DEPARTMENT OF ENERGY
IRELAND

SMALL-SCALE HYDRO-ELECTRIC POTENTIAL OF IRELAND

OCTOBER 1985

Micheál Mac Carthaigh

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WATER RESOURCES DIVISION
AN FORAS FORBARTHA

CIVIL WORKS DEPARTMENT
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The co-operation and assistance of the Office of Public Works and all those who provided information are also acknowledged.

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Foreword

I am very pleased to be associated with this publication. Although there have been previous works on hydro in Ireland this is by far the most comprehensive which has been undertaken. It is a study which will withstand the test of time.

In former times hydropower was rated highly in Ireland and was a major contributor to the growth of industry during the nineteenth century. The development of fossil fuels led to a decline in hydro use, but in recent times there has been a renewed interest and revival in hydropower with a particular attraction towards small scale installations. This is a welcome development. It is important that the potential for development of hydropower has been identified because as a power source it is renewable, plentiful, economical and free of the environmental problems associated with fossil fuels.

It is my earnest hope that the publication of this work will be of assistance towards further small scale hydro power developments not only at former mill sites but also at many of the new locations which have now been identified. In the context of national energy consumption the potential capacity listed in this report at 38MW is modest but it could nevertheless represent an important contribution to our requirements.

This report is intended as a guide to those who may wish to privately develop water power. Although the installation and maintenance of small hydro plants can be carried out with relative ease, to obtain permanent benefits the developer should take the utmost care at both the planning and development stage. Indeed it is considered that expert advice and guidance should be obtained for each installation.

I take this opportunity to offer a word of praise to all who were responsible for this excellent publication. It will prove without doubt both successful and beneficial to the exploitation of an important natural resource. I wish all those who intend installing a hydro scheme every success with their project.

Edward A. Collins

Edward A. Collins, T.D.,
Minister of State at the Department of Energy

Chapter 1

Introduction

1.1 Work on this survey concerning potential small hydro sites in Ireland commenced in 1982 and was completed in mid 1985. At a meeting of the National Alternative Energy Committee, the Department of Energy asked the participants to consider the possibility of a national hydro resource survey. Arising from this meeting in which they participated, the Electricity Supply Board, (ESB), An Foras Forbartha and the National Board for Science and Technology, made a proposal to the Department to carry out a comprehensive evaluation of the total national hydro-electric power resource which would identify sites suitable for development.

1.2 The detailing of our hydropower resources was seen as a fundamental part of the Department of Energy's hydropower programme, complementary to the demonstration programme and the guidance programme for developers.

1.3 The aim of the Department of Energy in publishing this report is to establish the proper basis for the systematic development of small hydro resources. It is apparent that this will be possible only when the resource is properly identified and a reliable assessment presented with regard to energy potential and development viability. Although a preliminary survey was undertaken in 1981 by the National Board for Science and Technology on behalf of the Department, the results were only indicative of the number of operating and potential small hydro sites in the country, and the site information obtained was insufficient for planning purposes. It was considered therefore that a more comprehensive study should be undertaken to validate the information in respect of operating sites and assess the potential of other suitable sites. This study was undertaken by An Foras Forbartha and the ESB, with co-ordination by the National Board for Science and Technology.

1.4 Site identification was done by examination of maps with confirmation coming at the field work stage. Weirs, old mills and waterfalls are recorded on six inch maps. By scanning over 2,000 maps, this information was made amenable to the fieldwork teams, through transfer on to half inch maps. The methodology of the survey was based on a similar study of Wales which was carried out by Salford University for the United Kingdom Department of Energy.[(1)]

1.5 Consideration was limited to those sites with a probable installed capacity of 10 kW or greater, in view of the need to publish a useful study within the constraint of available resources. Also the average requirement of most prospective developers would be of the order of 10 kW. It was recognised that this would result in the exclusion of a number of sites which could be developed by individuals with energy needs of less than 10 kW.

1.6 Up to the beginning of this 20th century there were over 1,800 mill sites in operation in Ireland where water wheels principally, and turbines in some instances, were installed to produce mechanical and electrical power. There were also a small number of various other types of installations, mainly high head schemes on small rivers. Up to 50 years ago these sites were an important energy source for individuals, agriculture, industry and for certain town electricity supply companies. Over the years, with the expansion of the national electricity network, most of these sites, particularly the mills, fell into disuse. There are now less than 100 operating sites in the country. At present, the installed capacity of operational small hydro schemes is approximately 5 MW.

1.7 It may be said that this report is the first real attempt to implement the recommendations made in the 1922 Report on Water Power[2]. For the first time, the small hydro resource has been adequately identified and although the actual potentials of installed capacity and annual energy at each site have been conservatively estimated, they do represent practical exploitable values. Engineering analysis of the best available technical and hydrological data has been the basis for the systematic assessment of every potentially useful hydro power site of 10 kW rating or greater. It can be concluded that there is substantial potential but that development will invariably require considerable resources. The extension of site assessment beyond the terms of the hydropower resource survey of Wales[1] to include site rating, is of considerable importance. Notwithstanding the fact that certain assumptions were necessary and consistent procedures had to be adopted in determining the site rating of a large number of sites with varied physical conditions, these ratings are a reasonable indication of their economic viability. They do not provide assurance to the developer that any particular scheme will pay its way.

1.8 The assessment of all the listed sites specifically avoid assumptions of large dam construction, tunnels or catchwaters and where weirs are required they are assumed always to be less than bank high. While some modern turbines can operate efficiently on heads as low as one metre, a comprehensive assessment of the potential for developing low-head, large volume rivers with small gradients has been omitted. Only sites where there are existing weirs and low dams suitable for repair or where very favourable bank configurations exist have been included. Special allowance has been made for the inclusion of high head sites with relatively small catchments. Bearing in mind the substantial energy potential of low-head large-volume rivers it was recognised that the size of civil works and mechanical plant necessary to realise this potential effectively precluded the consideration of such sites in the context of small scale hydro power.

1.9 A total of nearly 3,500 sites were inspected in order to carry out a thorough resource appraisal. At the time of carrying out the survey 85 sites were already in operation with a further 483 sites suitable for development. In total, these 568 sites could provide about 193 GWh of energy per annum from installed capacities amounting to some 38MW. This is equivalent to approximately 20 per cent of the present hydro-electric plant capacity of the ESB. Details of these 568 sites only are contained in this report. The overall summary of results is given in Table 5.1 and a summary on a county basis is given in -Table 5.2. Details of operating and potential sites in each county are given in Appendix A. The potential installed capacity, annual energy, site rating and other parameters are listed in this Appendix for individual sites. Information on the other sites surveyed and not contained in this Report may be obtained from the Department of Energy, Dublin.

1.10 There are limitations on the scope of this report by the use of selective criteria (c.f. Ch. 3). It is not a totally exhaustive survey of all the small scale hydro-electric resources in the country. Certain criteria have of necessity been adopted which have resulted in the exclusion of sites with (1) small power output, and (2) low head, as well as, (3) high head sites in mountainous areas.

Chapter 2

Hydrological Analysis

Introduction

2.1 The hydro power available at any site on a river is directly proportional to the fall at that site and to the flow in the river. Consequently the information needed to estimate the hydro power at any site is the height of the fall and the magnitude and frequency of river flows at the site. While in general the determination of the fall or head is a comparatively simple matter, for purposes of this report a method of extrapolation had to be developed so that flow data from gauged catchments could be applied to derive the frequency distribution of flows at all sites including those in ungauged catchments. A synthetic method termed the *regional unit flow duration curve* was employed for this purpose.

Flow Duration Curves (FDC's)

2.2 A flow duration curve is a graph of flow rate versus its exceedence percentile i.e. percentage of time when a given flow rate is equalled or exceeded. The bases for the derivation of regional flow duration curves are the flow duration curves produced from good quality records of daily mean flows from all suitable hydrometric gauging stations. The existing data available from approximately 185 gauging stations representing all the gauged catchments within the survey area were chosen for analysis.

2.3 Tables of daily mean flows were already available for some gauging stations. Where the data were in the form of chart records of water level at the gauging site these records were processed to derive tables of daily mean flows for each calendar year over the period of the record. Flow duration curves were then produced from the tables of daily mean flows.

2.4 The catchment area (in km^2) contributing to flow at the site and the long term average rainfall (in m) on that catchment were calculated for each gauge site. Catchment areas were measured by planimetering $\frac{1}{2}$" to 1 mile scale Ordnance Survey maps and rainfall was determined from $\frac{1}{4}$" to 1 mile scale isohyetal maps based on observations over the period 1941-1970.

Derivation of Regional Flow Duration Curves

2.5 Using the values of catchment area and rainfall each flow duration curve was normalised to a unit flow duration curve by dividing the flow ordinates by the appropriate catchment area and rainfall. The unit flow duration curve for a site represents the flow at that site generated by 1 km^2 of contributing catchment with an annual average rainfall of 1 metre. Unit flow duration curves are the basis for the derivation of regional unitised flow duration curves.

2.6 Unitised flow duration curves were produced for 185 hydrometric gauging stations throughout the country. The bodies responsible for data collection at these sites include

Local Authorities, the Office of Public Works and the Electricity Supply Board. Various lengths of records existed for the different gauge sites and the quality of the data also varied to some degree. This resulted in the reduction of the number of unitised curves selected for analysis. Thirty-one of the derived unitised FDC's were considered unsuitable for one or more of the following reasons:—

(i) The period of record was too short.

(ii) Flows at some gauging stations were seriously influenced by upstream storage.

(iii) The rating curve for the gauging station i.e. the relationship between water level and measured flows was of poor quality.

(iv) Where a particular gauging station was located close to another station with a longer period of record, then the station with the shorter period of record was excluded.

2.7 A total of 154 unitised FDC's were thus used in the determination of regional unitised FDC's. The hydrometric gauging stations to which these relate are listed in Appendix B.

2.8 Having normalised a set of standard flow duration curves with respect to catchment area and average rainfall, the variation in the resulting family of curves from that area depends almost completely on catchment geology and soil, assuming that a standard period of record was employed. Having regard to the quality of the hydrological data available, it was inevitable that considerable variation in flow duration curves would emerge. This was due to several factors which arose from a combination of particular local flow conditions, the use of FDC's from sites with small catchments and high rainfall, the inclusion of variable periods of flow records and the absence of information relating to specific geological and soil types. Typical variations in derived FDC's can be seen in Fig. 2.1 which compares 13 curves for gauging stations all in the catchment area of the river Suir. It was decided therefore that the regions to which a particular group of FDC's applied should be small to compensate for the possible inaccuracies arising from the various sources. Consequently the procedure of selecting regions on a county basis was adopted.

2.9 When a particular group of unit FDC's were considered to adequately represent flow conditions within a region a statistical curve fitting technique was applied to find the curve of best fit for the group. *This curve is then the unitised regional flow duration curve and it indicates the variation in flow rate generated by 1 km² of contributing catchment with an annual rainfall of 1 m anywhere within that region.* A total of 85 regional flow duration curves have been derived using the unit FDC's from 154 hydrometric gauging stations. A total of five maps were prepared to outline all 85 regions for which unitised flow duration curves were derived. These regions and their corresponding unitised regional flow duration curves are shown in Appendix C. In Figure 2.2 the unitised regional flow duration curve for a typical region is shown as an overlay on the group of FDC's in Figure 2.3 which describes that region.

2.10 *Hydrological records show that the mean flow in a natural watercourse is approximately equal to the 30 percentile flow.* The 30% exceedance coefficient of the unitised regional flow duration curve is therefore taken to be the provisional mean flow coefficient for that region. The mean flow at any site can be estimated by multiplying the relevant provisional mean flow coefficient by that catchment area to the site and the average rainfall on that catchment. Unique flow duration characteristics for the site can be established by applying the same parameters to the complete unitised regional FDC.

2.11 The level of installed generating capacity (maximum power output) appropriate to any hydroelectric power site can be determined only when the design parameters of head and flow are established. The measurement of head is usually a relatively simple matter.

The design flow rate of the installation may be chosen to be equal to the mean river flow rate or to some multiple of this flow. The adoption of a particular proportion of the mean

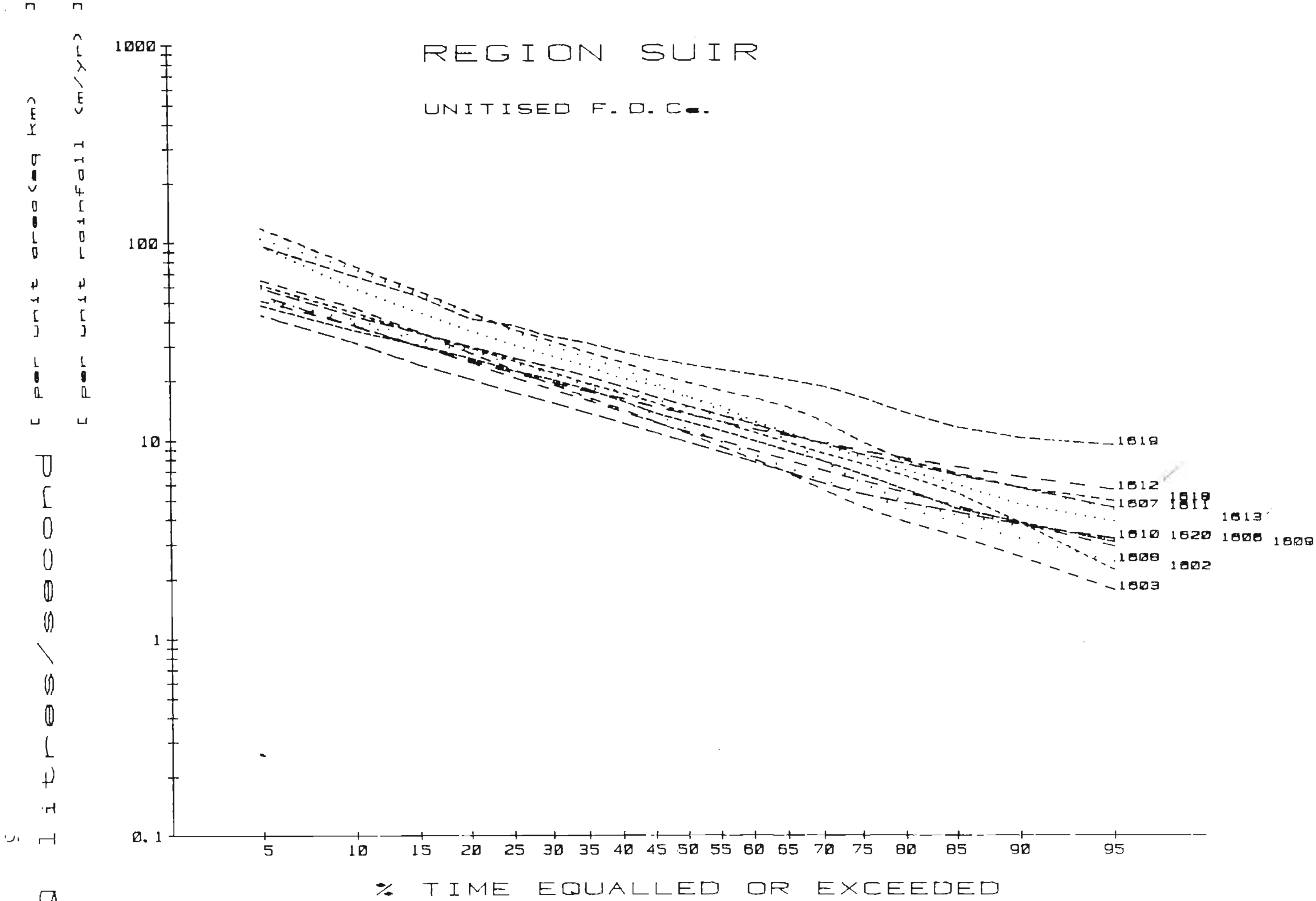

FIG. 2.1 THE VARIATION IN UNITISED FLOW DURATION CURVES FOR THE RIVER SUIR CATCHMENT

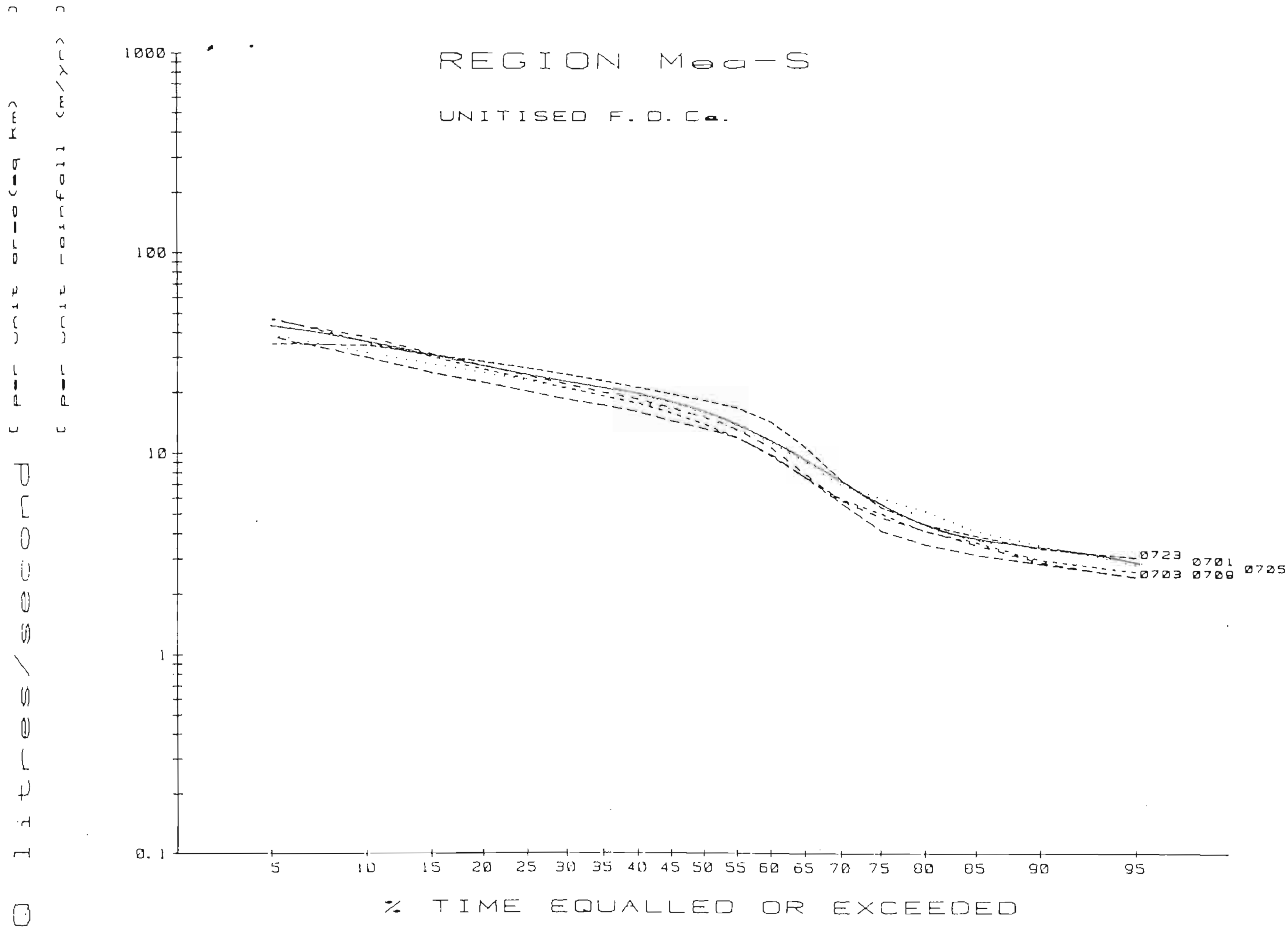

FIG. 2.2 UNITISED REGIONAL FLOW DURATION CURVE FOR REGION MEA—S

FIG. 2.3 UNITISED FLOW DURATION CURVES WHICH DETERMINE REGION MEA—S flow as a design flow is based on river size, geomorphology, the condition of intake channels and weirs, power demand, access and the disadvantages to fishery and amenity interests. Knowing the design head, the design flow rate and the expected efficiency of the turbine unit at full capacity the installed capacity of the site is obtained from the relationship

$$P = 9.81\ QH\eta$$

where P = maximum power output (kW)

H = Head (m)

Q = flow (m^3/s)

η = efficiency at full capacity

1,000 litres = $1 m^3/s$

The Use of Flow Duration Curves in Annual Energy Calculations:

2.12 The expected annual energy output is also of prime importance to the developer. The calculation of this energy potential is based entirely on the derived flow duration curve for the particular site. While the design flow rate will be the upper limit of turbine operation, the lower limit of operation is typically between 25% and 40% of the design flow depending on turbine characteristics. The effect of altering this limit is not large however, since not only are the volumes comparatively small at the lower end of the curve but the efficiency is less than for higher flows. *The lower limit of turbine operation is taken as 25% of the full capacity discharge.*

2.13 In Figure 2.4 a typical flow duration curve is plotted with time as abscissa and discharge as ordinate. The area under this curve represents the volume of water passing the site in unit time. The quantity used to produce electricity corresponds to the area ABCDF where A is the discharge when installed capacity is fully employed and G is one quarter of that volume.

The *annual energy coefficient* for the installation Ce is defined as this area multiplied by 9.81 (g) and 8,760 (the number of hours in a year). Since the area, and consequently the annual energy coefficient, is a function of the particular percentage of the mean flow (Q_m) which is chosen as the design flow (Q), it is necessary that a range of energy coefficients be available to the designer. For this study energy coefficients have been calculated for values of Q in the range of 1.65 Qm down to 0.2 Qm.

The *annual energy potential* of the site is given by

$$E = Ce\ ARH\eta$$

where E = Annual energy in kilowatt hours (kWh)

Ce = Annual energy coefficient

A = Catchment area (km^2)

R = Average rainfall (m/year)

H = Design Head (m)

η = Overall efficiency

The coefficients are listed in Tables C2-C6 of Appendix C.

Curve plotted to linear scales to emphasise the slope of the FDC

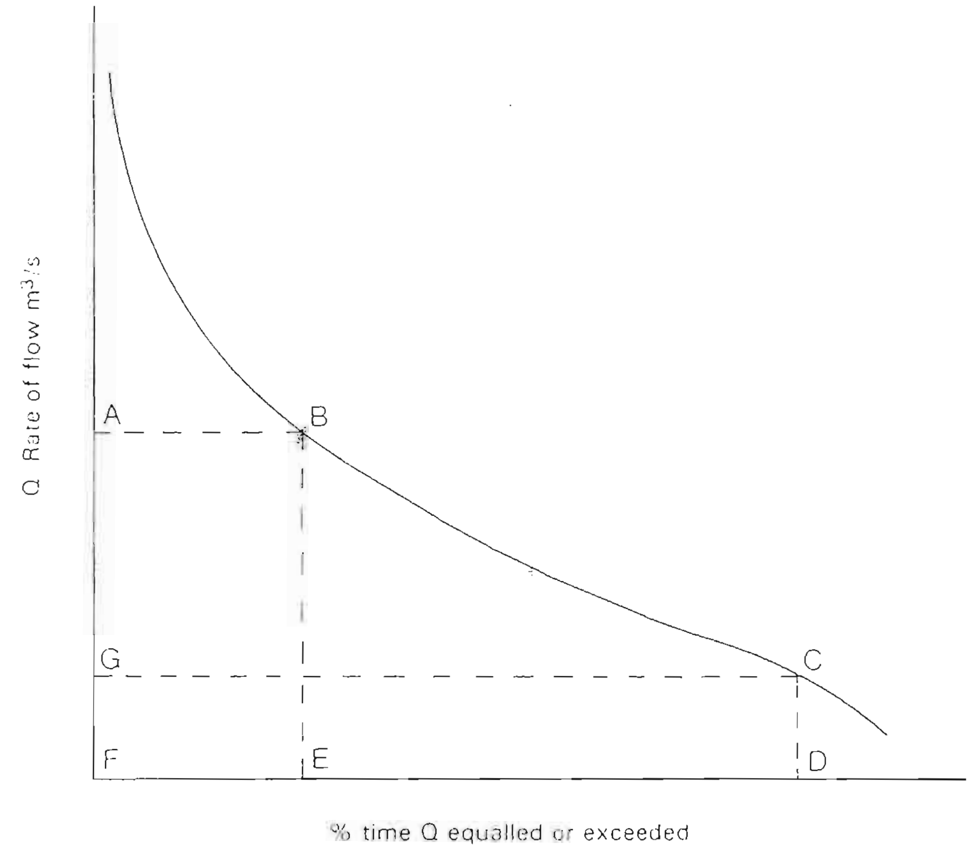

FIG. 2.4 TYPICAL FLOW DURATION CURVE

Possible Errors

2.14 The procedure outlined above to obtain the flow duration characteristics at all potential sites was simple and efficient having regard to the large number of sites where this information was required. However, it should be recognised that it is a synthetic method and there are possible inaccuracies arising both from the derivation of regional FDC's and in their application to ungauged catchments.

(a) The flow duration curves used to derive the regional curve should ideally be based on a standard period of record of daily mean flows. Relatively large differences in the length of records were inevitable due to the large number which were analysed.

(b) The basic FDC's do not take into account the effects of catchment geology and soil type.

(c) The regional flow duration curve is derived from a number of FDC's from a particular region. It represents the general flow conditions and does not show the effects of particular local conditions. Most of the curves are from river sites with relatively large catchment areas and mean average annual rainfall. Many of the actual sites investigated have small catchment areas and high average annual rainfall. The effect of decrease in area is to increase the influence of local conditions.

(d) Catchment areas have been drawn by study of the topography with no allowance being taken of geology.

(e) Water abstractions and storage will have appreciable effects on some of the flow duration curves used in the analysis which will not be evident in the regional FDC. However, the overall effect is to reduce the curvature of the extremities of the FDC while leaving the central section comparatively unaltered and it is the central section which is most important for energy generation as detailed in paragraph 2.13.

2.15 The preceding paragraphs outline the use of flow duration curves in the determination of the appropriate level of installed capacity for a site and the expected annual energy output from the installation. It is evident that this curve forms a basic parameter in assessing the potential of any particular hydro power site. The data in relation to regional flow duration curves given in Appendix C can be used by a prospective developer to obtain a flow duration curve for a site anywhere in the country provided that he determines the catchment area contributing to flow at the site and the average rainfall on that catchment. The additional pieces of information required to estimate the energy potential of a site are the available head and the expected efficiency of the chosen turbine/generator. The procedure involved in the application of the data is outlined fully in Appendix C. However, before committing himself to any sizeable investment in a particular development, the developer would be well advised to obtain the advice of a competent engineer on scheme feasibility and optimisation.

Chapter 3

Criteria for Site Assessment

General Criteria for Site Assessment

3.1 During the initial stages of formulating a methodology for the national resource survey, serious and lengthy consideration was given to the criteria which were to be applied in the assessment of sites. It was concluded that, as a rule, there would be four general criteria governing the inclusion of individual sites in the list to be assessed. These are outlined as follows:

(i) Output of each site to be greater than 10 kW, except in the case of a site currently operational.

(ii) Nett head at each site to be greater than 1 metre.

(iii) No sites to be considered in remote upland catchments, as there is no immediate use for the power and the distances to ESB lines are excessive.

(iv) The proposed schemes specifically avoid assumptions of dam construction, tunnels or catchwaters. Many sites are suited to the development of schemes involving catchment diversions and storage, but they have been purposely omitted from consideration here. Where weirs are required, they have been assumed always to be less than bank high.

(v) In certain cases, particularly with sites in hilly locations, the use of ingenuity and possibly greater investment could lead to combinations of two or more sites.

Criteria for Site Assessment — Physical and Hydrological factors

3.2 In order to ensure a consistent approach in the inspection of sites and in the evaluation of power and energy potential, assessment criteria were established for the principal physical and hydrological elements of each potential scheme. The pertinent factors governing potential power and energy output at a site were considered under the following headings: head; design flow; turbo-generator efficiency; annual energy co-efficients and tail-water back up. These factors are discussed in subsequent paragraphs.

Head

3.3 (i) *Definitions:* Gross head is the difference between the upstream and downstream water levels at a site under static (i.e. no flow) conditions. Nett head is the difference between the upstream and downstream water levels at a site under normal operating conditions. The difference between gross and nett head is termed head loss.

(ii) *Computations:* At all sites, except those which are operational, a measurement was taken to determine the gross head. From this measurement, the nett head was computed using the relationship—

Nett Head=(Gross Head − Head Loss)

The existence of a headrace and a tailrace was a common feature at many low head sites. Both were found, for example, at many old mill sites. The following water velocities were deemed to be acceptable:

Unlined Headrace: Water Velocity=0.6 m/sec.

Lined Headrace: Water Velocity=1.6 m/sec.
(stone or concrete)

Head losses in headraces were then calculated, assuming suitable roughness coefficients for lined and unlined channels.

3.4 In the case of medium and high head sites, a penstock was often the preferred or only option available to a developer. In general, where a penstock was required, it has been sized on the assumption that the velocity of water in the penstock does not exceed 2.5 m/sec. In the case of very short penstocks, higher velocities were permitted. The standard pipe size which gave a velocity closest to the design velocity was then chosen. Head losses were then computed using the appropriate hydraulic formulae. As a general guideline, the optimum penstock size was assumed to incur head losses of the order of 5%.

Design Flow

3.5 The design flow for each site was expressed as a percentage of the provisional mean flow, subject to an upper limit of 125% of this flow figure in all cases. In general, the proportion of provisional mean flow used will decrease as the physical size of the river increases, with proportions as low as 25% being considered appropriate in the case of new schemes on large rivers. Cognisance was taken of amenity and fisheries aspects when deciding upon a suitable design flow. It was envisaged that a load factor of at least 45% should be produced by this flow.

3.6 For whole river schemes, the design flow was taken as 125% of the provisional mean flow, subject to a satisfactory load factor being achieved. Where headraces or penstocks were not necessary, it was considered good practice to install somewhat more plant capacity than would be required for the mean flow. For schemes involving headraces and/or penstocks, the water bearing capacity of the headrace or penstock determined the design flow. This capacity was computed from data on the site survey sheets, using an appropriate water velocity. In some cases, an allowance has been made for an increase in existing headrace capacity, based on the engineering judgment of the site inspectors. For high head sites, the design flow varied from 75% to 125% of the provisional mean flow. The lower figure was used more frequently when the catchment area was small.

Turbo-Generator Efficiency

3.7 In general, the efficiencies of turbo-generator units are greatest in high head and high output sites. The criteria being adopted had to take account of both the size of installation and the head available. For the purpose of calculating the installed capacity at the suitable sites, values of combined turbo-generator efficiency in the range 65% to 75% were chosen. These were based on the following individual efficiencies:

(i) Turbines — 80% to 90% efficient at design flow

(ii) Generators — 90% efficient

(iii) Gearing, if required — 95% efficient

(iv) Transformer — 98% efficient

The following values of combined efficiencies were applied:

(a) Output less than 50 kW
or Head between 1m and 2 m — Efficiency=65%

(b) Output 50 kW – 100 kW
and Head not less than 2 m
or, output greater than 100 kW
and Head 2 m — 3 m — Efficiency=70%

(c) Output greater than 100 kW
and Head greater than 3 m — Efficiency=75%

Annual Energy Coefficient

3.8 The annual energy coefficient is determined from the area under the flow duration curve between the operational limits of the turbine. It corresponds to the area under the flow duration curve for a particular design flow, multiplied by g (9.81) and by 8,760 (the number of hours in a year), (c.f. paragraphs 2.12 and 2.13). By expressing the selected design flow as a percentage of the provisional mean flow, the appropriate annual energy coefficient for each site was obtained from AFF computerised flow data sheets (c.f. Appendix C, Tables C2—C6).

3.9 It was recognised that compensation water, to allow for fisheries and other needs, would be an essential part of hydroelectric schemes and it was considered that this compensation water should be at least equivalent to dry weather flow in the particular river. The effect of allowing for compensation flow at a site would be to decrease the area under the flow duration curve and consequently decrease the annual energy coefficient for that site. It was decided that a compensation flow equal to 5% of the provisional mean flow was appropriate in all cases except where very important fisheries existed. In the latter case, a compensation flow of 10% of the provisional mean flow was used. While the resulting reduction in annual energy output applies principally at part load operation, it was decided that an overall reduction in the annual energy coefficient of 5% (or, in some instances, 10%) would be applied.

Tail Water Back-Up

3.10 The existence of tail water back-up can cause an appreciable reduction in power and energy output at a small hydro site. Low head installations, particularly on larger rivers, are most likely to have this problem. Tail water back-up occurs when the water level in the river rises, e.g. in flood conditions. The water level in the tailrace channel also rises, thereby reducing the ability of this channel to discharge the flow through it. This effect is most noticeable when there is a flat gradient in the bed of the river channel downstream of its junction with the tailrace. Tail water back-up may also occur where there is a tidal backwater effect e.g. where there is a tidal influence on the level of the river at the junction of the river and the tailrace. Three factors were adopted to make allowance for a reduced annual energy output due to tail water back up. These were defined and applied as follows:

(a) 0%: Tail water back-up was unlikely to cause any problems and no reduction was made to the computed annual energy output.

(b) 5%: Tail water back-up was likely to cause some problems at very high flows and a reduction of 5% was made to the computed annual energy output.

(c) 10%: Tail water back-up was likely to be a serious problem at high flows and a reduction of 10% was made to the computed annual energy output.

Overall Efficiency

3.11 In general the part load efficiencies of most turbine types (with the notable exception of the propellor type) remain relatively high down to quite low flows. Since the percentage of output produced at low flows (i.e. less than 50% of design flow) will always be relatively small, it was concluded that it would be reasonable to use the same efficiencies for the energy calculations throughout the full operating range of the turbine/generator unit (paragraph 3.5). It was recognised that a slight overestimation of the annual energy output might result, but it was felt that the procedure was justified as the efficiencies adopted for the turbine/generator units were fairly conservative.

Criteria for Site Assessment—Economic Appraisal

3.12 The need for a consistent approach in the economic appraisal of all potential sites led to the establishment of a set of criteria which would govern the procedure. The purpose of the exercise was to divide those sites which were deemed suitable for development into three categories which would indicate their *relative* economic worth. The total cost of developing each site was estimated and the simple payback period was then used to determine the site rating. Sites were to be classified as follows:

Payback Period	*Site Rating*
Less than 6 years	G (Good)
Between 6 and 10 years	F (Fair)
Between 10 and 20 years	M (Marginal)

The annual revenue figure used in the calculation of the payback period was computed on the assumption that 100% of the annual energy output was sold to the ESB.

Estimation of Total Cost of Scheme

3.13 In order to assess the total cost of a scheme, the major elements likely to comprise a hydroelectric installation were considered individually.

(i) *Turbine/Generator Unit*
A large number of budgetary estimates for hydroelectric generating equipment were analysed. The cost/kW was found to depend primarily on the head available. For medium to low heads, cost/kW also increased with the size of the installation. The best fit formula, however, for general costing of turbine/generator units was found to take the form,

$$Ct = K \sqrt{Qt}$$

Where K is a constant with a range of values dependent upon the value of Qt (Design Flow of the turbine, expressed in m^3/s). This formula produced results which agreed well with many competitive quotations received for a wide range of equipment.

It was decided the minimum cost assigned to a turbine/generator unit would be £200/kW in all cases. This would cater for the high head/low flow situation.

(ii) *Weir*
If a weir is already in existence at a site, it may require either minor or major repairs. In many instances, there was no weir in existence, and consequently there was a need to construct a new one. The costs associated with the construction or repair of a weir were examined. A relationship was established between these costs and the provisional mean flow. Verification of the relationship was obtained by comparing the theoretical costs with the actual costs incurred by the Office of Public Works for similar works in recent years.

(iii) *Headrace and Tailrace*
As the headrace and tailrace capacities generally determined the design flows, it was found desirable to increase these capacities in many instances. In such cases, as in the construction of entirely new channels, current contractors' rates were applied both to hard and soft excavation. Similarly an appropriate rate was applied where a thorough cleaning was required to make existing channels operational again.

(iv) *Penstock*

The size, and correspondingly the cost, of a penstock is proportional to the design flow.

The two principal types of penstock considered were of PVC and GRP construction, the former generally up to 400 mm diameter and the latter for larger sizes. PVC pipes can be bought off the shelf up to 400 mm diameter, and current brochure costs were used. GRP pipes can be made to order in Ireland, or alternatively imported. Budget priccs from manufacturers were used for costing purposes. In some instances, it was considered necessary to use HDPE pipes and, in such cases, appropriate manufacturers' costs were applied.

Having analysed the costings of a number of recently completed small hydro schemes, it was considered appropriate to double the material cost of the penstock in order to arrive at a true cost for supplying, delivering and laying the penstock.

(v) *Intake and Powerhouse*

It was assumed that the size (and hence the cost) of the trash rack, intake gate and intake itself were directly related to the design flow at the site, and that the size (and hence the cost) of the powerhouse was related to the turbine throat diameter, which was also a function of flow.

Based on empirical data, a direct relationship was established between the cost of the intake/powerhouse and the design flow at the site. The cost thus obtained was for the provision of entirely new structures, and it could be modified in the light of information on any individual site.

(vi) *Interconnection Costs*

Since the economic appraisal of all potential sites was to be based on the sale of the total electrical output to the ESB, it was essential to include the cost of interconnection to the national grid. General estimates of likely costs were supplied by the ESB's Commercial Department.

Under present ESB regulations (1984) power from a small hydro development must be fed into the national grid at 10 kV, 3 phase. These power lines may be located close to the site or up to 8 km away, depending on local conditions. The costs of such lines, or the required contributions to same, may consequently prove to be substantial. Unless specific information was available about the location of the nearest 10 kV, 3 phase, line, it was assumed that a standard distance of 0.5 km, and consequently a cost of approximately £4,000, would apply at all sites.

In addition to line costs, a budget figure of approximately £6,000 was used to cover the costs of import/export metering and electrical protection. The electrical protection provided must meet strict ESB standards.

Transformer costs must also be included in total interconnection costs. For outputs not greater than 200 kVA, it may be possible to use a pole mounted transformer. The cost, depending on size, lies in the range £2,000-£4,000. In the case of larger outputs, a small sub-station must be constructed adjacent to the generator house. Total costs of the order of £20,000-£25,000 would be expected in such instances.

In order to make an accurate assessment of the cost of interconnection to the national grid, any proposal for development should be referred to the local ESB District Office.

(vii) *Miscellaneous*

Additional costs, which were particular to an individual site, were to be included under this heading. Typical items were costs associated with access, amenity preservation, fisheries, etc.

Chapter 4

Site Identification, Inspection and Assessment

Site Identification

Map Study

4.1 The identification of sites for the survey was primarily based on a detailed map study, which resulted in a catalogue of sites being produced for each county. The 6″ to 1 mile scale Ordnance Survey maps were closely examined to identify all features which could have some connection with existing or potential hydro power sites. Features such as mills, weirs, waterfalls and reservoirs were marked and numbered. For ease of reference, the sites were then marked on to ½″ to 1 mile scale Ordnance Survey maps, from which the national grid reference of each site was obtained. The catchment area of each site was also measured from the ½″ to 1 mile scale map. A total of 2,865 sites were identified by this method.

4.2 Before the fieldwork was undertaken in any county a second map study was carried out to establish locations of very steep falls in stream or river beds which might be suitable for comparatively high head schemes, and also to identify any lakes which could be utilised for storage schemes. Only reasonably accessible sites of these types were marked as the large number of sites to be visited precluded lengthy excursions to any but the most promising areas. During the course of site inspection work, the catalogue of sites for each county was regularly updated in the light of any additional information which became available.

Reference Works

4.3 A large number of sites were identified from previous surveys and the locations of sites were also known from prospective developers who had made enquiries to energy consultants.

(a) *Report on Water Power (January 1922)*
This report was produced by the Commission of Inquiry into the Resources and Industries of Ireland in January 1922. It is the only previous major survey of hydro power in Ireland and it covered the 32 counties. A total of 250 sites were identified in the 26 counties. A small percentage of these coincided with sites identified by the method outlined in paragraph 4.1. The emphasis of this survey differed from the present one in some respects. The major difference lay in the identification of many sites where the development of the power potential depended on the construction of dams and the consequent flooding of land upstream. Relatively few sites were actually visited during the survey and information on river flows was quite limited. Hence the estimates of power potential were not always totally reliable. However, in view of the significance of this original survey, it was decided that all sites identified in it were worthy of inspection. They were accordingly added to the catalogue of sites for each county.

(b) *Small Hydro Installation Survey (September 1981)*
This survey was undertaken for the Department of Energy by the National Board of Science and Technology (Energy Division). Listings of sites were included under the following headings:

Water Turbines in Use
Water Wheels in Use
Hydro Sites (with probable potential)
Hydro Sites (with little or no information available on same).

Data was supplied for the survey by various semi-state agencies, county councils, private consultants and turbine manufacturers. The report was a further source of site identification and proved to be a useful document for cross-referencing sites.

(c) *Files of Energy Consultants*
In recent years, numerous enquiries have been received by the ESB, private consultants and turbine manufacturers from individuals considering the development of small hydro installations. The locations of many of these proposed schemes were made available. These sites were added to the catalogues.

Classification of Sites

4.4 The various sources of site identification described increased the number of sites considered for inspection to a total 3,446 sites. Consequently a classification system was necessary to indicate the various types of site and the manner in which future development was most likely to be undertaken. The type of site was established at the time of inspection and the classification was as follows:

Whole River Schemes

A. Existing weirs where generating equipment would be incorporated into or beside the present structure.

B. Rapids where a new weir would have to be constructed but would cause little upstream disturbance.

C. Locations where there exist deep, steep sided banks but the bed gradient is such that construction of weir or low dam would raise the upstream water level for some distance. Though basically run-of-river some storage or daily pondage would be available.

Non-Storage Schemes

D. Low head locations where a weir supplies a headrace that leads directly to the turbine house.

E. Locations where a headrace or low pressure pipe feeds a penstock or the penstock runs directly from the weir to the turbine house.

Storage Schemes

F. Any scheme where substantial storage in terms of average daily flow is available permitting peaking or flexible time scheduling of generation.

Site Inspection

4.5 Site inspections were normally carried out by two-man teams, with the survey being carried out systematically on a county by county basis. A site survey sheet, a copy of which appears in Appendix D, was completed for each site which was inspected. The principal objectives of site inspection were as follows:

(i) to measure the gross head available;

(ii) to note existing conditions at the site;

(iii) to estimate the nature and extent of civil works required, identifying any particular difficulties which might arise during construction;

(iv) to identify any factors which might influence the proportion of mean flow to be used for power generation.

4.6 Having arrived at a site the inspection team ascertained the gross head available by obtaining appropriate physical measurements. This was usually a relatively straightforward operation, complicated occasionally by the existence of tail water back up at low head sites. A general site appraisal was carried out and existing features were compared with those which had been expected at the site. The relevant data was noted on the site survey sheets under the following headings:

(a) The types of site (ABC, etc. see 4.4) that existed or that could most probably be developed.

(b) The head available at the site.

(c) The dimensions, present condition and suitability of existing weirs, headraces, tailraces and penstocks.

(d) The present condition of known turbine sites and of sites found to be operational. Where possible details of power output, turbine and generator type and power usage were recorded and in all cases an assessment was made as to whether the potential of the site had been fully exploited.

(e) The proximity of the site to existing ESB lines.

(f) Access and the existing fishery and amenity interests pertaining to the area.

4.7 Photographs were taken to record a representative selection of the various site types. On completion of the inspection of each site, a subjective assessment was recorded by the inspection team as to its suitability for development.

Site Assessment

Objectives

4.8 The objectives of site assessment were to determine the following:

(a) The Installed Capacity (Power Output) appropriate to the site (kW).

(b) The Annual Energy Output at the site (MWh).

(c) The Economic Feasibility of developing the site.

The site assessments were based on the data recorded in the completed site survey sheets. The potential (kW) was calculated for all sites. In the event of a site having a capacity of 10 kW or more, the annual energy output (MWh) was then computed and an economic assessment was made of the feasibility of developing the site. This resulted in a site rating being assigned to those sites having a payback period not exceeding twenty years. The site rating is a measure of the relative worth of a particular site when compared to all others considered in the survey.

Installed Capacity and Annual Energy Output

4.9 The procedure for estimation of the installed capacity and annual energy output at a site is described in paragraphs 2.11 and 2.13 respectively, and also in Appendix C. The criteria governing this procedure are outlined in Chapter Three. In all cases the value of the nett head was computed. It was used in the calculation of both power and energy values. The adoption of a particular proportion of the mean flow called, in the majority of cases, for a subjective judgement by the inspecting engineers. This was based on the general suitability of the site as determined by river size, topography, the conditions of the intake channels and weirs, power demand and the requirements of fishery and amenity interests.

Economic Appraisal

4.10 The procedure for evaluating the economic feasibility of a scheme involved estimating the total cost of the scheme and the annual revenue likely to be generated by the scheme. The resulting payback period facilitated classification of the site as Good (G), Fair (F) or Marginal (M) and consequently provided an indication of the relative worth of the site. The criteria governing the procedure are outlined in Chapter Three. *Costs* were estimated for all the major items of investment likely to be incurred in the development of a hydroelectric scheme, viz. turbine/generator unit; weir; headrace/penstock; tailrace; intake and powerhouse; electrical interconnection to the grid; other miscellaneous items. The summation of these individual costs was the total estimated cost of the scheme. *All costings were based on 1984 rates and prices.* The *annual revenue* accruing from a scheme was computed on the assumption that 100% of the power which was generated would be sold to the ESB. The price which the ESB is willing to pay to small hydro suppliers varies depending on (i) whether supplies are metered at high tension or low tension; (ii) whether supplies are bought during day hours (8 a.m.-11 p.m.) or night hours (11 p.m.-8 a.m.). In addition there is a bonus capacity payment, which is payable subject to certain conditions being met.
Accordingly the rates were simplified for the purpose of this report and were applied as follows:

For supplies metered at HT — 3.24 p/kWh.
For supplies metered at LT — 3.00 p/kWh.

These rates were the maximum allowable under the current (1984) tariff structure. The payback period used was defined as:

$$\frac{\text{Estimated Total Cost of the Scheme}}{\text{Estimated Annual Revenue}}$$

4.11 The chosen method of economic assessment provides the best means of determining the relative worth of sites, given the scale of the survey. The site ratings however, could vary considerably if it was assumed that the total annual energy output from a scheme could be used by the producer in a domestic, commercial or industrial context. In that situation, the value assigned to the annual energy output would be greater, and the payback period would be reduced correspondingly.

4.12 Following from the above, it may prove that the method of assessment is weighted somewhat more against low cost, low output schemes, than against others as the cost of interconnection to the ESB grid is proportionately more in such cases. This highlights the necessity to use the ratings published in this survey for guidance only.

Chapter Five

Summary of Results

5.1 The overall result of the survey indicates that there are 85 small scale hydro sites in operation throughout the 26 counties with a further 483 sites suitable for development. In total these 568 sites would have an annual energy potential of the order of 193 GWh of electricity from installed capacities amounting to 38 MW. In the context of the national energy requirements the potential output of small hydro schemes could represent an annual saving of £9 million on imported oil (1984 prices).

Table 5.1

Overall Summary of Results

General

Total No. of Sites Surveyed	Total No. of Sites Rated	Installed Capacity (kW)	Annual Energy Output (MWh)
3,446	568	38.083	193,533

Classification by Site Rating

	Operating	Good	Fair	Marginal	Total
No. of Sites	85	112	146	225	568
Installed Capacity (kW)	4,416	16,620	9,859	7,188	38,083
Annual Energy Output (MWh)	19,600	82,544	54,172	37,217	193,533

Statistical Distribution of Sites

5.2 The distribution of sites by ranges of installed capacity is shown in Figure 5.1. The bar chart indicates the exponential nature of the relationship between the number of sites and potential capacity. If it had been decided to include sites between 5 kW and 10 kW rating in the survey, a further five hundred sites would have been catalogued.

5.3 The most effective method of developing small scale hydro power is by site Type D, that is where a weir and headrace are used to develop higher heads than those which occur naturally in rivers, especially the larger rivers. This is evident in Figure 5.2 which indicates that 60% of the total potential could be developed in this manner. As head increases the volumes of water necessary become smaller for the same power output. This means that the mechanical plant required becomes smaller, so too do the physical dimensions of the powerhouse and civil works and consequently the cost of the scheme.

5.4 It is by this method, Type D scheme, that most small scale hydro power was developed in the past in Ireland. By reference to the site ratings in the summary listings it can be seen that it is sites of this type which are the most economically viable with regard to reactivation and development. Generally, on the larger rivers at least, existing weirs are in excellent

Table 5.2

Results Summary on a County Basis

Province	County	No. of Sites (Operating Sites in Brackets)	Installed Capacity (kW)			Annual Energy Output (MWh)		
			Operating	Potential	Total	Operating	Potential	Total
Munster	Waterford	12(3)	74	623	697	247	2,828	3,075
	Cork	61(13)	584	3.185	3,769	3,088	17,851	20,939
	Kerry	60(3)	220	6.065	6,285	1,050	28,043	29,093
	Clare	9(2)	48	277	325	188	1,232	1,420
	Limerick	13(3)	300	987	1,287	976	4,934	5,910
	Tipperary	30(7)	431	901	1.332	1,818	4,687	6,505
Leinster	Louth	7(10)	20	248	268	90	1,020	1,110
	Meath	25(3)	134	1,536	1.670	536	9,257	9,793
	Dublin	26(6)	197	666	863	760	3,761	4,521
	Wicklow	16(6)	100	986	1,086	430	5,003	5,433
	Wexford	21(1)	175	693	863	500	3,455	3,955
	Kildare	13(4)	76	553	629	466	3,176	3,642
	Carlow	35(4)	250	3.263	3.513	1,240	21,676	22,916
	Kilkenny	23(3)	186	1,104	1,290	775	5.871	6,646
	Laois	6(1)	35	141	176	186	681	867
	Offaly	14(4)	633	330	963	2,768	1.638	4,406
	Westmeath	9(4)	112	183	295	470	842	1,312
	Longford	8(2)	5	339	344	20	1.790	1,810
Connacht	Galway	25(3)	54	1.821	1.875	220	9,929	10,149
	Mayo	15(2)	46	992	1,038	237	5.084	5,321
	Sligo	22(3)	643	2,073	2,716	3.182	10,587	13,769
	Leitrim	22(0)	—	1,178	1.178	—	5,778	5,778
	Roscommon	8(0)	—	667	667	—	3,178	3,178
Ulster	Donegal	47(4)	43	3.487	3,530	174	15,420	15,594
	Monaghan	19(2)	40	553	593	139	2,263	2,402
	Cavan	21(1)	10	816	826	40	3,949	3,989
Totals	26 Counties	568(85)	4,416	33,667	38,083	19,600	173,933	193,533

Note: In the case of operating sites:—

(a) The actual installed capacity has been included in the summaries. In cases where considerable extra power potential is available at particular sites, a note to this effect is included in the summary sheets in Appendix A.

(b) The annual energy output has been estimated in cases where only limited information has been made available.

condition with headraces and tailraces requiring very little attention. In some cases existing turbines may be refurbished but usually more modern turbines and generators would be required. Notwithstanding the cost of such items, the implementation of modern designs and control systems will enable efficient exploitation of even quite low head Type D schemes so that either G or F site ratings are relevant with regard to their development.

5.5 The second site type which is obviously attractive to the prospective developer is the relatively high head site, or Type E (paragraph 4.4) in the listings. For this configuration the flows to be harnessed are quite small so that relatively cheap home produced impulse turbines can be installed with minimal site works and minimum demand on local fitting skills. The suitability of the relatively high head site is perhaps best reflected in the number of such sites which have come into operation over the past five years. The use of readily available control equipment such as electronic load controllers, hydraulic governors and automatic synchronisers now means that the output of these turbines can be used in many varied applications.

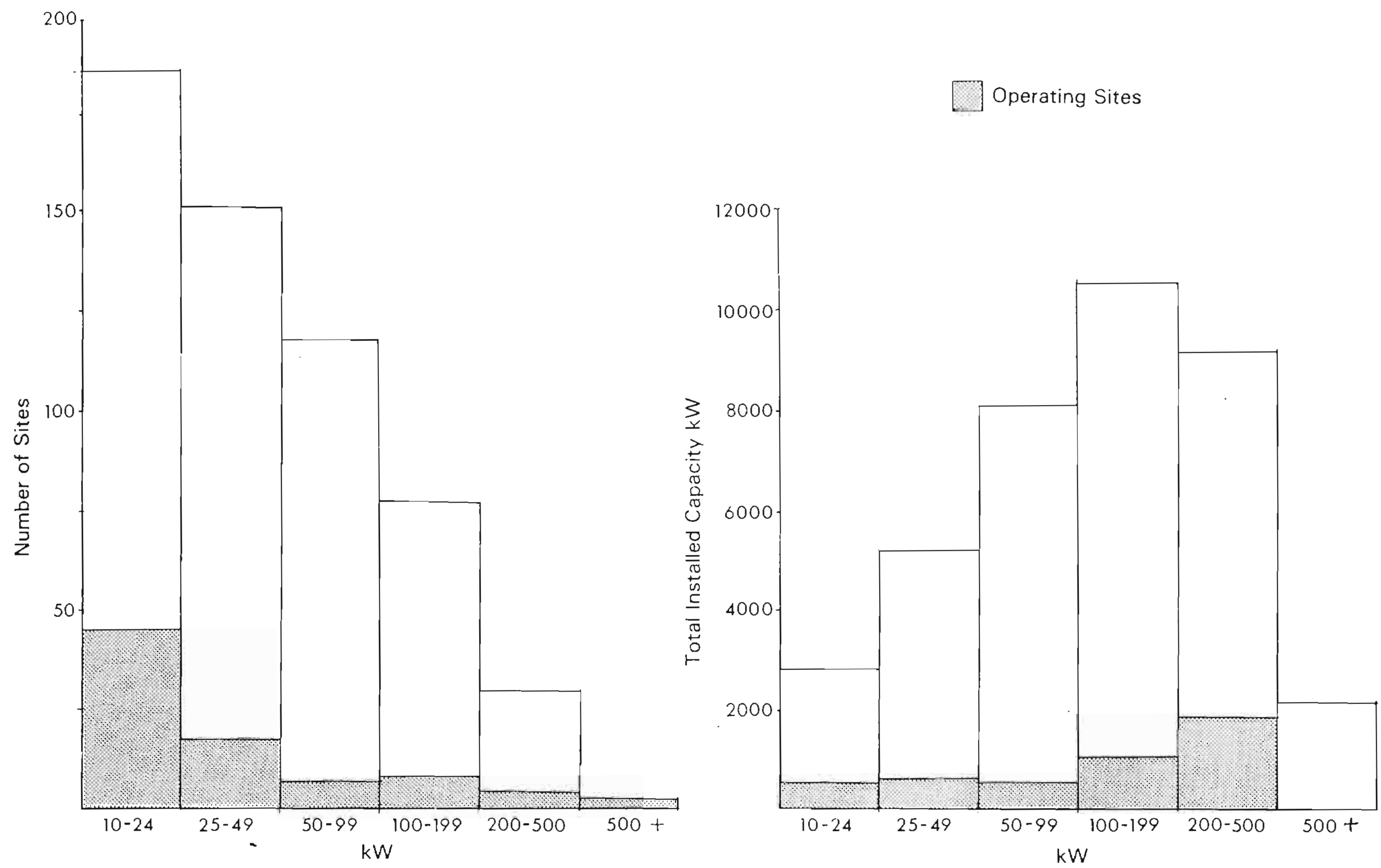

FIG. 5.1 DISTRIBUTION OF SITES BY RANGES OF INSTALLED CAPACITY

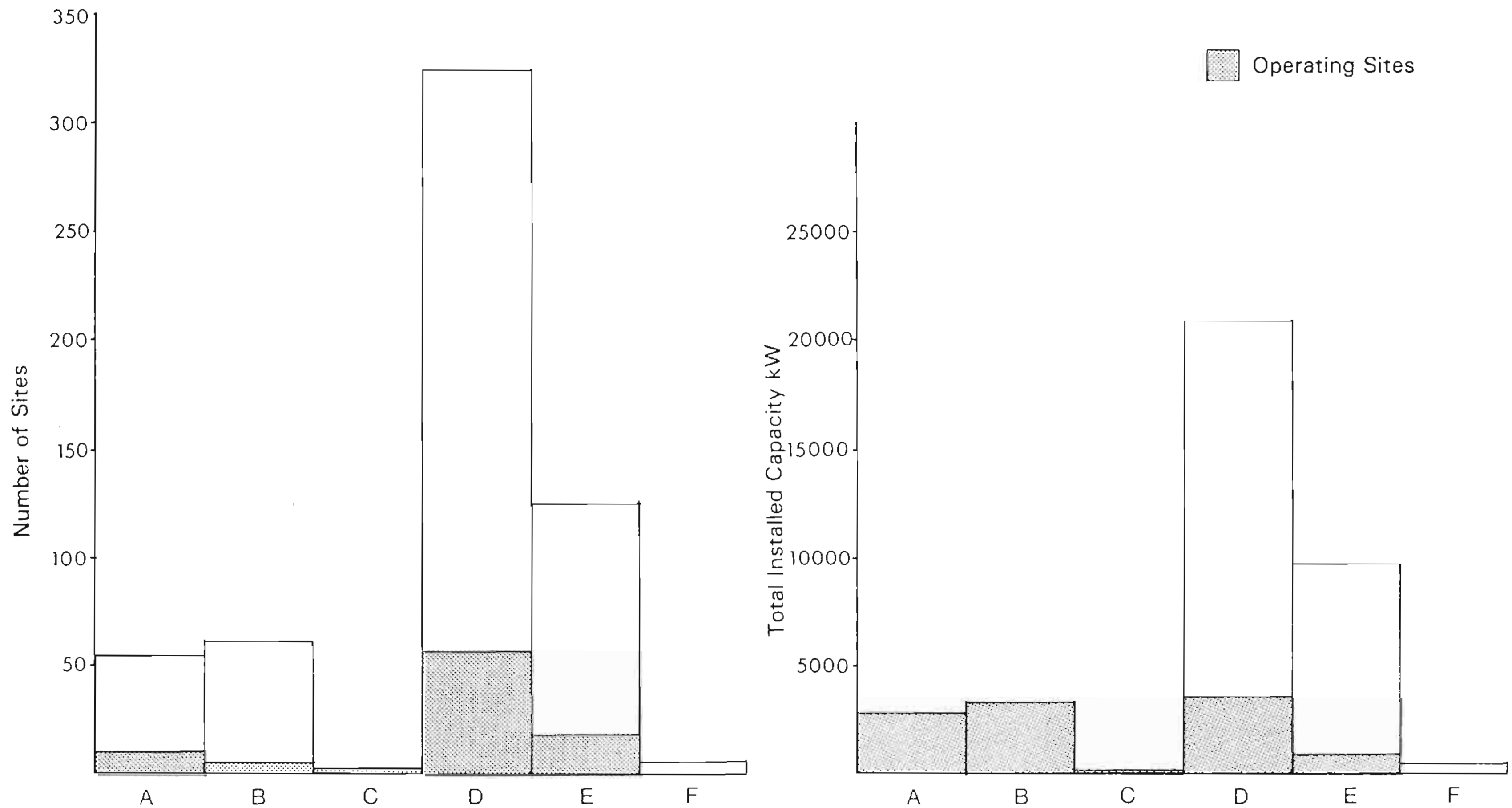

FIG. 5.2 DISTRIBUTION OF SITES BY TYPE

5.6 The distribution of operational small hydro schemes by ranges of installed capacity is shown on Figure 5.1. Distribution with regard to site type is shown on Figure 5.2. The better operating sites and operating sites with the greatest output are invariably of Type D, i.e. former mill sites. While most of these are mill sites where new turbines and generators have replaced obsolete machines and waterwheels, some are sites where operation of the turbines has never been discontinued, although the use of the energy produced may have changed. Type D sites account for about 75% of the current installed capacity of operating small hydro schemes.

5.7 Recent development in modern reaction turbines and control technology has extended the head at which these machines can operate economically down to 2 m and less. This is the order of magnitude of the head available at most of the Type D sites on the larger rivers in the country. This increases the number of potential sites and interest is being expressed, particularly by former mill owners, in the development of sites where power can be produced for sale to the national grid system.

5.8 Approximately 25 small hydro installations of the Type E or relatively high head configuration have come into operation over the past five years. While many of the mill sites in operation have an output in excess of 100 kW and sell electricity to the national grid, the high head sites are being developed generally to supply the needs of individual farms or dwellings. Current installed capacities at almost all operating Type E sites are invariably less than 20 kW. The attractiveness of this type of site to the unskilled developer obviously lies in the simplicity with which a supply penstock may be coupled with a low cost impulse turbine without the need for elaborate or expensive civil works. Some Type E sites already in operation have been developed to a comparatively high standard by individuals with limited technical or engineering experience.

Potential in Excess of 1 MW

Ballisodare River

5.9 The Ballisodare River falls some 20 m over a distance of 300 m at Ballisodare immediately before flowing into the sea. In the past there were three hydro power sites in series along this stretch of river operating on heads of about 6 m, 7 m and 7 m respectively going downstream. The output from these schemes was mostly mechanical and was used to power large mills on both sides of the river. One site is still operating with an output of 110 kW and the power potential of the other two sites (Nos. 32(i) and 32(ii), Co. Sligo) totals 1614 kW.

5.10 The ESB has considered the development of this site on several occasions. The most recent feasibility study (1981) indicated that the optimum capacity would be of the order of 4,000 kW, with a resulting annual energy output of 16×10^3 MWh.

River Corrib

5.11 A complicated network of headrace canals including the disused Eglinton Ship Canal exists in Galway City. There were at least eight distinct water power sites located in the area around Nun's Island where either mechanical or electrical power was produced. One site is still in operation and another has recently been developed by UCG. The total power which could be developed at eight locations in Galway City is in excess of 1.1 MW.

5.12 An independent survey of the waterways and canals in Galway City, commissioned by the ESB, has been carried out by the Department of Engineering Hydrology, UCG during 1983/84. A detailed report on the optimum potential of this resource is currently being finalised.

River Barrow

5.13 There are twenty-three locks along the entire length of the River Barrow. Nineteen of these lie between Carlow town and New Ross. The potential of these locks for hydro-electric power generation was first documented in the 1922 Report on Water Power. The locks, together with their associated navigation canals and weirs, are most suitable for hydro-power development.

5.14 Two operational sites have been identified on the River Barrow, one at Levitstown and the other at Muine Bheag, with a combined capacity of approximately 110 kW. A third site is currently being developed at Milford, where the final installed capacity will be 290 kW approximately. The combined potential of the locks on the River Barrow is of the order of 2.5 MW with individual capacities in the range 100-300 kW.

Chapter 6

Legal Considerations

In addition to the technical considerations already outlined, a developer should give early consideration to the legal and other requirements associated with the proposed development. In most cases, no major legal or other difficulties are likely to arise, but it is better that these matters be sorted out well in advance and it is recommended that legal advice be sought prior to embarking on any major expenditure. Generally, the following should be considered:

(a) *Riparian Rights*
The rights of other landowners whose property lies along the river bank must be taken into account. Where their use and enjoyment of these rights will be impinged upon an agreement should be made between the parties concerned. For these reasons, it may not be possible to extract all the flow.

(b) *Fish Movements*
Fishery needs might also dictate that not all the water be diverted from the river or stream. It is imperative that anyone considering the installation of a hydro-scheme should notify the Department of Fisheries and Forestry, Leeson Lane, Dublin 2, at the earliest stages of planning. That Department can advise on precautions necessary in the construction of the scheme to ensure free passage for fish, to maintain a minimum flow in the river or stream to meet the needs of migratory fish, and to prevent fish from entering the millrace and getting killed or injured in the turbine.
All dams for sustaining water for mill power, navigation, irrigation etc. in salmon rivers must have a fish pass incorporated therein to allow a free and uninterrupted passage to fish at all periods of the year.
The Statutory requirements in relation to fisheries are set out in Chapter 5 Part 8 of the Fisheries (Consolidation) Act, 1959.

(c) *Drainage and the Office of Public Works*
The Office of Public Works (O.P.W.), 51 St. Stephen's Green, Dublin 2, is the body charged with the responsibility for arterial drainage throughout the country under the 1949 Arterial Drainage Act. Under this Act it is unlawful for any person without the consent of the Commissioners of Public Works to erect or alter a weir or dam in a water channel where it might cause flooding of any land. Essentially, therefore, a developer cannot construct any structure in a river if it could ultimately result in flooding of adjacent lands. If there are any doubts regarding the possible flooding implications of the proposal, a developer should contact the O.P.W. before commencing any works.

(d) *Planning Permission*
Under the planning legislation, Local Planning Authorities have a responsibility to ensure that no development has an undesirable environmental impact. Consequently, it is essential that a developer consults with the appropriate Local Planning Authority, well in advance of any construction. There are eighty-seven such

Authorities in the country. The Local Planning Authority will generally advise whether planning permission is required for the proposed development. Where full planning permission is required, the Local Planning Authority will usually advise in relation to the plans and other documents that should be submitted. Generally, it takes about two months after submission of the necessary documents to obtain full planning permission; however, a further period of one month is allowed before any construction can commence in case there are any objections.

(e) *Safety*

Before commencing on an installation, the various bodies mentioned above should be consulted. The local ESB Office should be informed of the proposals in relation to electricity generation, wiring etc. The installation will need to comply with the requirements of the Electro Technical Council of Ireland, and should be guided by the ESB in regard to safety. If the proposal is to be used for a commercial venture, the Industrial Inspectorate in the Department of Labour, Mespil Road, Dublin 4 should be consulted.

(f) *Navigation*

A developer should bear in mind that there can be effects upon the water level as a result of a small hydro scheme. If the river is used by boatmen, care should be taken to ensure that their operations are not interfered with. There may be one or more statutory bodies with responsibility here. A point to be borne in mind is the fishing or sporting rights to which property may be subject. Others may have fishing rights and provision for this may have to be made in the development.

Also, the matter of insurance should be considered in order to allow for premiums to be included in the costings and, to cover the risk of loss to the owner and injury and damage to others.

Glossary of Technical Terms

Catchment area	The whole of the land and water surface area contributing to the discharge at a particular point on a stream or river.
Catchment-weighted rainfall	This is the average rainfall over an entire catchment that allows for the variation in rainfall between the highland and lowland areas.
Catchment	An open channel that effectively increases the catchment area of a particular site by diverting water from neighbouring catchments that would not normally contribute to the flow.
Compensation flow	The minimum flow legally required to be passed into the watercourse below a dam or weir, to ensure adequate flow downstream for environmental, abstraction and fisheries purposes.
Daily mean flow	The average flow of water passing a gauging station in a 24 hour period.
Diverted catchment	A catchment, the runoff from which has been diverted by tunnel or canal to augment the flow from a main catchment into a reservoir, or a river upstream of a hydro-electric site.
Efficiency	η_P is the efficiency when a scheme is operating at full capacity, i.e. when design flow is passing through the turbine. η_E is the efficiency over the range of flows which go to produce the annual energy output.
Energy coefficient	The area under the unitised regional flow duration curve between chosen percentage values of the mean flow multiplied by 9.81 (g) and 8,760 (the number of hours in a year).
Flow-duration curve	A graph showing the percentage of time that the flow at a particular gauging station equals or exceeds certain values.
GRP	Glass reinforced plastic.
Head	The level difference between the water surface at intake and tailrace of a turbine.
Headrace	A channel that conveys water at a shallow gradient from a river intake to a point above the river channel where sufficient head has been gained to allow a turbine (or waterwheel) to be installed.
HDPE	High density polyethylene.
Installed capacity	The rated power of a hydro-electric turbo-generator (in KW) that could be installed at a particular site.
Isohyetal map	Map showing lines joining points of equal annual average rainfall.
Load factor	Defined as the ratio: $\dfrac{\text{annual energy output}}{\text{max. power output} \times 8{,}760}$

Mean flow coefficient	The 30 percentile ordinate of the unitised regional flow duration curve.
Penstock	A pipe (usually of steel, concrete or PVC) that conveys water under pressure from intake to turbine.
Provisional mean flow	The mean flow throughout the year as calculated from the techniques developed for this report, i.e. catchment area × rainfall × mean flow coefficient.
Regional flow duration curve	The curve of best fit derived from a group of flow duration curves which are taken to determine the particular region.
Site rating	The site rating is a payback period and is defined as the total cost of a scheme divided by the annual value of the energy produced.
Tailrace	The discharge channel from a turbine or waterwheel before rejoining the main river channel.
Utilisation factor	The ratio found by dividing the number of hours per unit time (usually a year) that a machine is running and generating, by the number of hours in the unit time. This is not the same as load factor, though in this Report the two terms would differ numerically very little.
Whole river scheme	A hydro-electric site that utilises all the available flow in a river between limits prescribed by compensation flow requirements and equipment limits. There is no storage available except that afforded by the depth of river behind the weir.

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Appendix A

Summary of Operating and Potential Sites (≥10kW)

Listed by County Order

(A few cases of operating sites <10kW are also listed)

Notes on Column Headings and Data included in the Summary Catalogues

1. Site No.	This refers to the number in the relevant county catalogue of sites. (H..... denotes high-head sites). (L..... denotes lake). (r..... denotes a site identified by the 1922 Report (2) e.g. r26).
2. River	Name of river or stream used as source of power.
3. O.S. Map	The relevant Ordnance Survey Map in a particular county is identified under this heading. In general, each map is defined by two numbers, e.g. Carlow 13-7, which is a reference to a Carlow O.S. Map plotted at a scale of 25" to 1 mile. The relevant 6" to 1 mile scale Ordnance Survey Map is identified by the first of these two numbers e.g. Carlow 13. Occasionally, only the 6" O.S. Map is available, especially in remote mountainous areas.
4. Nat. Grid Reference	This reference identifies the particular site on the ½" to 1 mile scale Ordnance Survey Map.
5. S — Site Status	P denotes a site that has potential for development. O denotes a site that was operational at the time of inspection (1982-1984).
6. T — Site Type	The letters A-F incl. indicate the type of site development which is most likely to be undertaken (c.f. para. 4.4).
7. Catchment Area	The catchment area is the area (km^2) from which rainfall runoff is estimated to contribute to the flow (m^3/s) at a particular site.
8. Rainfall	This defines the average annual rainfall (mm) for a particular site.
9. Provisional Mean Flow	The value of provisional mean flow is calculated directly from catchment area, rainfall and the appropriate regional flow coefficient.
10. Head	Head refers to Gross Head (c.f. para. 3.3) and was established as follows: Types A-D — surveyed on site unless data were available from other sources. Types E-F — where such sites were already developed the required information could be obtained from the site operator. Otherwise it was measured or estimated on site with reference to contour lines on the 6" Ordnance maps.
11. Potential Installed Capacity and Annual Energy	The values in these columns are calculated directly from the data supplied in the catchment area, rainfall, head and provisional mean flow columns with appropriate values of efficiency applied (c.f. paras. 2.11, 2.13 and Appendix B).
12. Site Rating	The payback period i.e. the total cost of the scheme divided by the annual value of the energy produced determines the site rating.

Payback Period	*Rating*
Less than 6 years	G (Good)
6 years to 10 years	F (fair)
10 years to 20 years	M (Marginal)

(c.f. paras. 3.12 et seq.)

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES — COUNTY CARLOW

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov. Mean Flow m^3/s	Head m	Potential Inst. Cap. kW	Potential Annual Energy MWh	Site Rating
1	Slaney	3-15	S852 787	P	D	207	1220	7.57	2.0	70	407	M
1A	Barrow	2-10	S715 765	P	D	2240	880	35.48	1.5	114	780	M
3	Slaney	3-15	S878 822	P	D	186	1230	6.86	1.5	32	226	M
4	Douglas	4-7	S936 828	P	D	23	1130	0.78	3.0	18	79	M
9	Dereen	5-9	S975 807	P	D	63	1550	2.93	3.2	34	243	F
13	Burren	7-6	S727 756	P	D	156	900	4.21	2.0	54	279	M
28	Barrow	12-1	S700 702	O	D	2317	880	36.70	1.83	110	650	Operating
33	Slaney	13-7	S849 698	P	D	268	1120	9.0	1.5	46	320	M
34	Dereen	13-8	S857 701	P	D	391	1040	12.19	4.0	220	1475	G
36	Slaney	13-12	S856 683	P	D	517	1100	17.06	1.8	110	756	F
40	Barrow	16-5	S702 632	P	D	2414	880	38.23	2.0	133	915	M
50A	Derry	18-14	S915 605	P	D	228	1050	7.18	1.5	24	167	M
42	Barrow	16-9	S703 620	O	D	2414	880	38.23	3.05	101	340	Operating
43	Barrow	16-13	S697 595	P	D	2432	880	38.0	1.3	97	669	M
52	Barrow	19-1	S688 578	P	D	2442	880	36.68	1.55	112	808	M
54	Barrow	19-9	S686 550	P	D	2451	880	38.82	2.6	205	1414	F
55	Barrow	19-13	S687 534	P	D	2560	880	40.55	1.95	144	1001	F
57	Black	19-14	S731 528	P	D	48	970	1.39	4.0	28	164	F
62	Barrow	22-1	S696 516	P	D	2588	880	41.0	1.85	135	943	F
64	Barrow	22-6	S713 503	P	D	2604	880	41.24	2.2	174	1209	F
66	Dinin	22-6	S733 501	P	D	52	970	1.51	4.0	51	231	F
67	Dinin	22-6	S732 498	O	D	106	1080	3.43	2.1	19	150	Operating
69	Barrow	22-10	S731 482	P	D	2717	890	43.52	1.65	126	899	F
70	Barrow Trib.	22-15	S742 467	P	D	32	1125	1.08	4.5	37	168	F
71	Barrow Trib.	22-15	S736 462	P	D	32	1125	1.08	5.0	40	183	F
72	Un-named	22-16	S774 470	P	D	18	1200	0.65	4.0	20	88	M
73	Barrow	24-2	S726 455	P	D	2719	890	43.55	3.33	289	2024	G*
75	Barrow	24-3	S734 461	P	D	2719	890	43.55	1.6	122	872	F*
76	Barrow	24-5	S708 436	P	D	2790	890	44.69	1.15	88	621	M*
77	Barrow	24-10	S709 427	P	D	2793	890	44.74	3.2	274	1935	G*
78	Barrow	24-10	S724 417	P	D	2795	896	45.07	2.2	181	1291	F*
80	Barrow	26-2	S720 395	P	D	2801	896	45.07	2.2	181	1078	F*
81	Aughanaul	26-2	S728 383	P	D	29	1090	0.95	3.2	23	103	M
83	Aughanaul	26-6	S727 378	P	D	29	1090	0.95	10.0	81	328	G
84	Pollmounty	26-11	S742 270	O	D	33	1050	1.04	5.0	20	100	Operating

* Assumes use of canal as headrace.

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES

COUNTY CAVAN

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov. Mean Flow m³/s	Head m	Potential Inst. Cap. kW	Potential Annual Energy MWh	Site Rating
22	Un-named	6-10	H064 258	P	B	2.5	1700	0.119	15.0	10	48	M
31	Clodiagh	6-12	H148 255	P	B	10.5	1850	0.544	15.0	53	242	F
37	Swanlinbar	7-9	H151 248	P	B	12	1850	0.621	3.5	14	64	M
51	Woodford	10-10	H277 189	P	D	349	1266	12.37	3.0	135	823	G*
52	Un-named	10-13	H247 183	P	D	8.5	1260	0.299	6.0	11	51	M
55	Bunnoe	16-11	H508 136	P	D	88.5	1000	1.77	2.0	28	158	M
71	Annalee	23-1	H652 104	P	D	170	1050	3.57	2.0	44	183	M
72	Annalee	23-1	H659 105	P	D	168	1050	3.528	4.0	70	348	F
73	Knappagh	23-1	H680 102	P	B	80	1060	1.696	3.0	31	131	M
77	Un-named	23-15	H699 054	P	D	20.5	1080	0.443	4.5	12	49	M
90	Un-named	26-9	H492 028	P	B	36	1050	0.315	5.5	10	44	M
96/97	Un-named	28-13	N655 980	P	D	26	1125	0.672	7.5	40	165	F
104	Erne	31-10	N370 917	P	B	87	1000	2.00	2.0	25	120	M
106	Blackwater	33-8/12	N617 952	P	D	25	1100	0.632	3.0	12	56	M
108	Un-named	33-12	N621 943	P	D	55.5	1100	1.404	5.0	44	209	F
110	Un-named	34-1	N652 978	P	D	26	1125	0.627	5.5	23	110	F
122	Blackwater	39-7	N602 888	P	D	119	1075	2.942	4.5	89	422	G
123	Blackwater	39-11	N607 877	P	A	122	1075	3.016	3.2	83	314	F
100	Erne	30-8	N340 958	P	A	289	990	6.58	1.4	44	216	M
101	Erne	31-1	N358 970	O	D	296	990	6.74	1.2	10	40	Operating
128	Annalee	17-13	H543 114	P	D	522	1030	10.75	1.5	36	196	M

*Worked Example No. 1 (see Appendix C)

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES — COUNTY CLARE

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov. Mean Flow m^3/s	Head m	Potential Inst. Cap. kW	Potential Annual Energy MWh	Site Rating
20	Cullenagh	15-15	R128 885	O	A	174	1332	4.86	12.0	40	160	Operating
22	Fergus	16-7	R233 919	P	D	123	1465	3.784	4.0	71	262	F
38	Cullenagh	23-3	R131 878	P	D	174	1332	4.86	1.5	18	92	M
48	Inagh	24-5	R168 850	P	D	140	1352	3.975	5.5	70	347	F
93	Kiluran	36-10	R580 764	P	E	7.5	1250	0.196	17.0	14	60	M
122	Un-named	44-7	R618 724	P	E	4	1300	0.104	24.0	10	43	M
125	Un-named	45-6	R690 718	P	D	7.5	1250	0.243	8.6	10	53	M
169	Fergus	33-12	R335 777	P	A	615	1265	16.33	1.5	84	375	M
172	Un-named	32-9	R165 770	O	E			0.03	32	7.5	28	Operating

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY CORK

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov. Mean Flow m^3/s	Head m	Potential		Site Rating
										Inst. Cap. kW	Annual Energy MWh	
12	Awbeg	17-9	R544 088	P	D	176	1025	4.51	3.0	61	355	F
27	Awbeg	26-2	R676 067	P	A	323	1050	8.479	1.5	24	177	F
29	Awbeg	26-2	R685 022	P	D	346.2	1050	9.088	2.75	142	736	G
31	Funshion	27-16	R758 040	P	D	334	1203	10.045	1.8	34	247	M
34A	Araglin	28-13	R907 055	O	D	51.5	1319	1.698	2.4	7	28	Operating
39/40	Clyda	33-5/9	W543 976	P	D	111	1360	3.774	3.3	45	180	Operating
43	Un-named	35-5	W729 984	O	D	5.18	1300	0.168	11.0	4	16	Operating
44	Blackwater	35-8	W815 986	P	D	1750	1180	51.625	1.5	179	1268	F
45/46	Blackwater	36-1	W850 997	P	A	2280	1160	66.12	2.4	381	2828	G
55A	Un-named	45-6/10	W874 905	O	D	4.56	1150	0.131	11.0	9	36	Operating
35	Blackwater	31-9	W372 987	P	A	473	1450	17.15	1.5	66	424	M
58	Owenacurra	54-13	W843 816	P	D	19.7	1230	0.703	10.2	45	197	G
66	Laney	60-13	W357 762	P	D	79.0	1480	3.625	3.68	10	40	F
66A	Laney	60-13	W350 790	P	D	63.5	1550	3.051	4.9	51	285	F
67/68	Glashagarriff	60-16	W424 757	P	E	15.8	1290	0.632	9.0	25	118	F
69	Dripsey	61-14	W473 760	P	D	35	1420	1.541	3.8	33	143	F
73	Martin	62-16	W613 757	P	D	60.6	1210	2.273	5.0	104	379	F
75	Glashaboy	63-7	W701 794	P	D	41	1225	1.457	5.5	55	240	F
78(i)	Blarney	63-13	W640 761	P	A	13.9	1150	0.496	7	17	94	F
78(ii)	Blarney	63-13	W640 761	P	A	13.9	1150	0.496	4.57	11	62	M
78(iii)	Blarney	63-13	W640 761	P	A	13.9	1150	0.496	5.48	13	74	F
80	Glashaboy	63-16	W725 760	O	D	70	1200	2.436	4.1	30	120	Operating
92	Un-named	66-12	X004 780	P	A	29.3	1165	0.990	6.5	31	156	F
94	Un-named	68-4	W141 747	P	B	10.7	1800	0.482	12.0	23	133	F
96	Laney	71-5	W353 728	P	B	99.2	1440	4.428	6.0	73	467	G
98	Sullane	71-5	W335 728	P	D	206	1610	8.292	4.0	69	511	G
99	Dripsey	72-2	W482 755	O	A	60	1400	2,604	3.75	24	96	Operating
100	Dripsey	72-3	W482 755	O	D	75	1360	3.162	5.18	53	212	Operating
101/ 102	Lee	73-10/11	W592 714	P	A	918	1510	42.97	1.75	144	1019	F
107	Lee	74-9	W648 714	P	A	1143	1450	51.38	2.2	233	1736	G
111	Glashaboy	75-1	W727 746	O	D	95	1180	3.251	2.5	6	24	Operating
113	Owenacurra	76-3	W877 743	P	D	100	1201	3.483	3.5	84	361	F
113A	Dungourney	76-3	W885 733	P	D	49.4	1135	1.626	4.5	50	210	F
119	Lee	80-11	W108 659	P	E	13.5	2420	0.817	15.0	36	189	F
126	Bride	83-12	W425 658	P	D	54.8	1490	2.531	7.6	43	315	G
137	Kerry	90-10	V883 585	P	B	5.5	2610	0.445	18.6	37	177	G
139	Kerry	90-10	V895 585	P	D	11.7	2650	0.961	9.5	17	137	F
141	Glengarriff	90-15	V898 580	P	B	17.4	2600	1.402	2.75	12	68	M
170	Owngar	92-15	W097 573	P	B	9.2	1980	0.565	13.5	23	122	M

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov. Mean Flow m^3/s	Head m	Potential Inst. Cap. kW	Potential Annual Energy MWh	Site Rating
199/200	Adrigole	103-12	V833 530	O	E	4.4	2600	0.355	243	375	2250	Operating
273	Un-named	105-2	V995 562	P	D	11.6	2000	0.719	4.5	20	99	M
275	Owvane	106-1	W048 566	P	D	43.5	1940	2.616	3.8	68	279	F
282	Bandon	108-1	W238 561	P	B	58.7	2080	3.052	4.0	63	331	F
291	Bandon	110-3/4	W489 550	P	A	406	1623	18.45	2.0	101	642	F
302	Keelincha	115-1	V663 497	P	E	12.4	1690	0.65	12.0	32	150	F
321	Mealagh	118-3	W004 498	O	D	55.8	1780	3.079	8.45	118	596	G
329	Un-named	119-4	W114 489	P	E	8.76	2020	0.549	14.8	28	147	F
332	Owennashang	119-9	W056 455	P	D	21.75	1610	1.086	8.5	52	241	G
332A	Argideen	122-16	W410 433	P	D	73	1390	2.841	1.5	19	92	M
333A	Argideen	122-16	W425 446	P	D	77.6	1390	3.02	3.0	55	243	F
338	Argideen	121-12	W332 454	P	D	26.7	1500	1.121	2.8	16	78	M
340A	Un-named	127-4	V633 433	P	E	9	1500	0.418	7.0	14	66	M
341	Un-named	127-4	V637 427	P	B	13.3	151	0.623	6.7	15	79	M
343	Un-named	131-5	V946 420	P	D	26.3	1500	1.223	5	31	141	F
345	Un-named	131-2	V988 434	P	B	16.8	1550	0.807	3.3	13	62	M
370	Un-named	36-8	W905 980	O	D				7.5	4	16	Operating
381	Keelincha	114-4	V645 497	P	E	16.8	1690	0.88	13	78	382	G
390	Owenbaun	39-4	W335 945	P	D	60.5	1495	2.26	50	75	333	F
L1	Ownagappul	102-6	V700 540	P	E	8.3	1800	0.463	30	59	289	G
L2/r2	Banley L.	94-14	V890 573	P	E	2.6	2400	0.193	150	131	664	G
123A/r4	Coomhola	91-4/8	W030 630	P	E	3.5	2800	0.304	60	91	417	G
171(a)	Un-named	93-7	W162-593	O	E	2.6		0.068	30	7	21	Operating

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov. Mean Flow m³/s	Head m	Potential		Site Rating
										Inst. Cap. kW	Annual Energy MWh	
5	Donagh	11-7	C470 460	P	D	33	1320	0.78	4.6	22	88	M
15	Bredagh	21-8	C597 469	P	B	12	1250	0.27	10.0	21	80	F
17	Bredagh	21-12	C609 386	P	D	15	1250	0.338	8.0	21	80	F
24(i)	Glen	26-9	C125 315	O	E	8	1330	0.606	24	11	44	Operating
25A	Burnside	27-6/10	C212 325	O	D	11	1300	0.343	4.9	10	40	Operating
27	Drumhallagh	28-11	C285 320	P	B	10	1275	0.306	12.0	25	99	F
29/ r137	Crana	29-5	C350 335	P	D	98	1430	2.52	5.0	70	334	G
30/31	Mill	29-2/10	C350 315	O	E	44	1310	1.04	18.5	176	596	Operating
34	Drung	31-1	C540 342	P	E	40	1350	0.194	45.0	66	249	G
41	Bunlia	36-3	C185 280	P	D	7	1250	0.21	6.5	11	42	M
55	Burnfoot	38-15/16	C385 238	P	D	19.5	1300	0.456	6.4	19	71	M
64A	Gweedore	44-9	B830 193	P	B	40.5	1654	3.82	6.0	211	796	G
64B	Gweedore	44-11	B830 194	P	B	41.0	1654	3.87	9.0	213	806	G
68	Leannan	45-3	C195 208	P	D	211	1454	7.36	4.5	155	811	F
69	Leannan	45-4/8	C217 209	P	D	255	1418	8.68	4.0	62	383	G
80B	Leannan	52-3	C096 159	P	D	85	1640	3.35	3.3	22	131	F
80C	Leannan	52-3	C084 159	P	D	85	1640	3.35	4.0	22	184	F
113	Swilly	60-4	C117 090	P	D	49	1569	1.845	2.5	36	133	M
144	Swilly	60-4	C124 091	P	D	51	1569	1.92	3.0	22	120	M
115	Roughan	61-1	C135 095	P	D	11	1475	0.389	5.0	14	55	M
121	Corkey	62-1	C238 098	P	D	17.5	1200	0.504	5.4	21	84	M
160/ r126	Owentocker	73-16	G730 905	P	D	40	1740	2.02	6.2	115	387	G
181	Un-named	79-9	H230 939	P	D	10	1180	0.283	6.5	14	56	M
184	Un-named	79-11	H280 931	P	D	12.5	1160	0.348	6.5	17	67	M
186	Sruell	84-11	G909 866	P	E	12	2300	0.497	22.8	103	391	G
187-190	Corabber	85-6/10, 12/15	G977 876	P	E	9	2650	0.615	60	121	709	G
197	Un-named	94-4	H014 827	P	E	3.5	1800	0.183	30.0	28	118	M
198/ r123	Eske	94-6	G965 814	P	D	3.0	1975	9.46	3.0	156	832	F
200	Clogher	94-8	H001 813	P	E	2.5	1750	0.249	30.0	54	204	F
204	Drummenny	94-12	H005 793	P	E	3.5	1800	0.359	20.0	59	221	G
206	Glenaddragh	96-4	G630 760	P	D	16	2050	0.59	5.0	23	199	G
215	Ballintra	103-4	G910 699	P	D	45	1355	3.48	3.5	62	293	F
217	Un-named	104-1	G941 708	P	D	23	1485	1.95	7.0	125	458	G
219	Termon	105-12	H009 675	P	D	63	1470	5.28	2.5	54	302	F
220	Abbey	107-8	G870 622	P	D	40	1230	2.80	8.0	63	398	G
H1	Devlin	50-4	B928 183	P	E	11	2200	0.702	60.0	291	1250	G
H2	Lough Nacung	92-11	B900 188	P	E	3.5	2000	0.399	75.0	211	920	G

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov. Mean Flow m³/s	Head m	Potential		Site Rating
										Inst. Cap. kW	Annual Energy MWh	
H5	Un-named	43-11	B932 130	P	E	3.5	2000	0.203	100.0	137	588	G
H6	Un-named	50-1	B835 187	P	E	8	1800	0.821	18	61	397	G
H9	Un-named	74-12	G833 922	P	E	5.5	1700	0.271	60.0	103	433	G
H10	Un-named	82-3	G670 900	P	E	6.5	1900	0.222	90.0	134	574	G
H11	Un-named	85-8	H037 874	P	E	9	2200	0.574	14.0	43	185	F
23C/r130	Tullaghobegly	25-13	B935 295	P	B	26	1805	2.68	6.0	91	434	G
222	Owengarve	75-10	G869 933	O	E	6.5	1900	0.358	18	15	60	Operating
H12	Un-named	19-7/8	C391 388	P	D	9	1550	0.335	15	17	89	M
166	Effernagh	76-10	G965 923	P	D	2	2300	0.11	30	19	84	F
196	Laverymore	94-4	G992 826	P	B	30	2000	1.74	12	184	689	G

A SUMMARY OF OPERATING AND POTENTIAL SITES — COUNTY DUBLIN

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov. Mean Flow m^3/s	Head m	Potential Inst. Cap. kW	Potential Annual Energy MWh	Site Rating
3	Devlin	4-6	O131 611	P	A	37	850	0.66	4.5	15	80	M
8	Ward	11-10	O141 465	P	D	57	810	0.831	3.0	13	55	M
18	Liffey	16-5	O035 355	O	D	268	800	5.36	2.5	150	600	Operating
18A	Liffey	17-2	O042 365	P	D	268	800	5.36	1.52	6	24	Operating
18B	Liffey	17-5/6	O022 354	P	A	268	800	5.36	1.5	46	268	M
19	Liffey	17-3	O065 375	P	A	294	800	5.88	1.55	35	259	M
20/21	Liffey	17-8	O090 355	P	D	300	800	5.76	1.85	61	366	M
22	Cammock	17-15	O067 312	P	D	45	940	0.76	4.0	15	88	M
23	Tolka	18-10	O137 877	P	B	126	810	1.632	2.7	16	78	M
25	Liffey	17-10	O125 342	P	A	311	800	5.97	2.0	74	415	F
25A	Liffey	17-5	O101 348	P	D	306	800	5.87	1.5	50	315	M
25B	Liffey	17-5	O104 345	P	D	306	800	5.87	1.7	57	343	M
26/27	Cammock	21-10/14	O035 265	P	E	13	1130	0.246	19	32	161	G
28	Dodder	22-3	O160 300	P	A	90	1180	1.911	2.70	30	143	M
29	Dodder	22-7	O152 297	P	A	90	1180	1.911	3.55	39	209	F
32	Dodder	22-7	O174 308	P	A	106	1160	2.213	2.0	24	133	M
41	Dodder	22-13	O097 265	P	A	41	1400	1.033	7.3	43	233	G
43	Owendoher	22-14	O135 255	O	D	10.5	1100	0.2	9.75	20	80	Operating
46	Dodder	24-4	O090 245	P	A	36	1420	0.92	4.09	24	121	F
55	Dodder	25-14	O120 192	P	E	6	1800	0.194	30.0	31	159	F
56	Dodder	26-2	O228 241	P	B/E	15	950	0.256	8.0	10	54	M
H1	Slade Brook	25-13	O104 199	P	E	4	1750	0.126	36.0	21	113	F
H2	Cot Brook	25-13	O110 199	O	E	6	1850	0.20	9.0	12	24	Operating
67	Un-named	24-7	O067 220	P	D	6	1250	0.135	7.7	5.5	20	Operating
69	Un-named	22-14	O045 222	O	D				3.0	3	12	Operating
H3	Owendoher	25-11	O135 230	P	E	6	1200	0.13	55	30	168	F

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY GALWAY

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov. Mean Flow m³/s	Head m	Potential		Site Rating
										Inst. Cap. kW	Annual Energy MWh	
28	Un-named	46-9	M668 468	P	A	45	1100	0.99	2.5	13	76	M
29	Owenriff	54-7	M112 425	P	E	67	1665	3.569	9.83	118	719	G
33	Abbert	57-12	M460 420	P	A	191	1120	4.92	1.3	41	187	M
34	Abbert	58-2	M504 435	P	D	159	1120	4.095	2.33	63	274	M
38	Ahascragh	61-13/14	M77 385	P	D	93	1116	2.064	2.25	30	119	M
52A	Owenboliska	92-7/11	M126 260	P	F	79	1465	3.70	6.5	20	149	M
57(i)	Corrib	94-2	M295 250	P	D	3011	1338	124.89	2.5	100	549	M
57(ii)	Corrib	94-2	M295 250	P	D	3011	1338	124.89	3.9	465	2554	G
57(iii)	Corrib	94-2	M295 250	P	D	3011	1338	124.89	2.7	35	192	G
57(iv)	Corrib	94-2	M295 250	O	D	3011	1338	124.89	3.0	31	153	Operating
57(v)	Corrib	94-2	M295 250	P	D	3011	1338	124.89	2.6	33	181	F
76	Kilcrow	117-3	M800 120	O	A	190	1000	3.99	1.5	15	35	Operating
H2	Un-named	52-16	L973 407	P	B	37	1875	2.22	11.0	50	341	G
H3	Un-named	52-12	L973 420	P	E	30	1875	1.80	11.5	43	306	F
38A/r76	Un-named	66-15	M031 331	P	E	25	1645	1.316	9.0	32	185	M
20A/r80	Owenglin	35-8	L659 506	P	B	32	1846	1.890	10.9	78	424	G
57(vi)	Corrib	94-2/6	M295 250	P	D	3011	1338	124.89	2.6	33	181	F
57(vii)	Corrib	94-2/6	M295 250	P	D	3011	1338	124.89	5.8	330	1812	G
57(viii)	Corrib	94-2/6	M295 250	P	D	3011	1338	124.89	2.5	117	643	F
79/80	Un-named	12-12/16	L965 605	P	E	2.2	2800	0.197	60	72	333	G
94	Un-named	67-10	M115 325	O	B	6.7				8	32	Operating
95	Un-named	67-4	M149 388	P	A	16	1500	0.552	5	14	72	M
97	Un-named	38-4	L963 509	P	D	3.5	2400	0.269	8	10	53	M
98	Un-named	12-15	L928 591	P	E	1.0	2850	0.091	25	10	51	M
H4	Un-named	12-15	L940 591	P	E	3.8	2900	0.352	50	114	528	G

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY KERRY

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov. Mean Flow m^3/s	Head m	Potential		Site Rating
										Inst. Cap. kW	Annual Energy MWh	
45	Derrymore	37-6	Q746 100	P	E	4.9	1770	0.269	100.0	184	764	G
48	Finglas	37.9	Q700 095	P	B	15.9	1720	0.848	15.7	73	351	G
50/51	Un-named	37-5/9	Q717 097	P	E	1.8	1425	0.08	60	27	112	G
67A	Gweestin	57-11	V846 955	O	D	65.3	1280	2.01	4.07	40	160	Operating
69	Gleensk	62-7/6	V580 888	P	E	7.4	1900	0.436	25	52	245	G
71	Un-named	65-16	V880 873	P	E	8.6	2500	0.516	13.84	35	140	Operating
84	Un-named	83-4	V876 799	P	E	24	2800	1.613	22.6	112	743	G
89/r34	Un-named	85-11	W053 757	P	E	50.8	2150	3.386	16	256	1250	G
91	Owbeg	85-3/7	W000 750	P	B	32.6	2420	2.446	7.0	113	496	G
92	Owbeg	85-13	W002 746	P	E	33	2420	2.476	12	218	907	G
98	Un-named	90-16	V671 703	P	E	8.8	2780	0.758	20	82	347	F
101	Un-named	90-16	V676 683	P	B	17.7	2800	1.536	14.25	126	564	F
113 /r26	Sheen	93-13	V951 680	P	B	78	2370	5.73	6.85	244	1042	G
113A	Sheen	93-10	V933 700	O	D	91	2200	6.21	8.07	145	750	Operating
113B	Sheen	93-10	V925 701	P	B	91.5	2175	6.17	3.79	136	613	F
114	Un-named	94-1	W005 726	P	B	47.9	2100	3.12	4.0	86	338	F
116	Un-named	94-5	W005 716	P	E	3.5	1790	0.194	45	53	220	F
117	Un-named	94-5	W010 720	P	B	42.8	2180	2.89	3.5	69	289	F
119/ 120	Un-named	98-14	V527 627	P	E	3.4	1500	0.158	60	50	220	F
122/ 123	Un-named	99-13	V610 632	P	E	2.0	1850	0.115	20	13	82	M
137	Glain-chiquin	101-15	V854 620	P	E	3.3	2400	0.246	130	162	784	G
138/ 139	Un-named	101-15	V850 520	P	E	1.75	2300	0.125	60	32	148	F
140	Un-named	101-15	V854 622	P	E	1.9	2200	0.13	50	28	130	F
148	Un-named	109-2/6	V842 600	P	E	2.7	2150	0.18	100	90	416	G
149	Un-named	109-2/6	V827 597	P	E	2.6	2400	0.193	95	89	422	G
157	Un-named	109-5/9	V807 590	P	B	12.1	2250	0.844	8.0	34	158	F
158	Un-named	109-5/9	V808 581	P	B	12.5	2500	0.969	8.0	38	174	F
166	Un-named	111-3	V749 549	P	E	3.9	2100	0.254	75	92	417	G
171	Un-named	111-11	V748 516	P	E	5.3	1950	0.32	200	339	1607	G
H13	Un-named	73-11	V858 830	P	E	3.0	3000	0.216	100	107	522	G
H16	Un-named	66-9/13	V916 882	P	E	4.2	1850	0.186	150	150	730	G
H17	Un-named	103-2/6	W021 665	P	E	2.5	2400	0.186	100	85	466	G
H17A	Un-named	103-6	W022 658	P	E	1.8	2800	0.156	90	65	307	G*
H18	Un-named	102-16	V970 620	P	E	1.9	2550	0.15	100	73	345	G
H19	Un-named	102-17	V974 633	P	E	5.8	2400	0.432	60	129	611	G
H20	Un-named	102-1/5	V874 642	P	E	1.6	2050	0.102	60	20	103	G

*Worked Example No. 2 (Appendix C).

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov. Mean Flow m^3/s	Head m	Potential		Site Rating
										Inst. Cap. kW	Annual Energy MWh	
H22	Un-named	103-2	W025 660	P	E	6.2	2500	0.481	90	209	1029	G
H23	Un-named	73-11	V843 822	P	E	2.6	3100	0.193	120	122	594	G
H25	Un-named	73-9	V806 825	P	E	2.5	3200	0.192	100	102	496	G
H26	Un-named	83-4	V816 803	P	E	3.9	3200	0.3	100	158	769	G
H27	Un-named	76-5	W085 844	P	E	4.5	1900	0.205	75	73	353	G
H28	Un-named	111-4	V786 546	P	E	1.5	2350	0.109	100	50	235	G
H29	Un-named	108-16	V789 560	P	E	2.0	2350	0.146	90	60	284	G
H30	Derriana	90-6	V630 738	P	E	5.1	2250	0.356	75	139	661	G
H31	Un-named	98-11/12	V576 646	P	E	3.0	1850	0.172	100	76	373	G
H32	Un-named	98-14	V540 634	P	E	3.1	1650	0.159	100	76	358	G
H33	Cummera-looderry	83-6/7	V840 790	P	E	2.3	3000	0.166	60	45	217	G
H34	Un-named	84-1/5	V908 790	P	E	3.6	2450	0.212	75	78	379	G
L4/r49	L. Acoose	72-7	V743 853	P	E	12.2	2520	0.953	6	30	134	M
L8	L. Brin	82-12	V781 772	P	F	4.8	3000	0.446	275	52	249	F
L9	L. Currane	98-9	V505 654	P	F	101	1910	5.98	5.5	174	743	G
L10	Clonee L.	109-9	V798 637	P	F	24.9	1950	1.51	30	248	1056	M
175	Drishoge	36-13	Q620 081	P	E	2.6	2000	0.161	90	78	372	G
175a	Un-named	36-16/14	Q633 089	P	E	1.2	2000	0.074	100	32	149	F
186	Un-named	85-3	W044 794	P	E	1.3	2200	0.068	70	22	106	F
190	Un-named	93-7	V958 718	P	E	8	1780	0.44	47	104	498	G
193	Un-named	75-12	W076 828	P	E	2.6	2200	0.137	50	29	140	F
194	Un-named	100-9/10	V697 640	P	E			0.125	19.85	14	70	F
H2	Un-named	35-15	Q558 072	P	E	3	2300	0.213	120	136	645	G
L11/ r48	Cottoners	72-4/8	V787 854	P	E	3	2520	0.234	335	531	2210	G

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES — COUNTY KILDARE

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov. Mean Flow m³/s	Head m	Potential		Site Rating
										Inst. Cap. kW	Annual Energy MWh	
8	Ryewater	6-13	N960 380	P	A	194	840	2.28	3.7	58	241	F*
18	Liffey	11-10	N972 329	P	D	496	860	11.94	1.2	32	254	M
19	Liffey	11-9/13	N968 320	O	D	496	860	11.94	1.2	15	60	Operating
20	Liffey	14-4	N924 291	O	A	353	850	8.7	2.4	45	338	Operating
38	Liffey	23-3	N808 160	O	A	180	885	5.416	1.0	4.5	18	Operating
40	Liffey	23-15	N821 120	P	D	139	900	4.50	2.4	74	469	F
60	Barrow	35-14	S685 922	P	D	1628	880	24.35	1.2	69	484	M
61	Greese	36-2/6	S796 962	P	D	63.5	900	1.657	3.0	27	157	F
63	Greese	36-14	S790 923	P	D	98	895	2.543	1.5	24	134	M
65/66	Barrow	37-2/10	S692 905	O	D	1635	880	24.46	1.7	11	50	Operating
68	Greese	37-8/12	S735 880	P	D	131	880	3.343	2.3	51	288	F
70	Barrow	39-7	S714 835	P	D	1685	865	24.77	1.5	184	927	M
71/72	Lerr	40-1/5	S770 845	P	D	66	850	1.627	4.5	34	222	F

*High Amenity.

A SUMMARY OF OPERATING AND POTENTIAL SITES — COUNTY KILKENNY

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov. Mean Flow m³/s	Head m	Potential Inst. Cap. kW	Potential Annual Energy MWh	Site Rating
6	Dinin	5-12	S537 730	P	D	153	1050	2.73	2.9	50	198	M
12	Dinin	5-16	S535 715	P	D	158	1050	2.82	2.1	38	148	M
28	Nore	19-3	S500 580	P	D	1536	980	30.1	1.83	140	921	F
31	Nore	19-7	S512 558	P	D	1606	980	31.47	1.6	122	771	F
33	Nore	19-7	S532 547	P	D	1647	980	32.28	1.4	53	377	M
41	Nore	24-9	S553 492	O	D	1709	975	33.32	2.0	95	400	Operating
48	Kings	27-6	S480 430	P	D	294	1000	5.0	1.9	60	238	M
52	Kings	27-7	S512 437	P	D	377	990	6.34	1.85	75	294	M
53	Kings	27-8	S523 437	P	D	378	990	6.36	2.15	66	305	M
59(i)	Nore	28-10	S585 416	P	D	2276	975	44.38	1.6	102	611	M
59(ii)	Nore	28-10	S585 416	P	D	2276	975	44.38	1.7	89	535	F
59(iii)	Nore	28-10	S585 416	P	D	2276	975	44.38	2.13	117	699	M
63	Little Arrigle	28-13	S574 403	P	D	51	1040	0.90	4.85	14	58	M
66	Douske	29-7	S707 438	P	D	20	1020	0.346	9.5	21	83	M
70	Arrigle	32-3	S607 383	P	D	46	1170	0.915	4.6	22	96	M
72	Arrigle	32-7	S607 376	P	D	45	1170	0.895	5.0	22	96	M
77	Clodiagh	33-10	S675 350	P	D	11	1020	0.19	9.3	11	45	M
95	Blackwater	40-9	S561 221	P	D	103	1150	2.01	1.9	24	91	M
100	Blackwater	43-1	S570 200	P	D	108	1150	2.11	1.95	26	103	M
104	Blackwater	43-5	S565 181	O	D	113	1120	2.15	3.58	27	75	Operating
104A	Blackwater	43-5	S570 184	P	D	108	1150	2.11	11.9	64	300	Operating
105	Blackwater	43-9	S570 172	P	D	117	1120	2.22	2.1	30	118	M
107	Un-named	43-10	S595 156	P	D	42	1070	0.76	4.6	22	84	M

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES — COUNTY LAOIS

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov. Mean Flow m^3/s	Head m	Potential Inst. Cap. kW	Potential Annual Energy MWh	Site Rating
6	Barrow	3-13	N368 189	P	E	14	1400	0.49	10.7	33	181	M
48	Stradbally	14-15	S595 968	P	A	95	900	1.624	2.4	31	127	M
52	Nore	16-12	S342 920	O	D	278	1050	7.297	1.75	35	186	Operating
61	Timogue	19-2	S570 960	P	A	85	900	1.45	1.9	22	90	M
71	Goul	29-13	S367 774	P	D	47	900	0.80	2.45	12	57	M
74	Erkina	29-15	S418 775	P	D	387	900	6.617	1.4	43	226	M

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY LEITRIM

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov. Mean Flow m³/s	Head m	Potential Inst. Cap. kW	Potential Annual Energy MWh	Site Rating
1	Duff	1-3	G754 574	P	B	90	1347	3.15	3.5	76	340	F
3	Duff	1-3	G754 572	P	D	90	1347	3.15	7.0	161	724	G
4	Drowes	2-6	G832 568	P	D	248	1365	8.80	2.4	46	305	M
16	Un-named	4-1	G810 518	P	B	4.4	1500	0.172	12	12	55	M
17	Un-named	4-1	G818 515	P	B	4.4	1500	0.172	15	27	119	F
19	Un-named	4-9	G853 520	P	E	1.5	1550	0.06	90	29	130	G
20	Un-named	4-9	G858 520	P	E	2.5	1550	0.10	90	55	247	G
24	Un-named	4-4	G895 520	P	E	1.75	1470	0.06	76	22	110	F
27	Un-named	4-7	G858 502	P	D	3.3	1600	0.137	61	45	202	F
35	Un-named	5-1	G940 506	P	B	55	1412	2.02	3.0	39	173	M
37	County	5-6	G950 494	P	B	53	1412	1.945	3.5	30	148	M
38	Glenaniff	5-9	G914 481	P	B	25	1544	1.00	12	82	368	G
43	Un-named	6-7	G762 437	P	B	3	1621	0.126	45.73	32	145	F
48	Un-named	6-11	G764 423	P	B	2	1500	0.078	40	15	68	M
61	Un-named	7-13	G841 409	P	B	12	1520	0.474	4.0	11	51	M
83	Un-named	10-16	G798 342	P	B	8.5	1373	0.303	12	20	90	M
85	Owenmore	11-4	G892 391	P	D	42	1480	1.62	4.0	37	162	F
93	Bonet	14-8	G800 315	P	D	294	1394	10.7	5.5	302	1597	G
94	Un-named	14-16	G801 277	P	B	19	1280	0.632	12	18	129	M
147	Yellow	24-4	H080 130	P	B	18	1586	0.742	6.5	17	95	M
H1	Stony	20-8	G999 185	P	E	7.3	1550	0.294	30	38	197	G
H2	Un-named	10-11/12	G782 355	P	E	5.8	1410	0.212	60	64	323	G

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY LIMERICK

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov. Mean Flow m³/s	Head m	Potential		Site Rating
										Inst. Cap. kW	Annual Energy MWh	
12	Mulkear	6-9/13	R643 571	P	A	646	1143	12.55	2.52	114	563	F
13	Mulkear	6-13	R645 564	P	D	646	1143	12.55	3.08	127	653	F
21	Un-named	11-9/13	R341 505	P	D	14.5	950	0.344	4.5	10	40	M
22	Deel	11-13	R340 500	O	D	481	1045	12.56	5.52	270(O) 484(A)	836(O) 1936(A)	Operating
60	Daar	28-9	R235 383	O	E	6.3	1275	0.20	18	15	80	Operating
65	Maigue	30-4	R516 402	P	A	774	977	13.34	1.0	51	304	M
66	Maigue	30-4	R513 410	P	D	774	977	13.34	2.9	117	734	F
92	Maigue	39-5	R538 335	P	A	444	986	8.32	1.3	34	194	M
95	Maigue	39-13/14	R550 305	P	D	246	1002	4.68	6.0	217	915	G
112	Loobagh	47-8	R613 277	P	D	24	1125	1.56	3.7	36	155	F
153	Un-named	58-13	R825 177	P	B	24	1525	0.116	16.5	11	47	M
145	Assaroola	58-1	R830 232	P	E	1.5	1475	0.037	234	56	229	G
112a	Un-named	48-5	R627 272	O	A	11	980	0.205	3.9	15	60	Operating

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY LONGFORD

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov. Mean Flow m^3/s	Head m	Potential		Site Rating
										Inst. Cap. kW	Annual Energy MWh	
14/15	Camlin	10-5	N247 812	P	D	62	1000	1.302	3.0	30	113	M
19	Camlin	13-5	N063 759	P	D	70	950	1.396	1.3	41	170	M
38	Rath	27-12	N215 550	P	D	44	975	0.900	3.0	17	68	M
40	Camlin	14-5	N135 758	P	A	260	985	5.378	1.5	32	174	M
42	Camlin	10-1/5	N240 815	P	D	62	1000	1.302	5.3	58	220	F
18	Shannon	13-1/5	N055 766	P	A	2656	950	53.00	1.9	161	1045	F
44	Un-named	18-12	N116 666	O	E	6.5	950	0.129	3.0	2	8	Operating
45	Trib of Camlin River	14-14	N181 720	O	D					3.8	12	Operating

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY LOUTH

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov. Mean Flow m^3/s	Head m	Potential		Site Rating
										Inst. Cap. kW	Annual Energy MWh	
5	Ballmascanlon	4-12	J090 125	P	D	52	1100	1.144	5.82	28	162	F
7	Cully	4-13	J020 110	P	D	56	1050	1.176	5.0	20	90	Operating
8	Kilcurry	4-16	J027 104	P	D	115	1050	2.415	2.4	46	183	M
20	Castletown	6-4	H989 101	P	D	81	1100	1.782	6.73	110	378	G
43	White	18-10	T286 960	P	D	44	950	0.836	4.0	27	83	M
39	Dee	18-2	T269 975	P	D	380	910	6.916	1.5	26	166	M
58	Un-named	3-12	J008 124	P	A	85	980	0.167	10	11	48	M

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY MAYO

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov Mean Flow m^3/s	Head m	Potential		Site Rating
										Inst. Cap kW	Annual Energy MWh	
1	Ballinglen	7-13	G102 377	P	D	43	1433	1.663	2.2	24	92	M
3	Palmerstown	14-16	G169 309	P	D	122	1263	4.16	1.5	19	111	M
7	Owenmore	29-2	G110 235	O	D	35	1328	1.30		8	32	Operating
8	Brusna	30-12	G255 195	O	D	34	1190	3.098	5.4	38	205	Operating
21	Yellow	49-14	G318 062	P	B	9	1283	0.323	19.0	39	181	F
27	Newport	68-9	L995 640	P	D	140	1677	6.34	2.3	63	331	F
29	Un-named	68-15	M049 925	P	B	13	1337	0.469	6.3	16	67	M
30	Clydagh	70-16	M210 950	P	D	50	1532	2.145	2.0	17	98	M
41	Bunowen	86-14	L806 808	P	D	68	1698	3.695	2.75	26	162	F
45	Carrowbeg	88-1	L997 845	P	A	47	1453	2.185	2.1	29	129	M
45A	Carrowbeg	88-1	L997 845	P	A	47	1453	2.185	2.2	31	136	M
65A/ r87	Bundorragha	115-5	L841 650	P	D	45	2484	3.577	6.75	176	774	G*
67	Erriff	116-5	L895 645	P	B	163	2022	10.546	7.5	231	1446	G
70	Robe	118-1	M171 645	P	D	289	1170	8.115	2.3	36	248	F
L1/r90	L. Feeagh	67-4	L960 980	P	F	84	2070	4.694	9.75	285	1309	G*

*Major Fisheries

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY MEATH

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov Mean Flow m³/s	Head m	Potential Inst. Cap kW	Potential Annual Energy MWh	Site Rating
2	Un-named	4-12	N702 870	P	D	1.06	0.356	4.7	13	13	54	M
7/8	Corkey	7-5/9	N926 878	P	D	24	0.89	0.448	3.6	13	42	M
10	Upper Inny	8-8	N525 810	P	D	54	1.025	1.217	3.9	38	146	F
11	Upper Inny	8-12	N510 805	P	D	56	1.025	1.262	3.9	39	152	F
14	Un-named	9-13	N550 780	P	D	17.5	1.025	0.62	8.55	42	163	M
17	Moynalty	11-10	N735 825	P	D				1.5	4	16	Operating
24	Blackwater	16-4	N710 774	P	D	357	1.04	7.796	1.2	21	142	M
29	Blackwater	17-2/4	N761 759	P	D	388	1.04	8.473	1.0	54	292	M
39	Un-named	19-9	N951 740	P	A	21	0.95	0.42	3.0	10	41	M
40	Boyne	19-10	N950 740	O	D	2408	0.92	46.52	1.0	40	160	Operating
41	Boyne	19-10	N964 736	O	D	2432	0.92	46.98	2.2	90	360	Operating
43A	Boyne	19-13	N932 725	P	D	2400	0.92	46.36	2.0	198	1306	F
43B	Boyne	19-13	N933 725	P	D	2400	0.92	46.36	2.0	198	1306	F
46	Boyne	19-15	N992 728	P	D	2438	0.92	47.10	1.8	109	767	F
54	Boyne	25-4	N921 715	P	D	2379	0.92	45.96	1.2	46	391	F
58	Blackwater	25-10	N863 681	P	D	733	0.98	15.08	1.5	101	575	M
59	Blackwater	25-10	N866 682	P	D	733	0.98	15.08	1.3	27	211	M
60	Blackwater	25-10	N867 682	P	A	733	0.98	15.08	1.2	46	304	M
62	Boyne	25-12	N881 685	P	D	2357	0.92	45.53	2.0	125	934	F
66	Boyne	26-4	O007 719	P	D	2443	0.92	47.198	1.9	233	1536	F
66A	Nanny	27.7	O088 698	P	D	213	0.85	3.98	2.0	69	264	M
81	Nanny	32-2	N960 648	P	D	18	0.875	0.346	5.3	15	57	M
86	Hurley	32-15	N998 600	P	D	50.5	0.875	0.972	3.8	29	121	M
94	Delvin	34-9	O132 611	P	A	37	0.85	0.692	6.0	33	136	F
100	Knightsbrook	36-8	N828 560	P	D	102	0.85	1.90	4.7	77	317	F

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY MONAGHAN

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov Mean Flow m³/s	Head m	Potential Inst. Cap kW	Potential Annual Energy MWh	Site Rating
4	Un-named	4-9	H706 468	P	D	30	1140	0.615	4.3	21	75	F
11	Blackwater	7-13	H720 389	P	D	126	1025	2.324	2.5	39	155	M
15	Blackwater	9-1	H611 369	P	D	53	1150	1.097	2	13	64	M
19	Blackwater	9-6	H633 359	P	D	56	1140	1.149	2.7	24	91	M
29	Un-named	12-11	H568 270	O	D	7.5	1000	0.135	21.9	30	99	Operating
35	Un-named	13-5	H612 293	P	D	11	1000	0.198	9.25	15	56	M
41	Un-named	14-3	H765 313	P	D	16	1000	0.288	6.9	15	59	M
61	Muckno	20-10	H841 220	P	D	33	1130	0.671	5.8	29	113	F
62	County-Water	20-11	H856 215	P	D	46	1160	0.960	4.1	30	114	M
65	Un-named	23-4	H703 180	P	D	8	1070	0.171	9.27	12	46	M
67	Un-named	23-7	H677 163	P	B	10	1030	0.206	10.8	13	63	M
79	Fane	25-16	H886 130	P	D	212	1080	4.121	3.3	93	386	F
80	Knappagh	26-8	H688 104	P	D	77	1000	2.156	2.0	34	128	M
83	Knappagh Water	27-3	H774 117	P	D	25	1075	0.752	4.6	27	102	M
84	Knappagh Water	27-4	H803 115	P	D	14	1080	0.423	9.82	31	116	F
85	Knappagh Water	27-4	H794 112	P	D	16	1075	0.482	11.70	45	168	F
93	Fane	29-4	H940 066	P	D	238	1070	4.583	3.8	97	470	F
96	Un-named	31-5/9	H817 030	P	D	16	990	0.316	6.5	15	57	M
99	Un-named	30-16	H788 000	O	E	8	990	0.158	31.4	10	40	Operating

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES — COUNTY OFFALY

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov Mean Flow m^3/s	Head m	Potential		Site Rating
										Inst. Cap kW	Annual Energy MWh	
6	Brosna	8-6	N256 325	O	D	329	925	5.17	2.6	67	268	Operating
7	Brosna	8-6	N253 324	O	D	330	925	5.19	2.5	89	356	Operating
15	Silver	9-14	N359 289	P	D	30	900	0.459	4.0	12	53	M
20	Brosna	14-14	N073 221	O	D	1215	930	16.00	3.5	466	2100	Operating
22	Silver	16-4	N314 278	O	D	37	900	0.566	2.5	11	44	Operating
25	Tullamore	17-9	N336 249	P	D	112	880	1.675	2.0	26	107	M
35	Un-named	29-4	N015 139	P	D	18	890	0.272	8.0	17	78	M
41	Silver	32-13	N229 093	P	D	13.6	1350	0.316	4.0	10	45	M
45A	Camcor	35-10	N061 045	P	D	163	1042	2.887	2.0	45	206	M
45B	Camcor	35-10	N061 045	P	D	163	1042	2.887	3.3	81	367	F
53	Silver	37-1	N228 084	P	D	13	1370	0.3	5.0	11	52	M*
61	Little Brosna	42-12	S105 913	P	D	192.5	980	3.2	2.5	68	293	M
64B	LittleBrosna	42-16	S112 905	P	D	31	900	0.474	5.5	20	92	M
43	Little Brosna	35-1	N032 080	P	D	495	958	8.062	1.5	57	345	M

*High Amenity.

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES — COUNTY ROSCOMMON

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov Mean Flow m^3/s	Head m	Potential		Site Rating
										Inst. Cap kW	Annual Energy MWh	
17	Boyle	6-9	G799 025	P	D	520	1135	13.57	3.3	399	1622	G
21	Killakin	11-6	M930 976	P	D	31	1100	0.784	5.0	25	114	F
23	Un-named	11-10	M925 965	P	B	30	1100	0.759	5.6	24	113	M
35	Suck	26-3	M674 801	P	D	59	1090	1.479	4.5	40	186	F
38/39	Scramoge	29-7	M950 788	P	D	52.5	1010	1.219	4.5	29	134	M
48	Smaghraan	39-1	M816 680	P	D	73	1050	1.763	3.5	16	105	F
65	Suck	41-10	M830 578	P	A	622	1072	14.334	1.2	82	473	M
14	Boyle	5-12	G790 020	P	D	520	1135	13.57	3.6	52	431	F

A SUMMARY OF OPERATING AND POTENTIAL SITES — COUNTY SLIGO

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov Mean Flow m³/s	Head m	Potential		Site Rating
										Inst. Cap kW	Annual Energy MWh	
9A	Un-named	6-6	G740 502	P	B	16	1540	0.567	3.2	12	56	M
9B	Un-named	6-6	G740 502	P	B	16	1540	0.567	3.8	14	67	M
19	Un-named	12-13	G430 336	P	B	16	1.30	0.478	6.6	14	75	M
17	Ballymeeny	11-12	G415 361	P	B	8	1100	0.202	18.25	16	91	F
23	Dunneill	12-13	G436 340	P	B	17	1300	0.508	10.5	34	165	G
31	Un-named	19-11	G579 288	P	E	2.5	1300	0.075	50	17	95	F
32(i)	Ballisodare	20-11	G668 295	P	D	658	1206	18.25	5.8	875	3937	G
32(ii)	Ballisodare	20-11	G668 295	P	D	658	1206	18.25	7.25	739	4138	G
33	Ballisodare	20-11	G668 295	O	D	658	1206	18.25	7.5	110	50(E)	Operating
33A	Owenmore	20-15	G679 265	O	D	438	1227	12.4	10.3	500	3000	Operating
36	Owenboy	25-4	G605 251	P	D	80	1430	2.63	2.0	23	134	F
37	Moy	25-13	G525 217	P	E	8.5	1650	0.323	40	55	312	F
38	Owenbeg	26-3	G668 260	P	D	436	1227	12.3	1.3	32	231	M
46	Mad	31-7	G489 180	P	E	7	1650	0.266	30	34	194	F
47/r105	Owenaher	31-13	G442 150	P	B	34	1575	1.23	12.0	70	399	G
54	Bellamean	36-11	G389 097	P	E	6.5	1425	0.213	30	26	145	F
57	Owengarve	42-3	G488 071	P	D	80	1175	2.162	1.9	25	123	M
58	Owengarve	42-4	G493 064	P	D	79	1175	2.135	3.0	39	192	F
62	Un-named	12-14	G462 335	P	A	10	1210	0.278	5.0	10	45	M
63	Un-named	21-5	G736 307	P	E	3.5	1150	0.092	51	28	136	G

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY TIPPERARY

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov Mean Flow m³/s	Head m	Potential Inst. Cap kW	Potential Annual Energy MWh	Site Rating
1	Un-named	4.14	M901 015	P	D	45	900	0.688	4.9	21	92	M
2	Un-named	4-14	M909 011	P	D	45	900	0.688	3.45	15	61	M
11	Nenagh	14-11/15	R840 833	P	D	312	1115	7.305	1.9	57	327	F
15	Newtown	20-2	R804 803	P	D	15.5	1230	0.40	6.0	14	67	M
17	Newtown	20-6	R802 788	P	D	14	1250	0.367	6.5	15	71	M
22	Nenagh	21-6	R901 791	O	D	95	1045	1.687	5.7	11	37	Operating
25A	Nenagh	21-13	R890 748	P	D	90	1215	2.296	2.2	31	145	M
48A	Newport	37-2/3	R740 632	P	B	69.5	1405	2.050	3.0	24	131	M
50(P_1)	Clare	37-7/11	R730 600	P	B	56	1315	1.546	5.8	36	195	M
49(P_2)	Clare	37-7/11	R730 600	P	D	56	1315	1.546	9.4	91	425	F
49(P_3)	Clare	37-7/11	R730 600	P	D	56	1315	1.546	7.3	77	359	G
55A	Clodiagh	34-14	S012 640	O	A	36.5	1355	0.94	4.2	8	32	Operating
56	Owenbeg	40-10	S010 593	P	D	19	1325	0.478	4.5	14	66	M
68	Suir	47-5	S092 554	P	A	512	970	9.43	1.2	36	216	M
70	Suir	47-5	S087 537	O	D	514	970	9.47	2.84	250	1100	Operating
84	Kings	55-2	S296 488	P	D	18	1100	0.376	6.0	14	68	M
97	Clashawley	70-2	S196 365	P	A	84	995	1.588	2.8	28	139	M
112	Suir	75-16	S050 250	O	D	1580	1075	33.97	1.7	105	420	Operating
123	Un-named	80-13	S880 190	P	D	15	1710	0.332	5.0	13	98	M
128	Un-named	83-5	S170 220	O	E	21	980	0.39	8.2	21	85	Operating
133	Lingaun	85-3/7	S415 230	P	D	90	1130	1.932	2.3	37	180	F
139	Tar	87-11	S031 142	O	D	173	1330	5.06	1.83	30	120	Operating
147	Un-named	91-1	S084 105	P	B	5.5	1650	0.20	40	52	272	G
H8	Un-named	90-2	S010 120	P	E	2.75	1600	0.096	60	30	159	F
H10	Un-named	71-10	S270 282	P	E	5.5	1200	0.125	60	38	189	F
H11	Burncourt	80-10/11	R922 204	P	E	12	1760	0.464	40	81	507	G
46	Suir	35-7	P120 670	P	D	130	970	2.4	3.0	46	214	F
130	Suir	83-7	S193 225	P	A	2173	1100	47.8	1.2	110	602	M
154	Trib of Kilmastulla	26-12	R870 720	O	E	3	1310		3.0	6	24	Operating
156	Un-named	68-11	S043 330	P	D	37	950	0.668	5	21	104	M

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES — COUNTY WATERFORD

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov Mean Flow m^3/s	Head m	Potential		Site Rating
										Inst. Cap kW	Annual Energy MWh	
3	Authnacrone	3-6	S365 213	P	D	14	1200	0.495	12.6	40	198	G
9	Clodiagh	8-2	S460 154	P	D	126	1340	4.89	7.0	315	1344	G
13	Dawn	8-16	S506 117	O	D	44	1150	1.46	8.0	30	150	Operating
18A	Un-named	12-15	S098 040	O	E	Reser-voir	—	—	44	38	76	Operating
20	Finisk	13-10	S180 067	P	D	17	1380	0.68	6.0	33	139	F
25	Mahon	15-9	S338 066	P	D	10	1610	0.467	7.5	22	111	F
27	Mahon	15-11	S392 066	P	D	48	1400	1.95	5.8	78	367	G
28	Mahon	15-11	S394 062	P	D	62	1360	2.44	2.1	33	155	M
55	Abha na Siad	21-13	X045 993	P	D	52	1350	2.03	6.0	74	396	F
46	Abha na Siad	21-1	S044 025	P	E	5.5	1270	0.203	7.4	11	48	M
47	Glenshask	21-5	S043 017	P	E	2.5	1200	0.087	25	17	70	M
56	Un-named	8-1	S450 165	O	D				6	6	21	Operating

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A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY WESTMEATH

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km²	Rainfall mm	Prov Mean Flow m³/s	Head m	Potential Inst. Cap kW	Potential Annual Energy MWh	Site Rating
9	Glore	3-6	N445 743	P	D	37	1020	0.65	3.5	14	79	M
10	Glore	3.7	N457 738	P	D	35	1020	0.607	2.5	12	54	M
21A	Tang	16-6/10	N146 540	P	D	114	950	1.841	2.0	23	124	M
22	Un-named	17-8	N302 546	O	D					3	12	Operating
27	Un-named	24-3	N267 504	P	D	20.8	1020	0.36	7.3	17	88	Operating
32	Riverstown	27-3	N564 508	O	D	70	980	1.37	5.0	25	100	Operating
34	Broonslo Stream	29-3	N075 442	P	D	54	935	0.858	3.3	17	90	M
51	Brosna	38-6	N338 366	O	D	284	970	5.5	2.0	67	270	Operating
52	Brosna	38-6	N332 356	P	D	284	970	5.5	2.5	117	495	F

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES — COUNTY WEXFORD

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catch-ment Area km^2	Rainfall mm	Prov Mean Flow m^3/s	Head m	Potential		Site Rating
										Inst. Cap kW	Annual Energy MWh	
15	Clody	9-3	S911 570	P	D	35	1100	1.04	4.8	32	166	F
18	Clody	9-7	S906 561	P	D	32	1300	1.12	14.0	74	465	G
21	Slaney	9-12	S932 545	O	D	938	1020	25.8	2.0	175	500	Operating
28	Un-named	11-13	T062 528	P	E	15	1050	0.425	5.2	18	79	M
31	Banoge	12-5	T157 563	P	D	28	1000	0.56	6.75	30	111	F
32	Owengaragh	12-6	T187 566	P	D	143	950	2.7	2.25	48	171	M
35	Un-named	14-3	S964 457	P	D	18.5	1350	0.67	4.8	18	85	F
36	Un-named	15-1	S975 506	P	D	20	1150	0.65	4.5	19	93	M
48	Urrin	19-5	S890 436	P	D	49	1250	1.65	4.57	21	153	F
54	Un-named	20-15	S014 395	P	D	48.5	950	1.24	2.5	17	97	M
69	Un-named	25-12	S936	P	D	22	1050	0.62	3.05	15	69	M
71	Urrin	26-1	S968 388	P	D	109	1160	3.41	3.0	51	273	F
73	Boro	26-5	S969 365	P	D	174	1100	5.16	2.85	80	478	F
87	Sow	32-13	T035 285	P	D	55	950	1.04	3.45	29	106	M
88	Sow	32-16	T041 281	P	B	55	950	1.04	4.75	40	146	M
89	Sow	32-16	T041 280	P	E	55	950	1.04	9.5	68	285	G*
106	Corrack	40-4	S855 187	P	D	64	1050	1.81	4.0	35	185	F
107	Owenduff	40-6	S807 171	P	D	86.7	1050	2.46	3.0	47	217	F
109	Owenduff	40-10	S831 162	P	D	86	1050	2.46	2.0	31	144	M
72	Galley	26-5	S977 375	P	E	9	975	0.237	80	11	58	M
H8	Glasha	14-7	S910 504	P	C	16	1200	0.52	4.3	14	74	M

*Major Water Supply Scheme.

HYDROELECTRIC RESOURCE SURVEY

A SUMMARY OF OPERATING AND POTENTIAL SITES COUNTY WICKLOW

Site No.	River	OS Map	Nat. Grid Reference	S	T	Catchment Area km^2	Rainfall mm	Prov Mean Flow m^3/s	Head m	Potential		Site Rating
										Inst. Cap kW	Annual Energy MWh	
1A	Glencree	2-16	O142 197	P	E	5	1400	0.154	35	42	171	G
1B	Un-named	2-16	O140 178	O	E				52	12	50	Operating
8	Dargle	7-15	O205 128	P	D	13	1600	0.458	2.5	15	60	Operating
26	Glenmacnass	17-7	O112 030	P	E	12	2000	0.528	60	287	1163	G
35	Glendassan	23-3	T120 980	O	D	15	1900	0.627	3.0	15	59	Operating
39	Un-named	25-1	T270 975	P	D	88	1285	2.488	2.0	12	84	M*
40	Vartry	25-1	T256 979	P	D	77	1285	2.170	3.0	21	133	F
47	Slaney	27-5	S868 888	P	D	162	1160	5.45	1.5	52	248	M
58	Aughrim	34-15	T131 795	P	D	159	1380	4.827	6.5	109	712	G
87	Un-named	36-3	O069 220	O	D				7.7	7	28	Operating
88	Un-named	23-2	O159 002	O	E	1	1620		25	11	44	Operating
90	Cloghoge	12-9/13	O153 087	O	E	12.5	1900	0.523	12	40	189	Operating
91	Un-named	12-9/13	O159 085	P	E	2.3	1800	0.091	120	72	341	G
92	Cloghoge	12-9/13	O159 061	P	E	30	1900	1.254	30	199	1091	G
93	Inchavore	17-3/4	O134 047	P	E	17.5	2000	0.77	45	180	990	G
H17	Un-named	6-10	O096 136	P	E	3	1800	0.11	30	12	70	M

*High Amenity.

Appendix B

List of Hydrometric Gauging Stations used for FDC Analysis
Distribution of Stations

Station No.	River	Name of Station	Grid Ref.	Catchment Area km²	Rainfall mm/yr.
0141	Deele	Sandy Mills	H273 990	113	1293
0142	Finn	Dreenan Br.	H152 945	353	1713
0351	Blackwater	Faulkland Br.	H704 379	126	1026
0611	Fane	Moyles Mill	H918 076	230	1073
0613	Dee	Charleville	O044 907	307	907
0614	Glyde	Tallanstown	N953 978	270	943
0621	Glyde	Manfieldstown	O023 952	321	928
0623	Dee	Drumgoolestown	O030 909	302	907
0625	Dee	Burley Br.	N925 896	176	930
0626	Glyde	Aclint	N893 981	144	1072
0630	Big	Ballygoly	J152 100	12	1220
0631	Flurry	Curralhir	J083 143	46	1104
0633	White	Coneyburrow Br.	O056 893	54	957
0701	Tremblestown	Tremblestown	N755 577	150	950
0703	Castlerickard	Blackwater	N716 489	179	850
0705	Boyne	Trim	N802 568	1282	913
0706	Moynalty	Fyanstown	N790 757	179	980
0709	Boyne	Navan Weir	N878 667	1610	898
0710	Blackwater	Liscarton	N846 689	717	984
0711	Blackwater	O'Daly's Br.	N652 805	294	1043
0712	Boyne	Slane Castle	N949 738	2408	920
0714	Yellow	Garr Br.	N532 369	44	912
0717	Moynalty	Rosehill	N720 852	74	1070
0723	Athboy	Athboy	N717 640	98	982
0802	Delvin	Naul	O132 612	37	850
0803	Broadmeadow	Fieldstown	O116 503	72	854
0804	Ward	Owens Br.	O132 464	42	817
0805	Sluice	Kinsealy Hall	O220 417	10	780
0806	Mayne	Hole in the Wall	O222 415	16	780
0807	Broadmeadow	Ashbourne	O087 524	34	869
0901	Ryewater	Leixlip	O005 364	215	836
0902	Griffeen	Lucan	O005 352	38	826
0905	Cannock	Clondalkin	O083 321	60	879
0999	Liffey	Burgage Br.	—	288	1356
1002	Avonmore	Rathdrum	T197 883	233	1727
1003	Avonmore	Laragh	T146 965	107	1646
1004	Glenmacrass	Laragh	T143 965	28	1978
1017	Ballyman	Ballyman	O227 187	3	1050
1101	Owenavorragh	Boleany	T170 560	148	961
1201	Slaney	Scarrawalsh	S983 450	1036	1108
1213	Slaney	Rathvilly	S882 844	185	1231
1214	Bann	Pallis Br.	T116 683	15	1200
1215	Bann	Ferns	T030 493	161	1105
1216	Boro	Dunanore	S960 364	175	1108
1301	Corock	Goffs Br.	S874 180	56	1060
1302	Corock	Foulkesmill	S854 183	64	1050
1303	Owenduff	Mullinderry	S814 158	90	1050
1404	Figile	Clonbulloge	N609 235	268	850
1405	Barrow	Portarlington	N540 126	398	981
1406	Barrow	Pass Br.	N623 109	1096	897
1418	Barrow	Royal Oak	S689 614	2415	882
1419	Barrow	Levitstown	S705 876	1660	877
1423	Barrow	Graiguenamanagh	S727 418	2795	896
1424	Burren	Coolasnachta	S818 567	6	1182
1432	Triogue	Kyle Br.	N437 038	31	875
1433	Owenass	Mountmellick	N452 082	91	1104
1434	Barrow	Bestfield Lock	S717 797	2060	840

Station No.	River	Name of Station	Grid Ref.	Catchment Area km²	Rainfall mm/yr.
1501	Kings	Annamult House	S543 443	443	991
1502	Nore	Johns Br.	S506 561	1605	979
1503	Dinan	Dinan Br.	S479 628	298	1024
1504	Nore	McMahons Br.	S418 797	491	1018
1506	Nore	Brownsbarn Br.	S617 391	2388	978
1507	Nore	Kilbricken	S362 899	343	1063
1509	Kings	Callan	S415 438	201	1034
1510	Goul	Ballyboodin Mills	S368 774	159	934
1511	Nore	Mount Juliet	S550 422	2201	974
1521	Delour	Annagh Br.	S441 717	72	1315
1602	Suir	Beakestown	S092 552	512	970
1603	Clodiagh	Rathkennan	S051 530	246	1177
1605	Multeen	Aughnagross	R991 413	87	1197
1606	Multeen	Ballinaclogh	R985 408	75	1180
1607	Aherlow	Killardry	S017 294	273	1360
1608	Suir	New Br	S001 341	1120	1030
1609	Suir	Cahir Park	S052 228	1602	1075
1610	Anner	Anner Br.	S253 256	422	984
1612	Tar	Tar Br.	S107 134	228	1332
1613	Nier	Fourmilewater	S166 135	91	1394
1618	Glengalla	Knockballiniry	S076 117	12.5	1580
1620	Clodiagh	Portlaw	S449 154	124	1345
1701	Mahon	Kilmacthomas	S395 065	62	1360
1702	Tay	Fox's Castle	S340 004	33	1437
1802	Blackwater	Ballyduff	W965 991	2338	1159
1804	Awbeg	Ballynamona	R656 076	324	1064
1805	Funshion	Downing Br.	R822 020	363	1190
1806	Blackwater	Mallow	W525 973	1058	1303
1909	Butlerstown	Brookhill	W736 763	43	1216
1914	Lee	Dromcarra	W296 675	184	1964
1915	Shournagh	Healys Br.	W606 730	210	1219
1918	Shournagh	Tower Br.	W590 746	160	1234
1920	Owencurra	Ballyedmond	W859 766	75	1224
2009	Stick	Belgooly	W663 540	37	1150
2102	Coomhola	Coomhola	V998 548	65	2168
2103	Owvane	Ballylickey	W010 536	77	1861
2104	Mealagh	Inchiclough	W027 511	46	1809
2105	Adrigole	Adrigole	V813 505	27.6	2128
2203	Brown Flesk	Dicksgrove	Q976 145	272	1354
2204	Owgarriff	Owgarriff Weir	W000 856	7	2800
2205	Torc	Torc Weir	V967 838	8	2504
2206	Flesk	Flesk	V970 892	325	1747
2301	Galey	Inch Br.	Q957 363	196	1120
2302	Feale	Listowel	Q996 333	646	1336
2306	Feale	Neodata	R115 269	300	1425
2402	Camoge	Grays Br.	R580 404	231	978
2403	Loobagh	Garoose	R549 274	129	1051
2404	Maigue	Bruree	R550 304	246	1002
2405	Morningstar	Athlacca	R557 343	140	1002
2406	Maigue	Creggane	R533 273	88	950
2506	Brosna	Ferbane	N115 244	1207	931
2513	Brosna	Newells Br.	N383 423	221	975
2514	Silver	Millbrook	N135 188	165	992

Station No.	River	Name of Station	Grid Ref.	Catchment Area km^2	Rainfall mm/yr.
2519	Cappagh	Conicar	M752 071	125	1151
2520	Killimor	Killeen	M796 111	197	999
2521	Little Brosna	Croghan	N053 056	493	958
2522	Camcor	Syngefield	N080 046	160	1042
2525	Ballyfinboy	Ballyhooney	R862 959	160	919
2527	Ollatrim	Gourdeen	R886 797	118	1077
2529	Nenagh	Clarianna	R860 822	301	1117
2530	Graney	Scarriff	R640 843	279	1280
2544	Kilmastulla	Coole Br.	R712 693	95	1157
2605	Suck	Derrycahill	M824 426	1050	1057
2606	Suck	Willsbrook	M692 756	182	1080
2612	Boyle	Tinnecarra	G770 019	520	1135
2614	Lung	Banada Br.	M634 943	222	1116
2619	Camlin	Mullagh	N116 759	260	981
2620	Camlin	Argar	N181 793	126	997
2701	Claureen	Inch Br.	R301 755	48	
3007	Clare	Ballygaddy	M420 539	458	1148
3061	Corrib	Wolf Tone Br.	M294 249	3111	1338
3204	Owenglin	Clifden	L670 504	32	1846
3301	Glenamoy	Glenamoy	F895 337	73	1459
3304	Owenmore	Kilsallagh	F956 207	166	1591
3306	Owenduff	Srahnamanragh	F812 154	121	1752
3401	Moy	Rahans	G243 180	1911	1280
3403	Moy	Foxford	G267 039	1750	1270
3410	Moy	Cloonacannana	G388 024	471	1298
3424	Pollagh	Kiltimagh	M332 893	128	1175
3501	Owenmore	Ballynacarrow	G639 219	299	1163
3502	Owenbeg	Billa Br.	G638 257	90	1428
3503	Unshin	Ballygrania	G6 97 257	212	1181
3505	Ballisodare	Ballisodare	G669 290	658	1206
3511	Bonet	Dromahaire	G805 309	294	1394
3610	Annalee	Butlers Br.	H408 104	774	1020
3615	Finn	Anlore	H537 256	155	1058
3616	Annalee	Rathkenny	H540 114	522	1030
3618	Dromore	Ashfield Br.	H575 140	233	1020
3620	Blackwater	Killywillan	H203 146	95	1325
3627	Woodford	Ballyhendy	H250 156	324	1272
3631	Cavan	Lisdarn	H414 069	62	1008
3678	Derrygooney L.	Derrygooney	H693 108	77	1000
3679	L. Bawn	Corlea	H716 116	67	1000
3801	Ownea	Clonconwall	G765 927	109	1684
3805	Owengarva	Glenties	G870 935	7	1900
3901	Swilly	Newmills	C117 092	49	1569
3903	Crana	Tullyarvan	C349 330	99	1429

Appendix C

— The application of power coefficients and energy coefficients to determine installed capacity and annual energy for any site.

— Worked Examples.

— Summary of the 85 regions for which unitised regional flow duration curves were derived. Table C1.

— Figures C1 — C10: maps showing the 85 chosen regions together with the corresponding plots of the unitised flow duration curves for all 85 regions.

— Power coefficients and energy coefficients appropriate to each region. Tables C2-C6.

The Application of Power Coefficients and Energy Coefficients to Determine Installed Capacity and Annual Energy for any site.

The prospective developer of a small scale hydro-electric station is basically interested in:

(a) the level of installed power capacity appropriate to the scheme and,

(b) the expected annual energy output from the scheme.

Assuming that the developer already knows the head available at the site, the basic remaining requirement is the magnitude and frequency of river flows at the site. This Appendix attempts to explain the use of the data herein to derive the necessary information on river flows and to apply it using power coefficients and energy coefficients respectively to determine the parameters listed under (a) and (b) above.

The 85 regions in the 26 counties for which unitised regional flow duration curves were derived together with their corresponding curves are shown in Figures C1 through C10. A list of the regions is given in Table C1. The derivation of FDC's is discussed fully in Chapter 2. The unitised flow duration curve for any particular region represents the flow at any point on a river within that region generated by 1 km^2 of contributing catchment with an annual average rainfall of 1 metre. The regions mapped in Figures C1 through C10 were all chosen on a county basis, i.e. they refer to particular river catchments within each county with a small number of curves relating specifically to the main channel of large rivers.

A unique flow duration curve for a site anywhere within the survey area can be derived as follows:

1. Determine in which region the site lies by referring to Figures C1 through C10.
2. Select the appropriate unitised flow duration curve from Figures C1 through C10 for that region.
3. Calculate the catchment area (km^2) contributing to flow at the site and the average annual rainfall (m) on that catchment.
4. Multiply the ordinates of the unitised curve by the values of catchment area and average rainfall to give the flow duration curve for that site. This curve is a plot of flows versus the percentage of time they are equalled or exceeded. The mean flow Q_m in the river corresponds to the 30 percentile ordinate of the flow duration curve for the site and consequently this ordinate on the unitised regional curve is called the provisional mean flow coefficient C_F for the region.

$$Q_m = C_F AR$$

where A is the catchment area (km^2) and R is average annual rainfall (m). The design flow Q is determined by site conditions and can be expressed as a percentage of Q_m. Design flow Q will usually not exceed 1.25 Q_m but to allow for special circumstances in certain cases values of Q in the range 1.65 Q_m down to 0.2 Q_m have been evaluated to cover all possible design flows for the various site types. The installed power capacity P at a site is given by:

$$P = 9.81\ C_F AR\ H\eta_P\ (KW)$$

Where H is design head (m) and η_P is efficiency at full capacity. The value of 9.81 C_F has been evaluated for all C_F in the range of flows 1.65 Q_m down to 0.2 Q_m and these values are listed as power coefficients C_P in Tables C2-C6

$$P = C_P\ AR\ H\eta_P \ldots\ldots .1$$

When the proportion of Q_m is selected as the design flow the corresponding power coefficient C_P is chosen from Tables C2—C6 and the installed power capacity is calculated from equation 1.

The annual energy, E, is the number of units (kilowatt hours) of electricity produced annually by the installation. The total annual river flow at the site is given by the area under the flow duration curve. The volume used to produce the annual energy, E, is calculated from the area under the flow duration curve (Fig 2.4), between the operational limits of the turbine as described in Paragraph 2.13. These limits are taken to be the value of the design flow in the case of the upper limit and 25% of this value in the case of the lower limit. This volume multiplied by 9.81 (g) and 8760 (the number of hours in a year) is known as the annual energy co-efficient, C_e, for the installation. Since the volume, and consequently C_e, depends on the particular percentage of the mean flow, Q_m chosen as the design flow, Q, it is necessary that a range of energy coefficients be available to the designer. For the present study energy coefficients have been calculated for values of Q in the range 1.65 Q_m down to 0.2 Q_m. Annual energy coefficients in this range for all 85 regional flow duration curves have been reproduced in Tables C2—C6. When the appropriate energy coefficient C_e is selected from Tables C2—C6 the annual energy potential E can be calculated from

$$E = C_e\, ARH\eta_E \quad \ldots\ldots\, 2$$

where again A is the catchment area (km^2), R is the average annual rainfall (m), H is the design head (m) and η_E is overall efficiency.

Worked Example 1

Site No. 51, Co. Cavan *Site Type D*

Data	Catchment Area A	=	349 km^2
	Average Rainfall R	=	1.266 m
	Gross Head H	=	3.0 m
	Headrace	=	5 m wide × 2 m deep

From Figure C1 the site lies in region CAV-N. From Figure C2 the provisional mean flow coefficient C_F = 28 *l*/s/km^2/m rainfall and the provisional mean flow Q_m is given by:

$$Q_m = \frac{28}{1000} \times 349 \times 1.266$$
$$= 12.37 \ m^3/s$$

The headrace is unlined and the appropriate water velocity is 0.6 m/s. Headrace capacity = 5 × 2 × 0.6 = 6m^3/s, so that for minimum alteration to the headrace the design flow can be taken at 50% Q_m (6.18 m^3/s).

From Table C2, page79: C_P = 0.136
C_e = 871.

It is assumed that development can take place at a disused lock on the river bank where the head can be maintained at 3.0 m, i.e. no head loss envisaged.

From paragraph 3.7, page 11, the appropriate efficiency, η_P, is 75% and power output P is given by:

$$P = C_P ARH\eta_P$$
$$= 0.136 \times 349 \times 1.266 \times 3 \times 0.75$$
$$= 135 \ KW$$

To calculate annual energy E, the overall efficiency η_E is assumed equal to efficiency at full capacity η_P. To allow for compensation flow in the river, the annual energy coefficient C_e is reduced by 5% to 827.45 and the annual energy is:

$$E = C_e \ ARCH\eta_E$$
$$= 827.45 \times 349 \times 1.266 \times 3 \times 0.75$$
$$= 823 \ MWh$$

Worked Example 2

Site H 17A, Co. Kerry *Site Type E*

Data:	Catchment Area A	=	1.8 km^2
	Average Rainfall R	=	2.8 m
	Gross Head H	=	90 m
	Required Penstock Length L	=	600 m

From Figure C7 the site lies in region KER-CK. From Figure C8 the provisional mean flow coefficient C_F = 31 *l*/s/km^2/m rainfall.

$$Q_m = \frac{31}{1000} \times 1.8 \times 2.8$$

$$= 0.156 \text{ m}^3/\text{s}$$

This is a high head site and the catchment area is very small and a design flow equal to 75% Q_m is considered appropriate (paragraph 3.6).

$$\text{Design Flow } Q = 0.75 \times 0.156$$
$$= 0.117 \text{ m}^3/\text{s}$$

From Table C5, *page 102*: C_P = 0.229
C_c = 1138

Assuming a maximum velocity of 2.5 m/s in the penstock, the diameter D is given by:

$$D = \sqrt{\frac{4 \times 0.117}{2.5 \times 3.16}}$$

$$= 0.244 \text{ m}$$

A suitable penstock is a 280 mm nominal diameter PVC pipe with an internal diameter of 255 mm.

$$\text{Actual Velocity} = \frac{0.117 \times 4}{3.16\,(0.255)^2}$$

$$= 2.3 \text{ m/s}$$

Taking a friction factor f for PVC of 0.015, the head loss H_L is calculated from the standard formula:

$$H_L = \frac{fLV^2}{2gD}$$

$$= \frac{0.015 \times 600 \times (2.3)^2}{2 \times 9.81 \times 0.255}$$

$$= 9.5 \text{ m}$$

$$\text{Net Head} = 90 - 9.5 = 80.5 \text{ m}$$

From paragraph 3.7 the appropriate efficiency η_P is 70%.

$$\begin{aligned} P &= C_P\, ARH\eta_P \\ &= 0.119 \times 1.8 \times 2.8 \times 80.5 \times 0.7 \\ &= 65 \text{ KW} \end{aligned}$$

The annual energy coefficient C_e is reduced by 5% to 1081 to allow for compensation flow (paragraph 3.9). Again η_E is assumed equal to η_P.

$$\begin{aligned} E &= C_e\, ARH\eta_E \\ &= 1081 \times 1.8 \times 2.8 \times 80.5 \times 0.7 \\ &= 307 \text{ MWh} \end{aligned}$$

Power Coefficients and Energy Coefficients

(see Tables C2 — C6)

The power coefficients (C_P) and the energy coefficients (C_e) in tables C2 — C6 are computed from the corresponding multiples of the 30 percentile ordinate of the unitised regional flow duration curve and have units kW/m head/m rainfall/sq km and kWh/m head/m rainfall/sq km respectively. A turbine installed to accept a design flow equal to a specific multiple of the 30 percentile ordinate of the flow duration curve in the range given will have a design installed capacity P given by:

$$P(kW) = C_P \times AREA \times RAINFALL \times HEAD \times EFFICIENCY$$

and the energy produced annually E, will be given by:

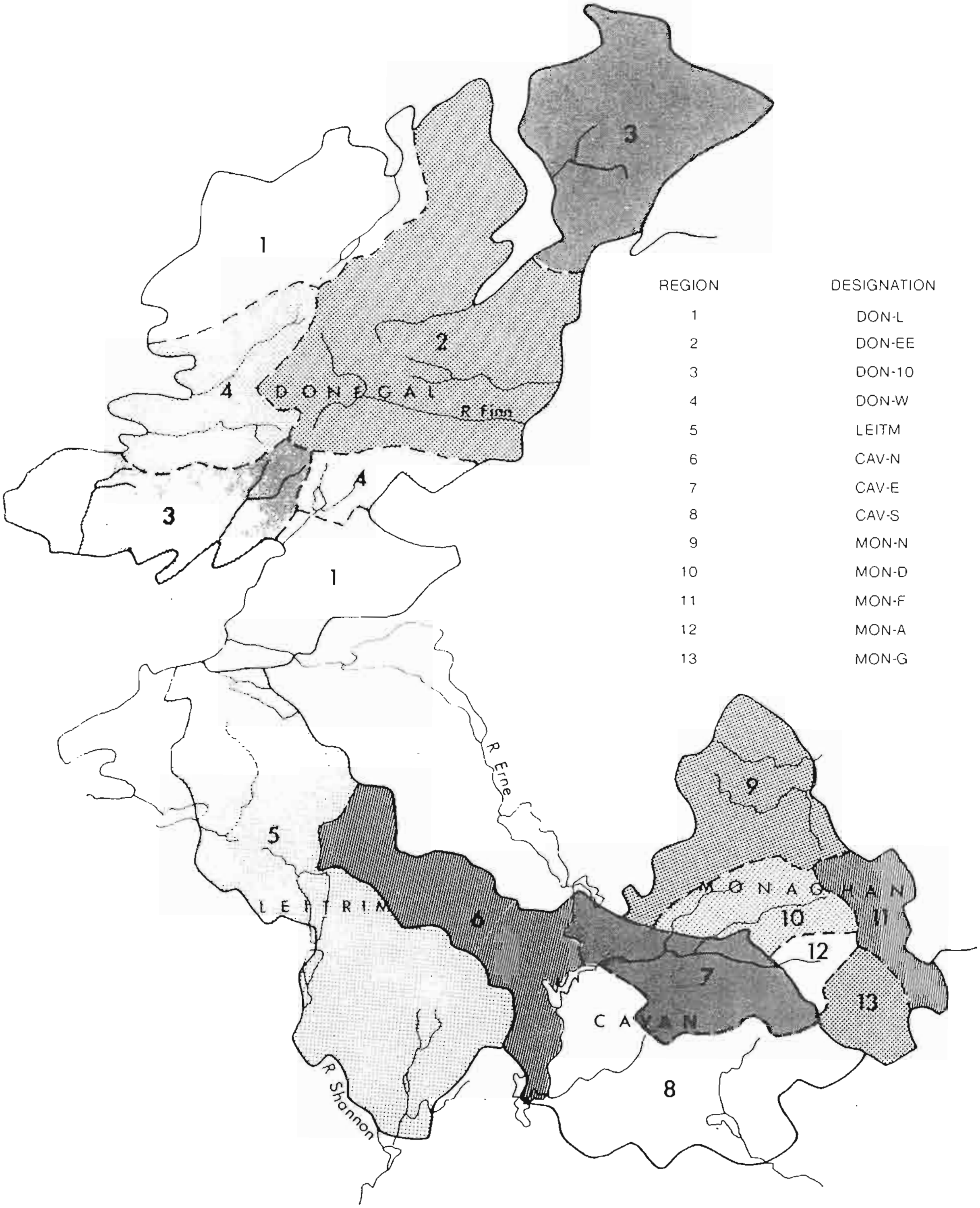
$$E(kWh) = C_e \times AREA \times RAINFALL \times HEAD \times EFFICIENCY$$

Power coefficients and energy coefficients are not given in respect of regions designated KID-L and DUB-L on Fig. C3 which refers to the main channel of the R. Liffey. Due to ESB generating stations, the flow in the river is controlled downstream of Pollaphouca and Leixlip reservoirs and a single unitised regional flow duration curve cannot be applied to any stretch of the river. Each potential site on the R. Liffey in regions DUB-L and KID-L must be treated as a special case by preparing a flow duration curve which accounts for the controlled flow in the main channel and the flow from tributary streams.

Table C1

County	Regions	Designation	Stations Used
Carlow	2	CAR-O	1213, 1216, 1424
		CAR-M	1418, 1423, 1434
Cavan	3	CAV-E	3610, 3616, 3618
		CAV-N	3620, 3627
		CAV-S	0711, 0717, 3631
Clare	2	CLA-SH	2530
		CLA-F	2701
Cork	6	COR-O	1909, 1920
		COR-C	1915, 1918
		COR-KE	2102, 2103, 2104, 2105
		COR-S	2009
		COR-E	1802, 1804, 1805, 1806
		COR-LW	1914
Donegal	4	DON-W	3801
		DON-EE	0141, 0142, 3901
		DON-IO	3903
		DON-L	3805
Dublin	5	DUB-C	0805, 0806, 0902
		DUB-N	0802
		DUB-B	0803, 0804
		DUB-S	0905, 1017
		DUB-L	0999, 0906
Galway	5	GAL-NE	2605, 2606, 2612, 2614
		GAL-W	3204
		GAL-E	2519, 2520
		GAL-C	3061
		GAL-M	3007
Kerry	3	KER-CK	2102, 2103, 2104, 2105
		KER-N	2301, 2302, 2306
		KER-C	2203, 2204, 2205, 2206
Kildare	6	KID-M	1405, 1406, 1419, 1433, 1434, 1507, 1510, 1504
		KID-L	0999, 0906
		KID-RY	0901
		KID-H	1213
		KID-BA	1405, 1406, 1419
		KID-BO	0703, 0714
Kilkenny	2	KIK-O	1501, 1503, 1509
		KIK-M	1502, 1504, 1506, 1511
Laois	2	LAO-L	1405, 1406, 1419, 1433, 1434, 1507, 1510, 1504
		LAO-H	1432, 1521
Leitrim	1	LEITM	2629, 3511, 3620, 3627
Limerick	4	LIM-E	2402, 2405
		LIM-CW	2302, 2404
		LIM-C	2403, 2404, 2406
		LIM-W	2306
Longford	1	LONFD	2619, 2620
Louth	4	LOU-C	0613, 0614, 0621, 0623, 0625, 0626
		LOU-F	0611
		LOU-S	0633
		LOU-N	0630, 0631

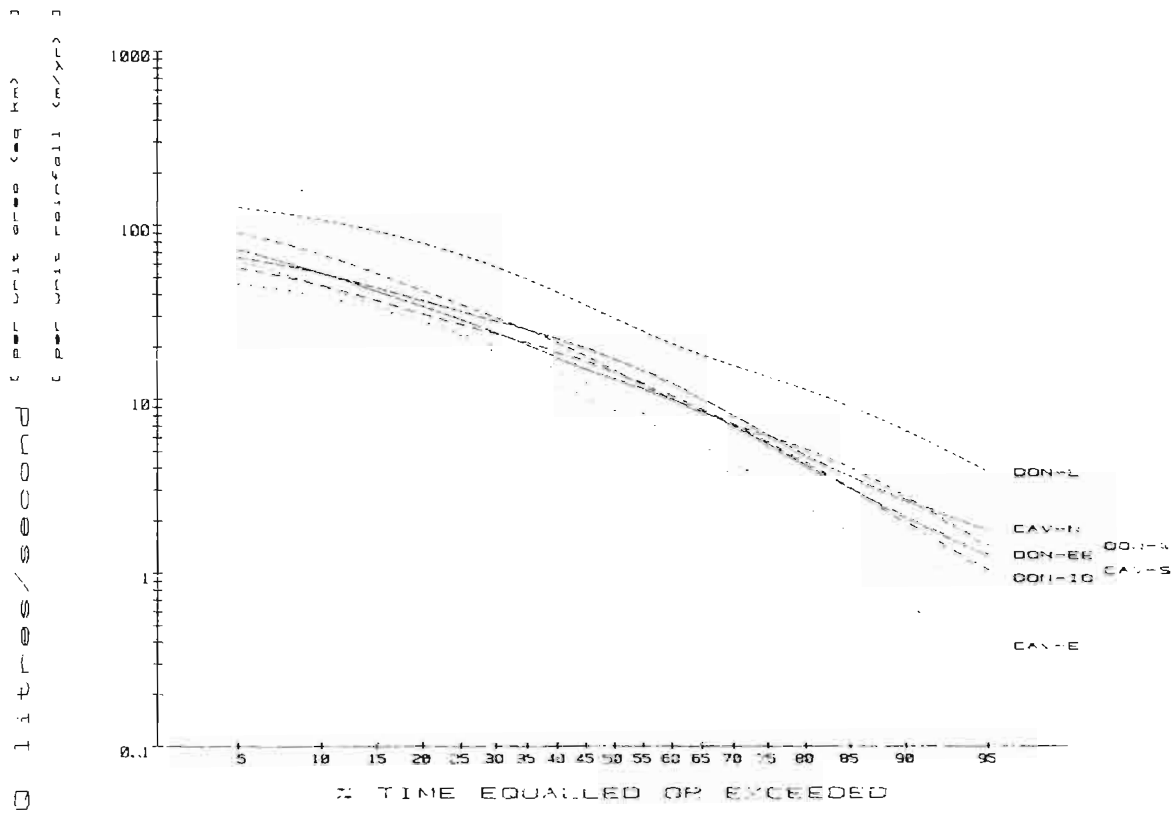
County	Regions	Designation	Stations Used
Mayo	4	MAYO-M	3401, 3403, 3410, 3424
		MAYO-H	3204
		MAYO-S	3007, 3424
		MAYO-W	3301, 3304, 3306
Meath	4	MEA-S	0701, 0703, 0705, 0709, 0723
		MEA-D	0625, 0626
		MEA-N	0706, 0710, 0711, 0712, 0802
		MEA-B	0807, 0901
Monaghan	5	MON-A	3678, 3679
		MON-G	0626
		MON-D	3616, 3618
		MON-F	0611
		MON-N	0351, 3615
Offaly	2	OFF-B	2506, 2514, 2521, 2522
		OFF-E	1404, 1405
Roscommon	1	ROS	2605, 2606, 2612, 2614
Sligo	1	SLIGO	3501, 3501, 3503, 3505, 3511
Tipperary	5	TIP-S1	1602, 1603, 1610
		TIP-S2	1605, 1606, 1607, 1612
		TIP-SM	1608, 1609
		TIP-NA	2525, 2527
		TIP-NB	2544, 2529
Waterford	1	WAT	1612, 1613, 1618, 1620, 1701, 1702
Westmeath	3	WES-M	2506, 2514, 2521, 2522
		WES-B	2513
		WES-E	0703, 0705, 0714, 0723, 1404
Wexford	3	WEX-B	1301, 1302, 1303
		WEX-R	1101
		WEX-C	1201, 1214, 1215, 1216
Wicklow	6	WIC-S1	1213
		WIC-S2	1201, 1214
		WIC-CR	1214
		WIC-R	1002
		WIC-C	1017, 1101
		WIC-M	0999, 1002, 1003, 1004, 1017



REGION	DESIGNATION
1	DON-L
2	DON-EE
3	DON-10
4	DON-W
5	LEITM
6	CAV-N
7	CAV-E
8	CAV-S
9	MON-N
10	MON-D
11	MON-F
12	MON-A
13	MON-G

FIG. C1. REGIONS FOR WHICH UNITISED FLOW DURATION CURVES WERE DERIVED

COUNTIES: DONEGAL, LEITRIM, CAVAN, MONAGHAN.



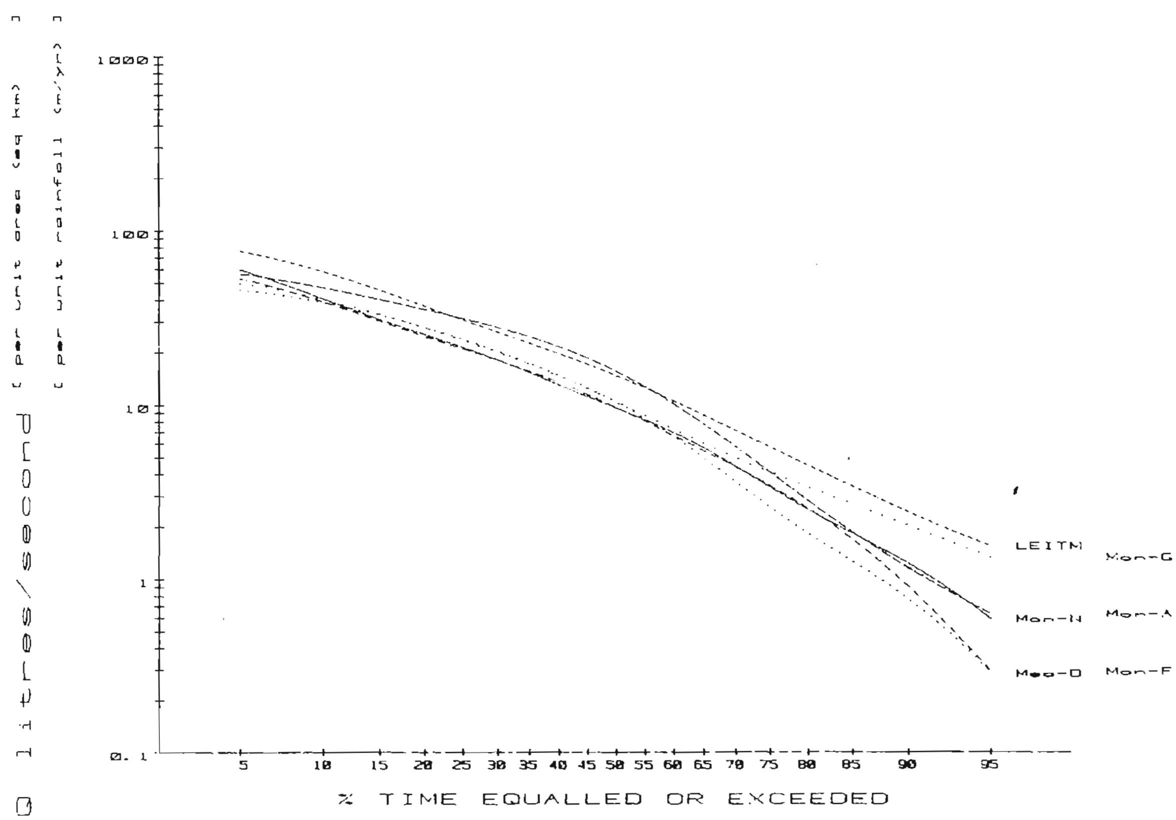


FIG. C2 UNITISED REGIONAL FLOW DURATION CURVES

TABLE C2

REGION DON—L.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.918	0.890	0.862	0.835	0.807	0.779	0.751	0.723	0.695	0.668
Ce	2984	2968	2949	2927	2904	2878	2349	2818	2784	2748

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.640	0.612	0.584	0.556	0.529	0.501	0.473	0.445	0.417	0.389
Ce	2708	2665	2618	2563	2513	2454	2389	2319	2243	2161

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.362	0.334	0.306	0.278	0.250	0.223	0.195	0.167	0.139	0.111
Ce	2072	1976	1874	1763	1645	1517	1380	1230	1065	883

REGION DON—EE.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.386	0.374	0.362	0.351	0.339	0.327	0.316	0.304	0.292	0.281
Ce	1312	1303	1294	1283	1271	1258	1244	1228	1211	1193

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.269	0.257	0.246	0.234	0.222	0.210	0.199	0.197	0.175	0.164
Ce	1173	1152	1129	1104	1078	1050	1020	988	954	917

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.152	0.140	0.129	0.117	0.105	0.094	0.082	0.070	0.058	0.047
Ce	878	836	791	743	690	633	572	506	436	361

REGION DON—IO.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.298	0.289	0.280	0.271	0.262	0.253	0.244	0.235	0.226	0.217
Ce	957	950	942	933	924	913	902	890	876	862

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.208	0.199	0.190	0.181	0.172	0.163	0.154	0.145	0.136	0.126
Ce	846	830	812	793	773	752	729	706	681	654

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.117	0.108	0.099	0.090	0.081	0.072	0.063	0.054	0.045	0.036
Ce	626	597	566	532	496	458	415	370	320	268

REGION DON—W.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.471	0.457	0.443	0.429	0.414	0.400	0.386	0.371	0.357	0.343
Ce	1535	1521	1508	1493	1477	1460	1443	1424	1404	1383

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.329	0.314	0.300	0.286	0.271	0.257	0.243	0.229	0.214	0.200
Ce	1361	1357	1312	1285	1257	1227	1194	1159	1121	1079

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.186	0.171	0.157	0.143	0.129	0.114	0.100	0.086	0.071	0.057
Ce	1034	996	933	877	818	754	885	611	531	442

REGION LEITM.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.421	0.409	0.396	0.383	0.370	0.357	0.345	0.332	0.319	0.306
Ce	1432	1422	1410	1397	1384	1369	1353	1336	1318	1298
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.294	0.281	0.268	0.255	0.243	0.230	0.217	0.204	0.191	0.179
Ce	1277	1254	1250	1204	1176	1146	1113	1078	1040	1000
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.166	0.153	0.140	0.128	0.115	0.102	0.089	0.077	0.064	0.051
Ce	956	909	959	806	749	687	622	552	477	396

REGION CAV—N.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.449	0.436	0.422	0.409	0.395	0.381	0.368	0.354	0.341	0.327
Ce	1552	1544	1534	1522	1510	1496	1481	1464	1445	1425
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.313	0.300	0.286	0.272	0.259	0.245	0.232	0.218	0.204	0.191
Ce	1403	1379	1353	1324	1293	1259	1222	1182	1138	1092
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.177	0.163	0.150	0.136	0.123	0.109	0.095	0.082	0.068	0.054
Ce	1042	988	931	871	807	739	667	591	510	424

REGION CAV—E.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.325	0.315	0.305	0.295	0.285	0.276	0.266	0.256	0.246	0.236
Ce	1046	1038	1029	1019	1008	997	984	970	955	939
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.226	0.217	0.207	0.197	0.187	0.177	0.167	0.159	0.148	0.138
Ce	921	803	883	361	838	814	788	760	731	699
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.128	0.118	0.108	0.098	0.089	0.079	0.069	0.059	0.049	0.039
Ce	666	631	594	555	513	470	423	375	323	269

REGION CAV—S.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.379	0.368	0.356	0.345	0.333	0.322	0.310	0.299	0.287	0.276
Ce	1310	1303	1295	1286	1277	1266	1253	1240	1225	1209
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.264	0.253	0.241	0.230	0.218	0.207	0.195	0.184	0.172	0.161
Ce	1181	1171	1149	1125	1099	1071	1040	1006	969	930
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.149	0.138	0.126	0.115	0.103	0.092	0.080	0.069	0.057	0.046
Ce	887	842	793	741	686	627	565	499	428	353

REGION MON—N.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.292	0.283	0.274	0.265	0.256	0.247	0.239	0.230	0.221	0.212
Ce	970	963	955	947	937	927	916	904	891	876

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.203	0.194	0.186	0.177	0.168	0.159	0.150	0.141	0.133	0.124
Ce	861	844	827	808	788	766	744	719	694	666

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.115	0.106	0.097	0.088	0.080	0.071	0.062	0.053	0.044	0.035
Ce	637	606	573	537	499	458	414	367	316	263

REGION MON—D.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.326	0.316	0.306	0.297	0.287	0.277	0.267	0.257	0.247	0.237
Ce	1056	1043	1039	1029	1013	1006	993	978	963	947

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.227	0.217	0.208	0.198	0.188	0.178	0.168	0.158	0.148	0.138
Ce	929	910	890	868	845	821	795	767	737	706

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.129	0.119	0.109	0.099	0.089	0.079	0.069	0.059	0.049	0.040
Ce	672	637	600	560	519	475	429	390	328	273

REGION MON—F.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.291	0.282	0.273	0.264	0.255	0.247	0.238	0.229	0.220	0.211
Ce	961	954	946	938	929	919	909	897	885	872

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.203	0.194	0.185	0.176	0.167	0.158	0.150	0.141	0.132	0.123
Ce	858	842	826	808	783	767	744	720	694	666

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.114	0.106	0.097	0.083	0.079	0.070	0.062	0.053	0.044	0.035
Ce	636	604	570	533	495	453	410	363	312	259

REGION MON—A.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.448	0.435	0.421	0.407	0.394	0.380	0.367	0.353	0.339	0.326
Ce	1459	1452	1444	1435	1424	1411	1397	1381	1363	1343

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.312	0.299	0.285	0.272	0.258	0.244	0.231	0.217	0.204	0.190
Ce	1321	1297	1270	1241	1209	1174	1137	1096	1053	1008

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.177	0.163	0.149	0.136	0.122	0.109	0.095	0.081	0.068	0.054
Ce	959	908	853	796	736	672	605	535	461	383

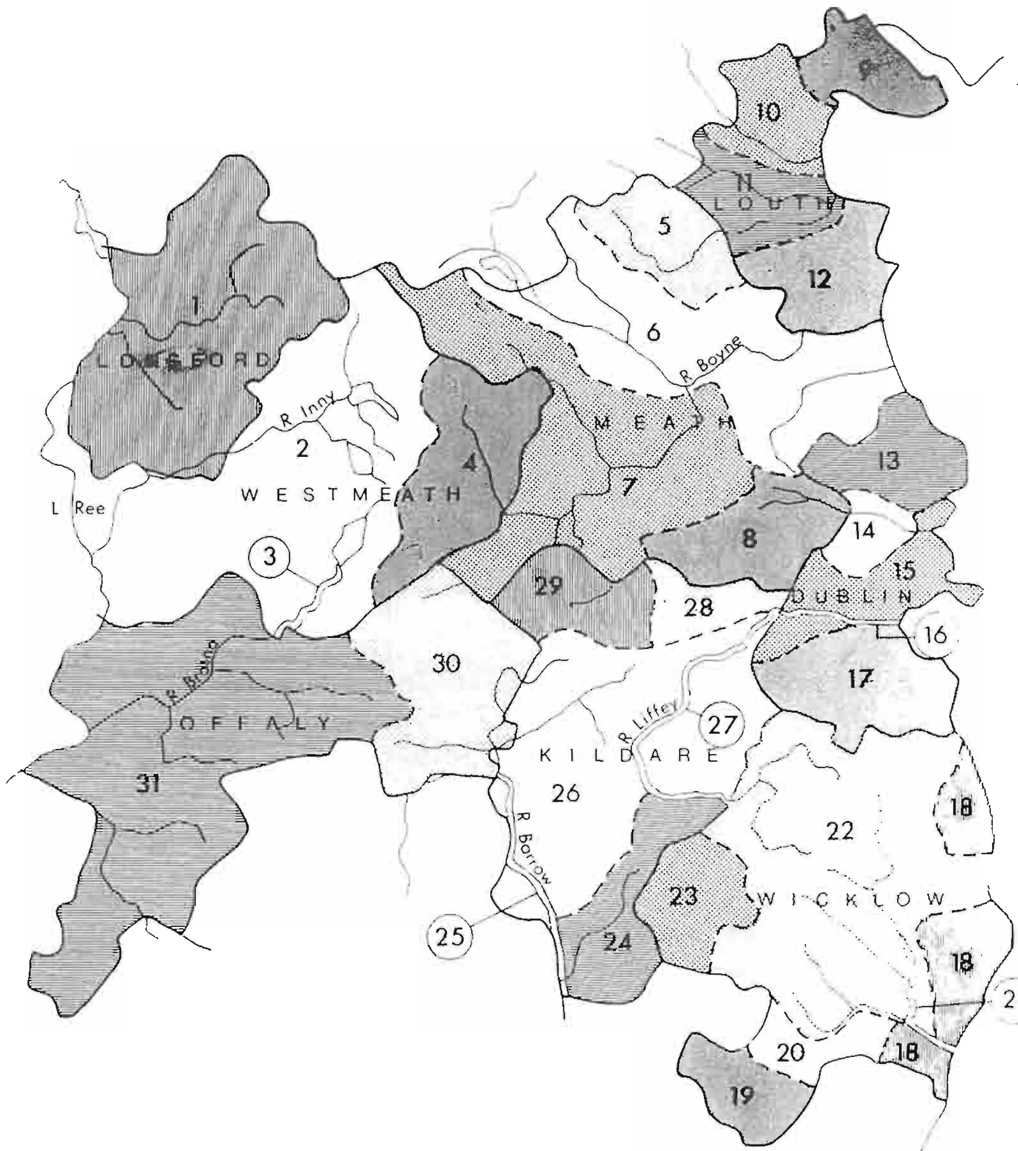
REGION MON—G.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.322	0.312	0.302	0.292	0.283	0.273	0.263	0.253	0.244	0.234
Ce	1056	1048	1040	1031	1021	1011	999	987	973	959

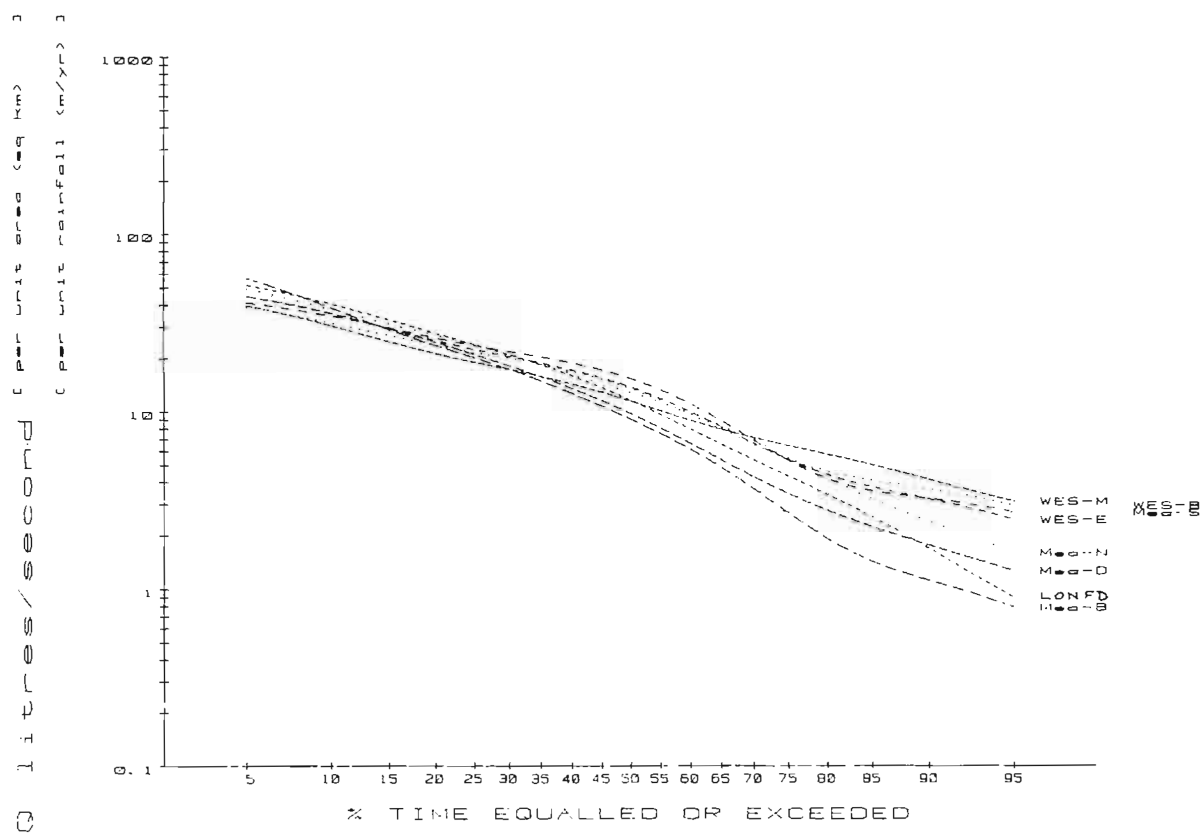
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.224	0.214	0.205	0.195	0.185	0.175	0.166	0.156	0.146	0.136
Ce	943	926	906	889	868	846	823	797	770	741

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.127	0.117	0.107	0.097	0.088	0.078	0.068	0.058	0.049	0.039
Ce	711	677	642	604	563	519	471	420	365	305



REGION	DESIGNATION	REGION	DESIGNATION
1	LONFD	17	DUB-S
2	WES-M	18	WIC-C
3	WES-B	19	WIC-S2
4	WES-E	20	WIC-CR
5	MEA-D	21	WIC-R
6	MEA-N	22	WIC-M
7	MEA-S	23	WIC-S1
8	MEA-B	24	KID-H
9	LOU-N	25	KID-BA
10	LOU-F	26	KID-M
11	LOU-C	27	KID-L
12	LOU-S	28	KID-RY
13	DUB-N	29	KID-BO
14	DUB-B	30	OFF-E
15	DUB-C	31	OFF-B
16	DUB-L		

FIG. C3 REGIONS FOR WHICH UNITISED FLOW DURATION CURVES WERE DERIVED.
COUNTIES: LONGFORD, WESTMEATH, MEATH, LOUTH, DUBLIN, WICKLOW, KILDARE, OFFALY.



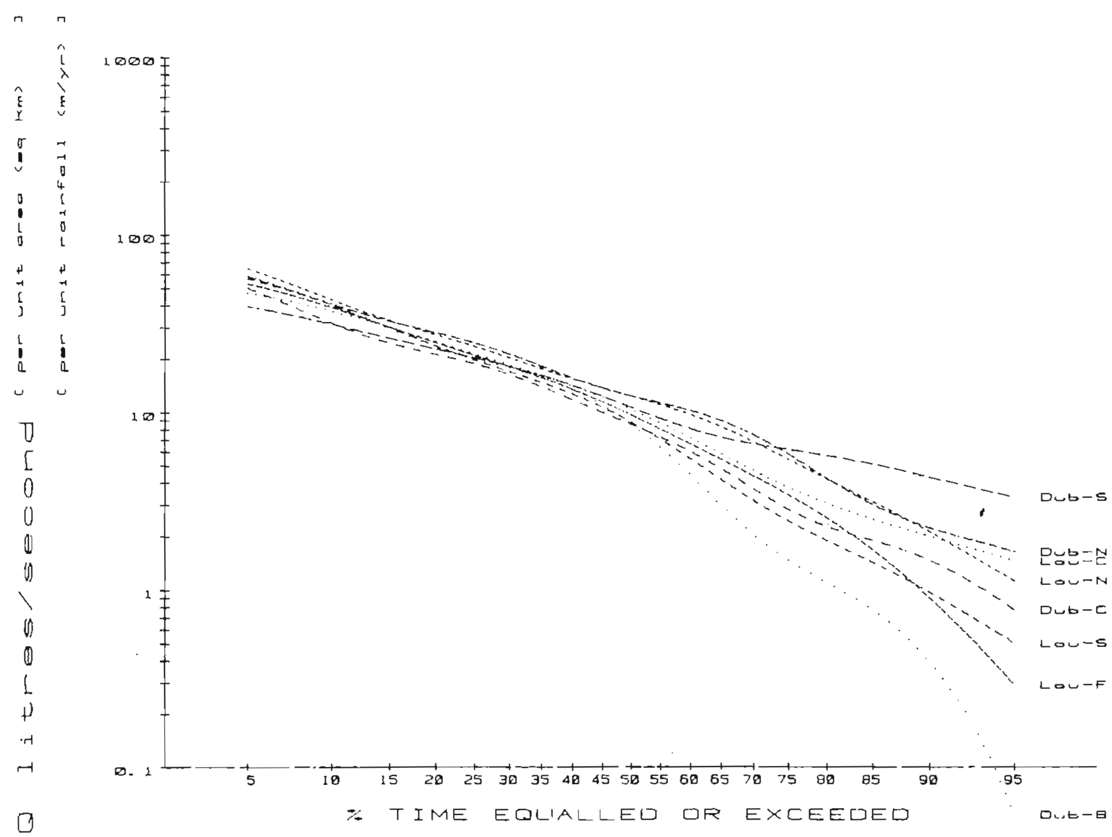
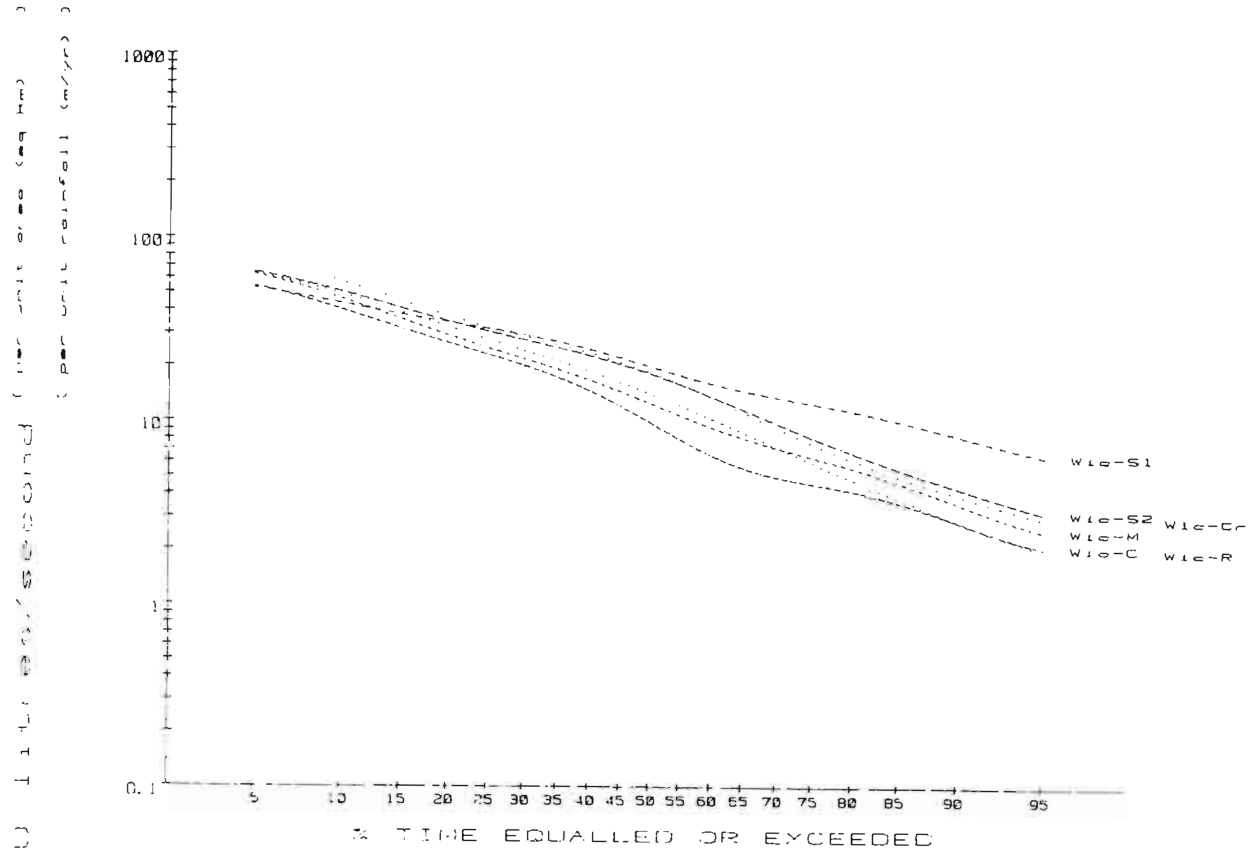


FIG. C4 UNITISED REGIONAL FLOW DURATION CURVES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5
10
15
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25
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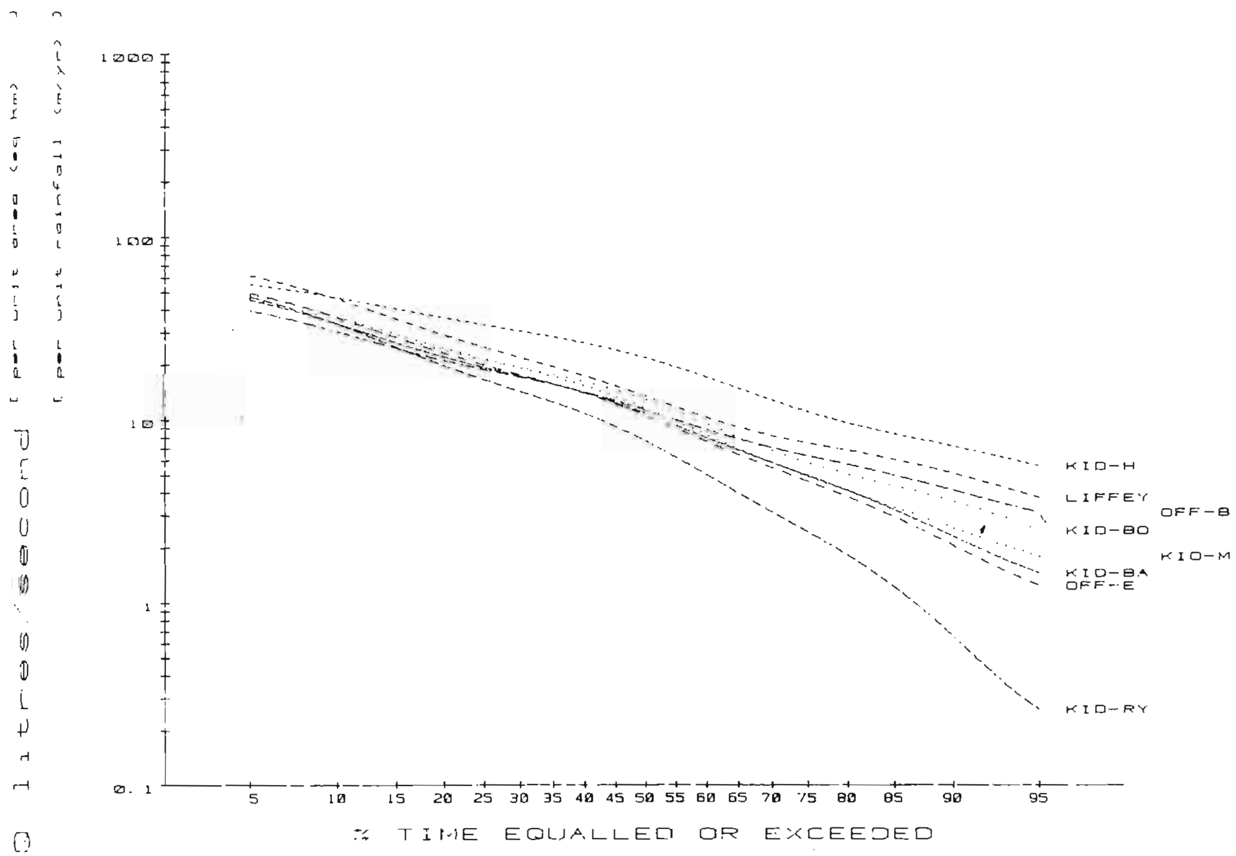
45
50
55
60
65
70
75
80
85
90
95
% TIME EQUALLED OR EXCEEDED
Wic-S1
Wic-S2
Wic-M
Wic-C
Wic-Cr
Wic-R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0.1
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
% TIME EQUALLED OR EXCEEDED
KID-H
LIFFEY
OFF-B
KID-BO
KID-M
KID-BA
OFF-E
KID-RY

TABLE C3

REGION LONFD.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.335	0.325	0.315	0.304	0.294	0.284	0.274	0.264	0.254	0.244
Ce	1110	1103	1096	1087	1078	1068	1057	1045	1031	1017

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.233	0.223	0.213	0.203	0.193	0.183	0.172	0.162	0.152	0.142
Ce	1001	984	965	945	922	899	873	845	815	782

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.132	0.122	0.112	0.101	0.091	0.081	0.071	0.061	0.051	0.041
Ce	748	711	671	629	594	537	485	431	372	309

REGION WES—M.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.276	0.268	0.259	0.251	0.243	0.234	0.226	0.219	0.209	0.201
Ce	1012	1012	1011	1010	1009	1006	1002	997	990	982

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.192	0.184	0.176	0.167	0.159	0.151	0.142	0.134	0.125	0.117
Ce	972	960	945	929	910	889	865	839	810	779

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.109	0.100	0.092	0.084	0.075	0.067	0.059	0.050	0.042	0.033
Ce	745	709	671	629	584	533	479	420	356	289

REGION WES—B.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.319	0.309	0.299	0.290	0.280	0.270	0.261	0.251	0.241	0.232
Ce	1105	1102	1099	1095	1090	1084	1077	1069	1060	1050

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.222	0.212	0.203	0.193	0.183	0.174	0.164	0.154	0.145	0.135
Ce	1038	1025	1009	992	972	951	927	902	874	842

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.126	0.116	0.106	0.097	0.087	0.077	0.068	0.058	0.048	0.039
Ce	805	765	721	675	626	574	518	460	397	328

REGION WES—E.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.326	0.316	0.306	0.297	0.287	0.277	0.267	0.257	0.247	0.237
Ce	1152	1147	1141	1135	1123	1119	1110	1100	1089	1076

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.227	0.218	0.208	0.198	0.188	0.178	0.168	0.158	0.148	0.138
Ce	1062	1046	1029	1010	988	964	937	908	877	844

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.129	0.119	0.109	0.099	0.089	0.079	0.069	0.059	0.049	0.040
Ce	808	768	725	678	628	575	519	460	397	329

REGION MEA—D.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.290	0.281	0.272	0.264	0.255	0.246	0.237	0.229	0.220	0.211
Ce	956	950	942	934	925	915	905	893	881	868

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.202	0.193	0.135	0.176	0.167	0.158	0.149	0.141	0.132	0.123
Ce	853	837	821	803	783	762	740	716	691	664

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.114	0.105	0.097	0.088	0.079	0.070	0.062	0.053	0.044	0.035
Ce	635	605	572	538	501	462	420	374	326	272

REGION MEA—N.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.335	0.325	0.315	0.305	0.295	0.234	0.274	0.264	0.254	0.244
Ce	1165	1161	1155	1148	1141	1132	1122	1110	1097	1083

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.234	0.223	0.213	0.203	0.193	0.183	0.173	0.163	0.152	0.142
Ce	1067	1049	1029	1008	985	960	933	903	872	838

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.132	0.122	0.112	0.102	0.091	0.081	0.071	0.061	0.051	0.041
Ce	902	762	720	674	625	572	516	456	392	324

REGION MEA—S.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.348	0.338	0.327	0.317	0.306	0.295	0.285	0.274	0.264	0.253
Ce	1239	1225	1220	1214	1207	1200	1190	1180	1168	1155

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.243	0.232	0.222	0.211	0.201	0.190	0.179	0.169	0.158	0.143
Ce	1140	1123	1104	1082	1057	1029	999	964	927	889

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.137	0.127	0.116	0.106	0.095	0.084	0.074	0.063	0.053	0.042
Ce	849	811	768	719	665	608	548	484	418	348

REGION MEA—B.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.277	0.268	0.260	0.252	0.243	0.235	0.227	0.219	0.210	0.201
Ce	907	900	893	984	876	866	855	844	832	819

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.193	0.185	0.176	0.168	0.159	0.151	0.143	0.134	0.126	0.117
Ce	904	789	772	754	734	714	692	668	643	616

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.109	0.101	0.092	0.084	0.076	0.087	0.059	0.050	0.042	0.034
Ce	538	553	526	492	456	418	379	337	292	245

REGION LOU—N.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.326	0.316	0.306	0.297	0.287	0.277	0.267	0.257	0.247	0.237
Ce	1157	1150	1142	1133	1124	1113	1102	1089	1075	1060

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.227	0.217	0.208	0.198	0.188	0.178	0.168	0.158	0.148	0.138
Ce	1043	1025	1006	985	962	938	912	895	854	822

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.128	0.119	0.108	0.099	0.089	0.079	0.069	0.059	0.049	0.040
Ce	787	748	705	659	610	557	500	441	379	311

REGION LOU—F.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.291	0.282	0.273	0.264	0.255	0.247	0.238	0.229	0.220	0.211
Ce	961	954	946	938	929	919	909	897	885	872

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.203	0.194	0.185	0.176	0.167	0.158	0.150	0.141	0.132	0.123
Ce	858	842	826	808	788	767	744	720	694	666

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.114	0.106	0.097	0.088	0.079	0.070	0.062	0.053	0.044	0.035
Ce	636	604	570	533	495	453	410	363	312	259

REGION LOU—C.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.297	0.288	0.279	0.270	0.261	0.252	0.243	0.234	0.225	0.216
Ce	997	990	983	974	965	955	945	933	920	907

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.207	0.198	0.189	0.180	0.171	0.162	0.153	0.144	0.135	0.126
Ce	892	876	859	841	821	799	776	752	725	697

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.117	0.108	0.099	0.090	0.081	0.072	0.063	0.054	0.045	0.036
Ce	667	635	601	565	527	485	440	392	340	284

REGION LOU—S.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.272	0.264	0.256	0.247	0.239	0.231	0.223	0.214	0.206	0.198
Ce	892	883	874	865	855	844	833	821	808	795

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.190	0.181	0.173	0.165	0.157	0.148	0.140	0.132	0.124	0.115
Ce	780	765	748	731	712	691	669	646	621	595

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.107	0.099	0.091	0.082	0.074	0.066	0.058	0.049	0.041	0.033
Ce	567	538	507	475	441	405	367	326	293	237

REGION DUB—N.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.343	0.331	0.321	0.311	0.300	0.290	0.280	0.269	0.259	0.249
Ce	1203	1198	1191	1183	1174	1164	1152	1138	1124	1107

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.238	0.228	0.217	0.207	0.197	0.186	0.176	0.166	0.155	0.145
Ce	1089	1070	1049	1026	1002	976	948	919	888	854

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.135	0.124	0.114	0.104	0.093	0.083	0.072	0.062	0.052	0.041
Ce	818	779	737	690	639	584	526	464	393	329

REGION DUB—B.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.286	0.277	0.269	0.260	0.251	0.243	0.234	0.225	0.217	0.208
Ce	905	897	888	878	869	857	845	833	820	805

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.199	0.191	0.182	0.173	0.165	0.156	0.147	0.139	0.130	0.121
Ce	790	773	755	736	715	692	668	642	615	586

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.113	0.104	0.095	0.087	0.078	0.069	0.061	0.052	0.043	0.035
Ce	556	525	492	458	422	385	347	308	267	223

REGION DUB—C.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.262	0.254	0.246	0.238	0.231	0.223	0.215	0.207	0.199	0.191
Ce	850	846	841	835	828	821	812	803	792	780

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.183	0.175	0.167	0.159	0.151	0.143	0.135	0.127	0.119	0.111
Ce	767	752	736	720	701	682	661	640	616	592

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.103	0.095	0.087	0.079	0.072	0.064	0.056	0.048	0.040	0.032
Ce	566	539	511	481	449	414	375	333	288	240

REGION DUB—S.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.291	0.283	0.274	0.265	0.256	0.247	0.238	0.229	0.221	0.212
Ce	999	1000	1001	1002	1003	1004	1005	1003	999	993

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.203	0.194	0.185	0.176	0.168	0.159	0.150	0.141	0.132	0.124
Ce	983	971	956	939	920	899	875	849	821	792

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.115	0.106	0.097	0.088	0.079	0.071	0.062	0.053	0.044	0.035
Ce	760	726	689	649	604	556	503	442	376	306

REGION WIC—C.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.324	0.315	0.305	0.295	0.285	0.275	0.265	0.256	0.246	0.236
Ce	1034	1027	1019	1010	1001	991	980	969	957	944

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.226	0.216	0.206	0.197	0.187	0.177	0.167	0.157	0.147	0.138
Ce	930	916	901	886	872	857	840	817	792	763

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.128	0.118	0.108	0.098	0.088	0.079	0.069	0.059	0.049	0.039
Ce	731	697	661	623	582	539	498	446	390	325

REGION WIC—S2.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.447	0.434	0.420	0.406	0.393	0.379	0.366	0.352	0.339	0.325
Ce	1598	1592	1585	1576	1567	1556	1544	1530	1515	1498

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.312	0.298	0.285	0.271	0.257	0.244	0.230	0.217	0.203	0.190
Ce	1479	1458	1435	1408	1379	1346	1309	1269	1225	1176

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.176	0.163	0.149	0.135	0.122	0.108	0.095	0.081	0.068	0.054
Ce	1124	1068	1008	943	874	801	723	639	549	452

REGION WIC—CR.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.465	0.450	0.436	0.422	0.408	0.394	0.380	0.366	0.352	0.338
Ce	1641	1632	1622	1611	1599	1585	1571	1555	1538	1519

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.324	0.310	0.296	0.282	0.267	0.253	0.239	0.225	0.211	0.197
Ce	1498	1475	1450	1422	1391	1357	1319	1278	1233	1184

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.183	0.169	0.155	0.141	0.127	0.113	0.099	0.084	0.070	0.053
Ce	1132	1075	1015	951	882	809	732	649	560	463

REGION WIC—R.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.389	0.378	0.366	0.354	0.342	0.330	0.319	0.307	0.295	0.283
Ce	1340	1332	1323	1313	1303	1291	1278	1264	1249	1232

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.271	0.260	0.248	0.236	0.224	0.212	0.201	0.199	0.177	0.165
Ce	1214	1194	1173	1149	1123	1096	1065	1033	997	959

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.153	0.142	0.130	0.118	0.106	0.094	0.083	0.071	0.059	0.047
Ce	917	873	825	773	719	660	597	530	458	381

REGION WIC—M.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.353	0.342	0.331	0.321	0.310	0.299	0.288	0.278	0.267	0.256
Ce	1210	1204	1198	1191	1184	1177	1168	1159	1149	1138

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.246	0.235	0.224	0.214	0.203	0.192	0.182	0.171	0.160	0.150
Ce	1125	1110	1093	1073	1051	1027	999	969	937	902

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.139	0.128	0.118	0.107	0.096	0.085	0.075	0.064	0.053	0.043
Ce	864	823	780	733	684	630	575	509	436	358

REGION WIC—S1.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.476	0.462	0.447	0.433	0.418	0.404	0.389	0.375	0.361	0.346
Ce	1793	1800	1806	1808	1808	1806	1801	1793	1782	1768

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.332	0.317	0.303	0.288	0.274	0.260	0.245	0.231	0.216	0.202
Ce	1751	1730	1704	1675	1640	1602	1559	1513	1462	1407

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.188	0.173	0.159	0.144	0.130	0.115	0.101	0.097	0.072	0.058
Ce	1348	1283	1210	1131	1045	950	847	738	623	503

REGION KID—H.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.493	0.478	0.463	0.448	0.433	0.418	0.403	0.388	0.373	0.358
Ce	1809	1810	1809	1807	1804	1799	1793	1785	1775	1763

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.343	0.328	0.314	0.299	0.284	0.269	0.254	0.239	0.224	0.209
Ce	1748	1730	1709	1682	1650	1613	1569	1520	1466	1406

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.194	0.179	0.164	0.149	0.134	0.119	0.105	0.090	0.075	0.060
Ce	1341	1271	1197	1119	1033	944	848	745	634	515

REGION KID—BA.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.280	0.271	0.263	0.254	0.246	0.237	0.229	0.220	0.212	0.204
Ce	978	974	970	964	959	952	945	937	927	917

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.195	0.197	0.178	0.170	0.161	0.153	0.144	0.136	0.127	0.119
Ce	906	893	878	861	843	822	799	774	746	717

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.110	0.102	0.093	0.085	0.076	0.068	0.059	0.051	0.042	0.034
Ce	685	650	614	575	533	488	441	390	336	277

REGION KID—M.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.310	0.301	0.291	0.282	0.273	0.263	0.254	0.244	0.235	0.226
Ce	1062	1056	1050	1044	1037	1029	1020	1010	999	987

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.216	0.207	0.197	0.188	0.179	0.169	0.160	0.150	0.141	0.132
Ce	974	959	943	925	905	883	859	833	804	773

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.122	0.113	0.103	0.094	0.085	0.075	0.066	0.056	0.047	0.038
Ce	739	703	665	623	579	532	482	429	371	307

REGION KID—RY.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.231	0.224	0.217	0.210	0.203	0.196	0.189	0.182	0.175	0.168
Ce	763	756	749	742	734	725	716	707	696	685

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.161	0.154	0.147	0.140	0.133	0.126	0.119	0.112	0.105	0.098
Ce	674	661	648	633	617	600	582	563	542	519

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.091	0.084	0.077	0.070	0.063	0.056	0.049	0.042	0.035	0.028
Ce	496	470	443	415	385	353	319	292	244	202

REGION KID—BO.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.311	0.302	0.292	0.283	0.273	0.264	0.254	0.245	0.236	0.226
Ce	1110	1106	1101	1095	1089	1082	1075	1066	1057	1047

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.217	0.207	0.198	0.188	0.179	0.170	0.160	0.151	0.141	0.132
Ce	1035	1023	1008	992	973	952	927	899	867	833

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.123	0.113	0.104	0.094	0.085	0.075	0.066	0.057	0.047	0.038
Ce	795	755	711	665	616	564	509	450	386	317

REGION OFF—E.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.285	0.276	0.268	0.259	0.250	0.242	0.233	0.224	0.216	0.207
Ce	980	975	969	963	956	948	939	930	920	909

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.198	0.190	0.181	0.173	0.164	0.155	0.147	0.138	0.129	0.121
Ce	897	883	868	851	833	812	780	765	738	709

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.112	0.104	0.095	0.086	0.078	0.069	0.060	0.052	0.043	0.035
Ce	677	644	608	569	529	485	438	388	334	277

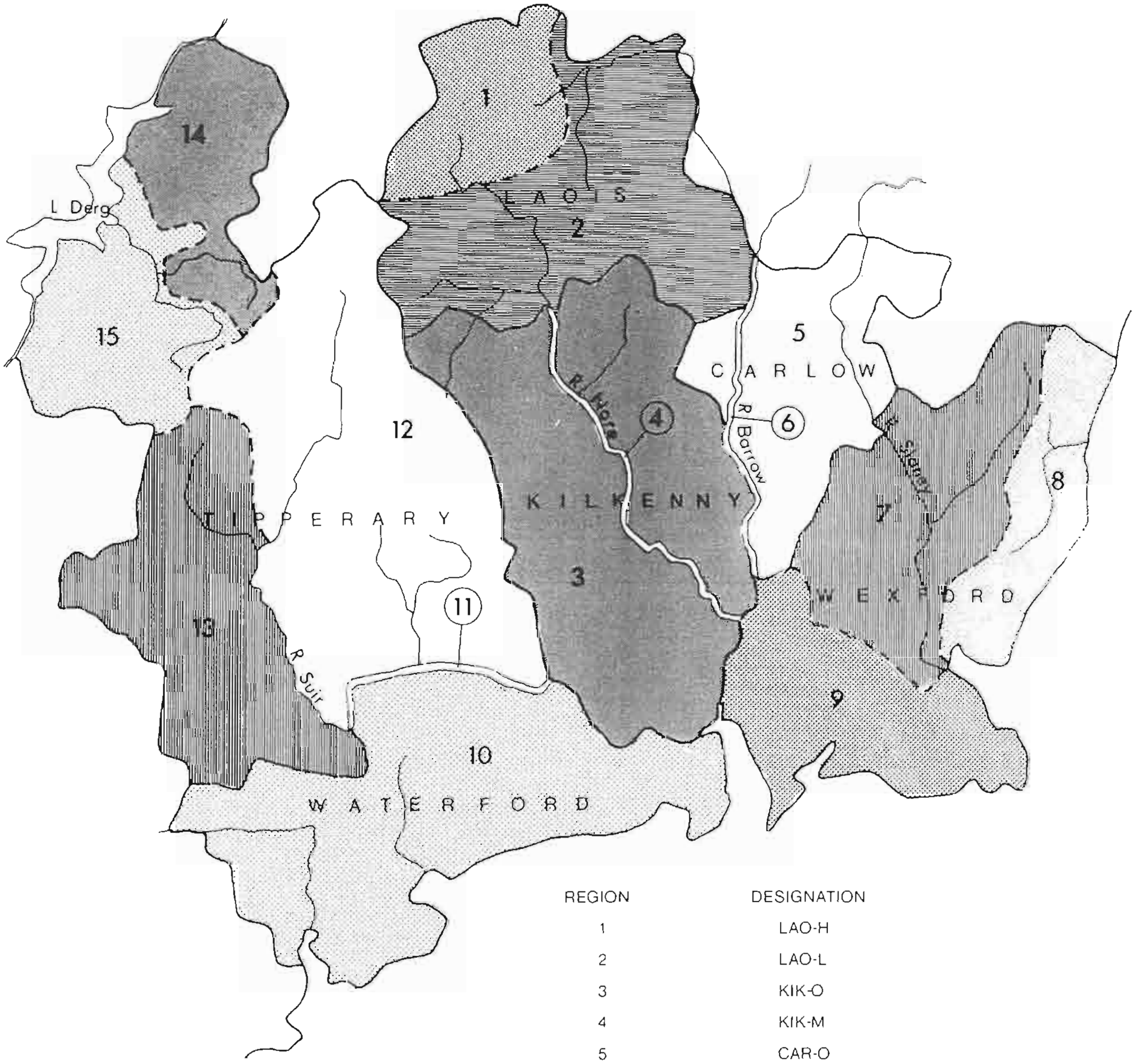
REGION OFF—B.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.276	0.268	0.259	0.251	0.243	0.234	0.226	0.219	0.209	0.201
Ce	1012	1012	1011	1010	1009	1006	1002	997	990	982

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.192	0.184	0.176	0.167	0.159	0.151	0.142	0.134	0.125	0.117
Ce	972	960	945	929	910	889	865	839	810	779

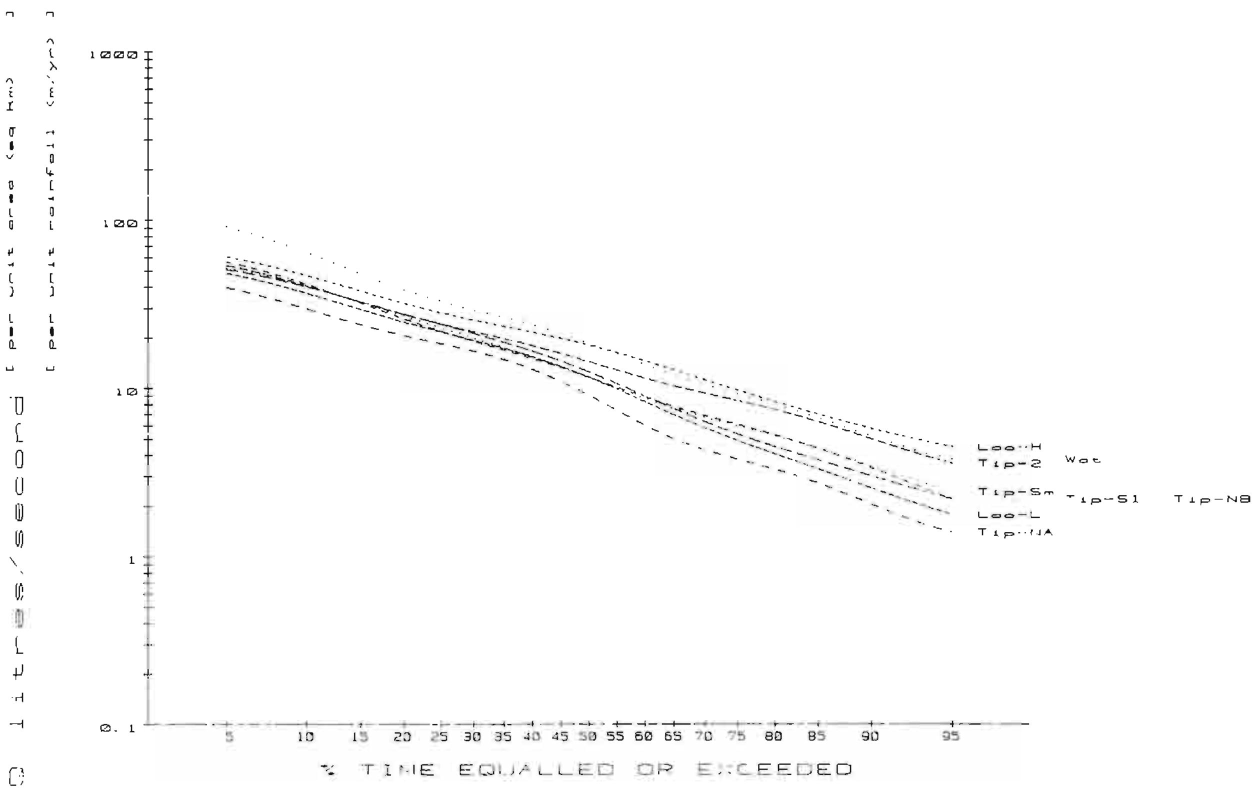
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.109	0.100	0.092	0.084	0.075	0.067	0.059	0.050	0.042	0.033
Ce	745	709	671	629	584	533	479	420	356	289



REGION	DESIGNATION
1	LAO-H
2	LAO-L
3	KIK-O
4	KIK-M
5	CAR-O
6	CAR-M
7	WEX-C
8	WEX-R
9	WEX-B
10	WAT
11	TIP-SM
12	TIP-S1
13	TIP-S2
14	TIP-NA
15	TIP-NB

FIG. C5 REGIONS FOR WHICH UNITISED FLOW DURATION CURVES WERE DERIVED.

COUNTIES: LAOIS, CARLOW, KILKENNY, WEXFORD, WATERFORD, TIPPERARY.



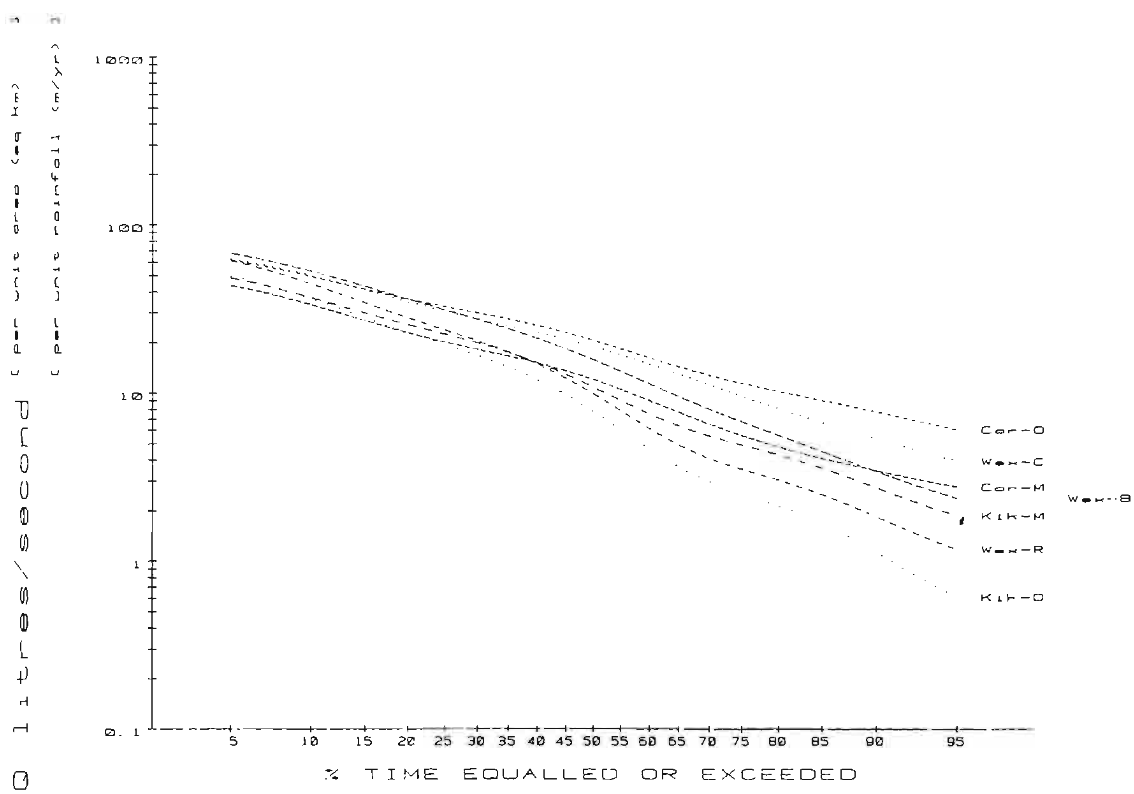


FIG. C6 UNITISED REGIONAL FLOW DURATION CURVES

TABLE C4

REGION LAO—H.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.409	0.397	0.384	0.372	0.360	0.347	0.335	0.322	0.310	0.298
Ce	1563	1558	1553	1546	1539	1530	1520	1508	1495	1481
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.285	0.273	0.260	0.248	0.236	0.223	0.211	0.198	0.186	0.174
Ce	1464	1445	1424	1400	1373	1341	1306	1267	1223	1175
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.161	0.149	0.136	0.124	0.112	0.099	0.087	0.074	0.062	0.050
Ce	1123	1066	1005	939	866	788	706	619	527	429

REGION LAO—L.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.310	0.301	0.291	0.282	0.273	0.263	0.254	0.244	0.235	0.226
Ce	1062	1056	1050	1044	1037	1029	1020	1010	999	987
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.216	0.207	0.197	0.188	0.179	0.169	0.160	0.150	0.141	0.132
Ce	974	959	943	925	905	883	859	833	804	773
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.122	0.113	0.103	0.094	0.085	0.075	0.066	0.056	0.047	0.038
Ce	739	703	665	623	579	532	482	429	371	307

REGION KIK—O.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.268	0.260	0.252	0.244	0.235	0.227	0.219	0.211	0.203	0.195
Ce	846	838	830	821	811	801	791	779	767	753
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.187	0.179	0.170	0.162	0.154	0.146	0.138	0.130	0.123	0.114
Ce	739	724	708	691	673	653	633	612	589	566
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.106	0.097	0.089	0.081	0.073	0.065	0.057	0.049	0.041	0.032
Ce	542	516	490	461	430	396	360	322	281	237

REGION KIK—M.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.319	0.309	0.299	0.290	0.230	0.270	0.261	0.251	0.241	0.232
Ce	1046	1041	1035	1029	1022	1014	1005	996	936	975
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.222	0.212	0.203	0.193	0.183	0.174	0.164	0.154	0.145	0.135
Ce	963	950	936	920	902	882	859	834	806	776
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.126	0.116	0.106	0.097	0.087	0.077	0.069	0.058	0.048	0.039
Ce	743	708	670	630	537	542	493	442	384	317

REGION CAR—O.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.481	0.466	0.451	0.437	0.422	0.408	0.393	0.379	0.364	0.350
Ce	1782	1783	1783	1782	1780	1776	1771	1764	1754	1742

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.335	0.320	0.306	0.291	0.277	0.262	0.248	0.233	0.218	0.204
Ce	1726	1706	1682	1654	1621	1584	1541	1494	1442	1386

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.189	0.175	0.160	0.146	0.131	0.117	0.102	0.087	0.073	0.058
Ce	1325	1259	1189	1112	1029	939	643	738	625	506

REGION CAR—M.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.292	0.283	0.274	0.265	0.257	0.248	0.239	0.230	0.221	0.212
Ce	1046	1042	1038	1033	1027	1020	1013	1005	996	986

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.203	0.185	0.186	0.177	0.168	0.159	0.150	0.142	0.133	0.124
Ce	975	962	948	932	914	894	871	846	818	767

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.115	0.106	0.097	0.088	0.080	0.071	0.062	0.053	0.044	0.035
Ce	753	716	676	634	589	539	486	429	368	302

REGION WEX—C.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.442	0.428	0.415	0.402	0.388	0.375	0.362	0.348	0.335	0.321
Ce	1640	1635	1629	1621	1612	1602	1591	1578	1563	1547

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.308	0.295	0.281	0.268	0.254	0.241	0.228	0.214	0.201	0.187
Ce	1528	1508	1485	1453	1429	1396	1359	1319	1272	1222

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.174	0.161	0.147	0.134	0.121	0.107	0.094	0.080	0.067	0.054
Ce	1168	1109	1045	977	904	826	743	653	558	456

REGION WEX—R.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.328	0.318	0.308	0.298	0.288	0.278	0.268	0.258	0.248	0.238
Ce	1047	1038	1029	1013	1006	994	982	983	953	938

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.228	0.218	0.209	0.199	0.189	0.179	0.169	0.159	0.149	0.139
Ce	921	903	884	864	842	819	795	770	744	716

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.129	0.119	0.109	0.099	0.089	0.079	0.070	0.060	0.050	0.040
Ce	637	656	623	586	546	504	459	411	359	303

REGION WEX—B.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.440	0.426	0.413	0.400	0.386	0.373	0.360	0.346	0.333	0.320
Ce	1491	1483	1474	1464	1453	1441	1427	1412	1396	1378
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.306	0.293	0.280	0.266	0.253	0.240	0.226	0.213	0.200	0.186
Ce	1358	1337	1313	1288	1260	1229	1196	1160	1120	1078
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.173	0.160	0.147	0.133	0.120	0.107	0.093	0.080	0.067	0.053
Ce	1032	983	830	873	812	747	677	602	521	432

REGION WAT.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.470	0.456	0.442	0.427	0.413	0.399	0.385	0.370	0.356	0.342
Ce	1678	1670	1662	1654	1644	1634	1623	1610	1596	1580
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.329	0.313	0.299	0.285	0.271	0.256	0.242	0.229	0.214	0.199
Ce	1562	1541	1517	1490	1499	1485	1386	1343	1297	1246
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.185	0.171	0.157	0.142	0.128	0.114	0.100	0.085	0.071	0.057
Ce	1192	1134	1073	1008	940	866	780	688	589	482

REGION TIP—SM.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.320	0.311	0.301	0.291	0.282	0.272	0.262	0.252	0.243	0.233
Ce	1105	1100	1095	1089	1083	1076	1069	1060	1051	1040
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.223	0.214	0.204	0.194	0.185	0.175	0.165	0.155	0.146	0.136
Ce	1028	1014	998	980	960	938	814	987	858	826
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.126	0.117	0.107	0.097	0.087	0.078	0.068	0.058	0.049	0.039
Ce	792	755	715	673	627	577	524	465	398	327

REGION TIP—S1.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.306	0.297	0.288	0.278	0.269	0.260	0.251	0.241	0.232	0.223
Ce	1091	1086	1081	1075	1069	1062	1054	1045	1035	1024
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.213	0.204	0.195	0.186	0.176	0.167	0.158	0.148	0.139	0.130
Ce	1012	997	981	963	943	921	997	870	840	808
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.121	0.111	0.102	0.093	0.084	0.074	0.065	0.056	0.046	0.037
Ce	774	737	697	654	607	557	503	444	380	311

REGION TIP—S2.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.350	0.339	0.329	0.318	0.308	0.297	0.286	0.276	0.265	0.255
Ce	1311	1311	1309	1305	1301	1295	1287	1278	1267	1254
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.244	0.233	0.223	0.212	0.202	0.191	0.180	0.170	0.159	0.148
Ce	1239	1222	1202	1180	1156	1128	1098	1065	1029	989
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.138	0.127	0.117	0.106	0.095	0.085	0.074	0.064	0.053	0.042
Ce	947	901	852	799	742	676	605	529	449	385

REGION TIP—NA.

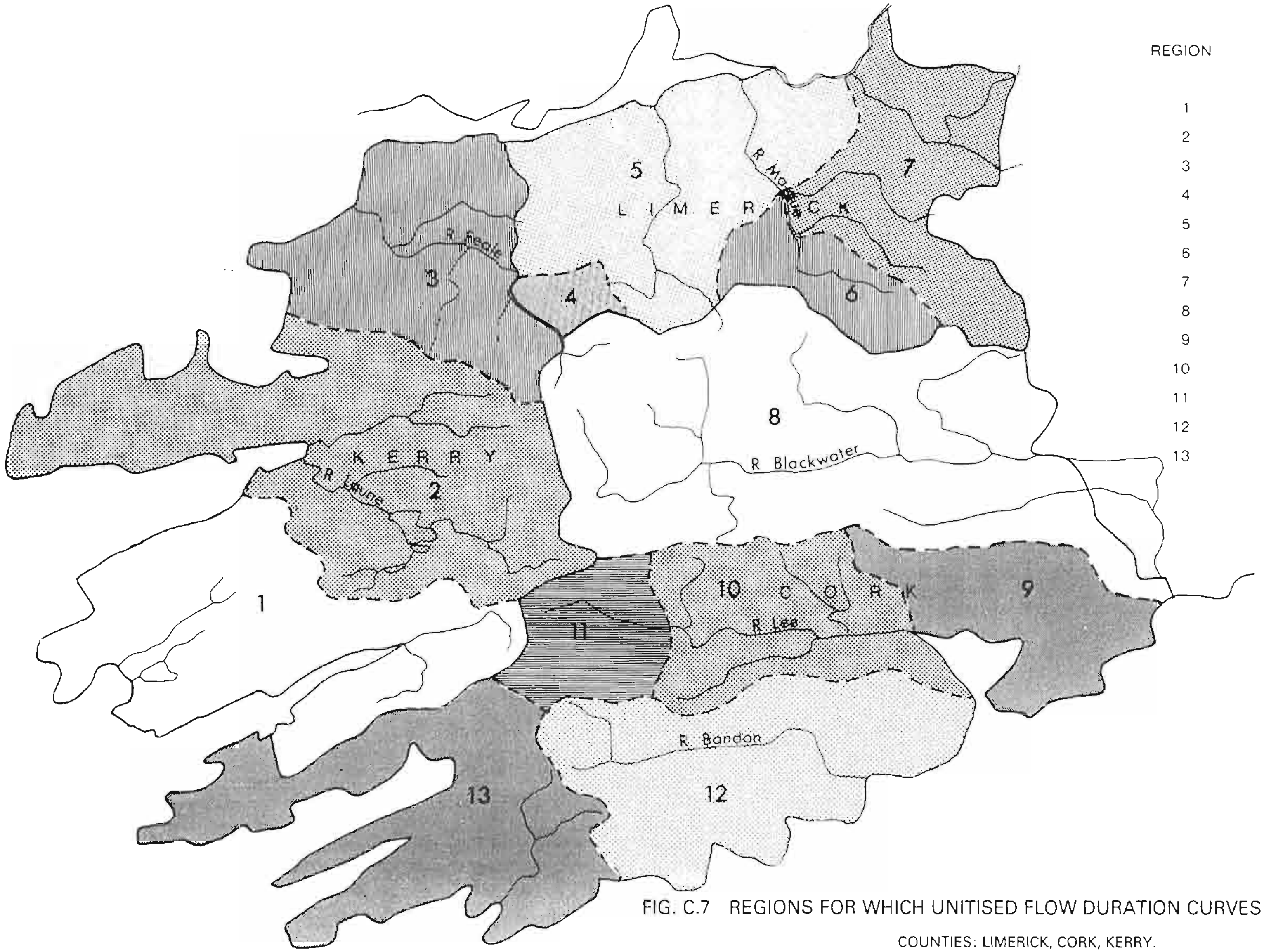
Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.268	0.259	0.251	0.243	0.235	0.227	0.219	0.211	0.203	0.195
Ce	864	860	855	850	845	838	831	824	815	806
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.187	0.178	0.170	0.162	0.154	0.146	0.138	0.130	0.122	0.114
Ce	796	784	772	758	742	726	707	686	663	638
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.105	0.097	0.089	0.081	0.073	0.065	0.057	0.049	0.041	0.032
Ce	611	581	550	516	481	443	404	362	317	263

REGION TIP—NB.

Power Coefficients [Cp] and Energy Coefficients [Ce]

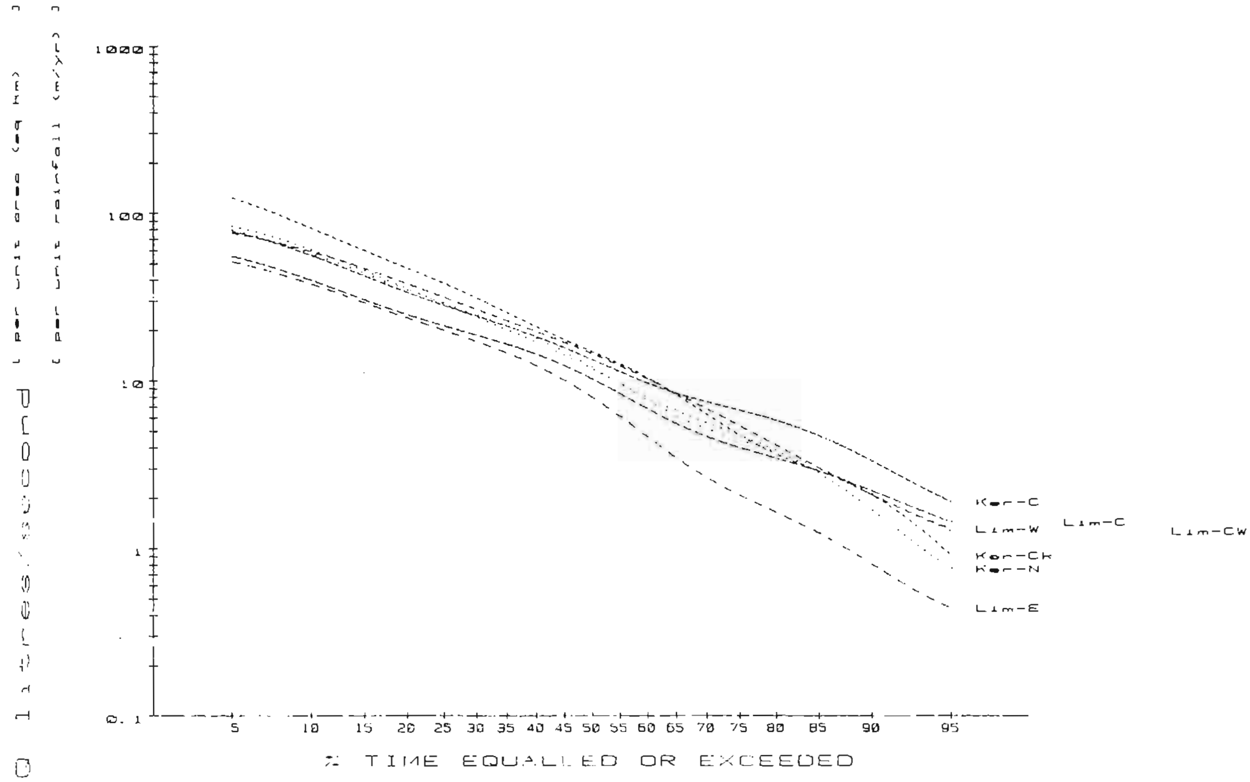
Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.341	0.331	0.321	0.310	0.300	0.290	0.279	0.269	0.259	0.348
Ce	1163	1157	1151	1143	1135	1126	1116	1104	1092	1078
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.238	0.227	0.217	0.207	0.196	0.186	0.176	0.165	0.155	0.145
Ce	1063	1047	1029	1010	988	965	939	911	881	848
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.134	0.124	0.114	0.103	0.093	0.083	0.072	0.062	0.052	0.041
Ce	813	774	733	688	641	589	534	475	411	340



REGION	DESIGNATION
1	KER-CK
2	KER-C
3	KER-N
4	LIM-W
5	LIM-C
6	LIM-CW
7	LIM-E
8	COR-E
9	COR-O
10	COR-C
11	COR-LW
12	COR-S
13	COR-KE

FIG. C.7 REGIONS FOR WHICH UNITISED FLOW DURATION CURVES WERE DERIVED.

COUNTIES: LIMERICK, CORK, KERRY.



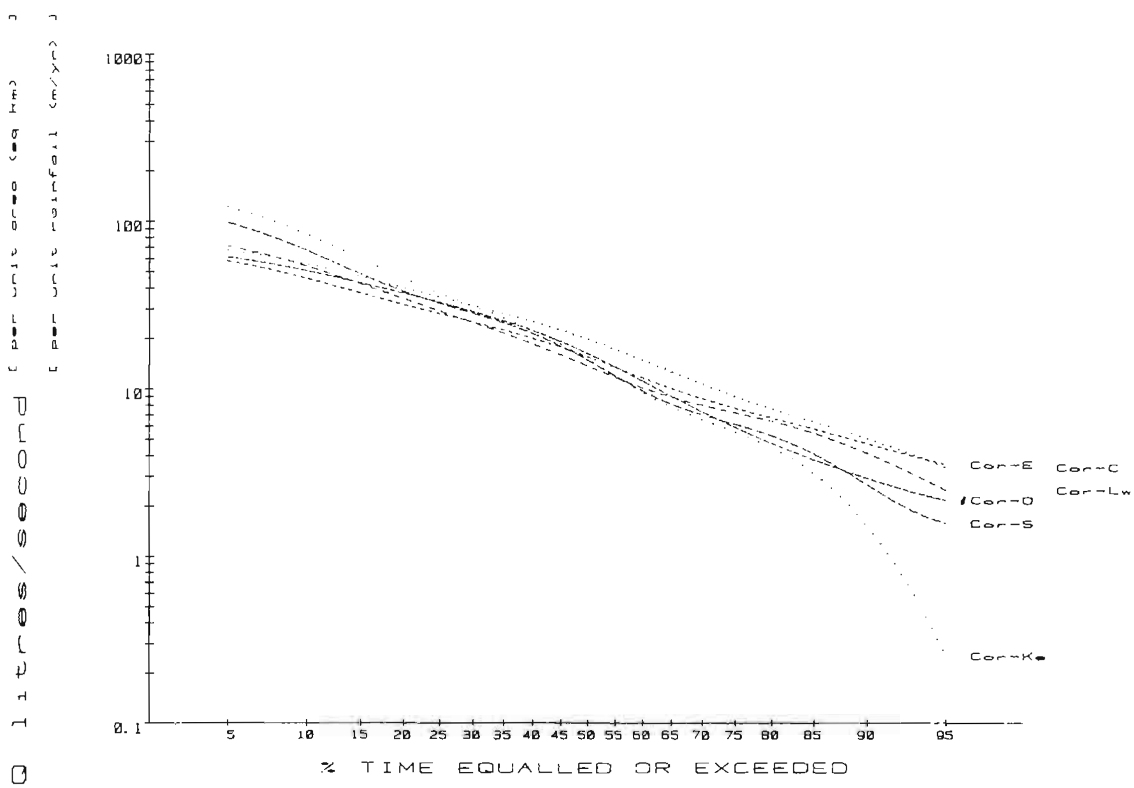


FIG. C8 UNITISED REGIONAL FLOW DURATION CURVES

TABLE C5

REGION KER—CK.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.504	0.488	0.473	0.458	0.442	0.427	0.412	0.397	0.381	0.366
Ce	1633	1618	1602	1585	1566	1546	1525	1502	1478	1452
Q	**115%Qm**	**110%Qm**	**105%Qm**	**100%Qm**	**95%Qm**	**90%Qm**	**85%Qm**	**80%Qm**	**75%Qm**	**70%Qm**
Cp	0.351	0.336	0.320	0.305	0.290	0.275	0.259	0.244	0.229	0.214
Ce	1424	1395	1364	1331	1296	1260	1221	1181	1138	1093
Q	**65%Qm**	**60%Qm**	**55%Qm**	**50%Qm**	**45%Qm**	**40%Qm**	**35%Qm**	**30%Qm**	**25%Qm**	**20%Qm**
Cp	0.198	0.183	0.168	0.153	0.137	0.122	0.107	0.092	0.076	0.061
Ce	1045	995	941	885	825	760	691	615	533	444

REGION KER—C.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.393	0.381	0.369	0.357	0.345	0.334	0.322	0.310	0.298	0.286
Ce	1326	1318	1309	1300	1291	1281	1270	1259	1247	1234
Q	**115%Qm**	**110%Qm**	**105%Qm**	**100%Qm**	**95%Qm**	**90%Qm**	**85%Qm**	**80%Qm**	**75%Qm**	**70%Qm**
Cp	0.274	0.262	0.250	0.238	0.226	0.214	0.203	0.191	0.179	0.167
Ce	1220	1204	1186	1165	1141	1114	1083	1051	1015	976
Q	**65%Qm**	**60%Qm**	**55%Qm**	**50%Qm**	**45%Qm**	**40%Qm**	**35%Qm**	**30%Qm**	**25%Qm**	**20%Qm**
Cp	0.155	0.143	0.131	0.119	0.107	0.095	0.083	0.071	0.060	0.048
Ce	934	890	842	791	737	679	616	547	471	388

REGION KER—N.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.386	0.375	0.363	0.351	0.340	0.328	0.316	0.304	0.293	0.281
Ce	1257	1246	1233	1220	1206	1192	1176	1160	1143	1125
Q	**115%Qm**	**110%Qm**	**105%Qm**	**100%Qm**	**95%Qm**	**90%Qm**	**85%Qm**	**80%Qm**	**75%Qm**	**70%Qm**
Cp	0.269	0.258	0.246	0.234	0.222	0.211	0.199	0.187	0.176	0.164
Ce	1106	1086	1065	1043	1019	993	966	937	905	871
Q	**65%Qm**	**60%Qm**	**55%Qm**	**50%Qm**	**45%Qm**	**40%Qm**	**35%Qm**	**30%Qm**	**25%Qm**	**20%Qm**
Cp	0.152	0.140	0.129	0.117	0.105	0.094	0.082	0.070	0.059	0.047
Ce	834	794	752	706	657	605	550	490	424	353

REGION LIM—W.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.430	0.417	0.404	0.391	0.378	0.365	0.352	0.339	0.326	0.313
Ce	1447	1436	1424	1410	1396	1381	1364	1346	1327	1307
Q	**115%Qm**	**110%Qm**	**105%Qm**	**100%Qm**	**95%Qm**	**90%Qm**	**85%Qm**	**80%Qm**	**75%Qm**	**70%Qm**
Cp	0.300	0.287	0.274	0.261	0.243	0.235	0.222	0.209	0.196	0.183
Ce	1285	1261	1236	1209	1180	1149	1116	1080	1042	1001
Q	**65%Qm**	**60%Qm**	**55%Qm**	**50%Qm**	**45%Qm**	**40%Qm**	**35%Qm**	**30%Qm**	**25%Qm**	**20%Qm**
Cp	0.170	0.157	0.143	0.130	0.117	0.104	0.091	0.078	0.065	0.052
Ce	957	910	860	806	749	687	622	552	477	397

REGION LIM—C.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.303	0.294	0.285	0.275	0.268	0.257	0.248	0.239	0.230	0.220
Ce	1001	994	986	977	968	959	949	938	926	913

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.211	0.202	0.193	0.184	0.174	0.165	0.156	0.147	0.138	0.129
Ce	899	884	863	851	832	812	790	767	743	715

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.119	0.110	0.101	0.092	0.083	0.073	0.064	0.055	0.046	0.037
Ce	685	652	617	580	540	497	451	403	351	294

REGION LIM—CW.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.400	0.388	0.376	0.364	0.351	0.339	0.327	0.315	0.303	0.291
Ce	1285	1273	1260	1247	1233	1218	1202	1185	1167	1148

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.279	0.267	0.254	0.242	0.230	0.218	0.206	0.194	0.182	0.170
Ce	1127	1106	1083	1059	1033	1006	977	947	916	882

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.158	0.145	0.133	0.121	0.109	0.097	0.085	0.073	0.061	0.048
Ce	846	807	765	719	670	618	562	503	439	369

REGION LIM—E.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.278	0.269	0.261	0.252	0.244	0.235	0.227	0.219	0.210	0.202
Ce	878	870	861	852	842	831	819	807	794	780

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.193	0.185	0.177	0.168	0.160	0.151	0.143	0.135	0.126	0.119
Ce	765	749	732	713	694	673	651	628	603	577

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.109	0.101	0.093	0.084	0.076	0.067	0.059	0.050	0.042	0.034
Ce	550	521	492	460	428	394	357	319	277	233

REGION COR—E.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.404	0.392	0.379	0.367	0.355	0.343	0.331	0.318	0.306	0.294
Ce	1410	1406	1401	1395	1388	1381	1372	1363	1351	1339

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.282	0.269	0.257	0.245	0.233	0.220	0.208	0.196	0.184	0.171
Ce	1324	1308	1289	1267	1242	1214	1183	1148	1110	1068

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.159	0.147	0.135	0.122	0.110	0.098	0.086	0.073	0.061	0.049
Ce	1023	974	921	865	805	740	670	592	508	416

REGION COR—O.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.467	0.453	0.439	0.424	0.410	0.396	0.382	0.368	0.354	0.340
Ce	1537	1530	1521	1511	1500	1488	1474	1458	1440	1420

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.325	0.311	0.297	0.283	0.269	0.255	0.241	0.226	0.212	0.198
Ce	1396	1374	1348	1320	1288	1255	1218	1179	1137	1092

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.184	0.170	0.156	0.141	0.127	0.113	0.099	0.085	0.071	0.057
Ce	1045	994	940	832	821	756	686	612	532	446

REGION COR—C.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.505	0.489	0.474	0.459	0.444	0.428	0.413	0.398	0.382	0.367
Ce	1771	1765	1757	1748	1737	1725	1712	1696	1679	1660

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.352	0.336	0.321	0.306	0.291	0.275	0.260	0.245	0.229	0.214
Ce	1639	1615	1589	1560	1529	1493	1454	1411	1364	1312

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.199	0.184	0.168	0.153	0.138	0.122	0.107	0.092	0.076	0.061
Ce	1255	1194	1127	1056	979	898	810	716	615	506

REGION COR—LW.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.401	0.389	0.377	0.365	0.353	0.341	0.328	0.316	0.304	0.282
Ce	1356	1349	1341	1333	1324	1315	1305	1295	1284	1272

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.280	0.268	0.255	0.243	0.231	0.219	0.207	0.195	0.182	0.170
Ce	1259	1243	1225	1204	1180	1152	1122	1089	1052	1013

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.158	0.146	0.134	0.122	0.109	0.097	0.085	0.073	0.061	0.049
Ce	971	926	877	825	770	709	644	572	491	402

REGION COR—S.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.454	0.440	0.427	0.413	0.399	0.385	0.372	0.358	0.344	0.330
Ce	1485	1473	1460	1446	1432	1417	1401	1384	1366	1347

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.317	0.303	0.289	0.275	0.261	0.248	0.234	0.220	0.206	0.193
Ce	1327	1306	1283	1259	1233	1205	1174	1140	1101	1059

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.179	0.165	0.151	0.138	0.124	0.110	0.096	0.083	0.069	0.055
Ce	1012	963	910	854	795	732	665	593	516	436

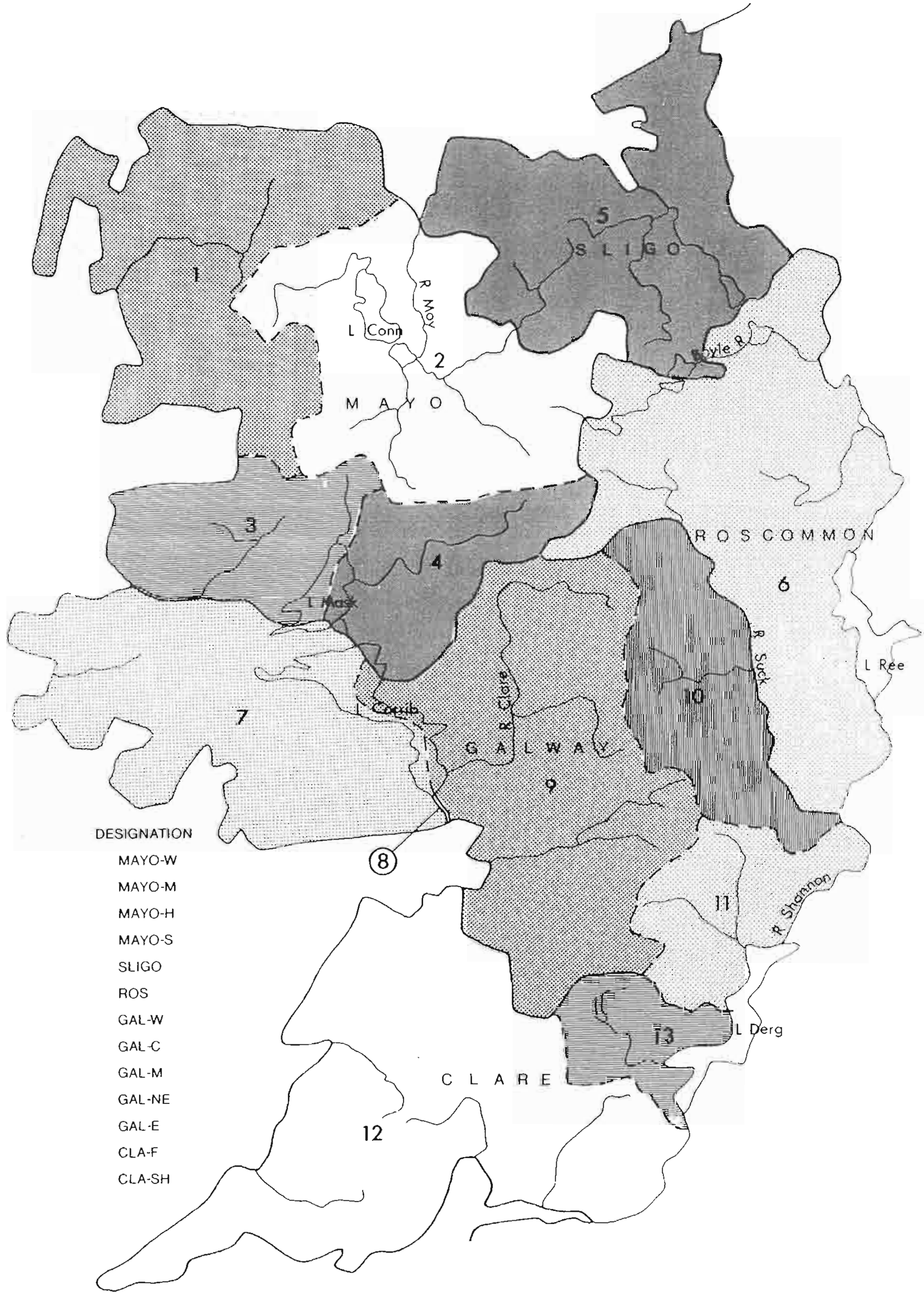
REGION COR—KE.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.502	0.486	0.471	0.456	0.441	0.426	0.410	0.395	0.390	0.385
Ce	1616	1600	1582	1564	1545	1524	1503	1481	1458	1433

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.350	0.334	0.319	0.304	0.289	0.274	0.258	0.243	0.228	0.213
Ce	1407	1380	1351	1321	1289	1255	1220	1182	1142	1099

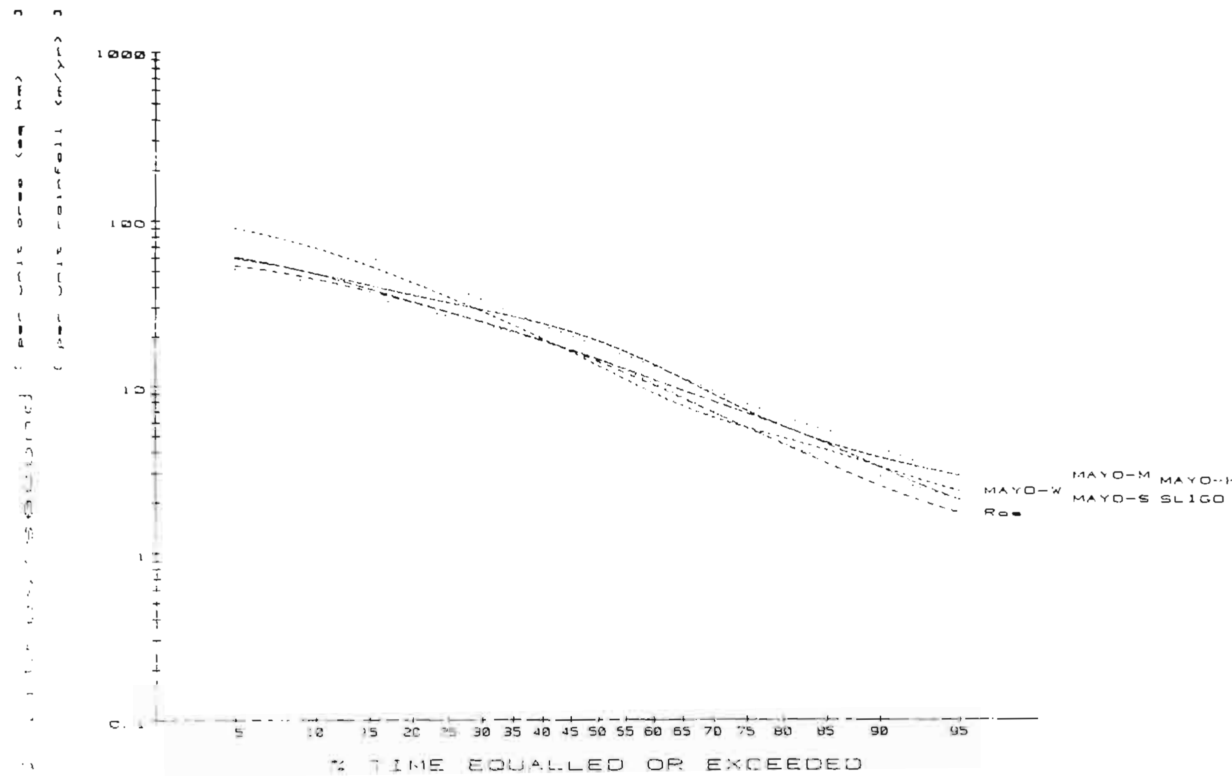
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.193	0.182	0.167	0.152	0.137	0.122	0.106	0.091	0.076	0.061
Ce	1053	1002	948	889	827	761	690	615	534	446



REGION	DESIGNATION
1	MAYO-W
2	MAYO-M
3	MAYO-H
4	MAYO-S
5	SLIGO
6	ROS
7	GAL-W
8	GAL-C
9	GAL-M
10	GAL-NE
11	GAL-E
12	CLA-F
13	CLA-SH

FIG. C.9 REGIONS FOR WHICH UNITISED FLOW DURATION CURVES WERE DERIVED.

COUNTIES: MAYO, SLIGO, GALWAY, ROSCOMMON, CLARE.



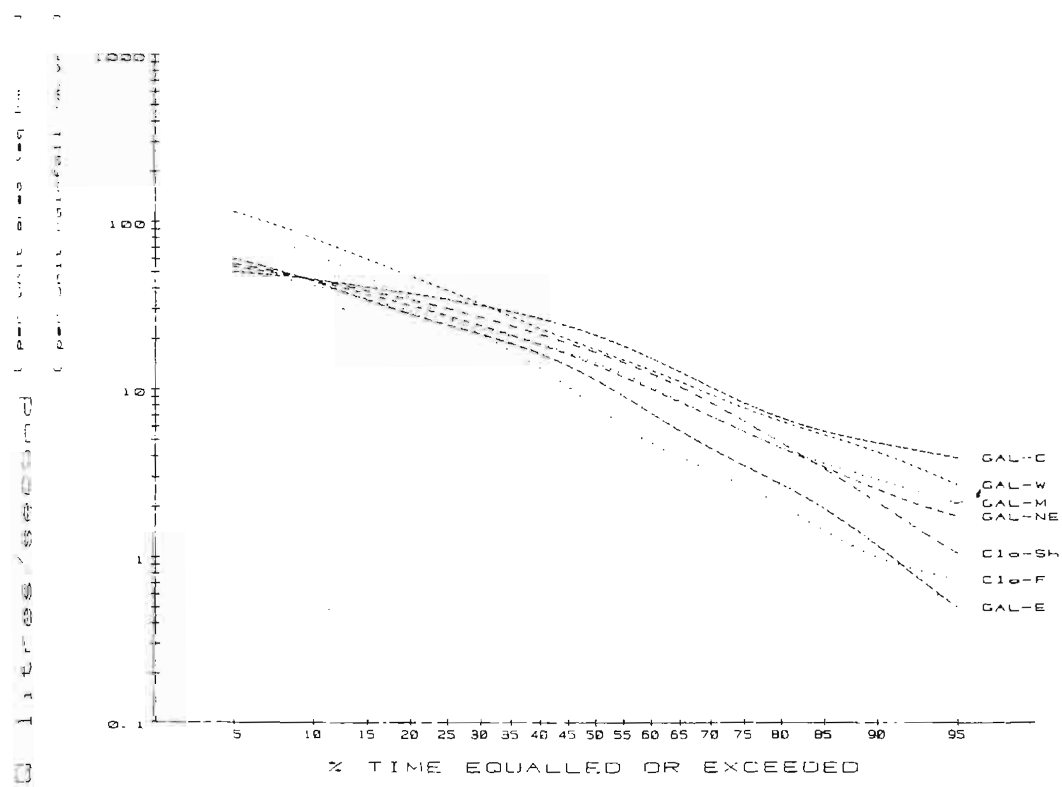


FIG. C.10 UNITISED REGIONAL FLOW DURATION CURVES

Table C6

REGION MAYO—W.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.440	0.427	0.414	0.400	0.387	0.374	0.360	0.347	0.334	0.320
Ce	1421	1407	1393	1377	1354	1344	1326	1307	1288	1267
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.307	0.294	0.280	0.267	0.254	0.240	0.227	0.213	0.200	0.187
Ce	1245	1222	1198	1173	1147	1119	1090	1059	1027	992
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.173	0.160	0.147	0.133	0.120	0.107	0.093	0.080	0.067	0.053
Ce	954	912	867	818	765	708	647	580	508	427

REGION MAYO—M.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.450	0.436	0.422	0.409	0.395	0.382	0.363	0.354	0.341	0.327
Ce	1563	1557	1550	1542	1532	1521	1509	1495	1480	1463
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.313	0.300	0.286	0.273	0.259	0.245	0.232	0.213	0.204	0.191
Ce	1443	1421	1396	1369	1338	1304	1266	1225	1181	1133
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.177	0.164	0.150	0.136	0.123	0.109	0.095	0.082	0.068	0.055
Ce	1052	1028	971	910	845	776	702	623	537	445

REGION MAYO—H.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.514	0.498	0.483	0.467	0.451	0.436	0.420	0.405	0.389	0.374
Ce	1735	1723	1709	1694	1677	1660	1641	1620	1593	1574
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.358	0.342	0.327	0.311	0.296	0.280	0.265	0.249	0.233	0.218
Ce	1549	1522	1493	1462	1429	1395	1358	1319	1278	1233
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.202	0.137	0.171	0.156	0.140	0.125	0.109	0.093	0.079	0.062
Ce	1185	1133	1076	1013	944	869	787	699	604	501

REGION MAYO—S.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.366	0.355	0.344	0.333	0.321	0.310	0.299	0.298	0.277	0.266
Ce	1261	1255	1248	1240	1231	1221	1210	1198	1184	1169
Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.255	0.244	0.233	0.222	0.211	0.200	0.188	0.177	0.166	0.155
Ce	1152	1134	1114	1091	1067	1040	1010	978	944	906
Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.144	0.133	0.122	0.111	0.100	0.089	0.078	0.067	0.055	0.044
Ce	867	824	778	730	678	622	563	499	431	358

REGION SLIGO.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.390	0.368	0.357	0.345	0.334	0.322	0.311	0.299	0.288	0.276
Ce	1325	1319	1312	1304	1296	1286	1275	1263	1249	1234

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.265	0.253	0.242	0.230	0.219	0.207	0.196	0.184	0.173	0.161
Ce	1217	1199	1178	1156	1131	1103	1073	1041	1005	966

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.150	0.138	0.127	0.115	0.104	0.092	0.081	0.069	0.058	0.046
Ce	925	880	831	780	724	664	600	531	456	377

REGION ROS.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.380	0.368	0.357	0.345	0.334	0.322	0.311	0.299	0.283	0.276
Ce	1288	1281	1274	1265	1256	1245	1233	1219	1205	1189

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.265	0.253	0.242	0.230	0.219	0.207	0.196	0.184	0.173	0.161
Ce	1171	1151	1130	1107	1081	1054	1024	992	957	920

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.150	0.136	0.127	0.115	0.104	0.092	0.081	0.069	0.058	0.046
Ce	830	837	790	741	688	632	572	508	440	366

REGION GAL—W.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.514	0.498	0.483	0.467	0.451	0.436	0.420	0.405	0.389	0.374
Ce	1735	1723	1709	1694	1677	1660	1641	1620	1598	1574

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.358	0.342	0.327	0.311	0.296	0.280	0.265	0.249	0.233	0.218
Ce	1549	1522	1493	1462	1429	1395	1358	1319	1278	1233

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.202	0.187	0.171	0.156	0.140	0.125	0.109	0.093	0.078	0.062
Ce	1185	1133	1076	1013	944	869	787	699	604	501

REGION GAL—C.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.500	0.485	0.470	0.454	0.439	0.424	0.409	0.394	0.379	0.364
Ce	1701	1703	1703	1702	1698	1692	1684	1673	1660	1643

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.348	0.333	0.318	0.303	0.288	0.273	0.258	0.242	0.227	0.212
Ce	1624	1601	1575	1545	1511	1473	1432	1396	1338	1286

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.197	0.182	0.167	0.151	0.136	0.121	0.106	0.091	0.076	0.061
Ce	1230	1171	1108	1038	964	883	798	707	609	504

REGION GAL—M.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.366	0.355	0.344	0.333	0.321	0.310	0.299	0.288	0.277	0.266
Ce	1261	1255	1249	1240	1231	1221	1210	1198	1184	1169

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.255	0.244	0.233	0.222	0.211	0.200	0.188	0.177	0.166	0.155
Ce	1152	1134	1114	1091	1067	1040	1010	978	844	906

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.144	0.133	0.122	0.111	0.100	0.099	0.078	0.067	0.055	0.044
Ce	867	824	778	730	678	622	563	499	431	358

REGION GAL—NE.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.380	0.368	0.357	0.345	0.334	0.322	0.311	0.299	0.288	0.276
Ce	1289	1281	1274	1265	1256	1245	1233	1219	1205	1189

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.265	0.253	0.242	0.230	0.219	0.207	0.196	0.184	0.173	0.161
Ce	1171	1151	1130	1107	1081	1054	1024	992	957	920

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.150	0.138	0.127	0.115	0.104	0.092	0.081	0.069	0.058	0.046
Ce	880	837	790	741	588	632	572	508	440	366

REGION GAL—E.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.337	0.327	0.317	0.307	0.296	0.286	0.276	0.266	0.256	0.245
Ce	1099	1091	1082	1072	1061	1050	1038	1025	1010	995

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.235	0.225	0.215	0.204	0.194	0.184	0.174	0.164	0.153	0.143
Ce	978	960	941	919	896	871	844	816	785	753

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.133	0.123	0.112	0.102	0.092	0.082	0.072	0.061	0.051	0.041
Ce	718	682	643	602	559	513	464	412	357	297

REGION CLA—F.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.357	0.327	0.317	0.306	0.296	0.286	0.276	0.266	0.255	0.245
Ce	1035	1021	1007	992	976	960	843	926	906	890

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.235	0.225	0.214	0.204	0.194	0.184	0.174	0.163	0.153	0.143
Ce	870	850	829	807	785	762	738	713	687	660

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.133	0.123	0.112	0.102	0.092	0.082	0.071	0.061	0.051	0.041
Ce	632	602	571	537	501	463	422	379	332	281

REGION CLA—SH.

Power Coefficients [Cp] and Energy Coefficients [Ce]

Q	165%Qm	160%Qm	155%Qm	150%Qm	145%Qm	140%Qm	135%Qm	130%Qm	125%Qm	120%Qm
Cp	0.427	0.414	0.401	0.388	0.376	0.363	0.350	0.337	0.324	0.311
Ce	1470	1465	1459	1451	1442	1431	1419	1405	1389	1370

Q	115%Qm	110%Qm	105%Qm	100%Qm	95%Qm	90%Qm	85%Qm	80%Qm	75%Qm	70%Qm
Cp	0.298	0.285	0.272	0.259	0.246	0.233	0.220	0.207	0.194	0.181
Ce	1350	1327	1302	1275	1245	1212	1177	1139	1097	1052

Q	65%Qm	60%Qm	55%Qm	50%Qm	45%Qm	40%Qm	35%Qm	30%Qm	25%Qm	20%Qm
Cp	0.168	0.155	0.142	0.129	0.117	0.104	0.091	0.079	0.065	0.052
Ce	1004	952	897	837	774	707	635	560	490	396

Appendix D

Sample Site Survey Form

Ref No. ....

National Small-scale Hydroelectric Survey

A. *Site*

1. County .... 6″ Map No. .... Site No..
2. Townland .... Grid Ref. ....
3. Hydrometric Area .... River.......... Region ....
4. Catchment Area.............. km².........Rainfall...m
5. Mean flow coefficient .... Prov. mean flow .... m ³/

B. *Site Conditions*

Date ....

6. Expected features .... Photo No...
   Existing features..
   ....
7. Suitable for development .... Type...... Gross head ....m
8. Weir: Existing/needs minor repair/needs major repair/Required:
   Height .... m Length .... m Gross head at weir .... Storage ....
9. Headrace: Existing/needs minor repair/needs major repair/ filled in/required:
   Existing length .... m Width .... m Depth .... m
   Possible Maximum .... Width .... m.
   Depth .... m
   Penstock: Existing/required length .... m Diameter ....m
10. Powerhouse: Derelict/existing/needs repair/can be adapted/required
    Approx. Distance to E.S.B. lines ....
11. Existing Mech. & Elec. equipment ....
    ....
    ....
12. Tailrace: Existing/needs repair/required/not necessary
    Length .... m Width .... m Depth .... m T.W. Back up ....
13. Access...
14. Amenity...
15. Fisheries ....
16. Remarks ....
    ....
    ....
    ....
    Visited by...

C. *Site Assessment*

17. Nett Head ....
18. Design Flow ....
19. % of Q Mean ....
20. Efficiency ....
21. Max. Power Output ....
22. Annual Energy Output ....
23. Site Rating ....