



Power Generation

report

River Liffey

Flood of November 2000

Client: Chief Civil Engineer - Power Generation

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FINAL REPORT



ESB INTERNATIONAL

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Note: - All levels refer to metres above Ordnance Datum, Poolbeg.

1. Introduction

Flooding was reported in many parts of Ireland during November 2000 following heavy rainfall, most of which fell on the 5th and 6th of the month. Rainfall during November was in excess of 200% of the normal rainfall in the east and southeast of the country. On the 5th of November Phoenix Park long term meteorological station, Co. Dublin had its wettest November day in over a century and a half of records, recording 76.2mm of rainfall. This rainfall caused extensive flooding over the east of the country most notably in the Liffey Catchment.

The Upper Catchment has a quick response to rainfall events and is characterised by a high percentage runoff, due to its mountainous terrain. The middle catchment is characterised by a relatively flat landscape and is consequently slower in response to rainfall events.

The most recent flood events of note on the Liffey Catchment prior to November 2000 were in June 1993 and in August 1986.

The main objective of this report is to assemble all available meteorological and hydrological information relating to the flood, to analyse the performance of the Liffey River and in particular the performance of the Liffey Dams throughout this period of extreme rainfall and to make recommendations based on experience gained during this flood event.

2. Scope of Report

This report

- Assesses the extent and severity of rainfall in the Liffey catchment during November 2000.
- Compares the rainfall that occurred with the design rainstorms presented in the report '*River Liffey – Flood Control and Dam Safety*' [1] and with the June 1993 rainstorm presented in the Report '*River Liffey Flood of June 1993*' [2].
- Examines the flows and flood levels which occurred during this period and compares them with historical values and in particular with those recorded in June 1993 [2].
- Estimates the return period of this flood event in the Upper and Middle Liffey catchments.
- Makes recommendations based on experience gained during this flood event.

3. River Liffey Catchment

The River Liffey which rises at about 760mOD in the Wicklow mountains is 120km long from source to sea, draining an area of over 1,300km². Glacial deposits overlie the rock everywhere in the catchment, except on the higher ground. The high ground on the upper catchment consists of the granite of the Leinster chain.

In 1937 the Electricity Supply Board commenced hydro-electric development of the River Liffey. Three dams were constructed at Pollaphuca, Golden Falls and Leixlip. See Figure 3.1.

3.1 Upper Catchment

The Upper Catchment from the source to Pollaphuca, with a catchment area of 308 km², comprises of steep mountainous countryside rising from an elevation of about 183mOD at the dam to a maximum elevation of 760mOD at Kippure.

The average annual rainfall, for the period 1951-1980 was 1,390mm, with a variation from 925mm to 2,000mm over the catchment.

Pollaphuca Dam impounds a reservoir with a surface area of 20 km². The maximum normal operating capacity of the reservoir is approximately equal to 50% of the annual average flow for the catchment.

Golden Falls Dam is situated two kilometres downstream of Pollaphuca Dam. The intermediate catchment to the dam is very small with an area of six kilometres squared and the associated reservoir has negligible flood storage. Therefore the inflow to this reservoir is effectively equal to the discharge from Pollaphuca.

3.2 Middle Catchment

The Middle Catchment, between Golden Falls and Leixlip, comprising of an area of 534 km², is characterised by a relatively flat landscape. The river runs for 56km through Co. Kildare to Leixlip Dam. Annual average rainfall for the period 1951-1980 was 825mm with little variation across the catchment, from 725mm to 925mm.

In contrast to the Upper Catchment, this catchment exhibits a slow response during rainstorms. There are deep sand and glacial deposits throughout the

catchment. Measurements by the Geological Survey of Ireland indicated rock to be 75m below the surface in some locations, such as the Curragh.

3.3 Lower Catchment

Leixlip Dam is 20km from Dublin City and there are four tributaries of the River Liffey between it and the Irish Sea as shown below;

- Rye Water - Catchment Area 215km²
- Griffeen - Catchment Area 50km²
- Cammock - Catchment Area 84km²
- Dodder - Catchment Area 113km²

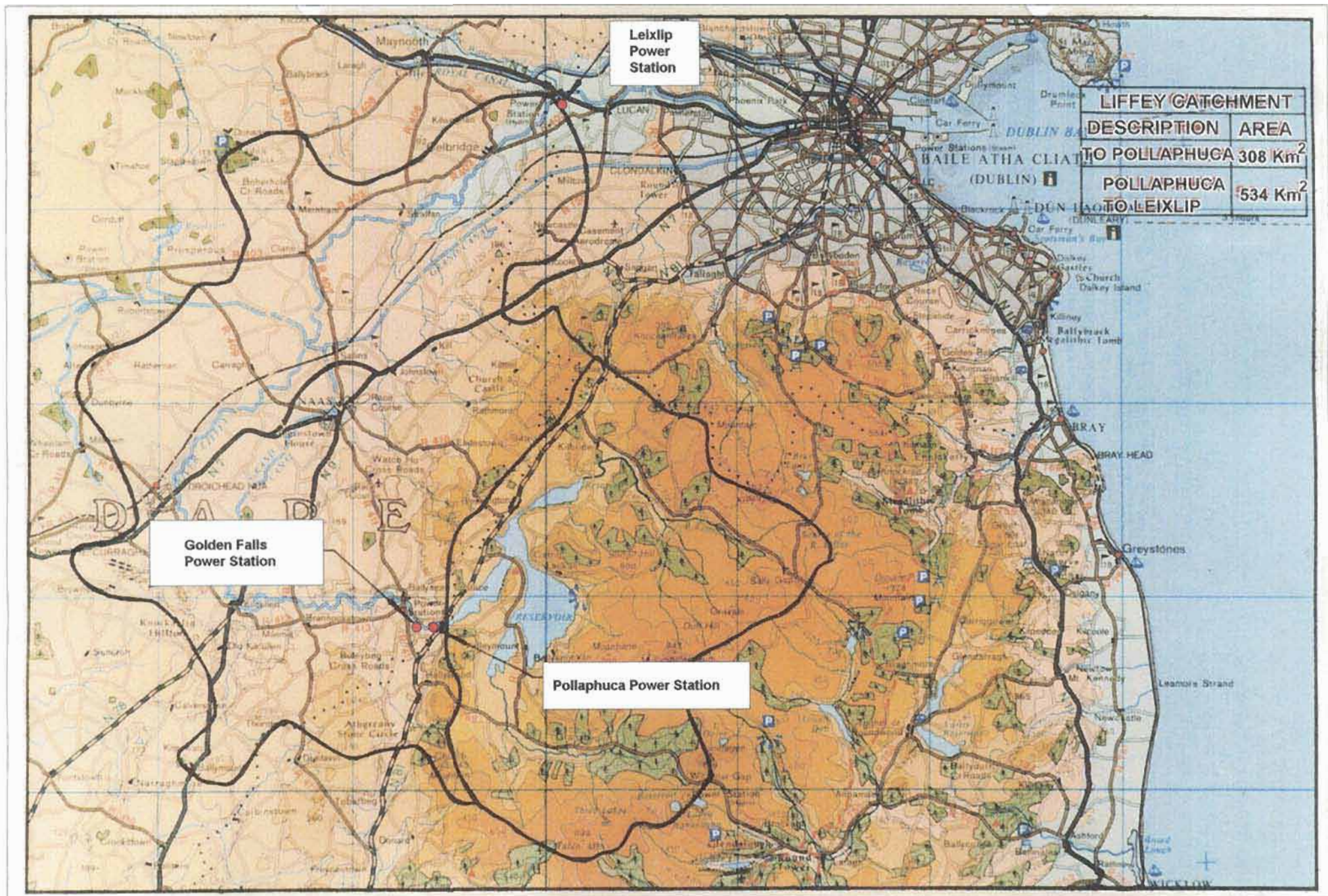


FIGURE 3.1 : River Liffey Catchment Area

4. Observed Rainstorm

4.1 *Meteorological Conditions*

November 2000 was the third successive month with above normal rainfall throughout Ireland. On average monthly totals of 160% above normal were experienced.

It was also very windy with mean windspeeds the highest for the month of November for 7-9 years. The mean temperatures for the month were below normal.

November began with two days of significant rainfall (circa 10mm) on the 1st and 2nd. This was followed by two dry days before the most significant rainfall of November was observed. Almost the entire normal monthly average rainfall occurred over the 5th and 6th of November.

There was little or no rain between the 8th and 17th November after which mainly very light rain prevailed to the month end with the occasional heavy shower.

The east and southeast of the country were particularly wet where falls of between 40mm and 150mm over the 5th and 6th of November occurred. The long-term station at Phoenix Park recorded rainfall of 76.2mm on the 5th November which was its wettest November day in over 150 years of records. The area concentrated around Co. Dublin, Co. Kildare, Co. Wicklow and Co. Carlow received over twice the normal November rainfall.

4.2 Rainfall Data

Rainfall recorded at a total of 15 stations was examined. These are listed in Table 4.1 along with the observed rainfall during the month of November 2000. The rainfall observed over the two day period from 5th to the 6th November is also listed. The locations of these stations are indicated on Figure 4.1. The daily rainfall recorded for each day during November 2000 is tabulated in Appendix A.

Catchment	Location	Monthly Average (1951-1980) November (mm)	Observed Rainfall November 00 (mm)	Observed 48hr Rainfall 5 th / 6 th November 00 (mm)
Upper Catchment	Pollaphuca	93	199(214%)*	113.1(122%)*
	Ballymore Eustace	95	201(212%)	105.2(111%)
	Blessington	94	178(189%)	87.5(93%)
	Glenmacnaas	176	390(222%)	180.5(103%)
	Glenasmole	136	268(197%)	151.1(111%)
	Turlough Hill	N/A	N/A	N/A
Middle Catchment	Leixlip	72	155(215%)	102.6(143%)
	Casement	70	146(209%)	94.1(134%)
	Naas	82	130(159%)	58.3(71%)
Surrounding Catchment	Dublin (Phoenix Park)	74	148(200%)	91.4(124%)
	Dublin (Merrion Sq.)	68	147(216%)	79.1(116%)
	Roundwood	126	281(223%)	141(112%)
	Dublin Airport	69	142(206%)	77.2(112%)
	Glen of Imaal	129	306(237%)	147.9(115%)
	Arklow WW	107	231(216%)	102.6(96%)

*(%) of average (1951-1980)

Table 4.1: Liffey Catchment - November 2000 observed rainfall

Heavy rainfall (greater than 25mm) fell throughout the Liffey catchment on the 5th and 6th November but this was followed by a relatively normal final three weeks of the month. Daily rainfall exceeded 10mm on five separate days between 7th and 30th November, otherwise rainfall was light or conditions were dry.

Table 4.1 illustrates clearly the significance of the two day period, 5th and 6th November relative to the total observed November 2000 rainfall and the average November totals. The average totals were exceeded almost everywhere over this two day period causing flood conditions to prevail on the catchment.

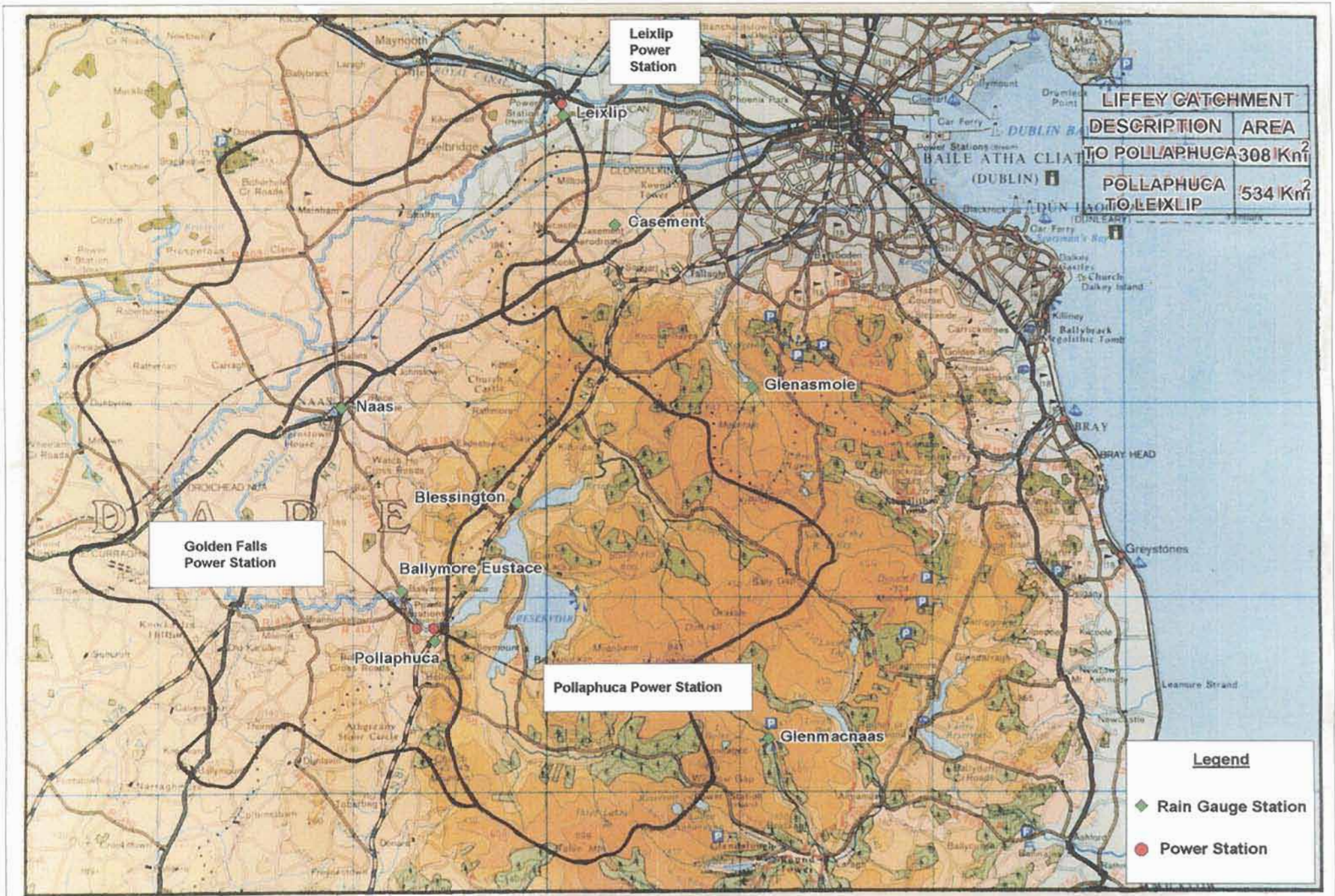


FIGURE 4.1 : River Liffey Catchment Area - Rain Gauge Locations

4.3 *Mean Areal Rainfall*

The mean areal rainfall for the Upper and Middle Liffey catchments was calculated using the iso-percentage method [1]. The daily rainfall at each station is expressed as a percentage of the annual rainfall at that station. The percentage values from all the stations are then averaged for that day, giving an average daily percentage, which is then applied to the sub-catchment's annual average rainfall to obtain the mean areal daily rainfall.

In the upper catchment the following stations were considered;

- Pollaphuca
- Ballymore Eustace
- Glenasmole
- Glenmacnaas
- Blessington
- Glen of Imaal

In the middle catchment the following stations were considered;

- Blessington
- Ballymore Eustace
- Naas
- Leixlip
- Casement Aerodrome

Figure 4.2 illustrates how the daily mean areal rainfall varied across the catchment for the month of November 2000.

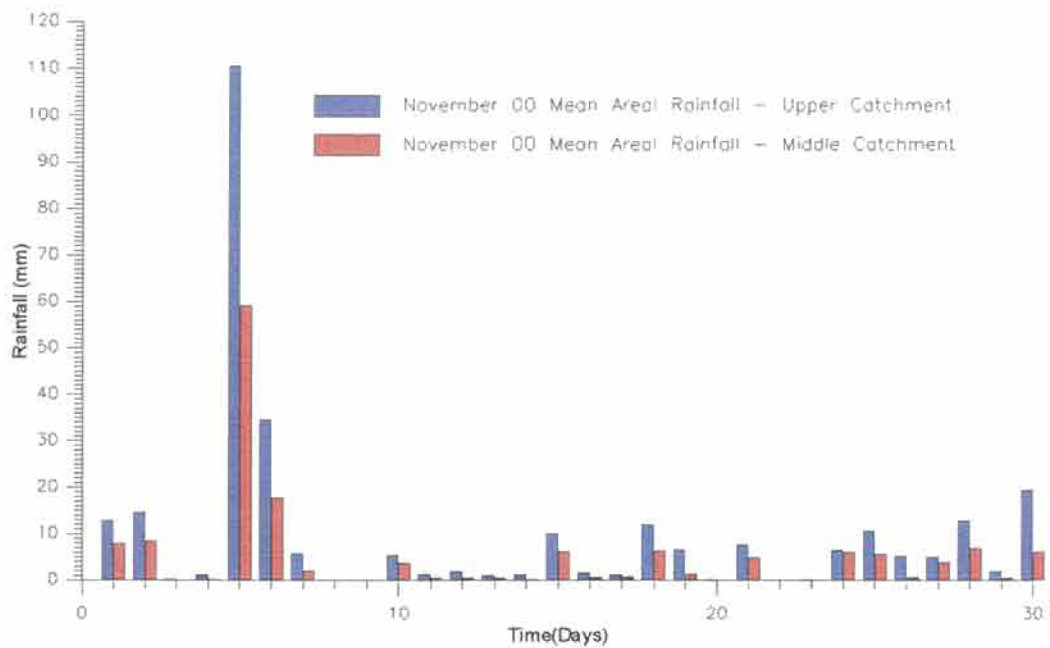


Figure 4.2 Daily mean areal rainfall for Liffey Upper and Middle Catchments November 2000.

It can be seen clearly from Figure 4.1 that the period from 4th – 9th covered the main storm on the Liffey catchment during November 2000.

The period from 4th – 18th November 2000 was considered in estimating the hourly mean areal rainfall for the Upper and Middle Catchments.

4.4 Storm Profile

There are four continuous record meteorological stations operational over the Liffey catchment at present. They are as follows :

- Pollaphuca (ESB Generating Station)
- Leixlip (ESB Generating Station)
- Casement Aerodrome (Baldonnel)
- Glenasmole (Castlekelly)

The continuous rainfall record for Leixlip was not legible for the period of the storm and had to be rejected in the calculation of hourly mean areal rainfall.

To determine the storm profile the hourly mean areal rainfall was estimated. The limited number of continuous record stations over the Liffey catchment means that the resultant hourly mean areal rainfall would not be representative of the catchment without some adjustment.

The daily mean areal rainfall estimates for the Upper and Middle Catchments were used to adjust the hourly mean areal rainfall estimates appropriately to produce a representative dataset.

Upper Catchment to Pollaphuca

Two automatic rainfall recorders were used to estimate the storm profile in the Upper Catchment. These are Glenasmole (D.C.W.W.) and Pollaphuca (ESB Generating Station). Turlough Hill continuous station is no longer operational. The storm profile is shown in Figure 4.3.

The 1,000 year design rainstorm and the June 1993 storm are also shown for comparison purposes.

Middle Catchment from Pollaphuca to Leixlip

Two automatic rainfall recorders were also used to estimate the storm profile in the Middle Catchment. These are Casement Aerodrome (Baldonnel) and Pollaphuca (ESB Generating Station). Leixlip had to be rejected. The storm profile is shown in Figure 4.4.

The 1,000 year design rainstorm and the June 1993 rainstorm are also shown for comparison purposes.

Table 4.2 lists the worst 39hr and 45hr rainfall for the Upper and Middle Catchments respectively and compares it with the 1,000 Year Design Rainstorm and the June 1993 rainstorm.

<i>Hours</i>	<i>Upper Liffey Catchment Rainfall</i>	<i>Middle Liffey Catchment Rainfall</i>	<i>June 93 Rainstorm Upper Catchment</i>	<i>June 93 Rainstorm Middle Catchment</i>	<i>1000 Year Rainstorm Upper Catchment</i>	<i>1,000 Year Rainstorm Middle Catchment</i>
1	0.63	0.69	0.24	0.22	1.2	0.9
2	1.01	0.57	0.00	0.00	1.4	0.9
3	1.75	0.69	0.00	0.00	1.4	0.9
4	3.25	0.87	0.00	0.00	1.6	0.9
5	5.11	1.23	0.00	0.00	2.0	1.1
6	7.74	2.30	2.93	1.11	2.0	1.4
7	8.90	4.21	2.41	2.24	2.0	1.4
8	8.25	4.53	0.00	0.59	2.1	1.4
9	7.78	4.20	0.12	0.07	2.3	1.4
10	8.68	3.90	0.00	0.00	2.7	1.5
11	7.82	4.23	4.43	1.71	3.7	1.5
12	5.75	3.58	1.32	1.38	4.1	2.2
13	4.11	2.60	0.00	0.44	5.2	2.4
14	3.77	1.74	0.12	0.07	5.3	2.8
15	4.42	1.79	0.00	0.07	7.7	3.2
16	2.61	2.73	1.03	0.47	8.9	3.2
17	3.82	1.92	1.38	0.74	9.3	4.7
18	3.77	1.96	6.37	6.25	9.4	5.3
19	4.68	2.33	1.59	0.40	11.4	6.2
20	3.13	3.10	2.83	1.35	11.6	6.3
21	4.55	2.19	3.93	2.86	11.4	6.5
22	4.64	3.01	5.30	3.86	9.4	7.5
23	3.73	3.11	6.57	3.63	9.3	7.6
24	3.51	2.19	7.53	2.17	8.9	7.5
25	3.56	1.90	3.83	2.16	7.7	6.5
26	2.56	1.77	4.69	3.94	5.3	6.3
27	2.65	1.42	4.97	4.55	5.2	6.2
28	2.18	1.50	3.43	2.56	4.1	5.3
29	2.39	1.21	5.09	3.32	3.7	4.7
30	1.49	1.38	4.88	3.30	2.7	3.2
31	1.23	0.89	5.47	3.96	2.3	3.2
32	0.93	0.64	5.20	4.64	2.1	2.8
33	0.71	0.46	5.64	4.40	2.0	2.4
34	0.97	0.36	6.08	4.67	2.0	2.2
35	1.14	0.54	5.31	3.82	2.0	1.5
36	1.06	0.57	4.82	3.39	1.6	1.5
37	1.49	0.57	4.51	3.16	1.4	1.4
38	1.31	0.78	3.05	2.32	1.4	1.4
39	1.66	0.67	2.33	1.84	1.2	1.4
40		0.94		1.16		1.4
41		0.05		0.89		1.1
42		0.80		0.67		0.9
43		0.11		0.39		0.9
44		0.16		0.39		0.9
45		0.60		0.48		0.9
Total	138.8mm	76.6mm	117.4mm	85.6mm	179.0mm	134.8mm

Table 4.2: November 2000, June 1993 Rainfall & 1000yr Design Rainstorms

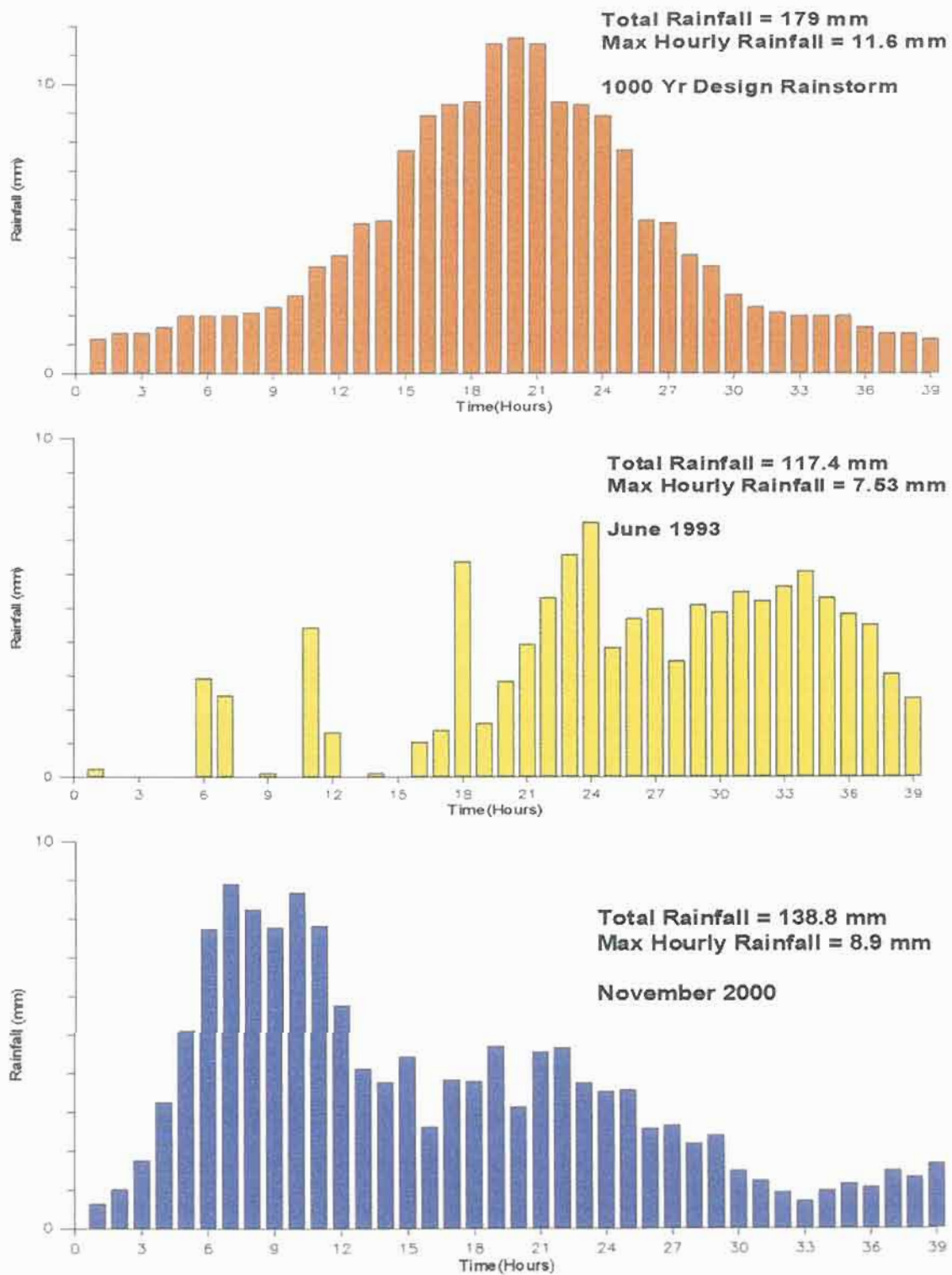


Figure 4.3 Upper Catchment to Pollaphuca – Comparison of November 2000 Storm Profile to June 1993 Storm Profile and 1000 Year Design Storm Profile.

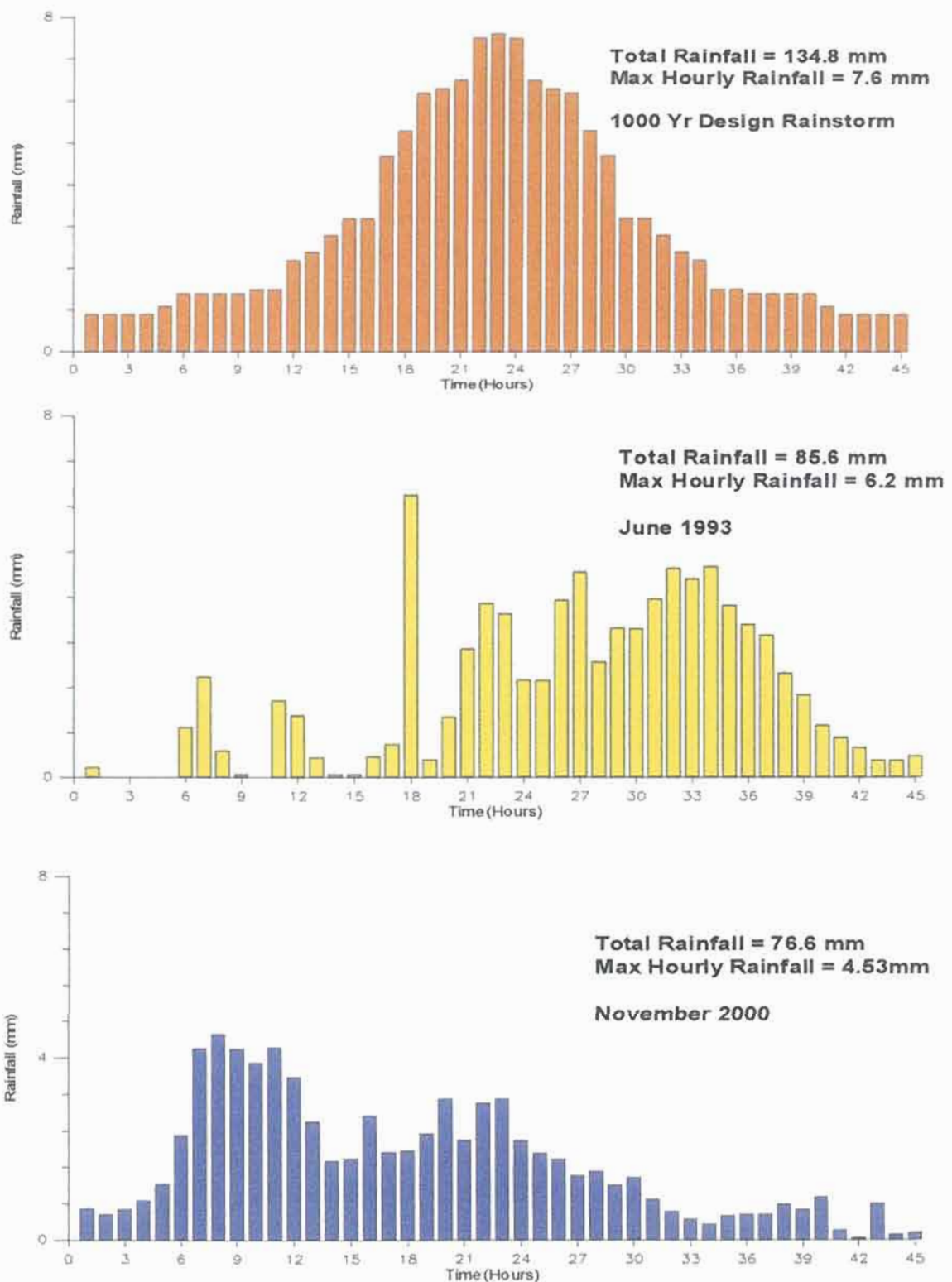


Figure 4.4 - Middle Catchment Pollaphuca to Leixlip - Comparison of November 2000 Storm Profile to June 1993 Storm Profile and 1000 Year Design Rainstorm.

Table 4.3 lists the maximum rainfall of varying duration that occurred during November 2000. Using procedures outlined in the Flood Studies Report [5] estimates of the return period for the rainfall were made.

The rainfall values on the Upper Catchment are exceptional. The 12-hour value is estimated to have a return period in excess of 50 years and both the 24-hour and 48-hour rainfall values are estimated to have return periods in excess of 100 years.

The rainfall values on the Middle Catchment are less severe. The 12-hour value is estimated to have a return period in excess of 5 years and both the 24-hour and 48-hour rainfall values are estimated to have return periods in excess of 20 years.

The Liffey Catchment has a fast response to rainfall in general with the 1,000 and 10,000 year design storms having 39hr and 45hr durations on the upper and middle catchments respectively. Therefore, it is the shorter more intense rainstorms that are the main cause of flooding in the Liffey Catchment.

<i>Rainfall Duration</i>	<i>Upper Liffey Catchment Rainfall (mm)</i>	<i>Middle Liffey Catchment Rainfall (mm)</i>
12-hour	76	38
24-hour	119	64
48-hour	146	78

Table 4.3: Maximum Rainfall recorded during November 2000

5. Hydrometric Data

The period from midnight on the 4th November 2000 to midnight on the 18th November 2000 was considered in analysing the flood on the Liffey catchment. Daily values for inflow, discharge and reservoir level during this period for Pollaphuca, Golden Falls and Leixlip are given in Appendix. B.

Hourly discharge and reservoir levels were abstracted from the daily load report sheets produced in Turlough Hill Control Room. OISHYDRO currently records daily values only. The system interpolates between the recorded daily values in OISHYDRO and produces an hourly dataset. This is a dangerous feature and could lead to incorrect data being used in analysis. It gives the user the impression that hourly values have been downloaded when in fact the interpolation feature of the system fills in the values between each daily reading.

Hourly inflows were determined using hourly discharges and hourly changes in reservoir storage. The storage in Pollaphuca, Golden Falls and Leixlip reservoirs at a given reservoir level was determined using Figures 3,9 and 17 respectively, from 'Regulations for the Control of the River Liffey' [3]. The calculated inflows were smoothed to remove unrealistic fluctuations due to rounding errors and wind effects [1].

5.1 Upper Catchment to Pollaphuca

Pollaphuca reservoir level at the start of November was 185.56m O.D. which is more than 0.7m below maximum normal operating level of 186.30m O.D.. Inflows due to the rainfall on the 1st and 2nd November were compensated for by controlled discharge from Pollaphuca, which resulted in a reservoir level of 185.66m O.D on the 4th November. (See Table B1, Appendix B & Figure 5.1).

Heavy rainfall on the 5th and 6th caused the level to rise from 185.66m O.D. on the 4th November to peak at 187.53m O.D. on the 8th November, a rise of 1.87m. There was a relatively dry three week spell between 7th and the 30th with rainfall exceeding 10mm on 5 separate days only. The level was reduced to 187.34m O.D. by midnight on the 9th November and from then was reduced steadily until the maximum normal operating level of 186.30m O.D. was reached on the 18th November. The details of the flood are shown in Figure 5.1.

The peak of 187.53m O.D. was the highest recorded in over 50 years. The peak level recorded in June 1993 was 187.51m O.D.. The peak hourly inflow to Pollaphuca was 430m³/s on 5th November 2000 at 21.00hrs. In June 1993 a peak hourly inflow of 225m³/s was recorded. Inflows exceeded 200m³/s for a continuous period of 22 hours and exceeded 100m³/s for a continuous period of

45 hours. In June 1993 inflows only exceeded $200\text{m}^3/\text{s}$ for a continuous 9 hour period and exceeded $100\text{m}^3/\text{s}$ for a continuous 24 hour period.

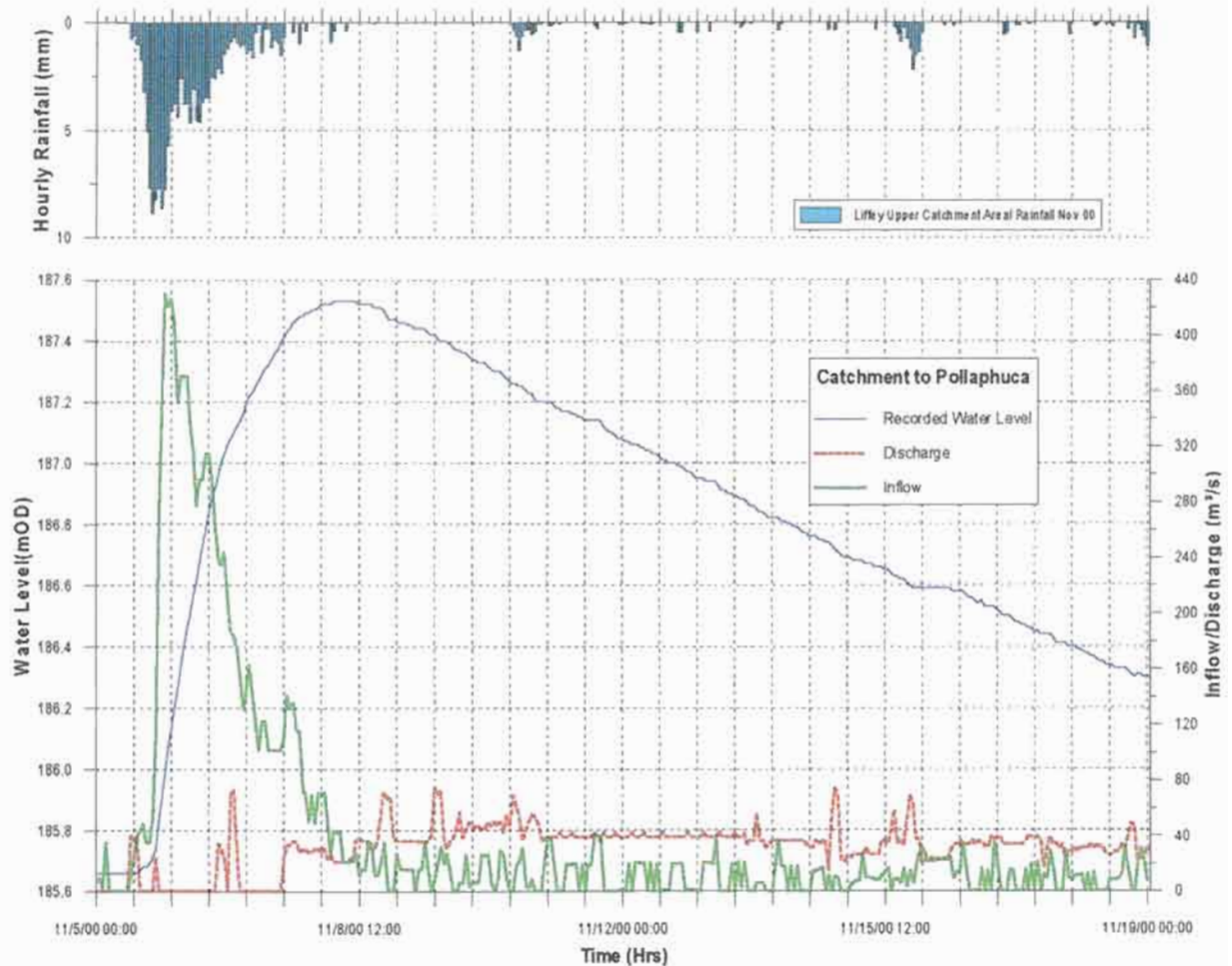


Figure 5.1: Upper Catchment to Pollaphuca – 4th to 18th November 2000

5.2 Pollaphuca to Golden Falls

The inflow to Golden Falls reservoir resulted almost entirely from the station discharge at Pollaphuca. A plot of the inflow/Discharge hydrograph at Golden Falls is shown on Figure 5.2. (See also Table B2 Appendix B)

At 20.00hrs on the 4th November 2000 Golden Falls reservoir level was 138.91m O.D., which is nearly 0.1m below the maximum normal operating level of 139.00m O.D. This level was drawn down to 137.04m O.D. by 09.00hrs on the 5th November 2000 after a 6hr continuous discharge of $30.4\text{m}^3/\text{s}$.

Further periodic discharge was timed to ensure that the inflow from Pollaphuca reservoir was passed safely through Golden Falls and the maximum normal

operating level was not exceeded during this flood period. From 12.00hrs on the 7th November 2000 the station at Golden Falls was run continuously. Spilling at Golden Falls commenced at 11.00hrs on the 8th November.

The highest recorded average daily discharge that occurred during this flood was $51.2\text{m}^3/\text{s}$ on 10th November 2000. This was made up of $30.5\text{m}^3/\text{s}$ through the station and $20.7\text{m}^3/\text{s}$ spilling. The equivalent peak value was $52.8\text{m}^3/\text{s}$ in June 1993, which was the highest recorded post scheme discharge at Golden Falls.

Spilling ceased at Golden Falls on the 17th November 2000.

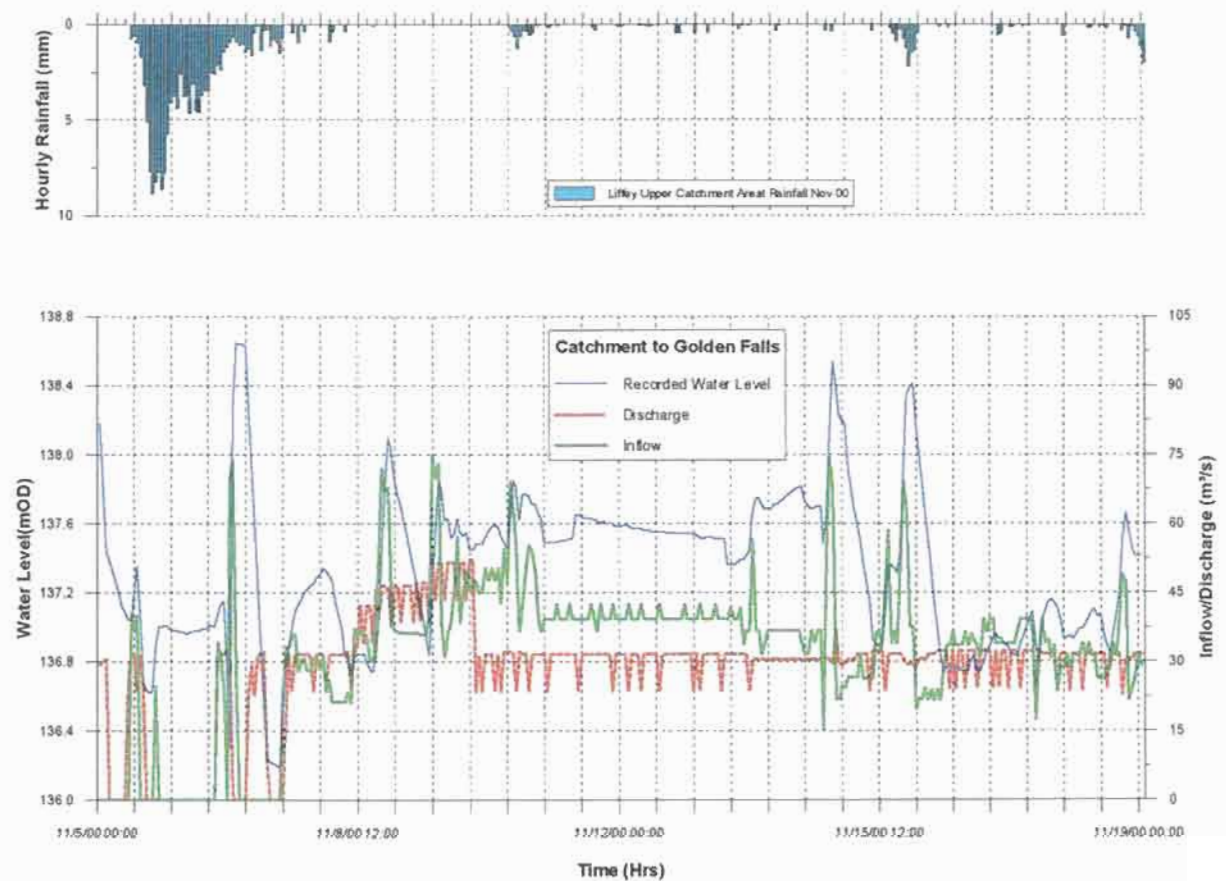


Figure 5.2 Golden Falls Inflow/Discharge and Water Level 4th to 18th November 2000.

5.3 Catchment from Golden Falls to Leixlip

The inflow to Leixlip reservoir is comprised of two parts – the natural inflow from the Middle Catchment between Golden Falls and Leixlip and the discharge from Golden Falls. The level at Leixlip was 44.20m O.D. at 13.00hrs on 5th November 2000. This was prior to the steady increase in inflows to Leixlip resulting from the heavy rainfall that occurred on the 5th and 6th on the middle catchment.

The peak inflow to Leixlip is estimated to have been 98m³/s – it is estimated that the natural inflow from the Middle Catchment was approximately 83m³/s and this was augmented by 15m³/s as a result of running the station at Golden Falls.

The storage at Leixlip is very small, therefore the flood is passed straight through by running the power station and spilling through the spillway gates. Spilling started at 02.00hrs on 6th November and continued uninterrupted until 09.00hrs on 21st November. The maximum spilling occurred at midnight on 6th November and amounted to 76m³/s. Figure 5.3 is a plot of the inflow/discharge and water level at Leixlip. (Note – the inflow illustrated is the total inflow to Leixlip). (See Also Table B3 Appendix B)

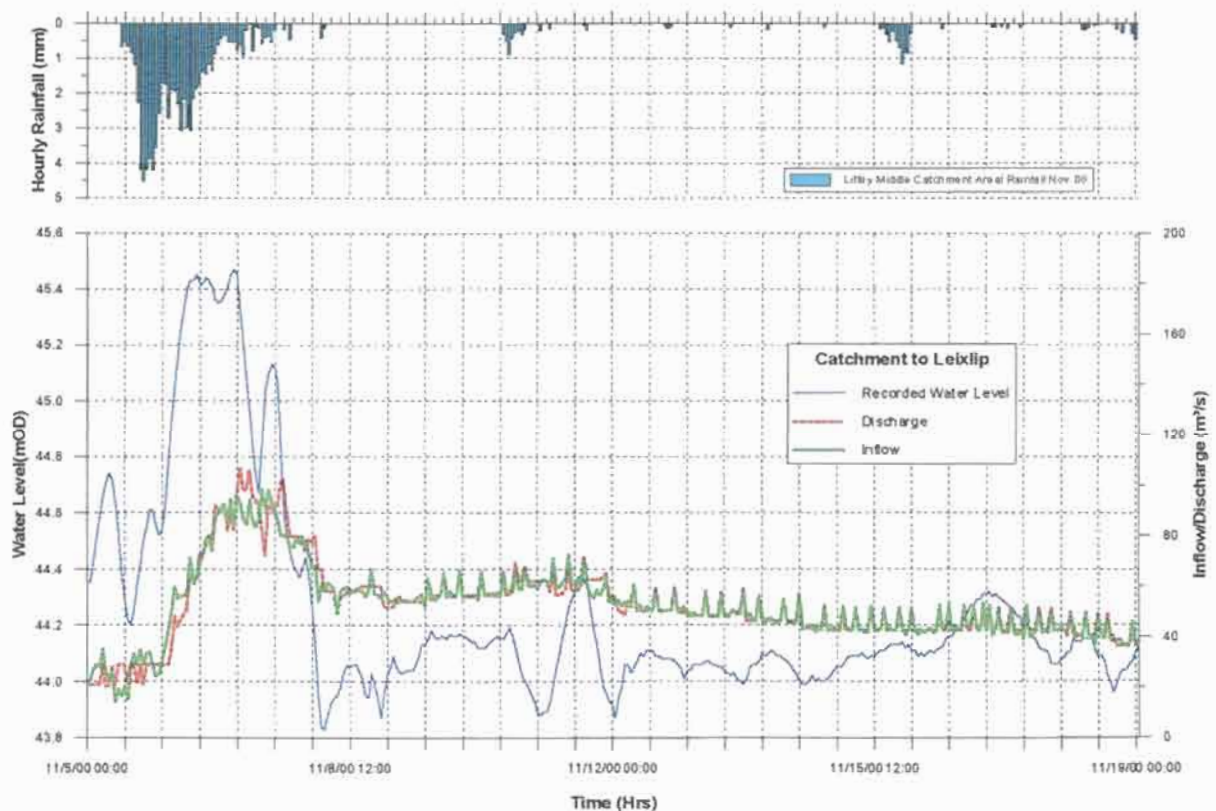


Figure 5.3: Middle Catchment to Leixlip – Inflows/Discharge and Water Level

The water level recorders at Celbridge and Straffan Bridge did not function properly for the period of the flood and as a result the peak discharge during the flood was not recorded at either locations. It is estimated that the time of peak discharge at both stations would have been sometime in the evening of 6th November 2000.

5.4 Lower Catchment

The OPW water level recorder on the Ryewater at Leixlip operated well for the duration of the flood and a copy of the chart is reproduced in Appendix C. The peak water level was estimated to be 32.18m O.D. with a corresponding estimated discharge of 82m³/s. This occurred at approximately 16.00hrs on the 6th November.

It is estimated that the peak flow downstream of the confluence of the Ryewater and the Liffey was approaching 170m³/s in the evening of 6th November. It can be deduced that the time of peak discharge on the Ryewater was between 7 and 10 hours prior to the time of peak discharge at Leixlip.

A peak flow of around 23m³/s was recorded in the Griffeen River at Lucan at 08.00hrs on 6th November 2000. The flow in the Griffeen at 24.00hrs on 6th November, the time of peak discharge at Leixlip, was approximately 10m³/s. Hence, the total peak flow in the River Liffey downstream of Lucan was in the region of 200m³/s and occurred at around 24.00hrs on 6th November.

The peak discharge in the River Dodder at Waldron's Bridge near the estuary was approximately 155m³/s and occurred at 23.00hrs on 5th November 2000.

6. Percentage Runoff

To estimate the percentage runoff (PR) for any flood event, the mean areal rainfall (P) and the storm runoff (R) are required i.e. $PR = R \cdot 100 / (P \cdot A)$ where A is the area of the catchment.

The storm runoff was estimated for the 5-day period from 4th to 9th November using the methodology outlined in the regulations for calculating inflows. The results are as follows:

Upper Catchment to Pollaphuca	=	40.94 x 10 ⁶ m ³
Middle Catchment from Golden Falls to Leixlip (excluding discharges from Golden Falls)	=	13.41 x 10 ⁶ m ³

The mean areal rainfall and actual percentage runoff values are presented in Table 6.1. Baseflow was subtracted from total runoff in estimating percentage runoff.

<i>Catchment</i>	<i>Mean Areal Rainfall (mm)</i>	<i>Percentage Runoff</i>
<i>Upper</i>	151.28	87.9%
<i>Middle</i>	80.20	31.3%

Table 6.1: Mean Areal Rainfall & Percentage Runoff Values

LIFMOD is a Fortran based model which can be used to predict the inflows into the Upper and Middle Catchments based on the estimated mean areal rainfall during the flood period.

A simulation using LIFMOD was carried out for November 2000 to compare the results with the actual inflows to the catchments. The results are presented in graphical format in Figures 6.1 and 6.2.

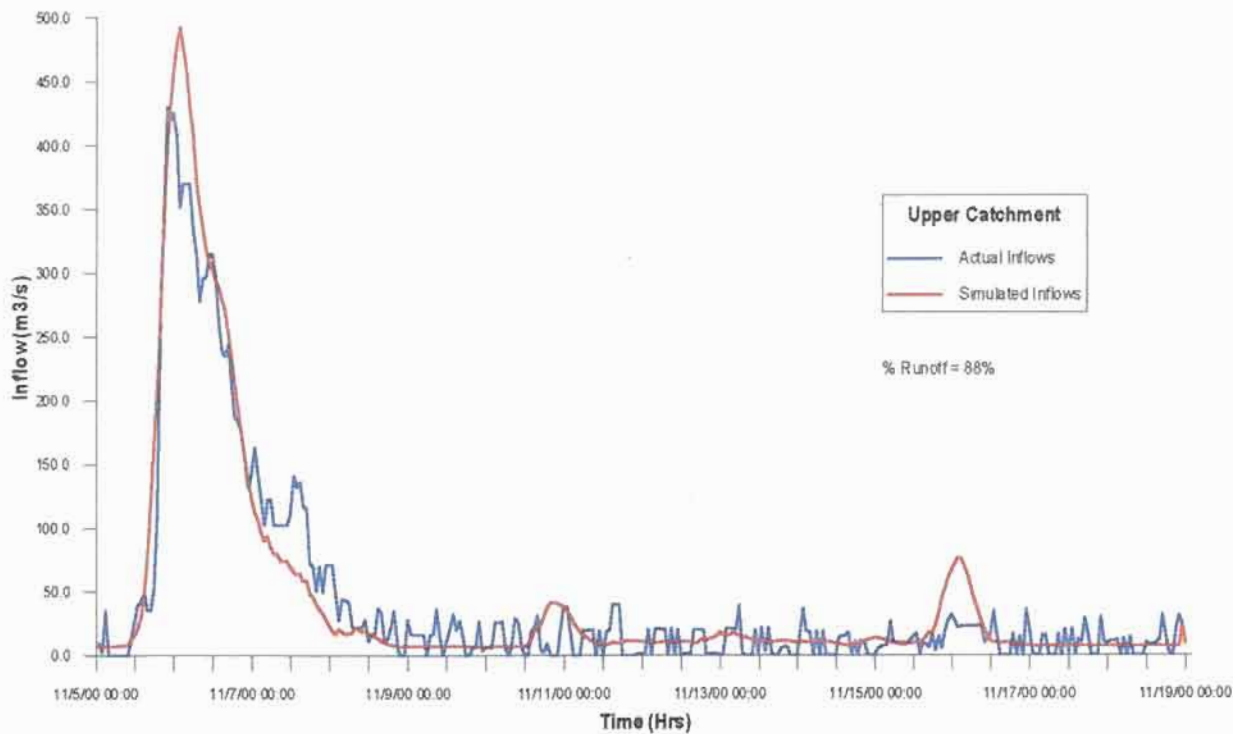


Figure 6.1: Actual vs Simulated Inflows to Pollaphuca Reservoir

The estimated percentage runoff value for the Upper Catchment compares quite well with those observed in previous floods [1]. The simulated inflows are quite accurate and the model can be considered to give a good representation of the catchment's response to the rainfall during November 2000. From Figure 6.1 it is apparent that the time of peak inflow was predicted very well by the model, within a couple of hours of the actual peak inflow. The magnitude of the peak inflow was overestimated by the model but otherwise the predicted inflows fit quite well with the actual inflows recorded to Pollaphuca reservoir. The apparent negative actual inflows arise because these inflows are calculated values, based on reservoir water levels. Over short periods water levels can be distorted due to wind action and water gradients in the reservoir.

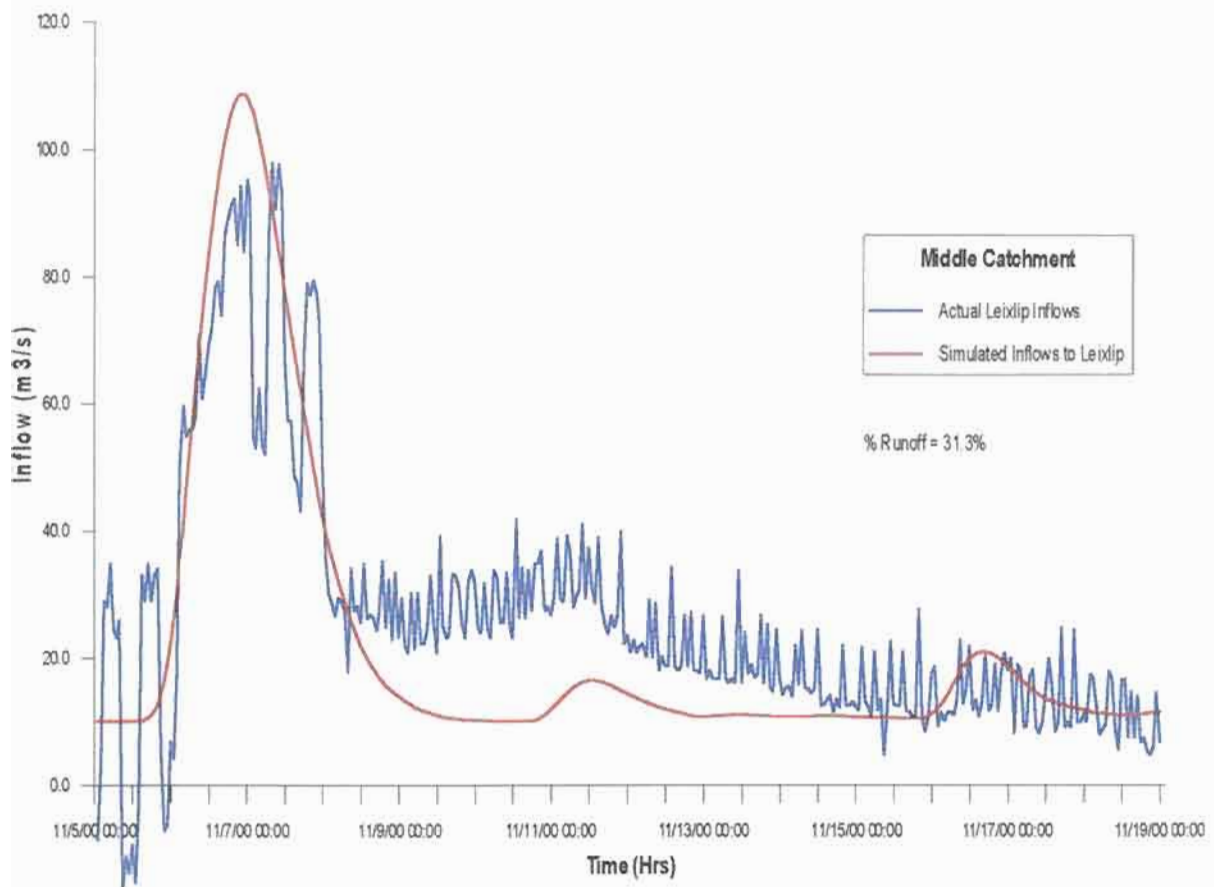


Figure 6.2 Actual v's Simulated Inflows to Leixlip Reservoir (minus the Golden Falls inflow component)

The estimated percentage runoff for the middle catchment is high relative to those observed during previous floods [1]. However, the value varies considerably from storm to storm. The two months previous to November were wet and this would cause groundwater levels to be high, thus giving a higher than expected percentage runoff.

Figure 6.2 compares the modelled inflows with the actual inflows to the Middle Catchment. The model predicts the time of the peak inflow very well. The predicted magnitude of the peak inflow to Leixlip is a bit higher than the actual but is good also. The model is calibrated to predict flood inflows only. This results in the model underestimating the catchment inflows once the flood inflows have passed. The graph of the actual inflow to Leixlip shows the inflow to fluctuate quite sharply. This is because the inflow component from Golden Falls has been subtracted to give the natural inflow to the Middle Catchment. This is also the cause of the apparent negative inflow values on the graph.

7. Return Period of November 2000 Flood

A flood frequency plot was constructed for the June 1993 flood report to estimate the return period of the flood on the Upper and Middle Catchments. This plot was reviewed for this report and considered satisfactory to apply to the November 2000 event. In addition, a flood frequency plot in terms of volumes was constructed for the Upper Catchment in June 1993 and this was applied to the November 2000 event.

7.1 Upper Catchment to Pollaphuca

Figure 7.1 shows the return period of inflows of varying magnitude to Pollaphuca Reservoir. This curve was constructed assuming an Extreme Value Type 1 statistical distribution for annual maximum inflows for floods of return periods less than 100 years and the rainfall/runoff approach for deriving floods greater than 100 year return period [1].

The return period of the November 2000 flood, when categorised by the peak hourly inflow to the reservoir, is in excess of 60 years, as can be seen in Figure 7.1.

In addition, the return period of the flood was estimated in terms of total volume for the duration of the flood. The annual maximum flood volume was estimated for each year since 1963 and return periods for each flood were estimated assuming an extreme Value Type 1 distribution. The least squares curve of best fit was plotted to yield the line in Figure 7.2.

The November 2000 flood had a return period also in excess of 60 years when categorised by inflow volumes.

7.2 Middle Catchment to Leixlip

Figure 7.3 shows the return period of inflows of varying magnitude to Leixlip Reservoir. As in the case of Pollaphuca inflows, the curve was constructed assuming an Extreme Value Type 1 statistical distribution for annual maximum inflows for floods of return periods less than 100 years and the rainfall/runoff approach for deriving floods greater than 100 year return period [1].

The return period of the November 2000 flood, when categorised by the peak hourly inflow to the reservoir, is in excess of 20 years, as can be seen in Figure 7.3.

9. Impact of Liffey Dams on Flooding

Pollaphuca Reservoir acts as a flood relief reservoir for the downstream Liffey Valley and greatly reduces the frequency and extent of flooding in the intermediate and lower Liffey Valley. The two other dams, at Golden Falls and Leixlip, impound relatively small reservoirs and would not have a significant attenuating impact on large floods on the Liffey such as occurred in November 2000.

A previous Study [6] simulated what would have occurred on the Liffey during Hurricane Charlie if the reservoirs had not been constructed. It estimated that a flow of approximately 380m³/s would have occurred at Leixlip under these circumstances and that there would have been extensive flooding of Leixlip, Lucan and the Dublin suburbs. However, the ability of Pollaphuca Reservoir to retain the large inflows and release the water subsequently in a controlled manner meant that there was no flooding along the lower reaches of the Liffey in contrast to that which occurred at the same time along the east coast of the country.

Comparison of the peak river flows on the Liffey and on the Rye Water at Leixlip during November 2000 demonstrates the influence of the controlled flows on the Liffey. The Rye Water with a catchment area of 215km² had a peak flow of approximately 80m³/s, while the peak flow on the Liffey, which has almost 4 times the catchment area, was just over 100m³/s at Leixlip.

An estimation of the magnitude of the flood that would have occurred on the Liffey in November 2000 if Pollaphuca Reservoir did not exist was made based on previous studies. The following table compares estimates of the peak flows with and without the dams.

Location	Estimated Peak Flow (m ³ /s)	
	With Dams	Without Dams
Ballymore Eustace	55	425
Upstream Leixlip	100	350
Downstream Leixlip	170	400

The estimated peak flow of 425m³/s at Ballymore Eustace would be greater than the 10,000 Year design discharge at Pollaphuca Dam. It is estimated that the flow at Kilcullen village, some 15km downstream, would be similar in magnitude to the 10,000 Year flood. Between Kilcullen and Leixlip it is estimated that the flows would be well in excess of the 1,000 Year flood. The predicted extent of flooding on the middle Liffey catchment from Pollaphuca to Leixlip for the 10,000 Year and 1,000 Year Floods has been shown previously on inundation maps [*River Liffey Inundation Study (Pollaphuca to Leixlip)*], March 1994, ESB International]. These give an indication of the extent of flooding which would have occurred in November 2000 without the flood alleviation benefits of

Pollaphuca reservoir. For example flooding in the villages of Newbridge, Straffan and Celbridge would have been far in excess of that which occurred in June 1993 [*'River Liffey Flood of June 1993', November 1993, ESB International*]

Based on the existing operating regime for the Liffey Reservoirs it is estimated that the peak discharge from Leixlip for the 1,000 and 10,000 Year Floods would be 240m³/s and 405m³/s respectively. When the discharge from the Rye Water catchment is added, the corresponding peak flows at Leixlip Town are estimated to be 315m³/s and 545m³/s. The estimated peak flows that would have occurred at Leixlip in November 2000 if there was no flood control on the Liffey would have been clearly in excess of the 1,000 Year Flood. Peak flood levels throughout the downstream valley would probably have been more than 1m higher than those which occurred in December 1954 – the worst flood on record. Extensive flooding would have occurred in Leixlip, Lucan and Chapelizod. Those areas likely to be affected by the 1,000 Year and 10,000 Year floods have been shown previously [*'River Liffey – Leixlip Inundation Study', January 1996, ESB International*].

10. Conclusions

November 2000 was one of the wettest months in the Liffey catchment since commissioning of the Liffey Stations and a very severe flood resulted from the rainstorm which occurred on the 5th – 6th November 2000. It was the third successive month of above average rainfall in the east of the country and thus this storm fell on an already saturated catchment. The prolonged hourly high flood inflows that resulted were the major cause of the flooding.

Table 10.1 summarises the November 2000 flood and compares the peak values during this event with those in June 1993 and with the 1,000-Year design events.

Event	Upper Catchment to Pollaphuca				Middle Catchment to Leixlip			
	Total Rainfall (39hr) (mm)	Peak Level (m O.D.)	Peak Inflow (m ³ /s)	Peak Discharge (m ³ /s)	Total Rainfall (45hr) (mm)	Peak Level (m O.D.)	Peak Inflow (m ³ /s)	Peak Discharge (m ³ /s)
Nov'00	138.8	187.53	430	74.8 ⁽¹⁾	76.6	45.47	98 ⁽²⁾	106.2
June'93	117.4	187.51	225	78	85.6	45.38	126	126
1,000 Year	179	188.30	581	335	134.8	48.15	214	213

(1) Hourly peak discharge, not continuous – occurred on 9th November after peak inflows to middle catchment had abated.

(2) Calculated value subject to inaccuracies in reservoir storage calculations.

Table 10.1: Peak Flood Values

It is estimated that the November 2000 flood had a return period in excess of 60 years on the Upper Catchment and in excess of 20 years on the Middle Catchment.

Discharges from Pollaphuca were not in accordance with the Regulations throughout this flood. However, it is clear that the actions taken protected the middle catchment to Leixlip from more extensive flooding.

Pollaphuca reservoir acts as a flood relief reservoir for the downstream Liffey valley. If the dam at Pollaphuca did not exist the flooding throughout the Liffey valley would have been considerably greater. The peak discharge at Leixlip would have approached 350m³/s as opposed to the 106.2m³/s observed. The impact of such a flood on the Liffey Middle Catchment and downstream of Leixlip would have been extreme with flood levels up to 1m higher than those recorded during the most severe flood in the last 50 years – December 1954.

References

1. 'River Liffey – Flood Control and Dam Safety', ESB Civil Works Dept., February 1986.
2. 'River Liffey Flood of June 1993', Report No. PA449-R5-004, ESB International, November 1993.
3. 'Regulations for the Control of the River Liffey', May 1995.
4. 'Operations Report on Liffey Flood November 2000' February 2001.
5. 'Flood Studies Report', Natural Environment Research Council, 1975.
6. 'River Liffey Flood of 25 – 26 August 1986', 1987.

APPENDIX A

METEOROLOGICAL DATA

Date	Pollaphuca	Ballymore Eustace	Blessington	Glenasmole	Glenmacnaas	Glen of Imaal	Roundwood
01/11/00	10.1	7.6	11.4	8.2	11	11.8	11.4
02/11/00	9.5	10.7	12.5	19.1	9.5	13	9.7
03/11/00	0	0	0.1	0.3	0	0.2	0
04/11/00	0	0.2	1.4	0.4	2.2	0	1.7
05/11/00	69.9	78.3	70.2	137.2	142	81.9	94
06/11/00	33.2	26.9	17.3	13.9	38.5	66	47
07/11/00	4	4.5	2.4	6.2	7.6	9.3	9.3
08/11/00	0	0.2	0	0.1	0	0	0
09/11/00	0	0	0	0	0	0	0
10/11/00	0	4.8	3.8	3.8	9.2	12	5.6
11/11/00	0	0.8	0.9	1	3	0.7	0
12/11/00	5.6	0.5	0	1.2	0	0.3	0
13/11/00	1.1	0.7	1	0.2	0	2.3	1.3
14/11/00	0.3	0.2	1.3	0.1	1.7	1.1	0
15/11/00	9	8.6	7.2	3.2	9.3	16.5	4
16/11/00	0.2	0.3	1.7	2	2	0.4	1
17/11/00	0	1.5	1.9	0.4	0	2	0
18/11/00	0	9.2	9.9	12.2	22.8	9.6	5
19/11/00	11.5	2	3.6	1.3	4.5	4.7	1
20/11/00	0	0	0	0	0	1.4	0
21/11/00	4.2	4.5	1.8	3.8	22.7	4.4	17
22/11/00	0	0.2	0.1	0	0	0.4	0
23/11/00	0	0	0.5	0	0	0	0
24/11/00	0	8.8	6.8	6.2	10.1	3.9	5.6
25/11/00	0	6	6.6	11.6	21.2	14.8	14.4
26/11/00	15.3	0	0.7	0.6	0.9	1	0
27/11/00	0	4.4	5.6	2.6	6.8	6.3	5.4
28/11/00	13.5	10.3	3.1	14.1	17.5	15.7	13.2
29/11/00	0.3	0.4	1.2	0	5.5	2.4	3.4
30/11/00	11	9.8	5.1	18.6	42	23.5	31

Table A1: Liffey Catchment Rainfall Data. November 2000 (Daily Totals mm)

<i>Date</i>	<i>Leixlip</i>	<i>Naas</i>	<i>Arklow WW</i>	<i>Phoenix Park</i>	<i>Merrion Sq.</i>	<i>Dublin Airport</i>
01/11/00	8.2	7.8	9.6	12.9	10.2	8.9
02/11/00	9.2	6.7	10.5	9.4	13.6	14.9
03/11/00	0	0	0	0.2	0.2	0.4
04/11/00	0	0	0	1.1	0.4	0.5
05/11/00	90.8	42	77.6	76.2	62.1	62.8
06/11/00	11.8	16.3	25	15.2	17	14.4
07/11/00	2.6	1	4	0.5	1.3	1.4
08/11/00	0	0	0	0	0	0
09/11/00	0	0	0	0	0	0.1
10/11/00	2.5	4	7	2.4	0.7	2.3
11/11/00	1.5	0	0.8	0.9	0.2	0.4
12/11/00	0.5	0.4	0	0.6	0.3	0.2
13/11/00	0	0.5	0.4	0.2	0.1	0.1
14/11/00	0	0	8.1	0	0	0.1
15/11/00	1.8	6.5	0.1	1.6	0.8	1.6
16/11/00	0.6	0.6	2	1	0.6	0.8
17/11/00	0.8	0.3	2.4	0.8	0.4	0.3
18/11/00	3.5	5.7	0.9	2.6	2.2	1.8
19/11/00	0.8	0.7	0.3	0.9	1	0.4
20/11/00	0	0	0	0	0	0.2
21/11/00	4.3	6.1	18.3	3.9	6.6	7.7
22/11/00	0	0	0	0	0	0
23/11/00	0	0	0	0	0	0.3
24/11/00	1.2	6.5	2.8	1.1	1	1.2
25/11/00	6.5	5.5	15.1	6.5	8.1	6.8
26/11/00	1.2	0.6	0	1.3	1.5	0.4
27/11/00	2.5	4.2	11.2	3.2	2	4.5
28/11/00	3.4	7.4	12.1	2.6	3.7	3.3
29/11/00	0.8	0.4	4.9	0.2	0.1	0.2
30/11/00	0.9	6.3	17.6	2.8	12.8	5.5

Table A2: Liffey Catchment Rainfall Data. November 2000 (Daily Totals mm)

APPENDIX D

Flood Hydrographs for Griffeen & Dodder And Chart for Ryewater

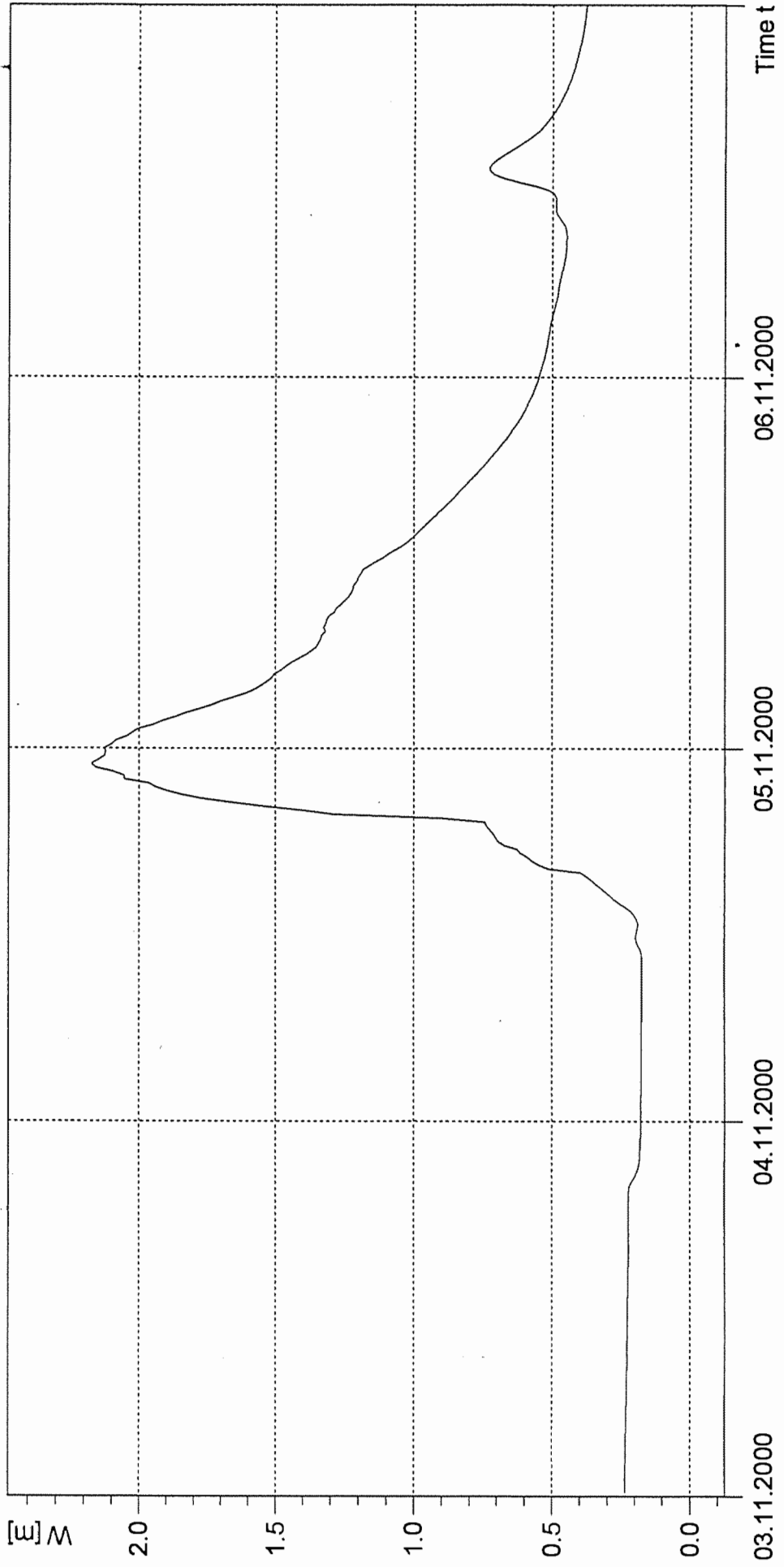
Hydrograph of Water level



Station number: 09010

Station name: WALDRON S BRIDGE

River: DODDER

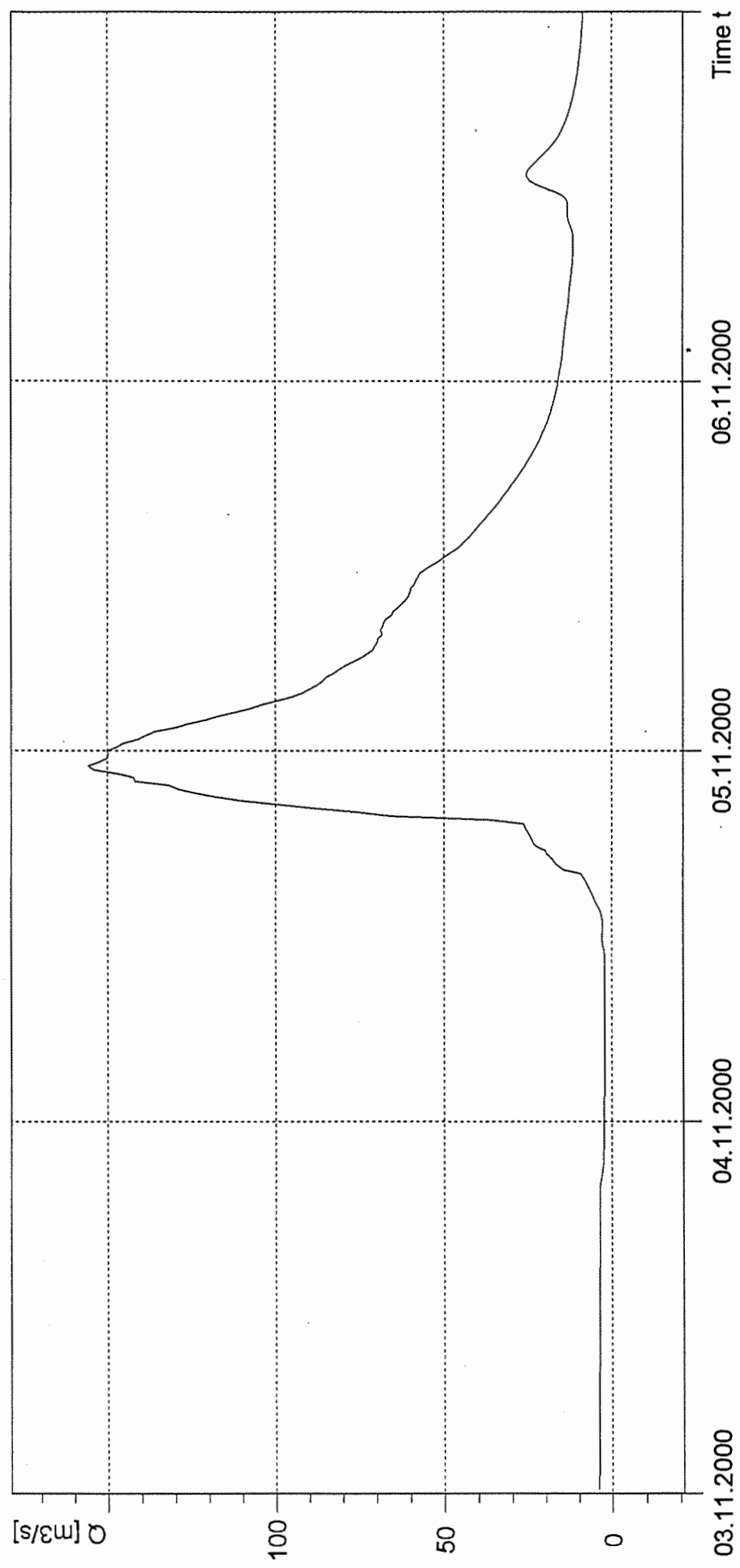


Hydrograph of Flow

River: DODDER

Station name: WALDRON S BRIDGE

Station number: 09010

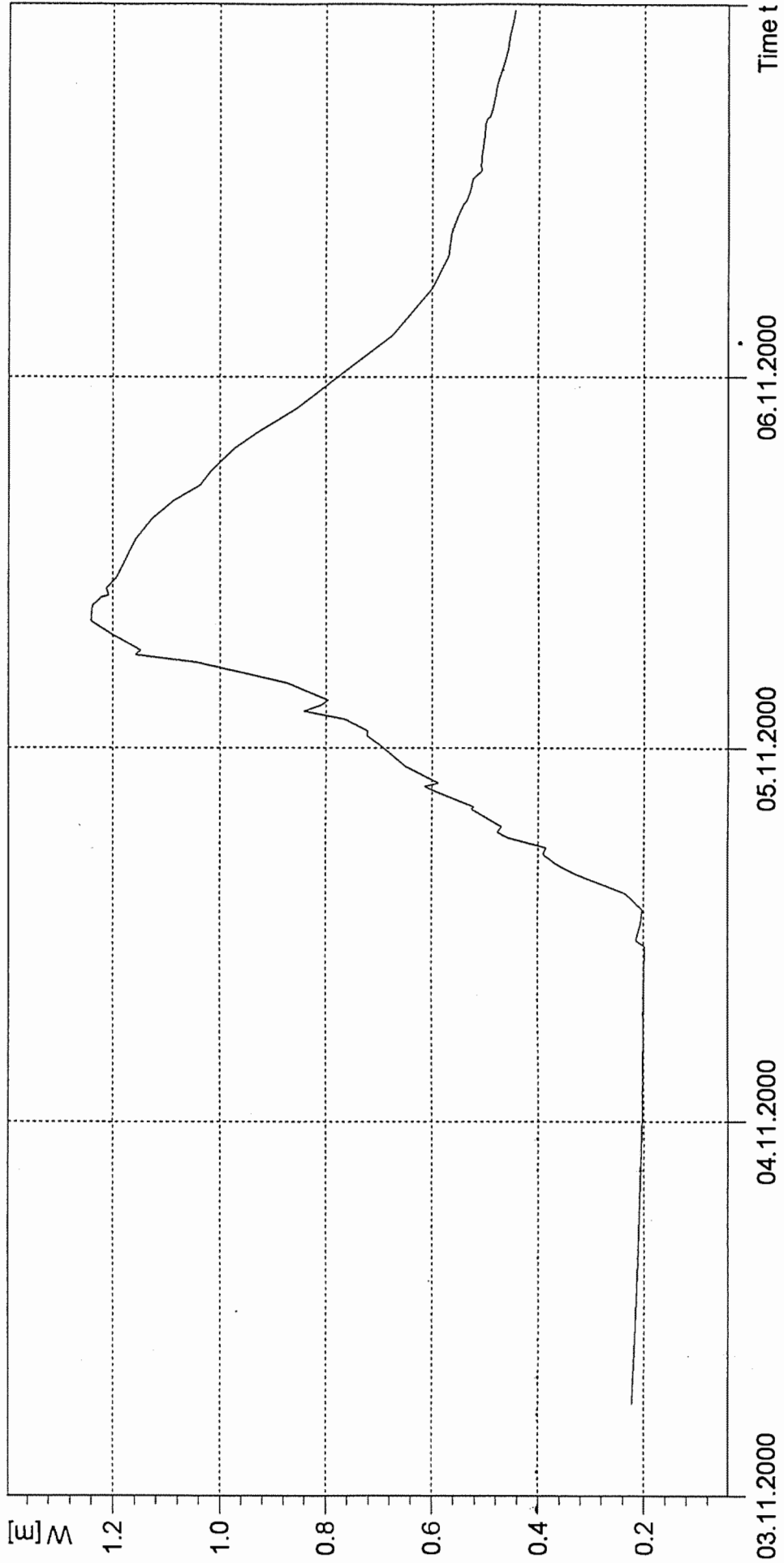
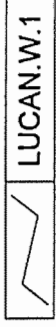


Hydrograph of Water level

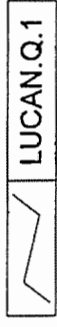
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Station name: LUCAN

River: GRIFFEEN



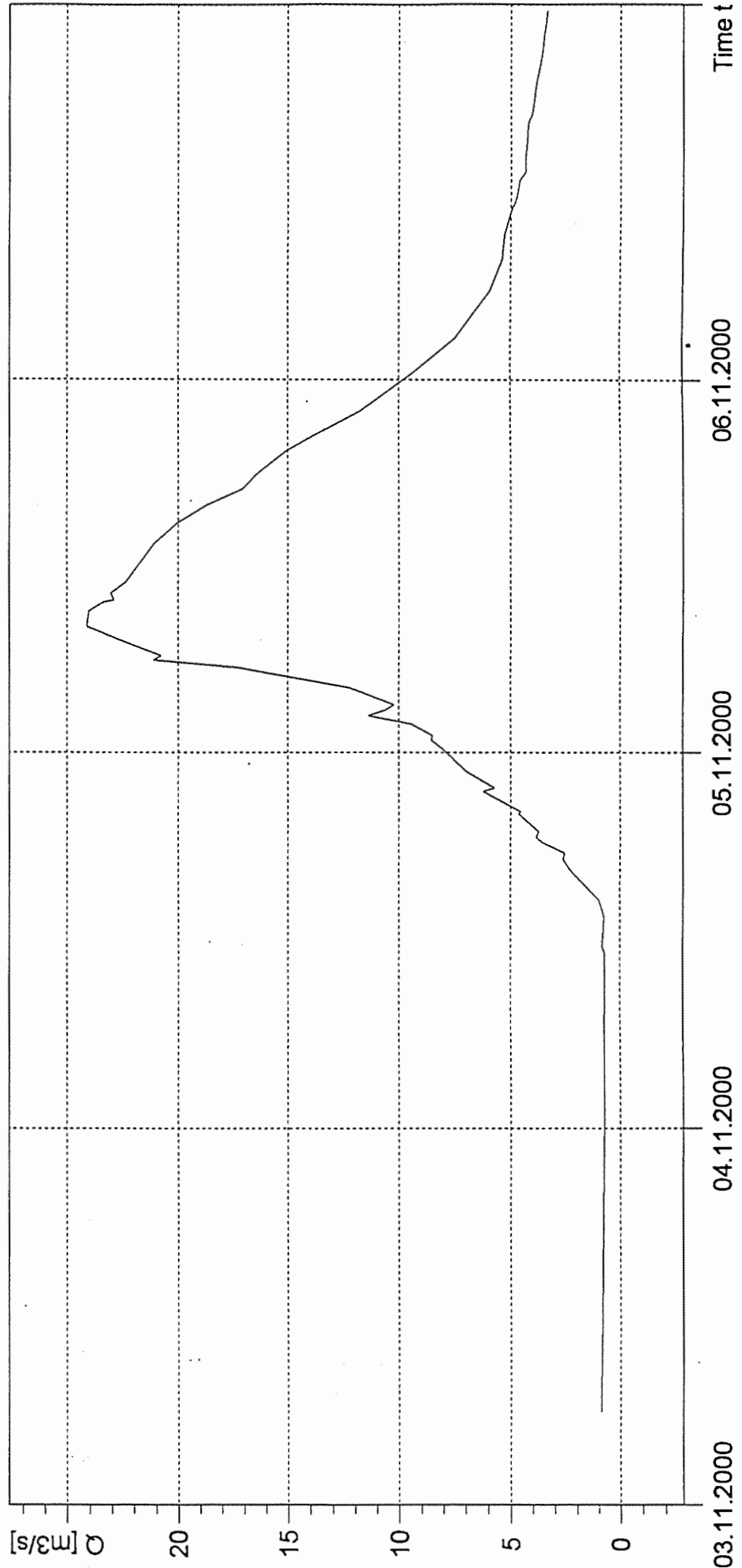
Hydrograph of Flow



Station number: 09002

Station name: LUCAN

River: GRIFFEEN



03.11.2000

04.11.2000

05.11.2000

06.11.2000

Time t

Station Number:

Station Name: LEW LIP weir

River: Rye Water

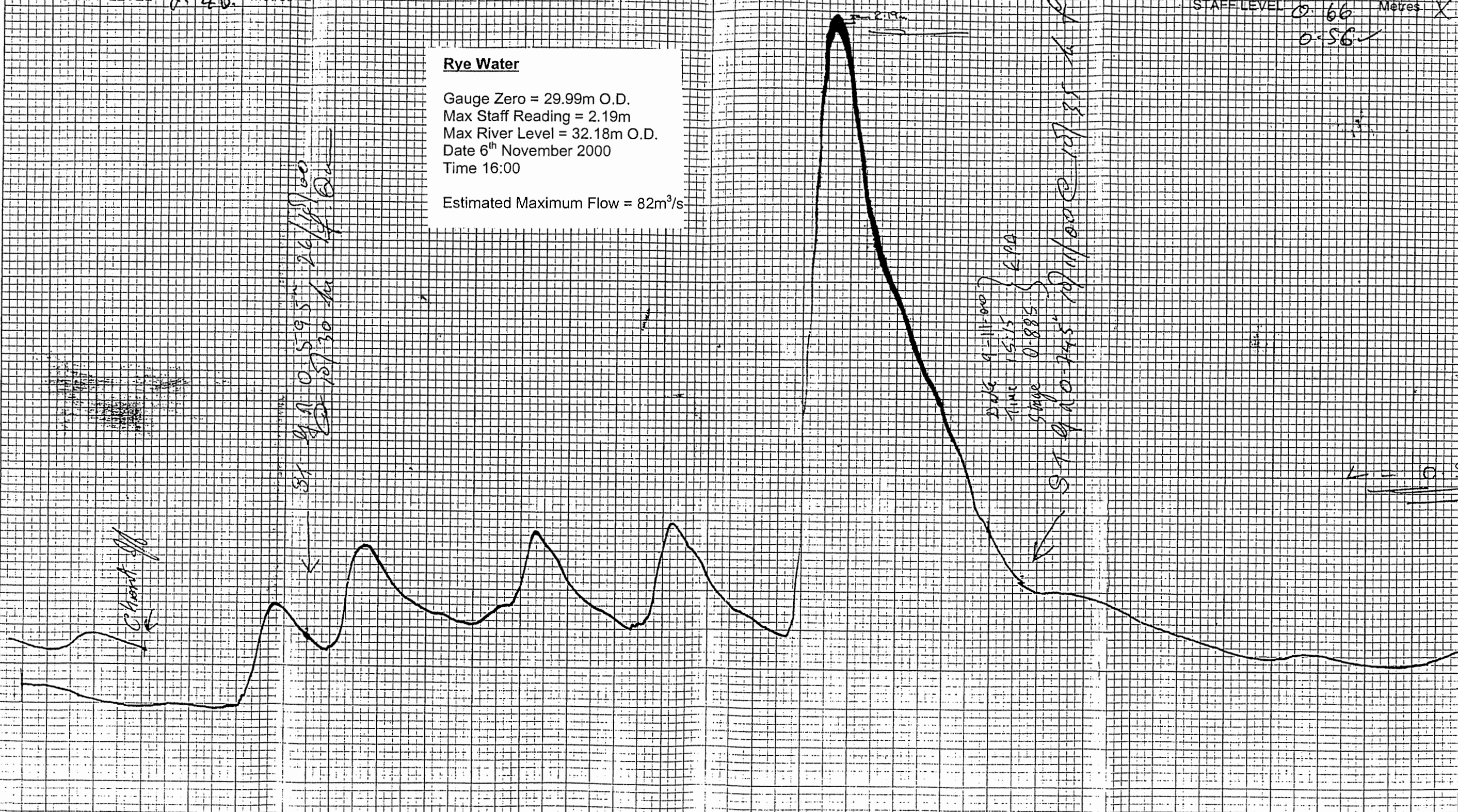
File Number: 151

CHART ON DAY 1
DAY 3rd Oct
DATE 20-10-00
TIME 11-15
STAFF LEVEL 0.46 Metres

CHART OFF
DAY 11th Nov
DATE 23-11-00
TIME 15-20
STAFF LEVEL 0.66 Metres X
0.56

Rye Water
Gauge Zero = 29.99m O.D.
Max Staff Reading = 2.19m
Max River Level = 32.18m O.D.
Date 6th November 2000
Time 16:00
Estimated Maximum Flow = 82m³/s

THIS SIDE UNDERNEATH



ST 20 0.55 9.5m 26/10/00
ST 21 0.57 30 10/11/00

Peak 2.19m
Time 15:15 6:00
Stage 0.885

0.56

Oct 00

Nov 00

DAY 20 21 22 23 24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 DAY

CLOCK END OF DRUM