIM	WIC	T176780	204.1
11001	BOLEANY	OWENAVORRAGH	OPW	T170560	148.0
12001	SCARAWALSH	SLANEY	OPW	S983450	1036.0
12013	RATHVILLY	SLANEY	CAR	S882844	185.0
12015	FERNS	BANN	WEX	T030493	161.0
12016	DUNANORE	BORO	WEX	S960364	175.0
14003	BORNESS	BARROW	OPW	N463092	276.0
14004	CLONBULLOGE	FIGILE	OPW	N609235	268.0
14006	PASS BR	BARROW	OPW	N622109	1096.0
14011	RATHANGAN	SLATE	OPW	N673193	163.0
14032	KYLE	TRIOGUE	LAO	N437038	31.3
14033	MOUNTMELICK	OWENASS	LAO	N252430	91.0
15001	ANNAMULT	KINGS	OPW	S543443	443.0
15002	JOHN'S BR.	NORE	OPW	S506561	1605.0
15003	DININ BR.	DININ	OPW	S479628	298.0
15004	MCMAHONS BR.	NORE	OPW	S418797	491.0
15005	DURROW FT. BR.	ERKINA	OPW	S406774	387.0
15006	BROWNSBARN	NORE	OPW	S617391	2388.0
15007	KILBRICKEN	NORE	OPW	S362899	343.0
15008	BORRIS IN OSSORY	NORE	OPW	S239880	111.0
15021	ANNAGH	DELOUR	LAO	S289936	72.0
16001	ATHLUMMON	DRISH	OPW	S176594	140.0
16002	BEAKSTOWN	SUIR	OPW	S092552	512.0
16003	RATHKENNAN	CLODIAGH	OPW	S051530	246.0
16008	NEW BRIDGE	SUIR	OPW	S001341	1120.0
16010	ANNER	ANNER	OPW	S253256	422.0
16011	CLONMEL	SUIR	OPW	S208222	2173.0
16020	PORTLAW	CLODIAGH	WAT	S449154	124.0
18002	BALLYDUFF	BLACKWATER	OPW	W964991	2338.0
18003	KILLAVULLEN	BLACKWATER	OPW	W647997	1258.0
18006	CSET MALLOW	BLACKWATER	CSE	W525973	1058.0
19015	HEALY'S BR.	SHOURNAGH	ESB	W606730	207.0
21002	COOMHOLA	COOMHOLA	COR	V998548	65.0
21003	BALLYLICKY	OWVANE	COR	W010536	75.3
21004	INCHILOUGH	MEALAGH	COR	W027511	46.0
22006	FLESK	FLESK(LAUNE)	OPW	V972894	325.0
23002	LISTOWEL	FEALE	OPW	Q997333	646.0
23005	GOULBURN	ALLAGHAUN	LIM	R168263	113.4
23006	NEODATA	FEALE	LIM	R112269	295.3
23007	OOLAGH RLY. BRIDGE	OOLAGH	LIM	R112278	34.2
24004	BRUREE	MAIGUE	OPW	R550303	246.0
24011	DEEL BR.	DEEL	OPW	R299327	273.0
25001	ANNACOTTY	MULKEAR	OPW	R642576	646.0

Table 3-1 contd. List of Hydrometric Stations used in this Report

STAT. No.	LOCATION	RIVER	BDS	NGR	Area (km <sup>2</sup> )
25003	ABINGTON	MULKEAR	OPW	R715534	397.0
25005	SUNVILLE	DEAD	OPW	R777478	190.0
25021	CROGHAN	LITTLE BROSNA	OPW	N053056	493.0
25027	GOURDEEN	OLLATRIM	OPW	R886797	118.0
25030	SCARRIFF	GRANEY	OPW	R641842	279.0
25040	ROSCREA	BUNOW	TIN	S135889	30.0
26006	WILLSBROOK	SUCK	OPW	M692756	182.0
26009	BELLANTRA BR.	BLACK	OPW	N128894	97.0
26014	BANADA BRIDGE	LUNG	OPW	M634943	222.0
26015	CORRASCOFFY	ESLIN	OPW	N053930	62.0
26029	DOWRA	SHANNON	CAV	G991271	109.3
27002	BALLYCOREY	FERGUS	OPW	R344803	562.0
30020	BALLYHAUNIS	DALGAN	MAY	M480795	20.2
30021	CHRISTINA'S BR.	ROBE	MAY	M346710	138.0
31002	CASHLA	CASHLA	GAL	L978276	72.0
32012	NEWPORT WEIR	NEWPORT	MAY	L997943	138.3
33001	GLENAMOY	GLENAMOY	MAY	F895337	73.0
33006	SRAHNAMANRAGH	OWENDUFF	MAY	F812154	121.0
34001	RAHANS	MOY	OPW	G243178	1911.0
34003	FOXFORD	MOY	MAY	G267039	1737.0
34004	BALLYLAHAN	MOY	OPW	M276992	898.0
35001	BALLYNACARROW	OWENMORE	OPW	G639219	299.0
35005	BALLYSADARE	BALLYSADARE	OPW	G669290	642.0
35011	DROMAHAIR	BONET	OPW	G805308	294.0
36020	KILLYWILLIN	BLACKWATER	OPW	H202146	95.0
36031	LISDARN	CAVAN	CAV	H416005	52.0
37020	VALLEY BR	GLENADDRAGH	DON	G642767	13.5
39001	NEW MILLS	SWILLY	OPW	C117092	49.0
39003	TULLYARVAN	CRANA	OPW	C349330	99.0

Where records of water level commenced at hydrometric stations after the 1976 drought, information on such stations is included in Table A2-1 (Appendix 2) in order to show the relative ranking of the low flow in 1989, 1990, 1991 and 1995.

The low flow recorded at the selected stations are presented in Table A2-1 (Appendix 2).

At a number of stations, it was not possible to use the processed water level records to obtain the low flow because the station calibration was not considered reliable or was subject to changing channel conditions or affected by weed growth. In these cases, use has been made of in-situ flow measurements carried out by the hydrometric teams operated by the EPA and OPW. These in-situ measurements are noted with an asterisk (\*) in Table A2-1 (Appendix 2). The date on which the flow measurement was taken is also given and in most cases, these measurements were carried out at or towards the end of the drought.

There may be hydrometric stations where the difference in the low flow from one year to the next is marginal or within experimental error and that, in absolute terms, there may be no significant difference in the recorded minimum flows in all the droughts examined. The reason for this is explained by the size of the catchment or by the absence of significant groundwater storage.

### **3.6 Hydrograph of Flow in 1976**

At most hydrometric stations throughout the country, the groundwater recession from winter/spring flows commenced in April/May and there was a steady decline until mid August. The rainfall in May, June and July did increase river flow but it did not alter the trend of the recession. At some stations there was very little variation in flow from mid August to mid September. For example, the low flow at the end of the drought in 1976 at Station 12013 Rathvilly on the River Slaney was 0.81 m<sup>3</sup>/s while the average flow for the month of June was 2.6 m<sup>3</sup>/s, July 2.1 m<sup>3</sup>/s, August 1.2 m<sup>3</sup>/s, September 2.4 m<sup>3</sup>/s and October 7.0 m<sup>3</sup>/s (see Figure 1). The hydrographs of flow for 1976 at a selection of stations are presented in Appendix 3.

Except for the South-Eastern and Southern Water Resource Region, there was a rapid recovery of groundwater flows to normal winter flows at virtually all stations throughout the country after the rainfall which fell in most areas on 9 September. The recovery of flows in the South-Eastern and Southern Water Resource Region did not take place until about 18 September and river levels continued to fall for a short period after the rainfall on 9 September.

### **3.7 Examination of Low Flow in 1976**

The low flows recorded in 1976 at selected hydrometric stations are presented in Table A2-1 (Appendix 2).

In 1976 the minimum flows occurred early in September, coinciding with the end of the drought on 9 September although there was a recurrence of very low flows until about 18 September at some stations in the south and south-east. This ties in with the periods of insignificant rainfall (Figure A1-1, Appendix 1).



The flows measured in September 1976 are among the lowest ever measured in this country.

### **3.8 Hydrograph of Flow in 1995**

The groundwater recession commenced in March 1995 and continued until August. The rainfall in April, May and July did increase river flow but it did not alter the trend of the recession. At some stations there was a negligible reduction in flow from mid August to early September: for example at Station 12013 Rathvilly, the low flow in September 1995 was 0.8 m<sup>3</sup>/s and the average monthly flow for June was 2.0 m<sup>3</sup>/s, July 1.7 m<sup>3</sup>/s, August 1.0 m<sup>3</sup>/s, September 1.0 m<sup>3</sup>/s and October 1.7 m<sup>3</sup>/s (Figure 1). Minimum flows in 1995 are similar to the minimum flows in 1976 in parts of the area most affected by drought. An examination of the hydrographs of daily mean flow at some of the hydrometric stations in the area most affected by the drought (see Appendix 3) indicates that the amount of river flow available in the months June-August 1995 was less than in the corresponding period in 1976.

The river flow at most hydrometric stations recovered steadily to normal winter flows from the end of September although at some stations there was a small increase in river flow in September with a further increase in runoff in October and river flows finally recovered in November.

Examples of the hydrographs of daily mean flows at selected hydrometric stations in 1995 are presented in Appendix 3.

### **3.9 Examination of Low Flow in 1995**

The low flows recorded in 1995 at selected hydrometric stations are presented in Table A2-1 (Appendix 2). In general, the lowest river flows in 1995 occurred in the month of September 1995. This ties in with the periods of insignificant rainfall.

While there are variations within the region, very low flows were recorded in 1995 in the region south of a line from drawn from Sligo to Dundalk and (2) east of a line from Cork to Galway (Figure A1-2, Appendix 1) and approximated to the low flow recorded at these stations in 1976.

In the Blackwater (Monaghan), Mague and Deel Rivers, the flow at the end of the 1995 drought approximated to the long term 95 percentile flowrate for these stations. Similarly the low flow in 1995 along the south coast to West Cork, in the Feale Catchment and in the Mulkear Catchment was above the 1976 low flow.

### **3.10 Examination of Low River Flows in 1975, 1989, 1990 and 1991**

The low flow recorded at selected hydrometric stations at the end of the drought in each of the years 1975, 1989, 1990 and 1991 are given in Table A2-1 (Appendix 2).

#### **1975**

Large areas of the country were affected by the drought in 1975. Low river flows occurred in the first week of July. Where there was a recurrence of drought conditions, generally in the area bounded by Dublin-Shannon-Wexford, minimum flow conditions recurred in the first week in September. This ties in with the periods of insignificant rainfall (Figure A1-3, Appendix 1).

#### **1989**

In general, the low flow in 1989 occurred about the end of July/beginning of August. This ties in with the periods of insignificant rainfall (Figure A1-4, Appendix 1). The lowest flows occurred in the region east of a line from Cork to Dundalk.

#### **1990**

North of a curved line from Dundalk to Limerick to West Cork (Figure A1-5, Appendix 1) the low flow in 1990 occurred around the end of July. In this region the flows were higher than the flows that occurred in 1989. South of this line there was a recurrence of low flows and the lowest flows of the year occurred in September. These latter flows were lower than the flows that occurred in 1989.

#### **1991**

In 1991 lowest flows occurred in a corridor from Wexford to Mayo (Figure A1-6, Appendix 1) and the lowest flows of the year occurred around the middle of September although there were low flows in June in Counties Donegal, Kerry and Limerick. In most cases the low flows were higher than the flows which occurred at these stations in 1990.

### **3.11 Comment on 1975, 1989, 1990 and 1991 Low Flows**

The flows measured in July 1975 and September 1975 are comparable to the low flow recorded at the end of the 1976 drought.

The flowrate at the end of the drought in 1989, 1990 and 1991 at the selected stations are presented (where data are available) in Table A2-1 (Appendix 2). In general terms, it can be seen from the table, the low flow at most stations from Dundalk to East Cork was of the same order of magnitude in each of these years. In some cases, these were as low as the low flow in 1976.

In certain areas, flow rates measured at the end of the drought in 1989, 1990 and 1991 approximate to the 95 percentile flowrate

### **3.12 Comparison of the Rainfall Pattern and Corresponding Flows in 1995 and 1976**

There was more rainfall in the months of January, February and March in 1995 than there was in the corresponding months in 1976. The rainfall total in April 1995 was about the same as in April 1976. There was more rainfall in May 1976 than in the same month in 1995 while the amounts in June in both 1976 and 1995 were about the same. There was more rainfall in the month of July 1995 than in the same month in 1976. The total amount of rainfall in August 1976 was less than the same month in 1995.

September 1976 was wetter than September 1995 and November 1995 was wetter than the same month in 1976. The rainfall totals in the months of October and December in 1976 and 1995 were about the same.

In 1976 there were continuous periods, lasting about 60 days, at most rainfall stations in the country, when there was negligible rainfall, ending early in September 1976 (Figure A1-1, Appendix 1). The situation was different in County Donegal where there was about 30 days with negligible rainfall, also ending in September 1976 (Figure A1-1, Appendix 1).

The rainfall records indicate that the 1976 drought was more extensive and more uniform than the 1995 drought. These show that the area most affected by the drought was (1) south of a line drawn from Sligo to Dundalk and (2) east of a line from Cork to Galway (Figure A1-2, Appendix 1). In this area, there were two periods of drought: the first period, lasting 20 days, ended on 5 July followed by some rainfall; the second period commenced around the end of July and lasted about 40 days until the end of August/early September. In large parts of the country, the rainfall that broke the drought early in September 1995 was not very large and, in some cases, it was not until the end of September that substantial amounts of rain fell.

In parts of the country, the total number of days in the summer period in 1995 when there was negligible rainfall was about the same as that which occurred in the drought in 1976. In addition, the drought in 1976 and in 1995 ended in the month of September.

An examination of the hydrographs of daily mean flow (Appendix 3) will show that there was more flow in the rivers throughout the country in January, February and March 1995 than in the corresponding months in 1976. In general, the runoff for April 1995 was about the same as that which occurred in the same month in 1976 while in May 1995, the runoff was less than that which occurred in May 1976. This pattern is consistent throughout the country. The runoff in June and July 1995 was about the same or slightly less than in same months in 1976. In August and early September 1995, there were some variations in the runoff pattern when compared to the runoff in the same period in August and September 1976:

- outside the area which the rainfall records indicate was most affected by the drought, the runoff in 1995 was greater than the runoff in the same period in August and September 1976;
- within the area most affected by drought, some variations were observed in the runoff pattern: in smaller catchments and in the upper parts of large catchments, the runoff in August and early September 1995 was very similar to the runoff in the same months in 1976; in the lower parts of large catchments, flows in August and early September 1995 were above the flows recorded in the same period in 1976.

The runoff in September and October 1995 was about the same or less than the runoff in the same months of 1976. In November and December 1995 the runoff was greater than the flow in the same months in 1976.

In general, the pattern of flow in 1995 (Appendix 3) in the area of severe drought indicates that there was more river flow in the period January-March, less in the period May-October and more in the period November-December than in the same period in 1976. However the data in Table A2-1 (Appendix 2) indicates that the low flow experienced in 1976 and 1995 in this area were quite similar in parts of the area most affected by the drought.

As can be seen from an examination of Table A2-1 (Appendix 2), the low flows recorded in 1995 in the region south of a line from drawn from Sligo to Dundalk and (2) east of a line from Cork to Galway (Figure A1-2, Appendix 1) were about as low or marginally lower than the low flows recorded in 1976 at the same stations although some variations were noted in this region. In particular the low flow at the end of the drought in 1995 in the Rivers Dee, Glyde, part of the Boyne Catchment, Avoca, Slaney, part of the Upper Barrow Catchment, part of the Nore Catchment, part of the Upper Suir Catchment, part of the Upper Shannon Catchment, Moy Catchment and Corrib Catchment was similar to the low flow in 1976. The low flows in 1995 in the Rivers Blackwater (Monaghan), part of the Nore Catchment, Lower Suir, Blackwater (Munster), Part of the Lee Catchment, Feale Catchment, Maigue Catchment, Mulkear Catchment were above the 1976 low flows.

## **SUMMARY AND CONCLUSIONS**

1. The results of this study indicate that the groundwater recession commences in most rivers in Ireland early in Spring and once its trend is established, the slope of the recession appears to be unaffected by rainfall in late Spring/Summer.
2. In general, a substantial period of insignificant rainfall ending in September will result in low river flows. Low river flows will occur in catchments with limited groundwater resources after a similar, or shorter period, of insignificant rainfall, irrespective of the time of year at which it occurs.
3. The minimum flow rates measured in the 1976 drought are among the lowest flows on record and can be used as a benchmark drought against which other droughts can be compared. However, the hydrographs of flow over the summer period need to be available to get an overall picture of the severity of the drought.
4. In many areas of the country, extreme low flows were measured at the end of the drought in 1995 which were comparable to the low flows measured at the end of the drought in 1976. However, in the south-west and parts of the north east, flows at the end of the 1995 drought approximated to the 95 percentile flowrate.
5. The low flow in all the drought years examined appears to be independent of the previous years low flows and were due to the lack of rainfall in each of these drought years.
6. From a river flow point of view, the period of insignificant rainfall and the time of year at which it occurs is more relevant to assessing extreme river flow conditions

than the use of periods described by the terms absolute drought, partial drought and dry spell.

## REFERENCES

1. Inter-Departmental Working Group on Air and Water Pollution. "Report on Water Pollution". Stationery Office. July 1972.
2. Mac Cárthaigh. M. "Assessment and Forecasting of Drought Flow Conditions in Irish Rivers". Water and Environmental Section, Institution of Engineers of Ireland. November 1992.
3. World Meteorological Organisation. "The Role of the World Meteorological Organisation in the WMO International Decade for Natural Disaster Reduction". WMO 745, 1990.
4. Rohan, P.K. "The Climate of Ireland". Stationery Office. January 1975.
5. British Standards Institute. "Methods of Measurement of Liquid Flow in Open Channels. BS 3680: Part 3A. Velocity Area Methods: 1980".
6. Fleming, E. "The Effect of the Summer Drought of 1990 on Vartry Waterworks". Water and Environmental Section, Institution of Engineers of Ireland. November 1992.
7. Chaloner Smith, J. "Notes upon the average volume of flow from large catchment areas in Ireland; the probable duration of stated rates of flow, deduced from gaugings on the River Shannon at Killaloe". ICEI. January 1919.
8. Dooge, J.C.I. "The flow of Irish Rivers". Seminar Proceedings, RIA. February 1989.
9. O'Riordan, J. A. "Run-off of the River Liffey and the Lower River Erne". ICEI. February 1949.
10. An Foras Forbartha. "1984 Drought River Flows. A Comparison with Other Years". Water Resources Division, An Foras Forbartha. December 1984.
11. An Foras Forbartha. "Surface Water Year Book Ireland 1975". Water Resources Division, An Foras Forbartha. April 1978.
12. An Foras Forbartha. "Surface Water Year Book Ireland 1976". Water Resources Division, An Foras Forbartha. August 1981.
13. An Foras Forbartha. "Surface Water Year Book Ireland 1977". Water Resources Division, An Foras Forbartha. August 1982.

## **APPENDIX 1**

**Periods of absolute drought, partial drought, dry spell and periods of insignificant rainfall in the period May-October ( inclusive ) in 1975, 1976, 1989, 1990, 1991 and 1995 at selected Rainfall Stations**

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**TABLE A1-1**

Periods of absolute drought, partial drought, dry spell and periods of insignificant rainfall in the period May-October ( inclusive ) in 1975, 1976, 1989, 1990, 1991 and 1995 at Clones, Mullingar, Dublin Airport, Casement Aerodrome, Kilkenny, Moorepark, Killarney, Shannon Airport, Birr, Claremorris, Glencolumbkille, Malin Head Rainfall Stations

Rainfall Station year	Period of Absolute Drought	Period of Partial Drought	Dry Spell	Period of Insignificant Rainfall(days)
<b>Clones</b>				
1975	15May-29May	none	15May-29May	
1975	none	none	20Jun-7Jul	14May-9Jul(57)
1976	13Aug-28Aug	none	13Aug-7Sep	16Jul-9Sep(56)
1984	none	none	24Jun-8Jul	24Jun-9Jul(17)
1989	none	none	none	2Jul-24Jul(23)
1990	none	none	none	10Jul-28Jul(19)
1991	19May-4Jun	9May-7Jun	none	30Apr-7Jun(39)
1991	27Aug-12Sep	none	none	10Aug-13Sep(35)
1995	none	none	25Apr-11May	
1995	none	none	20Jun-5Jul	20Jun-7Aug(18)
1995	none	none	none	1Aug-22Aug(22)
<b>Mullingar</b>				
1975	13May-31May	none	13May-31May	
1975	none	none	20Jun-8Jul	11May-9Jul(59)
1976	13Aug-30Aug	21Jul-7Sep	13Aug-7Sep	16Jul-9Sep(56)
1984	none	19 Apr-18May	19Apr-13May	
1984	none	none	23Jun-7Jul	
1984	15Jul-29Jul	none	14Jul-29Jul	
1989	none	none	2Jul-24Jul	2Jul-24Jul(23)
1990	none	none	none	7Jul-13Aug(38)
1990	none	none	none	1Sep-17Sep(17)
1991	none	30Apr-4Jun4	May-4Jun	30Apr-7Jun(39)
1991	28Aug-11Sep	none	none	28Aug-14Sep(18)
1995	none	none	29Mar-16Apr	
1995	none	none	20Jun-5Jul	21Jun-5Jul(15)
1995	none	22Jul-23Aug	28Jul-22Aug	24Jul-3Sep(42)



**Table A1-1 Continued**

Rainfall Station year	Period of Absolute Drought	Period of Partial Drought	Dry Spell	Period of Insignificant Rainfall(days)
<b>Dublin Airport</b>				
1975	15May-1Jun	15May-15Jun	14May-1Jun	
1975	none	none	17Jun-8Jul	11May-8Jul(59)
1975	none	none	none	22Aug-7Sep(17)
1976	13Aug-28Aug	21Jul-28Aug	21Jul-11Aug	
1976	none	none	13Aug-28Aug	16Jul-9Sep(56)
1984	19Apr-13May	none	none	
1984	none	none	23Jun-8Jul	
1984	15Jul-29Jul	none	none	
1989	none	none	none	1Jul-4Aug(35)
1990	none	16Jul-13Aug		7Jul-13Aug(38)
1990	none	none	30Aug-15Sep	30Aug-15Sep(17)
1991	10May-1Jun	30Apr-4Jun	none	30Apr-4Jun(36)
1991	28Aug-13Sep	none	none	24Aug-14Sep(22)
1995	30Mar-16Apr	none	29Mar-16Apr	
1995	none	none	20Jun-5Jul	21Jun-5Jul(15)
1995	none	21Jul-21Aug	24Jul-21Aug	21Jul-31Aug(42)
<b>Casement Aerodrome</b>				
1975	15May-31May	13May-8Jul	13May-14Jun	
1975	none	none	17Jun-8Jul	11May-8Jul(59)
1976	13Aug-28Aug	16Jul-9Sep	16Jul-6Aug	
1976	none	none	8Aug-28Aug	16Jul-9Sep(56)
1984	24Jun-8Jul	none	23Jun-8Jul	
1984	15Jul-29Jul	none	none	
1989	none	none	none	1Jul-4Aug(35)
1990	none	7Jul-11Aug	16Jul-11Aug	7Jul-11Aug(36)
1990	none	none	none	30Aug-15Sep(16)
1991	none	30Apr-1Jun	10May-4Jun	30Apr-4Jun(36)
1991	none	none	24Aug-13Sep	24Aug-13Sep(21)
1995	30Mar-16Apr	none	29Mar-16Apr	
1995	none	none	25Apr-11May	
1995	21Jun-5Jul	none	none	21Jun-5Jul(15)
1995	none	19Jul-31Aug	24Jul-11Aug	24Jul-31Aug(39)

Table A1-1Continued

Rainfall Station year	Period of Absolute Drought	Period of Partial Drought	Dry Spell	Period of Insignificant Rainfall(days)
<b>Kilkenny</b>				
1975	15May-29May	13May-14Jun	13May-29May	
1975	20Jun-6Jul	none	17Jun-8Jul	13May-8Jul(57)
1975	none	none	none	26Aug-5Sep(11)
1976	none	16Jul-9Sep	16Jul-11Aug	
1976	13Aug-7Sep	none	13Aug-7Sep	16Jul-9Sep(56)
1976	none	none	13Aug-7Sep	11Sep-18Sep(8)
1984	none	none	25Feb-10Mar	
1984	none	19Apr-21May	none	
1984	none	7Jun-8Jul	7Jun-6Jul	
1984	none	none	14Jul-29Jul	
1984	none	none	6Aug-20Aug	
1989	none	1Jul-30Jul	1Jul-30Jul	1Jul-4Aug(35)
1990	none	none	none	7Jul-26Jul(20)
1990	none	none	none	30Aug-15Sep(17)
1991	10May-2Jun	30Apr-4Jun	7May-4Jun	30Apr-4Jun(36)
1991	24Aug-11Sep	none	6Aug-21Aug	
1991	none	none	24Aug-13Sep	7Aug-14Sep(38)
1995	30Mar-16Apr	none	none	
1995	none	none	none	21Jun-10Jul(20)
1995	13Aug-31Aug	none	13Aug-31Aug	1Aug-9Sep(40)
<b>Moorepark</b>				
1975	15May-29May	15May-14Jun	15May-3Jun	
1975	18Jun-6Jul	none	18Jun-6Jul	15May-6Jul(53)
1975	none	none	none	23Aug-3Sep(13)
1976	none	19Jul-21Aug	19Jul-10Aug	15Jul-18Sep(66)
1984	none	none	4May-21May	
1984	none	7Jun-7Jul	7Jun-21Jun	
1984	none	none	23Jun-7Jul	
1984	none	none	11Jul-31Jul	
1989	1Jul-19Jul	none	1Jul-20Jul	1Jul-7Aug(38)
1990	none	none	none	30Jul-11Aug(13)
1990	none	none	none	1Sep-20Sep(20)
1991	10May-3Jun	none	none	1May-3Jun(34)
1991	none	none	6Aug-21Aug	
1991	25Aug-9Sep	none	24Aug-11Sep	24Aug-13Sep(21)
1995	30Mar-16 Apr	none	28Mar-16 Apr	
1995	none	none	none	30Jun-10Jul(21)
1995	none	3Aug-5Sep	13Aug-4Sep	3Aug-12Sep(41)

**Table A1-1continued**

Rainfall Station year	Period of Absolute Drought	Period of Partial Drought	Dry Spell	Period of Insignificant Rainfall(days)
<b>Killarney</b>				
1975	15May-29May	none	15May-29May	15May-5Jun(22)
1975	19Jun-6Jul	none	19Jun-6Jul	19Jun-6Jul(18)
1976	none	none	24Aug-7Sep	21Jul-9Sep(51)
1984	none	7Jun-7Jul	none	
1989	none	none	1Jul-19Jul	30Jun-27Jul(28)
1990	9Jul-25Jul	none	9Jul-25Jul	7Jul-25Jul(19)
1991	30Apr-3Jun	none	9May-3Jun	30Apr-3Jun(35)
1991	24Aug-8Sep	none	23Aug-9Sep	23Aug-12Sep(21)
1995	29Mar-16Apr	none	none	
1995	none	none	none	20Jun-5Jul(16)
1995	20Jun-5 Jul	none	none	30Jul-31Aug(33)
<b>Shannon Airport</b>				
1975	15May-29May	none	14May-29may	
1975	19Jun-4Jul	none	17Jun-4Jul1	4May-6Jul(54)
1975	none	none	22Aug-5Sep	22Aug-7Sep(17)
1976	none	none	24Aug-7Sep	16Jul-9Sep(56)
1984	none	none	2Feb-11Mar	
1984	none	none	22Jun-7Jul	
1984	none	none	14Jul-28Jul	
1989	none	none	19May-7Jun	19May-7Jun(20)
1989	none	none	none	1Jul-24Jul(24)
1990	none	none	1Jul-24Jul	8Jul-26Jul(19)
1990	none	none	none	1Sep-17Sep(17)
1991	19May-2Jun	none	none	30Apr-4Jun(36)
1991	26Aug-11Sep	none	24Aug-13Sep	24Aug-14Sep(22)
1995	none	none	29 Mar-16Apr	
1995	20Jun-4Jul	none	20Jun-5Jul	20Jun-5Jul(16)
1995	none	30Jul-5Sep	none	31Jul-12Sep(44)

Table A1-1Continued

Rainfall Station year	Period of Absolute Drought	Period of Partial Drought	Dry Spell	Period of Insignificant Rainfall(days)
<b>Birr</b>				
1975	14May-29May	13May-8Jul	13May-3Jun	
1975	22Jun-8Jul	none	17Jun-8Jul	10May-9Jul(61)
1975				26Aug-5Sep(11)
1976	13Aug-28Aug	21Jul-28Aug	13Aug-28Aug	16Jul-9Sep(56)
1984	none	19 Apr-18May	none	
1984	none	none	14Jul-29Jul	
1984	none	none	9Aug-24Aug	
1989	none	none	1Jul-20Jul	1Jul-4Aug(35)
1990	none	none	none	7Jul-26Jul(20)
1991	none	1May-2Jun	14May-4Jun	30Apr-4Jun(36)
1991	22Aug-11Sep	none	none	11Aug-14Sep(35)
1995	1Apr-16Apr	none	29Mar-16Apr	
1995	none	none	20Jun-5Jul	21Jun-9Jul(19)
1995	none	2Aug-31Aug	none	29Jul-11Sep(45)
<b>Claremorris</b>				
1975	14May-31May	none	14May-3Jun	
1975	20Jun-7Jul	none	20Jun-7Jul	13May-8Jul(67)
1976	13Aug-29Aug	16Jul-7Sep	19Jul-2Aug	
1976	8Aug-7Sep	none	none	16Jul-9Sep(56)
1984	none	none	22Jun-8Jul	
1984	14Jul-28Jul	none	13Jul-29Jul	
1989	none	none	1Jul-20Jul	1Jul-27Jul(27)
1990	none	none	none	7Jul-26Jul(20)
1991	none	none	none	30Apr-7Jun(39)
1991	24Aug-11Sep	none	none	10Aug-12Sep(34)
1995	none	none	28Mar-16Apr	
1995	20Jun-4Jul	none	20Jun-5Jul	20Jun-8Jul(19)
1995	none	none	none	30Jul-10Sep(43)

**Table A1-1Continued**

Rainfall Station year	Period of Absolute Drought	Period of Partial Drought	Dry Spell	Period of Insignificant Rainfall(days)
<b>Glencolumbkille</b>				
1975	14May-30May	none	14May-30May	14May-3Jun(21)
1975	none	none	19Jun-7Jul	20Jun-9Jul(20)
1976	12Aug-29Aug	none	12Aug-29Aug	12Aug-7Sep(27)
1984	none	none	none	
1989	none	none	none	1Jul-27Jul(27)
1990	none	none	none	16Jul-27Jul(12)
1991	none	none	19May-2Jun	13May-2Jun(21)
1991	28Aug-12Sep	none	none	19Aug-12Sep(25)
1995	none	none	none	20Jun-4Jul(15)
1995	none	none	none	30Jul-10Aug(12)
<b>Malin Head</b>				
1975	none	none	14May-31May	1May-3Jun(34)
1975	none	none	none	20Jun-12Jul(23)
1976	none	none	15Apr-30Apr	15Apr-30Apr(16)
1976	13Aug-29Aug	none	13Aug-7Sep	13Aug-9Sep(28)
1984	none	none	none	
1989	none	none	none	6Jun-24Jun(19)
1990	none	none	none	10Jul-2Aug(24)
1991	none	none	19May-7Jun	30Apr-7Jun(39)
1991	28Aug-12Sep	none	none	19Aug-12Sep(25)
1995	none	none	none	20Jun-1Jul(12)
1995	none	none	none	30Jul-23Aug(25)

KEY

● LOCATION OF RAINFALL STATIONS

( ) PERIODS OF INSIGNIFICANT RAINFALL

[ ] LENGTH IN DAYS OF PERIODS OF INSIGNIFICANT RAINFALL

1976

EXAMPLE :

KILKENNY

(16JUL-9SEP)

[ 5 6 ]

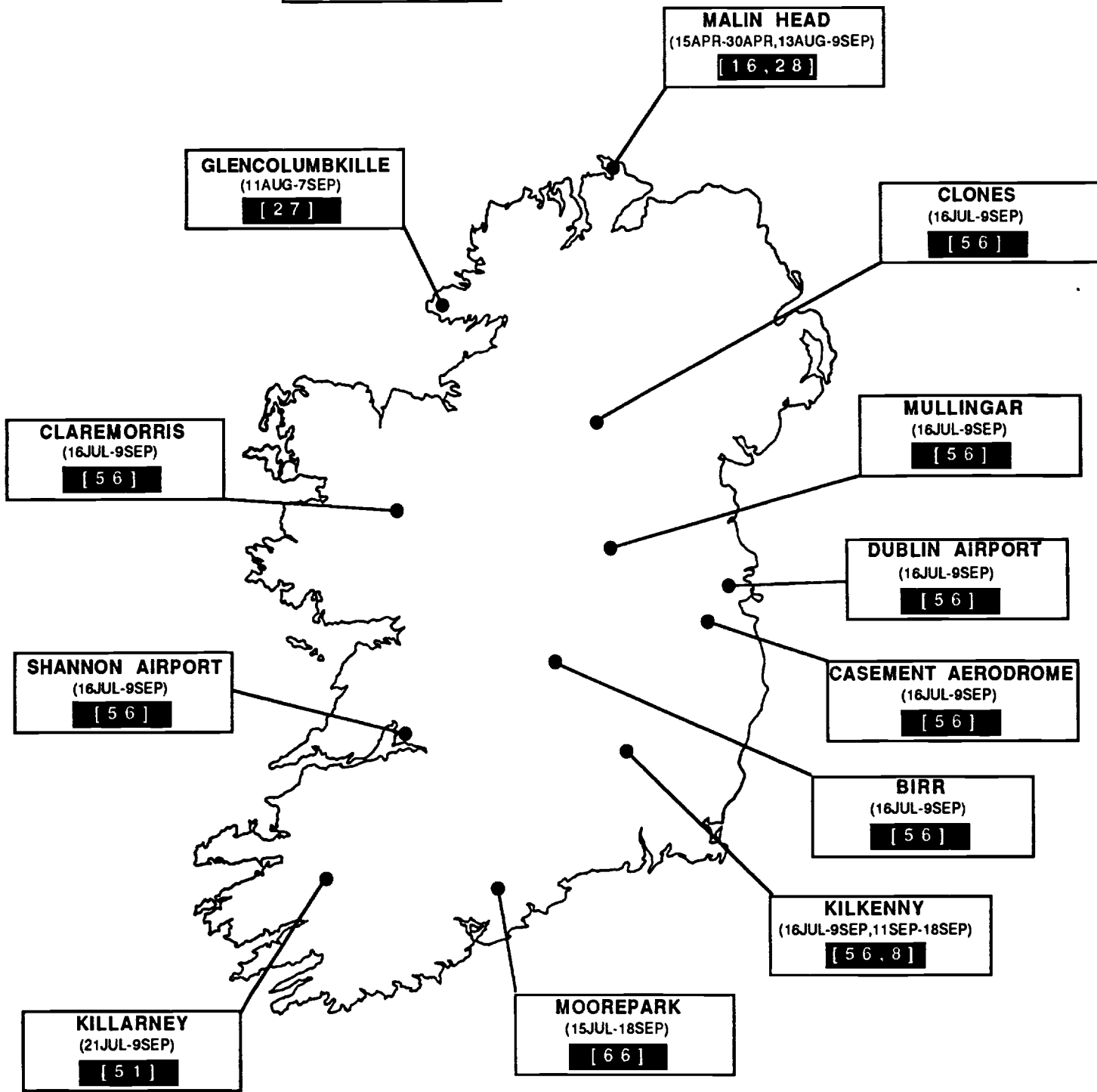


Fig. A1-1 PERIODS OF INSIGNIFICANT RAINFALL

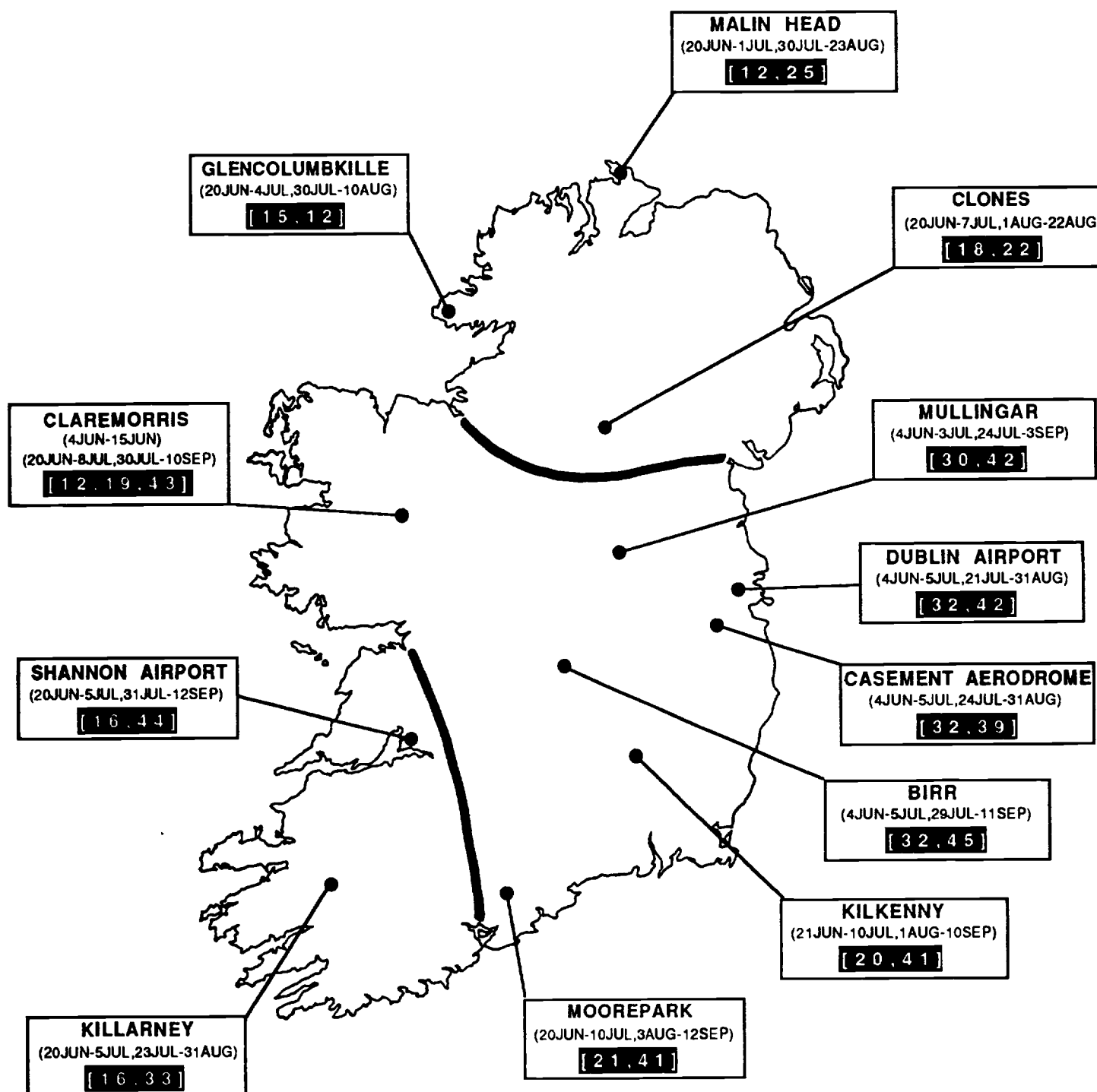
# KEY

- LOCATION OF RAINFALL STATIONS
- ( ) PERIODS OF INSIGNIFICANT RAINFALL
- [ ] LENGTH IN DAYS OF PERIODS OF INSIGNIFICANT RAINFALL

# 1995

EXAMPLE :

**KILKENNY**  
(21JUN-10JUL)  
[ 20 ]



**Fig. A1-2 PERIODS OF INSIGNIFICANT RAINFALL**

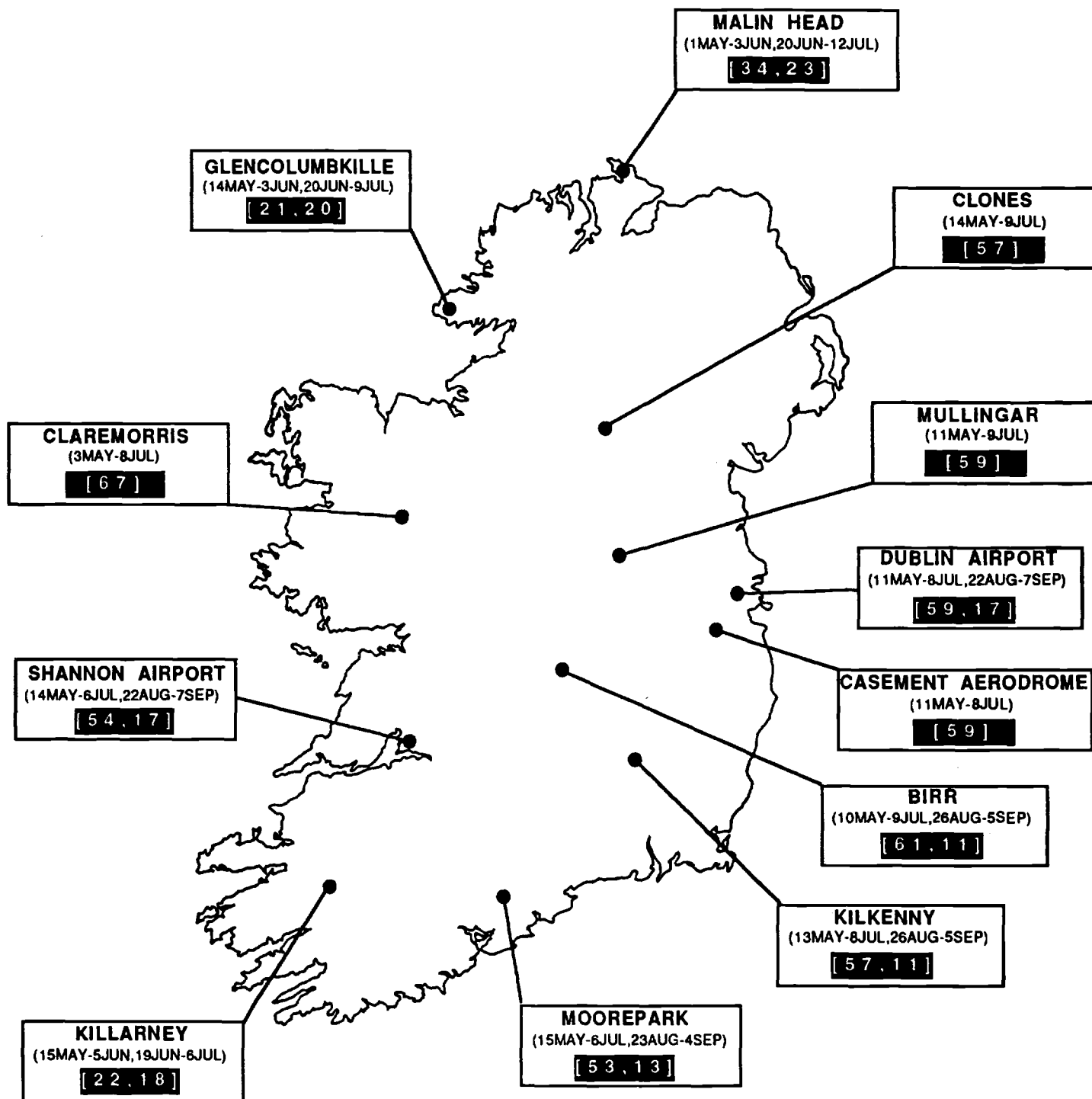
# KEY

- LOCATION OF RAINFALL STATIONS
- ( ) PERIODS OF INSIGNIFICANT RAINFALL
- [ ] LENGTH IN DAYS OF PERIODS OF INSIGNIFICANT RAINFALL

EXAMPLE :

**KILKENNY**  
(13MAY-8JUL)  
[ 57 ]

# 1975



**Fig. A1-3 PERIODS OF INSIGNIFICANT RAINFALL**



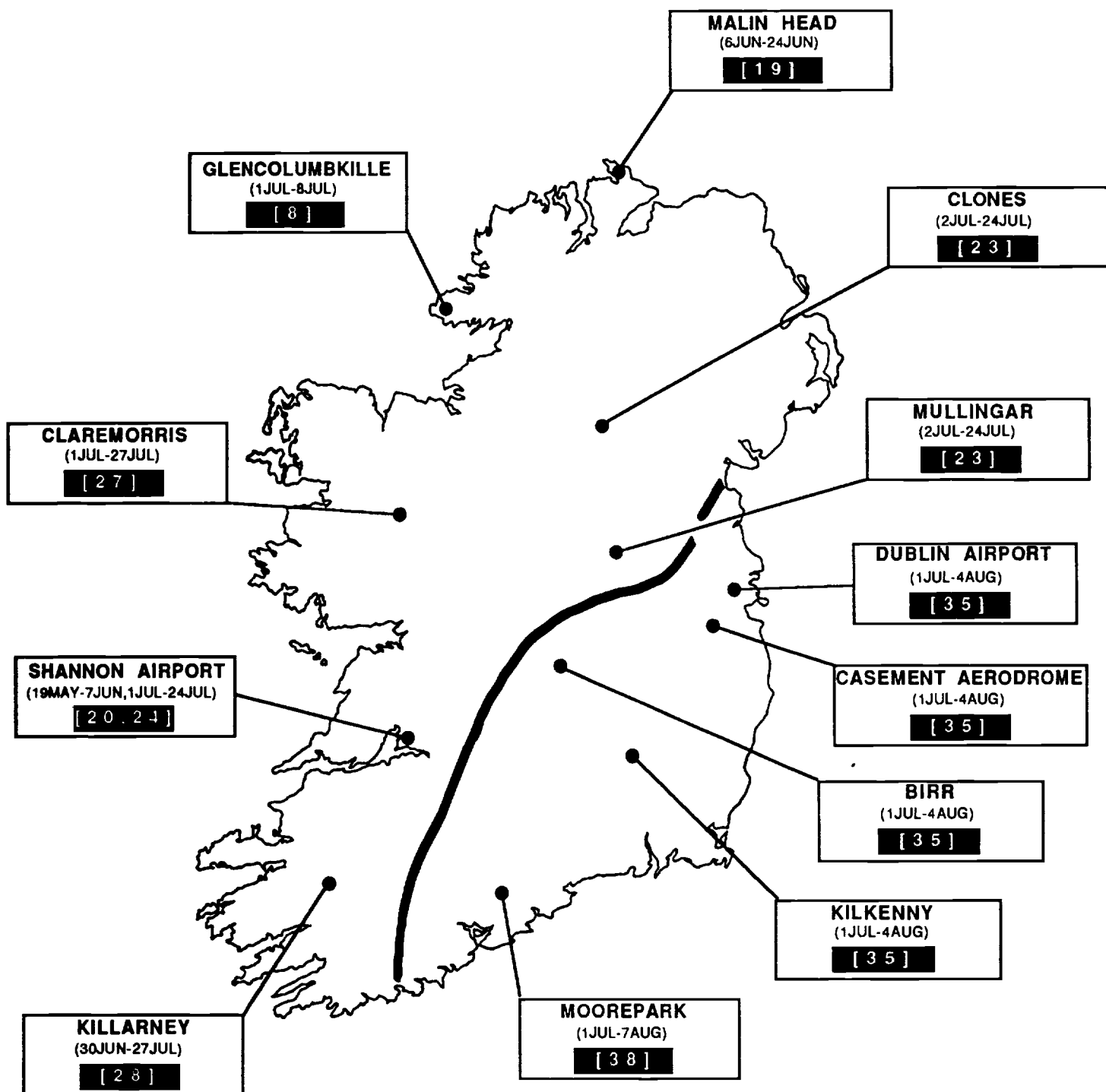
# KEY

- LOCATION OF RAINFALL STATIONS
- ( ) PERIODS OF INSIGNIFICANT RAINFALL
- [ ] LENGTH IN DAYS OF PERIODS OF INSIGNIFICANT RAINFALL

EXAMPLE :

**KILKENNY**  
(1JUL-4AUG)  
[ 3 5 ]

# 1989



**Fig. A1-4 PERIODS OF INSIGNIFICANT RAINFALL**

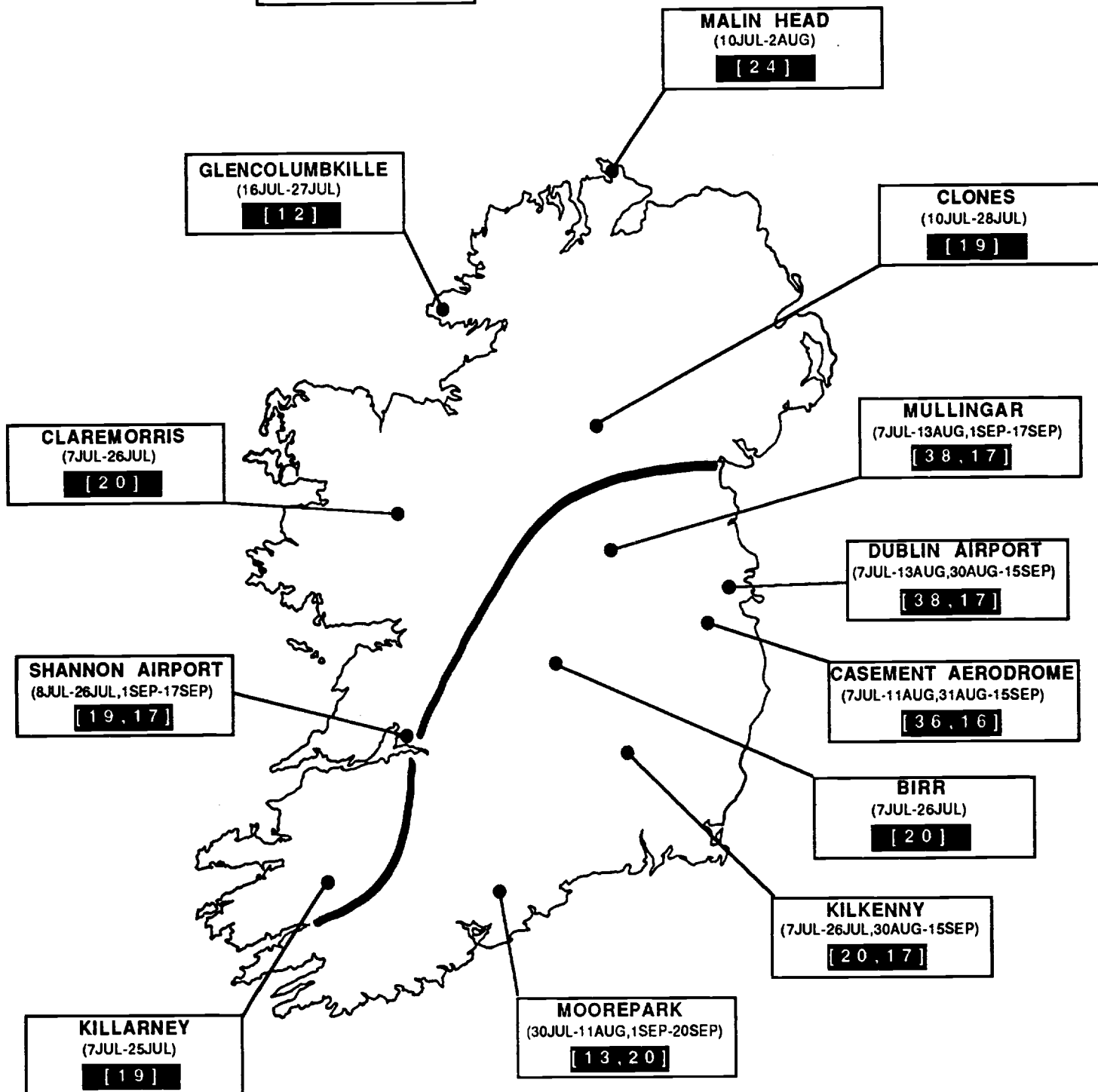
**KEY**

- LOCATION OF RAINFALL STATIONS
- ( ) PERIODS OF INSIGNIFICANT RAINFALL
- [ ] LENGTH IN DAYS OF PERIODS OF INSIGNIFICANT RAINFALL

EXAMPLE :

**KILKENNY**  
(7JUL-26JUL)  
[ 20 ]

**1990**



**Fig. A1-5 PERIODS OF INSIGNIFICANT RAINFALL**

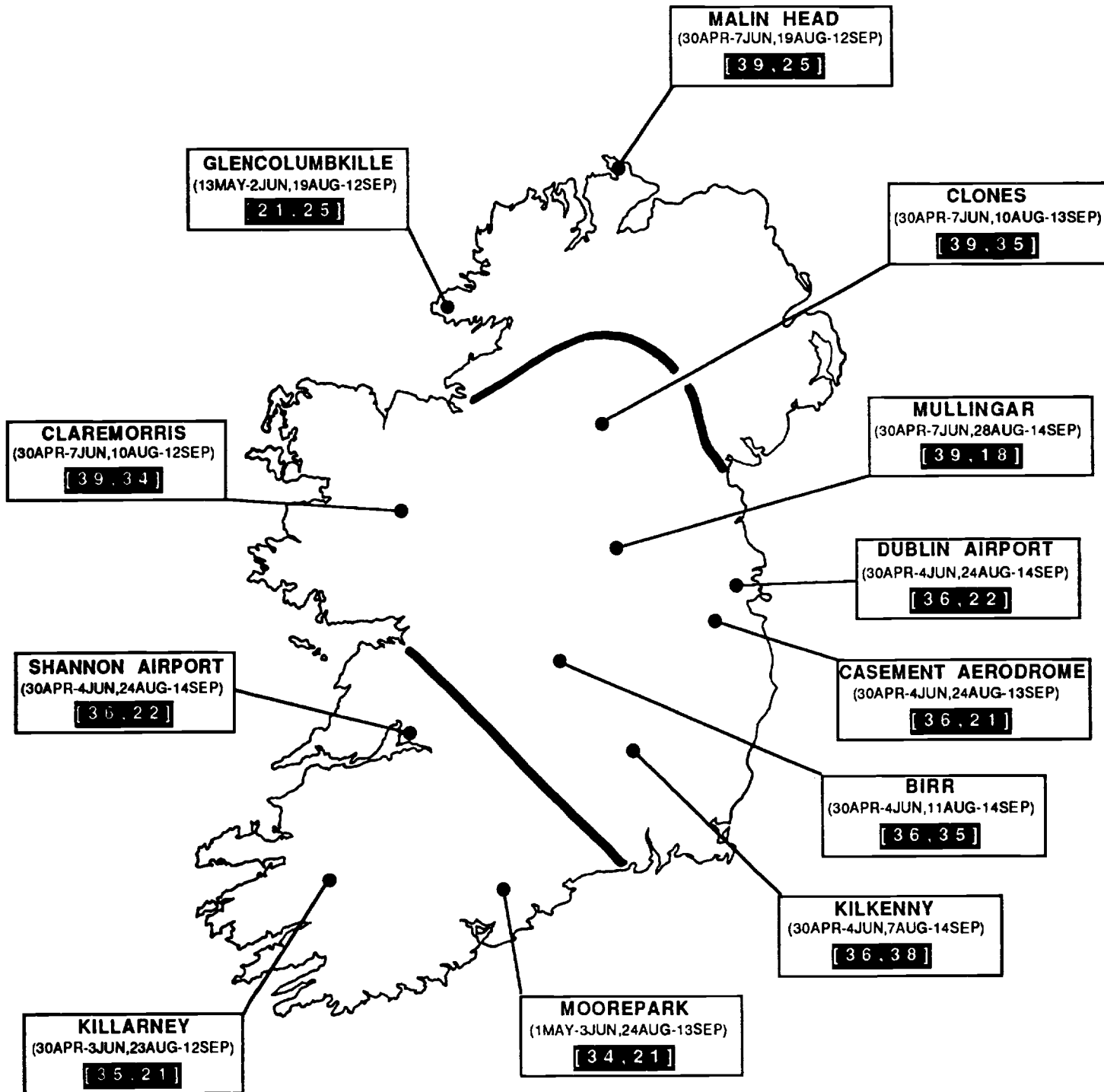
# KEY

- LOCATION OF RAINFALL STATIONS
- ( ) PERIODS OF INSIGNIFICANT RAINFALL
- [ ] LENGTH IN DAYS OF PERIODS OF INSIGNIFICANT RAINFALL

EXAMPLE :

**KILKENNY**  
(30APR-4JUN)  
[ 3 6 ]

# 1991



**Fig. A1-6 PERIODS OF INSIGNIFICANT RAINFALL**

## **APPENDIX 2**

Low flow recorded at selected gauging stations for the years indicated

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TABLE A2-1

LOW FLOW RECORDED AT SELECTED GAUGING STATIONS FOR THE YEARS INDICATED

Stat. No.	LOCATION	RIVER	BDS	AREA km <sup>2</sup>	1975 Flow m <sup>3</sup> /s (date)	1976 Flow m <sup>3</sup> /s (date)	1989 Flow m <sup>3</sup> /s (date)	1990 Flow m <sup>3</sup> /s (date)	1991 Flow m <sup>3</sup> /s (date)	1995 Flow m <sup>3</sup> /s (date)
01043	BALLYBOFEY	FINN	OPW	319	0.32* 03/07/75	0.46* 30/08/76	0.39* 21/07/89	1.8* 19/07/90	0.83* 04/09/91	0.37* 22/08/95
03051	FAULKLAND	BLACKWATER	MON	126	0.05* 29/08/75	0.03* 06/09/76	0.06* 25/07/89	0.2 17/09/90	0.05 11/09/91	0.04 28/08/95
06013	CHARLEVILLE	DEE	OPW	307	N.A.	0.19 09/09/76	0.34 16/09/89	0.25 08/08/90	0.2 15/09/91	0.14* 24/08/95
06014	TALLANSTOWN	GLYDE	OPW	270	N.A.	0.2 08/09/76	0.23 22/07/89	0.25 08/08/90	0.28 11/09/91	0.2* 24/08/95
07005	TRIM	BOYNE	OPW	1282	2.01* 15/08/75	1.83 07/09/76	3.02 28/07/89	3.56 01/10/90	2.94 15/09/91	1.5* 01/09/95
07009	NAVAN WEIR	BOYNE	OPW	1610	N.A.	1.94* 08/09/76	2.38 27/07/89	2.82 10/08/90	2.45* 04/09/91	1.7 31/08/95
07012	SLANE CASTLE	BOYNE	OPW	2408	2.28* 03/09/75	1.9* 25/08/76	2.72 12/09/89	3.61* 14/08/90	2.52 11/09/91	2.26* 31/08/95
08002	NAUL	DELVIN	DUN	37	N.A.	0.026* 25/08/76	0.03 27/07/89	0.03 18/08/90	0.03 18/08/91	0.03 01/09/95
10002	RATHDRUM	AVONMORE	WIC	233	0.4 06/09/75	0.50* 23/08/76	N.A.	0.79 18/09/90	0.73 13/09/91	0.38 03/09/95
10003	LARAGH	AVONMORE	WIC	107.2	0.22 09/09/75	0.17 08/09/76	N.A.	0.4* 03/08/90	N.A.	0.19* 22/08/95

\* indicates flow measurement, N.A. = not available

Table A2-1 Low Flow Recorded at Selected Gauging Stations for the Years Indicated (Contd.)

Stat. No.	LOCATION	RIVER	BDS	AREA km <sup>2</sup>	1975 Flow m <sup>3</sup> /s (date)	1976 Flow m <sup>3</sup> /s (date)	1989 Flow m <sup>3</sup> /s (date)	1990 Flow m <sup>3</sup> /s (date)	1991 Flow m <sup>3</sup> /s (date)	1995 Flow m <sup>3</sup> /s (date)
10004	LARAGH	GLENMACNASS	WIC	28	0.09 08/09/75	0.08* 23/08/76	N.A.	N.A.	N.A.	0.09 02/09/95
10028	KNOCKNAMOHILL	AUGHIRM	WIC	204.1	N.A.	N.A.	0.55 05/08/89	0.54 16/09/90	0.66 14/09/91	0.35 03/09/95
11001	BOLEANY	OWENAVORRAGH	OPW	148	0.19 04/09/75	0.15* 23/08/76	0.15 18/10/89	0.11 15/09/90	0.19 03/09/91	0.20* 01/09/95
12001	SCARAWALSH	SLANEY	OPW	1036	N.A.	1.99* 23/08/76	2.5* 28/07/89	3.2* 20/09/90	2.3* 09/09/91	2.1* 01/09/95
12013	RATHVILLY	SLANEY	CAR	185	N.A.	0.81* 08/09/76	1.16* 03/08/89	1.2* 15/09/90	1.14* 05/09/91	0.8 31/08/95
12015	FERNS	BANN	WEX	161	N.A.	0.21* 23/08/76	N.A.	0.27* 20/09/90	0.42* 03/09/91	0.22* 06/09/95
12016	DUNANORE	BORO	WEX	175	N.A.	0.62* 15/09/76	0.61 06/08/89	0.58 28/09/90	0.75 12/09/91	0.57 06/09/95
14003	BORNESS	BARROW	OPW	276	N.A.	0.08* 02/09/76	0.09* 01/08/89	N.A.	0.17* 10/09/91	0.077* 08/08/95
14004	CLONBULLOGE	FIGILE	OPW	268	0.35* 02/07/75	0.28* 03/09/76	0.25* 01/08/89	0.33* 25/07/90	0.46* 27/09/91	0.19* 30/08/95
14006	PASS BR	BARROW	OPW	1096	N.A.	1.1* 20/08/76	1.13* 04/08/89	1.45* 14/08/90	N.A.	1.08* 31/08/95
14011	RATHANGAN	SLATE	OPW	163	0.37* 02/07/75	0.28* 03/09/76	0.33* 01/08/89	0.35* 14/08/90	0.47* 14/08/91	0.33* 04/09/95

\* indicates flow measurement, N.A. = not available

Table A2-1 Low Flow Recorded at Selected Gauging Stations for the Years Indicated (Contd.)

Stat. No.	LOCATION	RIVER	BDS	AREA km <sup>2</sup>	1975 Flow m <sup>3</sup> /s (date)	1976 Flow m <sup>3</sup> /s (date)	1989 Flow m <sup>3</sup> /s (date)	1990 Flow m <sup>3</sup> /s (date)	1991 Flow m <sup>3</sup> /s (date)	1995 Flow m <sup>3</sup> /s (date)
14032	KYLE	TRIOGUE	LAO	31.3	N.A.	0.07 15/09/76	0.12* 24/07/89	0.09* 30/07/90	0.12* 10/09/91	0.06 08/08/95
14033	MOUNTMELICK	OWENASS	LAO	91	N.A.	0.02 01/09/96	0.04* 24/07/89	0.07* 26/07/90	0.07* 29/08/91	0.015* 24/08/95
15001	ANNAMULT	KINGS	OPW	443	N.A.	0.28* 30/08/76	0.58* 31/07/89	0.38* 26/09/90	0.53* 26/08/91	0.42* 28/08/95
15002	JOHN'S BR.	NORE	OPW	1605	2.3* 03/09/75	2.5* 20/09/76	2.93* 31/07/89	3.17* 31/07/90	2.91* 06/09/91	2.43* 21/08/95
15003	DININ BR.	DININ	OPW	298	0.1* 05/09/75	0.1* 27/08/76	0.13* 27/07/89	0.22* 24/09/90	0.19* 25/09/91	0.15* 31/08/95
15004	MCMAHONS BR.	NORE	OPW	491	0.74* 02/09/75	0.65* 23/09/76	0.96* 27/07/89	1.23* 10/09/90	1.34* 11/09/91	0.82 31/08/95
15005	DURROW FT. BR.	ERKINA	OPW	387	0.49* 02/09/75	0.42* 02/09/76	0.46* 27/07/89	0.52* 09/08/90	0.57* 06/09/91	0.50* 22/08/95
15006	BROWNSBARN	NORE	OPW	2388	3.13* 03/09/75	2.82 13/09/76	4.4* 31/07/89	4.3 20/09/90	4.7 09/09/91	4.6 03/09/95
15007	KILBRICKEN	NORE	OPW	343	0.50* 01/09/75	0.50* 22/09/76	0.41* 27/07/89	0.70* 10/09/90	0.80* 30/08/91	0.54* 18/09/95
15008	BORRIS IN OSSORY	NORE	OPW	111	0.05* 01/09/75	0.06* 22/09/76	0.05* 27/07/89	0.09* 10/08/90	0.15* 30/08/91	0.07* 15/08/95
15021	ANNAGH	DELOUR	LAO	72	N.A.	0.2* 01/09/76	0.25* 20/07/89	0.24 15/08/90	0.3 14/09/91	0.26* 15/08/95

\* indicates flow measurement, N.A. = not available



Table A2-1 Low Flow Recorded at Selected Gauging Stations for the Years Indicated (Contd.)

Stat. No.	LOCATION	RIVER	BDS	AREA km <sup>2</sup>	1975 Flow m <sup>3</sup> /s (date)	1976 Flow m <sup>3</sup> /s (date)	1989 Flow m <sup>3</sup> /s (date)	1990 Flow m <sup>3</sup> /s (date)	1991 Flow m <sup>3</sup> /s (date)	1995 Flow m <sup>3</sup> /s (date)
16001	ATHLUMMON	DRISH	OPW	140	N.A.	0.11 13/09/76	0.13* 24/07/89	N.A.	0.23* 28/08/91	0.09* 31/08/95
16002	BEAKSTOWN	SUIR	OPW	512	0.38 03/09/75	0.32 18/09/76	0.52 05/08/89	0.56 22/09/90	0.80* 10/09/91	0.52 06/09/95
16003	RATHKENNAN	CLODIAGH	OPW	246	N.A.	0.23* 08/09/76	0.28* 03/08/89	0.39* 20/09/90	0.44* 10/09/91	0.23* 12/09/95
16008	NEW BRIDGE	SUIR	OPW	1120	N.A.	1.97* 07/09/76	3.43* 17/08/89	2.65* 22/09/90	N.A.	2.46* 29/08/95
16010	ANNER	ANNER	OPW	422	1.03 13/09/75	0.86 18/09/76	1.17* 24/08/89	1.06* 13/09/90	1.13* 19/09/91	1.1* 26/08/95
16011	CLONMEL	SUIR	OPW	2173	6.76* 05/09/75	7.1* 27/08/76	9.9* 25/07/89	N.A.	N.A.	8.03* 28/08/95
16020	PORTLAW	CLODIAGH	WAT	124	0.37* 16/09/75	0.33* 01/09/76	0.62* 06/09/89	0.51* 10/09/90	0.81* 11/09/91	0.49* 15/08/95
18002	BALLYDUFF	BLACKWATER	OPW	2338	7.13 03/09/75	5.99 20/09/76	9.7* 02/08/89	8.5* 18/09/90	9.71 26/09/91	6.98* 05/09/95
18003	KILLAVULLEN	BLACKWATER	OPW	1258	N.A.	N.A.	3.36* 08/09/89	3.2* 17/09/90	3.4* 11/09/91	3.2* 04/09/95
18006	CSET MALLOW	BLACKWATER	CSE	1058	N.A.	N.A.	3 09/08/89	3.1 19/09/90	2.4 10/09/91	2.6 04/09/95
19015	HEALY'S BR.	SHOURNAGH	ESB	207	N.A.	0.18* 06/09/76	N.A.	0.27 28/09/90	0.35 14/09/91	0.22 23/09/95

\* indicates flow measurement, N.A. = not available

Table A2-1 Low Flow Recorded at Selected Gauging Stations for the Years Indicated (Contd.)

Stat. No.	LOCATION	RIVER	BDS	AREA km <sup>2</sup>	1975 Flow m <sup>3</sup> /s (date)	1976 Flow m <sup>3</sup> /s (date)	1989 Flow m <sup>3</sup> /s (date)	1990 Flow m <sup>3</sup> /s (date)	1991 Flow m <sup>3</sup> /s (date)	1995 Flow m <sup>3</sup> /s (date)
21002	COOMHOLA	COOMHOLA	COR	65	<0.01 06/07/75	<0.01 08/09/76	0.07 22/07/89	0.23 16/09/90	0.07 08/09/91	0.15 28/08/95
21003	BALLYLICKEY	OWVANE	COR	75.3	N.A.	0.04 08/09/76	0.07 21/07/89	0.22 20/09/90	0.1 10/09/91	0.09 06/09/95
21004	INCHILOUGH	MEALAGH	COR	46	<0.01 07/07/75	<0.01 09/09/76	0.02 21/07/89	0.09 27/09/90	0.07 10/09/91	0.05 06/09/95
22006	FLESK	FLESK(LAUNE)	OPW	325	N.A.	0.74* 18/08/76	1.77* 03/08/89	1.73 11/08/90	1.71* 02/09/91	1.85 25/08/95
23002	LISTOWEL	FEALE	OPW	646	0.55 05/07/75	0.51* 30/08/76	0.76* 28/07/89	N.A.	1.24 13/09/91	1.01* 15/08/95
23005	GOULBURN	ALLAGHAUN	LIM	113.4	N.A.	0.03* 03/09/76	0.06* 18/07/89	N.A.	0.13* 12/09/91	0.06* 23/08/95
23006	NEODATA	FEALE	LIM	295.3	N.A.	0.2 09/09/76	0.58* 18/07/89	N.A.	0.74* 12/09/91	0.53 28/08/95
23007	OOLAGH RLY. BRIDG OOLAGH		LIM	34.2	N.A.	0.01 02/09/76	0.04* 18/07/89	N.A.	0.06* 12/09/91	0.03* 23/08/95
24004	BRUREE	MAIGUE	OPW	246	N.A.	0.39* 26/08/76	0.44* 24/07/89	N.A.	0.44* 05/09/91	0.48* 04/09/95
24011	DEEL BR.	DEEL	OPW	273	0.15* 02/09/75	0.22* 30/08/76	0.39* 18/07/89	0.32 29/09/90	0.46* 27/08/91	0.48* 04/09/95
25001	ANNACOTTY	MULKEAR	OPW	646	1.04 03/09/75	N.A.	1.46* 19/07/89	N.A.	2.31 08/09/91	1.37 11/09/95

\* indicates flow measurement, N.A. = not available

Table A2-1 Low Flow Recorded at Selected Gauging Stations for the Years Indicated (Contd.)

Stat. No.	LOCATION	RIVER	BDS	AREA km <sup>2</sup>	1975 Flow m <sup>3</sup> /s (date)	1976 Flow m <sup>3</sup> /s (date)	1989 Flow m <sup>3</sup> /s (date)	1990 Flow m <sup>3</sup> /s (date)	1991 Flow m <sup>3</sup> /s (date)	1995 Flow m <sup>3</sup> /s (date)
25003	ABINGTON	MULKEAR	OPW	397	N.A.	0.76* 23/08/76	0.9* 20/07/89	N.A.	2.31* 19/08/91	0.91* 01/09/95
25005	SUNVILLE	DEAD	OPW	190	0.34 09/09/75	0.27 10/09/76	0.35* 20/07/89	0.43 17/09/90	0.45 14/09/91	0.43 07/09/95
25021	CROGHAN	LITTLE BROSNA	OPW	493	1.13 29/08/75	0.88 06/09/76	1.23* 03/08/89	N.A.	1.72* 02/09/91	1.01* 30/08/95
25027	GOURDEEN	OLLATRIM	OPW	118	0.17 03/09/75	0.15* 06/09/76	0.29* 02/08/89	0.24* 21/09/90	0.29* 05/09/91	0.22* 24/08/95
25030	SCARRIFF	GRANEY	OPW	279	0.25 13/07/75	0.21 09/09/76	0.36 03/08/89	N.A.	0.67 14/09/91	0.23* 05/09/95
25040	ROSCREA	BUNOW	TIN	30	N.A.	<0.01 09/09/76	<0.01 04/08/89	<0.01 16/09/90	0.02 06/09/91	<0.01 09/09/95
26006	WILLSBROOK	SUCK	OPW	182	0.18 09/07/75	0.2 01/09/76	0.08* 26/07/89	N.A.	0.36* 28/08/91	0.29* 16/08/95
26009	BELLANTRA BR.	BLACK	OPW	97	0.01 09/07/75	0.01* 15/09/76	0.01* 14/07/89	0.08* 25/07/90	0.01* 10/09/91	0.01* 01/09/95
26014	BANADA BRIDGE	LUNG	OPW	222	0.42 09/09/75	0.4 09/09/76	0.35* 25/07/89	N.A.	0.56* 11/09/91	0.43* 15/09/95
26015	CORRASCOFFY	ESLIN	OPW	62	N.A.	0.004* 15/09/76	0.002* 14/07/89	N.A.	0.005* 09/09/91	0.002* 02/09/95
26029	DOWRA	SHANNON	CAV	109.3	0.09 03/07/75	0.14* 20/08/76	0.13 27/07/89	0.26 26/07/90	0.21 13/09/91	0.25 21/08/95

\* indicates flow measurement, N.A. = not available

Table A2-1 Low Flow Recorded at Selected Gauging Stations for the Years Indicated (Contd.)

Stat. No.	LOCATION	RIVER	BDS	AREA km <sup>2</sup>	1975 Flow m <sup>3</sup> /s (date)	1976 Flow m <sup>3</sup> /s (date)	1989 Flow m <sup>3</sup> /s (date)	1990 Flow m <sup>3</sup> /s (date)	1991 Flow m <sup>3</sup> /s (date)	1995 Flow m <sup>3</sup> /s (date)
27002	BALLYCOREY	FERGUS	OPW	562	0.19 13/07/75	0.18 19/09/76	0.49 27/07/89	N.A.	1.2 16/09/91	0.4* 19/09/95
30020	BALLYHAUNIS	DALGAN	MAY	20.2	N.A.	0.08 07/09/76	0.1 28/07/89	0.09 30/08/90	0.08 13/09/91	0.09 08/09/95
30021	CHRISTINA'S BR.	ROBE	MAY	138	0.11* 08/07/75	0.12* 07/09/76	0.14 28/07/89	0.15 15/09/90	0.22* 14/09/91	0.1 13/09/95
31002	CASHLA	CASHLA	GAL	72	N.A.	0.12* 25/08/76	0.16 08/08/89	N.A.	0.38 14/09/91	0.11 18/09/95
32012	NEWPORT WEIR	NEWPORT	MAY	138.3	N.A.	0.21* 02/09/76	0.54 15/07/89	0.49 04/06/90	0.61 13/09/91	0.33* 13/09/95
33001	GLENAMOY	GLENAMOY	MAY	73	0.19* 11/06/75	0.15* 03/09/76	0.24 20/07/89	0.26 27/07/90	0.19* 11/09/91	0.19* 18/08/95
33006	SRAHNAMANRAGH	OWENDUFF	MAY	121	N.A.	0.42* 24/08/76	0.47* 14/07/89	N.A.	0.51* 08/09/91	0.35 03/07/95
34001	RAHANS	MOY	OPW	1911	4.0* 07/07/75	3.5 20/09/76	5.43 25/07/89	6.9 15/08/90	7.85 13/09/91	3.71* 19/09/95
34003	FOXFORD	MOY	MAY	1737	N.A.	3.3 19/09/76	3.67 21/07/89	5.1 14/08/90	6.19 13/09/91	2.7 23/09/95
34004	BALLYLAHAN	MOY	OPW	898	2.58* 11/07/75	N.A.	1.95* 27/07/89	N.A.	N.A.	2.58* 16/08/95
35001	BALLYNACARROW	OWENMORE	OPW	299	0.22* 16/07/75	0.34* 20/09/76	0.32* 20/07/89	N.A.	0.5* 11/09/91	0.28* 01/09/95

\* indicates flow measurement, N.A. = not available

Table A2-1 Low Flow Recorded at Selected Gauging Stations for the Years Indicated (Contd.)

Stat. No.	LOCATION	RIVER	BDS	AREA km <sup>2</sup>	1975 Flow m <sup>3</sup> /s (date)	1976 Flow m <sup>3</sup> /s (date)	1989 Flow m <sup>3</sup> /s (date)	1990 Flow m <sup>3</sup> /s (date)	1991 Flow m <sup>3</sup> /s (date)	1995 Flow m <sup>3</sup> /s (date)
35005	BALLYSDARE	BALLYSDARE	OPW	642	0.70* 07/07/75	0.95* 31/08/76	0.92* 19/07/89	N.A.	1.79* 11/09/91	0.71* 01/09/95
35011	DROMAHAIR	BONET	OPW	294	0.36* 03/07/75	0.39* 31/08/76	0.43* 25/07/89	N.A.	0.84* 13/09/91	0.63* 02/09/95
36020	KILLYWILLIN	BLACKWATER	OPW	95	N.A.	N.A.	0.05* 25/07/89	N.A.	0.12* 11/09/91	0.06* 18/09/95
36031	LISDARN	CAVAN	CAV	52	0.03 30/08/75	0.03 05/09/76	0.03* 26/07/89	0.04 01/10/90	0.029* 02/09/91	0.017 22/08/95
37020	VALLEY BR	GLENADDRAGH	DON	13.5	N.A.	0.02* 06/09/76	0.05* 07/07/89	N.A.	0.02* 12/09/91	0.03* 22/08/95
39001	NEW MILLS	SWILLY	OPW	49	N.A.	0.04* 24/08/76	0.03* 22/07/89	0.11* 27/07/90	N.A.	0.03* 21/08/95
39003	TULLYARVAN	CRANA	OPW	99	0.14* 25/06/75	0.15* 27/08/76	0.15* 18/07/89	0.31* 26/07/90	0.3* 06/09/91	0.15* 31/08/95

83

\* indicates flow measurement, N.A. = not available

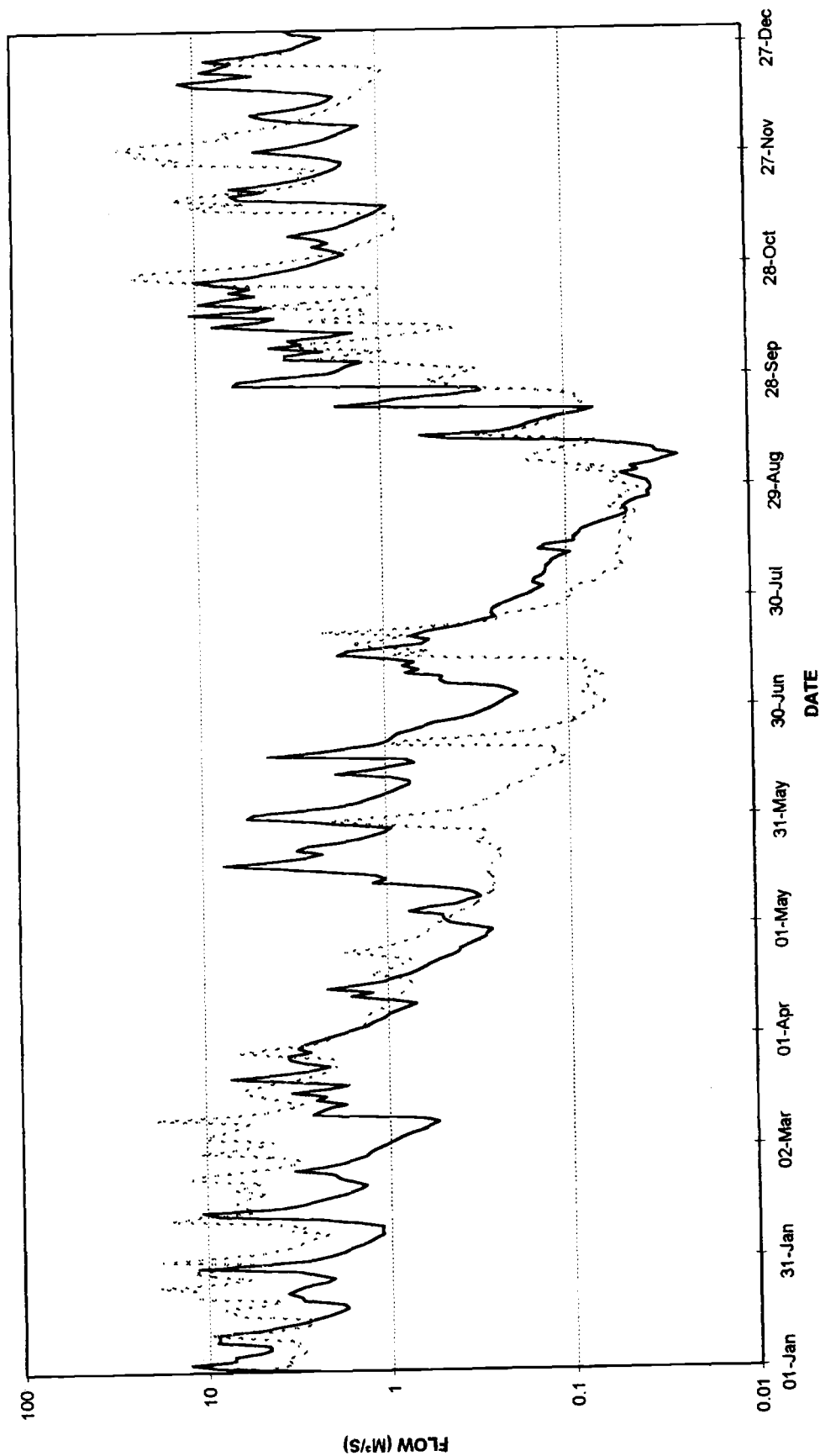
## **APPENDIX 3**

Hydrographs of daily mean flows at selected hydrometric stations for the years 1976 and  
1995

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# HYDROGRAPHS OF DAILY MEAN FLOWS

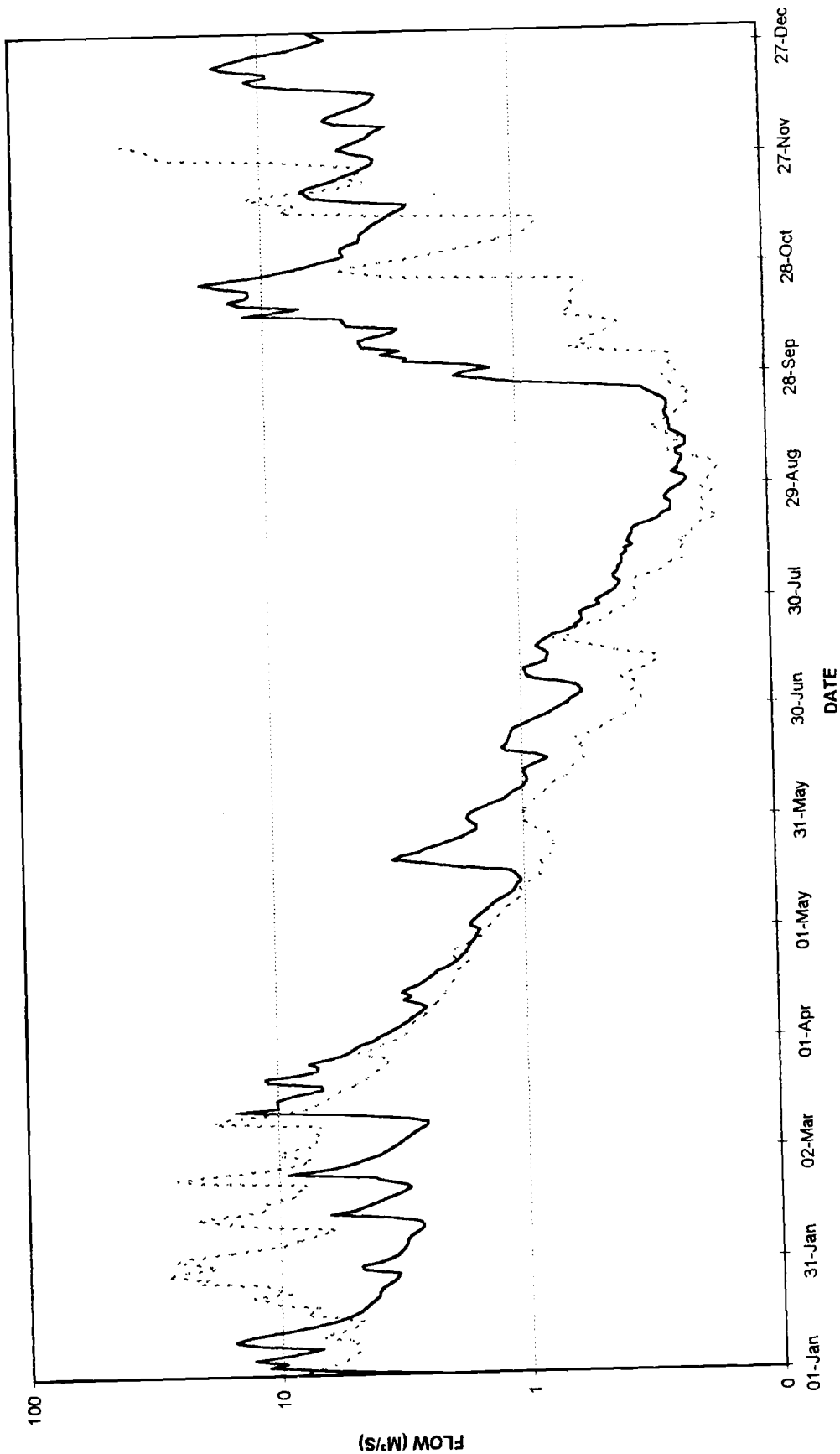
STATION 03051 FAULKLAND BRIDGE (RIVER BLACKWATER (MONAGHAN))





HYDROGRAPHS OF DAILY MEAN FLOWS

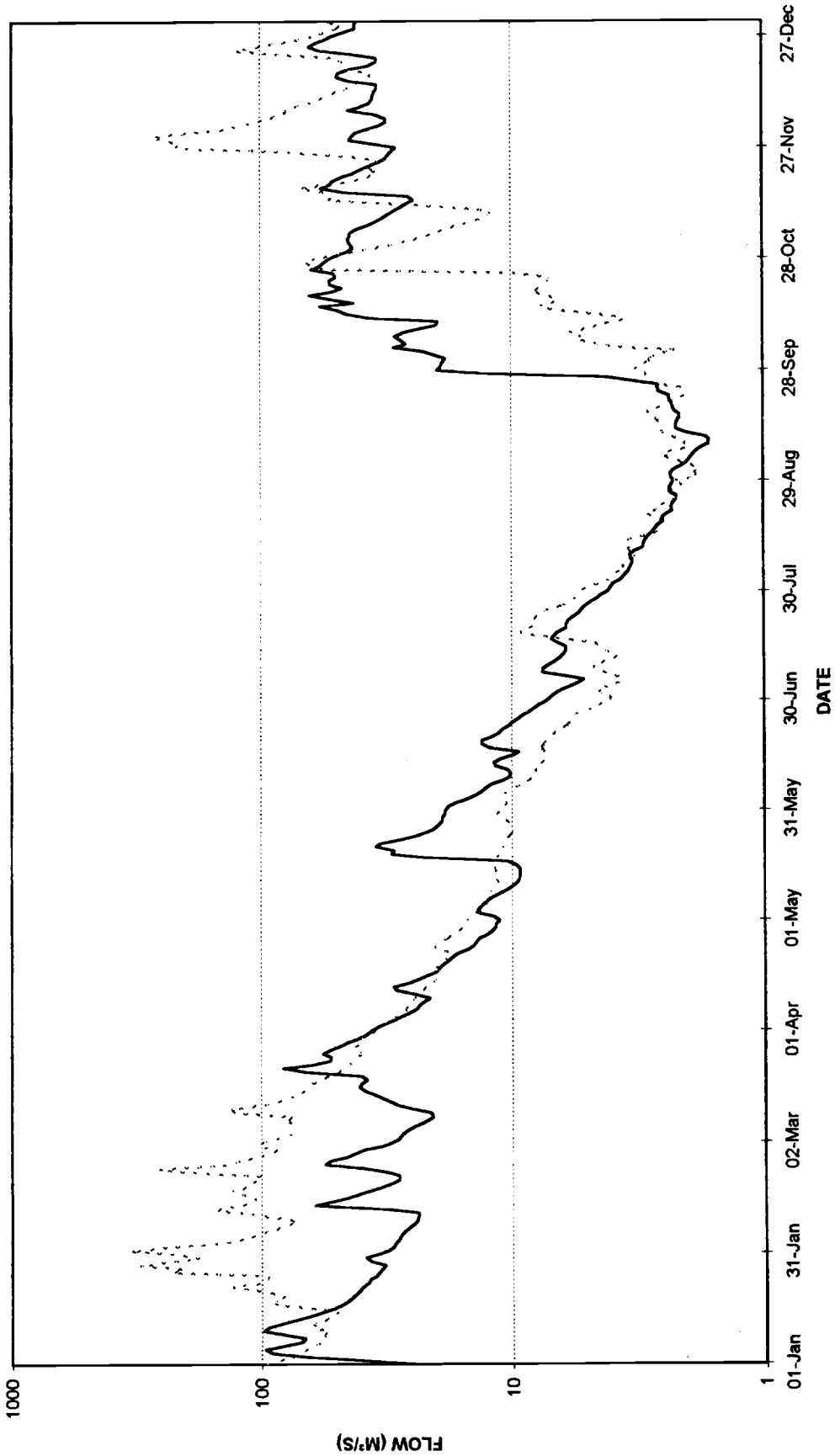
STATION 06013 CHARLEVILLE (RIVER DEE)



— 1976  
..... 1995

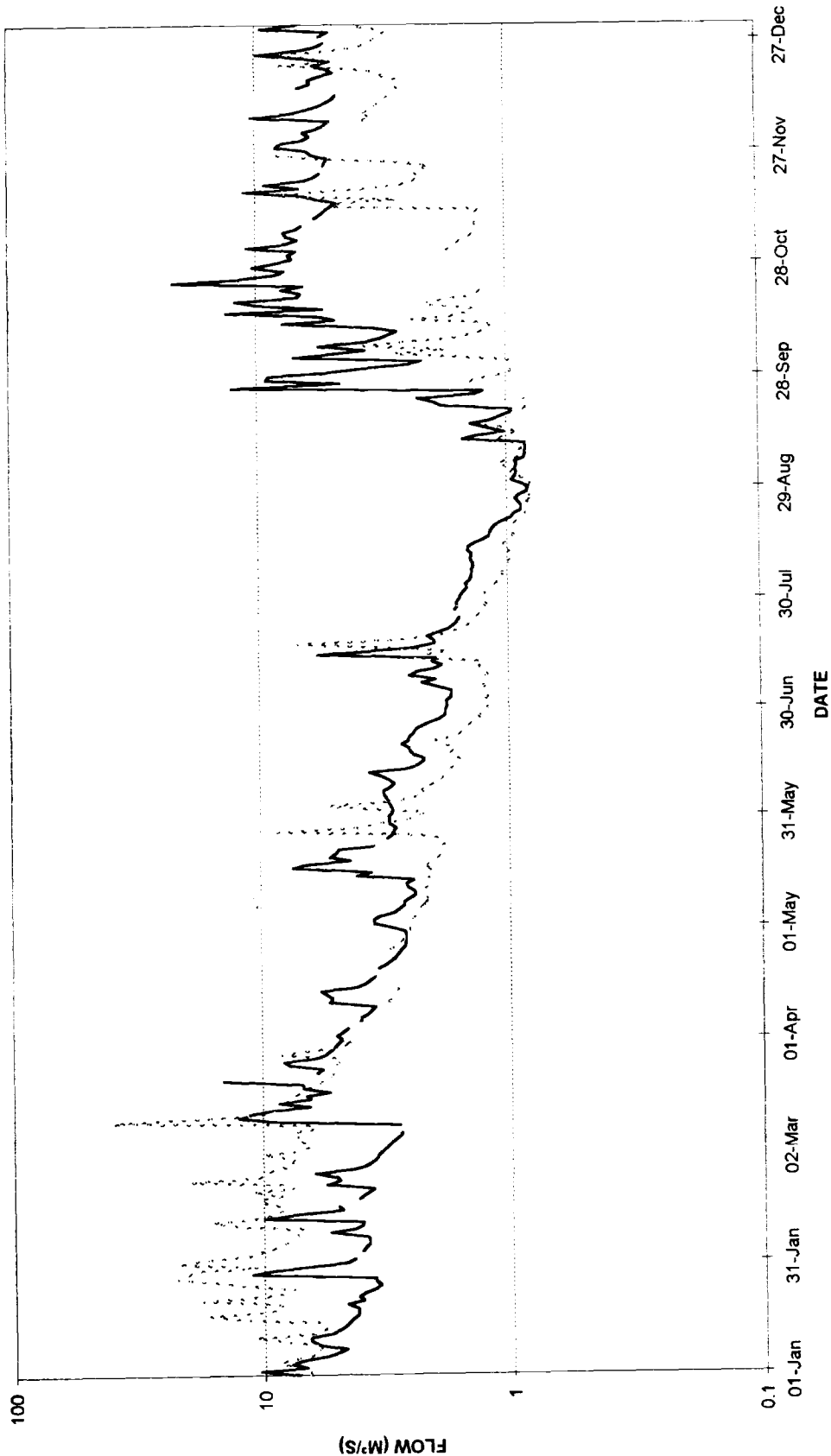
HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 07012 SLANE CASTLE (RIVER BOYNE)



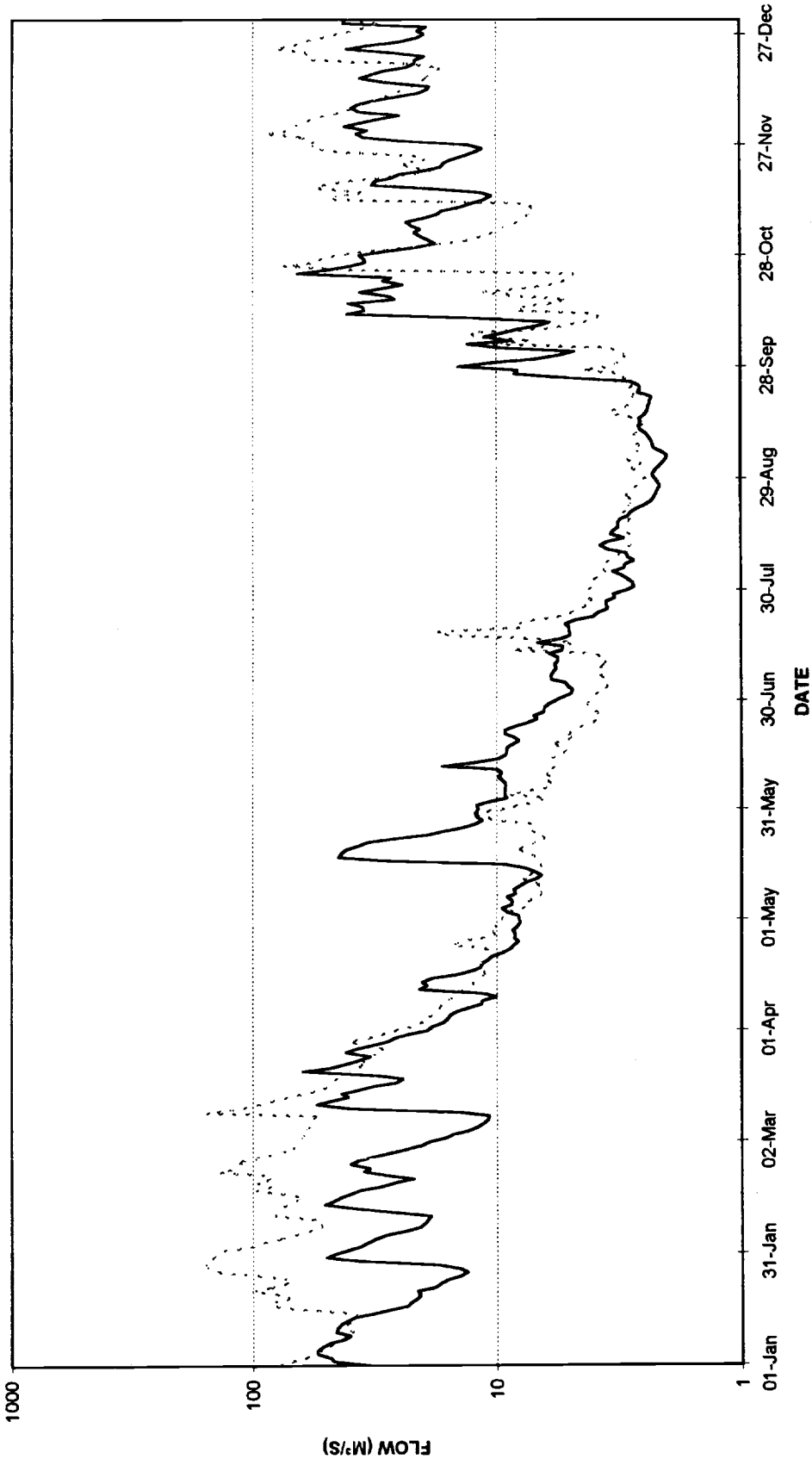
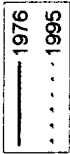
HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 12013 RATHVILLY (RIVER SLANEY)



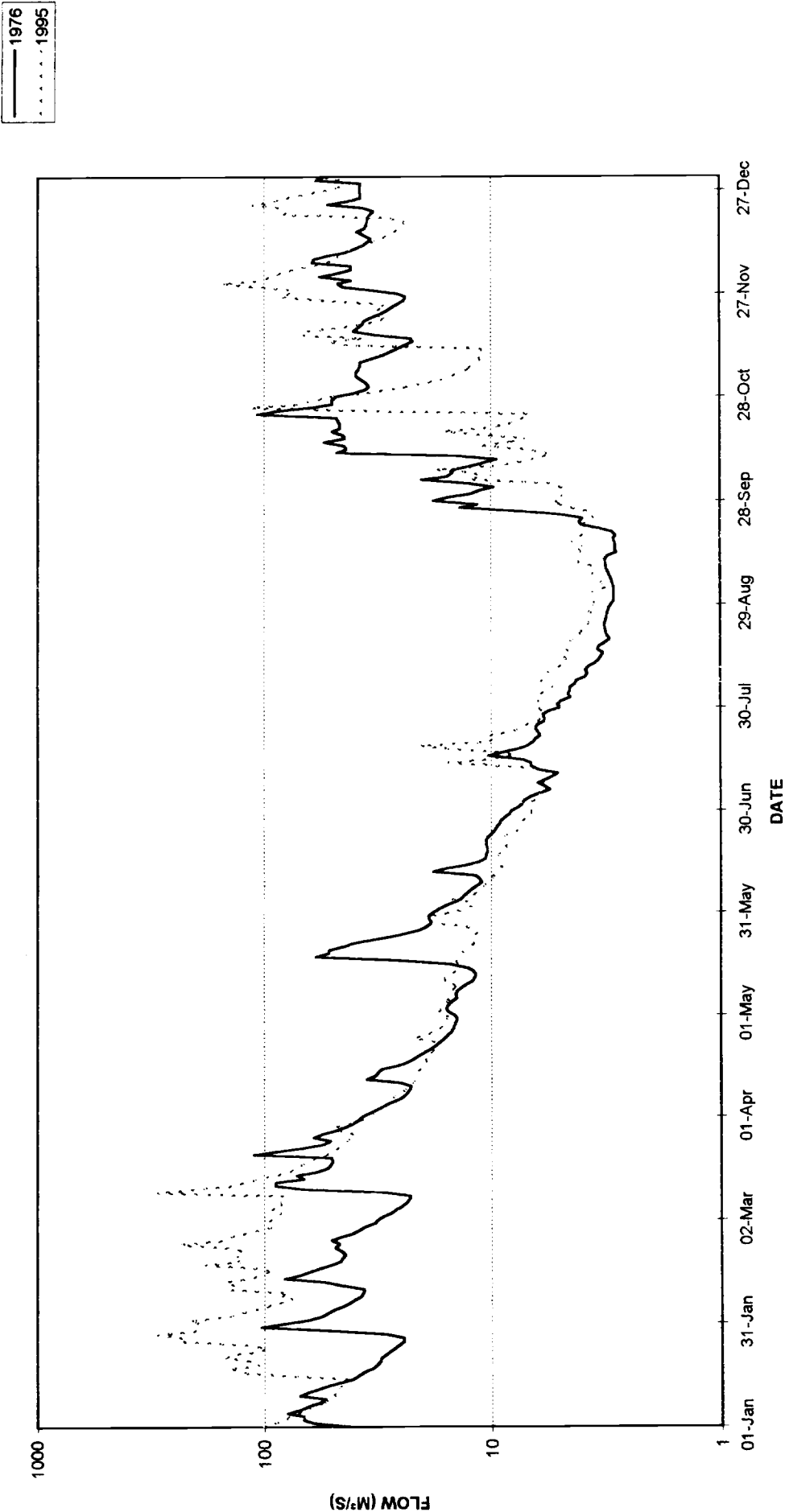
HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 15002 JOHN'S BRIDGE (RIVER NORE)



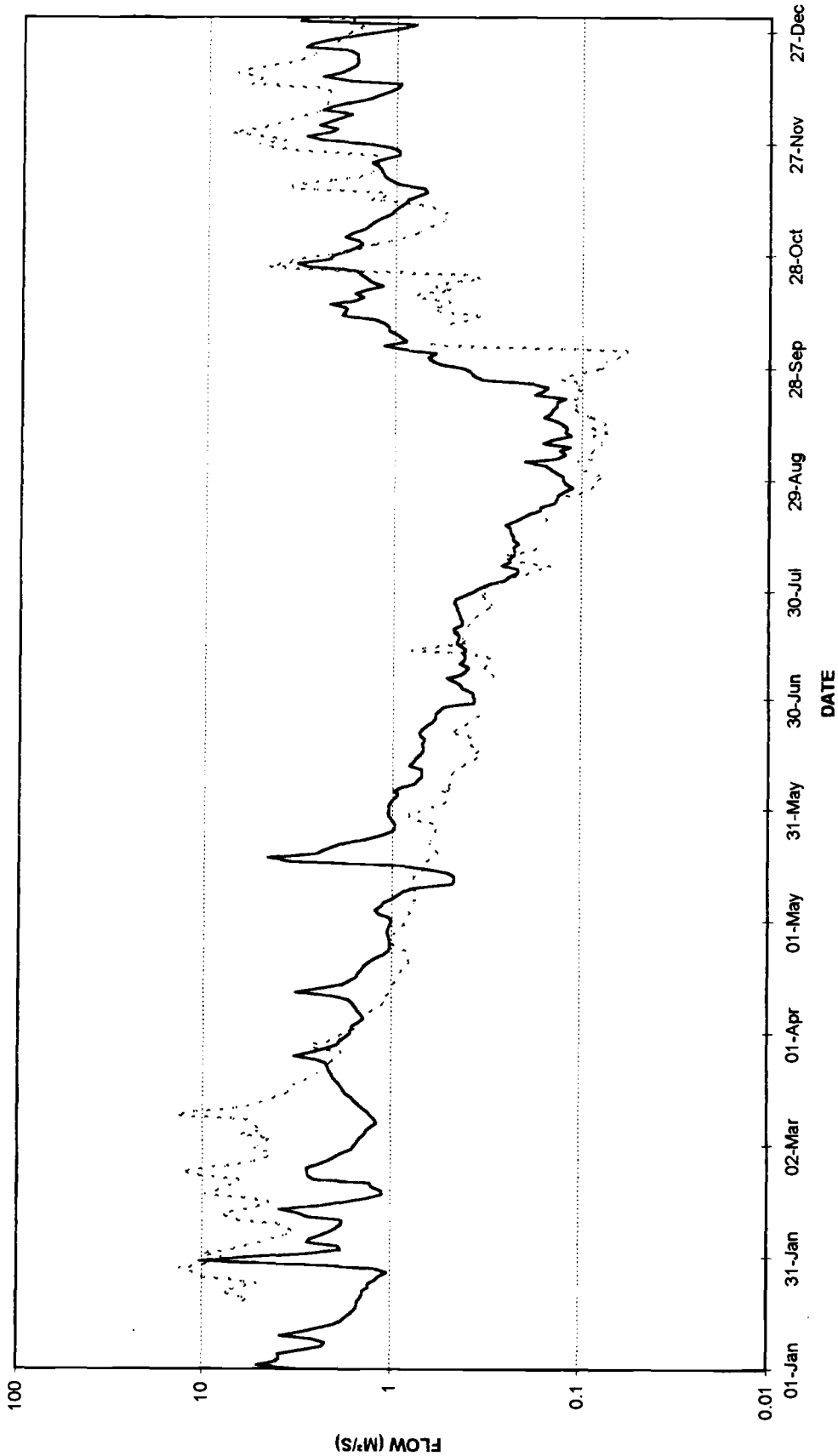
HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 15006 BROWNSBARN (RIVER NORE)



HYDROGRAPHS OF DAILY MEAN FLOWS

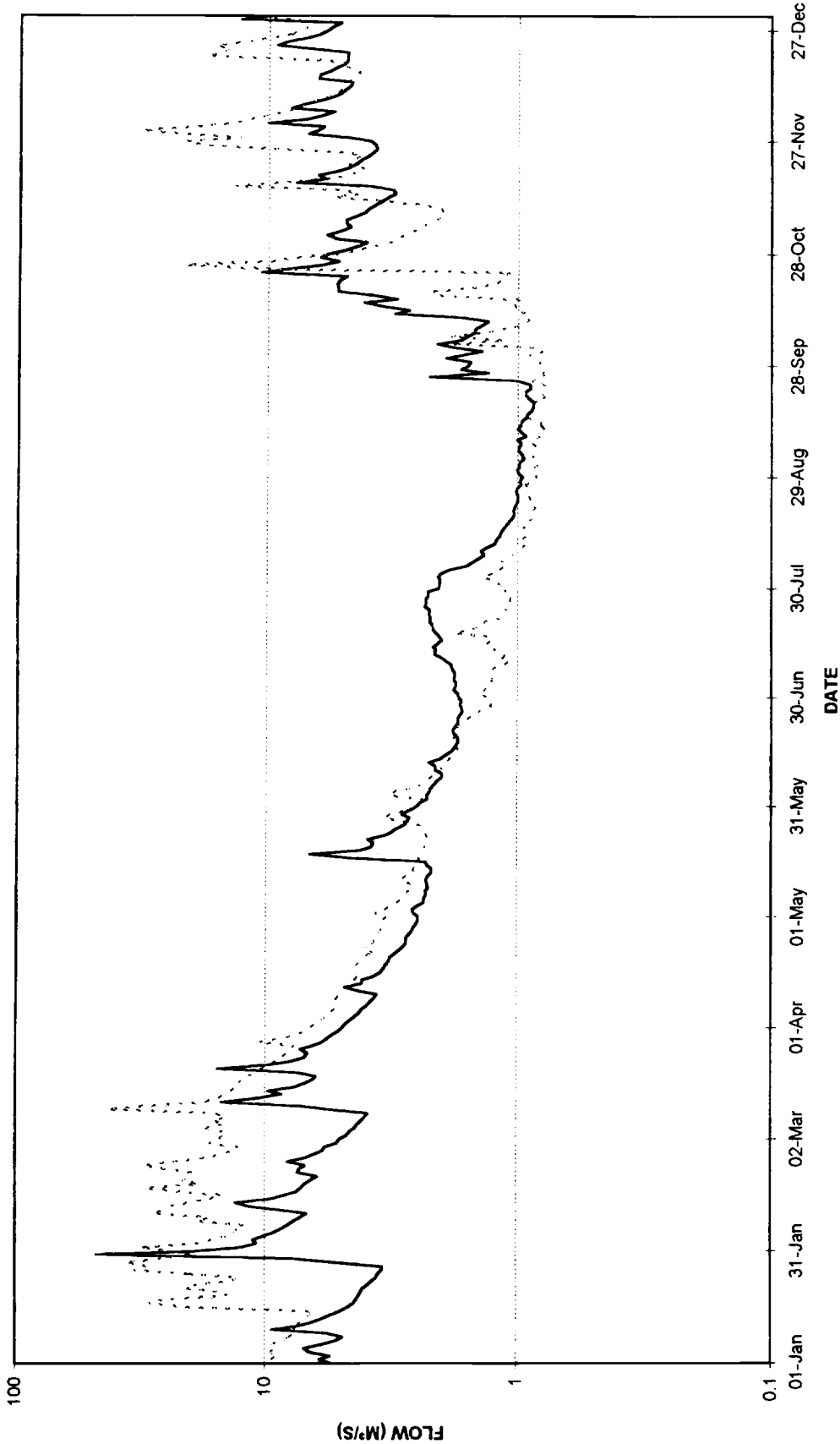
STATION 16001 ATHLUMMON (RIVER DRISH)



— 1976  
..... 1995

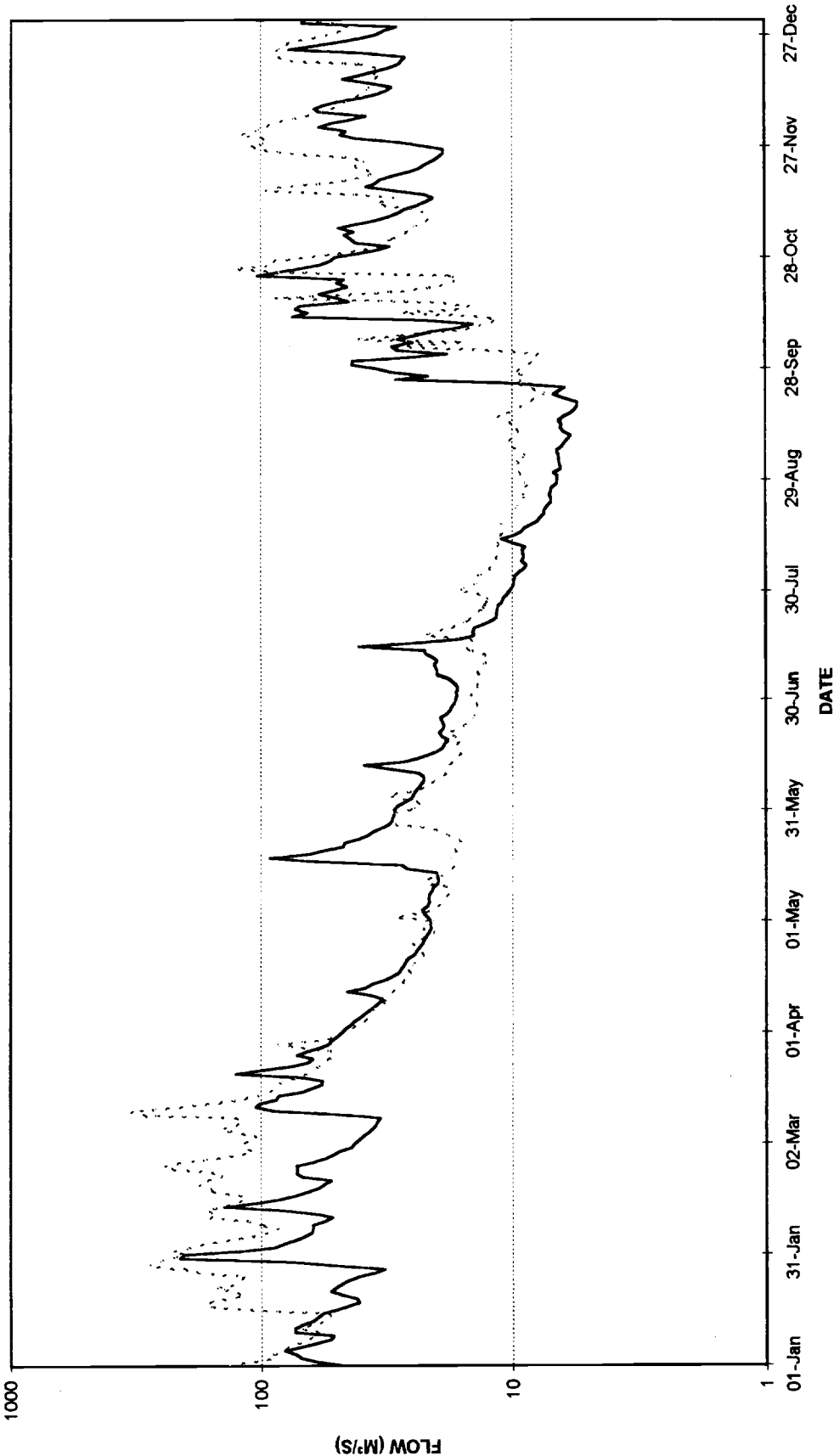
HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 16010 ANNER (RIVER ANNER)



HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 16011 CLONMEL (RIVER SUIR)

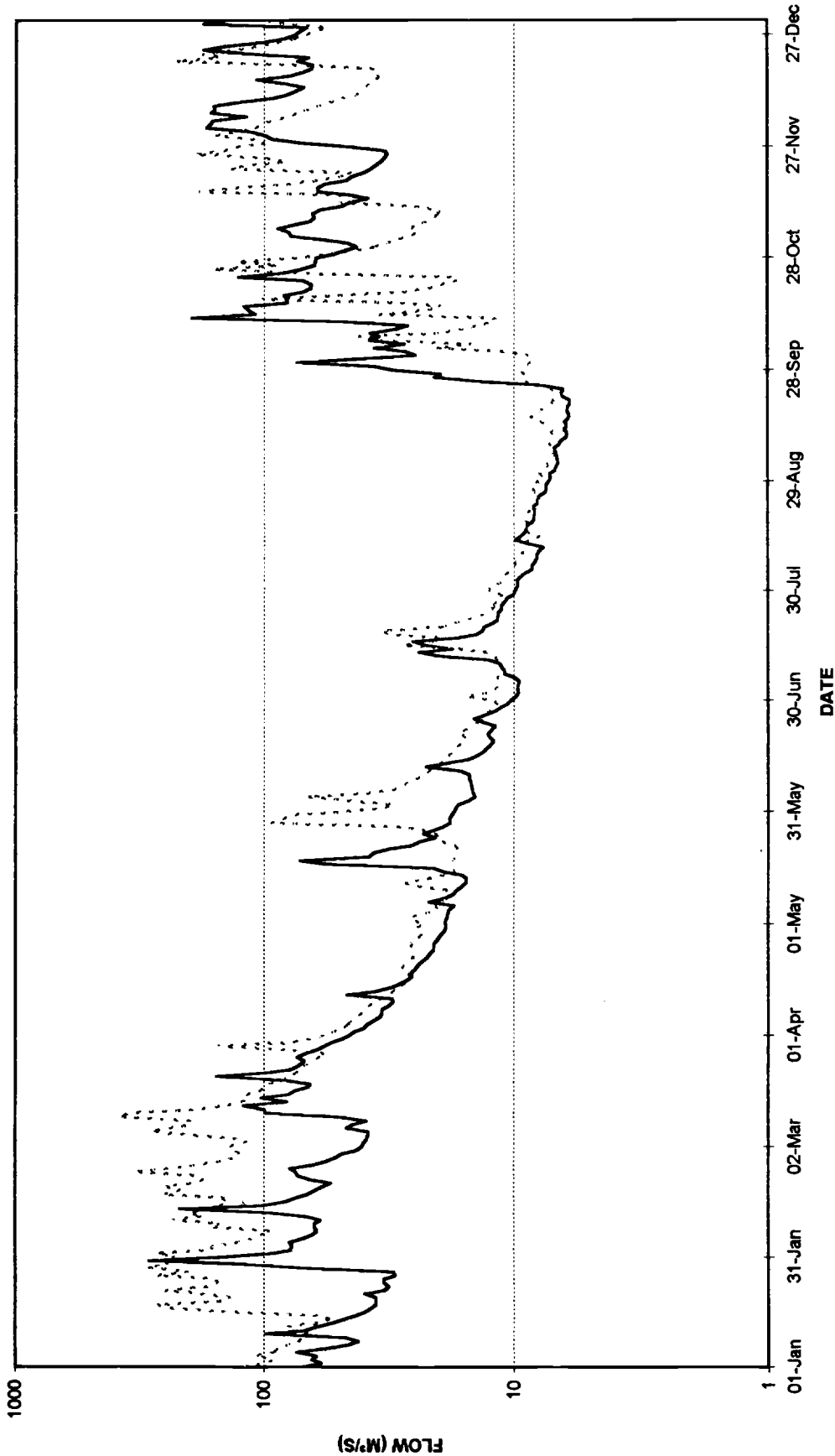


— 1976  
... 1995



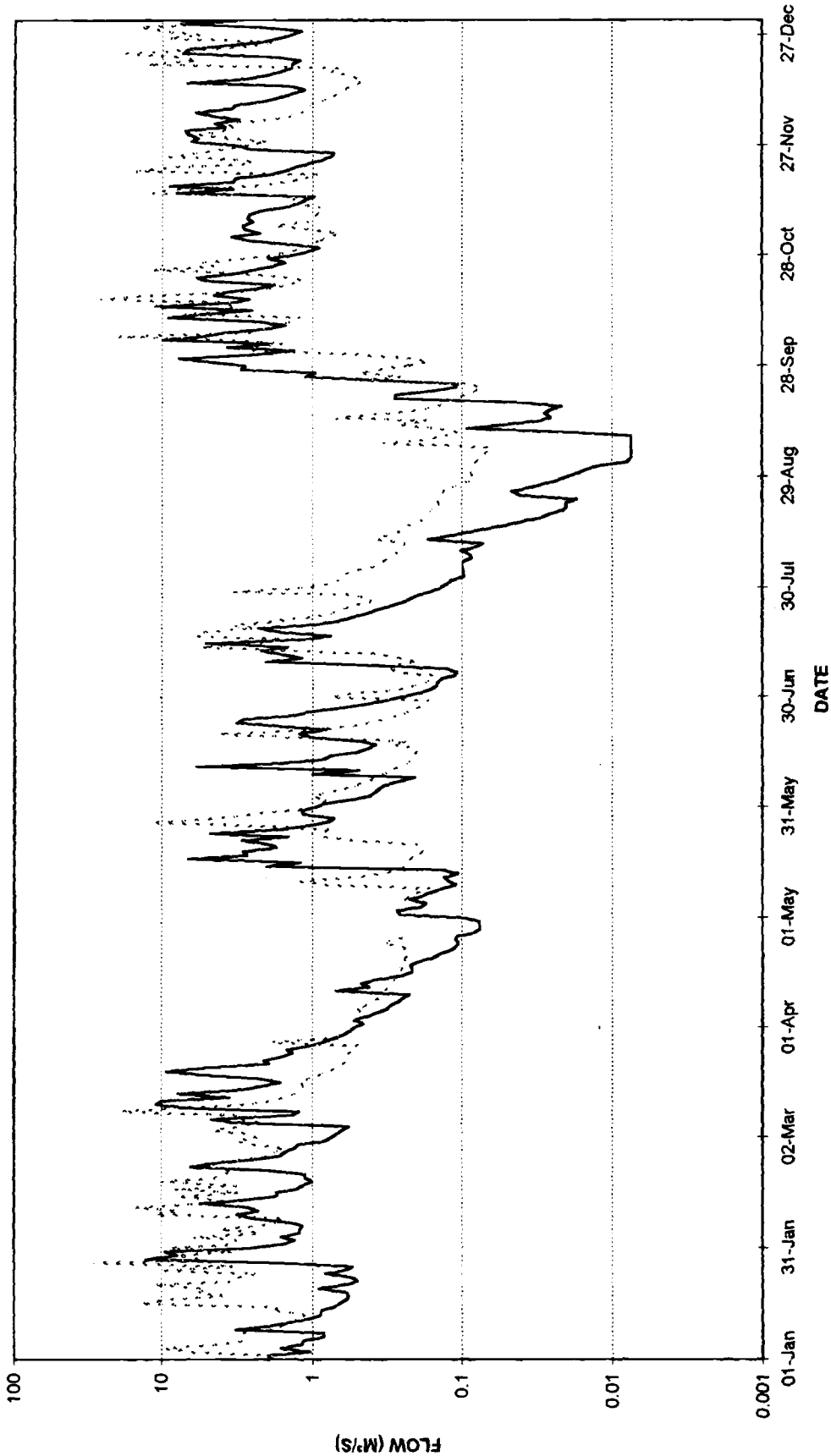
HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 18002 BALLYDUFF (RIVER BLACKWATER (MUNSTER))



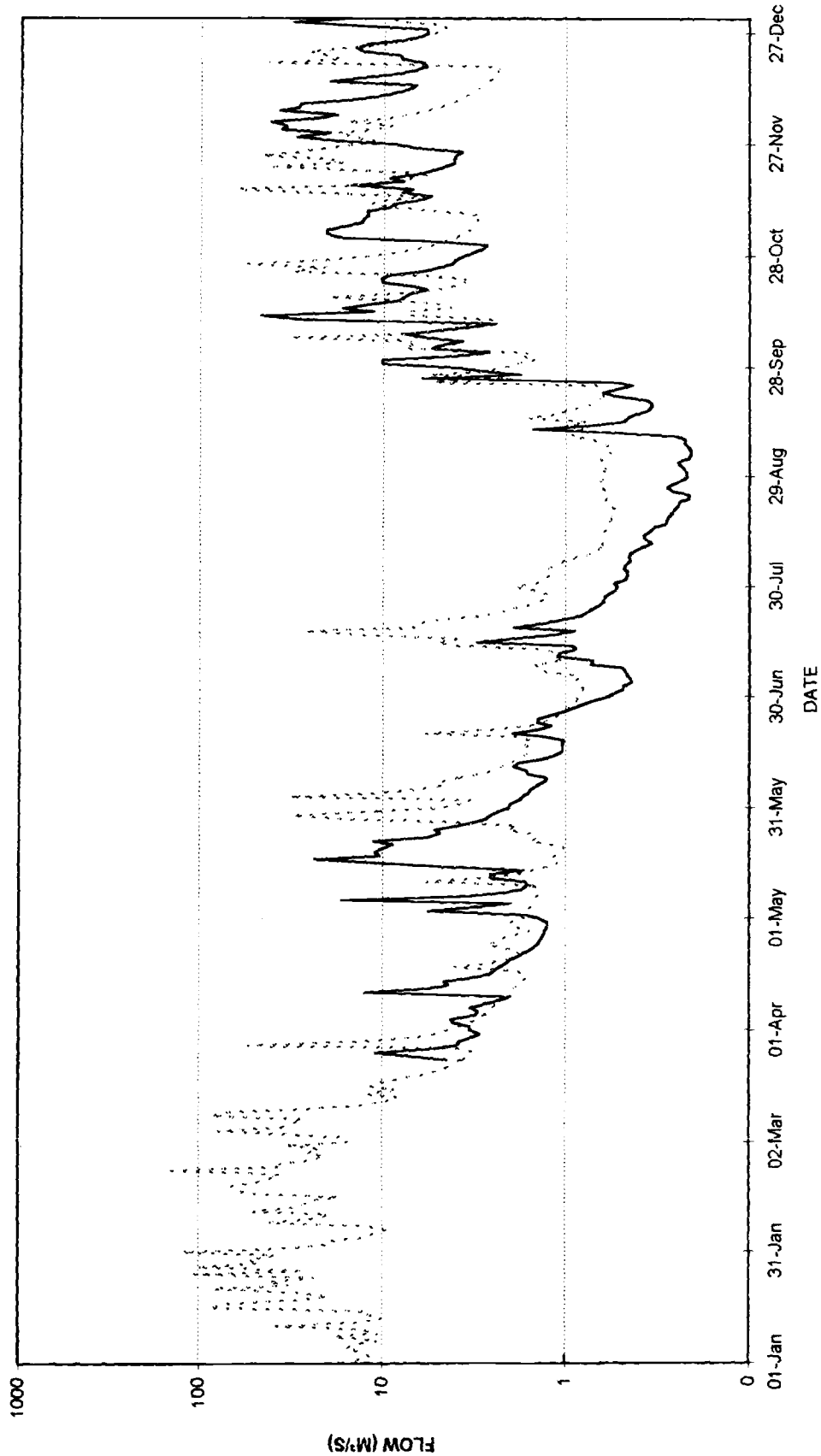
HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 21004 INCHICLOUGH (RIVER MEALAGH)



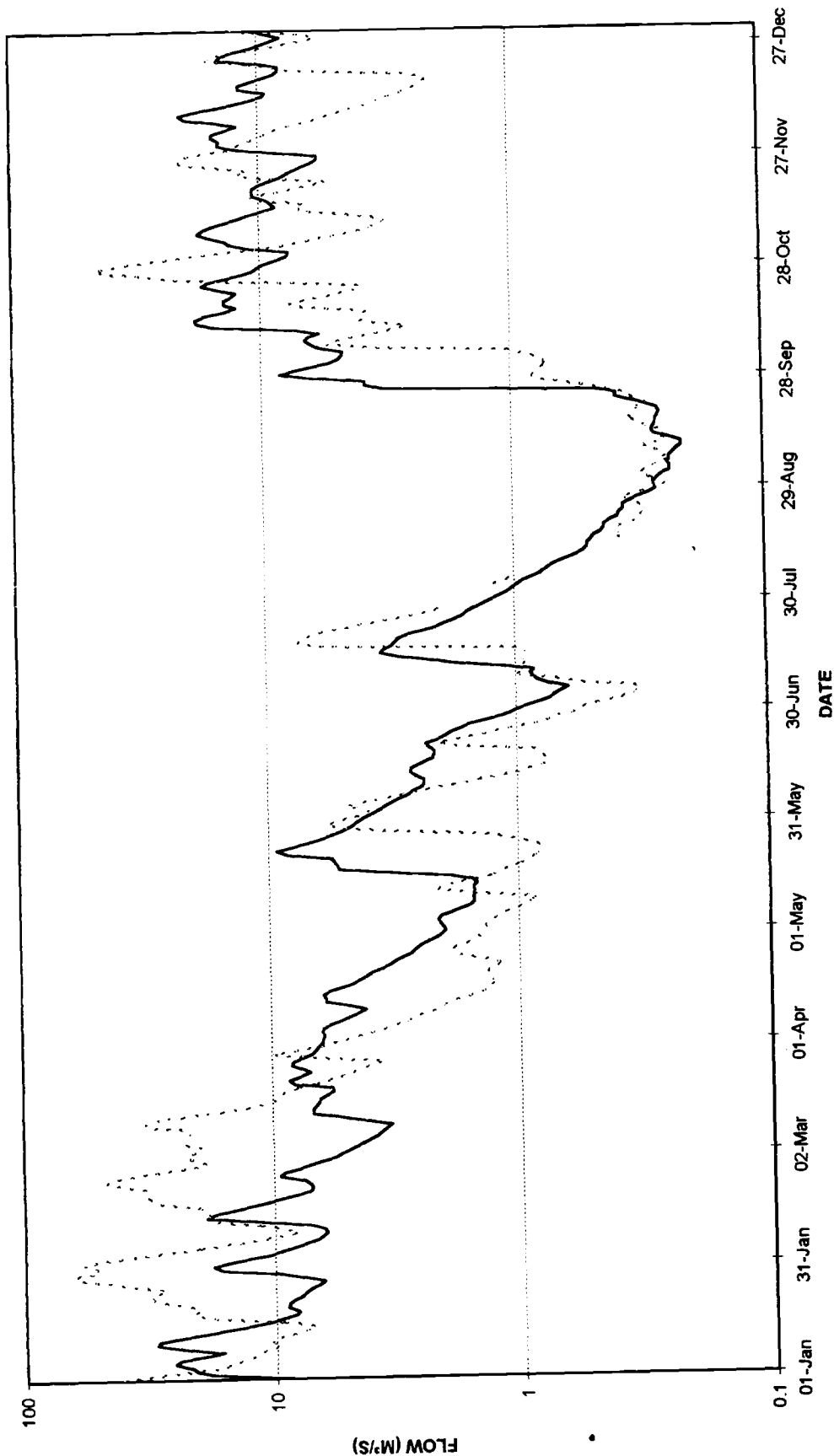
HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 23006 NEODATA (RIVER FEALE)



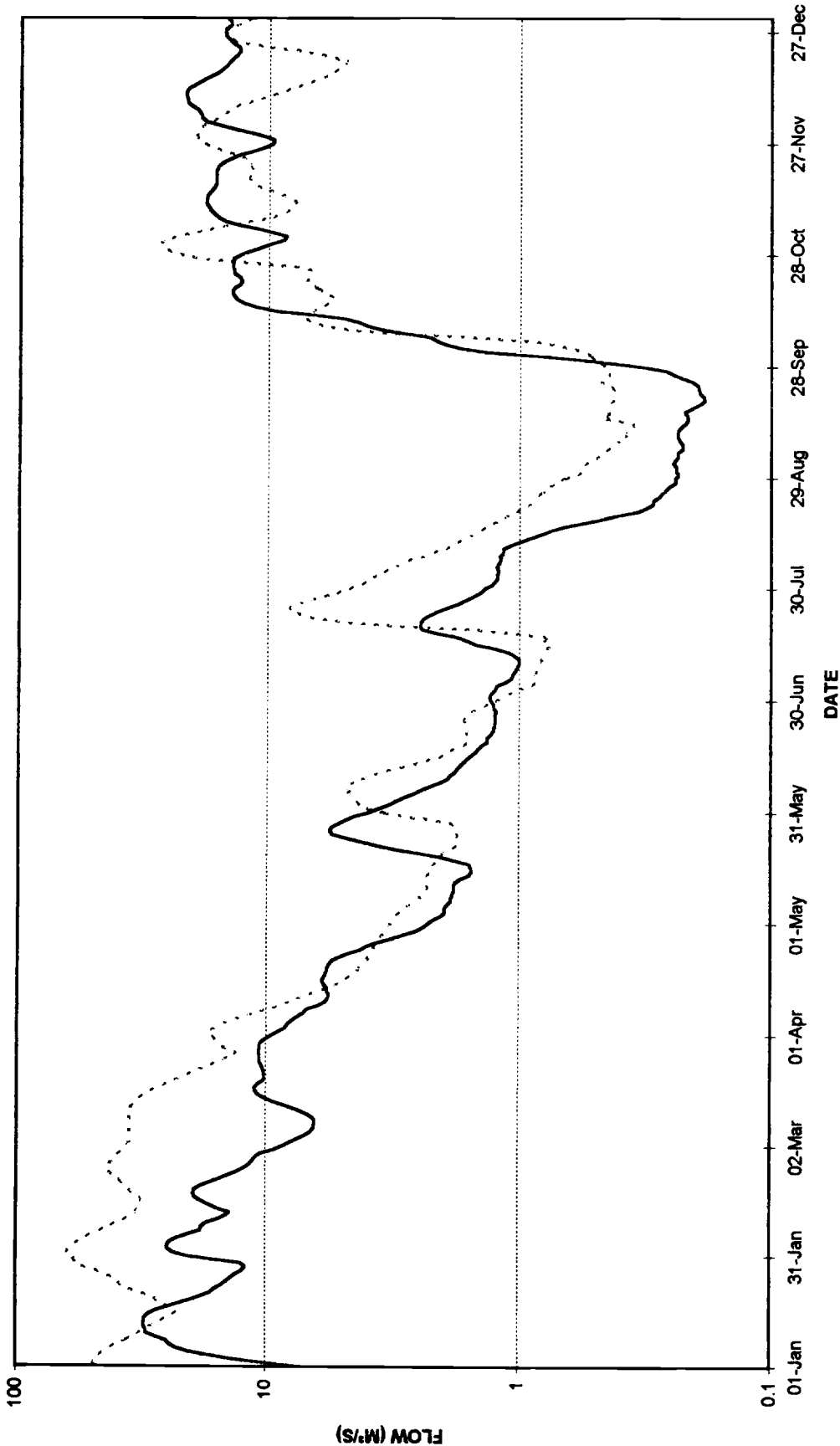
HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 25030 SCARRIFF (GRANEY RIVER)



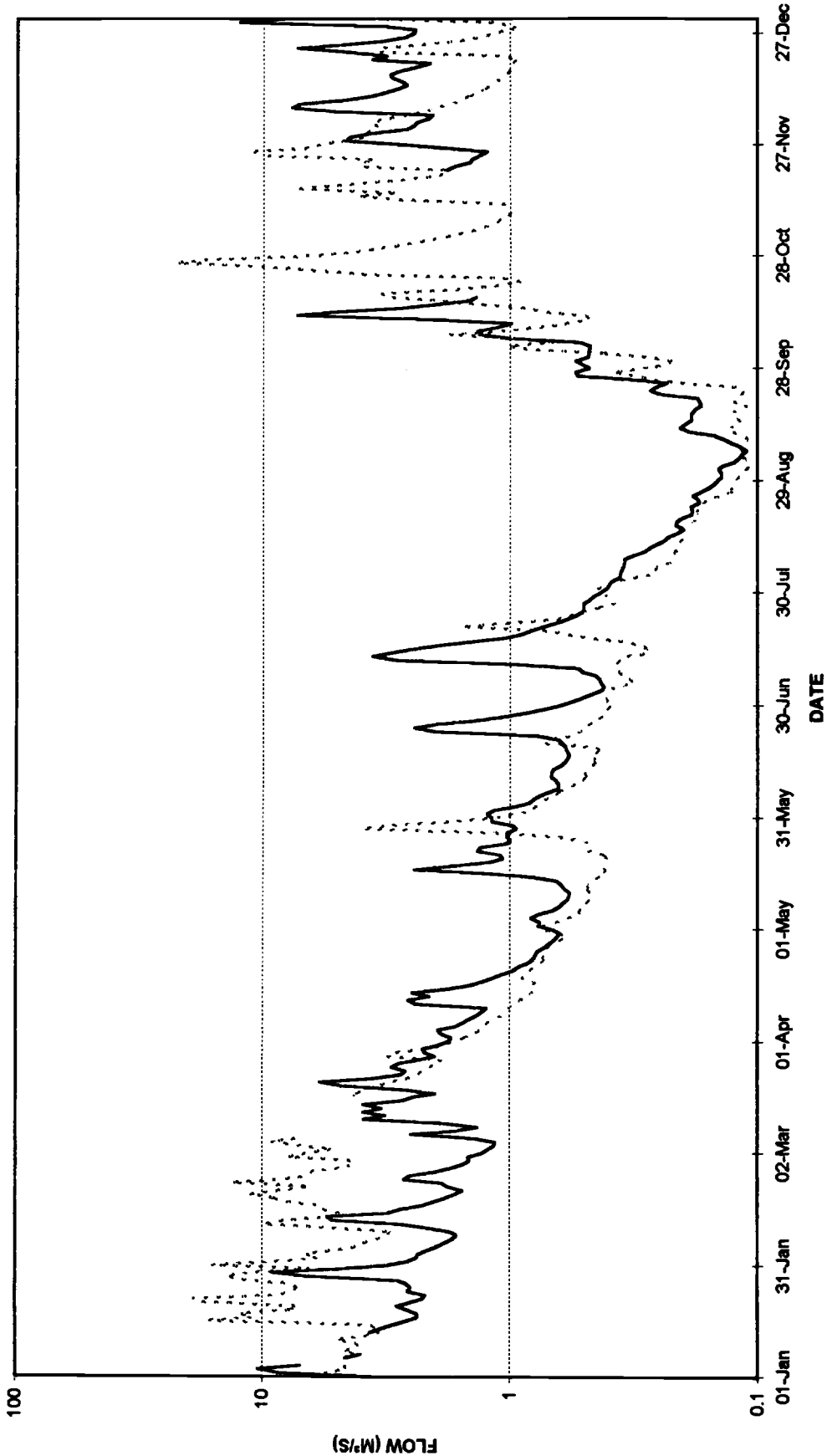
HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 27002 BALLYCOREY (RIVER FERGUS)



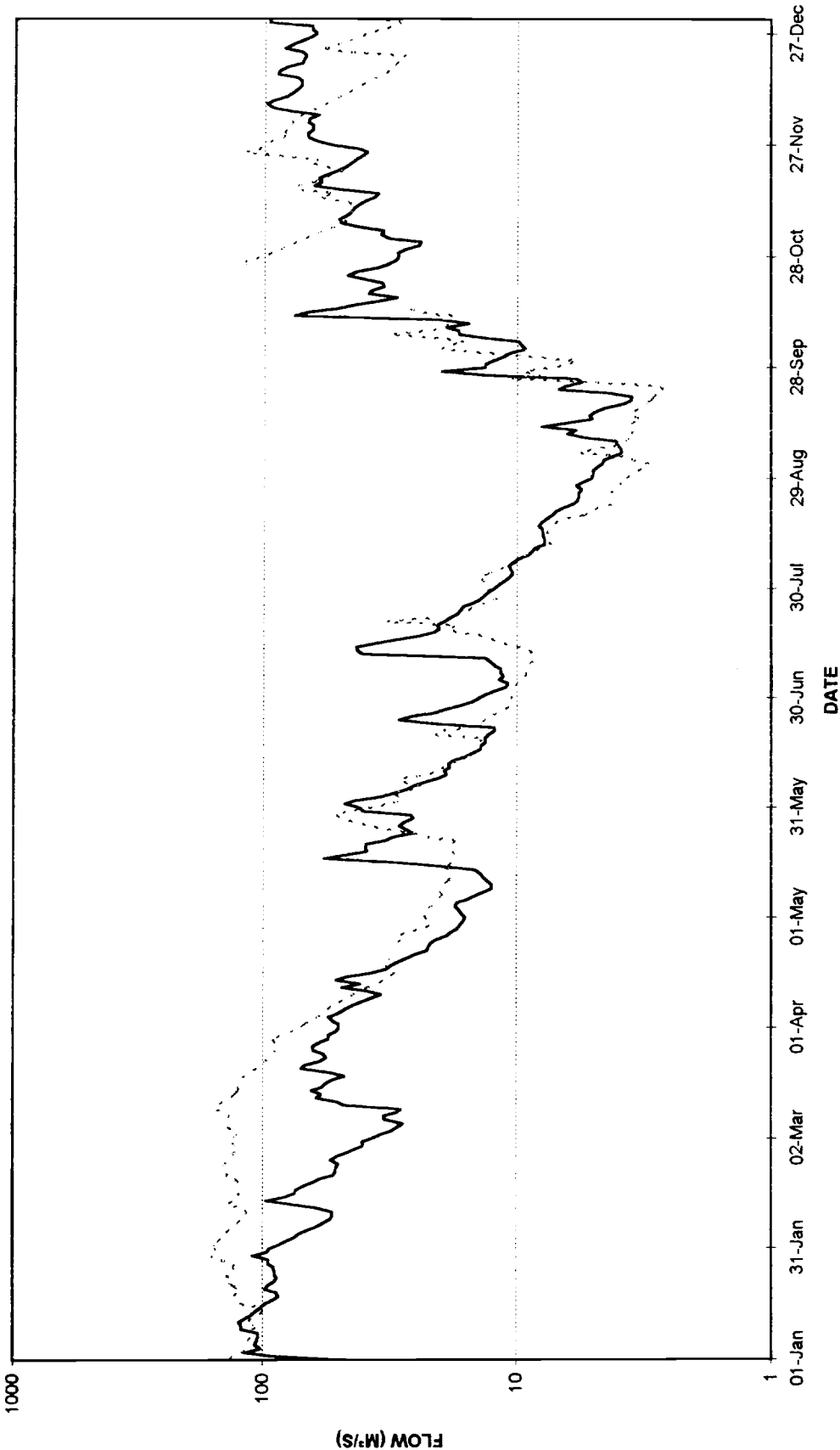
HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 30021 CHRISTINA'S BRIDGE (RIVER ROBE)



HYDROGRAPHS OF DAILY MEAN FLOWS

STATION 34001 RAHANS (RIVER MOY)



## **APPENDIX 4**

List of abbreviations used in this report



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# **LIST OF ABBREVIATIONS USED IN THIS REPORT**

## **BODIES RESPONSIBLE (BDS)**

### **COUNTY COUNCILS**

CAR	Carlow
CAV	Cavan
COR	Cork
DON	Donegal
DUN	Fingal
GAL	Galway
KER	Kerry
KIK	Kilkenny
LAO	Laois
LIM	Limerick
MAY	Mayo
MEA	Meath
MON	Monaghan
TIN	Tipperary (N.R.)
WAT	Waterford
WEX	Wexford
WIC	Wicklow

### **OTHER BODIES**

AFF	An Foras Forbartha
CSE	Comhlucht Siúicre Éireann
EPA	Environmental Protection Agency
ESB	Electricity Supply Board
OPW	Office of Public Works
RDS	Royal Dublin Society
UCD	University College Dublin

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