Flood Risk Assessment

ESB

Proposed Transition to Biomass and Associated Development - West Offaly Power

Document No.: QS-000206-01-R455-002

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1 Introduction

This Flood Risk Assessment addresses the proposed transition to biomass and associated development at West Offaly Power (WOP) Station, Shannonbridge, County Offaly. The station is a peat fire based load station which has a capacity of 152 MW and was commissioned in 2004. The station is located approximately 900 metres (m) south of Shannonbridge village centre and lies east of the River Shannon at grid reference 597406 E; 724880 N (Irish Transverse Mercator).

As part of a planning application, ESB and Bord na Mona have engaged ESB International to develop a Flood Risk Assessment for the proposed works at the station. The development will include:

- the continued operation of the existing WOP station and ADF beyond the permitted date of 31st December 2020 as provided for under the current permission (Offaly Co. Co. Reg. Ref. 01/187; An Bord Pleanála Ref. PL19.125575;);
- the phased transition of the WOP station to firing exclusively on renewable biomass. The transition to 100% biomass will comprise initial phases of co-firing characterized by the combustion of reducing volumes of peat and associated reduction in carbon dioxide emissions;
- the development of fuel management and handling facilities on the WOP station to facilitate the change in fuel type; and
- the development of additional landfill capacity at the existing dedicated ash disposal facility at Derrylahan, Co Offaly (in the townlands of Clonfinlough, Clondelara, Leitra and Derrylahan) to accept additional ash from WOP station.

As part of the development, the following will need to be constructed:

- Two number biomass storage areas, each consisting of a concrete slab and dedicated drainage features, and will have a combined footprint of approximately 10,100 m²;
- A pellet vehicle intake building;
- One pellet storage silos and associated pellet conveyors;
- Staff car park.

A map of the proposed works is provided in Figure 1-1.

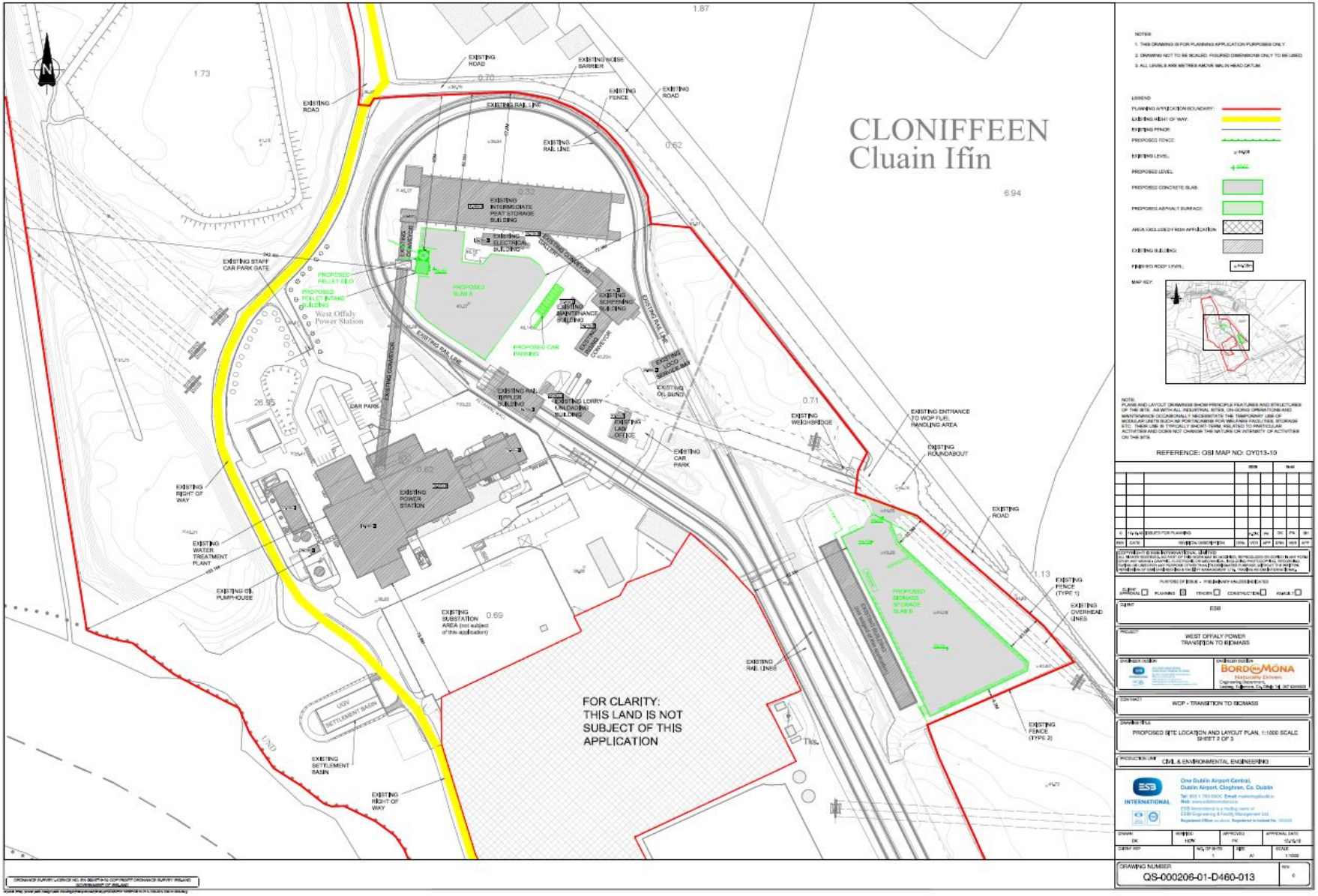


Figure 1-1 Proposed works location plan

This Flood Risk Assessment was prepared in accordance with 'The Planning System and Flood Risk Management - Guidelines for Planning Authorities' issued by the Department of Environment, Heritage and Local Government in November 2009. Flood risk from fluvial, surface water and ground water sources has been assessed based on existing available information.

1.1 Scope

This assessment considers the following:

- The Department of Environment, Heritage and Local Government guideline document to Planning Authorities in relation to Flood Risk Management.
- Risk of flooding to the proposed development from flood flow from neighbouring watercourses.
- Risk of flooding due to direct rainfall.
- Risk of flooding from groundwater.
- Impact of the presence of the proposed development on the existing flood risk regime at its proposed site. The impacts addressed under this heading comprise:
- The impact of surface water runoff from the development on the flow regimes in neighbouring watercourses.
- Loss of floodplain.
- Review of data on recorded historic floods.

2 Planning Guidelines

In November 2009 the Department of Environment, Heritage and Local Government issued a guideline document to Planning Authorities in relation to Flood Risk Management.

These Guidelines set out the policy on development and flood risk in Ireland and provide a framework for the integration of flood risk assessment into the planning process. The objective is to ensure that flood risk is taken into account at all stages in the planning process and as a result to:

- Avoid inappropriate development in areas at risk of flooding,
- Avoid new developments increasing flood risk elsewhere,
- Ensure effective management of residual risks for development permitted in floodplains.

The Guidelines set out a staged approach for the consideration of flood risk in relation to developments as follows:-

Stage 1: Flood risk identification – to identify whether there may be any flooding or surface water management issues related to either the area of regional planning guidelines, development plans and LAP's or a proposed development site that may warrant further investigation at the appropriate lower level plan or planning application levels;

Stage 2: Initial flood risk assessment – to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information and to scope the extent of the risk of flooding which may involve preparing indicative flood zone maps. Where hydraulic models exist the potential impact of a development on flooding elsewhere and of the scope of possible mitigation measures can be assessed. In addition, the requirements of the detailed assessment should be scoped; and

Stage 3: Detailed flood risk assessment – to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development or land to be zoned, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures.

The Guidelines classify developments into three vulnerability classes based on the effects of flooding:

i) Highly vulnerable development,

ii) Less vulnerable development and

iii) Water Compatible development.

Essential infrastructure such as electricity substations is classed as highly vulnerable development.

The Guidelines classify land areas within three flood zones based on the probability of flooding. Flood zones are defined as follows in the Guidelines:

Zone A is at highest risk. In any one year, Zone A has a 1 in 100 year (1%) chance of flooding from rivers and a 1 in 200 year (0.5%) chance of flooding from the sea.

Zone B is at moderate risk. The outer limit of Zone B is defined by the 1 in 1,000 year (or 0.1%) flood from rivers and the sea.

Zone C is at low risk. In any one year, Zone C has less than 1 in 1,000 year (<0.1%) chance of flooding from rivers, estuaries or the sea.

In the identification of flood zones, no account should be taken of any flood relief walls or embankments. Table 2-1 presents a matrix of vulnerability versus each flood zone.

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (including essential infrastructure)	Justification Test	Justification Test	Appropriate
Less vulnerable development	Justification Test	Appropriate	Appropriate
Water-compatible development	Appropriate	Appropriate	Appropriate

Table 2-1 Matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test (reproduced from Table 3.2 of the Planning Guidelines)

Table 2-1, which is reproduced from the guideline document to Planning Authorities in relation to Flood Risk Management states that essential infrastructure, including electricity substations should be located within Flood Zone C. Section 4 of this Flood Risk Assessment document will consider the Flood Zone assignment for the proposed site.

Table 2-1 refers to the use of a Justification Test under certain circumstances. In cases where there are insufficient sites available to locate a development in the appropriate low flood risk zone, the guideline documents allows for consideration of sites within flood risk zones. A Justification Test is then required to assess such proposals in the light of proper planning and sustainable development objectives.

This report considers the flood risk of the proposed development in relation to all three stages of the staged approach outlined above.

3 West Offaly Power Station

The proposed works are to take place inside the boundaries of WOP Station which is located in Shannonbridge, Co. Offaly. The existing station is accessed via the R357 regional road. The site is bound by the River Shannon to the west and agricultural land to the east and south. Shannonbridge's commercial and residential area bounds the north of the site. A site location plan is provided in Figure 3-1 and an aerial overview provided in Figure 3-2.

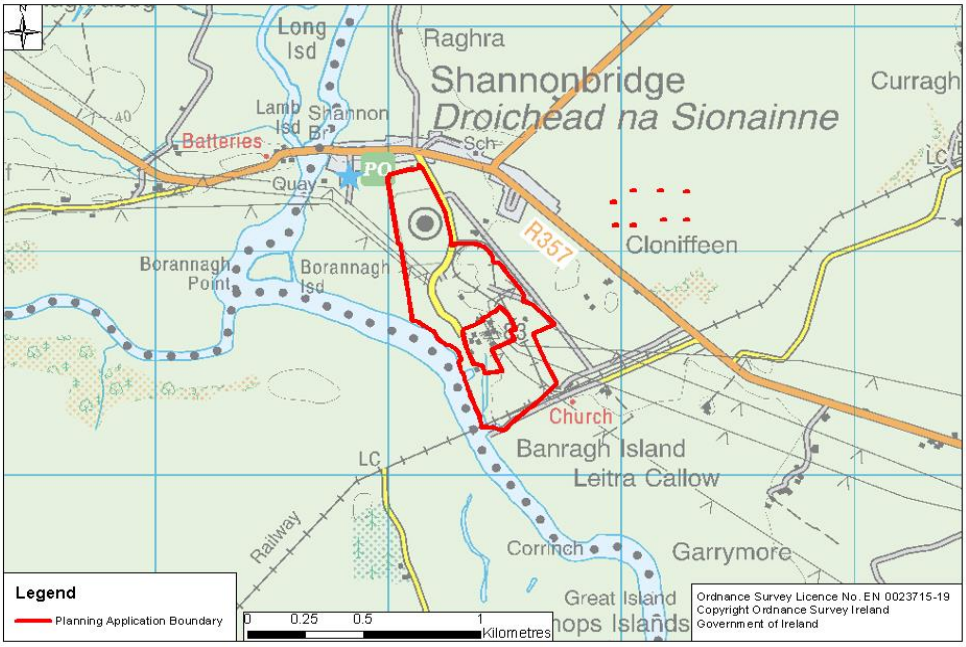


Figure 3-1 Site location map

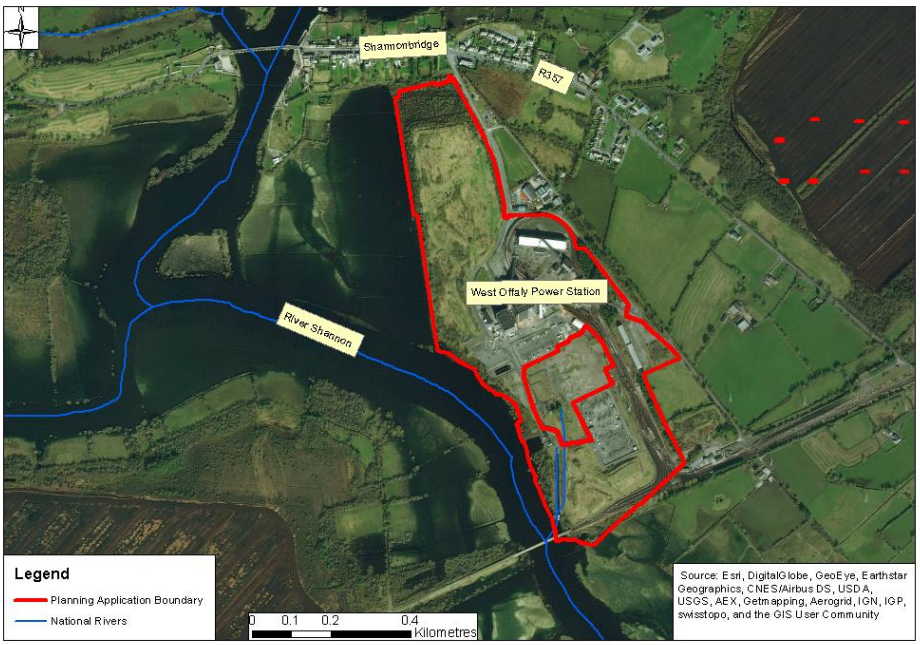


Figure 3-2 Aerial photograph of site location

4 Flooding Risk

Flood risk to the site of the new works is considered in relation to the following criteria:

- Fluvial Risk: Inundation from flow from neighbouring watercourses
- Available Predictive Flood Risk Mapping
- Pluvial Risk: Flooding due to direct rainfall
- Ground water flood risk
- Impact of presence of the proposed development on the existing flood risk regime at its proposed site.
- History of Flooding

4.1 Fluvial Flood Risk

The proposed development lies within the catchment of the River Shannon. It is situated on the eastern bank of the River Shannon.

The River Shannon, Ireland's largest river, drains a total area of more than 10,400 km² from its source to Ardnacrusha Power Station. The river drains three major lakes; Lough Allen, Lough Ree and Lough Derg, and also widens out into a number of smaller lakes between Lough Allen and Lough Ree. The fall between the outlets at Lough Allen and Lough Derg, a distance of 190 km, is only about 13 m. The Shannon's catchment draining into Shannonbridge is approximately 2,780 km² as per Office of Public Works (OPW) Flood Studies Update (FSU) web portal. The station drains in a westerly direction towards the River Shannon. The station site location in respect to the River Shannon's catchment is illustrated in Figure 4-1.

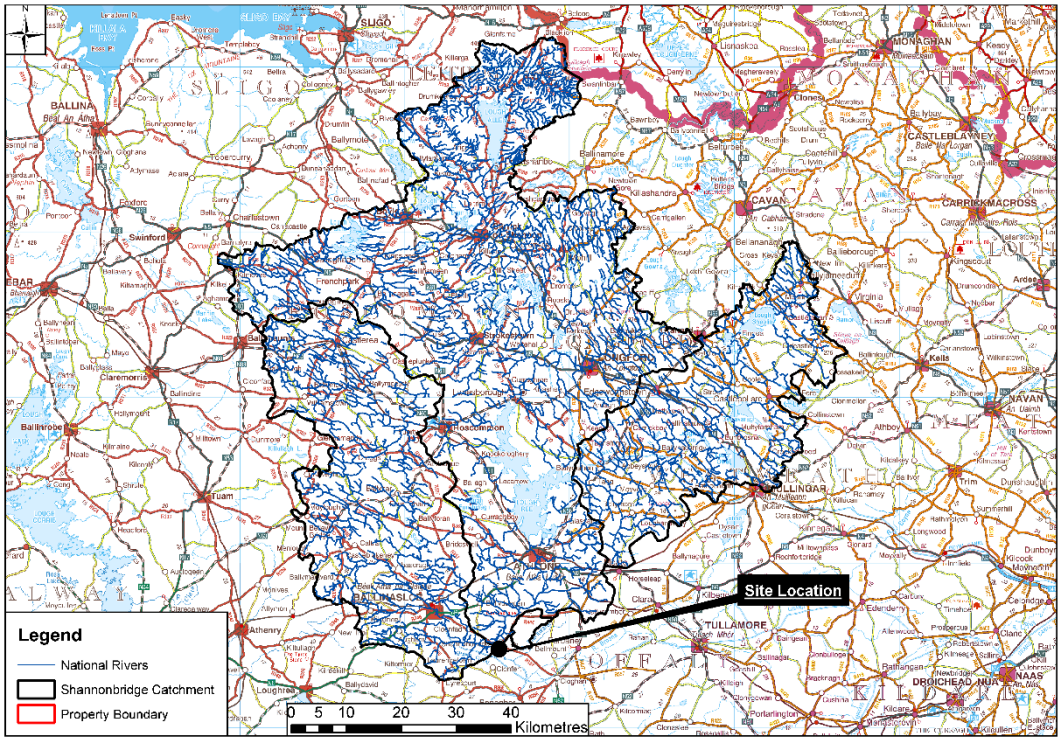


Figure 4-1 Upstream catchment of River Shannon draining into Shannonbridge

Levels on the eastern bank of the River Shannon are approximately 34.00 m Ordinance Datum (mOD). All levels shown on the site layout are to Ordnance Datum Malin. Levels start to rise significantly further inland where a level of 40.15 mOD was recorded 280 m from the bank where the more vulnerable northern structural slab, pellet intake building and pellet silo is proposed to be located. It is proposed that this slab, intake building and silo will have a minimum finished level of 40.15 mOD, rising up to 40.97 mOD. The second southern slab is located approximately 340 m from the river bank and shall have a finished level of 42.94 mOD. It is not anticipated that the River Shannon's flood waters will encroach on either of the structural slabs, pellet intake building and pellet silo due to the significant difference in levels and distance from the river. Further details of flood levels are provided in Section 4.2.

The most vulnerable asset of the existing infrastructure is the Power Station which is located approximately 130 m from the River Shannon. Ground levels in this area have been recorded at 35.91 mOD. This is approximately 1.91 m above the surveyed levels along the Shannon's eastern bank.

4.2 Review of OPW Flood Risk Mapping

As part of Ireland's obligations under the EU "Floods" Directive, the OPW has been engaged in the generation of new mapping which provide predictive estimates of the extent of floodplains as part of its Catchment Flood Risk Assessment Management Studies (CFRAMS). This programme has been undertaken on a River Basin District basis. The station is located within the Shannon River Basin District. The Shannon CFRAM programme was carried out between 2011 and 2016. Flood maps were released for parts of the catchment in mid-2016.

4.2.1 CFRAM Mapping

The CFRAM flood risk maps present indicative extents of lands at risk of flooding, predicted flood depths and predicted water levels in watercourses.

The mapping indicates the following:

- Indicative extent of lands with 1 in 10 chance of flooding in any given year
- Indicative extent of lands with 1 in 100 chance of flooding in any given year (generally corresponds with Flood Zone A as defined in Section 2)
- Indicative extent of lands with 1 in 1000 chance of flooding in any given year (generally corresponds with Flood Zone B as defined in Section 2)

The maps published in June 2016 include the catchment encompassing the station.

The station has been identified as an Individual Risk Receptor (IRR) within Unit of Management (UOM) 25/26 and thus features within the Flood Maps published in June 2016. Flood extents can be viewed in Figure 4-2.

Fluvial flood extent maps indicate that in the event of severe flood conditions, flood waters from the River Shannon will likely encroach on the western part of the property boundary during the 10%, 1% and 0.1% Annual Exceedance Probability (AEP) flood event. However, flood extent mapping illustrates that the flood zones do not encroach on the proposed work areas or any of the stations working environments. Inundation only occurs on the grassland area surrounding the station.

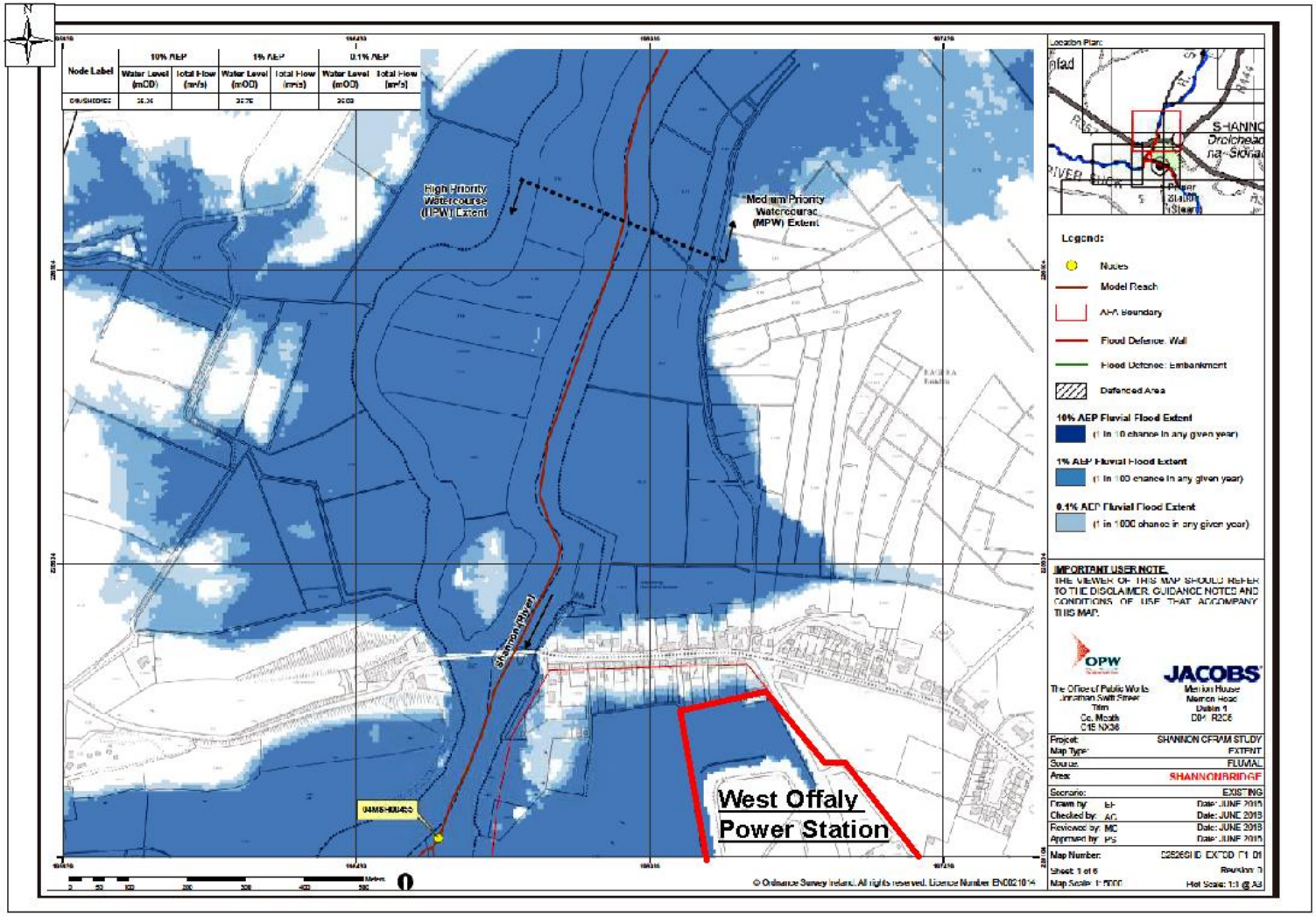
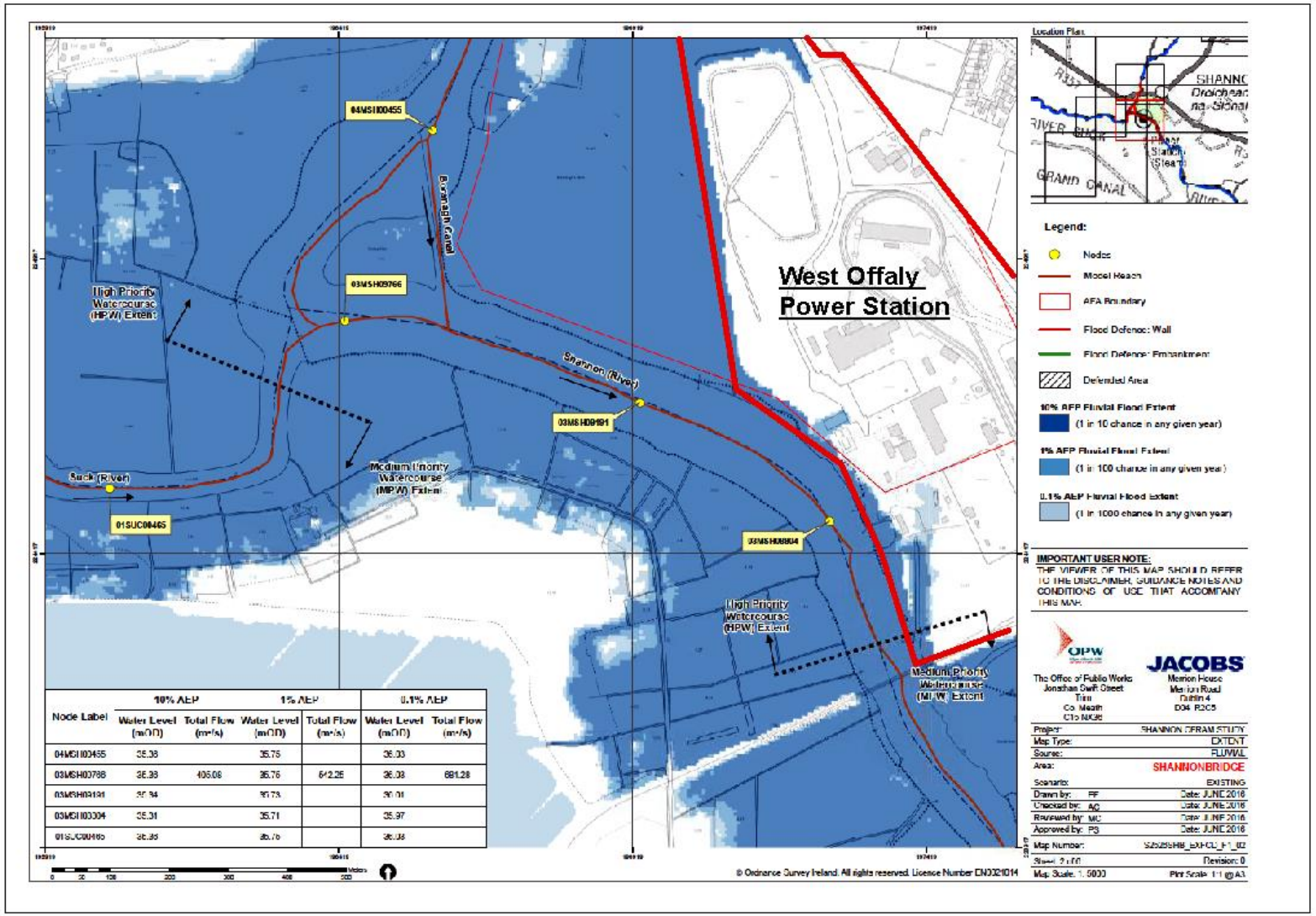


Figure 4-2 Published flood mapping for WOP Station – northern section



Node Label	10% AEP		1% AEP		0.1% AEP	
	Water Level (mOD)	Total Flow (m³/s)	Water Level (mOD)	Total Flow (m³/s)	Water Level (mOD)	Total Flow (m³/s)
04MSH00455	35.38		35.75		36.03	
03MSH00788	35.38	405.08	35.76	642.25	36.03	881.28
03MSH00191	35.34		35.73		36.01	
03MSH00304	35.31		35.71		35.97	
01SUC00465	35.35		35.76		36.08	

Figure 4-3 Published flood mapping for WOP Station – southern section

Predicted water levels within the River Shannon, taken from the CFRAMS mapping, for the 10%, 1% and 0.1% AEP are provided in Table 4-1. Water level locations and spot levels within the site are illustrated in Figure 4-4. Outputs from the CFRAM study and a full topographical survey of the site are presented in Appendix A and B respectively.

Node Label	Predicted 10% AEP Water Level mOD	Predicted 1% AEP Water Level mOD	Predicted 0.1% AEP Water Level mOD
04MSH00455	35.36	35.75	36.03
03MSH09766	35.36	35.75	36.03
03MSH09191	35.34	35.75	36.01
03MSH08804	35.31	35.71	35.97

Table 4-1 Predicted Water levels within local watercourses (OPW)

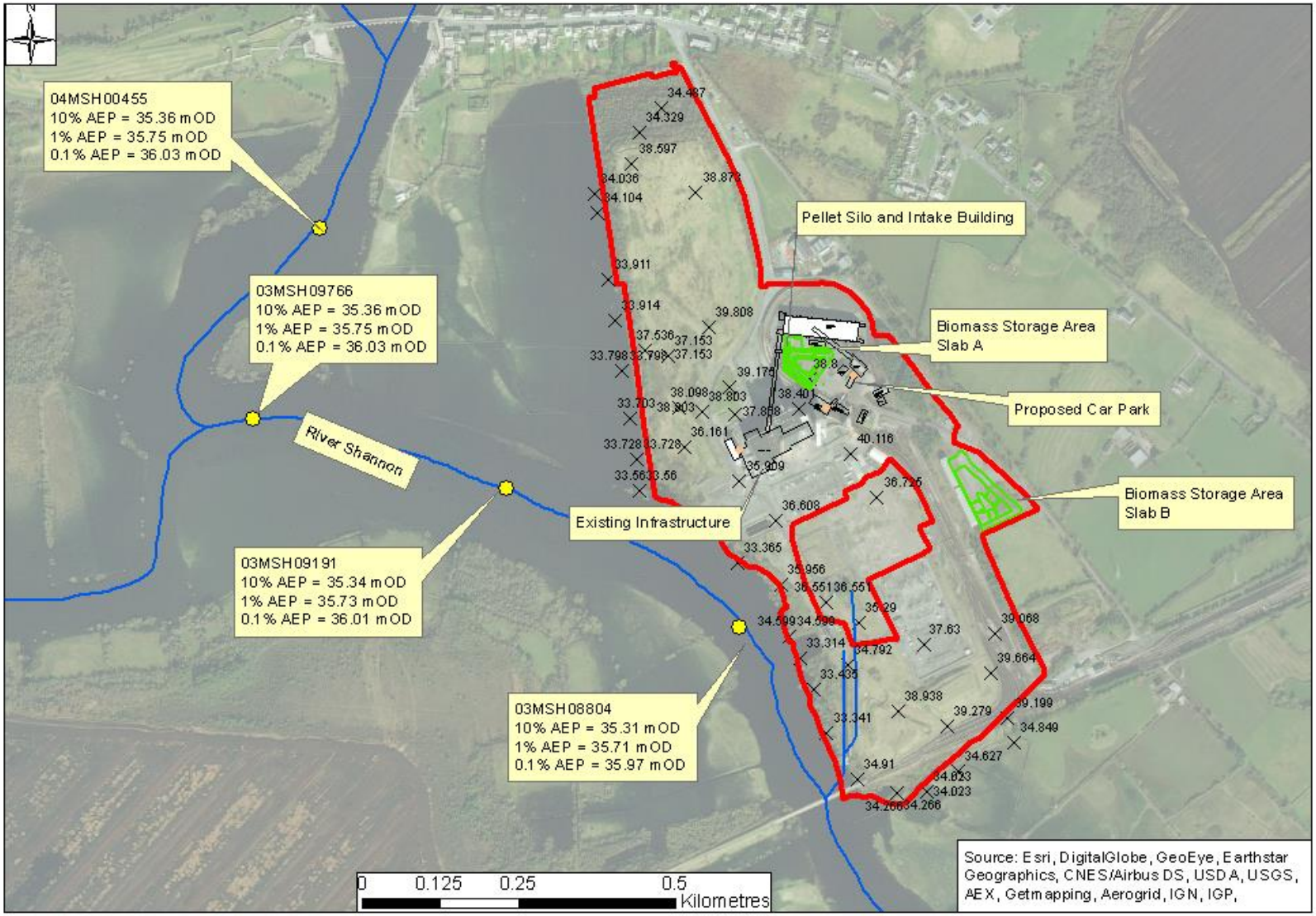


Figure 4-4 Watercourse levels and site spot levels

Figure 4-4 illustrates that during the 0.1% AEP flood event, all proposed works are located outside the OPW modelled extent of this flood extent.

The 0.1% AEP flood level within the River Shannon is 36.01 mOD at node 03MSH09191. The typical design floor levels of the western structural slab, pellet intake building and pellet silo levels are proposed to be 40.10 mOD which will give an estimated freeboard of 4.09 m during the 0.1% AEP flood event. The eastern structural slab level is proposed to be 42.94 mOD which will give a freeboard of 6.93 m above the 0.1% AEP flood level s proposed.

The ground floor level at the Power Station, the most vulnerable building of the existing infrastructure, is 35.91 mOD which is 0.1 m below the 0.1% AEP flood level. However, there are significant areas of higher ground levels of 36.16 to 36.80 m between the Power Station and the River Shannon banks. This higher ground provides a buffer to greatly reduce the risk of flood waters from the Shannon inundating the Power Station. The building is above the applicable predicted 1% AEP flood level of 35.75 mOD.

Based on the modelled results of the OPW CFRAMS programme and the significant difference in level between the proposed development and the watercourses, fluvial flooding was not considered a significant risk.

4.3 Pluvial Flood Risk

The proposed development will increase the impermeable area of the existing site by approximately 10,570 m² and hence surface water runoff from the site will be increased. This can present an increased risk of pluvial flooding on site and downstream if not managed properly. Consideration will be given to the existing surface water runoff route and the drainage characteristics in order to develop an appropriate site drainage system to minimise impacts that increased discharge from the site may have.

The site surface water drainage system will be designed to best practice to provide protection from surface runoff (pluvial flooding) due to direct rainfall. It is proposed that two separate attenuation systems will capture stormwater runoff from each of the biomass storage areas, pellet intake building, pellet conveyor's, pellet storage silos and car park, which is proposed to have a total impermeable footprint of approximately 10,570 m². The attenuation tanks are to be placed immediately south of each of the biomass storage areas shown in Figure 1-1. The tanks will discharge into the local surface water system through a flow control system which will be set to the pre-development runoff rate. This eliminates the risk of surcharging and pluvial flooding.

Due to the station's close proximity to the River Shannon and the small increase in proposed impermeable area within the catchment, the site is deemed to be at very low risk to pluvial flooding.

4.4 Groundwater Flood Risk

Groundwater can sometimes present a risk of flooding when high groundwater levels prevent surface water from infiltrating below ground level during extreme rainfall events. This can result in site flooding in the form of ponding.

The Geological Survey of Ireland (GSI) mapping indicates that the power station site is underlain by the Lucan Formation (comprising of dark and limestone shale), which is classified as a locally important aquifer (Ll), having bedrock that is moderately productive only for local zones.

The setting of the site and available mapping would suggest that the proposed development would be unlikely to be impacted by groundwater. The site is elevated from surrounding lands which will further reduce the groundwater flooding risk for the proposed substation.

4.5 Impact of Development on Current Flood Regime in the Area

4.5.1 Impact of Site Surface Water Runoff

All surface runoff to be discharged from the site is to be collected in a dedicated drainage network. The current site surface water drainage system is designed to best practice to provide protection from surface runoff due to direct rainfall. All drainage proposed to cater for runoff from new development areas will be designed to the same standards. The proposed drainage system will include three attenuation tanks which will store runoff from the proposed hardstanding areas during larger storms. The tanks will be released into the existing stormwater network through a flow control device which will be set to the pre-development runoff rate, thus, minimising the impact on downstream environments.

4.5.2 Loss of Floodplain

The proposed works are not located within a floodplain.

5 Historic Floods

A review of historic flooding was undertaken using the OPW website www.floodmaps.ie.

This website forms a record of all available flood records held by the OPW, all local authorities and other relevant state organisations such as the Environmental Protection Agency and the Department of Environment Heritage and Local Government. This website represents the current definitive database of historic flood information in this country.

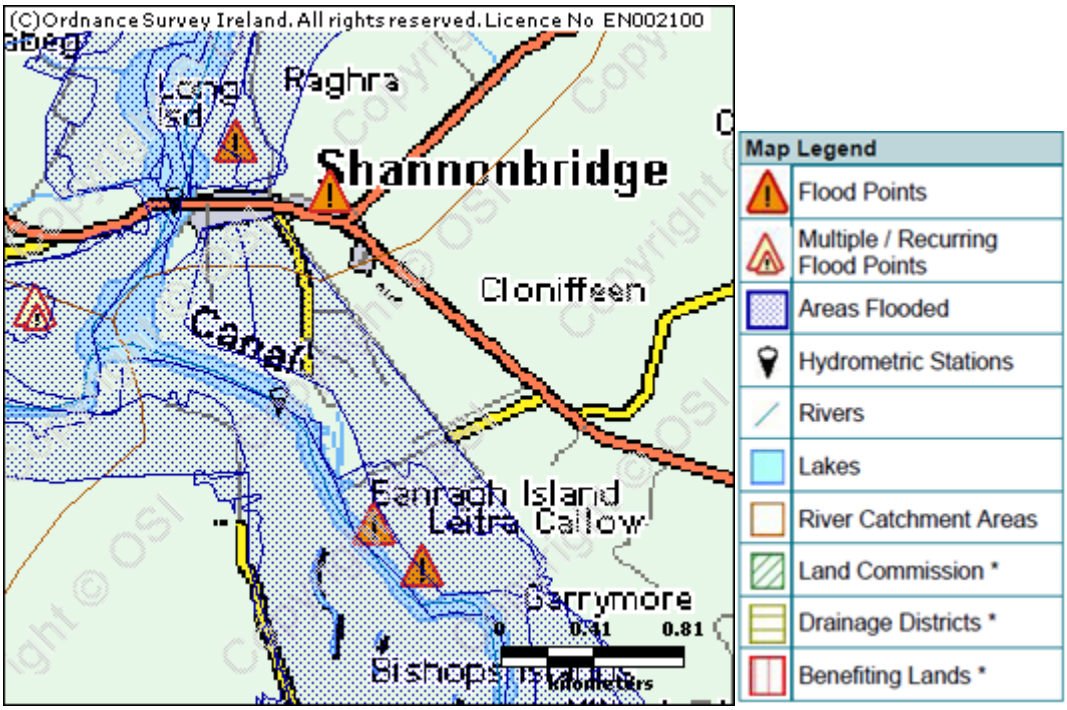


Figure 5-1 Extract from OPW www.floodmaps.ie summary map report of Historic Flooding

Reference is made to four historical incidents of flooding in Shannonbridge just upstream of the site. Flood events are summarised in the following sections.

5.1 December 1954 Flood Event

Floodmaps.ie provides information on a flood event in December 1954. From the various press clippings and reports no flooding on the station site was reported.

5.2 November 1999 Flood Event

Floodmaps.ie provides a link to one report issued by ESB International; 'River Shannon Winter Flood of 1999/2000'. The reports describes heavy rainfall during November and December 1999 which fell on the River Shannon catchment. WOP lies within the lower River Shannon catchment, between Lough Ree and Parteen Weir. No flooding of Shannonbridge or the station site was noted in the report.

5.3 January 2005 Flood Event

Floodmaps.ie provides a series of photographs of the January 2005 flood extent. The photographs show the flood extent around the stations site. No flooding of the stations site was evident as per Figure 5-2.

Figure 5-2 Aerial Photograph of the January 2005 Flood Event

5.4 August 2008 Flood Event

Floodmaps.ie provides a series of aerial photographs of the August 2008 flood event. The photographs show the flood extent around the Shannonbridge area. No flooding of the stations site was evident as per Figure 5-3.

Figure 5-3 Aerial Photograph of the August 2008 Flood Event

5.5 November 2009 Flood Event

Floodmaps.ie provides a flood report 'Flooding at Shannonbridge, Co Offaly, November 2009' by the Ferbane Area Engineer, Offaly County Council. The report highlights areas of flooding within Shannonbridge. Heavy rainfall on Wednesday 18th November lead to the River Shannon inundating parts of the village. The report highlights that the road through the village was flooded. A diversion through the station was provided for access and egress to parts of the village. Photographs are also provided. No flooding of the station site was highlighted in the report and provided photographs.

One flood map along the River Shannon is provided for this flood event on floodmaps.ie. The map shows flooding along the western boundary of the station site. This map is included in Appendix C. Levels from this flood event are discussed below.

The website provides water levels taken by the OPW during the November/ December 2009 flood event. Recorded level locations are illustrated in Figure 5-4. The first water level taken was located just inside the station's boundary. A water level of 35.71mOD was recorded. The proposed structural slab for the biomass storage area will be located approximately 220 m to the north of this point. The finished level is proposed to be 40.15 mOD. All other proposed works, located 200 m to the north of this water level, will have a finished floor/slab level of above 36.85 mOD. The second recorded water level located to the south of the power station was not considered due to the significant distance from the proposed works. Similarly, the risk to the second biomass storage slab was not considered due to the significant difference in level to the flood. Therefore, flood levels recorded during this event should not have a significant impact on the proposed works.

All reports and mapping taken from floodmaps.ie are provided in Appendix C.

Figure 5-4 Recorded water levels during the November/ December 2009 flood event (levels provided by the OPW)

5.6 Winter 2015/2016 Flood Event

Continuous heavy rain throughout November and December 2015 resulted in record high flood levels at some locations along the River Shannon. November rainfall was almost double the normal rainfall while December had more than two and a half times the normal. This greater than normal rainfall continued throughout January and February 2016 and consequently flood levels remained high for an extended period.

A hydrometric station located just upstream of the R357 bridge crossing in Shannonbridge recorded a max level of 35.964 mOD (level provided by OPW's www.waterlevel.ie) on the 05/01/2016. This was the highest level recorded at this hydrometric station since the gauge was established in 1954. No flooding at the stations site was recorded during this flood event.

6 Climate Change

The 2009 Planning Guidelines recommend that climate change be factored into consideration for flood risk assessments although there is no national guideline on how to account for the additional risk. Climate change along with other future changes (e.g. urbanisation, forestation, etc.) are being taken into account in the CFRAM study with two scenarios in particular being considered:

- Mid-Range Future Scenario (MRFS) – typical values of 20% for flood flow and 500 mm for Mean Sea Level rise will be considered.
- High-End Future Scenario (HEFS) – typical values of 30% for flood flow and 1000 mm for Mean Sea Level rise will be considered.

The Fluvial Flood Zone extents arising from the draft CFRAMS mapping represent the current status in relation to flood risk with no account taken of climate change. However, it is believed that a 20% increase in flow is unlikely to result in a large enough increase in the 1,000 year flood level to affect the proposed works in the station.

7 Conclusions

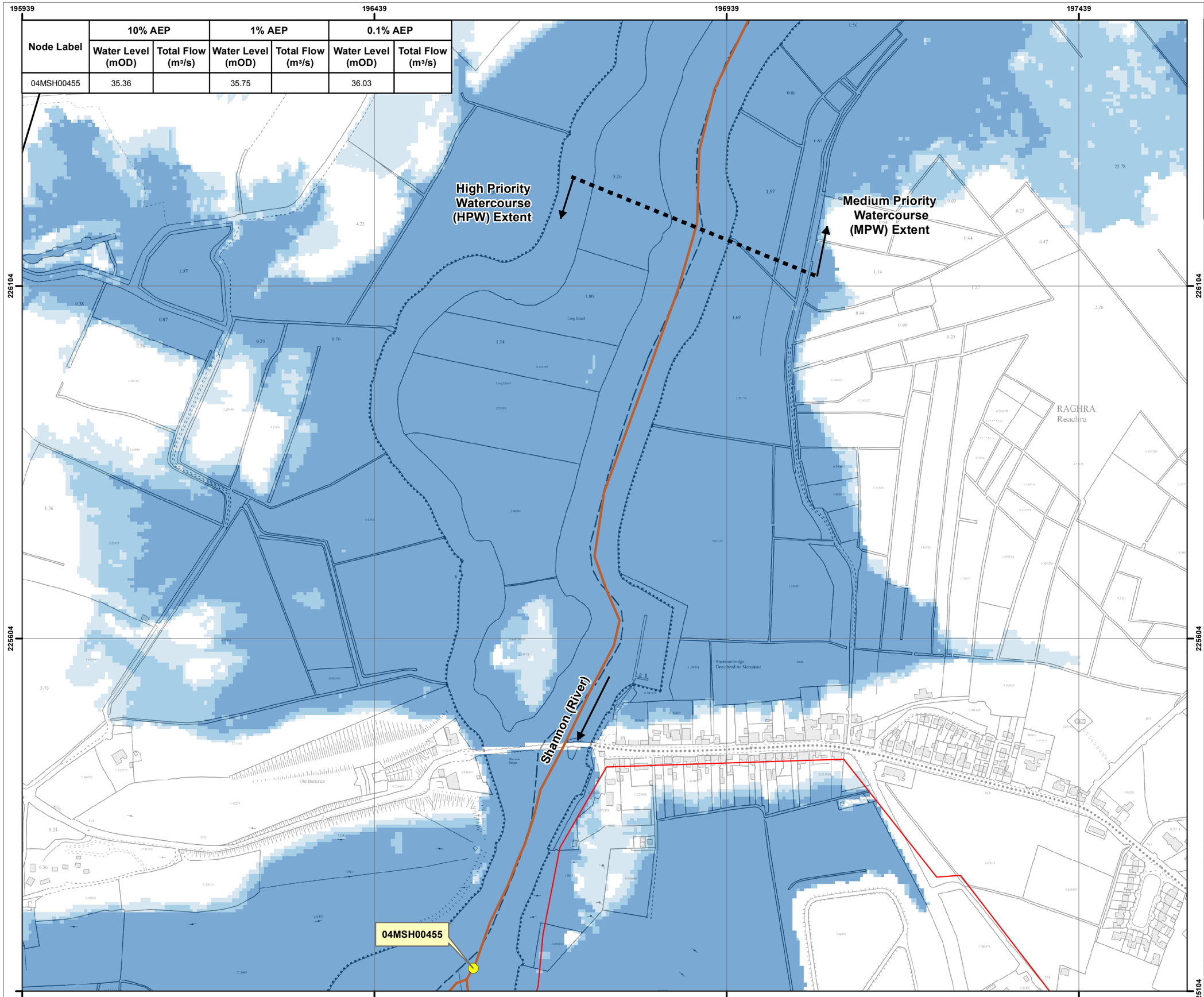
Based on the assessment undertaken, there is no significant risk of flooding to the new works and existing infrastructure at WOP Station. It is reasonable to conclude that the site of the new works and existing infrastructure lies within Flood Zone C as indicated on the OPW's CFRAM mapping and as defined by the guideline document to Planning Authorities in relation to Flood Risk Management. The proposed works within the station will not increase the current flood risk in the catchment.

Appendix A: Published CFRAM Flood Maps

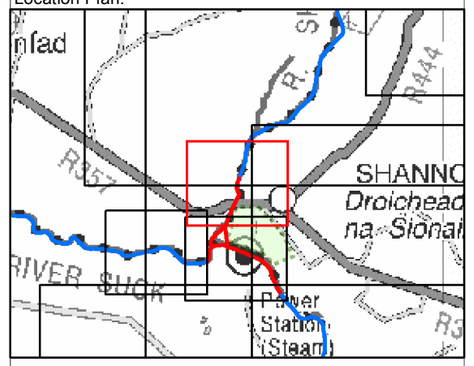
Maps published by the OPW Shannon CFRAM Study:

- S2526SHB_EXFCD_F1_01
- S2526SHB_EXFCD_F1_02

Node Label	10% AEP		1% AEP		0.1% AEP	
	Water Level (mOD)	Total Flow (m³/s)	Water Level (mOD)	Total Flow (m³/s)	Water Level (mOD)	Total Flow (m³/s)
04MSH00455	35.36		35.75		36.03	



Location Plan:



Legend:

- Nodes
- Model Reach
- AFA Boundary
- Flood Defence: Wall
- Flood Defence: Embankment
- Defended Area

10% AEP Fluvial Flood Extent
(1 in 10 chance in any given year)

1% AEP Fluvial Flood Extent
(1 in 100 chance in any given year)

0.1% AEP Fluvial Flood Extent
(1 in 1000 chance in any given year)

IMPORTANT USER NOTE:
THE VIEWER OF THIS MAP SHOULD REFER TO THE DISCLAIMER, GUIDANCE NOTES AND CONDITIONS OF USE THAT ACCOMPANY THIS MAP.

The Office of Public Works
Jonathan Swift Street
Trim
Co. Meath
C15 NX36

Merrion House
Merrion Road
Dublin 4
D04 R2C5

Project:		SHANNON CFRAM STUDY
Map Type:		EXTENT
Source:		FLUVIAL
Area:		**SHANNONBRIDGE**
Scenario:		EXISTING
Drawn by:	EF	Date: JUNE 2016
Checked by:	AC	Date: JUNE 2016
Reviewed by:	MC	Date: JUNE 2016
Approved by:	PS	Date: JUNE 2016
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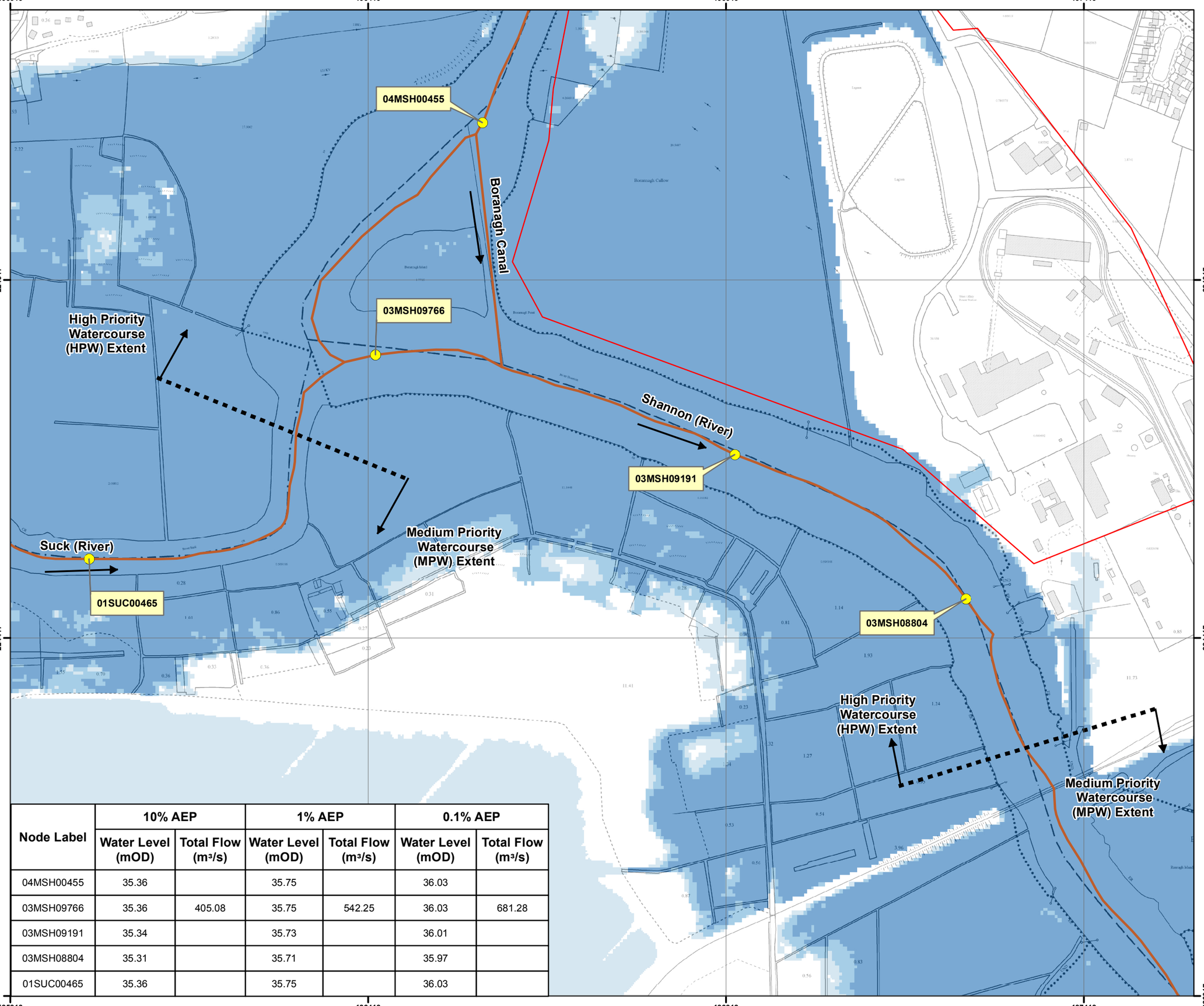

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03MSH09766	35.36	405.08	35.75	542.25	36.03	681.28
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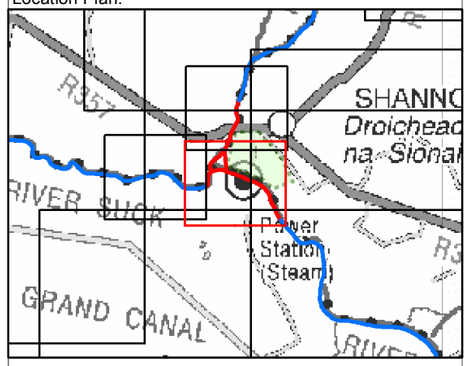
Location Plan:



Legend:

- Nodes
- Model Reach
- AFA Boundary
- Flood Defence: Wall
- Flood Defence: Embankment
- Defended Area

10% AEP Fluvial Flood Extent
(1 in 10 chance in any given year)

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(1 in 100 chance in any given year)

0.1% AEP Fluvial Flood Extent
(1 in 1000 chance in any given year)

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The Office of Public Works
Jonathan Swift Street
Trim
Co. Meath
C15 NX36

Merrion House
Merrion Road
Dublin 4
D04 R2C5

Project:		SHANNON CFRAM STUDY
Map Type:		EXTENT
Source:		FLUVIAL
Area:		SHANNONBRIDGE
Scenario:		EXISTING
Drawn by:	EF	Date: JUNE 2016
Checked by:	AC	Date: JUNE 2016
Reviewed by:	MC	Date: JUNE 2016
Approved by:	PS	Date: JUNE 2016
Map Number:		S2526SHB_EXFCD_F1_02
Sheet: 2 of 6		Revision: 0
Map Scale: 1: 5000		Plot Scale: 1:1 @ A3

Appendix B: Site Survey

Drawing submitted as part of this application:

- QS-000206-01-D460-011
- QS-000206-01-D460-012
- QS-000206-01-D460-013

AREA (not subject of this application)

EXISTING BUILDING (not subject of this application)

EXISTING RAIL LINES

FOR CLARITY:
THIS LAND IS NOT SUBJECT OF THIS APPLICATION

UGV SETTLEMENT BASIN

EXISTING SETTLEMENT BASIN

EXISTING RIGHT OF WAY

EXISTING PUMPHOUSE

EXISTING SUBSTATION AREA

EXISTING FENCE (TYPE 2)

EXISTING ROAD

EXISTING RAIL LINES

EXISTING RAIL LINES

Templeduff

0.83
0.85
11.72
0.44
2.58
0.30
2.80
4.71
24

NOTES:

1. THIS DRAWING IS FOR PLANNING APPLICATION PURPOSES ONLY.
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LEGEND

PLANNING APPLICATION BOUNDARY:

EXISTING RIGHT OF WAY:

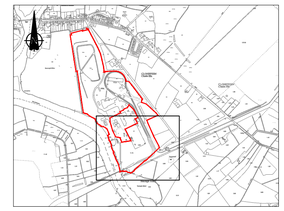
EXISTING FENCE:

EXISTING LEVEL: × 44,08

AREA EXCLUDED FROM APPLICATION:

EXISTING BUILDING:

MAP KEY:



NOTE:
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REFERENCE: OSI MAP NO: OY013-10

			ESBI			BnM		
0	12.10.18	ISSUED FOR PLANNING		H.O'K	PK	DK	PN	BH
REV	DATE	REVISION DESCRIPTION	DRN	VER	APP	DRN	VER	APP

PURPOSE OF ISSUE - PRELIMINARY UNLESS INDICATED

CLIENT APPROVAL ☐ PLANNING ☒ TENDER ☐ CONSTRUCTION ☐ AS-BUILT ☐

CLIENT: ESB

PROJECT: WEST OFFALY POWER
TRANSITION TO BIOMASS

ENGINEER DESIGN
ESB INTERNATIONAL
One Dublin Airport Central, Dublin Airport, Cloghran, Co. Dublin
Tel: 353 1 703 8000 Email: marketing@esbi.ie
Web: www.esbinternational.ie
ESB International is a trading name of ESBI Engineering & Facility Management Ltd
Registered Office: as above Registered in Ireland No. 155249

ENGINEER DESIGN
BORD NA MÓNA
Naturally Driven
Engineering Department,
Leabeg, Tullamore, Co. Offaly Tel: 057 9345900

CONTRACT: WOP - TRANSITION TO BIOMASS

DRAWING TITLE: EXISTING SITE LOCATION AND LAYOUT PLAN, 1:1000 SCALE
SHEET 3 OF 3

PRODUCTION UNIT: CIVIL & ENVIRONMENTAL ENGINEERING

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DRAWN	VERIFIED	APPROVED	APPROVAL DATE
DK	HO'K	PK	12.10.18

CLIENT REF	NO. OF SHTS	SIZE	SCALE
	1	A1	1:1000

DRAWING NUMBER: QS-000206-01-D460-011

REV: 0

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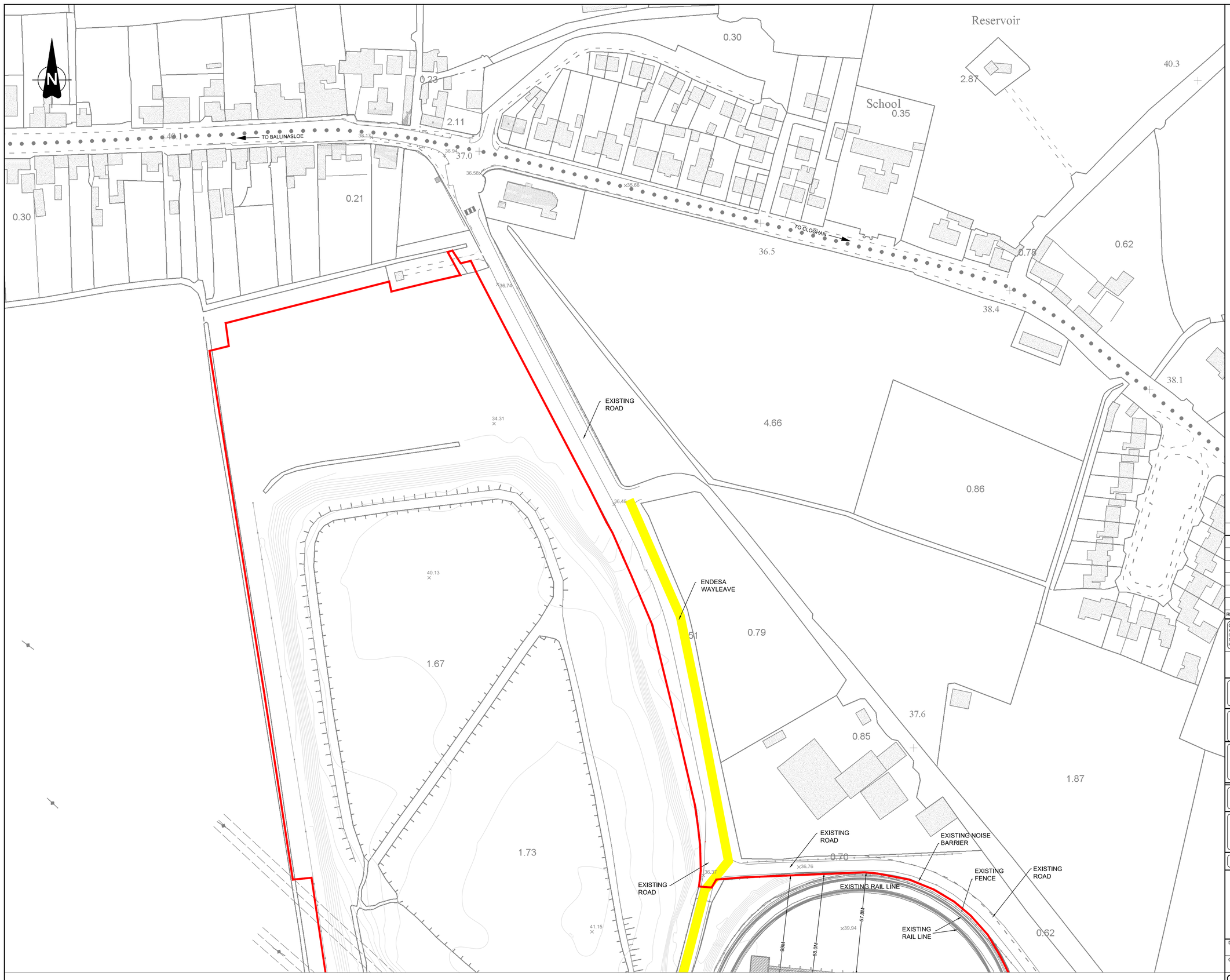

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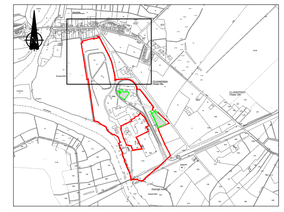
3. ALL LEVELS ARE METRES ABOVE MALIN HEAD DATUM.

LEGEND

PLANNING APPLICATION BOUNDARY:
EXISTING RIGHT OF WAY:
EXISTING FENCE:
PROPOSED FENCE:
EXISTING LEVEL: × 44.08
PROPOSED LEVEL: + 43.72
PROPOSED CONCRETE SLAB:
PROPOSED ASPHALT SURFACE:
AREA EXCLUDED FROM APPLICATION
EXISTING BUILDING:
FINISHED ROOF LEVEL; ×44.08m

MAP KEY:



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REV	DATE	REVISION DESCRIPTION	DRN	VER	APP	DRN	VER	APP

PURPOSE OF ISSUE - PRELIMINARY UNLESS INDICATED

CLIENT APPROVAL ☐ PLANNING ☒ TENDER ☐ CONSTRUCTION ☐ AS-BUILT ☐

CLIENT: ESB

PROJECT: WEST OFFALY POWER
TRANSITION TO BIOMASS

ENGINEER DESIGN

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ENGINEER DESIGN

BORD NA MÓNA
Naturally Driven
Engineering Department,
Leabeg, Tullamore, Co. Offaly Tel: 057 9345900

CONTRACT: WOP - TRANSITION TO BIOMASS

DRAWING TITLE: PROPOSED SITE LOCATION AND LAYOUT PLAN, 1:1000 SCALE
SHEET 1 OF 3

PRODUCTION UNIT: CIVIL & ENVIRONMENTAL ENGINEERING

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DRAWN	VERIFIED	APPROVED	APPROVAL DATE
DK	HO'K	PK	12.10.18

CLIENT REF	NO. OF SHTS	SIZE	SCALE
	1	A1	1:1000

DRAWING NUMBER: QS-000206-01-D460-012
REV: 0

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CLONIFFEEN
Cluain Ifín

EXISTING ROAD
EXISTING NOISE BARRIER
EXISTING FENCE
EXISTING ROAD
EXISTING RAIL LINE
EXISTING ROAD
EXISTING RAIL LINE
EXISTING INTERMEDIATE PEAT STORAGE BUILDING
EXISTING ELECTRICAL BUILDING
EXISTING CONVEYOR GALLERY
EXISTING CONVEYOR
EXISTING STAFF CAR PARK GATE
PROPOSED PELLET SILO
PROPOSED PELLET INTAKE BUILDING
PROPOSED SLAB A
West Offaly Power Station
EXISTING SCREENING BUILDING
EXISTING MAINTENANCE BUILDING
EXISTING RISING CONVEYOR
EXISTING RAIL LINE
PROPOSED CAR PARKING
EXISTING CONVEYOR
EXISTING RAIL TIPPLER BUILDING
EXISTING LORRY UNLOADING BUILDING
EXISTING OCO SERVICE BAY
EXISTING OIL BUND
EXISTING LAB/ OFFICE
EXISTING CAR PARK
CAR PARK
RETAINING WALL
EXISTING WEIGHBRIDGE
EXISTING ENTRANCE TO WOP FUEL HANDLING AREA
EXISTING ROUNDABOUT
EXISTING ROAD
EXISTING RIGHT OF WAY
EXISTING WATER TREATMENT PLANT
EXISTING OIL PUMPHOUSE
EXISTING POWER STATION
PIPE BRIDGE
UBR
EXISTING SUBSTATION AREA (not subject of this application)
PROPOSED BIOMASS STORAGE SLAB B
EXISTING BUILDING (Not subject of this application)
EXISTING RAIL LINES
EXISTING FENCE (TYPE 1)
EXISTING OVERHEAD LINES
EXISTING FENCE (TYPE 2)
EXISTING SETTLEMENT BASIN
UGV SETTLEMENT BASIN
EXISTING RIGHT OF WAY
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Tks
FOR CLARITY:
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LEGEND

PLANNING APPLICATION BOUNDARY:
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EXISTING FENCE:
PROPOSED FENCE:
EXISTING LEVEL: ×44.08
PROPOSED LEVEL: 43.72
PROPOSED CONCRETE SLAB:
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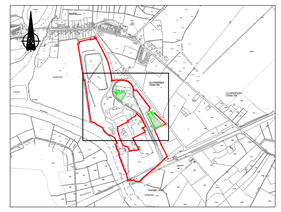

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			ESBI			BnM		
0	12.10.18	ISSUED FOR PLANNING		H.O'K	PK	DK	PN	BH
REV	DATE	REVISION DESCRIPTION	DRN	VER	APP	DRN	VER	APP

PURPOSE OF ISSUE - PRELIMINARY UNLESS INDICATED

CLIENT APPROVAL ☐ PLANNING ☒ TENDER ☐ CONSTRUCTION ☐ AS-BUILT ☐

CLIENT: ESB

PROJECT: WEST OFFALY POWER TRANSITION TO BIOMASS

ENGINEER DESIGN: ESB INTERNATIONAL, One Dublin Airport Central, Dublin Airport, Cloghran, Co. Dublin. Tel: 353 1 703 8000 Email: marketing@esbi.ie Web: www.esbinternational.ie. ESB International is a trading name of ESBI Engineering & Facility Management Ltd. Registered Office: as above Registered in Ireland No. 155249

ENGINEER DESIGN: BORD NA MÓNA Naturally Driven, Engineering Department, Leabeg, Tullamore, Co. Offaly Tel: 057 9345900

CONTRACT: WOP - TRANSITION TO BIOMASS

DRAWING TITLE: PROPOSED SITE LOCATION AND LAYOUT PLAN, 1:1000 SCALE SHEET 2 OF 3

PRODUCTION UNIT: CIVIL & ENVIRONMENTAL ENGINEERING

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DK	H'O'K	PK	12.10.18

CLIENT REF	NO. OF SHTS	SIZE	SCALE
	1	A1	1:1000

DRAWING NUMBER: QS-000206-01-D460-013
REV: 0

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Appendix C: Floodmaps.ie Outputs

Documents attached:

- OPW National Flood Hazard Mapping Summary Local Area Report and associated documents

OPW National Flood Hazard Mapping

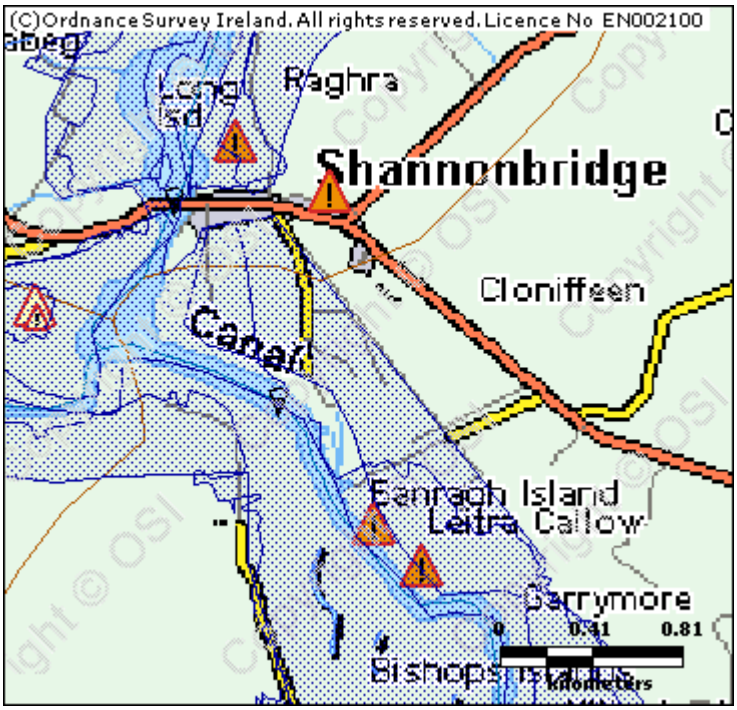
Summary Local Area Report

This Flood Report summarises all flood events within 2.5 kilometres of the map centre.

The map centre is in:

County: Offaly

NGR: M 975 247



Map Scale 1:33,657

Map Legend	
	Flood Points
	Multiple / Recurring Flood Points
	Areas Flooded
	Hydrometric Stations
	Rivers
	Lakes
	River Catchment Areas
	Land Commission *
	Drainage Districts *
	Benefiting Lands *

* Important: These maps do not indicate flood hazard or flood extent. Thier purpose and scope is explained in the Glossary.

8 Results

1. Shannon and Shannonbridge flood extents 30th Nov 2009
Start Date: 20/Nov/2009
County: Offaly
Flood Quality Code:2
Additional Information: Reports (6) More Mapped Information

2. Shannon Winter 1999/2000
Start Date: 30/Nov/1999
County: Galway, Leitrim, Longford, Offaly, Roscommon, Westmeath
Flood Quality Code:2
Additional Information: Photos (24) Reports (2) Press Archive (19) More Mapped Information

3. Shannon December 1954
Start Date: 01/Dec/1954
County: Clare, Galway, Leitrim, Limerick, Longford, Offaly, Roscommon, Tipperary, Westmeath
Flood Quality Code:1
Additional Information: Reports (4) Press Archive (16) More Mapped Information

4. Suck Shannon Confluence Jan 2005
Start Date: 08/Jan/2005
County: Roscommon
Flood Quality Code:2
Additional Information: Photos (6) More Mapped Information

5. Shannon at DS Shannonbridge Jan 2005
Start Date: 08/Jan/2005
County: Offaly
Flood Quality Code:2

Additional Information: Photos (3) More Mapped Information

---

6. Shannon Shannon Bridge 19th August 2008 — Start Date: 17/Aug/2008

County: Offaly — Flood Quality Code: 2

Additional Information: Reports (1) More Mapped Information

---

7. Suck and Shannon (Junction of) Recurring — Start Date:

County: Roscommon — Flood Quality Code: 2

Additional Information: Photos (6) Reports (3) More Mapped Information

---

8. Shannonbridge 2003 — Start Date:

County: Offaly — Flood Quality Code: 4

Additional Information: Reports (1) Press Archive (43) More Mapped Information

Flooding at Shannonbridge, Co. Offaly
November 2009

The information contained in this report has been extracted from a report dated the 25th November 2009, which was submitted to The Office Of Public Works (OPW) by the Ferbane Area Engineer, Offaly County Council.

1 Location and date of flood event:

Location: Shannonbridge, Co. Offaly

Irish Grid Co-ordinates: E 196,889 N 225,477

Heavy rainfall commenced on Wed 18th November, which resulted in flooding events beginning to occur towards the end of that week. Large areas of land and roads were inundated. Buildings were flooded or were in danger of being flooded.

2 Source and cause:

The source of the flooding was the Shannon River

4 Impacts of flooding event:

Impacts to Roads: Road through the village was flooded, diversion through the power station.

5 Additional Information

Flooding on the road through the village occurred on Sat. 21st and a diversion through the power station was set up. On Sun 22nd there were concerns about the houses and the Council were requested to provide a pump to stabilise matters. This was provided in the evening and was of assistance. A second pump was provided on Mon 23rd. A large amount of sand bags were provided to the residents by the Council.

6. Documents attached

Photos of the affected area are attached.

Shannonbridge, Co. Offaly

01.jpg

02.jpg

03.jpg

04.jpg

05.jpg

06.jpg

07.jpg

08.jpg

Flooding in Shannon Bridge Co. Offaly 19th August 2008

After very heavy and prolonged rainfall in the Offaly area flooding occurred in several parts of the county.
Offaly County Council on 19th August 2008 took a series of aerial photographs of the flooded areas, the photographs were not taken at peak water levels.

River Shannon

Flood of Winter 1999/2000

Prepared for

Chief Civil Engineer
Power Generation

by ESB International

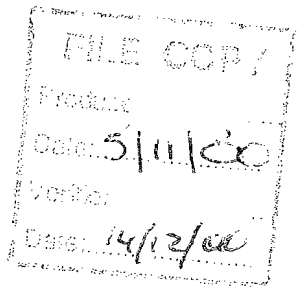
Client: Chief Civil Engineer, ESB
Report No. PA449-R46-14

November 2000

ESB INTERNATIONAL

File Reference: PA449-F46

Client: Chief Civil Engineer, ESB



Project Title: CCE Services

Report Title: River Shannon Flood of Winter 1999/2000

Report No.: PA449-R46-14

Rev. No.: 0

Volume 1 of 1

APPROVED: *TITLE: Senior Consultant*	*DATE: 14th December 2000*

Latest Revision Summary:

Table Of Contents

All levels refer to metres above Ordnance Datum Poolbeg.

EXECUTIVE SUMMARY

Heavy rainfall during December 1999 resulted in severe flooding along the Shannon. This report analyses the intensity and distribution of rainfall which fell on the Shannon catchment during the winter months and examines the extent and severity of the resulting flooding.

In general, the Winter 1999/2000 Flood Event can be considered as not significant on the Upper Shannon Catchment to Lough Allen.

On the middle catchment, between Lough Allen and Athlone, flood levels were among the highest on record. The level at Lough Ree was the highest since ESB records began in 1932. There was extensive flooding of land along the river on this reach.

On the Lower Shannon Catchment downstream of Athlone this flood event was among the worst on record. The effects of the flood were at their most severe just downstream of Athlone. Levels on Lough Derg were high but have been exceeded by two previous floods in the 1990s - February 1990, Winter 1994/95. Prior to this, these levels had not been exceeded since 1960. There is also an account of higher Lough Derg level in January 1925 prior to the construction of the Ardnacrusha Hydro-electric Scheme

1. Introduction

Flooding was reported in many parts of Ireland during Winter 1999/2000. Rainfall was concentrated in the months of November and December, with below average rainfall throughout the country in January. Rainfall in November was between 100% and 150% of the normal rainfall. Following this, the December rainfall, which was up to 250% of the normal rainfall in parts of the Shannon catchment, led to extensive flooding in many parts between Christmas and early January.

The Shannon, with its series of natural and artificial controls, has a slow response to rainfall and the heavy winter rainfall caused a build up of levels and flows throughout the catchment.

This was the third major flood event in the Shannon catchment in the 1990s - the first occurred in February 1990 and the second in Winter 1994/1995. Other significant major flood events on the Shannon, since ESB records began in 1932, occurred in December 1954 and in Winter 1959/1960. Accounts are available of another major Shannon flood in January 1925 prior to the construction of the Ardnacrusha Hydro-electric scheme. There was extensive flooding throughout the Shannon catchment on each of these occasions. Flooding, although less extreme, also occurred in many other years in various parts of the Shannon catchment.

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 Shannon River throughout this period of extreme rainfall and to make recommendations based on experience gained during this flood event.

Reference to historical records throughout this Report is to ESB records, post construction of the Shannon Hydro-electric scheme at Ardnacrusha, since 1932.

3. River Shannon Catchment

The River Shannon, Ireland's largest river, drains a total area of more than 10,400km^2 from its source to Ardnacrusha Power Station. (Figure 3.1). The river drains through three major lakes, Lough Allen, Lough Ree and Lough Derg, and also widens out into a number of smaller lakes between Lough Allen and Lough Ree. The fall between the outlet from Lough Allen and Lough Derg outlet, a distance of 190km, is only about 13 metres. The river is consequently quite slow moving with any floodwaters remaining on the flood plains for long periods. The presence of the lakes and the restrictive capacity of the river channel has a marked effect in attenuating run-off resulting in a lag of many days between causal rainfall and resultant run-off.

The main works leading to the development of the Shannon Hydro-electric Scheme at Ardnacrusha, were carried out between 1925 and 1929 under the 1925 Act. These included the construction of a gated spillway weir at Parteen, the adjoining intake to the head-race canal, the protection embankments at Fort Henry and Ardclooney, the head-race canal, Ardnacrusha Power Station, tailrace and navigation locks.

The Shannon Catchment is generally low lying with large areas below 50m O.D.. The western boundary rises only to about 100m O.D. and the eastern boundary to about 120m O.D.. However the northern boundary around Lough Allen rises to about 600m O.D. and the southern margin near the outlet from Lough Derg to about 500m O.D..

The hydrology of the Shannon catchment and the hydraulic characteristics of the main channel, which is extremely flat with a series of natural and man-made controls, are very complex. For the purpose of this study the catchment was divided into the following four sections:-

- Upper Catchment - Source to Lough Allen Outlet.
- Middle Catchment - Lough Allen to Lough Ree Outlet.
- Lower Catchment - Lough Ree to Parteen Weir.
- Downstream Parteen Weir.

Flooding on the Shannon catchment is not a new phenomenon. Reports were produced as long ago as 1862 when I F Bateman was appointed to look into flooding along the Shannon [3]. In ----, of the US Army Corps of Engineers, was asked by the government of the time to examine the problem of flooding on the Shannon. Neither report was able to propose any satisfactory solution to the flood problem. in his report [4] states that "the hydraulic, land use, and economic factors are too closely interwoven for any piecemeal approach". In his report he suggested that an interagency

Shannon Commission with an advisory brief was necessary to allow for the integration of the concerns of all the parties involved. He suggested many follow on studies and the institution of a program of stream gauging and river profile measurements to obtain more complete data.

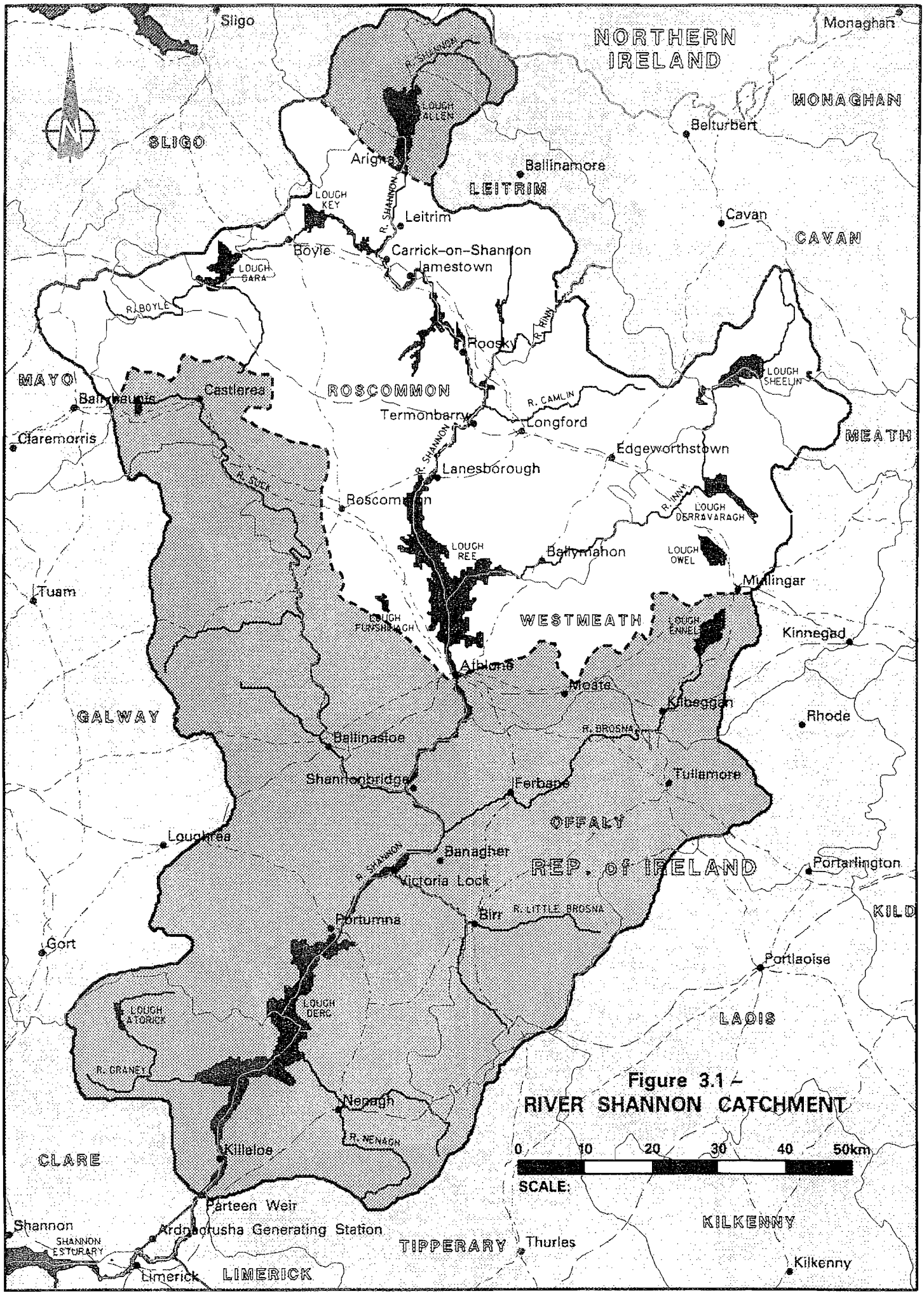


Figure 3.1 – RIVER SHANNON CATCHMENT

3.1 Upper Catchment - Source to Lough Allen Outlet.

The Upper Catchment has an area of 425km^2. The surface area of Lough Allen is 36km^2 and the surrounding catchment is very steep. The catchment has a rapid response to rainfall.

The water levels in and discharges from Lough Allen are regulated by a control structure at Bellantra at the outlet from the lake. This structure comprises two sluice gates each 6m wide and consisting of two leaves. The sill of the sluices is at 45.72m O.D.. When fully closed, the top of the lower leaf is at 49.21m O.D. and the top of the upper leaf is at 51.21m O.D.. Water may be discharged under the gates (usually drowned flow) or over the upper leaves.

Total discharge from the lake can be determined from the rated site downstream of the sluices or by application of the gate equations given in the Shannon Regulations [6]. Readings of the staff gauges, both upstream and downstream of the sluices, are recorded daily at 9 a.m..

3.2 Middle Catchment - Lough Allen to Lough Ree Outlet.

The middle catchment has a total area of 4,154km^2 and has a slow response to rainfall. The main channel broadens out into a number of small lakes along this stretch and there are navigational weirs at Jamestown, Rooskey and Termonbarry. The lag between Lough Allen and Lough Ree is estimated to be five days. The water level in and discharges from Lough Ree are controlled by a navigational weir at Athlone. The control works at Athlone, which are connected to Lough Ree by a channel 3 km long, consist of an overflow weir 170m long at a crest level of 37.40m O.D. and fifteen sluices. These sluices are normally closed during flood periods to reduce flooding of vast tracts of agricultural lands downstream and are only opened when drawing from storage. For large floods on the Shannon the discharge at Athlone weir is affected by backwater from the confluence of the River Suck and the main channel just downstream of Shannonbridge.

The surface area of Lough Ree is 106km^2 and the zero of storage is taken as 36.27m O.D..

3.3 Lower Catchment - Lough Ree to Parteen Weir.

The lower catchment has an area of 5,833km^2. The channel lag between Athlone and Lough Derg is approximately two days. The bulk of the lower catchment, including the catchment of the River Suck, the largest tributary of the Shannon which has an area of 1,619km^2, feeds into the Shannon upstream of Lough Derg. All this area is relatively low, the channels having large flood plains, and the inflow hydrograph to Lough Derg along the main channel is not

very peaky. However, the immediate catchment area around Lough Derg is quite steep and its resultant inflow hydrograph can be very flashy and cause a sudden rise in the level of Lough Derg.

The surface area of Lough Derg is 120km^2 and the perimeter of the lake is quite steep. The minimum statutory level in Lough Derg is 32.00m O.D., while the normal high water level of storage, in so far as it can be regulated, is 33.53m O.D..

The outlet from Lough Derg feeds into a channel about 3.5km long and then into an artificial reservoir about 4.5km long. The level of this reservoir is controlled by the sluice barrage at Parteen Weir. This channel and reservoir restrict the outflow from Lough Derg. The reservoir upstream of Parteen is contained partly by two embankments - Ardclooney to the West and Fort Henry to the East. The storage capacity of this reservoir is estimated to be 3.35 million m^3 at a level of 33.00m O.D..

Parteen Weir, at which flow diverges into the Ardnacrusha headrace, consists of six spillway crest gates which discharge back into the Shannon River. Gates 1 and 2 (starting from right bank) are shallow gates each 18m wide at sill level 30.85m O.D. and 30.05m O.D. respectively. The crest level of these gates, when closed, is 33.55m O.D.. Crest gates 3 to 6 inclusive are each 10m wide at sill levels of 24.80m O.D.. The crest level of these gates, when fully closed, is 35.70m O.D..

3.4 Downstream Parteen Weir.

Downstream of Parteen Weir the Shannon River flows a distance of approximately 20km to Limerick City. Tributaries which enter the Shannon in this reach include the Black, Kilmastulla, Mulkear, Groody and Blackwater Rivers. Flow which is diverted at Parteen Weir through Ardnacrusha Power Station re-enters the Shannon just upstream of Limerick City.

4. Observed Rainstorm

4.1 Meteorological Conditions

The total rainfall was slightly above normal in the Shannon catchment in November 1999 - the weather was dry for long periods, but there were some spells of very heavy rain. The heaviest of this rain fell between the 26th and 28th, with rainfall amounts of between 20mm and 60mm throughout the catchment.

December 1999 was exceptionally wet in the west and north-west of Ireland. For the third successive year, severe weather over the Christmas period disrupted communications and power supplies, as high winds, heavy rainfall, and thunderstorms affected many parts of the country. Over most of the country rain was recorded on all but 3 or 4 days. Rainfall in the Shannon catchment during December was measured at between 150% and 250% of monthly normals.

Just over half the normal rainfall was recorded at most stations countrywide during January 2000, with little or no rain between the 14th and 27th. Falls of over 20mm were recorded over most of the country between the 11th and the 12th January.

4.2 Rainfall Data

Daily rainfall data for the Shannon catchment was available at twelve sites for the selected time period (see Figure 4.1). Appendix A compares the recorded monthly rainfall (November '99 to January '00) with the monthly averages and also gives recorded daily rainfall at each of these sites for the period 01/11/99 to 31/01/00.

The rainfall totals were highest in the Lower Catchment, particularly between Portumna and Ardnacrusha (see Table 4.1). The highest daily total, which occurred at Killaloe on 04/11/99, was 42mm. Significant rainfall occurred throughout the catchment on this date. High daily rainfall throughout the catchment also occurred on 21/12/99 and 24/12/99. Total rainfall at Parteen during December was 273% of the average 1951-1980 value. During Winter 1999/2000 the highest monthly rainfall total, 296mm at Killaloe, occurred in December while the highest three-monthly total, December to February, was 574mm also at Killaloe.

There was no sustained dry spell during December to allow water levels to recede. At Killaloe for example, there were only five days with less than 2mm rainfall in December, while seven days during this period had greater than 15mm rainfall.

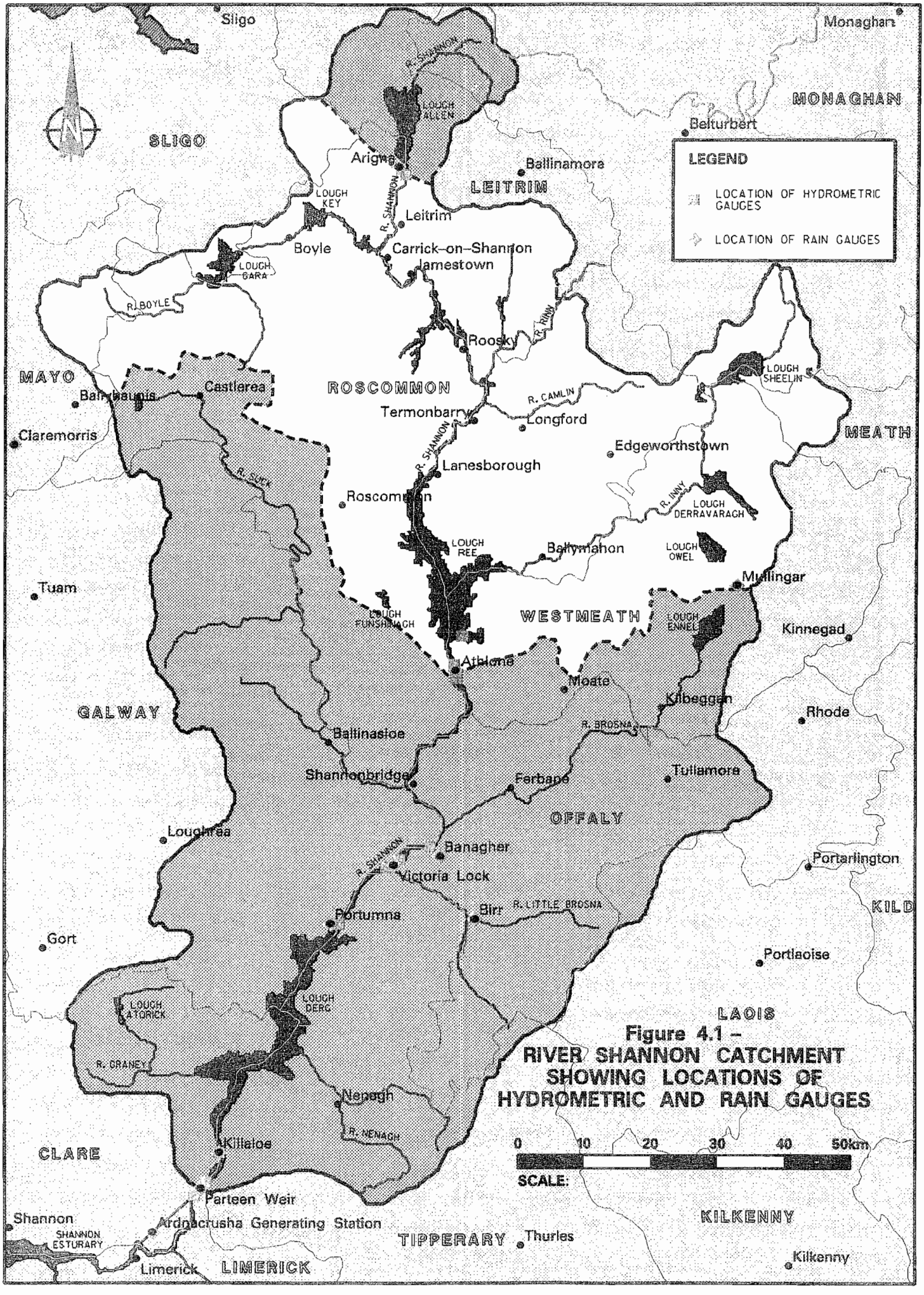


Figure 4.1 – RIVER SHANNON CATCHMENT SHOWING LOCATIONS OF HYDROMETRIC AND RAIN GAUGES

Catchment Section	Rainfall Station	Observed Rainfall Nov-99/ Jan-00 mm	Average Rainfall Nov/Jan. 1951-1980 mm	% of Average
Upper & Middle	L. Allen	495	385	127
	Claremorris	454	357	126
Middle & Lower	Athlone	342	267	128
	Mullingar	318	283	111
	Birr	308	239	126
Lower	Victoria	287	n/a	
	Banagher	296	247	118
Lower	Portumna	363	257	138
Lower	Killaloe	574	404	140
Lower	Parteen *	492	307	162
	Ardnacrusha	456	326	137
	Shannon	398	297	131

* Note: In general, 24 hour rainfall values only available on weekdays outside periods of flooding

TABLE 4.1 : Total Rainfall: November 1999 to January 2000.

Table 4.2 compares the monthly rainfall at four stations with that which occurred during the 1994/1995 flood. It can be seen that higher monthly rainfall occurred during Winter 1999/2000, but that there was more persistent heavy rain during the 1994/1995 flood.

Station	**Lough Allen**		**Athlone**		**Portumna**		**Killaloe**	
	99/00	94/95	99/00	94/95	99/00	94/95	99/00	94/95
November	148.7	105.7	103.6	76.4	103.9	67.2	138.9	82.8
December	272.4	154.0	174.9	161.5	190.2	179.7	296.3	267.7
January	73.6	196.6	63.3	173.9	69.3	185.5	139.0	255.8
Total	494.7	456.3	341.8	412.8	363.4	433.4	574.2	607.3

TABLE 4.2 : Comparison of Winter 99/00 and Winter 94/95 rainfalls at selected stations.

4.3 Mean Areal Rainfall

An estimate of the mean areal rainfall (i.e. average rainfall over whole catchment) on the Upper, Middle and Lower Shannon sub-catchments was made using the rainfall stations indicated in Table 4.1.

The daily mean areal rainfall for each sub-catchment, Upper, Middle and Lower, was estimated using the iso-percental method as recommended by the *Flood Studies Report* [5]. The daily rainfall recorded at each station is

expressed as a percentage of the monthly 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 average rainfall for that month to obtain the mean areal daily rainfall.

Studies undertaken during the review of the *Shannon Flood Control and Dam Safety* [1] used recorded rainfall at Lough Allen and at Carrick-on-Shannon to estimate the mean rainfall on the Upper Shannon Catchment. However, as the rainfall station at Carrick-on-Shannon is no longer in operation, catchment rainfall for the Winter 1999/2000 event had to be based solely on records at the Lough Allen station. The mean areal rainfall over the catchment would be considerably higher than that recorded at Lough Allen but the application of the iso-percental method, outlined above, provides a satisfactory estimate.

The average daily rainfall on the Middle Catchment was estimated using the two rainfall stations recommended in the Shannon FCDS [1]. These were:-

- Lough Allen
- Athlone

For the Lower catchment to Parteen the same five daily rainfall stations as recommended in the Shannon FCDS [1] were used. These were:-

- Athlone
- Victoria
- Portumna
- Killaloe
- Parteen*

* Note: In general, 24 hour rainfall values only available on weekdays outside periods of flooding

Examination of the rainfall records at other stations during the Winter 1999/2000 period support the assertion that these five stations give a good representation of the mean Lower Shannon catchment rainfall.

Figure 4.2 compares the monthly mean areal rainfall on the Upper, Middle and Lower Shannon catchments for the period November '99 to January '00 while Figure 4.3 shows total mean catchment rainfall for the same period. The total catchment rainfall for the 1999/2000 event is compared to the 1994/1995 event in Figure 4.4. This indicates that the 1999/2000 event had a higher monthly areal rainfall, but that rainfall during this event was not as persistent as that during the 1994/1995 event. The duration of flooding was consequently longer during the 1994/1995 event.

The design storm duration for the Shannon Catchment to Parteen Weir is 25 days. Figure 4.5 compares the estimated 25 day rainfall for the 1,000 and 10,000 Year return period events with that recorded in Winter 1999/2000. While the peak 25 day rainfall (195mm) during this event was just over half that predicted for the 10,000 Year design storm (384mm) it is noted that this was a higher total than the highest 25 day rainfall during the 1994/1995 storm

(180mm). This meant that even though the rainfall was not as persistent during the 1999/2000 storm as in 1994/1995, the peak levels and flows at some locations during Winter 1999/2000 were the highest on record.

In total 414mm rainfall fell in 92 days (November - January). However the bulk of rainfall (315mm) in Winter 1999/2000 fell during the 50 day period from the 25th November to the 13th January.

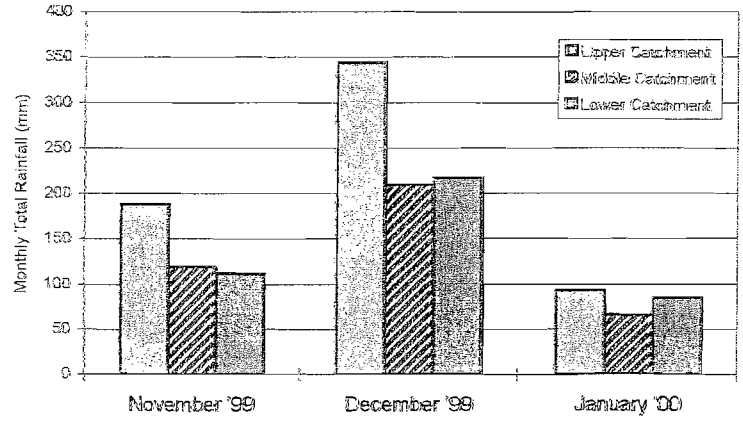


FIGURE 4.2 : Monthly Rainfall Totals areally distributed over each sub-catchment

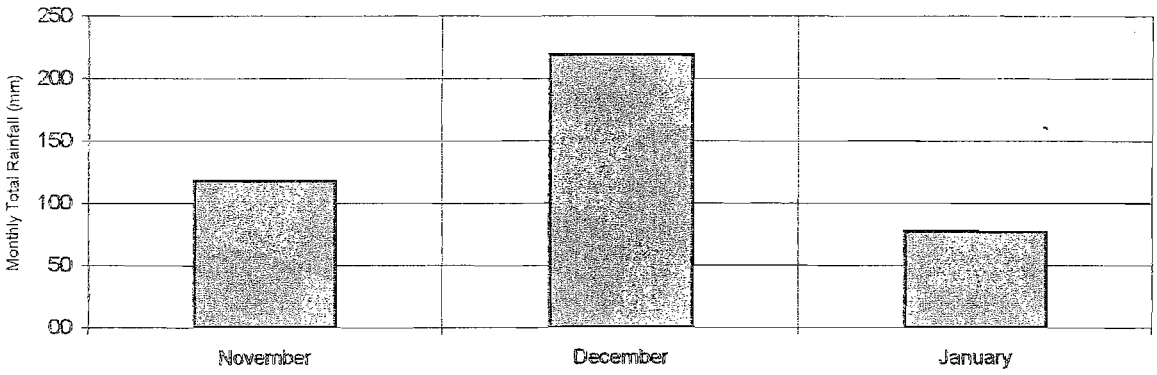


FIGURE 4.3 : Areal Adjusted Rain over entire catchment

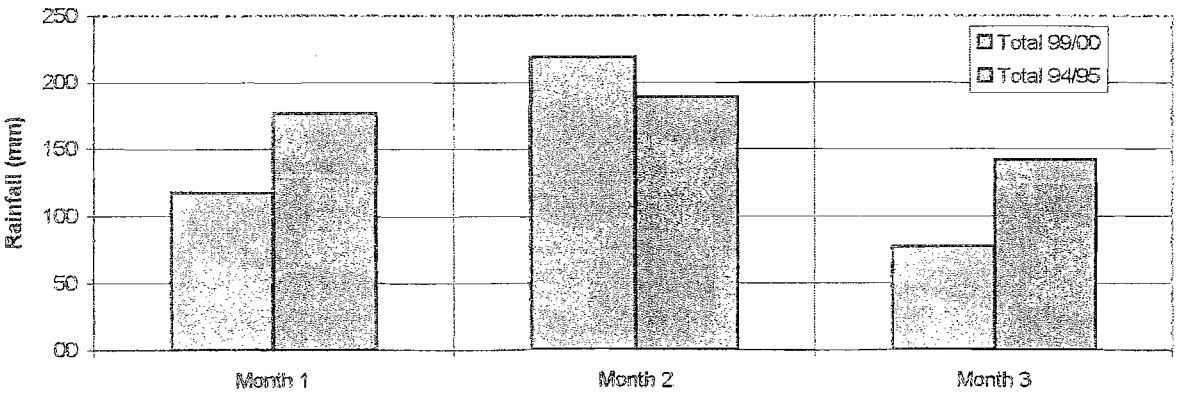


FIGURE 4.4 :Rainfall over entire catchment - Comparison of '99/'00 with '94/'95 Event

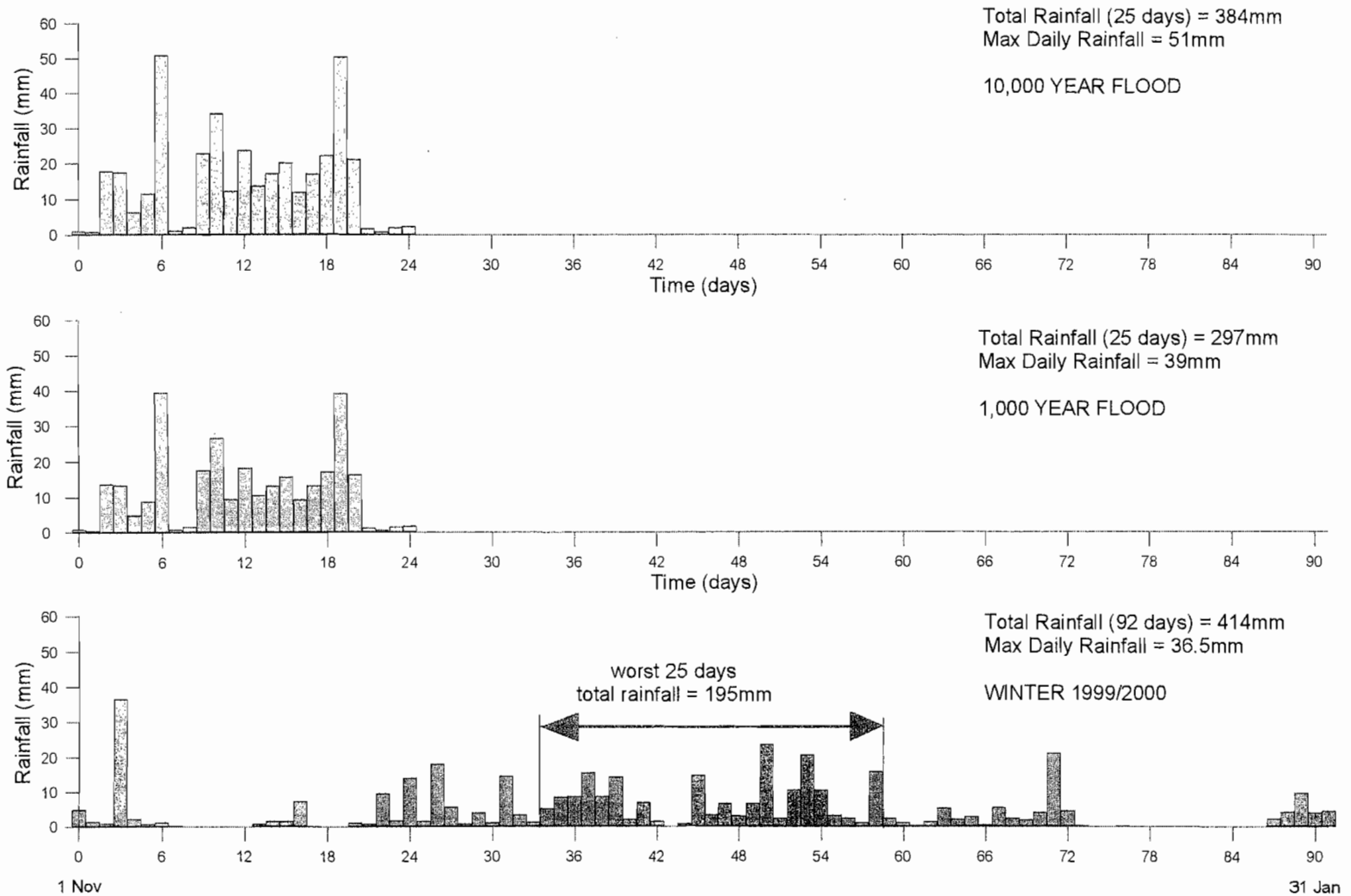


FIGURE 4.5: Shannon Catchment to Parteen. Comparison of Winter 99/00 Storm Profile to Design Storm Profiles

5. Flooding on Shannon Catchment

Details of the peak flood flows and levels during Winter 1999/2000 at Lough Allen, Lough Ree and Lough Derg are given below. Appendix B gives the daily levels and flows at the three lakes recorded in the ESB hydrometric database, during the period of interest.

5.1 Upper Catchment to Lough Allen

In 1994 ESB Ardnacrusha installed a new gauge immediately downstream of the sluices at Bellantra. At this stage it was hoped that this 'new' gauge could replace the then existing gauge which was originally located approximately 100m downstream of the sluices. However, subsequent checks on both gauges indicated that the new gauge was unsatisfactory particularly during high discharges. Using the new gauge led to overestimation of the discharge and it was also difficult to read accurately due to water turbulence at that location. (See River Shannon Flood of 1994/1995 - Appendix C [2]). The gauge was subsequently relocated back to it's old position. There is however still a discrepancy, which appears at high flows, between the discharges recorded in SEP/OISHYDRO and those calculated from the gate equations. This needs further investigation. The Lough Allen discharges used in this Report are those calculated from the gate equations (see Figures 6 & 7, Regulations for the River Shannon [6]).

The recorded levels at Lough Allen and the discharges estimated using the gate equations for the period November 1999 to January 2000 are listed in Table B1, Appendix B. These values are plotted in Figure 5.1. The water level in Lough Allen rose from 48.71m O.D. on the 22/11/99 to 50.55m O.D. on the 24/12/99. The maximum recorded level in Lough Allen since records began, 50.85m O.D., occurred on 24/01/65.

The daily discharge from Lough Allen estimated using the Bellantra Gate equations was 45.4 m^3/s on 24/12/99. The maximum daily inflow to Lough Allen during the flood, 156.5 m^3/s, occurred on 27/11/99.

5.2 Middle Catchment to Athlone

The levels and flows at Lough Ree recorded in SEP/OISHYDRO for the period November 1999 to January 2000 are listed in Table B2, Appendix B. The recorded levels are plotted in Figure 5.2. The water level at Lough Ree rose to a maximum of 39.17m O.D. on 31/12/99. This is the highest level recorded on the lake since records began. The previous highest level was 39.12m, recorded on 18/02/90.

The maximum discharge at Athlone, as calculated using the equations for Athlone Weir given in the *Regulations for the Control of the River Shannon* [6] was 379m³/s on 01/01/00. This compares with the previous highest flow on record of 364m³/s on 12/12/54.

5.3 Lower Catchment to Parteen

The levels and flows at Lough Derg recorded in SEP/OISHYDRO for the period November 1999 to January 2000 are listed in Table B3, Appendix B. The levels recorded are plotted in Figure 5.3. The water level recorded at Banagher rose from 35.48m O.D. on 22/11/99 to a maximum of 37.23m O.D. on 26/12/99. This compares with the maximum level on record at Banagher of 37.30m O.D. on 9/12/54.

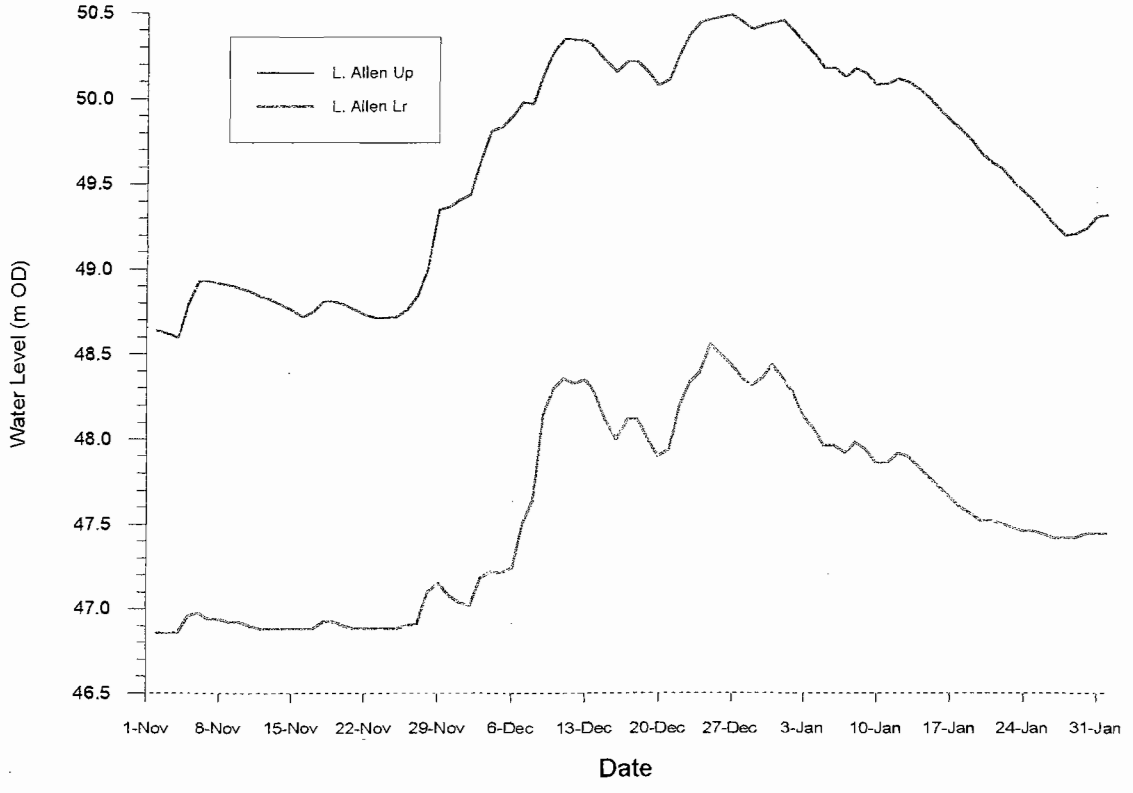
At Victoria Lock Lower the water level rose from 33.59m O.D. on 25/11/99 to a maximum of 35.11m O.D. which occurred on the 27/12/99. The highest recorded level at the site was 35.19m O.D. on the 31/01/95. The maximum level recorded at Victoria Lock Upper was 35.98m O.D. on the 26/12/99. The previous highest level on record was 35.95m O.D. on the 31/01/95 and in February 1990.

The effects of the flood were not quite so severe around Lough Derg. This was only the fourth highest flood on record at both Killaloe Pier Head and Portumna. The maximum levels, which both occurred on 27/12/99, were 33.90m O.D. at Killaloe and 34.30m O.D. at Portumna. The floods of 1959, 1990 and 1995 are the only ones to have produced higher levels in Lough Derg. The highest ever recorded levels, which both occurred on 01/02/95, were 34.01m O.D. at Killaloe and 34.40m O.D. at Portumna.

There is an account of a higher level at Killaloe, 34.10m O.D., in January 1925 prior to the construction of the Ardnacrusha Hydro-electric Scheme.

The maximum estimated Winter 1999/2000 daily inflow to Lough Derg was 757m³/s on 24/12/99. A peak value of 809m³/s was recorded during Winter 1994/1995.

The Shannon total catchment daily inflow is defined for ESB purposes as the total discharge at Parteen plus the change in storage in each of the three major lakes - Lough Allen, Lough Ree and Lough Derg. The maximum Shannon total catchment daily inflow was 1019m³/s and this occurred on 24/12/99. This is the second highest on record - the highest being 1035m³/s on 27/01/95. The maximum average daily discharge at Parteen was recorded as 701m³/s on 28/12/99 which is the twelfth highest value on record. This comprises 325 m³/s discharge through Ardnacrusha and 376 m³/s spilling at Parteen Weir.



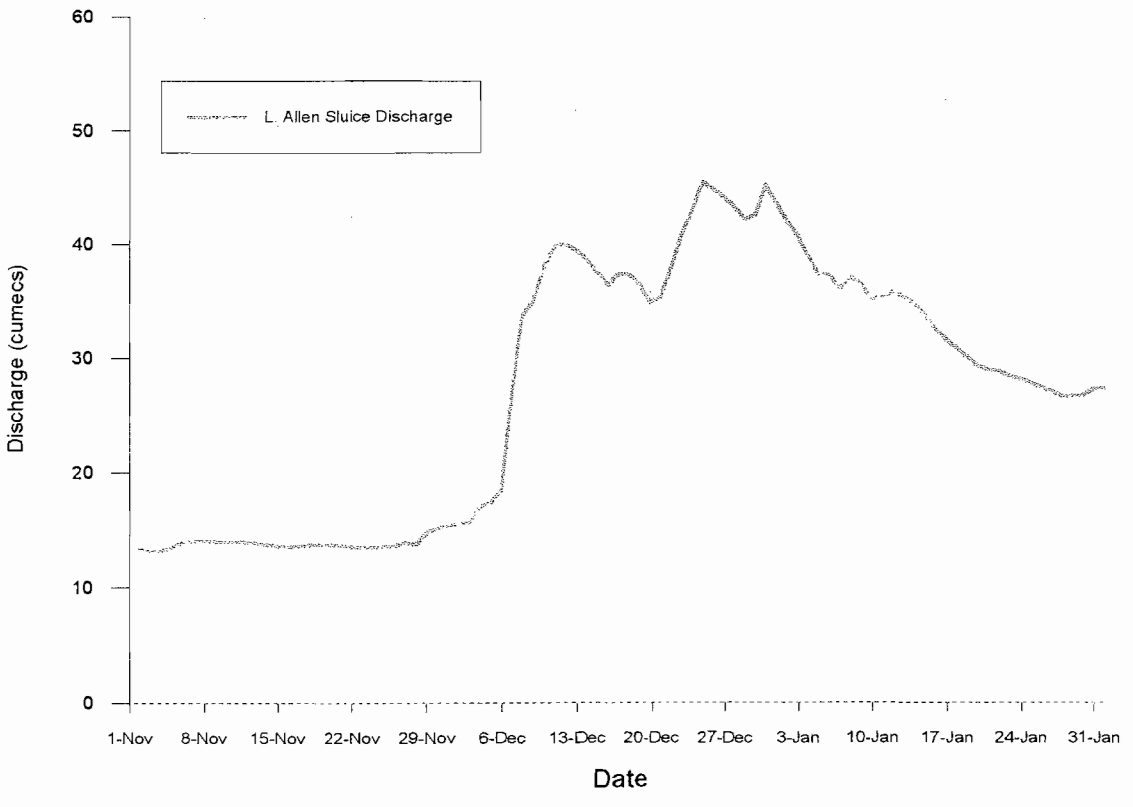
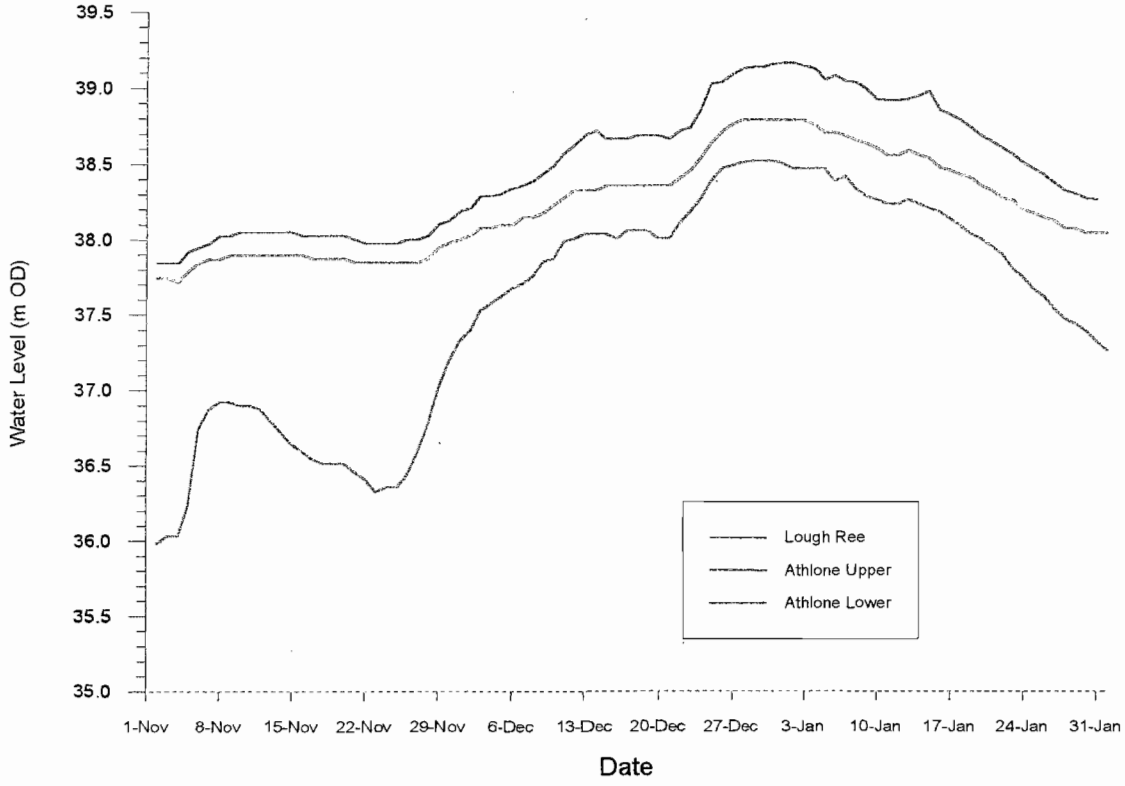


Figure 5.1 : Data for Lough Allen



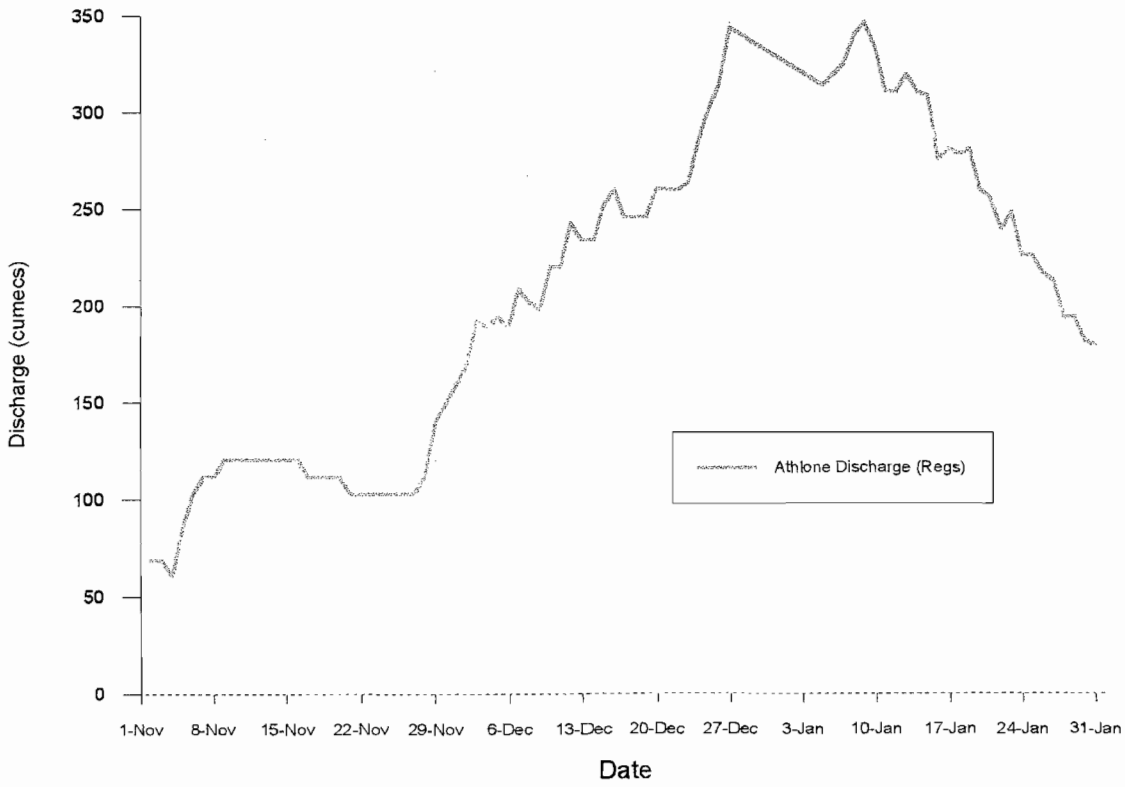
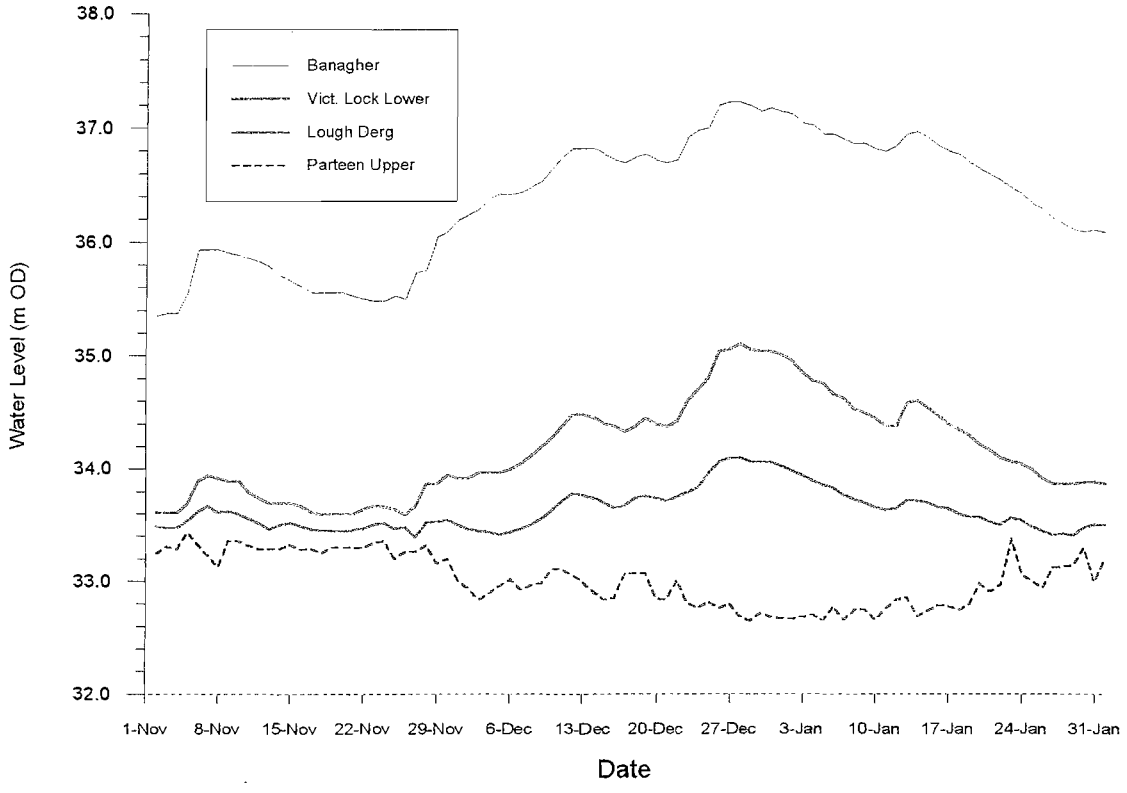


Figure 5.2 : Data for Lough Ree



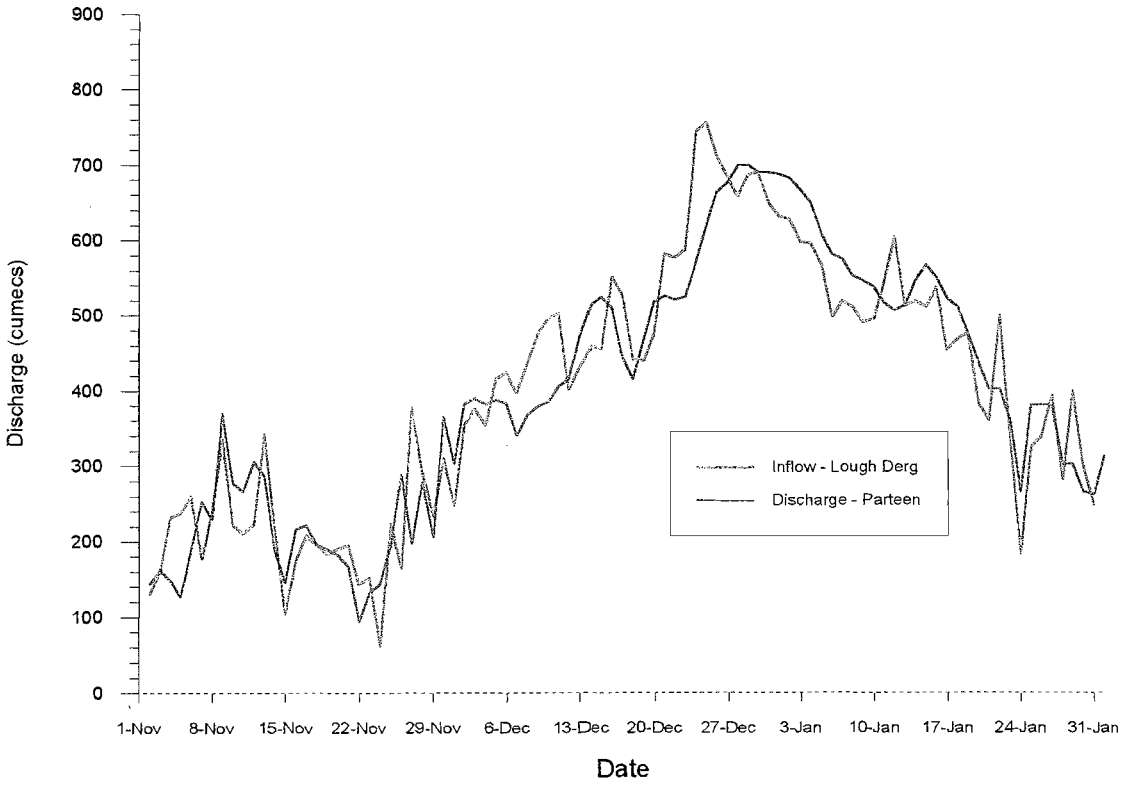


Figure 5.3 : Data for Lough Derg

6. Flood Frequency Analysis

A statistical assessment of the Winter 1999/2000 Shannon Flood was carried out and the results are summarised below. Comparisons are made with the 1994/1995 event. In general, the 1999/2000 flood event can be considered as not significant on the Upper Catchment. However, on the Middle and Lower Catchments, particularly between Lough Ree and Meelick Weir, this flood event was in many aspects the worst on record since 1932 and could therefore be considered as greater than a one in fifty year event. The increasing severity of the flood moving downstream, in the Shannon Catchment, was due to the prolonged nature of the rainfall which was persistent over a wide area. Table 6.1 lists the highest values recorded during Winter 1999/2000 and compares them with the 1994/1995 values and the highest on record.

The three most severe Shannon floods since 1960 all occurred in the 1990s - February 1990, Winter 1994/1995 and Winter 1999/2000. The 1990s were also the warmest decade of the century according to the Met Office. It is not possible to state whether this results from a natural statistical variation or part of climate change due to global warming.

6.1 Upper Catchment : Lough Allen

The maximum daily inflow to Lough Allen, 156.5m³/s, occurred on 27/11/99. This value is significantly below the historical daily maximum of 266.5m³/s, which occurred on 11/11/41. The maximum level on Lough Allen, 50.55m O.D. on 24/12/99, compares with the maximum level since records began in 1932 at the Lough Allen sluices - 50.85m O.D. recorded on 24/01/65. The corresponding values during Winter 1994/1995 were maximum level 50.50m OD and maximum inflow 118.6m³/s on 11/03/95.

The upper catchment received very heavy rainfall in December but the large size of Lough Allen relative to its catchment in conjunction with controlled discharges meant that levels on Lough Allen were not exceptional.

6.2 Middle Catchment to Athlone

The water level at Lough Ree rose to a maximum of 39.17m O.D. on 31/12/99. The maximum daily inflow to Lough Ree during the flood is estimated to have been 471m³/s on 23/12/99. This compares with the highest daily inflow on record of 522.6m³/s on 10/12/42 and a Winter 1994/1995 inflow of 396.5m³/s* on 27/01/95.

* discharges at Athlone (and hence inflows) during the 1994/1995 event were recalculated using modified equations

The maximum discharge at Athlone Weir was calculated as 378.6m³/s on 01/01/00 - this compares with the previous highest flow on record of 363.7m³/s on 11/12/54. The water level in Lough Ree had been at it's highest on the previous day and this caused the new year to start with a record flow over Athlone Weir.

The maximum level at the Athlone Upper gauge during the flood was 38.79m O.D. on 27/12/99. This level was only exceeded during the 1954 flood, when the maximum level reached was 38.81m O.D. At the Athlone Lower gauge, the maximum level recorded during the flood was 38.52m O.D. on 28/12/99. This level was also only exceeded during the 1954 flood.

The Lough Ree level is determined by the flow over Athlone Weir and the upstream and downstream levels at Athlone Weir. A high level downstream of Athlone Weir reduces the hydraulic capacity at Athlone for a given flood level causing an increased backwater effect up to Lough Ree.

6.3 Lower Catchment to Parteen

The maximum level recorded in Banagher, 37.23m O.D. on 26/12/99, compares with the maximum level on record at Banagher of 37.30m O.D. on 9/12/54. The flood here reached the same level as the flood in 1995, and was only exceeded by the 1954 and 1959 floods.

At Victoria Lock Lower the maximum level recorded was 35.11m O.D. which occurred on the 27/12/99. The highest level on record at the site is 35.19m O.D. on 31/01/95.

The level at Victoria Lock Upper on 26/12/99 at 35.98m O.D. was the highest level ever recorded. The previous highest level recorded at Victoria Lock Upper was 35.95m O.D. on the 31/01/95 and on 08/02/90.

The effects of the flood were not quite so severe around Lough Derg. This was only the fourth highest flood at both Killaloe Pier Head and Portumna. The maximum levels, which both occurred on 27/12/99, were 33.90m O.D. at Killaloe and 34.30m O.D. at Portumna. The floods of 1959, 1990, and 1995 were the only events to have produced higher levels in Lough Derg. The highest levels on record, which both occurred on 01/02/95, were 34.01m O.D. at Killaloe and 34.40m O.D. at Portumna. There is also an account of a higher Killaloe Pier Head level, 34.10m O.D., in January 1925 prior to the construction of the Ardnacrusha Hydro-electric Scheme

The maximum estimated daily inflow to Lough Derg was 757m³/s on 24/12/99. The highest daily inflow during Winter 1994/1995 was 809m³/s on 31/01/95.

The Shannon total catchment daily inflow is defined for ESB purposes as the total discharge at Parteen plus the change in storage in each of the three major

lakes - Lough Allen, Lough Ree and Lough Derg. The maximum Shannon total catchment daily inflow in Winter 1999/2000 was 1019m³/s and this occurred on 24/12/99. This is the second highest on record - the highest occurring in Winter 1994/1995 being 1035m³/s on 27/01/95.

The maximum average daily discharge at Parteen was recorded as 701m³/s on 28/12/99 which is the twelfth highest value on record. This comprised 325 m³/s discharge through Ardnacrusha and 376 m³/s spilling at Parteen Weir. The corresponding figures in Winter 1994/1995 were 352 m³/s discharge through Ardnacrusha and 390 m³/s spilling at Parteen Weir

6.4 Downstream Parteen Weir

The magnitude and duration of spilling at Parteen Weir influences the degree of flooding along the Shannon River between Parteen Weir and Athlunkard Bridge. It should be noted that the frequency and size of large flows along the Shannon River between Parteen Weir and Athlunkard Bridge are considerably less than those which occurred before the construction of the Ardnacrusha Hydro-electric Scheme.

The water level downstream of Parteen Weir is recorded daily at 9.00am - examination of the historical records indicates that this gauge is not always read at weekends. The level recorded on 27/12/99 was 28.04m O.D. and this is the fourth highest on record. It was exceeded during the floods of 1995 and 1946. However, as this level is not continuously recorded, it may have been exceeded at other times during this and previous floods.

Flooding occurred in Limerick City over the Christmas period. There were some temporary berms blocking the Abbey river in the city to allow for construction work in the river bed, and these would have been a major cause of that flooding.

Location	Parameter	1999/2000 Flood Maximum		1994/1995 Flood Maximum		Total Record Maximum		Comments on Winter 94/95 Flood
		Value	Date	Value	Date	Value		
Lough Allen Up	Level m O.D.	50.55	24/12/99	50.50	11/03/95	50.85	24/01/65	exceeded on average 1 in 5 years
Lough Allen	Discharge m^3/s	45.4	24/12/99	37.0	11/03/95	54.85	21/03/38	exceeded frequently
Lough Allen	Inflow m^3/s	156.5	27/11/99	118.6	11/03/95	266.5	11/11/41	exceeded frequently
Lough Ree	**Level m O.D.**	**39.17**	**31/12/99**	**38.97**	**02/02/95**	**39.17**	**31/12/99**	**highest ever**
Lough Ree	Inflow* m^3/s	471.4	23/12/99	396.5	27/01/95	522.6	10/12/42	4th highest
Athlone Upper	Level m O.D.	38.79	27/12/99	38.69	02/02/95	38.81	14/12/54	3rd highest (highest since 1954)
Athlone Lower	Level m O.D.	38.52	28/12/99	38.47	01/02/95	38.55	13/12/54	4th highest (highest since 1954)
Athlone	**Discharge* m^3/s**	**379.0**	**01/01/00**	**304.5**	**03/02/95**	**379.0**	**01/01/00**	**highest ever**
Banagher	Level m O.D.	37.23	26/12/99	37.23	31/01/95	37.30	09/12/54	3rd highest
Banagher	Discharge m^3/s	584.20	26/12/99	583.5	31/01/95	617.3	09/12/54	3rd highest
Victoria Lock Up	**Level m O.D.**	**35.98**	**26/12/99**	**35.95**	**31/01/95**	**35.98**	**26/12/99**	**highest ever**
Victoria Lock Lr	Level m O.D.	35.11	26/12/99	35.19	31/01/95	35.19	31/01/95	6th highest
Portumna	Level m O.D.	34.30	27/12/99	34.40	01/02/95	34.40	01/02/95	11th highest
Killaloe PH	Level m O.D.	33.90	27/12/99	34.01	01/02/95	34.01	01/02/95	12th highest
Lough Derg	Inflow m^3/s	756.9	24/12/99	809.0	31/01/95	819	27/12/59	
Shannon Catchment	Catch Inflow m^3/s	1019	24/12/99	1035	27/01/95	1035	27/01/95	2nd highest
Parteen (Spillway) + Ardnacrusha	Discharge m^3/s	701	28/12/99	741.7	01/02/95	749.8	01/01/60	12th highest
Parteen (Spillway)	Discharge m^3/s	376	28/12/99	390.0	01/02/95	442.0	10/02/46	since 1948, only exceeded in 1995
Parteen Downstream	Level m O.D.	28.04	27/12/99	28.18	31/01/95	28.18	31/01/95	4th highest

TABLE 6.1 Flood Frequency Analysis : Summary Table (based on SEP records since 1932)

References

1. 'River Shannon - Flood Control and Dam Safety', ESB International, September 1991.

2. 'River Shannon - Flood of Winter 1994/1995', ESB International, January 1997.

3. 'Report of Inquiry into the Shannon Floods', J.F. Bateman C.E.F.R.S., 1862.

4. 'River Shannon Flood Problem', L.E. Rydell, US Army Corps of Engineers, 20th August 1956.

5. 'Flood Studies Report', Natural Environment Research Council, 1975.

6. 'Regulations for the Control of the River Shannon', ESB International, Revision of December 1994.

APPENDIX A

METEOROLOGICAL DATA

Date	Station	Rain '99/'00 mm	Avg '51-'80 mm	% of Avg	Station	Rain '99/'00 mm	Avg '51-'80 mm	% of Avg
November	L. Allen	148.7	127	117	Banagher	87.5	81	108
December		272.4	132	206		155.7	88	177
January		73.6	126	58		52.9	78	68
Total		**494.7**	**385**	**127**		**296.1**	**247**	**118**
November	Athlone	103.6	86	120	Portumna	103.9	84	124
December		174.9	96	182		190.2	93	205
January		63.3	85	74		69.3	80	87
Total		**341.8**	**267**	**128**		**363.4**	**257**	**138**
November	Mullingar	101.3	92	110	Killaloe	138.9	133	104
December		157.1	99	159		296.3	146	203
January		59.3	92	64		139.0	125	111
Total		**317.7**	**283**	**111**		**574.2**	**404**	**140**
November	Birr	87.1	77	113	Parteen	120.4	104	116
December		165.8	86	193		270.7	99	273
January		55.0	76	72		101.3	104	97
Total		**307.9**	**239**	**126**		**492.4**	**307**	**162**
November	Shannon	94.5	98	96	Ardnacrusha	115.7	110	105
December		219.5	106	207		255.2	115	222
January		83.6	93	90		84.8	101	84
Total		**397.6**	**297**	**131**		**455.7**	**326**	**137**
November	Victoria	88.9			Claremorris	166.2	117	142
December		145.9				195.3	124	158
January		52.5				92.4	116	80
Total		**287.3**				**453.9**	**357**	**126**

TABLE A.1: Rainfall for November 1999 to January 2000.

Date	Shannon (mm)	Birr (mm)	Portumna (mm)	L. Allen (mm)	Athlone (mm)	Ardna (mm)	Killaloe (mm)	Victoria (mm)	Banagher (mm)	Parteen (mm)	Mullingar (mm)	Claremorris (mm)
01/11/99	8.7	3.1	4.3	1.8	5.1	9.2	9.7	5.5	7.9	7.2	4.3	2.3
02/11/99	0.9	0.4	1.1	3.3	0.9	1.2	1.5	0.6	1.1	1.5	0.8	1.9
03/11/99	1.5	0.3	1.7	0.0	1.1	0.0	1.2	0.7	0.1	2.4	1.3	2.5
04/11/99	26.9	29.7	31.5	34.3	37.5	38.3	42.4	31.6	32.2	41.2	35.9	41.1
05/11/99	0.6	2.5	0.5	2.7	3.4	2.8	3.3	1.6	2.1	0.0	3.2	2.5
06/11/99	0.3	0.8	1.7	1.1	0.5	0.0	1.0	1.0	0.9	0.0	0.4	0.5
07/11/99	1.4	1.0	1.7	0.8	0.4	0.0	3.7	0.5	0.3	3.7	0.5	0.7
08/11/99	0.0	0.4	0.4	0.2	0.3	1.7	0.5	0.3	0.0	0.5	0.2	0.1
09/11/99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10/11/99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11/11/99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12/11/99	0.0	0.1	0.4	0.0	0.0	0.0	0.1	0.1	0.2	0.0	0.4	0.0
13/11/99	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0
14/11/99	0.3	0.5	1.3	1.4	0.6	0.3	0.3	0.9	0.0	1.0	0.8	1.5
15/11/99	2.0	1.4	0.5	5.4	0.7	0.0	0.5	0.4	0.6	0.5	0.5	2.0
16/11/99	0.1	0.3	0.2	3.6	1.2	0.0	1.8	0.2	0.5	1.6	2.1	1.3
17/11/99	6.1	7.9	5.7	8.4	5.8	17.3	5.0	6.4	6.1	13.9	7.1	12.1
18/11/99	0.0	0.0	0.6	0.0	0.0	0.0	0.2	0.0	0.2	0.2	0.0	0.0
19/11/99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
20/11/99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21/11/99	0.2	1.7	1.7	1.0	1.0	1.1	1.5	1.0	0.9	1.2	1.0	2.8
22/11/99	1.6	0.7	1.0	0.6	0.5	0.0	2.5	0.6	0.5	1.5	0.3	1.8
23/11/99	10.2	8.4	10.3	8.9	6.1	9.8	22.4	7.8	7.1	11.0	6.3	10.3
24/11/99	0.7	0.3	0.3	2.1	2.4	0.0	1.6	0.3	0.6	2.5	0.7	1.0
25/11/99	12.4	9.3	18.0	15.5	13.8	0.0	12.3	15.4	12.8	6.8	7.4	15.0
26/11/99	3.3	3.0	2.4	0.9	2.3	16.0	2.2	0.9	1.3	0.0	3.9	1.1
27/11/99	12.4	9.8	15.2	41.2	12.5	12.2	17.8	10.6	8.4	0.0	14.6	41.8
28/11/99	0.4	2.0	0.6	10.6	2.1	0.0	0.8	0.4	1.3	18.6	4.8	22.1
29/11/99	0.2	0.1	0.3	2.0	0.6	0.2	0.4	0.1	0.1	0.3	0.4	0.4
30/11/99	4.3	3.3	2.5	2.9	4.8	5.6	6.2	1.9	2.1	4.8	4.4	1.3
01/12/99	0.7	0.0	0.7	2.9	0.5	2.0	2.3	0.0	0.4	0.9	0.1	4.2
02/12/99	4.9	7.2	10.1	29.3	13.3	4.0	9.0	5.0	9.1	6.3	12.7	17.1
03/12/99	2.1	0.1	0.9	12.4	0.5	1.8	3.4	0.1	0.2	0.0	0.5	3.7
04/12/99	0.6	0.0	0.4	2.8	1.6	0.0	0.2	0.2	0.2	0.0	2.9	0.0
05/12/99	1.3	0.6	2.3	5.1	5.5	7.0	7.8	1.1	2.8	7.6	4.6	6.4
06/12/99	8.0	9.3	11.2	3.9	6.7	7.0	18.1	6.6	7.4	12.5	8.1	6.4
07/12/99	8.6	7.8	10.5	7.4	7.6	11.7	13.3	6.4	6.7	9.3	6.8	11.1
08/12/99	8.5	7.2	9.1	30.4	11.4	11.7	11.7	11.4	7.9	11.6	8.6	12.0
09/12/99	4.8	3.7	3.5	11.0	5.8	0.0	18.5	5.0	3.5	13.1	2.8	9.6
10/12/99	19.0	12.3	11.6	11.3	15.5	34.6	23.4	11.1	11.6	13.1	12.7	8.5
11/12/99	4.6	0.4	0.7	4.4	1.4	6.8	4.5	1.4	1.5	0.0	1.3	3.5
12/12/99	10.7	0.7	1.2	5.8	0.9	13.4	5.3	1.9	2.2	35.6	0.1	1.7
13/12/99	8.5	0.0	1.0	1.4	0.4	0.0	3.7	0.0	0.3	4.5	0.1	
14/12/99	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.0	0.7
15/12/99	0.0	0.0	0.3	3.4	0.0	0.4	0.5	0.0	0.0	0.3	0.0	0.4
16/12/99	19.0	11.5	11.5	15.4	11.5	21.1	26.2	6.9	10.7	22.1	10.9	4.2
17/12/99	9.8	9.9	9.2	0.1	0.9	11.0	11.5	8.7	9.4	0.0	0.1	0.4
18/12/99	11.0	6.5	9.4	0.0	2.3	10.6	12.4	7.0	6.9	22.1	0.0	0.4
19/12/99	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	24.9	0.0	0.1
20/12/99	8.2	7.8	5.5	9.4	3.4	7.1	11.8	5.1	5.5	9.4	8.4	10.2
21/12/99	19.2	17.7	17.9	35.0	26.3	16.9	2.3	18.4	18.2	20.2	23.3	32.8
22/12/99	1.4	1.3	2.7	1.4	3.5	2.3	2.3	0.5	1.8	2.2	2.0	3.7
23/12/99	11.9	8.1	14.1	14.9	8.4	7.0	8.0	8.8	9.9	7.2	6.5	18.1
24/12/99	24.1	21.5	26.7	20.4	19.9	30.0	41.3	18.5	15.5	0.0	15.2	2.7
25/12/99	11.6	13.1	9.9	7.8	9.6	19.2	19.2	6.8	7.7	12.5	11.6	9.7
26/12/99	5.0	4.3	5.1	3.2	1.0	6.0	5.0	3.5	2.3	5.0	1.3	7.3
27/12/99	2.7	0.2	0.5	5.9	0.0	3.4	4.4	1.0	0.7	5.0	0.3	1.7
28/12/99	0.3	0.0	0.0	5.6	0.0	3.4	0.0	0.0	0.0	0.0	0.0	
29/12/99	11.6	12.5	12.1	14.1	14.3	14.0	23.4	9.1	11.8	25.3	13.1	15.3
30/12/99	0.3	1.3	1.2	6.6	1.4	1.0	2.8	1.2	0.9	0.0	1.9	2.7
31/12/99	1.1	0.5	0.9	1.1	1.3	1.8	3.5	0.2	0.5	0.0	1.2	0.7

TABLE A.2: Shannon Catchment Rainfall Data. November 1999 - January 2000

Date	Shannon (mm)	Birr (mm)	Portumna (mm)	L. Allen (mm)	Athlone (mm)	Ardna (mm)	Killaloe (mm)	Victoria (mm)	Banagher (mm)	Parteen (mm)	Mullingar (mm)	Claremorris (mm)
01/01/00	1.4	0.0	0.2	0.4	0.0	1.0	1.4	1.5	0.0	0.0	0.0	
02/01/00	1.2	0.5	1.8	1.8	1.0	2.2	5.5	0.7	0.4	0.0	0.8	3.9
03/01/00	5.0	3.4	4.8	3.5	3.3	5.3	6.2	4.3	4.1	14.0	4.6	4.0
04/01/00	1.7	1.1	1.1	1.5	2.8	1.8	2.9	1.5	0.9	2.2	0.9	6.0
05/01/00	1.5	0.4	0.7	10.3	0.8	1.1	0.9	0.3	0.5	0.9	1.1	9.1
06/01/00	0.0	0.0	0.3	2.2	0.0	0.5	0.0	0.0	0.2	0.0	0.0	4.8
07/01/00	2.5	2.2	7.2	7.7	6.2	3.2	4.1	3.4	3.1	0.0	3.8	7.8
08/01/00	5.5	2.7	3.0	2.4	1.0	6.2	7.4	4.3	2.6	0.0	0.5	4.4
09/01/00	0.2	0.0	0.2	0.9	0.3	0.7	1.7	0.0	0.1	12.5	0.0	5.5
10/01/00	3.7	1.4	2.6	2.8	3.0	4.3	8.8	2.0	2.7	7.7	2.5	2.4
11/01/00	19.1	18.3	21.9	12.5	22.0	21.5	31.4	15.6	18.5	26.7	24.0	13.8
12/01/00	4.8	5.0	4.5	3.3	5.7	3.0	4.5	4.0	4.9	2.7	3.2	3.3
13/01/00	0.0	0.2	0.0	0.9	0.3	0.2	0.0	0.3	0.1	0.0	0.1	4.5
14/01/00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
15/01/00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16/01/00	0.0	0.1	0.3	0.0	0.2	0.0	0.2	0.1	0.0	0.0	0.3	0.4
17/01/00	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
18/01/00	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.2	0.1	0.0	0.0
19/01/00	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0
20/01/00	0.0	0.9	0.3	0.5	0.0	0.0	0.4	0.1	0.4	0.5	0.2	1.1
21/01/00	0.0	0.1	0.0	0.2	0.4	0.0	0.1	0.0	0.0	0.0	0.6	0.3
22/01/00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23/01/00	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24/01/00	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25/01/00	0.0	0.2	0.0	0.0	0.3	0.2	0.0	0.1	0.3	0.0	0.0	0.2
26/01/00	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
27/01/00	3.8	2.2	2.9	1.0	2.1	0.0	3.7	1.1	1.8	3.7	1.3	1.0
28/01/00	7.2	1.6	1.8	5.2	1.6	10.2	13.2	0.8	1.1	7.7	4.1	2.8
29/01/00	18.3	11.9	11.5	9.4	5.1	18.4	36.6	8.6	8.3	0.0	6.9	7.1
30/01/00	1.5	1.6	1.5	1.5	2.3	1.0	3.4	1.2	1.5	17.9	2.3	0.8
31/01/00	5.8	0.9	2.5	5.2	4.5	4.0	6.6	2.4	1.2	4.6	2.1	9.0

TABLE A.2: Shannon Catchment Rainfall Data. November 1999 - January 2000

APPENDIX B

HYDROMETRIC DATA

Date	L.Allen Lr. Level (m OD)	L.Allen Up. Level (m OD)	L.Allen Discharge (m^3/s)	L.Allen Inflow (m^3/s)
01/11/99	46.86	48.64	13.3	5.2
02/11/99	46.86	48.62	13.3	5.1
03/11/99	46.86	48.60	13.2	94.7
04/11/99	46.96	48.80	13.6	66.6
05/11/99	46.98	48.93	14.0	14.0
06/11/99	46.94	48.93	14.1	10.0
07/11/99	46.94	48.92	14.1	10.0
08/11/99	46.92	48.91	14.1	5.9
09/11/99	46.92	48.89	14.0	5.9
10/11/99	46.90	48.87	14.0	1.8
11/11/99	46.88	48.84	14.0	5.8
12/11/99	46.88	48.82	13.9	1.7
13/11/99	46.88	48.79	13.8	1.6
14/11/99	46.88	48.76	13.7	-2.6
15/11/99	46.88	48.72	13.6	25.8
16/11/99	46.88	48.75	13.7	38.1
17/11/99	46.92	48.81	13.7	13.7
18/11/99	46.92	48.81	13.7	5.6
19/11/99	46.90	48.79	13.7	1.5
20/11/99	46.88	48.76	13.7	1.5
21/11/99	46.88	48.73	13.6	5.4
22/11/99	46.88	48.71	13.5	13.5
23/11/99	46.88	48.71	13.5	17.6
24/11/99	46.88	48.72	13.6	29.9
25/11/99	46.90	48.76	13.6	46.3
26/11/99	46.91	48.84	13.9	79.1
27/11/99	47.10	49.00	13.8	156.5
28/11/99	47.15	49.35	14.8	23.0
29/11/99	47.08	49.37	15.1	31.4
30/11/99	47.04	49.41	15.4	27.6
01/12/99	47.02	49.44	15.5	97.1
02/12/99	47.18	49.64	15.7	85.0
03/12/99	47.22	49.81	17.1	25.2
04/12/99	47.21	49.83	17.4	46.0
05/12/99	47.24	49.90	18.5	51.1
06/12/99	47.50	49.98	27.1	23.0
07/12/99	47.64	49.97	33.8	103.2
08/12/99	48.14	50.14	34.9	92.0
09/12/99	48.30	50.28	38.0	66.6
10/12/99	48.36	50.35	39.9	39.9
11/12/99	48.33	50.35	40.1	36.0
12/12/99	48.35	50.34	39.6	19.2
13/12/99	48.26	50.29	38.6	10.1
14/12/99	48.10	50.22	37.5	13.1
15/12/99	48.00	50.16	36.4	60.9

TABLE B.1: Lough Allen Hydrometric Data.

Notes:
1. Levels taken from SEP/OISHYDRO database.
2. Discharge calculated using gate equations (ref. Shannon Regulations)
3. Inflows estimated by backrouting.

Date	L.Allen Lr. Level (m OD)	L.Allen Up. Level (m OD)	L.Allen Discharge (m^3/s)	L.Allen Inflow (m^3/s)
16/12/99	48.12	50.22	37.4	37.4
17/12/99	48.12	50.22	37.4	12.9
18/12/99	48.00	50.16	36.4	3.8
19/12/99	47.90	50.08	34.9	47.1
20/12/99	47.94	50.11	35.4	96.6
21/12/99	48.20	50.26	38.1	87.0
22/12/99	48.34	50.38	41.0	69.5
23/12/99	48.40	50.45	43.0	83.8
24/12/99	48.56	50.55	45.4	33.2
25/12/99	48.50	50.52	44.8	32.5
26/12/99	48.44	50.49	44.1	27.8
27/12/99	48.36	50.45	43.3	26.9
28/12/99	48.32	50.41	42.2	50.3
29/12/99	48.36	50.43	42.6	79.3
30/12/99	48.44	50.52	45.2	20.7
31/12/99	48.36	50.46	43.6	19.1
01/01/00	48.28	50.40	42.1	13.5
02/01/00	48.14	50.33	40.7	12.2
03/01/00	48.06	50.26	39.0	6.4
04/01/00	47.96	50.18	37.3	37.3
05/01/00	47.96	50.18	37.3	16.9
06/01/00	47.92	50.13	36.1	56.5
07/01/00	47.98	50.18	37.2	24.9
08/01/00	47.94	50.15	36.6	8.0
09/01/00	47.86	50.08	35.2	39.2
10/01/00	47.86	50.09	35.4	47.7
11/01/00	47.92	50.12	35.8	27.7
12/01/00	47.90	50.10	35.4	19.1
13/01/00	47.84	50.06	34.8	14.4
14/01/00	47.78	50.01	33.9	5.3
15/01/00	47.72	49.94	32.6	8.1
16/01/00	47.66	49.88	31.7	7.2
17/01/00	47.60	49.82	30.9	6.4
18/01/00	47.56	49.76	30.1	-2.5
19/01/00	47.52	49.68	29.4	9.0
20/01/00	47.52	49.63	29.0	12.7
21/01/00	47.50	49.59	28.9	-3.7
22/01/00	47.48	49.51	28.5	8.1
23/01/00	47.46	49.46	28.3	3.8
24/01/00	47.46	49.40	27.8	-0.7
25/01/00	47.44	49.33	27.5	-1.1
26/01/00	47.42	49.26	27.1	2.6
27/01/00	47.42	49.20	26.7	30.7
28/01/00	47.42	49.21	26.7	39.0
29/01/00	47.44	49.24	26.8	55.4
30/01/00	47.44	49.31	27.3	31.4
31/01/00	47.44	49.32	27.4	19.2

TABLE B.1: Lough Allen Hydrometric Data.

Notes:
1. Levels taken from SEP/OISHYDRO database.
2. Discharge calculated using gate equations (ref. Shannon Regulations)
3. Inflows estimated by backrouting.

Date	Flow Athlone Regs (m^3/s)	Inflow L. Ree Regs (m^3/s)	Level L. Ree (m OD)	Level Athlone Upper (m OD)	Level Athlone Lower (m OD)
01/11/99	68.8	68.8	37.85	37.75	35.98
02/11/99	68.8	68.8	37.85	37.75	36.03
03/11/99	60.7	154.1	37.85	37.72	36.03
04/11/99	85.4	116.5	37.93	37.80	36.24
05/11/99	102.7	133.8	37.95	37.85	36.75
06/11/99	111.6	173.9	37.98	37.87	36.87
07/11/99	111.6	111.6	38.03	37.87	36.92
08/11/99	120.7	151.8	38.03	37.90	36.92
09/11/99	120.7	120.7	38.05	37.90	36.90
10/11/99	120.7	120.7	38.05	37.90	36.90
11/11/99	120.7	120.7	38.05	37.90	36.87
12/11/99	120.7	120.7	38.05	37.90	36.80
13/11/99	120.7	120.7	38.05	37.90	36.72
14/11/99	120.7	89.6	38.05	37.90	36.64
15/11/99	120.7	120.7	38.03	37.90	36.59
16/11/99	111.6	111.6	38.03	37.87	36.54
17/11/99	111.6	111.6	38.03	37.87	36.52
18/11/99	111.6	111.6	38.03	37.87	36.52
19/11/99	111.6	75.2	38.03	37.87	36.52
20/11/99	102.7	71.6	38.00	37.85	36.46
21/11/99	102.7	102.7	37.98	37.85	36.41
22/11/99	102.7	102.7	37.98	37.85	36.33
23/11/99	102.7	102.7	37.98	37.85	36.36
24/11/99	102.7	133.8	37.98	37.85	36.36
25/11/99	102.7	102.7	38.00	37.85	36.44
26/11/99	102.7	133.8	38.00	37.85	36.59
27/11/99	111.6	205.0	38.03	37.88	36.77
28/11/99	139.5	201.8	38.10	37.95	37.02
29/11/99	149.2	211.5	38.13	37.98	37.20
30/11/99	159.1	190.2	38.19	38.00	37.33
01/12/99	169.2	262.6	38.21	38.03	37.40
02/12/99	192.0	192.0	38.29	38.08	37.53
03/12/99	189.2	220.4	38.29	38.08	37.58
04/12/99	194.2	225.3	38.31	38.10	37.63
05/12/99	189.2	220.3	38.34	38.10	37.68
06/12/99	208.7	239.8	38.36	38.15	37.71
07/12/99	201.9	264.2	38.39	38.15	37.76
08/12/99	198.6	260.9	38.44	38.18	37.86
09/12/99	220.1	313.5	38.49	38.23	37.88
10/12/99	220.0	282.3	38.57	38.28	37.99
11/12/99	242.9	336.3	38.62	38.33	38.01
12/12/99	234.0	265.2	38.69	38.33	38.04
13/12/99	234.0	171.8	38.72	38.33	38.04
14/12/99	251.7	251.7	38.67	38.36	38.04
15/12/99	260.2	260.2	38.67	38.36	38.01

TABLE B.2: Lough Ree Hydrometric Data.

Notes:
1. Levels taken from SEP/OISHYDRO database.
2. Discharge calculated using weir equation (ref. Shannon Regulations)
3. Inflows estimated by backrouting.

Date	Flow Athlone Regs (m^3/s)	Inflow L. Ree Regs (m^3/s)	Level L. Ree (m OD)	Level Athlone Upper (m OD)	Level Athlone Lower (m OD)
16/12/99	245.7	276.8	38.67	38.36	38.06
17/12/99	245.7	245.7	38.69	38.36	38.06
18/12/99	245.7	245.7	38.69	38.36	38.06
19/12/99	260.2	229.0	38.69	38.36	38.01
20/12/99	260.2	322.4	38.67	38.36	38.01
21/12/99	259.9	291.1	38.72	38.41	38.11
22/12/99	262.9	418.5	38.74	38.46	38.19
23/12/99	284.5	471.4	38.86	38.54	38.27
24/12/99	301.6	332.8	39.03	38.64	38.39
25/12/99	314.3	376.5	39.04	38.71	38.47
26/12/99	344.2	375.3	39.09	38.76	38.49
27/12/99	357.9	389.0	39.13	38.79	38.51
28/12/99	352.3	352.3	39.14	38.79	38.52
29/12/99	352.3	352.3	39.14	38.79	38.52
30/12/99	352.3	383.4	39.16	38.79	38.52
31/12/99	363.2	363.2	39.17	38.79	38.50
01/01/00	378.6	347.5	39.17	38.79	38.47
02/01/00	378.6	347.5	39.15	38.79	38.47
03/01/00	354.8	261.4	39.13	38.76	38.47
04/01/00	314.3	376.5	39.06	38.71	38.47
05/01/00	355.0	292.7	39.09	38.71	38.39
06/01/00	325.2	325.2	39.05	38.69	38.42
07/01/00	340.3	278.0	39.04	38.66	38.34
08/01/00	346.6	253.2	39.00	38.64	38.29
09/01/00	333.5	333.5	38.93	38.61	38.27
10/01/00	310.8	310.8	38.92	38.56	38.24
11/01/00	310.8	310.8	38.92	38.56	38.24
12/01/00	319.6	350.7	38.93	38.59	38.27
13/01/00	310.8	341.9	38.95	38.56	38.24
14/01/00	308.6	184.0	38.98	38.54	38.21
15/01/00	276.2	213.9	38.86	38.48	38.19
16/01/00	281.2	250.1	38.83	38.46	38.14
17/01/00	278.7	216.5	38.79	38.43	38.09
18/01/00	281.3	219.0	38.74	38.41	38.04
19/01/00	260.2	197.9	38.69	38.36	38.01
20/01/00	255.9	224.7	38.65	38.33	37.96
21/01/00	240.0	177.7	38.61	38.28	37.91
22/01/00	248.3	186.1	38.56	38.26	37.81
23/01/00	226.0	163.7	38.51	38.20	37.76
24/01/00	226.1	195.0	38.47	38.18	37.68
25/01/00	216.8	154.5	38.43	38.15	37.63
26/01/00	213.0	150.8	38.38	38.13	37.55
27/01/00	193.8	162.6	38.33	38.08	37.48
28/01/00	194.4	163.3	38.31	38.08	37.45
29/01/00	182.1	150.9	38.28	38.05	37.40
30/01/00	179.5	148.4	38.27	38.05	37.33
31/01/00				38.05	37.27

TABLE B.2: Lough Ree Hydrometric Data.

Notes:
1. Levels taken from SEP/OISHYDRO database.
2. Discharge calculated using weir equation (ref. Shannon Regulations)
3. Inflows estimated by backrouting.

Date	Q-total Parteen (m^3/s)	Inflow Parteen (m^3/s)	Level L. Derg (m OD)	Level Parteen (m OD)	Level Portumna (m OD)	Level Killaloe (m OD)	Level Vict. Lk Lower (m OD)	Level Vict. Lk Upper (m OD)	Level Banagher (m OD)	Flow Banagher (m^3/s)
01/11/99	144.8	130.9	33.49	33.25	33.56	33.42	33.62		35.35	
02/11/99	163.3	163.3	33.48	33.31	33.56	33.40	33.62		35.38	
03/11/99	149.3	232.6	33.48	33.29	33.56	33.40	33.62		35.38	
04/11/99	127.5	238.6	33.54	33.44	33.58	33.50	33.69		35.55	
05/11/99	191.1	260.5	33.62		33.68	33.56	33.90		35.94	
06/11/99	253.9	177.5	33.67		33.74	33.60	33.95		35.94	
07/11/99	229.5	243.4	33.62	33.13	33.70	33.53	33.92		35.94	
08/11/99	370.7	336.0	33.63	33.36	33.68	33.57	33.90		35.91	
09/11/99	278.7	223.1	33.60	33.36	33.66	33.54	33.90		35.88	
10/11/99	266.9	211.3	33.56	33.32	33.62	33.50	33.79		35.86	
11/11/99	307.0	223.7	33.52	33.29	33.56	33.48	33.74		35.83	
12/11/99	287.5	343.0	33.46		33.50	33.42	33.69		35.78	
13/11/99	190.2	217.9	33.50	33.29	33.54	33.46	33.69		35.71	
14/11/99	146.7	105.0	33.52	33.33	33.58	33.46	33.69		35.66	
15/11/99	217.5	175.9	33.49	33.28	33.54	33.44	33.67		35.61	
16/11/99	222.6	208.7	33.46	33.29	33.52	33.40	33.62		35.55	
17/11/99	196.9	196.9	33.45	33.25	33.50	33.40	33.59		35.55	
18/11/99	190.4	183.4	33.45	33.30	33.50	33.40	33.59		35.55	
19/11/99	183.4	190.3	33.45	33.30	33.50	33.39	33.59		35.55	
20/11/99	167.3	195.1	33.45		33.50	33.40	33.59		35.53	
21/11/99	94.7	143.3	33.47	33.29	33.54	33.40	33.64		35.50	
22/11/99	131.6	152.5	33.51	33.34	33.56	33.45	33.67		35.48	
23/11/99	144.9	61.6	33.52	33.36	33.58	33.46	33.66		35.48	
24/11/99	195.2	223.0	33.46	33.20	33.52	33.40	33.64		35.53	
25/11/99	289.4	164.4	33.48	33.26	33.52	33.44	33.59		35.50	
26/11/99	197.9	378.4	33.39	33.26	33.48	33.30	33.67		35.73	
27/11/99	278.8	292.7	33.52	33.32	33.66	33.38	33.87		35.75	
28/11/99	206.3	234.1	33.53	33.16	33.62	33.44	33.87		36.04	
29/11/99	366.1	310.6	33.55	33.20	33.68	33.42	33.95		36.09	
30/11/99	303.2	247.7	33.51	33.01	33.60	33.42	33.92		36.19	
01/12/99	383.6	355.9	33.47	32.94	33.58	33.36	33.92		36.24	
02/12/99	390.4	376.5	33.45	32.84	33.58	33.32	33.97		36.29	
03/12/99	382.9	355.1	33.44		33.56	33.32	33.97		36.39	
04/12/99	388.7	416.5	33.42		33.54	33.30	33.97		36.42	
05/12/99	383.5	425.1	33.44	33.02	33.58	33.30	34.00		36.42	
06/12/99	341.3	396.8	33.47	32.93	33.60	33.34	34.05		36.44	
07/12/99	369.8	439.2	33.51	32.97	33.66	33.36	34.12		36.49	
08/12/99	379.9	477.1	33.56	32.99	33.70	33.42	34.20		36.54	
09/12/99	386.6	497.8	33.63	33.11	33.76	33.50	34.28		36.64	
10/12/99	406.7	503.9	33.71	33.11	33.84	33.58	34.38		36.75	
11/12/99	415.9	402.0	33.78		33.90	33.66	34.48		36.82	
12/12/99	474.1	432.4	33.77	33.00	33.92	33.62	34.48		36.82	
13/12/99	515.2	459.7	33.74	32.90	33.88	33.60	34.45		36.82	
14/12/99	524.8	455.3	33.70	32.84	33.84	33.56	34.40		36.77	
15/12/99	510.4	552.0	33.65	32.86	33.80	33.50	34.38		36.72	

TABLE B.3: Lough Derg Hydrometric Data.

Notes:
1. Readings taken from SEP/OISHYDRO database.
2. Flows refer to 24 hour period 09.00 am to 09:00 am.
3. Inflows estimated by backrouting.

Date	Q-total Parteen (m^3/s)	Inflow Parteen (m^3/s)	Level L. Derg (m OD)	Level Parteen (m OD)	Level Portumna (m OD)	Level Killaloe (m OD)	Level Vict. Lk Lower (m OD)	Level Vict. Lk Upper (m OD)	Level Banagher (m OD)	Flow Banagher (m^3/s)
16/12/99	445.4	528.7	33.68	33.07	33.80	33.56	34.33		36.70	
17/12/99	415.4	443.1	33.74		33.86	33.62	34.38		36.75	
18/12/99	469.1	441.4	33.76	33.07	33.90	33.62	34.45		36.77	
19/12/99	518.7	477.0	33.74	32.85	33.88	33.60	34.40		36.72	
20/12/99	526.9	582.4	33.71	32.84	33.84	33.58	34.38		36.70	
21/12/99	521.5	577.0	33.75	33.01	33.90	33.60	34.43		36.72	
22/12/99	525.4	587.9	33.79	32.81	33.98	33.60	34.61		36.92	
23/12/99	570.6	744.2	33.84	32.76	34.02	33.65	34.71		36.98	
24/12/99	618.0	756.9	33.96	32.82	34.18	33.74	34.81		37.00	
25/12/99	664.1	712.7	34.06	32.76	34.26	33.86	35.04		37.20	
26/12/99	677.9	684.9	34.09	32.80	34.30	33.89	35.06		37.23	
27/12/99	699.6	658.0	34.10	32.69	34.30	33.90	35.11		37.23	
28/12/99	700.8	687.0	34.07	32.65	34.26	33.88	35.06		37.20	
29/12/99	691.1	691.1	34.06	32.72	34.26	33.86	35.04		37.15	
30/12/99	690.6	648.9	34.06	32.69	34.26	33.86	35.04		37.18	
31/12/99	687.7	632.2	34.03	32.68	34.22	33.84	35.01		37.15	
01/01/00	683.2	627.7	33.99	32.67	34.18	33.80	34.96		37.13	
02/01/00	667.5	598.0	33.95	32.69	34.14	33.76	34.86		37.05	
03/01/00	651.0	595.5	33.90	32.71	34.08	33.72	34.78		37.03	
04/01/00	609.5	567.8	33.86	32.66	34.10	33.62	34.76		36.95	
05/01/00	581.5	498.2	33.83	32.78	34.00	33.66	34.66		36.95	
06/01/00	575.2	519.7	33.77	32.66	34.02	33.52	34.63		36.90	
07/01/00	552.7	511.0	33.73	32.75	33.90	33.56	34.53		36.87	
08/01/00	546.7	491.1	33.70	32.75	33.86	33.54	34.50		36.87	
09/01/00	538.2	496.5	33.66	32.66	33.84	33.48	34.45		36.82	
10/01/00	517.3	545.1	33.63	32.76	33.78	33.48	34.38		36.80	
11/01/00	507.5	604.7	33.65	32.84	33.80	33.50	34.38		36.85	
12/01/00	513.5	513.5	33.72	32.86	33.88	33.56	34.58		36.95	
13/01/00	547.4	519.6	33.72	32.69	33.88	33.56	34.61		36.97	
14/01/00	567.5	511.9	33.70		33.86	33.54	34.55		36.92	
15/01/00	551.1	537.2	33.66	32.79	33.82	33.50	34.48		36.85	
16/01/00	523.8	454.3	33.65	32.78	33.80	33.50	34.40		36.80	
17/01/00	511.3	469.7	33.60	32.74	33.74	33.46	34.35		36.77	
18/01/00	477.3	477.3	33.57	32.80	33.70	33.44	34.30		36.70	
19/01/00	439.6	384.0	33.57	32.98	33.70	33.44	34.22		36.64	
20/01/00	403.5	361.9	33.53	32.91	33.66	33.40	34.17		36.59	
21/01/00	402.8	500.0	33.50	32.97	33.60	33.40	34.10		36.54	
22/01/00	361.0	333.2	33.57	33.38	33.64	33.50	34.07		36.47	
23/01/00	266.5	183.1	33.55	33.07	33.64	33.46	34.05		36.42	
24/01/00	381.9	326.4	33.49	33.01	33.58	33.40	34.00		36.34	
25/01/00	382.5	340.9	33.45	32.94	33.54	33.36	33.92		36.29	
26/01/00	381.0	394.9	33.42	33.13	33.50	33.34	33.87		36.21	
27/01/00	303.9	283.1	33.43	33.14	33.56	33.30	33.87		36.16	
28/01/00	303.0	400.2	33.42	33.15	33.54	33.29	33.87		36.11	
29/01/00	267.2	301.9	33.48	33.30	33.60	33.37	33.89		36.09	
30/01/00	262.5	248.6	33.51	33.00	33.60	33.42	33.89		36.11	
31/01/00	313.7		33.50	33.20	33.58	33.42	33.87		36.09	

TABLE B.3: Lough Derg Hydrometric Data.

Notes:
1. Readings taken from SEP/OISHYDRO database.
2. Flows refer to 24 hour period 09.00 am to 09:00 am.
3. Inflows estimated by backrouting.

Flooding Water Level Profiles along the Shannon River November/December 2009

Water levels were collected by OPW staff along the River Shannon in November and December 2009 after extensive flooding. The findings are summarised in the following maps and table. Below is a map which shows the overall extent of the survey.

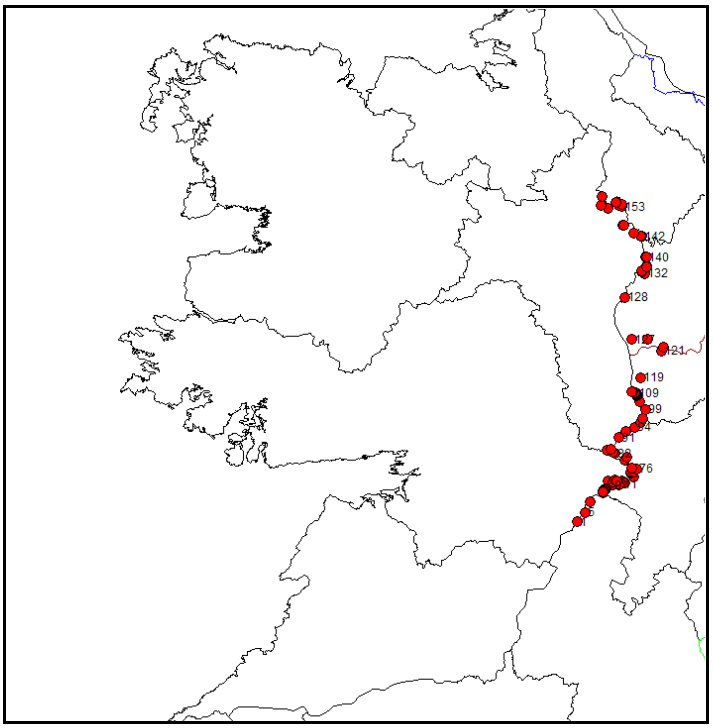


Figure 1 – Extent of water profile survey.

Each point in the map above corresponds to a reference point in the summary table. A GIS layer, displaying the exact locations of these points is available from OPW, on request.

Ref	Level (m)	Comment (all Malin Head)	X Co-ords	Y Co-ords
1	31.92		186906.84	204536.87
2	32.13	TRASH MARK	186908.45	204538.61
3	32.03	WL U/S	186939.54	204558.97
4	32.09	TRASH U/S	186934.07	204566.59
5	32.11	W/L	189166.64	207188.9
6	32.17	TRASH	189179.77	207192.43
7	32.42	W/L	190759.4	210427.01
8	32.54	TRASH	190760.86	210427.49
9	34.3	W/L JETTY	196823.81	215127.57
10	34.38	W/L	197286.29	215291.44

11	34.75 W/L C/L ROAD	199586.96	215393.65
12	34.87 HIGH WATER LEVEL	199539.83	215379.76
13	34.62 W/L	198939.37	215274.69
14	33.59 W/L	195100.48	214130.64
15	33.57 U/S WEIR	195002.23	213964.25
16	34.19 D/S WEIR STAFF GAUGE 2.89	194970.48	213937.2
17	33.42 D/S WEIR STAFF GAUGE 2.89	194958.29	213945.08
18	33.35 W/L AT EMB	194927.11	213959.7
19	33.29 WL	194848.57	213949.08
20	33.51 EMB	194848.09	213950.18
21	33.29 WL	194783.63	213930.59
22	33.29 EMB	194783.09	213931.65
23	33.25 WL	194641.51	213865.57
24	33.39 EMB	194640.44	213866.28
25	33.31 EMB	194564.3	213803.63
26	33.24 WL	194565.16	213803.17
27	33.11 WL EMB	194518.43	213682.34
28	32.96 WL	194477.81	213583.21
29	32.91 EMB	194476.68	213583.6
30	32.82 EMB WL	194419.63	213506.95
31	32.87 WL	194345.66	213399.08
32	32.83 EMB	194333.04	213369.61
33	32.79 WL	194333.99	213369.72
34	32.86 WL	194325.51	213308.18
35	32.68 EMB	194324.45	213308.91
36	32.84 WL	194330.32	213265.87
37	33.02 ROAD	194329.14	213265.55
38	32.92 ROAD	194333.59	213205.58
39	32.82 WL	194334.92	213205.7
40	32.83 WL	194336.35	213187.36
41	32.72 EMB	194335.5	213188.8
42	32.73 EMB WL	194347.43	213043.04
43	32.78 WL	194354.02	212971.65
44	32.74 EMB	194352.91	212971.03
45	32.73 WL	194354.3	212745.78
46	32.6 EMB	194353.81	212743.99
47	32.48 WL	194352.44	212747.33
48	32.48 WL	194360.64	212864.23
49	32.49 WL	194346.6	213024.68
50	32.47 WL	194327.85	213238.34
51	32.48 WL	194326.28	213349.55
52	32.48 WL	194446.74	213548.27
53	32.45 WL	194472.19	213581.28
54	32.46 WL	194641.8	213870.91
55	34.18 WL	195832.54	216248.46
56	34.29 TRASH	195833.24	216251.74
57	34.35 HIGH WATEMARK	195819.6	216271.42
58	34.31 WL	197135.07	216131.92
59	34.51 WL	197855.46	216533.82

60	34.67 TRASH	197853.65	216534.49
61	34.54 WL	198462.97	216368.46
62	34.69 TRASH	198470.69	216365.73
63	34.63 WL	199898.61	216327.44
64	34.75 WL	199879.7	216342.19
65	34.96 HIGH WATER	199883.89	216361.51
66	34.71 WLRB	200406.96	215882.35
67	34.73 WL RB D/S	200406.92	215882.38
68	34.78 WL RB U/S	200484.6	215973.54
69	34.85 WL LB U/S	200716.56	215811.68
70	35.08 CL ROAD	203161.87	217435.66
71	35.1 WL	202456.65	218740.65
72	35.29 TRASH	202457.77	218751.19
73	35.14 WL	202461.78	218778.54
74	35.44 OBM	202441.75	218758.68
75	35.08 WL	203296.7	218903.17
76	35.98 WL LITTLE RIVER	204191.58	219827.15
77	35.18 WL	202533.43	219914.01
78	35.35 HIGH WATER MARK	202538.61	219915.34
79	35.22 WL	200742.79	222194.13
80	35.45 WL C/L ROAD	201271.07	223313.94
81	35.62 TRASH	201288.24	223323.68
82	35.53 WL	197787.3	224292.42
83	35.65 TRASH	197787.62	224296.37
84	35.71 WL	197280.14	224660.47
85	35.89 TRASH	197280.99	224661.02
86	36.01 TRASH	196757.61	225394.56
87	35.83 WL	196753.97	225396.07
88	35.69 WL	195397.34	225088.79
89	35.83 WL	196774.74	225484.08
90	35.83 WL U/S RB	196774.75	225484.08
91	35.93 WL	198971.71	228912.93
92	36.03 TRASH	198970.49	228909.83
93	35.89 WL	200826.26	230654.47
94	36.04 WL	203513.39	231903.36
95	36.04 WL	205303.49	233272.78
96	36.24 HIGH WATER MARK	205316.05	233269.68
97	36.12 WL	205885.88	234361.9
98	36.24 HIGH WATER MARK	205893.91	234346.3
99	36.11 WL CLONBONNY HIGH WATER MARK	206581.06	237040.2
100	36.32 CLONBONNY	206598.81	237047.09
101	36.2 WL	204894.79	239290.84
102	36.36 TRASH	204870.78	239350.64
103	36.17 WL	204216.65	240972.38
104	36.3 TRASH	204218.84	240971.6
105	36.28 WL	204177.97	241300.2
106	36.41 TRASH	204138.81	241326.42
107	36.32 WL	204046.87	241399.86

108	36.34 WL D/S RB	203879.03	241455.53
109	36.48 WL	203690.44	241698.38
110	36.66 TRASH	203692.71	241695.57
111	36.57 C/L ROAD	203614.42	241789.54
112	36.31 U/S RLY BR RB NF	203546.69	241899.84
113	36.71 D/S BYPASS R	203071.6	242180.91
114	36.82 D/S BYPASS RB TRASH	203074.45	242177.03
115	36.69 WL	203056.03	242037.99
116	36.83 TRASH	203055.1	242040.73
117	36.83 U/S RB TRASH	202638.32	242187.11
118	36.71 U/S RB	202639.83	242189.64
119	36.79 WL	205114.38	246218.56
120	36.91 TRASH	205113.49	246218.51
121	36.8 WL ROAD ANNAGH	211140.68	253948.42
122	36.74 WL	211892.13	254958.29
123	36.83 WL U/S RED BR. LB	211917.42	254989.41
124	36.84 WL D/S RED BR. LB	211903.06	255016.6
125	36.77 WL ROAD	207262.65	257310.93
126	36.93 TRASH	207259.15	257318.66
127	36.76 WL	202718.22	257254.74
128	36.76 WL D/S LB	200578.89	269327.21
129	36.83 WL U/S RB	200544.48	269457.47
130	36.76 WL U/S LB	200594.76	269346.62
131	37.05 TRASH	200596.09	269344.12
132	38.38 WL D/S BR	206266.8	276243.75
133	38.35 WL U/S BR	206290.15	276353.77
134	38.96 TRASH	206269.36	276344.69
135	37.85 WL D/S RB	205432.77	276912.91
136	37.88 WL U/S LB	205571.97	276989.07
137	38.18 TRASH	205574.45	276989.64
138	38.66 WL	206873.18	278352.38
139	39.08 HIGH WATER MARK	206899.89	278306.05
140	39.6 TRASH	206801.09	280975.17
141	38.91 WL	206820.39	280992.38
142	39.64 WL	205436.22	286948.74
143	39.61 LB D/S BR	205435.58	286994.68
144	39.63 RB D/S BR	205353.48	286994.92
145	39.87 WL	203332.87	287830.93
146	40.24 TRASH	203350.29	287823.31
147	40.3 TRASH	200223.34	290353.24
148	39.92 WL	200220.35	290340.15
149	39.91 WL	200220.23	290340.16
150	40.25 TRASH	200223.89	290352.59
151	40.09 TRASH	200280.02	290322.62
152	39.93 WL	200281.84	290321.14
153	40.96 WL U/S LOCK	199900.58	295669.5
154	39.93 WL D/S LOCK	199857.38	295642.78
155	40.36 TRASH D/S LOCK	199860.69	295645.28
156	40.94 WL D/S BBR	198918.24	295859.08

157	41.93 WL U/S BBR	198837.26	295921.49
158	39.99 WL	199814.78	296251.67
159	41.93 WL	198177.4	296965.75
160	42.29 TRASH	198203.1	296976.72
161	41.98 WL	195668.16	295192.24
162	42.05 WL	193670.86	295916.17
163	42.39 TRASH	193636.32	295920.14
164	42.09 WL	194004.55	298536.93
165	42.08 WL	193922.86	298503.01
166	42.44 TRASH	193930.78	298504.07

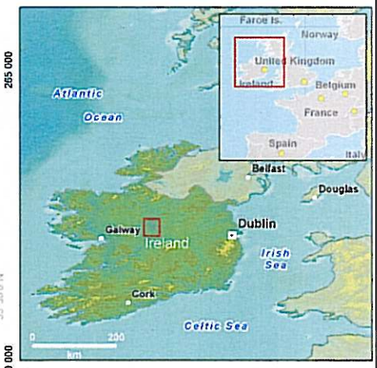
SAFER Action No. 022
Product n°03

IRELAND
Shannon river basin
Athlone

Flood impact on landcover
Situation the 30th of November 2009

Scale: 1:50 000

Location Diagrams



Legend

Crisis information

- Crisis time water body
- Urban / housing areas close to flooded area

Landcover and topography

- Reference water body
- Wood type vegetation
- Grassland
- Bogland
- Mineral surface
- Height contour (10m intervals)

Communication networks

- Motorway
- Secondary road
- Primary road
- Railroad

Administrative boundaries

- County boundary

Interpretation

Record flooding hit the Shannon river basin in late November 2009. This flood impact product maps the landcover affected by this event the morning of the 30th of November 2009 over the Athlone region. In this area, river levels were close to the maximum flooding recorded the 27th of November, a level never observed since records began a century ago. Landcover is indicative due to the date of the source image (2001). Overall the area under water has nearly doubled with respect to the reference date, with close to 20 000 ha flooded. From the mapping it seems that a number of urban areas are affected, not to mention isolated buildings.

Cartographic information

0 2 4 km

N

Local projection: Irish National Grid , Datum: TM 65
Geographic projection: Lat/Lon (DMS), Datum: WGS 84

Scale: 1:50 000 for A1 prints

Data Sources

Crisis time water bodies and urban areas are derived from SPOT 4 data acquired the 30th of November 2009
© SERTIT 2009 processing and analysis

Landcover is derived from LANDSAT 7 ETM+ acquired the 24th of February 2001
© SERTIT 2009 processing and analysis

Communication networks are derived from SPOT 4 data acquired the 30th of November 2009
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Others vector layers and toponyms
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Framework

The products elaborated for this Rapid Mapping Activity are realised to the best of our ability, with in a very short time frame, during a crisis/exercice, optimising the material available. All geographic information has limitations due to the scale, resolution, date and interpretation of the original source materials. No liability concerning the content or the use thereof is assumed by the producer.

Map produced the 2nd of December 2009 by SERTIT
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SAFER Action No. 022
Product n°05

IRELAND
Shannon river basin
Athlone

Flood impact on topographic map
Situation the 30th of November 2009

Scale: 1:50 000

Location Diagrams

Legend

Crisis information

Crisis time water body

Selected topographic information

Urban areas
Water bodies
Grassland
Bogland

Interpretation

Record flooding hit the Shannon river basin in late November 2009. This flood impact map incorporates the flood extent, extracted for the morning of the 30th of November 2009, covering the Athlone area, and a 1 : 50 000 topographic map.
In this area, river levels were close to the maximum flooding recorded the 27th of November, a level never observed since records began a century ago. Overall the area under water has nearly doubled with respect to the reference date, with close to 20 000 ha flooded. From the mapping it seems that a number of urban areas are affected, not to mention isolated buildings.

Cartographic Information

0 2 4 km

N

Local projection: Irish National Grid , Datum: TM 65
Geographic projection: Lat/Lon (DMS), Datum: WGS 84

Scale: 1:50 000 for A1 prints

Data Sources

Crisis time water bodies are derived from SPOT 4 data acquired the 30th of November 2009
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The topographic map is provided courtesy of the Ordnance Survey Ireland, under the following licence:
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SAFER Action No. 022
Product n°01

IRELAND
Shannon river basin

Flood extent
Situation the 30th of November 2009

Scale: 1:125 000

Location Diagrams

Legend

Water bodies
- Crisis time (30/11/2009)
- Reference time (24/02/2001)

Communication networks
- Motorway
- Primary road
- Secondary road
- Railroad

Administrative boundaries
- County boundary

- Urban areas
- Water bodies
- Grassland
- Bogland

Interpretation

End November 2009 the Shannon river basin has been affected by record flooding. This flood extent product maps the flooding detected on the morning of the 30th of November 2009 by SPOT 4 data (20 m). In Athlone river levels were close to maximum flooding recorded the 27th of November, a level never observed since records began a century ago.
The Cloudmade sourced road network may not be completed or up-to-date.

Cartographic Information

0 5 10 km

N

Local projection: Irish National Grid , Datum: TM 65
Geographic projection: Lat/Lon (DMS), Datum: WGS 84

Scale: 1:125 000 for A1 prints

Orthorectification RMS: 0.4 Pixels (20m)
Reference data: Landsat 7 ETM+ distributed by Maryland GLCF

Data Sources

Crisis time water bodies are derived from SPOT 4 data acquired the 30th of November 2009
© SERTIT 2009 processing and analysis

Reference time water bodies are derived from LANDSAT 7 ETM+ acquired the 24th of February 2001
© SERTIT 2009 processing and analysis

Background layers
Natural colours SPOT 4 (20 m) acquired the 30th of November 2009
© CNES 2009, distribution SPOT Image

Natural colours Landsat 7 ETM+ image (14.25 m) acquired the 24th of February 2001
© USGS 2001, distribution Maryland

Vector layers and toponyms
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Framework

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