Appendix D

Flood Assessment of River Liffey Report

R407 - SALLINS BYPASS

PRELIMINARY FLOOD ASSESSMENT OF THE RIVER LIFFEY AT SALLINS

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August 2007

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User is Responsible for Checking The Revision Status of this Document

Rev. Nr	Description of Changes	Prepared by:	Checked by:	Approved by:	Date
0	Working Draft, Issued for Comment	KB	AD		30/08/07
1	Final Draft	KB	AD	OT	20/11/07

Client: Kildare County Council

Keywords: Constraints study, route selection, preliminary design

Abstract: This preliminary flood study report estimates the design 100-year flood in the River Liffey near Sallins using various methods. Using approximate channel section of the River Liffey, it estimates the 100-water level in the river and determines the corresponding extent of flood plain. The results presented in this report are indicative only, as it does not use the available flood data and surveyed river cross sections. Once these inputs are available, the results presented in this report will be modified accordingly.

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1. INTRODUCTION

1.1. General Background

The Sallins Bypass Scheme is located near Sallins town, just to the north of Naas town in County Kildare. The extent of the study area of this scheme is spread over approximately 18 km^2 (6 km long and 3 km wide). Some major river/canal and hydraulic structures are situated in the relatively small study area, namely, the River Liffey, the Grand Canal and the Leinster Aqueduct (to cross the River Liffey by the Grand Canal). In additions, the railway line crosses the River Liffey and the Grand Canal (both main canal and the Naas & Corbally Branch) and the R407 crosses the Grand Canal within the study area.

1.2. The River Liffey

The River Liffey ('An Life' in Irish) is the major river in the Hydrometric Area No. 9 of Irish River Networks, with a total catchment area of approximately 1300km^2 and length 138 km. It rises in the Wicklow Mountains and runs in Counties Wicklow, Kildare, and Dublin. It flows in a generally northwesterly direction from its origin to the Pollaphuca Reservoir, after which it runs westward up to Newbridge, then gradually turns northeastward to Celbridge and Leixlip. It then flows eastward through the city of Dublin, in which it is extensively canalized and bordered with quays, and outflow to Dublin Bay, an arm of the Irish Sea. The entire catchment of the Liffey River can be classified into three distinct regions, upstream of the Pollaphuca/Golden Falls Reservoirs as the Upper catchment, between the Golden Falls Reservoir to the Leixlip Reservoir as the Middle catchment and downstream of the Leixlip Reservoir as the Lower catchment. The present study area is situated in the middle catchment of the River Liffey.

The Register of Hydrometric Gauging Stations in Ireland shows a list of 13 gauging stations on this river, among which the flowing four are at or close to the project area:

- the Leinster Aqueduct gauging station – Stn. No. 09033
- the Obsertstown gauging station – Stn. No. 09008 (catchment area = 564.2 km^2)
- the Straffan D/S gauging station – Stn. No. 09013 (catchment area = 658.1 km^2)
- the Straffan U/S gauging station – Stn. No. 09034.

Catchment area of the Liffey River at the project area is approximately 585km^2. The OPW website www.opw.ie/hydro does not consist of hydrometric data for any of these 13 gauging stations. The National Flood Hazard Mapping website www.floodmaps.ie, does not have any record of single or multiple/recurring flood points on the River Liffey in the Sallins (study) area. However, the River Liffey has history of recurring flooding at both further downstream (near Clane) and at further upstream (near Newbridge) of the study area.

2. EXTREME FLOODS IN THE RIVER LIFFEY

2.1. Reservoirs/dams in the River Liffey

According to J. Fitzpatrick and T. Bree (2001) of ESB International, Reservoir development on the river took place between 1937 and 1949, resulting in the commissioning of three dams namely Pollaphuca, Golden Falls and Leixlip. The middle and lower reaches of the Liffey have in the past been subject to chronic flooding. The construction of the three Liffey Dams, particularly Pollaphuca with its large associated reservoir, has significantly reduced major flooding on the river. Pollaphuca dam in the upper catchment is served by a catchment area of 308km² consisting mainly of a blanket bog overlying granite and having an average annual rainfall of 1,390mm. Pollaphuca Reservoir (Blessington Lake) is situated approximately 185m above sea level and has a surface area of 20km². The large storage available, at approximately 50% of the average annual inflow, is such that it has not been necessary, to date, to use the spillway gates. Golden Falls dam is situated about 2km downstream of Pollaphuca and acts as a regulating reservoir for discharges from Pollaphuca. It allows the generating turbines at Pollaphuca to run for four hours, filling Golden Falls. Then the volume of water is released downstream at a lower discharge rate over a 24 hour period. The catchment area of the Liffey River up to the Golden Falls dam is approximately 314km².

After passing through Golden Falls, the Liffey flows approximately 56km through Co. Kildare to a relatively small reservoir at Leixlip, which is 20km from Dublin City. There are a number of small towns and villages located on its course, including Ballymore Eustace, Kilcullen, Newbridge, Straffan and Celbridge, all of which have the potential to be affected by extreme floods on the Liffey (Fitzpatrick and Bree, 2001)

According to J. Fitzpatrick and T. Bree (2001), the Liffey reservoirs have a major role in the attenuation of floods in the Liffey catchment. The November 2000 flooding in the River Liffey was a significant flood event which is estimated to have a return period in excess of 50 years in the upper catchment. Heavy rainfall on the 5th and 6th of November 2000 in the eastern half of the country generated a major inflow to Pollaphuca reservoir from the upper Liffey catchment. As a result, the reservoir level reached its highest value in over 50 years. At its hourly peak, the maximum inflow to the reservoir was estimated at over 420m³/s. This compares with the maximum outflow from from Pollaphuca of 73m³/s.

Despite its relatively small size, further flood attenuation is achieved at Golden Falls reservoir. With the maximum inflow to the Golden Falls reservoir of 73m³/s, the outflow was just over 50m³/s. This attenuation was achieved by means of reservoir storage and discharge via the hydro station and spillway.

The Liffey Reservoirs have significantly reduced the frequency and extent of flooding along the Liffey as far as Dublin and this fact was highlighted in August 1986 when Hurricane Charlie caused extensive flooding on neighbouring catchments. Fitzpatrick and Bree (2001) used a hydrological model of the Liffey catchment to simulate what would have occurred in August 1986 if the reservoirs had not been constructed. The rainfall on the upper catchment was considerably more severe than that on the intermediate catchment. This model estimated that a flow approximately twice that which occurred in December 1954, the largest flood on record, would have occurred at Leixlip under these circumstances and there would have been extensive flooding of the Dublin suburbs. Extensive flooding occurred in 1954 in Lucan and Leixlip.

An analysis of the November 2000 Liffey flood was undertaken by Fitzpatrick and Bree (2001) to estimate the impact of the Liffey dams on the magnitude of the flooding. The results showed that without the Leixlip Dam, the peak flow value at the downstream of the Leixlip dam would have been approximately $400m^3/s$, whereas, with the dam in place, the recorded value was only $170m^3/s$. Their analysis indicated that without the dams, it was likely that severe flooding would have occurred throughout the Liffey valley downstream to Dublin and that peak levels would have exceeded those which occurred in December 1954.

2.2. Estimation of the extreme flow in the River Liffey at Sallins

2.2.1. Available annual maximum flow series and pre-processing of the data

As mentioned in Section 1.2 above, the OPW website www.opw.ie/hydro does not consists of annual maximum flow data for any of the hydrometric stations on the River Liffey. Therefore the OPW (Hydrometric Office at Headford, Co. Galway), ESBI and the EPA were contacted for providing the annual flood data of the River Liffey. Although no such data was available from the OPW, the following hydrometric data made available by the ESBI and the EPA:

- Annual maximum series of the River Liffey at Celbridge (Station No. 09006) for the period of 1967 – 1999 and at Straffan ((Station No. 09013) for the pre period of 1982 – 1999 were made available by the ESBI (see in the Appendix)

- Annual maximum series of the River Liffey at Celbridge (Station No. 09006) for the period of 1968 – 1996 were made available by the EPA (see in the Appendix).

The catchment area of the River Liffey near the Sallins project site is approximately 585 km^2 whereas those at the Straffan and Celbridge gauging stations are 658.1 and 808.1 km^2 respectively. Therefore, any flood data at the Straffan gauging station would help to estimate more accurate extreme flood values at the project site due to its proximity to the site. However, only 17 number of annual maximum flow values were available at Straffan whereas altogether 31 such values were available at Celbridge.

Although the Straffan gauging station is located approximately 7km upstream of the Celbridge gauging station, the annual maximum flood data for the two stations, made available by the ESBI, show that the annual peak flow value at Straffan for any year is higher than the corresponding value at Celbridge. One normally would expect the opposite scenario, i.e. Celbridge having higher values than Straffan. These lower annual peak flow values at Celbridge could be as a result of huge over-bank storage and high storage capacity of the River Liffey between Straffan and Celbridge.

It was further observed that, for the same gauge heights, the EAP annual maximum flow values for some of the years were different from those of the ESBI values. To check the consistency of the flow data, plots of peak flow values versus annual maximum gauge heights were prepared for both sets of data (i.e. the EPA and the ESBI data). These plots are presented in Fig. A.1 in Appendix A. It is observed from these two plots that the ESBI values are well represented by a straight line (R^2 = 0.99) whereas the EPA values are only fairly represented by a straight line (R^2 = 0.84). Therefore, it would seem that the ESBI values are more representative of the actual peak flow values and hence these values were adopted for further analysis.

From a comparison of the Annual Maximum Series (AMS) at the Celbridge and Straffan, it was observed that, although most of the annual maximum peak flows at these two stations occurred on different dates, three of such peak flows occurred on the same date. These included the peak flows on 7th of November 1982, on the 6th of February 1990 and on the 26th of January 1995 (see Table 2.1).

	Peak Flow Values (m^3/s) at		
Date	**Celbridge**	**Straffan**	$Q_{Celbridge}/Q_{Straffan}$
07/11/1982	53.91	65.76	1.220
06/02/1990	63.60	77.28	1.215
26/01/1995	56.61	69.36	1.225

Table 2.1: Comparison of annual peak flows at Straffan and at Celbridge

On these three days, the peak flow values at the Straffan were approximately 22% higher than those at Celbridge. Assuming this ratio holds for all other year, an annual peak flow series of 32 years was obtained at the Straffan gauging station with the help of the available peak flow series at Celbridge. This annual maximum series (see Table 2.2) consists of 11 peak flow values directly taken from the AMS at Straffan gauging station and the remaining 21 peak flow values generated from the Celbridge AMS.

It is observed from Table 2.2 that the mean annual flood (Qbar) obtained from the hydrometric data at Straffan gauging station is approximately 66.1m^3/s.

2.2.2. At-site flood frequency analysis of the available flood data

(i) At Straffan Gauging Station (GS)

The 32-year annual maximum flow data was fitted to the Generalized Extreme Value (GEV) distribution using the method of L-moments for estimating parameter of the fitted distribution. The flood frequency curve thus obtained is shown in Fig. 2.1.

The Fig. 2.1 shows the EV1 reduced variate (y_T) obtained from Gringerton Plotting Position and the corresponding return period on the abscissa and peak flow values in the ordinate. The frequency curve well defines the annual maximum flow series at Straffan GS. From the frequency curve, the 100-year peak flow value at the Straffan GS is found to be approximately 14 m^3/s.

Water Year	Date of peak flow (Q)	Value of the Q (m^3/s)	Flow obtained from
1966	23/02/1967	103.8	Celbridge (gen)
1967	09/01/1968	75.0	Celbridge (gen)
1968	25/12/1968	94.0	Celbridge (gen)
1969	25/04/1970	71.6	Celbridge (gen)
1970	24/11/1970	61.0	Celbridge (gen)
1971	19/01/1972	57.9	Celbridge (gen)
1972	14/02/1973	44.1	Celbridge (gen)
1973	24/12/1973	75.0	Celbridge (gen)
1974	24/11/1974	49.0	Celbridge (gen)
1975	10/01/1976	50.4	Celbridge (gen)
1976	11/01/1977	75.8	Celbridge (gen)
1977	14/03/1978	75.8	Celbridge (gen)
1978	29/11/1978	84.7	Celbridge (gen)
1979	19/03/1980	128.9	Celbridge (gen)
1980	05/11/1980	69.1	Celbridge (gen)
1981	22/12/1981	53.3	Celbridge (gen)
1982	07/11/1982	65.8	Straffan
1983	16/01/1984	54.8	Celbridge (gen)
1984	16/08/1985	57.5	Celbridge (gen)
1985	26/08/1986	56.3	Straffan
1986	09/12/1986	61.8	Straffan
1987	24/01/1988	55.9	Straffan
1988	28/03/1989	47.6	Celbridge (gen)
1989	06/02/1990	77.3	Straffan
1990	12/04/1991	65.8	Celbridge (gen)
1991			NA
1992	12/06/1993	113.2	Straffan
1993	10/01/1994	50.2	Straffan
1994	26/01/1995	69.4	Straffan
1995	12/02/1996	55.5	Straffan
1996	26/11/1996	57.9	Celbridge (gen)
1997	18/11/1997	60.5	Straffan
1998	21/09/1999	61.4	Straffan
Average flow (Qbar) =		68.1	

Table 2.2: AMS series at Straffan Gauging Station (09006)

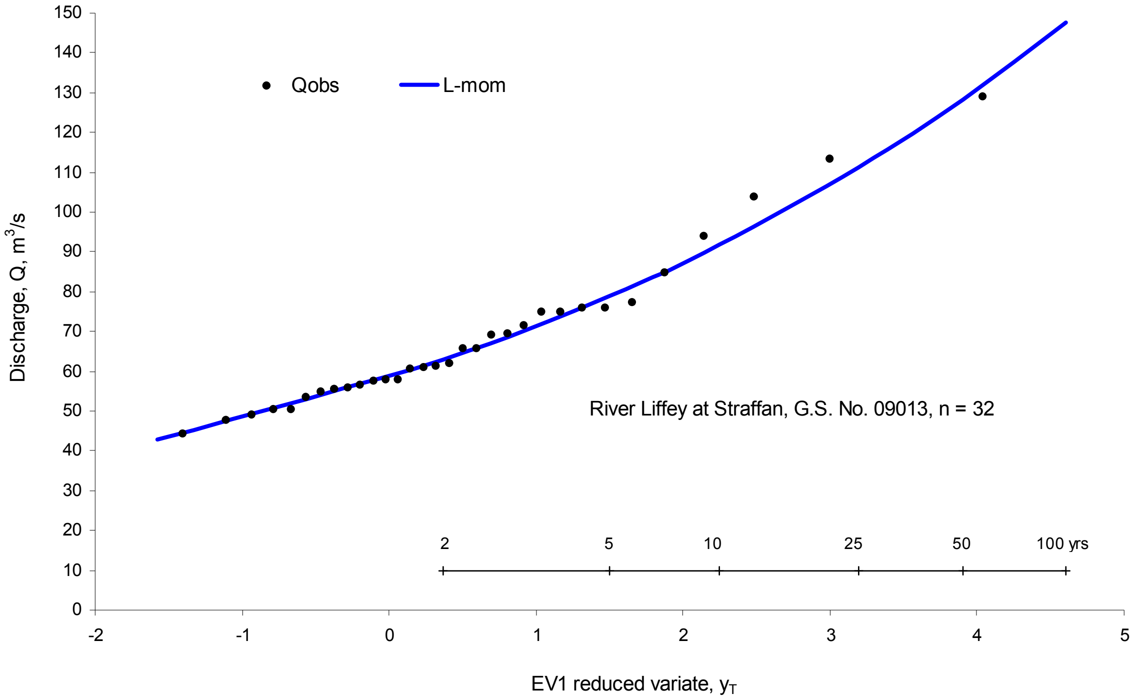

Fig. 2.1: Frequency curve for River Liffey at Straffan obtained from the flood frequency analysis of the AMS using GEV distribution and method of L-moments

(ii) At Sallins Bypass Site

For a river having no storage reservoir along its reach, generally higher values of peak flow are expected at the downstream reach (having larger catchment area) than at the upstream reach (having less catchment area). However, as the River Liffey has two big reservoirs at the upstream reach, one low reservoir at the downstream reach and over-bank flows on its flood plain at the intermediate reach, the above general rule may not apply. This is observed from the fact that the Celbridge GS at the downstream (with catchment area of 808.1km^2) recorded lower peak flow value in a year than the corresponding peak flow value at the upstream Straffan GS (with catchment area of 658.1km^2).

The proposed site at Sallins is located approximately 7km upstream of the Straffan GS and the catchment area of the Liffey at the two locations are 585km^2 and 658.1km^2 respectively. Assuming the effect of larger catchment area at the Straffan GS is compensated by the large river channel storage capacity between Sallins and Straffan, the annual peak flow values at the two stations have been assumed similar. Based on this assumption, the 100-year peak flow value in the River Liffey, from at-site flood frequency analysis has been taken similar to that at Straffan GS, i.e. **148 m^3/s.**

2.2.3. Extreme flood values using regional flood estimation method

(i) At Straffan Gauging Station

The mean annual flood value at Straffan, estimated form the data series is approximately 68.1m³/s (See Table 2.2 in Section 2.2.2).

Considering the regional growth factor of 2.6 as recommended by Bruen *et al.* (2005), the 100-year peak flow values in the River Liffey at Straffan GS was estimated as

$$Q_{100} \text{ (at Straffan)} = 2.6 * 68.1 = 177 m^3/s$$

This 100-year peak flow value estimated using the modified regional growth factor is larger than the corresponding values obtained from at-site flood frequency analysis. However, if the FSR a regional growth factor of 1.96 was considered, then the 100-year flood from region method would have been (1.96 * 68.1 =) 133.5m^3/s, which in fact is smaller than that obtained from the at-site flood estimate. Therefore, the 100-year flood value in the River Liffey at Straffan has been adopted as **177m³/s**.

(iii) At Sallins Bypass Project Site

As no annual maximum flood data are available at Sallins, these were estimated using an indirect method, as described below.

At first, the mean annual flood (Qbar) in the River Liffey at Straffan was estimated assuming this as an ungauged catchment. The ungauged Qbar at straffan was estimated following the procedure recommended by the Flood Studies Report (1975) involving the 6-variable equation and catchment characteristics. Using the mean annual flood values obtained from the actual annual maximum flood data at Strafan, the ratio between the Qbar(data) and Qbar(ungauge) is computed.

Next, the Qbar(ungauged) at Sallins was also estimated using the FSR (1975) method for ungauged catchment using the 6-variable equation involving their catchment characteristics. Then, assuming that the ratio between the Qbar(data) and Qbar(ungauged) at Straffan also hold at Sallins, the Qbar(data) was estimated from Qbar(ungauged) at Sallins.

Catchment characteristics of the River Liffey at Straffan

Catchment Area (AREA):	658.1km^2
Stream Frequency (STMFRQ):	1.0 per km^2 (assumed)
Soil Index (SOIL):	0.4
Lake:	0.477 (314 km^2 u/s of the reservoir)
Stream slope (S1085):	2.59m/km
Net 1 day rainfall of 5 year return period (RSMD):	41.568mm

Using the above catchment characteristics in the FSR 6-variable equation, the mean annual flood (Qbar) is estimate as

Qbar (ungauged) = 96.5m^3/s.

Qbar (data) (from Table 2.2) = 68.1m^3/s.

The ratio of Qbar (data) and Qbar (ungauged) = 68.1/96.5 = 0.705

<u>Catchment characteristics of the River Liffey at Sallins</u>

Catchment Area (AREA):	585km^2
Stream Frequency (STMFRQ):	1.0 per km^2 (assumed)
Soil Index (SOIL):	0.4
Lake:	0.537 (314km^2 u/s of the reservoir)
Stream slope (S1085):	3.33m/km
Net 1 day rainfall of 5 year return period (RSMD):	41.568mm

Using the above catchment characteristics in the FSR 6-variable equation, the mean annual flood (Qbar) in the River Liffey at Sallins was estimated as

Qbar (ungauged) = 87m^3/s.

Ratio between Qbar(data) and Qbar(ungauged) = 0.706

Qbar (data) = 0.705 * 87 = 61.34m^3/s/

Considering the regional growth factor of 2.6 as recommended by Bruen *et al.* (2005), the 100-year peak flow values in the River Liffey at Sallins was estimated as

$$Q_{100} = 2.6 * 61.34 \approx 160 \text{ m}^3/\text{s}$$

2.2.4. <u>The adopted design 1 in 100 extreme flood value</u>

The mean annual flood (Qbar) and the 100 year peak flow values in the River Liffey estimated from different methods are shown in the Table 2.3.

River Liffey at	Q_{100} (m^3/s) from at-site estimates	Qbar from flood data	Q bar for ungauged catchment	Q_{100} regional (growth factor x_{100} = 2.6)
Straffan GS	148	68.1	96.5	177
Sallins	148	61.4	87	**160**

Table 2.3: Estimated 100-year flood at Sallins

The estimated 100-year flood in the River Liffey at Sallins is approximately **160m^3/s**. Assuming an allowance of 20% to accommodate the effect of future climate change in Ireland, the adopted design 100-year flood is approximately **192m^3/s**.

2.3. Extent of the 100-year flood plain of the Liffey at Sallins

2.3.1. The river cross section and longitudinal gradient

Three river cross sections were drawn based on the topographic map, and a representative section (Section A) was considered for the estimation of approximate water level in the River Liffey at the 100-year design flood.

The typical cross section above the mean flow level (El. 68.079 m OD) has a width of 6m and side slope of 1V:6H. It was assumed that the river is 2m deep at this location, with the side-slope of the natural channel as 1V:0.5 H. This analysis gave the water area below the mean water level as approximately $10m^2$.

The average gradient of the river is assumed as 1 in 1000 (i.e. 0.1%) and the value of Manning's roughness co-efficient as 0.04 for the analysis.

2.3.2. The 100-year water levels and the extent of 100-year flood plain

With the above assumptions and the approximate cross-section, the depth of water above the mean water level was calculated, using the Manning's equation, for both the 100-year flood values of $160m^3/s$ and $192m^3/s$ (including climate change allowances).

The hydraulic analysis shows that the depth of water above the average mean flow level of 68.079m OD would be 3.923m and 4.252m respectively for the 100-year flood without and with the effect of climate change respectively.

The corresponding 100-yeare water levels are approximately **72.00m OD** in general case and approximately **72.33m OD** considering the effect of possible future climate change in Ireland.

These 100-year water levels of 72.30m OD and 72.33m OD (for climate change) were obtained by using approximate river x-section (no survey x-section is involved) and using Manning's equation. Therefore, these values have to be used as indicative values only.

A more refined 100-year water level could be estimated using the HECRAS software package and several surveyed river cross sections of the River at the Sallins area including some survey cross sections up and downstream of Sallins.

From the topographic map, it is observed that approximately **200m** of the road alignment along the River Liffey will pass through the 100-year flood plain.

3. SUMMARY OF THE PRELIMINARY FLOOD STUDY

The two reservoirs at the upstream (namely the Pollaphuca and the Golden Falls) and the one at the downstream (the Leixlip Reservoir) protect the surrounding areas at the upstream and downstream reach of the River Liffey from extreme floods. As there are no reservoirs in the middle reach of this river, a number of small towns and villages located on its course, including Ballymore Eustace, Kilcullen, Newbridge, Straffan and Celbridge, have the potential to be affected by extreme floods on the Liffey.

The Sallins Bypass Scheme, although lies in the middle reach of the River Liffey, is not reported to have the history of recurrent floods in the www.floodmaps.ie.

Annual maximum flow data the River Liffey at the Celbridge and Straffan gauging stations (both in the downstream reach with Straffan closer to Sallins) were made available by ESBI and EPA. From the analysis of these data, the 100-year flood value at Sallins was estimated as **160m^3/s** at the present case and **192m^3/s** considering the effect of future climate change in Ireland. The corresponding 100-year water levels in the River Liffey were estimated as approximately **72.0m OD** and **72.3m OD** respectively.

This means, out of the 400m stretch of road located close to the left bank of the River Liffey (the Red alternative route), approximately **200m** lies in the 100-year flood plain. The average elevation of the flood plain is 71.0m OD, which means the average depth of water on this flood plain would be approximately 1.0 m at the 100-year flood condition.

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E.J. Huyskes, A.D. Maguire, A. Jordan ( ) – Early Warning System – Feasibility for application to Dublin rivers. Paper submitted to the National Hydrology Seminar

J. Fitzpatrick and T. Bree (2001) - Flood risk management through reservoir storage and flow control. Paper submitted to the National Hydrology Seminar, Tullamore, November 2001.

Natural Environmental Research Council (1975) - Flood Studies Report, Vols 1 to 5, London, UK

OPW National Flood Hazard Mapping website www.floodmap.ie

Annual Maximum flow data for River Liffey at Celbridge and Straffan gauging station available from ESBI (contact: Mr James Fitzpatrick) through e-mail dated 30.07.2007.

Annual Maximum flow data for River Liffey at Celbridge available from EPA (contact: Ms. Rebecca Quinn) through e-mail dated 02.08.2007.

Appendix

Annual Maximum Series of the River Liffey at Celbridge and Straffan

Celbridge (09006)

Date	Stage m	Water Level mOD Poolbeg	Flow m³/s
23/02/1967	2.18	50.26	85.07
09/01/1968	1.87	49.95	61.46
25/12/1968	2.08	50.16	77.08
25/04/1970	1.83	49.91	58.67
24/11/1970	1.70	49.78	49.98
19/01/1972	1.66	49.74	47.44
14/02/1973	1.47	49.55	36.16
24/12/1973	1.87	49.95	61.46
24/11/1974	1.54	49.62	40.16
10/01/1976	1.56	49.64	41.33
11/01/1977	1.88	49.96	62.17
14/03/1978	1.88	49.96	62.17
29/11/1978	1.98	50.06	69.45
19/03/1980	2.42	50.50	105.66
05/11/1980	1.80	49.88	56.61
22/12/1981	1.60	49.68	43.73
07/11/1982	1.76	49.84	53.91
16/01/1984	1.62	49.70	44.95
16/12/1984	1.55	49.63	40.74
26/08/1986	1.64	49.72	46.19
28/03/1989	1.52	49.60	38.99
06/02/1990	1.90	49.98	63.60
12/04/1991	1.76	49.84	53.91
07/02/1994	1.59	49.67	43.12
26/01/1995	1.80	49.88	56.61
26/11/1996	1.66	49.74	47.44
25/11/1997	1.66	49.74	47.44
09/04/1998	1.75	49.83	53.25
20/09/1999	1.83	49.91	58.67

808.1 km2

Annual Maxima

Straffan (09013)

Date	Stage m	Water Level mOD Poolbe	Flow m³/s
07/11/1982	2.12	61.74	65.76
07/01/1983	1.63	61.25	45.56
16/11/1984	1.81	61.43	52.61
16/08/1985	1.93	61.55	57.54
09/12/1986	2.03	61.65	61.81
12/11/1987	1.63	61.25	45.56
24/01/1988	1.89	61.51	55.88
25/12/1989	1.66	61.28	46.71
06/02/1990	2.37	61.99	77.28
30/12/1992	1.55	61.17	42.57
12/06/1993	3.06	62.68	113.21
10/01/1994	1.75	61.37	50.21
26/01/1995	2.20	61.82	69.36
12/02/1996	1.88	61.50	55.46
18/11/1997	2.00	61.62	60.51
09/04/1998	1.98	61.60	59.66
21/09/1999	2.02	61.64	61.38

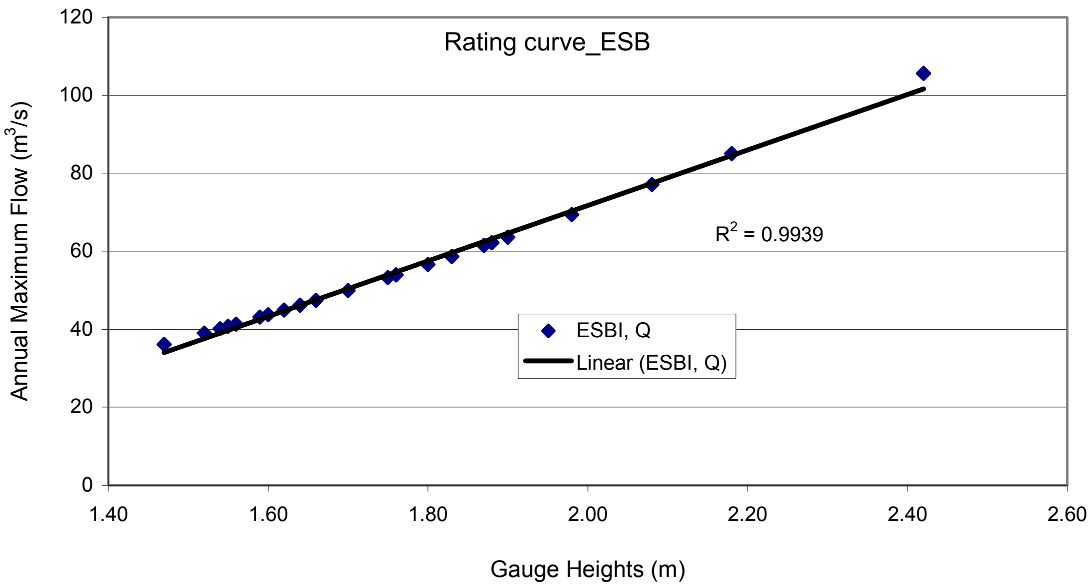
658.1 km2

Table A.1: Annual maximum flood data of the River Liffey at Celbridge and Straffan (source: ESBI)

Station Name:	CELBRIDGE
Station Number:	09006
River:	LIFFEY
Operator:	DUB
Easting:	297603
Northing:	233341
Datum:	48.079 m OD [Poolbeg]
Parameter Name:	Q
Parameter Type:	FQ
Time series Name:	CELBRIDGE / Q / CELBRIDGE.Q.YearMax
Time series Unit:	m3/s
Time level:	Annual value
Time series Type:	Maximum
Time series equidistant:	no
Time series value distance:	---
Time series quality:	2
Time series measuring system:	---

Date	Time	FQ [m3/s]	Quality flag	Comments
23/02/1967	07:00:00	---	M [U] BL>	
09/01/1968	10:53:00	77.798	C [U] BL>	
25/12/1968	08:12:00	96.796	C [U] BL>	
25/04/1970	16:01:00	55.474	C [U] BL>	
24/11/1970	08:26:00	47.495	C [U]	
19/01/1972	07:14:00	45.614	C [U]	
14/02/1973	12:11:00	35.334	C [U]	
24/12/1973	09:41:00	57.616	C [U] BL>	
24/11/1974	11:52:00	38.957	I [U]	
30/01/1976	11:00:00	54.928	C [U] BL>	
11/01/1977	06:46:00	58.791	C [U] BL>	
14/03/1978	08:32:00	58.543	C [U] BL>	
29/11/1978	17:02:00	64.987	C [U] BL>	
19/03/1980	14:44:00	95.331	C [U] BL>	
05/11/1980	12:40:00	53.903	C [U] BL>	
22/12/1981	11:02:00	42.375	C [U]	
07/11/1982	05:36:00	51.281	C [U]	
16/01/1984	17:34:00	43.426	C [U]	
15/12/1984	12:50:00	52.586	C [U]	
26/08/1986	03:04:00	44.207	C [U]	
01/10/1986	00:00:00	---	C [M]	
01/10/1987	00:00:00	---	C [M]	
01/10/1988	00:00:00	---	C [M]	
01/10/1989	00:00:00	---	C [M]	
01/10/1990	00:00:00	---	C [M]	
01/10/1991	00:00:00	---	C [M]	
01/10/1992	00:00:00	---	C [M]	
01/10/1993	00:00:00	---	C [M]	
26/01/1995	06:57:00	54.204	C [U] BL>	
09/01/1996	08:15:00	38.477	I [U]	
20/11/1996	09:53:00	---	M [U]	

Table A.2: Annual maximum flood data of the River Liffey at Celbridge (source: EPA)



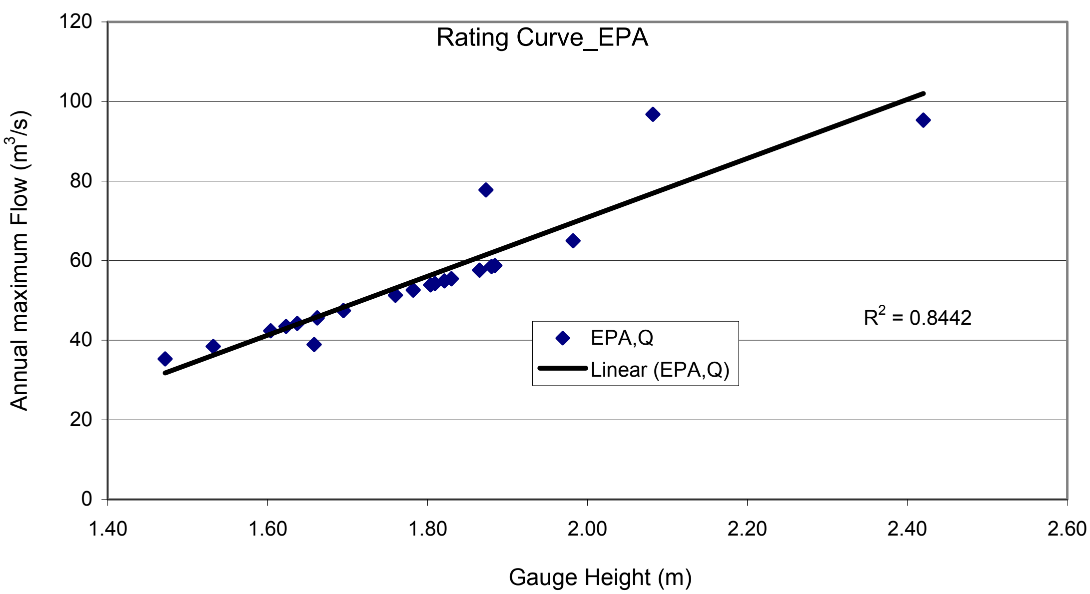


Fig. A.1: Plots of gauge heights and flow values of the River Liffey at Celbridge gaugins station received from ESBI (upper) and EPA (lower)