



Shannon Catchment-based Flood Risk Assessment and Management (CFRAM) Study

Preliminary Options Report Unit of Management 27

Option Appraisal

Final Report



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Abbreviations

A full glossary explaining abbreviations frequently used in the CFRAM Programme and more widely in flood risk management is provided in Appendix A. Set out below are abbreviations used herein.

AEP	Annual Exceedance Probability (expressed as a percentage)
AFA	Area for Further Assessment
APMR	Areas of Potential Moderate Risk
CFRAM	Catchment Flood Risk Assessment and Management
EU	European Union
FRM	Flood Risk Management
FRMP	Flood Risk Management Plan
GIS	Geographic Information System
IRR	Individual Risk Receptors
OPW	The Office of Public Works
RBD	River Basin District
SI	Statutory Instrument (SI No. 122 of 2010)
SOP	Standard of Protection
SSA	Spatial Scale of Assessment
UoM	Unit of Management
WFD	Water Framework Directive

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Introduction

1.1 Shannon CFRAM Study Area

The Shannon (the “Study Area”) is the largest River Basin District (RBD) in Ireland, covering approximately 17,800km² and more than 20% of the island of Ireland. The RBD includes the entire catchment of the River Shannon and its estuary as well as some catchments in North Kerry and West Clare that discharge directly to the Atlantic.

The Shannon River rises in the Cuilcagh Mountains, at a location known as the Shannon Pot in the counties of Cavan and Fermanagh. The river flows in a southerly direction before turning west and discharging through the Shannon Estuary to the Atlantic Ocean between counties Clare and Limerick. Whilst the River Shannon is 260km long from its source to the head of the Shannon Estuary in Limerick City, over its course the river falls less than 200m in elevation. The Shannon RBD is characterised as an ‘International RBD’ as it extends into Northern Ireland. However, there are no areas identified as being at significant flood risk in the Shannon RBD within Northern Ireland, and no significant cross-border issues.

Significant tributaries of the Shannon include the Inny, Suck, and Brosna. There are several lakes in the RBD, including Lough Ree, Lough Derg, and Lough Allen.

Other important rivers within the RBD include the Maigue, Deel and Feale discharging into the Shannon Estuary from the south, and the Fergus, Owenagarney (or Ratty) and Cloon discharging into the estuary from the north.

The RBD includes parts of 17 counties: Limerick, Clare, Tipperary, Offaly, Westmeath, Longford, Roscommon, Kerry, Galway, Leitrim, Cavan, Sligo, Mayo, Cork, Laois, Meath, and Fermanagh. While much of the settlement in the RBD is rural there are six significant urban centres within the RBD - Limerick City, Ennis, Tralee, Mullingar, Athlone and Tullamore.

The RBDs that were defined under the Water Framework Directive (WFD) were further divided into a number of Units of Management (UoM) for the purposes of the National CFRAM Programme. The UoM constitute major catchments or river basins (typically greater than 1000km²) and their associated coastal areas, or conglomerations of smaller river basins and their associated coastal areas. The Shannon RBD (and by definition the Shannon CFRAM Study Area) and the UoM within the Shannon RBD are shown in Figure 1.1. There are six hydrometric areas in total; these hydrometric areas have been grouped together to form four UoMs, as follows;

- Tralee Bay – Feale (Hydrometric Area 23 – ‘HA23’) – UoM 23;
- Shannon Estuary South - (Hydrometric Area 24 – ‘HA24’) – UoM 27;
- Shannon Upper and Lower (Hydrometric Area 25 & 26 – ‘HA25 & 26’) – UoM 25/26;
- Shannon Estuary North and Mal Bay (Hydrometric Area 27 & 28 – ‘HA27 & 28’) – UoM 27/28

1.2 Preliminary Options Report Scope

The specification for the Preliminary Options Report is set out in Section 1 of the Catchment – based Flood Risk Assessment and Management (CFRAM) Studies Stage 1 Project Brief (June 2010) and elements of Sections 2.25 to 2.27 of the Shannon CFRAM Study Stage II Project Brief (October 2010). There are four Preliminary Options Reports for the Shannon CFRAM Study Area, one for each UoM in which at least one fluvial hydraulic model or coastal flooding model exists.

1.2.1 AFAs for different SSAs

The development of flood risk management options has been carried out at four Spatial Scales of Assessments (SSAs). The four SSAs are;

- The UoM
- Each sub-catchment (SUB) or coastal area within the UoM
- AFAs
- IRRs

The Shannon CFRAM Study Area is comprised of six UoMs. Table 1.1 and figure 2.1 provides a summary of UoM 27, with a complete list of the associated SSA's considered.

Table 1.1 List of SSA by UoM

UoM	SSA level	AFA/IRR names	Fluvial (F) or Coastal (C) models
UoM 27	UoM	UoM 27	F / C
	SUB	Kilrush Sub Catchment	F / C
	SUB	Fergus Sub Catchment	F / C
	SUB	Shannon & Shannon Airport Sub Catchment	F / C
	SUB	Owenogarney Sub Catchment	F / C
	SUB	Moore Bay Sub Catchment	F / C
	AFA	Kilrush	F / C
	AFA	Quin	F
	AFA	Ennis	F / C
	AFA	Shannon	F / C
	IRR	Shannon Airport	C
	AFA	Sixmilebridge	F
	AFA	Bunratty	F / C
	AFA	Kilkee	F / C

1.3 Structure of this Report

1.3.1 Overview of Report

The Preliminary Options Report sets out the work and analysis undertaken in the development of flood risk management options for all the Spatial Scales of Assessment (SSA) within Unit of Management (UoM) 27.

1.3.2 Report Structure

This report, excluding appendices, is structured to reflect the specific reporting requirements of the CFRAM Studies Project Brief as follows:

- Section 1** Provides an introduction to the Preliminary Options Report and sets the context and scope of this activity within the Shannon RBD.
- Section 2** Provides an overview of the study area and the history of flooding.
- Section 3** Describes, in general terms, the approach taken in to development of the flood risk management measures and the options assessment process.
- Section 4** Describes the options appraisal results.
- Section 5** Presents the preferred options, prioritisation and other recommendations for the flood risk management plan.

1.3.3 Report Appendices

A series of appendices to this POR 'Option Assessment' report are relevant to summarising our adopted optioneering approach. These are:

- Appendix A** Glossary of Terms
- Appendix B** Flood Risk Management Definitions and the general methodology of how these measures are appraised.
- Appendices C** Detailed description of the work and analysis carried out in the development of the flood risk management options for each AFA/IRR.
- Appendix D** Detailed description the Economic Damage and Benefit Calculations and the Cost Benefit Analysis methodology
- Appendix E** Minutes from the option development meeting with the relevant Stakeholders
- Appendix F** MCA objectives and scoring methodology.
- Appendix G** This Appendix provides a detailed assessment of the freeboard allowances adopted in the outline design of embankments and flood walls for this study.
- Appendix H** CFRAM Unit Cost Development Project Final Report – Outlines the methodology used in determining the PV costs for the options.
- Appendix I** Flood defence asset failure maps

- Appendix J** Relevant Guidance Notes produced by the OPW which are referenced in this process.
- Appendices K** Detailed description of the work and analysis carried out in the development of the flood risk management options for each sub-catchment.
- Appendix M** Economic Sensitivity Analysis

Appendices C provide specific information for each respective AFA/ IRR, and Appendices K provide specific information for each sub-catchment. This enables different stakeholders to easily identify the AFA/IRR or sub-catchment that may be of interest, allowing them to view the **relevant Appendix section**. Table 1.2 summarises the Appendix section reference for each AFA/ IRR and sub-catchment within UoM 27.

Table 1.2 Summary of Appendices C and K

Appendix Section	AFA	County
Appendix C1	Kilrush	Clare
Appendix C2	Quin	Clare
Appendix C3	Ennis	Clare
Appendix C4	Shannon	Clare
Appendix C5	Shannon Airport (IRR)	Clare
Appendix C6	Sixmilebridge	Clare
Appendix C7	Bunratty	Clare
Appendix C8	Kilkee	Clare
Appendix K1	Shannon & Shannon Airport Sub-Catchment	Clare



2 Report Study Area and Data Collected

2.1 UoM Study Area

The Shannon Estuary North Unit of Management (UoM) 27 is shown in its wider context within the Shannon RBD in Figure 1.1, above, and in more detail in Figure 2.1, below. UoM 27 is located almost entirely within County Clare, with only a small part of the unit of management within Limerick and Galway. The total area of UoM 27 is approximately 1,650 km².

The unit of management is dominated by two main river catchments, which are, from east to west, the River Owenogarney (or Ratty) and the River Fergus, both of which discharge into the Shannon Estuary. The largest of these is the River Fergus. Further to the west, the rivers are much smaller, with several rivers draining generally southwards into the Shannon Estuary, such as the Crompaun and the Cloon.

The coastline extends along the Shannon Estuary from Limerick City in the east to where it meets the Atlantic Ocean at Loop Head in the far west of County Clare.

From Loop Head the coastline extends northeast to Kilkee, along which the coastline is exposed to the Atlantic Ocean. UoM 27 is bounded to the east by the Lower Shannon Hydrometric Area (part of UoM 25/26), to the north by the Western RBD and to the west by UoM 28, separated from it by the upland area which creates the catchment divide.

The far north of UoM 27 includes the southern part of The Burren, with its characteristic karst limestone features, and the virtual absence of any surface water features. The southern part of UoM 27 is dominated by the tidal influence of the Shannon Estuary, which is reflected by the extensive flood defence assets (typically tidal embankments) located along the low-lying shoreline for much of its length in the eastern part of UoM 27. In the central part of UoM 27, the River Fergus dominates, rising northwest of Corrofin near Lough Fergus, flowing through Corrofin and then through the central part of UoM 27, where it is dominated by numerous groundwater-fed lakes, heavily influenced by the limestone geology. Just north of Ennis it flows through Ballyallia Lough before splitting into two channels in the northern part of Ennis. The main River Fergus channel flows through the northwestern part of the town and the town centre (where the River Claureen or Inch joins the Fergus from the west) while the smaller channel flows southeast through the northern part of the town. The two parts of the Fergus re-join on the eastern side of Ennis. South of Ennis, the river widens and there is a tidal barrage located at Clarecastle approximately 4km south of the centre of Ennis. 3km south of Clarecastle, the River Rine (or Ardsolus in its lower reaches) flows into the tidal River Fergus before entering the Shannon Estuary.

Towards the eastern boundary of UoM 27, the River Owenogarney (or Ratty) flows into the Shannon Estuary, draining the eastern part of the catchment, and is separated from the Lower Shannon catchment (part of UoM 25/26) by the Slieve Bearnagh Mountains.

Table 2.1 below indicates the main sub-catchments and watercourses modelled in this unit of management. In accordance with the scope, the Crompaun catchment,

which includes Limerick AFA, has been included within the Shannon Upper and Lower Unit of Management UoM 25/26.

Table 2.1 AFAs/IRR and Hydrological Catchments

AFA/ IRR	Sub-catchment	County
Kilrush	Kilrush	Clare
Quin	Fergus	Clare
Ennis	Fergus	Clare
Shannon	Shannon & Shannon Airport	Clare
Shannon Airport (IRR)	Shannon & Shannon Airport	Clare
Sixmilebridge	Owenogarney	Clare
Bunratty	Owenogarney	Clare
Kilkee	Moore Bay	Clare

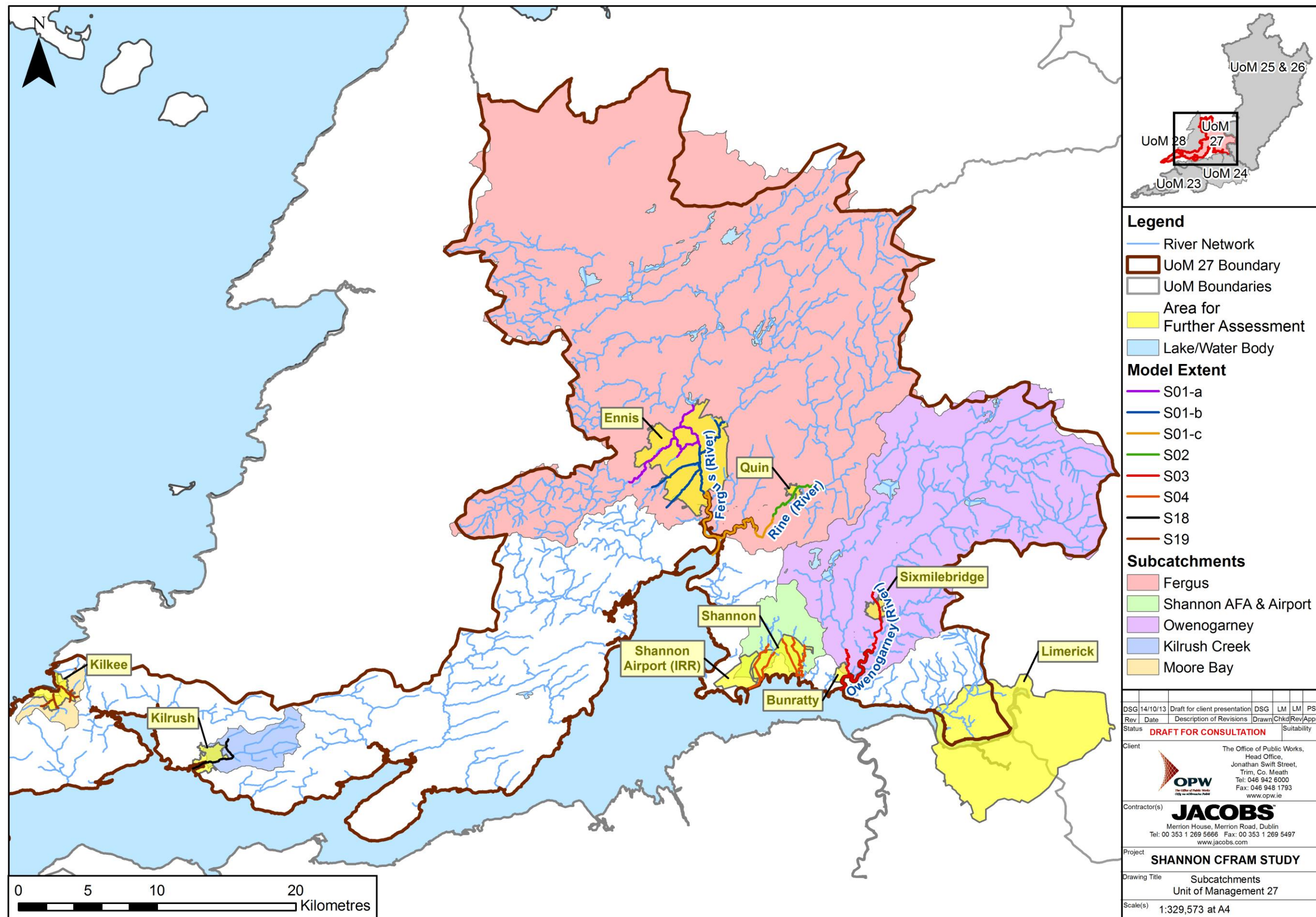


Figure 2.1 UoM 27 Sub-catchments

2.2 History of Flooding

Flood records were studied as part of the Inception Study to determine a flood history for the sub-catchments making up UoM 27. The findings are summarised below.

2.2.1 Fergus Catchment

Two AFAs, namely Ennis and Quin are located in the Fergus catchment. A brief review of the history of flooding in these two AFAs is presented below.

Ennis AFA

Several major flood events are known to have occurred in the Fergus catchment since 1947 that affected Ennis. These flood events include the March 1947, December 1955, December 1959, January/February 1995, December 1999, February 2002 and November 2009. The information available at the National Flood Hazard mapping website www.floodmaps.ie indicates that high tides coincident with high fluvial discharges cause flooding at Ennis. A tidal barrage was constructed in 1954 to reduce the tidal flood risk to Ennis.

The November 2009 flood in Ennis was considered to be due to the combination of prolonged intense rainfall over a period of several days coincident with high tides on the Fergus Estuary (the rainfall in November 2009 in Ennis was approximately five times the average rainfall). Approximately 112 houses in Ennis town and 12 properties in Ennis' environs were directly affected.

The February 2002 flood is reported as being caused by a combination of tidal and fluvial events, during which roads and two properties in Ennis were flooded.

The December 1999 flood event was caused by the coincidence of high river flow resulting from the extended heavy rainfall and the high tide on the Fergus Estuary. Subsequent to this flood event the Ennis Main Drainage and Flooding Study (June 2001) was carried out. As per the recommendation of the study a flood alleviation scheme was implemented in Ennis town.

The January/February 1995 flood event was also caused by a combination of prolonged intense rainfall coincident with the tidal peak on the Fergus Estuary. Similarly, the December 1959 flooding in Ennis occurred when exceptionally heavy rainfall, high tides and gale force south westerly winds coincided.

From the review of historic flood events it is observed that Ennis AFA is susceptible to flood risk from the River Fergus, which floods during prolonged extreme rainfall events coupled with high tides.

Quin AFA

Although no major historic flooding events have been reported at the Quin AFA, the local road and land adjacent to the River Rine (a tributary of the Fergus) in the vicinity of Quin are subject to recurrent flooding during extreme rainfall events.

2.2.2 Owenogarney (Ratty) Catchment

Two AFAs, namely Sixmilebridge and Bunratty are located in the Owenogarney catchment. A brief review of the history of flooding in these two AFAs of Owenogarney catchment is presented below.

Bunratty AFA

This AFA was affected by major historic flood events in January 2005, February 2002, February 1997 and January 1995. The main cause of flooding in Bunratty has been reported as high tides overtopping the flood defence embankments; and flooding associated with the inadequacy of the surface water drainage systems in the low lying areas.

During the January 2005 historic flood event, the low-lying area near Bunratty and some localised area of the L304 road adjacent to Bunratty Castle was flooded. The flooding was apparently caused by the surface water runoff from low lying land combined with high tide and high winds.

In February 2002, the land at Moyhill near Bunratty was flooded due to a high tide coupled with sluice failure. The sluice has subsequently been replaced.

During the February 1997 event, a dwelling at Moyhill near Bunratty was threatened by the high tide, and a stretch of wall to the north of the premises was washed away.

During the January 1995 tidal flooding event, lower levels in Bunratty castle were flooded due to overtopping of the flood protection embankment.

Sixmilebridge AFA

This AFA was affected by major historic flood events in November 2009, January 2005 and January 1995. The main cause of flooding is reported as the out of bank flows from the River Owenogarney after heavy rainfall; and backing up of water in a small tributary when the Owenogarney is flowing high.

During the November 2009 flooding event the R462 and R471 roads at this AFA were impassable and several commercial properties towards the northern end of the town were affected from the flooding in the River Owenogarney.

During the January 2005 flooding event several road sections at and in the vicinity of this AFA were flooded, mainly due to prolonged heavy rainfall and inadequate drainage capacity. The January 1995 flooding lasted for two weeks and caused substantial damage to 14 houses, threatened a number of other properties and inundated the sewerage treatment plant on the left bank of the Owenogarney. Subsequent to this flood event a study was carried out in December 1995 to investigate options for alleviating the flooding problem.

2.2.3 Shannon Catchment

Shannon AFA and Shannon Airport IRR

Shannon and Shannon Airport are located in the Shannon catchment. The historic flood event of January 2005 affected both the town and the airport whereas the December 1999 event affected the airport only. In addition, some recurring tidal flooding affected the local L7174 road around the year 2000.

The cause of flooding in Shannon (AFA) and Shannon Airport (IRR) appears to be due to high tide backing up from the estuary and inadequacy of the surface water drainage system at Ballycally.

2.2.4 Kilrush Catchment

Kilrush AFA

Kilrush is located in the Kilrush catchment and is susceptible to the fluvial flooding from the River Kilrush and tidal/coastal flooding from the Shannon Estuary. Major historic flood events were recorded in Kilrush AFA in January 2005, August 1986, January 1969, December 1968, January 1965, October 1961, October 1949, December 1924 and October 1986. The only information available for the historic flood event is for the recurring flooding of the low lying land and cut away bog on both side of the R483 road as a result of 'poor drainage'.

2.2.5 Moore Bay Catchment

Kilkee AFA

Kilkee is susceptible to flooding from high tides and strong winds and from the out-of-bank flows from the Victoria Stream at Carrigaholt Road. Major historic flood events recorded in Kilkee AFA in February 1990, January 1965, October 1961, December 1954, October 1954, October 1949 and August 1946.

During the February 1990 event County Clare experienced serious tidal flooding with approximately 200 houses and many roads affected. Kilkee AFA was one of the most seriously affected areas. During the January 1965 flood event, caused by a high tide and strong winds, portions of the promenade wall were severely damaged and a house was affected. The October 1961 flood event was caused by torrential rainfall damaging buildings along the seafront in Kilkee. The December 1954 event resulted in flooding to large areas of land and low lying roads in Kilkee. The October 1954 flood event was due to heavy rainfall resulting in flooding to low lying roads and land in Kilkee. In addition to the above major flood events some recurring flooding affects Church Street and Carrigaholt Road in front of St Patrick's Terrace and Well Road car park when the Victoria Stream just north of the R487 road overflows its banks. This can affect four to five houses. This is reported to happen approximately once a year and the flooding situation is said to be exacerbated by tides and wind.

3 Flood Defence Asset Failure

3.1 Background

Flood Defence Assets are defined as structures or features that were constructed to provide a formal flood defence function ('formal flood defences'), including those that may be in poor condition, and also those that may have been built for other purposes but would provide a flood defence function ('informal effective flood defences'). They do not include structures that were not constructed to provide a formal flood defence function and would fail to provide a flood defence function due to structural weakness, porosity or other such reasons ('informal ineffective flood defences'), such as garden walls or embankments perforated by uncontrolled culverts.

The standard of protection of a flood defence asset refers to the most severe (lowest AEP) of the 8 predefined AEP events that does not overtop the defence / defence group along its length. Therefore, by way of an example, if the 10% AEP is fully contained within the defence, but the 5% AEP overtops the defence / defence group at any point, then the effective standard of protection of the defence can be considered to be the 10% AEP event. The associated AEP is referred to as the Effective Standard of Protection, or SOP of the flood defence asset, see figure 3.1

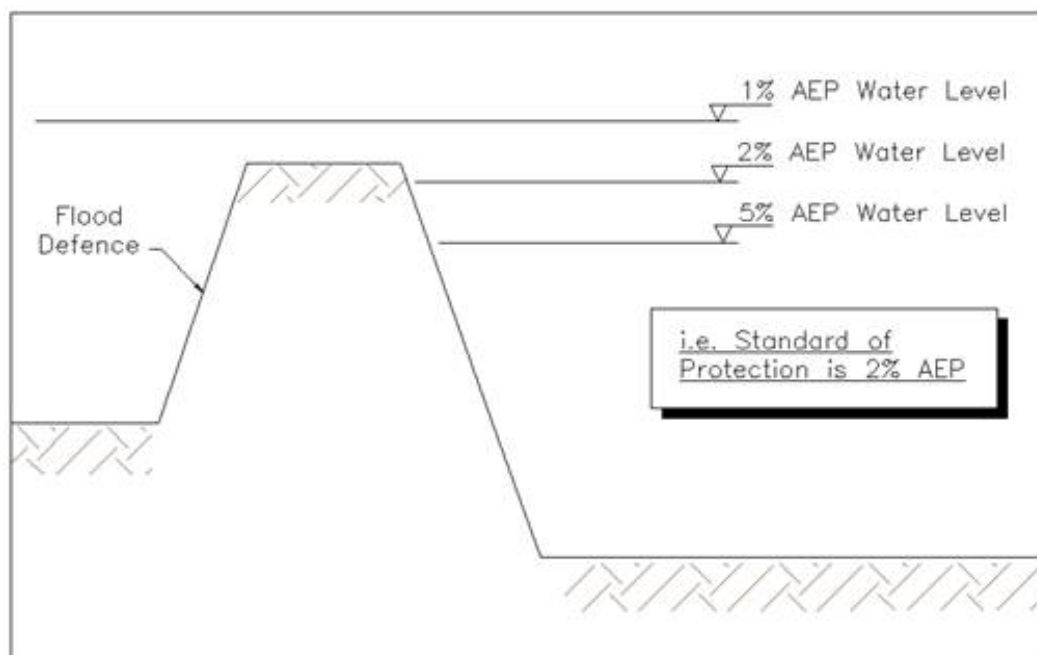


Figure 3.1 - Flood Defence Standard of Protection (SOP)

In the event of a failure of flood defence assets such as the localised breach of an embankment or a wall, areas that would otherwise be defended from flooding during a given event severity might become subject to flooding. Analysis has been carried out to identify the flood hazard and risk (with due consideration for flow velocities, rate of onset of flooding, likely flood volumes and potential flood damage), from the occurrence of failures to flood defence assets.

3.2 Identifying the Potential Failure Locations

There are approximately 400km of flood defences assets within the entire Shannon CFRAM study area. The risk of breach to these varies throughout. To comply with the CFRAM project brief the following was required:

- I. Identify effective flood defence assets where flooding within an AFA would occur if the flood defence failed.
- II. Identify the most suitable breach location.

The first step in identifying if defence failure analysis is required is to determine if there are there effective defences providing a level of protection to an AFA. Next the ground level adjacent to the defence is assessed based on the CFRAM LiDAR data. If the difference between the maximum water level for the SOP of the defence and the lowest ground elevation on the food plain adjacent to the defences is greater than 1m, defence failure analysis is required. If not no analysis is required. The following process has been applied to identify the need for breach analysis:

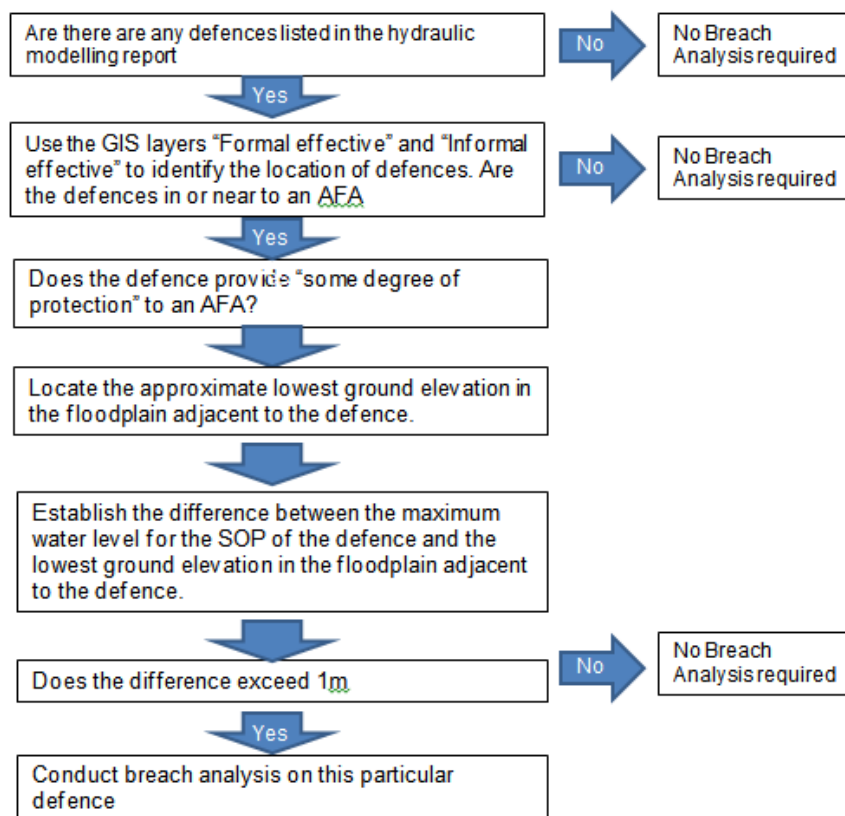


Figure 3.2 – Flood Defence Failure Flow Chart

Once the need for breach modelling has been established, the next step is to identify the most suitable breach locations. The project brief specified that each fluvial defence requires two breach locations, whereas coastal defences require only one. The following aspects were considered where possible during the selection of the breach location:

- Known problem embankments;
- Areas where failures have previously occurred;

- Current asset condition and rate of deterioration from the asset conditions survey;
- Topographic survey data;
- The lowest ground elevation in the floodplain adjacent to the defence;
- Presence of strategic receptors at risk downstream such as; hospitals, Garda stations, other emergency service stations, care homes, nurseries, schools or areas of high population density relative to the rest of the AFA.
- For coastal embankments, the Irish Coastal Protection Strategy Study (ICPSS) has been used as this identifies sections at risk from erosion in the future

The purpose of the analysis is to identify the hazard and risk from a potential defence failure; therefore, the aim was to select breach locations that would produce the worst possible scenario (i.e. greatest differential between ground level and maximum water level). Furthermore, particular emphasis was placed on vulnerable infrastructure (i.e. hospitals, schools, or areas of high population density) currently protected by flood defences.

3.3 Defence Failure Modelling

Defence failure analysis is carried out for the design event equivalent to the SOP of the defence. The timing of the breach is assumed to commence when at the peak water level of the event. This will result in the greatest head differential and produce the highest velocity rates.

The time it takes for the failure to occur is set to 0.5hrs within the defence failure model. This approach provided a conservative approach, as it promotes a rapid failure.

Analysis is undertaken at two failure scenarios for each of the existing flood defence assets selected for assessment. The scenarios considered depend on the defence and its location. For each defence the two scenarios could be a breach at two different locations on the defence or it could be two breaches at the same location but each of a different width.

3.4 Breach dimensions

The breach height or depth is defined as the distance from the defence crest to minimum elevation through the breach. To be conservative the entire height of the defence is removed (reduced to the same elevation as the adjacent floodplain) and the sides of the breach are assumed to be vertical.

Suitable breach dimensions were determined using the Environment Agency Strategic Flood Risk Assessment (SFRA) Guidance. The breach width is determined on the location and type of embankment as indicated in Table 3.1.

Table 3.1 – Breach Width

Location	Defence Type	Breach width (m)
Open Coast	Earth embankment	200
	Dunes	100
	Hard	50
Estuary	Earth embankment	50
	Hard	20
Tidal River	Earth embankment	50
	Hard	20
Fluvial River	Earth embankment	40
	Hard	20

3.5 UoM 27 Flood Defence Asset Failure

Following the screening process set out in section 3.2, above, the following AFA's/IRR's within UoM27 were identified as requiring flood defence failure analysis:

- Bunratty
- Shannon
- Shannon Airport

For each of the AFA's/IRR's two flood defence failure scenarios were carried out. Maximum flood extent, depth and flow velocity maps have been produced and are reported in Appendix I for each scenario. The maps also show the defence failure location relevant to the failure scenario.

4 Appraisal Methodology

4.1 Overview of the Option Appraisal methodology

The Option Appraisal methodology is a multi-staged approach to ensure the over-riding objectives for this phase of the project are achieved, namely:

- Identify appropriate flood risk management measures / options for the different SSAs;
- These measures / options should be robust and form the basis for any future planning stage associated with its implementation; and
- The rejection of any measure / option should be robust with clear and transparent reasoning.

Note; flood risk management measures/options were considered for AFAs to protect properties at risk of flooding from both fluvial and coastal sources. Flood risk management measures/options were not considered for properties at risk of wave overtopping.

To achieve these objectives, a five-stage Option Appraisal methodology has been developed which combines industry standard practices, specialist appraisal software, stakeholder engagement and professional judgement, to ensure a consistent approach to the decision making process.

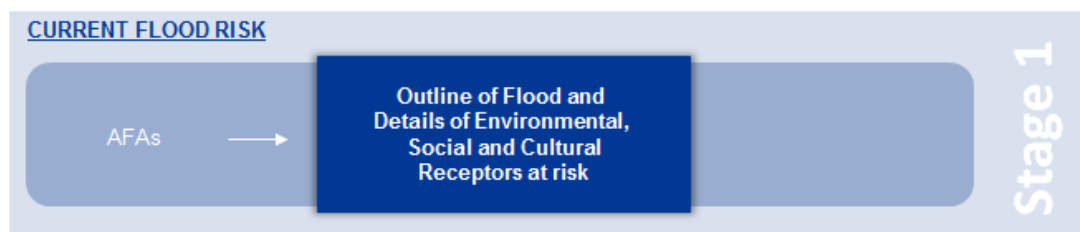
Figure 4.1 provides the five-stage Option Appraisal process as a flow chart. Each stage comprises a number of sub-stages, with a summary of these provided in Table 4.1 below.

Table 4.1: Option Appraisal Stage and Sub-Stage

Stage	Description
Stage 1 Current Flood Risk	
	Sub-stage 1.1 SSA / AFA and Watercourse Details
	Sub-stage 1.2 Summary of Flood Risk in design 1%/0.5% AEP Event
	Sub-stage 1.3 Existing Flood Risk Management Measures
	Sub-stage 1.4 Summary of PV Damages/Potential PV Benefits for the 1%/0.5% AEP SOP
	Sub-stage 1.5 Summary of Social receptors at risk of flooding
	Sub-stage 1.6 Summary of Environmental receptors at risk of flooding
	Sub-stage 1.7 Summary of Cultural Heritage receptors at risk of flooding
	Sub-stage 1.8 Summary of Economic receptors at risk of flooding
Stage 2 Screening of Measures	
	Sub-stage 2.1 Baseline, Structural Measures and Non-Structural measures – Viability Assessment
	Sub-stage 2.2 Justification Screened Out Baseline, Structural and Non – Structural Measures
	Sub-stage 2.3 Summary of ‘Screened In’ Measures
Stage 3 Development of Options	
	Sub-stage 3.1 Consideration of Options
Stage 4 Appraisal of Options	
	Sub-stage 4.1 Options Appraisal
Stage 5 Multi-Criterial Assessment	

	Sub-stage 5.1	Summary of MCA results for each option
	Sub-stage 5.2	Comparison of MCA Scores
	Sub-stage 5.3	Recommendation of Preferred Option

INTRODUCTION



APPRAISAL

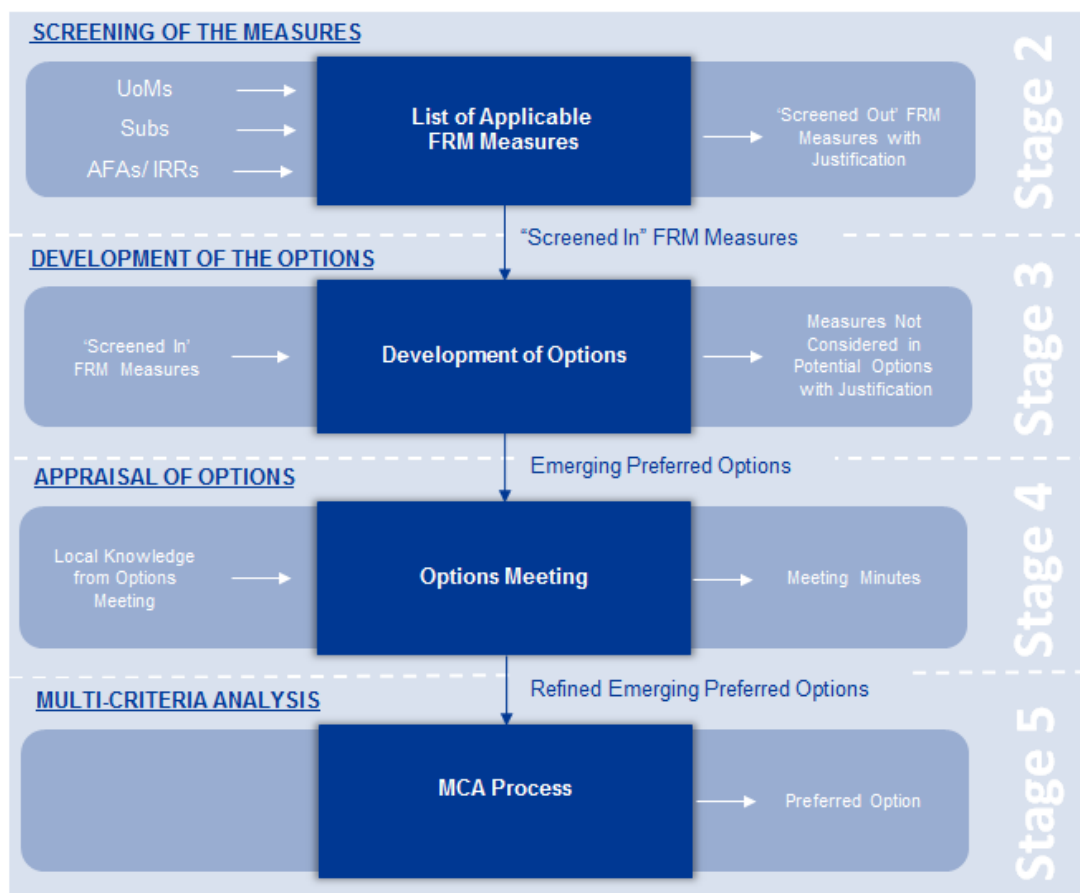


Figure 4.1: Option Appraisal Multi-Stage Process

To record the outcomes from each of these Option Appraisal stages / sub-stages, and ensure consistency in approach, we have developed a standard Option Appraisal Report format. The remainder of Section 3 provides more information on the purpose, method, and assumptions associated with each of the stages / sub-stages.

4.2 Stage 1: Summary of Current Flood Risk



*Relevant Extract
from Option
Appraisal Flow
Chart*

The purpose of this Stage 1 is to determine the significance of the flood risk within the SSA, summarise the potential economic damage and the impacts to key receptors.

To achieve these objectives, Stage 1 has been divided into the eight sub-stages, which are summarised in Table 4.2.

Table 4.2: Summary of Sub-stages for Stage 1

Ref	Title
1.1	SSA / AFA and Watercourse Details
1.2	Summary of Flood Risk in design AEP Event
1.3	Existing Flood Risk Management Measures
1.4	Summary of PV Damages/Potential PV Benefits for design SOP
1.5	Summary of Social receptors at risk of flooding
1.6	Summary of Environmental receptors at risk of flooding
1.7	Summary of Cultural Heritage receptors at risk of flooding
1.8	Summary of Economic receptors at risk of flooding

A Stage 1 assessment has been undertaken for each AFA/ IRR. Following this, for those AFA /IRR's deemed to have an insignificant flood risk the choice not to proceed through Stages 2 to 5, was available. Appendix C provides information on the Option Appraisal Stages completed for each AFA/ IRR.

The Option Appraisal Report records the information and decisions from each of these sub-stages; the following sections describe each of the sub-stages individually.

4.2.1 Sub-stage 1.1 SSA / AFA and Watercourse Details

This stage provides summary details of the SSA, the applicable AFAs / IRRs and the associated watercourse details.

4.2.2 Sub-stage 1.2 Summary of Flood Risk

This stage determines the significance of the flood risk by appraising the number of properties at risk in the 1% AEP Fluvial and 0.5% AEP Tidal, along with the number of individual flood cells. Table 4.3 provides a relevant extract from the Option Appraisal Report, for a worked example.

Table 4.3: Option Appraisal Report – Report Section 1.2

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event				
Source of flood risk:	Fluvial	Coastal		Both
		Residential	Non-Residential	Total
Total Number of Properties at risk in AFA:	Fluvial	33	161	194
	Coastal	22	127	149
	Combined	33	161	194
AFA Flood Cells:	Total Number:	3		
	Flood Cell Titles:	KIE_A, KIE_B, KIE_C		
Breakdown of properties at (combined) risk per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total
	KIE_A	45	118	163
	KIE_B	0	30	30
	KIE_C	0	1	1
Relevant Comments:	The AFA of Kilkee is at risk of flooding from both fluvial and coastal sources. Although in the 0.1% AEP coastal event the peak water level is not higher than sea wall or the ground behind the wall, there is a coastal flood risk associated with the backing up of fluvial flows during high tide events. The flood management measures for Kilkee will be designed to manage flood risk for the 1% AEP fluvial event and will also protect the properties from the 0.5% coastal event.			
Relevant Figure Ref:	Figure 1.1 and 1.2			

Only those properties whose centroid is within the 1% fluvial / 0.5% tidal AEP flood extent, has been counted as ‘at risk’ in this Option Appraisal Sub-stage 1.2. This is to ensure consistency with the approach to the calculation of the PV Damages.

4.2.3 Sub-stage 1.3 Summary of Existing Flood Risk Management Measures

This stage summarises our understanding of the existing flood management measures within the SSA. This information is available in the collect datasets, including the defence database and the arterial drainage maintenance schemes.

4.2.4 Sub-stage 1.4 Summary of PV Damages

This stage provides the economic, capped and uncapped, Present Value Damages (PVd), including a breakdown between residential and commercial across each flood cell.

The economic PVd is the discounted annual average damages sum. It is calculated using the Flood Hazard Research Centre Handbook of 2010 (FHRC, 2010) and the Multi-Coloured Manual” of 2005 (FHRC, 2005), based on the following:

- Direct damages based on flood depth, duration and property characteristics;
- Intangible damages, infrastructural utility damages and emergency services;
- The economic PVd does not include an allowance for Traffic disruption.

The following are important assumptions in our approach to the calculation of the PVd to ensure compliance with the project objectives:

- The property centroid must lie within the appropriate AEP flood extent to contribute a PVd;
- For residential properties, direct damages (PVd) commence at 0.3m below the property threshold level. This threshold is set at 0.15m above the LiDAR (bare earth) level at the property centroid;
- For non-residential properties, direct damages (PVd) commence at the property threshold level; This threshold is set at the LiDAR (bare earth) level at the property centroid;
- Site visits, including specific property inspections were carried out across all AFAs before adopting this approach to determining threshold level;
- Visual surveys have also been carried out of all non-residential properties contributing more than €500,000 PVd to ensure this property threshold assumption is appropriate. Where inappropriate, the property threshold has been adjusted and noted in the supplied datasets.

PVds were calculated for properties at risk of flooding from both Coastal and Fluvial sources. The PVds for properties at risk of wave overtopping sources was not assessed as part of the CFRAM Study.

Appendix D of this Report provides more detail on the data used, tools developed and assumptions made in calculating the economic PVd.

The PVd is calculated as the discounted sum of the annual average damages over the project horizon, where:

- The discount rate to be applied is 4%, and
- The project horizon is 50 years

Sensitivity tests were carried out on the PVd using higher and lower discount rates, 5% and 3% respectively. The results of these sensitivity tests are summarised in Appendix M of this Report.

4.2.5 Sub-stage 1.5 Summary of Social receptors at risk of flooding

This Stage (Section 1.5) reports the social receptors at risk of flooding within the SSA/AFA. These features may provide constraints to the proposed measures and it is important that the consequences of any recommendations are identified early in the appraisal process.

4.2.6 Sub-stage 1.6 Summary of Environmental receptors at risk of flooding

This stage (Section 1.6) reports the environmental receptors at risk of flooding within the SSA/AFA. These features may provide constraints to the proposed measures and it is important that the consequences of any recommendations are identified early in the appraisal process.

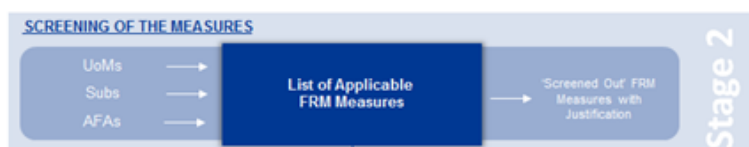
4.2.7 Sub-stage 1.7 Summary of Cultural Heritage receptors at risk of flooding

This stage (Section 1.7) reports the cultural heritage receptors at risk of flooding within the SSA/AFA. These features may provide constraints to the proposed measures and it is important that the consequences of any recommendations are identified early in the appraisal process.

4.2.8 Sub-stage 1.8 Summary of Economic receptors at risk of flooding

This stage (Section 1.8) reports the economic receptors at risk of flooding within the SSA/AFA. These features may provide constraints to the proposed measures and it is important that the consequences of any recommendations are identified early in the appraisal process.

4.3 Stage 2: Screening of the Measures



*Relevant Extract
from Option
Appraisal Flow
Chart*

The purpose of this Stage 2 is twofold:

- Determine the viability of Baseline, Structural and Non-Structural Flood Risk Management Measures for each SSA / AFA; and
- Provide robust, transparent reasoning for those measures identified as unviable.

To achieve these objectives, Stage 2 has been divided into the three sub-stages, which are summarised in Table 4.4.

In the case where no measures are found to be viable, the MCA process will not be carried out and no further work will be undertaken.

Table 4.4: Summary of Sub-stages for Stage 2

Ref	Title
2.1	Baseline, Structural Measures and Non-Structural measures – Viability Assessment
2.2	Justification Screened Out Baseline, Structural and Non – Structural Measures
2.3	Summary of ‘Screened In’ Measures

The ‘screening’ process essentially involves the identification of Flood Risk Management (FRM) measures which are deemed unviable. The FRM Measures which are ‘screened out’ will not provide applicable, acceptable or viable measures, either alone or in combination with other measures.

For the UoM and sub-catchment SAAs, FRM measures which provide benefits to multiple AFAs/IRRs within the UoM and other areas should be considered, along with the spatial and temporal coherence of methods being considered at AFA/IRR scales. Therefore, certain measures such as “relocation of properties” are not applicable at the UoM and sub-catchment scale.

Table 4.5 is the list of the FRM measures considered for this study and the spatial scale for which they are applicable, categorised into Baseline, Structural, and Non-Structural measures. Appendix B provides a definition for each of the FRM measures and reasoning for their categorisation.

Table 4.5: FRM Measures and applicable SSA

Flood Risk Management Measure		Applicable SSA
Ref	Title	
Baseline		
A	Do Nothing	AFA/IRR
B	Existing Regime	AFA/IRR
C	Do Minimum	AFA/IRR
Structural		
D	Storage	All
E	Flow Diversion	All
F	Increase Conveyance	All
G	Construct Flood Defences	All
H	Relocation of Properties	AFA/IRR
I	Other Measures	All
Non Structural		
J	Flood Forecasting / Warning / Response	All
K	Public Awareness	All
L	Individual property resistance	AFA/IRR
M	Individual property resilience	AFA/IRR
N	Planning and development control measures	UoM
O	Building regulations	UoM
P	Sustainable urban drainage systems	AFA/IRR
Q	Land use management	All
R	Strategic development management	UoM
S	Additional Monitoring (rain and river level/flow gauges)	UoM

The FRM measures have been assessed for their potential viability (screening) against the following five assessment criteria:

- i. Applicability to the Relevant Area (Appl.)
- ii. Economic (Econ.)
- iii. Environmental (Envir.)
- iv. Social (Soc.)
- v. Cultural (Cult.)

The 1% Annual Exceedance Probability (AEP) fluvial event and the 0.5% AEP tidal event are the preferred design standards for this screening assessment. However, other design standards should be considered under certain circumstances and the screening appraisal processes should consider this potential flexibility.

It should be noted from Table 4.4 that whilst measures P and Q are included as measures to be considered, they specifically considered within Report III of the Preliminary Options Report. As such, these measures are excluded from the analysis within this Options Appraisal Report.

The Option Appraisal Report records the information and decisions from each of the Stage 2, sub-stages; the following sections describe each of the sub-stages individually.

4.3.1 Stage 2.1 Baseline, Structural and Non-Structural Measures – Viability Assessment

This stage determines the viability for each of the Baseline and Structural FRM measures, using the 5 assessment criteria:

- i. Appl.:
- ii. Econ.:
- iii. Envir.:
- iv. Soc.:
- v. Cult.;

If the determination for any of these five criteria is 'unviable', then the FRM measure is 'screened out'. Only those FRM measures which are determined 'viable' for all five criteria are 'screened in' for inclusion in the development of options in Stage 3. Table 4.6 provides a relevant extract from the Option Appraisal Report, for a worked example.

Table 4.6: Option Appraisal Report – Stage 2.1

2.1 Baseline, Structural and Non-Structural Measures							
Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.							
Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	Screened Out
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	Screened In
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	Screened Out
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	Screened Out
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	Screened In
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	Screened In
H	Relocation of Properties	Unviable	Viable	Viable	Unviable	Viable	Screened Out
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Unviable	Viable	Viable	Viable	Viable	Screened Out
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	Screened Out
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	Screened In

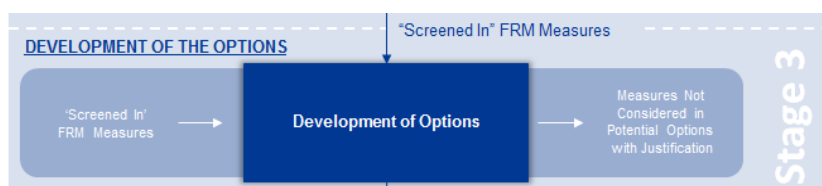
4.3.2 Stage 2.2 Justification for Screened Out Baseline, Structural and Non-Structural Measures

For those Baseline and Structural Measures ‘screened out’ in Stage 2.1, a robust and transparent reasoning for this conclusion is provided.

4.3.4 Stage 2.3 Summary of ‘Screened In’ Measures

This stage provides a summary of the Baseline, Structural, and Non Structural FRAM Measures which have been ‘Screened in’ as viable and have therefore be taken forward and used in Stage 3 – Development of Options.

4.4 Stage 3: Development of the Options



Relevant Extract from Option Appraisal Flow Chart

The purpose of this Stage 3 is to develop the concept designs for the potential FRM Options from the ‘screened in’ FRM measures.

Structural, Non Structural and Baseline FRM measures are considered both independently and in combination with other measures to develop FRM Options.

For the development of FRM Options, certain structural FRM measures including Storage, Flow Diversion, Increase Conveyance and Construct Flood Defences, are considered with regard to different variations of these measures to ensure applicability to site conditions; refer to Table 4.7.

The concept design of all likely FRM Options are identified and taken forward to Stage 4 – Appraisal of Options.

Table 4.7: Specific Detailed FRM Measures considered at Stage 3

Ref	Title	Ref	Specific Detailed Description
D	Storage	Di	On-line Storage
		Dii	Off-line Storage
		Diii	Other Storage
E	Flow Diversion	Ei	Full Diversion
		Eii	Flood Relief Channel
		Eiii	Other Diversion/Channel
F	Increase Conveyance	Fi	Channel Dredging
		Fii	Channel Widening
		Fiii	Structure Enhancement / Works
G	Flood Defences	Gi	New Flood Defences
		Gii	Raise Existing Flood Defences
		Giii	Demountable Defences
		Giv	Other Defences

At this concept, design phase a general freeboard allowance has been applied to all structural defences. This general allowance is outlined in Table 4.8 below and has

been calculated using the Environment Agency's Fluvial Freeboard Guidance Note, R&D Technical Report W187 (2000). The freeboard calculation is based on two elements, the uncertainties relating to the physical processes that affect the defence and the uncertainty in the prediction of the existing flood risk in terms of the hydrology and hydraulic modelling. Details of how the freeboard has been calculated are contained in Appendix G.

Table 4.8: Freeboard Allowance

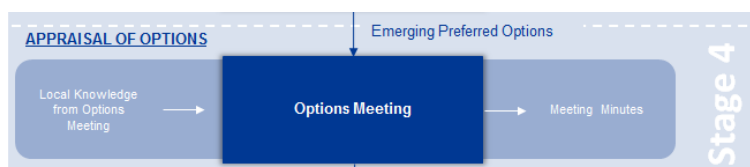
Defence Type	Fluvial	Coastal
Storage	210mm	n/a
Flow Diversion	210mm	n/a
Defences - Wall	210mm	210mm
Defences - Embankments	400mm	900mm

The following approach has been adopted when considering the replacement of existing formal effective flood defences as part of the option development:

- No existing flood defences are recommended for replacement, if their crest height currently provides the required design standard.
- If the crest height of an existing flood defence does not provide the required design standard, then the recommendation is for a new flood defence to be constructed as part of any option

Where existing defence form part of an option a geotechnical analysis of the existing defence should be carried out as part of the detailed design.

4.5 Stage 4: Appraisal of Options



*Relevant Extract
from Option
Appraisal Flow
Chart*

The purpose of this Stage 4 is twofold:

- Develop each option and to consider its viability and applicability to site;
- Gain local knowledge that may influence the local weightings.

Stage 4.1 provides details of each option considered, including a breakdown of the measures included in the options and specification of any of the structural measures where appropriate.

Modelling of the option, if required, is also carried out at this stage to ascertain if the option is viable technically and gain an understanding of the impacts on the upstream or downstream water levels.

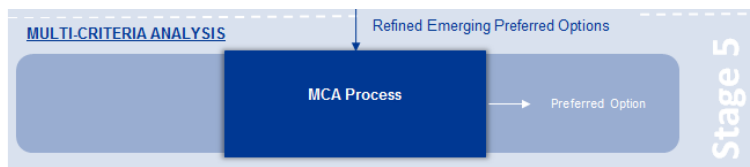
Table 4.9: Option Appraisal Report – Stage 4.1

4 STAGE 4: Appraisal of Options					
5.1 Options Appraisal Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.					
Option Ref:		KIE_01			
Option Measures	Baseline	B	Existing Regime		
	Structural	Gi	Flood Defences: New Flood Defences		
		Gii	Flood Defences: Raise Existing Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Option Description:		This option will provide a 1% Fluvial AEP design standard to all properties within the AFA and it will also protect the properties from the 0.5% coastal event. <ul style="list-style-type: none"> Construct new flood defence wall along the right bank of the Kilkee Lower (River) watercourse. Construct new flood defence walls along the left and right bank of the Kilkee Upper (River) watercourse. Any existing embankments along the left bank of the Kilkee Upper (Stream) watercourse will need to be assessed and raised in some places by 0.3m. Downstream of the existing embankment, the existing wall will need to be assessed and will need to provide a flood defence function up to a level a 5.8m OD. Construct new flood defence wall parallel to the Kilkee East watercourse. Construct new flood defence walls and parapets along the left and right bank of the Kilkee East watercourse. 			
Options Development Meeting:		Date:		16/09/2015	
		Summary:		This option was discussed in detail with Clare County Council at the options development meeting. Overall the option was considered sensible by the local authority representatives.	

Detailed costing of the option is carried out at this stage using the unit cost database spreadsheets (version 1.1) created for the CFRAM project. This database provides unit costs for common method of flood risk management, for a range of conditions and scales. The whole life present value costs (PVC) is determined from the sum of the Present Value costs over the project horizon of 50 years, with the future costs discounted by 4%. The Construction Price Index (CPI) is set at 0.987 for each option, as recommended in the CFRAM Unit Cost Development Project Final Report. This report has been included in Appendix H.

The whole life present value costs (PVC) are subject to sensitivity tests using higher and lower discount rates, 5% and 3% respectively. These are presented in Appendix M of this report.

4.6 Stage 5: Multi Criteria Assessment



*Relevant Extract
from Option
Appraisal Flow
Chart*

The purpose of this Stage 5 is threefold:

- Obtain MCA and economic scores for each viable option;
- Provide a comparison of the options using the MCA and economic scores;
- Make a recommendation on the preferred option.

To achieve these objectives, Stage 5 has been divided into three sub-stages, which are summarised in Table 4.10.

Table 4.10: Summary of Sub-stages for Stage 5

Ref	Title
5.1	Options selected for the Multi Criteria Assessment
5.2	Comparison of Multi Criteria Assessment Scores
5.3	Recommendation of Preferred Option

The MCA scores the performance of each option in managing flood risk relative to the baseline under the four objectives:

- Technical;
- Economic;
- Social and
- Environmental.

Each objective has been weighted, globally and locally to reflect the objectives importance and to ensure that those objectives most relevant to the SSA were given priority in the decision making process.

Appendix F provides an outlines of the scoring system under each objective. It also provides details of the global and local weightings applied to each score. The global weights are always set and are consistent with the other CFRAM studies. Some local weighting are set and constant whiles others are calculated or based on engineering judgement. This approach is outlined in further detail in Appendix F.

As outlined in Table 4.10, the Option Appraisal Report records the information and decisions from three sub-stages; the following sections describe each of the sub-stages individually.

4.6.1 Stage 5.1 Options selected for the Multi Criteria Assessment

This stage provides an overview of the options considered for MCA and provides specification details of the structural measures.

The outcome of the MCA includes:

- Criteria Scores for each objective
- Economic Scores
- MCA Scores

A brief outline for these scores is given in Table 4.11. Stage 5.1 of the Option Appraisal Report provides these scores for each option.

Table 4.11 MCA and Economic Analysis outcome

		Ref.
Criteria Score		
Technical	Sum of the Technical Sub Objectives Score, Range (-299700 to 1500)	GN 28 App F
Economic	Sum of the Economic Sub Objectives Score, Range (-299700 to 1500)	GN 28 App F
Social	Sum of the Social Sub Objectives Score, Range (-299700 to 1500)	GN 28 App F
Environmental	Sum of the Environmental Sub Objectives Score, Range (-299700 to 1500)	GN 28 App F
Economic Score		
PV Cost	Present Value cost (PVc) of the option including ongoing maintenance and optimism bias.	GN 27 App D
Economic PV Benefits	The economic PV Benefits (PVb) are the reduction in the economic damages the option will provide.	GN 27 App D
Economic BCR	The capped PVb, divided by the PVc	GN 27 App D
Net Present Value of Benefits	The capped PVb less the PVc .	GN 27 App D
MCA Scores		
MCA PV Benefits	The economic MCA PV Benefits are the reduction in the MCA economic damages the option will provide. These values are capped. For more detail refer to section in GN.	GN 27 App D
MCA Benefit Score	The sum of the economic, social, and environmental criteria scores. Range (-899100 to 4500)	GN 28
MCA BCR	The MCA Benefit Score per €1,000,000 PV Cost.	GN 28
Option Selection MCA	The sum of the technical, economic, social, and environmental criteria scores. Range (-1198800 to 6000)	GN 28

4.6.2 Stage 5.2 Comparison of Multi Criteria Assessment Scores

Stage 5.2 of the Option Appraisal Report provides a comparison of the option scores.

Table 4.12 provides a relevant extract from the Option Appraisal Report, for a worked example.

Table 4.12 Option Appraisal Report – Stage 5.2

5.2 Comparison of Multi Criteria Assessment Scores		
Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	Option Reference and Results	
	KIE_01	KIE_02
Criteria Scores		
Technical	800	750
Economic	757	757
Social	632	632
Environmental	-405	-260
Economic Values		
Economic PV Benefits	€ 7,054,150	€ 7,054,150
PV Cost	€ 4,438,063	€ 3,240,290
NPV Benefits	€ 2,616,087	€ 3,813,860
Economic BCR	1.59	2.18
Outcome Scores		
MCA PV Benefits	€ 3,744,238	€ 3,744,238
MCA Benefit Score	984	1129
MCA BCR	221.71	348.42
Option Selection MCA	1784	1879

4.6.3 Stage 5.3 Recommendation of the Preferred Option

The MCA scores provided by the MCA assessment are used to guide the decision making process for the preferred option. The MCA BCR has been given the greatest weight in determining the preferred option. The MCA BCR provides a measure of the overall benefits per euro investment.

Whilst the MCA BCR carries the greatest weight, and in general the preferred option is the option with the highest MCA BCR score, other factors are also taken into

account. This is particularly the case when MCA BCR scores are similar, but a comparison of other scores shows a significant difference, for example, a lower capital cost or a higher technical score. These differences are difficult to predict and hence, if the preferred option is selected on criteria other than the MCA BCR score, a clear justification for the recommendation of the preferred option is provided.

5 Option Appraisal Results

Section 6 outlines how the five-stage option appraisal process has been applied in the Spatial Scales of Assessment (SSAs) within UoM 27. UoM 27 comprises the following SSAs, which are outlined in Table 6.1:

- Unit of Management (UoM);
- Sub-catchment;
- Areas for Further Assessment (AFA) and;
- Individual Risk Receptor (IRR).

Table 5.1 SSAs for UoM27.

Spatial Scale			
UoM	Sub-catchment	AFA / IRR	
UoM 27	Kilrush	Kilrush	AFA
	Fergus	Quin	AFA
		Ennis	AFA
	Shannon & Shannon Airport	Shannon	AFA
		Shannon Airport	IRR
	Owenogarney	Sixmilebridge	AFA
		Bunratty	AFA
	Moore Bay	Kilkee	AFA

As outlined in Section 4.3, for the UoM and sub-catchment SSAs, FRM measures which provide benefits to multiple AFAs/IRRs are only considered. Therefore, certain measures such as “relocation of properties” which are impractical to implement at this scale, are not considered at the UoM and sub-catchment SSAs.

FRM measures providing benefits to multiple AFAs/IRRs are considered at the sub-catchment SSA while, FRM measures providing benefits to multiple sub-catchments are considered at the UoM SSA.

Table 4.5 outlines the list of the FRM measures considered for this study and the spatial scale for which they are applicable, categorised into Baseline, Structural, and Non-Structural measures. Appendix B provides a definition for each of the FRM measures and reasoning for their categorisation.

The 1% AEP fluvial event and the 0.5% AEP tidal event are the preferred design standards for the development of the FRM options. However, other design

standards have been considered where there is a clear technical, economic, social or environmental case as to why the preferred standards would not be appropriate.

5.1 Option Appraisal Results SSA: UoM 27

As outlined in Section 4.1 the option appraisal methodology is a multi-staged process. Stage 1, summary of the current flood risk for UoM 27, Stage 2, screening of the measures for UoM 27 and Stage 3: Development of Options for UoM 27 are outlined in Sections 5.2.1 to 5.2.3 below.

At the UoM SSA there are no FRM structural measures viable for UoM 27. Although there are viable non-structural FRM measures for UoM 27 at this SSA, Stage 4: Appraisal of Options for UoM 27 and Stage 5: Multi-Criteria Assessment has not been carried out as monetary or measurable benefits cannot be determined for such non-structural FRM measures at this SSA.

5.1.1 Stage 1: Summary of Current Flood Risk

The purpose of Stage 1 is to determine the significance of the flood risk within the UoM 27 and summarise the potential economic damage and the impacts to the key receptors. Stage 1 comprises 8 sub stages;

Stage 1.1: Sub-Catchment and Watercourse Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal & AEP Event Sub-Catchments and Watercourses Details

Stage 1.3: Summary of Existing Flood Risk Management Measures Sub-Catchment and Watercourse Details

Stage 1.4: Summary of PV damages

Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Tables 5.2 to 5.9 below outline the results of sub-stages 1.1 to 1.8 for UoM 27. All studied areas within the UoM but outside the AFAs/ IRRs are referred to as areas of potential moderate risk (APMRs). Details of the flood risk to the APMRs are provided at sub-catchment SSA along with summary details of flood risk within the AFAs. For further details of flood risk within each AFA, refer to the relevant Appendix C.

Table 5.2 Stage 1.1: Sub-catchment and Watercourse Details

Stage 1.1: Sub-Catchment and Watercourse Details	
Sub-Catchments within UoM	Kilrush, Moore Bay, Shannon Town & Airport, Fergus, Owenogarney
Primary Watercourse(s):	Shannon Estuary Owenogarney River River Rine River Fergus

Table 5.3 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
Properties at risk:	Sub-catchment	Event Type	Res	Non-Res	Total
	APMR_Kilrush	Fluvial	4	0	4
		Coastal	3	0	3
		Combined	4	0	4
	APMR_Fergus	Fluvial	1	0	1
		Coastal	0	0	0
		Combined	1	0	1
	APMR_Shannon & Shannon Airport	Fluvial	0	0	0
		Coastal	9	11	20
		Combined	9	11	20
	APMR_Owenogarney	Fluvial	0	2	2
		Coastal	0	6	6
		Combined	0	6	6
	APMR_Moore_Bay	Fluvial	27	5	32
		Coastal	27	5	32
		Combined	27	5	32
	Within AFAs	Fluvial	326	239	565
		Coastal	45	171	216
		Combined	336	244	580
	Total for UoM	Fluvial	358	246	604
		Coastal	84	193	277
		Combined	377	266	643
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 5.4 Stage 1.3: Summary of Existing Flood Risk Management Measures

1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	Yes	None	None

Table 5.5 Stage 1.4: Summary of PV damages

1.4 Total PV Damages								
Fluvial and coastal damages calculated based on flood depths for all return periods. Combined damages are a sum of the fluvial and coastal capped at value of the property.								
Total PV Damages		Event Type	Capped Res	Capped Non-Res	Capped Total	Uncapped Res	Uncapped Non-Res	Uncapped Total
	APMR_Kilrush	Fluvial	€ 753,686	€ 0	€ 753,686	€ 1,425,258	€ 0	€ 1,425,258
		Coastal	€ 333,843	€ 0	€ 333,843	€ 1,341,967	€ 0	€ 1,341,967
		Combined	€ 753,686	€ 0	€ 753,686	€ 1,425,258	€ 0	€ 1,425,258
	APMR_Fergus	Fluvial	€ 26,191	€ 0	€ 26,191	€ 26,191	€ 0	€ 26,191
		Coastal	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
		Combined	€ 26,191	€ 0	€ 26,191	€ 26,191	€ 0	€ 26,191
	APMR_Shannon & Shannon Airport	Fluvial	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
		Coastal	€ 3,345,313	€ 219,142	€ 3,564,455	€ 10,831,198	€ 219,142	€ 11,050,340
		Combined	€ 3,343,313	€ 219,142	€ 3,564,455	€ 10,831,198	€ 219,142	€ 11,050,340
	APMR_Owenogarney	Fluvial	€ 0	€ 3,065	€ 3,065	€ 0	€ 3,065	€ 3,065
		Coastal	€ 0	€ 55,458	€ 55,458	€ 0	€ 55,458	€ 55,458
		Combined	€ 0	€ 58,522	€ 58,522	€ 0	€ 58,523	€ 58,523
	APMR_Moore_Bay	Fluvial	€ 1,470,333	€ 1,171,012	€ 2,641,345	€ 2,751,388	€ 2,486,775	€ 5,238,163
		Coastal	€ 1,470,333	€ 1,171,012	€ 2,641,345	€ 2,751,388	€ 2,486,775	€ 5,238,163
		Combined	€ 1,470,336	€ 1,171,012	€ 2,641,348	€ 2,751,388	€ 2,486,775	€ 5,238,163
	Within AFAs	Fluvial	€ 20,325,670	€ 39,951,992	€ 60,277,662	€ 29,454,201	€ 71,077,257	€ 100,531,458
		Coastal	€ 4,838,478	€ 35,888,281	€ 40,726,759	€ 8,153,584	€ 53,314,107	€ 61,467,691
		Combined	€ 24,106,858	€ 45,955,984	€ 70,062,842	€ 38,392,153	€ 85,978,815	€ 124,370,968
	Total for UoM	Fluvial	€ 22,575,880	€ 41,126,069	€ 63,701,949	€ 33,657,038	€ 73,567,097	€ 107,224,135
		Coastal	€ 9,987,967	€ 37,333,893	€ 47,321,860	€ 23,078,137	€ 56,075,482	€ 79,153,619
		Combined	€ 29,702,384	€ 47,404,660	€ 77,107,044	€ 53,426,188	€ 88,743,255	€ 142,169,443

Table 5.6 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		Type	Number
	APMR_Kilrush	N/A	None
	APMR_Fergus	N/A	None
	APMR_Shannon & Shannon Airport	N/A	None
	APMR_Owenogarney	N/A	None
	APMR_Moore_Bay	N/A	None
	Within AFAs	School	6
		Health Centre	1
		Nursing Home	1
	Total for UoM	School	6
		Health Centre	1
		Nursing Home	1
Social Infrastructure Assets:		Type	Number
	APMR_Kilrush	N/A	None
	APMR_Fergus	N/A	None
	APMR_Shannon & Shannon Airport	N/A	None
	APMR_Owenogarney	N/A	None
	APMR_Moore_Bay	N/A	None
	Within AFAs	Civil Defence	1
		OPW Building Directory	2
	Total for UoM	Civil Defence	1
		OPW Building Directory	2
Social Amenity Sites:		Type	Number
	APMR_Kilrush	N/A	None
	APMR_Fergus	N/A	None
	APMR_Shannon & Shannon Airport	N/A	None
	APMR_Owenogarney	N/A	None
	APMR_Moore_Bay	N/A	None
	Within AFAs	N/A	None
	Total for UoM	N/A	None

Relevant Comments:	For AFA level breakdown see specific AFA reports.
Relevant Figure Ref:	General Risk - Social

Table 5.7 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		Type	Number
	APMR_Kilrush	N/A	None
	APMR_Fergus	N/A	None
	APMR_Shannon & Shannon Airport	N/A	None
	APMR_Owenogarney	WFD Drinking Water	4
	APMR_Moore_Bay	N/A	None
	Within AFAs	Licenced IPPC facility	5
	Total for UoM	WFD Drinking Water	4
		Licenced IPPC facility	5
Risk to SACs:		Type	Number
	APMR_Kilrush	N/A	None
	APMR_Fergus	Ballyallia Lake	1
	APMR_Shannon & Shannon Airport	Lower River Shannon	1
	APMR_Owenogarney	N/A	None
	APMR_Moore_Bay	N/A	None
	Within AFAs	Ballyallia Lake	1
		Lower River Shannon	1
	Total for UoM	Ballyallia Lake	1
		Lower River Shannon	1
Risk to SPAs:		Type	Number
	APMR_Kilrush	N/A	None
	APMR_Fergus	River Shannon and River Fergus Estuaries SPA	1
	APMR_Shannon & Shannon Airport	River Shannon and River Fergus Estuaries SPA	1
	APMR_Owenogarney	N/A	None
	APMR_Moore_Bay	N/A	None
	Within AFAs	River Shannon and River Fergus Estuaries SPA	2
	Total for UoM	River Shannon and River Fergus Estuaries SPA	4
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure:	General Risk - Environment		

Table 5.8 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Cultural Heritage:		Type	Number
	APMR_Kilrush	NIAH	1
		Recorded Monuments	1
	APMR_Fergus	NIAH	2
		Recorded Monuments	17
		National Heritage Area	2
		Proposed Natural Heritage Area	2
	APMR_Shannon & Shannon Airport	Recorded Monuments	3
	APMR_Owenogarney	Recorded Monuments	6
	APMR_Moore_Bay	N/A	None
	Within AFAs	NIAH	21
		Recorded Monuments	26
		Museums	1
		National Heritage Area	1
		Proposed Natural Heritage Area	3
	Total for UoM	NIAH	24
		Recorded Monuments	53
		Museums	1
		National Heritage Area	3
		Proposed Natural Heritage Area	5
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure:	General Risk – Cultural Heritage		

Table 5.9 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		Type	Number
	APMR_Kilrush	Regional Road	1
	APMR_Fergus	Motorway	2
		National Primary Road	1
		Regional Road	2
		Local Road	4
		Railway	1
	APMR_Shannon & Shannon Airport	Regional Road	1
		Local Road	2
	APMR_Owenogarney	Local Road	2
		Railway	3
	APMR_Moore_Bay	N/A	None
	Within AFAs	National Primary Road	4
		Regional Road	9
		Local Road	33
		Railway	1
		Airport	1
	Total for UoM	Motorway	2
		National Primary Road	5
		Regional Road	13
		Local Road	41
		Railway	5
		Airport	1
Risk to Utility Infrastructure:		Type	Number
	APMR_Kilrush	N/A	None
	APMR_Fergus	N/A	None
	APMR_Shannon & Shannon Airport	N/A	None
	APMR_Owenogarney	N/A	None
	APMR_Moore_Bay	N/A	None
	Within AFAs	Infrastructure	1
	Total for UoM	Infrastructure	1

Relevant Comments:	For AFA level breakdown see specific AFA reports.
Relevant Figure:	General Risk – Economy

5.1.2 Stage 2: Screening of the Measures UoM 27

The purpose of Stage 2 is to determine the viability of FRM measures for UoM 27 and to provide robust, transparent reasoning for those measures identified as unviable. This is achieved through 3 sub-stages;

Stage 2.1: Screening of the Measures Viability Assessment

Stage 2.2: Justification for Screened Out Baseline and Structural Measures

Stage 2.3: Summary of 'Screened In' Measures

Tables 5.10 to 5.12 below outline the results for each of these sub-stages.

Table 5.10 Stage 2.1: Screening of the Measures Viability Assessment

STAGE 2: Screening of the Measures							
Baseline, Structural and Non-Structural Measures							
Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.							
Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Not considered at this SSA refer to Table 4.5					
B	Existing Regime	Not considered at this SSA refer to Table 4.5					
C	Do Minimum	Not considered at this SSA refer to Table 4.5					
Structural							
D	Storage	Unviable	N/A	N/A	N/A	N/A	Screened Out
E	Flow Diversion	Unviable	N/A	N/A	N/A	N/A	Screened Out
F	Increase Conveyance	Unviable	N/A	N/A	N/A	N/A	Screened Out
G	Flood Defences	Unviable	N/A	N/A	N/A	N/A	Screened Out
H	Relocation of Properties	Not considered at this SSA refer to Table 4.7					
I	Other Measures	Unviable	N/A	N/A	N/A	N/A	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	Screened In
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual Property Resistance	Not considered at this SSA refer to Table 4.5					
M	Individual Property Resilience	Not considered at this SSA refer to Table 4.5					
N	Planning and development control measures	Viable	Viable	Viable	Viable	Viable	Screened In
O	Building Regulations	Viable	Viable	Viable	Viable	Viable	Screened In
P	Sustainable Urban Drainage Systems	Not considered at this SSA refer to Table 4.5					

Table 5.11 Stage 2.2: Justification for Screened Out Baseline and Structural Measures

5.1.3 Stage 3: Development of Options for UoM 27

As there were no viable structural measures for UoM 27 therefore this stage focuses on the development of the Non-Structural FRM measures into options, which is outlined in Table 5.13 below.

Table 5.13 Stage 3: Development of FRM measures to Options

2.1 Summary of 'Screened In' Measures		
The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.		
Non - Structural Measures		
K	Public Awareness	Regional public awareness campaigns should be considered to provide information to the public of potential measures and actions local residents, business owners and landowners could take to reduce flood risk to their properties and allow them to prepare themselves, their properties, businesses and land. However, awareness campaigns are better targeted at AFA level, rather than at UoM (or sub-catchment) SSAs.
N	Planning and development control measures	Considered in the Spatial Planning & Impacts to the Development report.
O	Building Regulations	Building Regulations could be applied in the construction of properties in areas of low or residual flood risk, to limit the damage to the properties in a flood event. These regulations would focus on the use of suitable materials and construction details. Guidelines on constructing in areas of flood risk are provided in the "Improving the Flood Performance of New Buildings" by the Department for Communities and Local Government, UK. Use of these measures would ensure the buildings are either flood resistant or flood resilient.
P	Sustainable Urban Drainage Systems	Considered in separate report on SUDs and Land Use Management
Q	Land use Management	Considered in separate report on SUDs and Land Use Management
R	Strategic development management	The proper application of the Guidelines on the Planning System and Flood Risk Management by the planning authorities is essential to avoid inappropriate development in flood prone areas, and hence avoid unnecessary increases in flood risk into the future. Flood Zones Mapping for the MRFS future scenarios are provided as part of the FRMP and will facilitate the application of the Guidelines.

S	Additional Monitoring (rain and river level/flow gauges)	<p>Across UoM 27, there is a varying degree of certainty on the flood risk assessment, due to the distribution of the catchment gauging stations.</p> <p>It is therefore a recommendation from this Study that additional gauging stations should be considered along watercourses where there is historical evidence of flood risk or properties are identified as being at risk in the 1% fluvial AEP event.</p> <p>Figure 5.3 and table 5.2 identifies indicative locations where gauging stations are recommended.</p> <p>These include several locations across the UoM (and in this regard this is a UoM measure), one of which would also have a benefit at a sub-catchment level. It is important to note however that the primary benefit of each gauging station will be for the AFA in which it is located</p>
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Recommendations for all the above “Screened In” measures will be made in the Flood Risk Management Plan (FRMP). MCA analysis of these recommended measures has not been carried out as monetary or measurable benefits cannot be determined for any of these measures as this SSA.

Table 5.2 – Location of Recommended Gauging Stations

ID	Easting	Northing
GS01	99668.00	154886.00
GS02	89154.67	160033.79
GS03	88347.30	159281.35
GS04	88242.58	159407.50
GS05	140127.74	172206.12
GS06	139242.80	162636.38
GS07	139961.81	162379.58
GS08	141219.41	162789.09
GS09	142460.38	163161.40
GS10	141690.36	162976.55

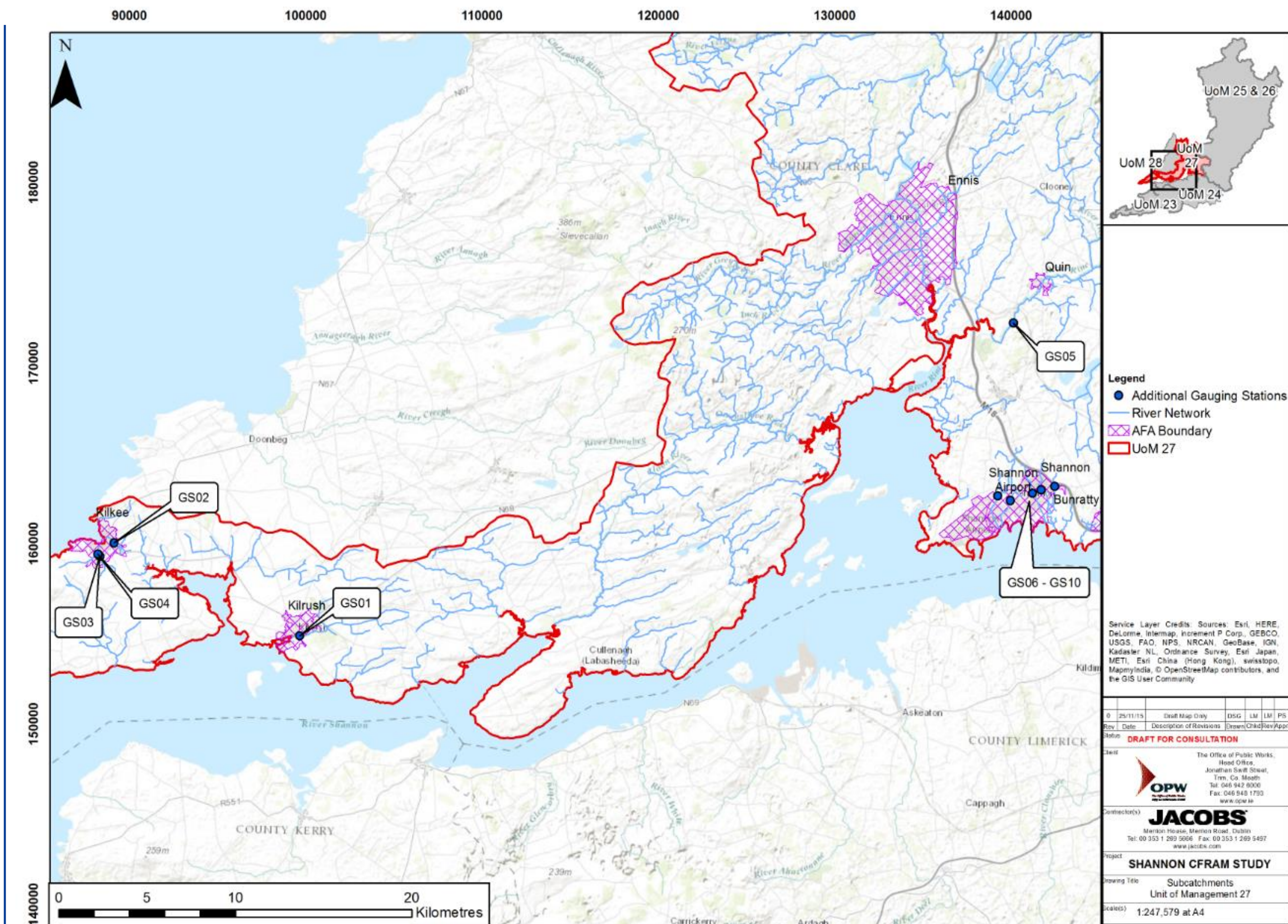


Figure 5.3 –Location of Recommended Gauging Stations

5.2 Option Appraisal Results SSA: Sub-Catchment and Coastal Area

The Sub-catchment SSA assessed and reported in this section, is as follows:

- Kilrush sub-catchment and coastal area
- Fergus sub-catchment and coastal area
- Shannon Town and Shannon Airport, sub-catchment and coastal area
- Owenogarney sub-catchment and coastal area
- Moore Bay sub-catchment and coastal area

Appendix K provides individual Option Appraisal Reports for sub-catchments with options within this Unit of Management. Each Option Appraisal Report provides a clear and robust assessment of the Option Appraisal process.

The following sections provide an overview of the results for each sub-catchment, at each of the Option Appraisal Stages.

5.2.1 Kilrush Sub-Catchment and Coastal Area

Tables 5.15 to 5.22 below outline the results of sub-stages 1.1 to 1.8 for the Kilrush Sub-catchment.

5.2.1.1 Stage 1: Summary of Current Flood Risk for Kilrush Sub-Catchment

Table 5.15 Stage 1.1: Sub-Catchment and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
Sub-catchment / Coastal Area	Kilrush
AFAs	Kilrush
Major Watercourses:	River Wood Kilrush Creek

Table 5.16 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
Properties at risk:	APMR_Kilrush	Event Type	Res	Non-Res	Total
		Fluvial	4	0	4
		Coastal	3	0	3
		Combined	4	0	4
	Within AFAs	Fluvial	19	1	20
		Coastal	0	0	0
		Combined	19	1	20

	Total for Sub-catchment	Fluvial	23	1	24
		Coastal	3	0	3
		Combined	23	1	24
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 5.17 Stage 1.3: Summary of Existing Flood Risk Management Measures

1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	Yes	None	None

Table 5.18 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages								
Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.								
Total PV Damages		Event Type	Capped Residential	Capped Non-Res	Capped Total	Uncapped Residential	Uncapped Non-Res	Uncapped Total
	APMR_Kilrush	Fluvial	€ 753,686	€ 0	€ 753,686	€ 1,425,258	€ 0	€ 1,425,258
		Coastal	€ 333,843	€ 0	€ 333,843	€ 1,341,967	€ 0	€ 1,341,967
		Combined	€ 753,686	€ 0	€ 753,686	€ 1,425,258	€ 0	€ 1,425,258
	Within AFAs	Fluvial	€ 112,034	€ 145,476	€ 257,510	€ 112,034	€ 145,476	€ 257,510
		Coastal	€ 5,175	€ 0	€ 5,175	€ 5,175	€ 0	€ 5,175
		Combined	€ 117,209	€ 145,476	€ 262,685	€ 117,209	€ 145,476	€ 262,6850
	Total for Sub-catchment	Fluvial	€ 865,720	€ 145,476	€ 1,011,196	€ 1,016,371	€ 145,476	€ 1,682,768
		Coastal	€ 339,018	€ 0	€ 742,870	€ 339,018	€ 0	€ 1,347,142
		Combined	€ 870,895	€ 145,476	€ 1,016,371	€ 1,016,371	€ 145,476	€ 1,687,943
Relevant Comments:		For AFA level breakdown see specific AFA reports.						

Table 5.19 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		Type	Number
	APMR_ Kilrush	N/A	0
	Within AFAs	Nursing Home	1
	Total for Sub-catchment	Nursing Home	1
Social Infrastructure Assets:		Type	Number
	APMR_ Kilrush	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Social Amenity Sites:		Type	Number
	APMR_ Kilrush	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Social		

Table 5.20 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		Type	Number
	APMR_ Kilrush	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Risk to cSACs, SPAs, & SACs :		Type	Number
	APMR_ Kilrush	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Environment		

Table 5.21 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		Type	Number
	APMR_ Kilrush	NIAH	1
		Recorded Monuments	1
	Within AFAs	Recorded Monuments	2
	Total for Sub-catchment	NIAH	1
		Recorded Monuments	3
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk – Cultural Heritage		

Table 5.22 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		Type	Number
	APMR_ Kilrush	Regional Road	1
	Within AFAs	National Road	1
		Regional Road	1
	Total for Sub-catchment	National Road	1
		Regional Road	2
Risk to Utility Infrastructure:		Type	Number
	APMR_ Kilrush	N/A	0
	Within AFAs	N/A	0
	Total for UoM	N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Economy		

Conclusion:

As there is only one AFA within this sub catchment/coastal area there can be no structural measures that will provide benefits to multiple AFA's therefore screening of the measures was not carried out. Non – structural measures such as; public awareness, planning, and development control measures, building regulation, land use management, strategic development management and additional monitoring have been considered for the sub-catchment and are addressed in the UoM spatial scale.

5.2.2 Fergus Sub-Catchment and Coastal Area

Tables 5.23 to 5.30 below outline the results of sub-stages 1.1 to 1.8 for the Fergus Sub-catchment.

5.2.2.1 Stage 1: Summary of Current Flood Risk for Fergus Sub-Catchment

Table 5.23 Stage 1.1: AFA and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
Sub-catchment / Coastal Area	Fergus
AFAs	Quin, Ennis
Major Watercourses:	Fergus (River), Fergus Minor (River), Claureen (River), Cloghleagh (Stream), Gaurus (River), Edenvale (Stream), Ballybeg (Stream), Ballybeg Lough, Rine (River),

Table 5.24 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
Properties at risk:	APMR_Fergus	Event Type	Res	Non-Res	Total
		Fluvial	1	0	1
		Coastal	0	0	0
		Combined	1	0	1
	Within AFAs	Fluvial	181	21	202
		Coastal	17	4	21
		Combined	190	21	211
	Total for Sub-catchment	Fluvial	182	21	203
		Coastal	17	4	21
		Combined	191	21	212
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 5.25 Stage 1.3: Summary of Existing Flood Risk Management Measures

1.2 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	Yes	None	Yes
Relevant Comments:	There is a tidal barrage in Clarecastle which limits the tidal flood risk in the AFA of Ennis.				

Table 5.26 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages								
Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.								
Total PV Damages		Event Type	Capped Residential	Capped Non-Res	Capped Total	Uncapped Residential	Uncapped Non-Res	Uncapped Total
	APMR_Fergus	Fluvial	€ 26,191	€ 0	€ 26,191	€ 26,191	€ 0	€ 26,191
		Coastal	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
		Combined	€ 26,191	€ 0	€ 26,191	€ 26,191	€ 0	€ 26,191
	Within AFAs	Fluvial	€ 15,783,490	€ 9,465,531	€ 25,249,021	€ 21,571,634	€ 23,023,536	€ 44,595,170
		Coastal	€ 425,311	€ 688,534	€ 1,113,845	€ 1,036,044	€ 1,459,174	€ 2,495,218
		Combined	€ 16,095,407	€ 10,016,192	€ 26,111,599	€ 22,607,678	€ 24,482,710	€ 47,090,388
	Total for Sub-catchment	Fluvial	€ 15,809,681	€ 9,465,531	€ 25,275,212	€ 21,597,825	€ 23,023,536	€ 44,621,361
		Coastal	€ 425,311	€ 688,534	€ 1,113,845	€ 1,036,044	€ 1,459,174	€ 2,495,218
		Combined	€ 16,121,598	€ 10,016,192	€ 26,137,790	€ 22,633,869	€ 24,482,710	€ 47,116,579
Relevant Comments:		For AFA level breakdown see specific AFA reports.						

Table 5.27 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		Type	Number
	APMR_Fergus	N/A	0
	Within AFAs	School	2
	Total for Sub-catchment	School	2
Social Infrastructure Assets:		Type	Number
	APMR_Fergus	N/A	0
	Within AFAs	Civil Defence	1
		OPW	1
	Total for Sub-catchment	Civil Defence	1
		OPW	1
Social Amenity Sites:		Type	Number
	APMR_Fergus	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Social		

Table 5.28 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		Type	Number
	APMR_Fergus	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Risk to cSACs, SPAs, & SACs :		Type	Number
	APMR_Fergus	SPA	1
		SAC	1
	Within AFAs	SAC	1
	Total for Sub-catchment	SPA	2
		SAC	2

Relevant Comments:	For AFA level breakdown see specific AFA reports.
Relevant Figure Ref:	General Risk - Environment

Table 5.29 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		Type	Number
	APMR_ Fergus	NIAH	2
		Recorded Monuments	17
		National Heritage Area	2
		Proposed National Heritage Area	2
	Within AFAs	NIAH	17
		Recorded Monuments	20
		Museum	1
		Proposed National Heritage Area	1
	Total for Sub-catchment	NIAH	19
		Recorded Monuments	37
		National Heritage Area	2
		Museum	1
		Proposed National Heritage Area	3
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk – Cultural Heritage		

Table 5.30 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		Type	Number
	APMR_ Fergus	Motorway	2
		National Road	1
		Regional Road	2
		Local Road	4
		Railway	1
	Within AFAs	National Road	1
		Regional Road	4

		Local Road	18
		Railway	1
	Total for Sub-catchment	Motorway	2
		National Road	2
		Regional Road	6
		Local Road	22
		Railway	2
Risk to Utility Infrastructure:		Type	Number
	APMR_ Fergus	N/A	0
	Within AFAs	Infrastructure	1
	Total for Sub-catchment	Infrastructure	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Economy		

As there is only one AFA within this sub catchment/coastal area for which optioneering is to be carried out, there can be no structural measures that will provide benefits to multiple AFA's therefore screening of the measures was not carried out. Non – structural measures such as; public awareness, planning, and development control measures, building regulation, land use management, strategic development management and additional monitoring have been considered for the sub-catchment and are addressed in the UoM spatial scale.

5.2.3 Shannon and Shannon Airport Sub-Catchment and Coastal Area

Tables 5.31 to 5.38 below outline the results of sub-stages 1.1 to 1.8 for the Shannon Town and Shannon Airport Sub-catchment.

5.2.3.1 Stage 1: Summary of Current Flood Risk for Shannon Town and Shannon Airport Sub-Catchment

Table 5.31 Stage 1.1: AFA and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
Sub-catchment / Coastal Area	Shannon and Shannon Airport
AFAs	Shannon, Shannon Airport
Major Watercourses:	Ballycasey Creek, Unnamed River, Ballycasey Tributary, Urian Beg, Drumgeely Creek, Unnamed Tributary

Table 5.32 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event					
Properties at risk:	APMR_Shannon & Shannon Airport	Event Type	Res	Non-Res	Total
		Fluvial	0	0	0
		Coastal	9	11	20
		Combined	9	11	20
	Within AFAs	Fluvial	90	49	139
		Coastal	6	37	43
		Combined	91	52	143
	Total for Sub-catchment	Fluvial	90	49	139
		Coastal	13	48	63
		Combined	100	63	163
Relevant Comments:	<p>Shannon and Shannon Airport are hydraulically connected. The ground levels within Shannon Town and Shannon Airport are less than the tide level in a 50% AEP coastal event, if the coastal defences in Shannon Airport were not in existence, properties within Shannon town would be at risk of flooding in a 50% AEP Coastal event and if the coastal defences in Shannon town were not in existence Shannon Airport would be at risk of flooding in a 50% AEP Coastal event. Flood management measures for the Shannon and Shannon Airport sub-catchment have been considered to provide 0.1% AEP coastal and 1% AEP fluvial event SOP, rather than the preferred 0.5% AEP coastal and 1% AEP fluvial event SOP as there is an economic justification to consider an increased standard of protection.</p> <p>For a detailed breakdown, see specific Shannon and Shannon Airport sub-catchment report</p>				

Table 5.33 Stage 1.3: Summary of Existing Flood Risk Management Measures

1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	Yes	None	None

Table 5.34 Stage 1.4: Summary of PV damages

Stage 1.4: Summary of PV Damages								
Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.								
Total PV Damages		Event Type	Capped Residential	Capped Non-Res	Capped Total	Uncapped Residential	Uncapped Non-Res	Uncapped Total
	APMR_Shannon & Shannon Airport	Fluvial	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
		Coastal	€ 3,345,313	€ 219,142	€ 3,564,455	€ 10,831,198	€ 219,142	€ 11,050,340
		Combined	€ 3,345,313	€ 219,142	€ 3,564,455	€ 10,831,198	€ 219,142	€ 11,050,340
	Within AFAs	Fluvial	€ 944,772	€ 25,607,349	€ 26,552,121	€ 944,772	€ 39,343,345	€ 40,288,117
		Coastal	€ 2,290,969	€ 30,773,055	€ 33,064,024	€ 2,290,969	€ 41,624,258	€ 43,915,227
		Combined	€ 3,757,691	€ 28,819,066	€ 32,576,757	€ 4,020,109	€ 42,555,054	€ 46,575,163
	Total for Sub-catchment	Fluvial	€ 944,772	€ 25,607,349	€ 26,552,121	€ 944,772	€ 39,343,345	€ 40,288,117
		Coastal	€ 5,636,282	€ 30,992,197	€ 36,628,479	€ 13,122,167	€ 41,843,400	€ 54,965,567
		Combined	€ 7,103,004	€ 29,038,208	€ 36,141,212	€ 14,851,307	€ 42,774,196	€ 57,625,503
Relevant Comments:		For AFA level breakdown see specific AFA reports.						

Table 5.35 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		Type	Number
	APMR_ Shannon & Shannon Airport	N/A	0
	Within AFAs	School	4
	Total for Sub-catchment	School	4
Social Infrastructure Assets:		Type	Number
	APMR_ Shannon & Shannon Airport	N/A	0
	Within AFA	OPW	1
	Total for Sub-catchment	OPW	1
Social Amenity Sites:		Type	Number
	APMR_ Shannon & Shannon Airport	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
		N/A	0
		N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Social		

Table 5.36 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
		Type	Number
Risk to WFD Annex IV :	APMR_ Shannon & Shannon Airport	N/A	0
	Within AFAs	Licensed IPPC Facility	5
	Total for Sub-catchment	Licensed IPPC Facility	5
Risk to cSACs, SPAs, & SACs :		Type	Number
	APMR_ Shannon & Shannon Airport	SPA	1
		SAC	1
	Within AFAs	SPA	1
		SAC	1
	Total for Sub-catchment	SPA	2
		SAC	2
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Environment		

Table 5.37 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
		Type	Number
Risk to Sites of Cultural Heritage:	APMR_ Shannon & Shannon Airport	Recorded Monument	3
	Within AFAs	Recorded Monument	1
	Total for Sub-catchment	Recorded Monument	4
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk – Cultural Heritage		

Table 5.38 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		Type	Number
	APMR_ Shannon & Shannon Airport	Regional Road	1
		Local Road	2
	Within AFAs	Primary Road	1
		Regional Road	1
		Local Road	7
		Airport	1
	Total for Sub-catchment	Primary Road	1
		Regional Road	2
		Local Road	9
		Airport	1
Risk to Utility Infrastructure:		Type	Number
	APMR_ Shannon & Shannon Airport	N/A	None
	Within AFAs	N/A	None
	Total for Sub-catchment	N/A	None
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Economy		

Conclusion:

Refer to Appendix K Shannon and Shannon Airport for a detailed breakdown of Stage 2 to 5 of the optioneering process.

5.2.4 Owenogarney Sub-Catchment and Coastal Area

Tables 5.38 to 5.45 below outline the results of sub-stages 1.1 to 1.8 for the Owenogarney Sub-catchment.

5.2.4.1 Stage 1: Summary of Current Flood Risk for Owenogarney Sub-Catchment

Table 5.38 Stage 1.1: Sub-Catchment and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
Sub-catchment / Coastal Area	Owenogarney
AFAs	Bunratty and Sixmilebridge
Major Watercourses:	Owenogarney River

Table 5.39 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details					
Properties at risk:	APMR_Owenogarney	Event Type	Res	Non-Res	Total
		Fluvial	0	2	2
		Coastal	0	6	6
	Within AFAs	Combined	0	6	6
		Fluvial	3	7	10
		Coastal	0	3	3
		Combined	3	9	12
	Total for Sub-catchment	Fluvial	3	9	12
		Coastal	0	9	9
		Combined	3	15	18
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 5.40 Stage 1.3: Summary of Existing Flood Risk Management Measures

1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	Yes	None	None

Table 5.41 Stage 1.3: Summary of Existing Flood Risk Management Measures

Stage 1.4: Summary of PV Damages								
Fluvial and coastal damages calculated based on flood depths for all return periods up to the 0.1% AEP. Combined damages are a sum of the fluvial and coastal capped at value of the property.								
Total PV Damages		Event Type	Capped Residential	Capped Non-Res	Capped Total	Uncapped Residential	Uncapped Non-Res	Uncapped Total
	APMR_Owenogarney	Fluvial	€ 0	€ 3,065	€ 3,065	€ 0	€ 3,065	€ 3,065
		Coastal	€ 0	€ 55,458	€ 55,458	€ 0	€ 55,458	€ 55,458
		Combined	€ 0	€ 58,522	€ 58,522	€ 0	€ 58,523	€ 58,523
	Within AFAs	Fluvial	€ 46,614	€ 2,158,063	€ 2,204,677	€ 46,614	€ 3,909,066	€ 3,955,680
		Coastal	€ 0	€ 2,628,754	€ 2,628,754	€ 0	€ 7,094,109	€ 7,094,109
		Combined	€ 46,614	€ 3,398,062	€ 3,444,676	€ 46,614	€ 11,003,175	€ 11,049,789
	Total for Sub-catchment	Fluvial	€ 46,614	€ 2,161,128	€ 2,207,742	€ 46,614	€ 3,912,131	€ 3,958,745
		Coastal	€ 0	€ 2,684,212	€ 2,684,212	€ 0	€ 7,149,567	€ 7,149,567
		Combined	€ 46,614	€ 3,456,584	€ 3,503,198	€ 46,614	€ 11,061,698	€ 11,108,312
	Relevant Comments:		For AFA level breakdown see specific AFA reports.					

Table 5.42 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		Type	Number
	APMR_ Owenogarney	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Social Infrastructure Assets:		Type	Number
	APMR_ Owenogarney	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Social Amenity Sites:		Type	Number
	APMR_ Owenogarney	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Social		

Table 5.43 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		Type	Number
	APMR_ Owenogarney	WFD Drinking Water	4
	Within AFAs	N/A	0
	Total for Sub-catchment	WFD Drinking Water	4
Risk to cSACs, SPAs, & SACs :		Type	Number
	APMR_ Owenogarney	N/A	0
	Within AFAs	N/A	0
		N/A	0
	Total for Sub-catchment	N/A	0
		N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		

Relevant Figure Ref:	General Risk – Environment
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Table 5.44 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		Type	Number
	APMR_ Owenogarney	Recorded Monument	6
	Within AFAs	NIAH	4
		Recorded Monument	3
		National Heritage Area	1
		Proposed National Heritage Area	1
	Total for Sub-catchment	NIAH	4
		Recorded Monument	9
		National Heritage Area	1
		Proposed National Heritage Area	1
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk – Cultural Heritage		

Table 5.45 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		Type	Number
	APMR_ Owenogarney	Local road	2
		Railway	3
	Within AFAs	Regional Road	2
		Local Road	3
	Total for Sub-catchment	Regional Road	2
		Local Road	5
		Railway	3
Risk to Utility Infrastructure:		Type	Number
	APMR_ Owenogarney	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0

Relevant Comments:	For AFA level breakdown see specific AFA reports.
Relevant Figure Ref:	General Risk - Economy

As there is only one AFA within this sub catchment/coastal area for which optioneering is to be carried out, there can be no structural measures that will provide benefits to multiple AFA's, therefore screening of the measures was not carried out. Non – structural measures such as; public awareness, planning, and development control measures, building regulation, land use management, strategic development management and additional monitoring have been considered for the sub-catchment and are addressed in the UoM spatial scale.

5.2.5 Moore Bay Sub-Catchment and Coastal Area

Tables 5.46 to 5.53 below outline the results of sub-stages 1.1 to 1.8 for the Moore Bay Sub-catchment.

5.2.5.1 Stage 1: Summary of Current Flood Risk for Moore Bay Sub-Catchment

Table 5.46 Stage 1.1: AFA and Watercourse Details

Stage 1.1: AFA and Watercourse Details	
Sub-catchment / Coastal Area	Moore Bay
AFA	Kilkee
Major Watercourses:	Kilkee East, Kilkee Lower (River), Kilkee Upper (River), Kilkee Upper (Stream)

Table 5.47 Stage 1.2: Summary of Properties Predicted at Risk in 1% Fluvial / 0.5% Coastal AEP Event Sub-Catchments and Watercourses Details

1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event					
Properties at risk:		Event Type	Res	Non-Res	Total
	APMR_Moore Bay	Fluvial	27	5	32
		Coastal	27	5	32
		Combined	27	5	32
	Within AFAs	Fluvial	33	161	194
		Coastal	22	127	149
		Combined	33	161	194
	Total for Sub-catchment	Fluvial	60	166	226
		Coastal	49	132	181
		Combined	60	166	226
Relevant Comments:	For AFA level breakdown see specific AFA reports.				

Table 5.48 Stage 1.3: Summary of Existing Flood Risk Management Measures

Stage 1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	Yes	None	None

Table 5.49 Stage 1.4: Summary of PV damages

Stage 1.4 Summary of PV Damages								
Fluvial and coastal damages calculated based on flood depths for all return periods. Combined damages are a sum of the fluvial and coastal capped at value of the property.								
Total PV Damages		Event Type	Capped Residential	Capped Non-Res	Capped Total	Uncapped Residential	Uncapped Non-Res	Uncapped Total
	APMR_Moore Bay	Fluvial	€ 1,470,333	€ 1,171,012	€ 2,641,345	€ 2,751,388	€ 2,486,775	€ 5,238,163
		Coastal	€ 1,470,333	€ 1,171,012	€ 2,641,345	€ 2,751,388	€ 2,486,775	€ 5,238,163
		Combined	€ 1,470,336	€ 1,171,012	€ 2,641,345	€ 2,751,388	€ 2,486,775	€ 5,238,163
	Within AFAs	Fluvial	€ 3,438,760	€ 2,575,573	€ 6,014,333	€ 6,779,147	€ 4,655,834	€ 11,434,981
		Coastal	€ 2,117,023	€ 1,797,938	€ 3,914,961	€ 4,821,396	€ 3,136,566	€ 7,957,962
		Combined	€ 4,089,937	€ 3,577,188	€ 7,667,125	€ 11,600,543	€ 7,792,400	€ 19,392,943
	Total for Sub-catchment	Fluvial	€ 4,909,093	€ 3,746,585	€ 8,655,678	€ 9,530,535	€ 7,142,609	€ 16,673,144
		Coastal	€ 3,587,356	€ 2,968,950	€ 6,556,306	€ 7,572,784	€ 5,623,341	€ 13,196,125
		Combined	€ 5,560,273	€ 4,748,200	€ 10,308,473	€ 14,351,931	€ 10,279,175	€ 24,631,106
Relevant Comments:		For AFA level breakdown see specific AFA reports.						

Table 5.50 Stage 1.5: Summary of Social Receptors at Risk of Flooding

Stage 1.5: Summary of Social Receptors at Risk of Flooding			
High Vulnerability Properties at risk :		Type	Number
	APMR_ Moore Bay	N/A	0
	Within AFAs	Health Centre	1
	Total for Sub-catchment	Health Centre	1
Social Infrastructure Assets:		Type	Number
	APMR_ Moore Bay	N/A	0
	Within AFAs	N/A	0
		N/A	0
		N/A	0
		N/A	0
	Total for Sub-catchment	N/A	0
		N/A	0
		N/A	0
		N/A	0
		Type	Number
	APMR_ Moore Bay	N/A	0
Social Amenity Sites:	Within AFAs	N/A	0
		N/A	0
		N/A	0
		N/A	0
	Total for Sub-catchment	N/A	0
		N/A	0
		N/A	0
		Type	Number
	APMR_ Moore Bay	N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Social		

Table 5.51 Stage 1.6: Summary of Environmental Receptors at Risk of Flooding

Stage 1.6: Summary of Environmental Receptors at Risk of Flooding			
Risk to WFD Annex IV :		Type	Number
	APMR_ Moore Bay	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Risk to cSACs, SPAs, & SACs :		Type	Number
	APMR_ Moore Bay	N/A	0
	Within AFAs	N/A	0
		N/A	0
	Total for Sub-catchment	N/A	0
		N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Environment		

Table 5.52 Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding

Stage 1.7: Summary of Cultural Heritage Receptors at Risk of Flooding			
Risk to Sites of Cultural Heritage:		Type	Number
	APMR_ Moore Bay	N/A	0
	Within AFAs	N/A	0
		N/A	0
	Total for Sub-catchment	N/A	0
		N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk – Cultural Heritage		

Table 5.53 Stage 1.8: Summary of Economic Receptors at Risk of Flooding

Stage 1.8: Summary of Economic Receptors at Risk of Flooding			
Risk to Transport Infrastructure:		Type	Number
	APMR_ Moore Bay	N/A	0
	Within AFAs	National Road	1
		Regional Road	1
		Local Road	5
	Total for Sub-catchment	National Road	1
		Regional Road	1
		Local Road	5
Risk to Utility Infrastructure:		Type	Number
	APMR_ Moore Bay	N/A	0
	Within AFAs	N/A	0
	Total for Sub-catchment	N/A	0
Relevant Comments:	For AFA level breakdown see specific AFA reports.		
Relevant Figure Ref:	General Risk - Economy		

Conclusion:

As there is only one AFA within this sub-catchment/coastal area there can be no structural measures that will provide benefits to multiple AFA's therefore screening of the measures was not carried out. In addition there are no properties at risk in this sub catchment/coastal area that are not at risk within the AFA. Non – structural measures such as; public awareness, planning, and development control measures, building regulation, land use management, strategic development management and additional monitoring have been considered for the sub-catchment and are addressed in the UoM spatial scale.

5.3 Option Appraisal Results SSA: AFA and IRR

The AFA and IRR SSA's assessed and reported in this section, is as follows:

- Kilrush AFA
- Quin AFA
- Ennis AFA
- Shannon AFA
- Shannon Airport (IRR)
- Sixmilebridge AFA
- Bunratty AFA
- Kilkee AFA

Appendix C provides individual Option Appraisal Reports for each AFA/ IRR within this Unit of Management. Each Option Appraisal Report provides a clear and robust assessment of the Option Appraisal process.

The following sections provide an overview of the results for each AFA/ IRR, at each of the six Option Appraisal Stages.

5.3.1 Stage 1: Summary of Current Flood Risk - Results

Table 5.54 Results for Stage 1: Summary of Current Flood Risk & MCA Approach

AFA/ IRR	Relevant Sub-Stage and Outcome ¹					
	Sub-Stage 1.2			Sub-Stage 1.4		
	No. Properties at Risk in 1% Fluvial / 0.5% Coastal AEP			Total Capped PV Damages		
	F	C	Com b.	F	C	Combined
Kilrush	20	0	20	€ 257,510	€ 5,175	€ 262,685
Quin	1	0	1	€ 18,885	€ 0	€ 18,885
Ennis	201	21	210	€ 25,230,136	€ 1,113,845	€ 26,092,714
Shannon	139	43	143	€ 26,545,337	€ 29,826,398	€ 46,555,772
Shannon Airport	0	0	0	€ 0	€ 224,237,626	€ 224,237,626
Sixmilebridge	9	0	9	€ 367,792	€ 0	€ 367,792
Bunratty	1	3	3	€ 1,836,885	€ 2,628,754	€ 3,076,884
Kilkee	194	149	194	€ 6,014,333	€ 3,914,961	€ 7,667,125

Note¹: Only sub-stages with defined outcomes are summarised in this Table. Refer to Appendix C for a full report.

Table 5.55 Results for Stage 1: Summary of Current Flood Risk & MCA Approach

AFA/ IRR	Relevant Sub-Stage and Outcome ¹			
	Sub-Stage 1.5	Sub-Stage 1.6	Sub-Stage 1.7	Sub-Stage 1.8
	Social Features	Environmental Features	Cultural Features	Economic Features
Kilrush	Yes	No	Yes	Yes
Quin	No	No	No	Yes
Ennis	Yes	Yes	Yes	Yes
Shannon	Yes	Yes	Yes	Yes
Shannon Airport	Yes	Yes	Yes	Yes
Sixmilebridge	No	No	Yes	Yes
Bunratty	No	Yes	Yes	Yes
Kilkee	Yes	No	No	Yes

Note¹: Only sub-stages with defined outcomes are summarised in this Table. Refer to Appendix C for a full report.

5.3.2 Stage 2: Screening of the measures - Results

Table 5.56 below outlines the screened in measures for each AFA/ IRR.

Ennis and Sixmilebridge are identified as AFAs that benefit from an existing flood relief schemes and therefore no further assessment to identify potentially viable flood risk management measures or options is required through this CFRAM Study. Therefore these AFAs are not reported in the stages below.

Table 5.56 Summary of Screened in Measures

Flood Risk Management Measure		AFA / IRR				
Ref	Title	Kilrush	Quin	Bunratty	Kilkee	Shannon Town
Baseline						
A	Do Nothing	Screened Out	Screened In	Screened Out	Screened Out	Screened Out
B	Existing Regime	Screened Out	Screened In	Screened In	Screened Out	Screened In
C	Do Minimum	Screened Out	Screened Out	Screened Out	Screened Out	Screened Out
Structural						
D	Storage	Screened Out	Screened Out	Screened Out	Screened Out	Screened In
E	Flow Diversion	Screened Out	Screened Out	Screened Out	Screened Out	Screened In
F	Increase Conveyance	Screened Out	Screened Out	Screened Out	Screened In	Screened In
G	Flood Defences	Screened In	Screened Out	Screened In	Screened In	Screened In
H	Relocation of Properties	Screened Out	Screened Out	Screened Out	Screened Out	Screened Out
I	Other Measures	Screened Out	Screened Out	Screened Out	Screened Out	Screened Out
Non Structural						
J	Flood Forecasting / Warning / Response	Screened Out	Screened Out	Screened In	Screened Out	Screened In
K	Public Awareness	Screened In	Screened In	Screened In	Screened In	Screened In
L	Individual Property Resistance	Screened Out	Screened Out	Screened Out	Screened Out	Screened In
M	Individual Property Resilience	Screened Out	Screened Out	Screened In	Screened In	Screened In

Bunratty

One option was considered for Bunratty, see Table 5.58. For more details on this option and the associated appraisal, refer to Appendix C.

Table 5.58 Summary of Screened in Measures for Bunratty

Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓						
Structural Measures								
Gi	New Flood Defences	✓						
Non-Structural Measures								
J	Flood Forecasting / Warning / Response							
K	Public Awareness	✓						
M	Individual Property Resilience	✓						
Option Reference		BUY_01						
Measures not screened out but not included in options								
Measures		Justification						
J	Flood Forecasting / Warning / Response	Flood Forecasting was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 0.5% coastal AEP standard of protection. Flood Forecasting does not improve the viability of the options under consideration.						

Kilkee

In Kilkee two options were considered, see Table 5.59. For more details of these options and the associated appraisal, refer to Appendix C.

Table 5.59 Summary of Screened in Measures for Kilkee

Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓	✓					
Structural Measures								
F	Increase Conveyance							
Fi	Channel Dredging							
Fii	Channel Widening							
Fiii	Structure Enhancement/Works		✓					
G	Flood Defences							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences	✓	✓					
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
K	Public Awareness							
M	Individual Property Resilience							
Option Reference		KIE_01	KIE_02					
Measures not screened out but not included in options								
Measures		Justification						
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.						
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required AEP standard of protection. Individual Property Resilience does not improve the viability of the options under consideration.						

Shannon Town

Two options were considered for Shannon Town, see Table 5.60. For more details on this option and the associated appraisal, refer to Appendix C.

Table 5.60 Summary of Screened in Measures for Shannon Town

Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓						
Structural Measures								
D	Storage							
Di	Online Storage	✓	✓					
Dii	Offline Storage							
Diii	Other Storage	✓	✓					
E	Flow Diversion							
Ei	Full Diversion	.						
Eii	Flood Relief Channel	✓						
Eiii	Other Diversion							
F	Increase Conveyance							
Fi	Channel Dredging							
Fii	Channel Widening							
Fiii	Structure Enhancement/Works	✓	✓					
G	Flood Defences							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response							
K	Public Awareness							
L	Individual Property Resistance							
M	Individual Property Resilience							
Option Reference		SHN_01	SHN_02					

5.3.4 Stage 5: Multi Criteria Assessment - Results

The MCA was carried out for each AFA/ IRR within UoM27. Further to this assessment, Tables 5.61 to 5.64 below show summary results for the options each AFA/ IRR.

Table 5.61 Comparison of Options for Kilrush

Categories	Option Reference and Results
	KIL_01
Criteria Scores	
Technical	1100
Economic	256
Social	477
Environmental	-147
Economic Values	
Economic PV Benefits	€ 181,055
PV Cost	€ 173,082
NPV Benefits	€ 7,973
Economic BCR	1.05
Outcome Scores	
MCA PV Benefits	€ 121,531
MCA Benefit Score	586
MCA BCR	3386.74
Option Selection MCA	1686

Table 5.62 Comparison of Options for Bunratty

Categories	Option Reference and Results
	BUY_01
Criteria Scores	
Technical	867
Economic	444
Social	239
Environmental	-720
Economic Values	
Economic PV Benefits	€ 1,493,788
PV Cost	€ 758,255
NPV Benefits	€ 735,533
Economic BCR	1.97
Outcome Scores	
MCA PV Benefits	€ 715,245
MCA Benefit Score	-37
MCA BCR	-49.18
Option Selection MCA	829

Table 5.63 Comparison of Options for Kilkee

Categories	Option Reference and Results	
	KIE_01	KIE_02
Criteria Scores		
Technical	800	750
Economic	829	829
Social	824	824
Environmental	-405	-260
Economic Values		
Economic PV Benefits	€ 7,054,150	€ 7,054,150
PV Cost	€ 4,438,063	€ 3,240,290
NPV Benefits	€ 2,616,087	€ 3,813,860
Economic BCR	1.59	2.18
Outcome Scores		
MCA PV Benefits	€ 3,744,238	€ 3,744,238
MCA Benefit Score	1248	1393
MCA BCR	281.26	429.97
Option Selection MCA	2048	2143

Table 5.64 Comparison of Options for Shannon Town

Categories	Option Reference and Results	
	SHN_01	SHN_02
Criteria Scores		
Technical	800	560
Economic	748	748
Social	505	505
Environmental	-485	-512
Economic Values		
Economic PV Benefits	€ 33,480,442	€ 33,480,442
PV Cost	€ 5,875,765	€ 21,151,116
NPV Benefits	€ 27,604,677	€ 12,329,326
Economic BCR	5.70	1.58
Outcome Scores		
MCA PV Benefits	€ 22,652,947	€ 22,652,947
MCA Benefit Score	768	741
MCA BCR	127.89	35.00
Option Selection MCA	1568	1301

6

Summary of Recommended Measures and Options

6.1 Recommendations at SSA: Unit of Management

The Flood Risk Management measures considered viable and therefore recommended for inclusion in the Flood Risk Management Plan at this Unit of Management SSA are:

- Public Awareness;
- Land Use Management;
- Strategic development Management; and
- Additional Monitoring.

No Flood Risk Management options were considered viable at this Unit of Management SSA.

6.2 Recommendations at SSA: Sub-Catchment

Different Flood Risk Management measures were considered viable and therefore recommended for inclusion in the Flood Risk Management Plan, for each sub-catchment. A summary of these recommendations with the outcomes of the MCA process for each sub-catchment is presented in Table 6.1.

Only the Shannon and Shannon Airport sub-catchment / coastal area has structural measures which provide benefits to multiple AFAs/ IRR and this has been detailed section 5.2.3 above and in Appendix C9. There are no structural measures providing benefits to multiple AFAs/ IRR for all other sub-catchments as demonstrated in the UoM spatial scale.

Table 6.1 Summary of MCA Outcomes for each sub-catchment

AFA/ IRR	MCA outcomes				
	Summary of Existing Risk / MCA		Recommended Measure		
	Total PV Damages		Baseline	Structural	Non Structural
	Capped	Uncapped			
Shannon Town and Airport	€ 270,802,132	€ 305,191,192	✓	✓	

The following sections summarise the preferred Flood Risk Management option being recommended for inclusion in the Flood Risk Management Plan, for each sub-catchment respectively.

6.2.1 Shannon and Shannon Airport

The preferred option for Shannon and Shannon Airport with a MCA benefit score of 27.36 is SUBSHN_01. A summary of the option is provided in Table 6.2 and Figure 6.1 below.

Table 6.2 Summary of the preferred option for Shannon and Shannon Airport

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Shannon and Shannon Airport Sub-Catchment		Option Ref: SUBSHN_01
Option Measures			
Baseline	B	Existing Regime	
Structural	Di	Online Storage	
	Diii	Other Storage	
	Eii	Flood Relief Channel	
	Fiii	Structure Enhancement/Works	
	Gi	New Flood Defences	
Non-Structural	N/A		
Criteria Scores			
Technical			800
Economic			837
Social			1021
Environmental			-779
Economic Values			
Economic PV Benefits			€ 268,925,432
PV Cost			€ 39,423,702
NPV Benefits			€ 229,501,730
Economic BCR			6.82
Outcome Scores			
MCA PV Benefits			€ 153,318,516
MCA Benefit Score			1079
MCA Benefit Score Ratio			27.36
Option Selection MCA			1879
Relevant Figure			Figure 6.1

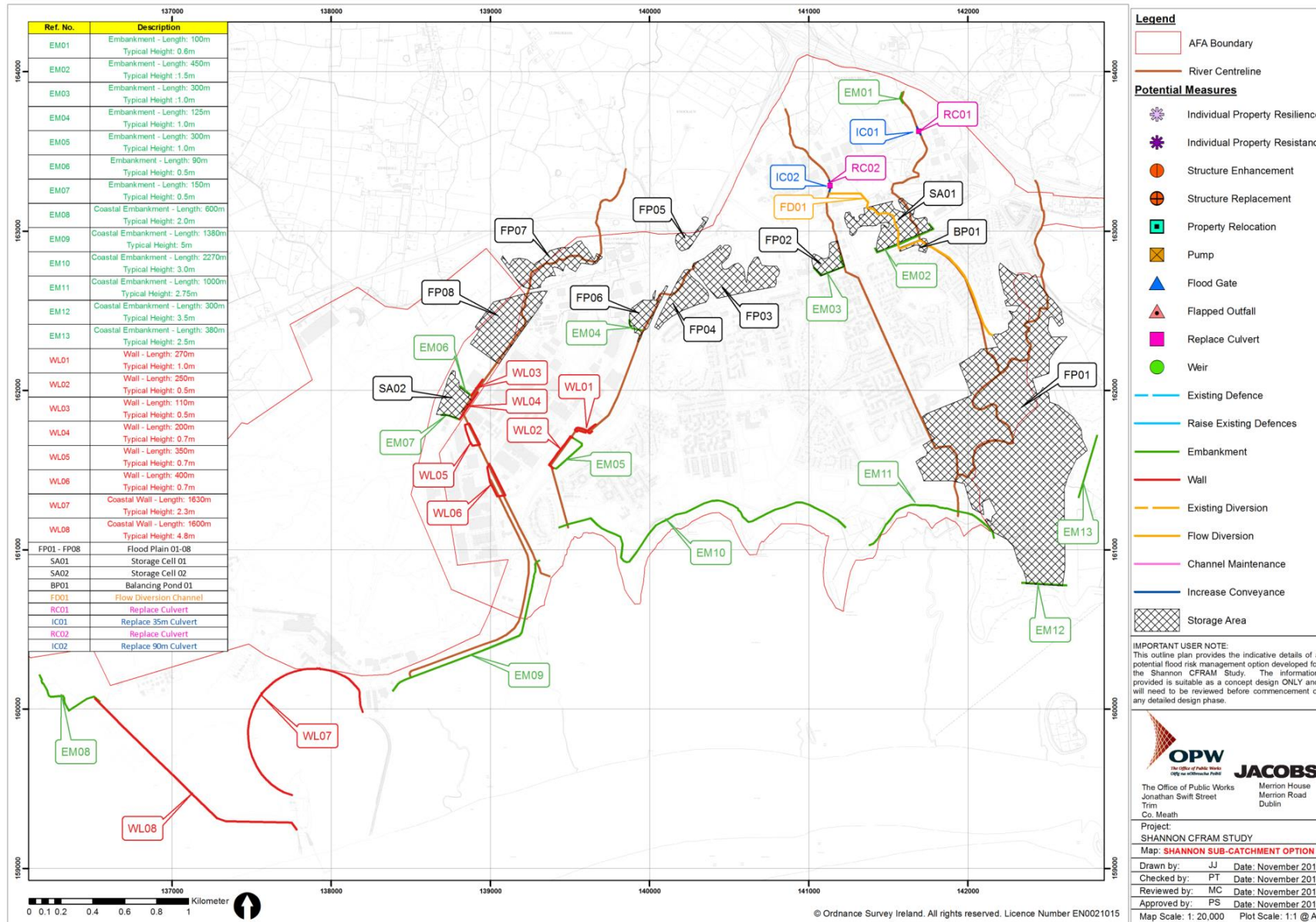


Figure 6.1 Summary of the preferred option for Shannon and Shannon Airport

6.3 Recommendations at SSA: AFA/ IRR

Different Flood Risk Management measures were considered viable and therefore recommended for inclusion in the Flood Risk Management Plan, for each AFA/ IRR. A summary of these recommendations with the outcomes of the MCA process for each AFA/ IRR is presented in Table 6.3.

Consultation days were held in all AFAs. Any comments that were made at these consultation days have been considered in both the development of the options and the selection of the preferred option for each AFA.

Table 6.3 Summary of MCA Outcomes for each AFA/ IRR

AFA/ IRR	MCA outcomes				
	Summary of Existing Risk / MCA		Recommended Measure		
	Total PV Damages		Baseline	Structural	Non Structural
	Capped	Uncapped			
Kilrush	€ 262,685	€ 262,685		✓	
Quin	€ 17,102	€ 17,102	No option		
Ennis	€ 26,092,714	€ 47,073,286	Existing FRS		
Shannon	€ 46,555,772	€ 80,943,162	✓	✓	
Shannon Airport (IRR)	€ 224,237,626	€ 224,237,626	No option		
Sixmilebridge	€ 367,792	€ 367,792	Existing FRS		
Bunratty	€ 3,076,884	€ 10,681,997	✓	✓	✓
Kilkee	€ 7,667,125	€ 19,392,943	✓	✓	

The following sections summarise the preferred Flood Risk Management option being recommended for inclusion in the Flood Risk Management Plan, for each AFA/ IRR respectively.

6.3.1 Kilrush

The preferred option for Kilrush with a MCA benefit score ratio of 3399.61 is KIL_01. A summary of the option is provided in Table 6.4 and Figure 6.2 below.

Table 6.4 Summary of the preferred option for Kilrush

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Kilrush		Option Ref: KIL_01
Option Measures			
Structural	Gi	Flood Defences: New Flood Defences	
Non-Structural		None	
Criteria Scores			
Technical		1100	
Economic		256	
Social		477	
Environmental		-147	
Economic Values			
Economic PV Benefits		€ 181,055	
PV Cost		€ 173,082	
NPV Benefits		€ 7,973	
Economic BCR		1.05	
Outcome Scores			
MCA PV Benefits		€ 121,531	
MCA Benefit Score		586	
MCA Benefit Score Ratio		3386.74	
Option Selection MCA		1686	
Relevant Figure		Figure 6.2	

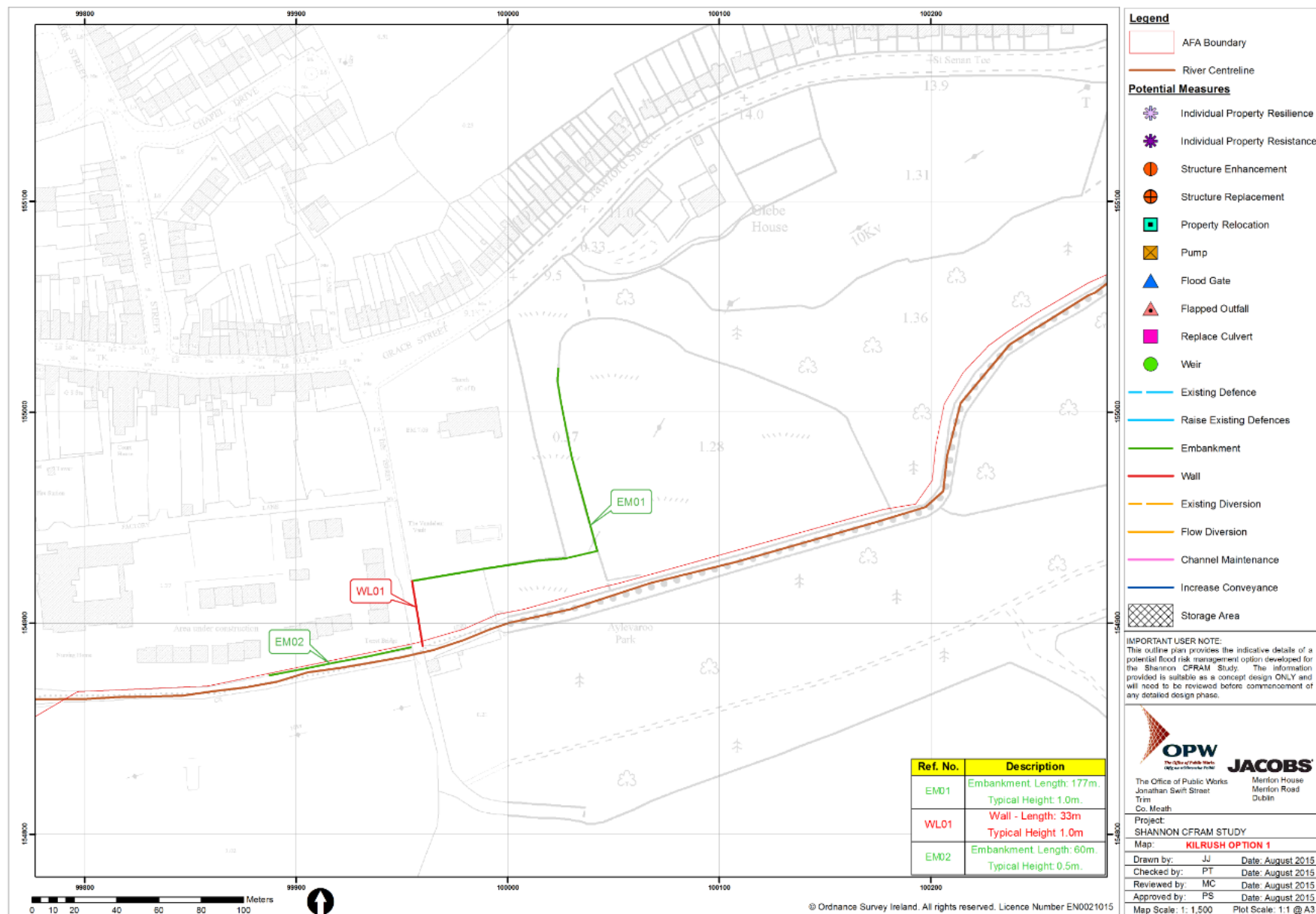


Figure 6.2 Summary of the preferred option for Kilrush

6.3.2 Quin

The only viable measures identified are “Do Nothing”, “Existing Regime” and “Public Awareness”. None of these measures can form an option that will provide the required 1% AEP event design standard. Therefore, no appraisal of options or multi criteria analysis has been carried out for this AFA.

For more details see Appendix C.

6.3.3 Bunratty

The preferred option for Bunratty with a MCA benefit score ratio of -48.62 is BUY_01. A summary of the option is provided in Table 6.5 and Figure 6.3 below.

Table 6.5 Summary of the preferred option for Bunratty

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Bunratty		Option Ref: BUY_01
Option Measures			
Baseline	B	Existing Regime	
Structural	Gi	Flood Defences: New Flood Defences	
Non-Structural	K	Public Awareness	
	M	Individual Property Resilience	
Criteria Scores			
Technical			867
Economic			444
Social			239
Environmental			-720
Economic Values			
Economic PV Benefits			€ 1,493,788
PV Cost			€ 758,255
NPV Benefits			€ 735,533
Economic BCR			1.97
Outcome Scores			
MCA PV Benefits			€ 715,245
MCA Benefit Score			-37
MCA Benefit Score Ratio			-49.18
Option Selection MCA			829
Relevant Figure			Figure 6.3

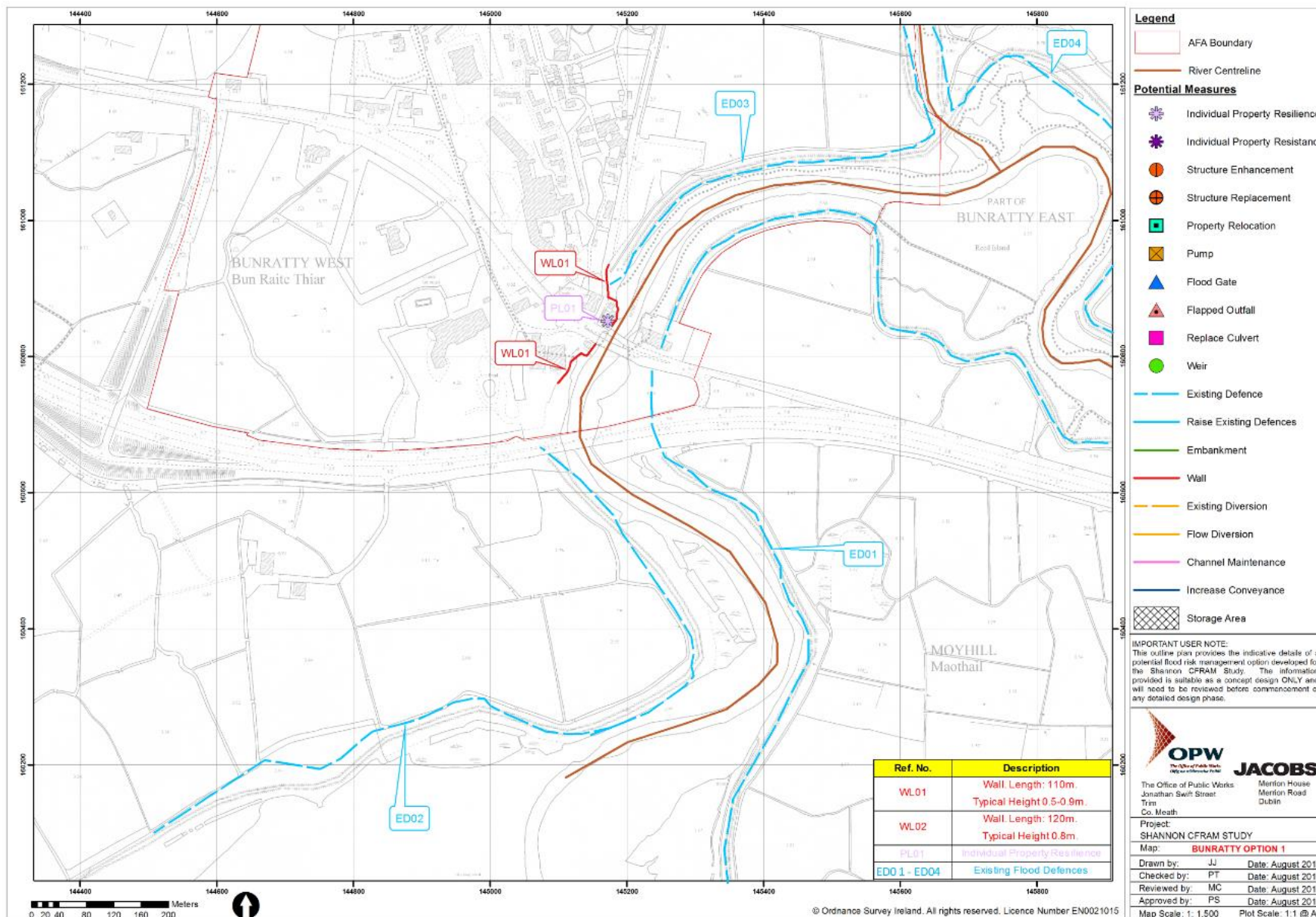


Figure 6.3 Summary of the preferred option for Bunratty

6.3.4 Kilkee

The preferred option for Kilkee with a MCA benefit score of 430.03 is KIE_02. A summary of the option is provided in Table 6.6 and Figure 6.4 below.

Table 6.6 Summary of the preferred option for Kilkee

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Kilkee		Option Ref: KIE_02
Option Measures			
Baseline	B	Existing Regime	
Structural	Fiii	Increase Conveyance: Structure Enhancement/Works	
	Gi	Flood Defences: New Flood Defences	
	Gii	Flood Defences: Raise Existing Flood Defences	
Non-Structural	N/A		
Criteria Scores			
Technical		750	
Economic		829	
Social		824	
Environmental		-260	
Economic Values			
Economic PV Benefits		€ 7,054,150	
PV Cost		€ 3,240,290	
NPV Benefits		€ 3,813,860	
Economic BCR		2.18	
Outcome Scores			
MCA PV Benefits		€ 3,744,238	
MCA Benefit Score		1393	
MCA Benefit Score Ratio		429.97	
Option Selection MCA		2143	
Relevant Figure		Figure 6.4	

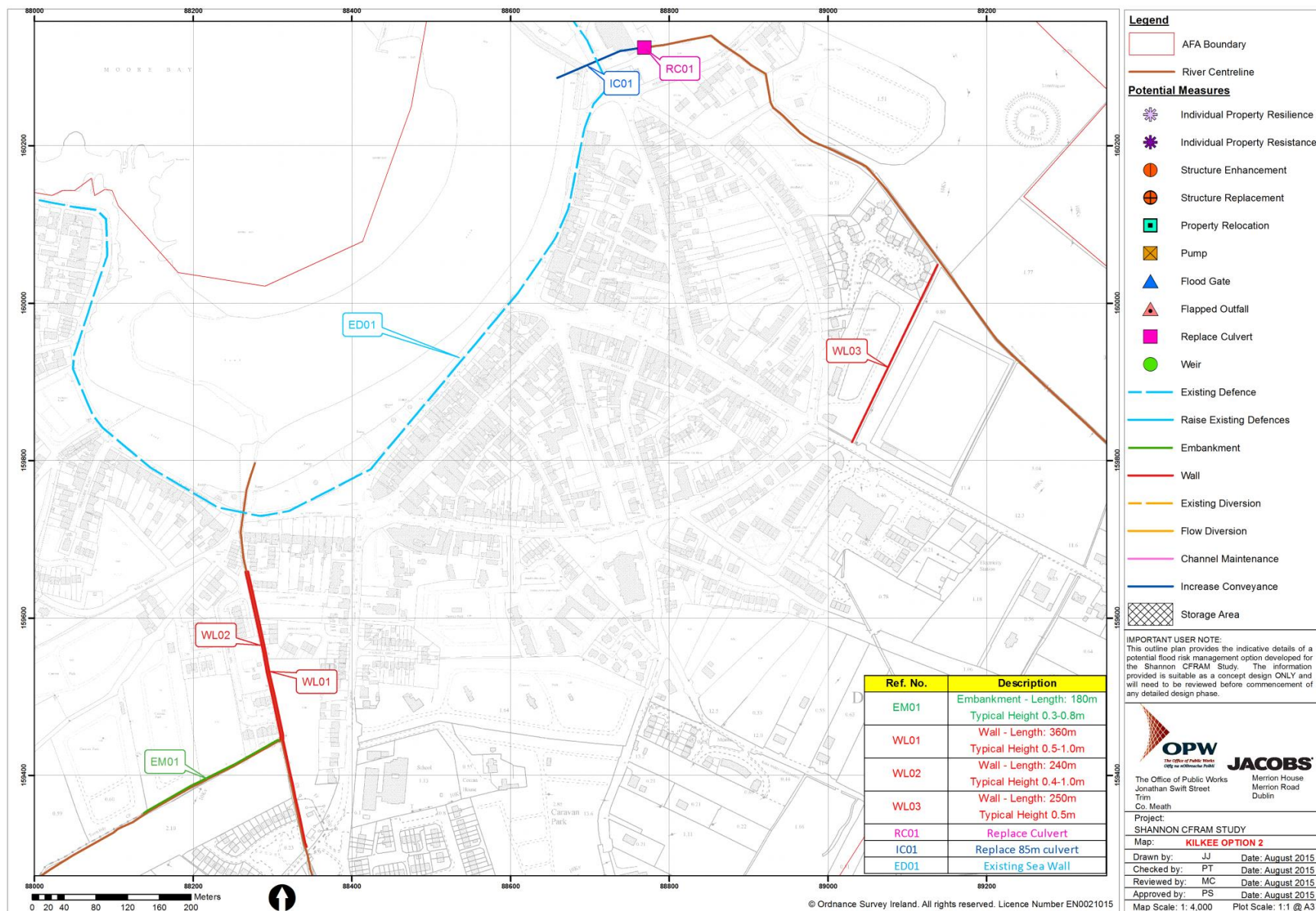


Figure 6.4 Summary of the preferred option for Kilkee

6.3.5 Shannon Town

The preferred option for Shannon Town with a MCA benefit score of 131.53 is SHN_01. A summary of the option is provided in Table 6.7 and Figure 6.5 below.

Table 6.7 Summary of the preferred option for Shannon and Shannon Airport

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Shannon		Option Ref: SHN_01
Option Measures			
Baseline	B	Existing Regime	
Structural	Di	Online Storage	
	Diii	Other Storage	
	Eii	Flood Relief Channel	
	Fiii	Structure Enhancement/Works	
	Gi	New Flood Defences	
Non-Structural	N/A		
Criteria Scores			
Technical		800	
Economic		748	
Social		505	
Environmental		-485	
Economic Values			
Economic PV Benefits		€ 33,480,442	
PV Cost		€ 6,003,635	
NPV Benefits		€ 27,476,807	
Economic BCR		5.58	
Outcome Scores			
MCA PV Benefits		€ 22,652,947	
MCA Benefit Score		768	
MCA Benefit Score Ratio		127.89	
Option Selection MCA		1568	
Relevant Figure		Figure 6.5	

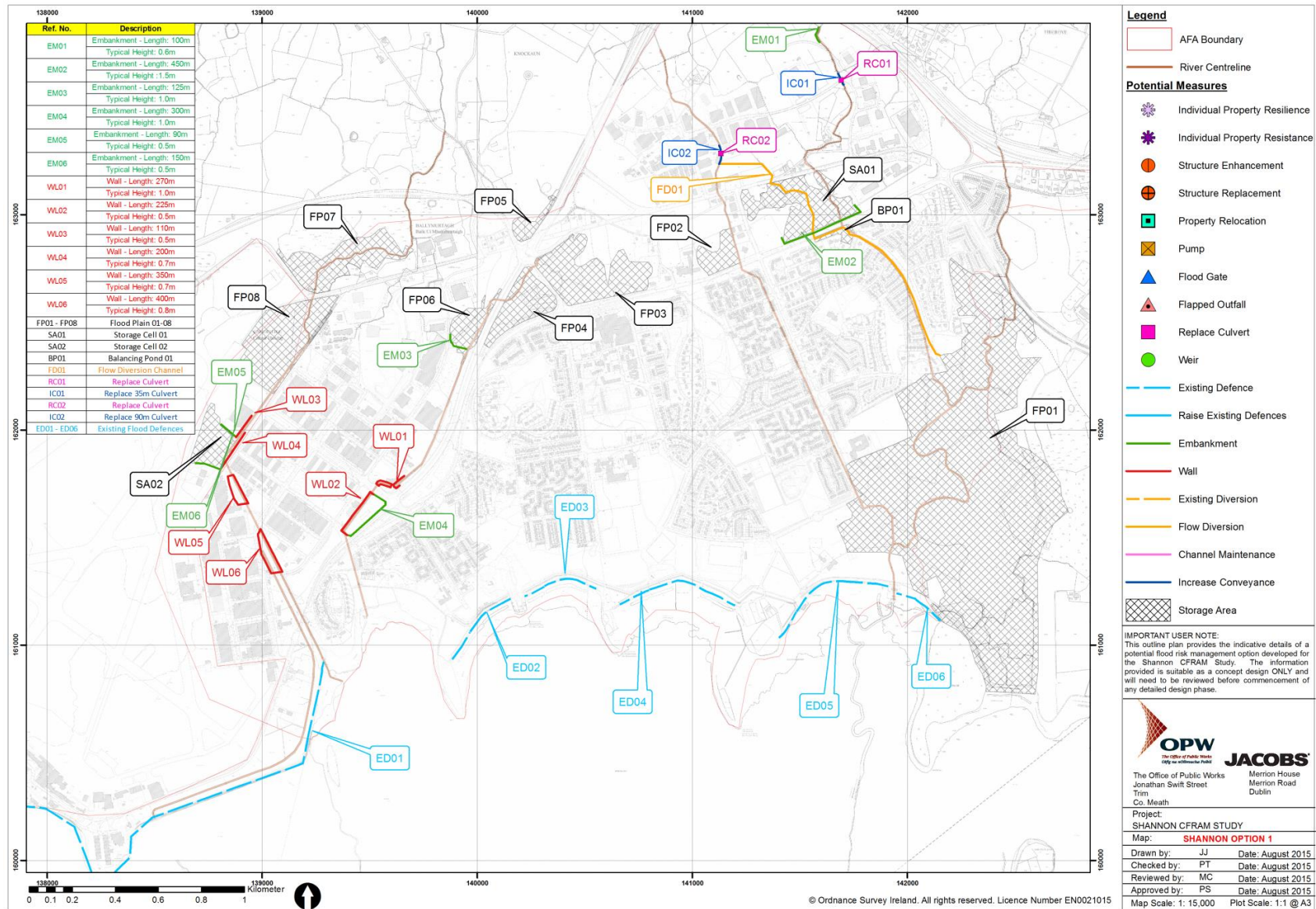


Figure 6.5 Summary of the preferred option for Shannon Town

6.3.6 Shannon Airport

With the existing coastal flood defences in place there is no flood risk to any properties in the IRR for the 1% AEP fluvial and the 0.5% AEP coastal events. There are not sufficient PV damages to promote any flood risk management measures for Shannon Airport for this design standard.. Considering there are significant PV damages of € 224,237,626 for the 0.1% AEP coastal event, the 0.1% AEP standard of protection has been considered.

Shannon Town and Shannon Airport are hydraulically connected for coastal flood events and the flood risk cannot be isolated to either site. The ground levels within Shannon Town and Shannon Airport are less than the tide level in a 50% AEP coastal event, if the defences in Shannon Airport were not in existence, properties within Shannon town would be at risk of flooding in a 50% AEP event. As the existing defences in Shannon Town have a SOP of less than the 0.1% AEP event, the 0.1% AEP design standard cannot be provided to Shannon Airport without increasing the height or replacing the existing defences in Shannon Town. Therefore the 0.1% AEP design standard can only be provided to Shannon Airport at a sub-catchment scale.

See Appendix K1 for the sub-catchment scale options.

Appendix A Glossary

Annual Exceedance Probability Or AEP	The probability that a certain flow value will be exceeded in any one year. For example the flow associated with the 1% AEP event at a particular location has a 1 in 100 chance of being exceeded in any year. A 5% AEP event has a 1 in 20 chance of being exceeded in any year.
Area for Further Assessment Or AFA	An area that is considered to be at potentially significant risk, thereby justifying its inclusion for further assessment. Note that the term AFA is a replacement term for what was previously referred to as an APSR (Area of Potential Significant Risk).
Areas of Potential Moderate Risk Or APMR	<p>The areas to which the MPWs could give to rise existing or potential future fluvial and estuarine flooding are defined as the Fluvial Areas of Potential Moderate Risk (APMRs).</p> <p>Areas outside of APSRs that could be prone to coastal flooding are defined as Coastal APMRs.</p>
Benefit – Cost Ratio	Present Value Benefits divided by the Present Value Costs
Catchment Flood Risk Assessment and Management Study Or CFRAM Study	The five year study covering the whole River Shannon catchment area which gives a picture of past flooding and areas at risk of future flooding, and sets out a prioritised set of specific measures for reducing and managing flood risk.
Flood Cell	Discrete areas of flood risk within a given AFA are referred to as 'flood cells'
Flood Risk Management Measure (FRM Measure)	A flood risk management strategy option ('option') consists of one or more flood risk management measures.
Habitats Directive	The Habitats Directive [92/43/EEC] aims at securing biodiversity through the provision of protection for animal and plant species and habitat types of European importance.
High – End Future Scenario Or HEFS	Potential future scenario representing climate change impacts not significantly outside the range of accepted predictions available, and with the allowances for increased flow, sea level rise etc. at the upper bounds of widely accepted projections
Individual Risk Receptor Or IRR	A single receptor (see below) that has been determined to represent a potentially significant flood risk (as opposed to a community or other area at potentially significant flood risk AFA).
Multi Criteria Assessment Or MCA	It is the framework which has been developed to assess the different range of potential impacts that the implementation of a measure/option will provide.
Mid – Range Future Scenario Or MRFS	Represents a 'likely' future scenario based on the wide range of predictions available and with the allowances for increased flow, sea level rise, etc. within the bounds of widely accepted projections

NIAH	National Inventory of Architectural Heritage
Present Value Damages	The present value of damages associated with the current flood risk.
Or	
PVd	
Present Value Benefits	The reduction of the PVd a flood risk management option will provide
Or	
PVb	
River Basin District	The natural geographical and hydrological units for water management, as defined during the implementation of the Water Framework Directive.
Or	
RBD	
Spatial Scale of Assessment	The scale at which an assessment is to be undertaken. There are four SSAs for this study:
Or	- UoM
SSA	- Sub-catchment
	- AFA
	- IRR
Unit of Management	The division of the study area into major catchments and their associated coastal areas..
Or	
UoM	

Appendix B Flood Risk Management Measures

The flood risk management (FRM) measures are set out in Table 3.7 of the main report, and presented again below in Table B.1 for clarity. These FRM measures will form the FRM option or options.

Table B.1: FRM Measures and applicable SSA

Flood Risk Management Measure		Applicable SSA
Ref	Title	
Baseline		
A	Do Nothing	AFA/IRR
B	Existing Regime	AFA/IRR
C	Do Minimum	AFA/IRR
Structural		
D	Storage	All
E	Flow Diversion	All
F	Increase Conveyance	All
G	Flood Defences	All
H	Relocation of Properties	AFA/IRR
I	Other Measures	All
Non Structural		
J	Flood Forecasting / Warning / Response	All
K	Public Awareness	All
L	Individual Property Resistance	AFA/IRR
M	Individual Property Resilience	AFA/IRR
N	Planning and development control measures	UoM
O	Building regulations	UoM
P	Sustainable urban drainage systems	AFA/IRR
Q	Land use management	All
R	Strategic development management	UoM
S	Additional Monitoring (rain and river level/flow gauges)	UoM

This Appendix provides:

- Definition for each FRM measure;
- How each FRM measure is considered and specified; and
- Assumptions made on the viability of FRM measures at the “screening of measures” stage.

Appendix B1: Baseline Measures

A - Do Nothing

Definition

Implement no new flood risk management measures and abandon any existing practices.

Screening of the Measure

The Do Nothing FRM measure can only be considered as an independent measure; it can not be considered in combination with another FRM measures.

The Do Nothing FRM measure has only been considered in the following scenarios;

- Where there is 'low' flood risk categorisation; and
- Abandoning any existing works (maintenance or capital) will not have a negative impact on the existing flood risk; and
- There are no location-specific reasons as to why measures need to be investigated; and
- There are no other viable measures, including the Existing Regime (Measure B) and Do minimum (Measure C) measures.

The Do Nothing FRM measure cannot be screened out until all other FRM methods have been assessed.

B - Existing Regime

Definition

Continue with any existing flood risk management practices, such as reactive maintenance.

Screening of the Measure

The Existing Regime FRM measure has been considered as an independent viable measure in the following scenarios:

- Where there is 'low' flood risk categorisation; and
- There are no location-specific reasons as to why measures need to be investigated; and
- There are no other viable measures, including the Do minimum (Measure C) measures.

The Existing Regime FRM measure has also been considered in combination with other FRM measures and has generally been considered 'viable', as to discontinue with existing flood risk management practices is likely to have a negative impact to the existing flood risk.

Where the Existing Regime FRM measure has been considered 'unviable' in combination with other FRM measures, is:

- When the existing flood risk management practices have been found to be economically unsustainable; and
- There are other viable FRM measures which will mitigate any negative impact resulting from the abandonment of the existing flood risk management practices.

The Existing Regime FRM measure can not be screened out until all other FRM methods have been assessed.

C - Do Minimum

Definition

Implement additional minimal maintenance type works to reduce the flood risk in specific locations. This includes implementing reactive maintenance where it has not previously being implemented i.e. removal of debris at structures, cutting of grass/ clearing hedgerows/ low lying branches along the river bank, removal of loose debris and rubbish from the channel bed.

Screening of the Measure

The Do Minimum FRM measure has been considered as an independent viable measure in the following scenarios:

- Where there is 'low' flood risk categorisation; and
- There are no location-specific reasons as to why measures need to be investigated; and
- There are no other viable measures,

The Do Minimum FRM measure has also been considered in combination with other FRM measures.

Assessing the likely reduction in flood risk from the Do Minimum FRM measure has been based on the following factors:

- Engineering judgement using site photographs and survey data. If this dataset indicates no build-up of debris/rubbish in channel, the conclusion can be drawn that the introduction of a reactive maintenance is likely not to have a significant impact on flood risk; and
- Sensitivity tests have been carried out using the hydraulic models which indicates the reduction in channel water levels subject to a 20% reduction in Manning's n. While it has not been anticipated that the introduction of reactive maintenance will provide a 20% reduction to Manning's n, the results of this sensitivity tests have provided an indication of the watercourse's sensitivity to an improvement of in channel conveyance.

The Do Minimum FRM measure can not be screened out until all other FRM methods have been assessed.

Appendix B2: Structural Measures

D - Storage

Definition

Single or multiple site, online or offline flood water storage, flood retardation, etc. Detention basins and ponds are not considered as storage as these are considered as SuDS FRM measures.

There are different sub-types of Storage FRM Measures, which are summarised in Table B.2.

Table B-2 Types of Storage FRM measures

D – Storage	Di – On-line Storage
	Dii – Off-line Storage
	Diii – Other Storage

Concept Design

The concept design for any storage measure will be unique and dependant on the existing ground topography, location from watercourses, and volume of flood water to be stored.

Consideration has been given to all these parameters, along with health and safety, operation and maintenance issues, when determining the viability of this FRM Measure.

Freeboard Allowance

A freeboard allowance has been applied to the retaining structures needed as part of the concept design for any storage measure. This freeboard is to allow for model and construction uncertainty with these allowances summarised in Table B.3.

Table B-3 Freeboard applied to retaining structure for Storage

Defence Type	Freeboard – Fluvial (m)	Freeboard – Tidal (m)
Storage reservoir walls	0.220	N/A

Climate change

Where possible, an allowance has been made in the concept designs for adaptability to the HEFS. This has primarily used the sensitivity results from the hydraulic modelling exercise where allowances to account for Climate Change, have been included.

Screening of the Measure

The Storage FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

The three key parameters when determining the viability of storage as a FRM measure are:

- Technically acceptable – Will the storing and attenuation of flood water significantly reduce flood risk.
- Suitable topography – Is the topography suitable to store the desired volume of flood water (either online or offline).
- Economics - What are the likely construction and maintenance costs for such a concept design.

Storage has not been considered viable where the source of flood risk is coastal.

The economic viability of the storage FRM measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the storage FRM measure have been calculated as the PV damages of the properties protected for all return periods up to the standard of protection of the storage unit.

Modelling of viable options

When a storage FRM measure has been considered a viable option independently or in combination with other measures, hydraulic modelling of the storage feature has been carried out:

- To confirm the required dimension of the storage area; and
- To confirm the dimensions of any weir structures required to divert flow; and
- To determine the standard of protection to be provided; and
- To understand the impact of water levels upstream and downstream of the storage area.

E - Flow Diversion

Definition

The diversion of flood waters to either increase conveyance or avoid area at risk. There are different sub-types of the Flow Diversion FRM Measure, which are summarised in Table B.4.

Table B-4 Types of Flow Diversion FRM measures

E – Flow Diversion	Ei – Full Diversion
	Eii – Flood Relief Channel
	Eiii – Other Diversion/Channel

Concept Design

The parameters used for the concept designs of this FRM Measure are as follows:

- Flow diversion channels have been specified as inverted channels where the excavated fill is used to form embankments along the side of the channel to allow additional storage. The formed embankments are considered as flood defences.

Freeboard

A freeboard allowance has been applied to any associated flood defence to allow for model and construction uncertainty with these allowances summarised in Table B.5.

Table B-5 Freeboard applied to Defences

Defence Type	Freeboard – Fluvial (m)	Freeboard – Tidal (m)
Storage reservoir walls	0.220	N/A

Climate change

Where possible, the measure has been designed to be adaptable for the HEFS. This has taken the form of over-designing the channel capacity and considerations for any associated flood defences.

Screening of the Measure

The Flow Diversion FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

The three key parameters when determining the viability of flow diversion as a FRM measure are:

- Technically acceptable – Will a Flow Diversion measure reduce flood risk.
- Suitable topography – Is the topography suitable for a Flow Diversion measure i.e. is there an acceptable route.
- Economics - What are the likely construction and maintenance costs for such a concept design.

Flow Diversion has not been considered viable where the source of flood risk is coastal.

The economic viability of this measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the measure have been calculated as the cumulative PV damages of the properties protected for all return periods up to the standard of protection of the flow diversion channel.

Modelling of viable options

When a Flow Diversion FRM measure has been considered viable either independently or in combination with other measures, modelling of the flow diversion channel has been carried out;

- To confirm the flow diversion is technically feasible.
- To confirm the dimensions of the channel and any associated flood defences.
- To determine the standard of protection to be provided
- To understand the impact on water levels upstream and downstream of the diversion channel

F - Increase Conveyance

Definition

In-channel works, floodplain earthworks, removal of constraints / constrictions, increasing culvert/bridge openings, channel / floodplain clearance, etc. In-channel works included localised removal of bed material, localised widening of the channel or the construction of a two stage channel.

There are different sub-types of the Increase Conveyance FRM Measure, which are summarised in Table B.5.

Table B-5 Types of Flow Diversion FRM measures

F – Increase Conveyance	Fi – Channel Dredging
	Fii – Channel Widening
	Fiii – Structure Enhancement / Works

Concept Design

As works associated with this Measure are ‘local’, the design concepts are typically unique, but could include:

- Additional bridge arches
- Localised removal of a known constraint – either in channel or on floodplain.
- Two stage channel.
- Underpinning of structures

Climate change

Due to the nature of this FRM measure, including an allowance or adaptability for climate change may be difficult.

Consideration will be given, where possible, for example if an additional bridge arch is required it will be designed using the sensitivity results for climate change (HEFS). Also, if a two stage channel is required, the two stage channel will allow for the measure to be adaptable for the HEFS.

Screening of the Measure

The Increase Conveyance FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

In-channel works are likely to have a significant negative environmental impact. Therefore such measures have only been considered viable in locations where it will eliminate / significantly reduce the flood risk and there are no other viable options.

The two key parameters when determining the viability of Increase Conveyance as a FRM measure are:

- Technically acceptable – Will Increasing Conveyance reduce flood risk.
- Economics - What are the likely construction and maintenance costs for such a concept design.

The economic viability of this measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the increase conveyance FRM measure have been calculated as the PV damages of the properties protected for all return periods up to the standard of protection of the in channel works.

Modelling of viable options

When an increase conveyance FRM measure has been considered a viable option independently or in combination with other measure modelling of the increased conveyance is carried out if required;

- To determine if the option is technically feasible.
- To determine the standard of protection to be provided.
- To understand the impact on waterlevels upstream and downstream of the works.

The requirement of modelling has been determined based on engineering judgement.

G – Flood Defences: Construct flood defences/ Rehabilitate, improve existing defences/ Localised protection works (e.g., minor raising of existing defences / levels)

Definition

All forms of flood defence. This includes construction of new flood defences (wall and embankment) raising existing flood defences (wall and embankment), rehabilitate or improve existing flood defences or demountable defences. There are therefore different sub-types of Flood Defence Measures, which are summarised in Table B.6.

Table B-6 Types of Construct Flood Defence FRM measures

G – Construct Flood Defences	Gi – New Flood Defences
	Gii – Raise Existing Flood Defences
	Giii – Demountable Defences
	Giv – Other Defences

Concept Design

The parameters used for the concept designs of this FRM Measure are as follows:

- Embankments: at least 1m wide on top to allow for the safe constructability and maintenance of the embankments. They will have a slope of 1:3 on the river side for stability and 1;5 on the landward side to allow for safe maintenance and cutting of grass. Modification of these dimensions has been considered on a site by site basis, using engineering judgement, if the above slope and dimensions cannot be maintained due to site space constraints.
- Raising existing. In locations where raising existing flood defences is the proposed measure, the type of structure to be provided has been dictated by the existing structure.

Freeboard

Freeboard has been applied to design height of the defences to allow for model and construction uncertainty; the allowances are provided in Table B.7.

Table B-7 Freeboard applied to Defences

Defence Type	Freeboard – Fluvial (m)	Freeboard – Tidal (m)
Walls	0.22	0.22
Embankment	0.4	0.9

Climate change

Where possible, defences have been specified to be adaptable for the HEFS.

Foundations for walls have been specified to provide a foundation that can be adaptable for the HEFS if economically viable.

The width of the top of the embankments have been specified to be wide enough to provide a sufficient foundation for the height of the embankments to be increased to the HEFS level and allow for the required slopes and embankment dimensions to be maintained.

Screening of the Measure

This FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

The three key parameters when determining the viability of flood defences as a FRM measure are:

- Technically acceptable – Will a Flood Defence measure reduce flood risk.
- Suitable topography – Is the topography suitable for Flood Defences
- Economics - What are the likely construction and maintenance costs for such a concept design.

The type of flood defence selected is specified depended on site suitability and any existing defences. Demountable defences have only been considered viable in catchments where flood forecasting is a viable FRM measure. Similarly set back defences which require demountable gates or sections have only been considered viable in catchment where flood forecasting is viable.

The economic viability of this measure has been estimated at the screening of measures phase (Stage 2 of the Optioneering Assessment). The PV benefits of the Defences measure have been calculated as the PV damages of the properties protected for all return periods up to the standard of protection of the flood defences.

Modelling of viable options

When a Flood Defences FRM measure has been considered viable, either independently or in combination with other measure, modelling of the Flood Defence is carried out if required;

- To determine if the defence is technically feasible;
- To determine the required height of the defence;
- To determine the standard of protection to be provided; and
- To understand the impact of water levels upstream and downstream of the structures.

The requirement of whether modelling is needed has been determined based on engineering judgement.

H - Relocation of properties**Definition**

The relocation of properties to outside the area at risk from the 1% AEP Fluvial and 0.5% Tidal flooding.

Concept Design

Will be the demolition of existing property and construction of new, on a 'like for like' basis.

Freeboard

Using the sensitivity results, the relocation of the property will be outside the area at risk from the HEFS assessment.

Screening of the Measure

This FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

Relocation of properties is considered a less desirable measure, as it does not make any attempt to reduce the existing flood risk to the existing properties, and should only be considered a viable measure independently or in combination with other FRM measures when there is no other viable measure.

Appendix B3: Non-Structural Measures

Non-structural measures have only been considered as viable FRM measures in combination with either a baseline or structural measure. Non-structural FRM measures assist in dealing with the existing flood risk, by reducing the impact of the hazard; the exposure to the hazard remains the same. In the circumstances where neither a baseline nor structural measure is viable, non- structural measures are considered independently and if viable are recommended in the Flood Risk Management Plan.

Table B.8 below is a summary of the Applicable SSA's for the Non Structural measures. The description of these Non Structural Measures are categorised in the different SSAs.

Flood Risk Management Measure		Applicable SSA
Ref	Title	
Non Structural		
J	Flood Forecasting / Warning / Response	All
K	Public Awareness	All
L	Individual property resistance	AFA/IRR
M	Individual property resilience	AFA/IRR
N	Planning and development control measures	UoM
O	Building regulations	UoM
P	Sustainable urban drainage systems	AFA/IRR
Q	Land use management	All
R	Strategic development management	UoM
S	Additional Monitoring (rain and river level/flow gauges)	UoM

Table B-8 Different SSAs for the Non Structural FRM Measures

J – Flood Forecasting/ Warning/ Response

Definition

Installation of a flood forecasting system to predict the onset of flooding, and an accompanying warning system. To support this, the development of emergency flood response procedures are included.

Applicable SSA

FRM Measure is applicable at all SSAs.

Concept Design

The flood forecasting and warning system FRM measure has only been considered viable in a catchment when the time between baseflow water levels and peak water levels, is greater or equal to 5 hours. This time is required to allow for the

evacuation of properties and the implementation of any temporary flood defences such as demountable defences and flood gates.

Screening of the Measure

This FRM measure has only be assessed as a viable FRM measure in combination with other FRM measures, particularly targeted public awareness and preparedness campaign, individual property protection and demountable defences.

K - Targeted public awareness and preparedness campaign

Definition

Raising awareness within the communities at risk through public campaigns; these would be targeted, regular and would involve meetings, workshops and information leaflets. The purpose of the campaign is to make residents aware of what they can do to stay safe in a flood event.

Applicable SSA

FRM Measure is applicable at all SSAs.

Concept Design

The targeted public awareness and preparedness campaign has been considered a viable measure in all AFAs where there is flood risk. The extent of the campaign depends on the level of flood risk within the AFA and the FRM measures considered along with the campaign. The aim of the campaign will be to make residents in the AFA aware of the existing flood risk and existing FRM measures and the operation protocol in the case of flood forecasting or demountable defences.

Screening of the Measure

This FRM measure can be assessed as a viable FRM measure independently or in combination with other FRM measures.

L - Individual property flood resistance

Definition

Individual property flood resistance is defined as a measure to prevent flood waters entering a property e.g. flood barriers, air brick covers, building skirts and non-return valves.

Applicable SSA

FRM Measure is applicable at all SSAs.

Concept Design

Individual property flood resistance has also only been considered suitable in areas where flood depths are less than 600mm. This assumption provides 400mm freeboard on a max permissible height of flood resistance of 1m. Flood resistance has not been provided in areas where flood risk in the 1% AEP event is greater than 1m due to the following factors;

- The risk of an ordinary masonry wall collapsing when the water pressure difference indoor and outdoor goes over 1m.
- An adult cannot easily step over an obstacle of greater than 1m in height.

Screening of the Measure

This FRM measure has only be assessed as a viable FRM measure in combination with the following FRM measures:

- J – Flood Forecasting/ Warning/ Response
- K - targeted public awareness and preparedness campaign,

M - Individual property flood resilience

Definition

Individual property flood resilience is defined as wet proofing a property by changing the materials use within the building and relocating vulnerable building services, in order to mitigate the flood vulnerability of a property and/or repair works. It does not prevent flood water from entering the property.

Applicable SSA

FRM Measure is applicable at all AFA and IRR scale SSAs.

Concept Design

Flood resilience has only been considered suitable in areas where flood depths are less than 1m as it not considered feasible to relocate all building services such as sockets at levels greater than 1.4m from ground level.

Screening of the Measure

Individual property flood resilience measures can be assessed as a viable FRM measure independently or in combination with other FRM measures.

Individual property flood resilience does not require time to implement immediately prior to a flood. Therefore this FRM measure does not require Measure J – Flood Forecasting/ Warning/ Response.

Flood resilience has been considered a less desirable FRM measure, as it does not make any attempt to reduce the exposure of the properties to the flood hazard, and has only been considered a viable measure when there are no other viable measures.

N - Planning and development control measures

Definition

Zoning of land for flood risk appropriate development, prevention of inappropriate incremental development, review of existing Local Authority policies in relation to planning and development and of inter-jurisdictional co-operation within the catchment, etc.

Applicable SSA

FRM Measure is applicable at UoM Scale only. It has not been considered at AFA scale, as it is being recommended for implementation at Sub-catchment and UoM Scale.

O - Building regulations

Definition

Regulations relating to floor levels, flood-proofing, flood - resilience, sustainable drainage systems, prevention of reconstruction or redevelopment in flood-risk areas, etc

Applicable SSA

FRM Measure is applicable at Sub-catchment and UoM Scale only. It has not been considered at AFA scale, as it is being recommended for implementation at Sub-catchment and UoM Scale.

P - Sustainable Urban Drainage Systems (SUDS)

Definition

Potential sustainable urban drainage systems, which will alleviate fluvial flood risk, at a strategic level.

Applicable SSA

FRM Measure is applicable at AFA/IRR Scale only.

Q - Land use management, including creation of wetlands, riparian buffer zones, etc.

Definition

Potential management practices within the catchment to attenuate existing runoff.

Applicable SSA

FRM Measure is applicable at all SSAs.

R - Strategic development management for necessary floodplain development

Definition

Proactive integration of structural measures into development designs and zoning, regulation on developer-funded communal retention, drainage and / or protection systems, etc.

Applicable SSA

FRM Measure is applicable at Sub-catchment and UoM Scale only. It has not been considered at AFA scale, as it is being recommended for implementation at Sub-catchment and UoM Scale.

Appendix C Option Appraisal Reports - AFA Spatial Scale



Appendix C1 Option Appraisal Report – Kilrush

1. Preliminary Report: Summary of Current Flood Risk					
1.1 AFA and Watercourse Details					
AFA:	Kilrush				
Unit of Management:	27				
Primary Watercourse(s):	River Wood Kilrush Creek				
1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event					
Source of flood risk:	Fluvial	Coastal		Both	
Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		Residential	Non-Residential	Total	
	Fluvial	19	1	20	
	Coastal	0	0	0	
	Combined	19	1	20	
AFA Flood Cells:	Total Number:	1			
	Flood Cell Titles:	KIL_A			
Breakdown of properties at (combined) risk per Flood Cell:	Flood Cell Ref	Residential	Non-Residential	Total	
	KIL_A	19	1	20	
Relevant Comments:	The AFA of Kilrush is at risk of flooding from both fluvial and coastal sources. The 1% AEP fluvial event is the dominant source of risk. The flood management measures for Kilrush will be designed to manage flood risk for the 1% AEP fluvial event and will also protect the properties from the 0.5% coastal event.				
Relevant Figure Ref:	Figure 1.1 to1.3				
1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
None	None	None	None	None	None
Relevant Figure Ref:	Figure 1.1 and 1.2				
1.4 Summary of PV Damages/Potential PV Benefits					
Total PV Damages:		Uncapped		Capped	
	Fluvial	€ 257,510		€ 257,510	
	Coastal	€ 5,175		€ 5,175	
	Combined	€ 262,685		€ 262,691	
Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal Event*:	€ 181,055				
Breakdown of Max Combined Capped PV benefits for 1% Fluvial and 0.5% Coastal AEP Event per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total	
	KIL_A	€ 132,164	€ 48,891	€ 181,055	
Relevant Figure Ref:	Figure 1.3				

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	Description
High Vulnerability Properties at risk:	Nursing Home	2% AEP Fluvial Flood Extent
		Kilrush Nursing Home Retirement Village
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	Description
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	None	N/A
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	Description
Risk to Sites of Cultural Heritage:	Clare National / Recorded Monuments	1% AEP Fluvial Flood Extent
		Graveyard
		0.5% AEP Fluvial Flood Extent
		Church
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	Description
Risk to Transport Infrastructure:	National Route	50% AEP Coastal and Fluvial Flood Extents
		N67
	Regional Road	10% AEP Coastal and Fluvial Flood Extents
		R 473 Cappagh Road
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

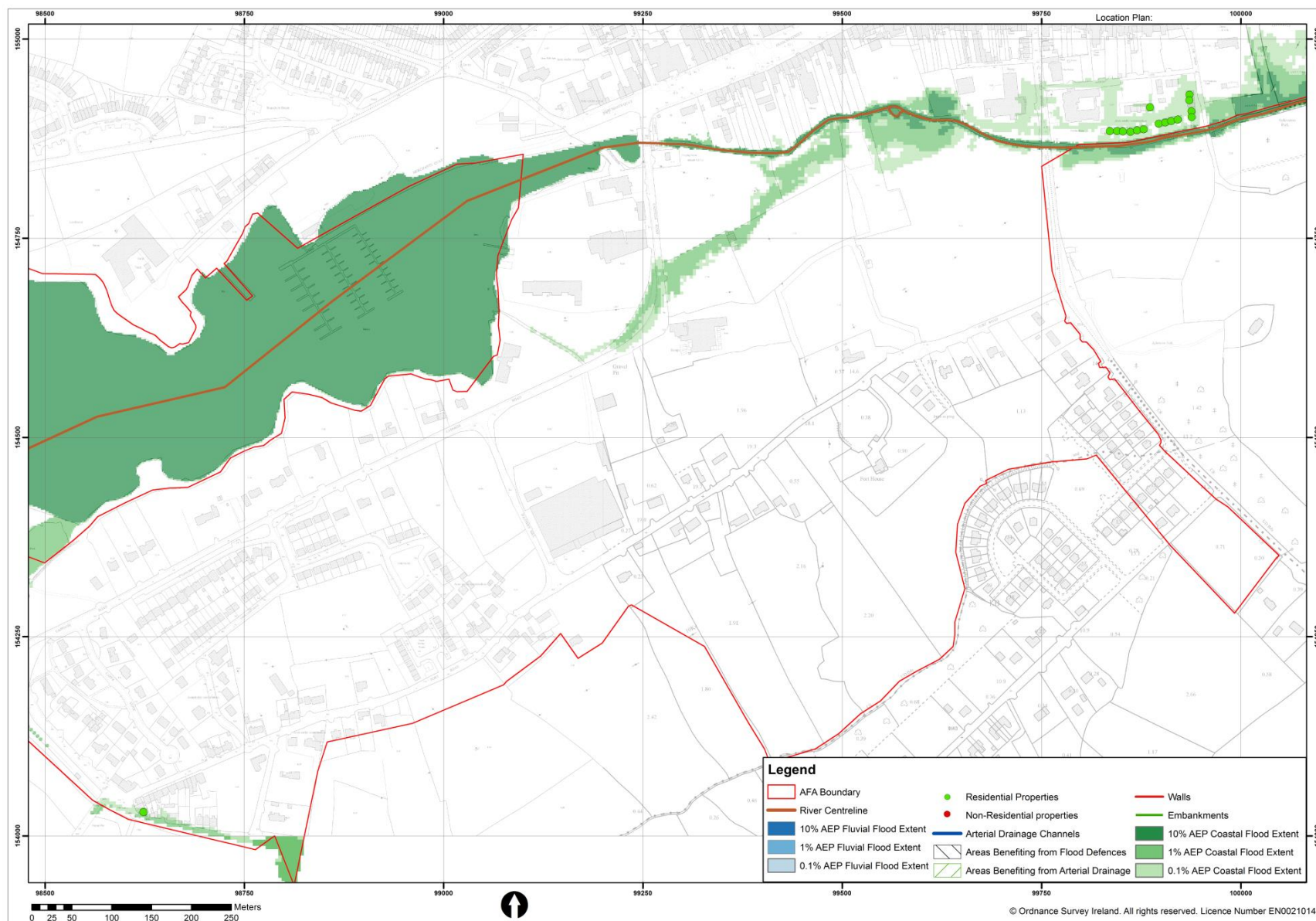


Figure 1.1 – Kilrush Coastal Flood Risk to Properties

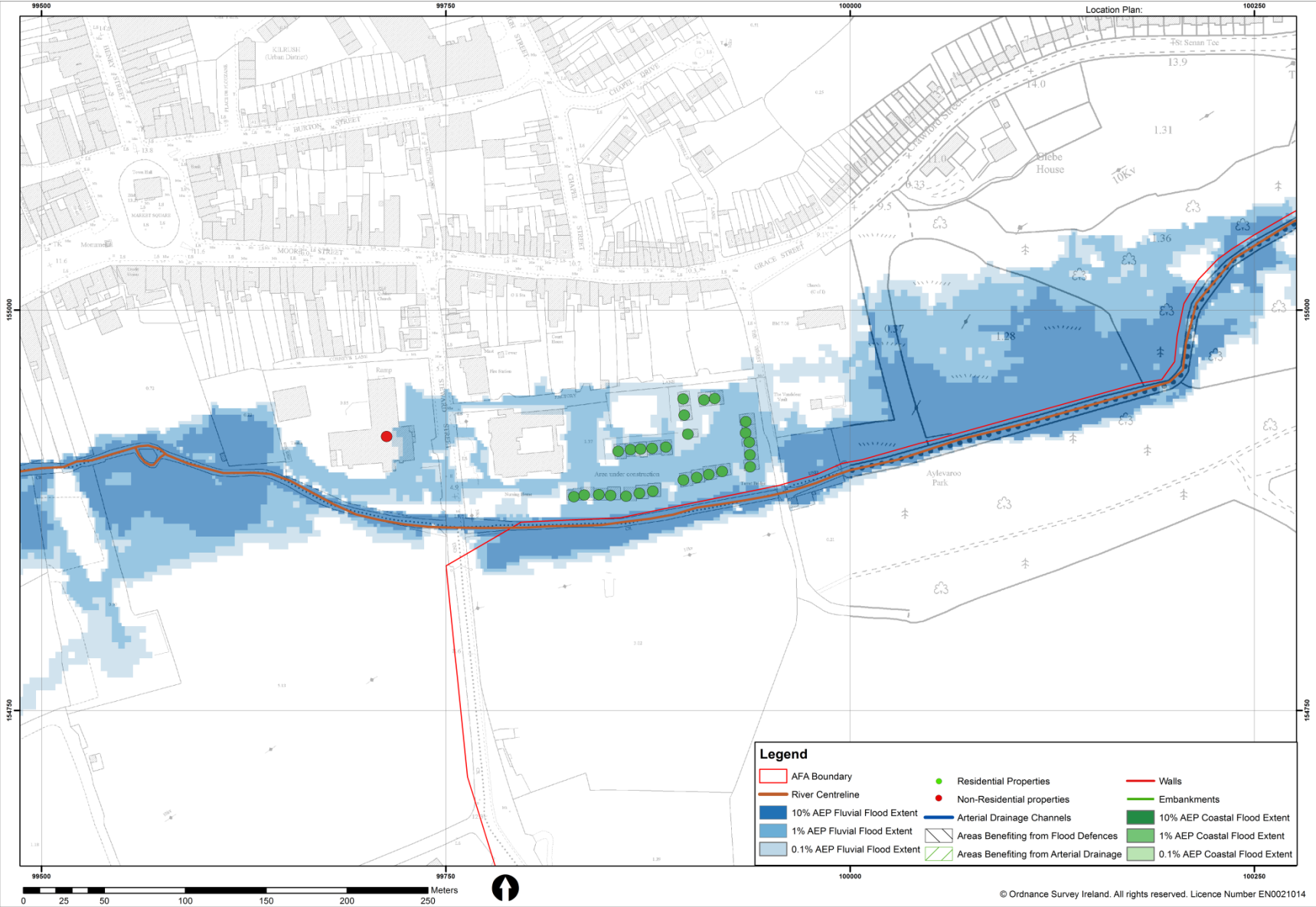


Figure 1.2 – Kilrush Fluvial Flood Risk to Properties

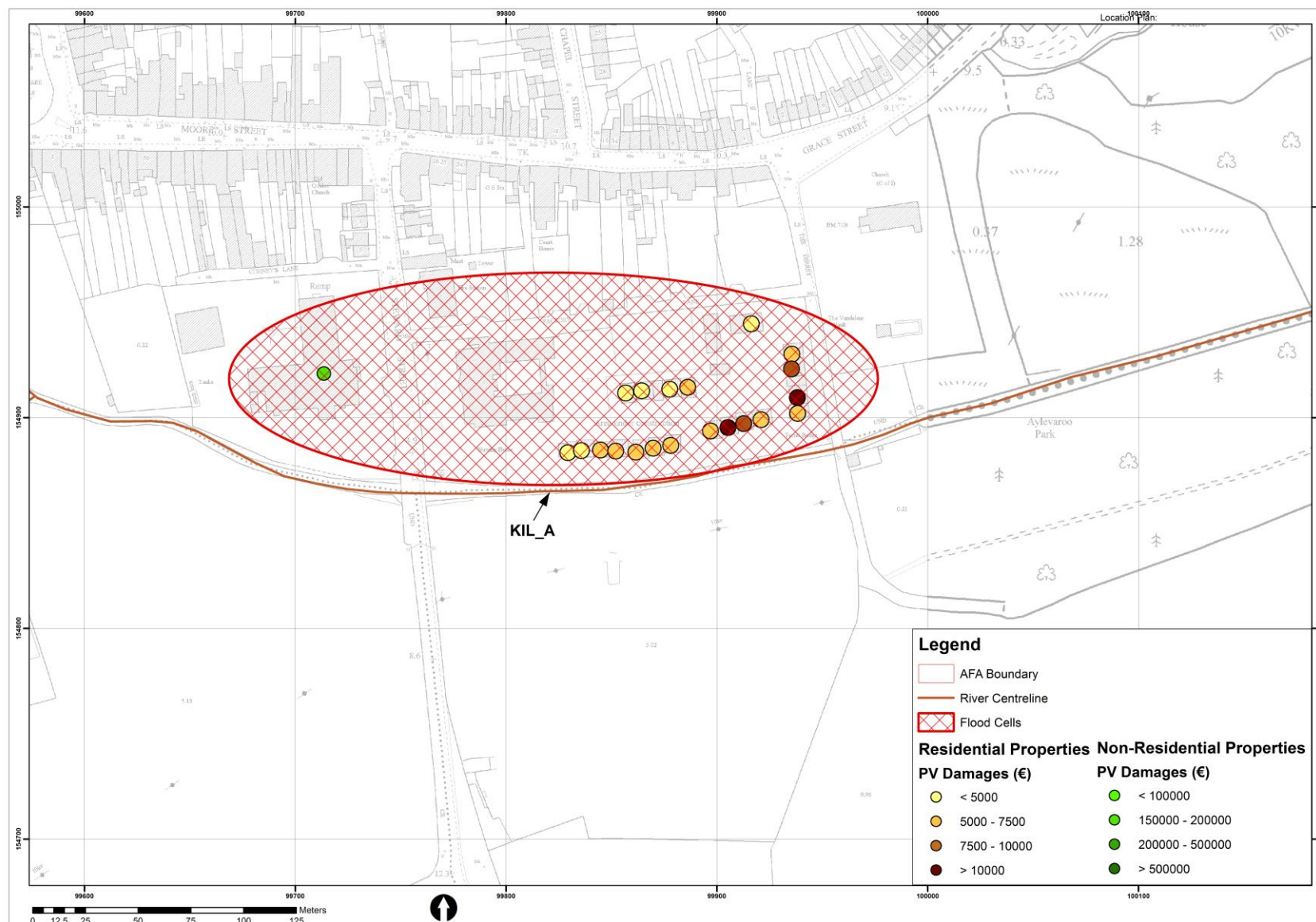


Figure 1.3 – Kilrush Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Flood Event and Flood Cells. Flood Cells are groupings of properties that are likely to be hydraulically linked.

2. STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	Screened Out
B	Existing Regime	Unviable	Viable	Viable	Viable	Viable	Screened Out
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	Screened Out
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	Screened Out
F	Increase Conveyance	Viable	Unviable	Viable	Viable	Viable	Screened Out
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	Screened In
H	Relocation of Properties	Unviable	Viable	Viable	Unviable	Viable	Screened Out
I	Other	Unviable	Unviable	Unviable	Unviable	Unviable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Unviable	Viable	Viable	Viable	Viable	Screened Out
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	Screened Out
M	Individual Property Resilience	Unviable	Viable	Viable	Viable	Viable	Screened In

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability	Not considered as there are other viable options.
		Economic	
		Environmental	
		Social	
		Cultural	
B	Existing Regime	Applicability	No existing flood risk management measures are currently undertaken in the AFA.
		Economic	
		Environmental	
		Social	
		Cultural	
C	Do Minimum	Applicability	Screened out, as the 'Do Minimum' measure would have negligible impact on the existing 1% AEP flood risk within the AFA.
		Economic	
		Environmental	
		Social	
		Cultural	
D	Storage	Applicability	Screened out. No viable storage locations were identified within the AFA.
		Economic	
		Environmental	
		Social	
		Cultural	

E	Flow Diversion	Applicability Economic Environmental Social Cultural	Screened out. No viable diversion routes were identified within the AFA.
F	Increase Conveyance	Applicability Economic Environmental Social Cultural	Screened out. Economically unviable as there are insufficient PV damages to promote a measure at this SSA. Removing and replacing Terret bridge was considered as a FRM measure as there is significant afflux at this structure. See Figure 2.1 below. This cost of replacing this bridge is estimated at approximately €500,000. With max PV Damages of €181,055 this measure is prohibitively expensive and has been screened out as economically unviable.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	Screened out. The relocation of 20 properties is neither applicable nor socially acceptable to the area.
I	Other Measures	Applicability Economic Environmental Social Cultural	No other measure are considered.
J	Forecasting / Warning / Response	Applicability Economic Environmental Social Cultural	Screened out as there are no current gauging stations in place on the watercourses in the AFA or upstream. A gauging station in Kilrush will be recommended in the FRMP to determine if a flood forecasting system could be viable in the future.
L	Individual Property Resistance	Applicability Economic Environmental Social Cultural	Screened out. Individual property resistance is not considered independently of flood forecasting, which has been deemed unviable.
M	Individual Property Resilience	Applicability Economic Environmental Social Cultural	Screened out. Economically unviable as there are insufficient PV damages to promote this measure. The cost of this measure using the OPW unit cost database is € 314,188. The total PV benefits when IPR is provided are €146,459.
2.3 Summary of 'Screened In' Measures The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.			
Structural Measures			Non-Structural Measures
G	Flood Defences		K Public Awareness

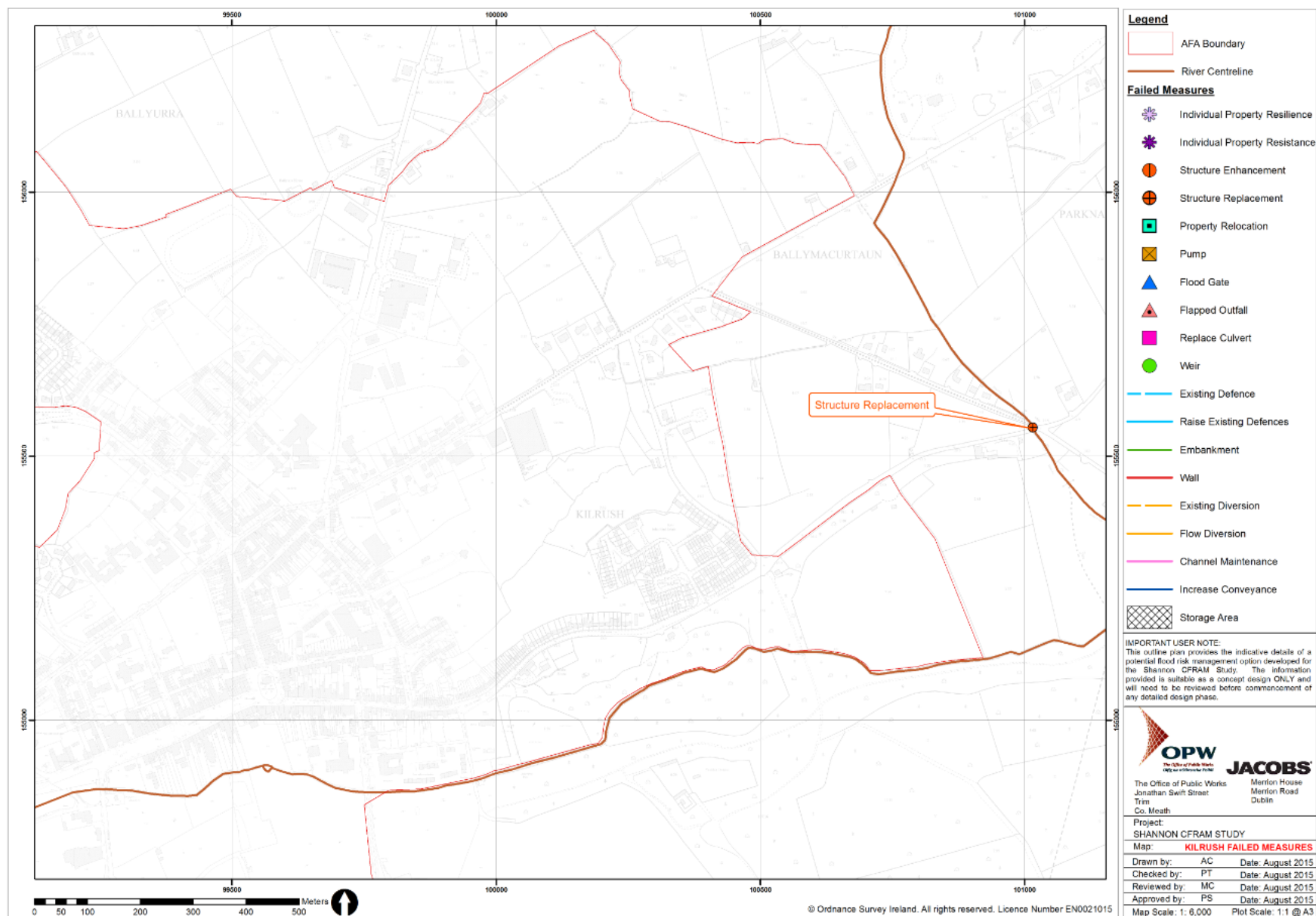


Figure 2.1- Kilrush Failed Measure

3 STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		Different composition of measures per option						
Structural Measures								
G	Flood Defences:							
Gi	New Flood Defences	✓						
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Gv	Other Defences							
Non-Structural Measures								
K	Public Awareness							
Option Reference		KIL_01						
Measures not screened out but not included in options								
Measures		Justification						
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial / 0.5% Coastal AEP standard of protection. Public Awareness does not improve the viability of the option under consideration.						

4 STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.

Option Ref:		KIL_01			
Option Measures	Baseline		None		
	Structural	Gi	Flood Defences: New Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Option Description:		<p>This option will provide a 1% Fluvial AEP design standard to all properties within the AFA and it will also protect the properties from the 0.5% coastal event.</p> <ul style="list-style-type: none"> Construct new flood defence embankments and wall along the right bank as shown in Figure 5.1 on page 11. 			
Option Development Meeting:		Date:	16/09/2015		
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting		

5 STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Development Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five stage MCA process.

Option Reference

KIL_01

Structural Measures

Gi

New Flood Defences

New flood defences as shown in Figure 5.1.

Table Reference

A summary of the outcome from the MCA is presented in the following table

Table 5.1

Table 5.1: Multi Criteria Assessment Outcome for Option KIL_01

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Kilrush		Option Ref: KIL_01
Option Measures			
Structural	Gi	Flood Defences: New Flood Defences	
Non-Structural		None	
Criteria Scores			
Technical		1100	
Economic		256	
Social		477	
Environmental		-147	
Economic Values			
Economic PV Benefits		€ 181,055	
PV Cost		€ 173,082	
NPV Benefits		€ 7,973	
Economic BCR		1.05	
Outcome Scores			
MCA PV Benefits		€ 121,531	
MCA Benefit Score		586	
MCA Benefit Score Ratio		3386.74	
Option Selection MCA		1686	
Relevant Figure		Figure 5.1	

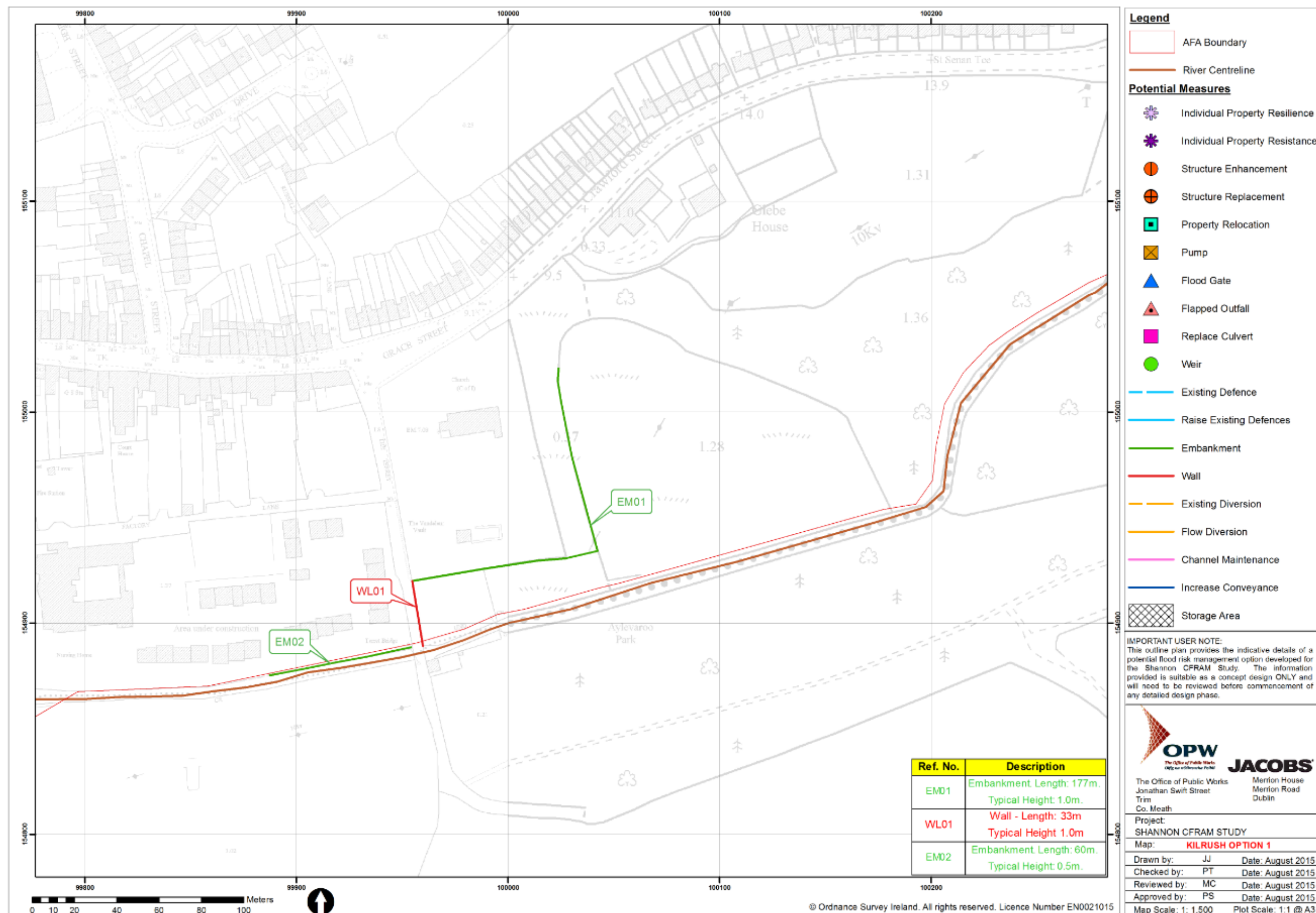


Figure 5.1 Option KIL_01

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	Option Reference and Results
	KIL_01
Criteria Scores	
Technical	1100
Economic	256
Social	477
Environmental	-147
Economic Values	
Economic PV Benefits	€ 181,055
PV Cost	€ 173,082
NPV Benefits	€ 7,973
Economic BCR	1.05
Outcome Scores	
MCA PV Benefits	€ 121,531
MCA Benefit Score	586
MCA BCR	3386.74
Option Selection MCA	1686

5.3 Recommendation of Preferred Option

It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.

Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below

Option Ref:		KIL_01			
Option Measures	Baseline	B	None		
	Structural	Gi	Flood Defences: New Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Comments		<p>This option has been designed to protect all properties at risk of flooding in the 1% AEP fluvial event as this is the most dominant source of flood risk. However, this option will also protect the properties from flooding in a 0.5% coastal AEP event. There are also properties at risk from wave overtopping within the AFA however it should be noted that this option does not negate the risk from this source.</p> <p>It will be recommended in the FRMP that a gauging station should be installed in Kilrush to confirm the current risk is as represented. Gauge data will also determine if flood forecasting is a viable measure.</p> <p>The MCA BCR is 3399.61 for KIL_01 and therefore this is the recommended emerging preferred option.</p>			

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential				
Catchment Information	Gauging Station		Catchment size (km ²)	Potential available forecast accuracy and reliability period
	Fluvial	Rainfall		
		Yes	No*	18.8
Relevant Information:	Kilrush gauging station (GS 27013) lies within the AFA			
Additional Infrastructure Recommended	Gauging Station		Other	
	Fluvial	Rainfall		
		No	No	No
Relevant Comments:	<p>As the catchment is small any potential flood forecasting early warning system would be unlikely to provide accurate and reliable predictions. Moreover, as the existing gauge is within the AFA, it is unlikely to provide significant warning time.</p> <p>Any accurate and reliable flood forecasting warning system would require installation of a series of rainfall and river gauges on the tributaries feeding into the AFA. However, it is unlikely that the forecast period would justify the introduction of such a system.</p> <p>There is little to no potential for the development of an effective flood forecasting system for Kilrush.</p>			

*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

Criteria		Objective		Global Weighting	Local Weighting	Comments	KIH_01				Option Score	Weighted Score	
							Gi	New Flood Defences					
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	None	Manageable	Gi	5.00	5.00	500	
							Negligible	Moderate / high					
							Very low	High					
							Low	Failure likely					
							Low / moderate	Unacceptable					
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	None	Manageable	Work near/in water		3.00	300	
							Negligible	Moderate / high					
							Very low	High					
							Low	Very High					
		c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.		Gi	3.00	3.00	300	
							Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.						
	Option cannot be adapted, but provides no to minor impediment to potential future interventions.												
			Option cannot be adapted, and provides moderate to major impediment to potential future interventions.										
	TECHNICAL CRITERIA SCORE											1100	
	2	Economic	a	Minimise economic risk	24	0.11		The score is calculated based on the reduction in AAD, following the full implementation of option.				3.41	9
b			Minimise risk to transport infrastructure	10	5.00		Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.				4.94	247	
c			Minimise risk to utility infrastructure	14	0.00		There is no risk to Utility infrastructure within Kilrush in the existing scenario				0.00	0	
d			Minimise risk to agriculture	12	0.02	Source of Flooding	Both Fresh & Salt Water	Area of Agricultural Land Flooded		No Change		0.00	0
						Percentage of AFA that is rural land	0.44%	Frequency & Seasonality of Flooding		No Change			
								Duration of Flooding		No Change			
								Risk to Agricultural Infrastructure		No Change			
								Flood Warning		Not Applicable			
								Agricultural Production Enhanced		No Change			
								Other (Please Specify)		Not Applicable			
ECONOMIC CRITERIA SCORE									256				
3	Social	a i)	Minimise risk to human health and life - Residents	27	1.39	Flood Depths & Velocities	Assumed low risk to life	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.				4.16	156
						Known Areas of Highly Vulnerable People	Particularly Vulnerable People						
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	5.00	Rate of Onset of flooding	Assumed 1-2 hours for evacuation	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.				3.75	319
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9	0.50	Assets of Particular Social Value	No	There is no risk to social Infrastructure & amenity assets in the existing scenario.				0.00	0
		b ii)	Minimise risk to community - Local employment	7	0.10	Asset of Particular Employment Value	No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.				3.75	3
SOCIAL CRITERIA SCORE											477		
4	Environmental	a	Support the objectives of the WFD	16	5.00	There are two WFD waterbodies within the AFA; the River Shannon Estuary North waterbody with a WFD Status of Bad and the Mouth of the Shannon with a WFD Status of unpolluted. There are no potential pollution sources within the 1% AEP Fluvial and 0.5% AEP Coastal. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies		Construction related impacts due to construction of embankments and walls adjacent to the River Shannon Estuary North waterbody. There will be reduced flooding in area with no significant polluting sources in 1% AEP Fluvial extents. Therefore, overall a short-term or intermittent impediment to the achievement of waterbody objective.				-0.50	-40
		b	Support the objectives of the Habitats Directive	10	5.00	There is one cSAC within the AFA, the Lower River Shannon [002165]. The Kilkee Reefs, Tullagher Lough & Bog, Carramore Point to Spanish Point and Islands and Carramore Dunes cSACs are all within 20 km of the AFA. There is one SPA within the AFA, River Shannon & River Fergus SPA. The Mid Clare Coast, Illaunonearaun and Stacks to Mullaghareik Mountains West Limerick Hills and Mount Eagle SPAs are all within 15 km of the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.		Potential significant effects are related to works outside the boundary of the SAC / SPA but which have hydrological links to the SAC and SPA. The embankments and wall construction are adjacent to the River Wood, which flows into the Lower River Shannon cSAC and River Shannon & River Fergus SPA (approx. 1.5km downstream of works). Potentially significant effects during construction are: - Pollution risks to the Lower River Shannon SAC and River Shannon & River Fergus SPA - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC . Therefore, there is potential for detrimental impact upon an existing cSAC / SPA site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.				-1.00	-50
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	1.00	There are no NHAs within the AFA. There are three within 20 km: Illaunonearaun, Bunaruddee Bog and Cragnashingaun Bog. There are no PNHAs within the AFA. The following are within 20 km of the AFA: Poulasherry Bay, Scattery Island, Beal Point, Cashen River Estuary, Moanveanlough Bog, Ballylongford Bay, Tarbert Bay, St. Senan's Lough, Clonderolaw Bay, Derryeeha Lough and Cloonsnaghta Lough. There is one Wildfowl Sanctuary located at Tullagher c. 6.7 km from the AFA. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no designated sites but habitats/species are likely to be present that could be affected		There are no nationally designated sites within the AFA, however, there is potential for habitats and populations of European and nationally protected species. Potentially significant effects include: - Increases in suspended sediment - Pollution risks to the River Wood - Risk of disturbance to protected species or their resting sites. - Risk of invasive species spread during proposed works - Impact to fish species includes salmon and lamprey. - Loss of fisheries habitat. Therefore, potential localised loss of or disturbance to flora/fauna.				-1.00	-5
		d	Protect, and where possible enhance, fisheries resource within the catchment	13	2.00	The waterbodies within the the AFA are not designated as a Salmonid River. The river is a low activity angling area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.		Construction works adjacent to the River Wood may impact water quality and construction of embankment adjacent to River Wood could cause access issues. Therefore, a potential short term minor impacts to fisheries habitat.				-1.00	-26
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	2.00	Part of Kilrush is a heritage landscape. The Wild Atlantic Way is within the AFA and c. 80m is subject to the 1% AEP Fluvial &/or 0.5% AEP Coastal. There is approx. 480m of Kilrush Town Walkway within the 1% AEP Fluvial &/or 0.5% AEP Coastal in the AFA. Local weighting of 2 set by professional judgement. Weighting of 2 applied where Landscape character type designated at a county level as low sensitivity and/or low value and potentially affected		Construction of embankment close to Kilrush Town Walkway may impact on the view from the walkway. However, it is noted the embankment is c. 0.5 m high. Therefore, short-term to medium term impact on moderate sensitivity landscape character/feature in the zone of visibility of the selected measure.				-2.00	-32
		f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	2.00	Kilrush is listed as a heritage town. There is 1 NIAH and no RPS within the 1% AEP Fluvial or 0.5% AEP Coastal. 0.008 km2 of ACA is within the 1% AEP Fluvial or 0.5% AEP Coastal. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.		This option reduces flooding to 1 NIAH site and reduces flooding to the setting (gardens and grounds) in the vicinity of 2 other NIAHs. There may be an impact to the setting of 3 NIAH however, due to the height of the embankment/wall this is unlikely to be significant. Therefore, overall a potential increase in level of protection for architectural features (Record of Protected Structures and NIAH) from flooding such that it is less vulnerable to flood damage.				0.50	4
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	1.00	There are 2 RMPs within or partially the 1% AEP Fluvial zone. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there is limited potential for effects on archaeological features and their setting.		This option will reduce the flooding for 1 RMP in the 1% AEP Fluvial. There may be an impact to the setting of this RMP however, due to the height of the embankment/wall this is unlikely to be significant. Therefore, overall a potential increase in the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.				0.50	2
		ENVIRONMENTAL CRITERIA SCORE											-147
Economic Values		Economic PV Benefits									€181,055		
		Cost									€173,082		
		NPV Benefits									€7,973		
		Economic BCR									1.05		
Outcome Scores		MCA PV Benefits									€121,531		
		MCA Benefit Score									586		
		MCA BCR									3386.74		
		Option Selection MCA									1686		

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has no operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has a very low health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted at a moderate impact on flood risk.
2.A	24	0.11	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of options.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of options.
2.C	14	0.00	calculated but adjusted by professional judgement	There is no risk to Utility infrastructure within Kilrush in the existing scenario.	There is no risk to Utility infrastructure within Kilrush in the existing scenario.
2.D	12	0.00	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This score is determined to be zero as the option has no effect on flood risk to agriculture.
3.A (i)	27	1.39	calculated but adjusted by professional judgement	Local weighting is calculated based on the baseline risk to residential properties. Local weighting increased by 50% as all properties are part of a retirement village.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option. The option score has been increased by 10% as highly vulnerable properties are protected.
3.A (ii)	17	5.00	calculated but adjusted by professional judgement	Local weighting is calculated based on the baseline risk to high vulnerability properties.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.
3.B (i)	9	0.50	calculated but adjusted by professional judgement	There is no risk to social Infrastructure & amenity assets in the existing scenario.	There is no risk to social Infrastructure & amenity assets in the existing scenario.
3.B (ii)	7	0.10	calculated but adjusted by professional judgement	Local weighting is calculated based on the baseline risk to local employment.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.
4.A	16	5.00	fixed	<p>There is one cSAC within the AFA, the Lower River Shannon [002165]. The Kilkee Reefs, Tullaheer Lough & Bog, Carramore Point to Spanish Point and Islands and Carramore Dunes cSACs are all within 20 km of the AFA.</p> <p>There is one SPA within the AFA, River Shannon & River Fergus SPA. The Mid-Clare Coast, Illaunonearaun and Stacks to Mullaghareik Mountains West Limerick Hills and Mount Eagle SPAs are all within 15 km of the AFA.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.</p>	<p>Construction related impacts due to construction of embankments and walls adjacent to the River Shannon Estuary North waterbody.</p> <p>There will be reduced flooding in area with no significant polluting sources in 1% AEP Fluvial extents.</p> <p>Therefore, overall a short-term or intermittent impediment to the achievement of waterbody objective.</p>
4.B	10	5.00	Professional judgement	<p>There is one cSAC within the AFA, the Lower River Shannon [002165]. The Kilkee Reefs, Tullaheer Lough & Bog, Carramore Point to Spanish Point and Islands and Carramore Dunes cSACs are all within 20 km of the AFA.</p> <p>There is one SPA within the AFA, River Shannon & River Fergus SPA. The Mid-Clare Coast, Illaunonearaun and Stacks to Mullaghareik Mountains West Limerick Hills and Mount Eagle SPAs are all within 15 km of the AFA.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.</p>	<p>Potential significant effects are related to works outside the boundary of the SAC / SPA but which have hydrological links to the SAC and SPA. The embankments and wall construction are adjacent to the River Wood, which flows into the Lower River Shannon cSAC and River Shannon & River Fergus SPA (approx. 1.5km downstream of works).</p> <p>Potentially significant effects during construction are:</p> <ul style="list-style-type: none">- Pollution risks to the Lower River Shannon SAC and River Shannon & River Fergus SPA- Disturbance to bird species within and outside the SPA- Disturbance to otter within and outside the cSAC . <p>Therefore, there is potential for detrimental impact upon an existing cSAC / SPA site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>
4.C	5	1.00	Professional judgement	<p>There are no NHAs within the AFA. There are three within 20 km: Illaunonearaun, Bunnaruddee Bog and Cragnashingaun Bog.</p> <p>There are no pNHAs within the AFA. The following are within 20 km of the AFA: Poulnasherry Bay, Scatterry Island, Beal Point, Cashen River Estuary, Moanveanlagh Bog, Ballylongford Bay, Tarbert Bay, St. Senan's Lough, Clonderolaw Bay, Derryeoha Lough and Cloonsnaghta Lough.</p> <p>There is one Wildfowl Sanctuary located at Tullagher c. 6.7 km from the AFA.</p> <p>Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no designated sites but habitats/species are likely to be present that could be affected</p>	<p>There are no nationally designated sites within the AFA, however, there is potential for habitats and populations of European and nationally protected species. Potentially significant effects include:</p> <ul style="list-style-type: none">- Increases in suspended sediment- Pollution risks to the River Wood- Risk of disturbance to protected species or their resting sites.- Risk of invasive species spread during proposed works- Impact to fish species includes salmon and lamprey.- Loss of fisheries habitat. <p>Therefore, potential localised loss of or disturbance to flora/fauna.</p>
4.D	13	2.00	Professional judgement	<p>The waterbodies within the the AFA are not designated as a Salmonid River. The river is a low activity angling area.</p> <p>Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.</p>	<p>Construction works adjacent to the River Wood may impact water quality and construction of embankment adjacent to River Wood could cause access issues.</p> <p>Therefore, a potential short term minor impacts to fisheries habitat.</p>
4.E	8	2.00	Professional judgement	<p>Part of Kilrush is a heritage landscape. The Wild Atlantic Way is within the AFA and c. 80m is subject to the 1% AEP Fluvial &/or 0.5% AEP Coastal. There is approx. 480m of Kilrush Town Walkway within the 1% AEP Fluvial &/or 0.5% AEP Coastal in the AFA.</p> <p>Local weighting of 2 set by professional judgement. Weighting of 2 applied where Landscape character type designated at a county level as low sensitivity and/or low value and potentially affected</p>	<p>Construction of embankment close to Kilrush Town Walkway may impact on the view from the walkway. However, it is noted the embankment is c. 0.5 m high.</p> <p>Therefore, short-term to medium term impact on moderate sensitivity landscape character/feature in the zone of visibility of the selected measure.</p>
4.F(i)	4	2.00	Professional judgement	<p>Kilrush is listed as a heritage town. There is 1 NIAH and no RPS within the 1% AEP Fluvial or 0.5% AEP Coastal. 0.008 km2 of ACA is within the 1% AEP Fluvial or 0.5% AEP Coastal.</p> <p>Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.</p>	<p>This option reduces flooding to 1 NIAH site and reduces flooding to the setting (gardens and grounds) in the vicinity of 2 other NIAHs. There may be an impact to the setting of 3 NIAH however, due to the height of the embankment/wall this is unlikely to be significant.</p> <p>Therefore, overall a potential increase in level of protection for architectural features (Record of Protected Structures and NIAH) from flooding such that it is less vulnerable to flood damage.</p>
4.F(ii)	4	1.00	Professional judgement	<p>There are 2 RMPs within or partially the 1% AEP Fluvial zone.</p> <p>Local weighting of 1 set by professional judgement. Weighting of 1 applied where there is limited potential for effects on archaeological features and their setting.</p>	<p>This option will reduce the flooding for 1 RMP in the 1% AEP Fluvial. There may be an impact to the setting of this RMP however, due to the height of the embankmentwall this is unlikely to be significant.</p> <p>Therefore, overall a potential increase in the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.</p>

CFRAM Programme – Option Costs for Cost Benefit Analysis						Option 1 Costs for CBA	
						Notes to CFRAM Consultants	

Appendix C2 Option Appraisal Report - Quin

1. Preliminary Report: Summary of Current Flood Risk					
1.1 AFA and Watercourse Details					
AFA:	Quin				
Unit of Management:	27				
Primary Watercourse(s):	River Rine				
1.2 Summary of Flood Risk in 1% Fluvial AEP Event					
Source of flood risk:	Fluvial	Coastal		Both	
Total Number of Properties at risk in AFA in 1% Fluvial AEP Event:		Residential	Non-Residential	Total	
	Fluvial	1	0	1	
AFA Flood Cells:	Total Number:	1			
	Flood Cell Titles:	QUI_A			
Breakdown of properties at risk per Flood Cell:	Flood Cell Ref	Residential	Non-Residential	Total	
	QUI_A	1	0	1	
Relevant Figure Ref:	Figure 1.1 and 1.2				
1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	None	None	None
Relevant Figure Ref:	Figure 1.1				
1.4 Summary of PV Damages/Potential PV Benefits					
Total PV Damages:		Uncapped		Capped	
	Fluvial	€ 17,102		€ 17,102	
Max Combined Capped Benefits for 1% Fluvial AEP Event:	€ 1,838				
Breakdown of Max Capped PV benefits per Flood Cell for 1% Fluvial AEP Event*:	Flood Cell Ref	Residential	Non-Res	Total	
	QUI_A	€ 1,838	€ 0	€ 1,838	
Relevant Comments:	Details of PV damages calculations are outlined in Appendix D.				
Relevant Figure Ref:	Figure 1.2				

*These are the maximum benefits available if a FRM option with a 1% Fluvial AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	Description
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	Description
Risk to WFD Annex IV	None	N/A
Risk to SACs	None	N/A
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	Description
Risk to Sites of Cultural Heritage:	Clare National Monuments	10% AEP Flood Extent
		Ritual site – holy well, Commons (Bunratty Upper By.)
		Hut site, Commons (Bunratty Upper By.)
	NIAH Buildings	50% AEP Flood Extent
		Quin Bridge
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	Description
Risk to Transport Infrastructure:	Regional Roads	10% AEP Flood Extent
		R469
	Local (Urban) Roads	10% AEP Flood Extent
		The Park
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

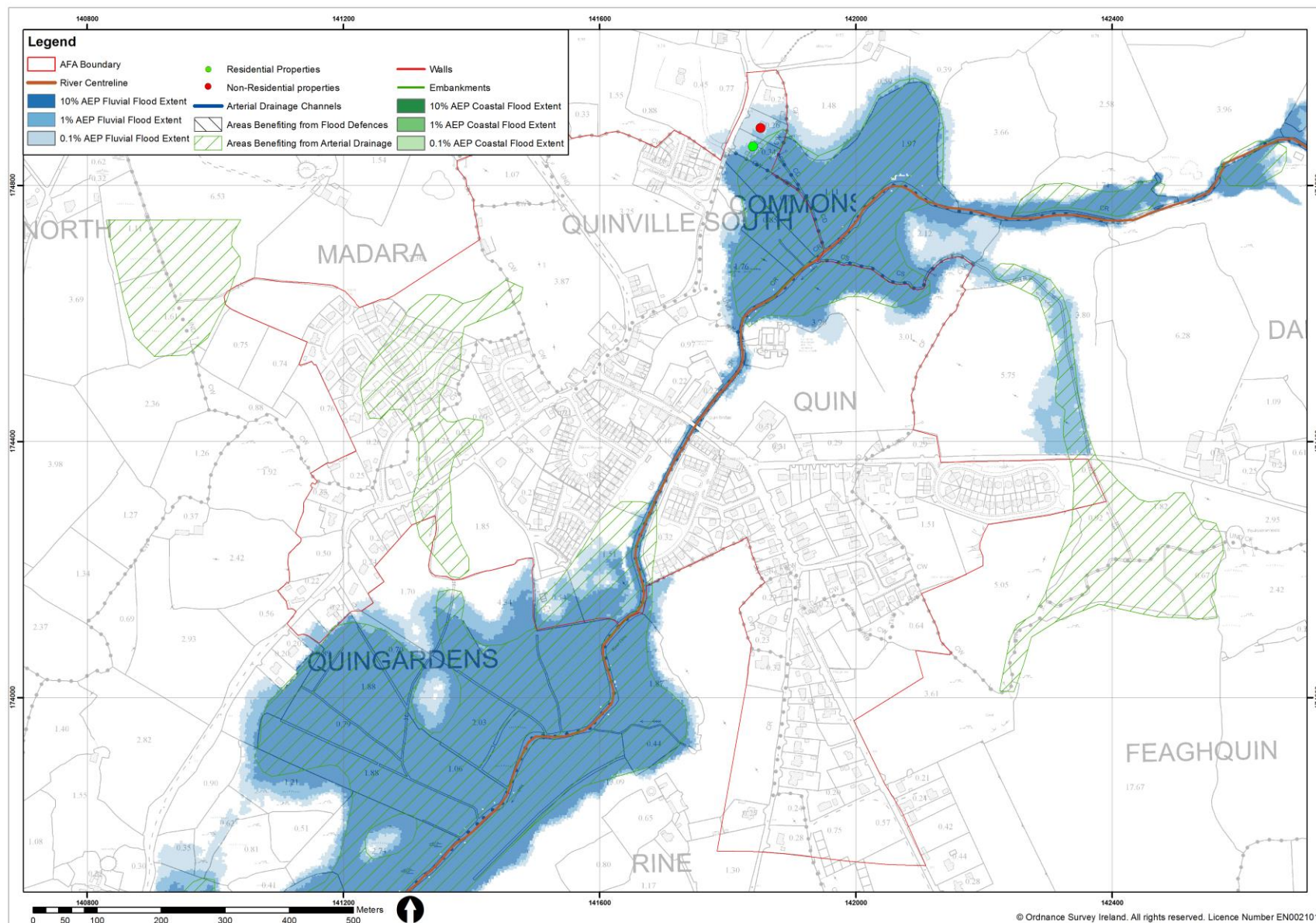


Figure 1.1 – Quin Flood Risk to Properties

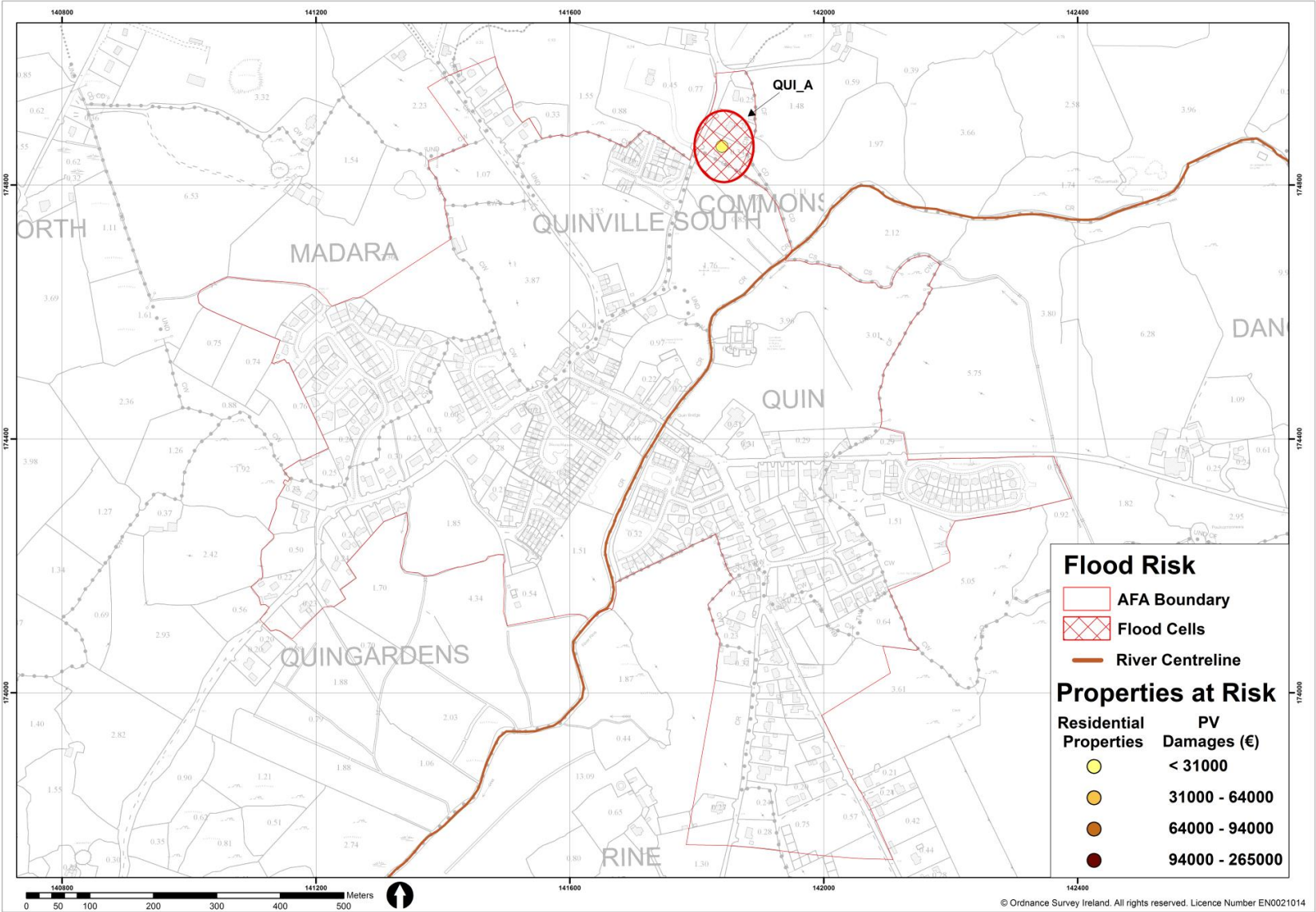


Figure 1.2 – Quin Total PV Damages for properties within 1% AEP Fluvial Flood Event and Flood Cell
Flood Cells are groupings of properties that are likely to be hydraulically linked.

2. STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Viable	Viable	Viable	Viable	Viable	Screened In
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	Screened In
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Viable	Unviable	Viable	Viable	Viable	Screened Out
E	Flow Diversion	Viable	Unviable	Viable	Viable	Viable	Screened Out
F	Increase Conveyance	Viable	Unviable	Viable	Viable	Viable	Screened Out
G	Flood Defences	Viable	Unviable	Viable	Viable	Viable	Screened Out
H	Relocation of Properties	Viable	Unviable	Viable	Viable	Viable	Screened Out
I	Other	Unviable	Unviable	Unviable	Unviable	Unviable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Unviable	Viable	Viable	Viable	Screened Out
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual Property Resistance	Viable	Unviable	Viable	Viable	Viable	Screened Out
M	Individual Property Resilience	Viable	Unviable	Viable	Viable	Viable	Screened In
2.2 Justification for Screened Out Baseline and Structural Measures							
The following provides justification on Measures with an overall viability ‘Screened Out’ categorisation.							
C	Do Minimum	Applicability	Screened out, as the ‘Do Minimum’ measure would have negligible impact on the existing 1% AEP flood risk within the AFA.				
		Economic					
		Environmental					
		Social					
		Cultural					
D	Storage	Applicability	Screened out. Considering the max PV benefits are €1,838 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote a storage FRM measure at this SSA.				
		Economic					
		Environmental					
		Social					
		Cultural					
E	Flow Diversion	Applicability	Screened out. Considering the max PV benefits are €1,838 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote a flow diversion FRM measure at this SSA.				
		Economic					
		Environmental					
		Social					
		Cultural					
F	Increase Conveyance	Applicability	Screened out. Considering the max PV benefits of €1,838 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote an increase conveyance FRM measure at this SSA.				
		Economic					
		Environmental					
		Social					
		Cultural					

G	Flood Defences	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	Screened out. A flood defence embankment was considered ,see figure 2.1. The construction cost of the embankment is estimated at € 50,000 using the cost database. Considering the max PV benefits are €1,838 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote a defence FRM measure at this SSA.
H	Relocation of Properties	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	Considering the max PV benefits are €1,838 this measure was considered economically unviable as there would be clearly insufficient PV benefits to relocate the property at risk.
I	Other Measures	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	No other measures are considered.
J	Forecasting / Warning / Response	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	Considering the max PV benefits are €1,838 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote a forecasting FRM measure at this SSA.
L	Individual Property Resistance	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	Considering the max PV benefits are €1,838 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote individual property resistance FRM measure at this SSA.
M	Individual Property Resilience	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	Considering the max PV benefits are €1,838 this measure was considered economically unviable as there would be clearly insufficient PV benefits to promote a individual property resilience FRM measure at this SSA.
2.3 Summary of 'Screened In' Measures The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.			
Baseline Measures		Non-Structural Measures	
A	Do Nothing	K	Public Awareness
B	Existing Regime		

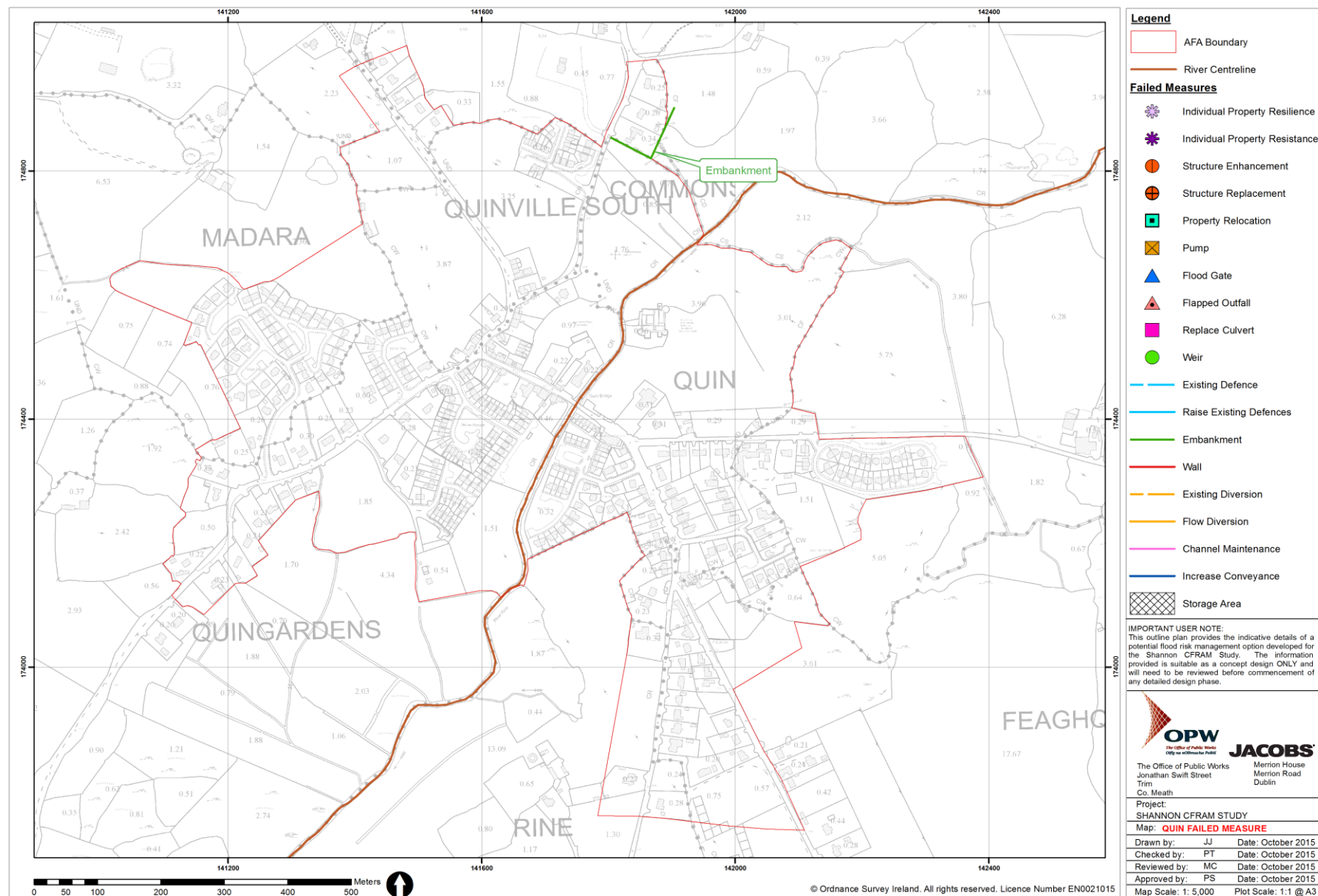


Figure 2.1 – Quin Screened Out Measure

The only viable measures identified are “Do Nothing”, “Existing Regime” and “Public Awareness”. None of these measures can form an option that will provide the required 1% AEP event design standard. Therefore, no appraisal of options or multi criteria analysis has been carried out for this AFA.

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential				
Catchment Information	Gauging Station		Catchment size (km ²)	Potential available forecast accuracy and reliability period
	Fluvial	Rainfall		
	No	No*	98	Unknown
Relevant Information:	This is determined unknown for the following reasons; <ul style="list-style-type: none">• No suitable rain gauge• No suitable gauging station			
Additional Infrastructure Recommended	Gauging Station		Other	
	Fluvial	Rainfall		
	Yes	No	No	
Relevant Comments:	As no MPW is modelled upstream of Quin it is not possible to accurately predict the potential available forecast period. A simple flood forecasting system on the River Rine has potential to provide a small flood forecasting period based on a level trigger.			

*For this assessment only 15 minute tipping bucket gauge were considered.

Appendix C3 Option Appraisal Report - Ennis

1. Preliminary Report: Summary of Current Flood Risk					
1.1 AFA and Watercourse Details					
AFA:	Ennis				
Unit of Management:	27				
Primary Watercourse(s):	Fergus (River), Fergus Minor (River), Claureen (River), Cloghleagh (Stream), Gaurus (River), Edenvale (Stream), Ballybeg (Stream), Ballybeg Lough, Rine (River)				
1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event					
Source of flood risk:	Fluvial		Coastal		Both
Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		Residential	Non-Residential	Total	
	Fluvial	180	21	201	
	Coastal	17	4	21	
	Combined	189	21	210	
AFA Flood Cells:	Total Number:	8			
	Flood Cell Titles:	ENS_A, ENS_B, ENS_C, ENS_D, ENS_E, ENS_G			
Breakdown of properties at (combined) risk per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total	
	ENS_A	3	0	3	
	ENS_B	6	0	6	
	ENS_C	3	0	3	
	ENS_D	21	13	34	
	ENS_E	144	8	152	
	ENS_F	8	0	8	
	ENS_G	4	0	4	
Relevant Comments:	The AFA of Ennis is at risk of flooding from both fluvial and coastal sources. The dominant source of flood risk within the AFA is fluvial.				
Relevant Figure Ref:	Figure 1.1 to 1.3				
1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
None	None	None	Yes	None	Yes
Relevant Comments:	There is a tidal barrage in Clarecastle which limits the tidal flood risk in the AFA of Ennis.				
Relevant Figure Ref:	Figure 1.1 and 1.2 (Tidal barrage not shown as it is outside the AFA.)				
1.4 Summary of PV Damages/Potential PV Benefits					
Total PV Damages:		Uncapped		Capped	
	Fluvial	€ 44,578,068		€ 25,230,136	
	Coastal	€ 2,495,218		€ 1,113,845	
	Combined	€ 47,073,286		€ 26,092,714	

Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal AEP Event*:	€ 21,198,474			
Breakdown of Max Combined Capped PV benefits for 1% Fluvial and 0.5% Coastal AEP Event per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total
	ENS_A	€ 3,797	€ 0	€ 3,797
	ENS_B	€ 69,146	€ 0	€ 69,146
	ENS_C	€ 8,687	€ 0	€ 8,687
	ENS_D	€ 293,431	€ 1,535,995	€ 1,829,426
	ENS_E	€ 13,287,346	€ 5,956,659	€ 19,244,005
	ENS_F	€ 22,289	€ 0	€ 22,289
	ENS_G	€ 21,124	€ 0	€ 21,124
Relevant Figure Ref:	Figure 1.3			

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	Description
High Vulnerability Properties at risk :	School	50% AEP Fluvial and Coastal Flood Extent
		St Flannan's College
		0.1% AEP Fluvial Flood Extent
		Bunscoil na Mbraithre on New Road
Social Infrastructure Assets:	Civil Defence Buildings	0.5% AEP Fluvial Flood Extent
		County Clare Civil Defence HQ, Clonroadmore Business Park
	OPW Buildings	0.1% AEP Fluvial Flood Extent
		Ennis Army Barracks
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	Description
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	Proposed Natural Heritage Areas	50% AEP Coastal and Fluvial Flood Extent
		Fergus Estuary and Inner Shannon, North Shore
	Special Areas of Conservation	50% AEP Coastal and Fluvial Flood Extent
		Lower River Shannon
	Special Protection Areas	50% AEP Coastal and Fluvial Flood Extent
		River Shannon and River Fergus Estuaries SPA
Relevant Figure Ref:	General Risk - Environment	

1.7 Risk to Cultural Heritage		
	Type	Description
Risk to Sites of Cultural Heritage:	IMA - Museum	0.1% AEP Fluvial Flood Extent
		De Valera Library and Gallery, Harmony Row
	Clare National Monuments	50% AEP Fluvial and Coastal Flood Extent
		Fulacht fia, Lifford
		Fulacht fia, Newpark (Bunratty Upper By.)
		Burnt mound, Lifford
		Redundant record, Lifford
		2 Bridges, Clonroad More
		50% AEP Coastal Flood Extent
		Ritual site – holy well, Ballaghboy (Bunratty Upper By.)
		50% AEP Fluvial Flood Extent
		4 Burnt mounds, Cahircalla More
		10% AEP Fluvial and Coastal Flood Extent
		Bridge, Clonroad Beg, Lifford
		0.1% AEP Fluvial Flood Extent
		Architectural fragment, Clonroad Beg
		Brickworks, Clareabbey
		Fulacht fia, Clareabbey
		Burnt mound, Clareabbey
		House (16 th /17 th century), Clonroad Beg
		Fulacht fia, Skehanagh
		Watermill-vertical wheeled, Cloghleagh, Lifford
	NIAH Buildings	50% AEP Fluvial and Coastal Flood Extent
		Sluice/sluice gate, Mill Road
		3 Bridges, Mill Road, Lifford
		50% AEP Fluvial Flood Extent
		Claureen Bridge, Claureen
		20% AEP Fluvial Flood Extent
		Inch Bridge, Inch More
		Latoon Bridge, Manusmore
		10% AEP Fluvial and Coastal Flood Extent
		New Bridge, Abbey Street
		1% AEP Fluvial Flood Extent
		2 Regional Houses, Bank Place
		0.5% AEP Coastal Flood Extent
		Thomond Villas barracks, Clare Commons
		0.1% AEP Fluvial Flood Extent
		Mill (water), Mill Road
		Mill (water), Cornmarket Street

		2 Regional House, Bank Place
		Abbeyfield House, Clonroad Beg
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	Description
Risk to Transport Infrastructure:	National Roads	50% AEP Fluvial and Coastal Flood Extent
		N85
	Regional Roads	50% AEP Fluvial and Coastal Flood Extent
		R352
		R458
		R469
	Local (Urban) Roads	10% AEP Fluvial Flood Extent
		Cloughleigh Road
		Wood Quay
		High Street
		Abbey Street
		Francis Street
		L4118
		L4599 (Drumcliffe Road)
		L4608
		Knockanean Road
		Kevin Barry Avenue
		1% AEP Fluvial Flood Extent
		Bank Place
		Harmony Row
		L4526 (Drumbiggle Road)
		0.1% AEP Fluvial Flood Extent
		Watery Road
		Brookville
		Parnell Street
		College Road
	Railways	50% AEP Fluvial and Coastal Flood Extent
		Ennis – Limerick Rail Line
Risk to Utility Infrastructure:	Infrastructure Point	0.1% AEP Fluvial Flood Extent
		Telephone Exchange
Relevant Figure Ref:	General Risk - Economy	

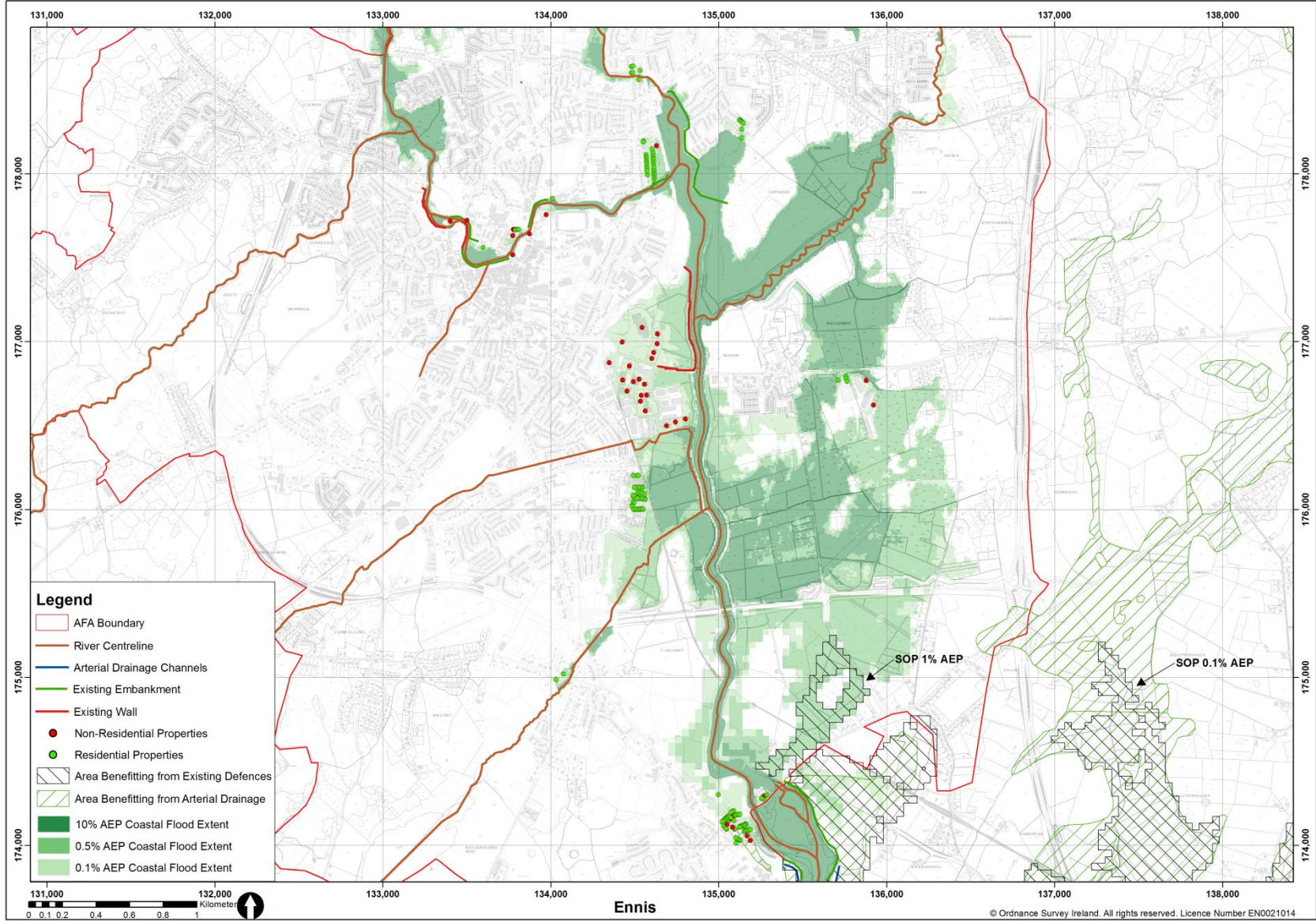


Figure 1.1 – Ennis Coastal Flood Risk to Properties

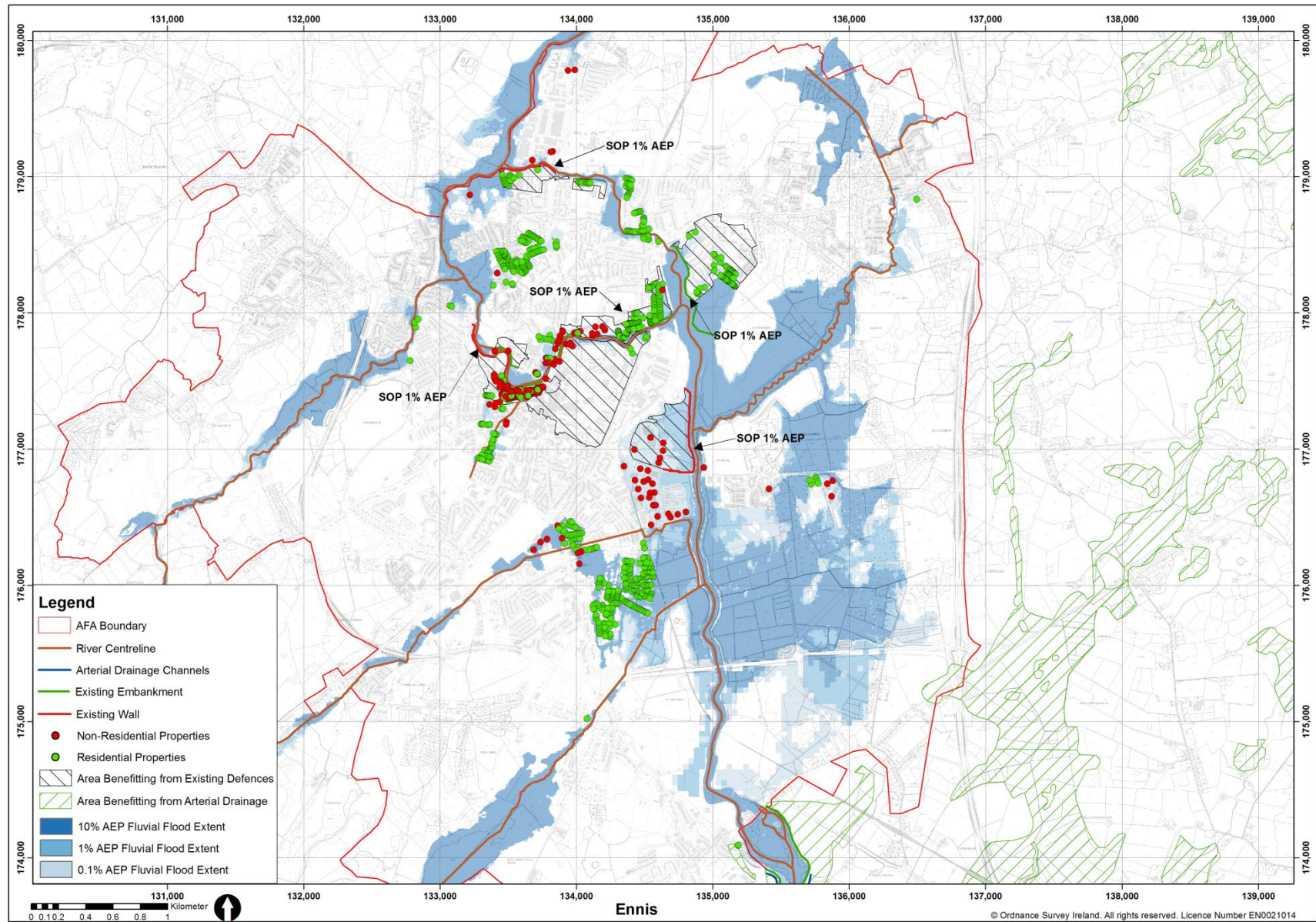


Figure 1.2 – Ennis Fluvial Flood Risk to Properties

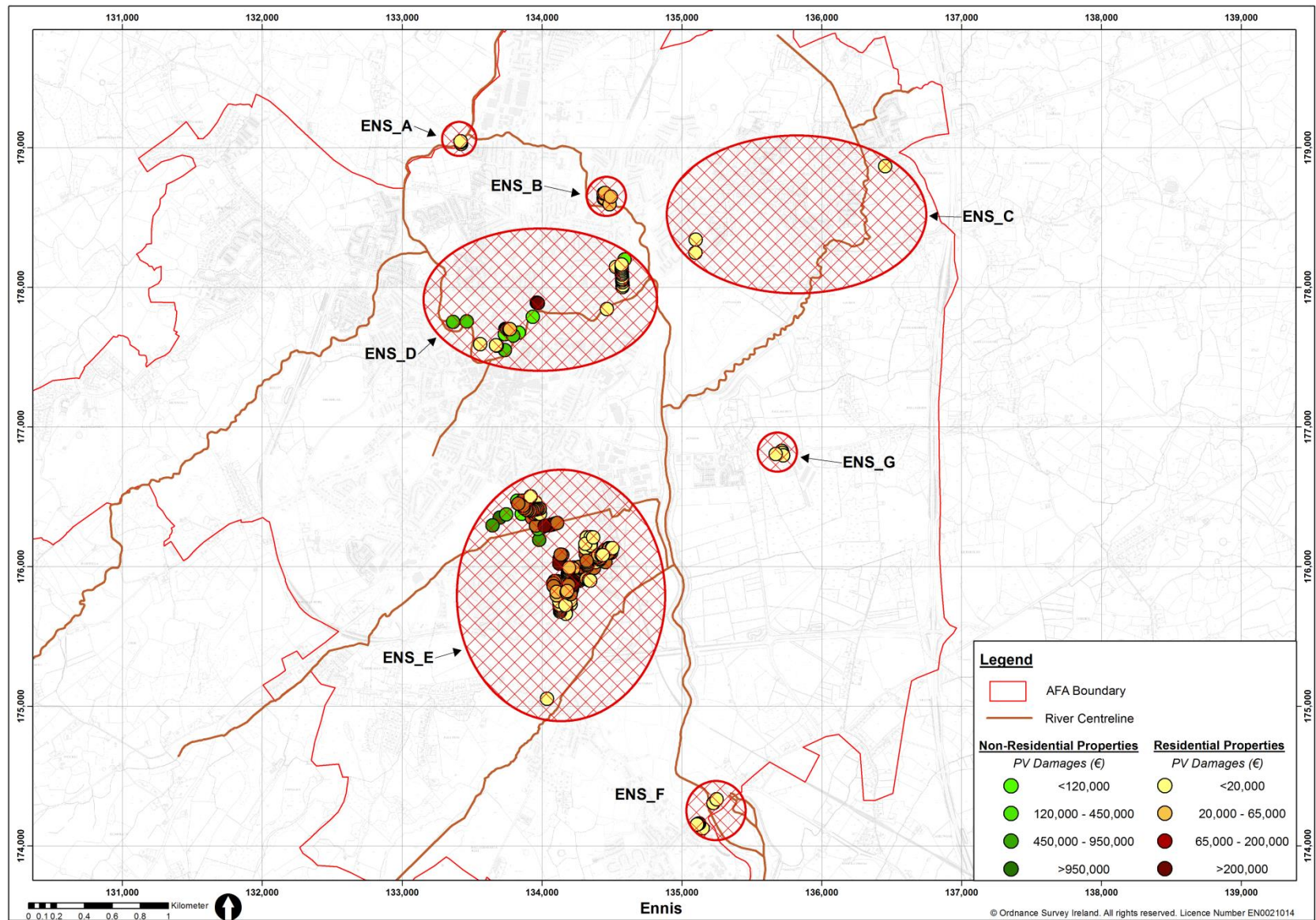


Figure 1.3 – Ennis Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Flood Event and Flood Cells. Flood Cells are groupings of properties that are likely to be hydraulically linked.

Ennis is identified as an AFA that benefits from an existing flood relief scheme and therefore no further assessment to identify potentially viable flood risk management measures or options is required through this CFRAM Study. Recommendations will be made in the FRMP that the existing flood relief scheme must be monitored and maintained.

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential				
Catchment Information	Gauging Station		Catchment size (km ²)	Potential available forecast accuracy and reliability period
	Fluvial	Rainfall		
	27003	No*	624	Unknown
	27002			
	27028			
	27026			
	27025			
	27023			
	27066			
	27060			
27064				
27065				
27068				
27001				
Relevant Information:	Corrofin Fergus (GS 27003) lies 17 km upstream of Ennis			
	Ballycorey (GS 27002) lies within the AFA			
	Gaurus Bridge (GS 27028) lies within the AFA			
	Tulla Road Bridge (GS 27026) lies within the AFA			
	Knox's Bridge (GS 27025) lies within the AFA			
	Victoria Bridge (GS 27023) lies within the AFA			
	Ennis Bridge (GS 27066) lies within the AFA			
	Doora Bridge (GS 27060) lies within the AFA			
	Clarecastle U/S (GS 27064) lies within the AFA			
	Clarecastle Barrage D/S (GS 27065) lies within the AFA			
	Clarecastle Bridge (GS 27068) lies within the AFA			
	Inch Bridge Claureen (GS 27001) lies 1.8 km upstream of Ennis			
Additional Infrastructure Recommended	Gauging Station		Other	
	Fluvial	Rainfall		
	Yes	Yes	No	
Relevant Comments:	Corrofin Fergus (GS 27003) lies 17 km upstream of Ennis on the River Fergus. GS 27003 only represents 27% of the total catchment of Ennis. As no MPW is modelled upstream of Ennis it is not possible to accurately predict the potential available forecast period for the River Fergus. A number of tributaries also join the River Fergus downstream of this gauge which complicates any flood forecasting system. An accurate and reliable flood forecasting warning system for the River Fergus would require a series of rainfall gauges feeding into a rainfall-runoff model and river gauges. Inch Bridge Claureen (GS 27001) lies 1.8 km upstream of Ennis on the Claureen River. As the catchment of this watercourse is small any potential flood forecasting early warning system would be unlikely to provide accurate and reliable predictions. Moreover, it is unlikely to provide significant warning time.			

	<p>The gauges within the AFA are unsuitable for flood forecasting as the forecast period is too small.</p> <p>It must be noted that Ennis is tidally influenced and an understanding of the coincidence of peak tide level would have to be included in any fluvial flood forecasting system. Tidal flooding could be predicted by a simple forecasting system.</p>
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*For this assessment only 15 minute tipping bucket gauge were considered.

Appendix C4 Option Appraisal Report - Shannon

1. Preliminary Report: Summary of Current Flood Risk					
1.1 AFA and Watercourse Details					
AFA:	Shannon				
Unit of Management:	27				
Primary Watercourse(s):	Ballycasey Creek, Unnamed River, Ballycasey Tributary, Urian Beg, Drumgeely Creek, Unnamed Tributary				
1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event					
Source of flood risk:	Fluvial		Coastal		Both
Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		Residential	Non-Residential	Total	
	Fluvial	90	49	139	
	Coastal	6	37	43	
	Combined	91	52	143	
AFA Flood Cells:	Total Number:	3			
	Flood Cell Titles:	SHN_A, SHN_B, SHN_C			
Breakdown of properties at (combined) risk per Flood Cell:	Flood Cell Ref	Residential	Non-Residential	Total	
	SHN_A	0	10	10	
	SHN_B	91	4	95	
	SHN_C	0	38	38	
Relevant Comments:	It should be noted that there are significant numbers of properties at risk in the 0.1% AEP coastal event. This risk and the proposed mitigation measures are discussed in the sub-catchment Shannon document.				
Relevant Figure Ref:	Figure 1.1, 1.2, and 1.3				
1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
None	None	None	Yes	None	None
Relevant Figure Ref:	Figure 1.1 to 1.3				
1.4 Summary of PV Damages/Potential PV Benefits					
Total PV Damages:		Uncapped		Capped	
	Fluvial	€ 40,281,333		€ 26,545,337	
	Coastal	€ 40,677,601		€ 29,826,398	
	Combined	€ 80,943,162		€ 46,555,772	
Max Combined Capped Benefits for Design SOP*:	€ 33,480,442				
Breakdown of Max Combined Capped PV benefits per Flood Cell for 1% Fluvial and 0.5% Coastal AEP Event:	Flood Cell Ref	Residential	Non-Res	Total	
	SHN_A	€ 0	€ 4,690,596	€ 4,690,596	
	SHN_B	€ 624,656	€ 6,727	€ 631,383	
	SHN_C	€ 0	€ 28,158,463	€ 28,158,463	
Relevant Figure Ref:	Figure 1.3				

*These are the maximum benefits available if a FRM option with a 1% Fluvial/ 0.5% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	Description
High Vulnerability Properties at risk:	School	0.1% AEP Coastal Flood Extent
		2 No. National Schools
		Naomh Tola National School
		Shannon Comprehensive School
Social Infrastructure Assets:	OPW Building	0.1% AEP Coastal Flood Extent
		Shannon Driving Test Centre
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	Description
Risk to WFD Annex IV:	Licensed IPPC Facilities	0.1% AEP Coastal Flood Extent
		Lufthansa Technik Painting Shannon Limited
		Element Six
		Heraeus Metal Processing Limited
		UCB Manufacturing Ireland Limited
Risk to SACs:	Proposed National Heritage Areas	20% AEP Fluvial Flood Extent
		Fergus Estuary and Inner Shannon, North Shore
	Special Area of Conservation	20% AEP Fluvial Flood Extent
		Lower River Shannon
	Special Protection Area	20% AEP Fluvial Flood Extent
		River Shannon and River Fergus Estuaries SPA
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	Description
Risk to Sites of Cultural Heritage:	Clare National Monuments	10% AEP Fluvial Flood Extent
		Enclosure, Ballycasey Beg
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	Description
Risk to Transport Infrastructure:	National Road	0.1% AEP Coastal Flood Extent
		N19
	Regional Road	20% AEP Fluvial Flood Extent
		R472
	Local (Urban) Road	20% AEP Fluvial Flood Extent
		Drumgeely Road
		Ballycasey Grove

		10% AEP Fluvial Flood Extent
		Bothar na Luachra
		5% AEP Fluvial Flood Extent
		Tullyvaraga Road
		0.1% AEP Coastal Flood Extent
		Gort Road
		Bóthar Sioda
		Bealach Brí
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

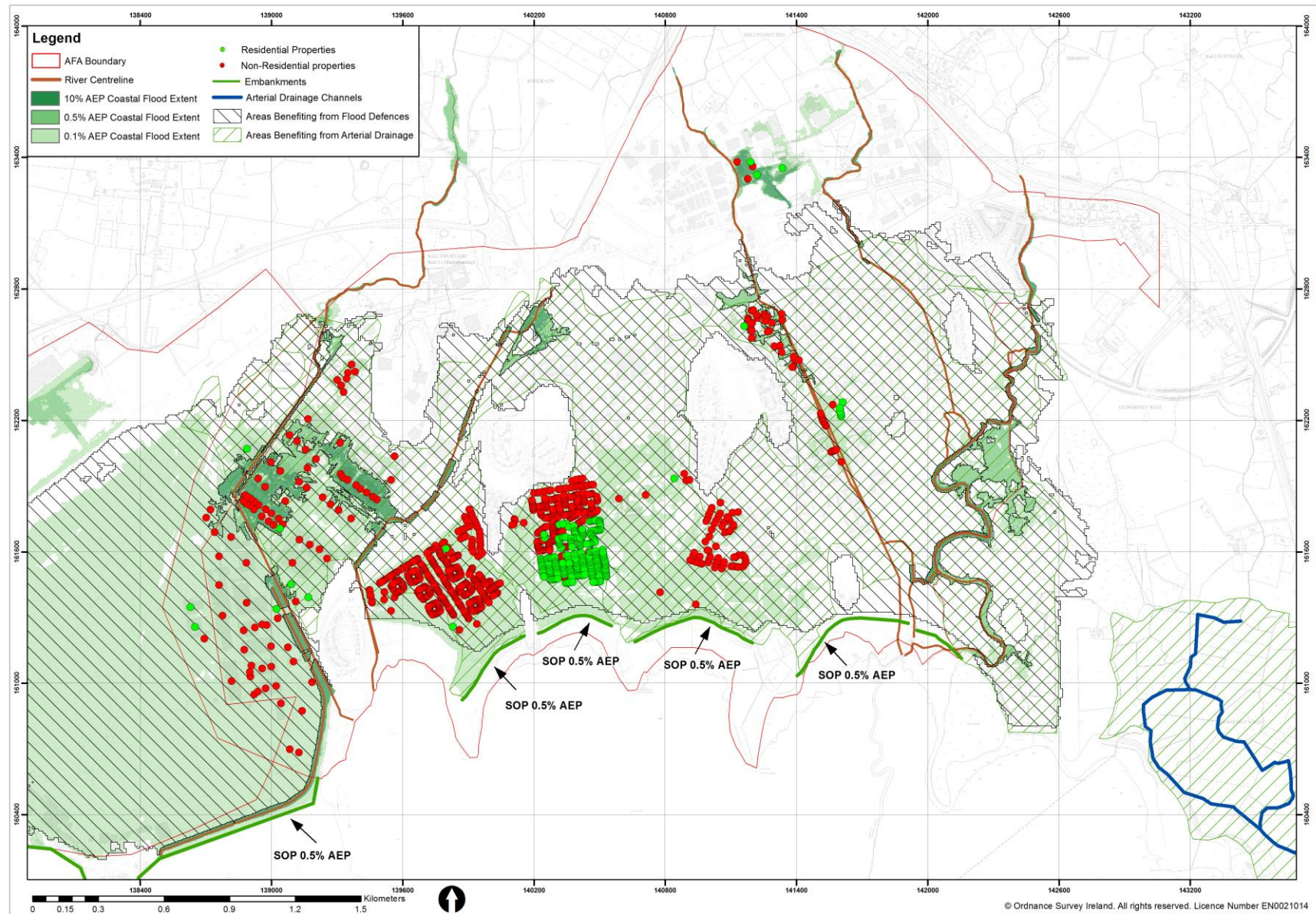


Figure 1.1 – Shannon Coastal Flood Risk to Properties

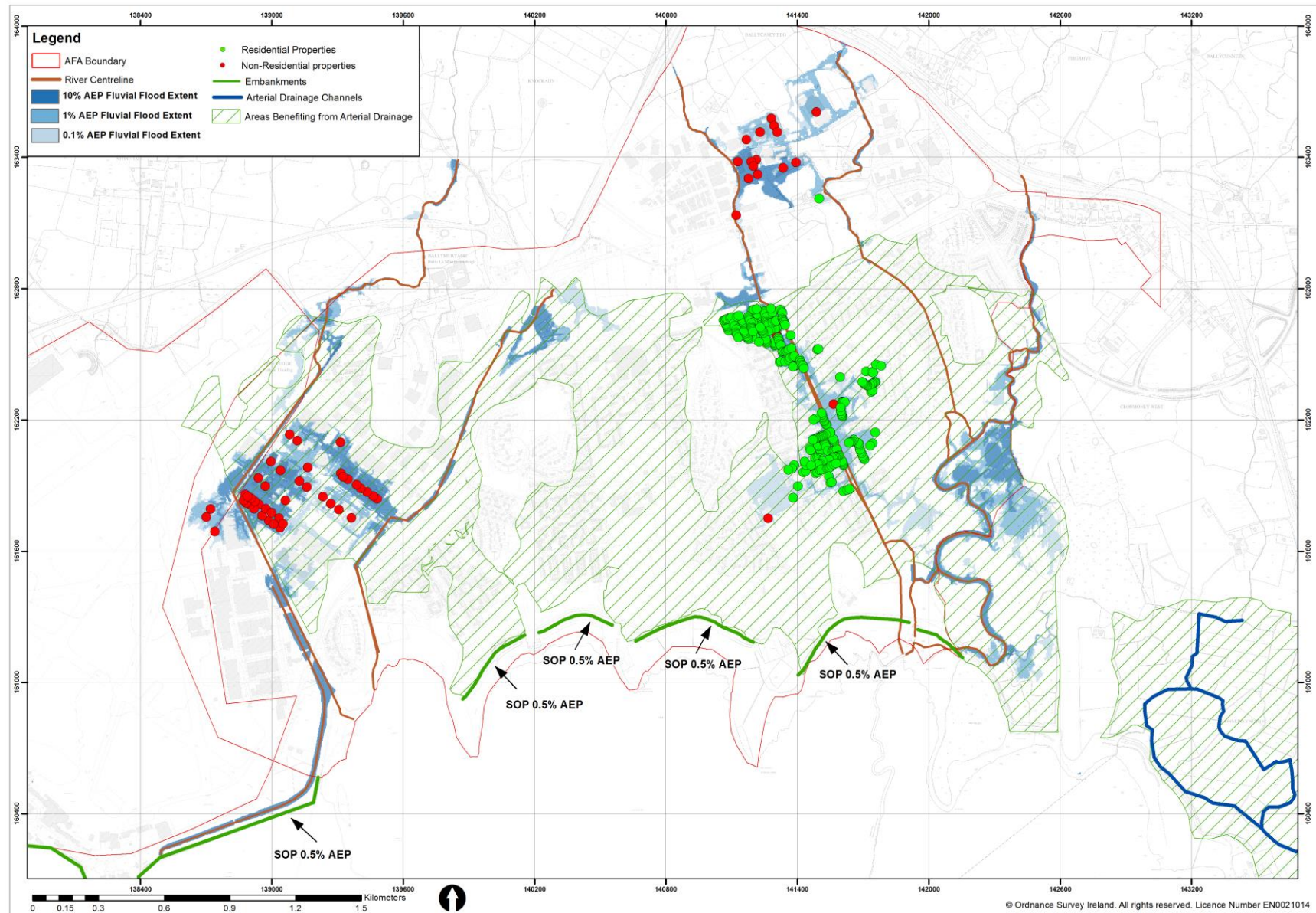


Figure 1.2 – Shannon Fluvial Flood Risk to Properties

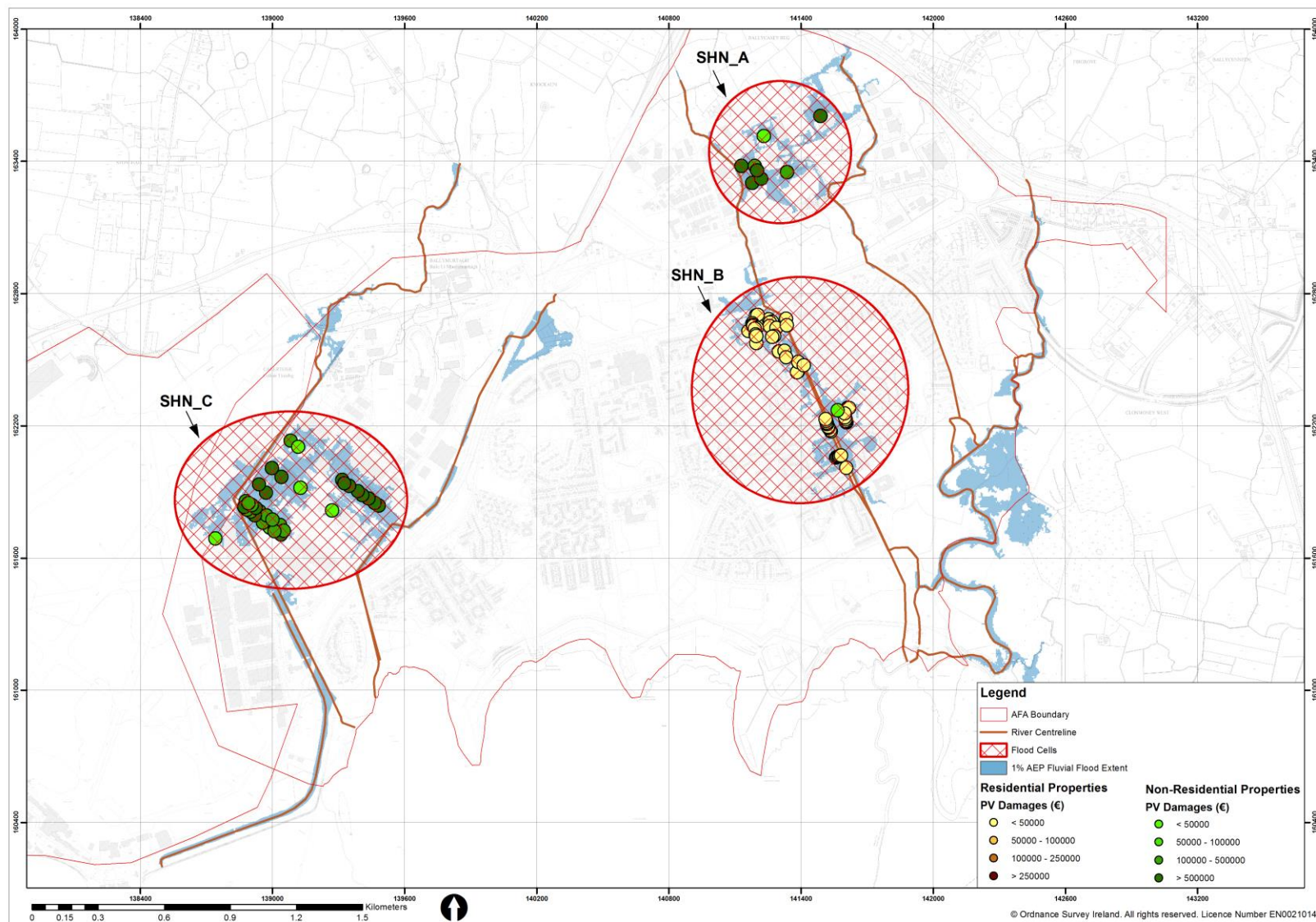


Figure 1.3 – Shannon Town Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Flood Event and Flood Cells. Flood Cells are groupings of properties that are likely to be hydraulically linked.

2 STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	Screened Out
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	Screened In
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Viable	Viable	Viable	Viable	Viable	Screened In
E	Flow Diversion	Viable	Viable	Viable	Viable	Viable	Screened In
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	Screened In
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	Screened In
H	Relocation of Properties	Unviable	Viable	Viable	Unviable	Viable	Screened Out
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	Screened In
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual Property Resistance	Viable	Viable	Viable	Viable	Viable	Screened In
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	Screened In
2.2 Justification for Screened Out Baseline and Structural Measures							
The following provides justification on Measures with an overall viability 'Screened Out' categorisation.							
A	Do Nothing	Applicability Economic Environmental Social Cultural	Not considered as there are other viable options.				
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact to the existing flood risk.				
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	Screened out. The relocation of 143 properties is neither applicable nor socially acceptable to the area				
I	Other Measures	Applicability Economic Environmental Social Cultural	No other measures have been identified.				

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		Non-Structural Measures	
B	Existing Regime	J	Flood Forecasting / Warning / Response
Structural Measures		K	Public Awareness
D	Storage	L	Individual Property Resistance
E	Flow Diversion	M	Individual Property Resilience
F	Increase Conveyance		
G	Flood Defences		

3 STAGE 3: Selection of Options								
3.1 Consideration of Options								
The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.								
Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.								
Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓	✓					
Structural Measures								
D	Storage							
Di	Online Storage	✓	✓					
Dii	Offline Storage							
Diii	Other Storage	✓	✓					
E	Flow Diversion							
Ei	Full Diversion							
Eii	Flood Relief Channel	✓						
Eiii	Other Diversion							
F	Increase Conveyance							
Fi	Channel Dredging							
Fii	Channel Widening							
Fiii	Structure Enhancement/Works	✓	✓					
G	Flood Defences							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response							
K	Public Awareness							
L	Individual Property Resistance							
M	Individual Property Resilience							
Option Reference		SHN_01	SHN_02					
Measures not screened out but not included in options								
Measures		Justification						
J	Flood Forecasting / Warning / Response	Flood Forecasting was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 1% fluvial/0.5% coastal AEP standard of protection.						

		Flood Forecasting does not improve the viability of the options under consideration.
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 1% fluvial/0.5% coastal AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.
L	Individual Property Resistance	Individual property resistance was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 1% fluvial/ 0.5% coastal AEP standard of protection. Individual property resistance does not improve the viability of the options under consideration.
M	Individual Property Resilience	Individual property resilience was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 1% fluvial/ 0.5% Coastal AEP standard of protection. Individual property resilience does not improve the viability of the options under consideration.

4 STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.

Option Ref:		SHN_01			
Option Measures	Baseline	B	Existing Regime		
	Structural	Di	Online Storage		
		Diii	Other Storage		
		Eii	Flood Relief Channel		
		Fiii	Structure Enhancement/Works		
		Gi	New Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Option Description:		<p>This option will provide a 1% fluvial AEP design standard to all properties within the AFA and it will also protect the properties from the 0.5% coastal event.</p> <ul style="list-style-type: none"> Construct new flood defence walls and embankments as shown in Figure 5.1. Diversion of flow, from Unnamed River to a natural storage area located between Unnamed River and Ballycasey Creek, north of the R471 Road (see Figure 5.1). Natural online storage areas, balancing pond and natural flood plain areas to be located as shown on Figure 5.1. Replace existing 90m culvert as shown on Figure 5.1. Replace existing 35m culvert as shown on Figure 5.1. Maintain existing coastal defences. 			
Option Development Meeting:		Date:	16/09/2015		
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting		

Option Ref:		SHN_02				
Option Measures	Baseline	B	Existing Regime			
	Structural	Di	Online Storage			
		Diii	Other Storage			
		Fiii	Structure Enhancement/Works			
		Gi	New Flood Defences			
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience	
Option Description:		<p>This option will provide a 1% fluvial AEP Design standard to all properties within the AFA and it will also protect the properties from the 0.5% coastal event.</p> <ul style="list-style-type: none">• Construct new flood defence walls and embankments as shown in Figure 5.2.• Natural online storage areas, balancing pond and natural flood plain areas to be located as shown on Figure 5.2.• Replace existing 90m culvert as shown on Figure 5.2.• Replace existing 1500m culvert as shown on Figure 5.2.• Replace existing 35m culvert as shown on Figure 5.2.• Maintain existing coastal defences.				
Option Development Meeting:		Date:	16/09/2015			
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting			

5 STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Development Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five stage MCA process.

Option Reference		SHN_01	SHN_02
Baseline			
B	Existing Regime	Maintain existing coastal defences.	Maintain existing coastal defences.
Structural Measures			
Di	Online Storage	Natural storage areas to be located as shown on Figure 5.1.	Natural storage areas to be located as shown on Figure 5.2.
Diii	Other Storage	Balancing pond and natural flood plain areas to be located as shown on Figure 5.1.	Balancing pond and natural flood plain areas to be located as shown on Figure 5.2.
Eii	Flood Relief Channel	Diversion of flow, from Unnamed River to a natural storage area located between Unnamed River and Ballycasey Creek, north of the R471 Road (see Figure 5.1).	
Fiii	Structure Enhancement/Works	Replace existing 90m culvert as shown on Figure 5.1. Replace existing 35m culvert as shown on Figure 5.1.	Replace existing 90m culvert as shown on Figure 5.2. Replace existing 1500m culvert as shown on Figure 5.2. Replace existing 35m culvert as shown on Figure 5.2.
Gi	New Flood Defences	Construct new flood defence walls and embankments as shown in Figure 5.1.	Construct new flood defence walls and embankments as shown in Figure 5.2.
Table Reference			
A summary of the outcome from the MCA is presented in the following table		Table 5.1	Table 5.2

Table 5.1: Multi Criteria Assessment Outcome for Option SHN_01

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Shannon		Option Ref: SHN_01
Option Measures			
Baseline	B	Existing Regime	
Structural	Di	Online Storage	
	Diii	Other Storage	
	Eii	Flood Relief Channel	
	Fiii	Structure Enhancement/Works	
	Gi	New Flood Defences	
Non-Structural	N/A		
Criteria Scores			
Technical		800	
Economic		748	
Social		505	
Environmental		-485	
Economic Values			
Economic PV Benefits		€ 33,480,442	
PV Cost		€6,003,635	
NPV Benefits		€27,476,807	
Economic BCR		5.58	
Outcome Scores			
MCA PV Benefits		€ 22,652,947	
MCA Benefit Score		768	
MCA Benefit Score Ratio		127.89	
Option Selection MCA		1568	
Relevant Figure		Figure 5.1	

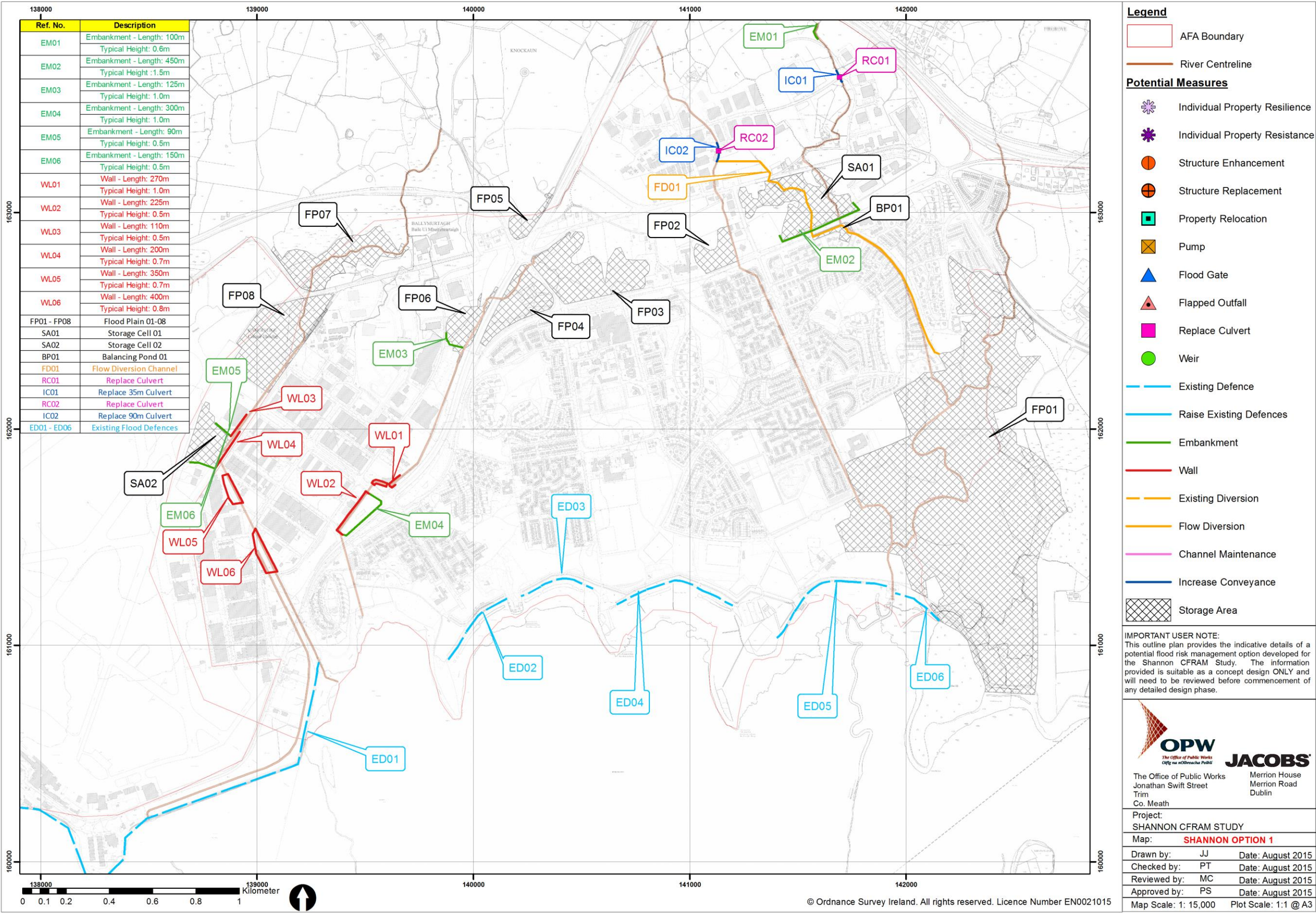


Figure 5.1 Option SHN_01

Table 5.1: Multi Criteria Assessment Outcome for Option SHN_02

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Shannon		Option Ref: SHN_02
Option Measures			
Baseline	B	Existing Regime	
Structural	Di	Online Storage	
	Diii	Other Storage	
	Fiii	Structure Enhancement/Works	
	Gi	New Flood Defences	
Non-Structural	N/A		
Criteria Scores			
Technical		560	
Economic		748	
Social		505	
Environmental		-512	
Economic Values			
Economic PV Benefits		€ 33,480,442	
PV Cost		€21,164,137	
NPV Benefits		€12,316,305	
Economic BCR		1.58	
Outcome Scores			
MCA PV Benefits		€ 22,652,947	
MCA Benefit Score		741	
MCA Benefit Score Ratio		35.00	
Option Selection MCA		1301	
Relevant Figure		Figure 5.2	

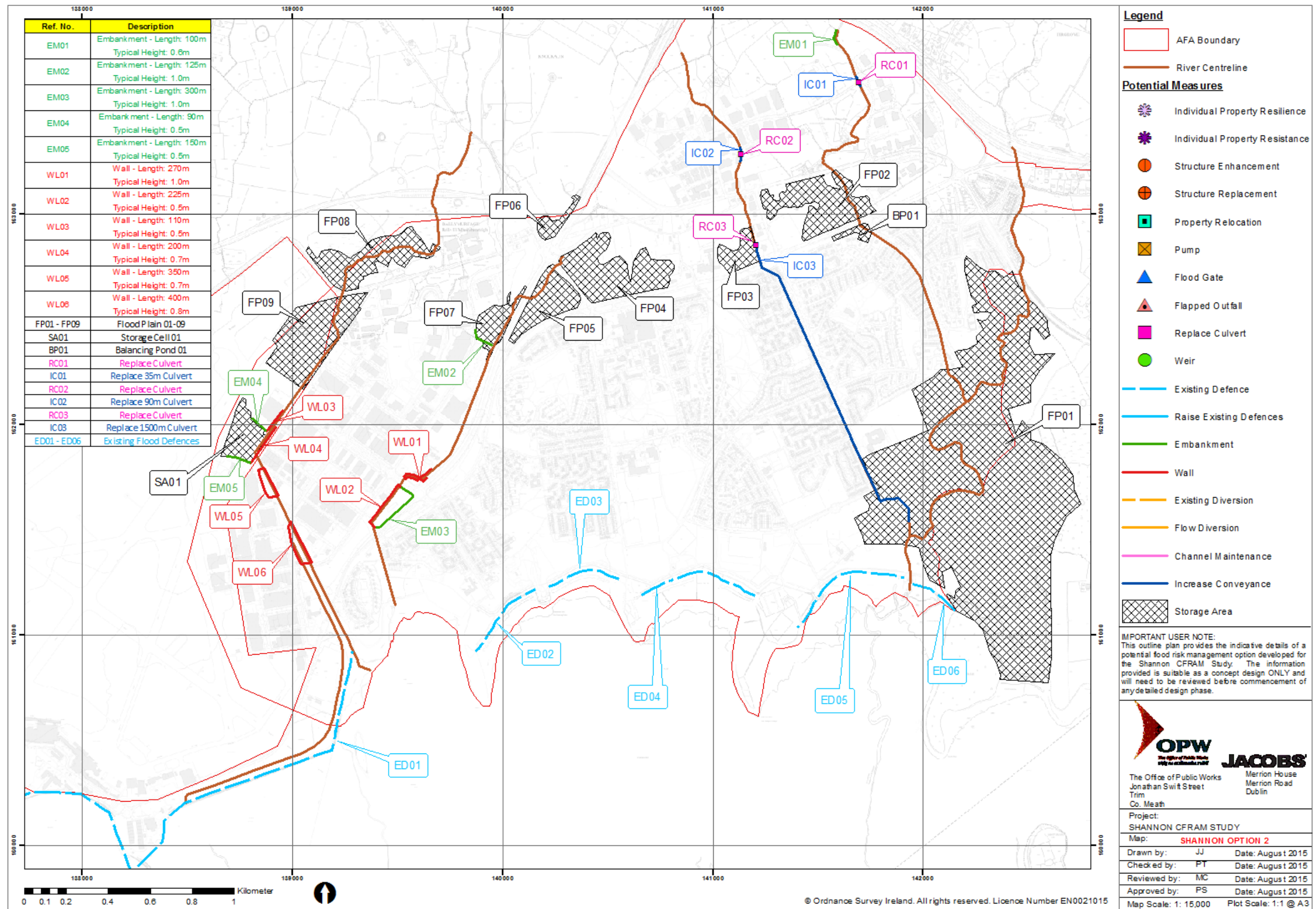


Figure 5.2 Option SHN_02

5.2 Comparison of Multi Criteria Assessment Scores		
Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	Option Reference and Results	
	SHN_01	SHN_02
Criteria Scores		
Technical	800	560
Economic	748	748
Social	505	505
Environmental	-485	-512
Economic Values		
Economic PV Benefits	€ 33,480,442	€ 33,480,442
PV Cost	€6,003,635	€21,164,137
NPV Benefits	€27,476,807	€12,316,305
Economic BCR	5.58	1.58
Outcome Scores		
MCA PV Benefits	€ 22,652,947	€ 22,652,947
MCA Benefit Score	768	741
MCA BCR	127.89	35.00
Option Selection MCA	1568	1301

5.3 Recommendation of Preferred Option

It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.

Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below

Option Ref:		SHN_01			
Option Measures	Baseline	B	Existing Regime		
	Structural	Di	Online Storage		
		Diii	Other Storage		
		Eii	Flood Relief Channel		
		Fiii	Structure Enhancement/Works		
		Gi	New Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Comments		<p>This option has been designed to protect all properties at risk of flooding in the 1% AEP fluvial event. Shannon Town and Shannon Airport are hydraulically connected for coastal flood events and the flood risk cannot be isolated to either site. The ground levels within Shannon Town and Shannon Airport are less than the tide level in a 50% AEP coastal event, if the defence in Shannon Airport was not in existence properties within Shannon town are at risk of flooding in a 50% AEP event.</p> <p>The MCA BCR is highest for SHN_01 and therefore this is the recommended emerging preferred option.</p> <p>The watercourses in this AFA are ungauged, therefore there is uncertainty associated with the fluvial flows. The fluvial system is heavily integrated with the urban drainage system therefore it is recommended that a fully integrated drainage model is completed to fully assess the flood risk.</p> <p>This option will provide protection to the 0.5% AEP coast event provided all existing coastal flood defences in Shannon Town and Shannon Airport are maintained in good condition. The defences in Shannon Airport are in poor condition and the cost of replacing these is estimated at €11,000,000. This cost is not allowed for in the option.</p> <p>At Shannon sub-catchment scale an option has been considered which will provide protection to the Shannon town and Shannon Airport for the 0.1% AEP coastal event/ 1% AEP fluvial event. This option allows for the replacement of all the existing coastal defences in Shannon Town and Shannon Airport to bring them up to the 0.1% AEP design standard.</p>			

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential				
Catchment Information	Gauging Station		Catchment size (km ²)	Potential available forecast accuracy and reliability period
	Fluvial	Rainfall		
	No	Yes*	28	Unknown
Relevant Information:	This is determined unknown for the following reasons; <ul style="list-style-type: none">No suitable rain gaugeNo suitable gauging station			
Additional Infrastructure Recommended	Gauging Station		Other	
	Fluvial	Rainfall		
	No	No	No	
Relevant Comments:	As the four separate watercourses in this AFA each have a contributing catchment of less than 12km ² any fluvial flood forecasting system would be unlikely to provide accurate and reliable predictions and any potential forecast period would be small. The majority of this catchment is dominated by tidal flooding. Tidal flooding could be predicted by a simple forecasting system.			

*Rainfall Gauge located in the Shannon Airport AFA

Annex - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	SHN_01				Option Score	Weighted Score	SHN_02				Option Score	Weighted Score						
							B	Existing Regime					B	Existing Regime										
							Di	Online Storage																
							Diii	Other Storage																
							Eii	Flood Relief Channel																
							Fiii	Structure Enhancement / Works																
							Gi	New Flood Defences																
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	No risks	Manageable	B	5.00	4.33	433	No risks	Manageable	B	5.00	4.20	420						
							Negligible	Moderate / high	Di	3.00			Negligible	Moderate / high	Di	3.00								
									Diii	4.00					Diii	4.00								
									Eii	5.00					Fiii	5.00								
									Gi	4.00					Gi	4.00								
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks	Moderate	Work near/in water			1.00	100	No risks	Moderate	Work near/in water			-1.00	-100				
							Negligible	Moderate / high	Work near services or buildings					Negligible	Moderate / high	Deep or complex excavations								
							Very low	High						Very low	High									
							Low	Very High						Low	Very High									
c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.		B	2.00	2.67	267	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.		B	2.00	2.40	240								
							Di	3.00					Di	3.00										
							Diii	3.00					Diii	3.00										
							Eii	2.00					Fiii	1.00										
							Fiii	3.00					Gi	3.00										
							Gi	3.00																
TECHNICAL CRITERIA SCORE											800								560					
2	Economic	a	Minimise economic risk	24	5.00	The score is calculated based on the reduction in AAD, following the full implementation of option.	4.25	510	The score is calculated based on the reduction in AAD, following the full implementation of option.	4.25	510													
												b	Minimise risk to transport infrastructure	10	5.00	Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.	4.75	237	Scoring is based on the reduction in flood risk to transport routes , following the full implementation of option.	4.75	237			
																						c	Minimise risk to utility infrastructure	14
		d	Minimise risk to agriculture	12	0.00	Source of Flooding	Both Fresh & Salt Water	Area of Agricultural Land Flooded	No Change	0.00	0	Area of Agricultural Land Flooded	No Change	0.00	0									
						Percentage of AFA that is rural land	23.78%	Frequency & Seasonality of Flooding	No Change			Frequency & Seasonality of Flooding	No Change											
								Duration of Flooding	No Change			Duration of Flooding	No Change											
								Risk to Agicultrual Infrastructure	No Change			Risk to Agicultrual Infrastructure	No Change											
								Flood Warning	Not Applicable			Flood Warning	Not Applicable											
								Agricultural Production Enhanced	No Change			Agricultural Production Enhanced	No Change											
								Other (Please Specify)	Not Applicable			Other (Please Specify)	Not Applicable											
ECONOMIC CRITERIA SCORE											748								748					
3	Social	a i)	Minimise risk to human health and life - Residents	27	5.00	Flood Depths & Velocities	Assumed low risk to life	2.48	334	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.	2.48	334												
						Known Areas of Highly Vulnerable People	Reasonable Cross Section of Society						0.00	0	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.	0.00	0							
		a ii)	Minimise risk to human health and life - High vulnerability properties	17	0.20	Rate of Onset of flooding	Assumed 1-2 hours for evacuation	0.00	0	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	0.00	0												
						b i)	Minimise risk to community - Social Infrastructure & Amenity						9	0.13	Assets of Particular Social Value	Yes	0.00	0	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	0.00	0			
		b ii)	Minimise risk to community - Local employment	7	5.00			Asset of Particular Employment Value	No	4.88	171	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.			4.88	171								
SOCIAL CRITERIA SCORE													505								505			
4	Environmental	a	Support the objectives of the WFD	16	5.00	There are six waterbodies within the AFA. The WFD status for waterbodies sampled by the EPA ranges from good to high. There are 2 polluting sources within or partly within the 0.5% AEP Coastal and 1% AEP Fluvial. There are a number of Annex IV areas within the AFA. There are 3 SPA/SAC waterbodies including the Shannon Estuary and 2 salmonid waterbodies.	-2.00	-160	There will be 2 pollution sources potentially removed from the 1% AEP.	-2.00	-100													
												b	Support the objectives of the Habitats Directive	10	5.00	Construction related impacts due to significant construction works in and adjacent to watercourses including construction of walls, embankments, storage options, balancing ponds, culvert replacement and flow diversion channels.	-2.00	-100						
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	5.00	Permanent impact related to flow diversion channels, storage areas and replacement of natural banks with flood defence walls. All these measures could cause potential changes to the hydrological and morphological regime of the watercourses.	-4.00	-100																
									d	Protect, and where possible enhance, fisheries resource within the catchment	13	2.00	Overall a potential short-term or intermittent impediment to the Potential significant effects are related to works within watercourse connected to the Lower River Shannon cSAC and River Shannon and River Fergus Estuary SPA. These significant construction works are to improve/replace culverts, provide a flow diversion channel, provide walls and embankments. Due to the proximity to the SAC there are potential for significant effects	-4.50	-117									
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	1.00	The Lower Shannon cSAC [002165] is within the AFA. Lough Gash Turlough cSAC [000051] is located c. 5 km from the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] is within the AFA.	-1.00	-8																
									f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	0.00	Potential significant effects are related to works within the boundary of the Fergus Estuary and Inner Shannon, North Shore pNHA in relation to works on the existing flood defence earth embankments.	0.00	0									
		f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	0.00	Potential impacts include: - Pollution risks to the pNHA - Disturbance to protected species	0.00	0																
									ENVIRONMENTAL CRITERIA SCORE											-485				
		Economic Values																						
		Economic PV Benefits																		€33,480,442				
Cost																		€6,003,635						
NPV Benefits																		€27,476,807						
Economic BCR																		5.58						
Outcome Scores																								
MCA PV Benefits																		€22,652,947						
MCA Benefit Score																		768						
MCA BCR																		127.89						
Option Selection MCA																		1568						
																		1301						

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments	Option 2 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has moderate/high health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	5.00	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement, if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting capped at maximum of 5.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.00	calculated but adjusted by professional judgement, if necessary	There is no risk to utility infrastructure within this AFA.	There is no risk to utility infrastructure within this AFA.	There is no risk to utility infrastructure within this AFA.
2.D	12	0.00	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This option has no effect on agriculture.	This option has no effect on agriculture.
3.A (i)	27	5.00	calculated but adjusted by professional judgement, if necessary	Local weighting is calculated based on the baseline risk to residential properties.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.
3.A (ii)	17	0.20	calculated but adjusted by professional judgement, if necessary	There are no high vulnerability properties at risk.	There is no risk to high vulnerability properties within the AFA.	There is no risk to high vulnerability properties within the AFA.
3.B (i)	9	0.20	calculated but adjusted by professional judgement, if necessary	Local weighting is calculated based on the baseline risk to social infrastructure.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.
3.B (ii)	7	5.00	calculated but adjusted by professional judgement, if necessary	Local weighting is calculated based on the baseline risk to local employment. The local weighting is capped at the maximum value of 5.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.
4.A	16	5.00	fixed	<p>The Lower Shannon cSAC [002165] is within the AFA. Lough Gash Turlough cSAC [000051] is located c. 5 km from the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] is within the AFA.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SCA/SPA/Ramsar) is present (within AFA) and potentially affected.</p>	<p>There will be 2 pollution sources potentially removed from the 1%AEP.</p> <p>Construction related impacts due to significant construction works in and adjacent to watercourses including construction of walls, embankments, storage options, balancing ponds, culvert replacement and flow diversion channels.</p> <p>Permanent impact related to flow diversion channels, storage areas and replacement of natural banks with flood defence walls. All these measures could cause potential changes to the hydrological and morphological regime of the watercourses.</p> <p>Overall a potential short-term or intermittent impediment to the achievement of wb objectives.</p>	<p>There will be 2 pollution sources potentially removed from the 1%AEP.</p> <p>Construction related impacts due to significant construction works in and adjacent to watercourses including construction of walls, embankments, storage options, balancing ponds, culvert replacement and flow diversion channels.</p> <p>Permanent impact related to flow diversion channels, storage areas and replacement of natural banks with flood defence walls. All these measures could cause potential changes to the hydrological and morphological regime of the watercourses.</p> <p>Overall a potential short-term or intermittent impediment to the achievement of wb objectives.</p>
4.B	10	5.00	Professional judgement	<p>The Lower Shannon cSAC [002165] is within the AFA. Lough Gash Turlough cSAC [000051] is located c. 5 km from the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] is within the AFA.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SCA/SPA/Ramsar) is present (within AFA) and potentially affected.</p>	<p>Potential significant effects are related to works within watercourse connected to the Lower River Shannon cSAC and River Shannon and River Fergus Estuary SPA. These significant construction works are to improve/replace culverts, provide a flow diversion channel, provide walls and embankments. Due to the proximity to the SAC there are potential for significant effects</p> <p>Potentially significant effects during construction are:</p> <ul style="list-style-type: none"> - Pollution risks to the cSAC/SPA - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC <p>Therefore a potential detrimental impact upon existing SAC or SPA site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>	<p>Potential significant effects are related to works within watercourse connected to the Lower River Shannon cSAC and River Shannon and River Fergus Estuary SPA. These significant construction works are to improve/replace culverts, provide a flow diversion channel, provide walls and embankments. Due to the proximity to the SAC there are potential for significant effects</p> <p>Potentially significant effects during construction are:</p> <ul style="list-style-type: none"> - Pollution risks to the cSAC/SPA - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC <p>Therefore a potential detrimental impact upon existing SAC or SPA site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>
4.C	5	5.00	Professional judgement	<p>The Fergus Estuary and Inner Shannon Estuary - North Shore pNHA [002048] is within the AFA.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc.) is present (within AFA) and potentially affected.</p>	<p>Potential significant effects are related to works within the boundary of the Fergus Estuary and Inner Shannon, North Shore pNHA in relation to works on the existing flood defence earth embankments.</p> <p>Potential impacts include:</p> <ul style="list-style-type: none"> - Pollution risks to the pNHA - Disturbance to protected species <p>Therefore, a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>	<p>Potential significant effects are related to works within the boundary of the Fergus Estuary and Inner Shannon, North Shore pNHA in relation to works on the existing flood defence earth embankments.</p> <p>Potential impacts include:</p> <ul style="list-style-type: none"> - Pollution risks to the pNHA - Disturbance to protected species <p>Therefore, a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>
4.D	13	2.00	Professional judgement	<p>The Shannon Estuary North 1 Clenagh and Shannon Estuary North 1 Drumline are designated as a Salmonid river. There is Medium angling activity in the area.</p> <p>Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.</p>	<p>Construction works adjacent to and in the waterbodies may impact water quality and cause access issues.</p> <p>Part of the natural banks will be replaced by walls on the WFD Salmonid waterbodies.</p> <p>Operational impact may include changes to angling access or locations.</p> <p>Therefore, a potential for permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.</p>	<p>Construction works adjacent to and in the waterbodies may impact water quality and cause access issues.</p> <p>Part of the natural banks will be replaced by walls on the WFD Salmonid waterbodies.</p> <p>Operational impact may include changes to angling access or locations.</p> <p>However, no flow diversion for this option.</p> <p>Therefore, a potential for permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.</p>
4.E	8	1.00	Professional judgement	<p>Working landscape, Vulnerable Landscape and Heritage Landscape as designated within Clare County Council Development Plan 2011 fall within 1% AEP Fluvial & the 0.5% AEP Coastal.</p> <p>The Estuary Walk West Shannon, Estuary Walk East Shannon and Free Zone / Estuary Walkway Shannon are local walking trails along the Shannon Estuary within the AFA but outside the 1% AEP Fluvial & the 0.5% AEP Coastal.</p> <p>Local weighting of 1 set by professional judgement. Weighting of 1 applied where there are no specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected.</p>	<p>Construction related impacts and replacement of natural banks with flood walls, creation of embankments. These are not in the vicinity of any designated landscape features.</p> <p>Short to long term impact on local sensitivity landscape character/feature in the zone of visibility of the selected measure.</p>	<p>Construction related impacts and replacement of natural banks with flood walls, creation of embankments. These are not in the vicinity of any designated landscape features.</p> <p>Short to long term impact on local sensitivity landscape character/feature in the zone of visibility of the selected measure.</p>
4.F(i)	4	0.00	Professional judgement	<p>Shannon is not a heritage town. There are no protected features of architectural value within the AFA.</p> <p>Local weighting of 0 set by professional judgement. Weighting of 0 applied where no sites/features are at risk.</p>	No Potential Impacts. Therefore, no effects on architectural features.	No Potential Impacts. Therefore, no effects on architectural features.
4.F(ii)	4	0.00	Professional judgement	<p>Shannon is not a heritage town. There are no protected features of architectural value in the 1% AEP Fluvial or 0.5% AEP Coastal within the AFA.</p> <p>Local weighting of 0 set by professional judgement. Weighting of 0 applied where there are no archaeological features at risk.</p>	No Potential Impacts. Therefore, no effects on archaeological features.	No Potential Impacts. Therefore, no effects on archaeological features.

SHN01 Option Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis						Notes to CFRAM Consultants	
			€	€	€		
(1) Basic Construction Costs (Estimate)					2,578,766		Construction Cost of each measure <u>including</u> Method Factor and CPI Adjustment but <u>excluding</u> Preliminaries
(2) Preliminaries	13.9%				358,608		Refer to UCD for selecting Preliminaries. %
		Sub-Total:			2,937,374		
(3) Optimism Bias	40.0%				1,174,949		Refer to UCD for selecting OB %
(4) Construction Costs (Excl VAT)					4,112,323		
(5) Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)	13.0%				534,602		Set at 13%
Construction Costs and Fees					4,646,925		
(6) Other Items							
(a) Allowance for Archaeology & Environmental Mitigation Measures	10.0%			411,232			Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b) Allowance for compensation and land acquisition	10.0%			411,232			Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c) Site investigation							Professional judgement to be applied in estimating a suitable sum.
(d) Art Allowance							See “Guidance E – Per Cent for Art Note”
(e) Est. NPV Operation & Maintenance			381,604				From PVC Summary sheet: PVC – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%	152,641	534,245	1,356,710		Refer to UCD for selecting OB %
Option Cost for Cost Benefit Analysis					6,003,635		



DONNACHADH O'BRIEN
& ASSOCIATES CONSULTING ENGINEERS



CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	M Cairns	Date:	27.08.15
Checked by:		Date:	

Project reference	S04
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Project name:	Shannon Option 1
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Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	0.987
Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€1,915,031	urban, stone cladding, no piles
Total embankment costs	€270,969	imported material, no piles
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs	€71,190	Flow diversion Channel
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs	€321,576	
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€2,578,766	
Apply update to unit rate (CPI) if appropriate (cell N15)	€2,545,242	
Enter appropriate preliminaries estimate (%)	14%	
Enter other applicable costs (€)	0	
Total capital cost (€)	€2,937,374	
Consider amendments based on site issues/constraints (cell N16)	€2,937,374	
Total capital cost (€)	€2,937,374	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€436	average O&M costs
Total embankment O&M costs	€3,844	average O&M costs
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs	N/A	
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€13,601	average O&M costs
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€17,881	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€3,318,977	
Optimism bias rate (from external sheet)	40%	
Total Cost including Optimism Bias	€4,646,568	

Whole life cost and PVC analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)

Enter year of capital works (all other costs start after this year)

Enter 'other' costs and frequency (e.g. replacement costs) if applicable

Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€2,937,373.7
Annual maintenance cost (€)	€17,880.9
Other cost (€)	€0.0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVC (€k): 3318977		
Cash sum		0	2937374	876162	0	3813535	3318977
year	Discount Factor	Cost Elements				TOTALS:	
		Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	2937374			2937373.7	2937373.7
1	0.962			17881		17880.9	17193.1
2	0.925			17881		17880.9	16531.9
3	0.889			17881		17880.9	15896.0
4	0.855			17881		17880.9	15284.6
5	0.822			17881		17880.9	14696.8
6	0.790			17881		17880.9	14131.5
7	0.760			17881		17880.9	13588.0
8	0.731			17881		17880.9	13065.4
9	0.703			17881		17880.9	12562.8
10	0.676			17881		17880.9	12079.7
11	0.650			17881		17880.9	11615.1
12	0.625			17881		17880.9	11168.3
13	0.601			17881		17880.9	10738.8
14	0.577			17881		17880.9	10325.7
15	0.555			17881		17880.9	9928.6
16	0.534			17881		17880.9	9546.7
17	0.513			17881		17880.9	9179.6
18	0.494			17881		17880.9	8826.5
19	0.475			17881		17880.9	8487.0
20	0.456			17881		17880.9	8160.6
21	0.439			17881		17880.9	7846.7
22	0.422			17881		17880.9	7544.9
23	0.406			17881		17880.9	7254.7
24	0.390			17881		17880.9	6975.7
25	0.375			17881		17880.9	6707.4
26	0.361			17881		17880.9	6449.4
27	0.347			17881		17880.9	6201.4
28	0.333			17881		17880.9	5962.9
29	0.321			17881		17880.9	5733.5
30	0.308			17881		17880.9	5513.0
31	0.296			17881		17880.9	5301.0
32	0.285			17881		17880.9	5097.1
33	0.274			17881		17880.9	4901.0
34	0.264			17881		17880.9	4712.5
35	0.253			17881		17880.9	4531.3
36	0.244			17881		17880.9	4357.0
37	0.234			17881		17880.9	4189.4
38	0.225			17881		17880.9	4028.3
39	0.217			17881		17880.9	3873.4
40	0.208			17881		17880.9	3724.4
41	0.200			17881		17880.9	3581.1
42	0.193			17881		17880.9	3443.4
43	0.185			17881		17880.9	3311.0
44	0.178			17881		17880.9	3183.6
45	0.171			17881		17880.9	3061.2
46	0.165			17881		17880.9	2943.4
47	0.158			17881		17880.9	2830.2
48	0.152			17881		17880.9	2721.4
49	0.146			17881		17880.9	2616.7

SHN02 Option Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis					Notes to CFRAM Consultants
		€	€	€	
(1) Basic Construction Costs (Estimate)				10,067,974	Construction Cost of each measure <u>including</u> Method Factor and CPI Adjustment but <u>excluding</u> Preliminaries
(2) Preliminaries	7.8%			782,983	Refer to UCD for selecting Preliminaries. %
Sub-Total:				10,850,957	
(3) Optimism Bias	40.0%			4,340,383	Refer to UCD for selecting OB %
(4) Construction Costs (Excl VAT)				15,191,339	
(5) Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)	13.0%			1,974,874	Set at 13%
Construction Costs and Fees				17,166,213	
(6) Other Items					
(a) Allowance for Archaeology & Environmental Mitigation Measures	10.0%		1,519,134		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b) Allowance for compensation and land acquisition	10.0%		1,519,134		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c) Site investigation					Professional judgement to be applied in estimating a suitable sum.
(d) Art Allowance					See “Guidance E – Per Cent for Art Note”
(e) Est. NPV Operation & Maintenance		685,468			From PVC Summary sheet: PVc – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
Optimism Bias	40.0%	274,187	959,655	3,997,923	Refer to UCD for selecting OB %
Option Cost for Cost Benefit Analysis				21,164,137	



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CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by: M Cairns Date: 27.08.15
Checked by: Date:

Project reference: S04

Project name: Shannon Option 1

Base date for estimates (year 0): Oct-2013

Scaling factor (e.g. €m, €k, €): €

Construction Price Index (CPI): 0.987

Method Factor - to take into account particular site issues /constraints: 1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€1,915,031	urban, stone cladding, no piles
Total embankment costs	€162,514	Imported material, no piles
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs	€7,990,428	
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€10,067,974	
Apply update to unit rate (CPI) if appropriate (cell N15)	€9,937,090	
Enter appropriate preliminaries estimate (%)	8%	
Enter other applicable costs (€)		
Total capital cost (€)	€10,850,957	
Consider amendments based on site issues/constraints (cell N16)	€10,850,957	
Total capital cost (€)	€10,850,957	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€436	average O&M costs
Total embankment O&M costs	€2,420	average O&M costs
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs	N/A	
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€29,263	
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€32,119	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€11,536,425	
Optimism bias rate (from external sheet)	40%	
Total Cost including Optimism Bias	€16,150,995	

Whole life cost and PVC analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)

Enter year of capital works (all other costs start after this year)

Enter 'other' costs and frequency (e.g. replacement costs) if applicable

Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€10,850,956.7
Annual maintenance cost (€)	€32,119.1
Other cost (€)	€0.0
Other works frequency (years)	

Key

	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVC (€k): #####		
Cash sum		0	10850957	1573834	0	12424791	11536425
year	Discount Factor	Cost Elements				TOTALS:	
		Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	10850957			10850956.7	10850956.7
1	0.962			32119		32119.1	30883.7
2	0.925			32119		32119.1	29695.9
3	0.889			32119		32119.1	28553.7
4	0.855			32119		32119.1	27455.5
5	0.822			32119		32119.1	26399.5
6	0.790			32119		32119.1	25384.2
7	0.760			32119		32119.1	24407.8
8	0.731			32119		32119.1	23469.1
9	0.703			32119		32119.1	22566.4
10	0.676			32119		32119.1	21698.5
11	0.650			32119		32119.1	20863.9
12	0.625			32119		32119.1	20061.5
13	0.601			32119		32119.1	19289.9
14	0.577			32119		32119.1	18548.0
15	0.555			32119		32119.1	17834.6
16	0.534			32119		32119.1	17148.6
17	0.513			32119		32119.1	16489.1
18	0.494			32119		32119.1	15854.9
19	0.475			32119		32119.1	15245.1
20	0.456			32119		32119.1	14658.7
21	0.439			32119		32119.1	14094.9
22	0.422			32119		32119.1	13552.8
23	0.406			32119		32119.1	13031.6
24	0.390			32119		32119.1	12530.3
25	0.375			32119		32119.1	12048.4
26	0.361			32119		32119.1	11585.0
27	0.347			32119		32119.1	11139.4
28	0.333			32119		32119.1	10711.0
29	0.321			32119		32119.1	10299.0
30	0.308			32119		32119.1	9902.9
31	0.296			32119		32119.1	9522.0
32	0.285			32119		32119.1	9155.8
33	0.274			32119		32119.1	8803.6
34	0.264			32119		32119.1	8465.0
35	0.253			32119		32119.1	8139.5
36	0.244			32119		32119.1	7826.4
37	0.234			32119		32119.1	7525.4
38	0.225			32119		32119.1	7236.0
39	0.217			32119		32119.1	6957.7
40	0.208			32119		32119.1	6690.0
41	0.200			32119		32119.1	6432.7
42	0.193			32119		32119.1	6185.3
43	0.185			32119		32119.1	5947.4
44	0.178			32119		32119.1	5718.7
45	0.171			32119		32119.1	5498.7
46	0.165			32119		32119.1	5287.2
47	0.158			32119		32119.1	5083.9
48	0.152			32119		32119.1	4888.4
49	0.146			32119		32119.1	4700.3

Appendix C5 Option Appraisal Report – Shannon Airport (IRR)

1. Preliminary Report: Summary of Current Flood Risk					
1.1 AFA and Watercourse Details					
AFA:	Shannon Airport				
Unit of Management:	27				
Primary Watercourse(s):	Two Unnamed Rivers, Shannon Estuary				
1.2 Summary of Flood Risk in 0.5% Coastal AEP Event					
Source of flood risk:	Fluvial		Coastal		Both
Total Number of Properties at risk in AFA in 0.5% Coastal AEP Event:		Residential	Non-Residential	Total	
	Coastal	0	0	0	
AFA Flood Cells:	Total Number:	0			
	Flood Cell Titles:	N/A			
Breakdown of properties at risk per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total	
	N/A	0	0	0	
Relevant Comments:	Although there are no properties flooded in the 0.5% coastal AEP event, there is significant flood risk in the 0.1% AEP which accrue significant PV damages. Therefore the flood risk for the 0.1% AEP event has been considered in section 1.2 (a) below.				
Relevant Figure Ref:	Figure 1.1 and 1.2				
1.2 (a) Summary of Flood Risk in 0.1% Coastal AEP Event					
Source of flood risk:	Fluvial		Coastal		Both
Total Number of Properties at risk in AFA in 0.1% Coastal AEP Event:		Residential	Non-Residential	Total	
	Coastal	0	21	21	
AFA Flood Cells:	Total Number:	2			
	Flood Cell Titles:	SAI_A, SAI_B			
Breakdown of properties at risk per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total	
	SAI_A	0	14	14	
	SAI_B	0	7	7	
Relevant Comments:					
Relevant Figure Ref:	Figure 1.1 and 1.2				
1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
None	None	None	Yes	None	None
Relevant Comments:	Coastal flood defences as shown in Figure 1.				
Relevant Figure Ref:	Figure 1.1				

1.4 Summary of PV Damages/Potential PV Benefits				
Total PV Damages:		Uncapped		Capped
	Coastal Direct Damages *	€ 124,237,626		€ 124,237,626
	Coastal Indirect Damages **	€ 100,000,000		€ 100,000,000
Max Capped Benefits for 0.1% Coastal AEP ***:		€ 224,237,626		
Breakdown of Max Capped PV benefits for 0.1% Coastal SOP per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total
	SAI_A	€ 0	€ 221,370,513	€ 221,370,513
	SAI_B	€ 0	€ 370,513	€ 370,513
Relevant Comments:	<p>* Based on consultation with the Capital and Engineering Projects Manager of Shannon Airport Authority (SAA) (email dated 22/10/15) the total airport infrastructural value is in the region of €605M. Using professional judgement, it is estimated that damages during a flood event will be 20% of the total airport infrastructural value, this has been added to the direct damages already calculated.</p> <p>** As detailed above, following consultation with SAA (email dated 09/12/15), a figure in excess of €100M has been estimated for operation disruption costs to the airport. This has been included as indirect damages for this IRR.</p>			
Relevant Figure Ref:	Fig 1.2			

*** These are the maximum benefits available if a FRM option with a 0.1% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	Description
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	Description
Risk to WFD Annex IV:	Licensed IPPC Facilities	0.1% Coastal AEP Flood Extent
		Lufthansa Technik Painting Shannon Limited
Risk to SACs:	None	N/A
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	Description
Risk to Sites of Cultural Heritage:	None	N/A
Relevant Figure Ref:	General Risk – Cultural Heritage	

1.8 Risk to the Economy		
	Type	Description
Risk to Transport Infrastructure:	Airport	0.1% Coastal AEP Flood Extent
		Shannon Airport
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

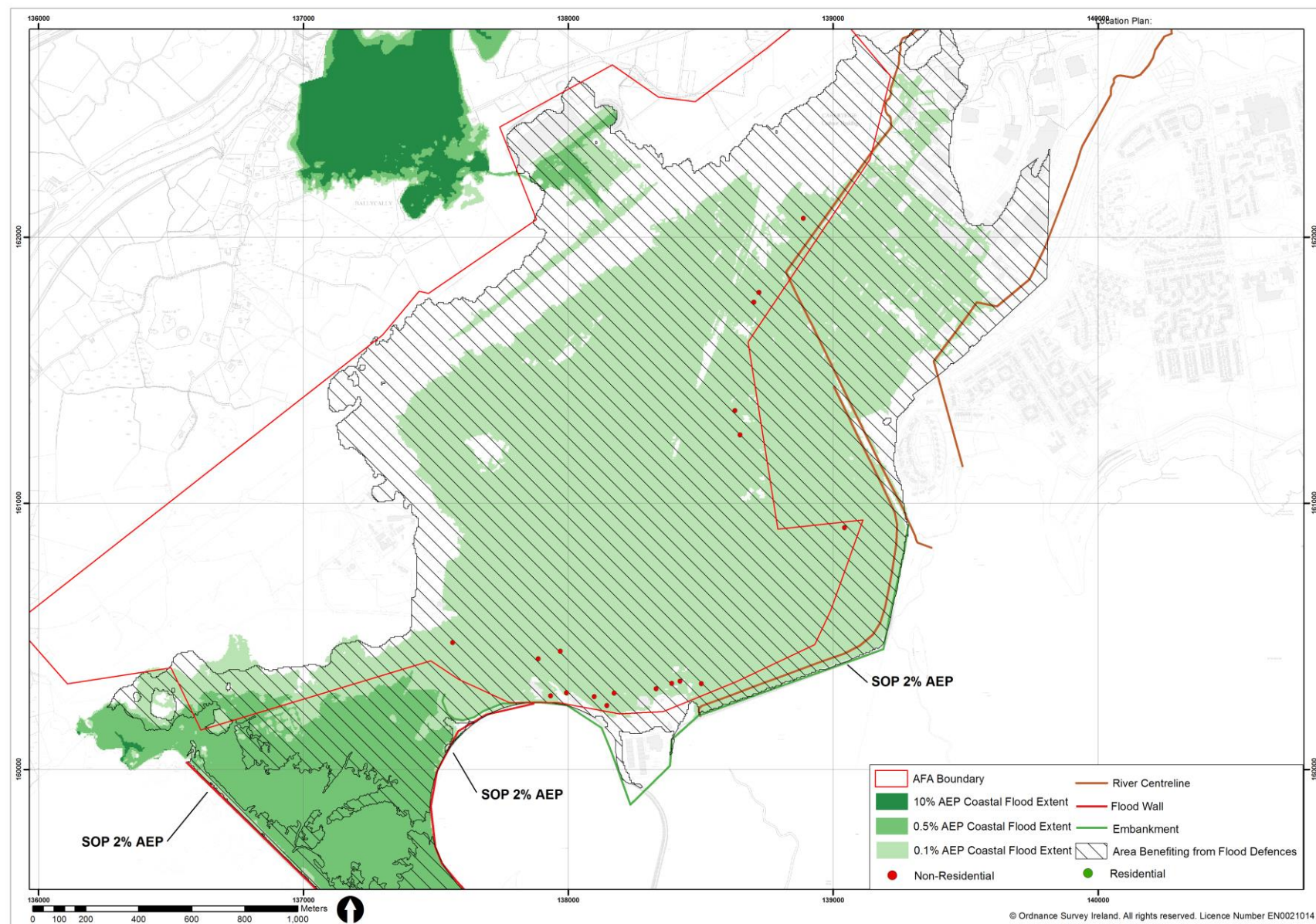


Figure 1.1 – Coastal Flood Risk to Properties

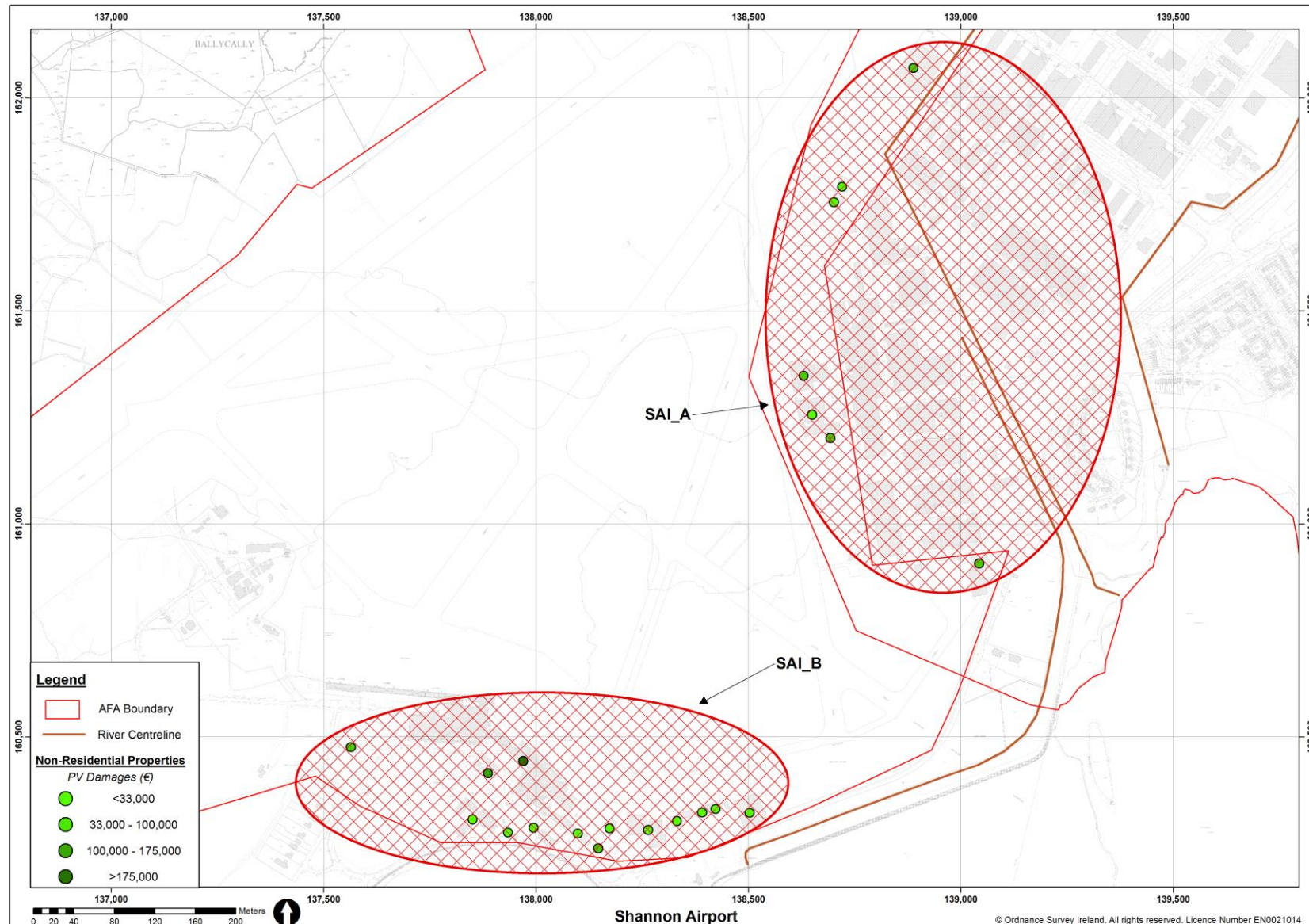


Figure 1.2 – Shannon Airport Total PV Damages for Properties in the 0.5% Coastal AEP Flood Event and Flood Cells.
Flood Cells are groupings of properties that are likely to be hydraulically linked.

With the existing coastal flood defences in place there is no flood risk to any properties in the IRR for the 1% AEP fluvial and the 0.5% AEP coastal events. There are not sufficient PV damages to promote any flood risk management measures for Shannon Airport for this design standard.. Considering there are significant PV damages of € 224,237,626 for the 0.1% AEP coastal event, the 0.1% AEP standard of protection has been considered.

Shannon Town and Shannon Airport are hydraulically connected for coastal flood events and the flood risk cannot be isolated to either site. The ground levels within Shannon Town and Shannon Airport are less than the tide level in a 50% AEP coastal event, if the defences in Shannon Airport were not in existence, properties within Shannon town would be at risk of flooding in a 50% AEP event. As the existing defences in Shannon Town have a SOP of less than the 0.1% AEP event, the 0.1% AEP design standard cannot be provided to Shannon Airport without increasing the height or replacing the existing defences in Shannon Town. Therefore the 0.1% AEP design standard can only be provided to Shannon Airport at a sub-catchment scale.

See Appendix K1 for the sub-catchment scale options.

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential				
Catchment Information	Gauging Station		Catchment size (km ²)	Potential available forecast accuracy and reliability period
	Fluvial	Rainfall		
	n/a	Yes	n/a	Unknown
Relevant Information:	This is determined unknown for the following reasons; <ul style="list-style-type: none">No fluvial watercourse in this AFA			
Additional Infrastructure Recommended	Gauging Station		Other	
	Fluvial	Rainfall		
	No	No	No	
Relevant Comments:	As the catchment is small and dominated by tidal flooding any potential flood forecasting early warning system would be unlikely to provide accurate and reliable predictions. There is little to no potential for the development of an effective fluvial flood forecasting system for Shannon Airport. Tidal flooding could be predicted by a simple forecasting system.			

Appendix C6 Option Appraisal Report – Sixmilebridge



1. Preliminary Report: Summary of Current Flood Risk					
1.1 AFA and Watercourse Details					
AFA:	Sixmilebridge				
Unit of Management:	27				
Primary Watercourse(s):	Owenogarney (River)				
1.2 Summary of Flood Risk in 1% Fluvial AEP					
Source of flood risk:	Fluvial		Coastal		Both
Total Number of Properties at risk in AFA in 1% Fluvial AEP Event:		Residential	Non-Residential		Total
	Fluvial	3	6		9
AFA Flood Cells:	Total Number:	1			
	Flood Cell Titles:	SIE_A			
Breakdown of properties at risk per Flood Cell:	Flood Cell Ref	Residential	Non-Res		Total
	SIE_A	3	6		9
Relevant Figure Ref:	Figure 1.1 and 1.2				
1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
Yes	None	None	Yes	None	None
Relevant Comments:	There are two existing flood risk management schemes for the Owenogarney River through Sixmilebridge. The locations and associated benefiting areas are shown in Figure 1.1.				
Relevant Figure Ref:	Figure 1.1				
1.4 Summary of PV Damages/Potential PV Benefits for 1% Fluvial					
Total PV Damages:		Uncapped		Capped	
	Fluvial	€ 367,792		€ 367,792	
Max Combined Capped Benefits for 1% Fluvial AEP:	€ 254,430				
Breakdown of Max Capped PV benefits 1% Fluvial AEP per Flood Cell*:	Flood Cell Ref	Residential	Non-Res		Total
	SIE_A	€ 30,440	€ 223,990		€ 254,430
Relevant Figure Ref:	Figure 1.2				

*These are the maximum benefits available if a FRM option with a 1% Fluvial AEP SOP is provided to all properties within the AFA

1.5 Social Risk		
	Type	Description
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	

1.6 Risk to the Environment		
	Type	Description
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	None	N/A
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	Description
Risk to Sites of Cultural Heritage:	NIAH Buildings	2% AEP Fluvial Flood Extent
		The Riverside Inn, Frederick Square
		0.1% AEP Fluvial Flood Extent
		The Old House Bar, Ballyliddan West
	Clare National Monuments	0.5% AEP Fluvial Flood Extent
		Settlement cluster, Ballyliddan West
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	Description
Risk to Transport Infrastructure:	Regional Road	2% AEP Fluvial Flood Extent
		R462
		5% AEP Fluvial Flood Extent
		R471
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

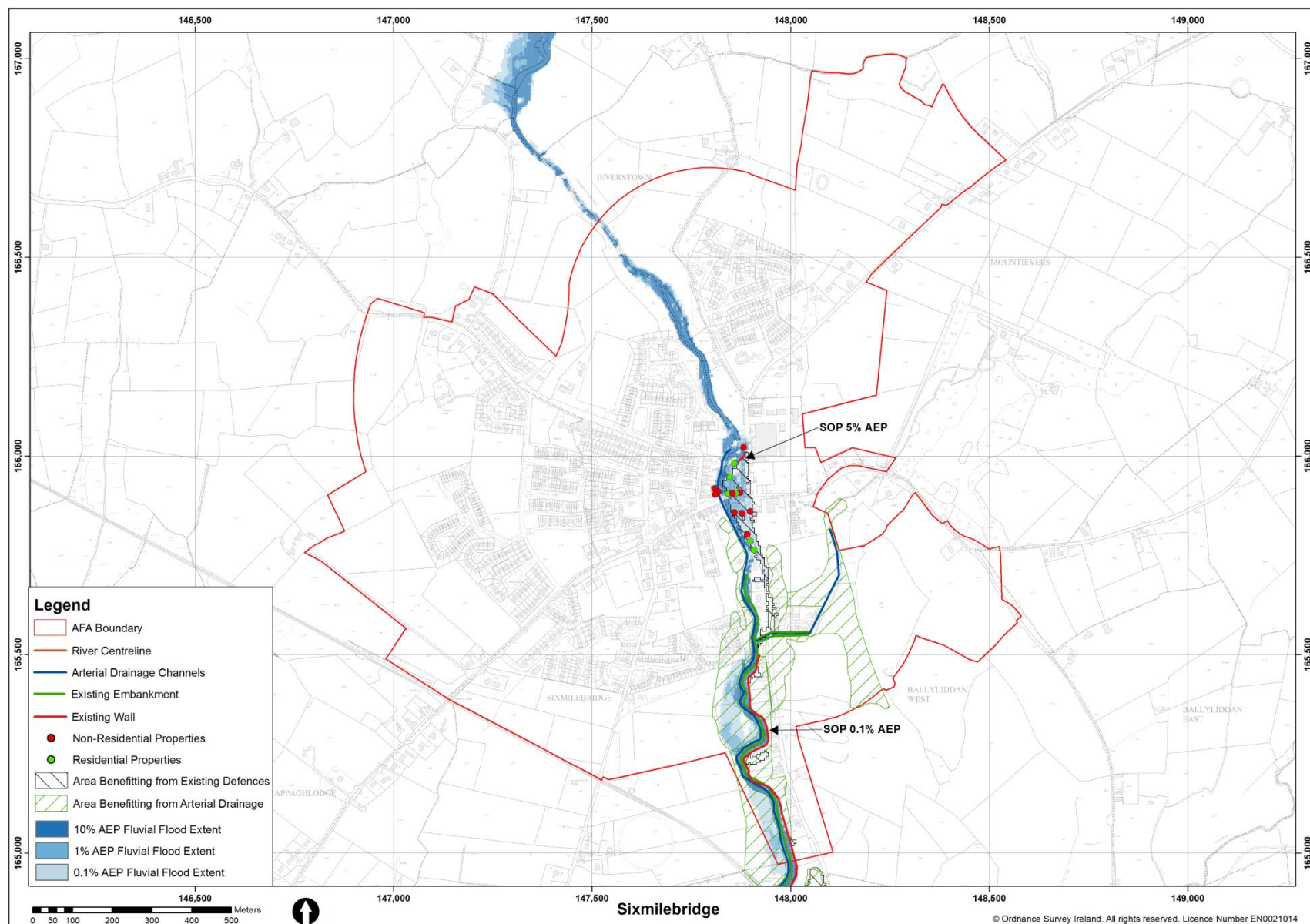


Figure 1.1 – Sixmilebridge Fluvial Flood Risk to Properties

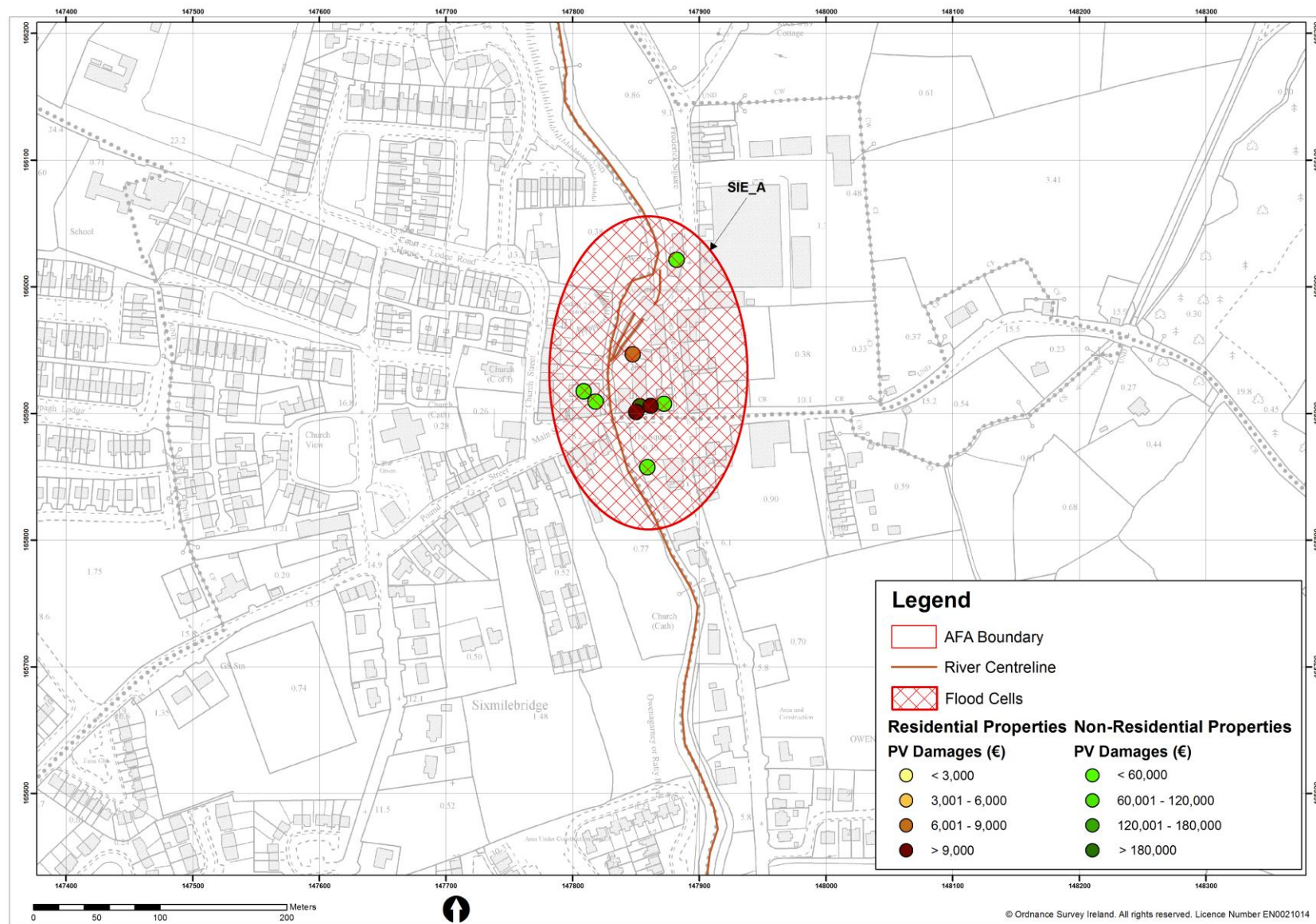


Figure 1.2 – Sixmilebridge Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Flood Event and Flood Cells. Flood Cells are groupings of properties that are likely to be hydraulically linked.

Sixmilebridge is identified as an AFA that benefits from an existing flood relief scheme and therefore no further assessment to identify potentially viable flood risk management measures or options is required through this CFRAM Study. Recommendations will be made in the FRMP that the existing flood relief scheme must be monitored and maintained.

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential				
Catchment Information	Gauging Station		Catchment size (km ²)	Potential available forecast accuracy and reliability period
	Fluvial	Rainfall		
		Yes	No*	161
Relevant Information:	<ul style="list-style-type: none">Owenagarney Railway Bridge (GS 27011) immediately downstream of Sixmilebridge			
Additional Infrastructure Recommended	Gauging Station		Other	
	Fluvial	Rainfall		
		Yes	No	No
Relevant Comments:	<p>Due to the number of equal sized tributaries which confluence approximately 10km upstream of the AFA, an accurate and reliable flood forecasting warning system would require a series of rainfall gauges feeding into a rainfall-runoff model and river gauges. As no MPW is modelled upstream of Sixmilebridge it is not possible to accurately predict the potential available forecast period.</p> <p>A simple flood forecasting system on the main River Owenagarney may have potential to provide a small flood forecasting period based on a level trigger.</p>			

*For this assessment only 15 minute tipping bucket gauge were considered.

Appendix C7 Option Appraisal Report - Bunratty

1. Preliminary Report: Summary of Current Flood Risk					
1.1 AFA and Watercourse Details					
AFA:	Bunratty				
Unit of Management:	27				
Primary Watercourse(s):	Owenogarney River				
1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event					
Source of flood risk :	Fluvial		Coastal		Both
Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		Residential	Non-Residential	Total	
	Fluvial	0	1	1	
	Coastal	0	3	3	
	Combined	0	3	3	
AFA Flood Cells:	Total Number:	1			
	Flood Cell Titles:	BUY_A			
Breakdown of properties at (combined) risk per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total	
	BUY_A	0	3	3	
Relevant Comments:	The AFA of Bunratty is at risk of flooding from both fluvial and coastal sources. Therefore the flood management measures for Bunratty will be designed to manage flood risk both for the 0.5% AEP coastal event and the 1% AEP fluvial event.				
Relevant Figure Ref:	Figure 1.1 and 1.2				
1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
None	None	None	Yes	None	None
Relevant Figure Ref:	Figure 1.1 and 1.2				
1.4 Summary of PV Damages/Potential PV Benefits					
Total PV Damages:		Uncapped		Capped	
	Fluvial	€ 3,587,888		€ 1,836,885	
	Coastal	€ 7,094,109		€ 2,628,754	
	Combined	€ 10,681,997		€ 3,076,884	
Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal AEP Event*:	€ 2,804,623				
Breakdown of Max Combined Capped PV benefits for 0.5% AEP Coastal and 1% AEP Fluvial Events per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total	
	BUY_A	€ 0	€ 2,804,623	€ 2,804,623	
Relevant Figure Ref:	Figure 1.3				

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	Description
High Vulnerability Properties at risk:	None	N/A
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	Description
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	Proposed National Heritage Area	50% AEP Fluvial & Coastal Flood Extent
		Fergus Estuary and Inner Shannon, North Shore
Relevant Figure Ref:	General Risk – Environment	
1.7 Risk to Cultural Heritage		
	Type	Description
Risk to Sites of Cultural Heritage:	NIAH Buildings	10% AEP Coastal Flood Extent
		Bunratty Castle
		5% AEP Coastal Flood Extent
	Recorded Monuments	Bunratty Bridge
		10% AEP Coastal Flood Extent
		Castle – Anglo-Norman masonry castle (Bunratty West, River Shannon)
		Sheela-na-gig (Bunratty West, River Shannon)
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	Description
Risk to Transport Infrastructure:	Local (Urban) Road	50% AEP Fluvial & Coastal Flood Extent
		L3126 (Bunratty East)
		L3126 (Moyhill)
		0.1% AEP Fluvial & Coastal Flood Extent
		The Low Road
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

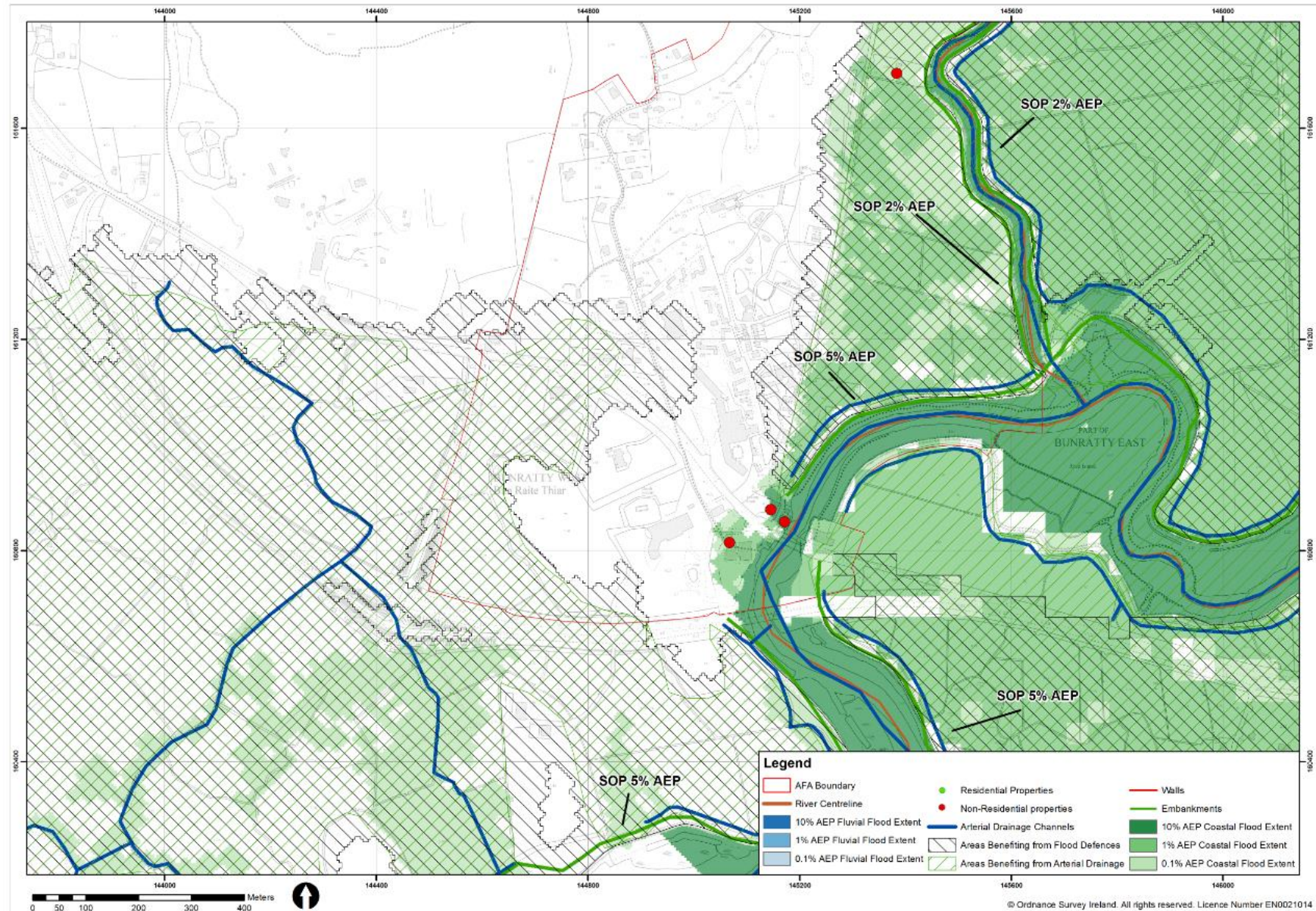


Figure 1.1 – Bunratty Coastal Flood Risk to Properties

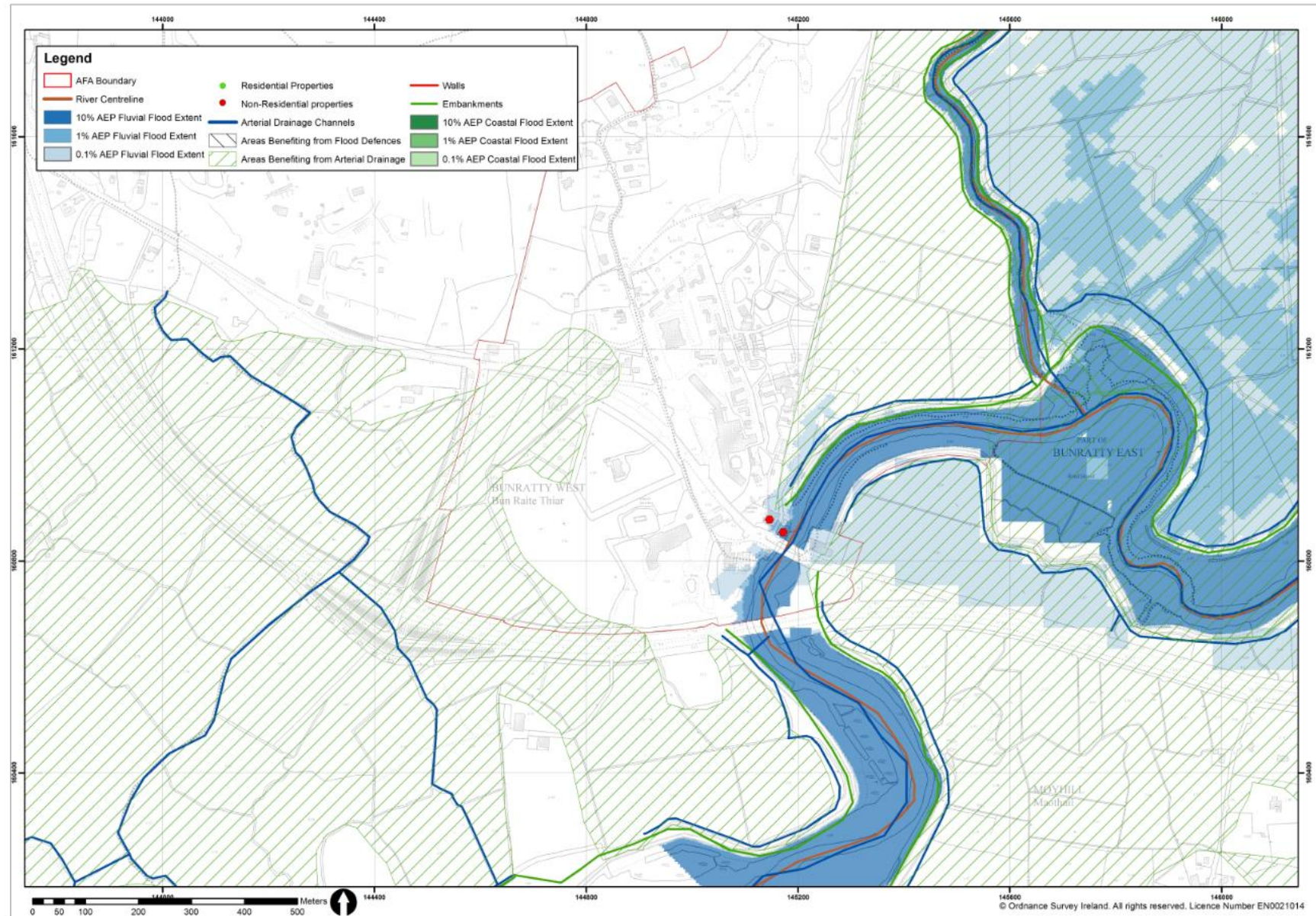


Figure 1.2 – Bunratty Fluvial Flood Risk to Properties

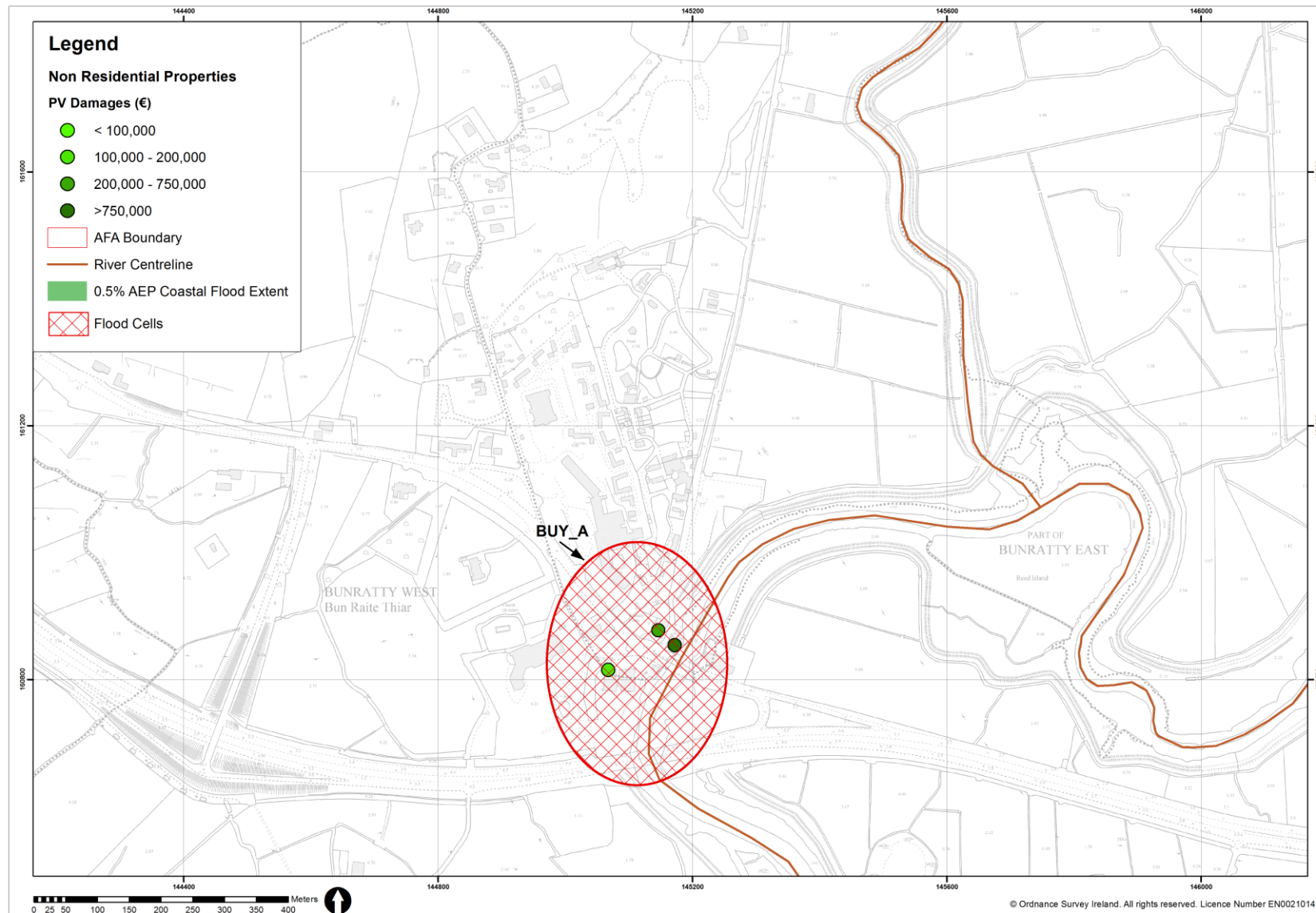


Figure 1.3 – Bunratty Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Flood Event and Flood Cell. Flood Cells are groupings of properties that are likely to be hydraulically linked.

2 STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	Screened Out
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	Screened In
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	Screened Out
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	Screened Out
F	Increase Conveyance	Unviable	Viable	Viable	Viable	Viable	Screened Out
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	Screened In
H	Relocation of Properties	Unviable	Viable	Viable	Viable	Viable	Screened Out
I	Other: Tidal Barrage	Unviable	Viable	Viable	Viable	Viable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	Screened In
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	Screened Out
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	Screened In

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out as there are other viable options.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the 'Do Minimum' measure would have negligible impact on the existing flood risk within the AFA.
D	Storage	Applicability Economic Environmental Social Cultural	Screened out. As the dominant source of risk to the AFA is coastal, storage is not considered applicable to the AFA.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	Screened out. As the dominant source of risk to the AFA is coastal, flow diversion is not considered applicable to the AFA.

F	Increase Conveyance	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	Screened out. As the dominant source of risk to the AFA is coastal, increase conveyance is not considered applicable to the AFA.
H	Relocation of Properties	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	Screened out. It is not applicable to area to relocate these properties as 1 property is Bunratty castle and the other 2 are non-residential properties dependant on local tourist trade.
I	Other: Tidal Barrage	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	Screened out as no suitable location for a Tidal Barrage could be identified.
L	Individual Property Resistance	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	Screened out as flood depths are in excess of 1.3m in some areas.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		Non-Structural Measures	
B	Existing Regime	J	Flood Forecasting / Warning / Response
Structural Measures		K	Public Awareness
G	Flood Defences	M	Individual Property Resilience

3 STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓						
Structural Measures								
G	Flood Defences							
Gi	New Flood Defences	✓						
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response							
K	Public Awareness	✓						
M	Individual Property Resilience	✓						
Option Reference		BUY_01						
Measures not screened out but not included in options								
Measures		Justification						
J	Flood Forecasting / Warning / Response	Flood Forecasting was not considered as either an independent measure or in combination with other measures, as the option being appraised would provide the required 1% Fluvial / 0.5% Coastal AEP standard of protection. Flood Forecasting does not improve the viability of the options under consideration.						

4 STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.

Option Ref:		BUY_01			
Option Measures	Baseline	B	Existing Regime		
	Structural	Gi	Flood Defences: New Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Option Description:		<p>This option will provide a 0.5% coastal AEP design standard to 2 of the 3 properties within the AFA and will reduce the impact of the flood risk to the remaining 1 property.</p> <ul style="list-style-type: none"> Construct new flood defence walls on the right bank side of the Owenagarney River, upstream and downstream of Bunratty Bridge, as shown in Figure 5.1 (Quay walls – on upstream bank). Individual Property Resilience and Public Awareness will apply to one commercial property (COM_01), as shown in Figure 5.1. A wall was consider in this location but the walls of this property form the existing river bank therefore it is not feasible to construct walls to protect this property. Existing flood defences will need to be maintained as part of this option. 			
Option Development Meeting:		Date:	16/09/2015		
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.		

5 STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Development Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five stage MCA process.

Option Reference		BUY_01
Baseline Measures		
B	Existing Regime	Existing flood defences will need to be maintained as part of this option.
Structural Measures		
Gi	New Flood Defences	Construct new flood defences as shown in Figure 5.1.
Non-Structural Measures		
K	Public Awareness	Public Awareness will apply to properties as shown in Figure 5.1.
M	Individual Property Resilience	Individual Property Resilience will apply to properties as shown in Figure 5.1.
Table Reference		
A summary of the outcome from the MCA is presented in the following table		Table 5.1

Table 5.1: Multi Criteria Assessment Outcome for Option BUY_01

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Bunratty		Option Ref: BUY_01
Option Measures			
Baseline	B	Existing Regime	
Structural	Gi	Flood Defences: New Flood Defences	
Non-Structural	K	Public Awareness	
	M	Individual Property Resilience	
Criteria Scores			
Technical		867	
Economic		444	
Social		239	
Environmental		-720	
Economic Values			
Economic PV Benefits		€ 1,493,788	
PV Cost		€ 758,255	
NPV Benefits		€ 735,533	
Economic BCR		1.97	
Outcome Scores			
MCA PV Benefits		€715,245	
MCA Benefit Score		-37	
MCA Benefit Score Ratio		-49.18	
Option Selection MCA		829	
Relevant Figure		Figure 5.1	

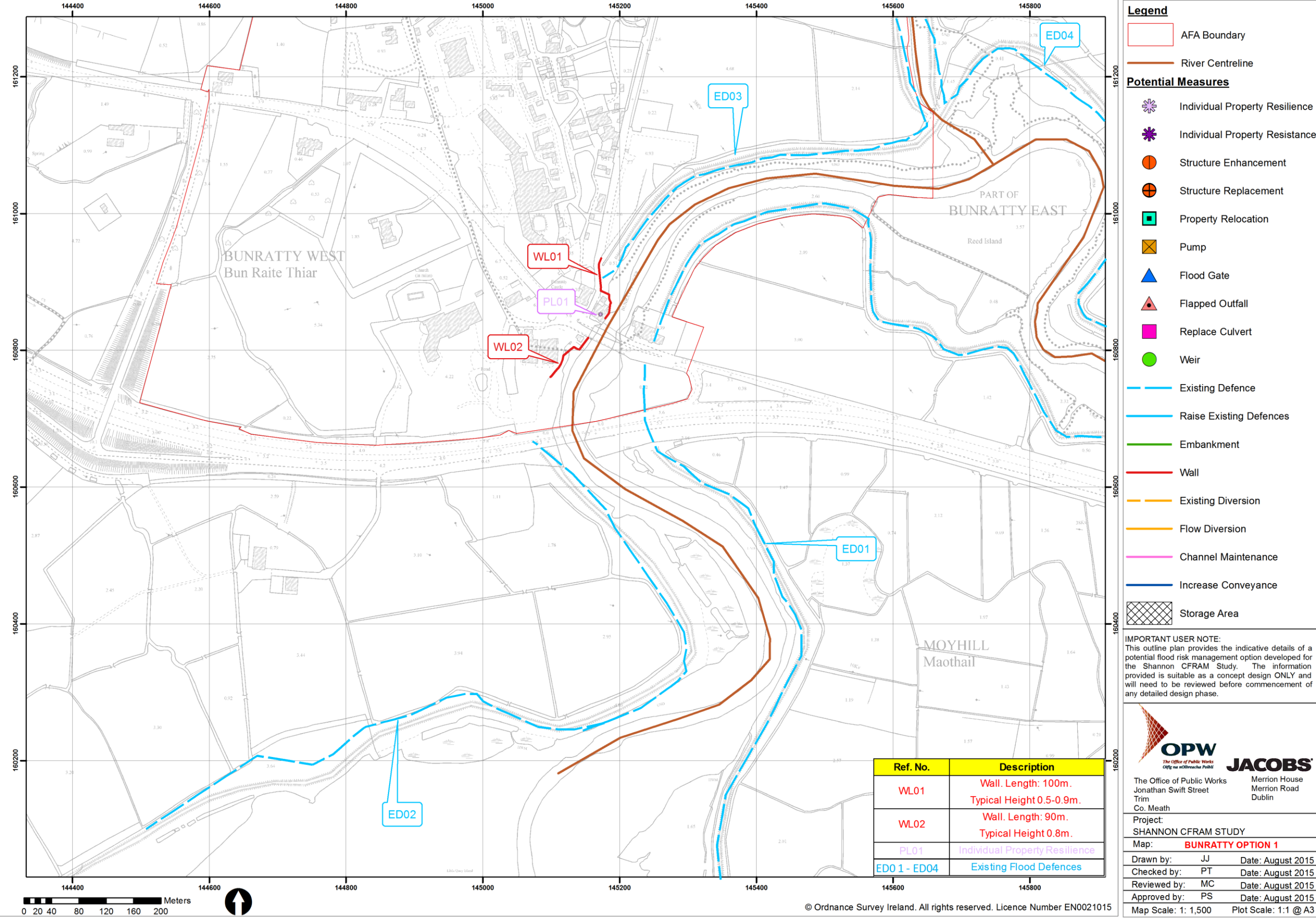


Figure 5.1 Option BUY_01

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	Option Reference and Results
	BUY_01
Criteria Scores	
Technical	867
Economic	444
Social	239
Environmental	-720
Economic Values	
Economic PV Benefits	€ 1,493,788
PV Cost	€ 758,255
NPV Benefits	€ 735,533
Economic BCR	1.97
Outcome Scores	
MCA PV Benefits	€715,245
MCA Benefit Score	-37
MCA BCR	-49.18
Option Selection MCA	829

5.3 Recommendation of Preferred Option

It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.

Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below

Option Ref:		BUY_01			
Option Measures	Baseline	B	Existing Regime		
	Structural	Gi	Flood Defences: New Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Comments		<p>This option will provide a 0.5% coastal AEP design standard to 2 of the 3 properties within the AFA and will reduce the impact of the flood risk to the remaining 1 property.</p> <p>The economic BCR is greater than 1 for BUY_01 therefore this is a viable emerging preferred option.</p> <p>Existing flood defences will need to be maintained as part of this option.</p>			

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential				
Catchment Information	Gauging Station		Catchment size (km ²)	Potential available forecast accuracy and reliability period
	Fluvial	Rainfall		
		GS 27011	No*	260
Relevant Information:	Owenogarney Railway Bridge (GS 27011) 5km upstream of Bunratty			
Additional Infrastructure Recommended	Gauging Station		Other	
	Fluvial	Rainfall		
		No	No	No
Relevant Comments:	As this catchment is dominated by tidal flooding there is little to no potential for the development of an effective fluvial flood forecasting system for Bunratty. Tidal flooding could be predicted by a simple forecasting system.			

*For this assessment only 15 minute tipping bucket gauge were considered.




Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments		<table><tr><td>B</td><td colspan="2">Existing Regime</td></tr><tr><td>Gi</td><td colspan="2">New Flood Defences</td></tr><tr><td>K</td><td colspan="2">Public Awareness</td></tr><tr><td>M</td><td colspan="2">Individual Property Resilience</td></tr><tr><td></td><td colspan="2"></td></tr><tr><td></td><td colspan="2"></td></tr></table>		B	Existing Regime		Gi	New Flood Defences		K	Public Awareness		M	Individual Property Resilience								Option Score	Weighted Score																				
B	Existing Regime																																																
Gi	New Flood Defences																																																
K	Public Awareness																																																
M	Individual Property Resilience																																																
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	<table><tr><td>None</td><td>Manageable</td><td>B</td><td>5.00</td></tr><tr><td></td><td></td><td>Gi</td><td>5.00</td></tr><tr><td></td><td></td><td>K</td><td></td></tr><tr><td>Negligible</td><td>Moderate / high</td><td>M</td><td>4.00</td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td>Very low</td><td>High</td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td>Low</td><td>Failure likely</td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td></tr><tr><td>Low / moderate</td><td>Unacceptable</td><td></td><td></td></tr></table>	None	Manageable	B	5.00			Gi	5.00			K		Negligible	Moderate / high	M	4.00					Very low	High							Low	Failure likely							Low / moderate	Unacceptable			4.67	467
							None	Manageable	B	5.00																																							
									Gi	5.00																																							
									K																																								
							Negligible	Moderate / high	M	4.00																																							
		Very low	High																																														
		Low	Failure likely																																														
		Low / moderate	Unacceptable																																														
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	<table><tr><td>None</td><td>Manageable</td><td colspan="2">Work near/in water</td></tr><tr><td></td><td></td><td colspan="2">Work near services or buildings</td></tr><tr><td>Negligible</td><td>Moderate / high</td><td colspan="2"></td></tr><tr><td></td><td></td><td colspan="2"></td></tr><tr><td>Very low</td><td>High</td><td colspan="2"></td></tr><tr><td></td><td></td><td colspan="2"></td></tr><tr><td>Low</td><td>Very High</td><td colspan="2"></td></tr><tr><td></td><td></td><td colspan="2"></td></tr><tr><td>Low / moderate</td><td>Unacceptable</td><td colspan="2"></td></tr></table>	None	Manageable	Work near/in water				Work near services or buildings		Negligible	Moderate / high							Very low	High							Low	Very High							Low / moderate	Unacceptable			1.00	100				
None	Manageable						Work near/in water																																										
							Work near services or buildings																																										
Negligible	Moderate / high																																																
Very low	High																																																
Low	Very High																																																
Low / moderate	Unacceptable																																																
c	Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	<table><tr><td rowspan="3">Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.</td><td>B</td><td>3.00</td><td></td></tr><tr><td>Gi</td><td>3.00</td><td></td></tr><tr><td>K</td><td></td><td></td></tr><tr><td rowspan="3">Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.</td><td>M</td><td>3.00</td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td rowspan="3">Option cannot be adapted, but provides no to minor impediment to potential future interventions.</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td rowspan="3">Option cannot be adapted, and provides moderate to major impediment to potential future interventions.</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table>	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.	B	3.00		Gi	3.00		K			Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	M	3.00								Option cannot be adapted, but provides no to minor impediment to potential future interventions.										Option cannot be adapted, and provides moderate to major impediment to potential future interventions.										3.00	300		
					Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.		B	3.00																																									
							Gi	3.00																																									
						K																																											
					Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	M	3.00																																										
Option cannot be adapted, but provides no to minor impediment to potential future interventions.																																																	
Option cannot be adapted, and provides moderate to major impediment to potential future interventions.																																																	

TECHNICAL CRITERIA SCORE							867			
2	Economic	a	Minimise economic risk	24	3.08		The score is calculated based on the reduction in AAD, following the full implementation of option.	2.63	195	
b	Minimise risk to transport infrastructure	10	5.00		Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.	4.98	249			
c	Minimise risk to utility infrastructure	14	0.00		There is no risk to Utility infrastructure in the existing scenario	0.00	0			
d	Minimise risk to agriculture	12	3.68	Source of Flooding	Both Fresh & Salt Water	Area of Agricultural Land Flooded	No Change	0.00	0	
Percentage of AFA that is rural land	73.62%	Frequency & Seasonality of Flooding	No Change							
		Duration of Flooding	No Change							
		Risk to Agricultural Infrastructure	No Change							
		Flood Warning	Not Applicable							
		Agricultural Production Enhanced	No Change							
		Other (Please Specify)	Not Applicable							
ECONOMIC CRITERIA SCORE							444			
3	Social	a i)	Minimise risk to human health and life - Residents	27	0.00	Flood Depths & Velocities	Assumed low risk to life	There are no residential properties at risk of flooding in the existing scenario	0.00	0
	Known Areas of Highly Vulnerable People	Reasonable Cross Section of Society								
a ii)	Minimise risk to human health and life - High vulnerability properties	17	0.00	Rate of Onset of flooding	Assumed 1-2 hours for evacuation	There are no residential properties at risk of flooding in the existing scenario	0.00	0		
b i)	Minimise risk to community - Social Infrastructure & Amenitv	9	3.00	Assets of Particular Social Value	Yes	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.	4.95	134		
b ii)	Minimise risk to community - Local employment	7	3.03	Asset of Particular Employment Value	No	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.	4.97	105		
SOCIAL CRITERIA SCORE							239			
4	Environmental	a	Support the objectives of the WFD	16	5.00	There are three WFD waterbodies within the AFA. The WFD status of these waterbodies ranges from poor to good. There are no polluting sources within the 1% AEP Fluvial and the 0.5% AEP Coastal. There are a number of WFD protected areas within the AFA. Part of the Bunratty River is used for drinking water. The Bunratty Clovemill Watercourse is an SAC waterbody and a Salmonid Waterbody. The Upper Shannon Estuary is an SAC/SPA waterbody. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	Construction related impacts due to significant construction works in and adjacent to watercourses. Part of the Bunratty River bank will be permanently removed and replaced by a wall. There is reduced flooding in area with no significant polluting sources in 1% AEP Fluvial or 0.5% AEP Coastal extent. Therefore, overall a potential medium-term or recurring impediment to the achievement of wb objectives.	-3.00	-240	
b	Support the objectives of the Habitats Directive	10	5.00	The Lower River Shannon cSAC [002165] is within the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] is within the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.	There are significant works proposed within the boundary of the Lower Shannon cSAC in order to provide the flood wall along the Bunratty River. Potentially significant effects during construction are: - Pollution risks to the cSAC - Disturbance to intertidal habitat adjacent to the cSAC in relation to the proposed wall - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC Therefore, overall a potential detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar site, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-5.00	-250			
c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	5.00	The Inner Shannon Estuary - North Shore pNHA [002048] is within the AFA. There are a number of pNHA within 5 km off the AFA: Garrannon Wood pNHA [001012], Inner Shannon Estuary - South Shore pNHA [000435] and Woodcock Hill Bog NHA [002402]. Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc) is present (within AFA) and potentially affected.	Potentially significant effects are related to works within the boundary of the Inner Shannon Estuary - North Shore pNHA in relation to the construction of the flood walls. However, it is noted in relation to the proposed wall that the boundary of the pNHA in this area partly falls on an existing building and a carpark which is highly unlikely to be qualifying habitat. Potential impacts include: - Pollution risks to the pNHA - Loss of habitat - Disturbance to bird species - Disturbance to otter Therefore, overall a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.	-4.00	-100			
d	Protect, and where possible enhance, fisheries resource within the catchment	13	2.00	The Bunratty Clovemill Watercourse (Bunratty River) is designated as a Salmonid river. There is Medium angling activity in the area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	Construction related impacts due to significant construction works in and adjacent to watercourses. Part of the Bunratty River bank will be permanently removed and replaced by a wall. Construction related impacts on water quality and subsequent fish species. Therefore, overall a potential long term impact associated with permanent loss of river bank. Permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration, adjusted by professional judgement.	-5.00	-130			
e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	3.00	There are no protected/ valued landscape areas in the spatial scale. Under the Clare County Council Development Plan 2011, areas within the AFA were classified as heritage landscapes. Local weighting of 3 set by professional judgement. Weighting of 3 applied where landscape character type is designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected.	The construction of the proposed walls will have an impact on the setting of the area however, given the location and height of the walls they are not likely to impact in the long-term the landscape and visual environment as long as there is appropriate detailed design taking account of environmental mitigation/recommendation. Therefore, overall a potential for short term to long term impacts on local sensitivity landscape character/feature in the zone of visibility of the selected measure.	-1.00	-24			
f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	2.00	Bunratty is not a heritage town. Two RPS / NIAH fall within the 0.5% AEP Coastal, Bunratty Castle and Bunratty Bridge. Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.	The proposed walls will offer protection to Bunratty Castle in addition the walls are unlikely to effect the setting of Bunratty Castle and Bunratty bridge significantly. Therefore a potential increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	1.00	8			
f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	4.00	Bunratty is not a heritage town. There are two RMP in the 0.5% AEP Coastal within the AFA including Bunratty Castle which is an National Monument in State care. Local weighting of 4 set by professional judgement. Weighting of 4 applied where there are nationally important archaeological feature(s) (e.g. National Monument in State Care, sites on which Preservation Orders or Temporary Preservation Orders have been served) present and potentially affected.	The proposed walls will offer protection to Bunratty Castle and the location and height of the proposed walls are unlikely to effect the setting of Bunratty Castle significantly. Therefore, overall a potential to increase the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.	1.00	16			
ENVIRONMENTAL CRITERIA SCORE							-720			
Economic Values	Economic PV Benefits						€1,493,788			
Cost						€758,255				
NPV Benefits						€735,533				
Economic BCR						1.97				
Outcome Scores	MCA PV Benefits						€715,245			
MCA BCR						-37				
MCA Benefit Score						-49.18				
Option Selection MCA						829				

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	3.08	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement, if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting already at maximum value of 5.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.00	calculated but adjusted by professional judgement, if necessary	There is no risk to utility infrastructure within this AFA.	There is no risk to utility infrastructure within this AFA.
2.D	12	0.00	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	There is not is score is no effect to agriculture, following full implementation of the option.
3.A (i)	27	0.00	calculated but adjusted by professional judgement, if necessary	There is no risk to residential properties within this AFA.	There is no risk to residential properties within this AFA.
3.A (ii)	17	0.00	calculated but adjusted by professional judgement, if necessary	There is no risk to high vulnerability properties within this AFA.	There is no risk to high vulnerability properties within this AFA.
3.B (i)	9	5.00	calculated but adjusted by professional judgement, if necessary	Local weighting is calculated based on the baseline risk to social infrastructure but adjusted by professional judgement. Local weighting increased by 20% due to presence of Assets of Particular Social Value.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.
3.B (ii)	7	5.00	calculated but adjusted by professional judgement, if necessary	Local weighting is calculated based on the baseline risk to local employment.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.
4.A	16	5.00	fixed	<p>The Lower River Shannon cSAC [002165] is within the AFA.</p> <p>The Rivers Shannon and River Fergus Estuaries SPA [004077] is within the AFA.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.</p>	<p>Construction related impacts due to significant construction works in and adjacent to watercourses. Part of the Bunratty River bank will be permanently removed and replaced by a wall.</p> <p>There is reduced flooding in area with no significant polluting sources in 1% AEP Fluvial or 0.5% AEP Coastal extent.</p> <p>Therefore, overall a potential medium-term or recurring impediment to the achievement of wb objectives.</p>
4.B	10	5.00	Professional judgement	<p>The Lower River Shannon cSAC [002165] is within the AFA.</p> <p>The Rivers Shannon and River Fergus Estuaries SPA [004077] is within the AFA.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.</p>	<p>There are significant works proposed within the boundary of the Lower Shannon cSAC in order to provide the flood wall along the Bunratty River.</p> <p>Potentially significant effects during construction are:</p> <ul style="list-style-type: none">- Pollution risks to the cSAC- Disturbance to intertidal habitat adjacent to the cSAC in relation to the proposed wall- Disturbance to bird species within and outside the SPA- Disturbance to otter within and outside the cSAC <p>Therefore, overall a potential detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar site, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>
4.C	5	5.00	Professional judgement	<p>The Inner Shannon Estuary - North Shore pNHA [002048] is within the AFA. There are a number of pNHA within 5 km off the AFA: Garrannon Wood pNHA [001012], Inner Shannon Estuary - South Shore pNHA [000435] and Woodcock Hill Bog NHA [002402].</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc) is present (within AFA) and potentially affected.</p>	<p>Potential significant effects are related to works within the boundary of the Inner Shannon Estuary - North Shore pNHA in relation to the construction of the flood walls. However, it is noted in relation to the proposed wall that the boundary of the pNHA in this area partly falls on an existing building and a carpark which is highly unlikely to be qualifying habitat.</p> <p>Potential impacts include:</p> <ul style="list-style-type: none">- Pollution risks to the pNHA- Loss of habitat- Disturbance to bird species- Disturbance to otter <p>Therefore, overall a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>
4.D	13	2.00	Professional judgement	<p>The Bunratty Clovemill Watercourse (Bunratty River) is designated as a Salmonid river. There is Medium angling activity in the area.</p> <p>Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.</p>	<p>Construction related impacts due to significant construction works in and adjacent to watercourses. Part of the Bunratty River bank will be permanently removed and replaced by a wall. Construction related impacts on water quality and subsequent fish species.</p> <p>Therefore, overall a potential long term impact associated with permanent loss of river bank. Permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration, adjusted by professional judgement.</p>
4.E	8	3.00	Professional judgement	<p>There are no protected/ valued landscape areas in the spatial scale. Under the Clare County Council Development Plan 2011, areas within the AFA were classified as heritage landscapes.</p> <p>Local weighting of 3 set by professional judgement. Weighting of 3 applied where landscape character type is designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected.</p>	<p>The construction of the proposed walls will have an impact on the setting of the area however, given the location and height of the walls they are not likely to impact in the long-term the landscape and visual environment as long as there is appropriate detailed design taking account of environmental mitigation/recommendation.</p> <p>Therefore, overall a potential for short term to long term impacts on local sensitivity landscape character/feature in the zone of visibility of the selected measure.</p>
4.F(i)	4	2.00	Professional judgement	<p>Bunratty is not a heritage town. Two RPS / NIAH fall within the 0.5% AEP Coastal, Bunratty Castle and Bunratty Bridge.</p> <p>Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.</p>	<p>The proposed walls will offer protection to Bunratty Castle in addition the walls are unlikely to effect the setting of Bunratty Castle and Bunratty bridge significantly.</p> <p>Therefore a potential increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.</p>
4.F(ii)	4	4.00	Professional judgement	<p>Bunratty is not a heritage town. There are two RMP in the 0.5% AEP Coastal within the AFA including Bunratty Castle which is an National Monument in State care.</p> <p>Local weighting of 4 set by professional judgement. Weighting of 4 applied where there are nationally important archaeological feature(s) (e.g. National Monument in State Care, sites on which Preservation Orders or Temporary Preservation Orders have been served) present and potentially affected.</p>	<p>The proposed walls will offer protection to Bunratty Castle and the location and height of the proposed walls are unlikely to effect the setting of Bunratty Castle significantly.</p> <p>Therefore, overall a potential to increase the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.</p>

CFRAM Programme – Option Costs for Cost Benefit Analysis						Option Costs for CBA	
						Notes to CFRAM Consultants	

		
<h2 style="margin: 0;">CFRAM Unit Cost Development Project</h2>		
<h3 style="margin: 0;">Whole Life Cost Tool</h3>		
Prepared by:	M Cairns	Date: 31.07.15
Checked by:	J Reynolds	Date: 31.07.15

Project reference	S03	Project name:	Bunratty Option 1
Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	0.987
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€251,814	urban, stone cladding, no sheet piling
Total embankment costs		
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs	€24,750	
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs	€5,296	2weeks initially
Total Construction costs	€281,860	
Apply update to unit rate (CPI) if appropriate (cell N15)	€278,196	
Enter appropriate preliminaries estimate (%)	24%	
Enter other applicable costs (€)	0	
Total capital cost (€)	€349,133	
Consider amendments based on site issues/constraints (cell N16)	€349,133	
Total capital cost (€)	€349,133	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€72	assuming average O&M costs
Total embankment O&M costs		
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs	€1,059	2days annually
Total Operation and Maintenance costs	€1,131	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€373,269	
Optimism bias rate (from external sheet)	40%	
Total Cost including Optimism Bias	€522,576	

Whole life cost and Pvc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€349,133.3
Annual maintenance cost (€)	€1,130.9
Other cost (€)	€0.0
Other works frequency (years)	

Key	
	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total Pvc (€k):		373269
Cash sum		0	349133	55415	0	404549	373269
year	Discount Factor	Cost Elements				TOTALS:	
		Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	349133			349133.3	349133.3
1	0.962			1131		1130.9	1087.4
2	0.925			1131		1130.9	1045.6
3	0.889			1131		1130.9	1005.4
4	0.855			1131		1130.9	966.7
5	0.822			1131		1130.9	929.5
6	0.790			1131		1130.9	893.8
7	0.760			1131		1130.9	859.4
8	0.731			1131		1130.9	826.4
9	0.703			1131		1130.9	794.6
10	0.676			1131		1130.9	764.0
11	0.650			1131		1130.9	734.6
12	0.625			1131		1130.9	706.4
13	0.601			1131		1130.9	679.2
14	0.577			1131		1130.9	653.1
15	0.555			1131		1130.9	628.0
16	0.534			1131		1130.9	603.8
17	0.513			1131		1130.9	580.6
18	0.494			1131		1130.9	558.3
19	0.475			1131		1130.9	536.8
20	0.456			1131		1130.9	516.1
21	0.439			1131		1130.9	496.3
22	0.422			1131		1130.9	477.2
23	0.406			1131		1130.9	458.8
24	0.390			1131		1130.9	441.2
25	0.375			1131		1130.9	424.2
26	0.361			1131		1130.9	407.9
27	0.347			1131		1130.9	392.2
28	0.333			1131		1130.9	377.1
29	0.321			1131		1130.9	362.6
30	0.308			1131		1130.9	348.7
31	0.296			1131		1130.9	335.3
32	0.285			1131		1130.9	322.4
33	0.274			1131		1130.9	310.0
34	0.264			1131		1130.9	298.1
35	0.253			1131		1130.9	286.6
36	0.244			1131		1130.9	275.6
37	0.234			1131		1130.9	265.0
38	0.225			1131		1130.9	254.8
39	0.217			1131		1130.9	245.0
40	0.208			1131		1130.9	235.6
41	0.200			1131		1130.9	226.5
42	0.193			1131		1130.9	217.8
43	0.185			1131		1130.9	209.4
44	0.178			1131		1130.9	201.4
45	0.171			1131		1130.9	193.6
46	0.165			1131		1130.9	186.2
47	0.158			1131		1130.9	179.0
48	0.152			1131		1130.9	172.1
49	0.146			1131		1130.9	165.5

Appendix C8 Option Appraisal Report - Kilkee

1. Preliminary Report: Summary of Current Flood Risk					
1.1 AFA and Watercourse Details					
AFA:	Kilkee				
Unit of Management:	27				
Primary Watercourse(s):	Kilkee East, Kilkee Lower (River), Kilkee Upper (River), Kilkee Upper (Stream)				
1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event					
Source of flood risk:	Fluvial		Coastal		Both
Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		Residential	Non-Residential	Total	
	Fluvial	33	161	194	
	Coastal	22	127	149	
	Combined	33	161	194	
AFA Flood Cells:	Total Number:	3			
	Flood Cell Titles:	KIE_A, KIE_B, KIE_C			
Breakdown of properties at (combined) risk per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total	
	KIE_A	45	118	163	
	KIE_B	0	30	30	
	KIE_C	0	1	1	
Relevant Comments:	The AFA of Kilkee is at risk of flooding from both fluvial and coastal sources. Although in the 0.1% AEP coastal event the peak water level is not higher than sea wall or the ground behind the wall, there is a coastal flood risk associated with the backing up of fluvial flows during high tide events. The flood management measures for Kilkee will be designed to manage flood risk for the 1% AEP fluvial event and will also protect the properties from the 0.5% coastal event.				
Relevant Figure Ref:	Figure 1.1 and 1.2				
1.3 Summary of Existing Flood Risk Management Measures					
Arterial Drainage	Storage	Flow Diversion	Flood Defences	Level Control	Other
None	None	None	Yes	None	None
Relevant Comments:	The shoe-horn shaped sea wall adjacent to the central beach does not provide a coastal flood defence function, as the ground level and properties on the landward side of the sea wall are at a higher level than the 0.1% AEP coastal event peak water level. However, it is recognised that the sea wall does provide local protection in terms of wave overtopping and dissipating wave energy.				
Relevant Figure Ref:	Fig 1.1 and 1.2				

1.4 Summary of PV Damages/Potential PV Benefits				
Total PV Damages:		Uncapped		Capped
	Fluvial	€ 11,434,981		€ 6,014,333
	Coastal	€ 7,957,962		€ 3,914,961
	Combined	€ 19,392,943		€ 7,667,125
Max Combined Capped Benefits for 1% Fluvial and 0.5% Coastal AEP Event*:	€ 7,054,150			
Breakdown of Max Combined Capped PV Benefits per Flood Cell for 1% Fluvial and 0.5% Coastal AEP Event:	Flood Cell Ref	Residential	Non-Res	Total
	KIE_A	€ 3,661,346	€ 1,460,838	€ 5,122,184
	KIE_B	€ 0	€ 155,400	€ 155,400
	KIE_C	€ 0	€ 1,776,566	€ 1,776,566
Relevant Figure Ref:	Figure 1.2			

*These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.5% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	Description
High Vulnerability Properties at risk:	Health Centre	0.1% AEP Fluvial Flood Extent
		Kilkee Health Centre, Church Road
Social Infrastructure Assets:	None	N/A
Social Amenity Sites:	None	N/A
Relevant Figure Ref:		General Risk - Social
1.6 Risk to the Environment		
	Type	Description
Risk to WFD Annex IV:	None	N/A
Risk to SACs:	None	N/A
Relevant Figure Ref:		General Risk - Environment
1.7 Risk to Cultural Heritage		
	Type	Description
Risk to Sites of Cultural Heritage:	None	N/A
Relevant Figure Ref:		General Risk – Cultural Heritage
1.8 Risk to the Economy		
	Type	Description
Risk to Transport Infrastructure:	National Road	50% AEP Fluvial and Coastal Flood Extent.
		N67
	Regional Road	5%AEP Fluvial and Coastal Flood Extent.
		R487
	Local (Urban) Road	50% AEP Fluvial and Coastal Flood Extent.
		Strand Line

		Circular Road
		Well Road
		Victoria Park
		E End
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

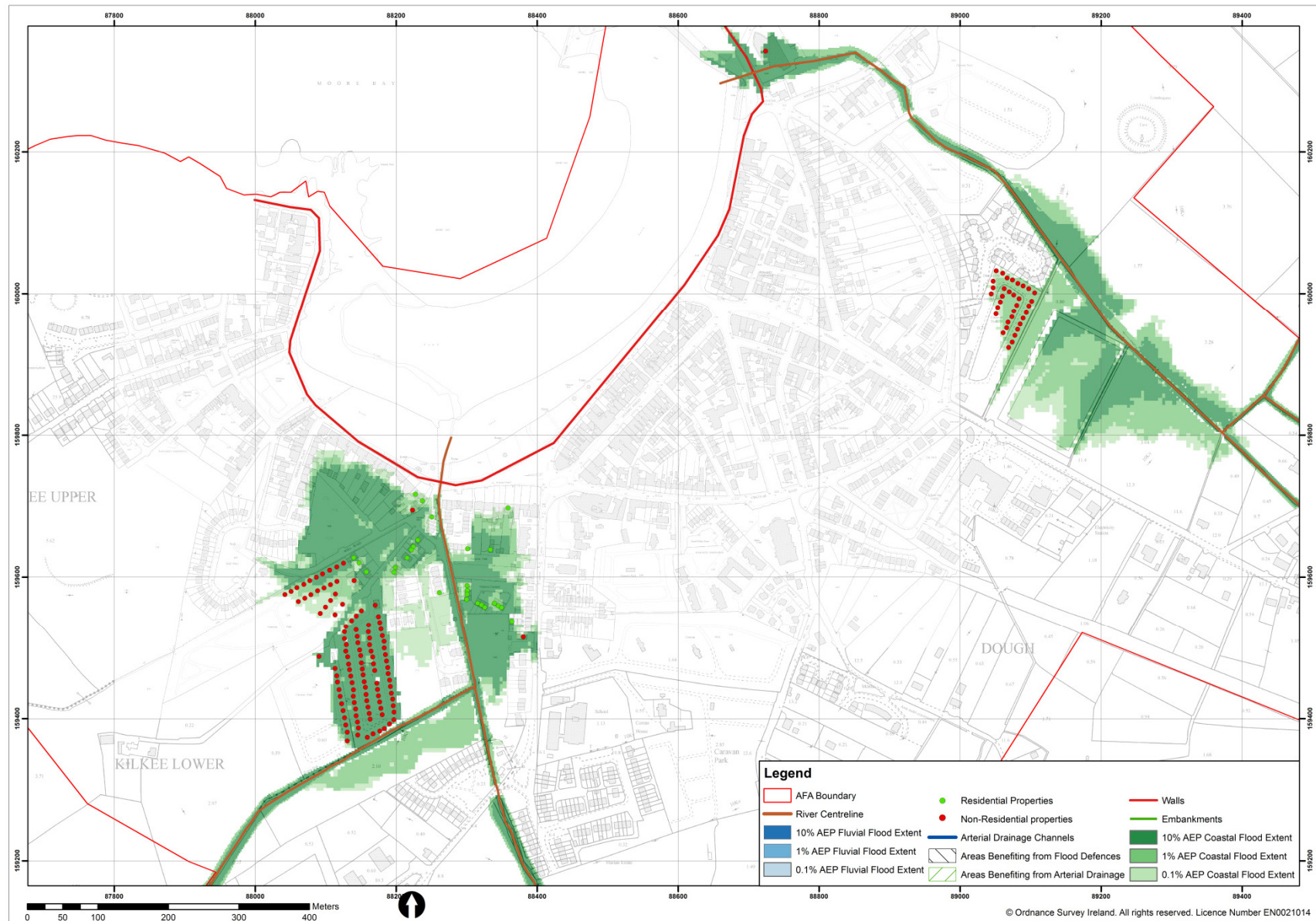


Figure 1.1 – Kilkee Coastal Flood Risk to Properties

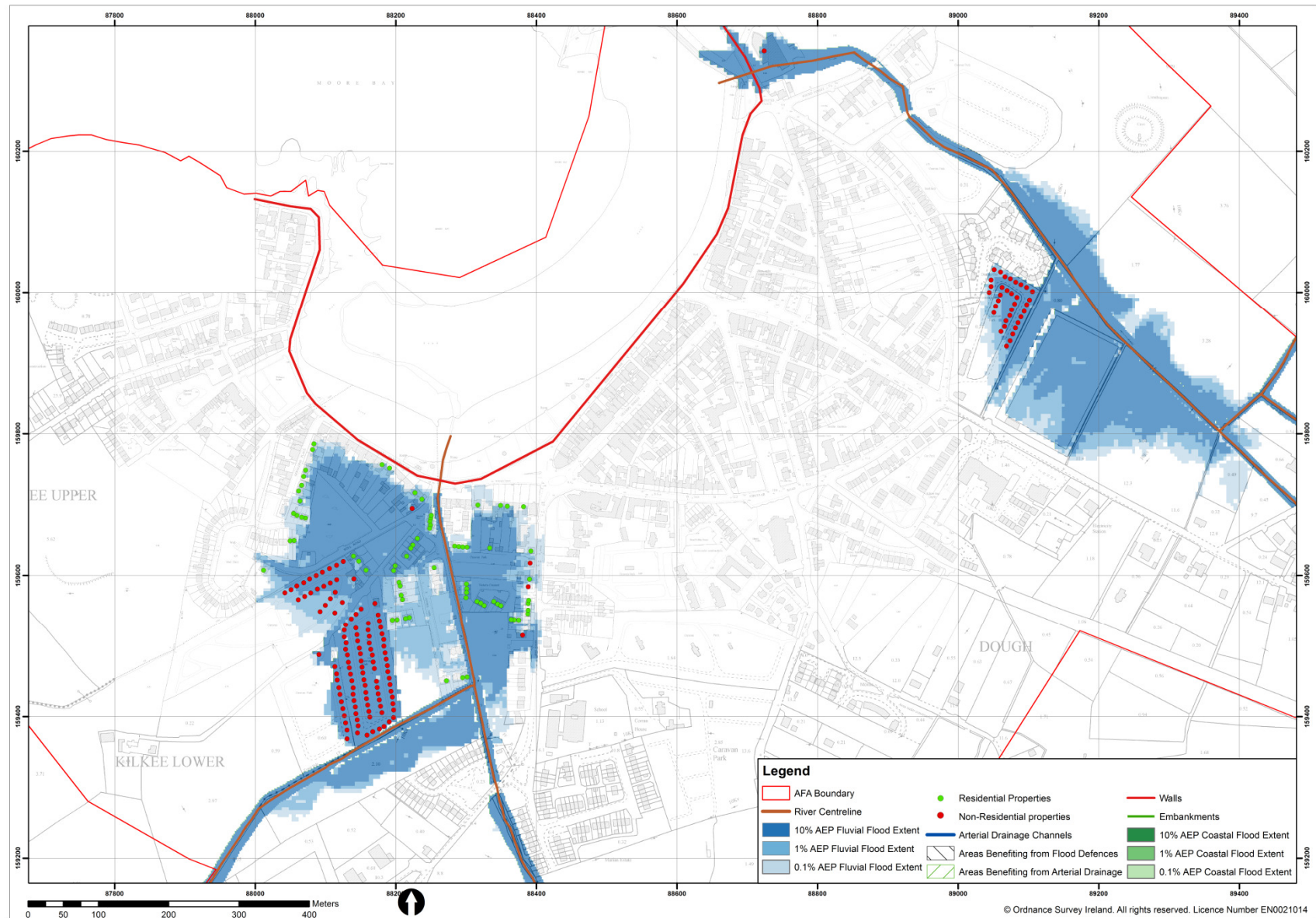


Figure 1.2 – Kilkee Fluvial Flood Risk to Properties

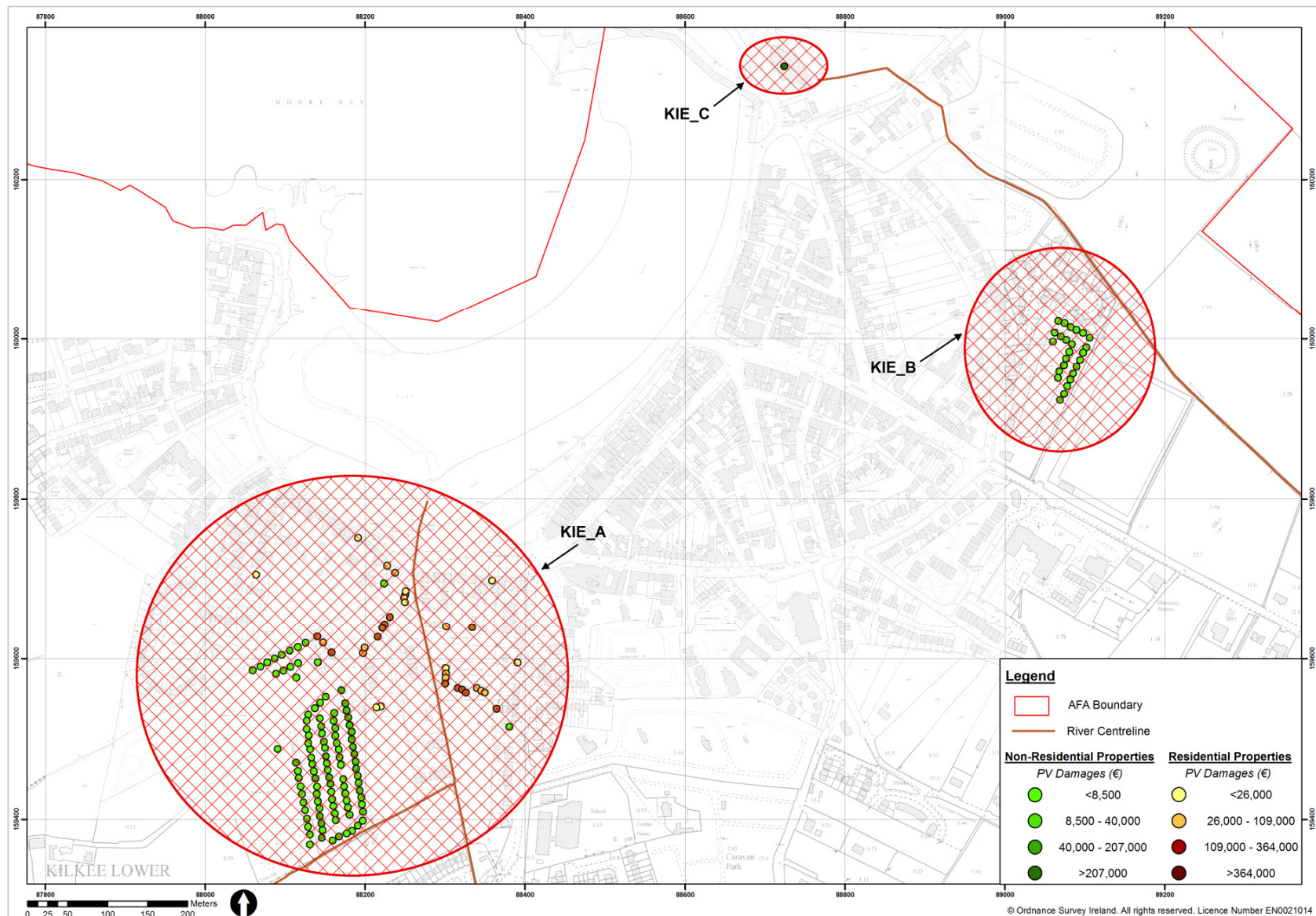


Figure 1.3 – Kilkee Total Combined PV Damages for Properties in the 1% Fluvial & 0.5% Coastal AEP Flood Event and Flood Cells. Flood Cells are groupings of properties that are likely to be hydraulically linked

2 STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	Screened Out
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	Screened In
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Unviable	Viable	Viable	Viable	Viable	Screened Out
E	Flow Diversion	Unviable	Viable	Viable	Viable	Viable	Screened Out
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	Screened In
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	Screened In
H	Relocation of Properties	Unviable	Viable	Viable	Unviable	Viable	Screened Out
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Unviable	Viable	Viable	Viable	Viable	Screened Out
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual Property Resistance	Unviable	Viable	Viable	Viable	Viable	Screened Out
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	Screened In

2.2 Justification for Screened Out Baseline and Structural Measures

The following provides justification on Measures with an overall viability 'Screened Out' categorisation.

A	Do Nothing	Applicability Economic Environmental Social Cultural	Screened out as there are other viable options.
C	Do Minimum	Applicability Economic Environmental Social Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact to the existing flood risk.
D	Storage	Applicability Economic Environmental Social Cultural	Screened out. No suitable storage areas were identified.
E	Flow Diversion	Applicability Economic Environmental Social Cultural	Screened out. No viable diversion routes were identified.
H	Relocation of Properties	Applicability Economic Environmental Social Cultural	Screened out. The relocation of 194 properties is neither applicable nor socially acceptable to the area.

I	Other Measures	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	No other measures have been identified.
J	Flood Forecasting / Warning / Response	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	Screened out. Due to the relatively small and steep catchment of the watercourses in Kilkee, using professional judgement it has been determined that any flood forecasting system would not provide adequate time for a warning or response to be effective as time to peak between the base flow and peak flow is less than 5 hours.
L	Individual Property Resistance	<div>Applicability</div> <div>Economic</div> <div>Environmental</div> <div>Social</div> <div>Cultural</div>	Screened out. Individual property resistance is not considered independently of flood forecasting, which has been deemed unviable.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Structural Measures		Non-Structural Measures	
B	Existing Regime	K	Public Awareness
F	Increase Conveyance	M	Individual Property Resilience
G	Construct Flood Defences		

3 STAGE 3: Selection of Options

3.1 Consideration of Options

The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration.

Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.

Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓	✓					
Structural Measures								
F	Increase Conveyance							
Fi	Channel Dredging							
Fii	Channel Widening							
Fiii	Structure Enhancement/Works		✓					
G	Flood Defences							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences	✓	✓					
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
K	Public Awareness							
M	Individual Property Resilience							
Option Reference		KIE_01	KIE_02					
Measures not screened out but not included in options								
Measures		Justification						
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.						
M	Individual Property Resilience	Individual Property Resilience was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required AEP standard of protection. Individual Property Resilience does not improve the viability of the options under consideration.						

4 STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each option and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.

Option Ref:		KIE_01			
Option Measures	Baseline	B	Existing Regime		
	Structural	Gi	Flood Defences: New Flood Defences		
		Gii	Flood Defences: Raise Existing Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Option Description:		<p>This option will provide a 1% Fluvial AEP design standard to all properties within the AFA and it will also protect the properties from the 0.5% coastal event.</p> <ul style="list-style-type: none"> Construct new flood defence wall along the right bank of the Kilkee Lower (River) watercourse. Construct new flood defence walls along the left and right bank of the Kilkee Upper (River) watercourse. Any existing embankments along the left bank of the Kilkee Upper (Stream) watercourse will need to be assessed and raised in some places by 0.3m. Downstream of the existing embankment, the existing wall will need to be assessed and will need to provide a flood defence function up to a level a 5.8m OD. Construct new flood defence wall parallel to the Kilkee East watercourse. Construct new flood defence walls and parapets along the left and right bank of the Kilkee East watercourse. 			
Option Development Meeting:		Date:	16/09/2015		
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.		

Option Ref:		KIE_02			
Option Measures	Baseline	B	Existing Regime		
	Structural	Fiii	Increase Conveyance: Structure Enhancement / Works		
		Gi	Flood Defences: New Flood Defences		
		Gii	Flood Defences: Raise Existing Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Option Description:		<p>This option will provide a 1% Fluvial AEP design standard to all properties within the AFA and it will also protect the properties from the 0.5% coastal event.</p> <ul style="list-style-type: none"> Construct new flood defence wall along the right bank of the Kilkee Lower (River) watercourse. Construct new flood defence walls along the left and right bank of the Kilkee Upper (River) watercourse. Any existing embankment along the left bank of the Kilkee Upper (Stream) watercourse will need to be assessed and raised in some places by 0.3m. Downstream of the existing embankment, the existing wall will need to be assessed and will need to provide a flood defence function up to a level of 5.8m OD. Construct new flood defence wall parallel to the Kilkee East watercourse. Upgrade existing culvert downstream of the Kilkee East watercourse. 			
Option Development Meeting:		Date:	16/09/2015		
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.		

5 STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Development Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five stage MCA process.

Option Reference		KIE_01	KIE_02
Structural Measures			
F	Increased Conveyance		
Fiii	Structure Enhancement/Works		Culvert downstream of Kilkee East watercourse to be upgraded.
G	Flood Defences		
Gi	New Flood Defences	New flood defences as shown in figure 5.1.	New flood defences as shown in figure 5.2.
Gii	Raise Existing Flood Defences	Raise existing embankments as shown in figure 5.1.	Raise existing flood defences as shown in figure 5.2.
Table reference			
A summary of the outcome from the MCA is presented in the following table		Table 5.1	Table 5.2

Table 5.1: Multi Criteria Assessment Outcome for Option KIE_01

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Kilkee		Option Ref: KIE_01
Option Measures			
Baseline	B	Existing Regime	
Structural	Gi	Flood Defences: New Flood Defences	
	Gii	Flood Defences: Raise Existing Flood Defences	
Non-Structural	N/A		
Criteria Scores			
Technical		800	
Economic		829	
Social		824	
Environmental		-405	
Economic Values			
Economic PV Benefits		€ 7,054,150	
PV Cost		€ 4,438,063	
NPV Benefits		€ 2,616,087	
Economic BCR		1.59	
Outcome Scores			
MCA PV Benefits		€ 3,744,238	
MCA Benefit Score		1248	
MCA Benefit Score Ratio		281.26	
Option Selection MCA		2048	
Relevant Figure		Figure 5.1	

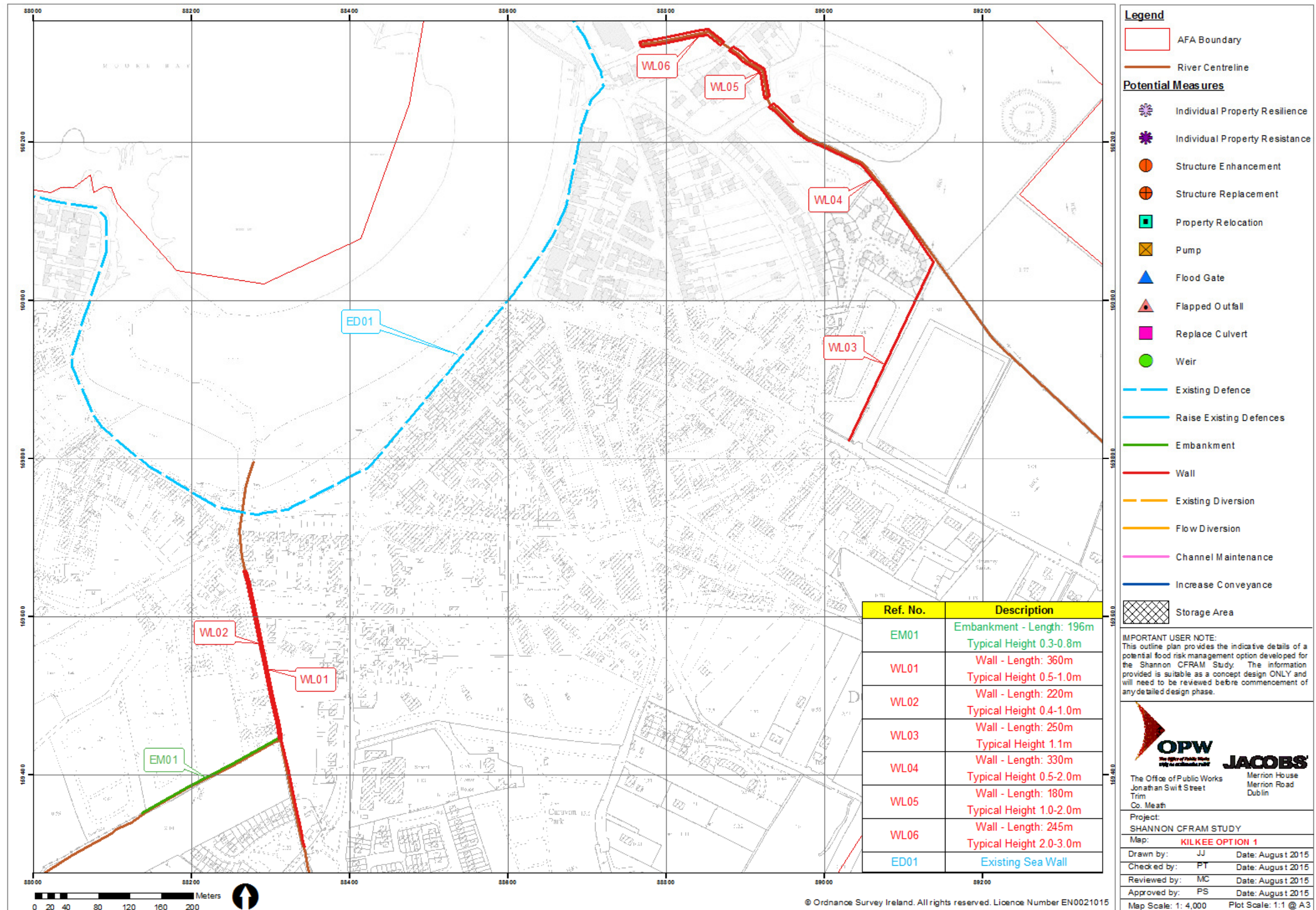


Figure 5.1 Option KIE_01

Table 5.2: Multi Criteria Assessment Outcome for Option KIE_02

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Kilkee		Option Ref: KIE_02
Option Measures			
Baseline	B	Existing Regime	
Structural	Fiii	Increase Conveyance: Structure Enhancement/Works	
	Gi	Flood Defences: New Flood Defences	
	Gii	Flood Defences: Raise Existing Flood Defences	
Non-Structural	N/A		
Criteria Scores			
Technical		750	
Economic		829	
Social		824	
Environmental		-260	
Economic Values			
Economic PV Benefits		€ 7,054,150	
PV Cost		€ 3,240,290	
NPV Benefits		€ 3,813,860	
Economic BCR		2.18	
Outcome Scores			
MCA PV Benefits		€ 3,744,238	
MCA Benefit Score		1393	
MCA Benefit Score Ratio		429.97	
Option Selection MCA		2143	
Relevant Figure		Figure 5.2	

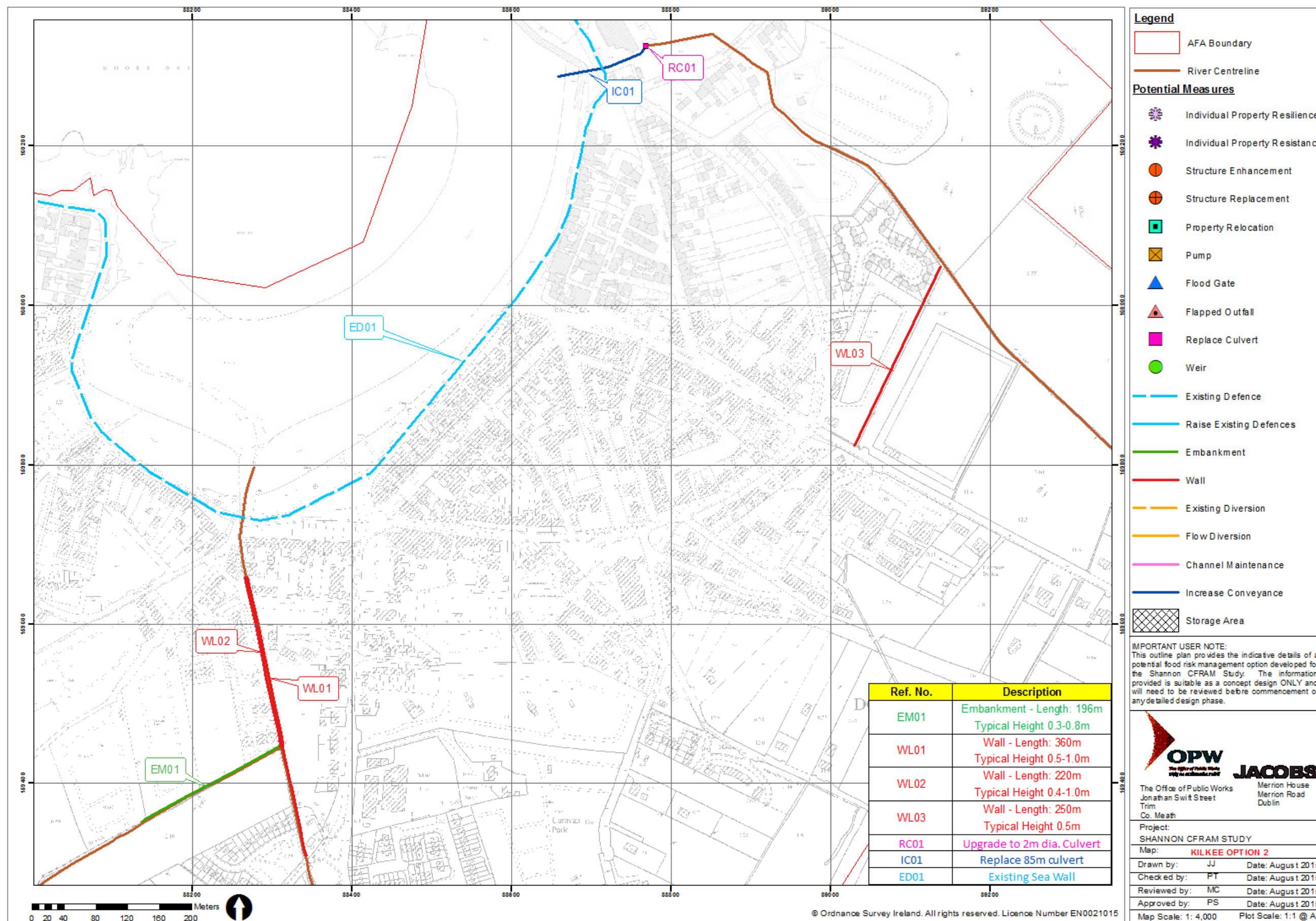


Figure 5.2 Option KIE_02

5.2 Comparison of Multi Criteria Assessment Scores

Each option taken forward for further consideration through the Option Development Meeting has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).

Categories	Option Reference and Results	
	KIE_01	KIE_02
Criteria Scores		
Technical	800	750
Economic	829	829
Social	824	824
Environmental	-405	-260
Economic Values		
Economic PV Benefits	€ 7,054,150	€ 7,054,150
PV Cost	€ 4,438,063	€ 3,240,290
NPV Benefits	€ 2,616,087	€ 3,813,860
Economic BCR	1.59	2.18
Outcome Scores		
MCA PV Benefits	€ 3,744,238	€ 3,744,238
MCA Benefit Score	1248	1393
MCA BCR	281.26	429.97
Option Selection MCA	2048	2143

5.3 Recommendation of Preferred Option

It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.

Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below

Option Ref:		KIE_02			
Option Measures	Baseline	B	Existing Regime		
	Structural	Fiii	Increase Conveyance: Structure Enhancement/Works		
		Gi	Flood Defences: New Flood Defences		
		Gii	Flood Defences: Raise Existing Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Comments		<p>This option has been designed to protect all properties at risk of flooding in the 1% AEP fluvial event and the 0.5% coastal AEP event. There are also properties at risk from wave overtopping within the AFA, it should be noted that this option does not negate the risk from this source. As the existing sea wall provides a level of protection to the AFA from wave overtopping this would need to be structurally assessed and maintained to continue providing protection.</p> <p>The MCA BCR is highest for KIE_02 and therefore this is the recommended emerging preferred option.</p>			

As part of the optioneering process an analyses was carried out on the potential for the development of an effective flood forecasting system for every AFA. The results of this assessment are presented in the Table below.

Fluvial Flood Forecasting Potential				
Catchment Information	Gauging Station		Catchment size (km ²)	Potential available forecast accuracy and reliability period
	Fluvial	Rainfall		
		No	No*	11.5
Relevant Information:	This is determined unknown for the following reasons; <ul style="list-style-type: none">• No suitable rain gauge• No suitable gauging station			
Additional Infrastructure Recommended	Gauging Station		Other	
	Fluvial	Rainfall		
		No	No	No
Relevant Comments:	As the catchment is small any potential flood forecasting early warning system would be unlikely to provide accurate and reliable predictions. Moreover, the potential forecast period is small.			
	There is little to no potential for the development of an effective fluvial flood forecasting system for Kilkee.			
	As this catchment is influenced by tidal flooding. Tidal flooding could be predicted by a simple forecasting system.			


*For this assessment only 15 minute tipping bucket gauge were considered.

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	KIE_01				Option Score	Weighted Score	KIE_02				Option Score	Weighted Score		
							B	Existing Regime					B	Existing Regime						
							Gi	New Flood Defences			Fiii							Structure Enhancement / Works		
							Gii	Raise Existing Flood Defences			Gi							New Flood Defences		
											Gii							Raise Existing Flood Defences		

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments	Option 2 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has no operational risks to operate or perform successfully.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	5.00	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement, if necessary	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting capped at maximum of 5.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.00	calculated but adjusted by professional judgement, if necessary	There is no risk to utility infrastructure within this AFA.	There is no risk to utility infrastructure within this AFA.	There is no risk to utility infrastructure within this AFA.
2.D	12	0.00	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This option has no effect on agriculture.	This option has no effect on agriculture.
3.A (i)	27	5.00	calculated but adjusted by professional judgement, if necessary	Local weighting is calculated based on the baseline risk to residential properties.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.
3.A (ii)	17	0.00	calculated but adjusted by professional judgement, if necessary	There are no high vulnerability properties at risk.	There is no risk to high vulnerability properties within the AFA.	There is no risk to high vulnerability properties within the AFA.
3.B (i)	9	0.03	calculated but adjusted by professional judgement, if necessary	Local weighting is calculated based on the baseline risk to social infrastructure. Local weighting increased by 20% due to asset of particular social value.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.
3.B (ii)	7	5.00	calculated but adjusted by professional judgement, if necessary	Local weighting is calculated based on the baseline risk to local employment. The local weighting is capped at the maximum value of 5.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.
4.A	16	5.00	fixed	<p>The Kilkee Reefs cSAC [002264] is within the AFA. The Tullaheer Lough And Bog cSAC [002343] is c. 5 km from the AFA. The Lower River Shannon cSAC [002165] is c. 1 km from the AFA.</p> <p>There are no SPAs within the AFA. The River Shannon and River Fergus Estuaries SPA [004077] is c. 3.5 outside the AFA. The Illaunonearaun SPA and Mid-Clare Coast SPA is within 15km from the AFA.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.</p>	<p>Construction related impacts from works in and adjacent to the waterbody to construct new flood walls and embankments. Permanent replacement of the natural banks with flood defence walls. These walls could cause potential changes to the hydrological and morphological regime of the watercourses.</p> <p>Reduced flooding in area with significant polluting sources in 1% AEP Fluvial extent.</p> <p>Therefore, overall a potential short-term or intermittent impediment to the achievement of wb objectives.</p>	<p>Construction related impacts from works in and adjacent to the waterbody to construct new flood walls and embankments. Permanent replacement of the natural banks with flood defence wall however significantly less than KIE01. These walls cause potential changes to the hydrological and morphological regime of the watercourses.</p> <p>Reduced flooding in area with significant polluting sources in 1% AEP Fluvial extent.</p> <p>Therefore, overall a potential short-term or intermittent impediment to the achievement of wb objectives.</p>
4.B	10	5.00	Professional judgement	<p>The Kilkee Reefs cSAC [002264] is within the AFA. The Tullaheer Lough And Bog cSAC [002343] is c. 5 km from the AFA. The Lower River Shannon cSAC [002165] is c. 1 km from the AFA.</p> <p>There are no SPAs within the AFA. The River Shannon and River Fergus Estuaries SPA [004077] is c. 3.5 outside the AFA. The Illaunonearaun SPA and Mid-Clare Coast SPA is within 15km from the AFA.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SAC/SPA/Ramsar) is present (within AFA) and potentially affected.</p>	<p>Potential effect are related to works in close proximity to the Kilkee Reefs cSAC. Potentially significant effects during construction are related to sediment or pollution risks to the cSAC. There is potential for disturbance to bird species related to the SPAs in the surrounding area.</p> <p>Therefore, overall a potential for a detrimental impact upon existing SAC or SPA site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>	<p>This option has significantly less construction works. Potential effects are related to works in close proximity to the Kilkee Reefs cSAC. Potentially significant effects during construction are related to sediment or pollution risks to the cSAC. There is potential for disturbance to bird species related to the SPA in the surrounding area.</p> <p>Therefore, overall a potential for a detrimental impact upon existing SAC or SPA site, including a delay in recovery of the site, but excluding impacts on the conservations objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>
4.C	5	2.00	Professional judgement	<p>There are no nationally designated ecological sites within the AFA. Illaunonearaun NHA is within 15km of the AFA. There are a number of pNHAs within c. 5km of the AFA: Poulmasherry Bay pNHA [000065], Tullaheer Lough And Bog NHA [000070] and Farrihy Lough pNHA [000200].</p> <p>Local weighting of 2 set by professional judgement. Weighting of 2 applied where there are no designated sites but habitats/species are likely to be present that could be affected.</p>	<p>There are no nationally designated ecological sites within the AFA. Potentially significant effects are related too:</p> <ul style="list-style-type: none"> - Pollution risks to the watercourse and the coastal waters - Increases in suspended sediment - Risk of disturbance to protected species or their resting sites - Risk of invasive species spread during proposed works - Impact to fish species <p>Therefore, potential localised loss of or disturbance to flora/fauna.</p>	<p>There are no nationally designated ecological sites within the AFA. This option has significantly less construction works than Option 1. Potentially significant effects are related too:</p> <ul style="list-style-type: none"> - Pollution risks to the watercourse and the coastal waters - Risk of disturbance to protected species or their resting sites - Risk of invasive species spread during proposed works - Impact to fish species <p>Therefore, potential localised loss of or disturbance to flora/fauna.</p>
4.D	13	2.00	Professional judgement	<p>Shannon Plume is not designated as a Salmonid waterbody. Kilkee and Kilkee Pier are South Clare angling 'fishing spots' as developed in maps by the IFI in the 1980's. The Shannon Plume is a high angling activity area.</p> <p>Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.</p>	<p>Construction related impacts from works in and adjacent to the waterbody to construct new flood walls and embankments. Construction works adjacent to the waterbody may impact water quality and cause access issues. Also the permanent replacement of the natural banks with flood defence walls.</p> <p>Therefore, overall a permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.</p>	<p>KIE02 has significantly less works than KIE02. However there are still construction related impacts from works in and adjacent to the waterbody to construct new flood walls and embankments. Construction works adjacent to the waterbody may impact water quality and cause access issues. Also permanent replacement of the natural banks with flood defence walls.</p> <p>Therefore, overall a permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.</p>
4.E	8	3.00	Professional judgement	<p>Heritage landscape as identified within the Clare County Council Development Plan 2011 fall within the AFA, along with a county scenic route. The Wild Atlantic Way falls within 1% AEP Fluvial & the 0.5% AEP Coastal.</p> <p>Local weighting of 3 set by professional judgement. Weighting of 3 applied where landscape character type is designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected.</p>	<p>There will be construction related impacts in the area surrounding the proposed flood defence walls and embankments.</p> <p>There will be long term localised impacts by replacing the watercourse banks with flood defence walls/embankments however, this should not impact on any designated landscape features.</p> <p>Therefore, there will be potential short to long term impact on local sensitivity landscape character/feature in the zone of visibility of the selected measure.</p>	<p>There will be construction related impacts in the area surrounding the proposed flood defence walls and embankments.</p> <p>There will be long term localised impacts by replacing the watercourse banks with flood defence walls/embankments however, this should not impact on and designated landscape feature. KIE02 has significantly less walls than KIE01.</p> <p>Therefore, there will be potential short to long term impact on local sensitivity landscape character/feature in the zone of visibility of the selected measure.</p>
4.F(i)	4	2.00	Professional judgement	<p>Kilkee is not a heritage town. 0.004 km2 of the ACA falls within the 1% AEP Fluvial &/or 0.5% AEP Coastal. There are 2 other protected features of architectural value within or partly within the 1% AEP Fluvial &/or 0.5% AEP Coastal; 1 NIAH and 1 RPS.</p> <p>Local weighting of 2 set by professional judgement. Weighting of 2 applied where there area number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.</p>	<p>The option will reduce the potential for flooding in the 1% AEP Fluvial and/or 0.5% AEP Coastal for the NIAH, the RPS and for the ACA. No impact on setting is anticipated.</p> <p>Therefore, there is a potential increase in the level of protection for architectural features (RPS, NIAH and ACA) from flooding, such that it is less vulnerable to flood damage.</p>	<p>The option will reduce the potential for flooding in the 1% Fluvial AEP and/or 0.5% AEP Coastal for the NIAH, the RPS and for the ACA. No impact on setting is anticipated.</p> <p>Therefore, there is a potential increase in the level of protection for architectural features (RPS, NIAH and ACA) from flooding, such that it is less vulnerable to flood damage.</p>
4.F(ii)	4	0.00	Professional judgement	<p>Kilkee is not a heritage town. There are no protected features of archaeological value in the 1% AEP Fluvial or 0.5% AEP Coastal within the AFA.</p> <p>Local weighting of 0 set by professional judgement. Weighting of 0 applied where there is no archaeological features at risk.</p>	<p>No change from the baseline. Therefore no effects on archaeological features.</p>	<p>No change from the baseline. Therefore no effects on archaeological features.</p>

CFRAM Programme – Option Costs for Cost Benefit Analysis						Option 1 Costs for CBA	
						Notes to CFRAM Consultants	



DONNACHADH O'BRIEN

& ASSOCIATES CONSULTING ENGINEERS

CFRAM Unit Cost Development Project


Whole Life Cost Tool

Prepared by: M Cairns

Checked by: J Reynolds

Date: 29.07.15

Date: 29.07.15



OPW

The Office of Public Works

Oifig na nOibreacha Poiblí

Project reference

Project name:

Kilkee Option 1

Base date for estimates (year 0)

Oct-2013

Construction Price Index (CPI)

0.987

Scaling factor (e.g. €m, €k, €)

€

Method Factor - to take into account particular site issues /constraints

1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs

Cost (€)

Comment

Total enabling costs (if applicable, may be sunk cost)

Capital costs

Cost (€)

Comment

Total wall costs

€1,936,634

urban, stone cladding, no sheet piling

Total embankment costs

€25,058

assuming imported fill, no piles

Total demountable barrier costs

Total demountable gate costs

Total in-channel excavation costs

Total excavation on land costs

Total weir construction costs

Total weir removal costs

Total bridge construction costs

Total bridge removal costs

Total bridge underpinning costs

Total culvert costs

Total sluice gate costs

Total road raising costs

Total individual property protection costs

Total hydrometric gauging station costs

Total flood forecasting costs

Total pumping station costs

Total channel maintenance costs

Total bank protection costs

Total manhole sealing costs

Total user specified method costs

Total Construction costs

€1,961,692

Apply update to unit rate (CPI) if appropriate (cell N15)

€1,936,190

Enter appropriate preliminaries estimate (%)

15%

Enter other applicable costs (€)

0

Total capital cost (€)

€2,258,633

Consider amendments based on site issues/constraints (cell N16)

€2,258,633

Total capital cost (€)

€2,258,633

Operation and Maintenance Cost Tool

Cost (€)

Comment

Total wall O&M costs

€598

Total embankment O&M costs

€620

Total demountable barrier O&M costs

Total demountable gate O&M costs

Total in-channel excavation O&M costs

Total excavation on land O&M costs

Total weir O&M costs

Total weir removal O&M costs

Total bridge O&M costs

Total bridge removal O&M costs

Total bridge underpinning O&M costs

Total culvert O&M costs

Total sluice gate O&M costs

Total road raising O&M costs

Total individual property protection O&M costs

Total hydrometric gauging station O&M costs

Total flood forecasting O&M costs

Total pumping station O&M costs

Total channel maintenance O&M costs

Total bank protection O&M costs

Total manhole sealing O&M costs

Total user specified method O&M costs

Total Operation and Maintenance costs

€1,218

Other costs

Cost (€)

Comment

Other costs (consider the need for additional longer term or intermittent costs)

Total PV Cost

Cost (€)

Comment

Total PVc costs (see PVc calculator below)

€2,284,622

Optimism bias rate (from external sheet)

40%

Total Cost including Optimism Bias

€3,198,470

Whole life cost and PVC analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€2,258,632.5
Annual maintenance cost (€)	€1,217.8
Other cost (€)	€0.0
Other works frequency (years)	

Key	
	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVC (€):		2284622
Cash sum		0	2258633	59671	0	2318303	2284622
year	Discount Factor	Cost Elements				TOTALS:	
		Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	2258633			2258632.5	2258632.5
1	0.962			1218		1217.8	1170.9
2	0.925			1218		1217.8	1125.9
3	0.889			1218		1217.8	1082.6
4	0.855			1218		1217.8	1041.0
5	0.822			1218		1217.8	1000.9
6	0.790			1218		1217.8	962.4
7	0.760			1218		1217.8	925.4
8	0.731			1218		1217.8	889.8
9	0.703			1218		1217.8	855.6
10	0.676			1218		1217.8	822.7
11	0.650			1218		1217.8	791.0
12	0.625			1218		1217.8	760.6
13	0.601			1218		1217.8	731.4
14	0.577			1218		1217.8	703.2
15	0.555			1218		1217.8	676.2
16	0.534			1218		1217.8	650.2
17	0.513			1218		1217.8	625.2
18	0.494			1218		1217.8	601.1
19	0.475			1218		1217.8	578.0
20	0.456			1218		1217.8	555.8
21	0.439			1218		1217.8	534.4
22	0.422			1218		1217.8	513.8
23	0.406			1218		1217.8	494.1
24	0.390			1218		1217.8	475.1
25	0.375			1218		1217.8	456.8
26	0.361			1218		1217.8	439.2
27	0.347			1218		1217.8	422.3
28	0.333			1218		1217.8	406.1
29	0.321			1218		1217.8	390.5
30	0.308			1218		1217.8	375.5
31	0.296			1218		1217.8	361.0
32	0.285			1218		1217.8	347.1
33	0.274			1218		1217.8	333.8
34	0.264			1218		1217.8	320.9
35	0.253			1218		1217.8	308.6
36	0.244			1218		1217.8	296.7
37	0.234			1218		1217.8	285.3
38	0.225			1218		1217.8	274.3
39	0.217			1218		1217.8	263.8
40	0.208			1218		1217.8	253.6
41	0.200			1218		1217.8	243.9
42	0.193			1218		1217.8	234.5
43	0.185			1218		1217.8	225.5
44	0.178			1218		1217.8	216.8
45	0.171			1218		1217.8	208.5
46	0.165			1218		1217.8	200.5
47	0.158			1218		1217.8	192.8
48	0.152			1218		1217.8	185.3
49	0.146			1218		1217.8	178.2

CFRAM Programme – Option 2 Costs for Cost Benefit Analysis						Option 2 Costs for CBA
			€	€	€	Notes to CFRAM Consultants
(1) Basic Construction Costs (Estimate)					1,291,220	Construction Cost of each measure <u>including</u> Method Factor and CPI Adjustment but <u>excluding</u> Preliminaries
(2) Preliminaries	17.0%				219,752	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				1,510,972	
(3) Optimism Bias	40.0%				604,389	Refer to UCD for selecting OB %
(4) Construction Costs (Excl VAT)					2,115,361	
(5) Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)	13.0%				274,997	Set at 13%
Construction Costs and Fees					2,390,358	
(6) Other Items						
(a) Allowance for Archaeology & Environmental Mitigation Measures	10.0%			211,536		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b) Allowance for compensation and land acquisition	12.0%			253,843		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c) Site investigation	3% assumed			63,461		Professional judgement to be applied in estimating a suitable sum.
(d) Art Allowance				25,500		See “Guidance E – Per Cent for Art Note”
(e) Est. NPV Operation & Maintenance				211,137		From PVC Summary sheet: PVC – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
	Optimism Bias	40.0%		84,455	295,592	Refer to UCD for selecting OB %
Option Cost for Cost Benefit Analysis					3,240,290	



CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by: M Cairns Date: 29.07.15
Checked by: J Reynolds Date: 29.07.16

Project reference

Project name:

Kilkee Option 2

Base date for estimates (year 0) Oct-2013
Scaling factor (e.g. €m, €k, €) €

Construction Price Index (CPI) 0.987
Method Factor - to take into account particular site issues /constraints 1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€1,038,608	urban, stone cladding, no sheet piling
Total embankment costs	€25,058	assuming imported fill, no piles
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs	€227,554	2m dia., 85m length
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€1,291,220	
Apply update to unit rate (CPI) if appropriate (cell N15)	€1,274,434	
Enter appropriate preliminaries estimate (%)	17%	
Enter other applicable costs (€)		
Total capital cost (€)	€1,510,972	
Consider amendments based on site issues/constraints (cell N16)	€1,510,972	
Total capital cost (€)	€1,510,972	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€313	average o&m assumed.
Total embankment O&M costs	€620	average o&m assumed.
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€8,960	average o&m assumed.
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€9,893	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€1,722,109	
Optimism bias rate (from external sheet)	40%	
Total Cost including Optimism Bias	€2,410,953	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€1,510,972
Annual maintenance cost (€)	€9,893
Other cost (€)	€0.0
Other works frequency (years)	

Key	
	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVc (€k):		1722109
Cash sum		0	1510972	484771	0	1995743	1722109
year	Discount Factor	Cost Elements				TOTALS:	
		Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	1510972			1510972.1	1510972.1
1	0.962			9893		9893.3	9512.8
2	0.925			9893		9893.3	9146.9
3	0.889			9893		9893.3	8795.1
4	0.855			9893		9893.3	8456.8
5	0.822			9893		9893.3	8131.6
6	0.790			9893		9893.3	7818.8
7	0.760			9893		9893.3	7518.1
8	0.731			9893		9893.3	7228.9
9	0.703			9893		9893.3	6950.9
10	0.676			9893		9893.3	6683.6
11	0.650			9893		9893.3	6426.5
12	0.625			9893		9893.3	6179.3
13	0.601			9893		9893.3	5941.7
14	0.577			9893		9893.3	5713.1
15	0.555			9893		9893.3	5493.4
16	0.534			9893		9893.3	5282.1
17	0.513			9893		9893.3	5078.9
18	0.494			9893		9893.3	4883.6
19	0.475			9893		9893.3	4695.8
20	0.456			9893		9893.3	4515.2
21	0.439			9893		9893.3	4341.5
22	0.422			9893		9893.3	4174.5
23	0.406			9893		9893.3	4014.0
24	0.390			9893		9893.3	3859.6
25	0.375			9893		9893.3	3711.1
26	0.361			9893		9893.3	3568.4
27	0.347			9893		9893.3	3431.2
28	0.333			9893		9893.3	3299.2
29	0.321			9893		9893.3	3172.3
30	0.308			9893		9893.3	3050.3
31	0.296			9893		9893.3	2933.0
32	0.285			9893		9893.3	2820.2
33	0.274			9893		9893.3	2711.7
34	0.264			9893		9893.3	2607.4
35	0.253			9893		9893.3	2507.1
36	0.244			9893		9893.3	2410.7
37	0.234			9893		9893.3	2318.0
38	0.225			9893		9893.3	2228.8
39	0.217			9893		9893.3	2143.1
40	0.208			9893		9893.3	2060.7
41	0.200			9893		9893.3	1981.4
42	0.193			9893		9893.3	1905.2
43	0.185			9893		9893.3	1831.9
44	0.178			9893		9893.3	1761.5
45	0.171			9893		9893.3	1693.7
46	0.165			9893		9893.3	1628.6
47	0.158			9893		9893.3	1565.9
48	0.152			9893		9893.3	1505.7
49	0.146			9893		9893.3	1447.8

Appendix D: Economic Damage & Benefit Calculation and Cost Benefit Analysis

Contents

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1 Introduction

This Appendix explains the process and methodology for the calculation of economic flood damages and the use of these economic damages for option benefit analysis. This methodology is based on OPW Guidance Note 27 (Rev.C).

The aim of OPW Guidance Note 27, and this Appendix, is to apply a common approach to the calculation of monetarised, economic flood damages, and the economic benefits of flood risk management options. These are then used for undertaking cost-benefit analysis, with a view to ensuring that damages, benefits, and benefit-cost calculations are determined in a nationally consistent manner, to enable inter-comparability of proposed measures across the country.

2 Economic Damage and Benefit Calculation

2.1 Introduction

The calculation of economic benefits is undertaken using standardised guidelines and figures, provided in the Flood Hazard Research Centre Handbook of 2010 (FHRC, 2010) and the 'Multi-Coloured Manual' of 2005 (FHRC, 2005) as referred to in FHRC, subject to caveats, amendment and clarification set out in the OPW Guidance Note 27 'Economic Damage and Benefit Calculation and Cost-Benefit Analysis' Rev. C.

The approach provides an economic, as opposed to financial assessment. For example, residential property damages take account of depreciation of the value of contents (e.g. replacing items like-for-like, as opposed to purchasing new items). Indirect damages to non-residential properties are included for some types (e.g. damage to small, individually, or family owned businesses) whereas loss of business is generally not included as this is assumed to be displaced to elsewhere within the economy.

2.2 Methodology

The assessment of the overall economic damages associated with flooding is composed of the following components:

- **Principal Direct Damages:** Direct property damage to residential and non-residential properties
- **Intangible and Intangible damage**
- **Emergency services**
- **Infrastructural Utility Assets**

2.2.1 Direct Property Damage – Residential and Non-Residential

(a) Residential Properties

Direct property damages to Residential Properties are calculated according to the depth-damage data presented in the 2010 Handbook for economic appraisal. The data is matched to each property based on the depth of flooding and the MCM code which categorises the property into various residential categories (e.g. detached, semi-detached, terraced, Bungalow). Details of the property types are provided in the GeoDirectory for Ireland.

Flood damages for residential properties begin at flood depths of -0.3 m relative to threshold levels. This only applies however, to properties whose footprint lies within the flooded area.

For properties with basements, the flood damages for the property assume a depth of 2.4m once the flood depth exceeds the threshold level for the basement. This damage is in addition to the normal depth-damage calculation for the ground floor of the property.

Different depth damage curves are used for the different property types dependant on the duration of flooding;

- >12 hours
- <12 hours

An additional 10% is applied to the damages for non –residential properties at risk of flooding from coastal sources.

The damages from the depth damage curve are converted to Euros using £1 = €1.279 conversion rate and an inflation multiplication factor of 1.051 has been applied. This is derived from inflation rates based on the CPI in Ireland for the period 2010 - 2013.

(b) Non Residential Properties

Direct property damages to Non - Residential Properties are calculated according to the indicative susceptibility depth-damage data presented in the 2010 Handbook for economic appraisal. The data is matched to each property based on the depth of flooding and the “MCM code” as referred to the FHRC 2005 and 2010 which categorises the property into various non- residential categories (e.g. high street shop, warehouse). There are different depth-damage curves for each MCM code.

Although, the GeoDirectory for Ireland does not provide a MCM code for each non-residential property type, it does provide a NACE code which has been used to determine the representative MCM code for each Non-Residential Property. In instances where the NACE code is not provided in the Geodirectory it is determined manually using professional judgement and a combination of site visits and remote data, such as ‘Google Street Map’.

Direct flood damages for non-residential properties are calculated on a £/m² basis (converted to €/m²).

Flood damages for non-residential properties begin at flood depths of 0m relative to threshold levels.

Depth damage curves for non-residential properties are only available for durations less than 12 hours in the FHRC 2010.

An additional 10% is applied to the damages for non –residential properties at risk of flooding from coastal sources.

Where the property type is mixed i.e. there is both residential and non-residential classification applied to the property, it has been assumed that the non-residential element of the property is located on the ground floor and damages associated with non-residential properties has been applied. Spot checks of this have been carried out using ‘Google Street Map’.

As for residential properties the damages from the depth damage curve are converted to Euros using £1 = €1.279 conversion rate and an inflation multiplication factor of 1.051 has been applied. This is derived from inflation rates based on the CPI in Ireland for the period 2010 - 2013.

2.2.2 Principal Direct Damage

Principal Direct Damages are the sum of the residential and non-residential property damages.

The Average Annual Damages (AAD) are based on the modelled probability events occurring in any given year. A minimum of three events are required to generate a meaningful result, and a maximum of eight events can be considered. The total PV direct damages are then calculated by discounting the AAD over the specified appraisal period.

2.2.3 Intangible and Indirect Damages

Flood events can cause significant stress, anxiety, and ill health to potentially affected people, during and then after a flood. Individuals generally incur some costs due to their properties flooding that are not directly related to damage, such as evacuation, temporary accommodation, loss of earnings, increased travel and shopping costs, etc.

While these negative impacts are difficult to monetarise or quantify, it is recognised that these impacts are significant, and professional opinion has indicated that they could well be greater than the direct damages to residential properties.

For residential properties, the intangible and indirect flood damages shall together be set equal to the total (direct) property damages.

Intangible damages may also be applied in the case of small, individually, or family-owned businesses where the intangible impact would be personal and similar in nature to that which might be experienced were the property residential.

2.2.4 Emergency Services

Costs to emergency services (which include evacuation costs) are included in the economic damages, and are calculated as 8.1% of the total Principal Direct Damage (PDD) Costs.

2.2.5 Infrastructural Utility Assets

Economic damages to infrastructural utility assets (e.g. electrical sub-stations, gas installations and pipe-work, telecommunications assets, etc.) are calculated as 20% of total PDD Costs.

2.2.6 Annual Average Damage

Damages are calculated for each property residential and non-residential for each of the following AEP events;

- 50%, 20%, 10%, 4%, 2%, 1%, 0.5% and 0.1%

The Annual Average Damage (AAD) is calculated using linear interpolation between damage values for each of these defined design events; i.e. with a damage value calculated for each 'slice' based on the average of the damages for the design event damages that form the probability boundaries for the 'slice', and the probability range of the 'slice'.

The AAD is calculated as the sum of the damage values of each slice, up to and including the 'slice' with the 0.1% AEP event as the upper bounding event.

The AAD is also calculated for the MRFS and the HEFS scenarios. For The HEFS as the depth are only available for the 10%, 1% (0.5% for coastal flooding) and 0.1% AEP events the damages for these events are calculated these values are used to shift the MRFS damage curve to derive an indicative damage curve for the HEFS.

2.2.7 Present Value Damages

The PVd are calculated as the discounted sum of the annual average damages over the project horizon, where:

- The discount rate to be applied is 4%
- The project horizon is 50 years

2.2.8 Capped Present Value Damages

Capped PV Damages are the damages capped at the value of the properties contributing to the damages.

The capping value of the direct damages for a residential property is the value of that property. The value of the property has been based on the property price guide¹ see annex B1.

The capping value of the intangible and indirect damage for a residential property is also the value of the property.

The capping value of the direct damages for a non- residential property is 10 time the rateable value of the property multiplied by the floor area and the yield value, see annex B2.

2.3 ArcGIS Tool

An ArcGIS tool has been developed for this project that rapidly calculates the economic cost of flooding to properties, based on model predictions of flood depth. Compared with the alternative calculation methods based in Excel, the ArcGIS tool offers a number of benefits, including efficiency and robustness.

2.3.1 Parameters

The tool is set up to use hydraulic model predictions of flood depth at individual property locations that have already been incorporated into a property database (ArcGIS point layer). Each unique property point in the GeoDirectory is assigned a flood depth for each modelled probability event.

The following key information, used by the tool, is provided in the Geodirectory for each address point:

- Unique geo-database ID

¹ "Property Price Guide" - The Sunday Times 11/01/2015

- Building use type (residential, non-residential, or unknown)
- Residential property type
- Non-Residential property type
- Location coordinates (Easting and Northing)
- European industrial activity classification (NACE) code

In addition to the above parameters the floor area for non-residential properties are required.

Note that where any of the above data is not available, assumptions using professional judgement have been used in order to approximate the damages.

The following parameters must be specified as the tool is run:

- Region of Study – select from 14 regions in the Shannon RBD² to load approximate market values for each type of residential property (see Annex B). This is to allow damage estimates to be capped at market prices.
- Appraisal period – the default project horizon is 50 years and the default discount rate is specified as 4%. Additional discount rates of 3% and 5% can be selected. As specified in OPW GN27 Section 3.8.
- Emergency service costs – specified value of 8.1% is applied as a default (see Section 2.2.4).
- Property threshold – The default values are 0.15 m for residential and 0.0 m for non-residential. When surveyed thresholds are available then the tool will revert to that value.
- Duration of flooding – specify shorter or longer than 12 hours as there are different depth-damage datasets for residential property types depending on the duration (see Section 2.2.5).
- Coastal uplift – an uplift (10%) to account for increased property damages due to coastal (saltwater) inundation.

² Clare, Cork, Galway, Galway City, Kerry, Laois, Leitrim, Limerick, Limerick City, Longford, Offaly, Roscommon, Tipperary, and Westmeath

3**Cost Benefit Analysis****3.1 General Methodology**

As detailed in OPW Guidance Note 27, the benefit-cost ratio (BCR) is produced as the output of the cost-benefit analysis. This is calculated by dividing the Present Value Benefits (PVB) for an option or measure, capped as appropriate, by the whole life costs (PVC) of that option or measure. Measures are only recommended as measures to be put forward in the Flood Risk Management Plan if their BCR is greater than unity.

In addition, the Net Present Value of the benefits (NPVB) of the option is calculated by deduction the PVC from the capped PVB.

Table C.1, below, taken from OPW Guidance Note 27 - Appendix B, and sets out which parameters are applicable for each use (Economic CBA, Economic Risk Mapping, and appraisal against MCA Objective 2.1), and how some of the parameters (e.g. Total damages for a given event, AAD) are calculated based on previous parameters.

As set out in the Generic CFRAM Project Brief, sensitivity tests are undertaken to determine the BCR using higher or lower discount rates, which are 5% and 3% respectively.

Further guidance on deriving costs for options or measures is provided in the OPW Guidance Note on the use of Unit Cost Database.

Table C.1 Cost Benefit Analysis Explanatory Table

Parameter		Application		
		Economic CBA	Economic Risk Mapping	MCA Appraisal Objective 2.a
1.	Residential Damages	Yes	Yes	Yes
2.	Non-Residential Damages	Yes	Yes	Yes
3.	Principal Direct Damages (PDD)	1 + 2	1 + 2	1 + 2
4.	Intangible Damages	Yes	Yes	No
5.	Infrastructural Utility Damages	Yes	Yes	No
6.	Emergency Services	Yes	Yes	Yes
7.	Traffic Disruption	Possibly	Possibly	No
8.	Event Damage	3 + 4 + 5 + 6 + 7	3 + 4 + 5 + 6 + 7	3 + 6
9.	Annual Average Damage (AAD)	Annualise 8	Annualise 8	Annualise 8
10.	Present Value of Damages (PVd)	Discounted sum of 9 over the Project Horizon	N/A	Discounted sum of 9 over the Project Horizon
11.	Un-capped PVb	Reduction in PVd (10) provided by option	N/A	Reduction in PVd (10) provided by option
12.	Capping Value	Double Residential Property Value, or, = Non-Residential Property Value	N/A	N/A
13.	Capped PVb	11, but not > 12	N/A	11
14.	PVc	Whole Life Scheme Cost	N/A	Whole Life Scheme Cost
15.	BCR	13 / 14	N/A	13 / 14
16.	NPVb	13 - 14	N/A	13 - 14

Annex A Direct Damage Values (2014-15 Price Base)

A.1 Residential Properties Short Duration Flooding (<12 Hours)

		MCM Damage Data - Direct Damage (€/m depth)														
MCM Code	Property Type	-0.30	0.00	0.05	0.10	0.20	0.30	0.60	0.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00
110	DETACHED	1103	1103	13005	19238	32571	39371	47997	52439	57472	61986	69524	73807	77613	86219	90731
120	SEMI DETACHED	1476	1476	10851	14867	23799	27912	34399	36779	40156	42834	48214	51137	54220	60437	63476
130	TERRACE	1282	1282	9410	12949	21119	24786	30710	32823	35777	37968	42326	44515	46862	52628	54995
140	BUNGALOW	1030	1030	12888	18962	30643	36171	44664	48956	54063	58684	66296	70888	75340	84196	88899
150	FLAT	861	861	10824	14849	23924	27917	34748	37071	39797	41628	46074	47802	49213	54121	56054

A.2 Residential Properties Long Duration Flooding (<12 Hours)

		MCM Damage Data - Direct Damage (€/m depth)														
MCM Code	Property Type	-0.30	0.00	0.05	0.10	0.20	0.30	0.60	0.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00
110	DETACHED	1690	5271	23909	34105	47730	57471	64134	68302	72318	79174	87493	97363	102668	108187	114594
120	SEMI DETACHED	1853	3891	17130	24836	34171	40770	45135	47766	50338	54547	60061	66876	70418	74255	78534
130	TERRACE	1655	3327	14721	21463	29974	35913	39799	42183	44369	47579	51967	58035	60317	62817	65677
140	BUNGALOW	1768	5043	22843	33627	46399	54661	61385	66185	70367	77501	85955	96665	102804	108436	115519
150	FLAT	1168	3086	16548	24169	33165	39272	43581	46087	48008	50290	54780	60141	62162	64256	66891

A.3 Non-Residential Properties Short Duration Flooding (<12 Hours)

		MCM Damage Data - Direct Damage (€/m ² /m depth)																
MCM Code	Property Type	-1.00	-0.75	-0.5	-0.25	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
210	Shop/Store (Weighted mean)	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
211	(High Street) Shop	0	0	0	0	0	249	540	811	1022	1167	1291	1384	1469	1534	1597	1640	1686
213	Superstore/Hypermarket	0	0	0	0	0	441	991	1421	1794	2210	2430	2525	2619	2659	2703	2729	2758
214	Retail Warehouse	0	0	0	0	0	600	804	997	1142	1267	1383	1457	1524	1578	1629	1677	1717
215	Showroom	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
216	Kiosk	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
217	Outdoor market	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
218	Indoor Market	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
220	Vehicle Services (Weighted mean)	0	0	0	0	0	111	255	374	456	514	571	607	640	666	693	715	741
221	Vehicle Repair Garage	0	0	0	0	0	75	209	315	385	437	489	520	548	572	596	615	638
222	Petrol Filling Station	0	0	0	0	0	190	352	481	586	644	701	731	758	779	801	818	839
223	Car Showroom	0	0	0	0	0	220	394	568	691	778	860	929	989	1036	1084	1125	1172
224	Plant Hire	0	0	0	0	0	71	147	246	320	423	512	599	684	767	849	929	1008
230	Retail Services (Weighted mean)	0	0	0	0	0	205	395	608	772	897	1009	1097	1169	1219	1271	1311	1361
231	Hairdressing Salon	0	0	0	0	0	56	141	199	274	364	420	461	485	511	541	568	605
232	Betting Shop	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
233	Laundrette	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
234	Pub/Social club/wine bar	0	0	0	0	0	202	371	582	732	836	939	1018	1087	1133	1182	1219	1264
235	Restaurant	0	0	0	0	0	210	433	712	928	1098	1236	1349	1450	1522	1596	1656	1728
236	Café/Food Court	0	0	0	0	0	379	713	985	1204	1366	1528	1663	1745	1793	1838	1872	1914
237	Post Office	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
238	Garden Centre	0	0	0	0	0	53	112	148	184	215	245	273	299	309	317	325	334
300	Office (Weighted mean)	0	0	0	0	0	197	378	585	738	830	915	978	1033	1077	1123	1159	1202
310	Offices (non-specific)	0	0	0	0	0	196	376	581	733	824	909	972	1027	1070	1116	1151	1194
311	Computer Centres (Hi-Tech)	0	0	0	0	0	1854	3482	4589	5410	6061	6364	6458	6543	6609	6679	6732	6796
320	Bank	0	0	0	0	0	172	340	546	683	782	875	943	1006	1060	1120	1169	1219
400	Distribution/Logistics (Mean-all 4 w/h codes)	0	0	0	0	0	198	394	614	796	950	1101	1237	1371	1489	1607	1720	1824
410	Warehouse (including store)	0	0	0	0	0	76	141	218	275	317	358	389	417	436	455	470	488
420	Land Used for Storage	0	0	0	0	0	1	9	86	137	189	239	269	294	311	327	340	353
430	Road Haulage	0	0	0	0	0	76	141	218	275	317	358	389	417	436	455	470	488
411	Warehouse	0	0	0	0	0	254	487	713	919	1109	1298	1486	1679	1856	2034	2210	2332
412	Warehouse	0	0	0	0	0	100	200	332	432	505	583	648	702	755	806	847	899
413	Warehouse	0	0	0	0	0	360	747	1195	1556	1868	2165	2426	2684	2909	3132	3354	3577
510	Leisure (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
511	Hotel	0	0	0	0	0	217	400	652	922	1034	1144	1222	1292	1346	1404	1448	1502
512	Boarding House	0	0	0	0	0	68	113	362	588	733	862	944	1010	1058	1104	1140	1174
513	Caravan Mobile	0	0	0	0	0	0	0	448	611	724	913	1042	1100	1147	1188	1224	1269

514	Caravan Static	0	0	0	0	0	53	95	178	229	296	359	422	464	487	502	524	537
515	Self-catering Unit	0	0	0	0	0	247	326	433	511	566	619	660	696	724	754	777	805
516	Hostel (including prisons)	0	0	0	0	0	247	326	433	511	566	619	660	696	724	754	777	805
517	Bingo hall	0	0	0	0	0	801	1597	2474	2622	2725	2826	2897	2962	3012	3065	3105	3154
518	Theatre/Cinema	0	0	0	0	0	416	736	1086	1345	1525	1656	1748	1833	1903	1971	2023	2078
519	Beach Hut	0	0	0	0	0	29	68	113	169	187	194	199	203	204	204	204	205
520	Sport (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
521	Sports Grounds and Playing Fields	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
522	Golf Courses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
523	Sports and Leisure centres	0	0	0	0	0	181	369	558	715	800	884	951	1013	1051	1088	1119	1156
524	Amusement Arcade/Park	0	0	0	0	0	262	552	821	1031	1177	1301	1393	1478	1542	1605	1648	1693
525	Football Ground and Stadia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
526	Mooring/Wharf/Marina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
527	Swimming Pool	0	0	0	0	0	181	369	558	715	800	884	951	1013	1051	1088	1119	1156
600	Public Building (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
610	School/College/University/Nursery	0	0	0	0	0	432	786	1164	1440	1673	1838	1969	2085	2191	2295	2371	2458
620	Surgery/Health Centre	0	0	0	0	0	332	465	559	647	790	874	923	970	1015	1049	1093	1136
625	Residential Home	0	0	0	0	0	247	326	433	511	566	619	660	696	724	754	777	805
630	Community Centres/Halls	0	0	0	0	0	73	169	245	325	370	417	460	506	532	538	543	546
640	Library	0	0	0	0	0	244	490	889	1146	1346	1536	1697	1844	1889	1936	1972	2016
650	Fire/Ambulance station	0	0	0	0	0	120	255	419	552	668	791	868	983	1013	1044	1068	1098
651	Police Station	0	0	0	0	0	196	376	581	733	824	909	972	1027	1070	1116	1151	1194
660	Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
670	Museum	0	0	0	0	0	244	490	889	1146	1346	1536	1697	1844	1889	1936	1972	2016
680	Law court	0	0	0	0	0	196	376	581	733	824	909	972	1027	1070	1116	1151	1194
690	Church	0	0	0	0	0	70	144	205	266	298	332	364	398	419	424	428	431
800	Industry (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
810	Workshop	0	0	0	0	0	204	519	728	861	941	1006	1046	1082	1113	1140	1169	1203
820	Factory/Works/Mill	0	0	0	0	0	204	519	728	861	941	1006	1046	1082	1113	1140	1169	1203
830	Extractive/heavy Industry	0	0	0	0	0	3	45	146	201	271	335	386	425	455	486	545	581
840	Sewage treatment works	0	0	0	0	0	3	45	146	201	271	335	386	425	455	486	545	581
850	Laboratory	0	0	0	0	0	3456	3970	4544	5007	5513	6018	6440	6907	6957	7010	7050	7100
900	Miscellaneous (Weighted mean)	0	2	5	17	32	32	32	32	32	32	32	32	32	32	32	32	32
910	Car Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
920	Public Convenience	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
930	Cemetery/Crematorium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
940	Bus Station	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
950	Dock Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
960	Electricity Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

A.4 Non-Residential Properties Long Duration Flooding (>12 Hours)

		MCM Damage Data - Direct Damage (€/m ² /m depth)																
MCM Code	Property Type	-1.00	-0.75	-0.5	-0.25	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
210	Shop/Store (Weighted mean)	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
211	(High Street) Shop	0	0	0	0	0	328	702	1022	1246	1400	1536	1633	1733	1795	1869	1919	1972
213	Superstore/Hypermarket	0	0	0	0	0	582	1288	1790	2188	2652	2892	2979	3090	3111	3162	3193	3227
214	Retail Warehouse	0	0	0	0	0	793	1045	1256	1394	1520	1646	1720	1798	1846	1906	1962	2009
215	Showroom	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
216	Kiosk	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
217	Outdoor market	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
218	Indoor Market	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
220	Vehicle Services (Weighted mean)	0	0	0	0	0	147	332	471	557	617	679	716	755	779	811	836	867
221	Vehicle Repair Garage	0	0	0	0	0	99	272	397	469	524	581	613	647	669	697	719	746
222	Petrol Filling Station	0	0	0	0	0	251	458	606	715	773	834	863	894	912	938	958	982
223	Car Showroom	0	0	0	0	0	290	513	716	843	933	1023	1097	1167	1212	1268	1317	1371
224	Plant Hire	0	0	0	0	0	94	192	310	390	867	1338	1781	2231	2258	2304	2327	2355
230	Retail Services (Weighted mean)	0	0	0	0	0	270	513	766	942	1076	1200	1294	1379	1426	1487	1534	1593
231	Hairdressing Salon	0	0	0	0	0	75	183	250	334	436	499	544	573	598	633	665	707
232	Betting Shop	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
233	Laundrette	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
234	Pub/Social club/wine bar	0	0	0	0	0	266	482	733	893	1004	1118	1201	1282	1326	1383	1426	1479
235	Restaurant	0	0	0	0	0	277	563	897	1132	1318	1471	1592	1711	1781	1867	1938	2022
236	Café/Food Court	0	0	0	0	0	501	927	1241	1469	1639	1818	1962	2059	2098	2151	2190	2239
237	Post Office	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
238	Garden Centre	0	0	0	0	0	69	146	187	224	258	292	322	353	361	371	380	390
300	Office (Weighted mean)	0	0	0	0	0	260	492	737	900	995	1089	1154	1219	1260	1314	1356	1406
310	Offices (non-specific)	0	0	0	0	0	258	488	732	895	989	1082	1147	1212	1252	1305	1347	1396
311	Computer Centres (Hi-Tech)	0	0	0	0	0	2448	4526	5782	6600	7273	7574	7621	7720	7732	7814	7876	7952
320	Bank	0	0	0	0	0	227	441	688	833	939	1041	1112	1187	1240	1311	1368	1427
400	Distribution/Logistics (Mean-all 4 w/h codes)	0	0	0	0	0	261	512	774	971	1140	1310	1460	1617	1742	1880	2012	2134
410	Warehouse (including store)	0	0	0	0	0	101	183	274	336	380	426	459	492	510	532	549	571
420	Land Used for Storage	0	0	0	0	0	1	12	108	167	227	285	317	347	364	383	398	413
430	Road Haulage	0	0	0	0	0	101	183	274	336	380	426	459	492	510	532	549	571
411	Warehouse	0	0	0	0	0	336	633	898	1121	1331	1545	1754	1981	2172	2380	2585	2728
412	Warehouse	0	0	0	0	0	132	260	418	527	607	694	765	829	883	943	991	1052
413	Warehouse	0	0	0	0	0	475	972	1506	1898	2242	2576	2862	3167	3404	3665	3924	4185
510	Leisure (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
511	Hotel	0	0	0	0	0	286	520	822	1125	1241	1361	1442	1524	1575	1643	1694	1757
512	Boarding House	0	0	0	0	0	89	146	456	718	879	1026	1114	1192	1238	1291	1333	1374
513	Caravan Mobile	0	0	0	0	0	0	0	564	746	869	1087	1230	1298	1342	1390	1432	1484

514	Caravan Static	0	0	0	0	0	70	124	224	280	355	427	498	547	570	587	613	629
515	Self-catering Unit	0	0	0	0	0	326	424	546	623	679	737	779	821	848	882	909	942
516	Hostel (including prisons)	0	0	0	0	0	326	424	546	623	679	737	779	821	848	882	909	942
517	Bingo hall	0	0	0	0	0	1057	2077	3117	3199	3270	3363	3419	3495	3524	3586	3633	3691
518	Theatre/Cinema	0	0	0	0	0	550	957	1369	1640	1830	1971	2063	2163	2227	2306	2367	2431
519	Beach Hut	0	0	0	0	0	38	88	143	206	224	231	235	239	239	239	239	240
520	Sport (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
521	Sports Grounds and Playing Fields	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
522	Golf Courses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
523	Sports and Leisure centres	0	0	0	0	0	240	480	703	872	959	1052	1122	1195	1229	1273	1310	1353
524	Amusement Arcade/Park	0	0	0	0	0	346	718	1035	1257	1412	1548	1644	1744	1804	1878	1928	1981
525	Football Ground and Stadia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
526	Mooring/Wharf/Marina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
527	Swimming Pool	0	0	0	0	0	240	480	703	872	959	1052	1122	1195	1229	1273	1310	1353
600	Public Building (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
610	School/College/University/Nursery	0	0	0	0	0	570	1022	1466	1756	2008	2187	2324	2461	2563	2685	2774	2876
620	Surgery/Health Centre	0	0	0	0	0	439	604	705	789	948	1040	1089	1145	1187	1228	1279	1329
625	Residential Home	0	0	0	0	0	326	424	546	623	679	737	779	821	848	882	909	942
630	Community Centres/Halls	0	0	0	0	0	96	220	308	396	444	496	543	598	623	629	635	639
640	Library	0	0	0	0	0	322	637	1120	1399	1615	1828	2003	2175	2210	2265	2307	2359
650	Fire/Ambulance station	0	0	0	0	0	158	331	528	673	801	942	1024	1160	1185	1222	1250	1284
651	Police Station	0	0	0	0	0	258	488	732	895	989	1082	1147	1212	1252	1305	1347	1396
660	Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
670	Museum	0	0	0	0	0	322	637	1120	1399	1615	1828	2003	2175	2210	2265	2307	2359
680	Law court	0	0	0	0	0	258	488	732	895	989	1082	1147	1212	1252	1305	1347	1396
690	Church	0	0	0	0	0	92	188	258	325	358	395	429	469	490	496	501	505
800	Industry (Weighted mean)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
810	Workshop	0	0	0	0	0	269	675	917	1051	1129	1197	1235	1276	1302	1333	1367	1407
820	Factory/Works/Mill	0	0	0	0	0	269	675	917	1051	1129	1197	1235	1276	1302	1333	1367	1407
830	Extractive/heavy Industry	0	0	0	0	0	4	58	184	245	325	399	456	501	533	569	637	679
840	Sewage treatment works	0	0	0	0	0	4	58	184	245	325	399	456	501	533	569	637	679
850	Laboratory	0	0	0	0	0	4562	5161	5725	6109	6616	7161	7599	8150	8140	8202	8249	8307
900	Miscellaneous (Weighted mean)	0	2	5	17	32	43	42	41	39	39	38	38	38	38	38	38	38
910	Car Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
920	Public Convenience	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
930	Cemetery/Crematorium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
940	Bus Station	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
950	Dock Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
960	Electricity Hereditament	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Annex B Default Market Values

B.1 Residential Property Market Values

The value of residential properties has been based on the price guide from the “Property Price Guide” - The Sunday Times (11/01/2015).

Table B.1 Residential Property Market Values

Region	Bungalow	Detached	Semi-detached	Terrace	Duplex
Leitrim	€ 95,271	€ 112,308	€ 56,822	€ 49,521	€ 0
Roscommon	€ 68,667	€ 83,750	€ 76,800	€ 62,500	€ 0
Longford	€ 89,700	€ 103,400	€ 63,800	€ 27,500	€ 49,500
Westmeath	€ 111,700	€ 239,100	€ 107,325	€ 76,100	€ 82,475
Offaly	€ 122,500	€ 176,800	€ 137,700	€ 52,200	€ 56,000
Laois	€ 126,200	€ 107,300	€ 172,640	€ 64,000	€ 0
Tipperary	€ 90,100	€ 250,700	€ 103,500	€ 47,303	€ 0
Galway	€ 80,660	€ 171,000	€ 105,525	€ 99,800	€ 165,600
Galway City	€ 390,750	€ 313,829	€ 255,969	€ 212,300	€ 187,900
Clare	€ 117,226	€ 143,000	€ 98,300	€ 56,700	€ 83,500
Limerick	€ 77,980	€ 136,400	€ 120,700	€ 72,720	€ 146,450
Limerick City	€ 160,040	€ 225,300	€ 126,660	€ 69,300	€ 0
Kerry	€ 110,100	€ 93,200	€ 125,800	€ 78,400	€ 74,000
Cork (Charleville & Milford only)	€ 132,200	€ 102,110	€ 52,800	€ 38,000	€ 0

B.2 Non-Residential Property Values

Non-residential rateable values are taken from the ‘Commercial and Industrial Floorspace and Rateable Value Statistics’ - April 2008 values. (<https://www.gov.uk/government/statistical-data-sets/live-tables-on-commercial-and-industrial-floorspace-and-rateable-value-statistics>).

It has been determined that non-residential rateable values for the South West of England provide the most representative rates for Irish rates.

An inflation rate of 1.052 was applied to these rates to obtain the 2010 rateable values. Once the 2010 values were obtained a currency conversion of 1.279 and inflation rate of 1.051 was applied as for the direct property damages.

No rateable information is provided for property classes of Leisure or Public Buildings, therefore the assumption was made that Leisure and Public Building are set to be equal to the ‘Other’ category.

An EY factor is used to convert the rateable value into an estimated market value for non-residential properties. The market value is estimated by the following calculation:

$$\text{Market Value (£/m}^2\text{)} = \text{Rateable Value (£/m}^2\text{)} * 100/\text{EY}$$

For all non-residential property types the EY factor has been set at 10%.

Table B.2 Rateable Values

Region	Retail	Office	Warehouse	Leisure & Public	Industry
London	267	252	86	74	72
South East	195	146	74	47	57
Eastern	181	137	64	49	51
South West	161	115	51	37	41
East Midlands	148	99	49	42	38
West Midlands	158	120	51	47	37
Wales	139	96	40	31	31
North West	161	108	44	41	34
Yorkshire & Humberside	160	107	42	37	33
North East	157	96	37	28	31

Appendix E Option Development Meeting - Minutes

Appendix F MCA objectives and Scoring Methodology

MCA Objectives

The MCA objectives are outlined in GN 28. GN 28 has been provided for reference in Appendix F of this report. The FRM objectives reflect what the overall flood risk management programme is seeking to achieve, expanding on the requirements of the National Flood Policy Review and the European Unions (EUs) 'Floods' Directive.

At a local level, and for the purposes of the MCA, the objectives set out an aim that the each flood risk management option should be seeking to achieve, if possible. The degree to which an option achieves the objective is an indication of the 'success' of the option, and equally, the more an option achieves across all of the objectives, then the greater the preference that will be given to that option relative to others, taking account also of the cost of each of the options.

The flood risk management objectives are split into four categories:

- Technical
- Economic
- Social
- Environmental

These objectives have been split into sub-objective. The sub-objectives for each category and the scoring mechanism used are outlined in Tables F.1 to Tables F.4 overleaf.

Table F.1 Technical Objective

Technical Objective					
Objective	Description of Scoring	Global Weighting	Local Weighting	Scoring Range	
Technical 1A – Ensure flood risk management options are operationally robust	Scoring is to be by professional judgement, based on the guidance, taking into account the degree of reliance of the option on mechanical, electrical or electronic systems ('systems'), or on human intervention, action or decision ('intervention') to operate or perform successfully.	20	5 (Constant)	5 4 to 5 3 to 4 2 to 3 1 to 2 0 to 1 -1 to 0 -3 to -1 : High Operational Risk -5 to -3 : Foreseeable likelihood of failure -999 to -5 : Unacceptable Risk	: No Operation Risk : Negligible Operational Risk : Very Low Operational Risk : Low Operational Risk : Low / Moderate Operational Risk : Moderate but Manageable Operational Risk : Moderate / High Operational Risk
Technical 1B – Minimise health and safety risk in construction and operation of the flood risk management option	Scoring is to be by professional judgement, The indicative score under this objective should be set at five, and then have a point deducted for each specific risk (as defined under the Safety, Health and Welfare at work (Construction) Regulations) likely to be encountered in a) construction and then again in b) operation and maintenance.	20	5 (Constant)	5 4 to 5 3 to 4 2 to 3 1 to 2 0 to 1 -1 to 0 -3 to -1 -5 to -3 -999 to -5	: No H&S Risk : Negligible H&S Risk : Very Low H&S Risk : Low H&S Risk : Low / Moderate H&S Risk : Moderate but Manageable H&S Risk : Moderate / High H&S Risk : High H&S Risk : High H&S Risk : Unacceptable Risk
Technical 1C – Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change	Scoring is to be by professional judgement, based on guidance.	20	5 (Constant)	>3 0 to 3 -3 to 0 -999 to -3	: Option can be adapted at no to limited cost and difficulty, and provides no impediment to future interventions. : Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions. : Option cannot be adapted, but provides no to minor impediment to potential future interventions. : Option cannot be adapted, and provides moderate to major impediment to potential future interventions.

Table F.2 Economic Objective

Economic Objective				
Objective	Description of Scoring	Global Weighting	Local Weighting	Scoring Range
Economic 2A – Reduce economic damages	<p>Option Score = 0.05 X Percentage Reduction in AAD.</p> <p>The following values should apply as the percentage reduction in AAD for non-structural options (i.e. those that do not reduce hazard, but can reduce it)</p> <p>% Reduction in AAD</p> <p>10 % : >12 hours warning</p> <p>6% : 6-12 hours warning</p> <p>4% : 2-6 hours warning</p> <p>0% : < 2 hours warning</p>	24	AAD for the SSA / € 75,000. Subject to a maximum local weighting of 5.	<p>5 : 100 % reduction in AAD</p> <p>0 : No change in AAD</p> <p>< 0 : A negative score indicates that AAD has increased</p>
Economic 2B – Minimise risk to transport infrastructure	Scoring is based on degree of reduction of flood risk to transport receptors at risk from flooding. Each type of transport receptor is assigned a score and scoring is calculated based on a score derived from the number and type of transport infrastructure receptors potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that receptor. This score can be adjusted by professional judgement.	10	Based on calculated assessment, adjusted by professional judgement, subject to a maximum local weighting of 5.	<p>N/A : No transport infrastructure at risk</p> <p>5 : The risk to transport infrastructure is reduced to zero</p> <p>0 : No change in risk to transport infrastructure</p> <p>< 0 : A negative score indicates an increased risk to transport infrastructure.</p>
Economic 2C – Minimise risk to utility infrastructure	Scoring is based on degree of reduction of flood risk to utility receptors at risk from flooding. Each type of utility receptor is assigned a score and scoring is calculated based on a score derived from the number and type of utility infrastructure receptors potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that receptor. This score can be adjusted by professional judgement.	14	Based on calculated assessment, adjusted by professional judgement, subject to a maximum local weighting of 5.	<p>N/A : No utility infrastructure at risk</p> <p>5 : The risk to utility infrastructures is reduced to zero</p> <p>0 : No change in risk to utility infrastructure</p> <p>< 0 : A negative score indicates an increase in risk to utility infrastructure</p>
Economic 2D – Manage risk to agriculture	Scoring is by professional judgement, taking into account local advice.	12	By professional judgement, taking account of the value and social importance of the agricultural industry in the area (this is aided by the percentage of non-urban land in the AFA). Subject to a maximum local weighting of 5.	Scoring is by professional judgement, taking into account local advice.

Table F.3 Social Objective

Social Objective				
Objective	Description of Scoring	Global Weighting	Local Weighting	Scoring Range
Social 3A(i) – Minimise risk to human health and life – Residents	Scoring is calculated based on a score derived from the number of residential properties potentially affected by flooding and the highest probability (lowest magnitude) of a flood event that causes flooding of each property. This score can be adjusted by professional judgement.	27	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of residential properties at risk 0 : No change to the number or probability of flooding to residential properties at risk < 0 : A negative score indicates the number of residential properties at risk or the probability of flooding is increased
Social 3A(ii) – Minimise risk to human health and life – High Vulnerability	Scoring is calculated based on a score derived from the number and type of high vulnerability properties potentially affected by flooding, and the highest probability (lowest magnitude), adjusted by professional judgement of a flood event that causes flooding of that property. This score can be adjusted by professional judgement	17	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of high vulnerability properties at risk 0 : No change to the number of high vulnerability properties at risk < 0 : A negative score indicates the number of high vulnerability properties at risk is increased or the probability of flooding is increased
Social 3B(i) – Minimise risk to community – Social Infrastructure	Scoring is calculated based on a score derived from the number of social infrastructure assets potentially affected by flooding, and the highest probability (lowest magnitude) of a flood event that causes flooding of each asset. This score can be adjusted by professional judgement.	9	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of social infrastructure assets at risk 0 : No change to the number of social infrastructure assets at risk < 0 : A negative score indicates the number of social infrastructure assets at risk is increased or the probability of flooding is increased
Social 3B(ii) – Minimise risk to community – Local Employment	Scoring is calculated based on a score derived from the number of non-residential properties (taken as a place of employment) potentially affected by flooding, and the highest probability (lowest magnitude) of a flood event that causes flooding of each property. This score can be adjusted by professional judgement.	7	Based on calculated assessment, adjusted by professional judgement. Subject to a maximum score of 5	5 : 100 % reduction in the number of non-residential properties at risk 0 : No change to the number of non-residential properties at risk < 0 : A negative score indicates the number of non-residential properties at risk is increased or the probability of flooding is increased

Table F.4 Environmental Objective

Objective	Description of Scoring	Global Weighting	Local Weighting	Scoring Range
Environmental 4A – Support the objectives of the WFD	Scoring is guided by professional judgement with reference to a specified scoring system which takes into account the duration and permanence of likely impacts of the options on water body status elements, the sensitivity of the receiving bodies and the potential sources of pollution in the flood extent area. A generic description of the likely impacts of measures of water body status is also taken into account	16	5 (Constant)	5 : Permanent or long term contribution to the achievement of wb objectives 0 : No constraint of the achievement of wb objectives -999 : Unacceptable negative impact where feasible alternative exists
Environmental 4B – Support the objectives of the Habitat and Birds Directives	Scoring by professional judgement based upon the following key datasets: - Natura 2000 sites (SACs, SPAs) - Ramsar Site - Annex IV (Habitats Directive) species of flora and fauna and their key habitats	10	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Potential to create or enhance NHA sites to SAC, SPA or Ramsar status 0 : No impact on existing SAC, SPA or Ramsar sites -999 : Any detrimental impact upon existing SAC, SPA or Ramsar sites
Environmental 4C – Avoid damage to, and where possible enhance the flora and fauna of the catchment	Scoring by professional judgement based upon the following key datasets: - Natural Heritage Areas (& proposed Natural Heritage Areas) - Nature Reserves - Wildfowl Sanctuary - OSPAR - National Parks	5	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Potential to create new national, regional and local conservation sites 0 : No impact on existing national, regional and local sites -999 : Any detrimental impact upon national, regional or local sites
Environmental 4D – Protect and where possible enhance fisheries resource within the catchment	Scoring is guided by professional judgement with reference to a specified scoring system which takes into account the duration and permanence of likely impacts of the options on fisheries and fisheries potential and the sensitivity of the receiving bodies and species	13	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Creation of fisheries habitat or removal of barrier to upstream migration for wb where sensitive species are known to be present 0 : No change to fisheries potential of wb -999 : Unacceptable negative impact where a feasible alternative exists
Environmental 4E – Protect, and where possible, enhance landscape character and visual amenity within zone of influence	Scoring is guided by professional judgement taking into account the duration and permanence of the likely impacts of the options on landscape value and the sensitivity of landscape to change	8	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Permanent significant enhancement of high sensitivity landscape character/feature in the zone of visibility of the selected measure 0 : No change to existing landscape character/feature in the zone of influence of the selected measure -999 : Unacceptable negative impact where feasible options exist
Environmental 4F(i) – Avoid damage to or loss of architectural features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods	Scoring is guided by professional judgement taking into account the number of architectural features, institutions and collections subject to flooding and the impact of the flood risk management measure on architectural features, institutions and collections.	4	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	5 : Complete removal of all architectural features, institutions, and collections form the risk of harm by extreme floods and enhanced protection and value of architectural features, institutions, and collections importance arising from the implementation of the FRM. 0 : No effects on architectural features, institutions, and collections. -999 : Unacceptable negative impact where feasible options exist

Environmental 4F(ii) – Avoid damage to or loss of archaeological features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods	Scoring is guided by professional judgement taking into account the number of archaeological features, institutions and collections subject to flooding and the impact of the flood risk management measure on architectural features, institutions and collections.	4	By professional judgement, taking into account local advice. Subject to a maximum local weighting of 5.	<div>5 : Complete removal of all architectural features, institutions, and collections form the risk of harm by extreme floods and enhanced protection and value of archaeological features, institutions, and collections importance arising from the implementation of the FRM.</div> <div>0 : No effects on architectural features, institutions, and collections.</div> <div>-999 :Unacceptable negative impact where feasible options exist</div>
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Appendix G Freeboard

Introduction

This Appendix provides a detailed assessment of the freeboard allowances adopted in the outline design of embankments and flood walls for this Shannon CFRAM Study. The assessment is based on the Environment Agency's Fluvial Freeboard Guidance Note, R&D Technical Report W187 (2000) which provides practical guidance on the determination of freeboard allowances during the design of flood defences and is therefore appropriate for use in the design of all embankments and flood walls for this Study. The guidance note divides freeboard into two elements, with an allowance to take account of the physical processes that affect the defence level and an allowance to account for the uncertainty in the prediction of physical processes.

Methodology

The Guidance Note details a 'Quick' and 'Detailed' method. Given the catchment scale assessment of CFRAMs, it is appropriate that the 'Quick' method is used. However, it is recommended that during the future detailed design stages, the freeboard allowances should be rechecked using the 'Detailed' method.

The 'Quick' method involves two stages. Firstly, the physical processes affecting the defence performance is determined. Secondly, the uncertainty is quantified.

The assessment is applicable to the following four design scenarios:

1. Embankment design (fluvial)
 - Physical processes: Settlement of embankment foundations (consolidation settlement).
 - Uncertainty allowance
2. Embankment design (coastal)
 - Physical processes: Settlement of embankment foundations, wave overtopping (surcharge) allowance
 - Uncertainty allowance
3. Flood wall design (fluvial)
 - Physical processes: N/A
 - Uncertainty allowance
4. Flood wall design (coastal)
 - Physical processes: Wave overtopping (surcharge) allowance
 - Uncertainty allowance

Physical Processes

As outlined above, there are the following two physical processes which can apply during the design scenarios:

- Settlement (consolidation settlement)
- Wave overtopping (surcharge).

Settlement

The settlement (consolidation settlement) is calculated using the below formulae. This takes account of the coefficient of volume compressibility, the shape of the foundation and the applied pressure.

$$\rho_c = \mu_g \rho_{oed}$$

$$\rho_{oed} = I_p m_v p B$$

Where:

I_p = influence factor

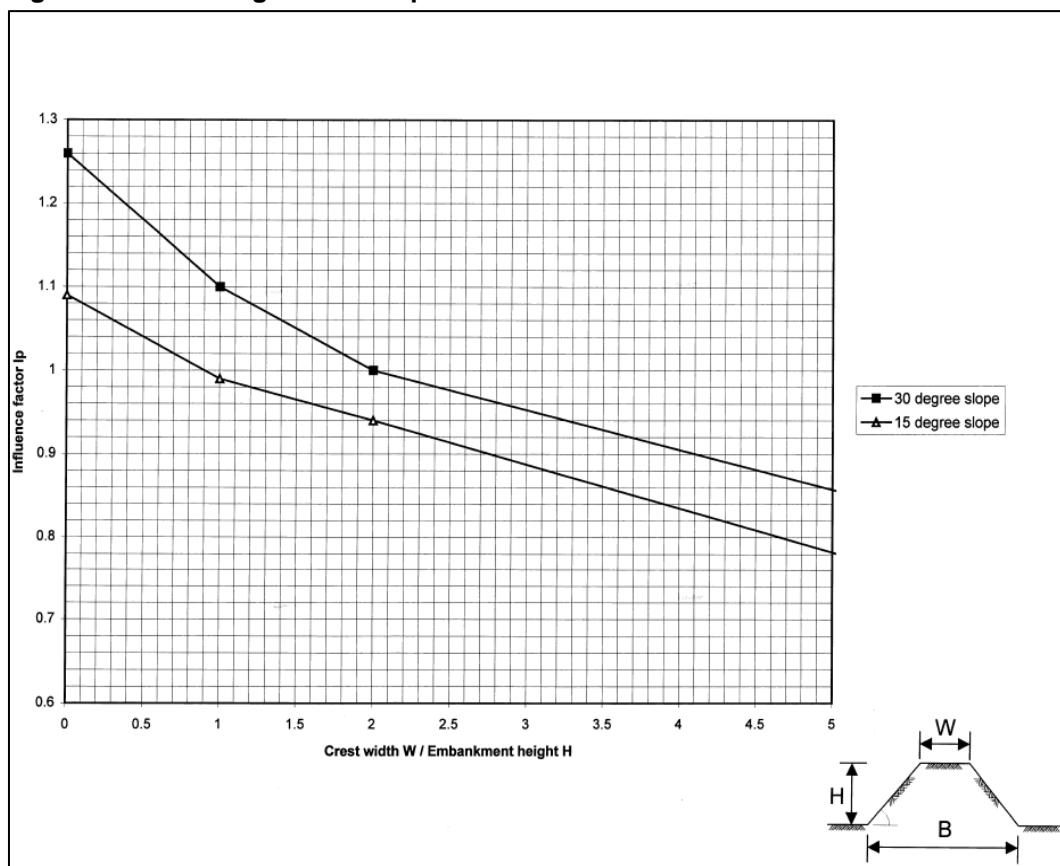
m_v = average coefficient of volume compressibility

p = applied pressure (kN/m²)

B = foundation width (m)

For CRFAMS the following typical embankment design has been adopted: height of the embankment at 1.5m (which is the typical height of high embankments), the crest width of 4m and side slopes as 1:3. The influence factor is determined from Figure 1 below.

Figure 1: Influencing Factor Graph



The underlying material is assumed to be normally consolidated alluvial clay. The coefficients μ_g and m_v are dependent on this clay selection, with the range of values detailed in Tables 1 and 2 below.

Table 1: Values of coefficient μ_g

Type of Clay	μ_g
Heavily over-consolidated clays (glacial till, Keuper Marl)	0.2 - 0.5
Over-consolidated clays (London Clay, Weald, Kimmeridge, Oxford, and Lias Clays)	0.5 - 0.7
Normally-consolidated clays	0.7 - 1.0
Very sensitive clays (soft alluvial, estuarine, and marine clays)	1.0 - 1.2

Table 2: Typical values of the coefficient of compressibility m_v

Type	Qualitative Description	$m_v (m^2/kN)$
Heavily over-consolidated boulder clays (e.g. many Scottish boulder clays) and stiff weathered rocks (e.g. weathered siltstone), hard London Clay, Gault Clay, and Oxford Clay	Very low compressibility	Below 0.05×10^{-3}
Boulder Clays (e.g. Tees-side, Chesire) and very stiff 'blue' London Clay, Oxford Clay, Keuper Marl	Low compressibility	$(0.05 \text{ to } 0.10) \times 10^{-3}$
Upper 'blue' London Clay, weathered 'brown' London Clay, fluvio-glacial clays, Lake Clays, weathered Oxford Clay, weathered Boulder Clay, weathered Keuper Marl, normally consolidated clays (at depth)	Medium compressibility	$(0.10 \text{ to } 0.30) \times 10^{-3}$
Normally-consolidated alluvial clays (e.g. estuarine clays of Thames, Firth of Forth, Bristol Channel)	High compressibility	$(0.30 \text{ to } 1.50) \times 10^{-3}$
Very organic alluvial clays and peats	Very high compressibility	Above 1.50×10^{-3}

Based on the normally consolidated alluvial clay assumption, the value of μ_g assumed to be 0.8, and m_v as 1×10^{-3} . The soil weight is assumed to be 20 kN/m^3 . This yields a value of 19.62 kN/m^2 for the applied pressure coefficient.

Wave Overtopping

The Guidance Note assumes that the wave overtopping associated with non-erodible defences (sheet pile walls or concrete retaining walls) is unlikely to cause failure of the defence. Therefore a wave surcharge allowance of nil for the flood wall design scenario is assumed.

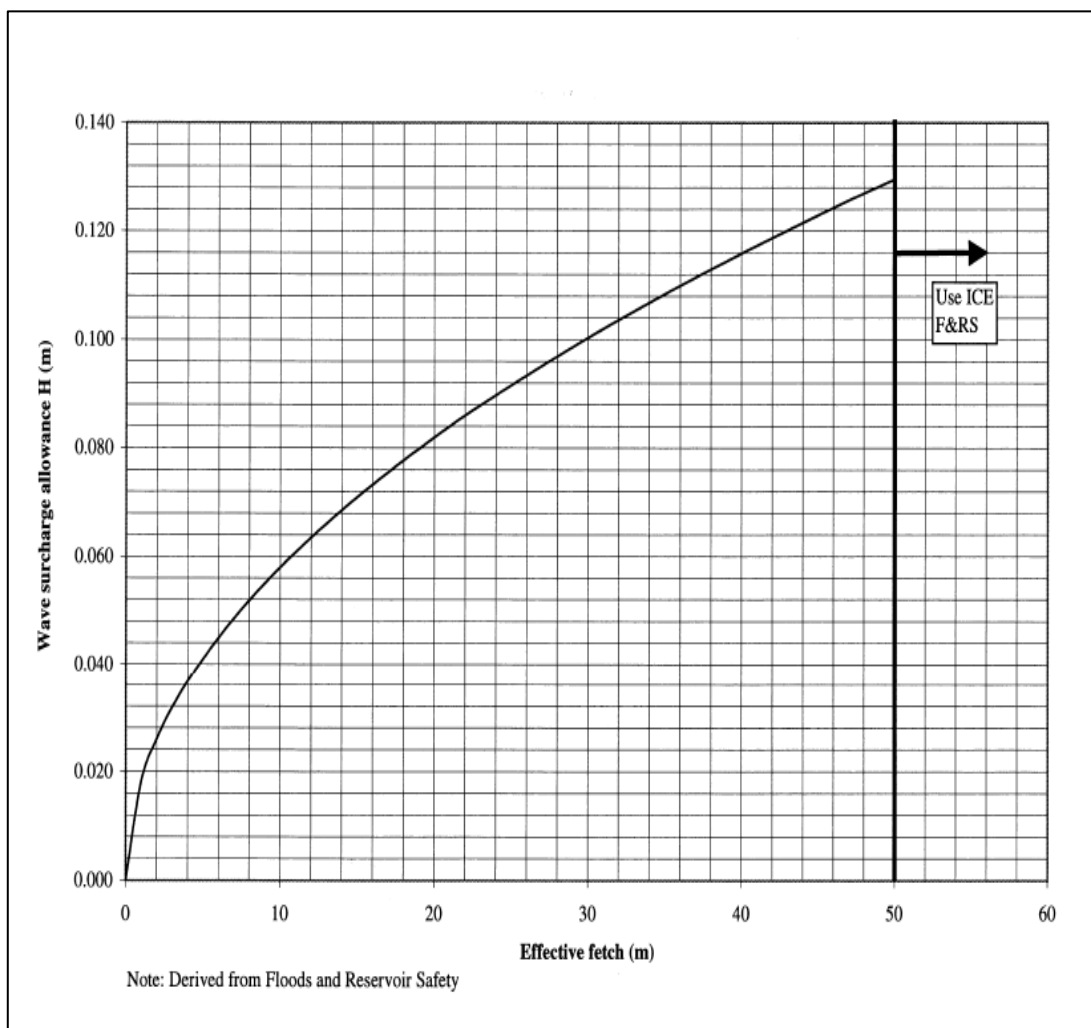
Regarding embankment design, the wave surcharge allowance for erodible defences is broken down into four conditions, as detailed in the below Table 3. Depending on the wave surcharge calculated, the actual surcharge to be provided is 0m, 0.05m or 0.1m.

Table 3: Surcharge Calculation

Calculated wave surcharge allowance H (m)	Actual wave surcharge allowance to be provided (m)
$0.000 < H < 0.025$	0
$0.025 < H < 0.075$	0.05
$0.075 < H < 0.125$	0.10
$0.125 < H$	Recalculate using ICE's Floods and Reservoirs Safety

The wave surcharge is determined from Figure 2 below. The figure is based on a grassed embankment with a 1:2.5 slope, a typical average annual maximum wind speed of 16m/s and a non-worst case scenario of the river in relation to the predominant wind direction.

Figure 2: Wave Surcharge



If the defence being considered does not conform with the above description the estimated wave surcharge value is multiplied by the factors in the below Table 4 to take account of different embankment slopes and embankment types (with the values chosen highlighted).

Table 4: Multiplication Factors

Type	Factor
Embankment Slope	
1:2.0 slope	1.13
1:3.0 slope	0.9
1:3.5 slope	0.81
Embankment Type	
Crest protected	0.92
Crest and backslope protected	0.85

The determination of wave surcharge is dependent on the effective fetch of the river. A value of 0.05m is chosen for the actual wave surcharge allowance, which is the value to be used if the calculated wave surcharge allowance falls in the range of 0.025m to 0.075m. Taking account of the embankment type and slope, this range corresponds to an effective fetch in the range of 2.5m to 24m, which is deemed a suitable range.

Uncertainty Assessment

Having determined the physical processes affecting the flood defence level, the next step is to quantify the level of uncertainty associated with the prediction of the physical processes, using the following calculation.

$$\text{Uncertainty Allowance (m)} = k \times \frac{\text{Overall Score (in range 6 – 30)}}{30} \times (FL - MAMWL)$$

Overall Score

The Guidance Note sets out that the Overall Score should be assessed by allowing for the uncertainty associated with the following six parameters:

- Accuracy of hydrological data
- Accuracy of hydrological analysis
- Accuracy of hydraulic data
- Accuracy of hydraulic model
- Consequences of failure
- Accuracy of the physical processes

Each parameter is assigned a score from 1 to 5, where 1 represents a low level of impact and 5 a high level of impact. For each of the parameters a description is provided against each score, this is provided below with the adopted score for each parameter highlighted below.

Accuracy of Hydrological Data

1	Hydrological conditions throughout catchment well defined or reliable continuous flow gauging records on river at area of interest
2	Hydrological conditions throughout catchment fairly well defined or flow gauging records available on river at some distance from area of interest or water level records available at area of interest
3	Some variability in hydrological conditions in catchment or water level records available at more than one site at some distance from area of interest or flow gauging records available for similar nearby catchment flow
4	Hydrological conditions in catchment fairly variable or water level records available at one site some distance from area of interest
5	Complex catchment with wide variation in hydrological conditions or limited water level records

Accuracy of Hydrological Method

1	Rainfall runoff analysis give consistent results using different methods, or greater than 75 years of flow records for statistical analysis
2	Rainfall runoff analysis give consistent results using different methods, long duration storm gives greatest discharge or 50 to 75 years of flow records available for statistical analysis
3	Rainfall runoff analysis give fairly consistent results using different methods, moderate duration storm gives greatest discharge or 25 to 50 years of flow records available for statistical analysis
4	Rainfall runoff analysis gives poor correlation between results using different methods, short duration storm gives greatest discharge or 10 to 25 years of flow records available for statistical analysis
5	Rainfall runoff analysis gives very poor correlation between results using different methods, very short duration storm gives greatest discharge or less than 10 years of flow records available for statistical analysis

Accuracy of Hydraulic Data

1	Very well defined channel, no floodplain flow, channel roughness low and consistent seasonally along river and across river section
2	Well defined channel, no floodplain flow, channel roughness fairly low, only small changes in roughness likely
3	Minor floodplain flow, moderate changes in roughness likely
4	Poorly defined channel, some floodplain flow, changes in roughness likely
5	Very poorly defined channel with mobile bed, considerable complex floodplain flow, channel roughness very variable seasonally, along river and across river section

Accuracy of Hydraulic Method

1	Well defined boundary data, well defined flood routing, transient model
2	Fairly well defined boundary data and flood routing, transient model
3	Moderately well-defined boundary data and flood routing, steady state model
4	Fairly poorly defined boundary data and flood routing, steady state model
5	Poorly defined or complex boundary data and flood routing, simple backwater analysis

Significance of Physical Parameters

1	Uncertainties in physical processes are negligible, allowance is < 5% of (FL - MAMWL)
2	Uncertainties in physical processes are of marginal significance, allowance is = 5 to 10% of (FL - MAMWL)
3	Uncertainties in physical processes are of some significance, allowance is = 10 to 20% of (FL - MAMWL)
4	Uncertainties in physical processes are significant, allowance is = 20 to 30% of (FL - MAMWL)
5	Uncertainties in physical processes are very significant, allowance is > 30% of (FL - MAMWL)

Consequences of Failure

1	Typically low grade agricultural land, often grass, at risk from flooding or impeded land drainage, with isolated agricultural properties at risk from flooding, or environmental assets at little risk frequent inundation
2	Typically mixed agricultural land with occasional, often agriculturally related, properties at risk from flooding. Agricultural land may be prone to flooding or water-logging. May also apply to environmental assets of local significance
3	Typically large areas of high grade agricultural land and/or environmental assets of national significance at risk from flooding or impeded drainage with some properties also at risk from flooding
4	Typically less extensive urban areas with some high grade agricultural land and/or environmental assets of international importance requiring protection
5	Typically large urban areas at risk from flooding

For the purposes of this assessment, conservative figures are chosen, ranging from 4 to 5. As equal weight is given to each parameter, the scores are then accumulated to give an overall score out of a total of 30.

FL-MAMWL

This is the difference between the flood level and mean annual maximum water level. The Q_2 and Q_{100} mean water levels for the Shannon River Basin District were reviewed and the differences between these mean water levels is in summarised in the below table for the different UoMs.

Location	Average Diff
UOM23	0.6m
UOM24	0.4m
River Shannon	0.5m
UoM25/26 (Tribes of the Shannon)	0.4m
Overall Average	0.5m

0.5m was the overall average, and this has therefore been used as the FL – MAMWL value throughout.

K coefficient

The uncertainty allowance is calculated using the below formula, in which the coefficient k is assumed to be 0.5, based on advice provided within the Guidance Note

$$\text{Uncertainty Allowance (m)} = k \times \frac{\text{Overall Score (in range 6-30)}}{30} \times (FL - MAMWL)$$

Results

The freeboard allowance figures yielded from the model for the four scenarios are set out below:

1. Embankment design
 - Physical processes: Settlement of embankment foundations
 - Uncertainty allowance

Freeboard allowance = 0.396m, therefore take freeboard allowance as 400mm

2. Embankment design (coastal)
 - Physical processes: Settlement of embankment foundations, wave overtopping (surcharge) allowance
 - Uncertainty allowance

Freeboard allowance = 0.896m, therefore take freeboard allowance as 900mm

3. Flood wall design
 - Physical processes: N/A
 - Uncertainty allowance

Freeboard allowance = 0.208m, therefore take freeboard allowance as 210mm

4. Flood wall design (coastal)
 - Physical processes: Wave overtopping (surcharge) allowance
 - Uncertainty allowance

Freeboard allowance = 0.208m, therefore take freeboard allowance as 210mm

Appendix H

Cost Database





JBA
consulting

.....
DONNACHADH O'BRIEN
.....
& ASSOCIATES CONSULTING ENGINEERS
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CFRAM Unit Cost Development Project

Final Report

October 2014



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Final Report / 08-10-2014	Final Amendments to report	OPW
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Contract

This report describes work commissioned by Eileen Hughes, on behalf of the OPW, by a letter dated 18/09/2013. The OPW's representative for the contract was Conor Galvin. Angus Pettit, Deirdre McDonnell and Jonathan Garrett of JBA Consulting and Donnachadh O'Brien of Donnachadh O'Brien & Associates carried out this work.

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Purpose

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JBA Consulting has no liability regarding the use of this report except to OPW.

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Peter Newport	Office of Public Works
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Mr. Ruairi O Conchuir	Inland Fisheries Ireland - Mulkear Life Project
Mr. Tony Moran	JBA Consulting

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Executive Summary

This report provides a summary of the methodology and the approach to estimating costs for flood risk management measures to support the CFRAM studies. This report provides background to whole life costing and details the methodology for each method and factor.

A range of costing approaches have been presented and used depending on the availability of information, costing requirements and future needs. Nineteen further method specific summary spreadsheets are provided separately and contain all relevant costing information and whole life cost tools.

In addition JBA have provided explanatory text on the approach adopted for whole life costing which included key cost components (where applicable and proportional) to include the following:

- Enabling costs (if applicable)
- Capital costs
- Operation and maintenance costs
- Other costs (e.g. event costs for demountables or running costs for pumping stations)

This document also outlines some of the key assumptions and factors that need to be considered at this stage to ensure a consistent approach across all CFRAM studies. This included factors such as:

- Discounting
- Financial periods
- Base dates
- Timing of works

In addition, an optimism bias tool is provided to ensure that a standard approach to construction risk is undertaken across all CFRAM studies.

Cost calibration has been completed for 4 separate projects illustrating that the tools and unit costs provided adequately estimate construction and whole life costs for real flood defence works in Ireland. Confidence can therefore be given to the results and costs provided for use within early stage appraisals as part of the wider CFRAM process.

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Abbreviations

CFRAM	Catchment-based Flood Risk Assessment and Management
CIRIA	Company providing research and training in the construction industry
CPI	Consumer Price Index
EA	Environment Agency
FRM	Flood Risk Management
JBA	JBA Consulting – Engineers & Scientists
LA	Local Authority
MCM	Multi-Coloured Manual (Flood Hazard Research Centre damage data)
MCA	Multi-criteria Analysis
OPW	Office of Public Works
PV	Present Value
R&D	Research and Development
RPI	Retail Price Index
SUDS	Sustainable Urban Drainage Systems
PVc	Present Value Cost
WLC	Whole Life Costing

1 Introduction

1.1 Background

The Office of Public Works (OPW) has commissioned six Catchment-based Flood Risk Assessment and Management (CFRAM) studies to assess and determine viable measures for managing flood risk in a large number of locations around Ireland. To determine the viability of the selected measures at each location and to help prioritise budgetary spend, it is necessary to determine their likely costs of construction and long term maintenance.

Once the preferred measures have been determined, they will need to be prioritised to ensure that communities most at risk are protected. It is therefore important that measures in different parts of the country are comparable in the terms of their viability, which in turn requires a consistent approach to determining the likely costs of construction and long term maintenance.

The OPW has commissioned JBA Consulting to undertake this project to prepare a database of unit costs to enhance consistency in determining the likely costs of construction and maintenance of measures under the CFRAM project.

1.2 Purpose of this report

The objective of the project is to determine appropriate unit costs for common methods of flood risk management, for a range of conditions and scales, calibrated against actual costs (taking into account the date, condition and scale of construction), and to present the costs in a simple database for easy use by the OPW and the consultants appointed to undertake the CFRAM studies.

This report provides a summary of the project and an introduction to whole life costing for those consultants undertaking the appraisal of flood risk management measures. The report summarises the approach to costing for each mitigation method and gives indicative costs for each. This report should be read in accordance with the summary MS Excel templates produced for each flood risk method.

1.3 Generic cost guidance

The OPW are currently developing guidance notes on appraisal and the assessment of flood risk damages and cost estimation (Guidance Note 27). This report is primarily aimed at providing information and guidance to support cost estimation at the CFRAM level of assessment. The approach takes into account standard approaches currently used within the industry and provides the necessary level of accuracy for the regional and initial level of appraisal of options within a CFRAM study.

1.4 Whole life cost estimation

Whole life cost (WLC) estimation is a process that helps to combine cost elements incurred over time for different asset types and alternative approaches to flood risk management (FRM) intervention. The use of whole life cost estimation procedures will help to achieve the following aims for flood and coastal erosion management:

- Good decision making about FRM options.
- Consistent approach across different areas for CFRAM appraisal.
- Helps to determine the longer term expenditure budget for the OPW.
- Encourages efficient resource allocation.

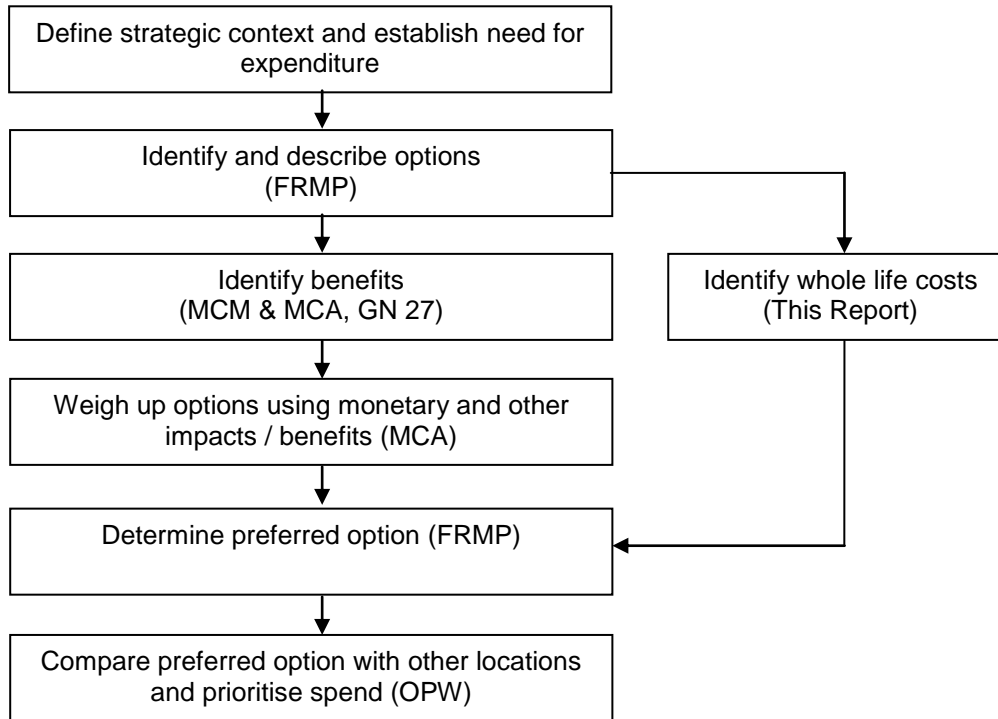
Whole life costing is an essential tool to help manage future and ongoing costs associated with capital and expenditure/operational costs and to help make informed choices between different approaches of delivering an option that meets the needs of communities at risk. The choice is often one between high capital and low maintenance or vice versa and the use of whole life costing and the consistent comparison between options allows an economic valuation of these aspects to be considered.

1.5 Cost estimation within the appraisal process

Whole life cost estimation forms part of the overall CFRAM appraisal process, as shown in the figure below. Each of the steps below forms part of standard appraisal processes. This report

and the costs derived aim to assist those undertaking cost estimates and provides guidance and data to support cost estimation and the appraisal process.

Figure 1-1: Cost estimation within the wider appraisal process



2 Categorisation of methods and factors

Whole life cost estimates should be based on data appropriate and proportional to the level of assessment of options. Costs are typically based on data assembled from recent tenders, completed projects, published articles and estimating price books, estimates and quotations from companies for specialist work and the estimator's own experience.

2.1 Generic cost estimation methodologies

At different stages of an analysis, different data will be appropriate for cost estimation, as indicated below. There are four general approaches to estimating project costs:

1. Estimation of labour, plant and materials costs for each specific activity.
2. Estimation of costs from first principles using industry or specific unit costs for materials and construction activities to derive a unit cost per unit.
3. Reliance on existing outturn costs or cost relationships from previous projects that hide certain internal costs such as overheads, minor and temporary works.
4. Engineering judgement in cases where existing data are unobtainable or measures are poorly understood / tested.

In addition to this there are obviously target costs for tendering purposes and recorded quantities. These are the most accurate as they are based on site specifics or real costs, however the recording of this information varies between and within organisations.

Each of the above approaches has benefits and constraints for the application on the CFRAM. None of the approaches is applicable to all flood risk management methods, however Option 2 is preferred for the majority of methods as this will provide the most applicable costs for Ireland at the level of detailed required.

2.2 Cost methodology approach

In total, 19 key flood risk management methods were investigated and costed. With the inclusion of key asset factors (e.g. cost variations by defence height or length) a total of over 220 combinations have unit costs mapped out within the database provided.

The methodology undertaken varies with each measure due to the varied nature of the measures and the fact that they cover both structural and non structural options. Both core unit costs and factors have some uncertainty that is presented in this report and the cost database assumptions. This uncertainty needs to be understood and accepted by CFRAM consultants in order to ensure that consultants apply the costs appropriately.

Ideally, costing would be undertaken through a robust review of previous OPW schemes. Unfortunately, data sources from past OPW schemes are statistically limited and not recorded in a way that specific asset or flood risk mitigation method costs can be extracted to enable past scheme costs as a guide to the future. As a result 'bottom-up' pricing was the preferred option for this study. Furthermore, this approach allowed the extrapolation of costs to account for the specified range of factors required.

Thus our preferred approach was to generate a series of 'typical' engineered elements for each method that can be costed by an experienced quantity surveyor using local rates reflecting the market. Once complete for each method, variations in costs for each factor have been generated either from variations in key elements or by scaling and weighting approaches from other available unit costs. This latter approach helps to identify economies of scale and other cost savings (or risks), where appropriate.

In some instances, alternative approaches have been taken to provide the necessary coverage of costs for all methods and factors required. This includes:

- The use of outturn costs from existing projects collated within available unit cost reports (option 3 above). The risk is that these outturn costs do not necessarily reflect the costs associated with schemes constructed in Ireland. It should be noted that the applicability of costing databases derived using UK data in Ireland may significantly under-predict costs.
- The scaling of unit rates derived for this project based on weightings provided in available UK cost databases (e.g. the Environment Agency unit cost handbook).

- A 'top down' approach whereby cost estimates gathered purely from example projects and case studies is used to inform and provide indicative unit costs.

Full details of the costing approach used for each method and the level of detail and confidence that can be applied are discussed further in Section 4.

2.3 Flood risk management methods and factors

Unit costs for a range of methods have been determined to support the CFRAM process. The costs relate to the construction and implementation of each method and include relevant annual operation and maintenance costs (if applicable). The range of factors cover a range of flood risk management activities covering both structural and non-structural approaches. A full list of the methods and factors costed is provided in Table 2-1.

The list is not exhaustive but cover the majority of measures likely to be required as part of the CFRAM process. Unit costs have been defined for a range of factors that cover the typical range of method variables (e.g. length and height).

The unit costs are intended to be indicative, generic costs that might be expected for the implementation of a method in typical conditions. They are not intended to be accurate across the full range of potential application of such methods, and the CFRAM Consultants will review the local context for application and adjust the Unit Cost accordingly, where necessary.

It should be noted that the unit costs are intended to be for outline design and pricing only, and are applicable for a common, representative type of each method and factor listed. It should be noted that the CFRAM Consultants are required to use their professional judgement in using the unit costs, and should vary costs to take into account local requirements or conditions that are not provided for explicitly in the methods and factors.

Other methods or factors outside the range costed here, may be applicable in some sites or special circumstances. In these instances, the CFRAM consultants will need to prepare bespoke cost estimated using experienced engineers and/or specialist advice.

Table 2-1: Summary of flood risk methods and factors assessed within this report

Method	Relevant Factor Types				
Flood Protection Wall	Urban / Rural	Quay / Floodplain / Coastal sea wall	Structure	Height	Length
Embankment	Rural	Structure	Height	Length	Material
Demountable Barriers	Length	Height	Wall/Gate	With/without Ground Beam	
In-Channel Excavation	Urban / Rural	Material	Volume	Material disposal	
Excavation on Land	Rural	Material	Volume		
Weir	Height	Weir Length			
Weir Removal	Weir Length				
Bridge Removal	Bridge Type				
Bridge Construction	Bridge Type				
Bridge Underpinning					
New Culvert	Urban / Rural	Size	Length	Depth of Invert	Material
Sluice Gate	Flap Gate / Vertical Sluice		Size		
Road Raising	Urban / Rural	Height	Length		
Pumping Station	Capacity				

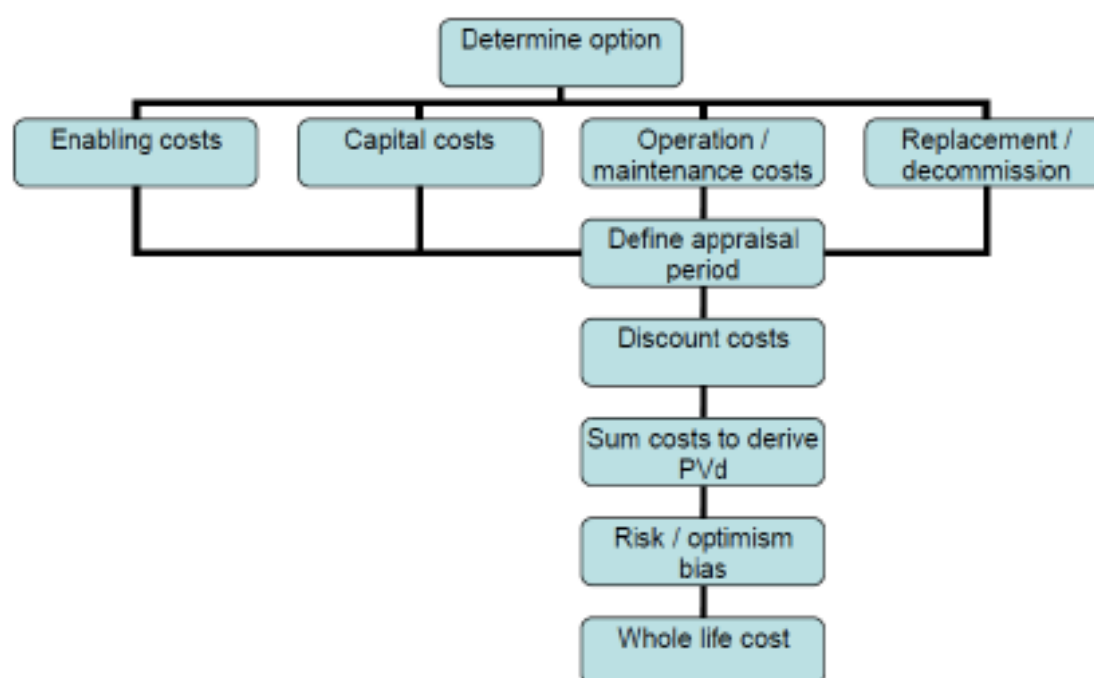
Method	Relevant Factor Types				
Individual Property Protection	Property Type	PLP Type (Manual / Automatic)			
Hydrometric Gauging Station					
Flood Forecasting System	Simple Alarm / Simple Forecast / Complex Forecast				
River Maintenance	Channel Width	Urban / Rural			
Bank Protection	Coastal Erosion Protection / River Bank Protection				Length
Manhole Sealing					
Mobilisation and Site Set-Up	Urban / Rural	Construction Cost			

3 Whole life costing and methodology

Whole life costs enable investment options to be more effectively evaluated through the consideration of all costs rather than just the initial capital costs. This facilitates the choice between competing alternative options/strategies and ensures planning decisions and sustainable solutions are sufficiently robust and backed up by consistent and accurate costed programmes of activities.

Whole life estimation will require costs of acquiring the solution (consultancy, design, construction etc), operating the system, and maintaining the system over the whole life through to disposal (as shown in the figure below).

Figure 3-1: Whole life cost estimation



Whole life cost estimation needs to identify all activities that constitute flood defence management practice e.g. inspection, vegetation management, repair, operations, incident management, general administration and regulatory activities.

3.1 Cost elements

The four key cost elements that would normally need consideration as part of a whole life cost include the following:

- Acquisition or enabling costs.
- Capital costs.
- Operational costs.
- Other and end of life costs.

This report focuses on the capital and operational cost elements.

3.1.1 Enabling costs

Enabling costs include all pre construction costs and may include planning and administration, scheme feasibility and appraisal, design, project management and consultation costs. Enabling costs can be a significant cost to whole life costs but can also be highly variable. These costs are typically 10-30% of the capital costs.

Appraisers should be aware that land purchase costs can be significant and should be included within capital costs if these have not yet been considered. This can be important for schemes where flood storage, managed retreat or channel diversion is required.

These costs have been ignored by this project as it is assumed that all costs required have already been considered by the OPW and included within the wider CFRAM process. They are thus 'sunk costs' as they represent expenditure on goods and services, or resources that are already irrevocably committed and should be ignored within an appraisal of the schemes.

As such, all unit costs provided as part of this report and associated spreadsheets exclude enabling costs. If this is not appropriate for any given project, the inclusion of these must be confirmed with the OPW.

3.1.2 Capital costs

The construction costs of a project are made up of many elements such as mobilisation, demolition and site clearance, materials, compensation, insurance, diversion of existing facilities, construction and post construction landscaping.

3.1.3 Operation and maintenance costs

Whole life cost estimation needs to identify all activities that constitute flood defence management practice e.g. inspection, vegetation management, repair, operations, incident management, general administration and regulatory activities. Operational costs may include annual maintenance as well as intermittent costs if relevant and proportional and data is available.

3.1.4 Other costs

Other costs are likely to vary by the categories and measures. For example, other costs for demountable barriers such as event response, training and practice sessions are critical and essential to include within the whole life costs. Other costs may also include decommissioning or replacement costs at the end of the design life although these costs may be less important in terms of whole life costs due to the heavy discounting of these costs late in the financial period.

3.2 Whole life costing and present values

3.2.1 Discounting and Present Value Costs (PVC)

Appraisals need to compare options that will impact over a period of years into the future. Discounting is commonly used to compare costs and benefits over this time period and how future cost and benefits should be valued in today's terms. The discount rate used by the OPW assumes a standard rate of 4% over the appraisal period.

This standard discount rate has been used in the calculation of present value costs. The sum of discount rates over the standard 50 year appraisal period (the discount factor) is 22.3415 and can be used by appraisers to calculate PV costs for annual maintenance costs, for example.

3.2.2 Financial period

The estimation of Present Value costs is typically applied over a project financial period. For the case of flood mitigation works for the OPW, this is usually assumed to be a 50 year financial period for consistency. It is anticipated that a 50 year financial period is typical and appropriate for most studies. If a shorter financial period is required, whole life costing will need to be carried out separately.

3.3 Other cost considerations

3.3.1 Cost conversions

Where applicable costs from the UK have been used, a conversion from Euros to Sterling has been applied based on a factor of 1.161 for 2013 (year of latest values). This is based on using Purchasing Power Parities (PPP) with current factors derived from the Organisation for Economic Co-Operation and Development (OECD)¹ using Purchasing Power Parities (PPP) statistics.

This dataset contains Purchasing Power Parities for GDP for OECD countries. PPP table is net of currency conversion with the US\$ as the baseline, so to derive the value of £ in € in Ireland,

¹ <http://stats.oecd.org/Index.aspx?DataSetCode=PPPGDP>
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one needs to divide the Ireland value (0.806 for 2013) by the UK value (0.694), which gives 1.161. .




3.3.2 Base dates and updating of costs

Provided inflation for all costs is approximately equal, it is normal practice to exclude inflation effects when undertaking WLC analysis and to only include these aspects as a sensitivity test or when these uncertainties may affect the option choice. As such, inflation has not been considered for the purposes of this project.

The year used as the basis for pricing is 2013 and has been indicated in the summary sheets for each method. This is to ensure consistency across all measures and categories. All costs have been updated using either the Central Statistics Office (CSO) Production in Building and Construction Index² or the Consumer Price Index³.

Future updating of costs can be done for all associated cost summary sheets by applying a weight to the 'Construction Price Index (CPI)' cell (as shown in the figure below). For example, the first quarter 2014 Indices of Production in Civil Engineering is 88.0. The 2013 fourth quarter value was 89.2. Thus a CPI weighting of 0.987 (88.0/89.2) would be used to update costs within the cost spreadsheets.

Figure 3-2: Updating of costs to analysis base date

 		
CFRAM Unit Cost Development Project		
Method	Wall	
Prepared by:	Date:	
Checked by:	Date:	
Project reference		Project name:
Base date for estimates (year Q)	Oct-2013	Construction Price Index (CPI)
Scaling factor (e.g. €m, k€, €)	€	Method Factor - to take into account particular site issues /constraints
		1.000
		1.00

3.3.3 Design life assumptions

The design life of a measure is the minimum length of time that the asset performs to its intended function. The design life may vary depending upon external factors that impact upon the assets condition or deterioration and the maintenance carried out on the asset. The design life can also be applied to components within an asset where internal structures might have shorter life cycles to the overall asset.

Where design life is thought to be less than the 50 year financial period of assessment an understanding of the design life is critical for the whole life costing. Most assets constructed will have a design life in excess of 50 years and will be maintained over the appraisal period. Therefore it has been assumed that no end of life replacement or decommissioning costs are applicable.

3.4 Risk and optimism bias

There is a demonstrated, systematic, tendency for project appraisers to be overly optimistic. The aim of adding an optimism bias is to allow a contingency on cost estimates to cater for unknowns and help ensure project promoters retain adequate project budget.

An appropriate uplift or optimism bias is recommended at the relevant stage of the appraisal process to negate this optimism. An optimism bias of 60% is typically used for projects at an early stage of consideration, and a value of 30% at the more detailed project stage.

Optimism bias has not been included within the costs provided but will need to be included as part of the appraisal process. Appraisers must ensure that an appropriate allowance for optimism bias is included within the total whole life costs. The reason for excluding optimism

² <http://www.cso.ie/en/statistics/construction/>

³ <http://www.cso.ie/en/releasesandpublications/prices/>
2013s7549 CFRAM Unit Cost Report Final v4.0 (final)

bias is that appraisers typically apply a standard uplift at the appraisal or design stage without further proper consideration of project risks.

For the purpose of this project and the CFRAM studies, the OPW wish to apply a more robust appraisal of risk for each site. Rather than to supply a specific rate that would not reflect site specifics, this project has defined a set of standard key components of risk for all projects that typically increase or decrease the construction risk. By presenting these factors, appraisers can then select whether the specific factor is present or applicable and score the risk accordingly. A separate weighting methodology used to weight each individual risk/factor. Total risk scores are generated and used to define an appropriate optimism bias that should be used within pre-defined boundaries.

For example, a site with good access to be constructed in summer months, with low complexity, available funding and good community involvement would have a low optimism bias (for example; between 10-20%). On the other hand, a tidally located site with known invasive species and located on contaminated land, with poor urban access and a highly innovative, complex design would have a higher optimism bias (for example; between 45-60%).

3.4.1 Optimism bias tool

JBA Consulting have developed an optimism bias tool that CFRAM appraisers should use when determining the optimism bias for each appraisal site. The tool forces users to determine the relative risk value for a range of risk components broken down into the following 5 categories:

- Procurement risks
- Project specific risks
- Client specification risks
- Environmental risks
- External influence risks




For each risk component under the above categories the appraiser should select a risk category (Very High to Very Low) from the pull down menu. Additional comments are provided to assist users for each risk component (within the MS Excel 'Comments' functionality). The default value is set to medium risk. There is space for appraisers to add remarks or comments to justify each risk component score.

A pre-defined weighting is also supplied to weight the score based on existing OPW knowledge of relative risks. For example 'Services' and 'Ground Conditions' have a weighting of 3 whereas 'Amenity and Art' have a score of 1 to reflect the impact that these uncertainties can have on the overall project costs.

Once all risk components have been defined, the tool will multiply each risk component by the weight to derive an overall site/option weighting. The weighting is then used to define the optimism bias between pre-selected upper and lower optimism bias bands (currently set at 10% and 70%).

Should a medium weighting be given to all risk components the resulting optimism bias is 40%. Should all risk be set to Very Low (10%) or Very High (90%) the resulting optimism bias are 16% and 64% respectively.

Figure 3-3: Optimism bias tool

					
CFRAM Unit Cost Development Project					
Optimism Bias Calculator					
Prepared by : AEP		Date: December 2013			
Site Reference :		Site Name :			

Project risk components that influence total project cost	Weight 1-3 (3 being a higher weight)	Risk value (0-100%) 0% = no risk 100% = risk expected and not mitigated		Key:						
Procurement	Weight	Risk score	50%	Comment/Justification						
Complexity of Contract Structure	1	Medium	50%							
Late Contractor Involvement in Design	2	Medium	50%							
Poor Contractor Capabilities	1	Medium	50%							
Government Guidelines	1	Medium	50%							
Dispute & Claims Occurred	3	Medium	50%							
Information Management	1	Medium	50%							
Budgeting	2	Medium	50%							
Other	1	Medium	50%							
Project Specific										
Design Complexity	2	Medium	50%							
Degree of Innovation	2	Medium	50%							
Technology	2	Medium	50%							
Services	3	Medium	50%							
Ground conditions	3	Medium	50%							
Health and Safety	3	Medium	50%							
Other	1	Medium	50%							
Client Specification										
Inadequacy of the Business Case	3	Medium	50%							
Large No. of Stakeholders	2	Medium	50%							
Funding Availability	2	Medium	50%							
Project Management Team	1	Medium	50%							
Poor Project Intelligence	2	Medium	50%							
Other	1	Medium	50%							
Environment										
PUBLIC Relations	2	Medium	50%							
Site Characteristics	2	Medium	50%							
Environmental Impact	3	Medium	50%							
Permits / Consents / Approvals	4	Medium	50%							
Amenity and art	1	Medium	50%							
Contaminated land	3	Medium	50%							
Archaeology	3	Medium	50%							
Other	1	Medium	50%							
External Influences										
Political	3	Medium	50%							
Economic	2	Medium	50%							
Legislation / Regulations	1	Medium	50%							
Multiple river users / stakeholders	2	Medium	50%							
Flood events during construction	3	Medium	50%							
Other	1	Medium	50%							
		63	50%							
Weighting to apply :		0.850	<table border="1"> <tr> <td>Minimum Optimism Bias:</td> <td>10%</td> </tr> <tr> <td>Maximum Optimism Bias:</td> <td>70%</td> </tr> <tr> <td>Calculated Optimism bias:</td> <td>40%</td> </tr> </table>		Minimum Optimism Bias:	10%	Maximum Optimism Bias:	70%	Calculated Optimism bias:	40%
Minimum Optimism Bias:	10%									
Maximum Optimism Bias:	70%									
Calculated Optimism bias:	40%									

4 Summary of costs

4.1 Overview of summary templates

A summary template is provided for each flood risk management method. These sheets highlight key aspects with regard to each method and provide available information and the derived cost estimates for each of the flood risk methods and factors. Costs are broken down by capital costs and operation and maintenance costs. Each summary sheet prepared contains the following aspects:

- A summary of types of FRM measures covered and method of assessment.
- The assumptions used to derive the costs.
- Unit costs for each Method and Factor.
- Any specific data comments or additional factor considerations that may influence the costs and require adjustments to the costs (using the method factor or as part of the wider project risks in the Optimism Bias adjustment).
- Calibration and validation data used to benchmark the derived costs.
- Operation and maintenance costs applicable for each method.
- Links to any relevant documents used as part of the cost estimation.

It is expected that this information will be useful in developing costs for CFRAM appraisal options. It is not anticipated that the cost information provided will be relevant for detailed scheme estimates where site specific information is required.

Nineteen separate summary sheets have been generated. Each method has differing levels of detail depending on the costing approach and the available data, which are discussed further in the sub-sections below.

4.2 Overview of costing approach and data quality

The summary table below illustrates the costing approach undertaken for each method assessed and the relative data quality. This data should be reviewed by all appraisers to assess the level of detail used within the calculations and to highlight which methods are based on more broad scale data.

As discussed in Section 2.1 most methods have used a more reliable 'bottom up' approach using unit rates defined by an experienced quantity surveyor. However, some methods use a less reliable (top down) methodology due to the limited available data or the fact that some methods are simply too broad to be able to provide sufficiently accurate unit costs. These include methods such as bridges and weir removal.

Those methods where only indicative costs have been provided reflect the fact that unit costs cannot be provided for all sites and asset variations without a more detailed understanding of the design and site constraints. Appraisers should be aware that unit costs provided for these lower quality methods are indicative only and should be treated as a starting point only in terms of cost estimation. Where applicable, appraisers should seek more specialist advice or at least consider varying the costs to account for site specific or asset specific variations.

Table 4-1: Summary of flood risk methods and factors assessed within this report

Method	Costing approach	Quality
Flood Protection Wall	Bottom up analysis for majority of factors, calibrated against out-turn costs. Some scaling used for certain factors.	Best in class
Embankment	Bottom up analysis for all factors, calibrated against out-turn costs.	Best in class
Demountable Barriers	Costs provided by suppliers. O&M costs based on experience and best practice.	Data with known deficiencies
In-Channel Excavation	Bottom up analysis for all factors. Limited calibration data to validate costs.	Data with known deficiencies
Excavation on Land	Bottom up analysis for all factors. Limited	Best in class

Method	Costing approach	Quality
	calibration data to validate costs.	
Weir Construction	Bottom up analysis for all factors. Limited calibration data to validate costs.	Best in class
Weir Removal	Top down approach based on multiple case studies.	Gross assumptions
Bridge Removal	Costs based available but external (non Irish) unit rates.	Gross assumptions
Bridge Construction	Costs based available but external (non Irish) unit rates.	Gross assumptions
Bridge Underpinning	Bottom up analysis, calibrated against out-turn costs. Highly site specific and variable method.	Data with known deficiencies
New Culvert	Bottom up analysis for majority of factors, calibrated against out-turn costs. Some scaling used for certain factors.	Best in class
Sluice Gate	Bottom up analysis with supply informed rates for gate/penstock costs. Limited calibration data to validate costs.	Best in class
Road Raising	Bottom up analysis. Limited calibration data. Highly site specific and variable method.	Data with known deficiencies
Pumping Station	Top down approach based on JBA data for capital, running and O&M costs.	Data with known deficiencies
Individual Property Protection	Top down approach based on available research and internal JBA data, calibrated against Irish studies.	Best in class
Hydrometric Gauging Station	Bottom up analysis, calibrated against out-turn costs.	Best in class
Flood Forecasting System	Top down approach based on OPW research and internal data.	Data with known deficiencies
River Maintenance	Generic cost information based on OPW internal data.	Data with known deficiencies
Bank Protection	Bottom up analysis for all factors. Limited calibration data to validate costs.	Best in class
Manhole Sealing	Bottom up analysis. Limited calibration data to validate costs.	Data with known deficiencies
Mobilisation and Site Set-Up	Bottom up analysis for all factors.	Best in class

4.3 General costing assumptions

A number of assumptions have to be made for any costing approach and particularly for those aspects costed from first principals ('bottom up'). Individual assumptions for each method are provided in the summary sheets. However these are a number of generic assumptions as listed below:

- Rates used are inclusive of labour, plant and materials and assume a competent civil engineering contractor undertakes the work.
- The rates used represent a 'sunny day' scenario and in no way try to cover all possible risks or unseen eventualities. For this reason, consultants should take care when using the rates and applying these to the sites of interest. It will be important to fully consider all possible risks as part of the assessment and to make allowances for these as part of the method factor or optimism bias.

- Rates used are generally based on Dublin region prices, but it is considered that limited regional variations would be warranted, as insufficient data was available to determine this.
- Temporary works have been allowed for based on what we consider to be reasonable, but are not intended to be definitive for all possible eventualities or be a definitive methodology or sequence.
- Health and safety aspects assume a competent contractor, but site specific risks have not been allowed for. This aspect could be covered by the optimism bias risks.

A summary of the methodology and key factors costed for each option is provided in the following sections.

4.4 Walls

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for each wall type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

All walls assume a reinforced concrete construction, with urban wall including the option for stone cladding. Costs include hoarding fence, removal of concrete path to facilitate construction and services diversions, wall foundation costs, replacement of paths and reinstatement of area.

Cost information is provided for the following factors:

- **Wall type.** Costs have been provided for rural, urban walls, quay walls and sea walls. Quay walls have been provided for 0.0, 0.6 and 1.2m heights only. Sea walls assume a single height based on the required design for an exposed location with re-curve wall.
- **Rural and urban.** It is assumed that urban walls will include stone cladding and a degree of works associated with services (excavation, lighting, backfill etc.).
- **Height variations of 0.6m, 1.0m, 2m and 3m.** These are typical wall heights used for flood mitigation. Wall heights assume a freeboard is included. Walls heights of 0.6m assume a 0.6m high railing on top.
- **Asset length categories of <100m and >100m.** Efficiencies of scale are anticipated for longer lengths, although analysis based on the above assumptions suggests that this is not as sensitive as expected. Users may wish to apply a factor for very short or much longer asset lengths.
- **Structure type.** An allowance for sheet piling has been included within the urban and quay walls. Sheet piling is not anticipated for rural locations. A sheet piling depth of 2m is included within the sea wall design as standard. Sheet piling costs are highly variable and will depend on site characteristics, ground conditions and the difficulty of installation. For this reason, sheet piling costs for urban walls have been derived based on weighting from an existing unit cost database. Sheet piling costs for quay walls have been estimated from rates supplied by an engineering contractor.

For comparison, we have provided the unit cost results and compared these against unit cost database rates from the Environment Agency. The comparison for urban and rural walls is shown below. The generated urban walls unit costs compare well with the Environment Agency unit costs. The rural walls unit costs are at the lower end of costs available which is to be expected for rural walls.

Figure 4-1: Urban wall cost curve and comparison with Environment Agency unit costs (adjusted to € and preliminaries removed)

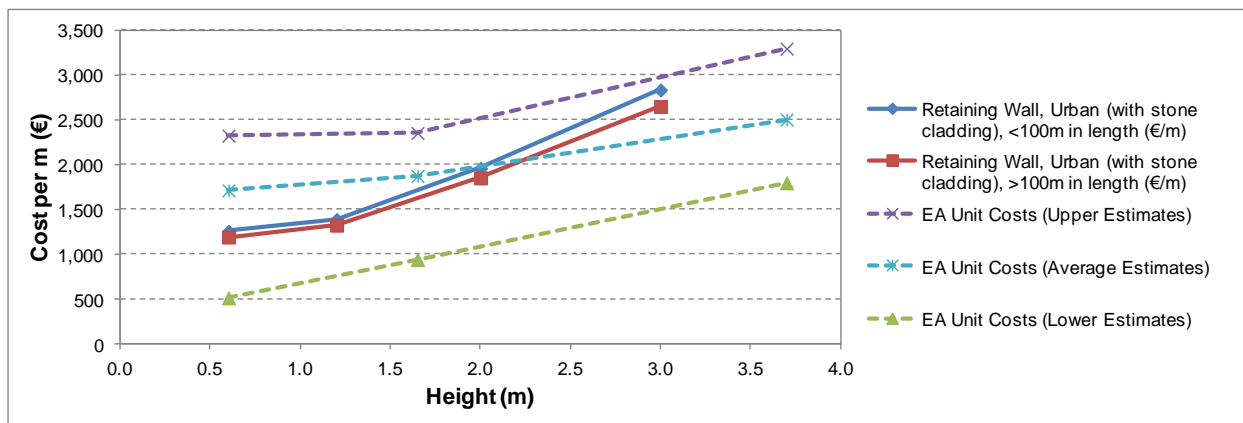
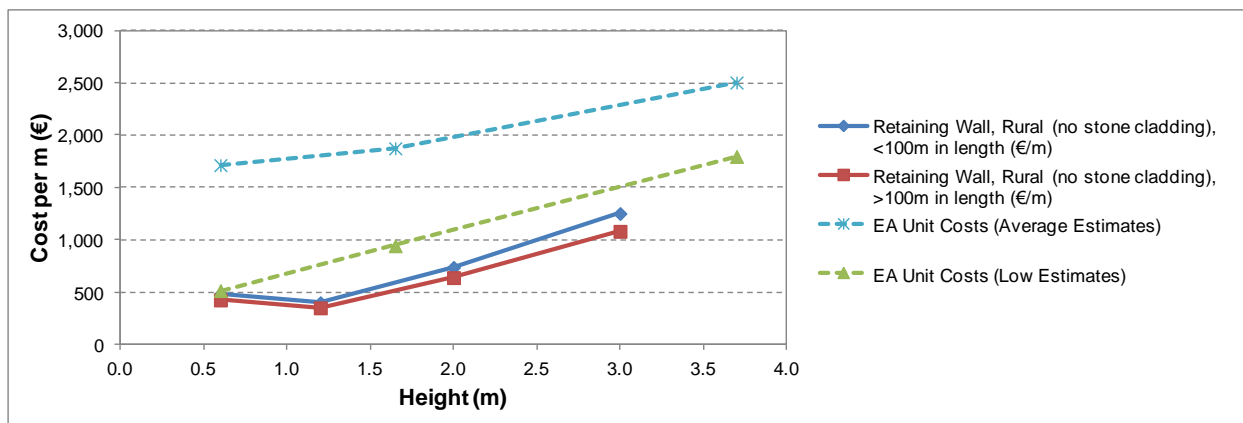


Figure 4-2: Rural wall cost curve and comparison with Environment Agency unit costs (adjusted to € and preliminaries removed)



4.5 Embankments

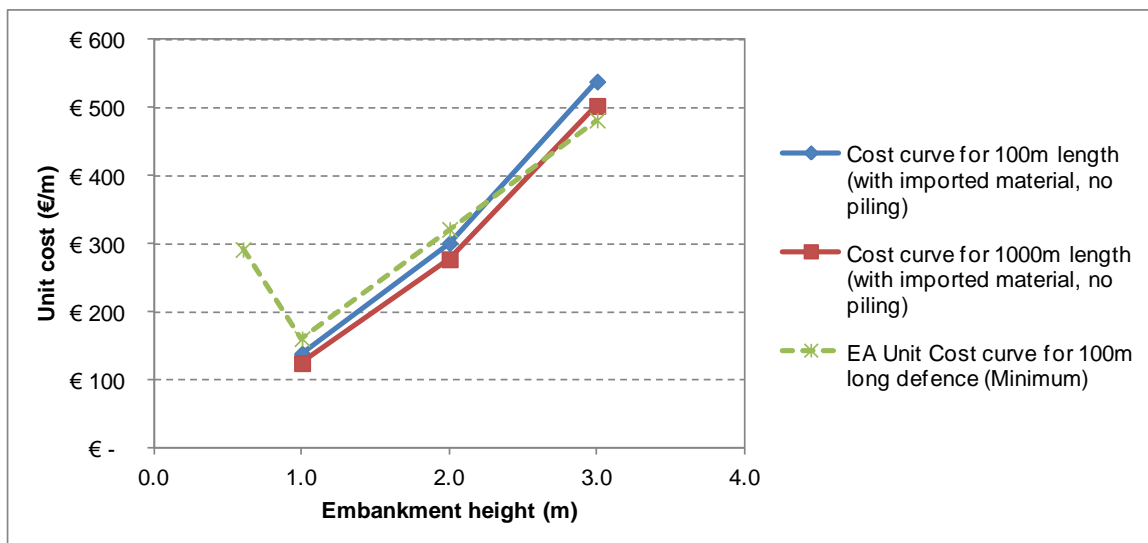
Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for each embankment type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

It is assumed that embankments will be constructed of suitable soil types, with a top width of 2m and a side-slope of 3:1 (i.e. 3m horizontally for each metre of height).

Cost information is provided for the following asset types:

- **Rural assets only.** It is not anticipated that embankments in urban locations will vary in cost as embankments will only be located in areas of open access.
- **Height variations of 1.0m, 2m and 3m.** These are typical embankment heights used for flood mitigation. Embankment heights assume a freeboard is included.
- **Asset length categories of <100m, 100-1,000m and >1000m.** Efficiencies of scale are anticipated for longer lengths.
- **Embankments formed from imported material and local material.** This is an important aspect that was included as the source of material can impact on costs significantly.
- **Embankment construction type.** Costs for standard embankments, embankments with a 5m pile and embankments with a 10m pile were costed separately as aspects will significantly influence costs.

Figure 4-3: Embankment cost curve and comparison with Environment Agency unit costs (adjusted to € and preliminaries removed)



4.6 Demountable barriers

Costs have been derived and obtained from a number of suppliers of demountable barriers and flood gates. Demountable barrier costs assume a pillar and slat type of construction and include the supply and installation of barriers. Costs for gates have been provided for a range of types.

Cost information is provided for the following factors:

- **Rural and urban.** No cost variation is provided for this aspect. The costs of supply will be the same for both scenarios. The ground work costs may vary due to the need for concrete foundations and possible cut-off, although this factor will depend on ground conditions at site rather than a rural or urban classification.
- **Height variations of 0.6m, 1.2m, 1.8m and 2.1m.** These are typical demountable barrier heights used for flood mitigation. Costs over and above 2.1m are possible but would need bespoke design from a specialist. Gates have been provided for 0.6m, 1.0m, 1.2m and 1.8m.
- **Asset length categories of 1m, 2.5m and 5m.** Costs have been provided by suppliers for very short lengths only. Costs for longer reaches should use the 5m lengths to scale up costs as barrier lengths beyond 5m will have less scale efficiencies unless suppliers choose to provide this. For very long lengths we recommend that costs are obtained from suppliers at an early stage.
- **Foundations.** Supply costs include the installation and supply of a ground beam. This incorporates the fixing plates for the posts and thus takes the onus off the contractor for the accuracy required with these. The greater cost however is the foundation cost. This could be as simple as a 600m x 600m concrete trench, although past experience suggests that costs for cut-offs and poor ground conditions can make up a large proportion of costs for these works.

In some circumstances demountable barriers will be constructed on top of flood walls. In this instance, appraisers should combine the two unit costs making any additional allowance for the works to tie the two together structurally and any additional costs associated with improved or extended foundations.

To aid this combined measure a range of basic additional foundation costs have been provided depending on the approach proposed. The three options where costs are provided include:

- Cost per m for basic foundation
- Cost for low wall (assuming demountables on top)
- Cost for quay wall

It should be noted that the wall unit costs provided do not allow for a further demountable barrier on top and that the wall foundations would need to make an allowance for the additional barrier height. An appropriate contingency should be applied for this aspect unless additional specific engineering design and expertise is provided to inform the design and costs.

All relevant event, operation and maintenance and storage costs are provided. These costs include general administration, storage costs and all inspection costs.

4.7 In-channel excavation

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for in-channel excavation works. The above costs have been developed from a breakdown of costs for excavation and disposal costs along with costs for construction of silt traps, replacement of gravel layer post works and the reinstatement of works access and storage areas. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Rural and urban.** Costs are broken down into rural and urban locations reflecting the more complex access and obstructions within urban locations.
- **Excavation material.** Costs are provided for excavation in soft soil and rock. Costs assume that all materials excavated are taken to a waste facility.
- **Volume of material.** Costs have been assessed for 3 categories: 100m³, 500m³ and 1000m³.

Operation and maintenance costs are assumed to be zero in the long term and do not add to expenditure budgets. Appraisers should consider initial post works monitoring for a number of years if this is anticipated to be required.

4.8 Excavation on land

Costs have been derived from bottom up analysis using unit rates defined by an experienced Irish quantity surveyor based on a specific set of design requirements for in-channel excavation works. The above costs have been developed from a breakdown of costs for excavation and disposal costs. Excavation on land is anticipated for channel diversions or natural flood management purposes. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Rural only.** Costs are broken down into rural locations only as unit costs cannot be provided for excavation of land in urban areas due to the highly variable site conditions and constraints.
- **Excavation material.** Costs are provided for excavation in soft soil and rock.
- **Disposal.** Costs have been provided assuming that all materials excavated are either taken to a waste facility or disposed on site. The latter may be applicable for rural works.
- **Volume of material.** Costs have been assessed for 3 categories: 100m³, 550m³ and 1000m³.

Operation and maintenance costs are assumed to be zero in the long term and do not add to expenditure budgets. Appraisers should consider initial post works monitoring for a number of years if this is anticipated to be required. Additionally, operation and maintenance costs may be required for channel creation aspects. In this instance, channel maintenance costs should be applied.

4.9 Weir construction

It is not anticipated that new in-line weirs would be constructed for flood risk management purposes as part of the CFRAM process, other than for lateral weirs (side spillways) to convey water into new diversion channels or storage areas. Therefore costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for a side weir construction.

Costs assume a reinforced concrete construction (similar to the assumptions used for concrete walls) with all necessary temporary works and bank protection. Full details and all assumptions are given in the summary spreadsheet.

There are considerable uncertainties associated with providing unit rates for all possible weir structures proposed as part of the CFRAM projects. As a result the rates provided should be used with caution and as a starting point only.

Cost information is provided for the following factors:

- **Weir height.** Costs have been provided for 1m and 2m high weirs. Total costs and unit costs are provided.
- **Weir length.** Costs have been assessed for 10m and 20m long weir lengths. Total costs and unit costs are provided.

Operation and maintenance costs have been provided.

4.10 Weir removal

Costing and providing unit rates for weir removal is complicated by the inherent variations in weir design and size, site specifics and site constraints. As a result costs have been derived from top down analysis derived from gathering case studies of weir removal to derive example costs. A number of examples have been sourced and provided to illustrate the range of costs likely. Costs appear to correlate with structure length and an indicative cost curve has been provided. It should be noted however that most sites collated are predominantly rural rather than urban and care should be utilised when applying this cost curve to urban sites as costs could be substantially higher.

There are considerable uncertainties associated with providing unit rates for the removal of weir structures proposed as part of the CFRAM projects. As a result the values used and cost curve provided should be used with caution and as a starting point only.

Operation and maintenance costs have been included to account for post works monitoring to ensure watercourse channels remain stable.

4.11 Bridge construction/removal

Costing and providing unit rates for bridge construction/removal is complicated by the inherent variations in bridge design and size, site specifics and site constraints. As a result costs have been derived from top down analysis, derived from existing unit costs from a range of available sources from the UK and the USA. The UK costs are deemed to be most applicable although data from the USA provides additional confidence in the data used. There are existing National Roads Authority (NRA) cost databases that have this information and could be used to reduce the reliance on non-Irish unit rates. We recommend that access to the cost database is agreed between the NRA and the OPW to improve future bridge costs.

Costs are available for the following:

- Footbridge
- Reinforced concrete bridges
- Bridge removal

These costs are highly indicative and should only be used for early level appraisals where bridge costing is required, and where site details and designs are not yet understood. Costs should therefore be used with care and may not be applicable to all structures. Costs will be highly dependent on the presence of existing services and anticipated traffic loading and these factors should be considered by the CFRAM consultants when using the rates provided.

Appraisers should select an appropriate unit cost from the range provided based on the site characteristics and the risk factors identified.

4.12 Bridge underpinning

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for in-channel excavation works. The unit costs have been developed from a breakdown of costs for all associated site works, temporary works and phased construction works. The costing process is based on a theoretical case study: a 3 span bridge with four 13m long support walls. Full details and all assumptions are given in the summary spreadsheet.

No further cost factors have been allowed for, therefore care should be exercised in using these costs for anything other than early level appraisals where bridge underpinning has been identified, but site details and designs are not yet fully understood.

Operation and maintenance costs are assumed to be zero in the long term and do not add to expenditure budgets (these works may actually reduce inspection and maintenance costs for at risk structures). Appraisers should consider initial post works monitoring for a number of years if this is anticipated to be required.

4.13 Culvert

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a specific set of design requirements for each culvert type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

All culverts assume a site preparation and trench excavation, disposal, granular bedding, supply and placement of precast culvert, backfilling and reinstatement. In addition to culvert works, the costs of headwall construction are provided separately. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Rural and urban.** Culverts in an urban area assume additional works for manhole provision, additional excavation and service diversions, temporary trenching and traffic management, road re-instatement and connection of existing services. Costs for urban culverts relate to new culverts and the replacement of existing culverts. Costs for urban reaches only relate to pipes as it is unlikely that long lengths of box culverts will be needed in urban environments.
- **Culvert sizes for pipes (1.05 and 1.5m dia) and box culverts (2.1x1m, 2.4x2.1m and 3.0x2.1m).** These are typical culvert sizes applicable for a range of flood mitigation measures. Costs for replacement culvert sizes (pipes of 1.05m and 1.5m diameters) were selected as it is assumed that large culvert online replacement is unlikely in the urban environment.
- **Depth of invert (2, 4, 6m).** The depth of invert can influence the construction costs due to greater excavation and backfilling costs.
- **Excavation material (soil and rock).** Costs of construction will vary greatly for construction in rock. This variation has been applied to rural culverts only.
- **Disposal of waste material.** Costs for disposal will vary depending on where material is disposed and distance of haulage. Costs have been broken down between disposal on site and disposal at a licensed tip. This variation has been applied to rural culverts only.
- **Asset length.** Costs have been developed for a 100m culvert length. Costs increase substantially for short lengths. To take this aspect into consideration existing unit rates have been used to define factor adjustments for very short culvert lengths. Users may wish to apply a factor for very short or much longer asset lengths.
- **Headwalls.** Costs have been developed for headwalls as a separate item. Costs have been provided for the 5 culvert size dimensions and assume that the total height of the reinforced concrete headwall will be 1500mm above the top of the pipe or culvert.

Operation and maintenance costs are provided for short, medium and long culvert lengths and for 3 categories of culvert size (<1.2m², 1.2-4.0m² and >4.0m²).

4.14 Road Raising

Costs have been derived from bottom up analysis using unit rates defined by an experienced quantity surveyor based on a defined set of design requirements for road raising. It is very difficult to provide a unit cost that will be applicable for all sites. Therefore costing process is based on a theoretical road raising approach that allows for the raising of a 7.5m road, kerbs, grass verges and footpath. Full details and all assumptions are given in the summary spreadsheet.

No further cost factors have been allowed for, therefore care should be exercised in using these costs for anything other than early level appraisals where road raising is proposed but specific site details and designs are not yet fully understood.

This operation is not anticipated to have any net increase in existing operation and maintenance costs: indeed it may reduce them.

4.15 Individual property protection

Costs for individual property protection have been derived from existing research into PLP costs and JBA information on survey and administration costs. Unit rates for individual property level protection products have been used and multiplied by standard packages for typical property types in order to derive a unit cost per property. Costs allow for survey and administration, door guards, airbrick covers, sump pumps, waterproofing of external walls, non return valves or toilet bungs. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Property type.** Unit costs have been provided for the following property types: Detached, Semi-Detached, Terraced, Flat, Residential Average (where property types are unknown), shops and offices.
- **PLP product type.** Unit costs have been provided for manual products and automatic measures. Manual products need to be fitted manually by residents or homeowners, whereas automatic measures require minimal operation prior to a flood event but are generally more costly.

O&M costs are recommended to be 2% for manual measures and 5% for automatic measures.

4.16 Hydrometric gauging station

Costs have been built up from unit rates for specification/administration, monitoring equipments and installation/communication rates to cover the cost of installation and running of a hydrometric gauging station. It is assumed that this is a relatively simple water level monitoring station fitted with telemetry and costs include annual costs for undertaking flow gaugings.

No further cost factors have been allowed for. Costs do not assume weir, stilling wells, recorder house and cableway construction. Whilst the unit cost for such stations will be significantly greater and are excluded, the summary provides costs for such structures based on other unit rates from the UK for completeness.

4.17 Flood forecasting

Costs for the provision of flood forecasting are highly variable and will depend on the level of existing hydrometric coverage, the size of catchment, the forecasting requirements and the degree of software and hardware to support forecast data and models.

Costs have been broken down into simple alarms and complex forecasting models. Rates for simple alarms have been built up from unit rates for specification/administration, monitoring equipment and installation/communication rates. Costs are broken down into the following factors:

- **Simple alarm system.** Water level monitoring station fitted with public alarm when level reaches specified level(s). Costs are provided per station for gauges with audio alarms and those with signage (e.g. for road crossings liable to flooding).
- **Simple forecast system.** Water level monitoring station fitted with telemetry to send text messages when level reaches specified level(s). Costs are provided per station for gauges with audio alarms and those with signage (e.g. for road crossings liable to flooding).

Costs for complex alarm systems have not been defined although a range of typical costs are provided for key aspects that may be needed depending of the site of catchment and scope required. These costs are predominantly based on existing information provided by the OPW and updated from other sources. Costs include specification, site survey and administration, gauging and telemetry, forecast model set-up, calibration, configuration and testing, forecasting system development, design and plan of training package and public awareness campaigns.

The Present Value cost summary tool allows users to specify the number and rate (guided by typical rates) for each item for a specified forecast model. Obviously there are large uncertainties and the rates used are indicative. Whilst costs include hardware and software costs for new forecasting capabilities (if not already available), appraisers should be aware that if multiple

forecast models and systems are proposed and run regionally or centrally, there may be cost savings that apply.

4.18 Pumping stations

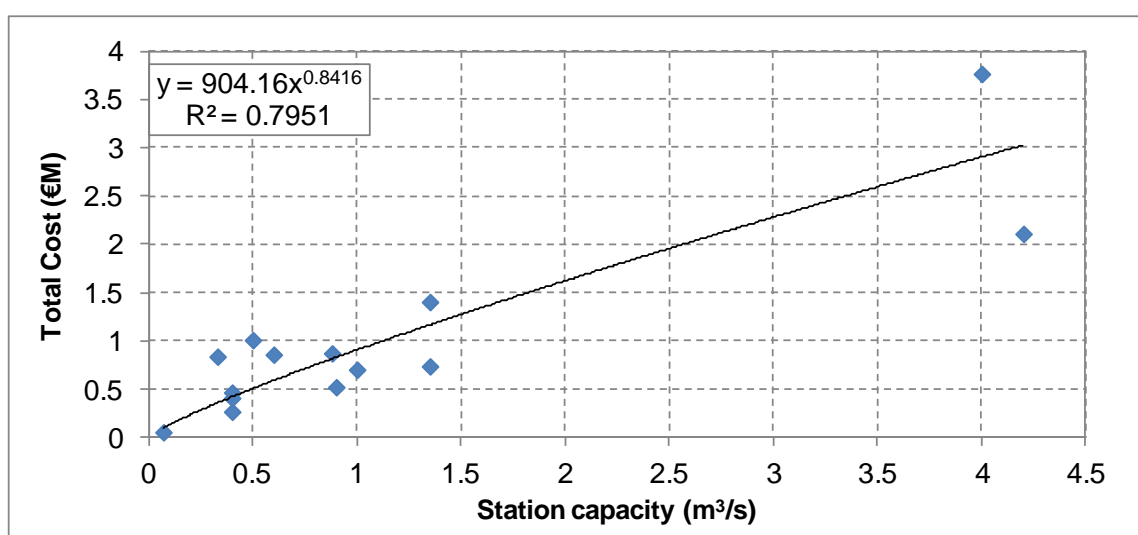
Costs have been derived from top down analysis through the assessment of multiple pumping station case studies. Costs are highly indicative due to the large variation in design of pumping stations and the wide range of factors that need to be considered. Capital costs will relate to the supply of pumps and construction of all pumping station civil works. This may include site clearance, pump installation and ancillary electrical and mechanical equipment, excavation, pipework and manhole construction, kiosk/housing installation/construction, connection with power supplies, and telemetry/cctv installation and testing.

Whilst a range of factors need to be considered for all pumping stations, all costs gathered have been plotted against the pump capacity to determine a cost curve for use at the high level, early stage assessment prior to site specific design (Figure 4-4).

Cost information is provided for the following factors:

- **Capacity.** Based on cost curve derived a series of unit costs have been derived for 7 categories of pump capacity (20l/s, 50l/s, 100l/s, 500l/s, 1,000l/s, 2,000l/s and 3,000l/s).

Figure 4-4: Pumping station construction cost curve



No further cost factors have been allowed for, therefore care should be exercised in using these costs for anything other than early level appraisals where pumping stations have been identified, but site details and designs are not yet fully understood.

Operation and maintenance costs are an important consideration for pumping stations due to the annual running and operational costs and annual/intermittent maintenance costs. Detailed analysis of existing pumping stations assessed by JBA have been used to define unit rates for these aspects for this study. The following aspects are provided:

- **Annual maintenance costs.** These are highly variable and will depend on the need for inspections, condition assessments, repairs and replacement of parts, removal of blockages and telemetry checks. A unit rate for each category of pump station capacity has been provided as well as an upper and lower rate.
- **Running costs.** This will include all electricity costs. Based on the output of JBA analysis a cost curve has been derived to determine costs for the range of pumping station capacities. It should be noted that Maximum Import Capacity (MIC) charges may also apply for larger pumping stations with significant implications for running costs (see below).
- **Intermittent replacement costs.** In addition to annual and periodic maintenance costs, refurbishment works are generally carried out at approximately 15 to 25 year intervals for

mechanical and electrical equipment with any major structural repairs and improvements being carried out. For the purposes of whole life costing we recommend that refurbishment costs are included every 25 years over the appraisal period.

4.18.1 Note on Maximum Import Capacity (MIC) charges

MIC charges are applied for all new pumping stations to cover the energy distributor's costs of connection and meter installation. However, for larger pumping stations MIC charges may also be applied as an annual cost. The current MIC charge is €0.0734/kVA/day. This charge is applied whether the pump is in use or not and is set to cover the demand usage of the pumping station when required. An example is the Ennis FRS which has a pump capacity of 3.8m³/s and a power requirement of 1000KVA. This results in an annual MIC charge of €28965 (including VAT).

These costs are not included in the running costs provided, but need to be included for larger pumping stations to ensure that these important costs are fully considered by the CFRAM consultants. There are options to design out these charges however, that may need to be investigated at an early stage in the appraisal process. Options may include the use of more efficient pumps with lower power requirements (although higher capital costs), the use of generators to power the pump (noting that there may be maintenance and site layout constraints to consider also).

4.19 Channel maintenance

Channel maintenance costs vary considerably depending on the state of watercourse and channel sizes. Unit costs have been derived from a top down approach utilising existing information from the OPW and the Environment Agency (the latter adjusted to Euros).

Costs relate to inspections, bank clearance, obstruction removal, weed control and intermittent works such as bank protection and repairs. A range of costs (broken down by channel type (urban/rural), clearance method (manual/mechanical)) are provided as well as upper and lower bounds for the EA data.

All costs represent annual costs rather than capital costs. Full details and all assumptions are given in the summary spreadsheet. Recommended costs are provided for the following factors:

- **<5m wide channels in rural areas**
- **<5m wide channels in urban areas**
- **5-10m wide channels in rural areas**
- **5-10m wide channels in urban areas**
- **Channels in poor condition requiring heavy maintenance**

4.20 Bank protection

Costs have been derived from bottom up analysis using unit rates defined by an experienced Irish quantity surveyor based on a specific set of design requirements for each bank protection type and factor variation. Full details and all assumptions are given in the summary spreadsheet.

Cost information is provided for the following factors:

- **Fluvial and coastal.** Two alternative designs have been prepared for bank protection in a fluvial environment (4m high gabion protection) and in a coastal environment (rock revetment).
- **Length.** Fluvial bank protection costs have been provided for 3 length categories (<25m, 25 to 100m and >100m). Coastal rock revetments have been costed for a single 100m length although additional unit rates have been used to apply weightings to longer and shorter lengths. .

Operation and maintenance costs are also provided but are anticipated to be minimal.

4.21 Manhole sealing

Manhole sealing costs have been provided by Gerry O'Connell of Dublin City Council for a range of options including alternative pressures and construction methods. Costs include the supply and fit of a pressure manhole cover of 1-2 bar rating (10-20m water head).

4.22 Additional cost elements

4.22.1 Preliminaries

Construction costs do not include preliminaries as these are most likely to be applied to the total cost for a range of asset types rather than per asset. Despite this the user can apply them to the PV cost tool for individual methods or as part of the combined portfolio of methods tool. To assist the inclusion of preliminaries a method of estimating preliminaries has been derived.

Preliminaries and other construction costs have been built up from unit rates for the following items:

- Compound
- Site cabins and services
- Temporary power and generators
- Protection to overhead services
- Protection to underground services
- Road sweeping of public roads
- Preparation of as constructed drawings
- Health and safety
- Security
- Wheel wash provision at exits to public roads
- Manual washing prior to vehicles existing to public roads
- Supervision
- Setting out
- Mobilisation and demobilise
- Insurance

In addition to the above, each of the separate unit costs includes an estimate of some of the additional preliminaries, such as temporary works, environmental mitigation and temporary flow controls. The temporary works costs are based on what would be required on all sites but are not intended to be definitive for all possible eventualities. As a result, CFRAM consultants should increase the preliminary or method costs to take into account those sites where non-standard, difficult, or additional temporary works are likely to be required.

For each of the above factors a representative cost has been determined for a particular project total cost from €100,000 to €15,000,000. These are shown in Table 4-2 below.

Table 4-2: Preliminaries cost curve

Construction cost:	€100k	€250k	€500k	€1m	€2m	€5m	€10m	€15m
Total Preliminaries	€32k	€51k	€89k	€199k	€330k	€512k	€743k	€932k
Preliminaries as a % of total	32%	20%	18%	20%	16%	10%	7%	6%

Based on the above analysis we recommend that typical preliminary estimates should be between 10-30% of total construction costs, although the tool provided allows appraisers to estimate the preliminaries costs for any given total construction cost.

4.22.2 Haul roads

Construction costs do not include method related costs. A method of estimating two key method related costs (haul roads and works access) have been derived to assist CFRAM consultants. These costs have been derived from worked up rates for a range of activities. It is recommended that the above costs are applied to all capital costs estimates where haul roads or works access is required. This has been addressed in the preliminaries summary cost sheet.

5 Cost database structure

5.1 Database files

A number of files have been prepared and provided to OPW and CFRAM consultants. These include the following:

- 20 CFRAM Consultant FRM method summary cost sheets
- CFRAM Consultant Combined Method WLC tool
- CFRAM Consultant Optimism Bias tool (see Section 3.4.1)
- OPW calculation sheets

5.2 CFRAM Consultant summary sheets

The CFRAM consultant spreadsheets provide all necessary unit rates derived, but none of the background base rates or breakdown of costs. These are included in associated OPW calculation spreadsheets. This is to ensure that the OPW remains the keepers of the data and can make updates to specific rates as and when changes and updates are required, without overloading the CFRAM consultants.

5.2.1 Approach to cost estimation

The basic approach to cost estimation is shown in the Figure 5-1 overleaf. It is up to the consultant to review both this report and each of the summary reports to firstly check that the costs provided cover the types of works proposed and include the factors and sizing applicable to the site. If this database of costs does not provide the necessary information, additional bespoke costing may be required.

Consultants should also review the assumptions used for each approach and decide if any additional weighting or adjustments to the unit costs are required to match the particular site, or whether these can be suitably allowed for as part of an overall optimism bias.



5.3 Layout of CFRAM Consultant Summary sheets

For each method a summary MS Excel workbook exists. Within each is a series of sheets as follows:

- **Revision History** sheet. A basic history of revisions to be kept up to date by JBA/OPW.
- **PVc Summary** sheet (See Figure 5-1 as an example). This allows whole life present value costs to be derived for single method cases (e.g. a series of walls). Appraisers can enter a series of assets and apply specific rates and units to develop a total cost. Appraisers must also enter in any applicable preliminaries, enabling, O&M costs and other costs to derive a whole life cost. A separate tool is provided to generate a whole life cost for a portfolio of assets/methods.
- **Cost Summary** sheet. This sheet provides the unit costs derived, information on how the costs were derived, key assumptions and O&M/other costs.
- **Example** sheet. This is provided for methods where costs have been built up from bottom up costing and includes drawings illustrating the asset type.

The PVc summary sheet should not be used to combine method costs as items like preliminaries will be double counted.

Figure 5-1: Example of PVc summary sheet

		DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS		 OPW <i>The Office of Public Works</i> <i>Oifig na nOibreacha Poiblí</i>	
CFRAM Unit Cost Development Project					
Method		Embankment			
Prepared by:		Date:			
Checked by:		Date:			

Project reference	XXXXXX	Project name:	EXAMPLE PROJECT
Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	1.000
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues/constraints	1.10

This sheet should only be used when assessing single method options as double counting may occur when method costs are added.

Single Method Capital Cost Tool

	1	2	3	4	5	6	Comment/justification
Embankment ref/type	Left bank	Right bank					Embankments on both banks required
Embankment length	50	200					2m high embankment costs
Embankment unit rate	300	285					Costs assume imported material
Total costs						€72,000	
Apply update to unit rate (CPI) if appropriate (cell N15)						€72,000	
Enter appropriate preliminaries estimate (%)						15%	15% enabling costs assumed
Enter other applicable costs (€)						10000	Access over embankment required
Total capital cost (€)						€92,800	
Consider amendments based on site issues/constraints (cell N10)						€102,080	Difficult access, 10% uplift assumed
Total capital cost (€)						€102,080	

Operation and Maintenance Cost Tool

Total annual O&M costs	€100	
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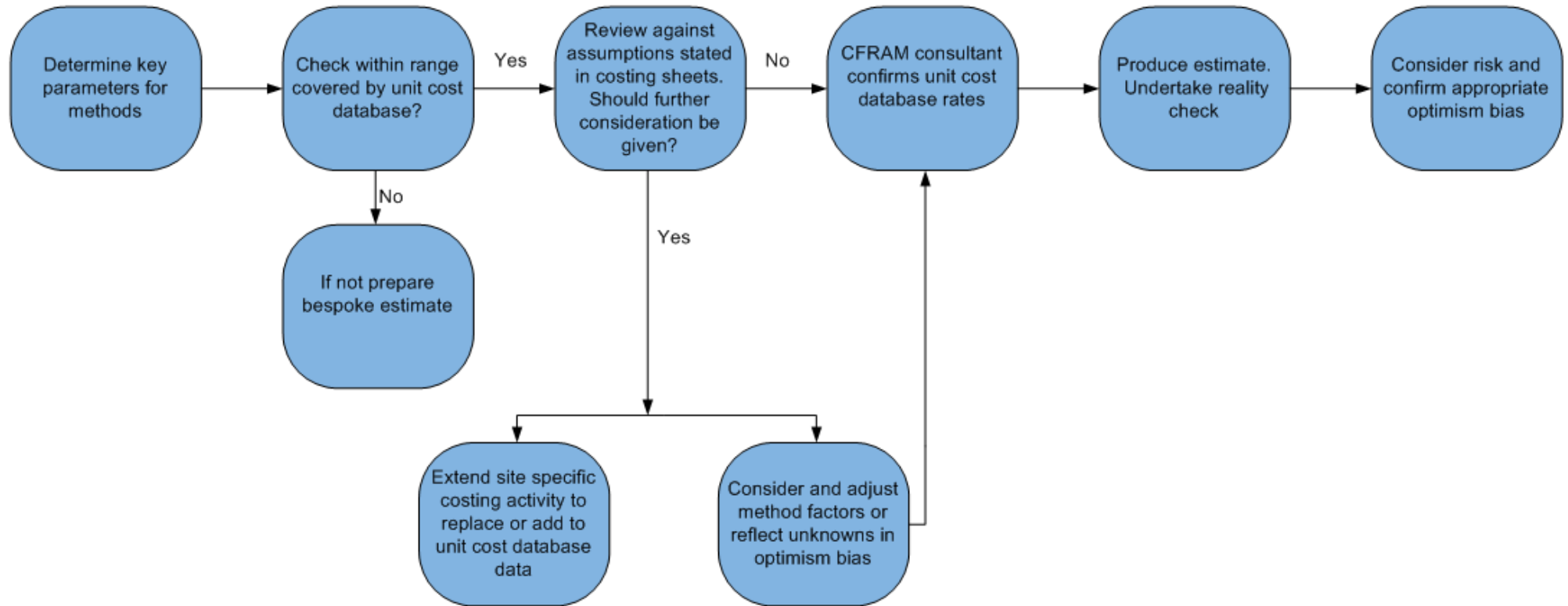
Other costs

Other costs (user defined - consider the need for additional longer term or intermittent costs)		
---	--	--

Total PV Cost

Total PVc costs (see PVc calculator below)	€104,214	
Optimism bias rate (from external sheet)	50%	
Total Cost including Optimism Bias	€156,321	

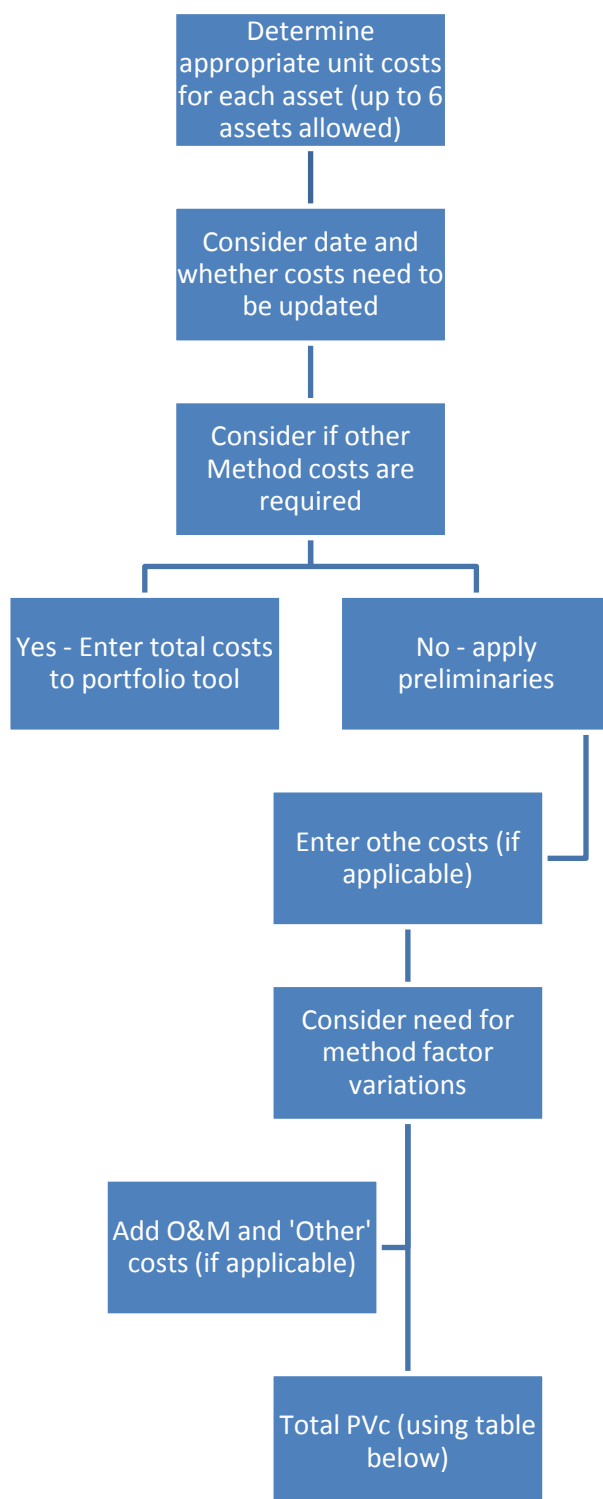
Figure 5-2: CFRAM costing approach



5.3.1 Present Value (whole life cost) summary explanation

The PVc summary is provided in each summary sheet and enables whole life costs for single asset cases to be derived. The following flow path should be followed when entering data from the 'Cost summary' sheet.

Figure 5-3: Present Value Cost tool process



Each stage is provided in the spreadsheet as a separate row with space consultants to enter appropriate comments and/or justification for the values entered as shown in Figure 5-4.

Figure 5-4: Cost summary inputs

Single Method Capital Cost Tool							
	1	2	3	4	5	6	Comment/justification
Culvert ref.							
Culvert length (m)	25	50					
Culvert unit rate (€/m)	2500	1800					
Total costs						€152,500	
Apply update to unit rate (CPI) if appropriate (cell N15)						€152,500	
Enter appropriate preliminaries estimate (%)						15%	
Enter other applicable costs (€)						0	
Total capital cost (€)						€175,375	
Consider amendments based on site issues/constraints (cell N16)						€175,375	
Total capital cost (€)						€175,375	

Operation and Maintenance Cost Tool		
Total annual O&M costs		

Other costs		
Other costs (user defined - consider the need for additional longer term or intermittent costs)		

Total PV Cost		
Total PVc costs (see PVc calculator below)	€168,630	
Optimism bias rate (from external sheet)	50%	
Total Cost including Optimism Bias	€252,945	

5.3.2 Data inputs

In each summary sheet the following colour codes apply to cells within the working area:

- Cells normally requiring data entry: Orange
- Cells where data may be amended, if necessary: White
- Main calculation areas where values generated automatically: Light Green
- Titles, etc. outside main calculation areas: Blue

It should be noted that unit costs from the 'Cost Summary' sheets are not linked and need to be added by CFRAM consultants

5.3.3 Present Value cost tool inputs

For the purposes of this project a standard present value spreadsheet has been developed to allow appraisers to input basic cost information and to derive whole life costs by applying standard discount rates over the standard appraisal period. The tool automatically brings in summary costs for each of the applicable cost elements (Capital, O&M, and 'Other' costs).

This tool is provided for each method summary (to allow whole life costing for single asset types, e.g. embankments) and on a separate 'portfolio tool' that allows appraisers to input costs for a range of flood risk management methods. An example of the spreadsheet is shown in Figure 5-4.

Enabling costs (**(a)** in Figure 5-5), if applicable, are assumed to occur in year 0. If enabling works are likely to extent to 2 or more years, users should enter these manually within the PVc table.

Whilst the user has the ability to define the year of capital costs (**(b)** in Figure 5-5)⁴, the OPW standard for the purposes of CFRAM projects is that this should be set to year 0 as it will not be known when projects will be implemented (this will only be known once prioritisation of schemes has been completed). This application has only been given for completeness and users should only change this value with the consent of the OPW for particularly larger schemes where construction may be delayed or phased.

Maintenance works are assumed to be annual starting the year after capital works. The user has the ability to enter intermittent or other costs. The 'other' costs element is linked to the cost summary, although users should enter the frequency (**(c)** in Figure 5-5), of these costs (e.g. 1 for annual costs, 5 for 5 yearly repeat costs). These costs are repeated for the full 50 year period starting the year after the capital works are completed.

⁴ Entering a value of 2 for example shifts the capital costs to year 1. Should users wish to enter a phased or multi-year construction period, this must be done manually.
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Figure 5-5: Whole life cost and PVC analysis tool

Whole life cost and PVC analysis - for Whole Life Cost Tool
Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	€10,000	(a)
Year of capital works (year)	1	(b)
Capital cost (€)	€250,000.0	
Annual maintenance cost (€)	€2,500.0	
Other cost (€)	€10,000.0	
Other works frequency (years)	10	(c)

Key

	Information
	Calculation
	Cost input

(e)

Discount rate:	4.0%	Present Value Factor:	22.341	Total PVc (€k):	317186	
Cash sum	10000	250000	120000	40000	420000	
					317186	
	Discount Factor	Cost Elements			TOTALS:	
year		Enabling	Capital	Maint.	Other	
0	1.00 (d)	10000				10000.0
1	0.962		250000			250000.0
2	0.925			2500		2500.0
3	0.889			2500		2500.0
4	0.855			2500		2500.0
5	0.822			2500		2500.0
6	0.790			2500		2500.0
7	0.760			2500		2500.0
8	0.731			2500		2500.0
9	0.703			2500		2500.0
10	0.676			2500		2500.0
11	0.650			2500	10000	12500.0
12	0.625			2500		2500.0
13	0.601			2500		2500.0
14	0.577			2500		2500.0
15	0.555			2500		2500.0
16	0.534			2500		2500.0
17	0.513			2500		2500.0
18	0.494			2500		2500.0
19	0.475			2500		2500.0
20	0.456			2500		2500.0
21	0.439			2500	10000	12500.0
22	0.422			2500		2500.0
23	0.406			2500		2500.0

The tool enters the annual cash costs for the 50 year appraisal period (years 0 to 49) based on the input data. Standard discount rates ((d) in Figure 5-4) are provided in the second column and total cash and Present Value costs are summed in 'totals' columns to the right. The total PV cost is summed in the upper right cell ((e) in Figure 5-4). PV costs determined can then be added to the optimism bias tool to generate a total PVc including project risks.

5.4 Updating of costs

The unit rates supplied in each individual sheet are intended as a starting point for cost estimation and should be used by experienced staff with knowledge of scheme design and cost estimation. It should be noted that the costs represent common, representative types for each method and factor listed. CFRAM Consultants are required to use their professional judgement in using the unit costs, and should vary costs to take into account local requirements or conditions that are not provided for explicitly in the methods and factors.

Two options have been provided to allow CFRAM Consultants to update costs in the PVC summary sheet:

- **Construction Price Index.** This allows appraisers to update costs for future years if a rise in inflation or construction prices occurs.
- **Method factors.** This allows users to apply adjustments to the total capital cost for each method based on known and particular site issues and constraints. This is separate from the optimism bias that tries to take into account of under-predictions due to unforeseen risks in the design and construction.

Whilst method factors may be open to mistreatment and goes against the aim of the project to provide a consistent approach to costing across all CFRAM studies, the costs provided are a single cost for each method and factor that cannot necessarily cover every site and situation. The use of method factors are therefore recommended to enable CFRAM consultants to vary costs for those sites where the standard assumptions for each method and factor will not apply.

For example, a consultant requires a 200m long embankment of 2m height made from imported material with no piling (unit cost of €285 per m length). However, access is constrained and the current watercourse bank is showing signs of erosion so additional scour protection will be required. Based on this knowledge and experience, the consultant applies a 1.3 method related factor to increase the unit cost by 30% to account for these site conditions.

Factors that should be considered by consultants for each method and factor are provided in the summary sheets. Furthermore, for quality control and auditing purposes and in order to allow the OPW to review each cost estimate, consultants should provide justification on the method related factor used (see below).

Figure 5-6: Example use of method factors within PVC cost sheet

Method		Embankment	
Prepared by:		Date:	
Checked by:		Date:	
Project reference: XXX		Project name: XXX	
Base date for estimates (year 0)	01-2013	Construction Price Index (CPI)	1.000
Scaling factor (e.g. km, k€, €)	€	Method Factor - to take into account particular site issues /constraints	1.30

This sheet should only be used when assessing single method options as double counting may occur when method costs are added.

Single Method Capital Cost Tool							
	1	2	3	4	5	6	Comment/justification
Embankment ref/type	Emb 1						
Embankment length	200						200m long embankment at x
Embankment unit rate	285						Standard unit rate for 2m high
Total costs						€57,000	
Apply update to unit rate (CPI) if appropriate (cell N15)						€57,000	N/A
Enter appropriate preliminaries estimate (%)						25%	Low project cost.
Enter other applicable costs (€)						0	N/A
Total capital cost (€)						€74,250	
Consider amendments based on site issues/constraints (cell N15)						€2,625	Site constrained with need for additional scour protection
Total capital cost (€)						€76,875	

5.5 Portfolio whole life cost tool

In addition to the 20 summary sheets we have provided a whole life cost tool that combines costs from different methods to help build up a total cost for a scheme. This tool allows users to enter in capital and O&M costs for each method defined as well as a user specified entry if required. Total capital costs across all methods are summed, after which users can update to current prices, enter other applicable costs and add appropriate total preliminaries costs. The Present Value calculations undertaken are then applied as per the single method cost tool. This is shown in Figure 5-7.

Figure 5-7: Portfolio tool (to gather multiple asset costs and derive a scheme PVc

Project reference		Project name:	
Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	1.000
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs		
Total embankment costs		
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€0	
Apply update to unit rate (CPI) if appropriate (cell N15)	€0	
Enter appropriate preliminaries estimate (%)		
Enter other applicable costs (€)	0	
Total capital cost (€)	€0	
Consider amendments based on site issues/constraints (cell N16)	€0	
Total capital cost (€)	€0	

5.6 OPW calculation sheets

The OPW calculation sheets include the following sheets:

- A summary unit cost sheet
- A base rate sheet holding all rates used in the calculations
- Cost calculation sheets for each method/factor

5.6.1 Updating of costs

In order for the database to remain up to date and applicable, we recommend that certain factors are updated or modified. All costs are applicable to 2013 values. Updating of costs may be needed in the future once updated inflation or construction price indices are released.

The OPW may wish to update the base rates used in the analysis. This may need to be done for particular rates that could change significantly beyond normal construction price indices e.g. rebar costs, sheet piling, pre-cast culverts and fuel costs.

This can be done in the 'base rate' sheet for each of the calculation sheets. A comment specifying the reason for change should be added. Any updates to these base rates will be applied to each relevant cost sheet and relevant summary tables. Manual edits required to update the summary sheets as these are not currently linked to the summary sheets provided to CFRAM Consultants.

6 Cost validation

6.1 Methodology

In order to confirm that the unit costs provided are applicable to real-world examples a number of validation tests have been undertaken on 4 case studies in Ireland. The aim of these validation tests are to independently calculate the costs of the schemes based on initial design proposals using the unit costs and spreadsheet tools provided as part of this project.

This assessment investigates four projects that serve as acceptable surrogates for the work expected as part of any CFRAM flood relief or management scheme.

6.2 Calibration projects

The calibration projects are as follows:

- Deansgrange Flood Alleviation Scheme. Located in Clonkeen Park, South Dublin.
- Rolestown Minor Works Flood Scheme. Located in Rolestown a small village 10 km north-west of Swords in County Dublin.
- Mornington Flood Relief Scheme. Located at the downstream end of the Mornington catchment near the Boyne Estuary.
- Clonmel Drainage Scheme.

6.3 Deansgrange Flood Alleviation Scheme

The purpose of the scheme is to protect residential properties in the Monaloe Way and Little Meadow housing estates from excessive water levels, whilst retaining the public amenity function of the park. Historical flooding has occurred in this area a number of times affecting local residents, with the most severe flooding witnessed on the 24th October 2011. The proposed works include:

- The realignment of the Deansgrange Stream towards the centre of the park, which includes the construction of a wider open channel to provide additional conveyance capacity.
- Re-grading of lands to provide additional flood storage capacity.
- Construction of a section of new culvert, with associated culvert inlet and headwalls to increase inlet capacity.
- Decommission & backfilling of the existing stream channel, a section of existing culvert, headwall and screen.
- Diversion of existing stormwater drainage where required and construction of new stormwater drainage and French drain inclusive of outfalls to new channel.
- Provision of an earth embankment along the left bank of Deansgrange Stream.
- Additional landscaping, fencing, boundary works and realignment of existing cycle track and associated public lighting. Other miscellaneous works (inclusive of fencing, new footpaths, new lighting etc)

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

• Total Capital Cost	€206,600
• Total O&M Cost (Annual)	€4,707
• Total Present Value Cost	€322,599
• Total PV Cost inc. Optimism Bias (40%)	€451,639

This scheme was designed by JBA and JBA have been involved in the project from concept stage through to construction and completion. The project is now at substantial completion stage. .

In summary, the total sum tendered by the appointed contractors was €239,000 ex. VAT and the actual final account is balancing generally close to the tendered sum. The same figure, as calculated by the Unit Cost database, was €206,600. In general, when comparing the tendered

sums and the total costs calculated by the Unit Cost database, there is an acceptable level of agreement. This is despite large variations in some areas. For example, the appointed Contractor priced the installation of the new culvert at €19,700, significantly less than the tool at €29,700.

The spreadsheet tool lacked the ability in this instance to account for the construction of a new off-line manhole, nor the construction of a new permanent cycle-track. Thus, whilst there are many nuances and project-specific tasks that cannot be accounted for in the spreadsheets that would explain any differences in cost estimations, the overall costs seem to predict the costs well in this instance.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €451,639. This an overly conservative figure compared to the tendered sum in this instance.

6.4 Rolestown Minor Works Flood Scheme

The site is a small development consisting of three properties and is bounded by the R125 to the north and the Rolestown Stream to the east, south and west. The Rolestown Stream diverges at the southern boundary of the site and is an artificial watercourse that has been diverted to supply a mill in the village. The proposed works include:

- A concrete spillway
- Embankment stability works
- Western Channel culvert
- New embankment
- Eastern channel spillway wall
- East Channel culvert
- Relief Stream widened
- Spillway service and paving

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

• Total Capital Cost	€107,344
• Total O&M Cost (Annual)	€2,681
• Total Present Value Cost	€157,854
• Total PV Cost inc. Optimism Bias (40%)	€220,996

This scheme was also designed by JBA Consulting. The OPW constructed this scheme and provided cost estimates.

The actual costs for this projects were circa €105,840. In general, when comparing the build costs (€105,840) and the total costs calculated by the Unit Cost database (€107,344), there is an acceptable level of agreement. The optimism bias adjustment provides a more conservative estimate.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €220,996. This an overly conservative figure compared to the tendered sum in this instance.

6.5 Mornington Flood Relief Scheme

Historically, there has been a severe tidal flooding problem at the downstream end of the Mornington catchment near the Boyne Estuary. The completed works include;

- 1540m of flood protection wall
- 4600m of clay embankments
- Construction of a footbridge
- 48 sluice gates
- The underpinning of 2 bridges

- The culvert on the tributary
- Upsizing of minor culverts and the channel capacity increased
- Two minor pumping stations were constructed to alleviate internal drainage problems at the two worst affected areas
- A linear storage channel was installed at Tower Road.
- Where discharge outfalls are located at a level below that of the 1:100 year flood level flap valves were installed
- The number of surface water drainage outlets through the flood defence structures were be minimised by the connection of outlets to a main interceptor pipeline which would discharge at one point
- Temporary river gauge was installed on the Mornington River to help verify the hydrological analysis

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

• Total Capital Cost	€3,516,971
• Total O&M Cost (Annual)	€38,102
• Total Present Value Cost	€4,158,219
• Total PV Cost inc. Optimism Bias (40%)	€5,821,507

The OPW provided scheme and actual build cost details for this project. The estimated build cost of the project is circa €3,974,343

In summary, the cost to date is €3,974,343. The same figure, as calculated by the Unit Cost database, was €3,516,971 providing confidence in the unit costs used for such a complex scheme. Despite this similarity in total costs, there are many nuances and project-specific tasks that cannot be accounted for in the spreadsheets that explain some of the internal differences for certain asset types. For example, the spreadsheets cannot account for the drainage system in the project and a lack of information regarding the pumping stations, the storage channel and the culvert replacements.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €5,821,507. This an overly conservative figure compared to the final cost.

6.6 Clonmel Drainage Scheme

The Clonmel Drainage Scheme was designed to protect the town of Clonmel from flooding from the River Suir, the Whitening Stream and the Auk Streams. A number of works were included as part of the 3 projects including:

- Dredging and widening of the channel
- Construction of a town bypass channel
- Upstream storage
- A channel bypass around Dudley's Mills
- A fully defended urban area
- Replace masonry arch bridges at Old Bridge
- Demountable barriers
- Embankments
- Sheet piled walls
- Rock ramp fish-pass

The results of the analyses, as tabulated on the Whole Life Cost Tool spreadsheet, are summarised below:

• Total Capital Cost	€32,232,000
• Total O&M Cost (Annual)	€253,105
• Total Present Value Cost	€30,922,308
• Total PV Cost inc. Optimism Bias (45%)	€44,938,846

The OPW provided scheme and actual build cost details for this project. The estimated build cost of the project is circa €40,000,000

In general, when comparing the final cost of the project and the costs calculated by the Unit Cost Database, there is an acceptable level of agreement with an inclusion of the optimism bias. The estimated cost of the project is €40,000,000. The same figure, as calculated by the Unit Cost database, was €32,232,000.

There are many nuances and project-specific tasks that cannot be accounted for in the spreadsheets that would explain any differences in estimations. For example, the spreadsheets cannot account for the drainage system in the project. Given this and the lack of information for the 3 bridges that were replaced, this explains the key reasons for the price from the database is considerably lower.

One must also remember that upon application of the Optimism Bias, the total cost of the project becomes €44,938,846. This a conservative figure compared to the final cost. Therefore, any decision with regards to project approval would be made using this figure rather than the €32,232,000 total. This demonstrates the importance of the application of the optimism bias.

6.7 Summary of calibration

The above calibration sites cover a wide range of flood protection measures included within the CFRAM unit cost project and a range of project types and spatial extents. Overall the costs derived adequately match the out-turn costs. One of the case studies underestimates the out-turn costs, but are within the optimism bias allowance for all examples, whereas the other three projects derive a similar capital cost but the inclusion of optimism bias would appear to overly estimate total project costs. Despite these variations, a consistent approach is required for CFRAM projects and the need to assess optimism bias as best as can be based on site knowledge and project requirements should be carefully considered.

7 Recommendations

7.1 Cost data and cost capture

This project has delivered cost estimates for a wide range of flood risk management methods and factors. It should be seen as a starting point to inform the CFRAM process as well as a resource that needs to be maintained and kept up to date. Key to this is the updating of the database with new data as and when this becomes available.

The recording of cost information for capital and maintenance activities is essential to ensure that data is recorded in a way that the database can be added to and updated. This will necessitate requirements for the OPW and partners to record and report on cost information in a more detailed way than is currently undertaken. Enabling this and providing procedures to allow this will help to improve cost estimation in the future.

Some cost data uniform or repeated activities should be available to inform future updates, although substantial analysis may be required for other areas where costs are harder to separate out. The collation of this information will need to be consistent with benchmarking required to check information between regions.

It is hoped that this report and cost database forms the baseline for collation of future data and updating of outturn cost information. This could be achieved by initiating procedures to collate outturn costs at the asset level and through the provision of a pro-forma for the collection of future project costs. This would help to build up a longer term database of costs that could eventually be used to update and improve the costs derived as part of this study, for benchmarking future studies and to increase the range of factors and accuracy of cost information.

It may also be worth investigating additional cost factors excluded from this analysis such as regional cost variations.

8 Glossary

The following definitions in relation to cost estimation and useful terms referred to elsewhere in this guidance are provided for completeness below.

Appraisal period – the period over which costs and benefits are assessed. This period is defined by guidance from the OPW and is normally 100 years for capital assessments.

Benefit-Cost Analysis (BCA) - Analysis that seeks to quantify all of the costs and benefits of a proposed scheme in monetary terms, including items for which the market does not provide a satisfactory monetary value. Sometimes referred to as Cost-Benefit Analysis.

Benefit-Cost Ratio (BCR) - A ratio of the present benefits and costs of an option, calculated as the total benefits divided by the total costs. A BCR of >1 indicates benefits are greater than costs.

Capital costs - Costs incurred during detailed planning, design and construction of an asset or service. Also referred to as Capital Expenditure (CAPEX).

Cost-Effectiveness Analysis (CEA) - Analysis that compares the costs of alternative ways of producing the same or similar outputs.

Design life – The design life of a new structure or structural component under normal loading and environmental conditions before replacement or major rehabilitation is expected.

Discounting - The conversion of future costs or benefits to present values using a discount rate. It is often necessary to compare options that will impact over a period of years into the future, which raises the question of how future cost and benefits should be valued in today's terms. Normally people prefer to receive cash sooner rather than later, and pay bills later rather than sooner. This is true even after allowing for inflation. For an individual this time preference may be indicated by the real interest rate on money lent or borrowed. In the public sector, likewise, we reflect social time preference by giving more weight to earlier than to later costs and benefits. This process of “discounting” is usually given effect by applying a “discount rate” to future costs and benefits.

Discount Rate - The annual percentage rate at which the present value of a future Euro, or other unit of account, is assumed to fall away through time. It is currently set at 4% pa in real terms. Mathematically, a discount rate is the opposite of a compound interest rate. The discount rate defines how rapidly the value today of a future Euro declines through time in real terms, just as a real rate of interest determines how fast the real value of a Euro invested now will increase over time.

Enabling costs - Costs those incurred between the decision to proceed with the procurement and the construction of the asset. Some of these may represent sunk costs depending on the point of appraisal within the whole life cost process.

End life costs - Costs associated with the disposal, decommissioning, termination or replacement of the asset or service. These costs can be split between replacement/refurbishment costs (where an assets standard of service is not altered) or change works (where the intention is to alter the standard of service of an asset).

Expenditure budgets - longer term revenue costs outside capital expenditure budgets.

Frequent maintenance – Activities that maintain current defence standards by reducing the rate of deterioration. Frequent maintenance provides for efficient, effective and safe operation in a cost-effective manner. It normally includes annual costs associated with planned proactive activities.

Intermittent maintenance – Infrequent and one-off activities that cover infrequent planned and recurring activities required within an assets design life.

Maintenance – Work that sustains the desired condition and intended performance of an asset. In some circumstances maintenance may accept a gradual decline in standard. For existing assets that have no residual life, maintenance may not result in an acceptable Standard of Service and only refurbishment or replacement will reinstate an acceptable Standard of Service.

Net Present Value (NPV) - The discounted value of a range of costs and benefits. Calculated as the PV benefits minus the PV costs. NPV is used to describe the difference between the

present value of costs and benefits in future years. NPV is a primary investment decision criterion. NPV is defined as the difference between the present value of a stream of benefits and that of a stream of costs. A positive NPV occurs when the sum of the discounted benefits exceeds the sum of the discounted costs. A negative NPV is usually called a Net Present Cost (NPC). The decision rule is to select the option that offers to maximise NPV, or minimise NPC. This is subject to assessment of those impacts that cannot be valued in money terms. NPV takes account not only of social time preference through discounting, but also, by combining capital and recurrent cost and benefits into a single present day value indicator, enables direct comparison of options with very different patterns of costs and benefits over time.

Operational costs - The costs incurred through the day-to-day management of an operation, and maintenance of an asset or a scheme. (Also known as revenue costs or Operational Expenditure - OPEX). See also Expenditure Budgets.

Optimism Bias - The demonstrated systematic tendency for appraisers to be over-optimistic about key project parameters, including capital costs, operating costs, works duration and benefits delivery.

Present Value - The present day value of a future stream of costs or benefits. Calculated by discounting a stream of future costs or benefits. (See also Net Present Value, Discount Rate).

Price Index - A measure of the amount by which prices change over time. General price indices cover a wide range of prices and include the Consumer Price Index (CPI) and the Retail Price Index (RPI).

Residual life – Residual life is the time until assets need replacing. Residual life can be extended or reduced by altering maintenance practices. The point at which the asset requires replacement may be estimated by a condition grade or performance measures that reflect an unacceptable Standard of Service.

Risk Register / Risk log - A useful tool to identify, quantify and value the risks and uncertainties relating to a proposal.

Sensitivity Analysis - Analysis of the effects on an appraisal outcome of varying the projected values of important variables.

Sunk Costs - Expenditures that have already been incurred on goods and services, or resources that are already irrevocably committed. These costs should be ignored in an appraisal. Sunk costs may include items such as previous investment in defences and expenditure on feasibility studies.

Unit rates - The cost per unit measure (number/length/area/volume) to replace an asset or part of an asset.

Whole life cost – The total cost of managing an asset over the design life of the asset. This will include the full cost of construction, use, maintenance and replacement/decommission. All reasonably foreseeable costs over the whole life period should be included.

A Example costs

A.1 Single asset whole life cost example

A.1.1 Example of option

A single pumping station is proposed in an urban area to pump water backing up within a small watercourse over an existing embankment in a tidal location when water levels are high. The pump capacity required from modelling is 2m³/s.

A.1.2 Capital costs

Based on the unit rate cost curve provided the anticipated capital costs are €1,620,000. Due to the urban location, existing services and construction through the embankment a method factor of 1.2 is recommended by the appraiser as an uplift to the basic unit cost.

An estimate of preliminaries of 16% is assumed.

Other costs for the replacement of the embankment for a 2m height and 40m length is also assumed at a unit rate of €301/m.

Based on the above a total capital cost of €2,269,500 is assumed.

A.1.3 O&M and other costs

Standard unit rates for operation and maintenance and running costs are applied.

Other costs assume a 25 year pumping station replacement cost of €900,000.

Figure A-1: Example of cost inputs

Project reference	Example 1	Project name:	Example Project Name x
Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	1.000
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.20

This sheet should only be used when assessing single method options as double counting may occur when method costs are added.							
Single Method Capital Cost Tool							
	1	2	3	4	5	6	Comment/justification
Pumping Station ref/type	Ref 1						
Pumping Station number	1						Single 2m ³ /s pump
Pumping Station unit rate	1620000						Rate based on existing cost curve
Total costs						€1,620,000	
Apply update to unit rate (CPI) if appropriate (cell N15)						€1,620,000	
Enter appropriate preliminaries estimate (%)						16%	
Enter other applicable costs (€)						12040	Embankment replacement
Total capital cost (€)						€1,891,240	
Consider amendments based on site issues/constraints (cell N16)						€2,269,488	Urban site with existing services
Total capital cost (€)						€2,269,488	
Operation and Maintenance Cost Tool							
Total annual O&M costs						€10,600	Basic cost from cost curve
Total annual running costs						€18,600	Basic cost from cost curve
Other costs							
Other costs (user defined - consider the need for additional longer term or intermittent costs)						€900,000	Refurbishment costs at year 25

A.1.4 Whole life cost assumptions

Enabling costs assume £100,000 for additional design, consultant, administration and land consultation fees that have not been included within the capital costs and are not yet been incurred as part of the CFRAM process.

The year of capital works is assumed to be year 1, with enabling costs in year 0.

Other works (refurbishment costs) are assumed at a 25 year interval.

The total PVc is assumed to be €3,202,000, exclusive of optimism bias.

Figure A-2: Example of present value cost inputs and calculations

Whole life cost and PVC analysis - for Pumping Station							
Enter applicable costs (enabling, capital and O&M)							
Enter year of capital works (all other costs start after this year)							
Enter 'other' costs and frequency (e.g. replacement costs) if applicable							
Enabling costs assume to start in year 0 (amend manually if required)							
Enabling cost (€) (if applicable, may be sunk cost)		£100,000.0					
Year of capital works (year)		1					
Capital cost (€)		£2,269,488.0					
Annual maintenance cost (€)		£29,200.0					
Other cost (€)		£900,000.0					
Other works frequency (years)		25					

A.2 Multiple asset whole life cost example

A.2.5 Example of option

The same option as above is assumed, although further investigation has indicated that the embankment is no longer suitable and a new embankment needs to be constructed. The required additional embankment is 3m in height for a length of 80m with a lower section of 2m in height for a length of 200m. Two headwall outlet structures (600mm) with flap valves are also required.

A.2.6 Capital costs

The pumping station costs are the same as in the previous example - €1,620,000. The embankment is made up the following unit costs:

- 80m with a unit rate of €539/m
- 200m with a unit rate of €516/m
- The appraiser also allows for a unit rate of €50/m for the removal of the existing embankment.

The total embankment cost is therefore €160,300.

The headwall structure with flap valves with a unit cost of €9,750 are taken from the sluice gate summary sheet.

The total costs for each asset are added to the portfolio tool to estimate total capital costs as shown below.

Figure A-3: Example of cost inputs

Project reference	Example 1	Project name:	Example Project Name x
Base date for estimates (year 0)	Oct-2013	Construction Price Index (CPI)	1.000
Scaling factor (e.g. €m, €k, €)	€	Method Factor - to take into account particular site issues /constraints	1.20

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods		
Combined Method Whole Life Cost Tool		
Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		
Capital costs	Cost (€)	Comment
Total wall costs		
Total embankment costs	160300	2 sections of embankment plus removal of existing
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs		
Total sluice gate costs	19500	2 600mm headwall structures with flap valves
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs	1620000	2m3/s pumping station
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€1,799,800	
Apply update to unit rate (CPI) if appropriate (cell N15)	€1,799,800	
Enter appropriate preliminaries estimate (%)	16%	Based on preliminaries cost curve
Enter other applicable costs (€)	0	None assumed
Total capital cost (€)	€2,087,768	
Consider amendments based on site issues/constraints (cell N16)	€2,505,322	Uplift for urban area and existing services
Total capital cost (€)	€2,505,322	

Due to the urban location and existing services a method factor of 1.2 is recommended by the appraiser as an uplift to the basic unit costs.

An estimate of preliminaries of 16% is assumed.

Based on the above a total capital cost of €2,505,300 is assumed.

A.2.7 O&M and other costs

O&M costs assume the following:

- Standard pumping station unit rates for O&M and running costs (€29,200 per annum)
- Other costs assume a 25 year pumping station replacement cost of €900,000
- Embankment O&M costs (€2,725/km, or €763 per annum)
- Sluice gate O&M costs of €2,700 per gate per annum

Figure A-4: Example of O&M cost inputs

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs		
Total embankment O&M costs	763	280m length of embankment
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs		
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs		
Total sluice gate O&M costs	5400	2 No. sluice gates in urban area
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs	29200	O&M and running costs
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€35,363	

A.2.8 Whole life cost assumptions

Enabling costs assume £120,000 for additional design, consultant, administration and land consultation fees that have not been included within the capital costs and are not yet been incurred as part of the CFRAM process.

The year of capital works is assumed to be year 1, with enabling costs in year 0.

Other works (refurbishment costs) are assumed at a 25 year interval.

The total PVc is assumed to be €3,574,000, exclusive of optimism bias.

Figure A-5: Example of present value cost inputs and calculations

Whole life cost and PVC analysis - for Whole Life Cost Tool							
Enter applicable costs (enabling, capital and O&M)							
Enter year of capital works (all other costs start after this year)							
Enter 'other' costs and frequency (e.g. replacement costs) if applicable							
Enabling costs assume to start in year 0 (amend manually if required)							
Enabling cost (€) (if applicable, may be sunk cost)		€120,000					
Year of capital works (year)		1					
Capital cost (€)		€2,505,321.6					
Annual maintenance cost (€)		€35,363.0					
Other cost (€)		€900,000.0					
Other works frequency (years)		25					

Key

Information

Calculation

Cost input

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVC (€k):		3574279
Cash sum		120000	2505322	1697424	900000	5222746	3574279
year	Discount Factor	Cost Elements				TOTALS:	
		Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	120000				120000.0	120000.0
1	0.962		2505322			2505321.6	2408963.1
2	0.925			35363		35363.0	32695.1
3	0.889			35363		35363.0	31437.6
4	0.855			35363		35363.0	30228.4
5	0.822			35363		35363.0	29065.8
6	0.790			35363		35363.0	27947.9
7	0.760			35363		35363.0	26873.0
8	0.731			35363		35363.0	25839.4
9	0.703			35363		35363.0	24845.6
10	0.676			35363		35363.0	23890.0
11	0.650			35363		35363.0	22971.1
12	0.625			35363		35363.0	22087.6
13	0.601			35363		35363.0	21238.1
14	0.577			35363		35363.0	20421.3
15	0.555			35363		35363.0	19635.8
16	0.534			35363		35363.0	18880.6
17	0.513			35363		35363.0	18154.4
18	0.494			35363		35363.0	17456.2
19	0.475			35363		35363.0	16784.8
20	0.456			35363		35363.0	16139.2
21	0.439			35363		35363.0	15518.5
22	0.422			35363		35363.0	14921.6
23	0.406			35363		35363.0	14347.7
24	0.390			35363		35363.0	13795.9
25	0.375			35363		35363.0	13265.3
26	0.361			35363	900000	935363.0	337375.4
27	0.347			35363		35363.0	12264.5
28	0.333			35363		35363.0	11792.8
29	0.321			35363		35363.0	11339.2
30	0.308			35363		35363.0	10903.1
31	0.296			35363		35363.0	10483.7
32	0.285			35363		35363.0	10080.5
33	0.274			35363		35363.0	9692.8
34	0.264			35363		35363.0	9320.0
35	0.253			35363		35363.0	8961.5
36	0.244			35363		35363.0	8616.9
37	0.234			35363		35363.0	8285.4
38	0.225			35363		35363.0	7966.8
39	0.217			35363		35363.0	7660.4
40	0.208			35363		35363.0	7365.7
41	0.200			35363		35363.0	7082.4
42	0.193			35363		35363.0	6810.0
43	0.185			35363		35363.0	6548.1
44	0.178			35363		35363.0	6296.3
45	0.171			35363		35363.0	6054.1
46	0.165			35363		35363.0	5821.2
47	0.158			35363		35363.0	5597.3
48	0.152			35363		35363.0	5382.1
49	0.146			35363		35363.0	5175.1

A.3 Optimism Bias example

Risks for the above project have been assessed and noted within the Optimism Bias calculator. For each risk component a risk value (from Very High to Very Low) has been defined with additional user remarks made. These are completely theoretical for this above case study but aim to give CFRAM consultants an indication of the level of detail required.

Based on the assumptions applied for each risk component an optimism bias of 46% is recommended for this scheme.

Figure A-6: Example Optimism Bias calculator

JBA consulting		DONNACHADH O'BRIEN & ASSOCIATES CONSULTING ENGINEERS		OPW The Office of Public Works Oifig na nOibreacha Poiblí	
CFRAM Unit Cost Development Project					
Optimism Bias Calculator					
Prepared by:	AEP	Date:	December 2013		
Site Reference:	Example 1	Site Name:	Example Project Name x		
Project risk components that influence total project cost	Weight 1-3 (3 being a higher weight)		Risk value (0-100%) 0% = no risk 100% = risk expected and not mitigated	User remarks/comments/justification	
Procurement					
Complexity of Contract Structure	1	High	70%	Contract structure unknown at present - high defined for this reason	
Late Contractor Involvement in Design	2	High	70%	Possible risk	
Poor Contractor Capabilities	1	Medium	50%	Pumping station design required experienced engineering and contract team	
Government Guidelines	1	Very Low	10%	Not anticipated to alter	
Dispute & Claims Occurred	3	Medium	50%	Too early to tell	
Information Management	1	Very Low	10%	Not anticipated to alter risk	
Budgeting	2	High	70%	Multiple schemes from CFRAM identified in area - budgeting risk	
Other	1	Medium	50%	No other risks identified	
Project Specific					
Design Complexity	2	High	70%	Complex design	
Degree of Innovation	2	Medium	50%	No complex innovation required at present	
Technology	2	Low	30%	Not anticipated to be a key risk	
Services	3	High	70%	Urban area - high risk	
Ground conditions	3	High	70%	Unknown at present - assume high risk until additional GI undertaken	
Other	1	Medium	50%	No other risks identified	
Client Specification					
Inadequacy of the Business Case	3	Medium	50%	Not anticipated at this time	
Large No. of Stakeholders	2	Medium	50%	Medium risk	
Funding Availability	2	High	70%	Multiple schemes from CFRAM identified in area - funding risk is high	
Project Management Team	1	High	70%	Large pumping station requires experience	
Poor Project Intelligence	2	Very High	90%	Additional surveys required to reduce this aspect	
Other	1	Medium	50%	No other risks identified	
Environment					
Public Relations	2	High	70%	Urban area	
Site Characteristics	2	High	70%	Urban area	
Environmental Impact	3	Medium	50%	Average risk	
Permits / Consents / Approvals	2	Medium	50%	CFRAM environmental scoping indicates possible risks with mitigation measures possible	
Amenity and art	1	High	70%	Urban area and large pump building required - amenity value needs to be considered	
Contaminated land	3	High	70%	Unknown - set at high until investigations can reduce this	
Archaeology	3	High	70%	Unknown - set at high until investigations can reduce this	
Other	1	Medium	50%	No other risks identified	
External Influences					
Political	3	Medium	50%	Unknown - set at medium risk for now	
Economic	2	Medium	50%	Unknown - set at medium risk for now	
Legislation / Regulations	1	Medium	50%	Unknown - set at medium risk for now	
Multiple river users / stakeholders	2	High	70%	Urban site with multiple interested parties	
Flood events during construction	3	High	70%	Yes - possible risk even with temporary works	
Other	1	Medium	50%	No other risks identified	
65		57%			
Weighting to apply:		0.592		Minimum Optimism Bias: 10% Maximum Optimism Bias: 70% Calculated Optimism bias: 46%	

Registered Office

**24 Grove Island
Corbally
Limerick
Ireland**

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e: info@jbaconsulting.com

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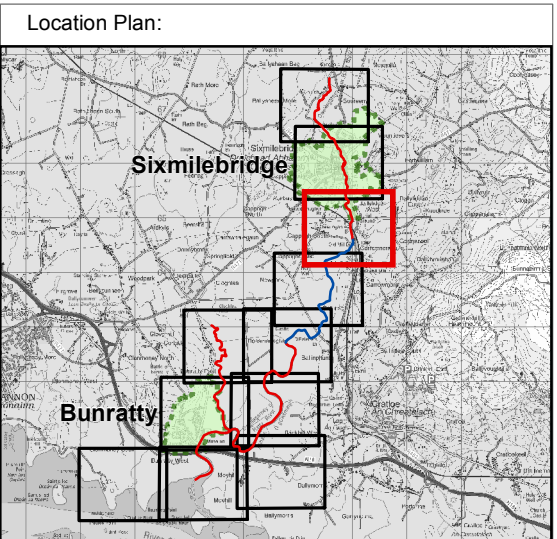
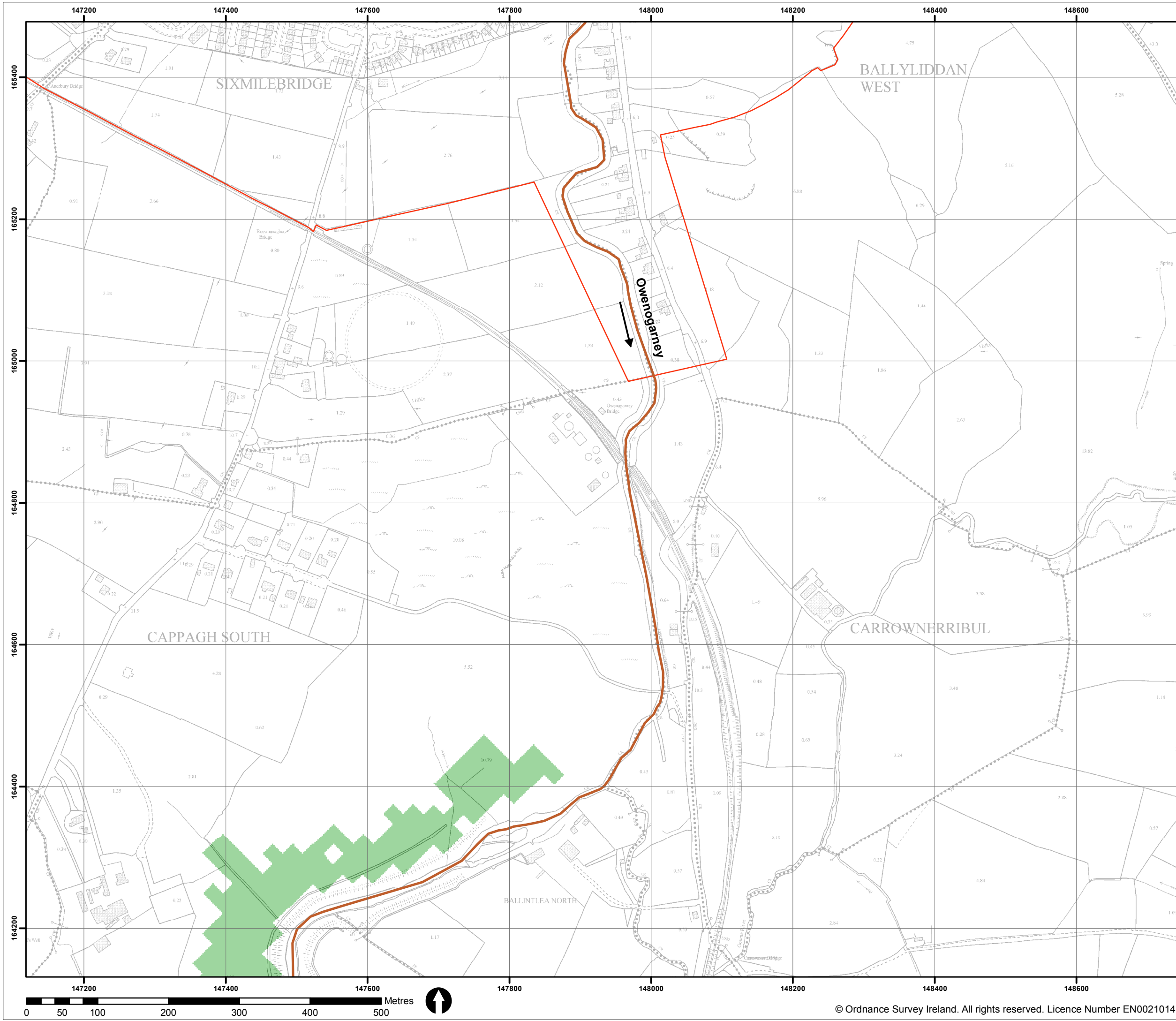
Registration number 444752



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Appendix I Flood Defence Asset Failure Maps





- Legend:**
- River Centreline
 - AFA Boundary
 - Defence - Embankment
 - Defence Failure Location
 - 5% AEP Coastal Failure Scenario 1

SOP = Standard of Protection

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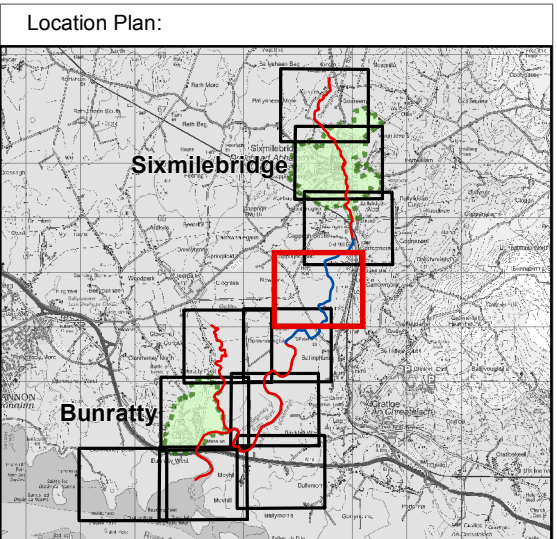
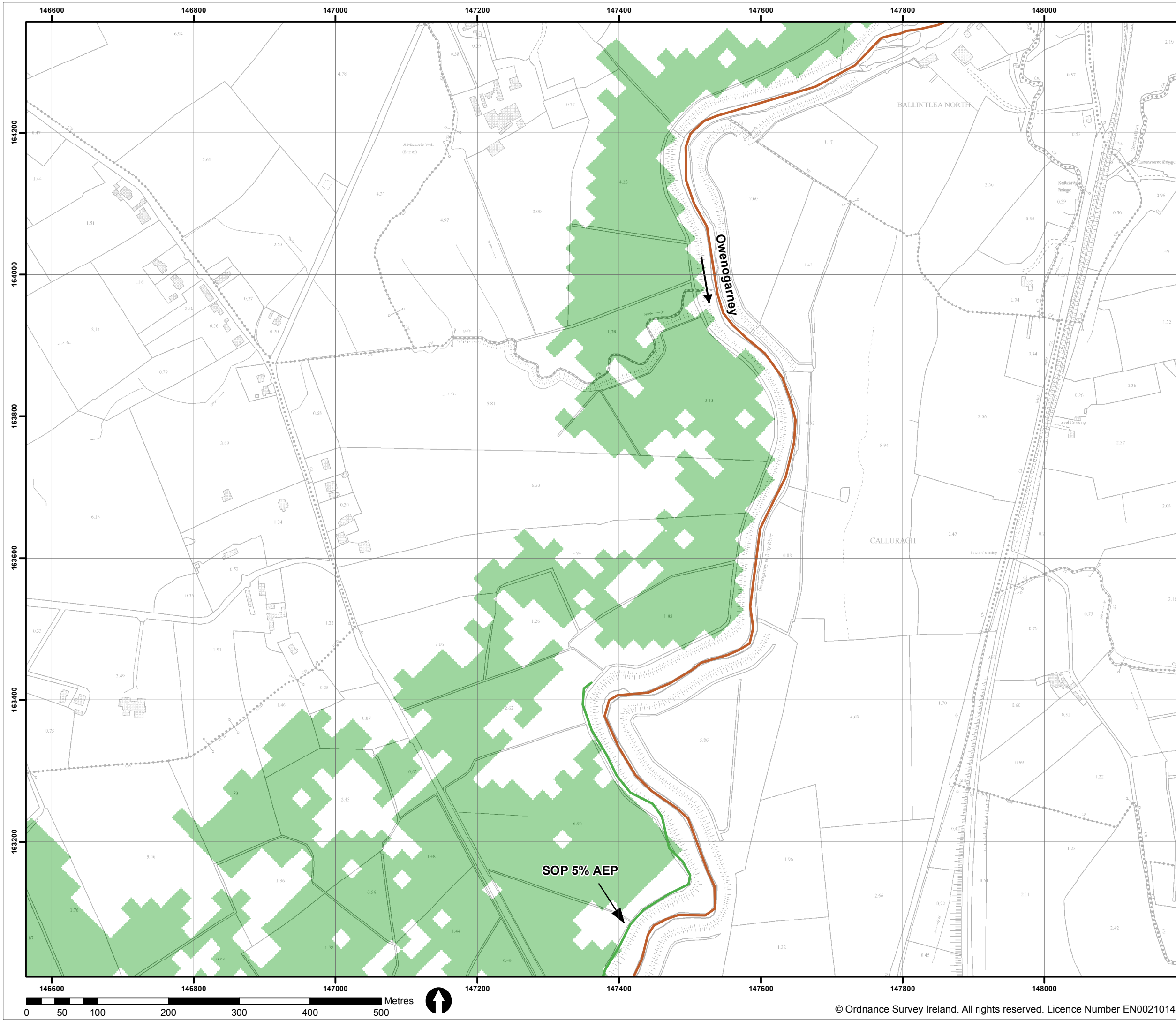


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Scenario:	EXISTING
Drawn by:	EH
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Checked by:	PT
Date:	November 2015
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Date:	November 2015
Approved by:	PS
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Map No.: S03FECCDC1	
Sheet:	3 of 11
Revision:	0
Map Scale:	1: 5000
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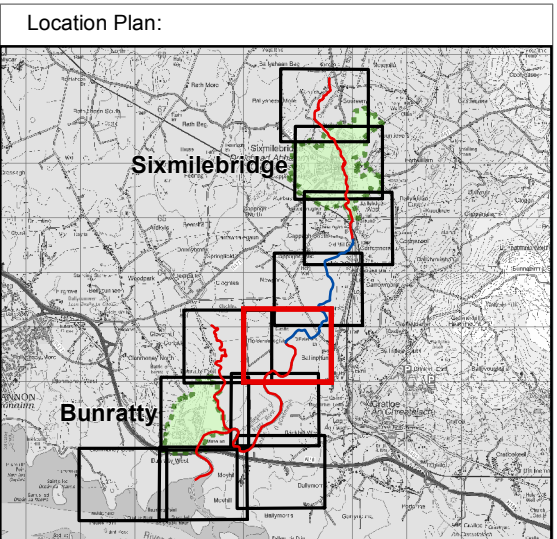
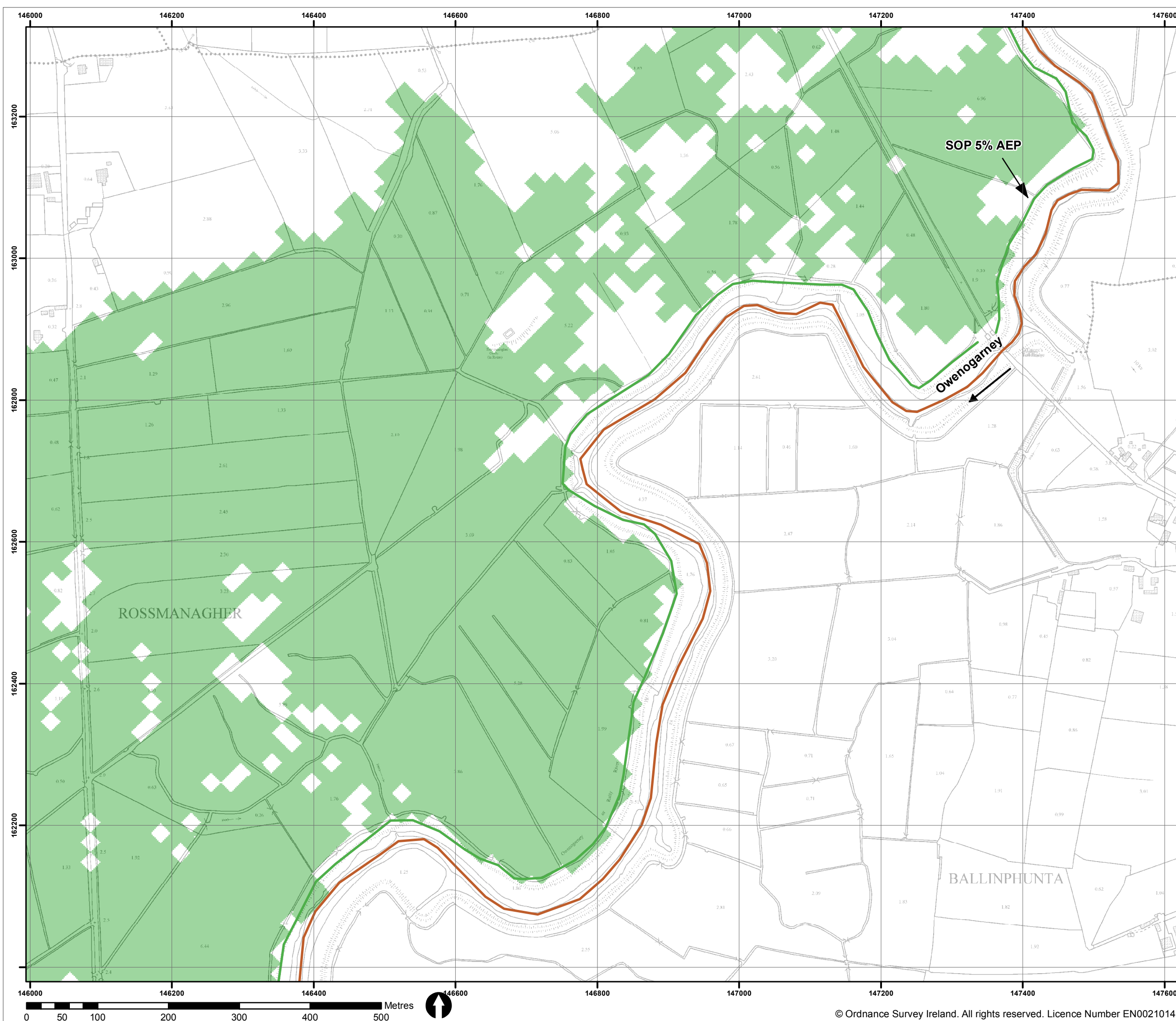


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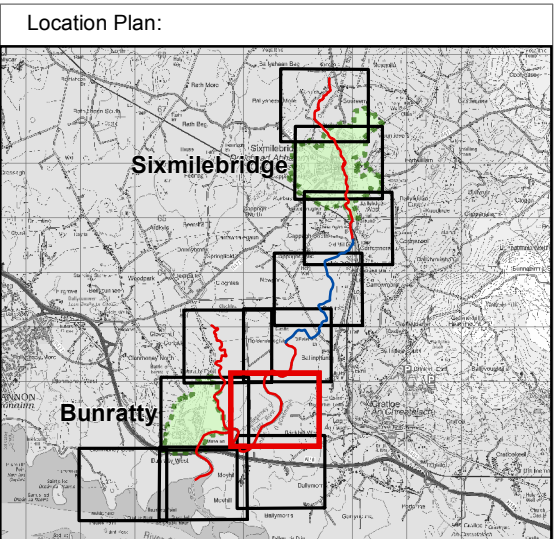
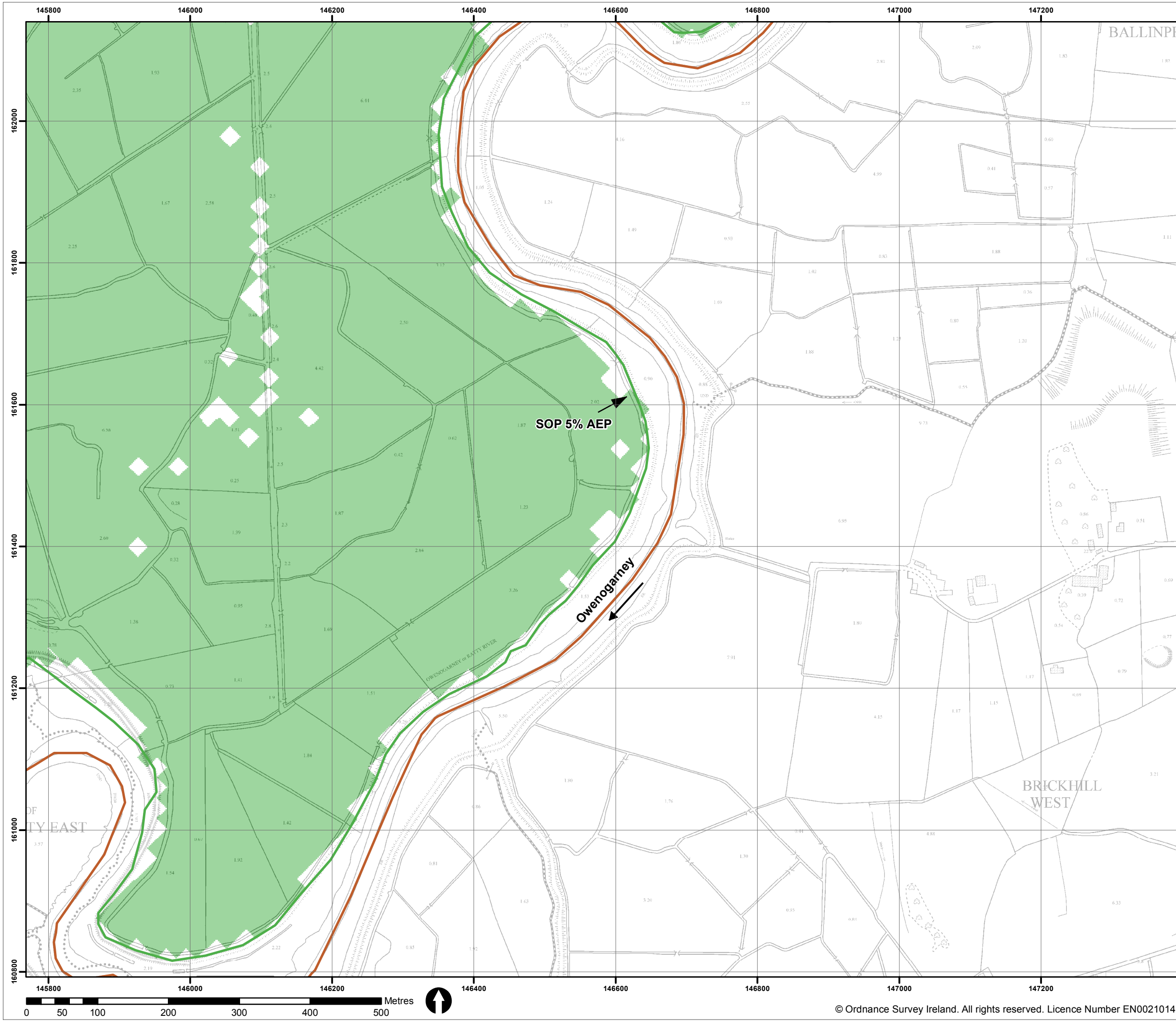


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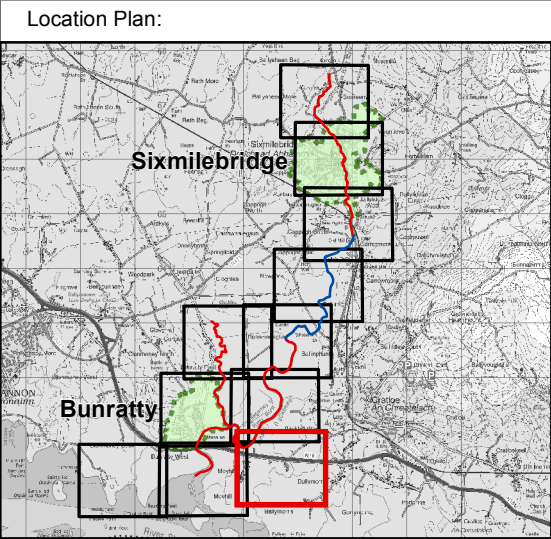


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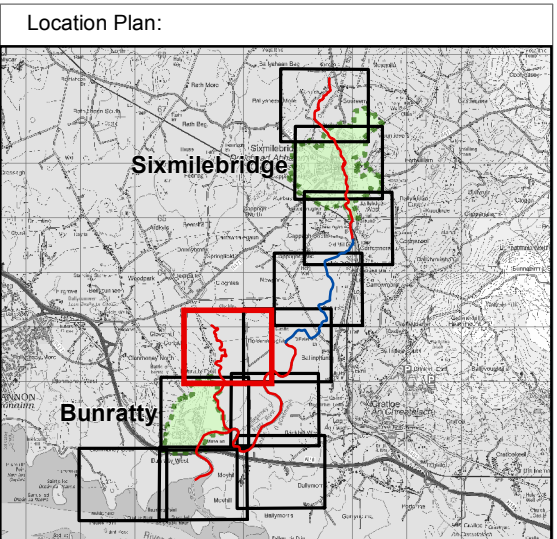
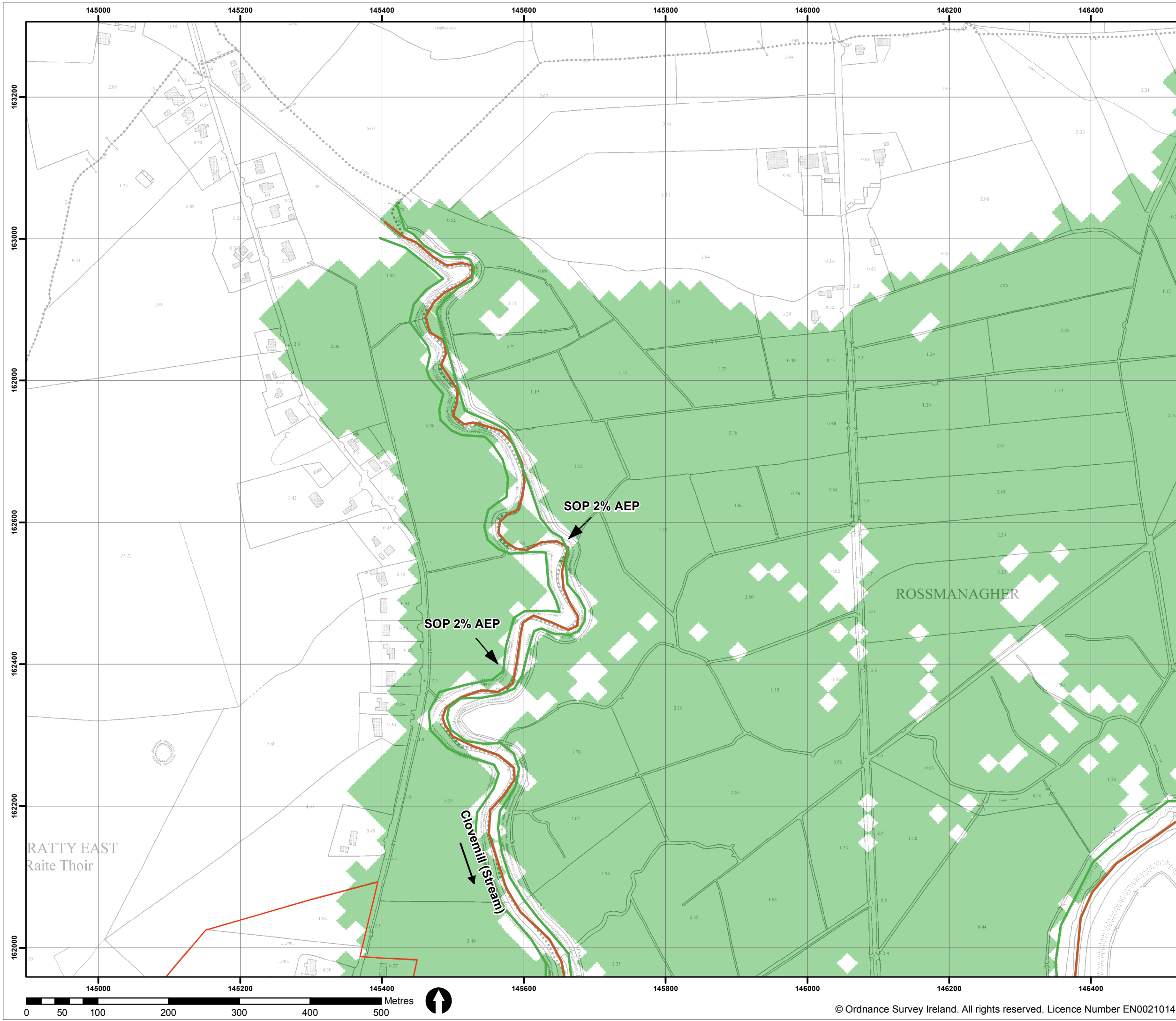


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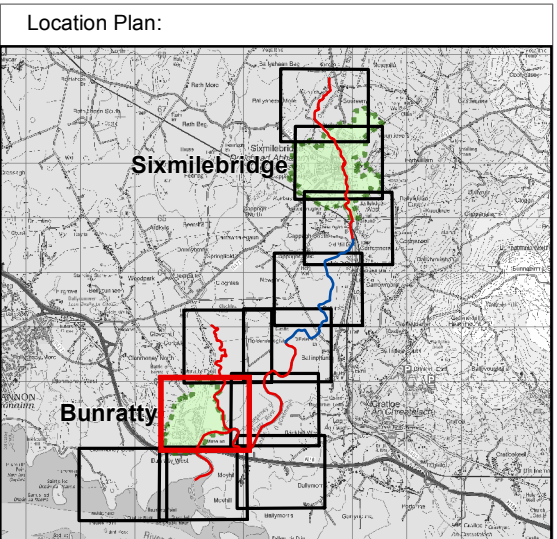
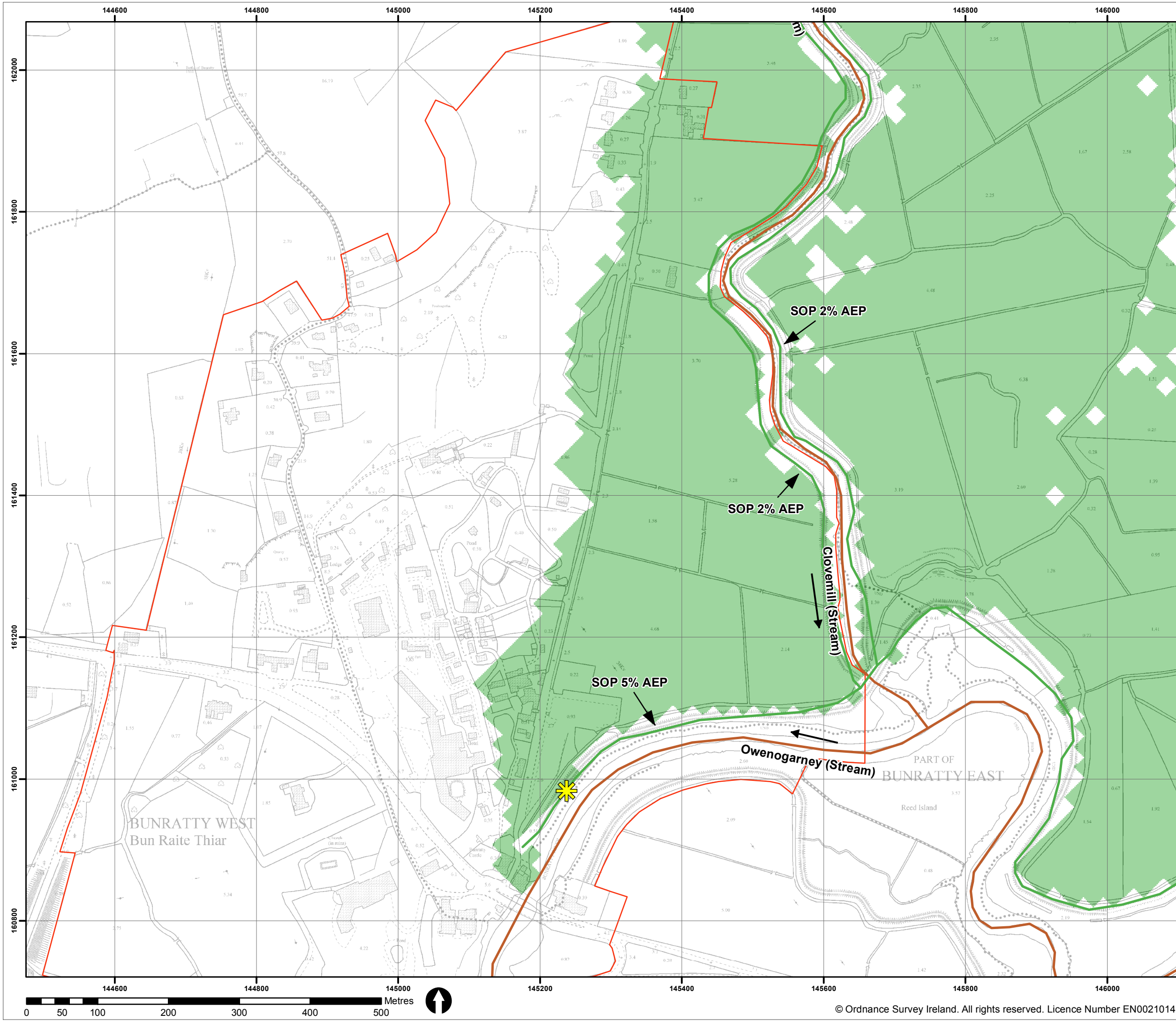


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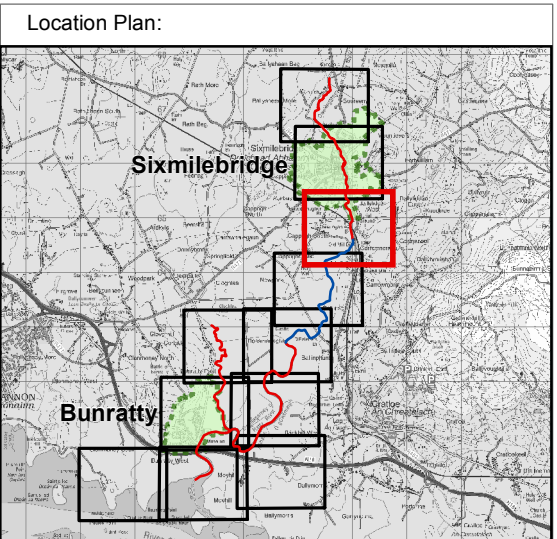
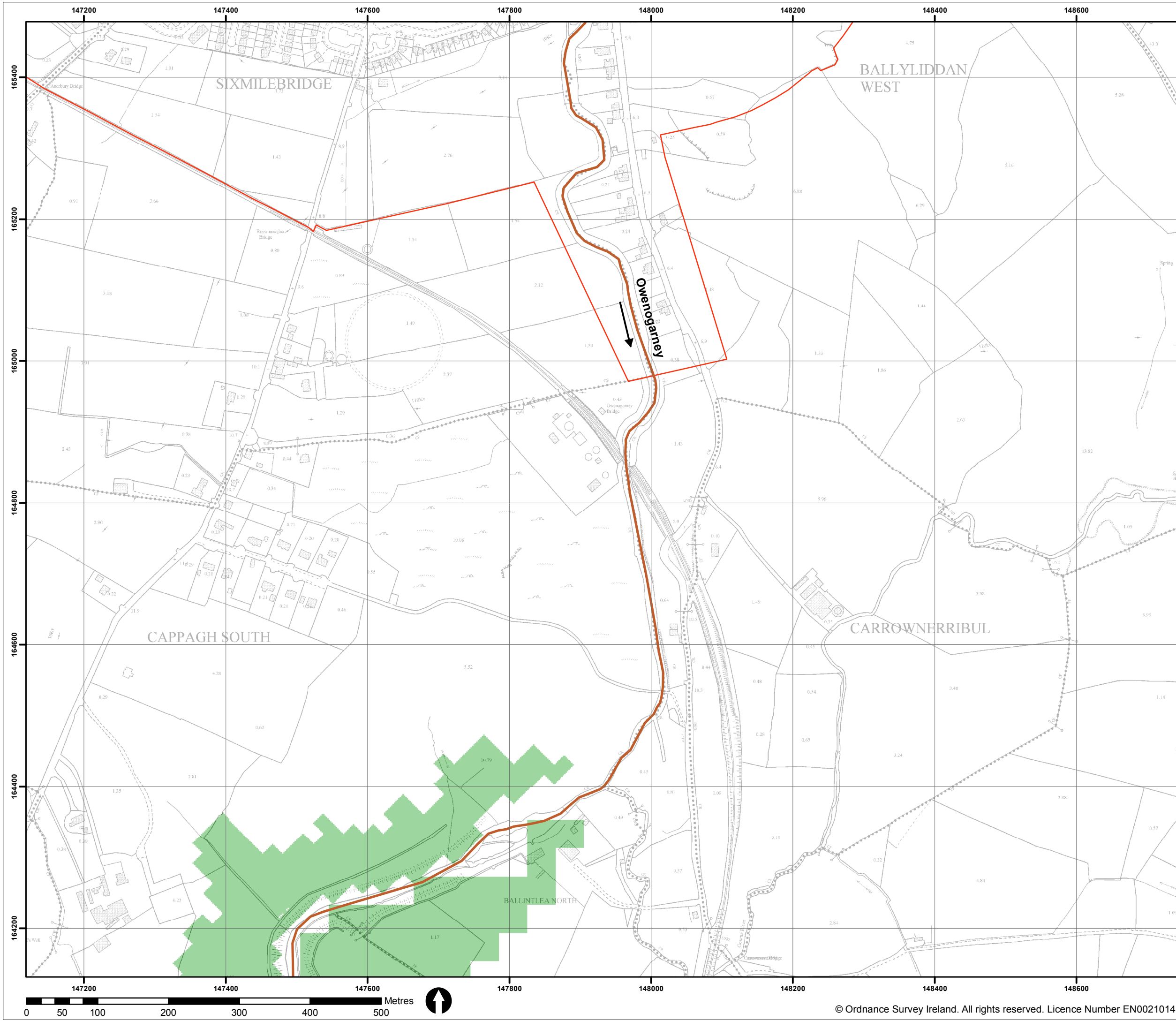


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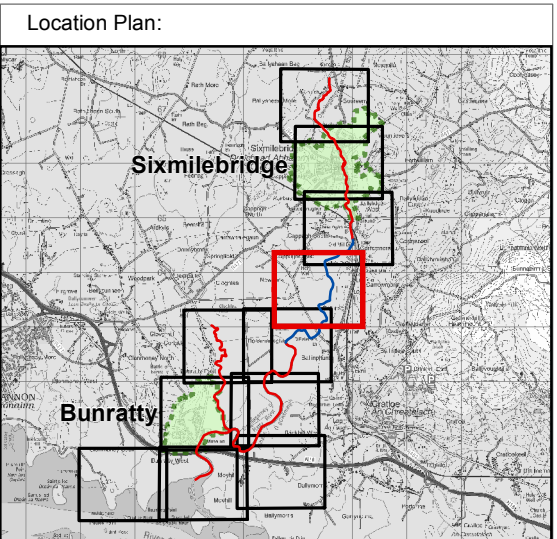
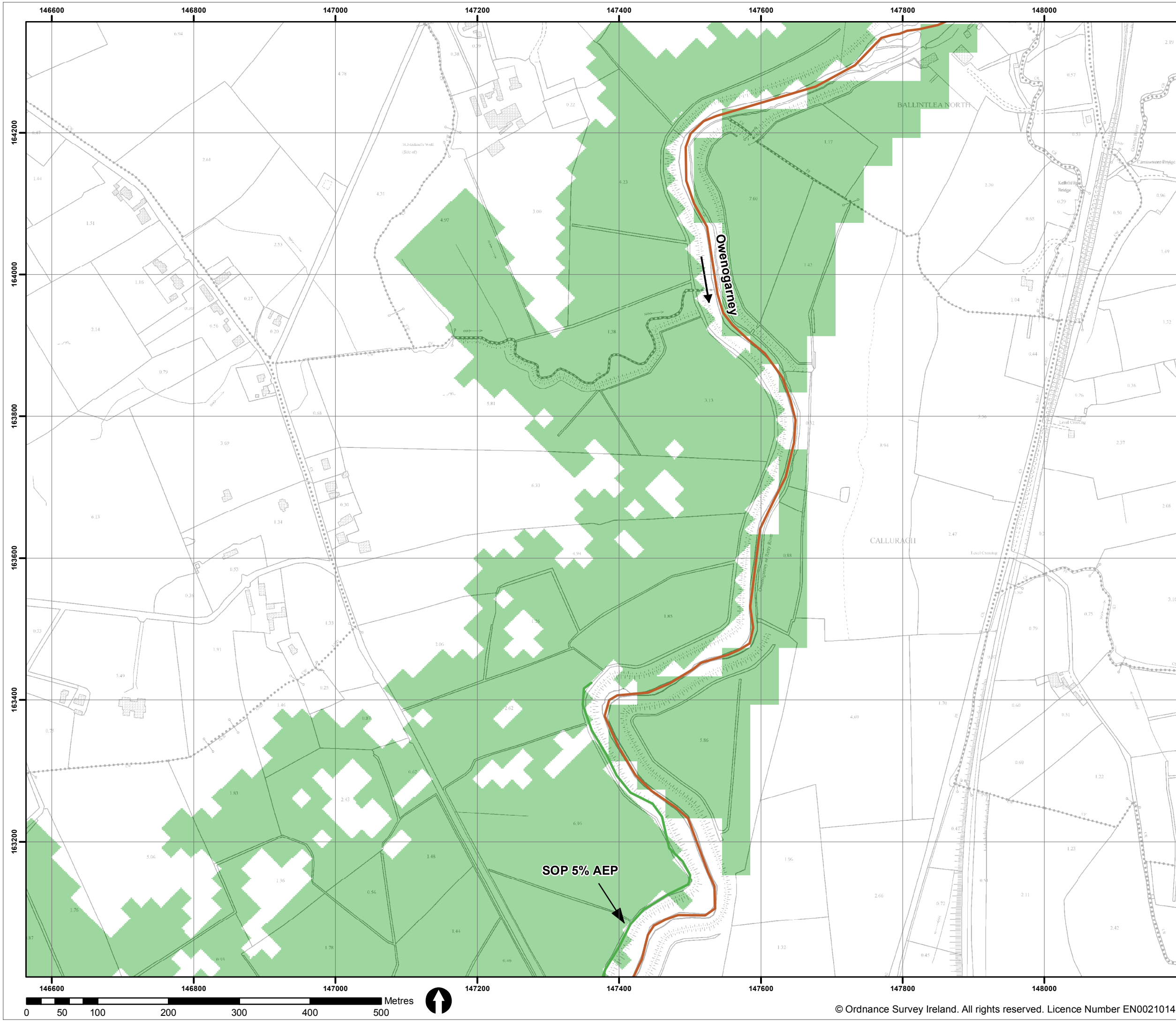


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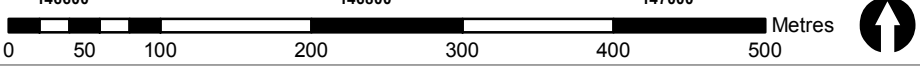


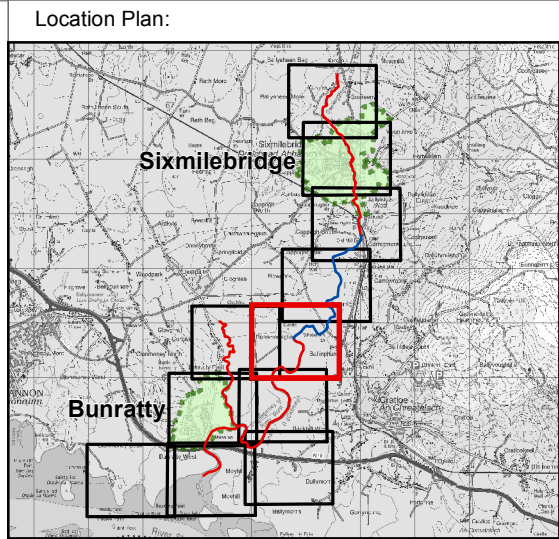
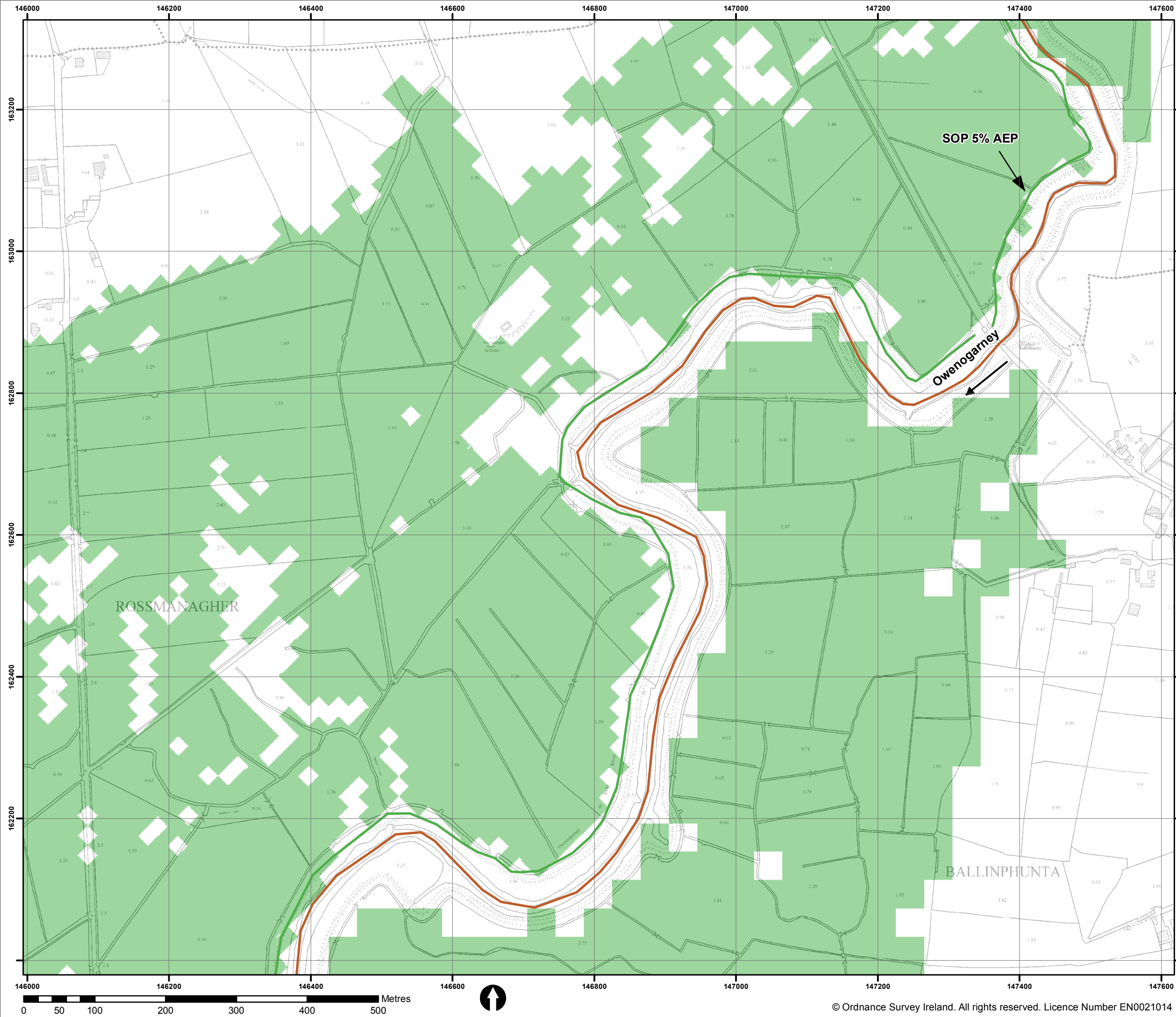
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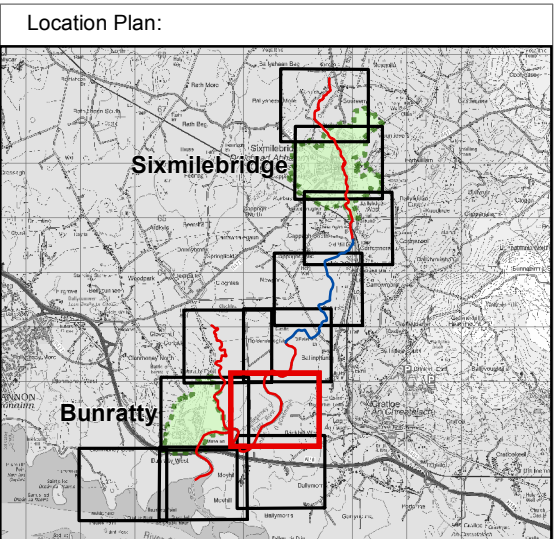
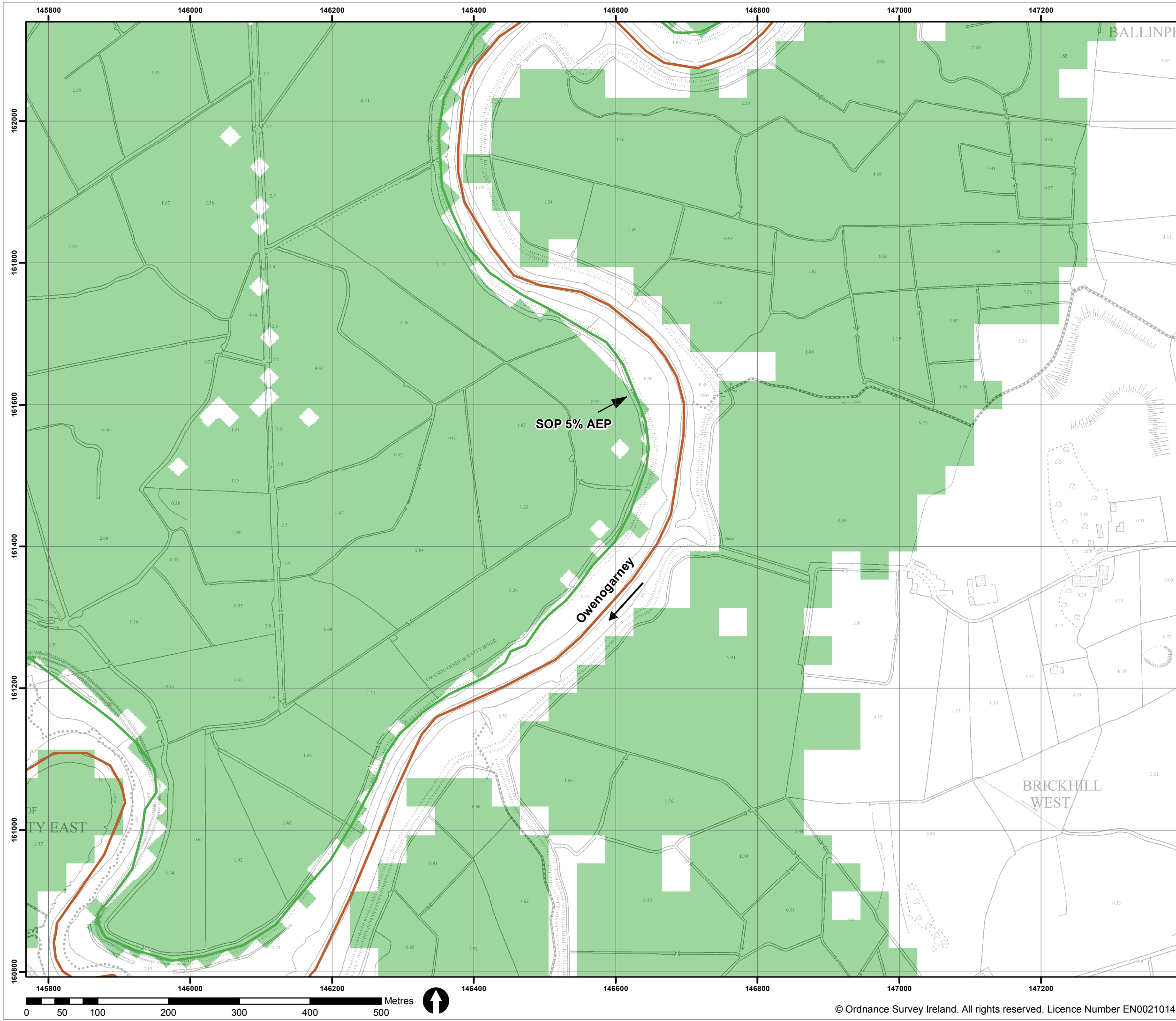


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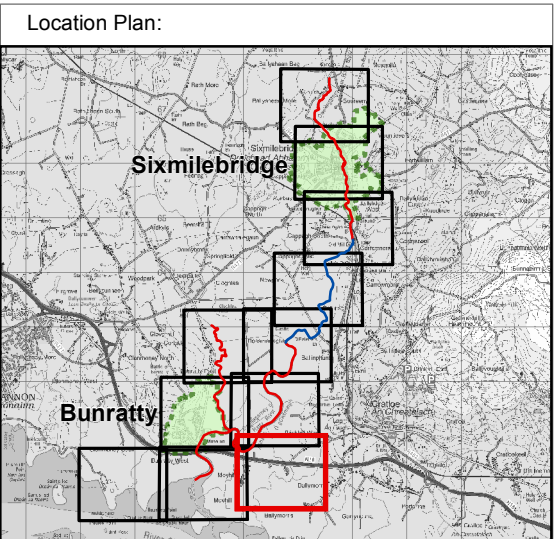
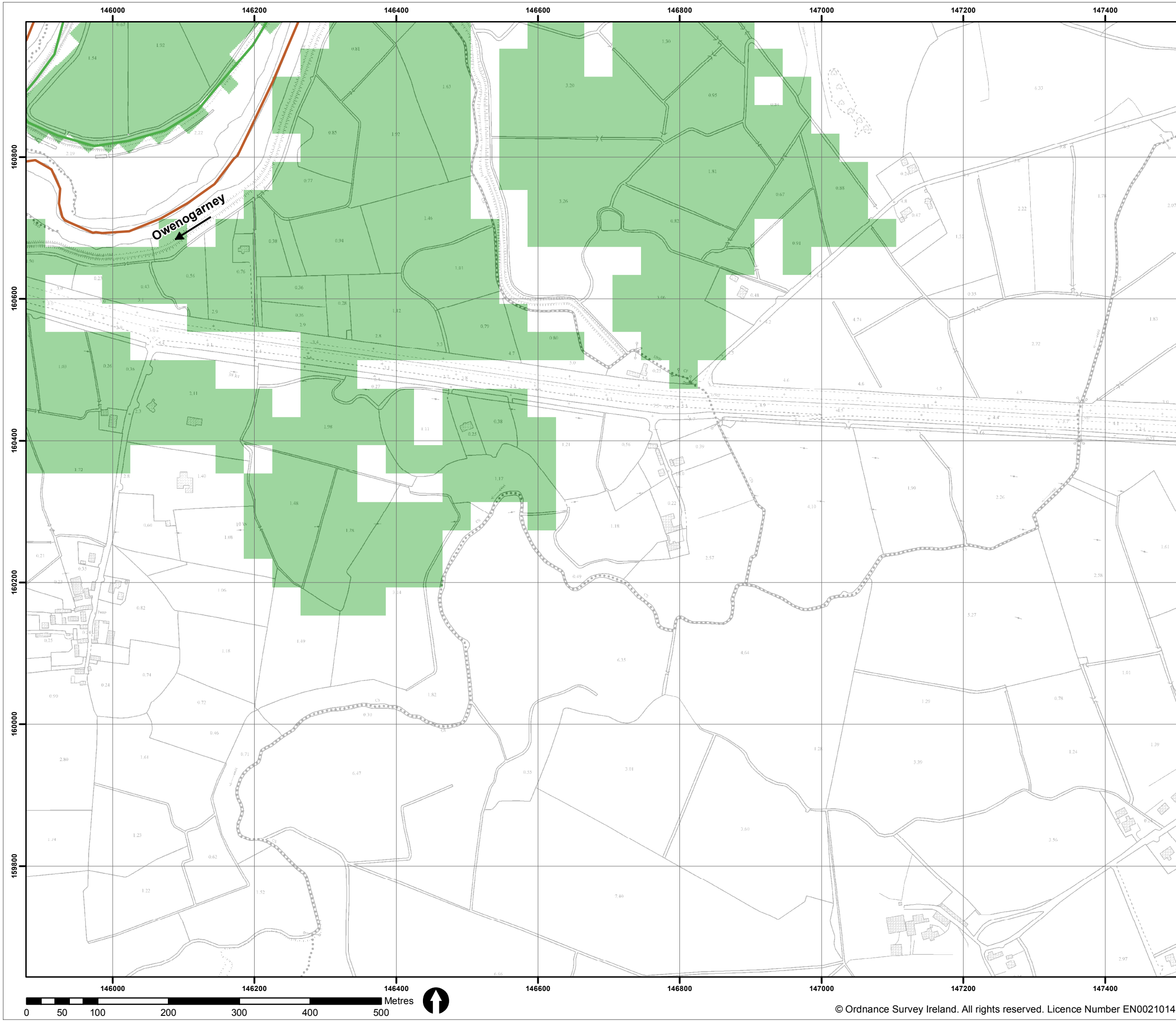


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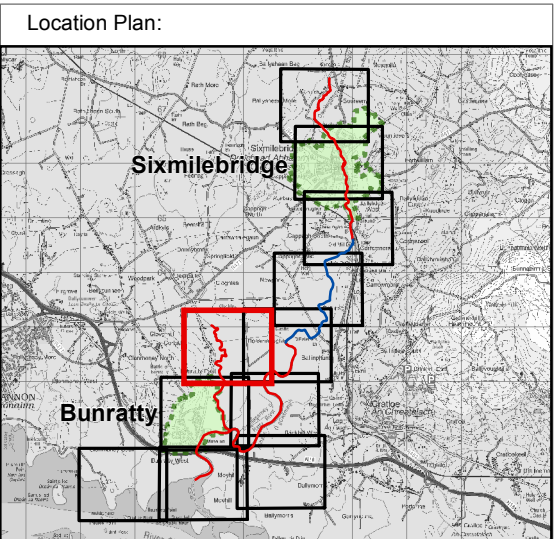
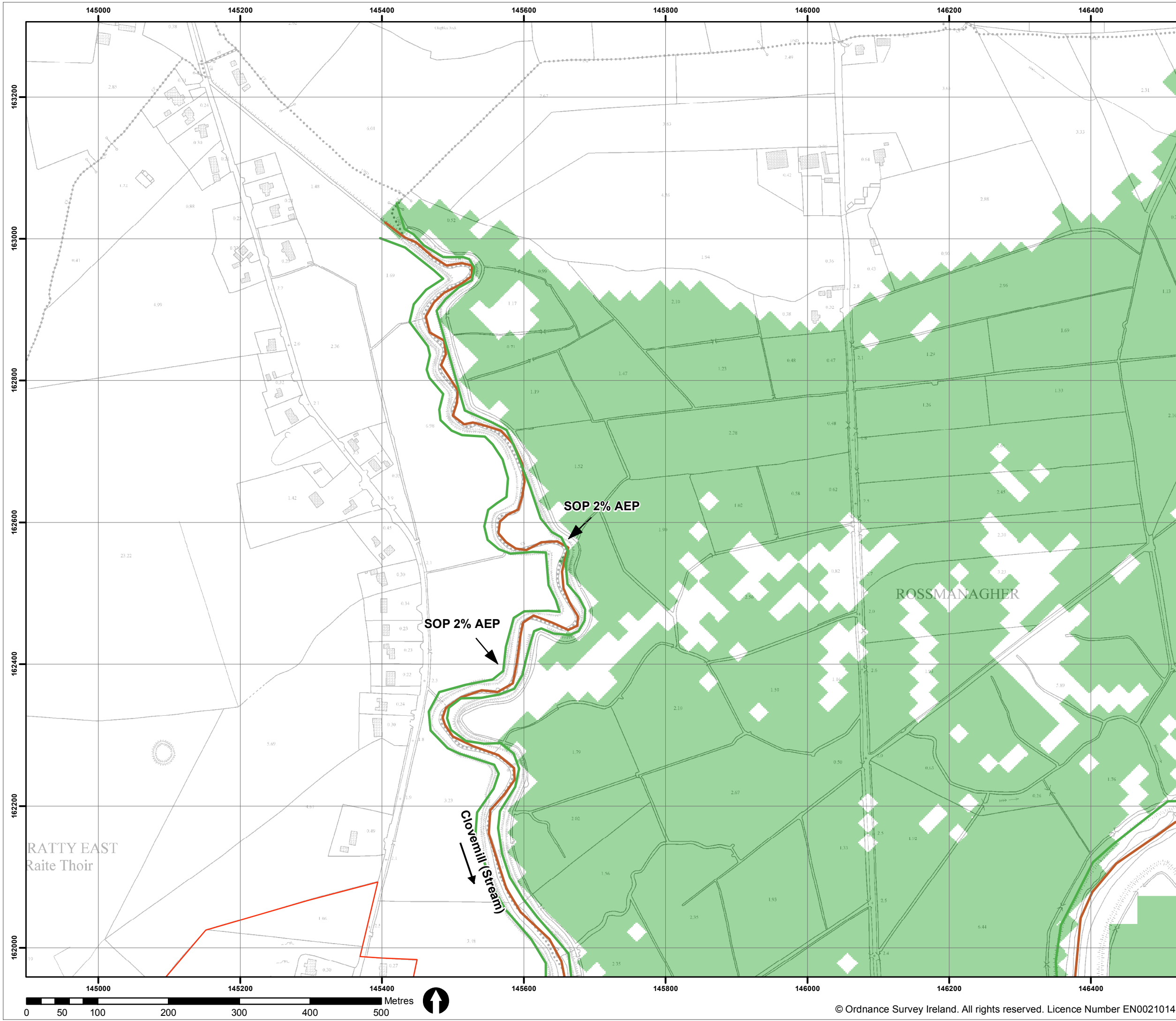


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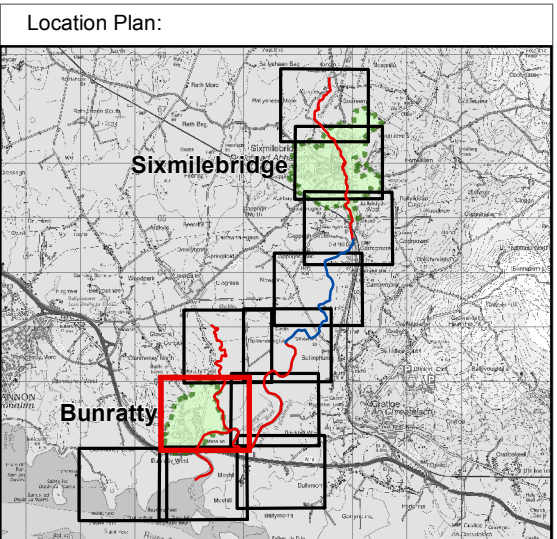
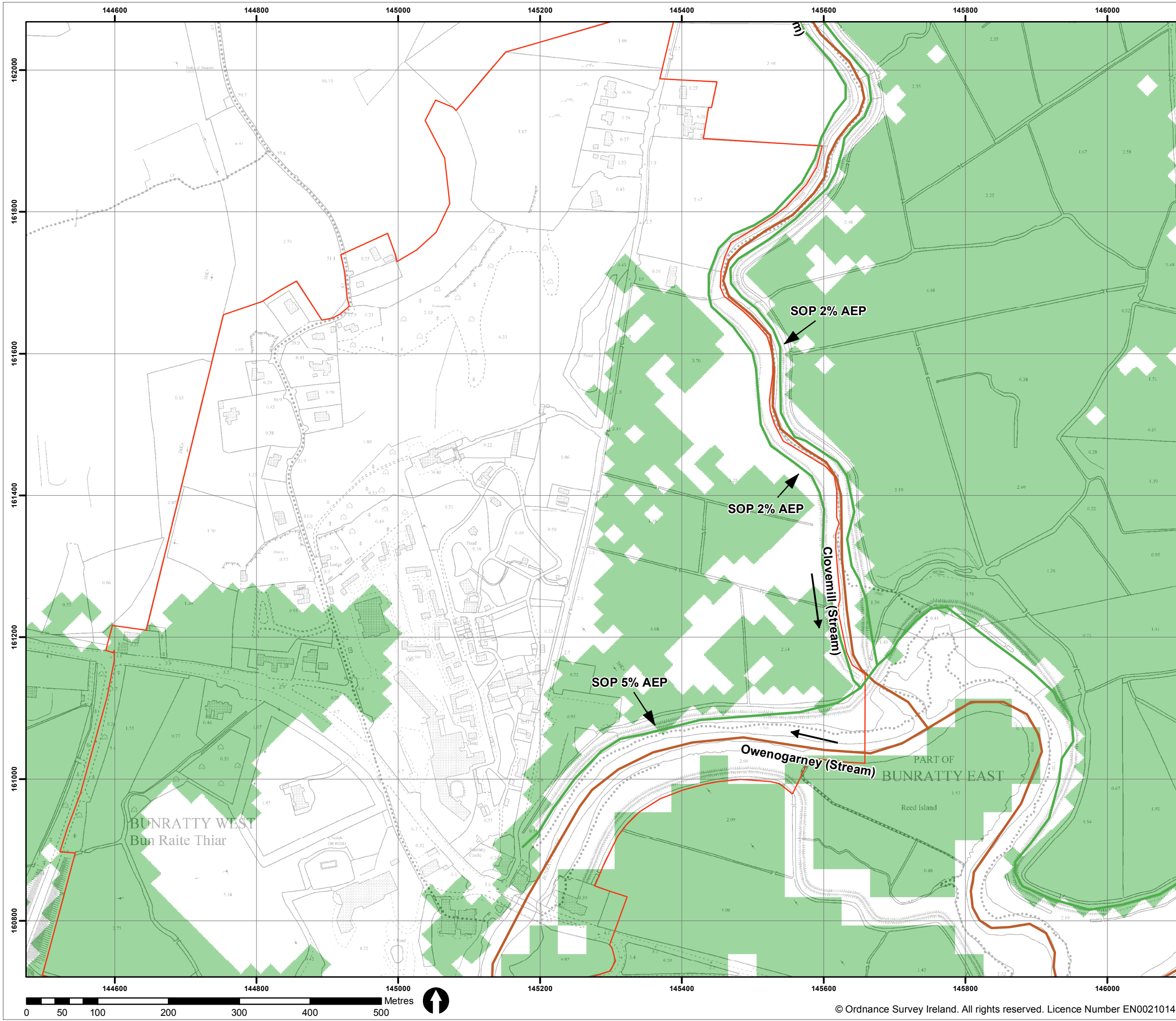


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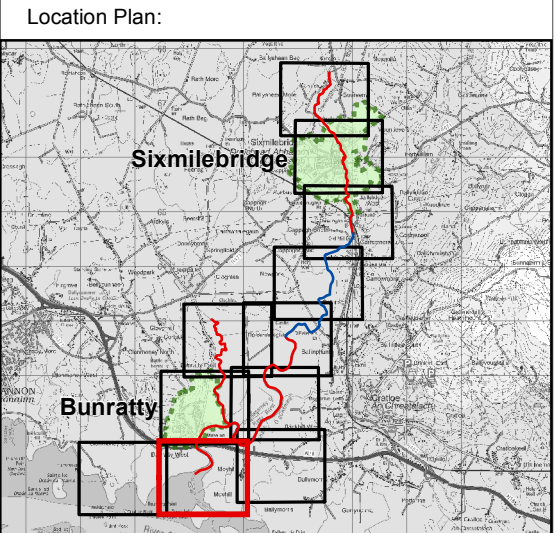
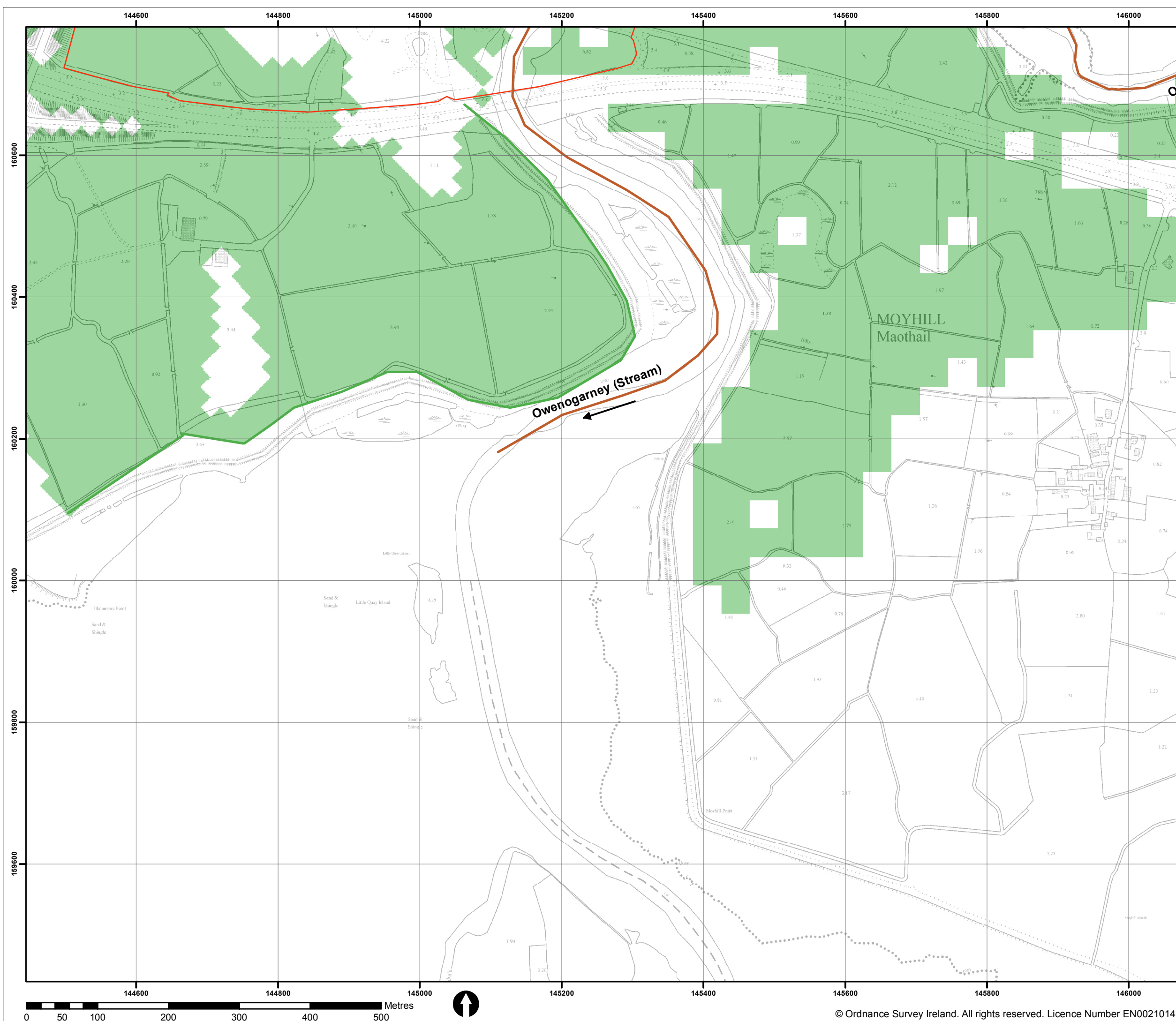


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- Legend:**
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 - AFA Boundary
 - Defence - Embankment
 - Defence Failure Location
 - 0.5% AEP Coastal Failure Scenario 2

SOP = Standard of Protection

IMPORTANT USER NOTE:

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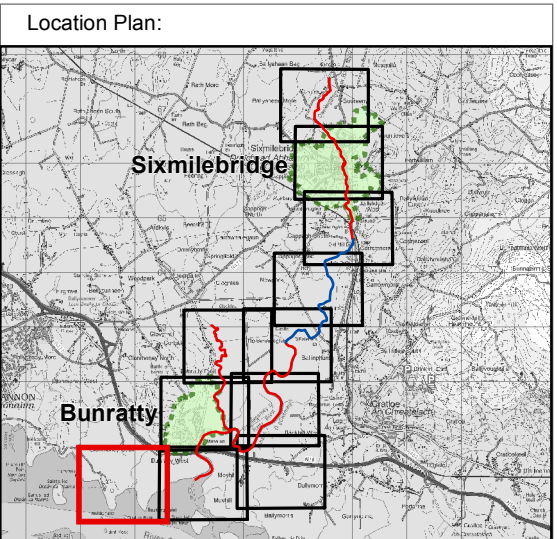
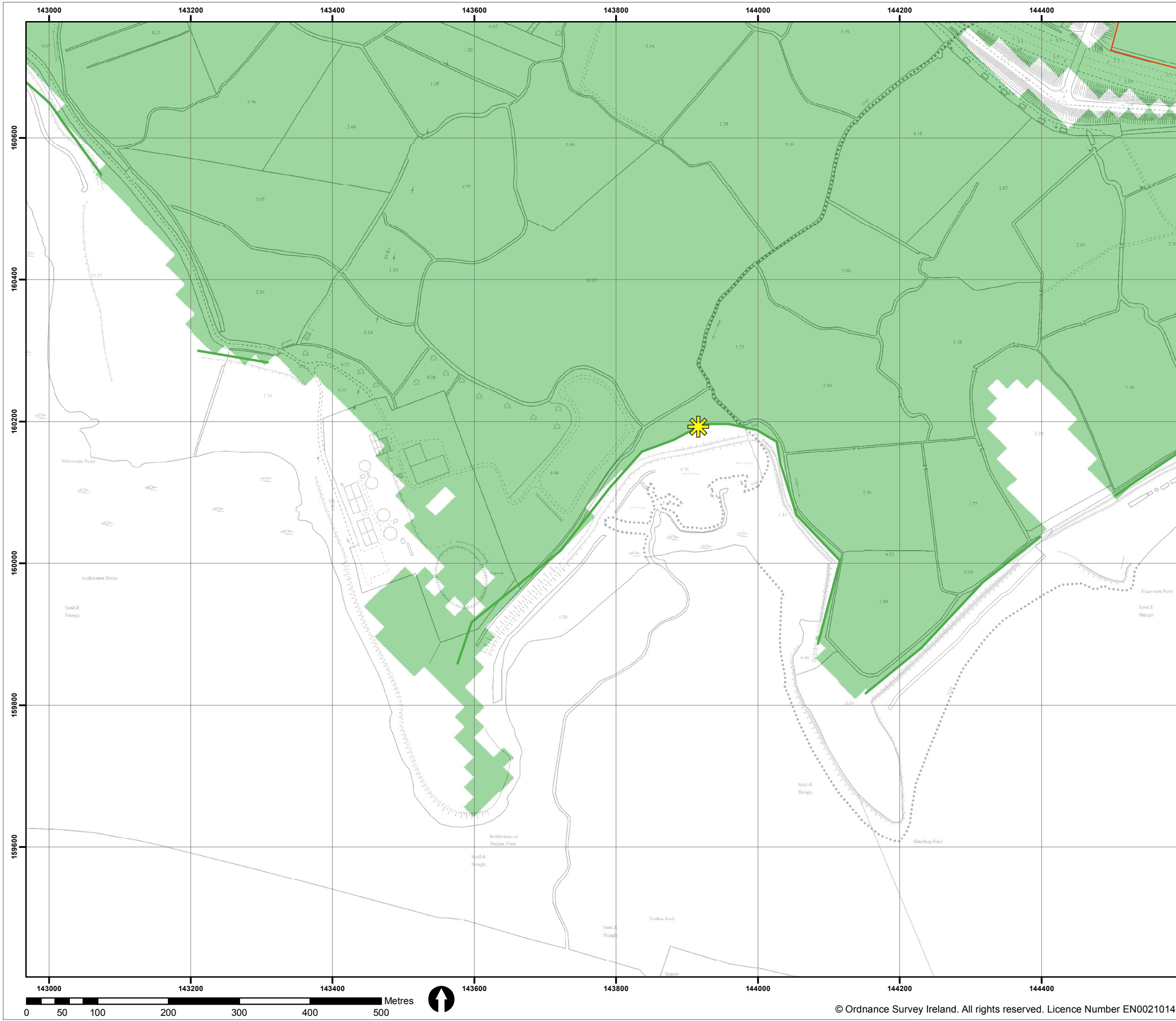


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Project: SHANNON CFRAM STUDY	
Map: SIXMILEBRIDGE & BUNRATTY	
Map Type: DEFENCE FAILURE EXTENT MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2	
Map area: SIXMILEBRIDGE & BUNRATTY	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: S03FECCDC1	
Sheet: 10 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



- Legend:**
- River Centreline
 - AFA Boundary
 - Defence - Embankment
 - Defence Failure Location
 - 0.5% AEP Coastal Failure Scenario 2

SOP = Standard of Protection

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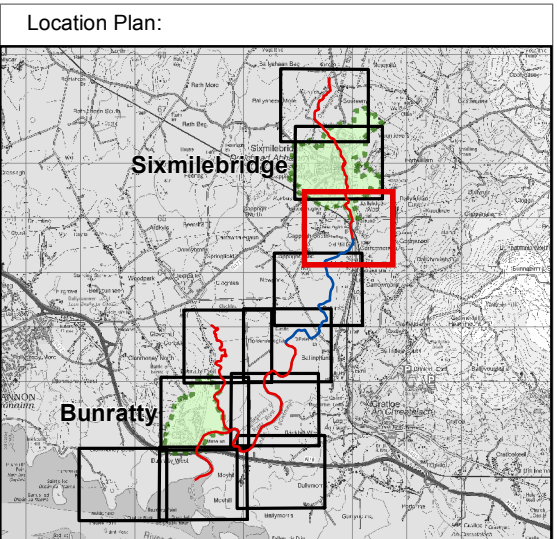
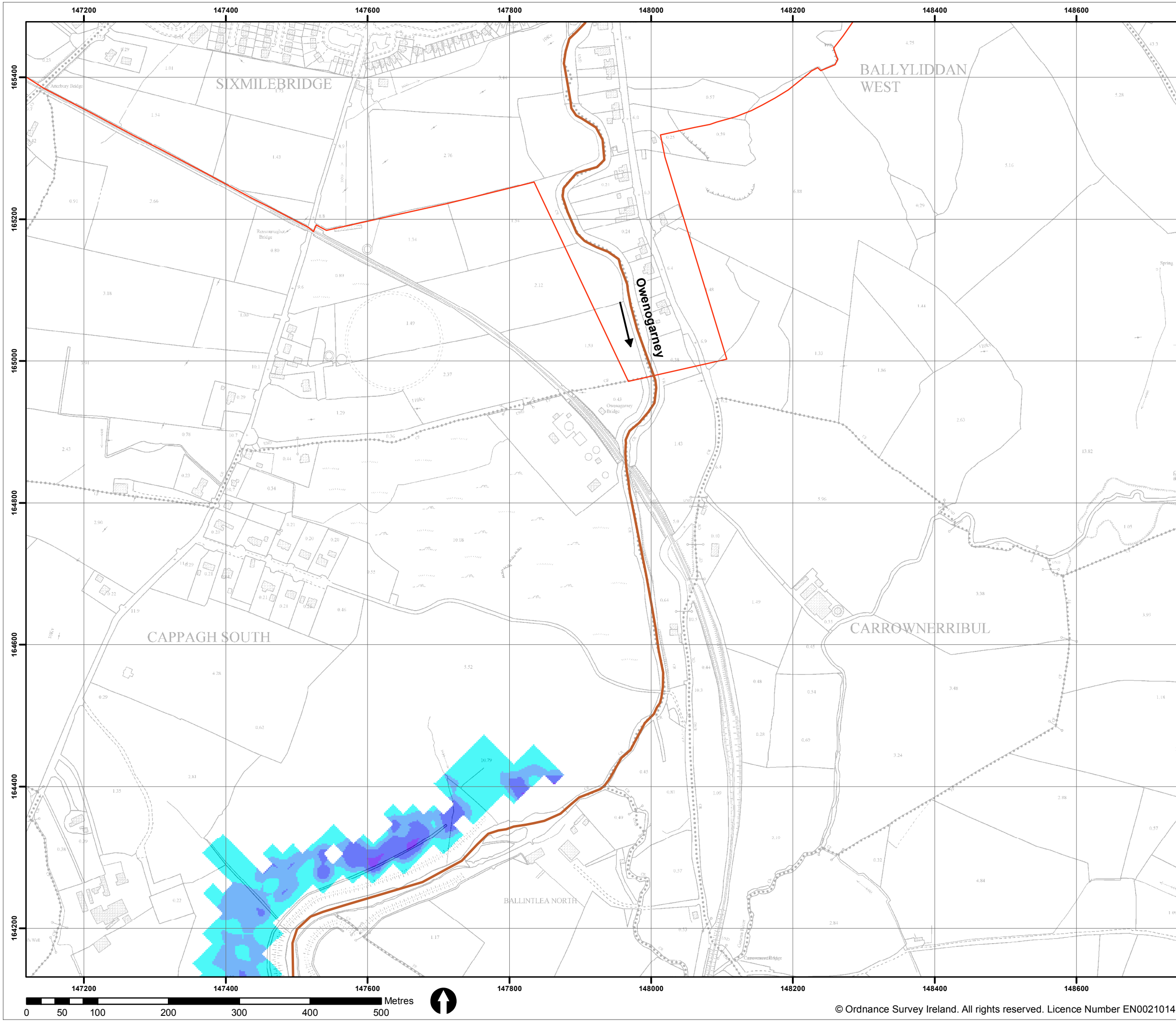


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Project: SHANNON CFRAM STUDY	
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Approved by: PS	Date: November 2015
Map No.: S03FECCDC1	
Sheet: 11 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

5% AEP Coastal Failure Scenario 1 (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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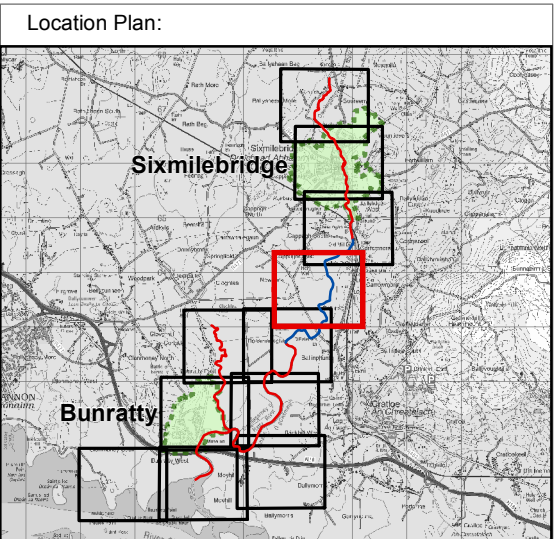
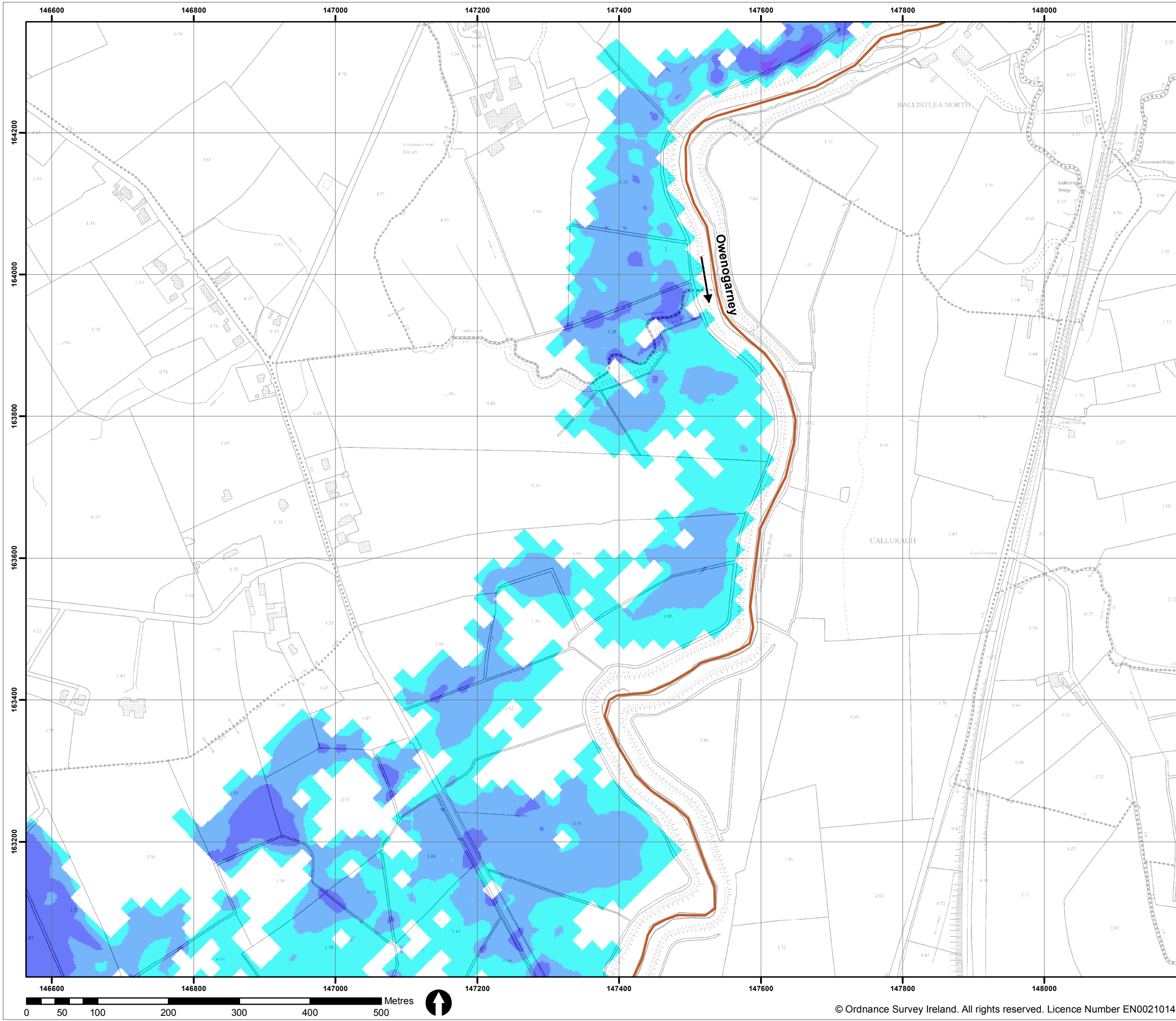


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Project: SHANNON CFRAM STUDY	
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Map Type:	DEFENCE FAILURE DEPTH MAP
Source:	5% AEP COASTAL FAILURE SCENARIO 1
Map area:	SIXMILEBRIDGE & BUNRATTY
Scenario:	EXISTING
Drawn by:	EH
Date:	November 2015
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Map No.:	S03FDCCDC1
Sheet:	3 of 11
Map Scale:	1: 5000
Plot Scale:	1:1 @ A3
Revision: 0	



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


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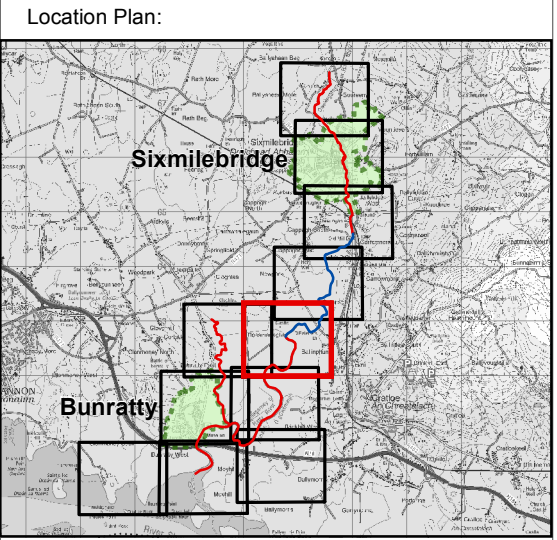
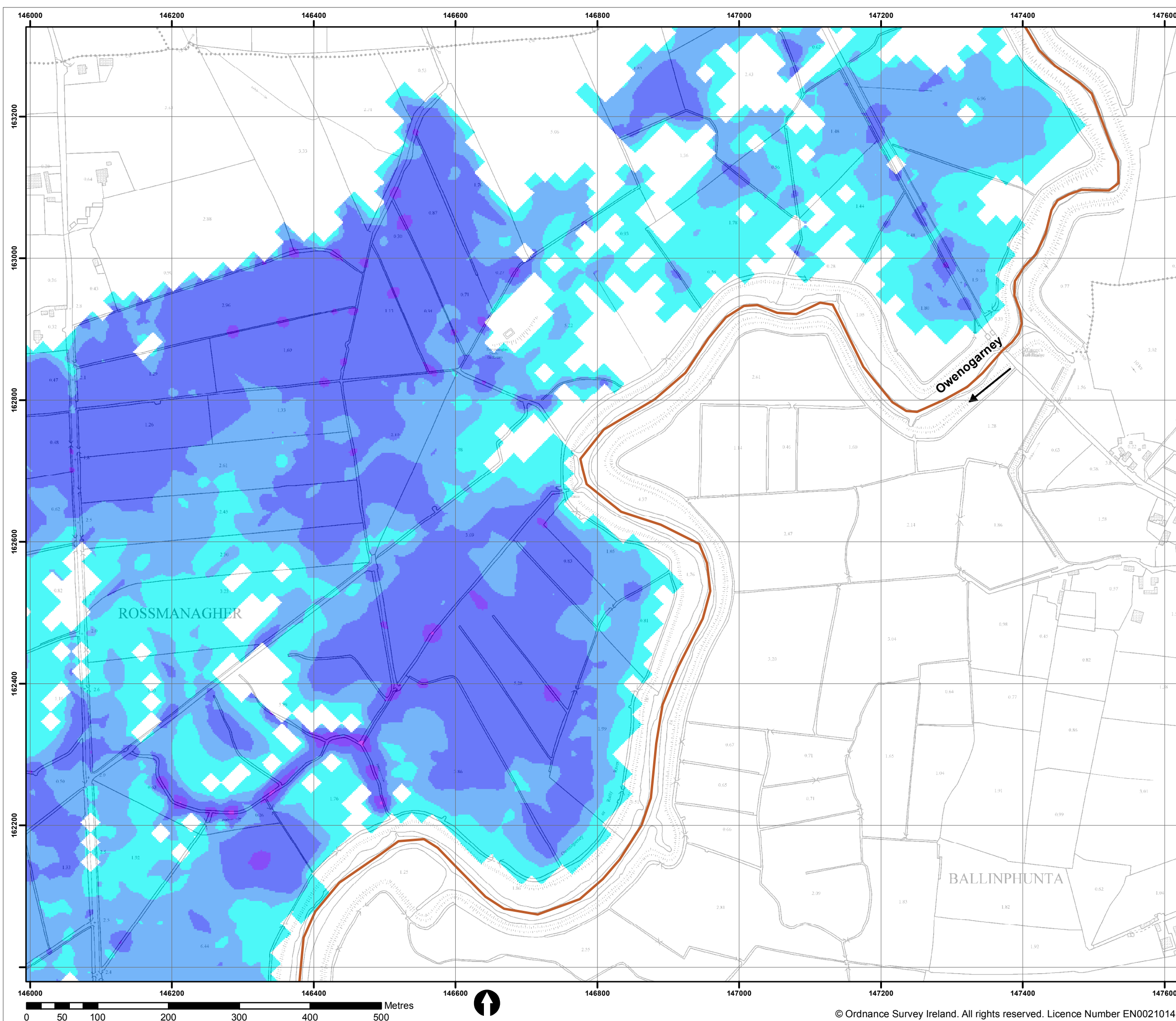
Project:
SHANNON CFRAM STUDY

Map:
SIXMILEBRIDGE & BUNRATTY

Map Type:	DEFENCE FAILURE DEPTH MAP		
Source:	5% AEP COASTAL FAILURE SCENARIO 1		
Map area:	SIXMILEBRIDGE & BUNRATTY		
Scenario:	EXISTING		
Drawn by:	EH	Date:	November 2015
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Map No.:
S03FDCCDC1

Sheet: 4 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

5% AEP Coastal Failure Scenario 1 (m)

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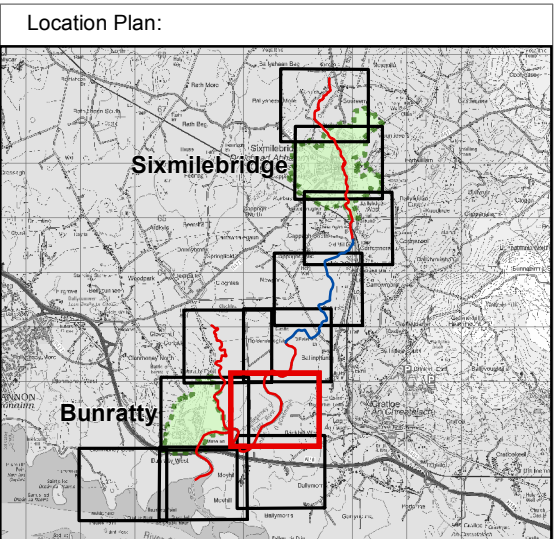
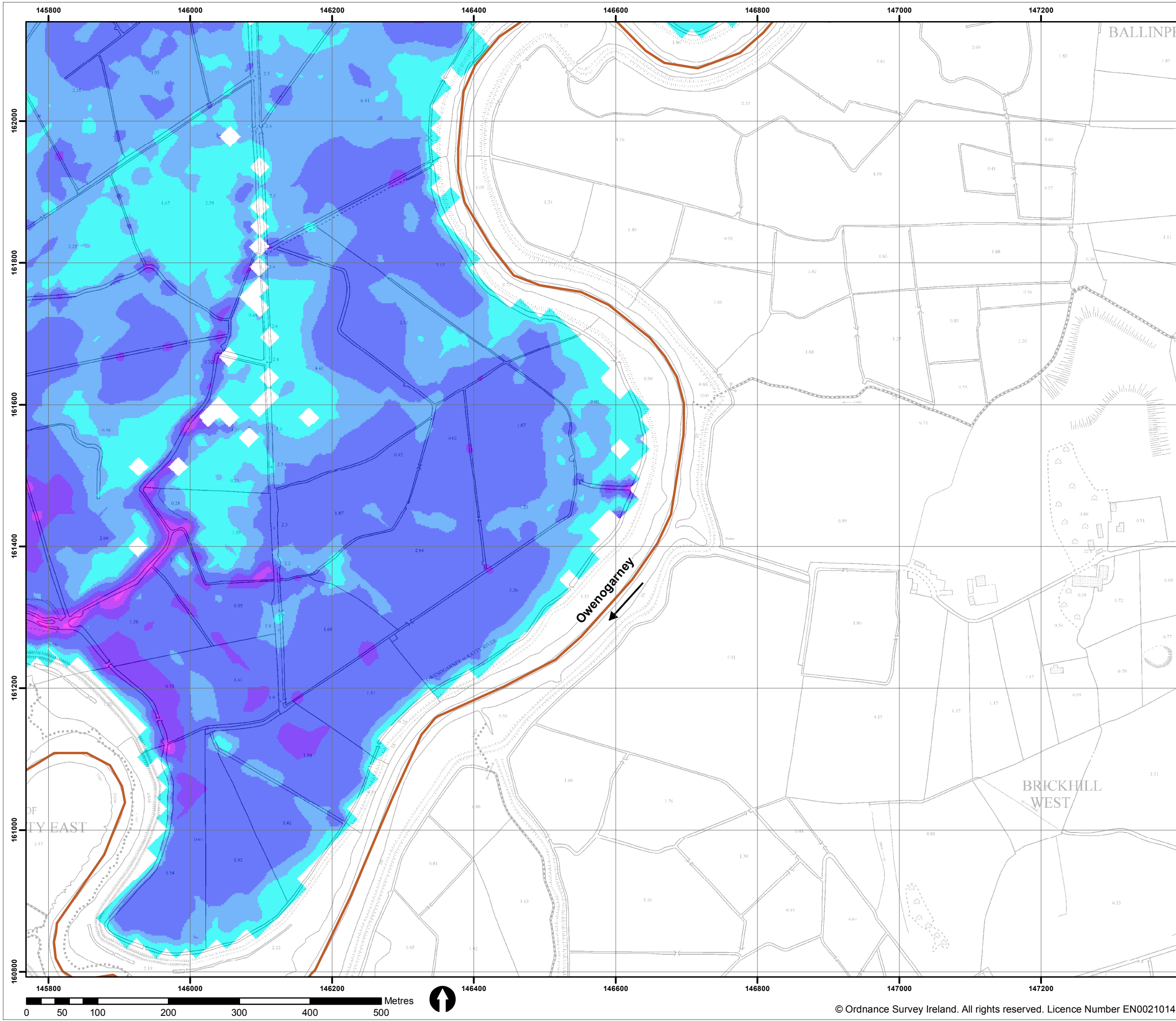


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Project: SHANNON CFRAM STUDY			
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Source:	5% AEP COASTAL FAILURE SCENARIO 1		
Map area:	SIXMILEBRIDGE & BUNRATTY		
Scenario:	EXISTING		
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Sheet: 5 of 11		Revision: 0	
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Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

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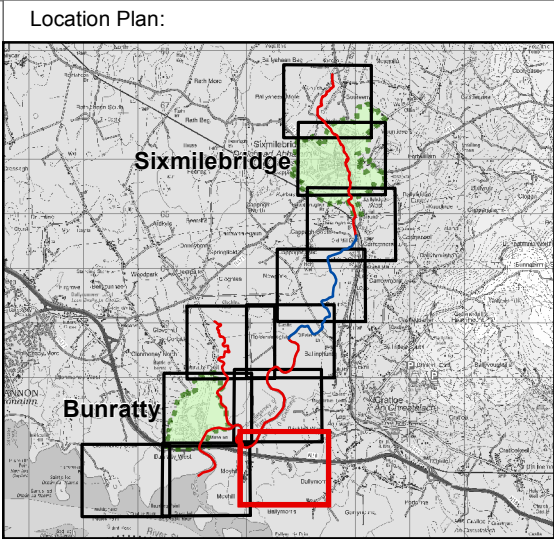
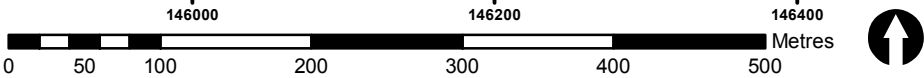
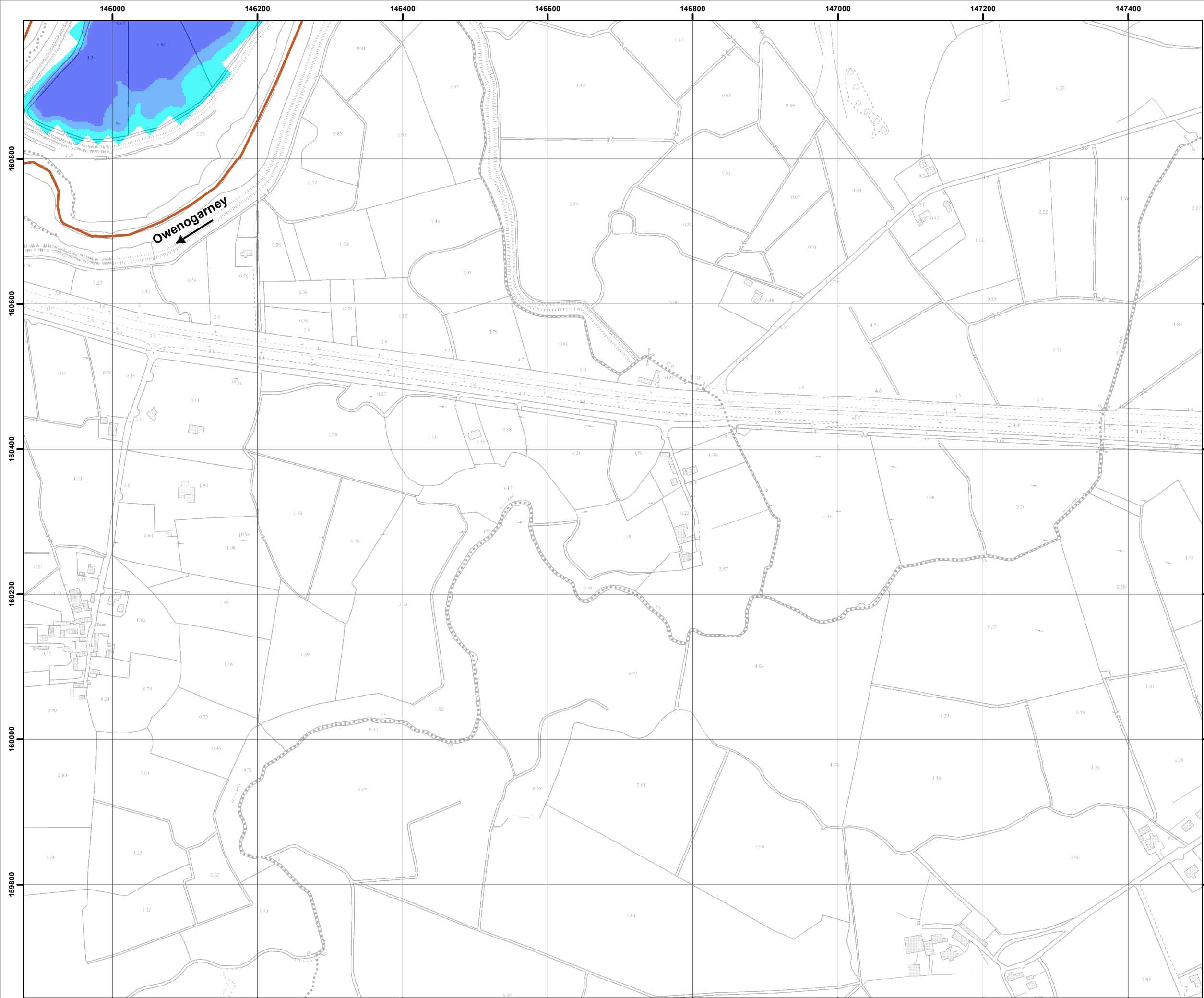


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Project: SHANNON CFRAM STUDY			
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Source:	5% AEP COASTAL FAILURE SCENARIO 1		
Map area:	SIXMILEBRIDGE & BUNRATTY		
Scenario:	EXISTING		
Drawn by:	EH	Date:	November 2015
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Map No.: S03FDCCDC1			
Sheet: 6 of 11		Revision: 0	
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Legend:

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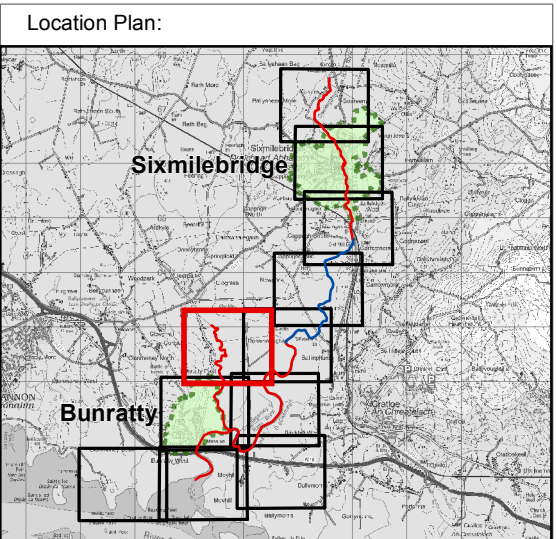
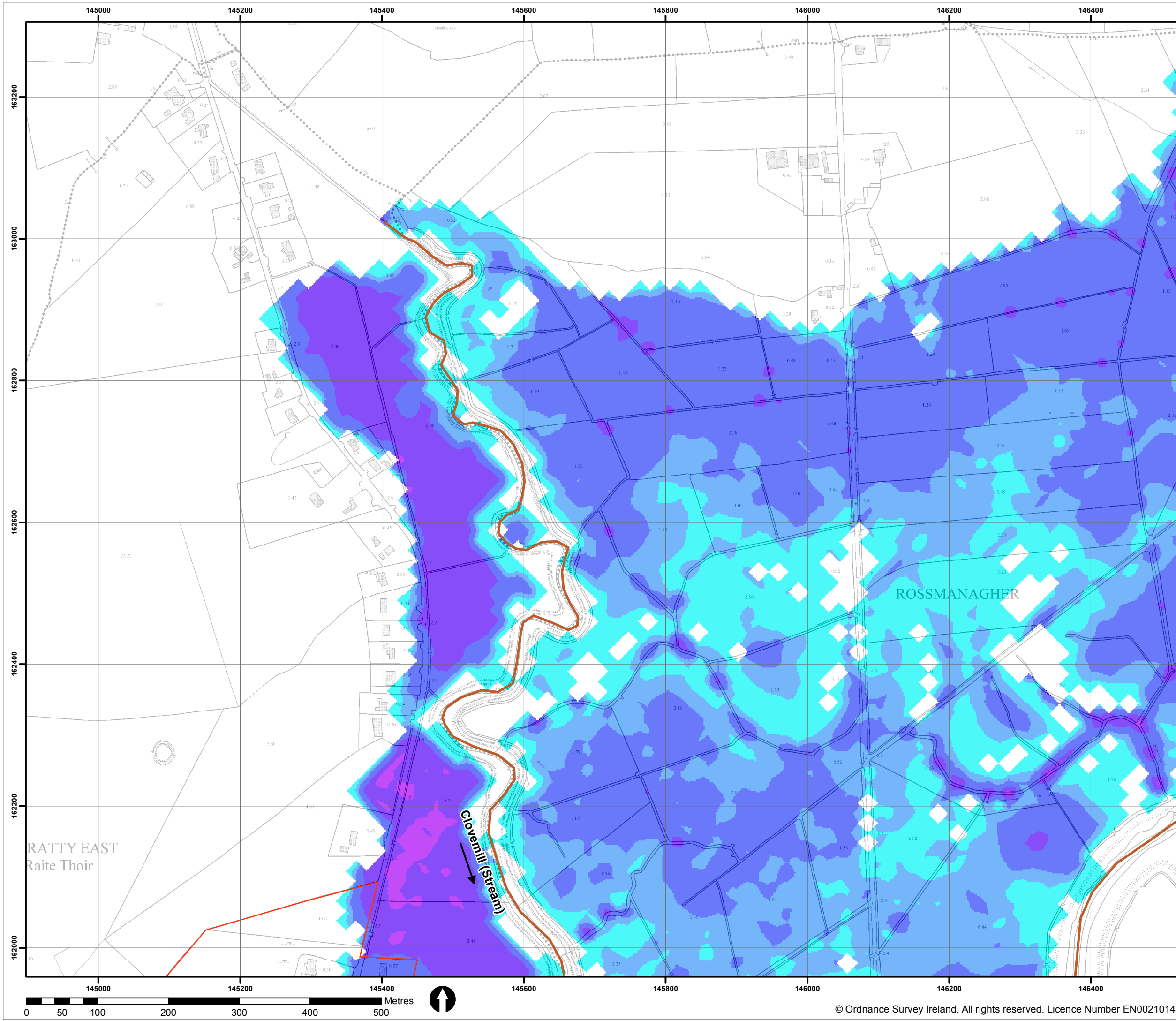


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Project: SHANNON CFRAM STUDY	
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Source:	5% AEP COASTAL FAILURE SCENARIO 1
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Legend:

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5% AEP Coastal Failure Scenario 1 (m)

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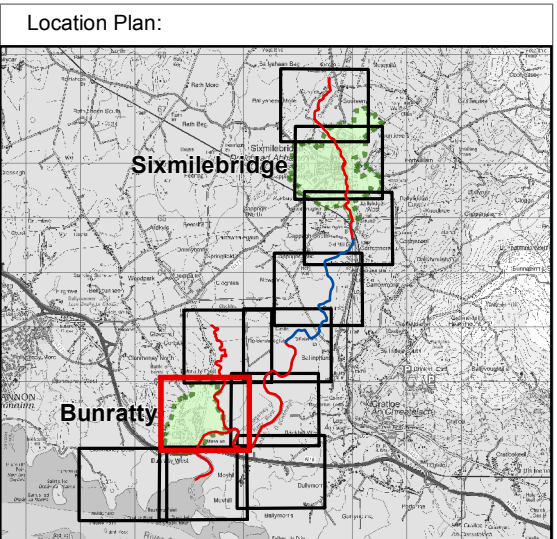
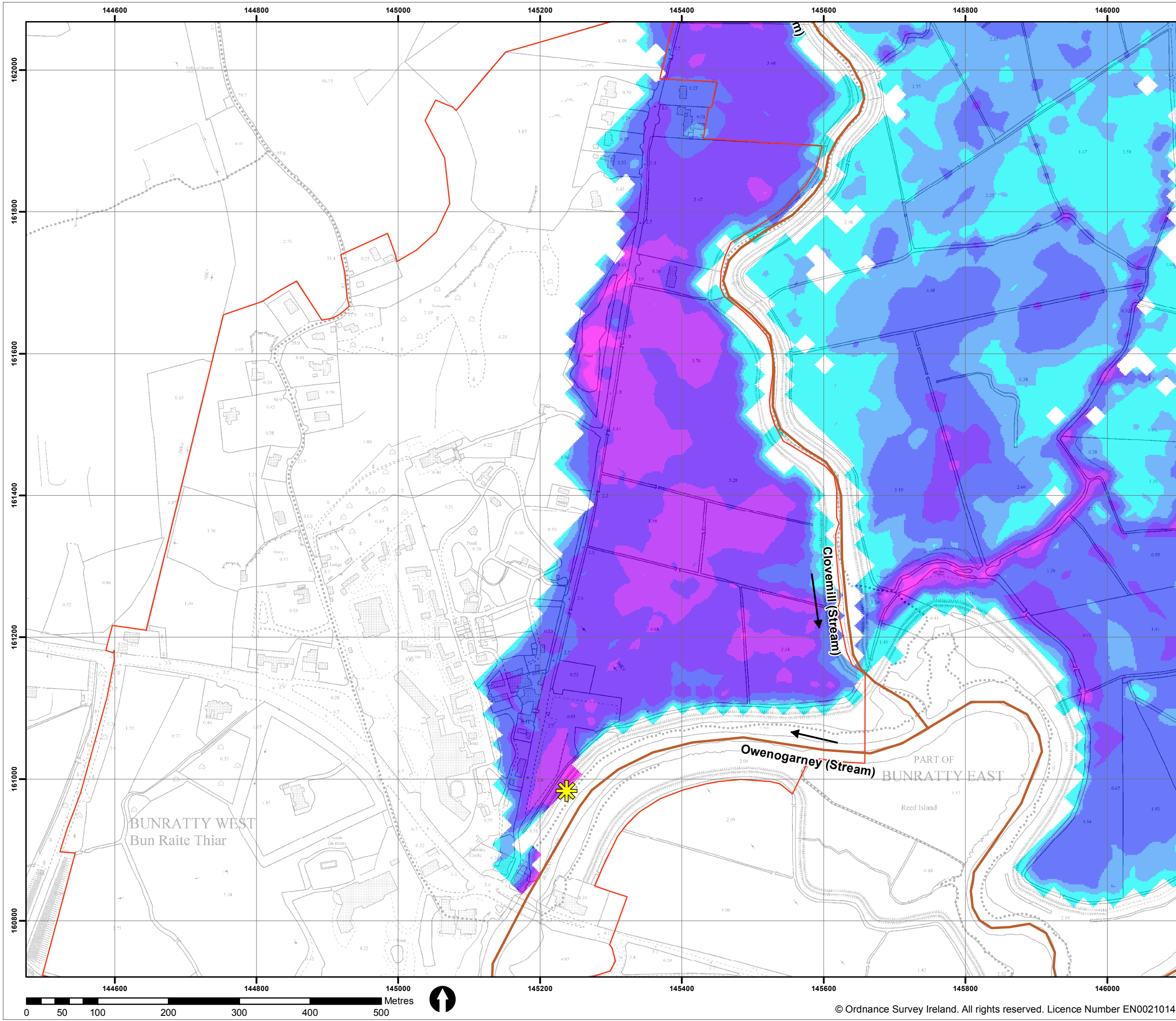


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Revision:	0
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Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

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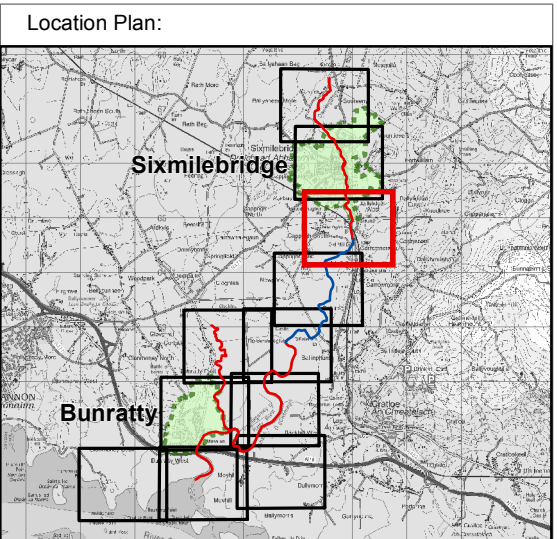
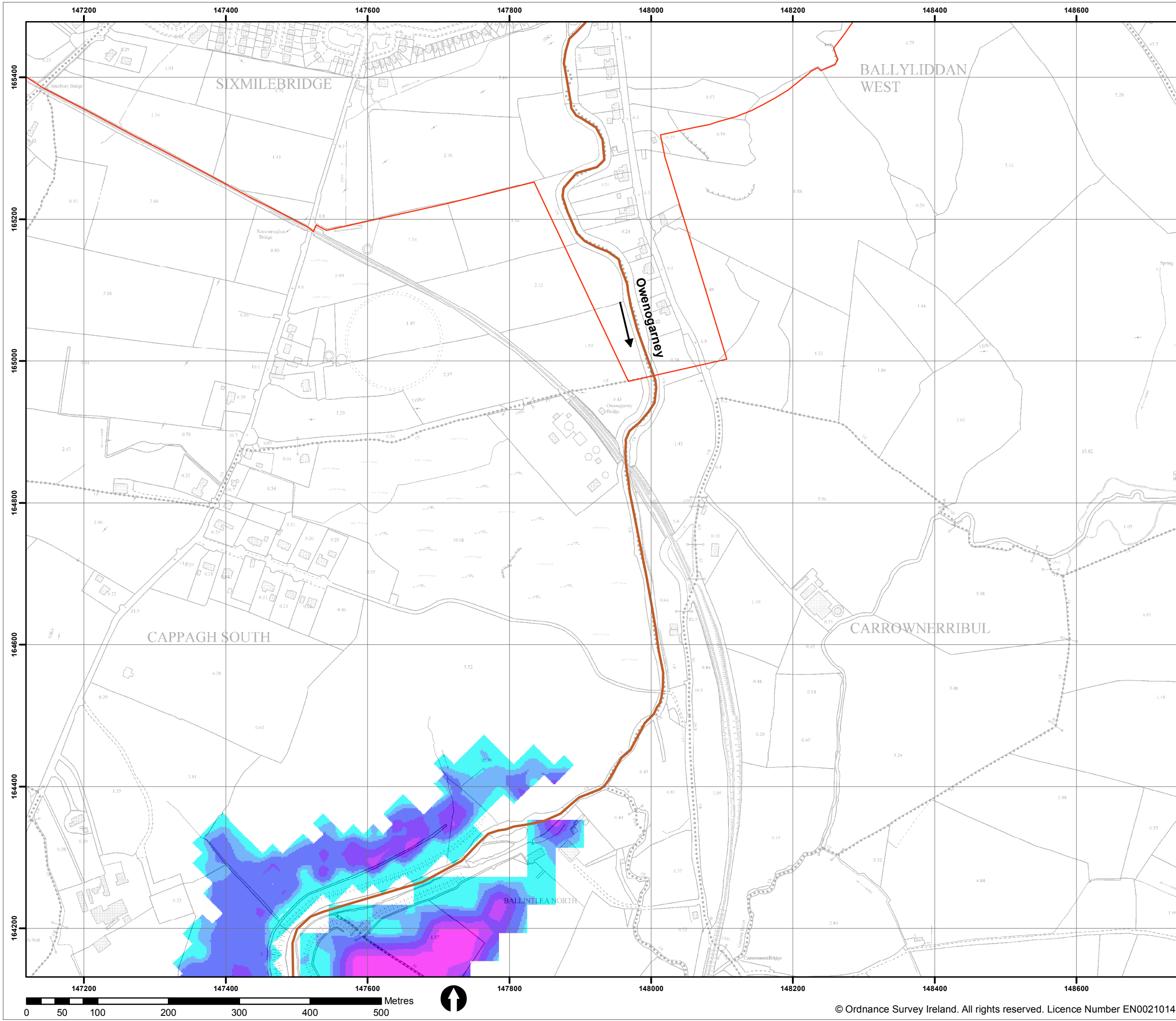


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Project: SHANNON CFRAM STUDY	
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Map Type:	DEFENCE FAILURE DEPTH MAP
Source:	5% AEP COASTAL FAILURE SCENARIO 1
Map area:	SIXMILEBRIDGE & BUNRATTY
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Date:	November 2015
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Map No.: S03FDCCDC1	
Sheet: 9 of 11	
Map Scale: 1: 5000	
Revision: 0	
Plot Scale: 1:1 @ A3	



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
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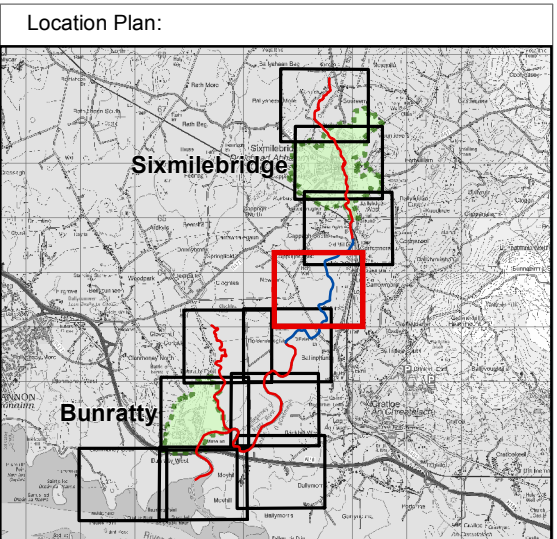
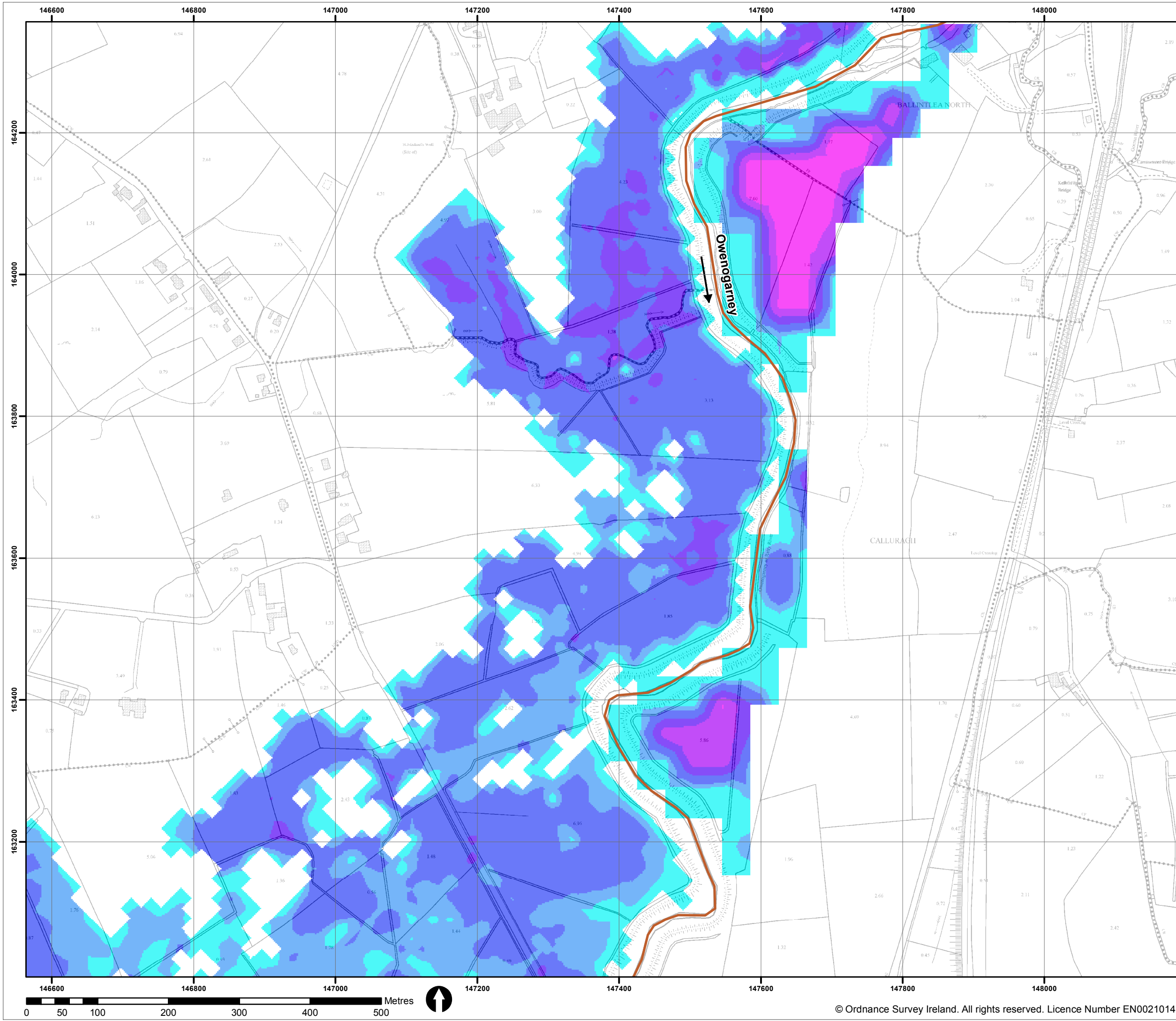


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Project: SHANNON CFRAM STUDY	
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Source: 0.5% AEP COASTAL FAILURE SCENARIO 2	
Map area: SIXMILEBRIDGE & BUNRATTY	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Map No.: S03FDCCDC1	
Sheet: 3 of 11	
Map Scale: 1: 5000	
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Legend:

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- Defence Failure Location

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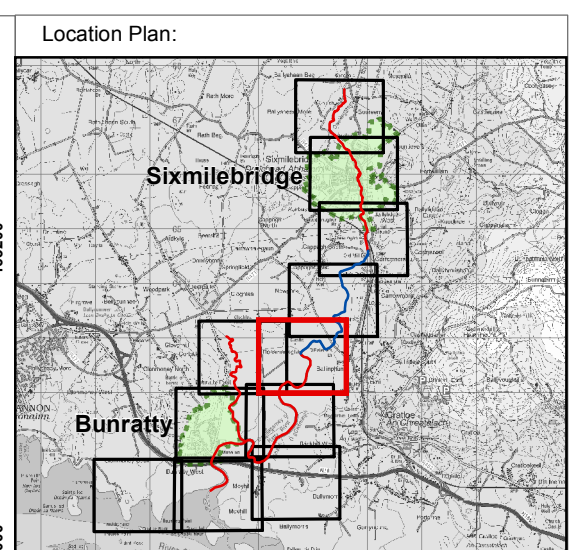
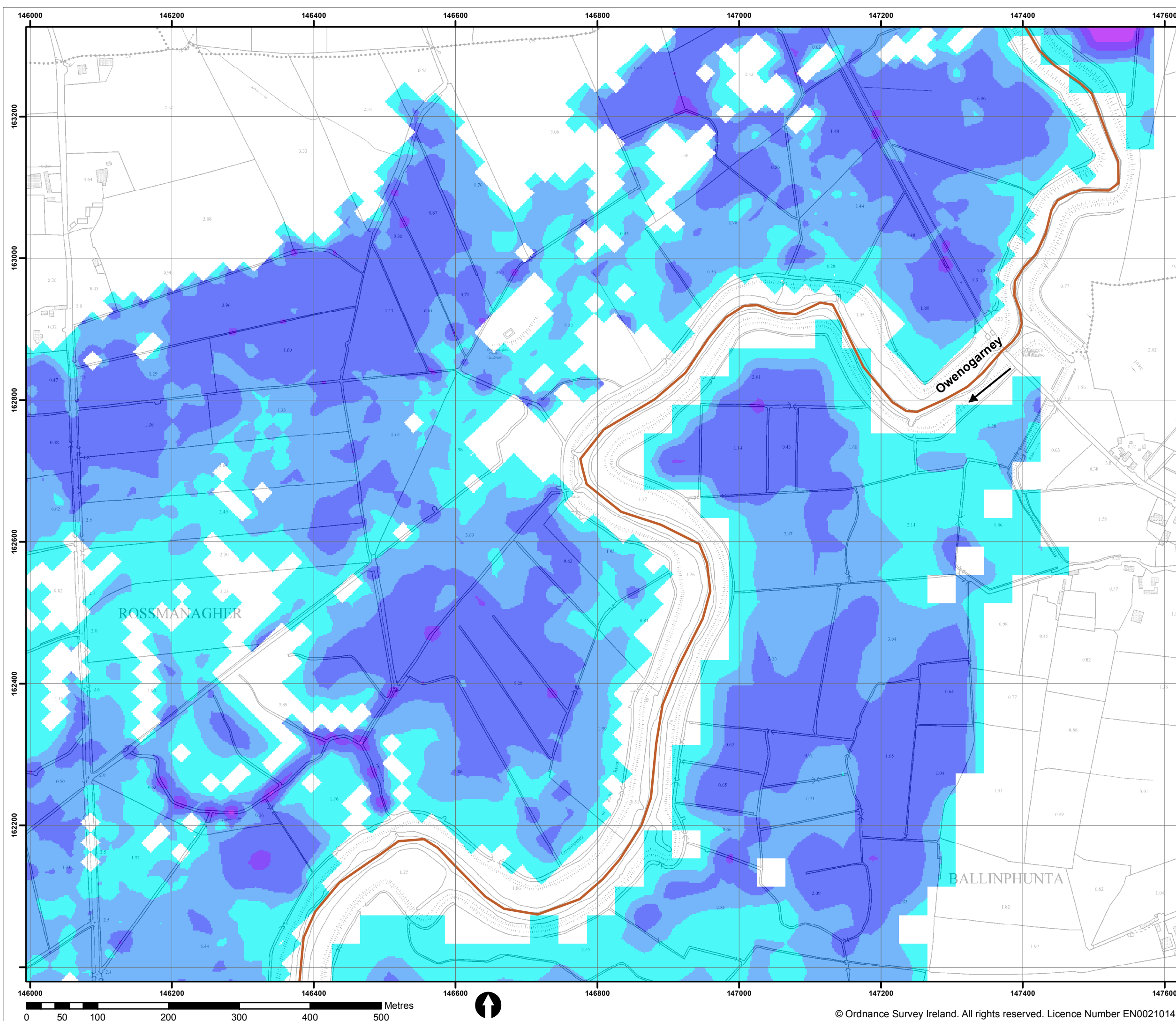


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Legend:

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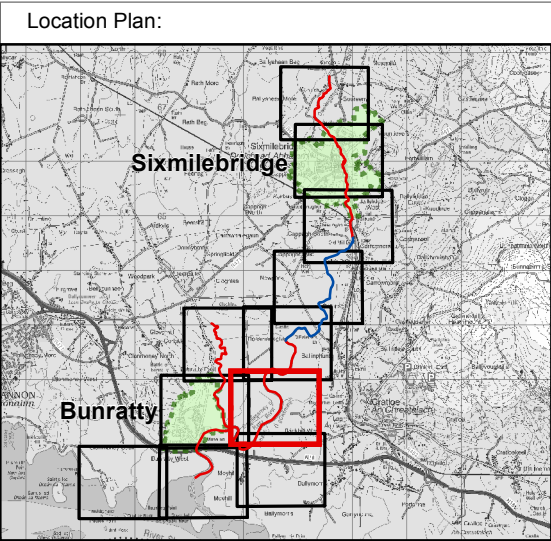
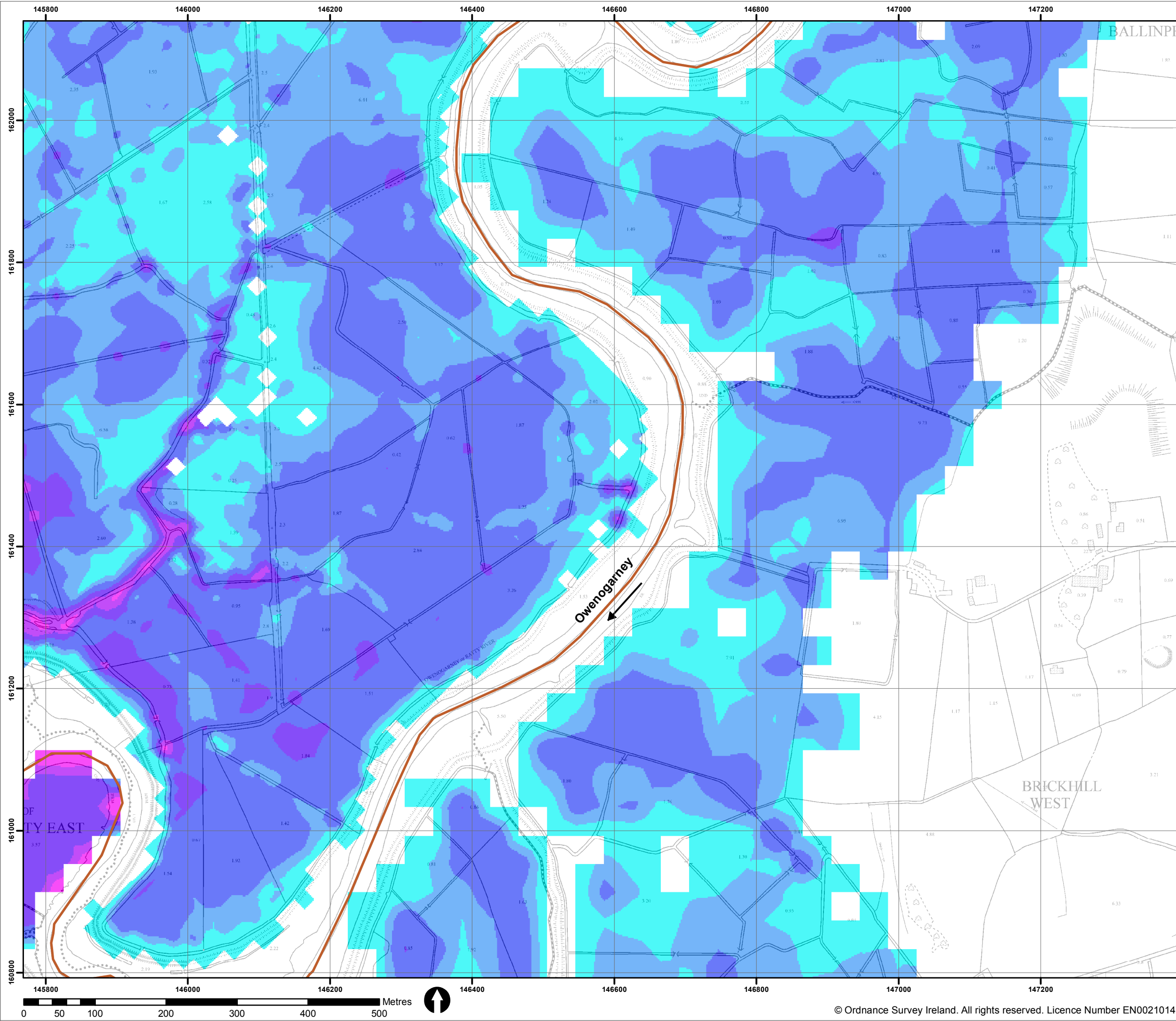
Project:
SHANNON CFRAM STUDY

Map:
SIXMILEBRIDGE & BUNRATTY

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SIXMILEBRIDGE & BUNRATTY
Scenario: EXISTING

Drawn by: EH	Date: November 2015
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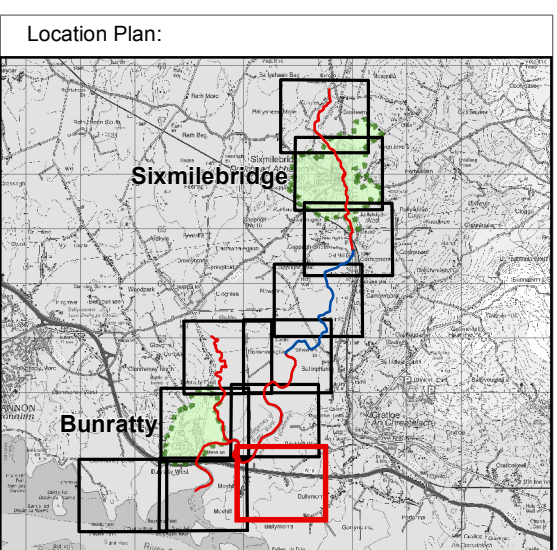
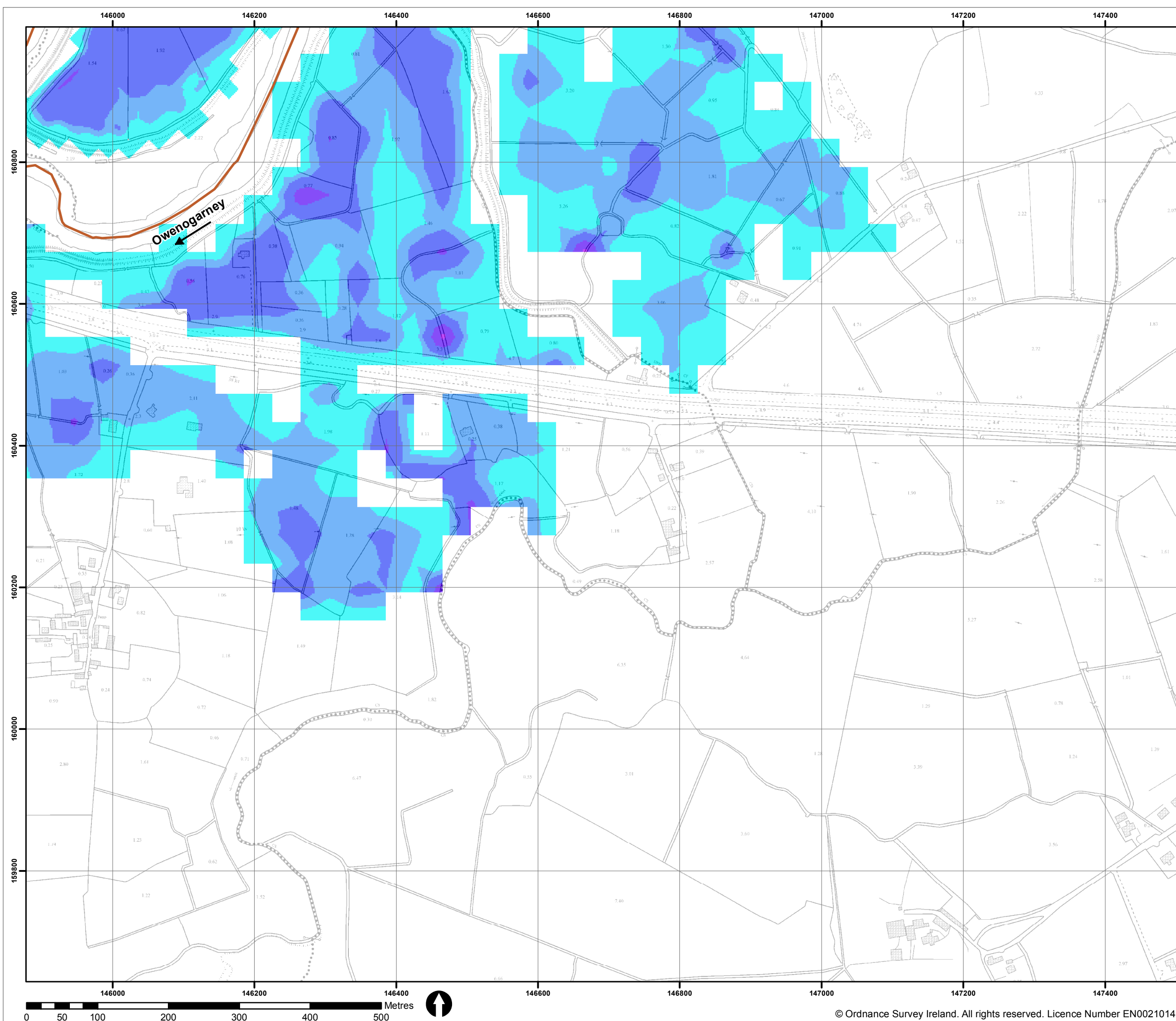


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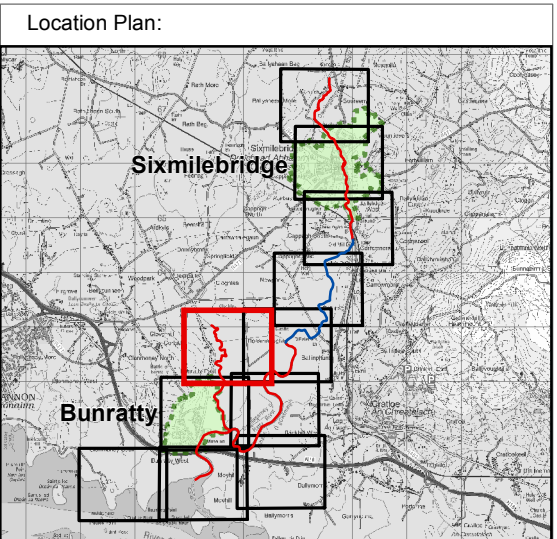
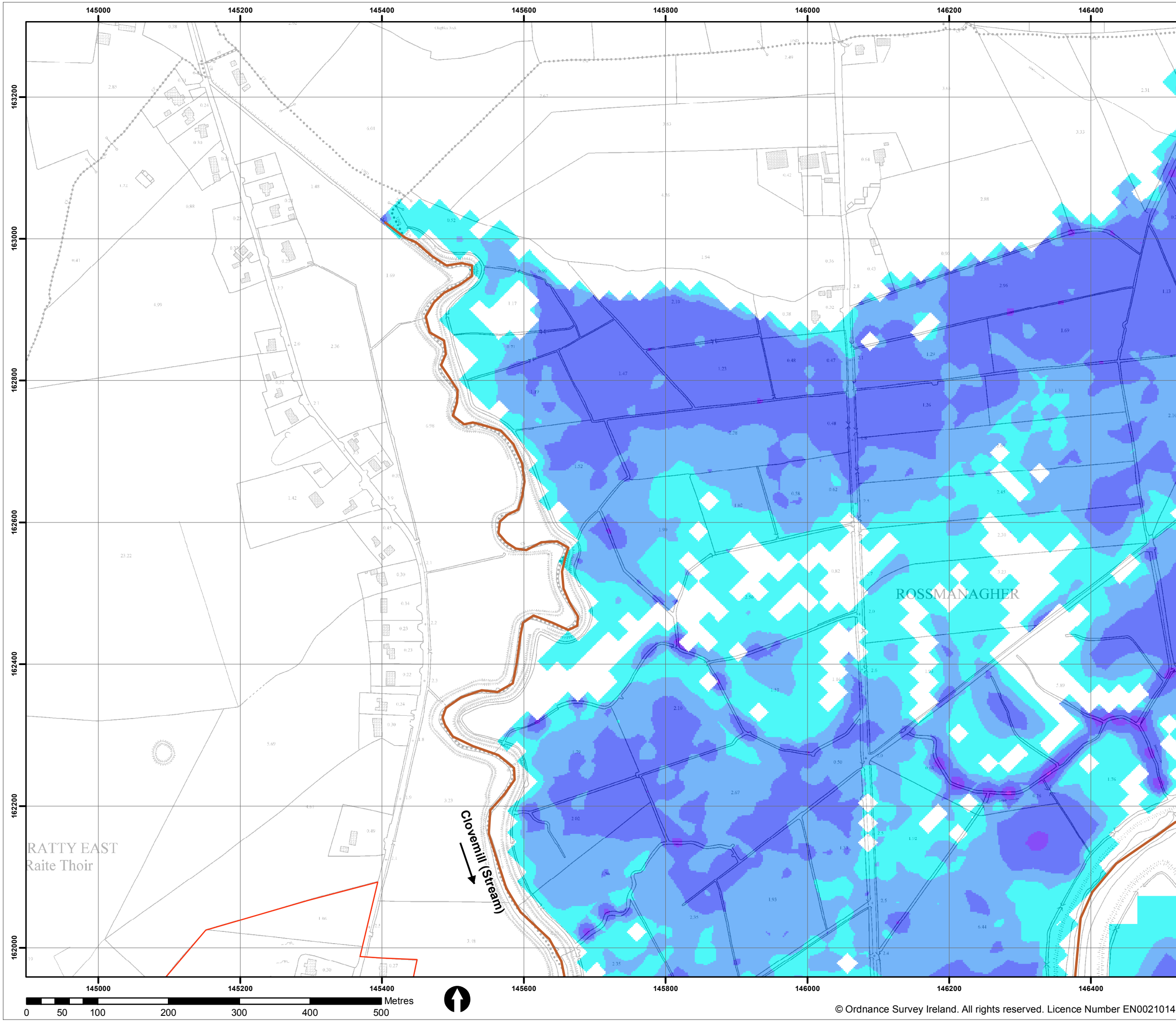
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SHANNON CFRAM STUDY

Map:
SIXMILEBRIDGE & BUNRATTY

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SIXMILEBRIDGE & BUNRATTY
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Drawn by: EH	Date: November 2015
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Map No.: S03FDCCDC1	Revision: 0
Sheet: 7 of 11	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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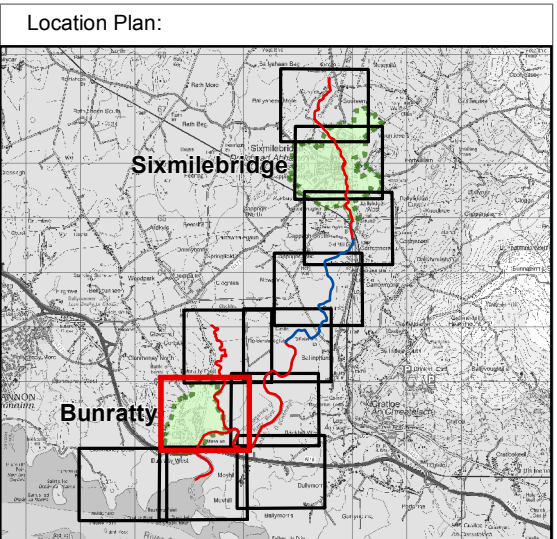
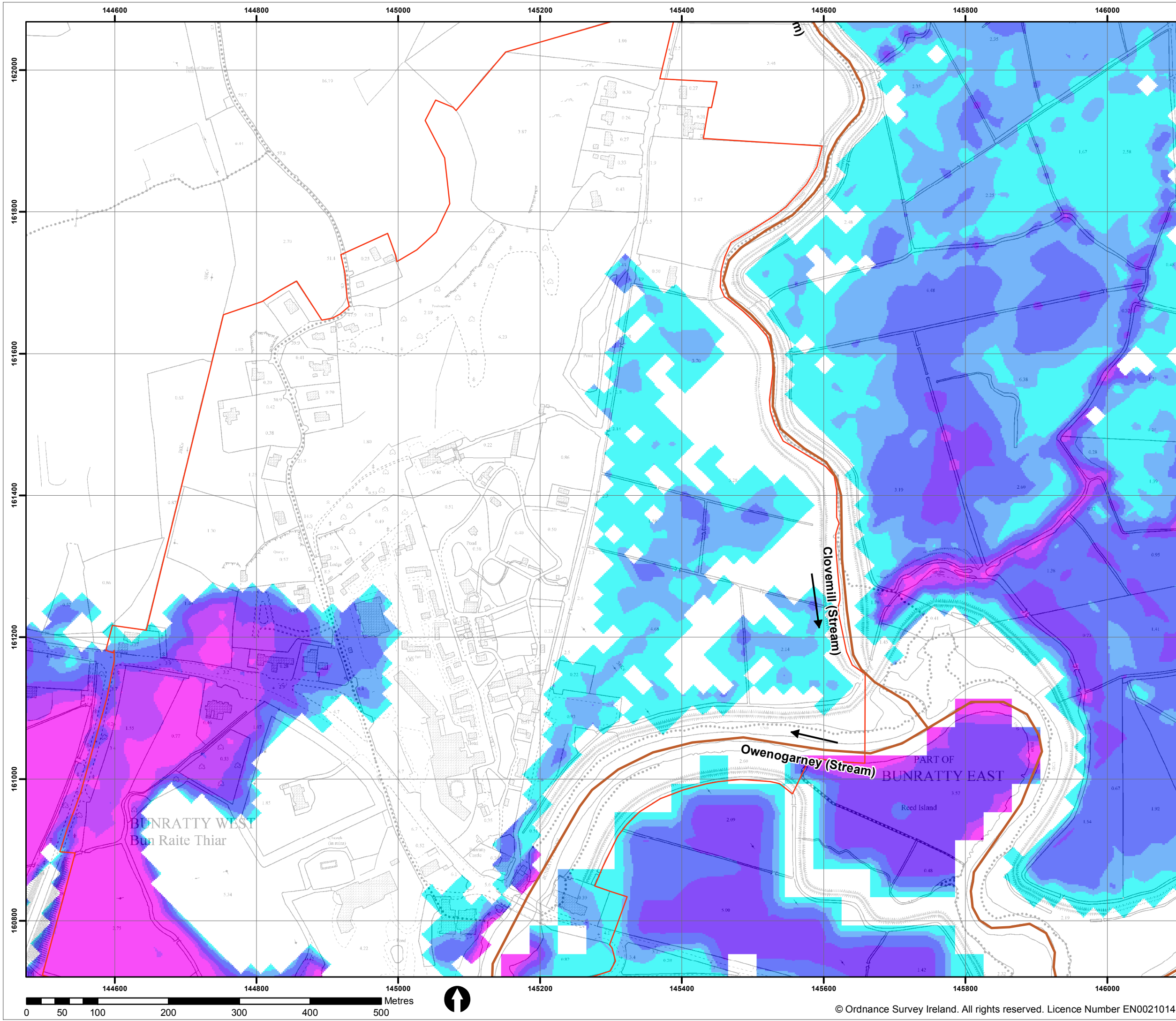


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Project: SHANNON CFRAM STUDY	
Map: SIXMILEBRIDGE & BUNRATTY	
Map Type: DEFENCE FAILURE DEPTH MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2	
Map area: SIXMILEBRIDGE & BUNRATTY	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: S03FDCCDC1	
Sheet: 8 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
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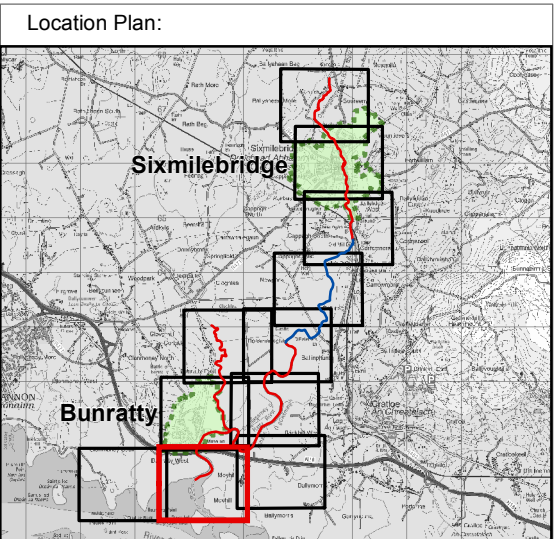
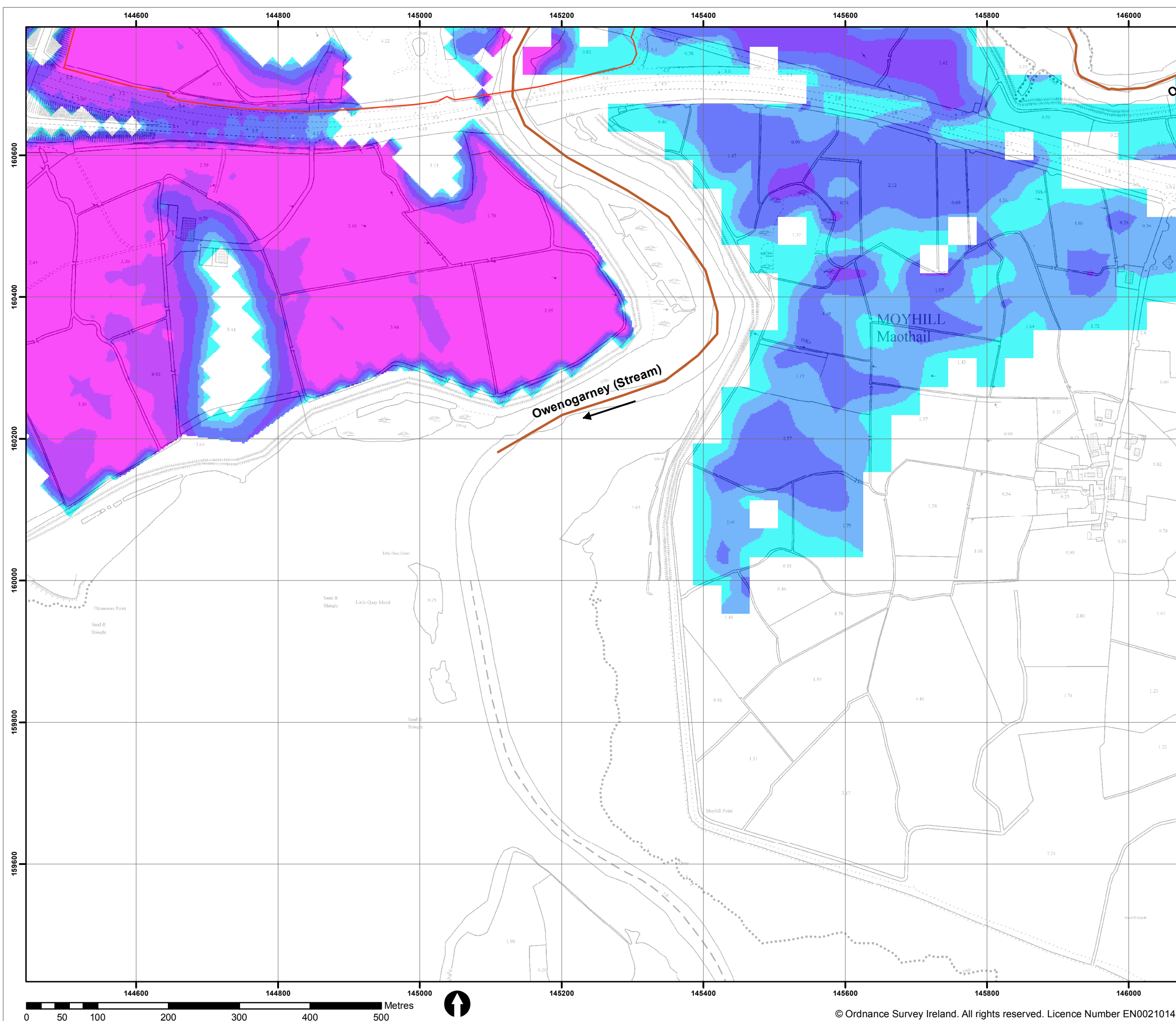


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Sheet: 9 of 11	Revision: 0
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Legend:

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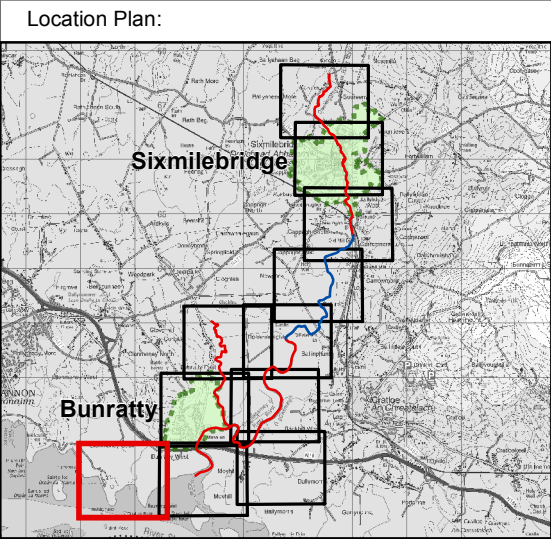
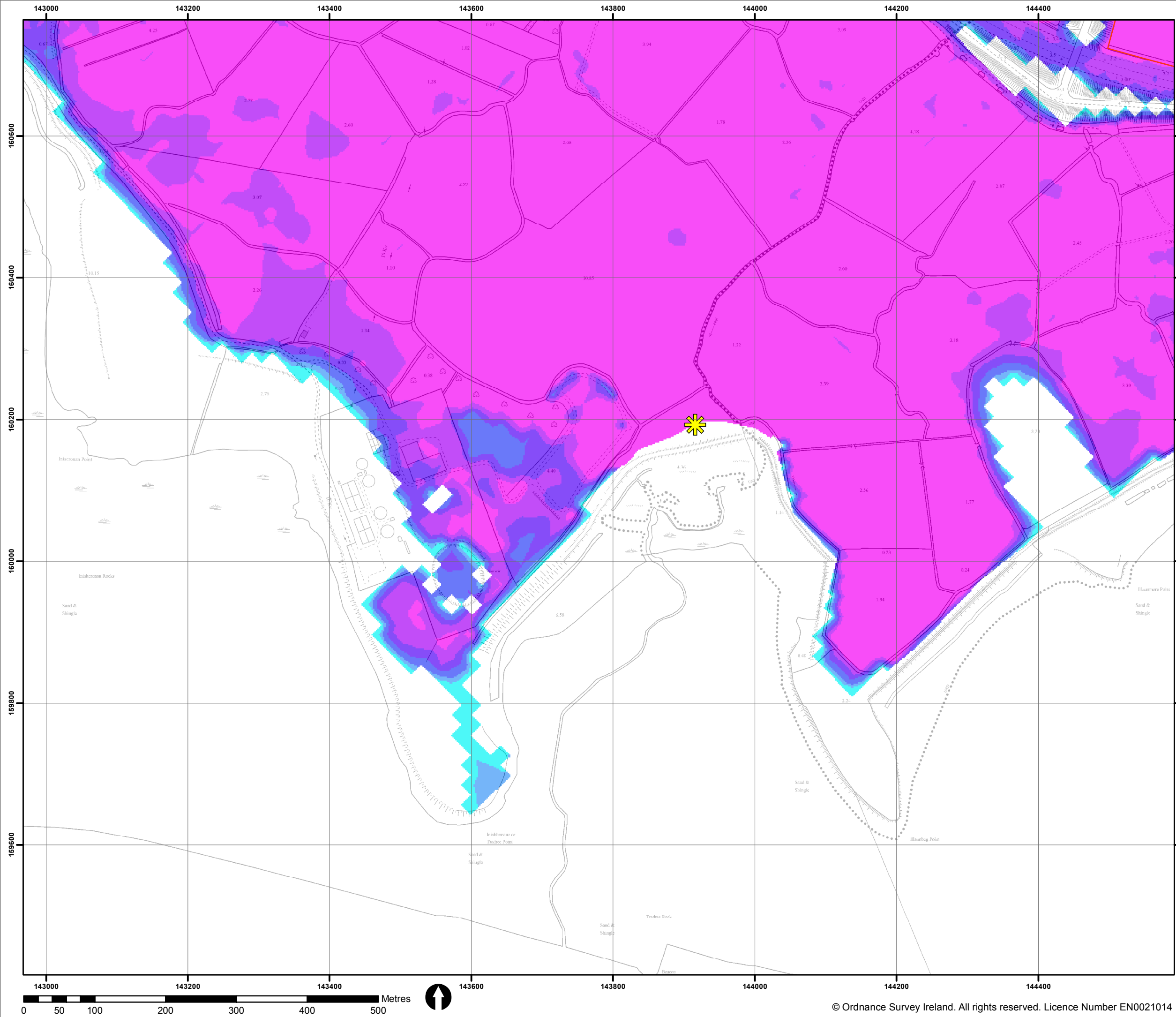


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Project: SHANNON CFRAM STUDY	
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Map area: SIXMILEBRIDGE & BUNRATTY	
Scenario: EXISTING	
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Sheet: 10 of 11	Revision: 0
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Legend:

- Model Reach
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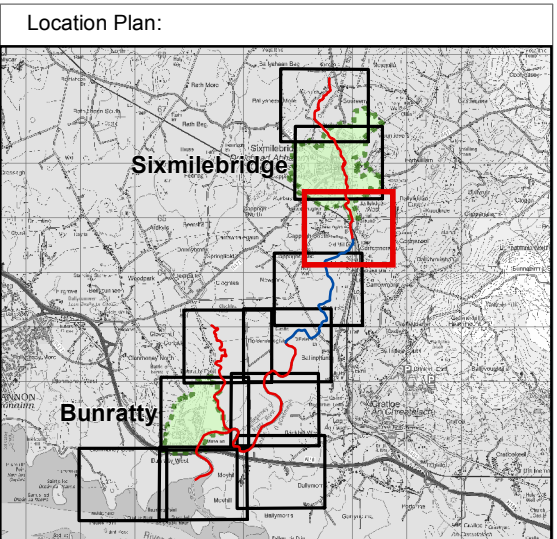
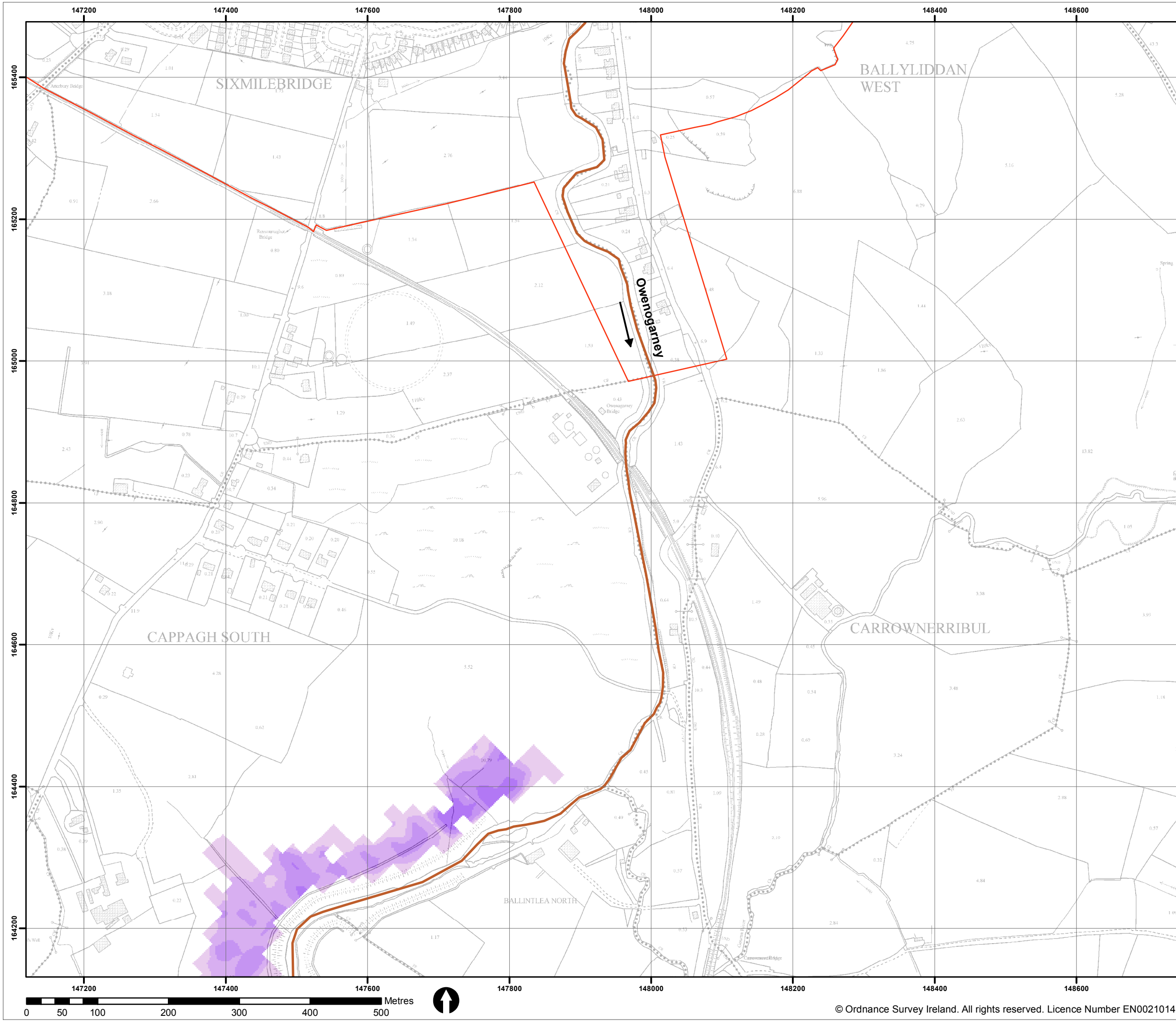


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Project: SHANNON CFRAM STUDY	
Map: SIXMILEBRIDGE & BUNRATTY	
Map Type: DEFENCE FAILURE DEPTH MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2	
Map area: SIXMILEBRIDGE & BUNRATTY	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Approved by: PS	Date: November 2015
Map No.: S03FDCCDC1	
Sheet: 11 of 11	
Revision: 0	
Map Scale: 1: 5000	
Plot Scale: 1:1 @ A3	



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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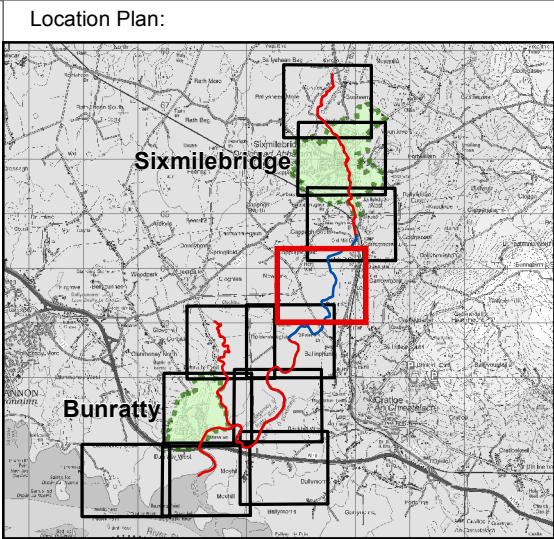
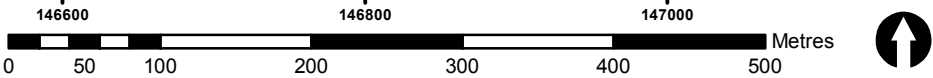
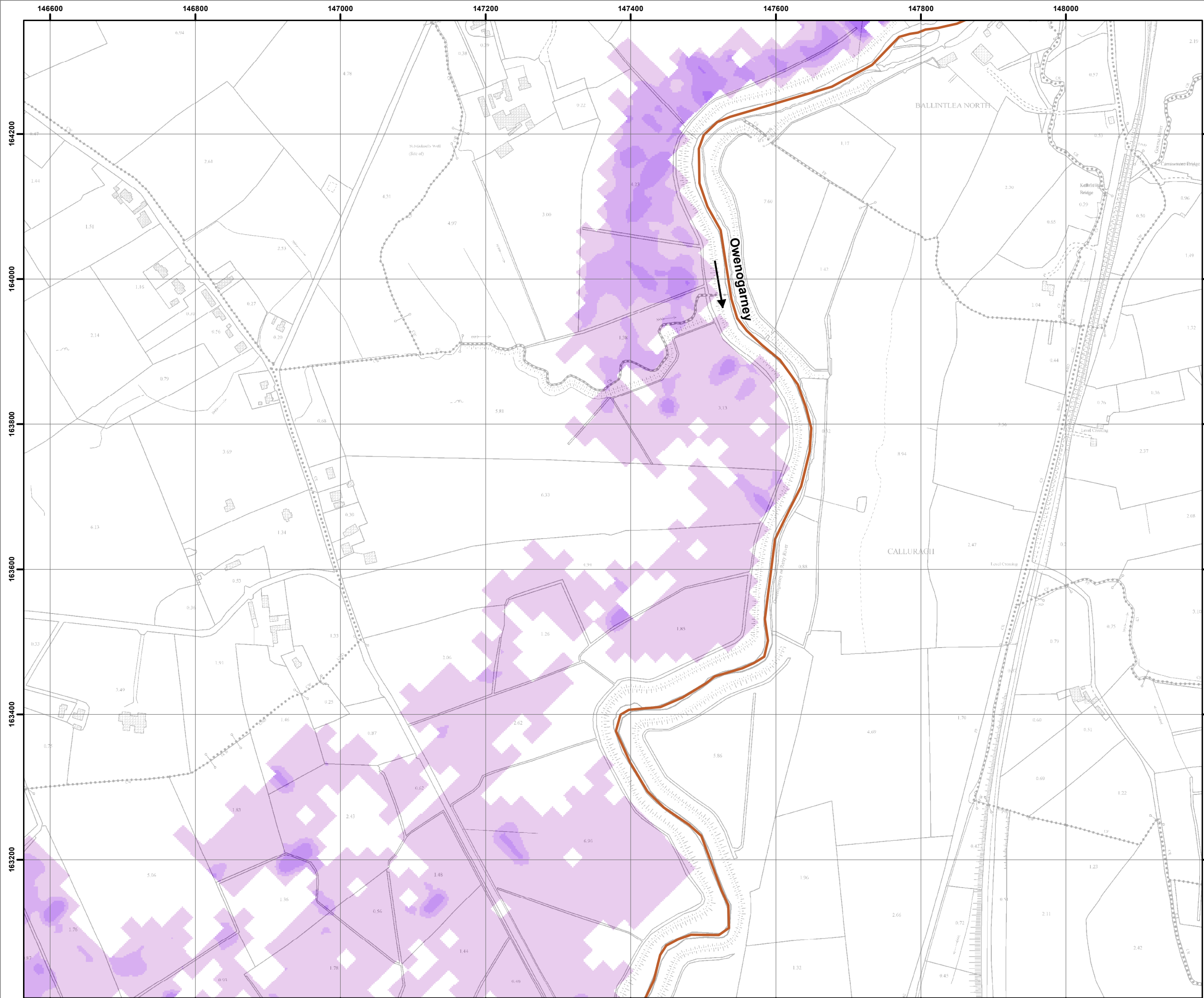


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Project: SHANNON CFRAM STUDY	
Map: SIXMILEBRIDGE & BUNRATTY	
Map Type:	DEFENCE FAILURE VELOCITY MAP
Source:	5% AEP COASTAL FAILURE SCENARIO 1
Map area:	SIXMILEBRIDGE & BUNRATTY
Scenario:	EXISTING
Drawn by:	EH
Date:	November 2015
Checked by:	PT
Date:	November 2015
Reviewed by:	MC
Date:	November 2015
Approved by:	PS
Date:	November 2015
Map No.: S03FVCCDC1	
Sheet:	3 of 11
Revision:	0
Map Scale:	1: 5000
Plot Scale:	1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
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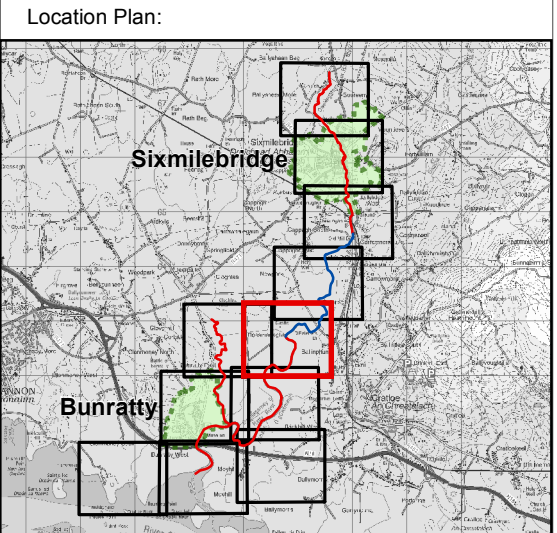
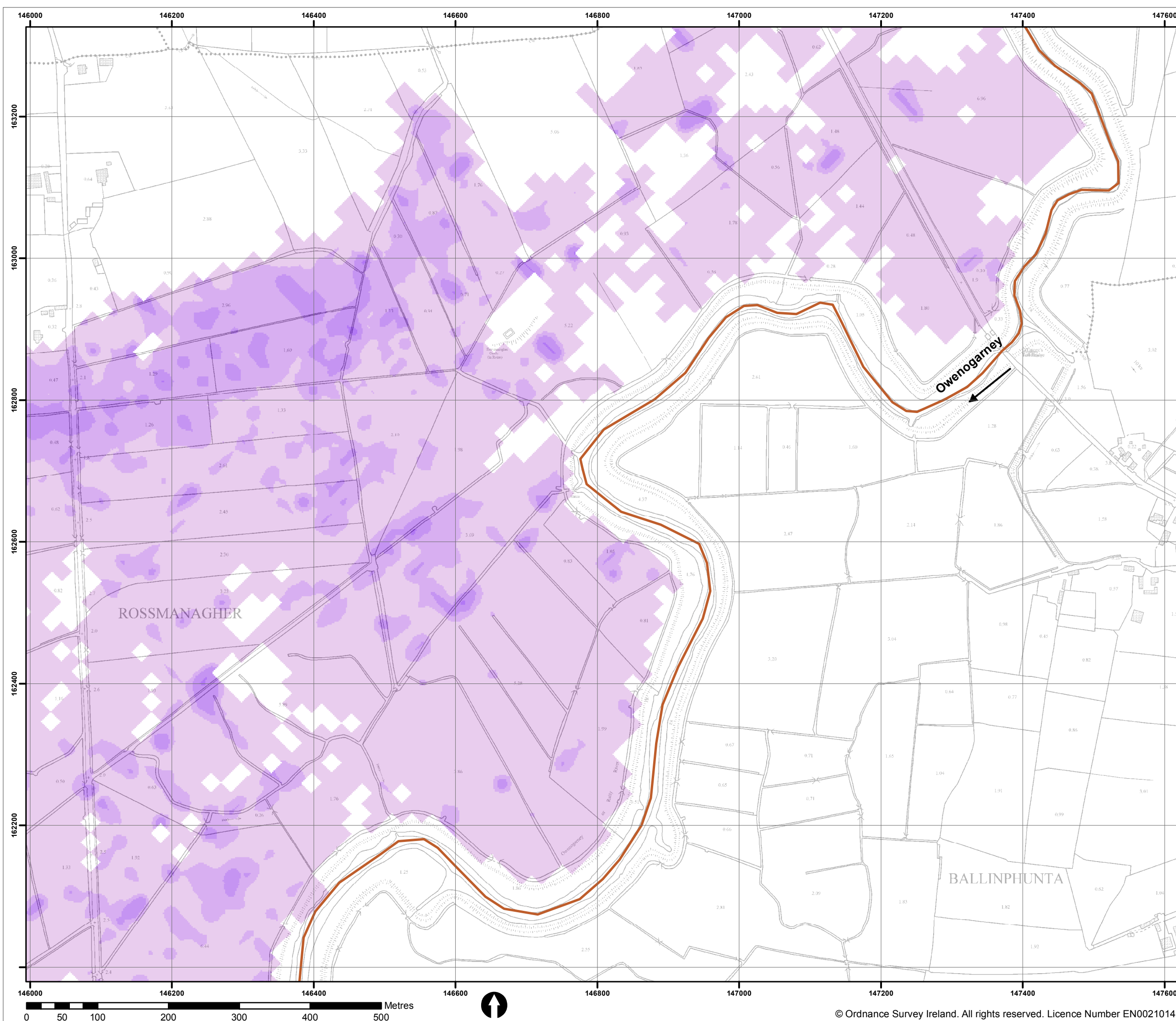


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Project:
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Map:
SIXMILEBRIDGE & BUNRATTY

Map Type:	DEFENCE FAILURE VELOCITY MAP		
Source:	5% AEP COASTAL FAILURE SCENARIO 1		
Map area:	SIXMILEBRIDGE & BUNRATTY		
Scenario:	EXISTING		
Drawn by:	EH	Date:	November 2015
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Reviewed by:	MC	Date:	November 2015
Approved by:	PS	Date:	November 2015
Map No.:	S03FVCCDC1		
Sheet:	4 of 11	Revision:	0
Map Scale:	1: 5000	Plot Scale:	1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
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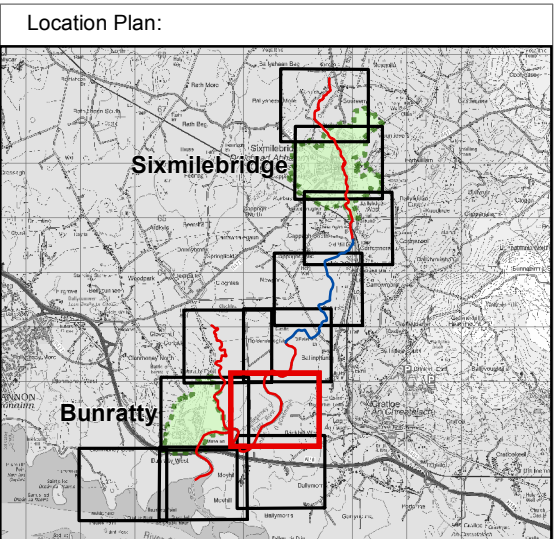
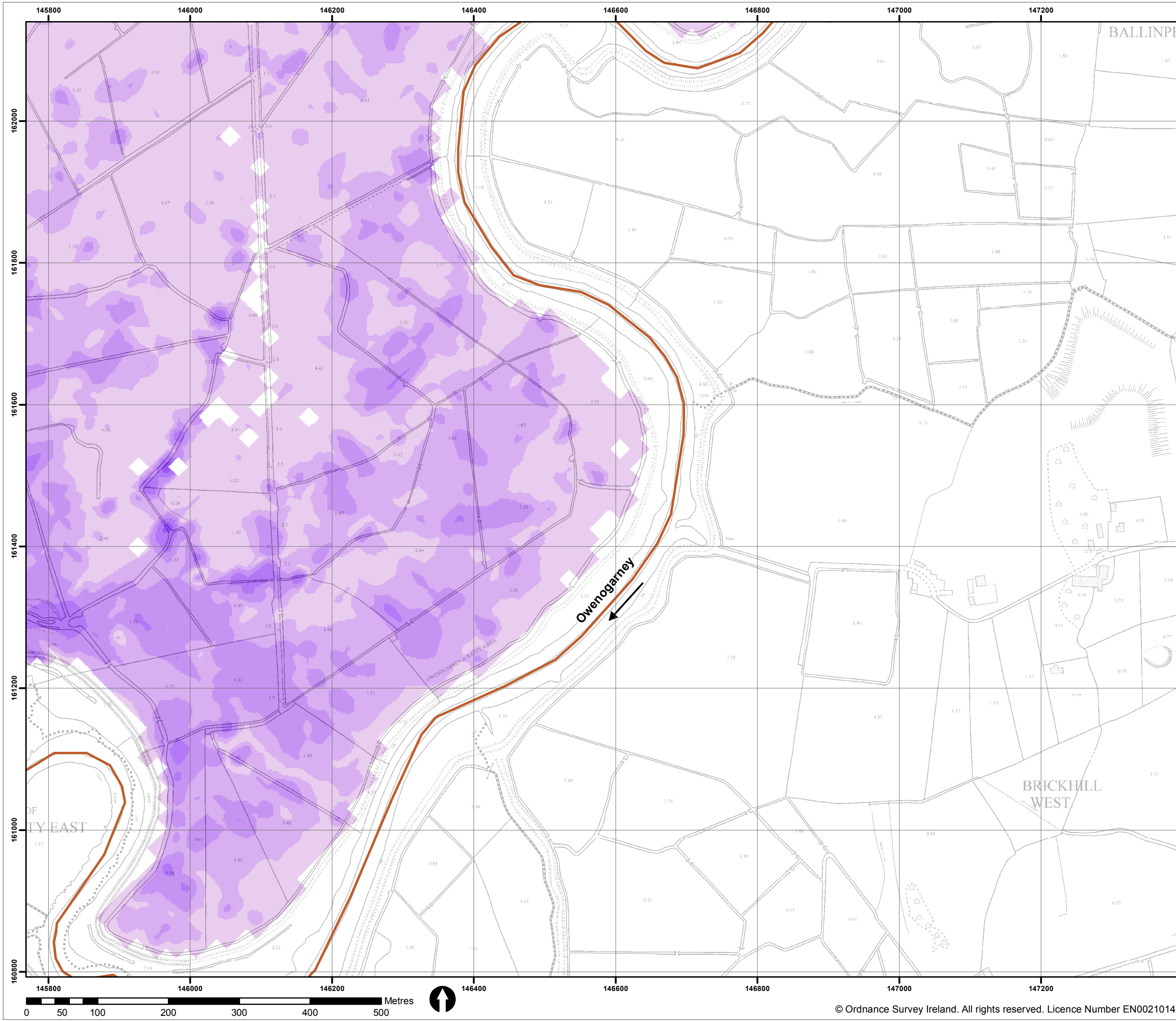
Map:
SIXMILEBRIDGE & BUNRATTY

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 5% AEP COASTAL FAILURE SCENARIO 1
Map area: SIXMILEBRIDGE & BUNRATTY
Scenario: EXISTING

Drawn by: EH	Date: November 2015
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Map No.: S03FVCCDC1

Sheet: 5 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
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5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
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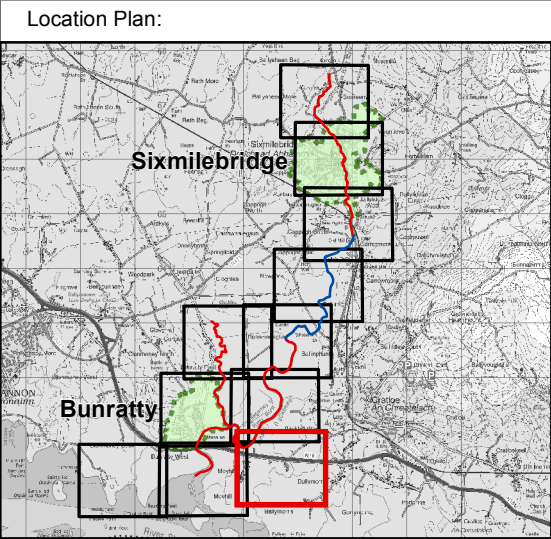
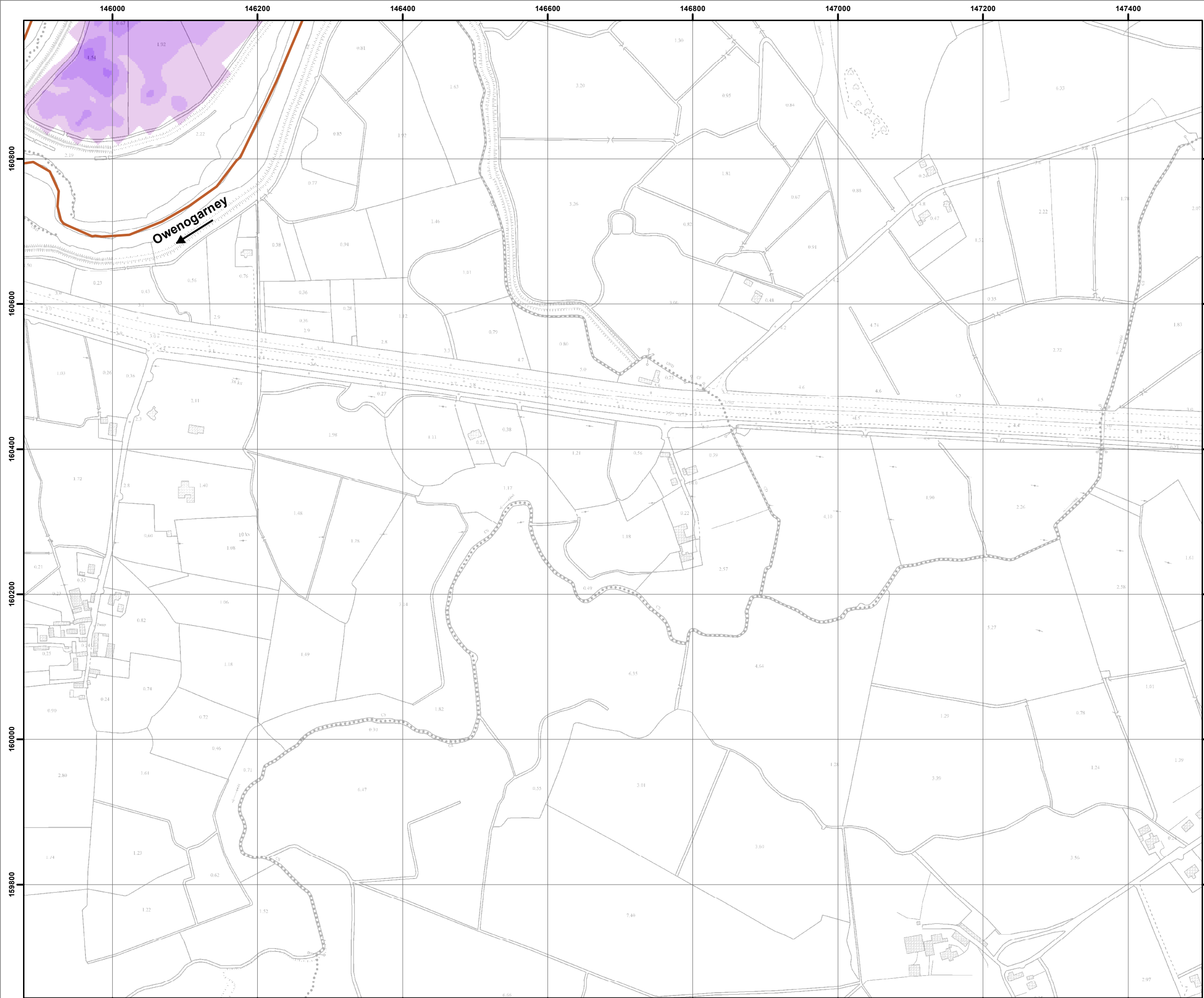
Map:
SIXMILEBRIDGE & BUNRATTY

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 5% AEP COASTAL FAILURE SCENARIO 1
Map area: SIXMILEBRIDGE & BUNRATTY
Scenario: EXISTING

Drawn by: EH	Date: November 2015
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Map No.: S03FVCCDC1

Sheet: 6 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0


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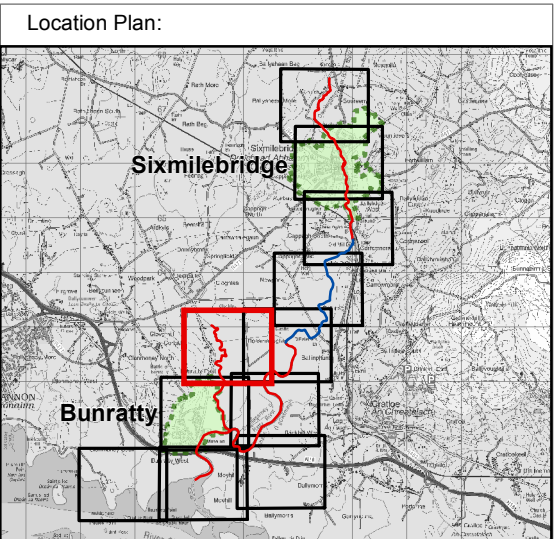
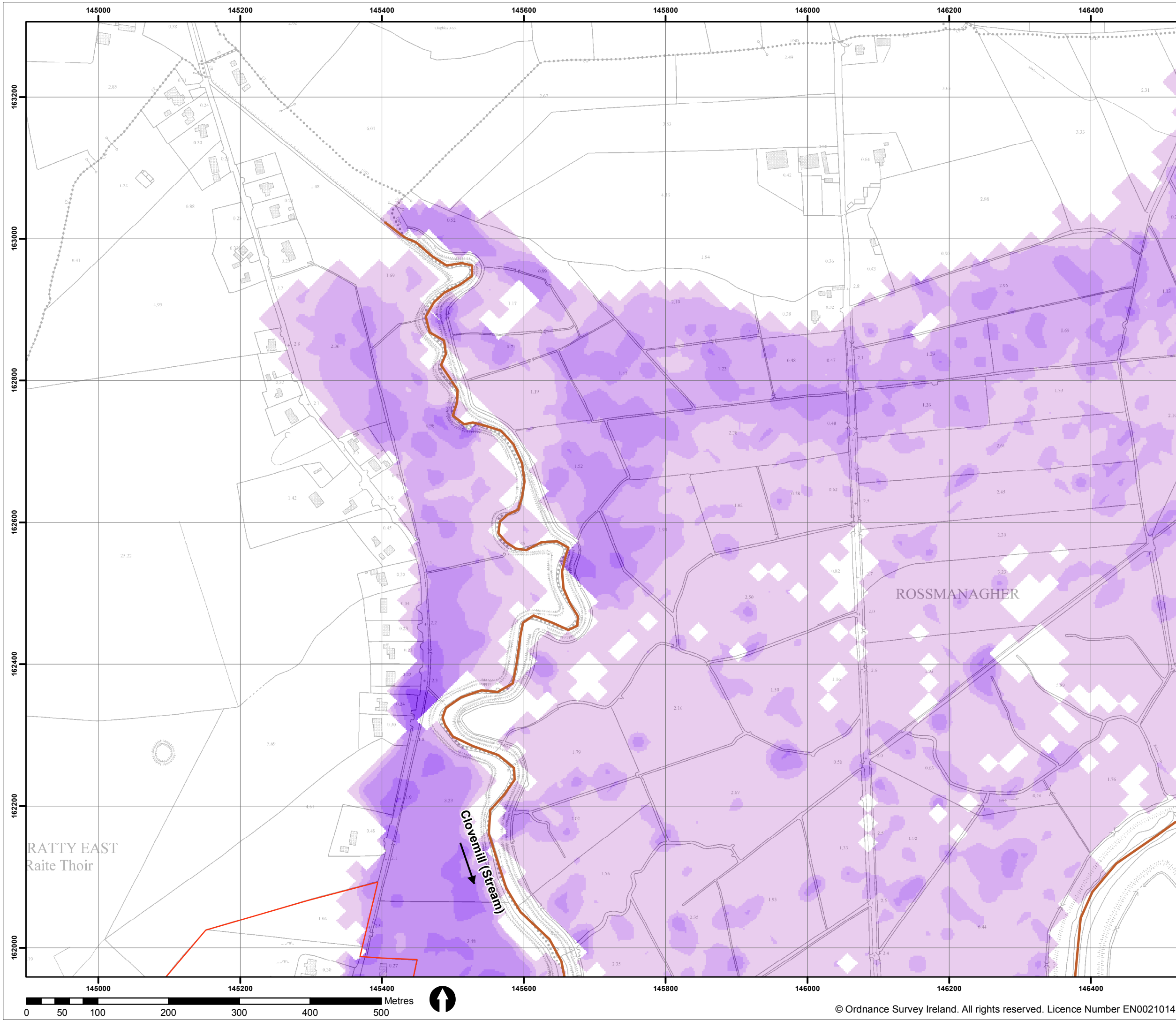
Project:
SHANNON CFRAM STUDY

Map:
SIXMILEBRIDGE & BUNRATTY

Map Type:	DEFENCE FAILURE VELOCITY MAP	
Source:	5% AEP COASTAL FAILURE SCENARIO 1	
Map area:	SIXMILEBRIDGE & BUNRATTY	
Scenario:	EXISTING	

Drawn by:	EH	Date:	November 2015
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Map No.:	S03FVCCDC1		
Sheet:	7 of 11	Revision:	0
Map Scale:	1: 5000	Plot Scale:	1:1 @ A3



Legend:

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- AFA Boundary
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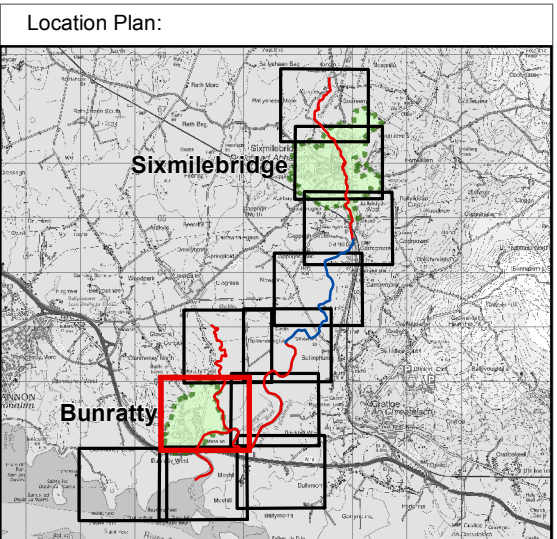
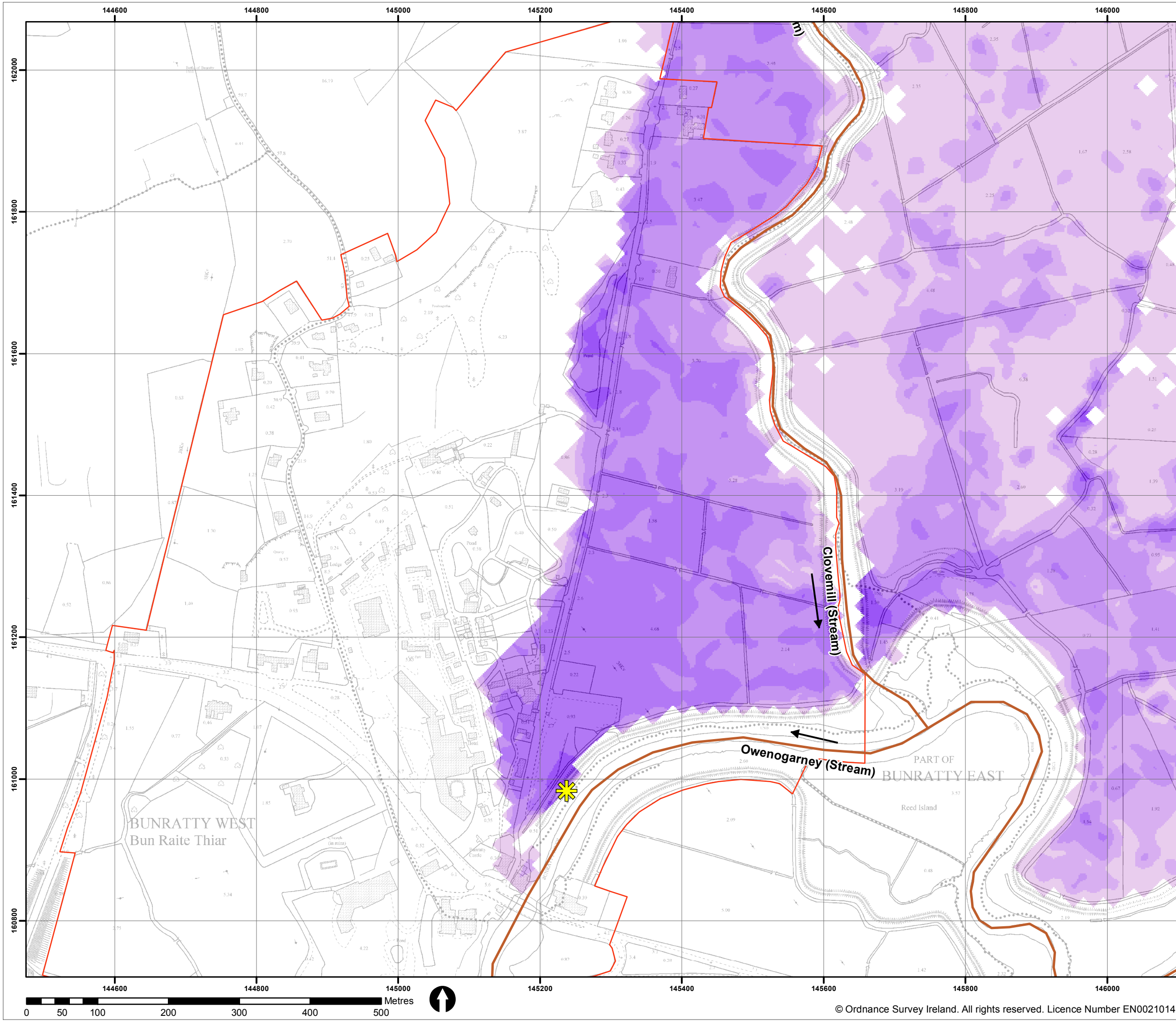


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Project: SHANNON CFRAM STUDY	
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Map Type:	DEFENCE FAILURE VELOCITY MAP
Source:	5% AEP COASTAL FAILURE SCENARIO 1
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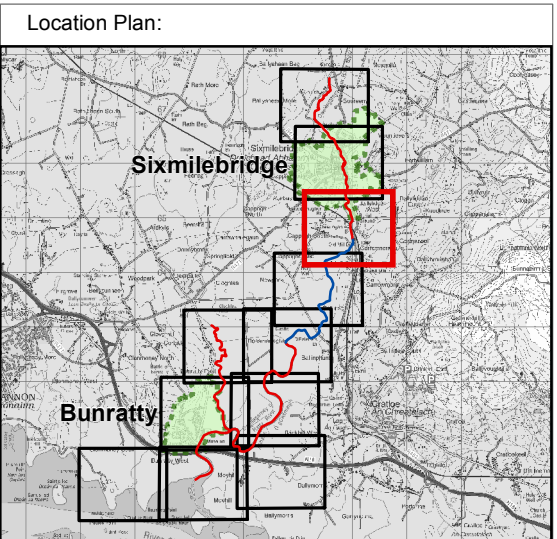
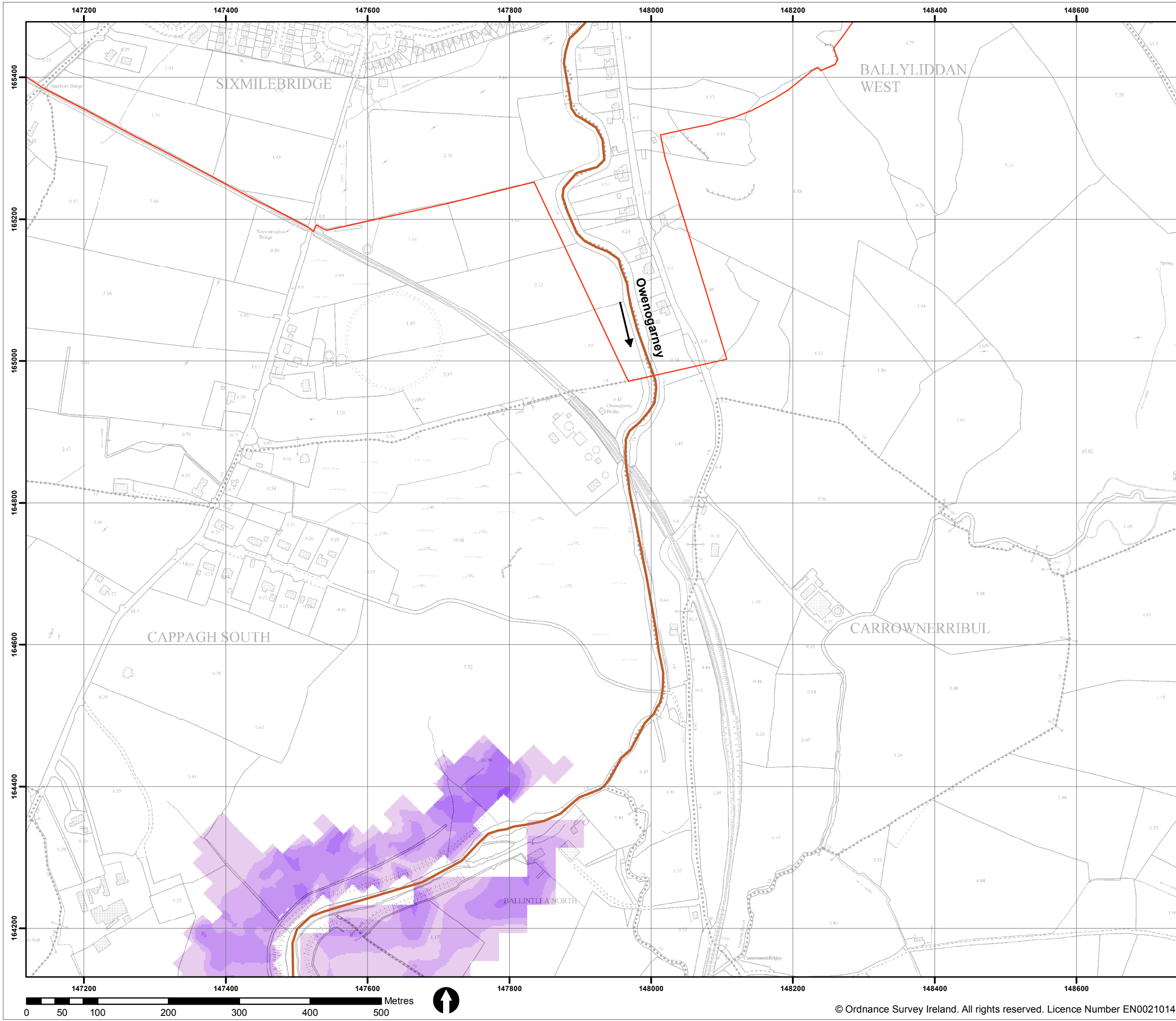
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SIXMILEBRIDGE & BUNRATTY

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Scenario: EXISTING

Drawn by: EH	Date: November 2015
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Legend:

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0.5% AEP Coastal Failure Scenario 2 (m/s)

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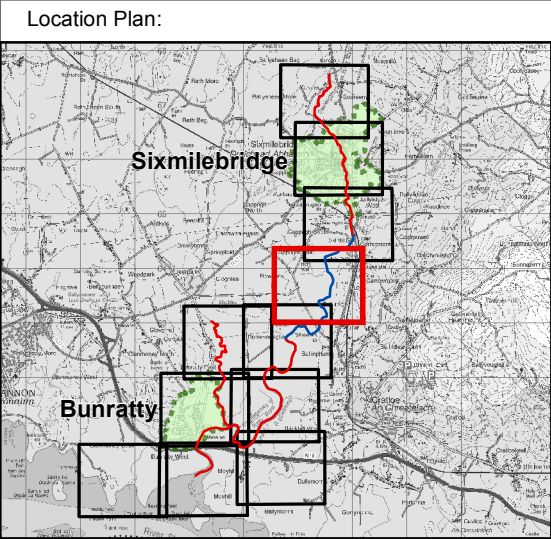
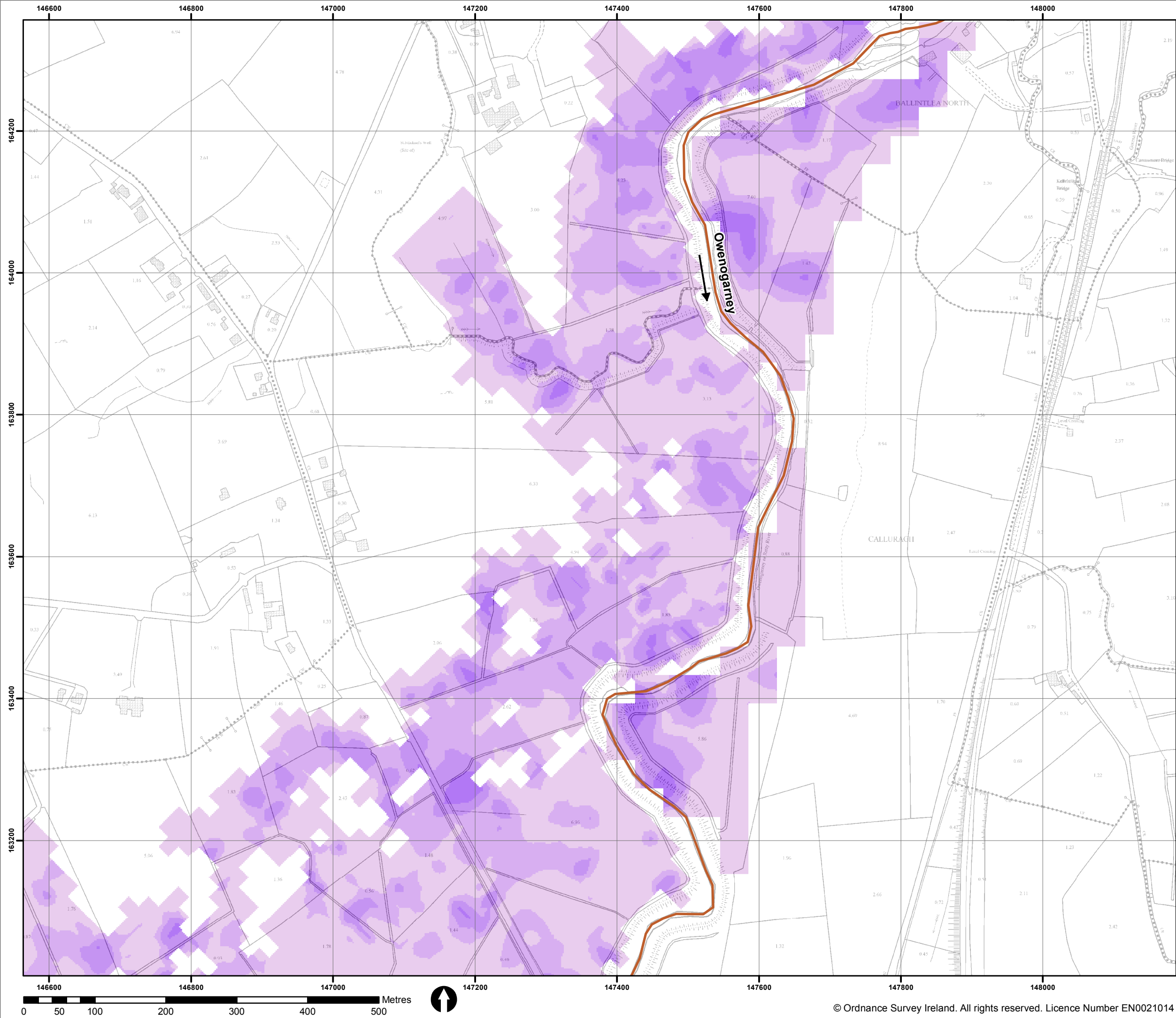


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Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2	
Map area: SIXMILEBRIDGE & BUNRATTY	
Scenario: EXISTING	
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SHANNON CFRAM STUDY

Map:
SIXMILEBRIDGE & BUNRATTY

Map Type: DEFENCE FAILURE VELOCITY MAP

Source: 0.5% AEP COASTAL FAILURE SCENARIO 2

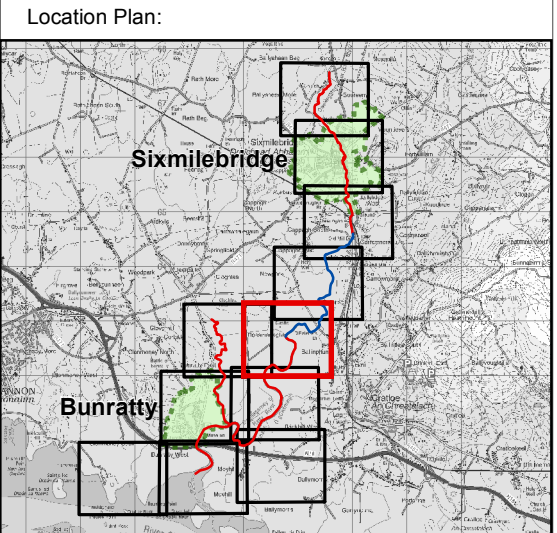
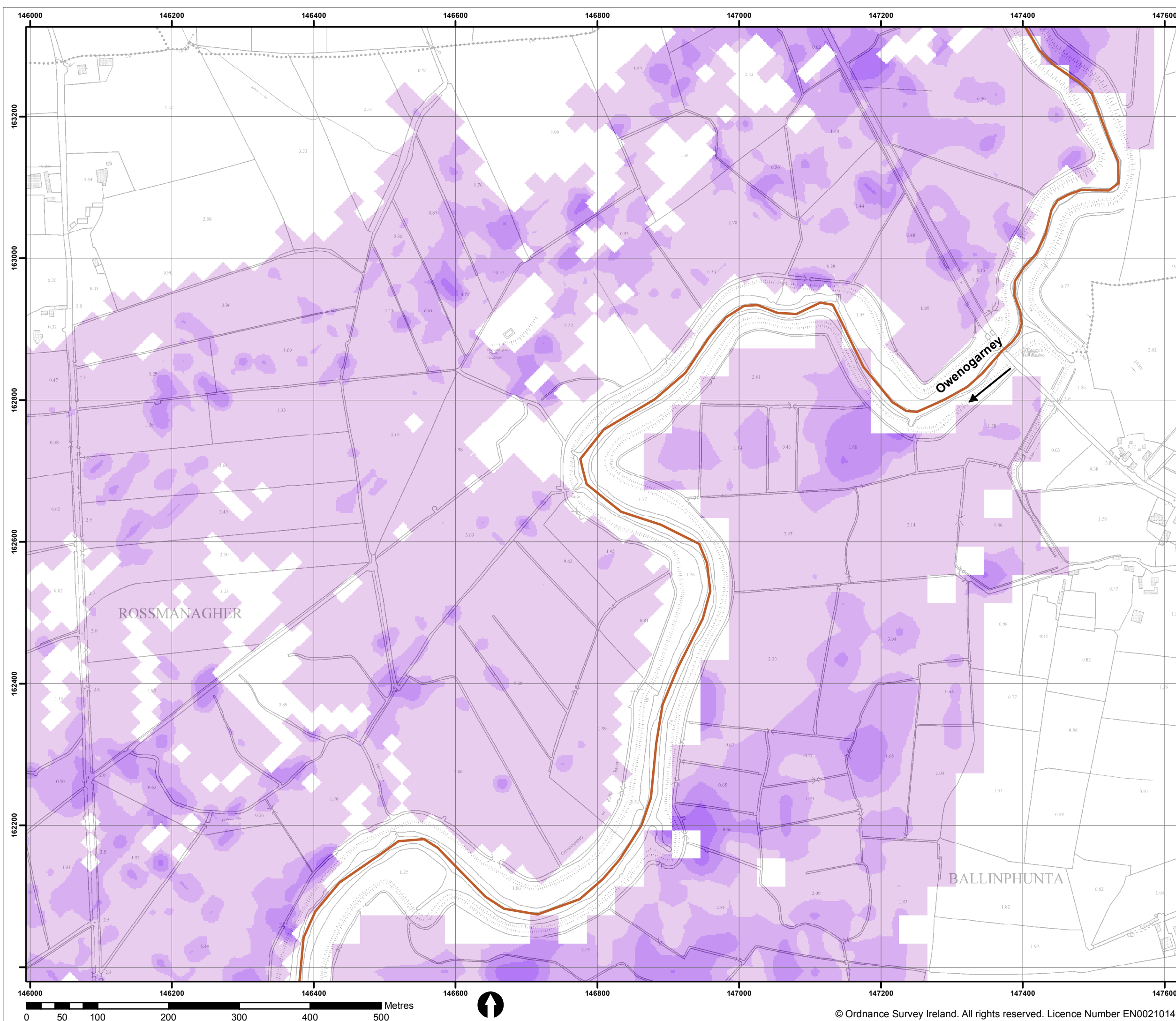
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Scenario: EXISTING

Drawn by: EH	Date: November 2015
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Map No.: S03FVCCDC1

Sheet: 4 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
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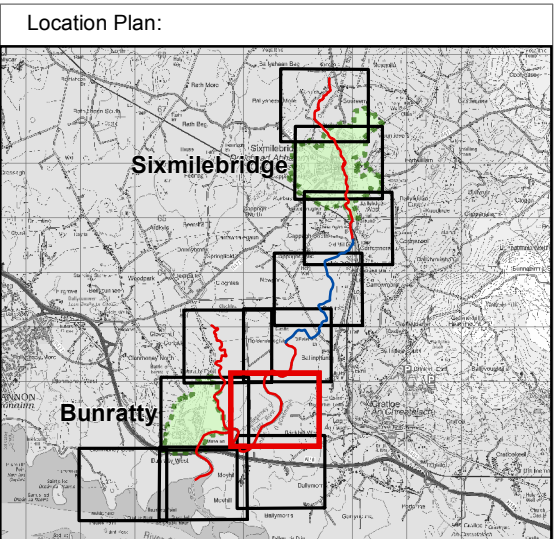
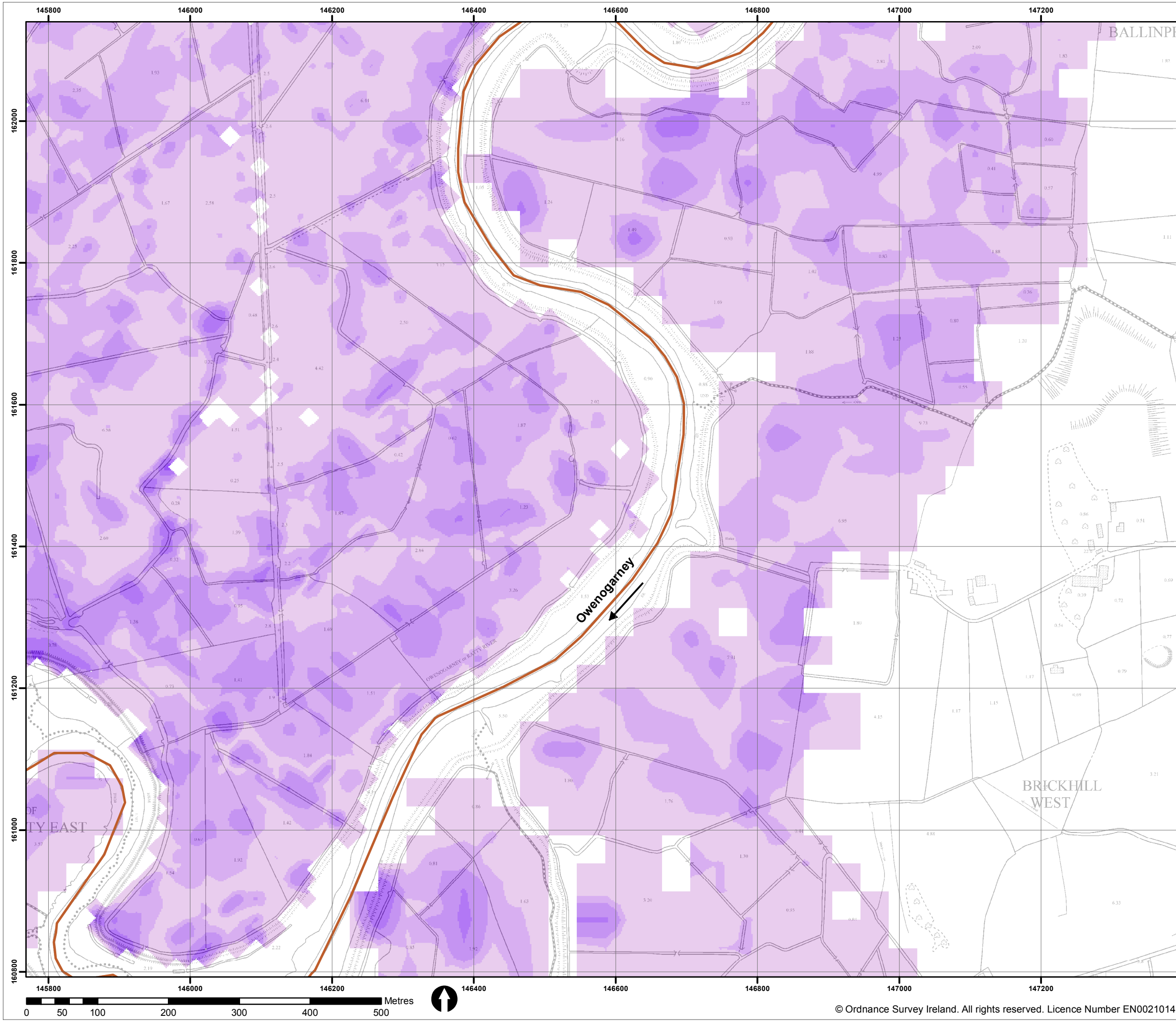
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SIXMILEBRIDGE & BUNRATTY

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SIXMILEBRIDGE & BUNRATTY
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Drawn by: EH	Date: November 2015
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Map No.: S03FVCCDC1

Sheet: 5 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0


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Project:
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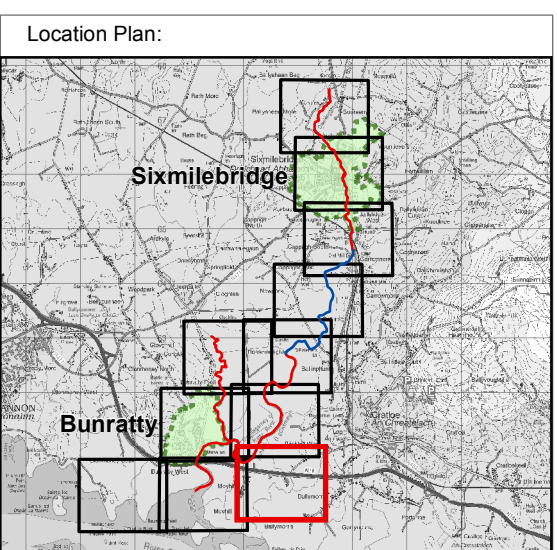
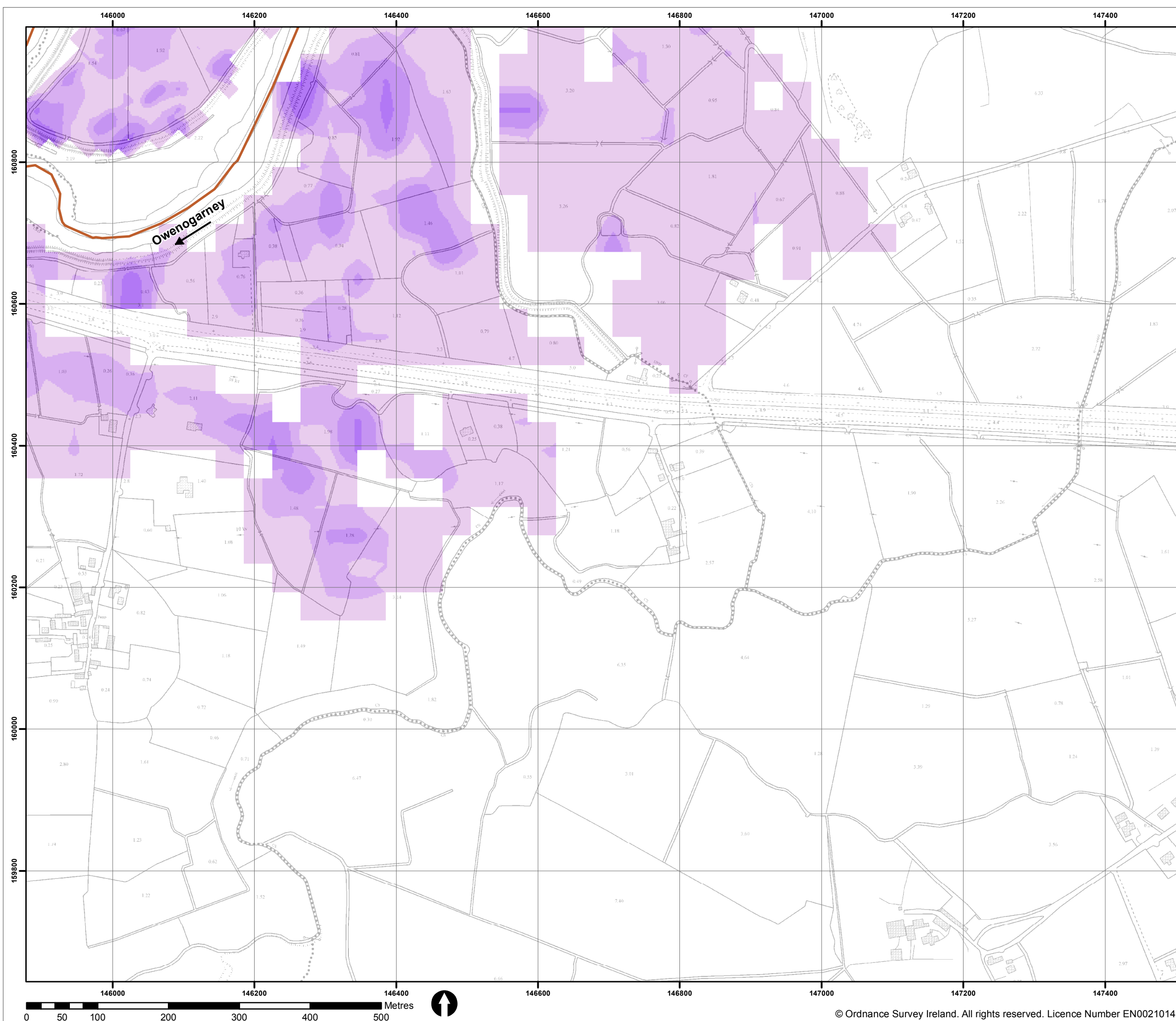
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SIXMILEBRIDGE & BUNRATTY

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SIXMILEBRIDGE & BUNRATTY
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: S03FVCCDC1

Sheet: 6 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
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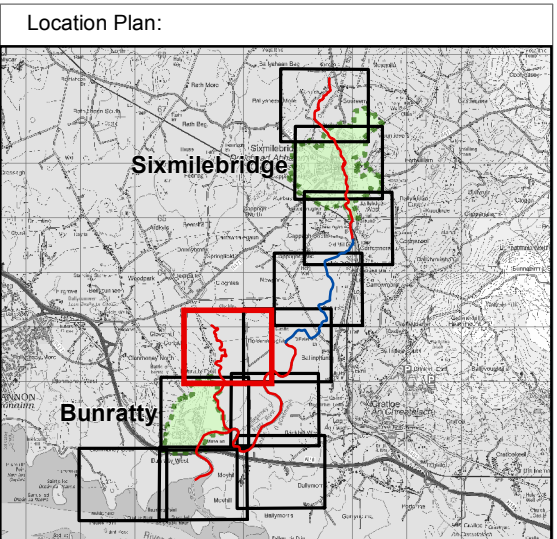
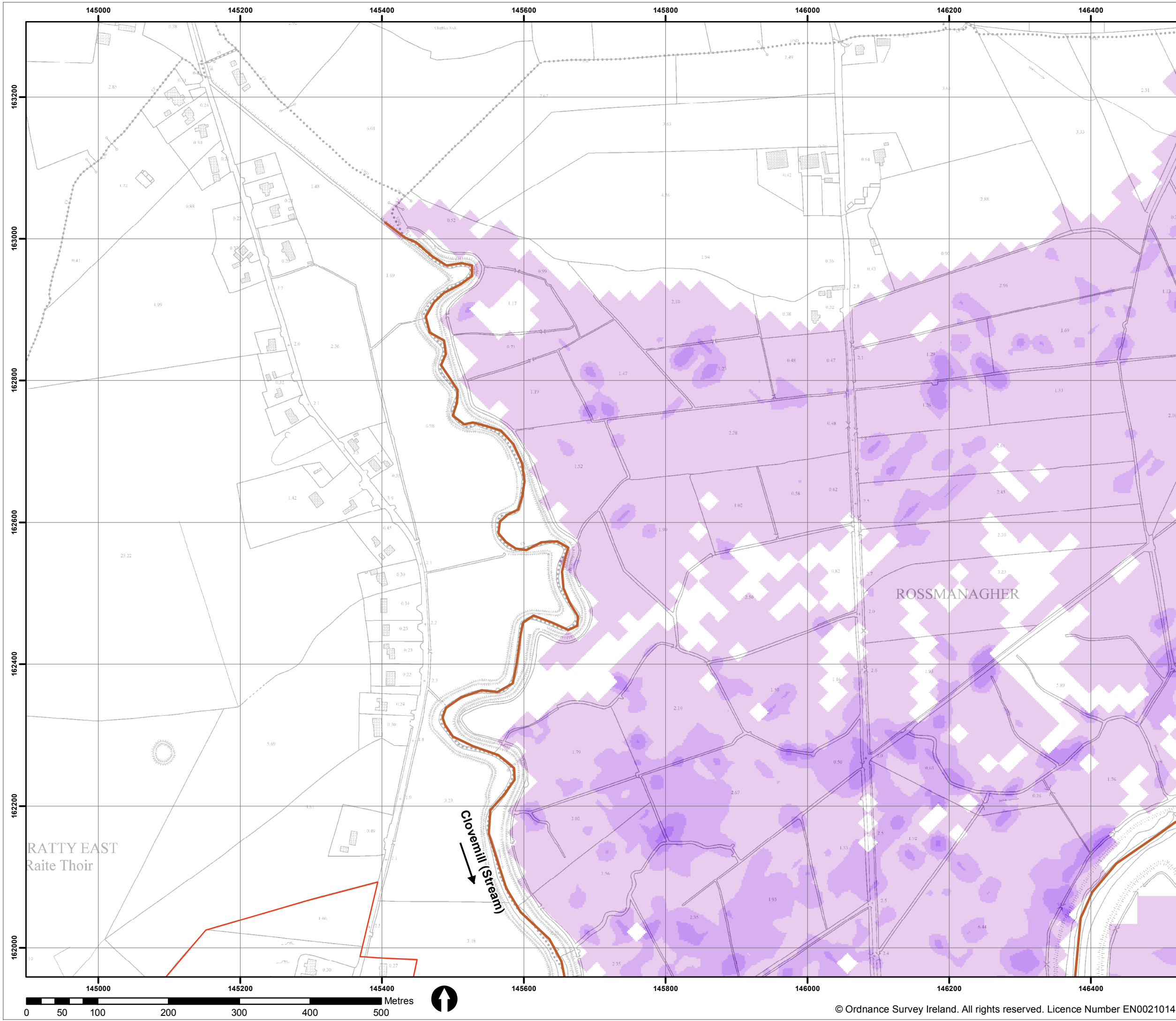


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Project: SHANNON CFRAM STUDY	
Map: SIXMILEBRIDGE & BUNRATTY	
Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2	
Map area: SIXMILEBRIDGE & BUNRATTY	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: S03FVCCDC1	
Sheet: 7 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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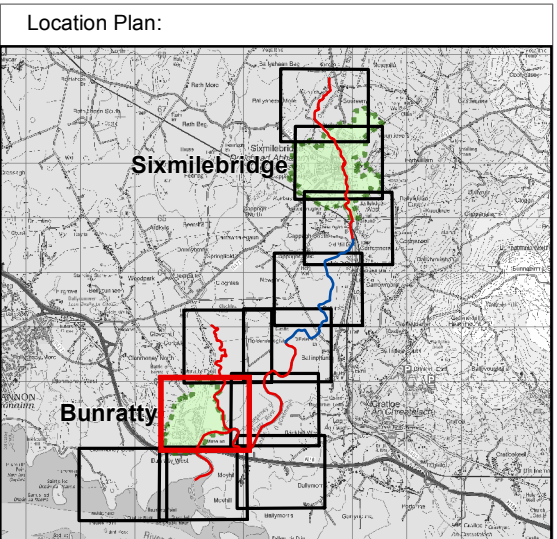
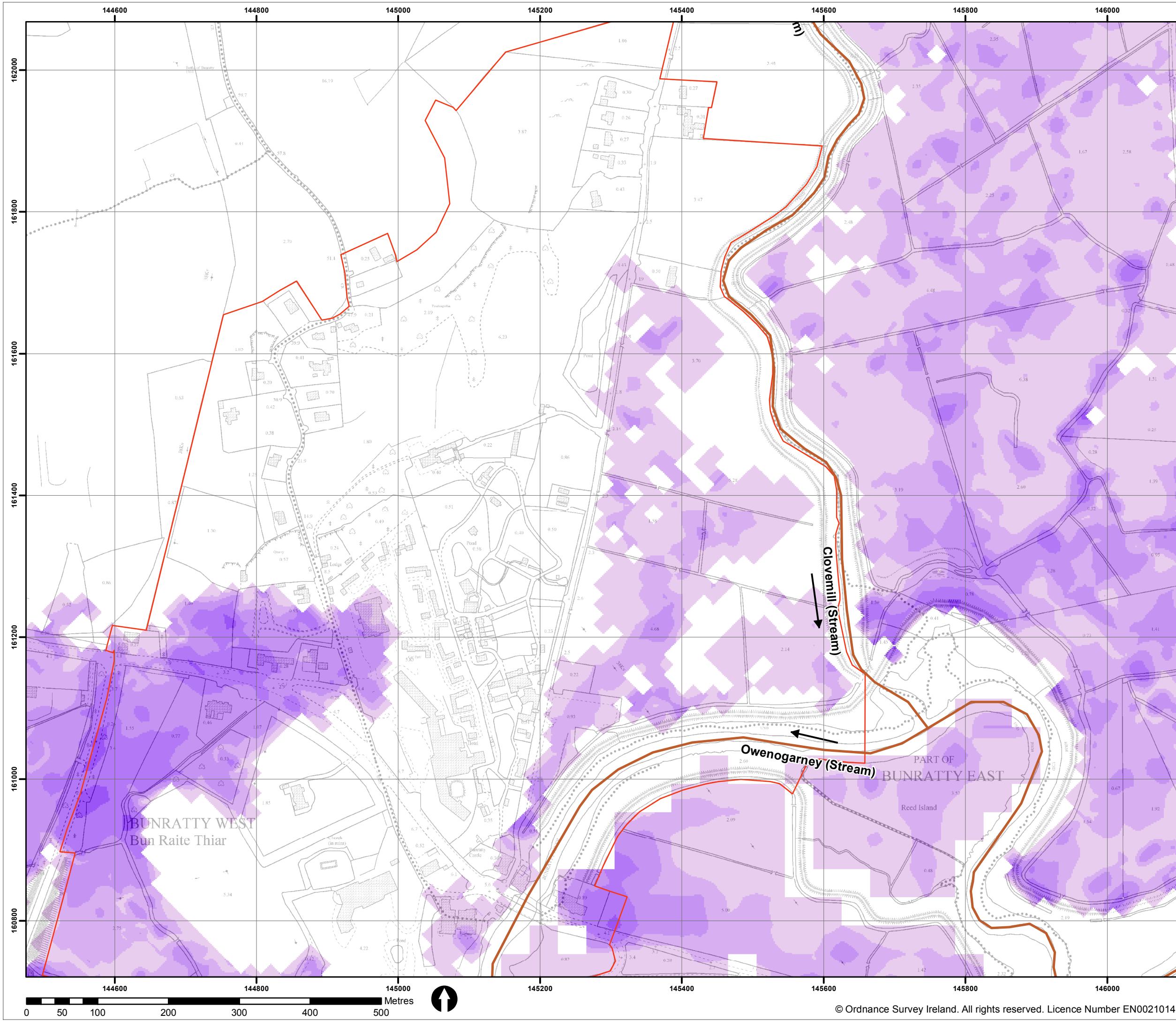


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Project: SHANNON CFRAM STUDY	
Map: SIXMILEBRIDGE & BUNRATTY	
Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2	
Map area: SIXMILEBRIDGE & BUNRATTY	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: S03FVCCDC1	
Sheet: 8 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
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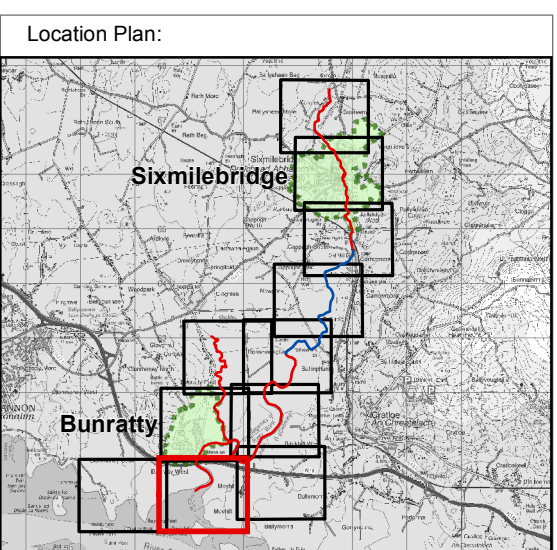
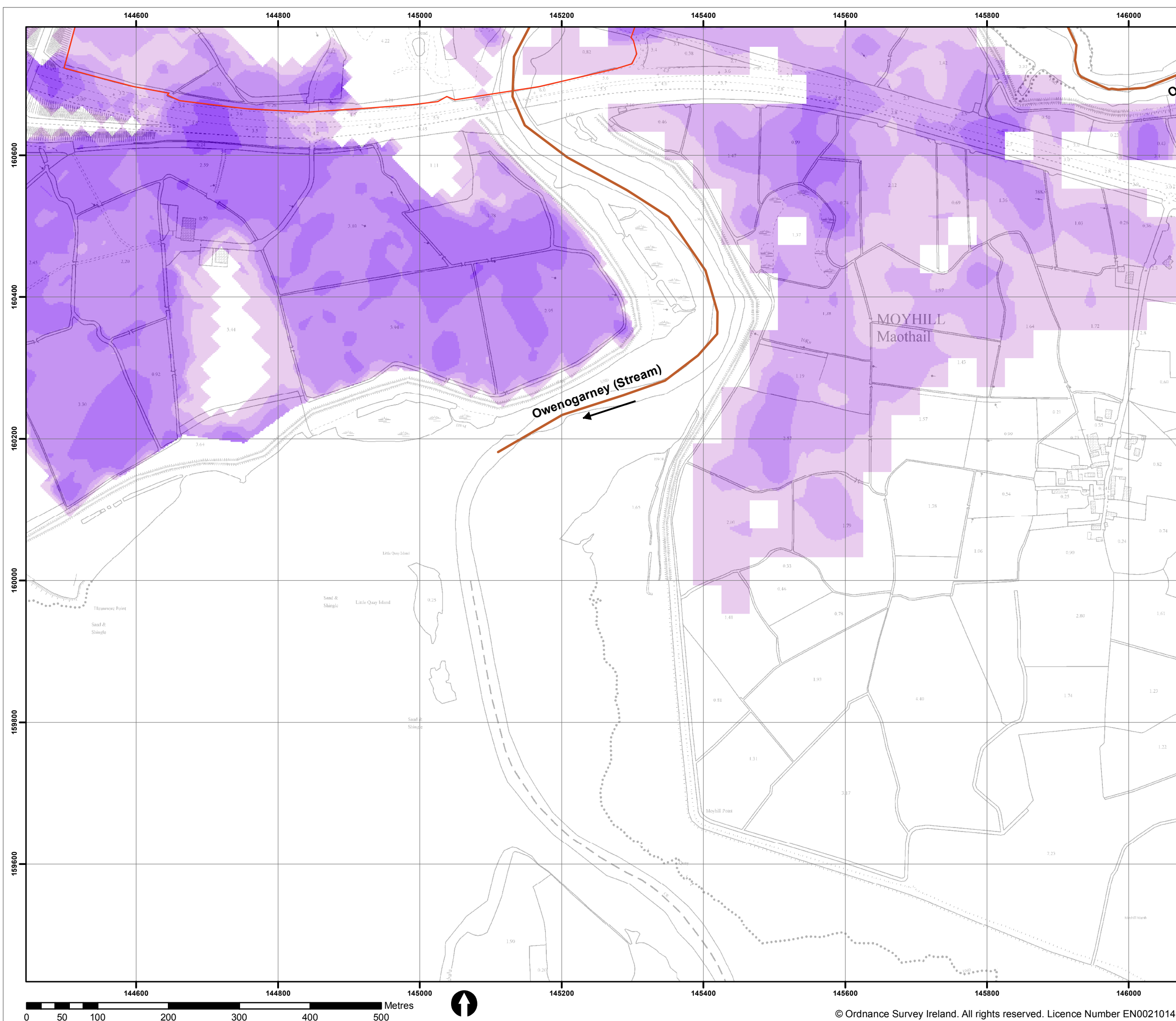
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SIXMILEBRIDGE & BUNRATTY

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SIXMILEBRIDGE & BUNRATTY
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: S03FVCCDC1
Sheet: 9 of 11
Map Scale: 1: 5000

Revision: 0
Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
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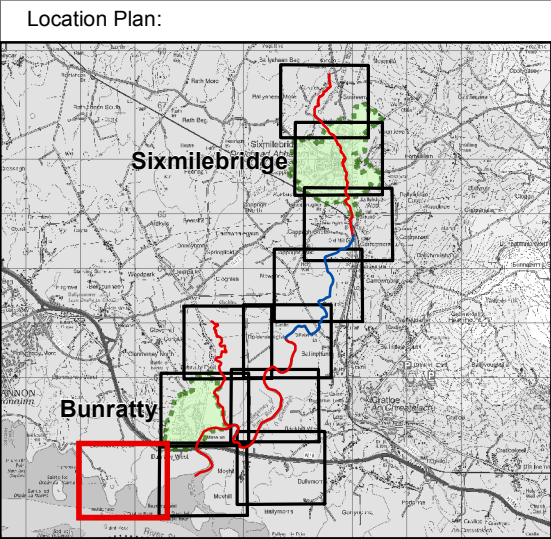
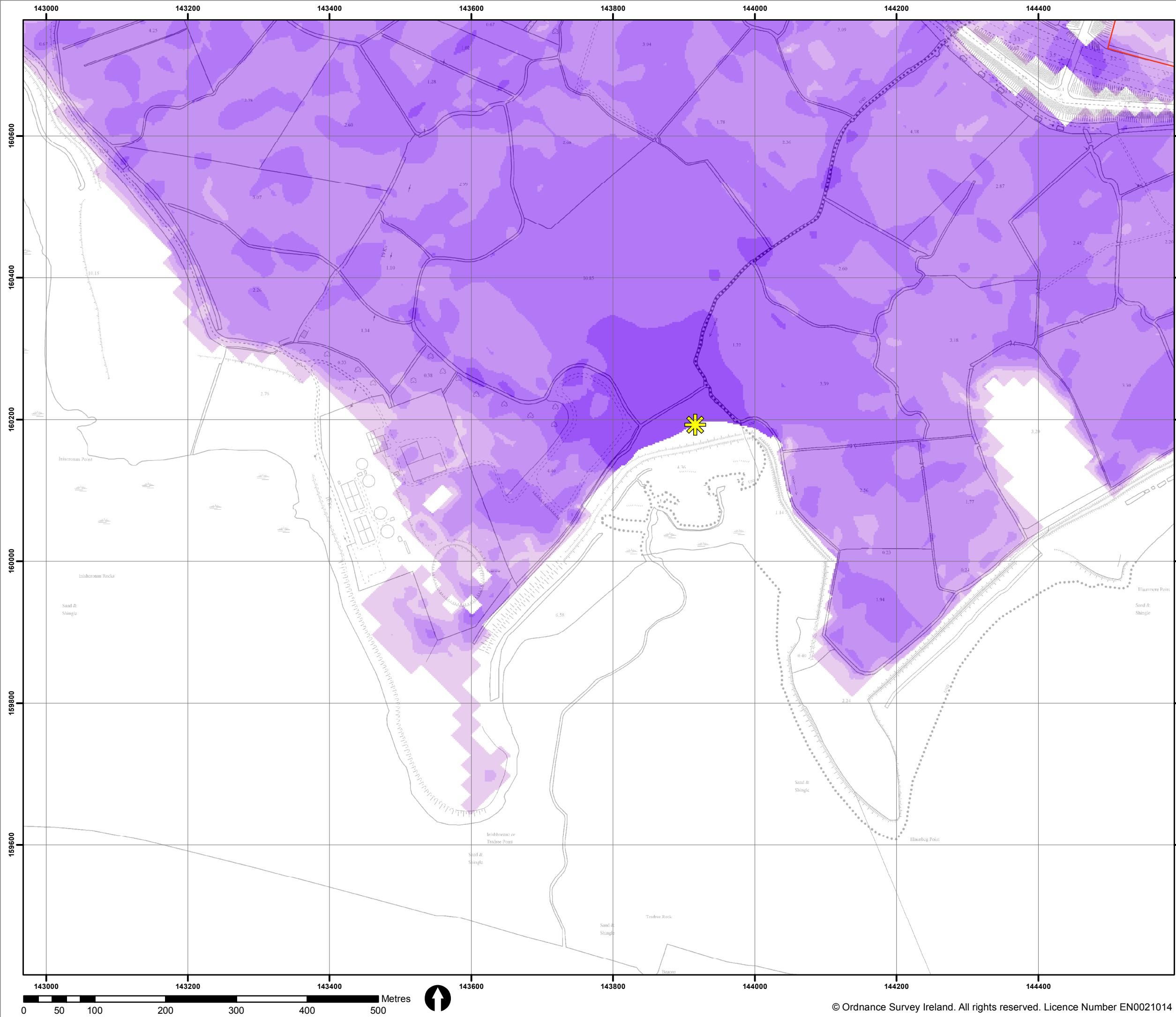
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SIXMILEBRIDGE & BUNRATTY

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SIXMILEBRIDGE & BUNRATTY
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: S03FVCCDC1

Sheet: 10 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0


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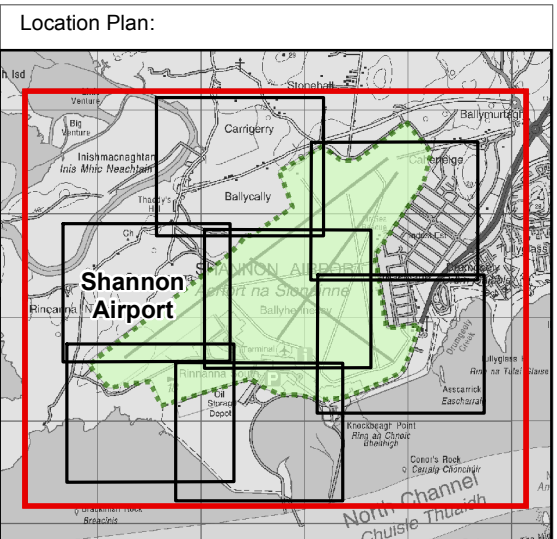
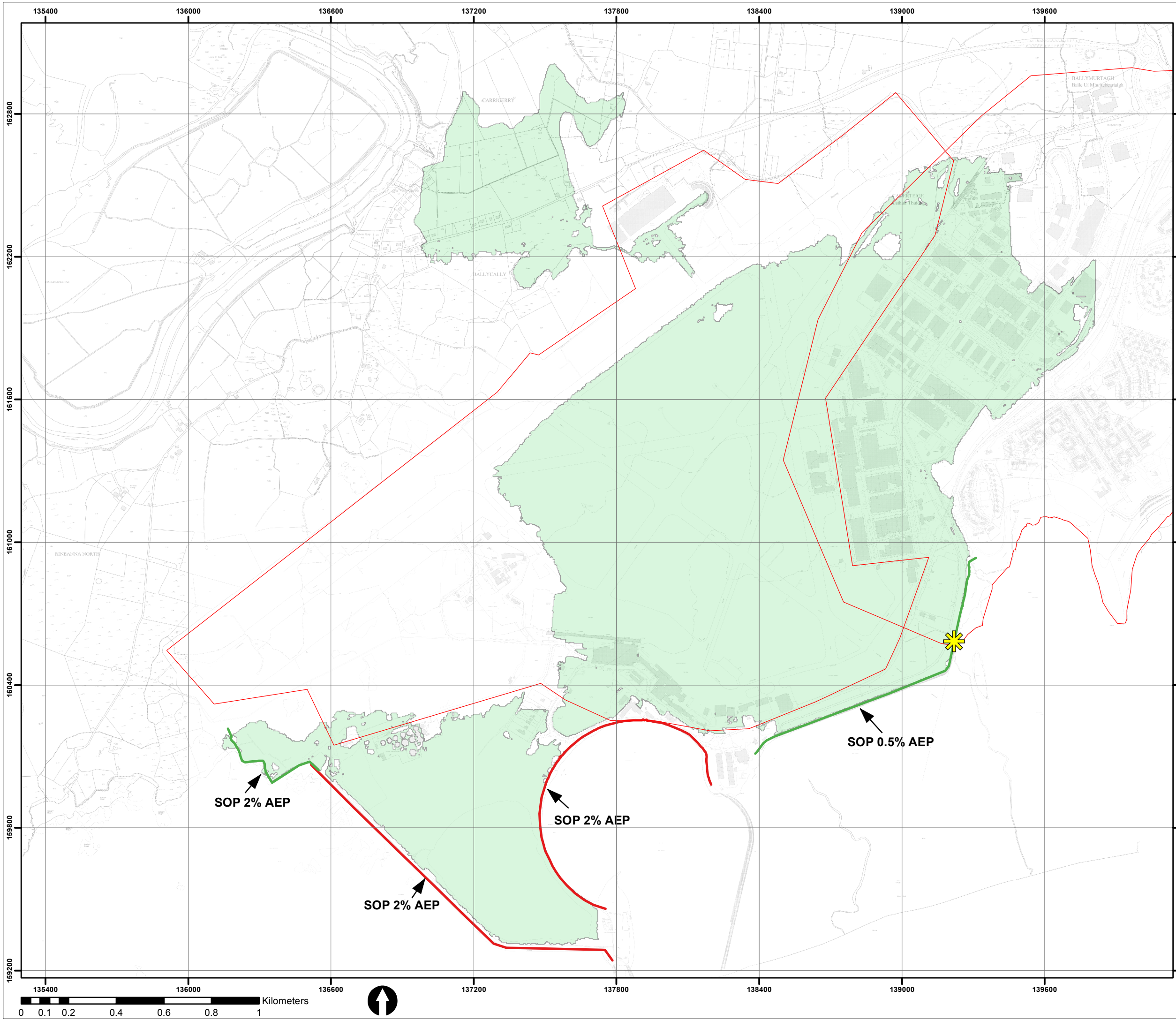
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SIXMILEBRIDGE & BUNRATTY

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SIXMILEBRIDGE & BUNRATTY
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: S03FVCCDC1

Sheet: 11 of 11	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3




- Legend:**
- AFA Boundary
 - Defence - Wall
 - Defence - Embankment
 - Defence Failure Location
 - 0.5% AEP Coastal Failure Scenario 1


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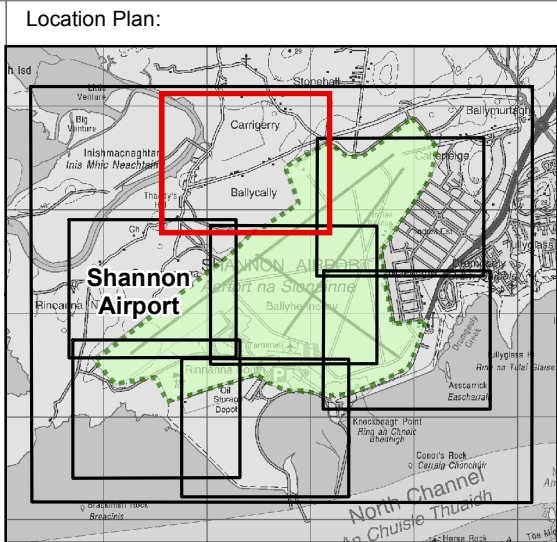
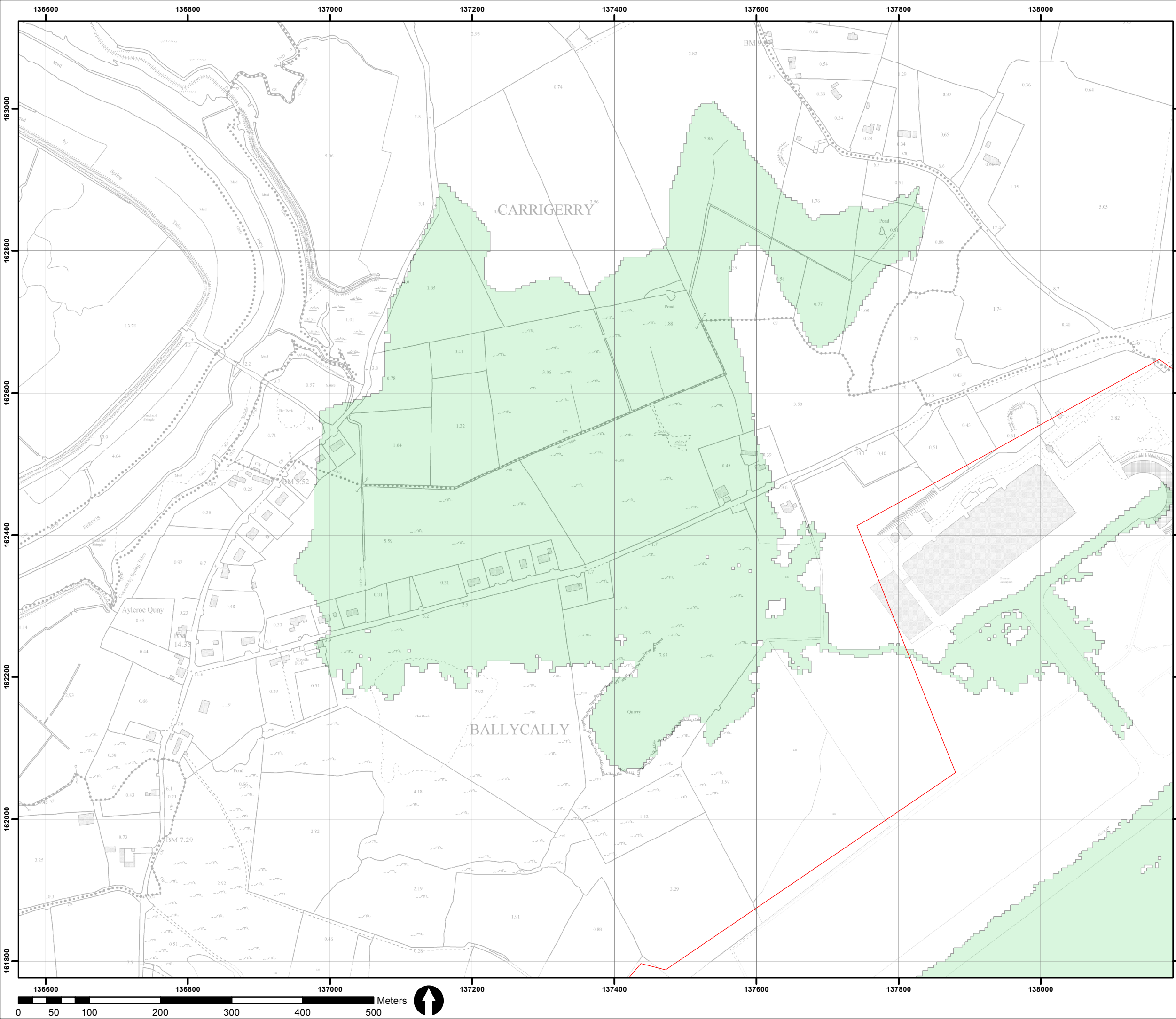
Map:
SHANNON AIRPORT

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON AIRPORT
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: IRR3FECCDC1

Sheet: 1 of 8	Revision: 0
Map Scale: 1: 15000	Plot Scale: 1:1 @ A3



- Legend:**
- AFA Boundary
 - Defence - Wall
 - Defence - Embankment
 - Defence Failure Location
 - 0.5% AEP Coastal Failure Scenario 1

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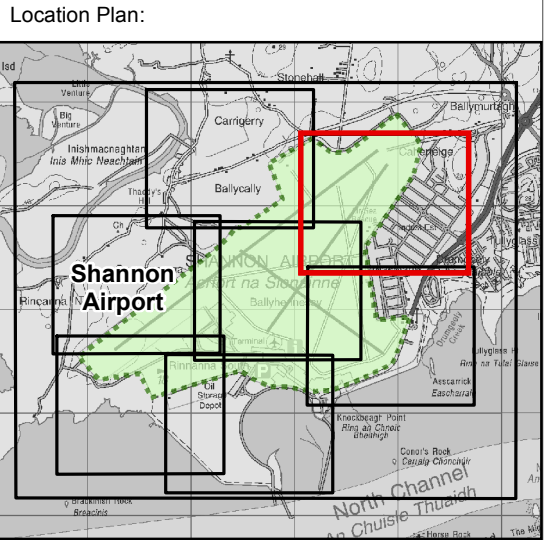
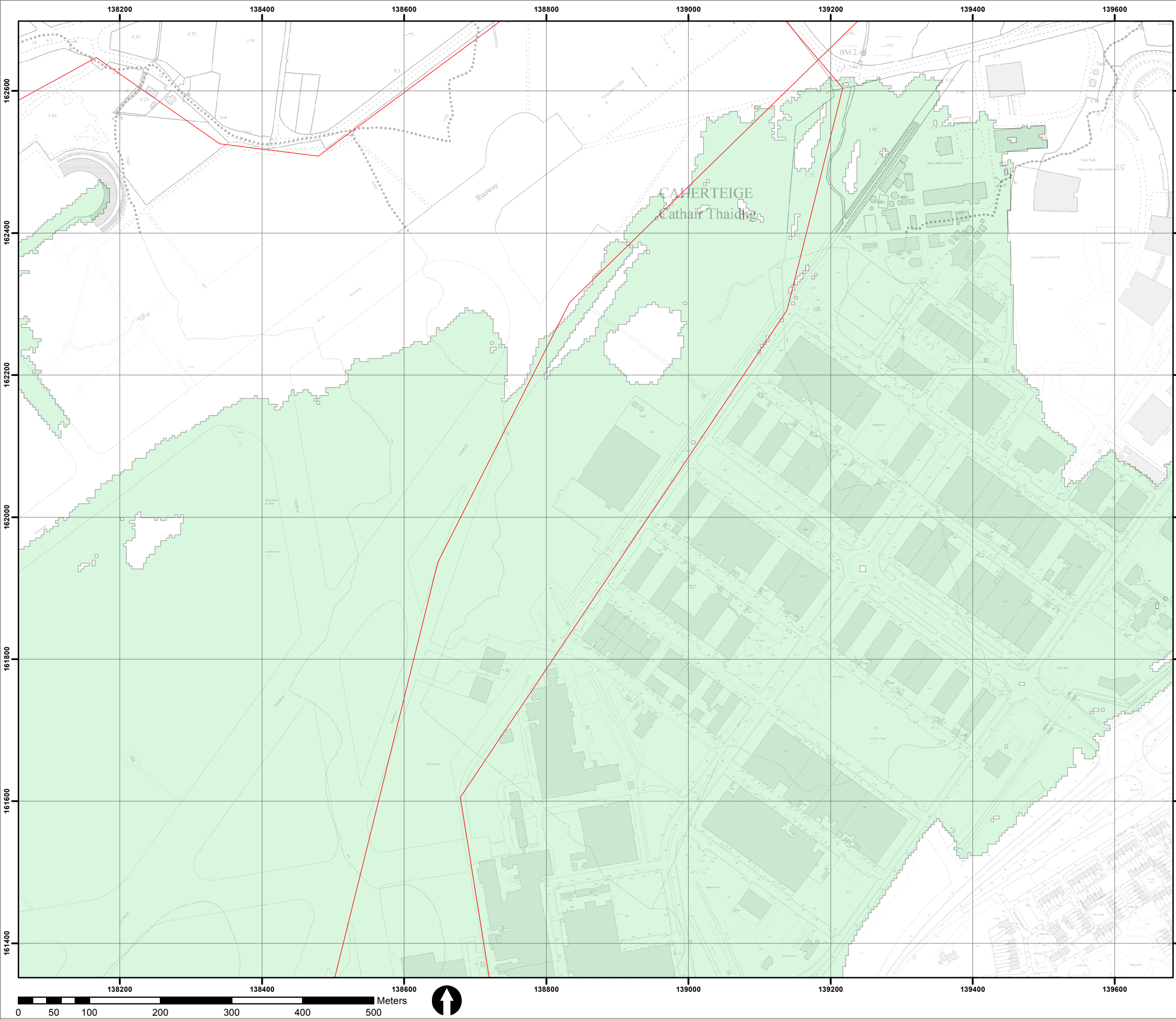


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Project: SHANNON CFRAM STUDY	
Map: SHANNON AIRPORT	
Map Type: DEFENCE FAILURE EXTENT MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 2 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



- Legend:**
- AFA Boundary
 - Defence - Wall
 - Defence - Embankment
 - Defence Failure Location
 - 0.5% AEP Coastal Failure Scenario 1

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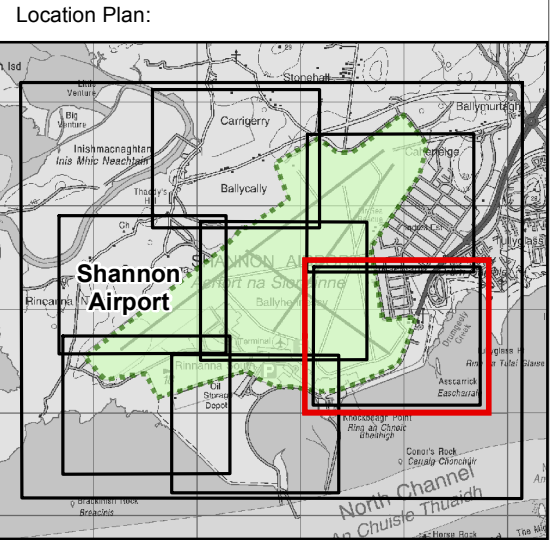
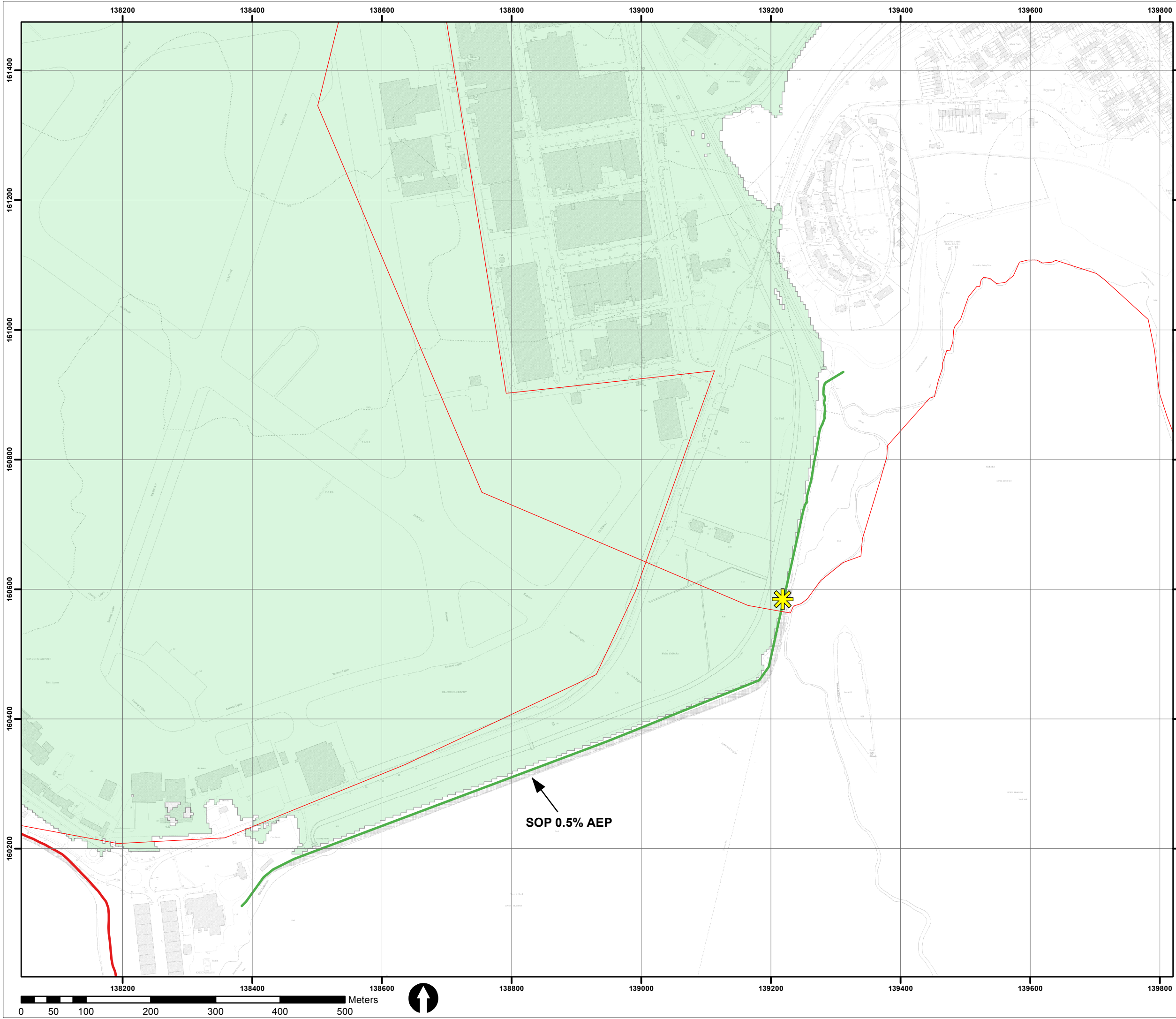


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Project: SHANNON CFRAM STUDY	
Map: SHANNON AIRPORT	
Map Type: DEFENCE FAILURE EXTENT MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 3 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



- Legend:**
- AFA Boundary
 - Defence - Wall
 - Defence - Embankment
 - Defence Failure Location
 - 0.5% AEP Coastal Failure Scenario 1

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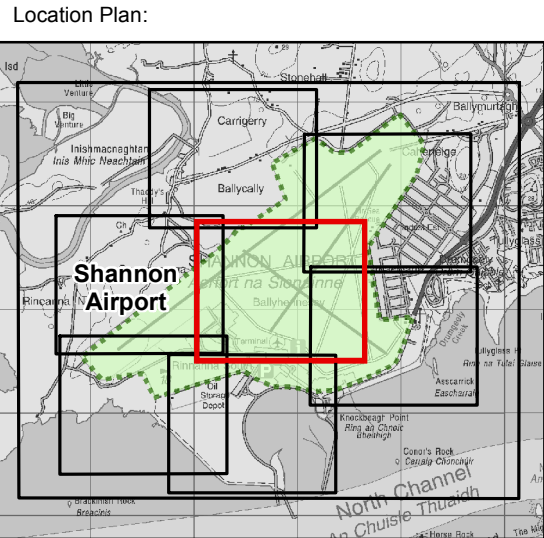
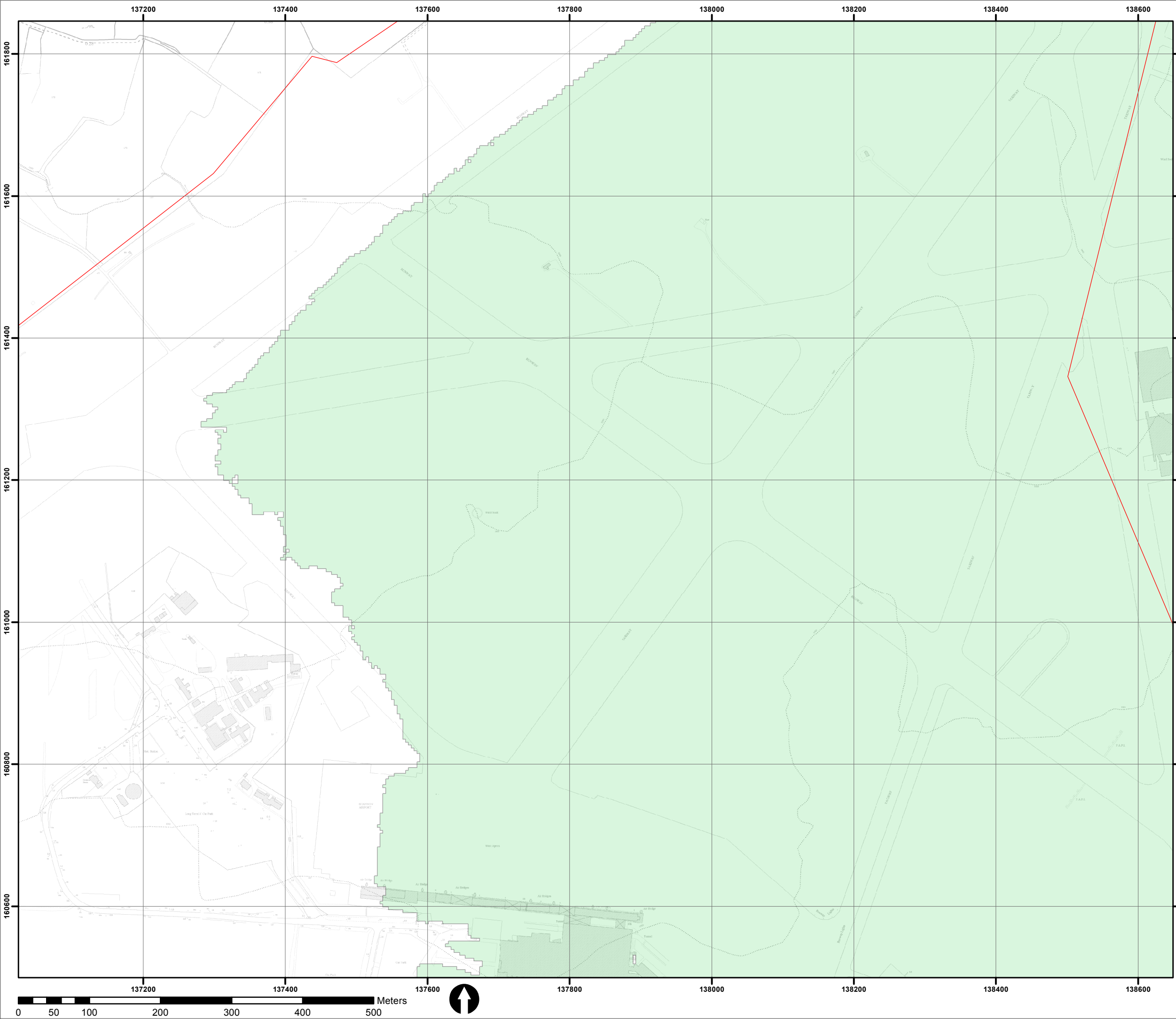


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Project: SHANNON CFRAM STUDY	
Map: SHANNON AIRPORT	
Map Type: DEFENCE FAILURE EXTENT MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 4 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



- Legend:**
- AFA Boundary
 - Defence - Wall
 - Defence - Embankment
 - Defence Failure Location
 - 0.5% AEP Coastal Failure Scenario 1

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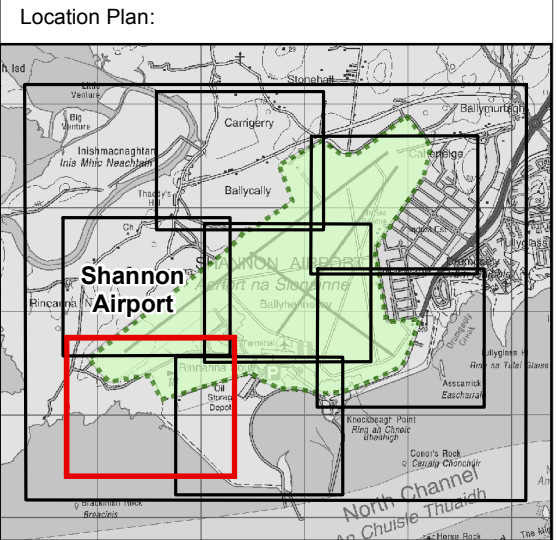
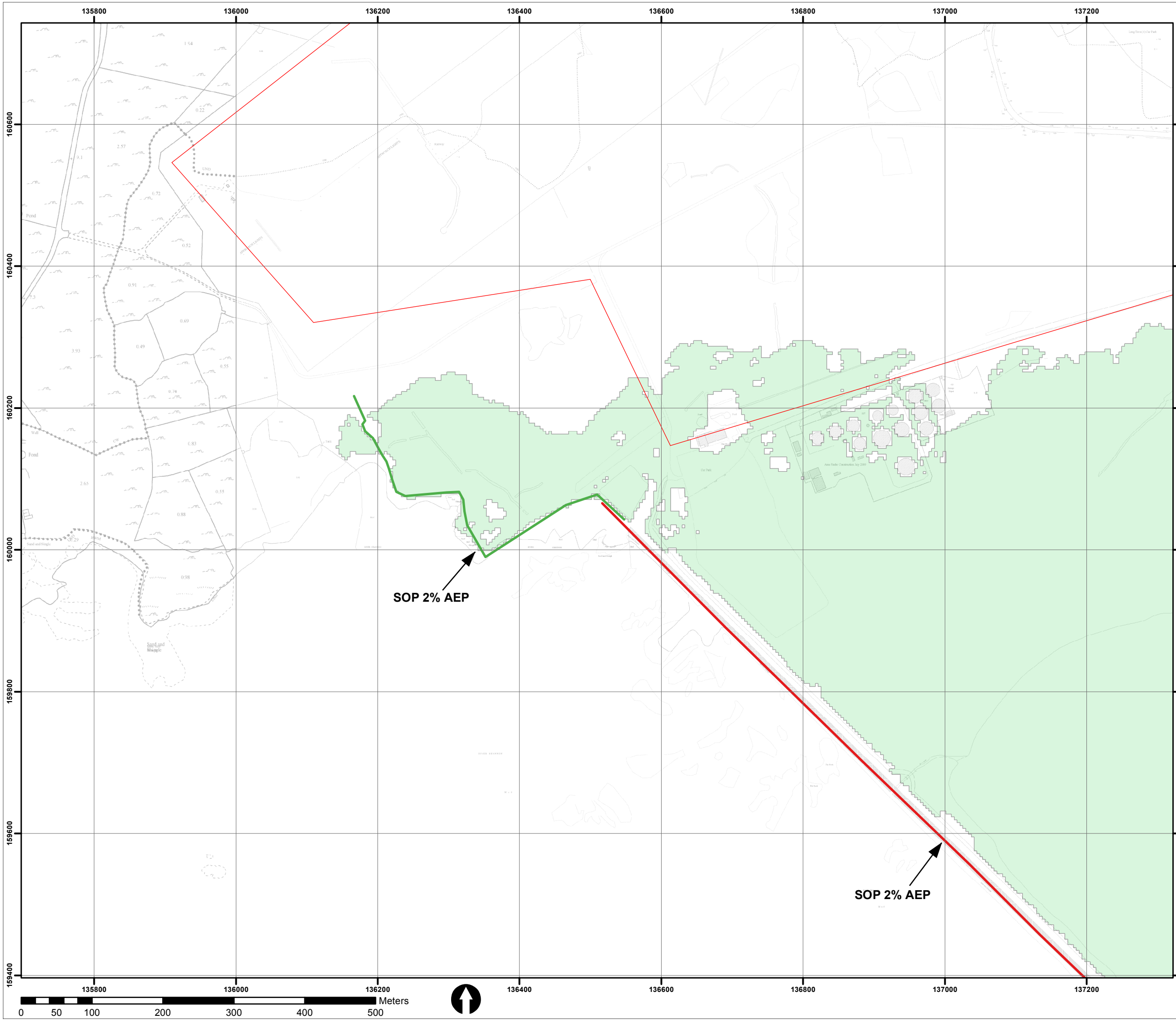


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Project: SHANNON CFRAM STUDY	
Map: SHANNON AIRPORT	
Map Type: DEFENCE FAILURE EXTENT MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 5 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3




- Legend:**
- AFA Boundary
 - Defence - Wall
 - Defence - Embankment
 - Defence Failure Location
 - 0.5% AEP Coastal Failure Scenario 1


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Project:
SHANNON CFRAM STUDY

Map:
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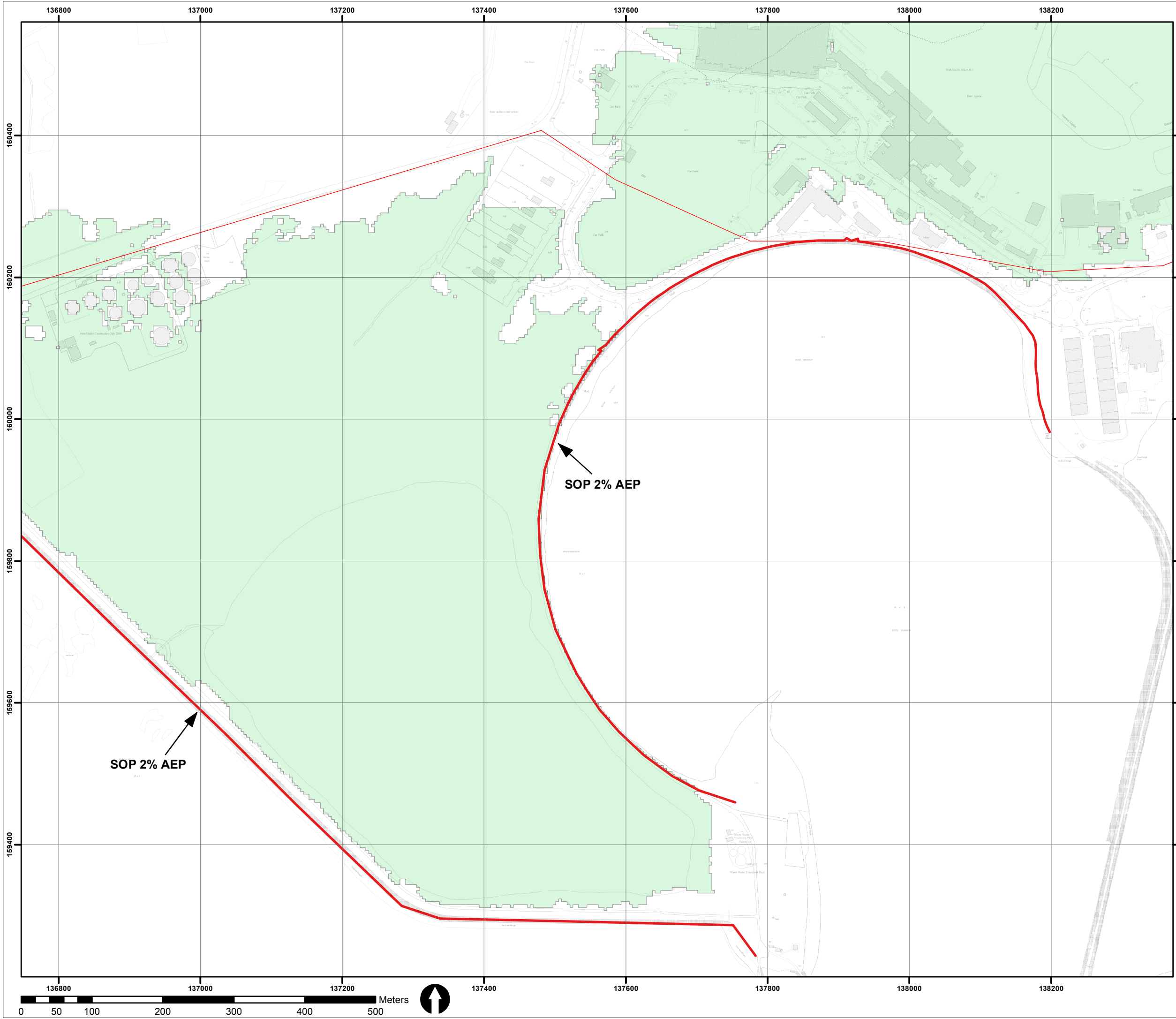
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Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON AIRPORT
Scenario: EXISTING

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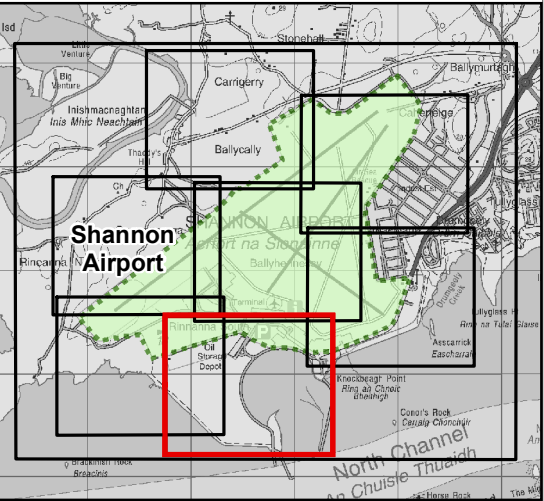
Map No.:
IRR3FECCDC1

Sheet: 7 of 8
Map Scale: 1: 5000

Revision: 0
Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- AFA Boundary
- Defence - Wall
- Defence - Embankment
- Defence Failure Location
- 0.5% AEP Coastal Failure Scenario 1

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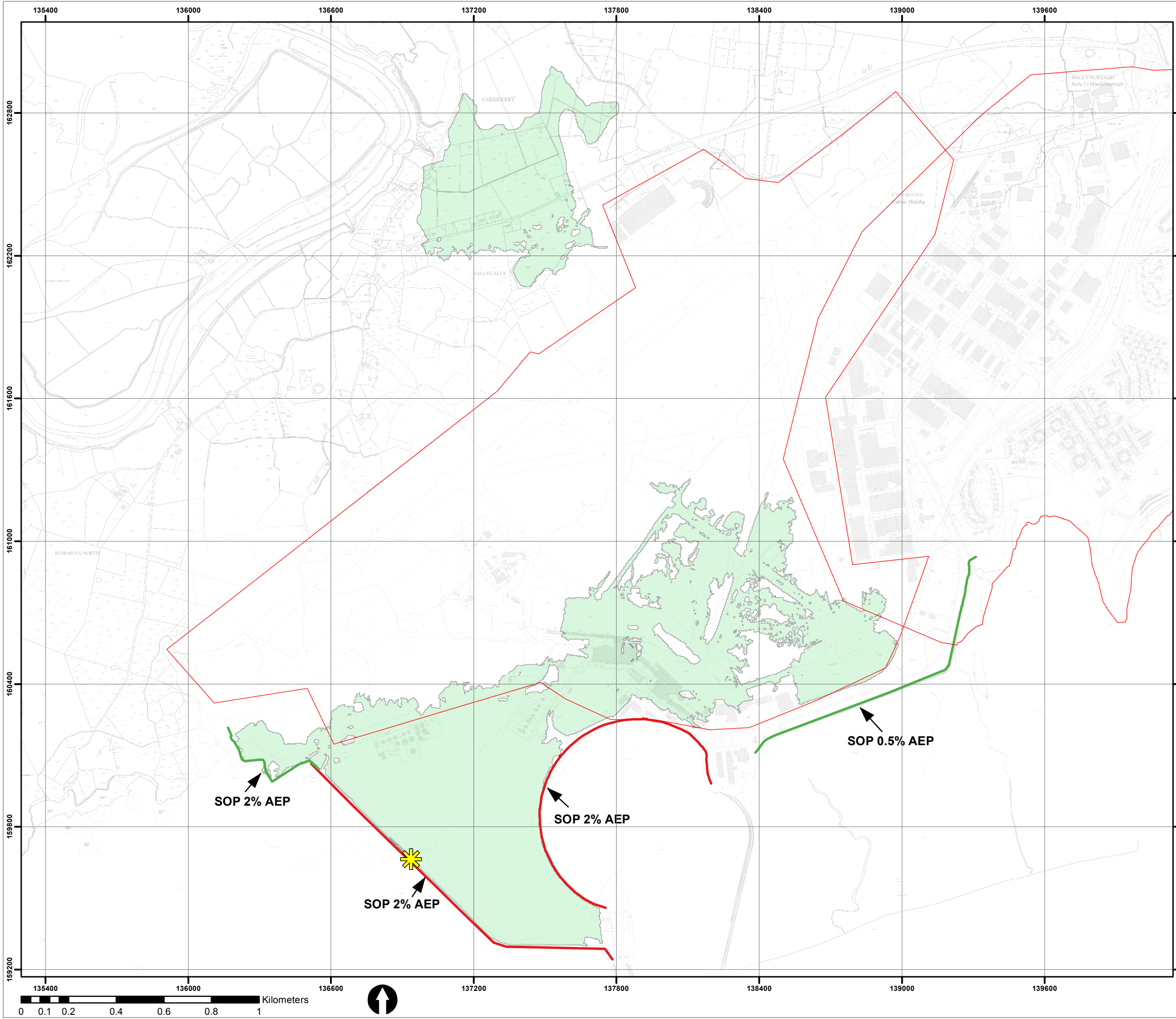
Project:
SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

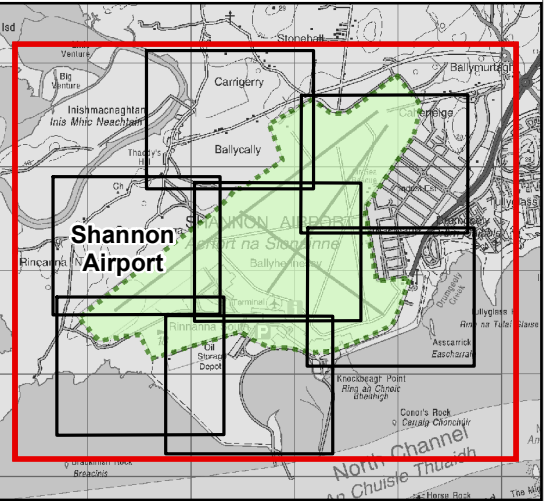
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Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON AIRPORT
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: IRR3FECCDC1
Sheet: 8 of 8
Map Scale: 1: 5000
Revision: 0
Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- AFA Boundary
- Defence - Wall
- Defence - Embankment
- Defence Failure Location
- 2% AEP Coastal Failure Scenario 2

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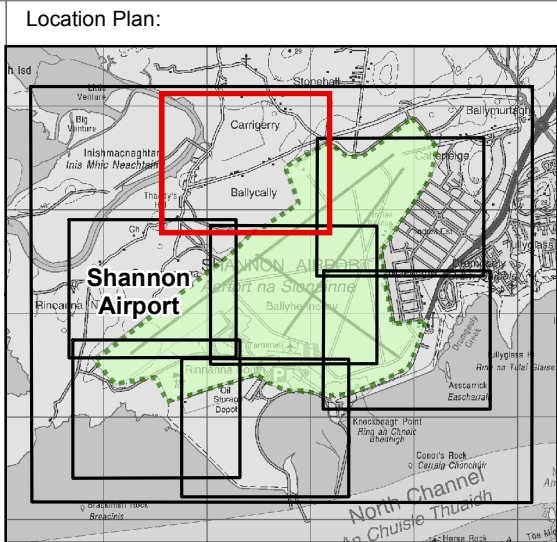
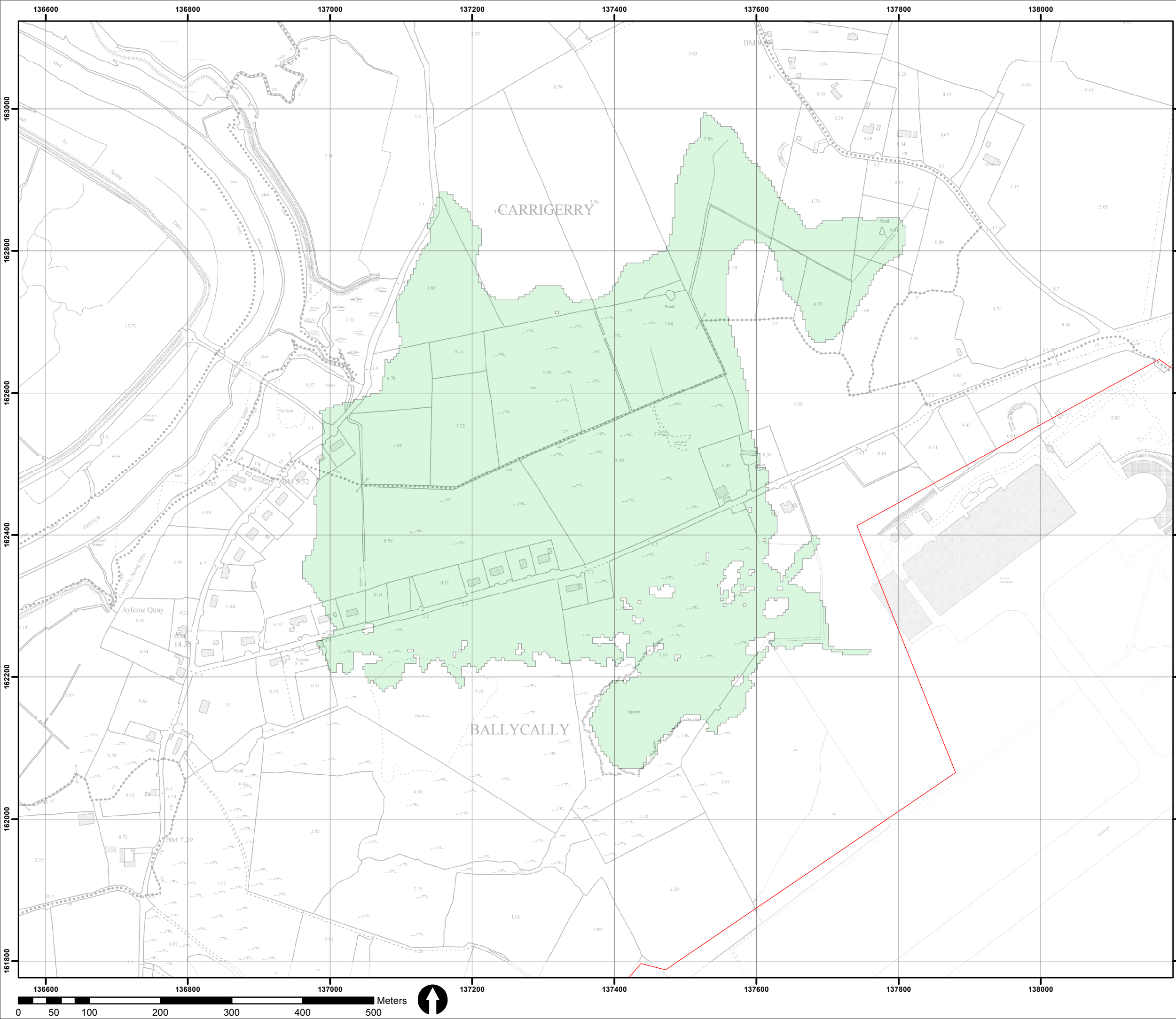


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Project: SHANNON CFRAM STUDY	
Map: SHANNON AIRPORT	
Map Type: DEFENCE FAILURE EXTENT MAP	
Source: 2% AEP COASTAL FAILURE SCENARIO 2	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 1 of 8	Revision: 0
Map Scale: 1: 15000	Plot Scale: 1:1 @ A3



- Legend:**
- AFA Boundary
 - Defence - Wall
 - Defence - Embankment
 - Defence Failure Location
 - 2% AEP Coastal Failure Scenario 2

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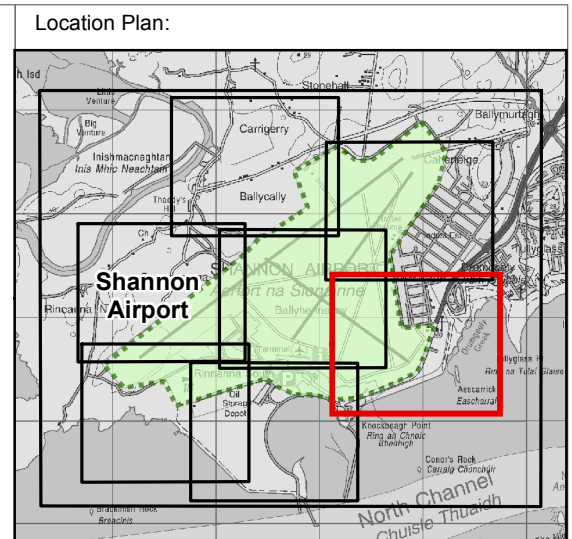


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Project: SHANNON CFRAM STUDY	
Map: SHANNON AIRPORT	
Map Type: DEFENCE FAILURE EXTENT MAP	
Source: 2% AEP COASTAL FAILURE SCENARIO 2	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 2 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



- Legend:**
- AFA Boundary
 - Defence - Wall
 - Defence - Embankment
 - Defence Failure Location
 - 2% AEP Coastal Failure Scenario 2

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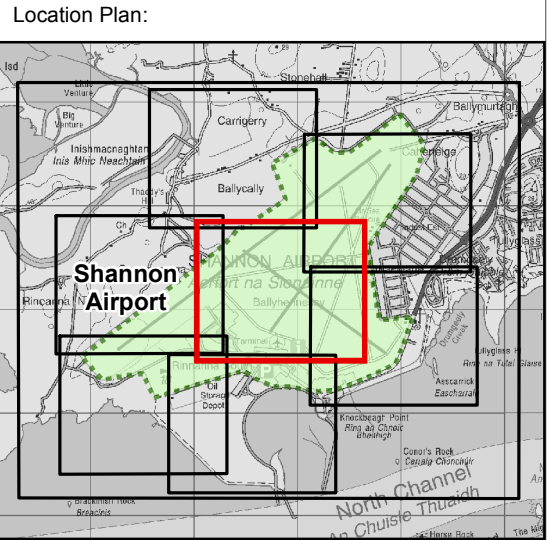
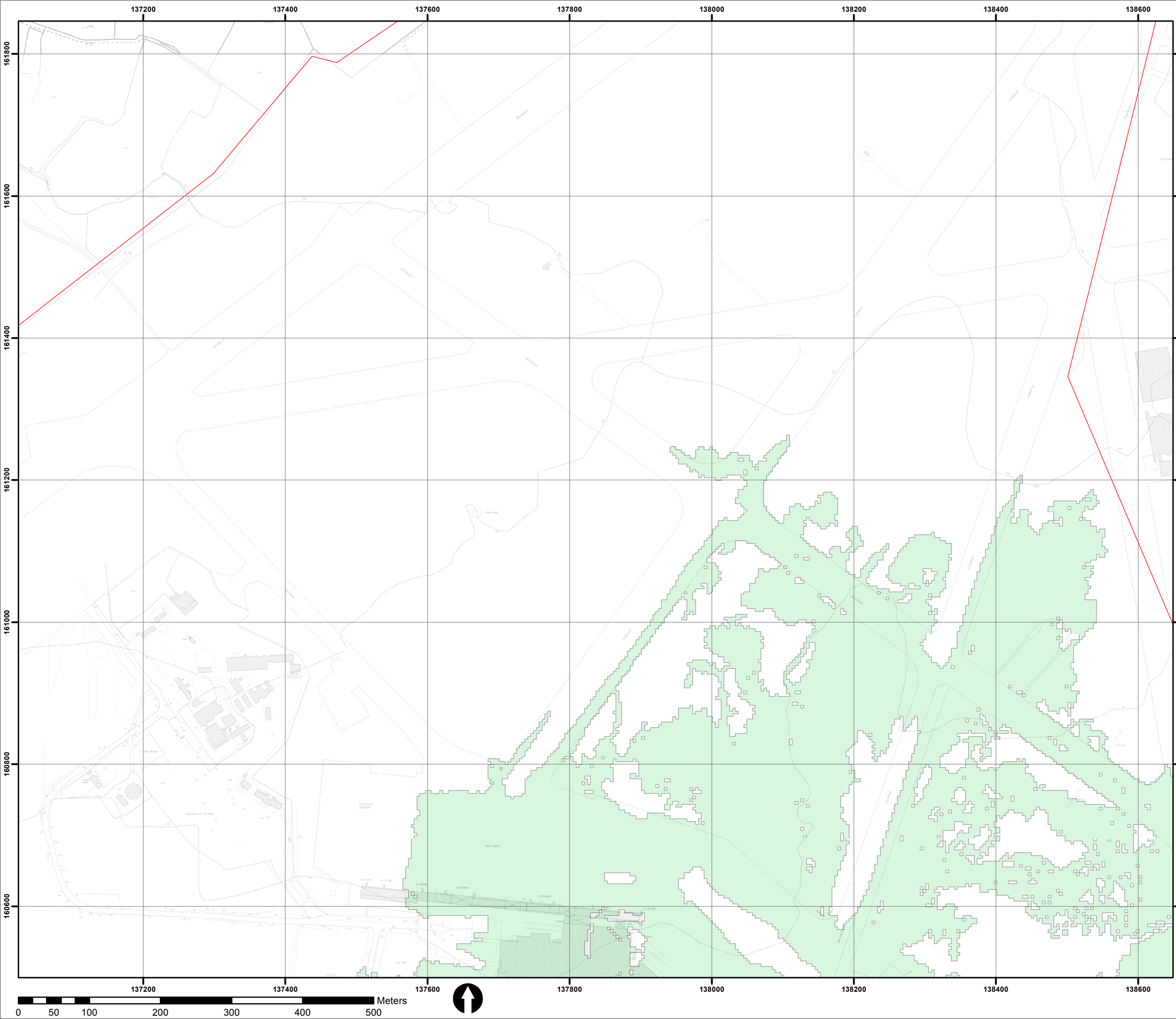


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Project: SHANNON CFRAM STUDY	
Map: SHANNON AIRPORT	
Map Type: DEFENCE FAILURE EXTENT MAP	
Source: 2% AEP COASTAL FAILURE SCENARIO 2	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 4 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



- Legend:**
- AFA Boundary
 - Defence - Wall
 - Defence - Embankment
 - Defence Failure Location
 - 2% AEP Coastal Failure Scenario 2

IMPORTANT USER NOTE:

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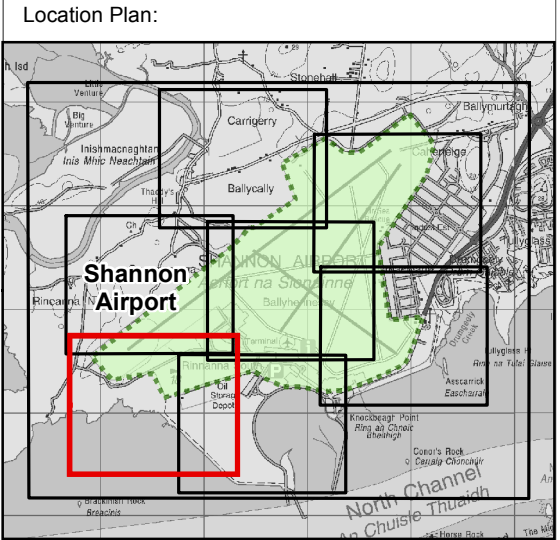
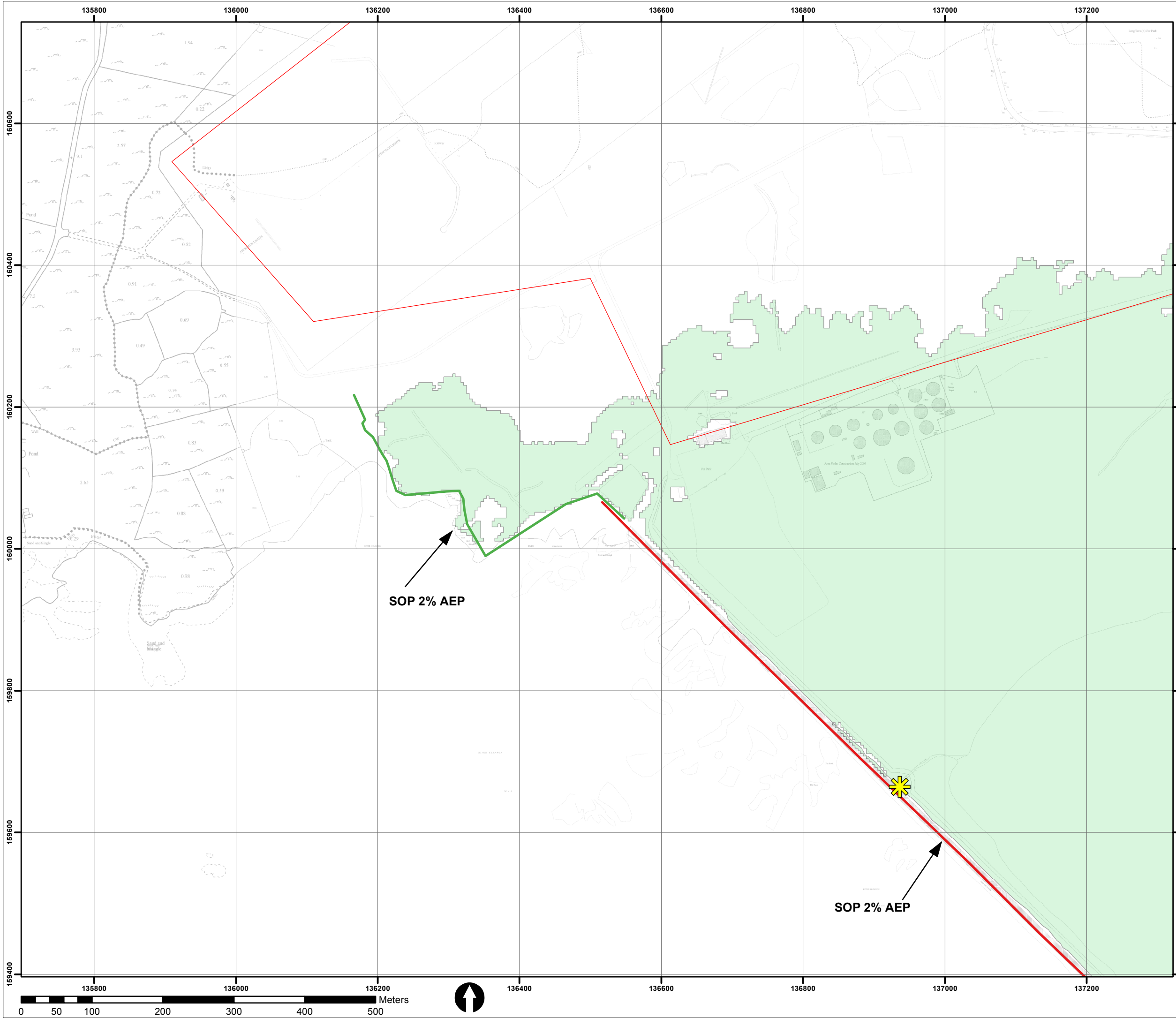


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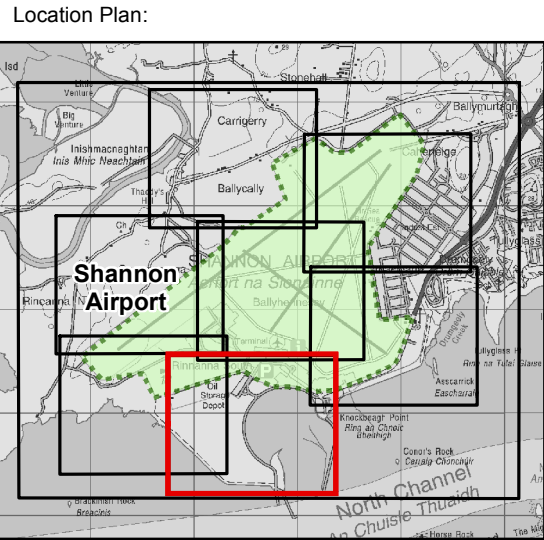
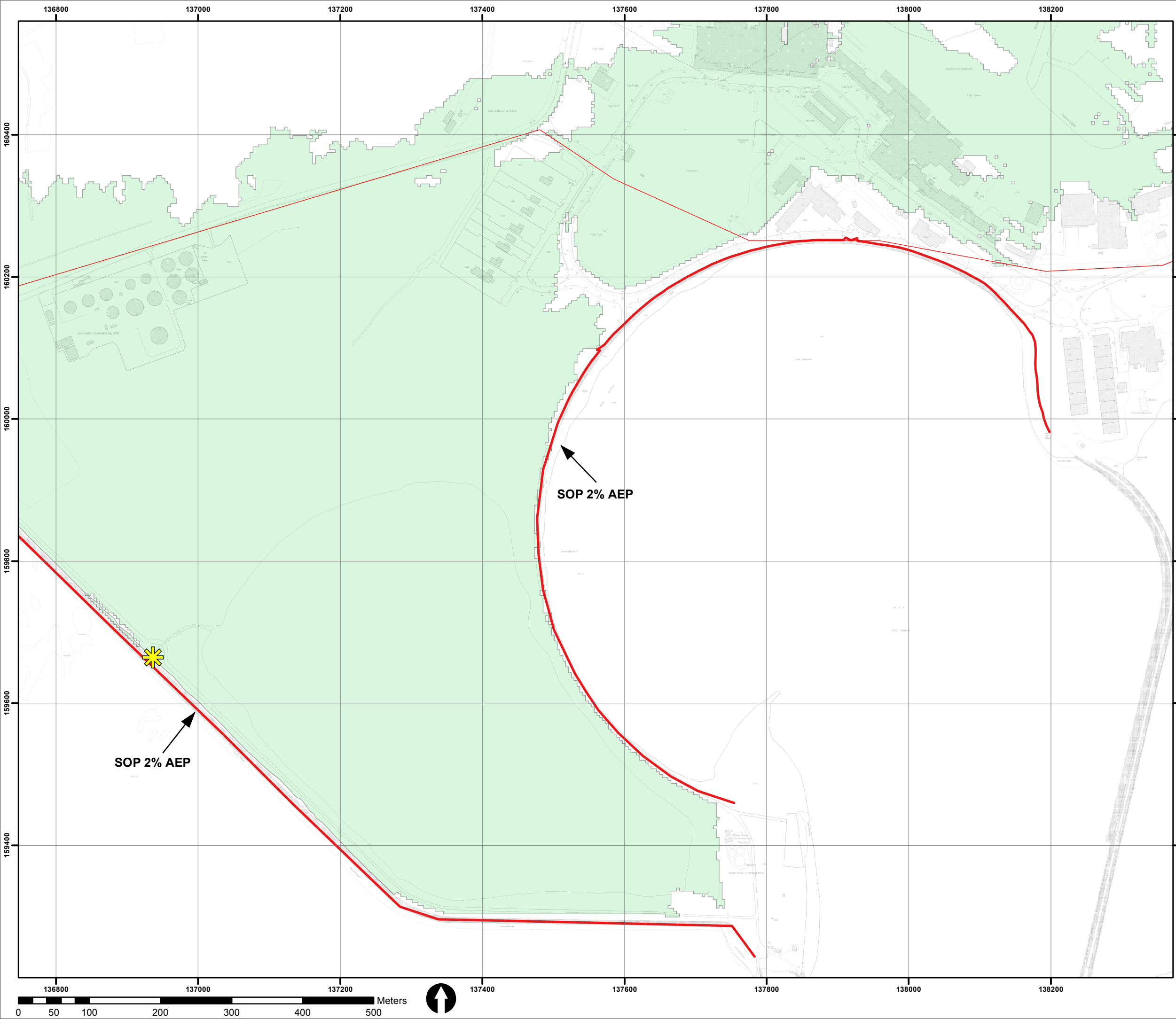


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Sheet: 7 of 8	Revision: 0
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- Legend:**
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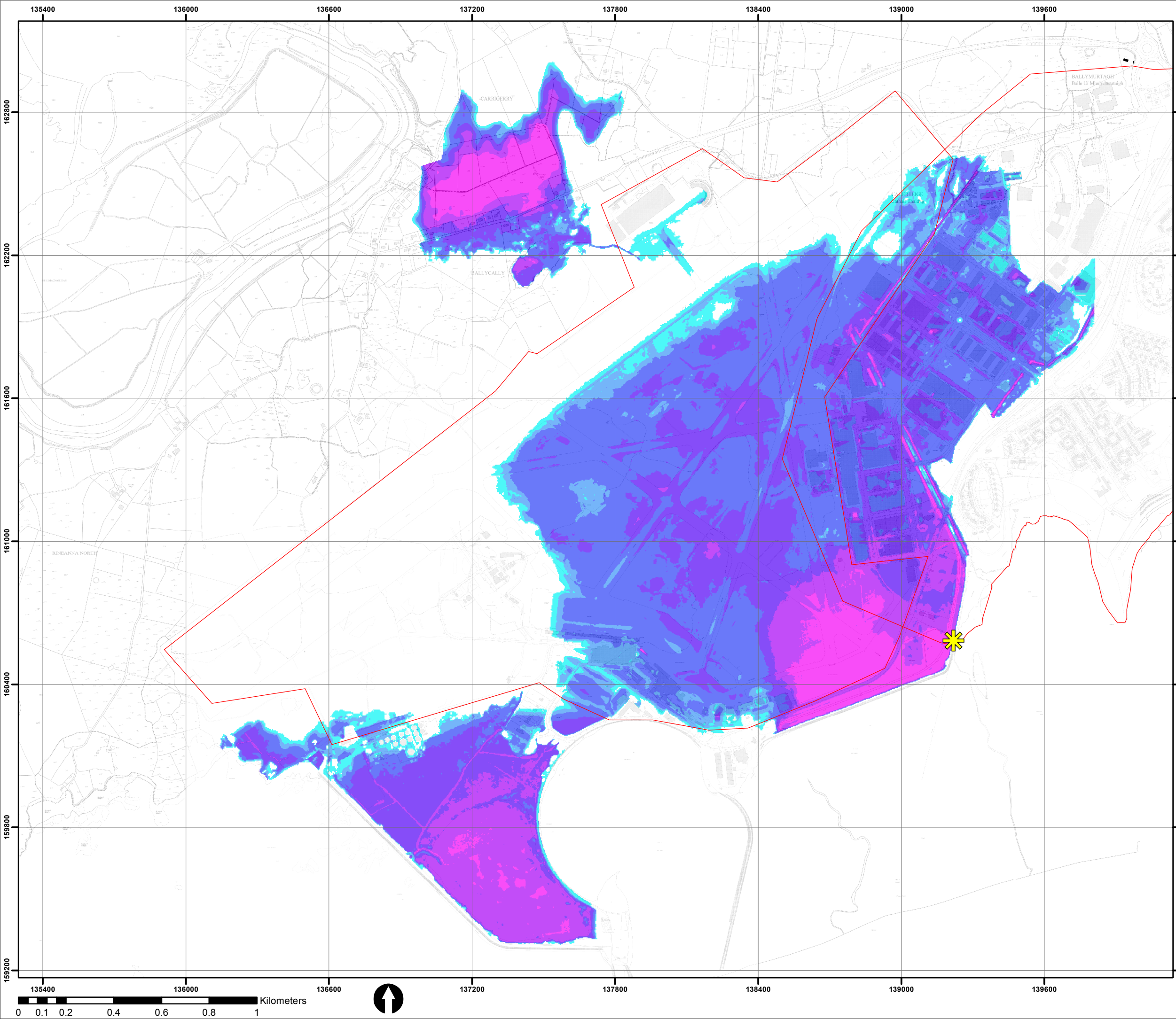
Project:
SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

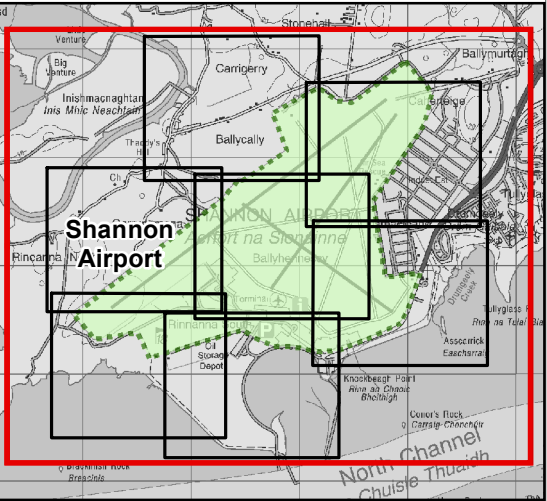
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Source: 2% AEP COASTAL FAILURE SCENARIO 2
Map area: SHANNON AIRPORT
Scenario: EXISTING

Drawn by: EH Date: November 2015
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Map No.: IRR3FECCDC1
Sheet: 8 of 8 Revision: 0
Map Scale: 1: 5000 Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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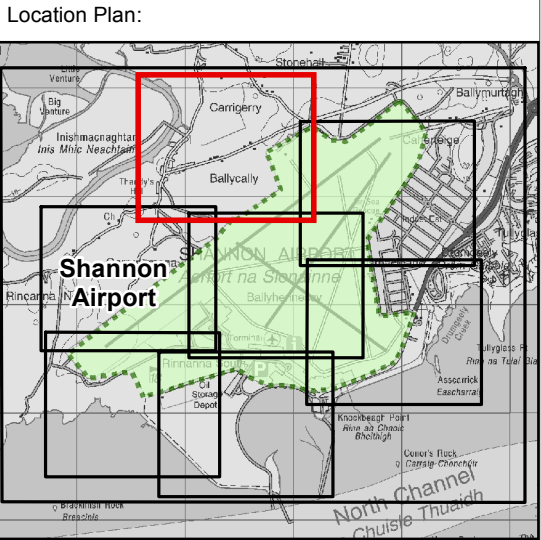
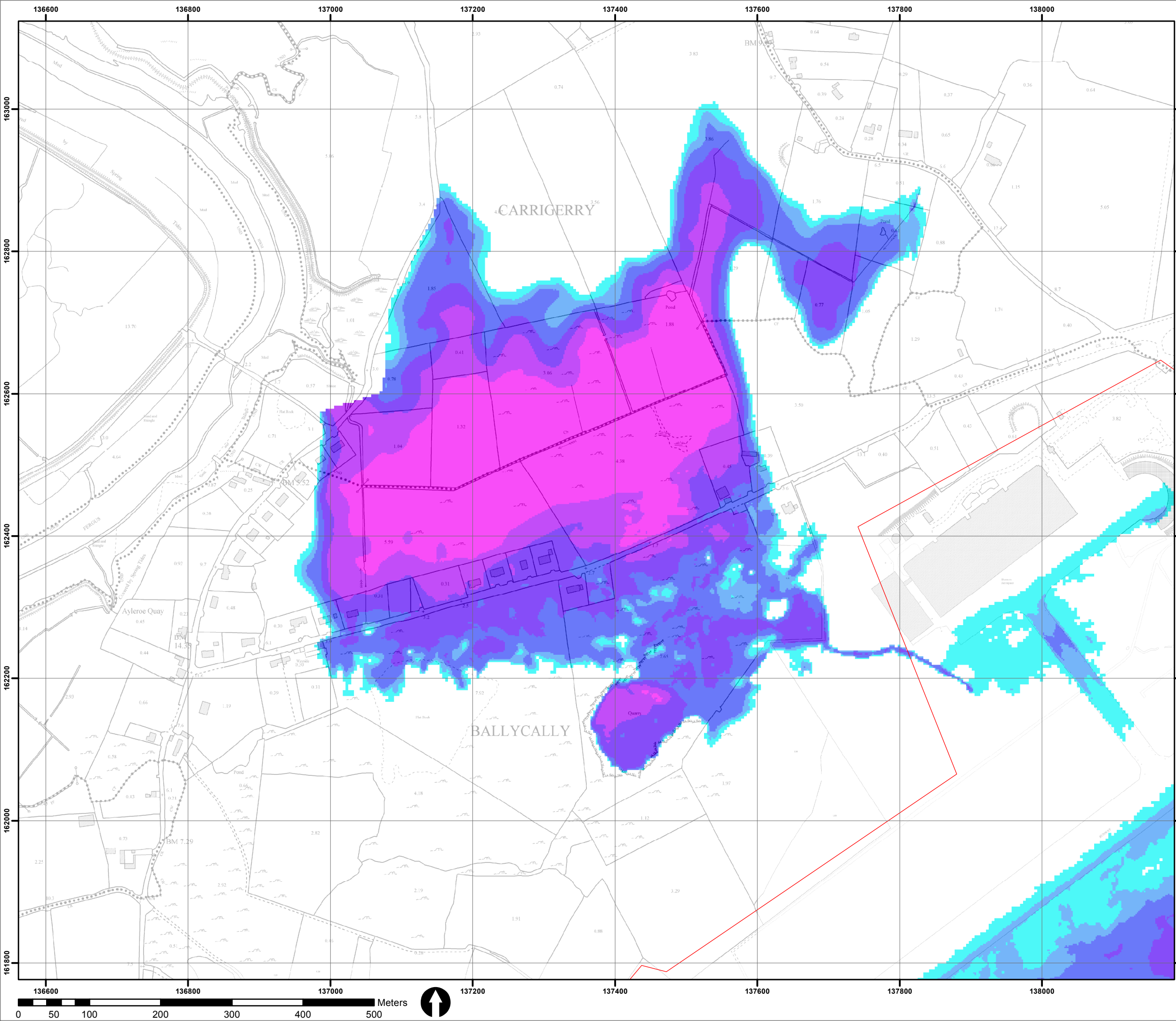
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Project:
SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

Map Type: DEFENCE FAILURE DEPTH MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Map No.: IRR3FDCCDC1
Sheet: 1 of 8
Map Scale: 1: 15000
Revision: 0
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Legend:

- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m)

- 0- 0.25
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Project:
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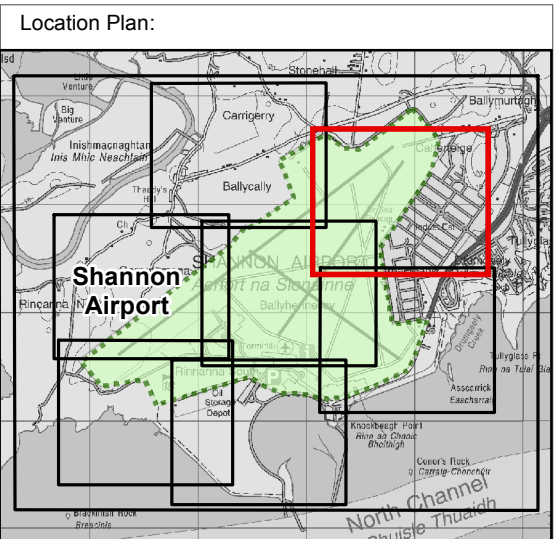
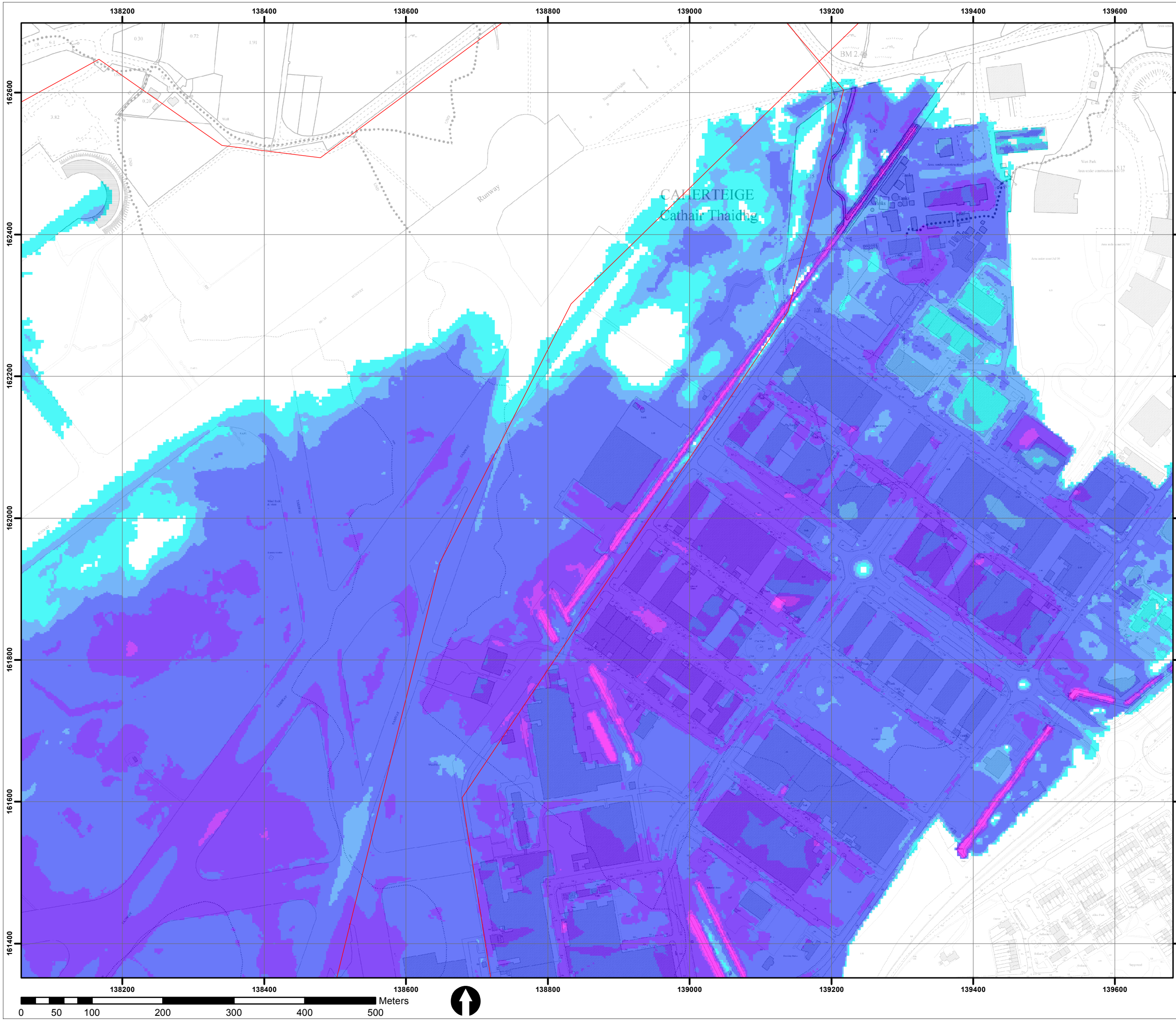
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SHANNON AIRPORT

Map Type:	DEFENCE FAILURE DEPTH MAP		
Source:	0.5% AEP COASTAL FAILURE SCENARIO 1		
Map area:	SHANNON AIRPORT		
Scenario:	EXISTING		
Drawn by:	EH	Date:	November 2015
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Approved by:	PS	Date:	November 2015

Map No.:
IRR3FDCCDC1

Sheet: 2 of 8
Map Scale: 1: 5000

Revision: 0
Plot Scale: 1:1 @ A3



Legend:

- AFA Boundary
- Defence Failure Location


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Project:
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Map:
SHANNON AIRPORT

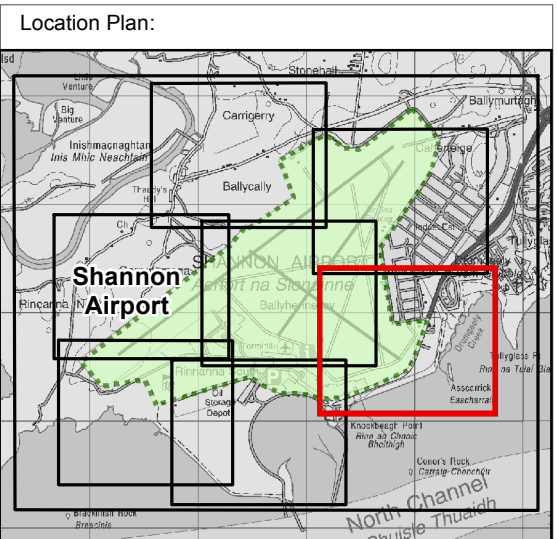
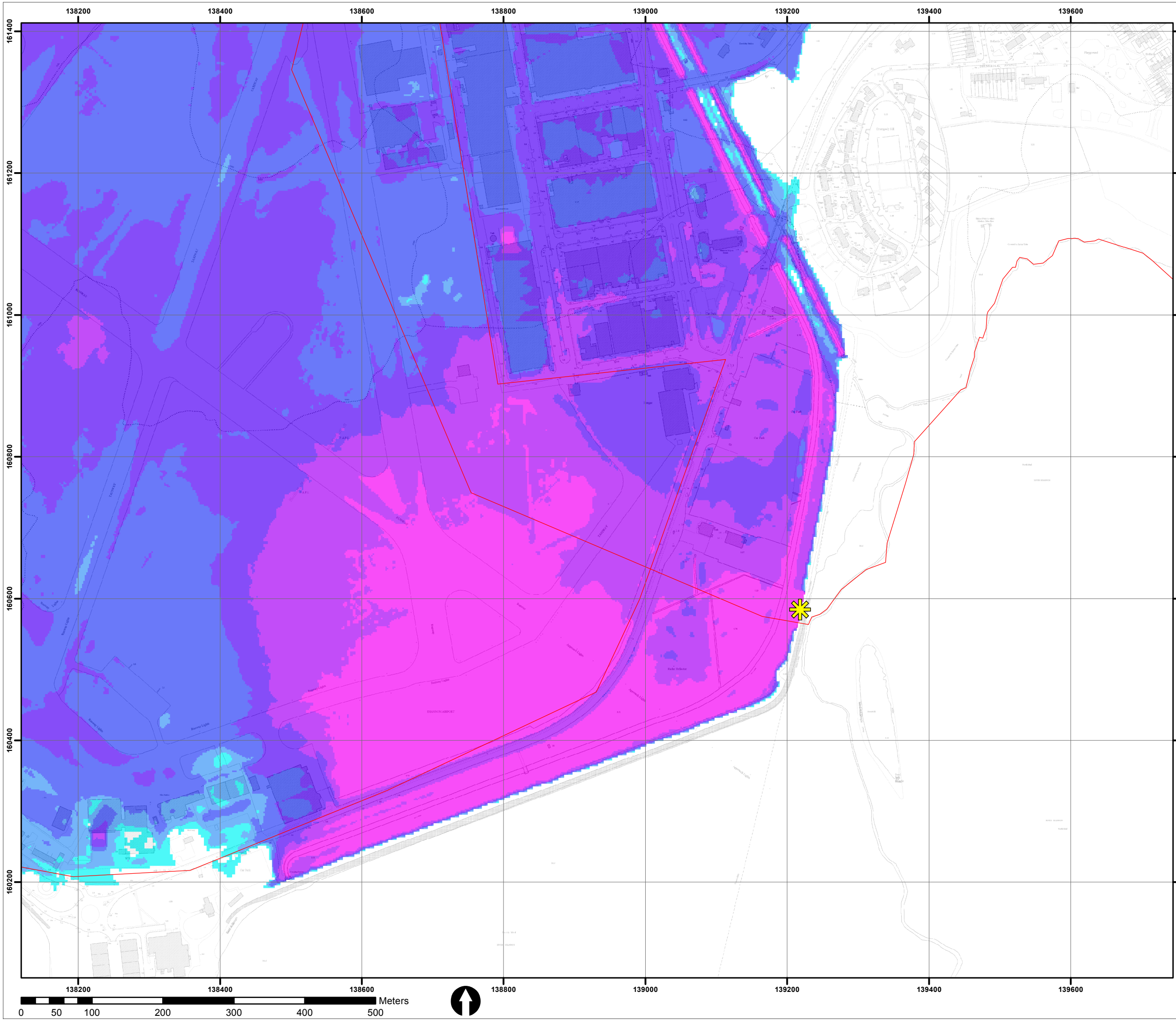
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Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON AIRPORT
Scenario: EXISTING

Drawn by: EH	Date: November 2015
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Map No.: IRR3FDCCDC1

Sheet: 3 of 8
Map Scale: 1: 5000

Revision: 0
Plot Scale: 1:1 @ A3



Legend:

- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m)

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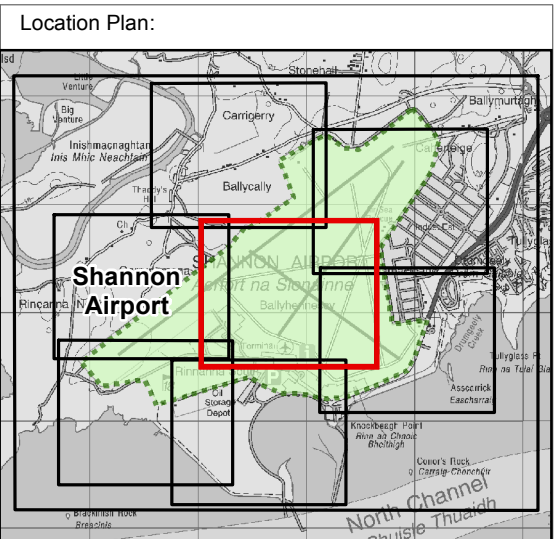
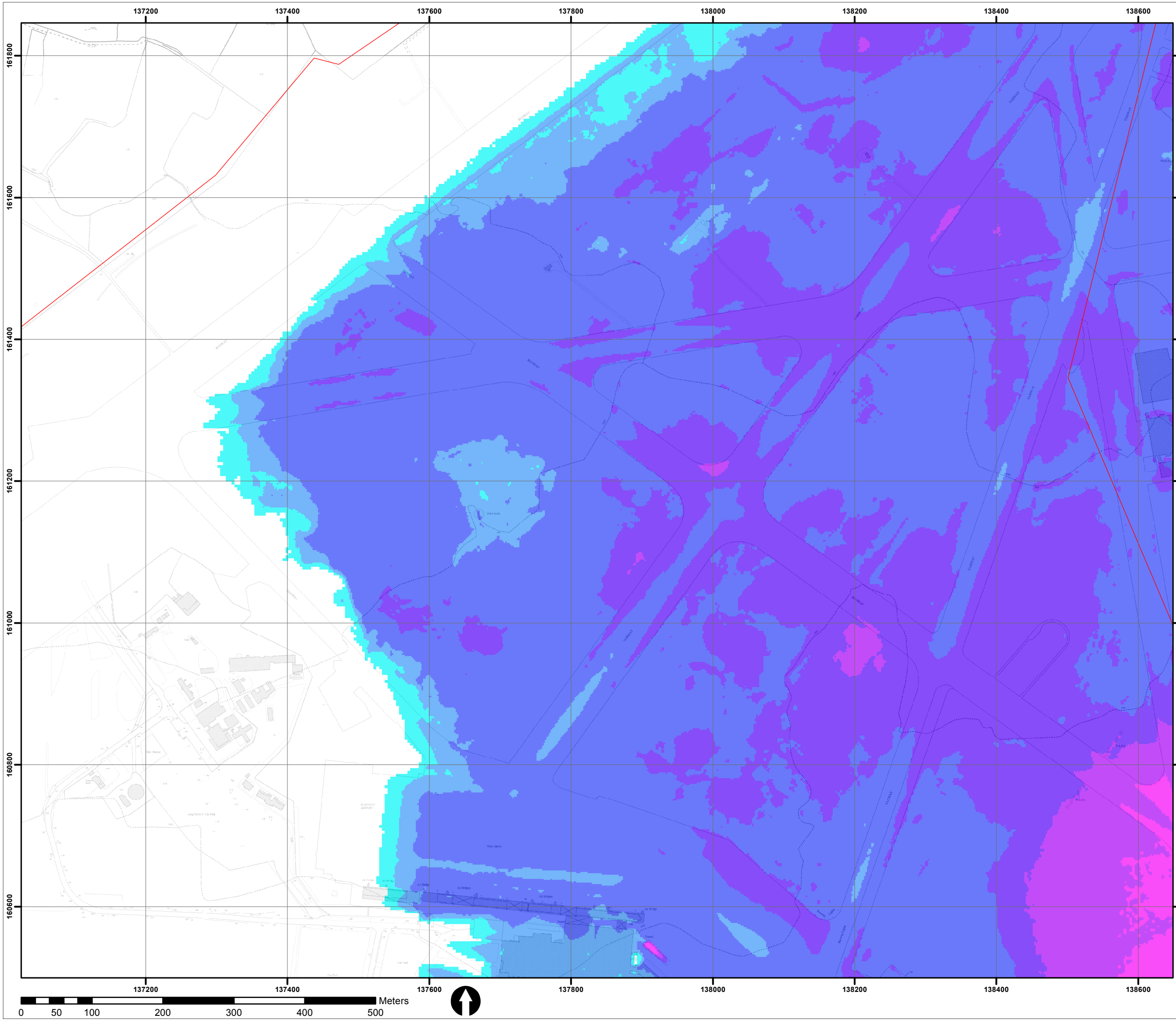
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SHANNON AIRPORT

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON AIRPORT
Scenario: EXISTING

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Map No.:
IRR3FDCCDC1

Sheet: 4 of 8	Revision: 0
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Legend:

- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m)

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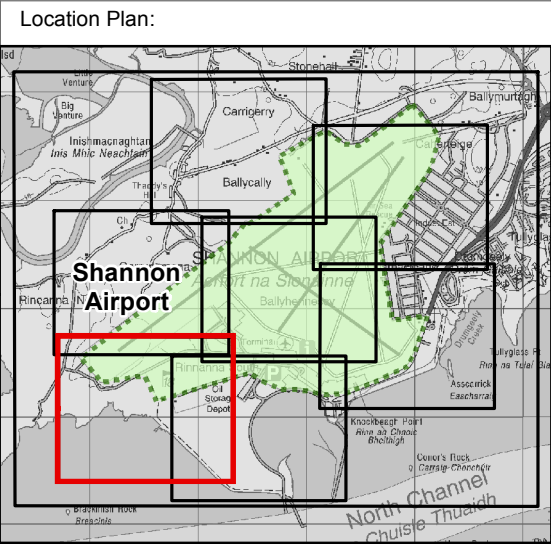
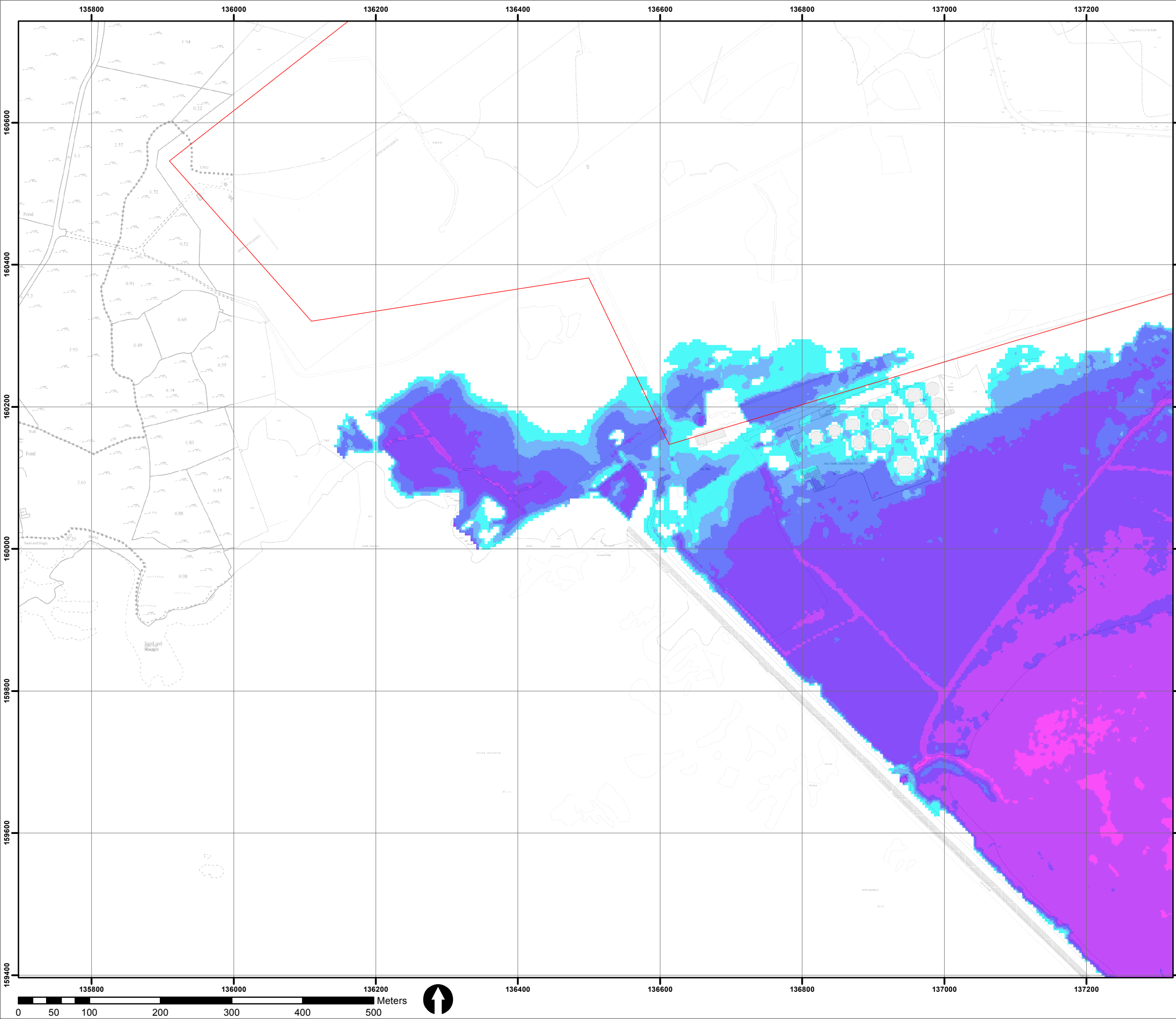
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SHANNON AIRPORT

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON AIRPORT
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Map No.: IRR3FDCCDC1

Sheet: 5 of 8	Revision: 0
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Legend:

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- Defence Failure Location


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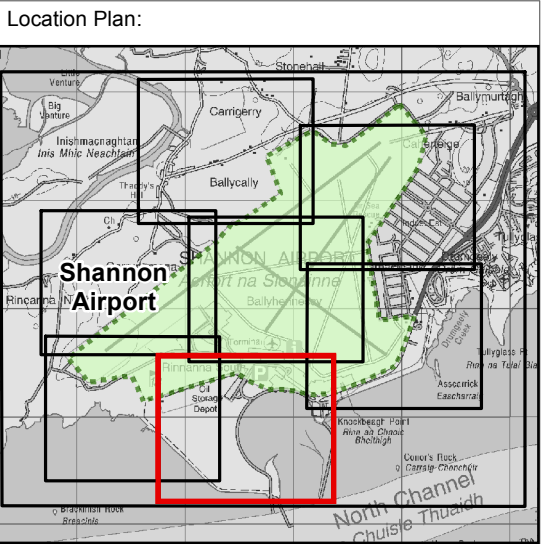
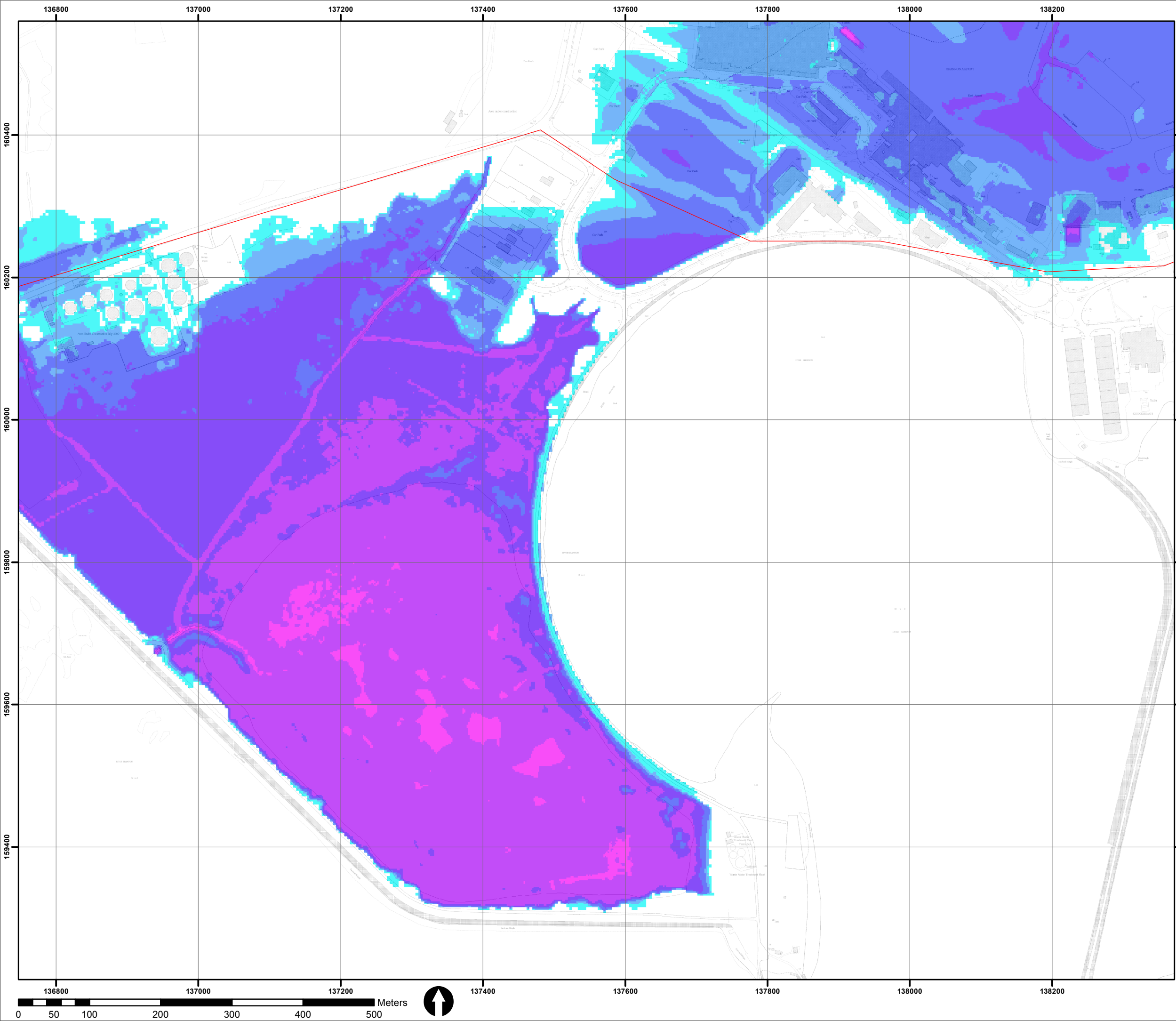
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SHANNON AIRPORT

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Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON AIRPORT
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Map No.:
IRR3FDCCDC1

Sheet: 7 of 8	Revision: 0
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Legend:

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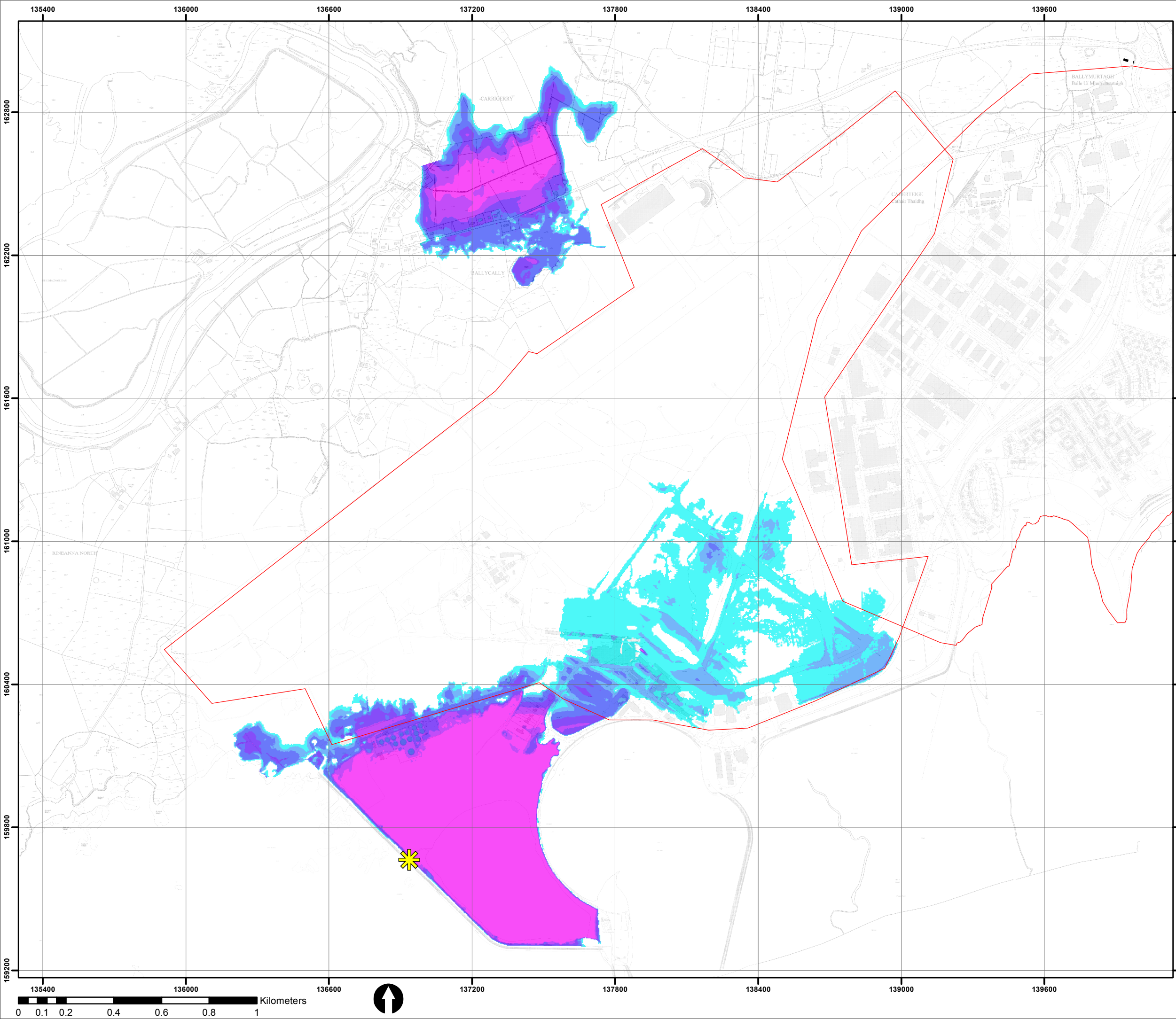
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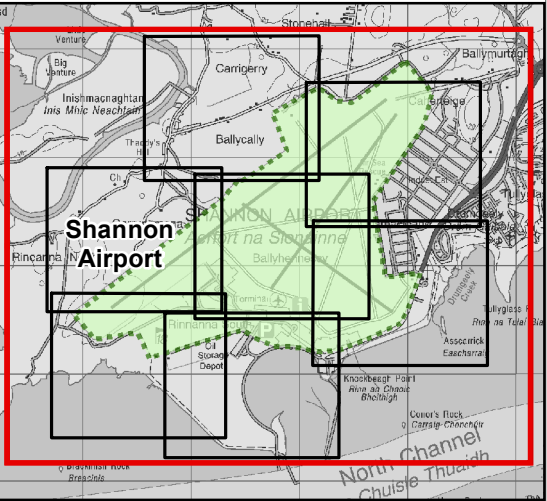
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IRR3FDCCDC1

Sheet: 8 of 8	Revision: 0
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Location Plan:



Legend:

- AFA Boundary
- Defence Failure Location

2% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
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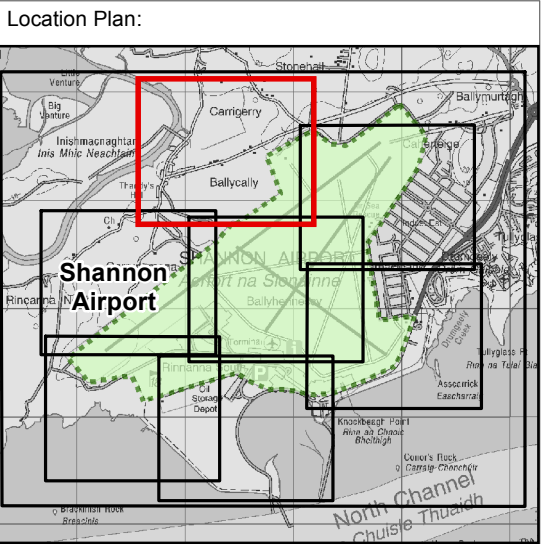
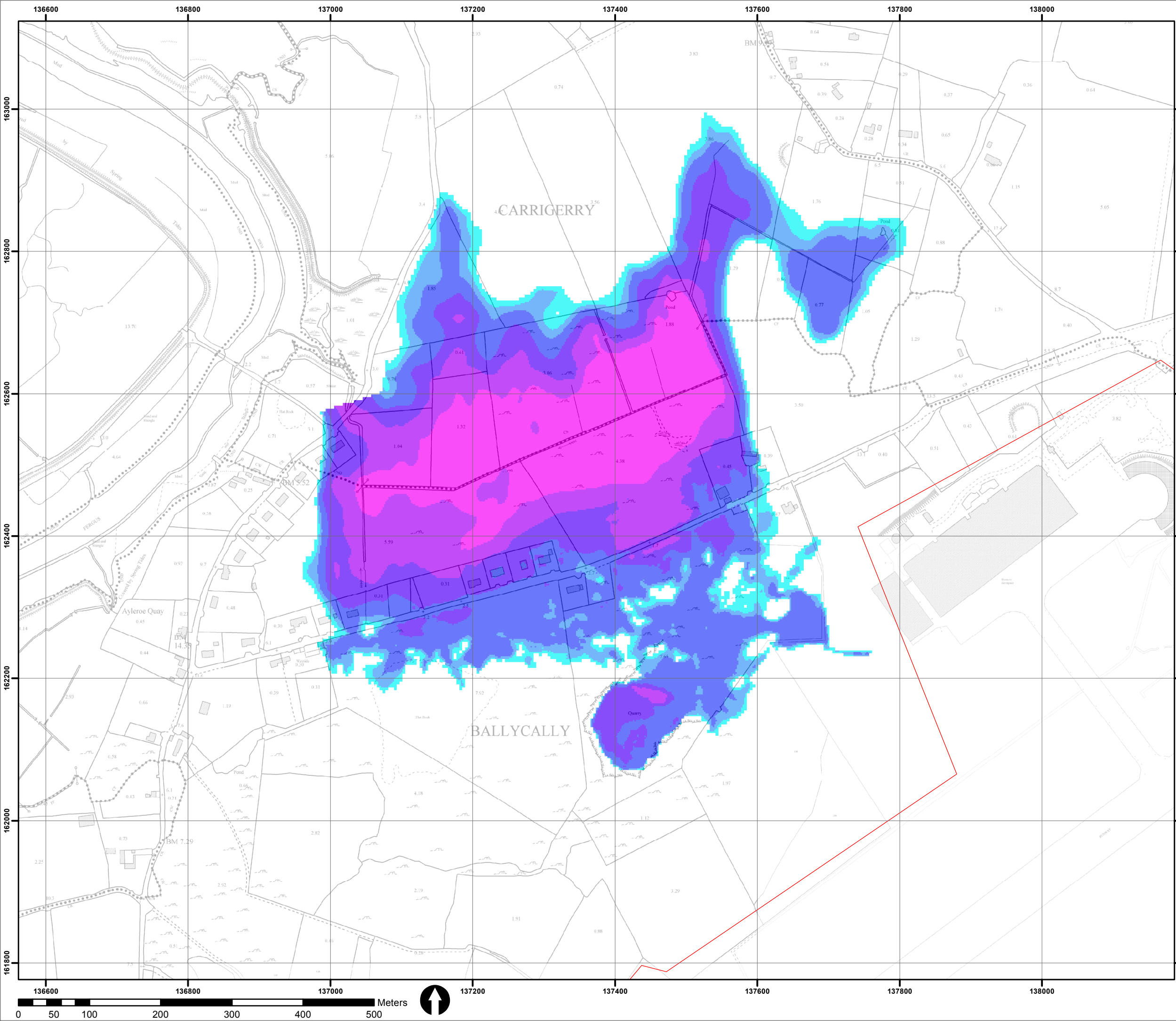
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SHANNON AIRPORT

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 - Defence Failure Location

2% AEP Coastal Failure Scenario 2 (m)

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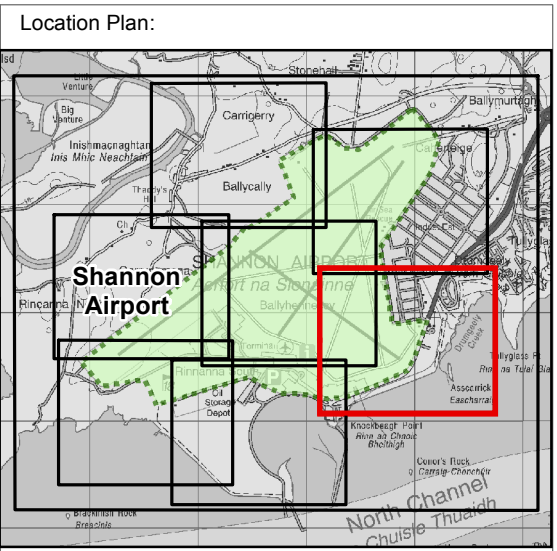
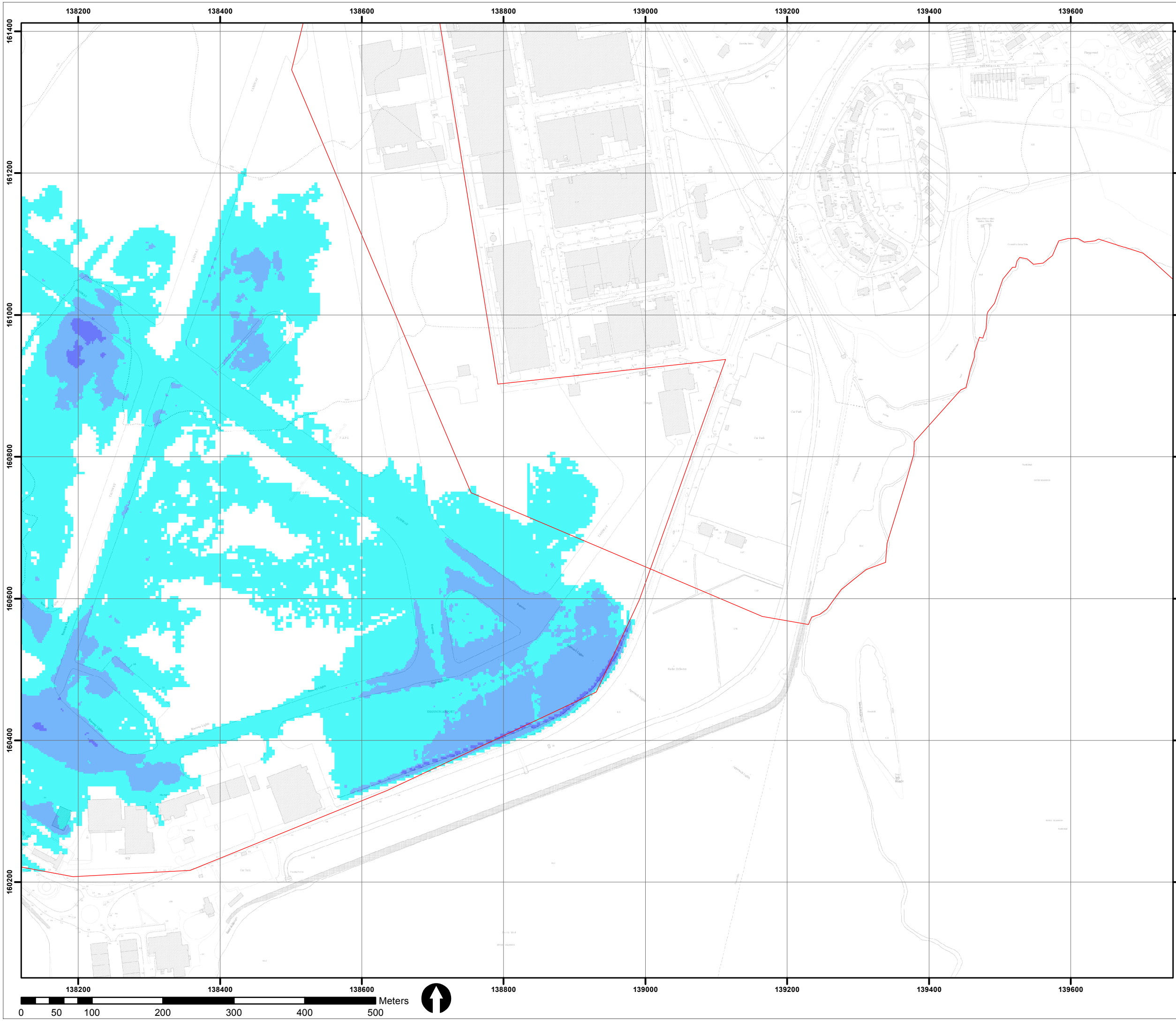
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 - Defence Failure Location

- 2% AEP Coastal Failure Scenario 2 (m)**
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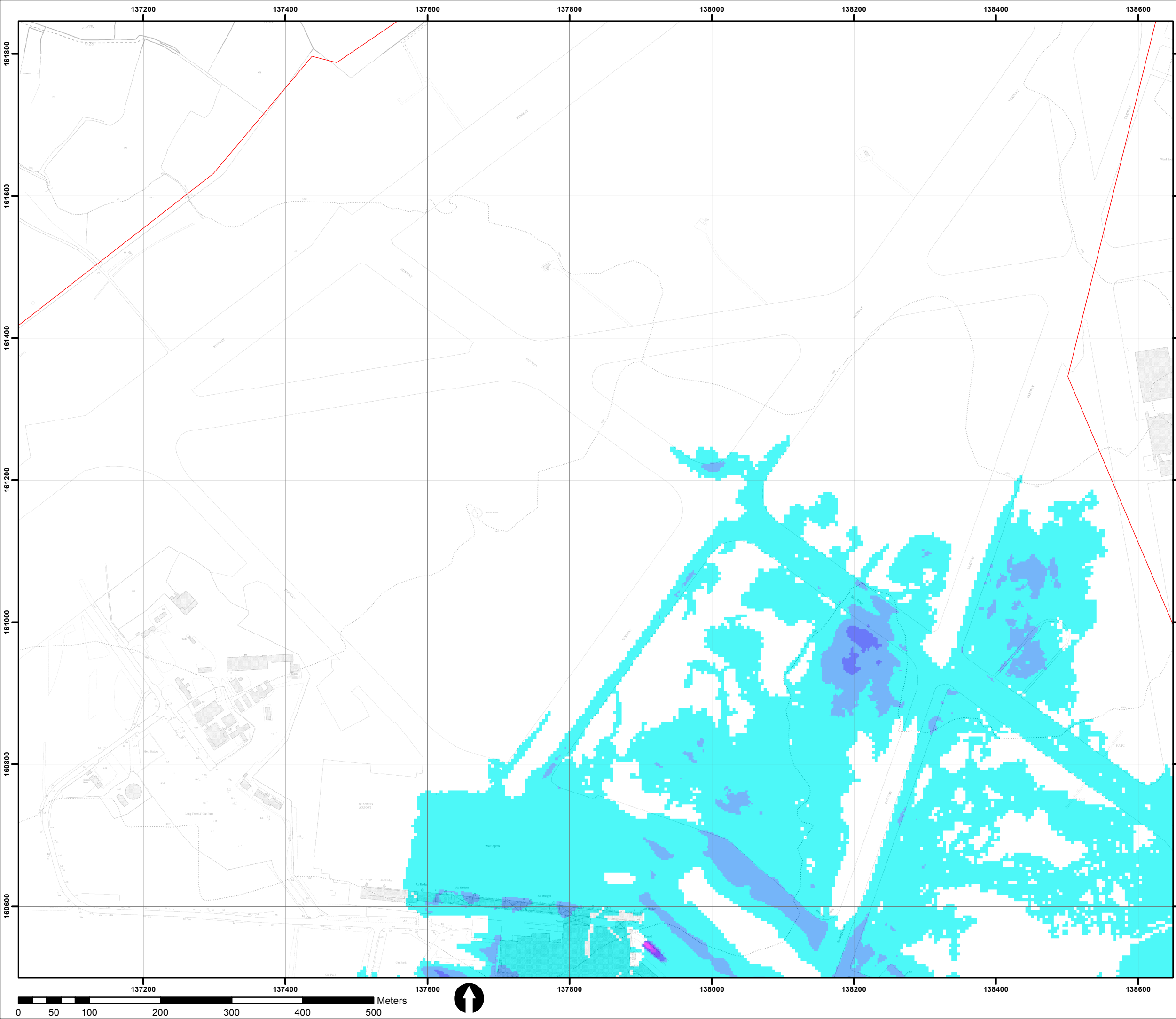


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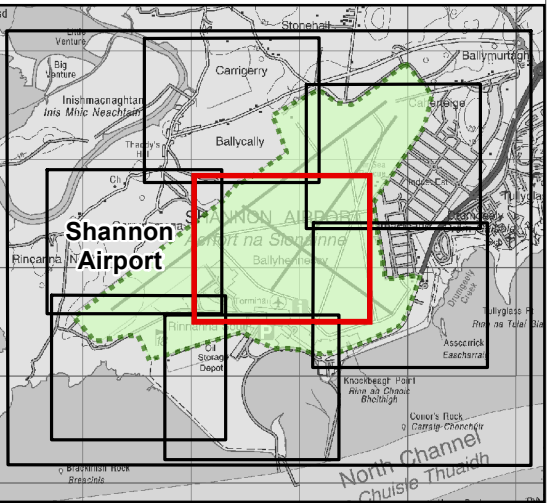
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Location Plan:



Legend:

- AFA Boundary
- Defence Failure Location

2% AEP Coastal Failure Scenario 2 (m)

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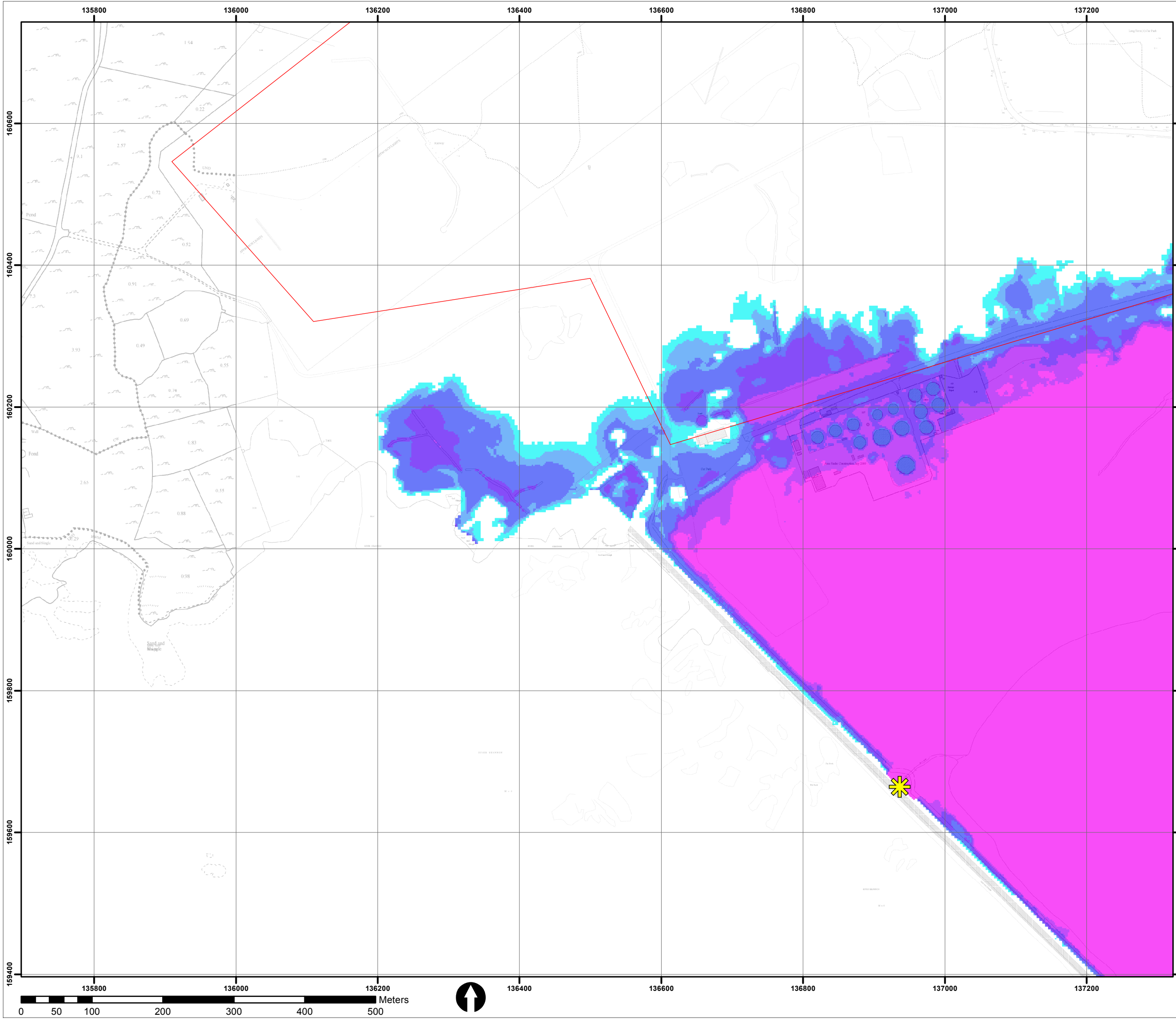
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SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

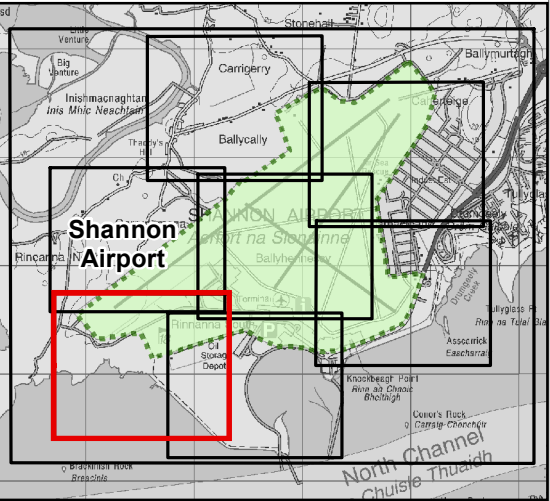
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Source: 2% AEP COASTAL FAILURE SCENARIO 2
Map area: SHANNON AIRPOR
Scenario: EXISTING

Drawn by:	EH	Date: November 2015
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Map No.: IRR3FDCCDC1
Sheet: 5 of 8
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Location Plan:



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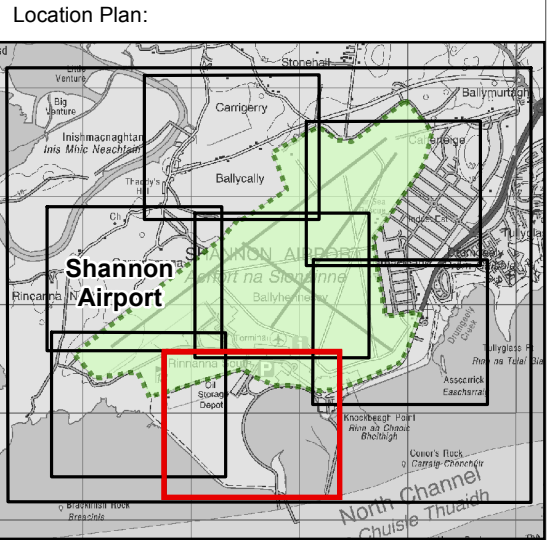
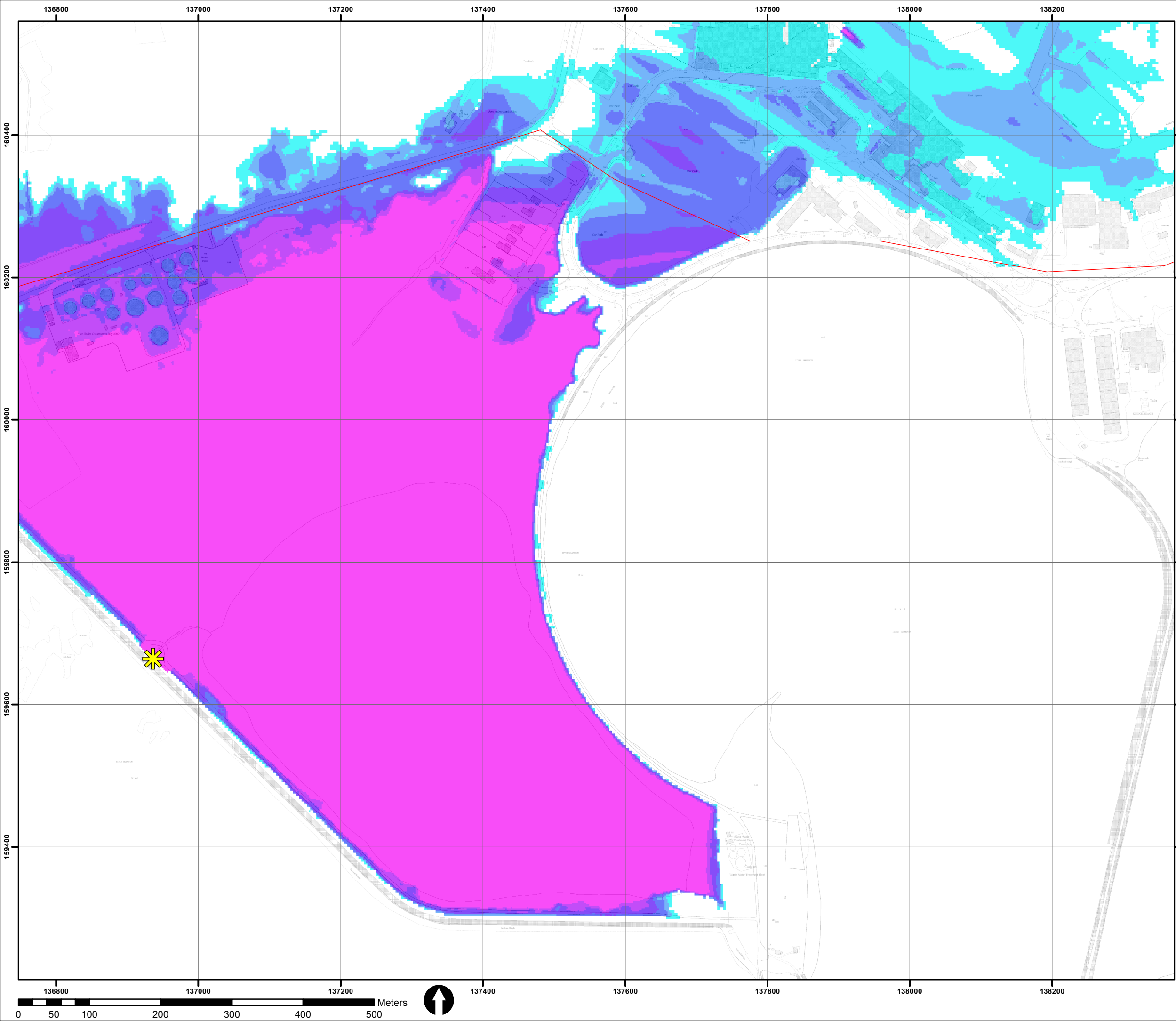
Merrion House
Merrion Road
Dublin

Project:
SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

Map Type:	DEFENCE FAILURE DEPTH MAP	
Source:	2% AEP COASTAL FAILURE SCENARIO 2	
Map area:	SHANNON AIRPOR	
Scenario:	EXISTING	
Drawn by:	EH	Date: November 2015
Checked by:	PT	Date: November 2015
Reviewed by:	MC	Date: November 2015
Approved by:	PS	Date: November 2015

Map No.:
IRR3FDCCDC1
Sheet: 7 of 8
Map Scale: 1: 5000
Revision: 0
Plot Scale: 1:1 @ A3



- Legend:**
- AFA Boundary
 - Defence Failure Location

2% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

IMPORTANT USER NOTE:

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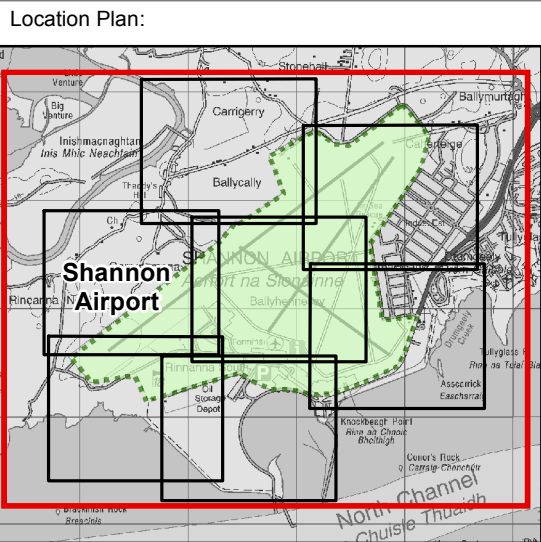
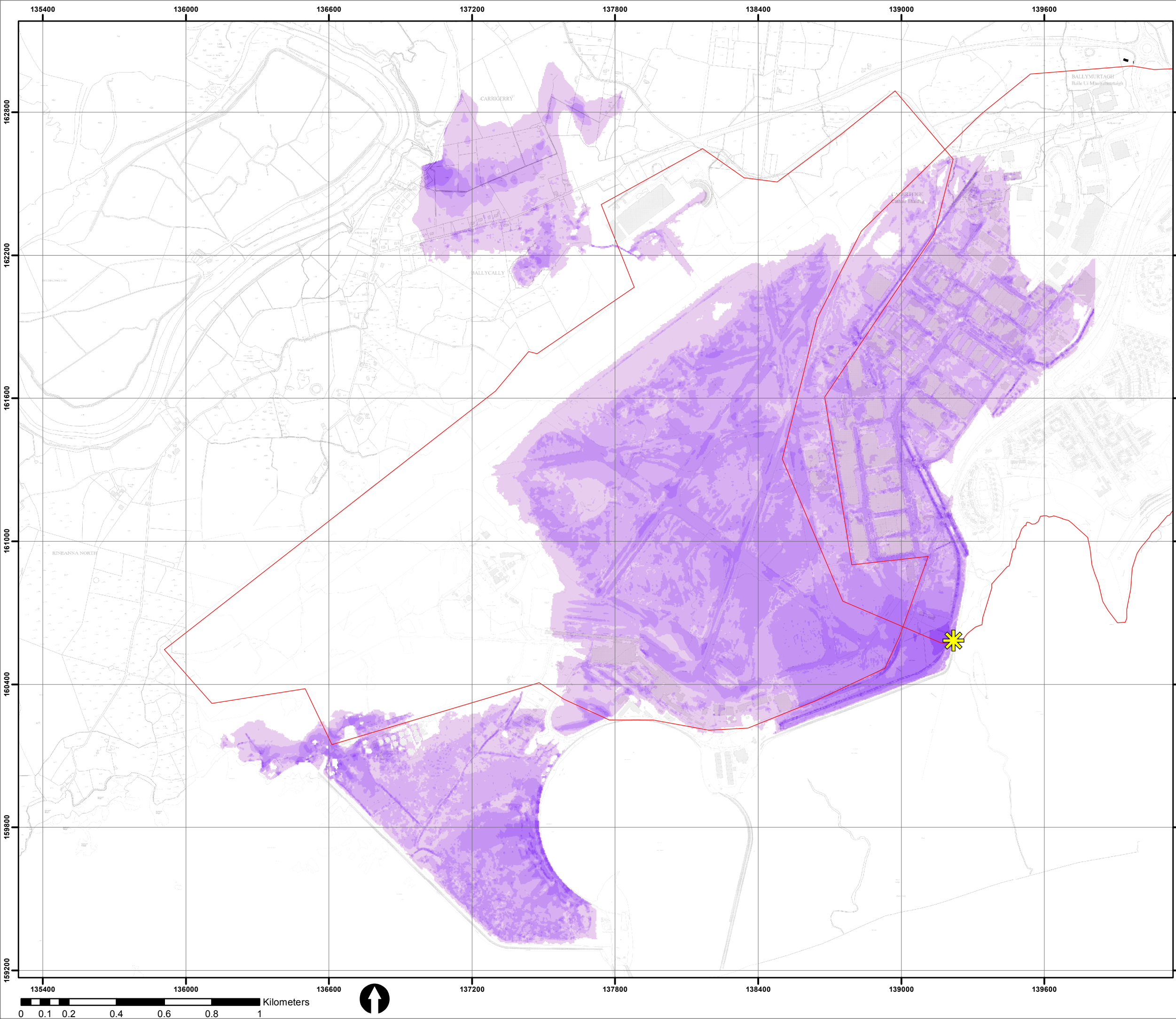


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Project:
SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

Map Type:	DEFENCE FAILURE DEPTH MAP		
Source:	2% AEP COASTAL FAILURE SCENARIO 2		
Map area:	SHANNON AIRPOR		
Scenario:	EXISTING		
Drawn by:	EH	Date:	November 2015
Checked by:	PT	Date:	November 2015
Reviewed by:	MC	Date:	November 2015
Approved by:	PS	Date:	November 2015
Map No.:	IRR3FDCCDC1		
Sheet:	8 of 8	Revision:	0
Map Scale:	1: 5000	Plot Scale:	1:1 @ A3



Legend:

- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0


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Project:
SHANNON CFRAM STUDY

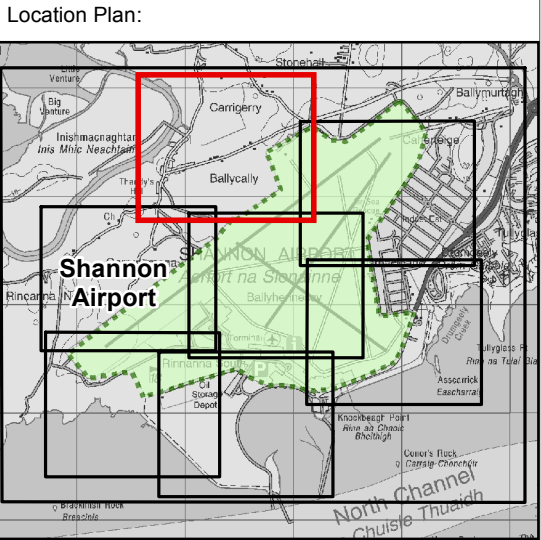
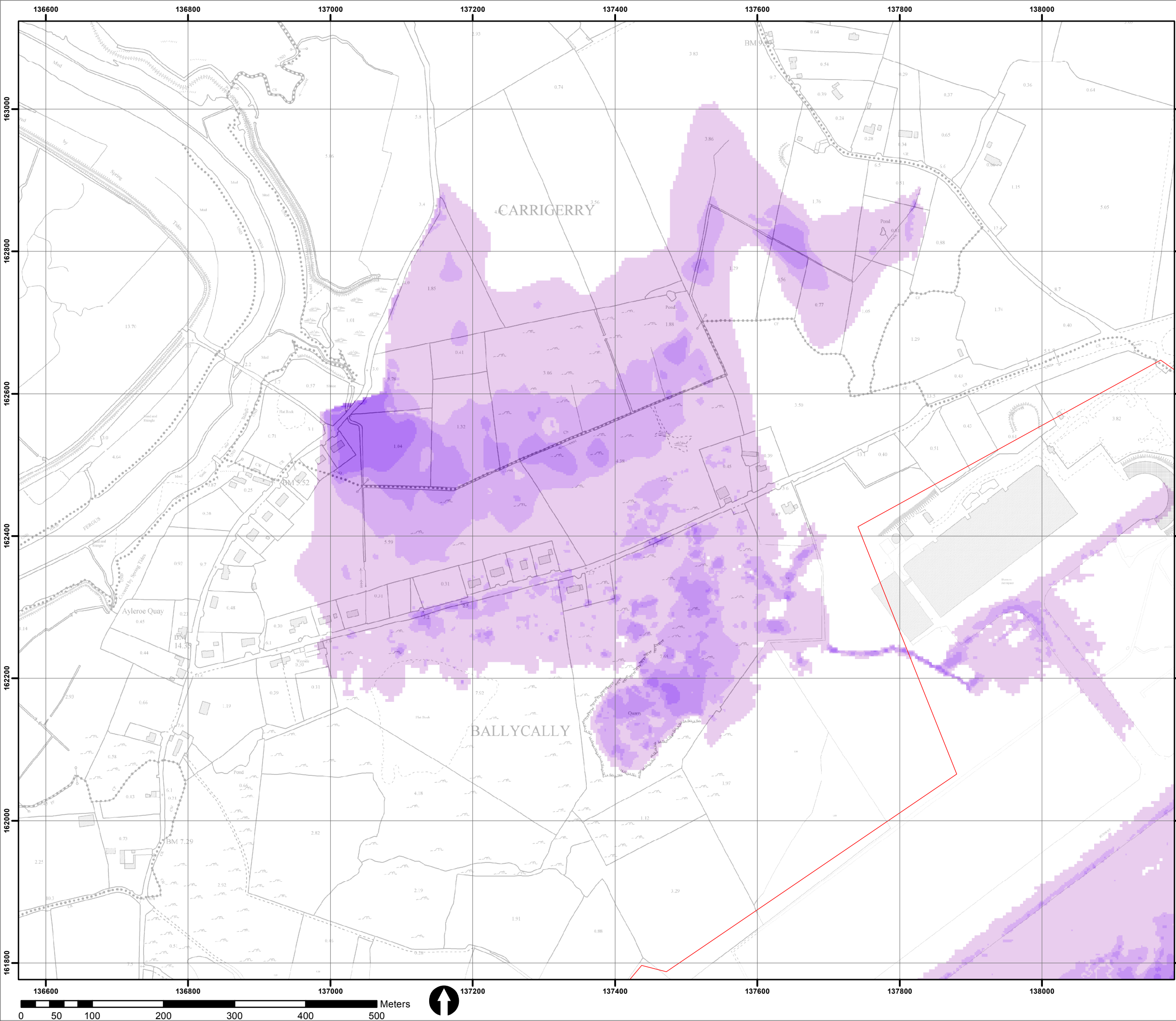
Map:
SHANNON AIRPORT

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON AIRPORT
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.:
IRR3FECCDC1

Sheet: 1 of 8	Revision: 0
Map Scale: 1: 15000	Plot Scale: 1:1 @ A3



- Legend:**
- AFA Boundary
 - Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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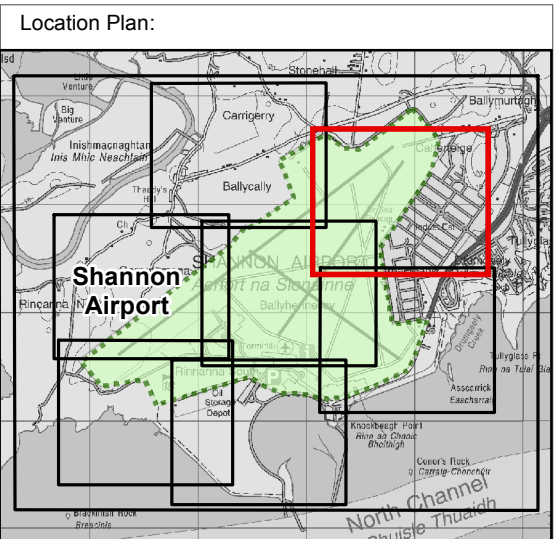
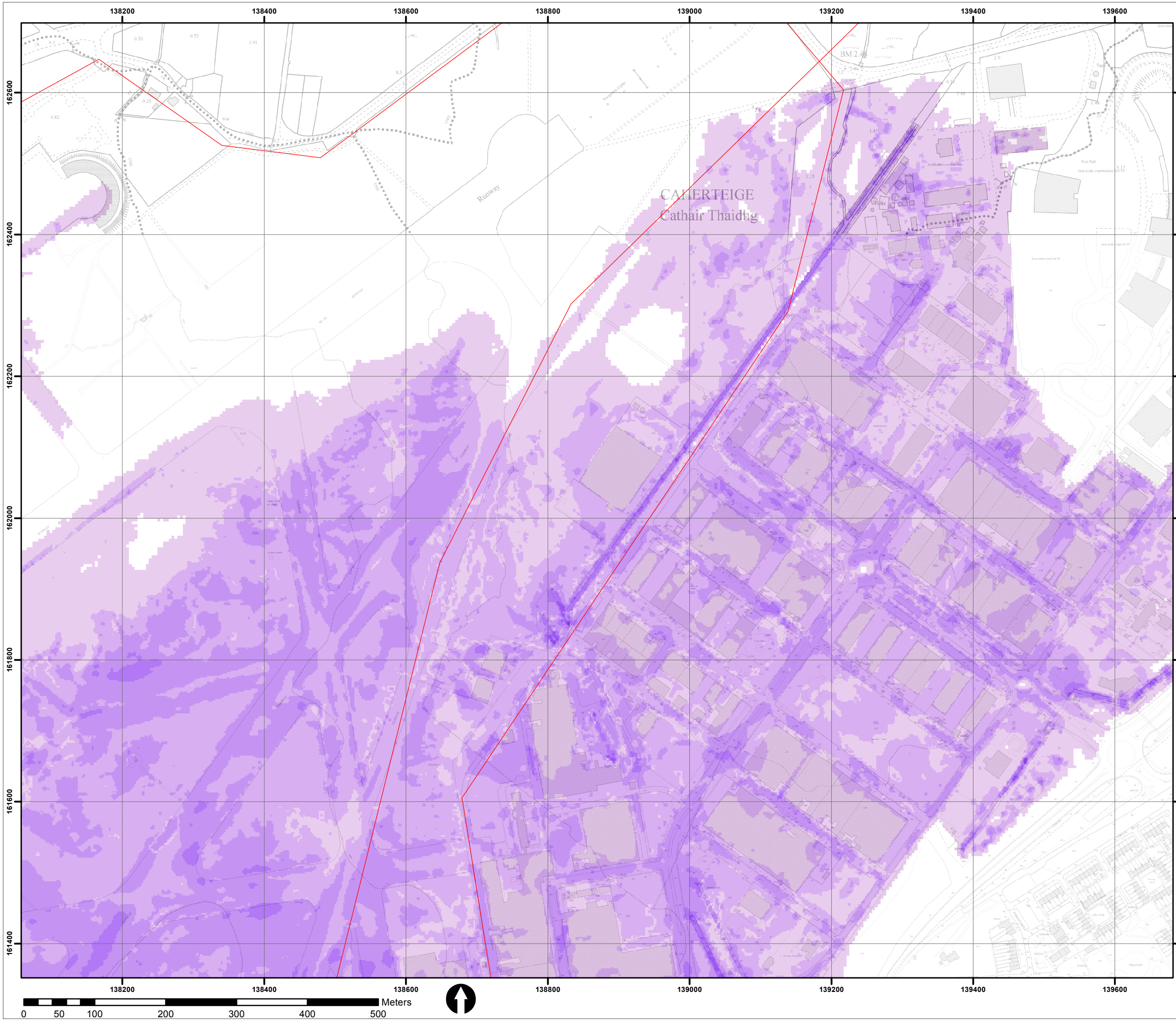
Project:
SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: IRR3FECCDC1

Sheet: 2 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



- Legend:**
- AFA Boundary
 - Defence Failure Location

- 0.5% AEP Coastal Failure Scenario 1 (m/s)**
- 0 - 0.25
 - 0.25 - 0.5
 - 0.5 - 1.0
 - 1.0 - 2.0
 - > 2.0

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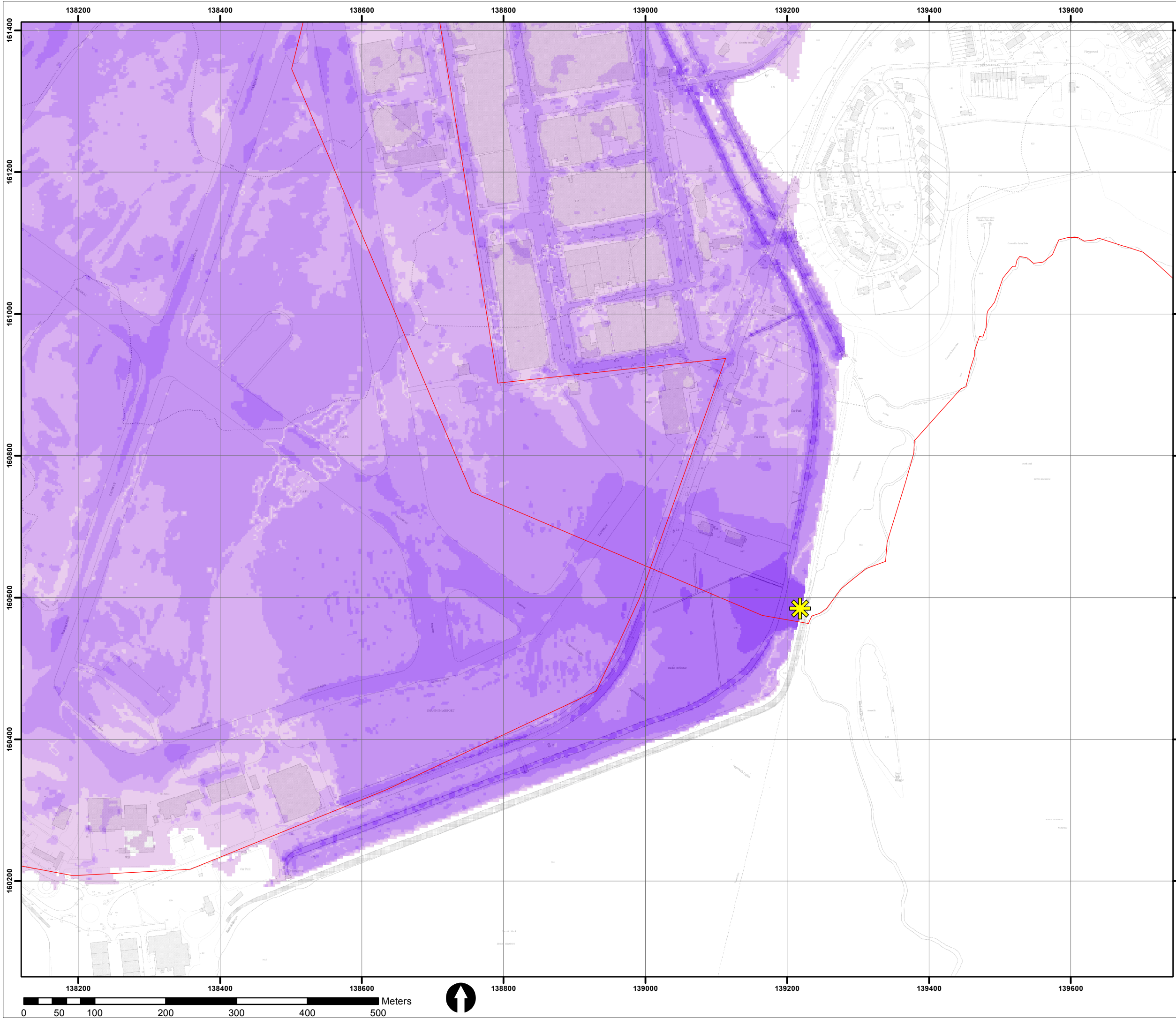


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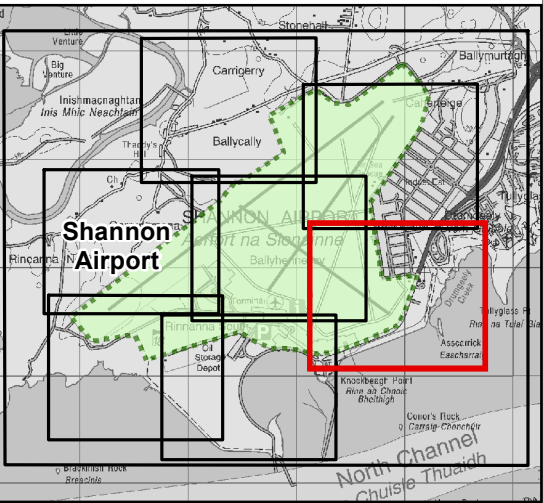


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Project: SHANNON CFRAM STUDY	
Map: SHANNON AIRPORT	
Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 3 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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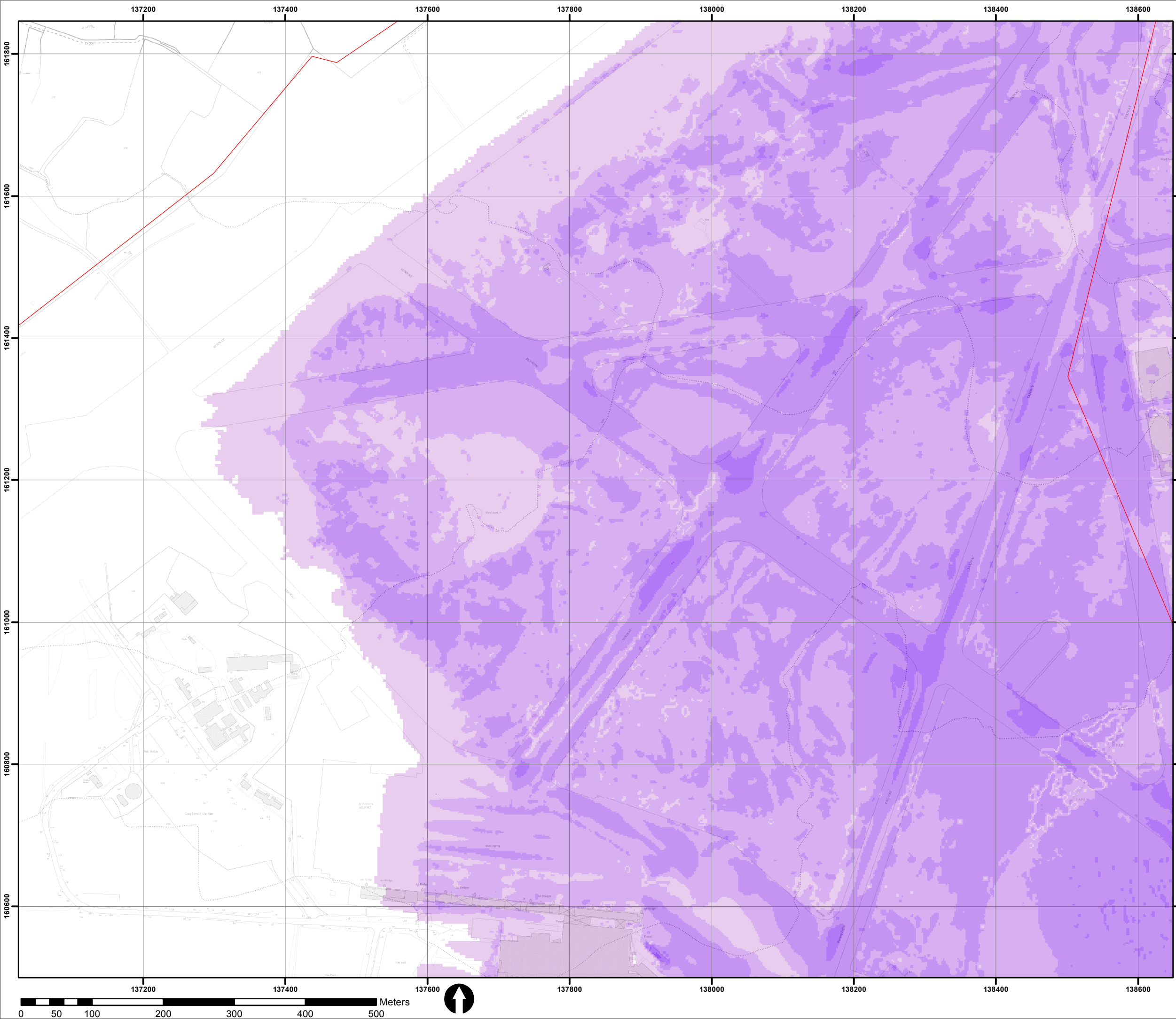
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Merrion Road
Dublin

Project:
SHANNON CFRAM STUDY

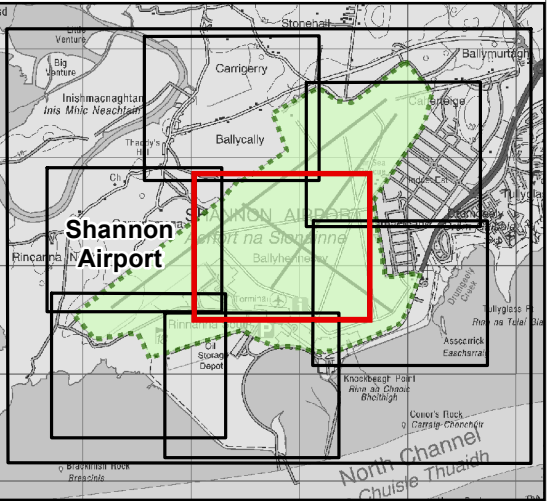
Map:
SHANNON AIRPORT

Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: IRR3FECCDC1
Sheet: 4 of 8
Map Scale: 1: 5000
Revision: 0
Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure
Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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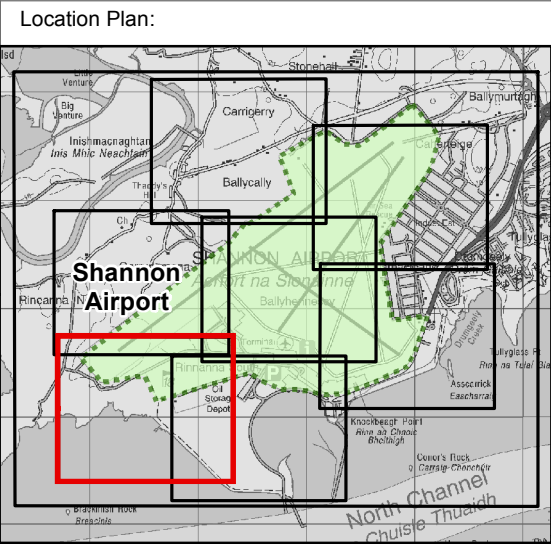
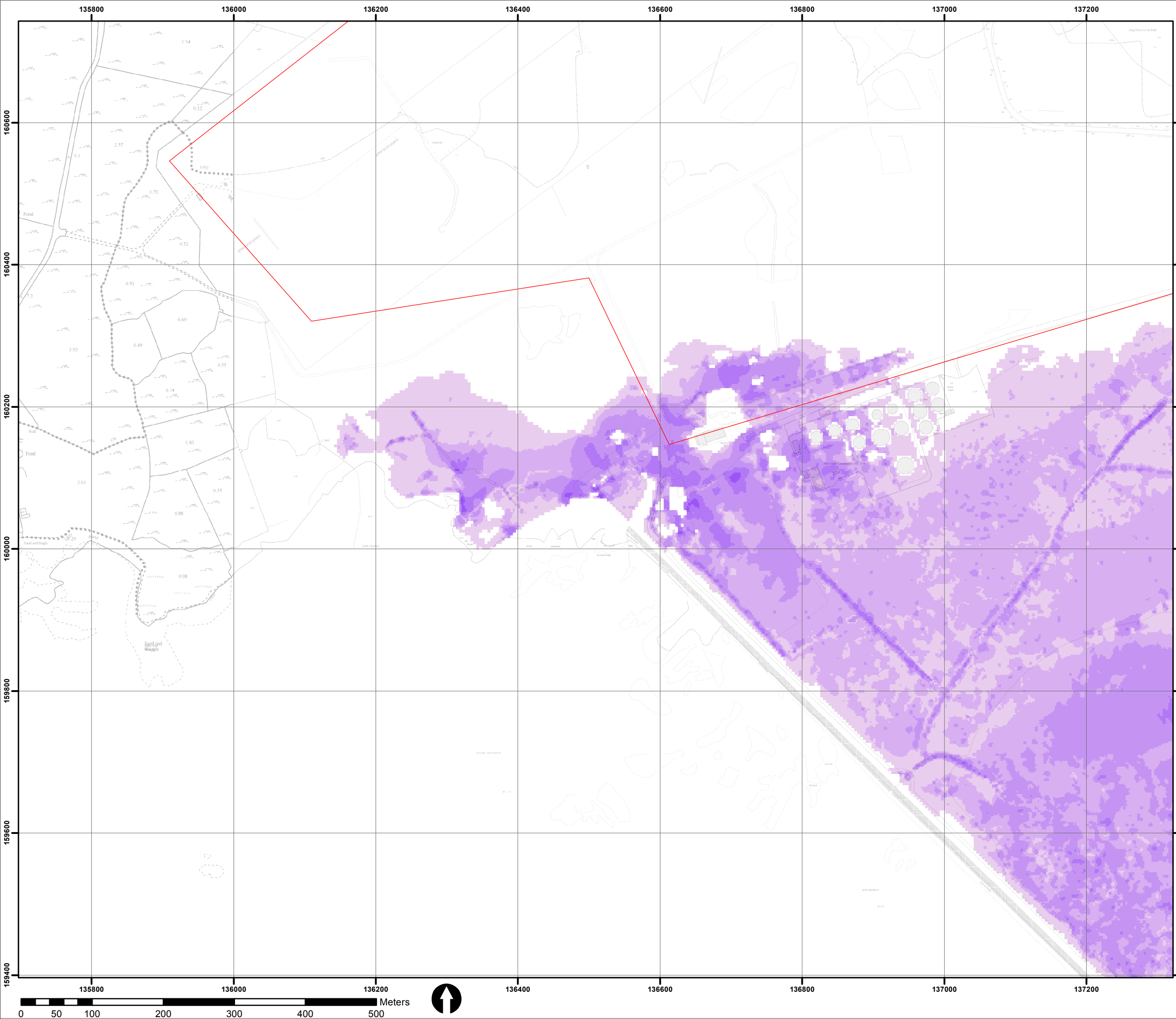


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Project:
SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 5 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0


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Project:
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Map:
SHANNON AIRPORT

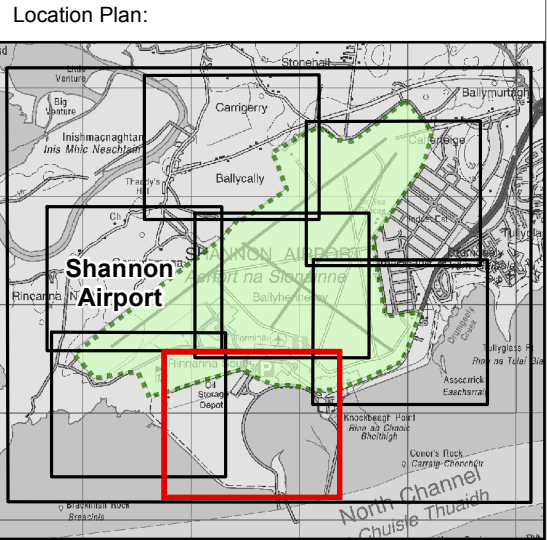
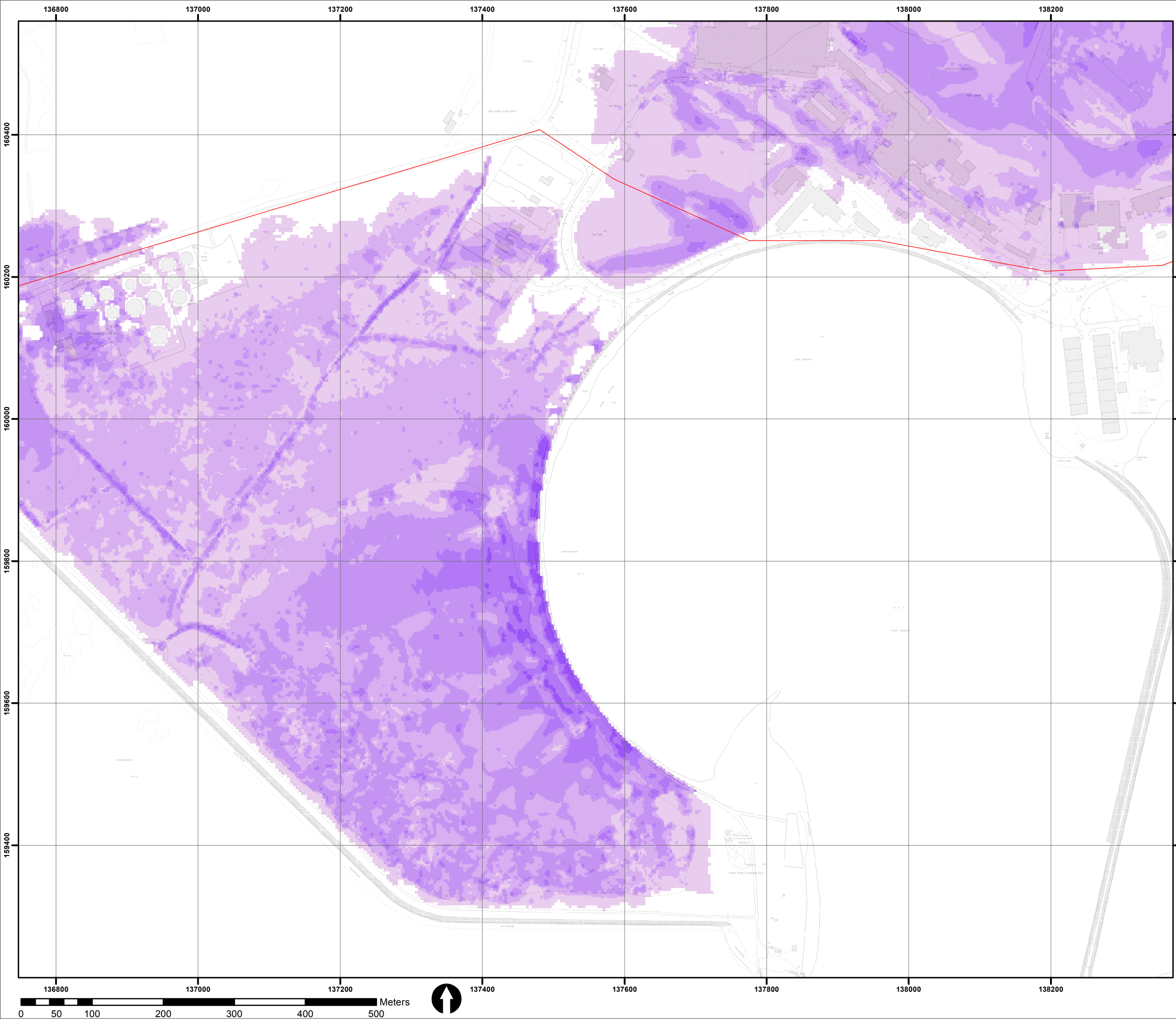
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Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON AIRPORT
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.:
IRR3FECCDC1

Sheet: 7 of 8
Map Scale: 1: 5000

Date: November 2015
Revision: 0
Plot Scale: 1:1 @ A3



Legend:

- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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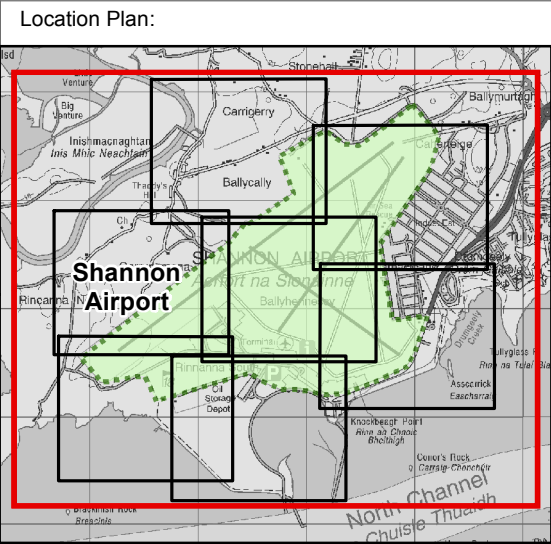
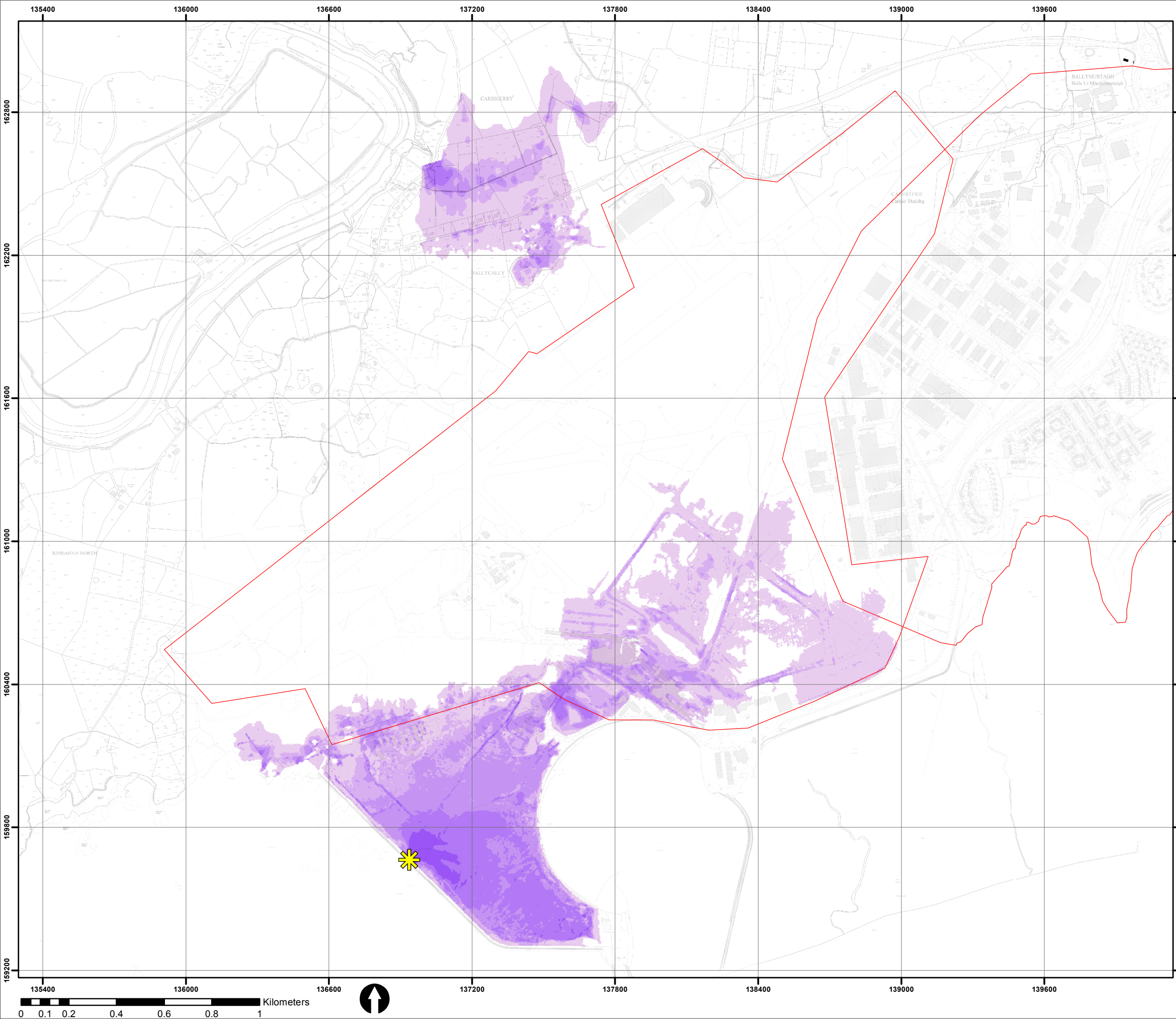


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Project: SHANNON CFRAM STUDY	
Map: SHANNON AIRPORT	
Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 8 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

AFA Boundary

Defence Failure Location

2% AEP Coastal Failure Scenario 2 (m/s)

0 - 0.25

0.25 - 0.5

0.5 - 1.0


1.0 - 2.0

> 2.0


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Project:
SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

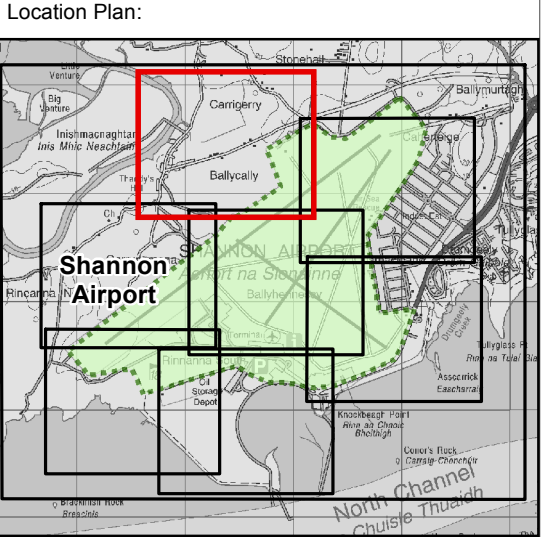
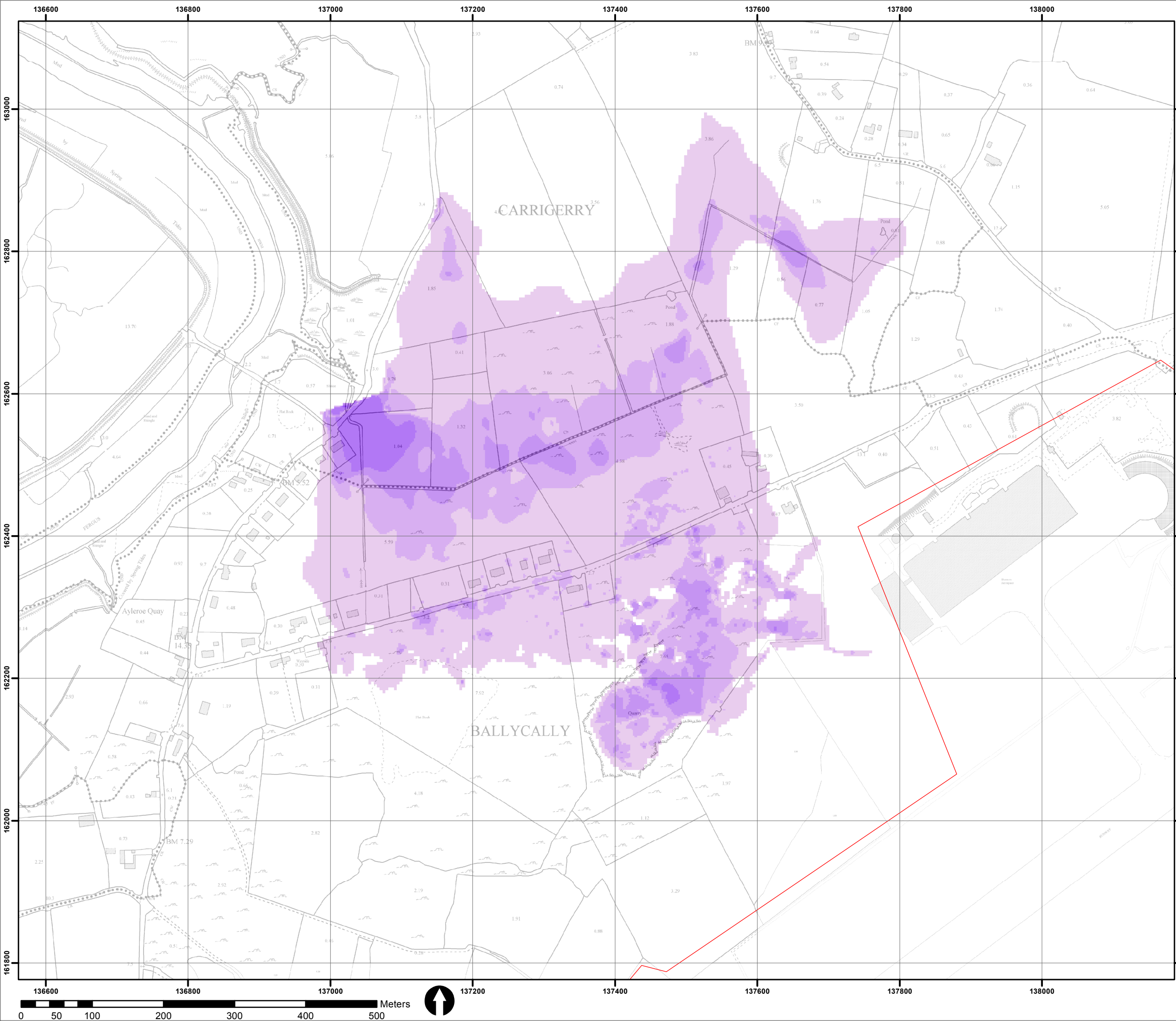
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Source: 2% AEP COASTAL FAILURE SCENARIO 2
Map area: SHANNON AIRPORT
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.:
IRR3FECCDC1

Sheet: 1 of 8
Map Scale: 1: 15000

Revision: 0
Plot Scale: 1:1 @ A3



- Legend:**
- AFA Boundary
 - Defence Failure Location

**2% AEP Coastal Failure
Scenario 2 (m/s)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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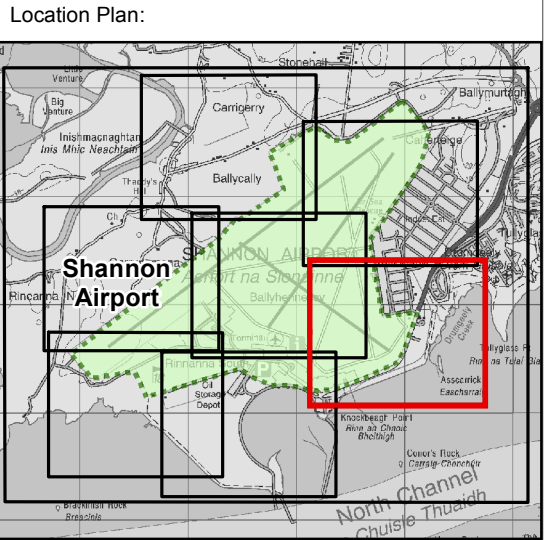
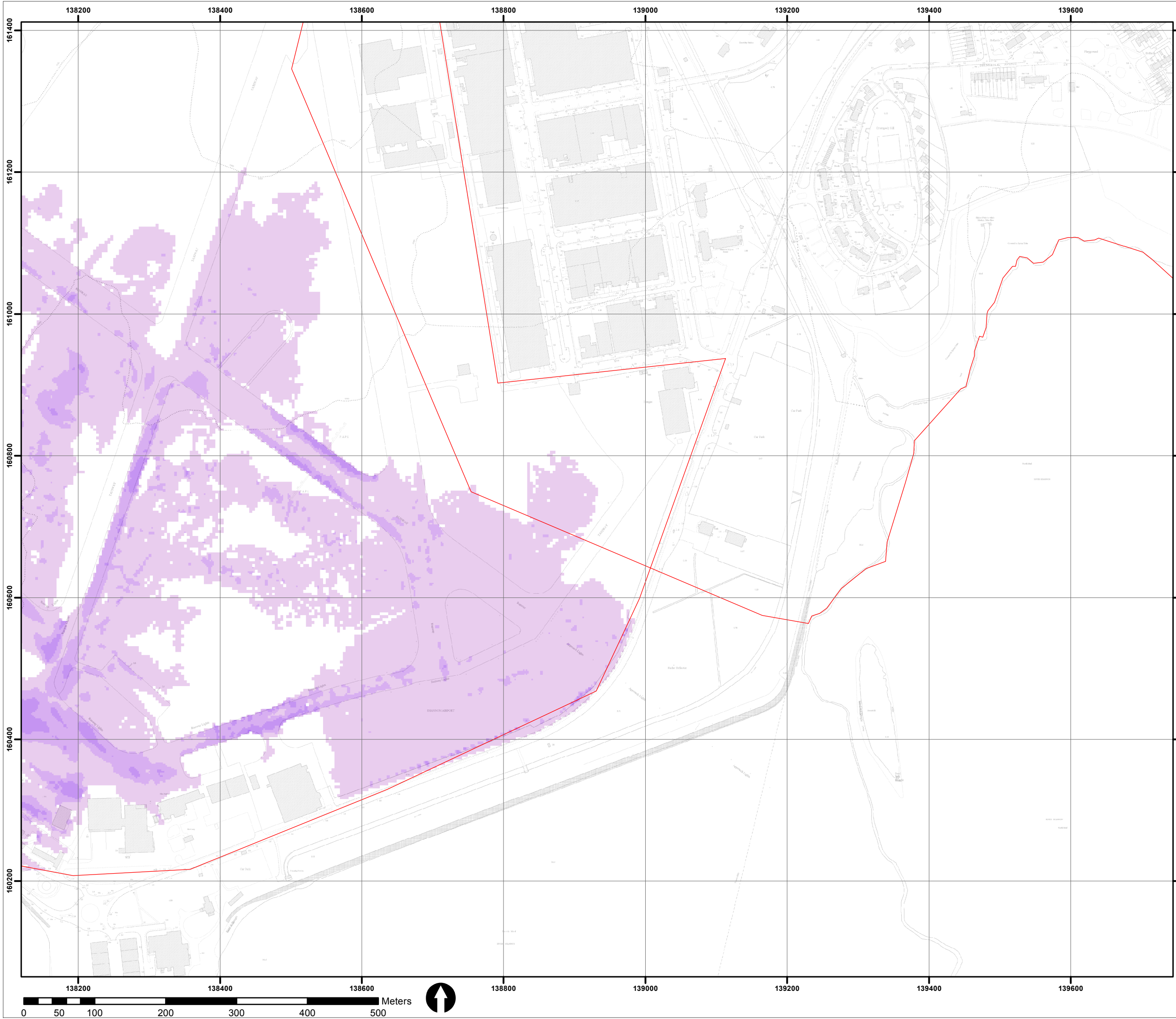
Project:
SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

Map Type:	DEFENCE FAILURE VELOCITY MAP	
Source:	2% AEP COASTAL FAILURE SCENARIO 2	
Map area:	SHANNON AIRPORT	
Scenario:	EXISTING	
Drawn by:	EH	Date: November 2015
Checked by:	PT	Date: November 2015
Reviewed by:	MC	Date: November 2015
Approved by:	PS	Date: November 2015

Map No.:
IRR3FECCDC1

Sheet: 2 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- AFA Boundary
- Defence Failure Location


2% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0


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Project:
SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

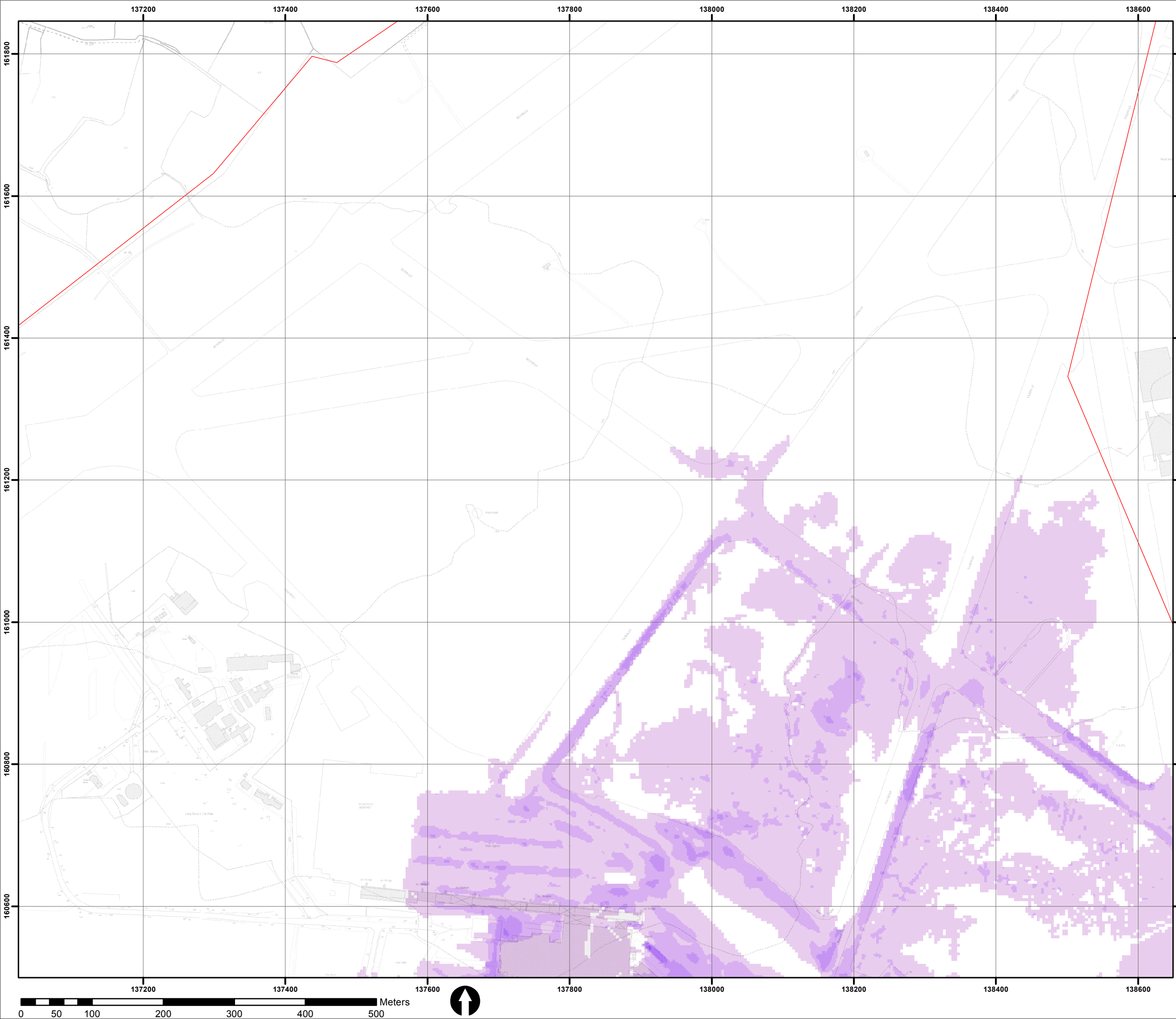
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Source: 2% AEP COASTAL FAILURE SCENARIO 2
Map area: SHANNON AIRPORT
Scenario: EXISTING

Drawn by: EH Date: November 2015
Checked by: PT Date: November 2015
Reviewed by: MC Date: November 2015
Approved by: PS Date: November 2015

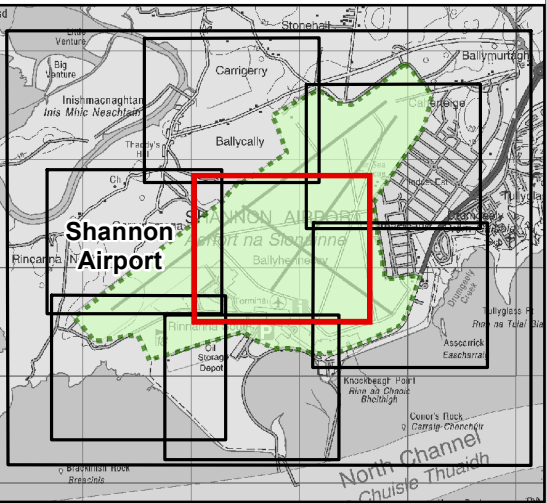
Map No.:
IRR3FECCDC1

Sheet: 4 of 8
Map Scale: 1: 5000

Revision: 0
Plot Scale: 1:1 @ A3



Location Plan:



Legend:

- AFA Boundary
- Defence Failure Location

2% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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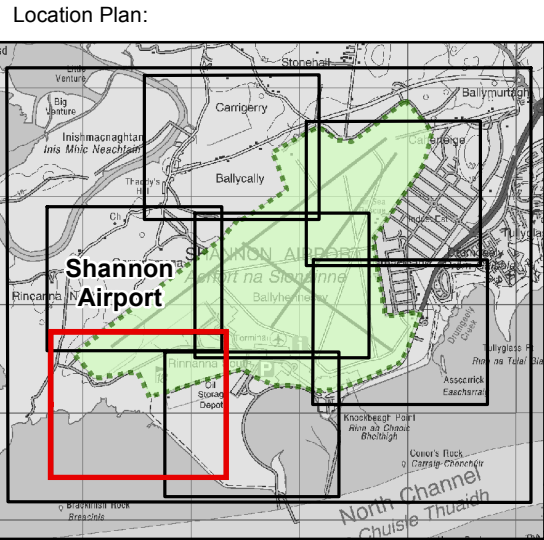
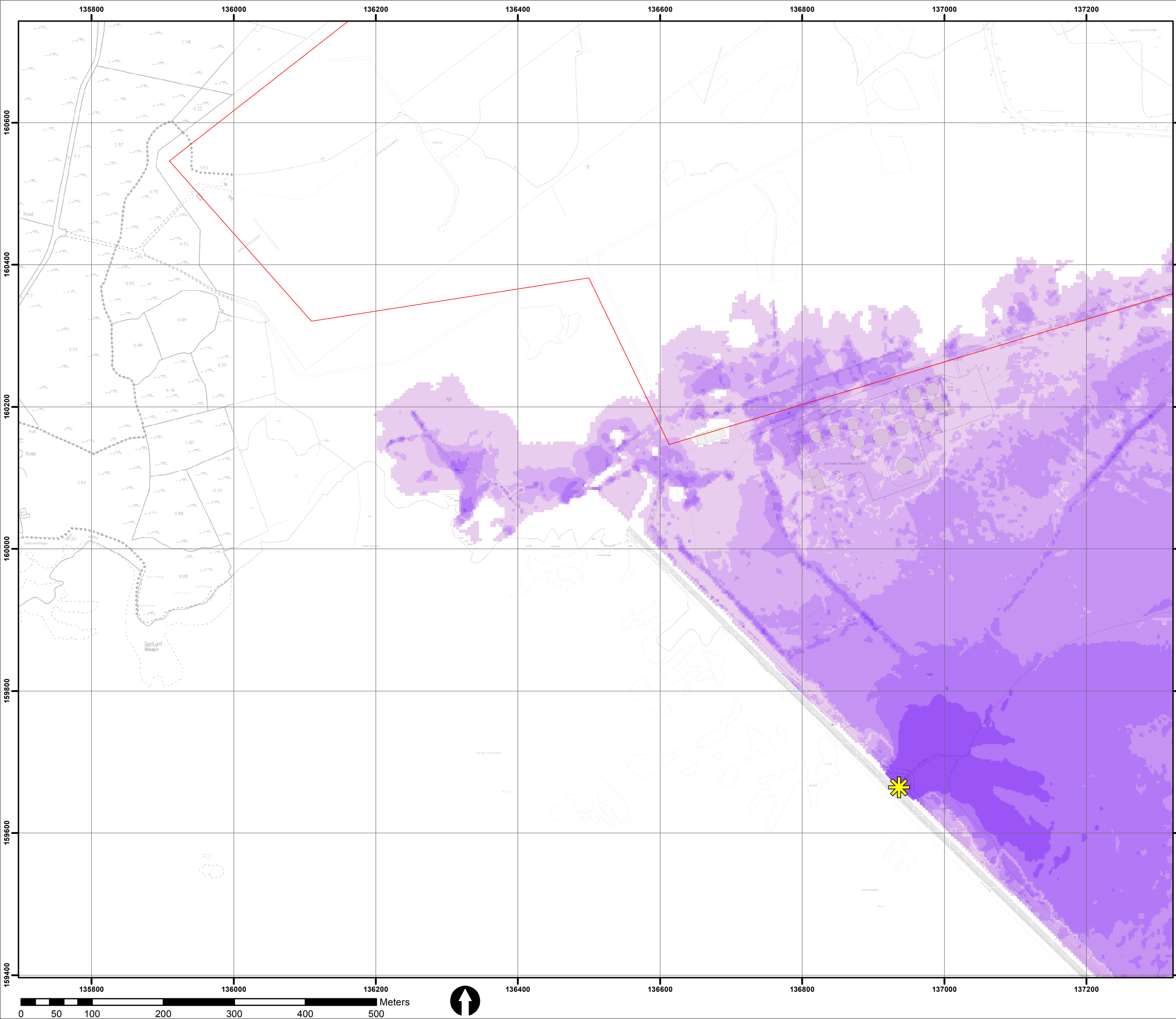
Project:
SHANNON CFRAM STUDY

Map:
SHANNON AIRPORT

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 2% AEP COASTAL FAILURE SCENARIO 2
Map area: SHANNON AIRPORT
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: IRR3FECCDC1	Revision: 0
Sheet: 5 of 8	Plot Scale: 1:1 @ A3
Map Scale: 1: 5000	



- Legend:**
- AFA Boundary
 - Defence Failure Location

**2% AEP Coastal Failure
Scenario 2 (m/s)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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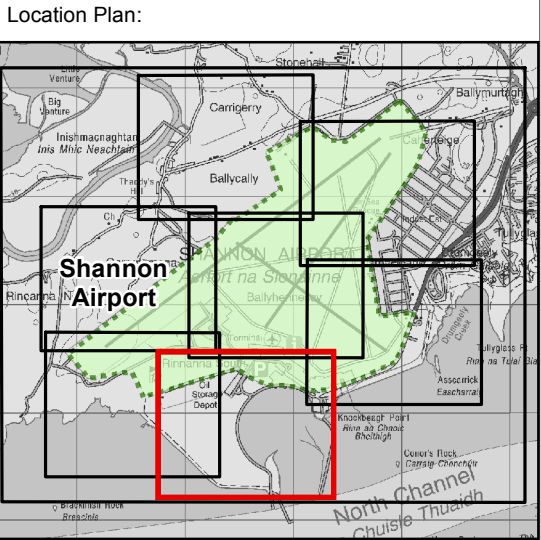
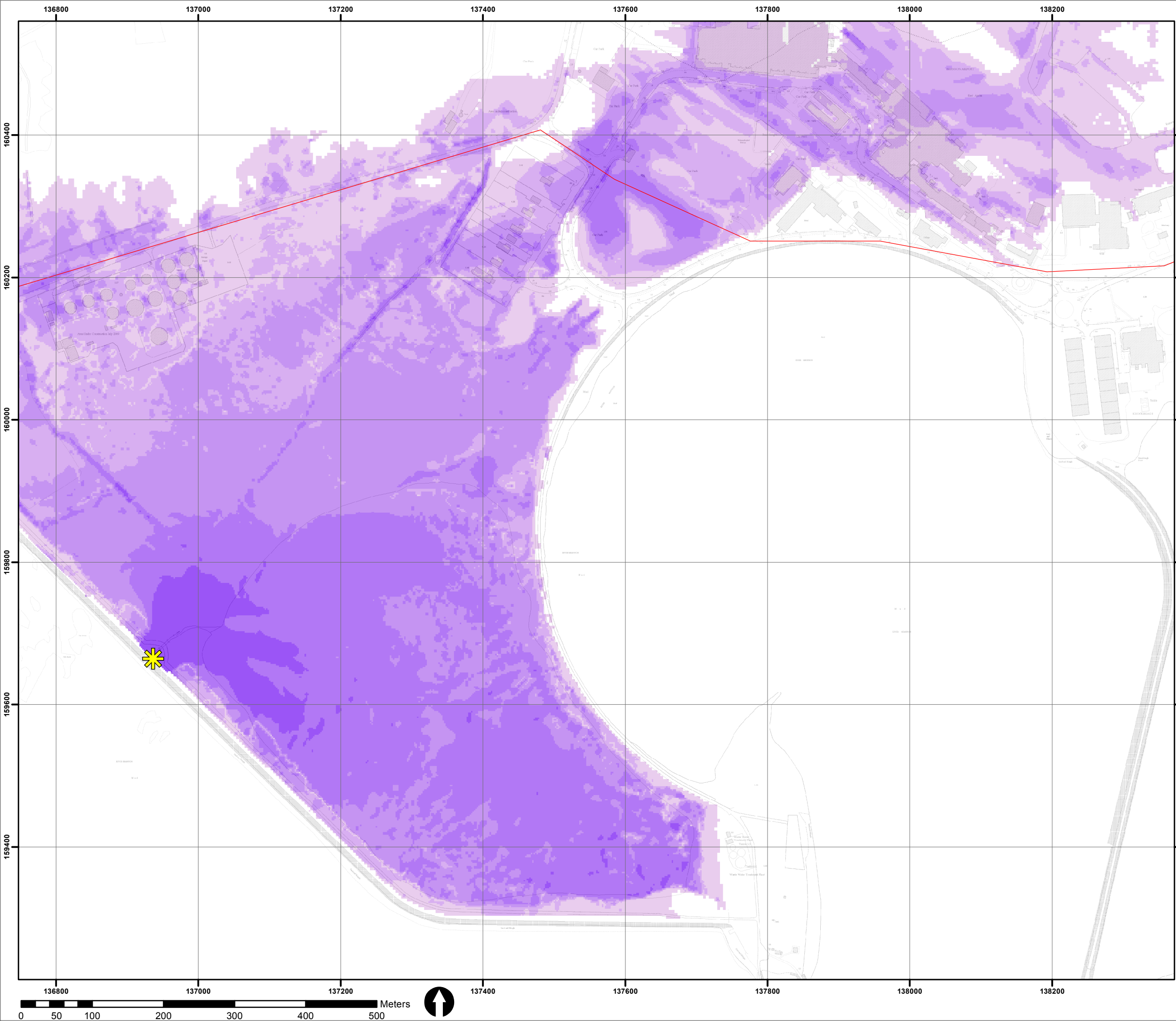


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Project: SHANNON CFRAM STUDY	
Map: SHANNON AIRPORT	
Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 2% AEP COASTAL FAILURE SCENARIO 2	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 7 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- AFA Boundary
- Defence Failure Location

2% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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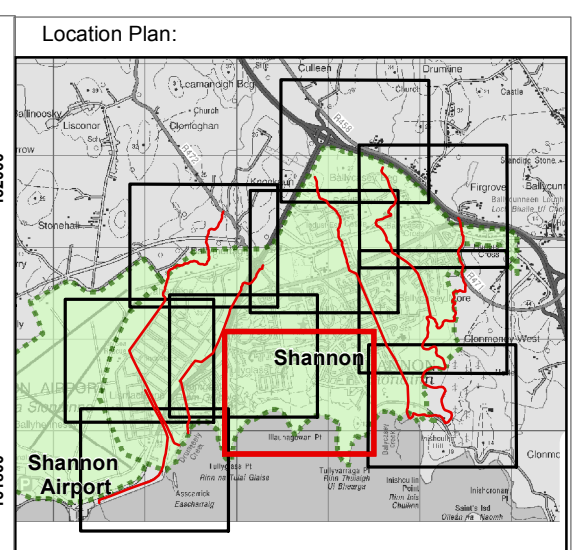
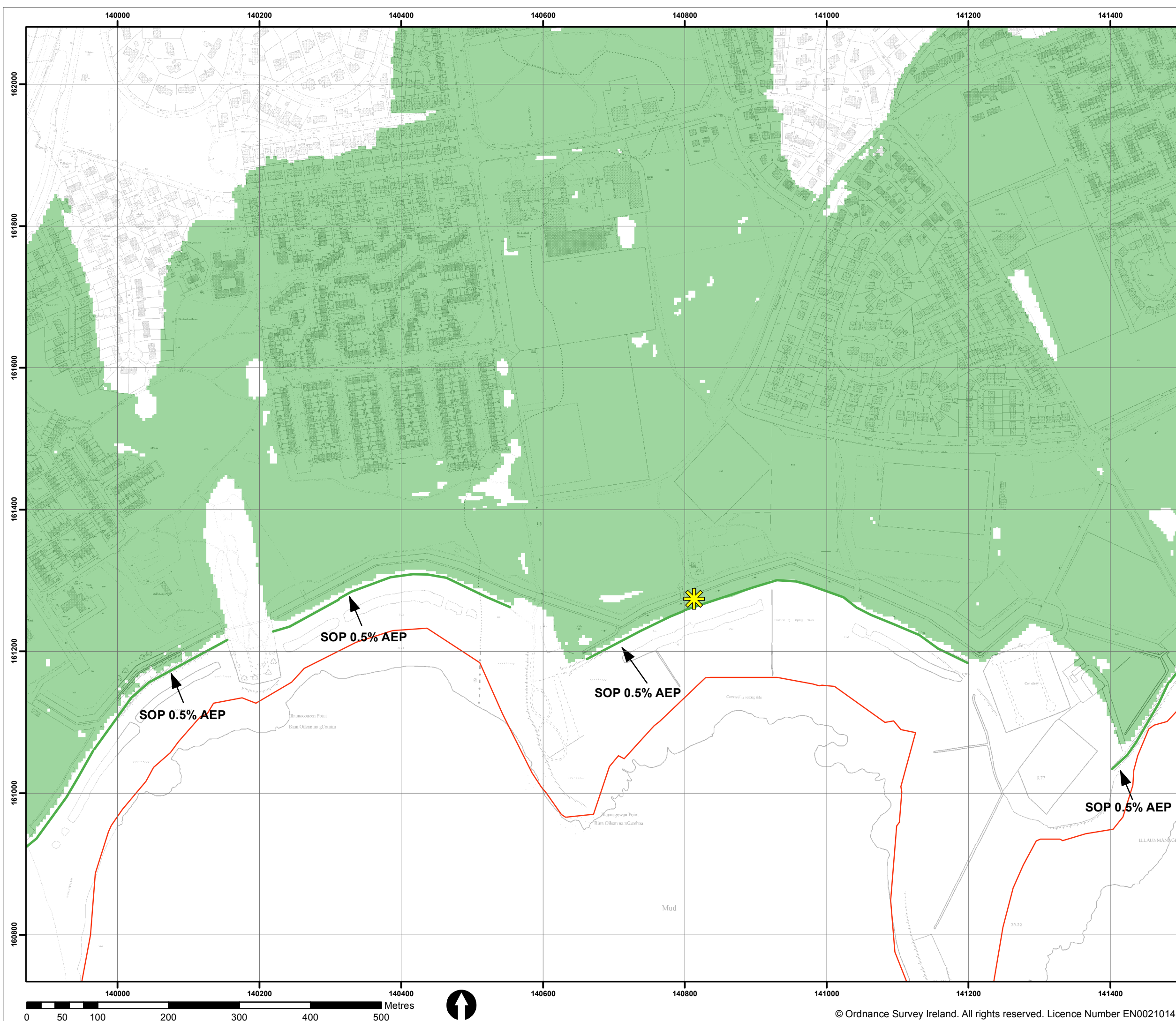


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Project: SHANNON CFRAM STUDY	
Map: SHANNON AIRPORT	
Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 2% AEP COASTAL FAILURE SCENARIO 2	
Map area: SHANNON AIRPORT	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015
Map No.: IRR3FECCDC1	
Sheet: 8 of 8	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3




- Legend:**
- River Centreline
 - AFA Boundary
 - Defence - Embankment
 - Defence Failure Location
 - 0.5% AEP Coastal Failure Scenario 1


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Project:
SHANNON CFRAM STUDY

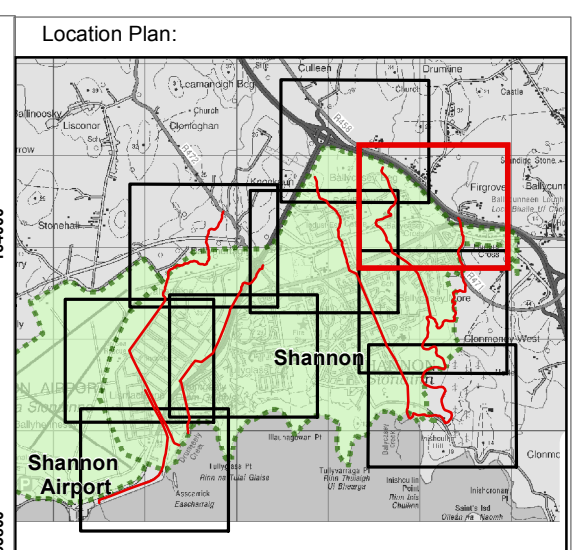
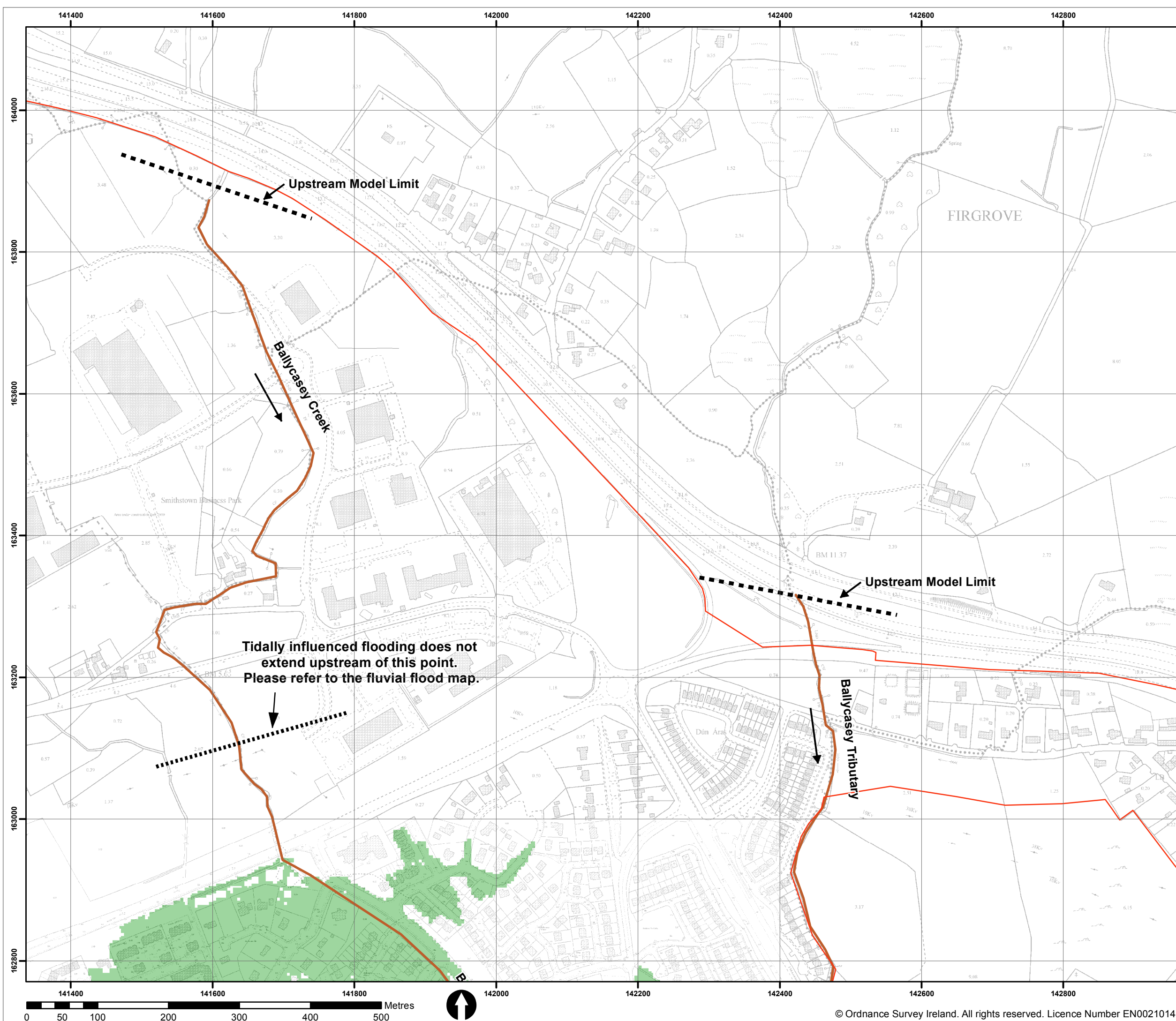
Map:
SHANNON

Map Type: DEFENCE FAILURE EXTENT MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.:
S04FECCDC1

Sheet: 2 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



- Legend:**
- River Centreline
 - AFA Boundary
 - Defence - Embankment
 - Defence Failure Location
 - 0.5% AEP Coastal Failure Scenario 1

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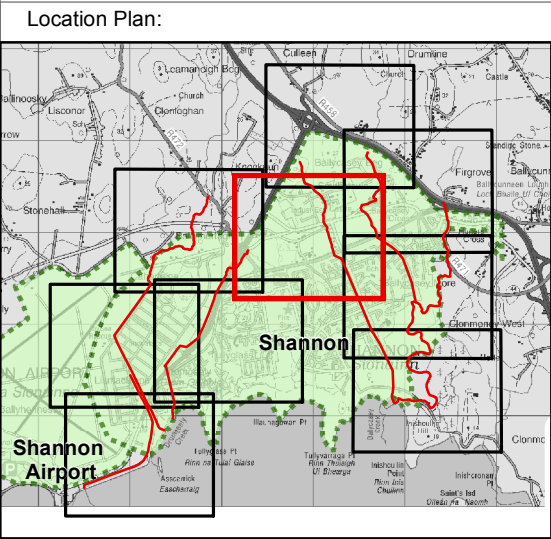
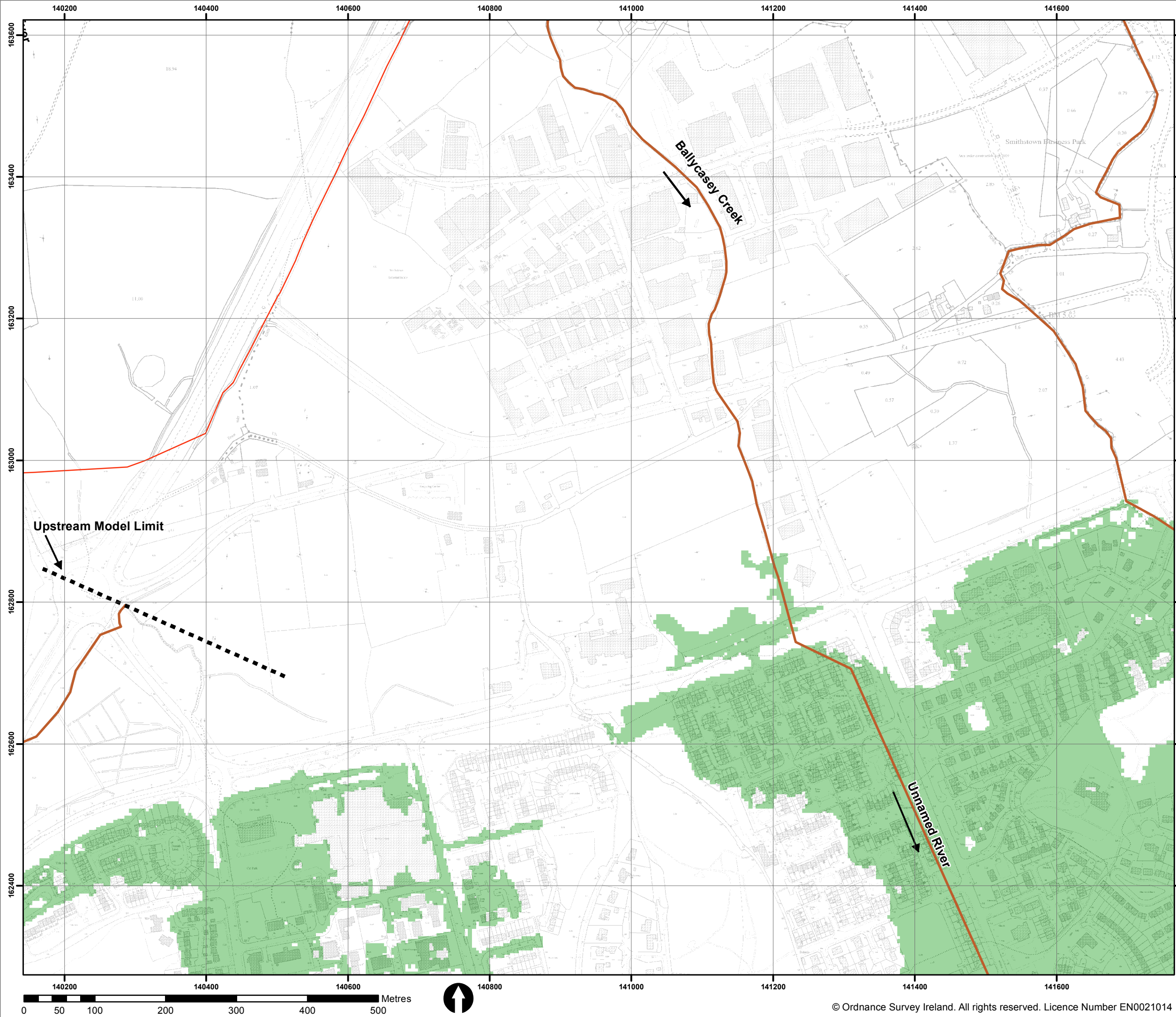


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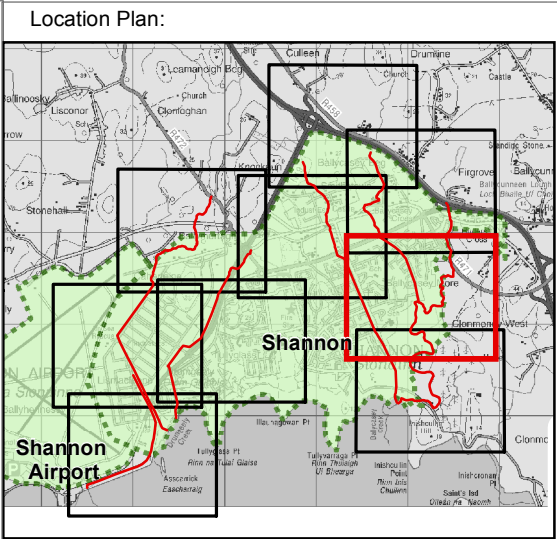
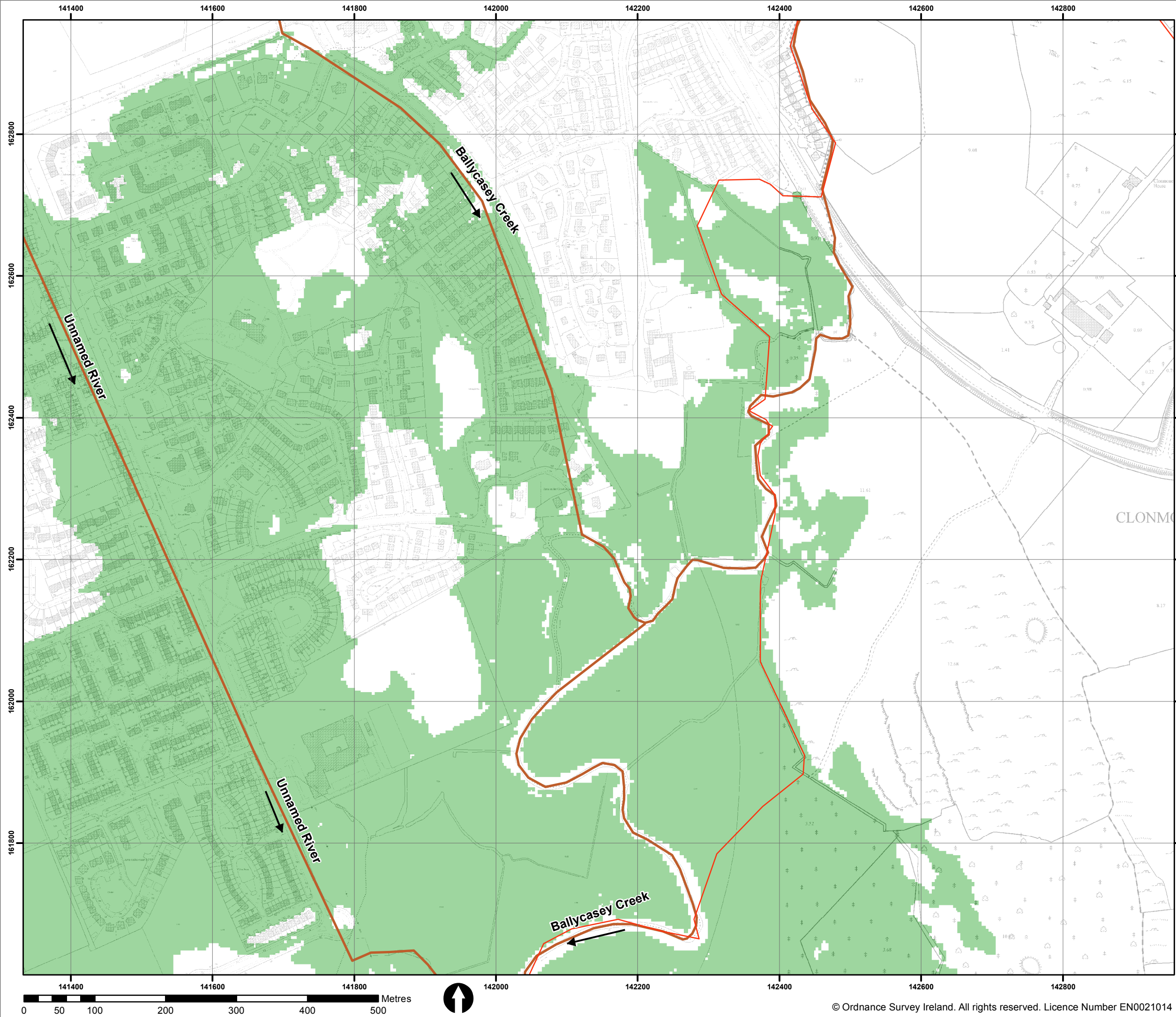


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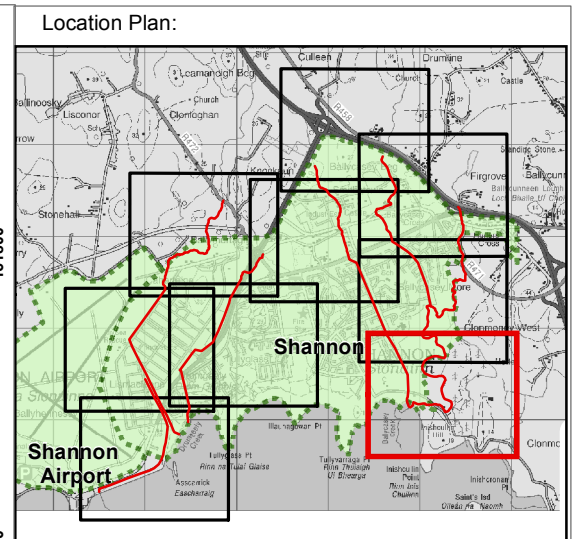
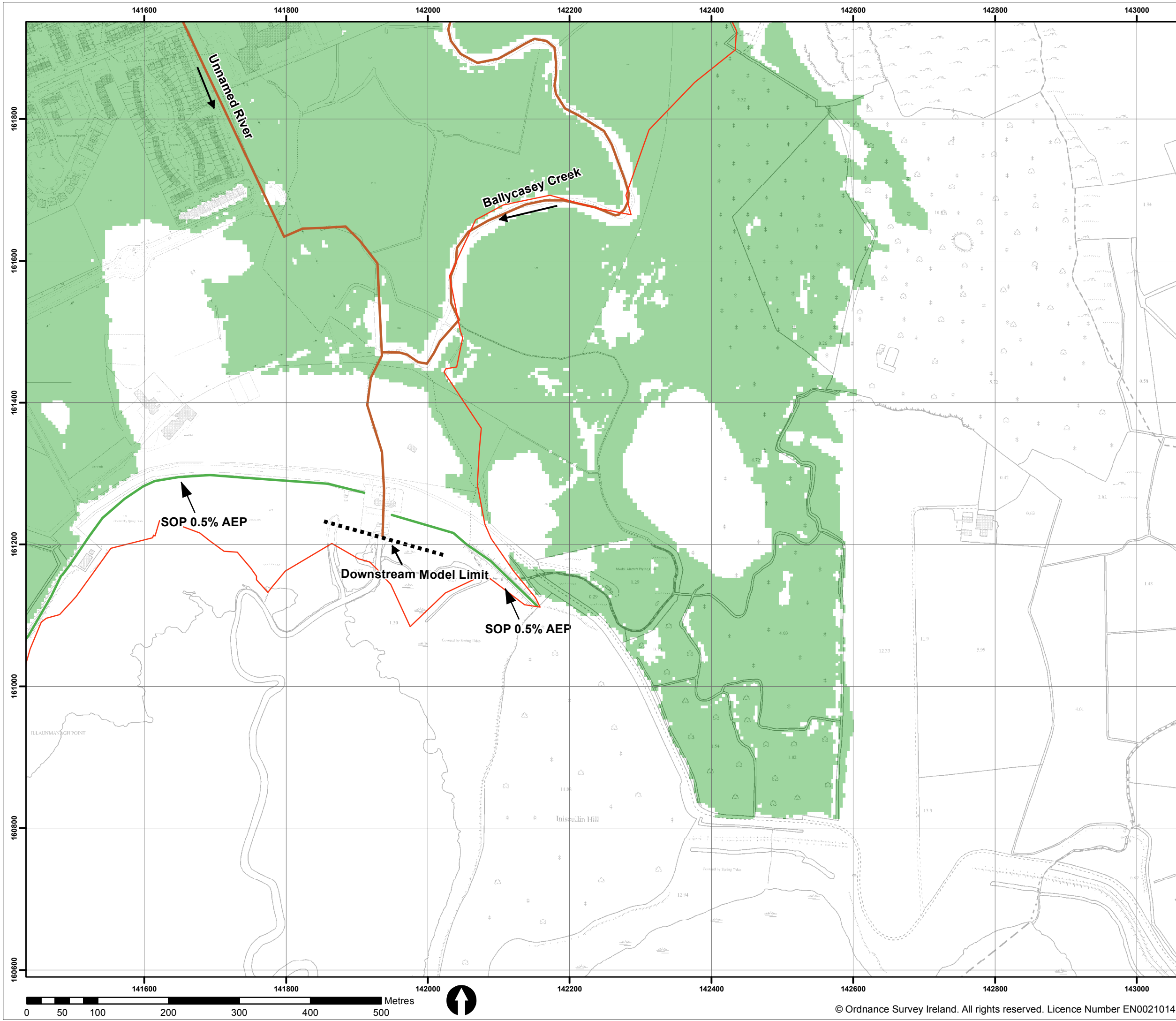


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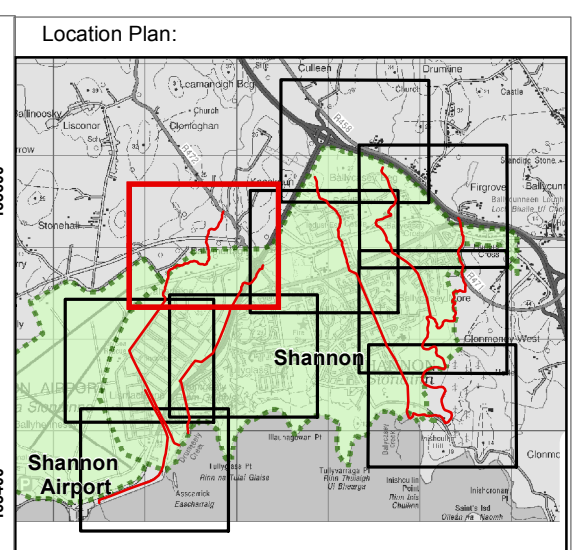
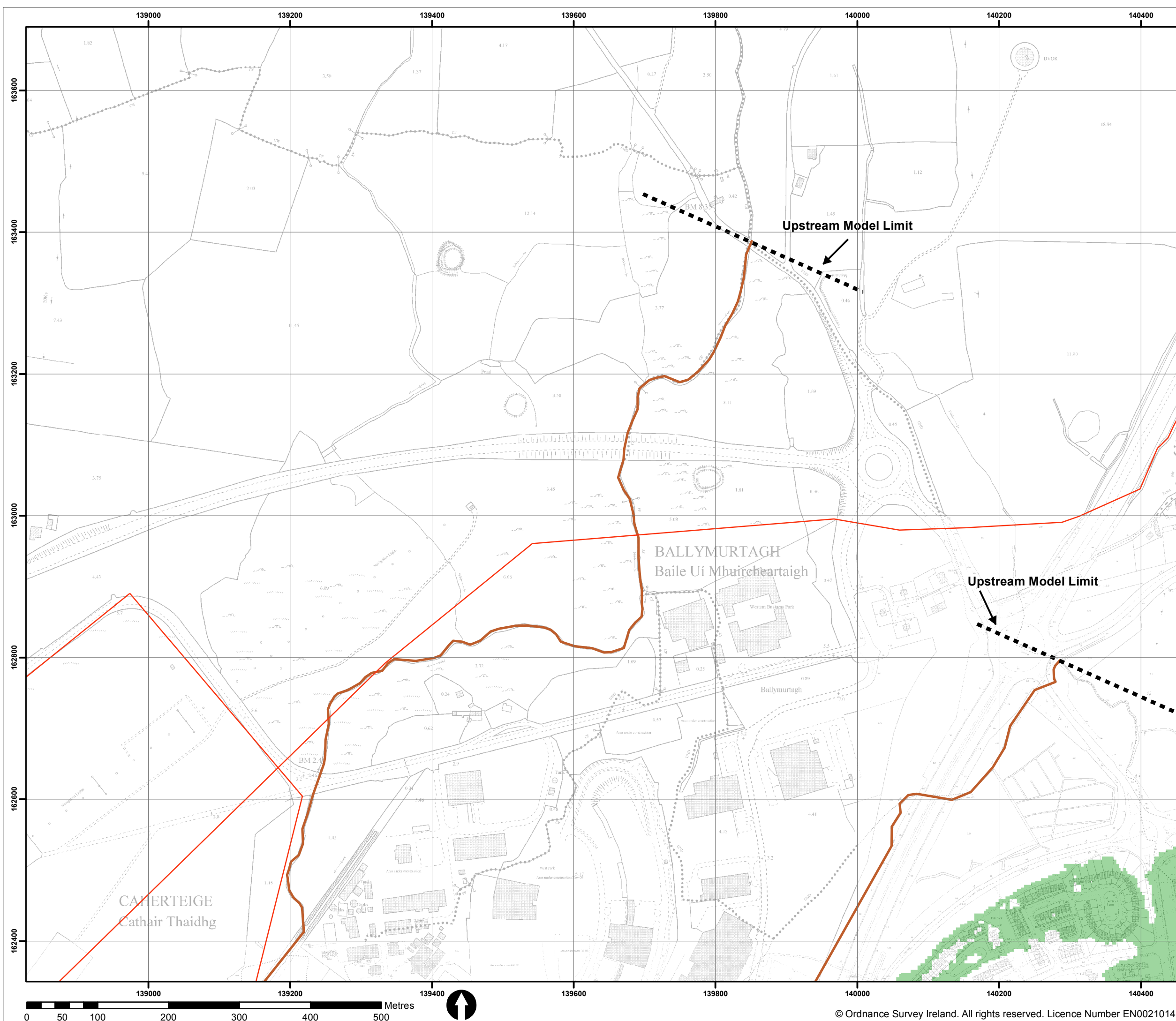


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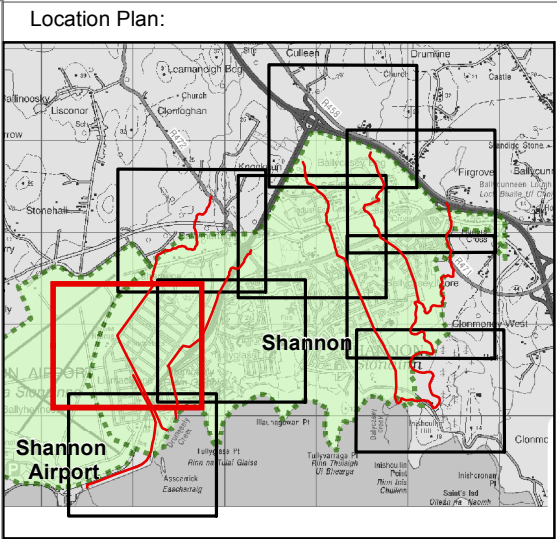
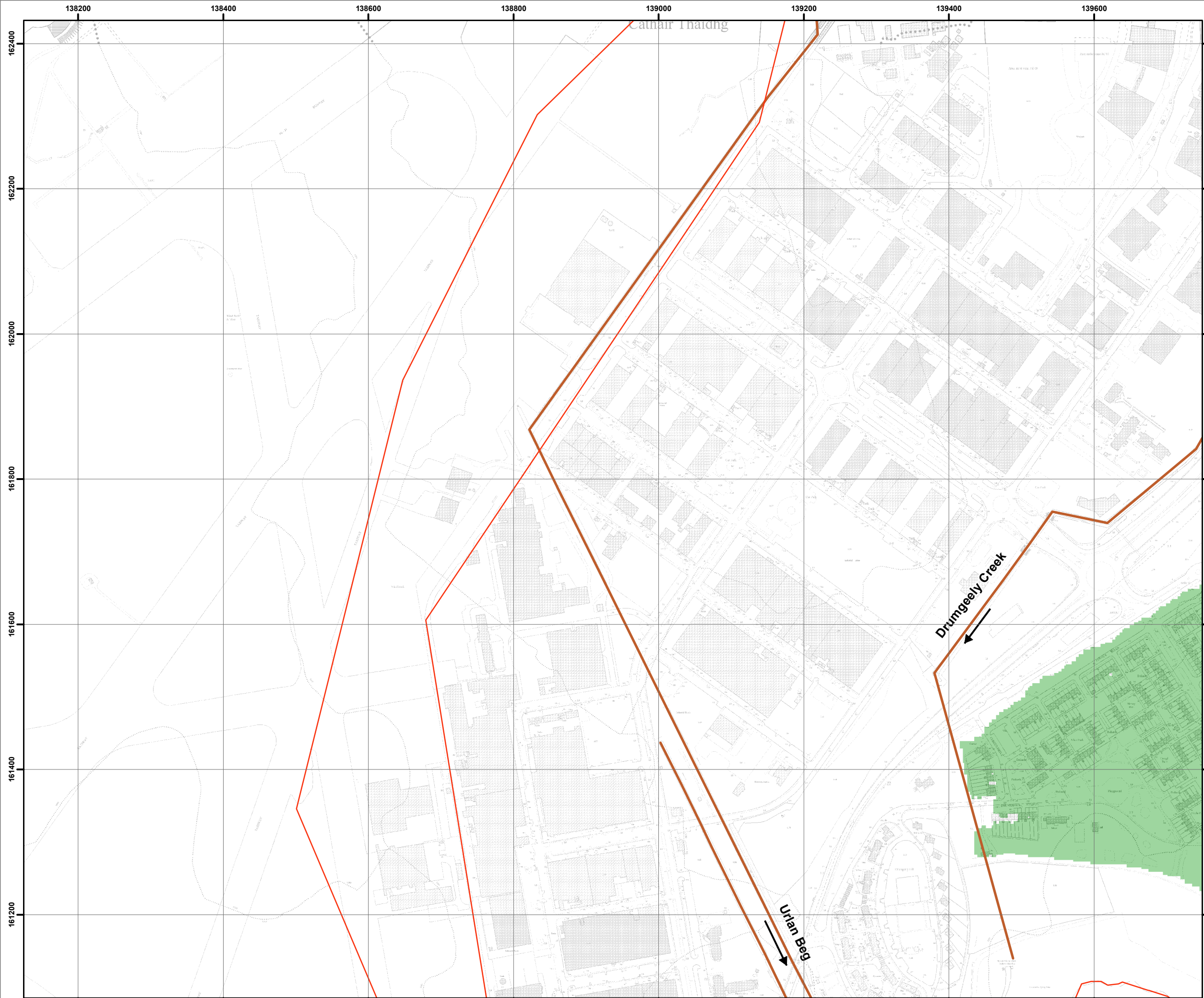
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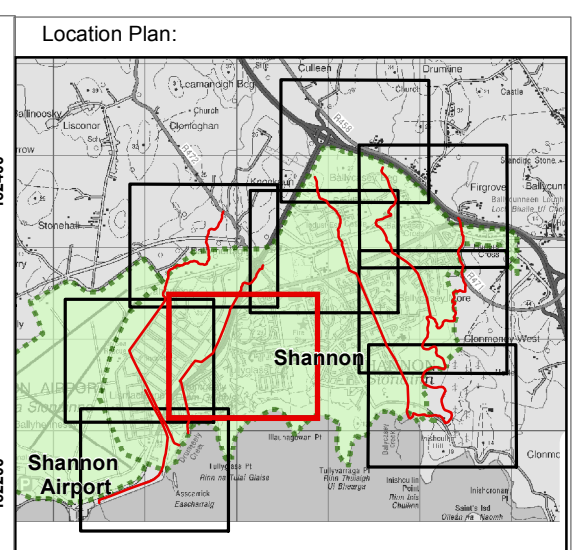
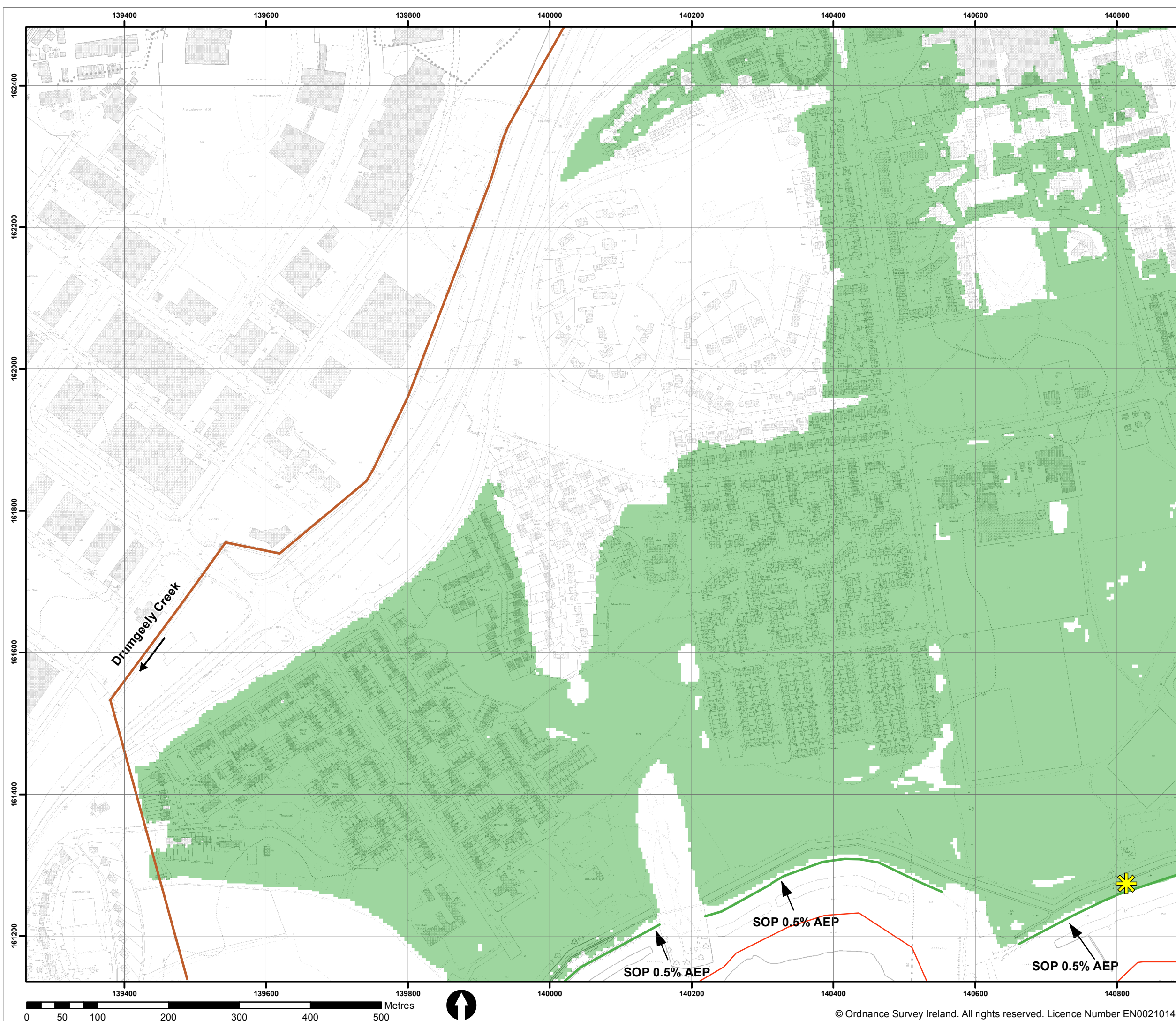


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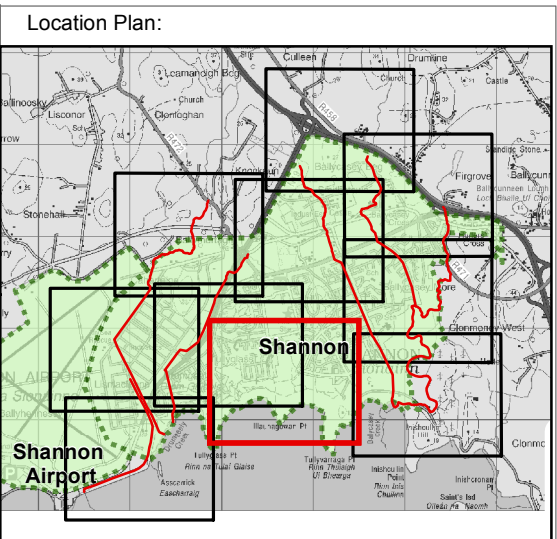
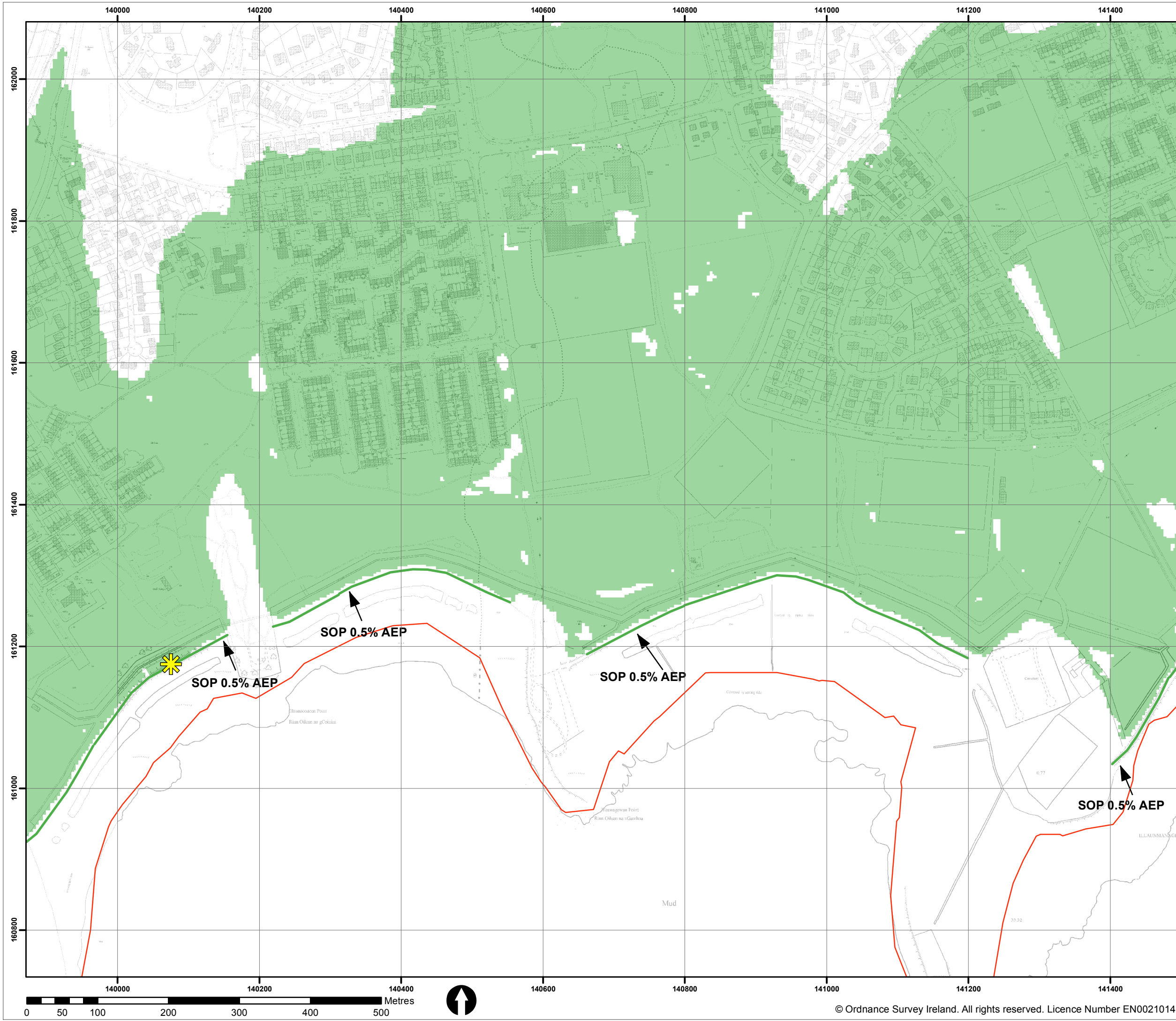


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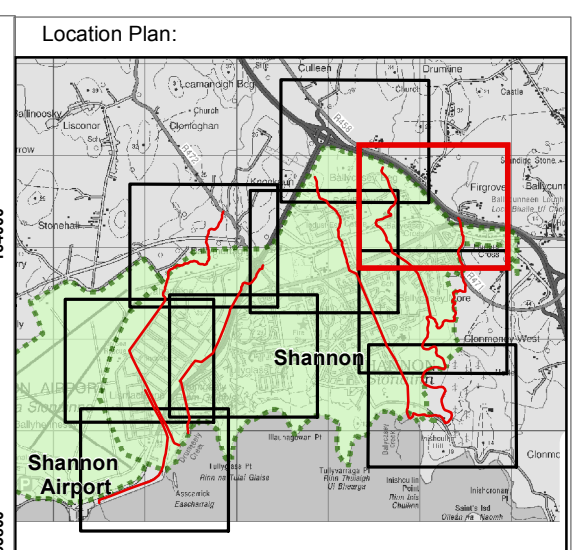
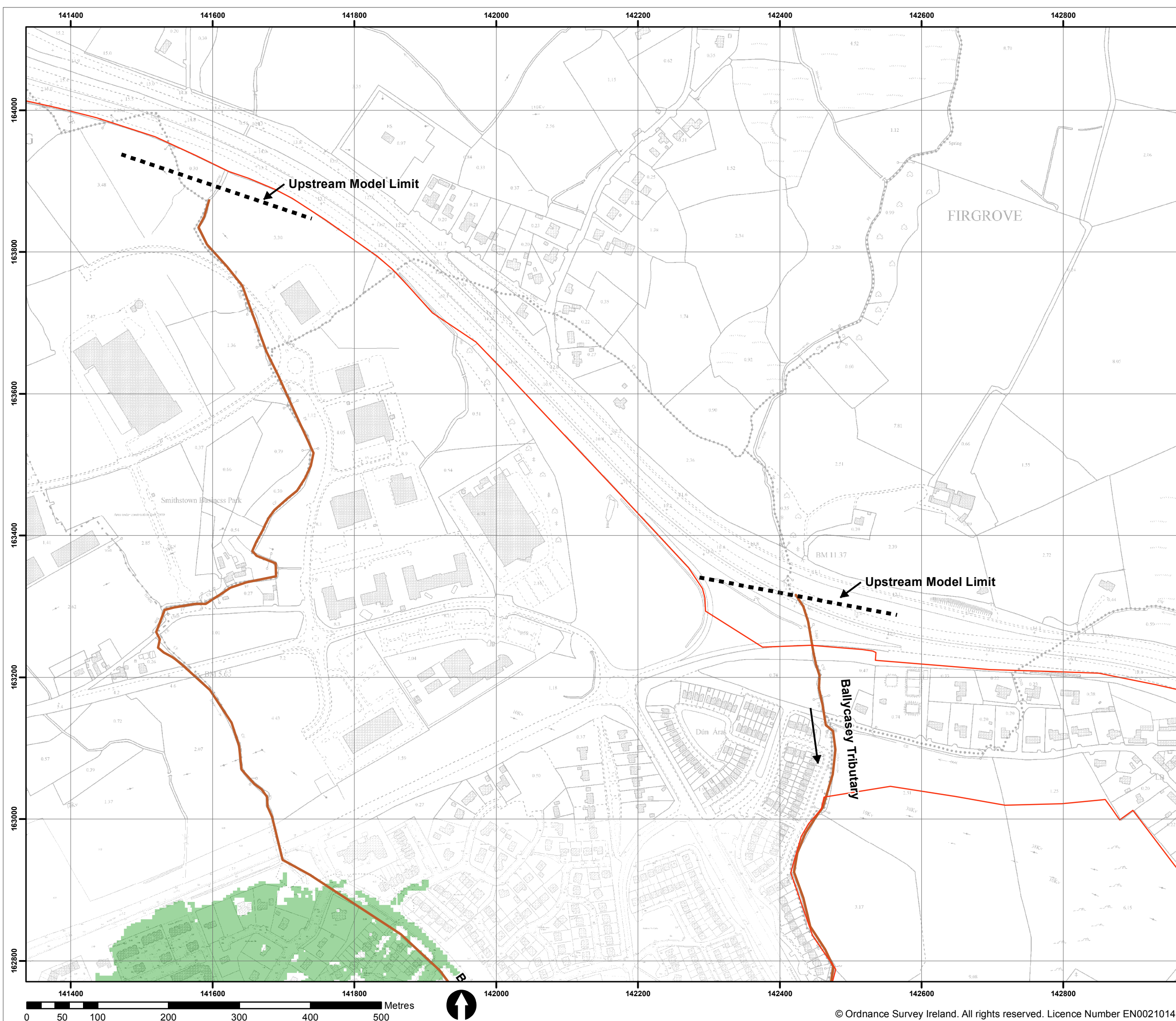
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Drawn by: EH	Date: November 2015
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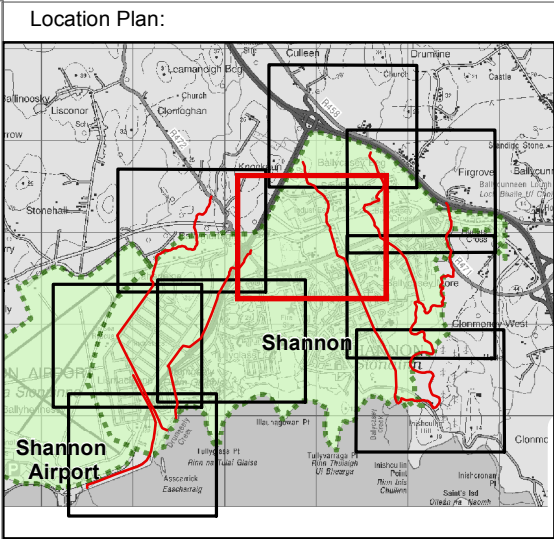
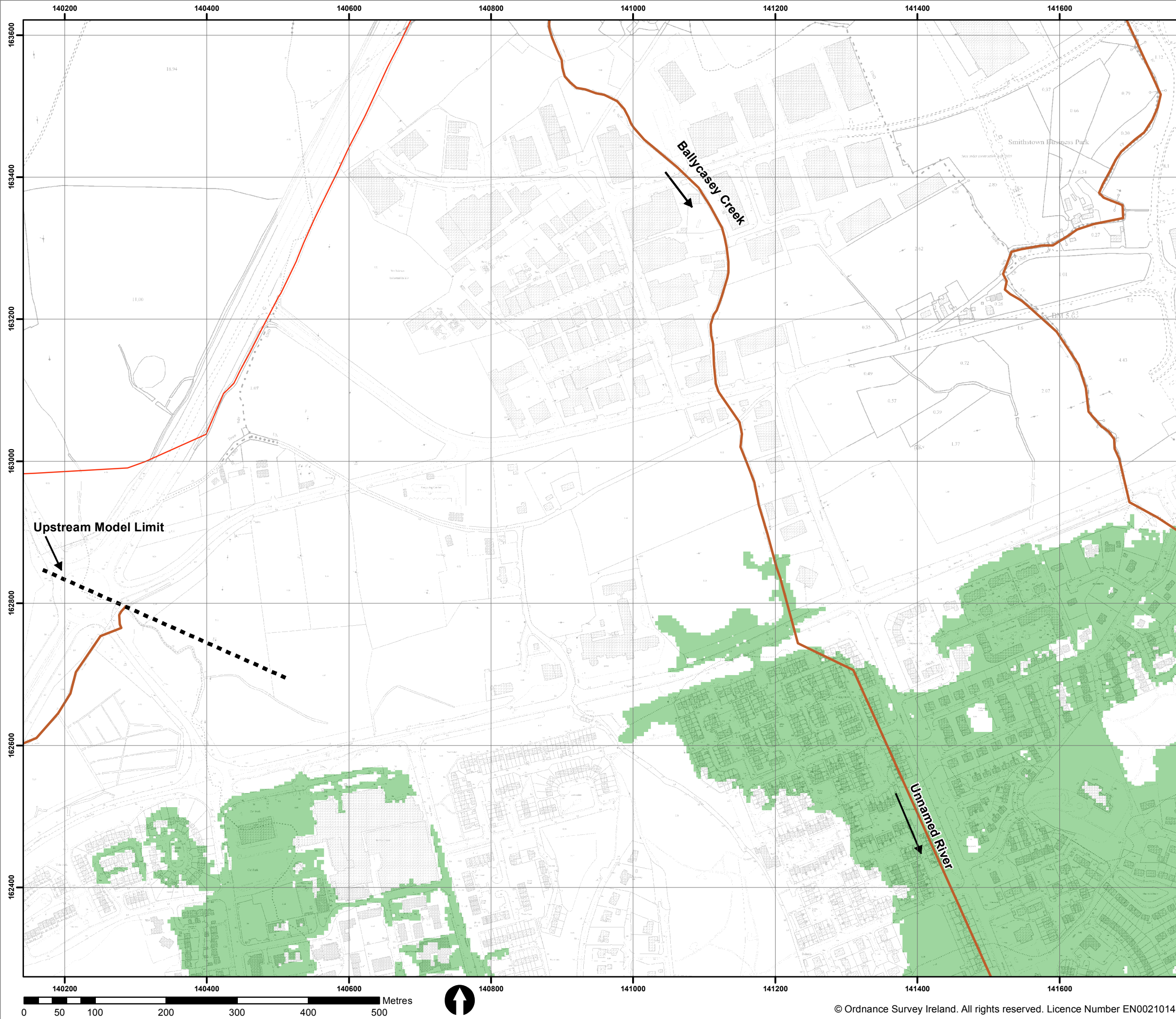


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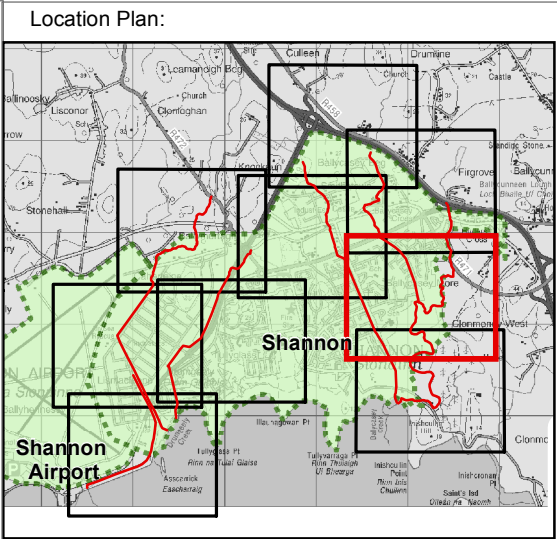
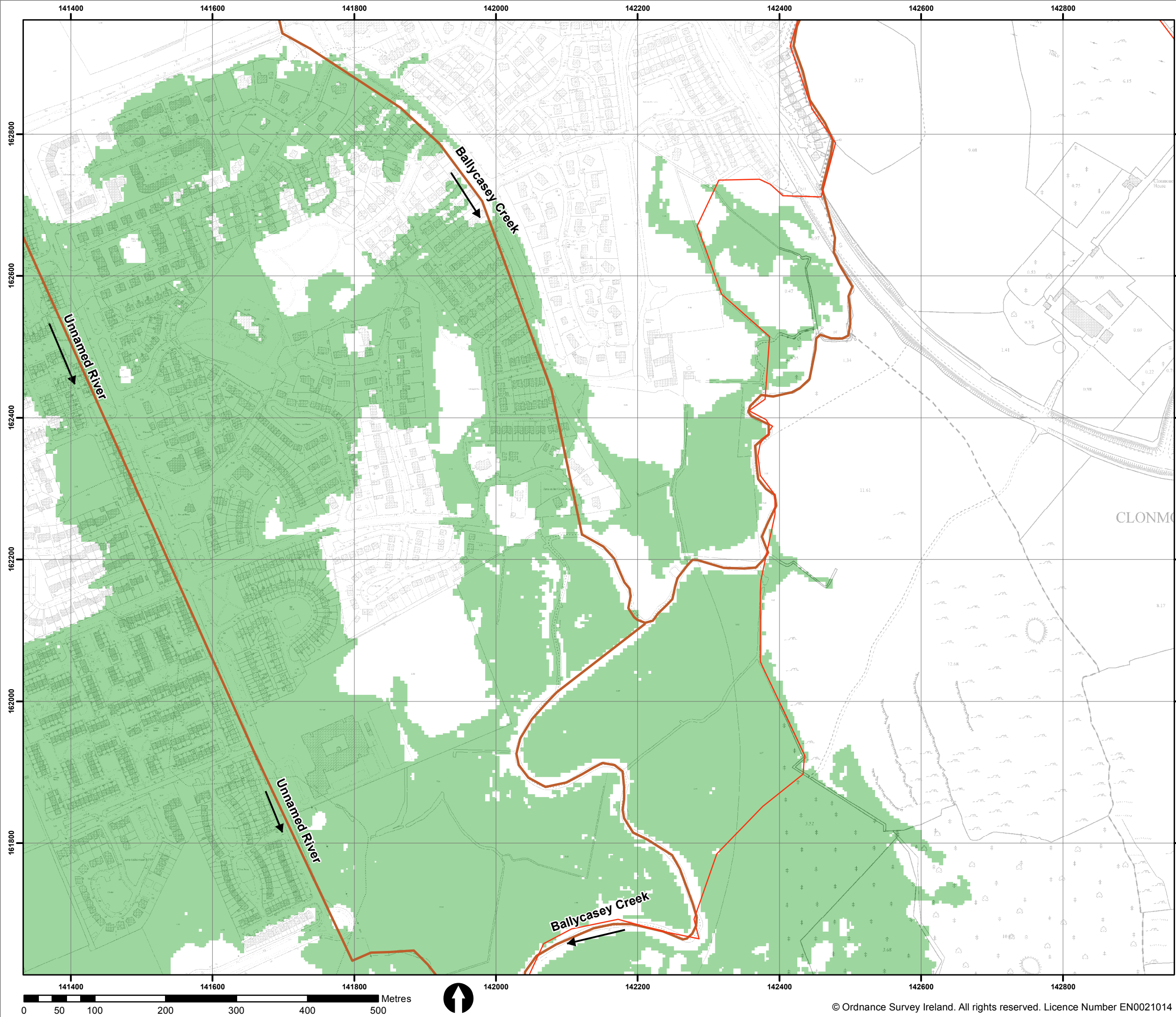


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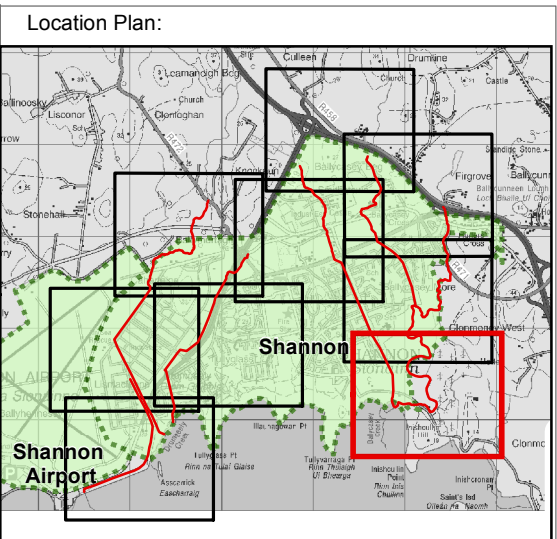
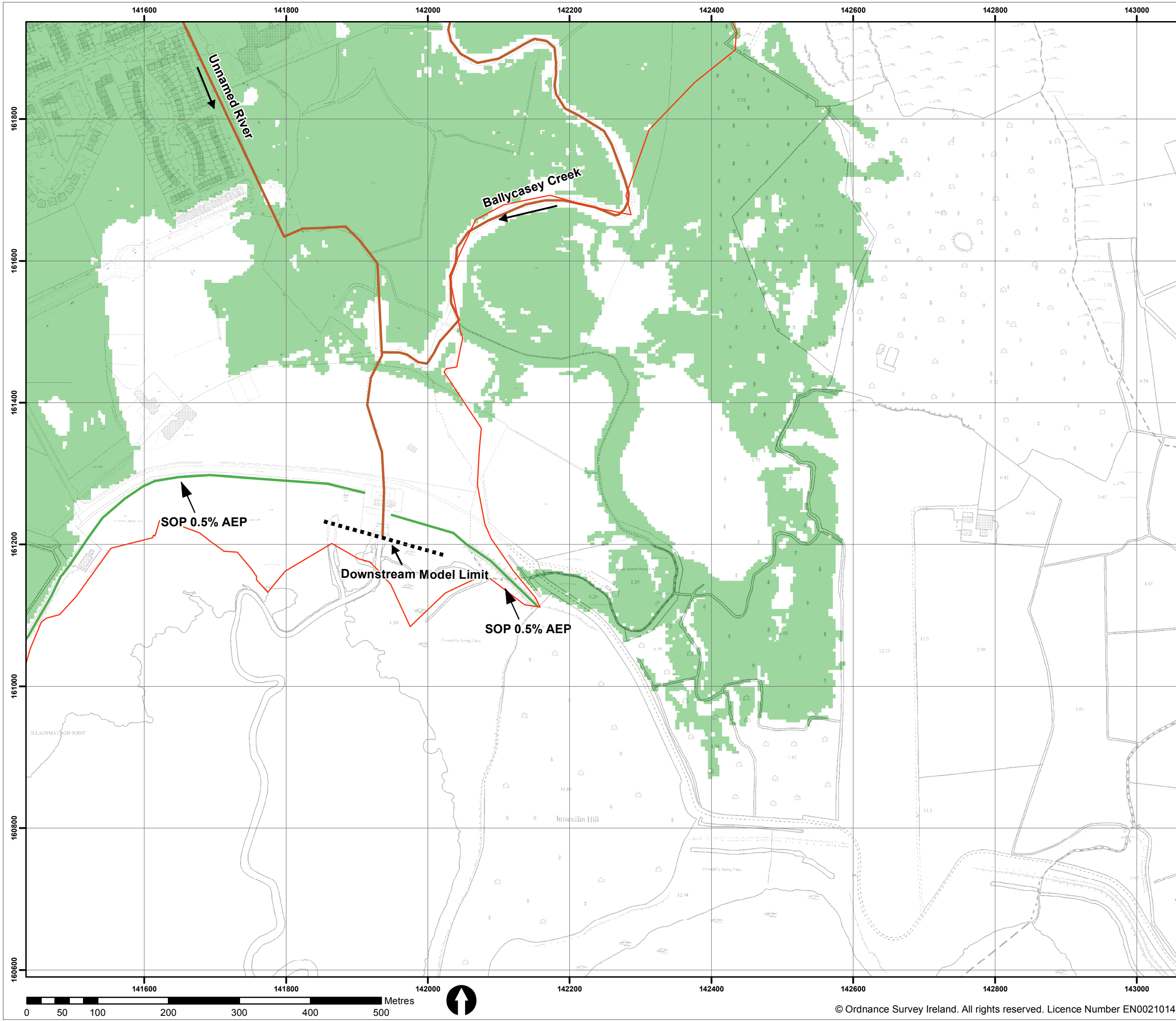


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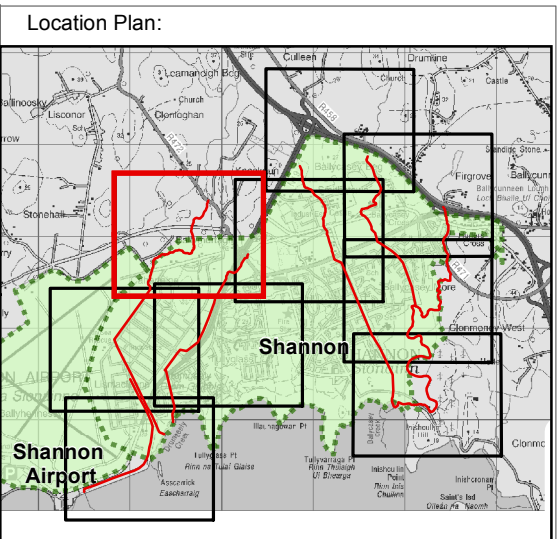
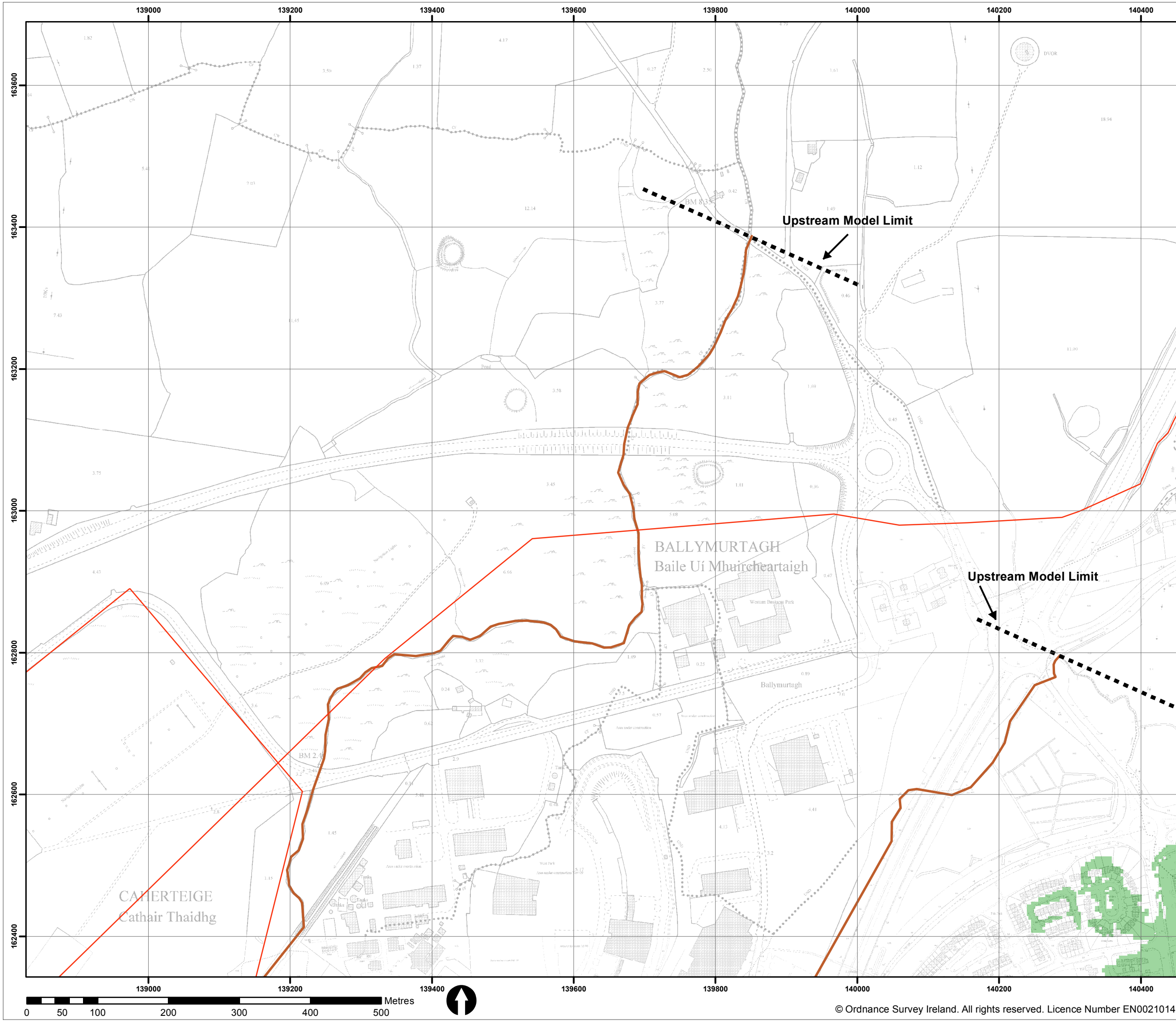


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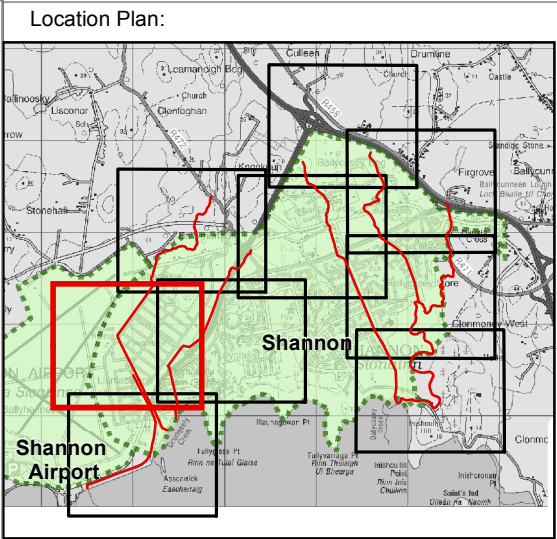
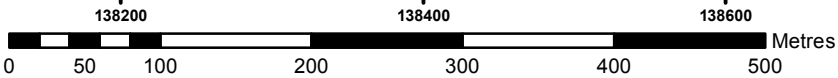
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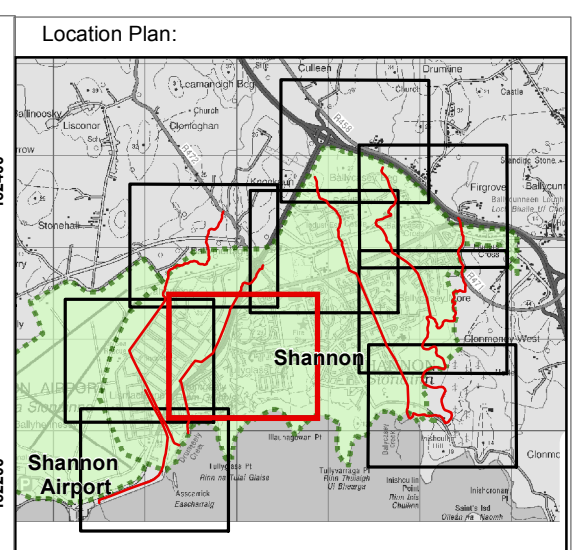
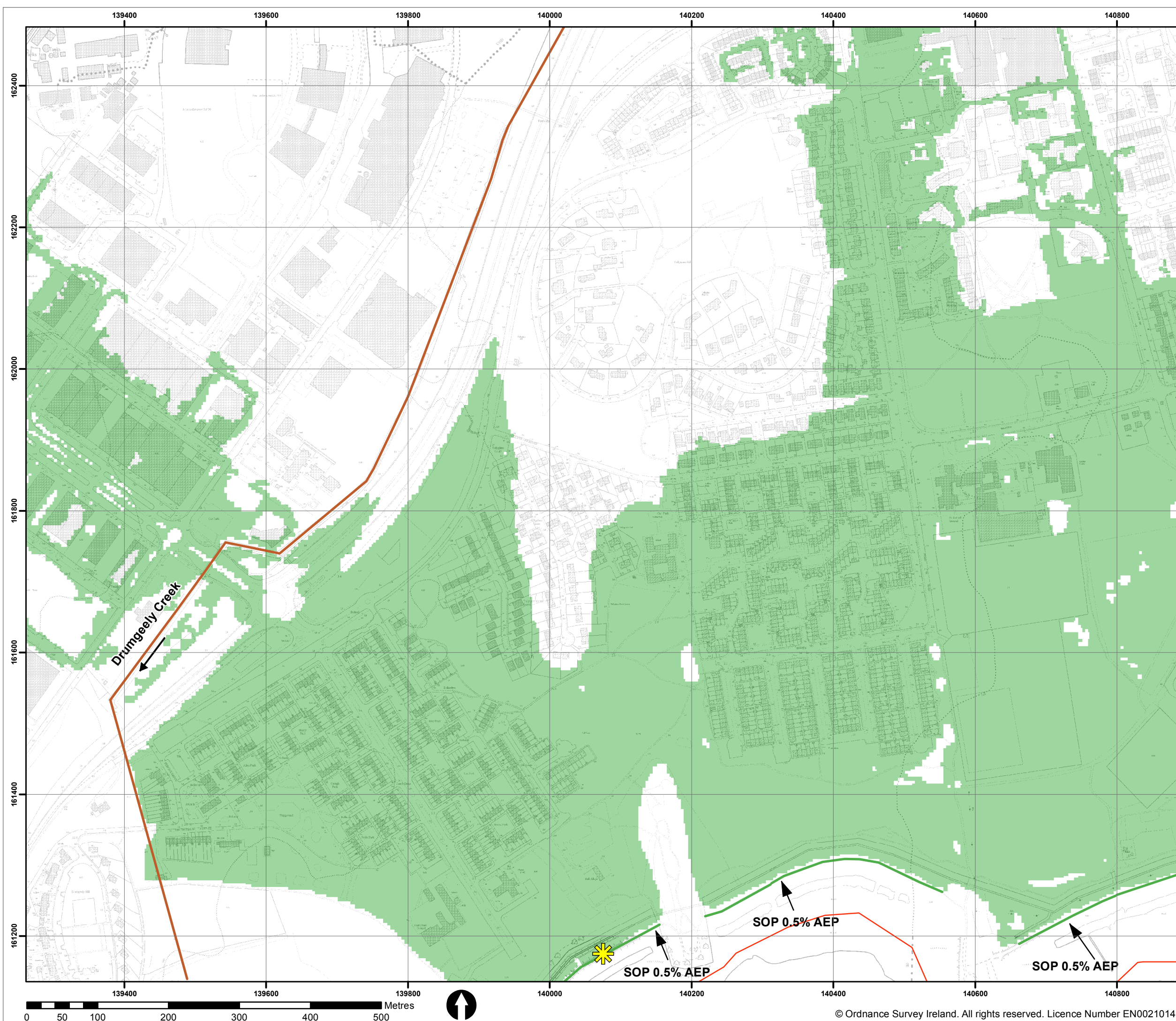
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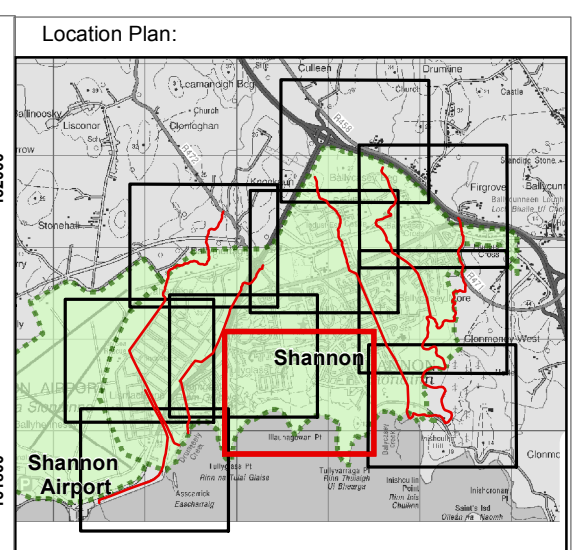
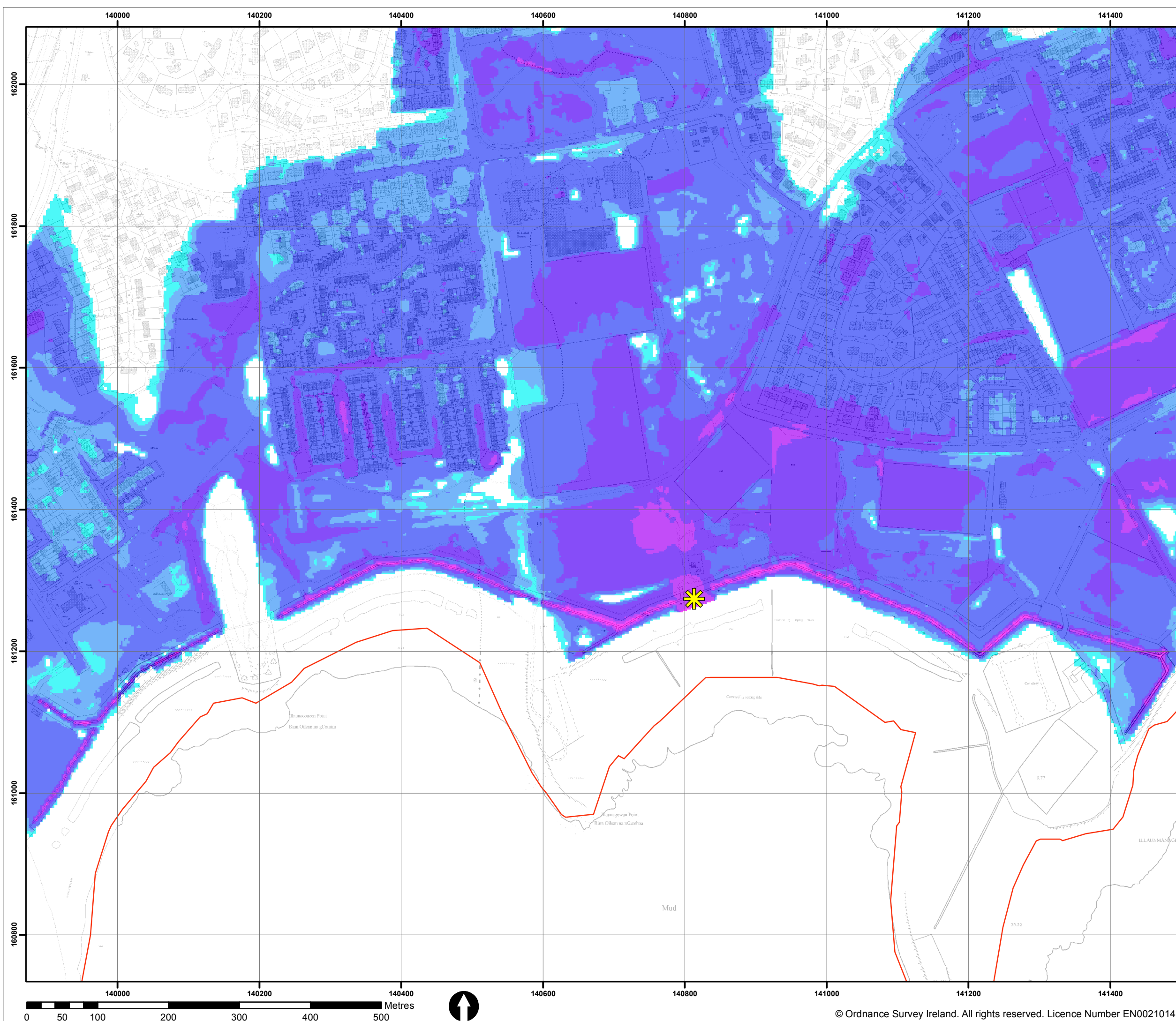
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Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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Project:
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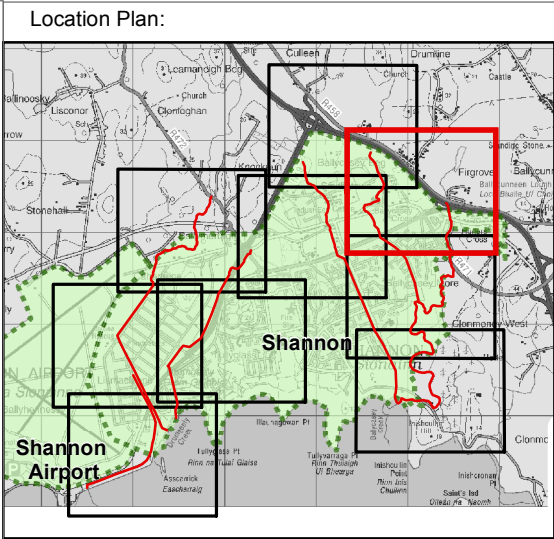
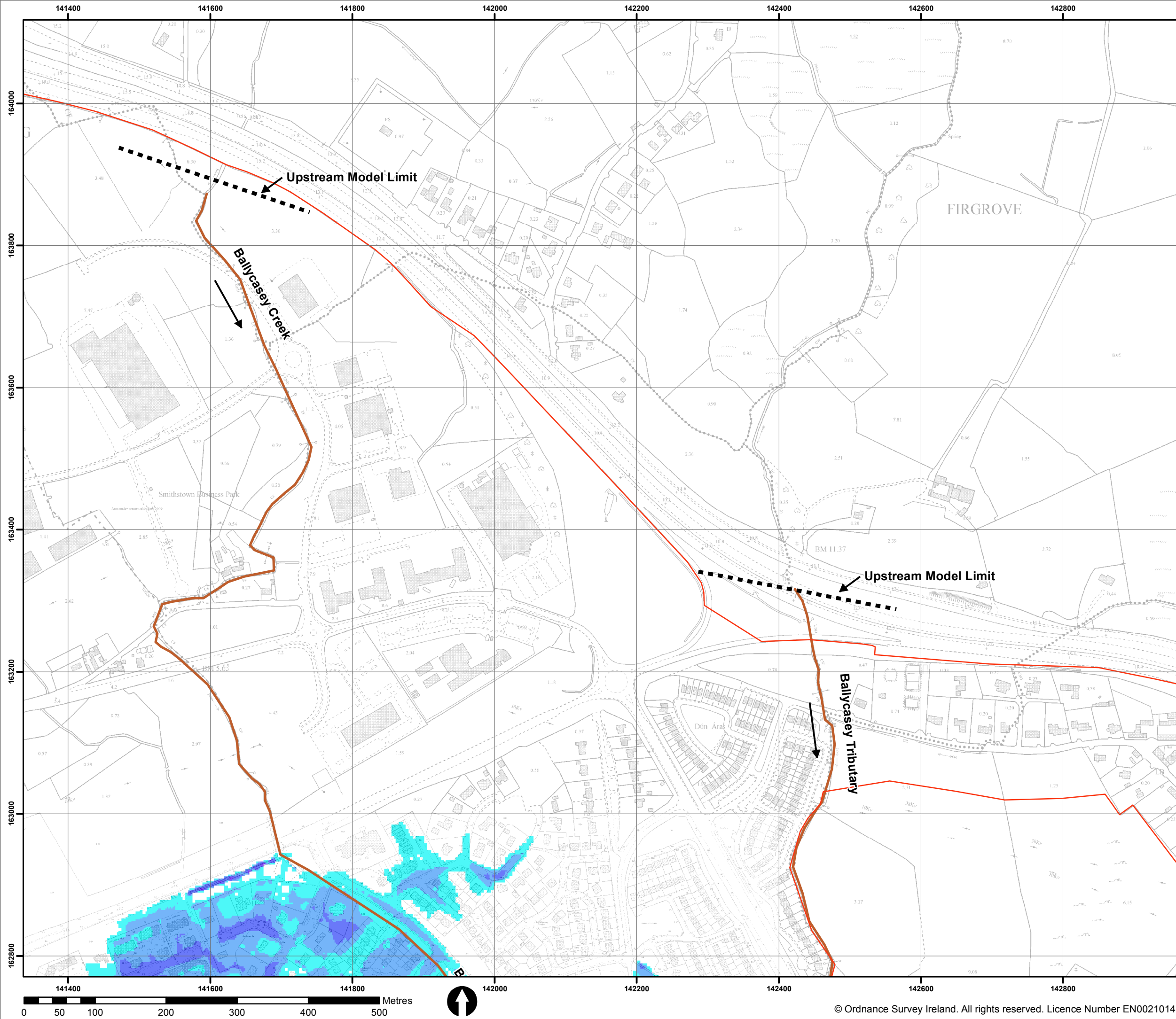
Map:
SHANNON

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: S04FDCCDC1

Sheet: 2 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m)

0 - 0.25
0.25 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2.0
> 2.0

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Map:
SHANNON

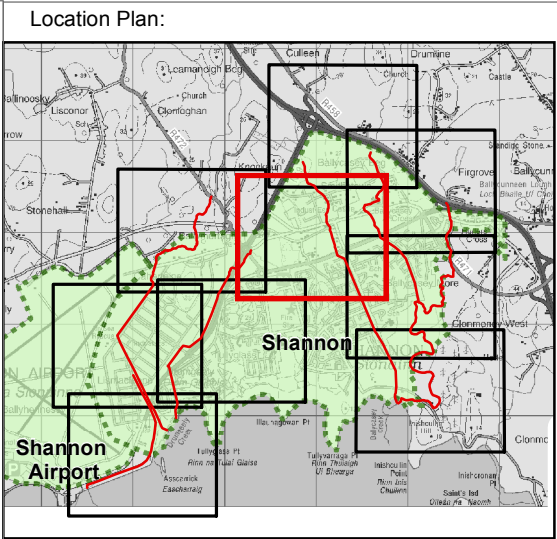
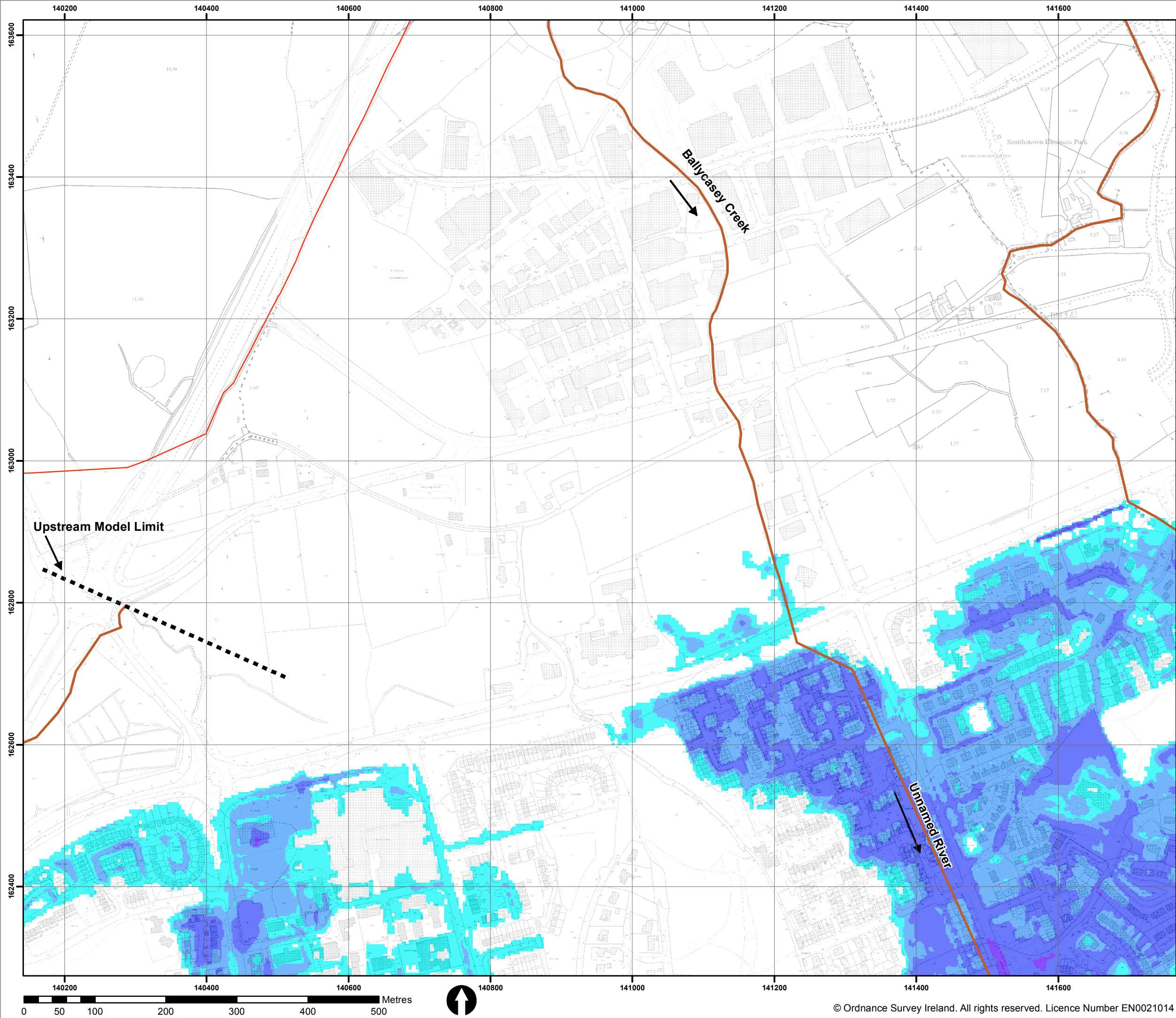
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Sheet: 3 of 10
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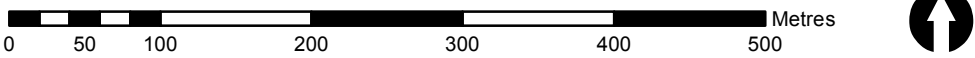
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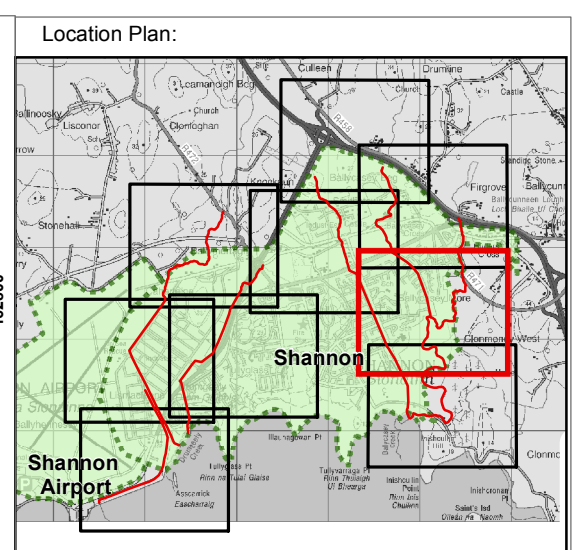
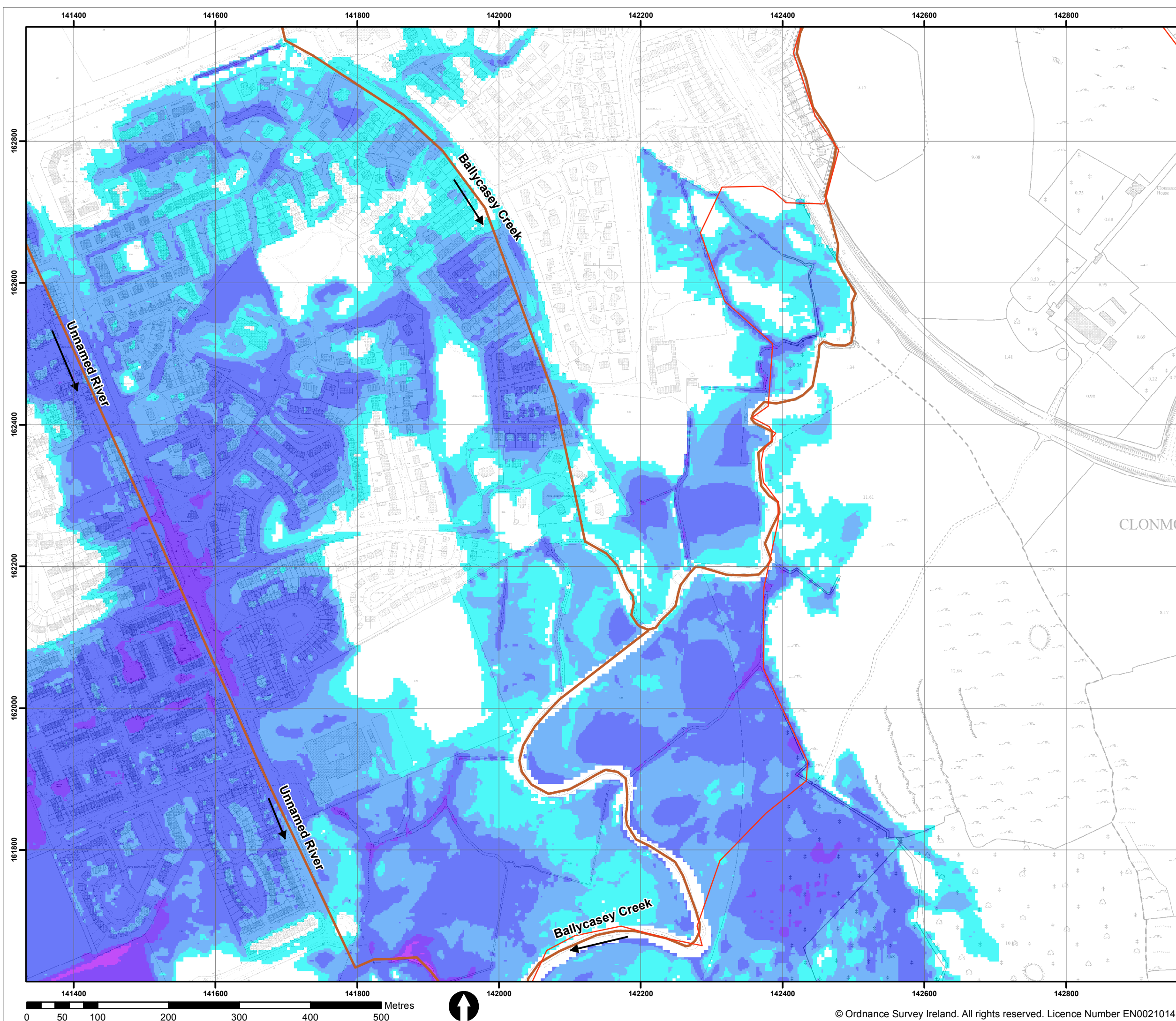
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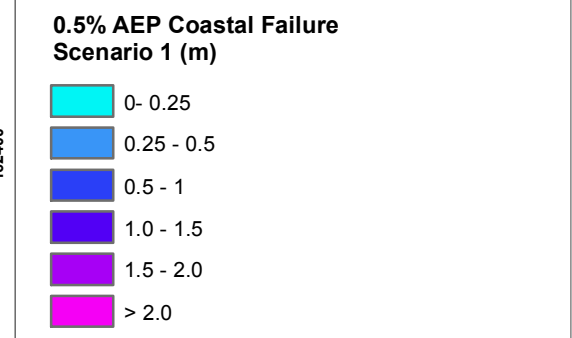
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Map Scale: 1: 5000

Revision: 0
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- Legend:**
- Model Reach
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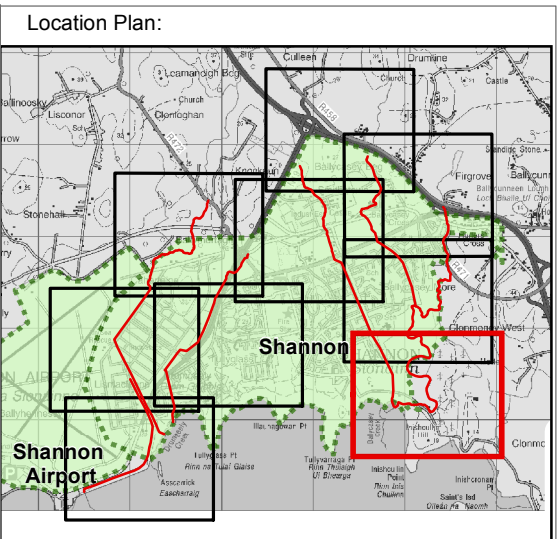
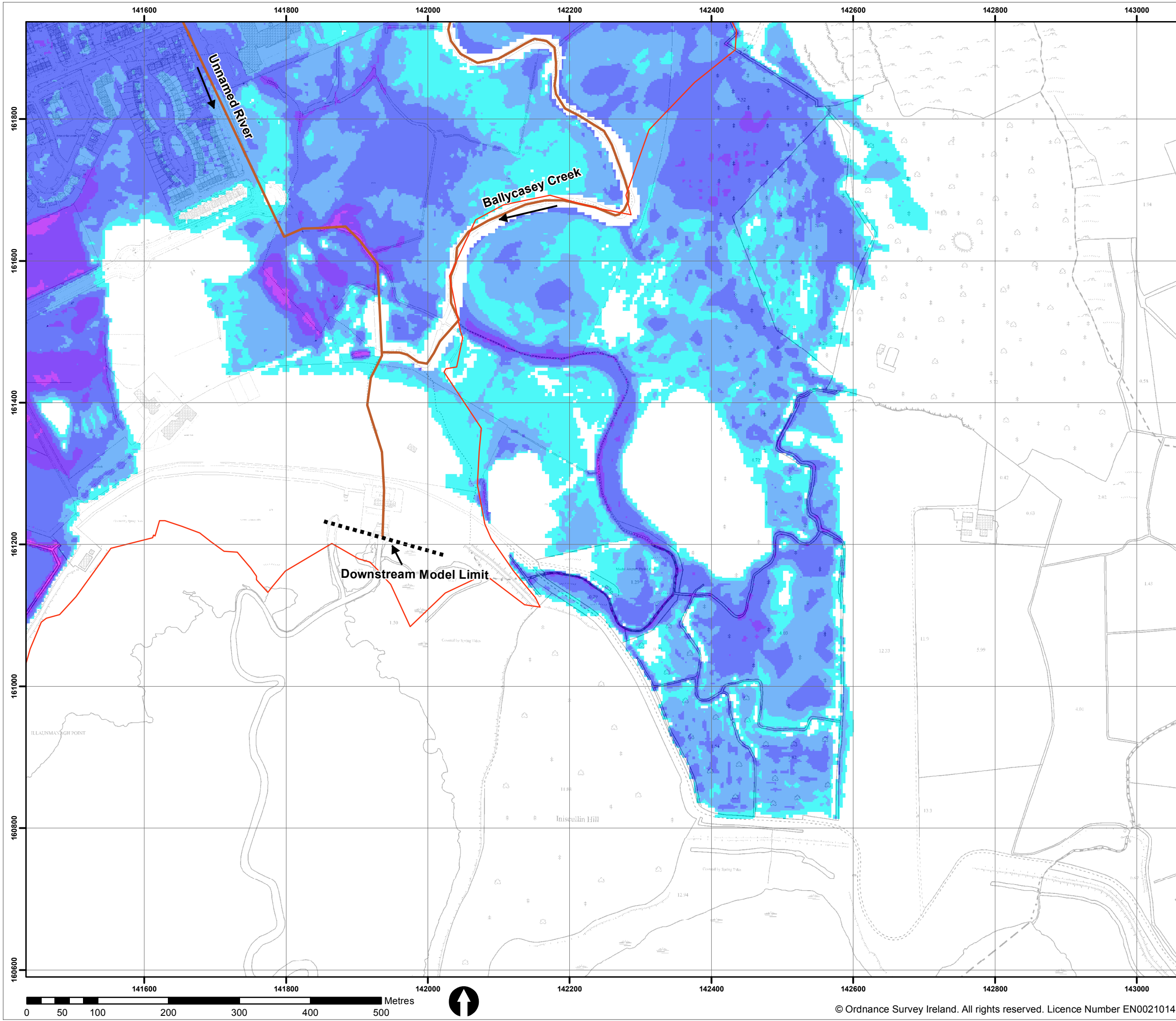


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Map:	SHANNON
Map Type: DEFENCE FAILURE DEPTH MAP	
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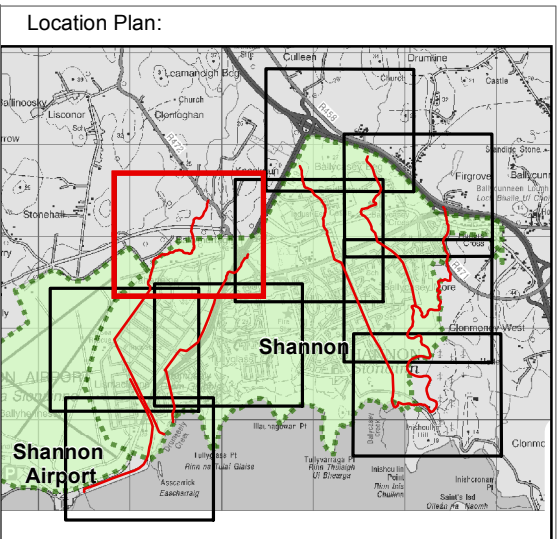
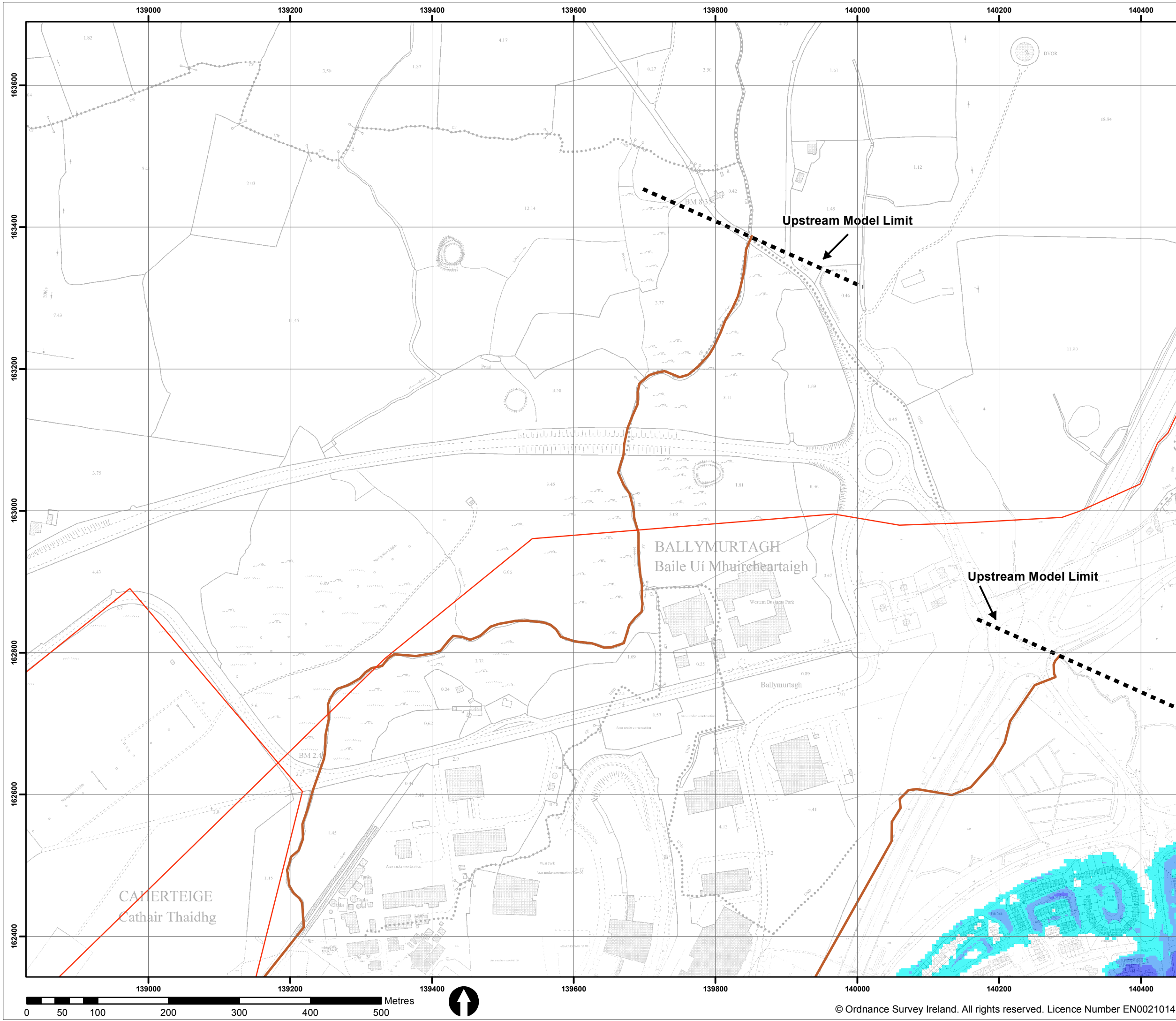


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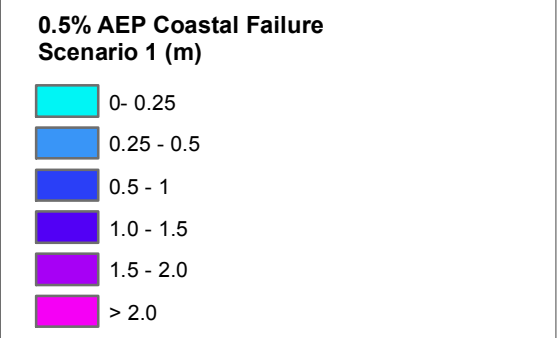
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- Legend:**
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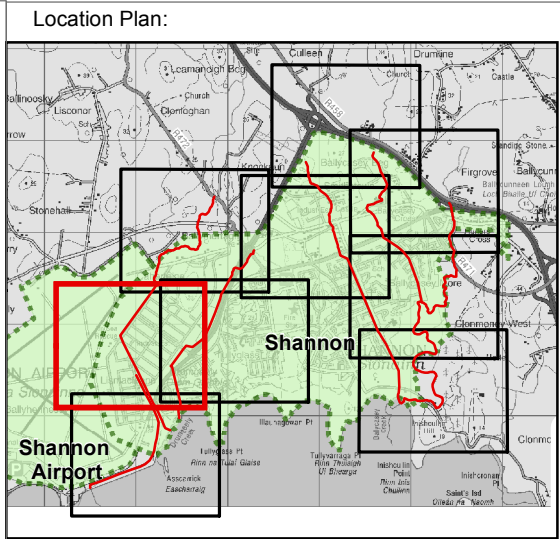
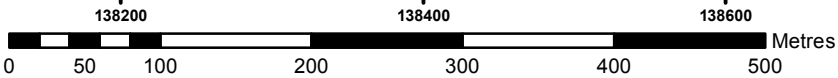
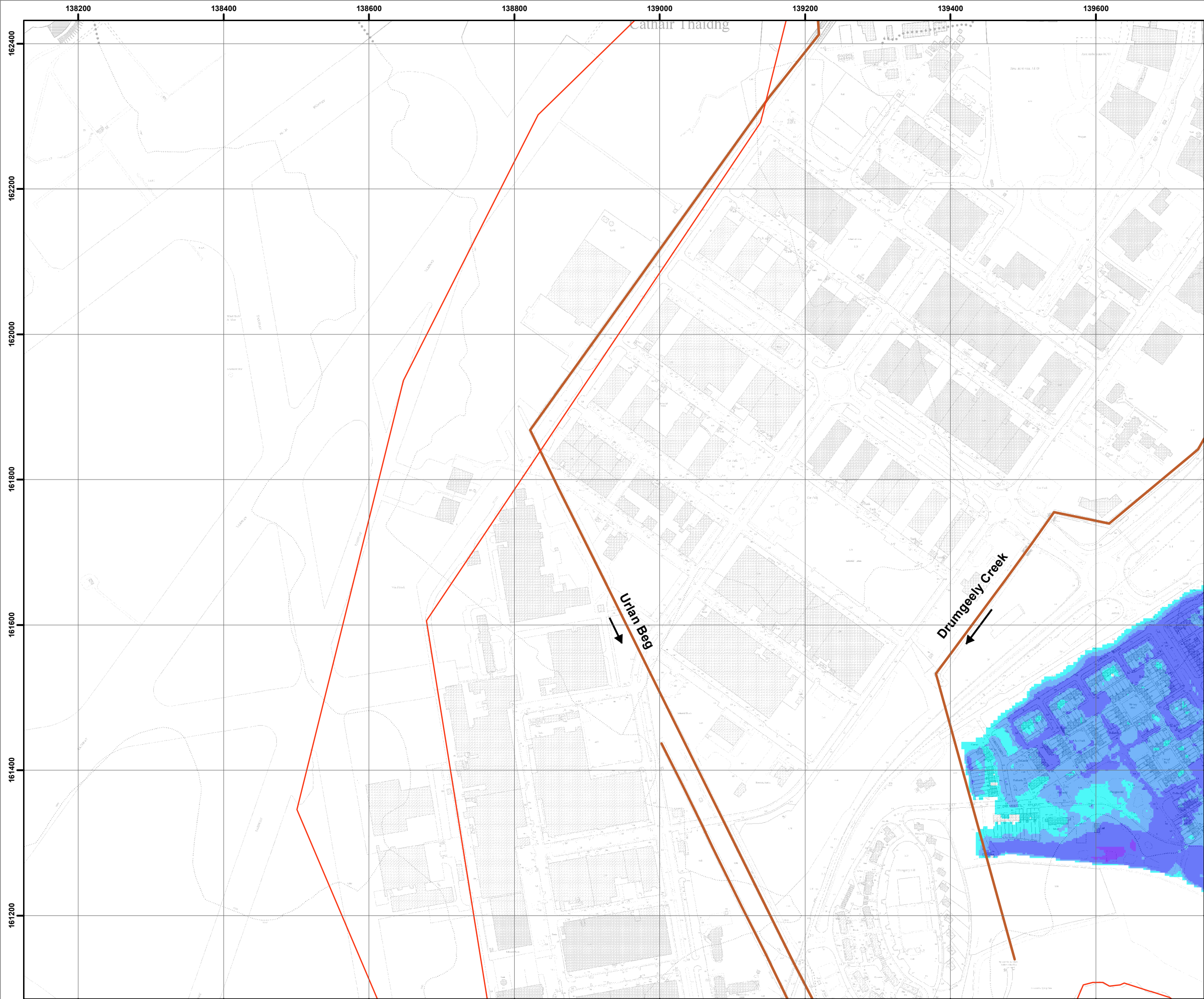
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Project: SHANNON CFRAM STUDY	
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Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
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Scenario: EXISTING	
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Legend:

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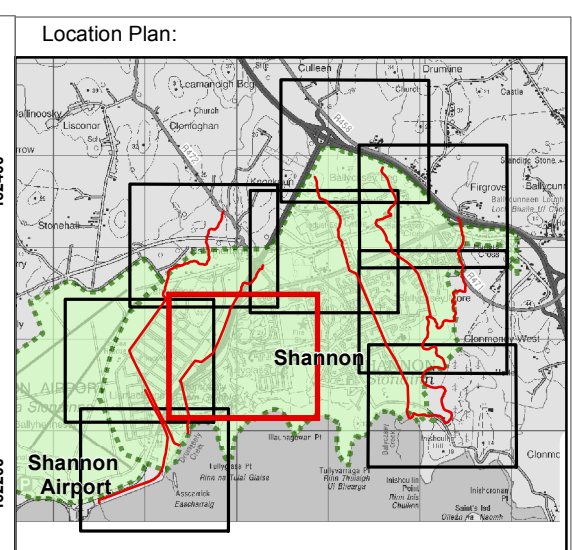
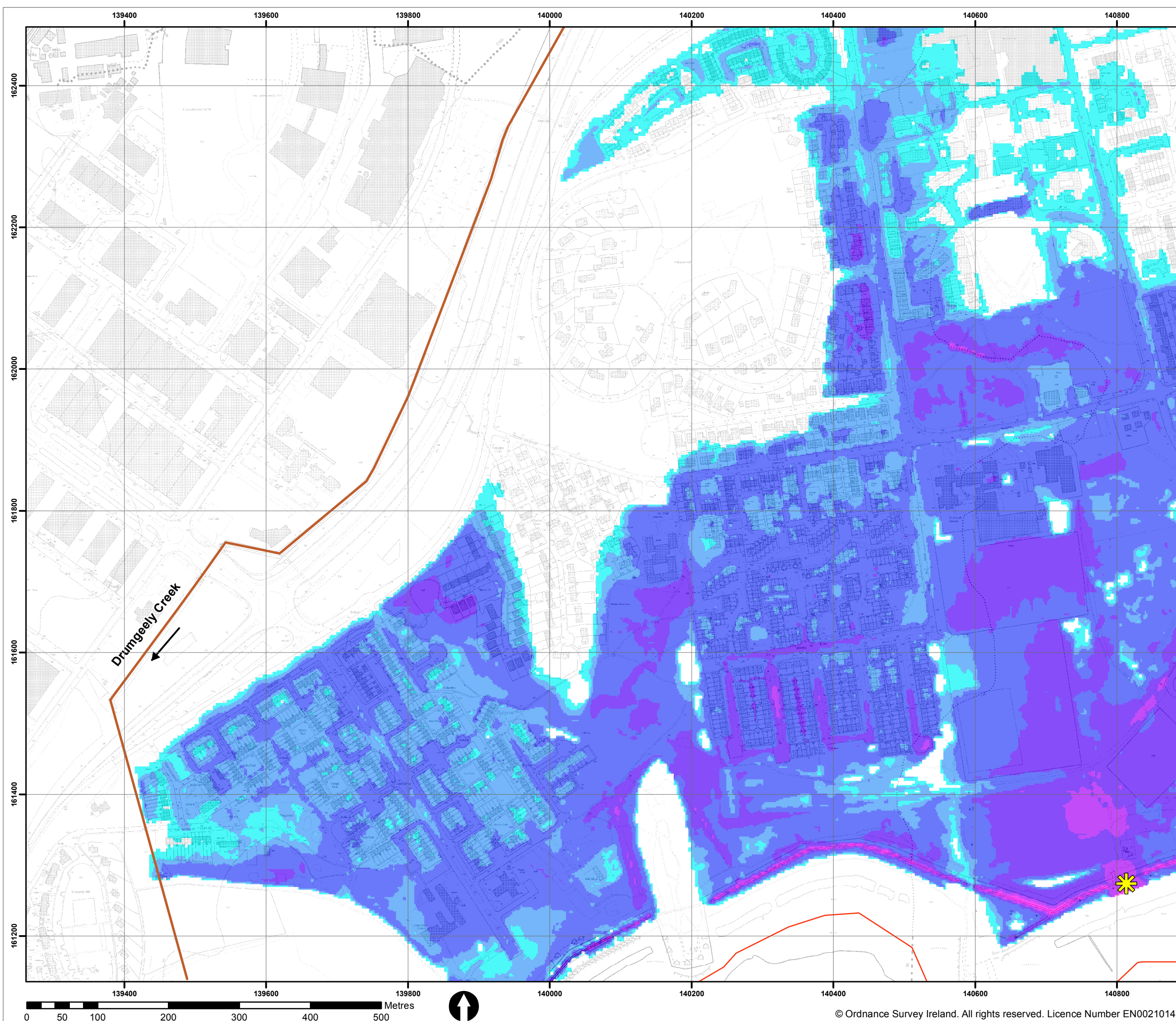
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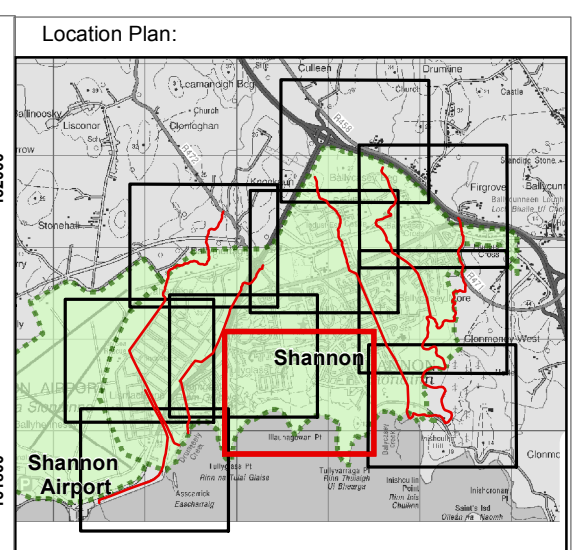
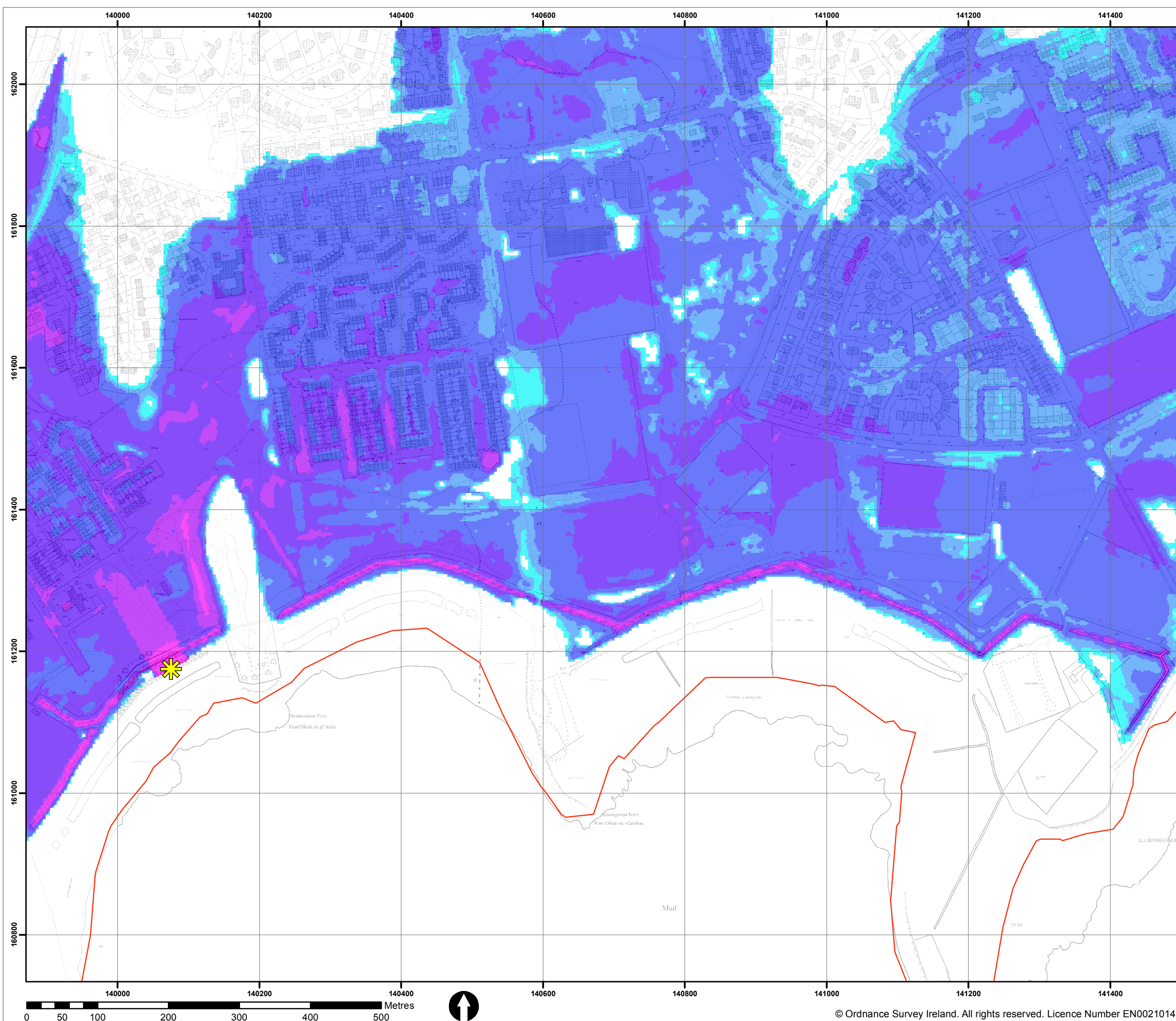


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Project: SHANNON CFram STUDY	
Map: SHANNON	
Map Type: DEFENCE FAILURE DEPTH MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Map No.: S04FDCCDC1	
Sheet: 9 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 2 (m)

- 0- 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
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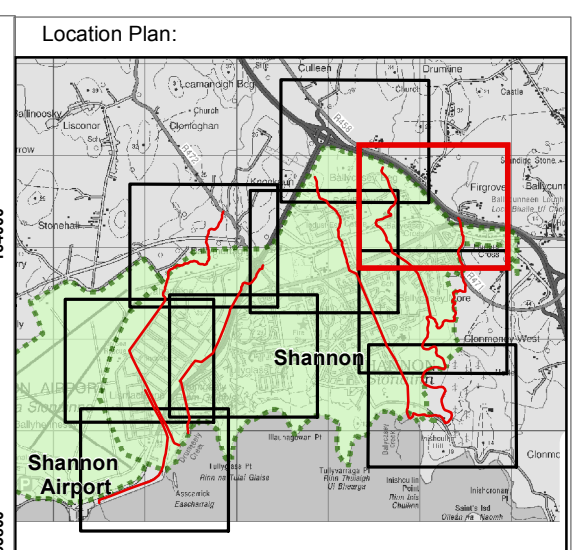
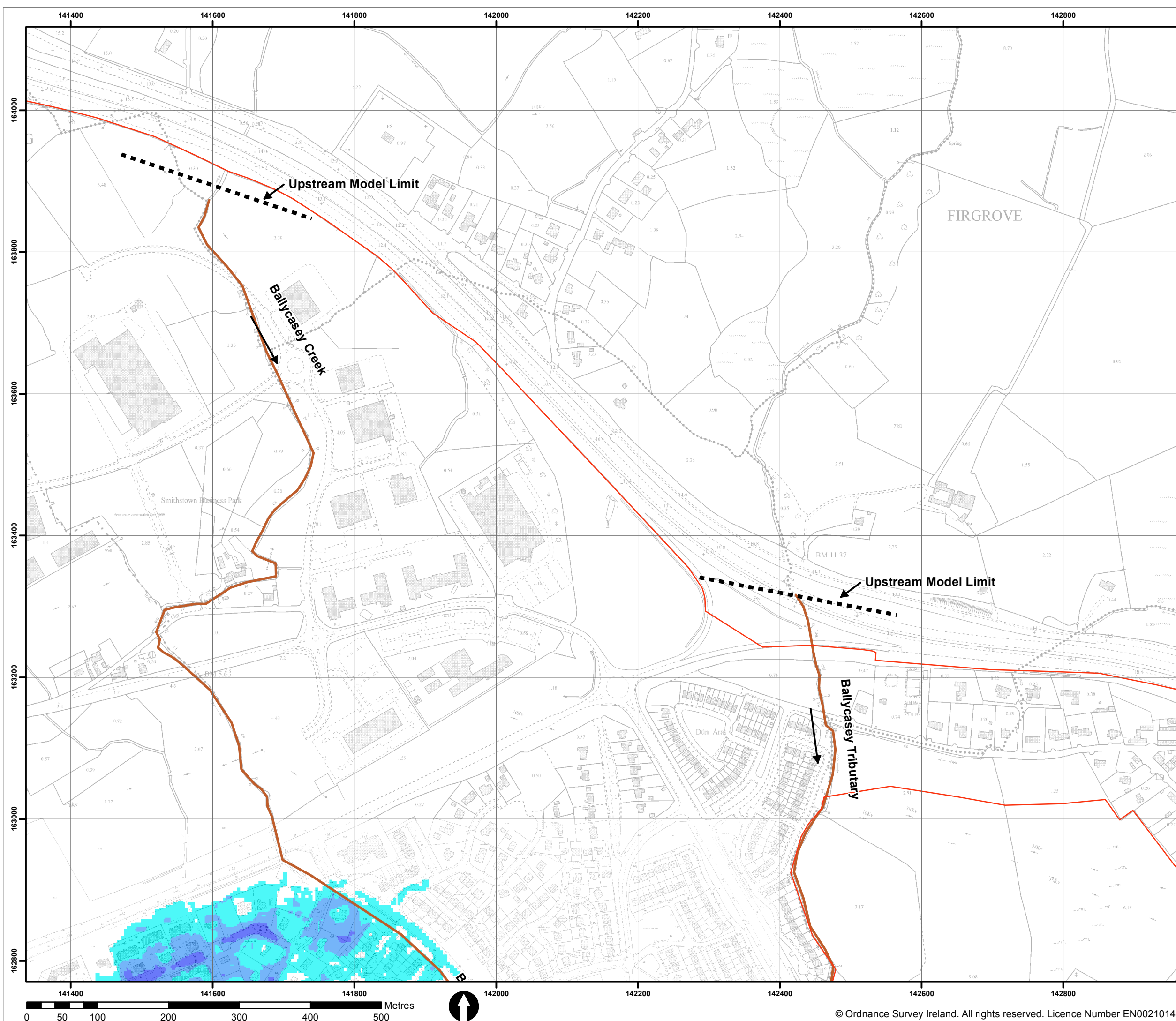
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Map area: SHANNON
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
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Map No.: S04FDCCDC1

Sheet: 2 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

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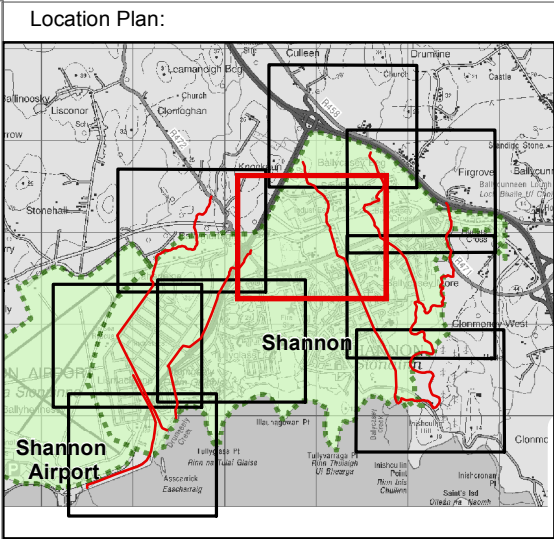
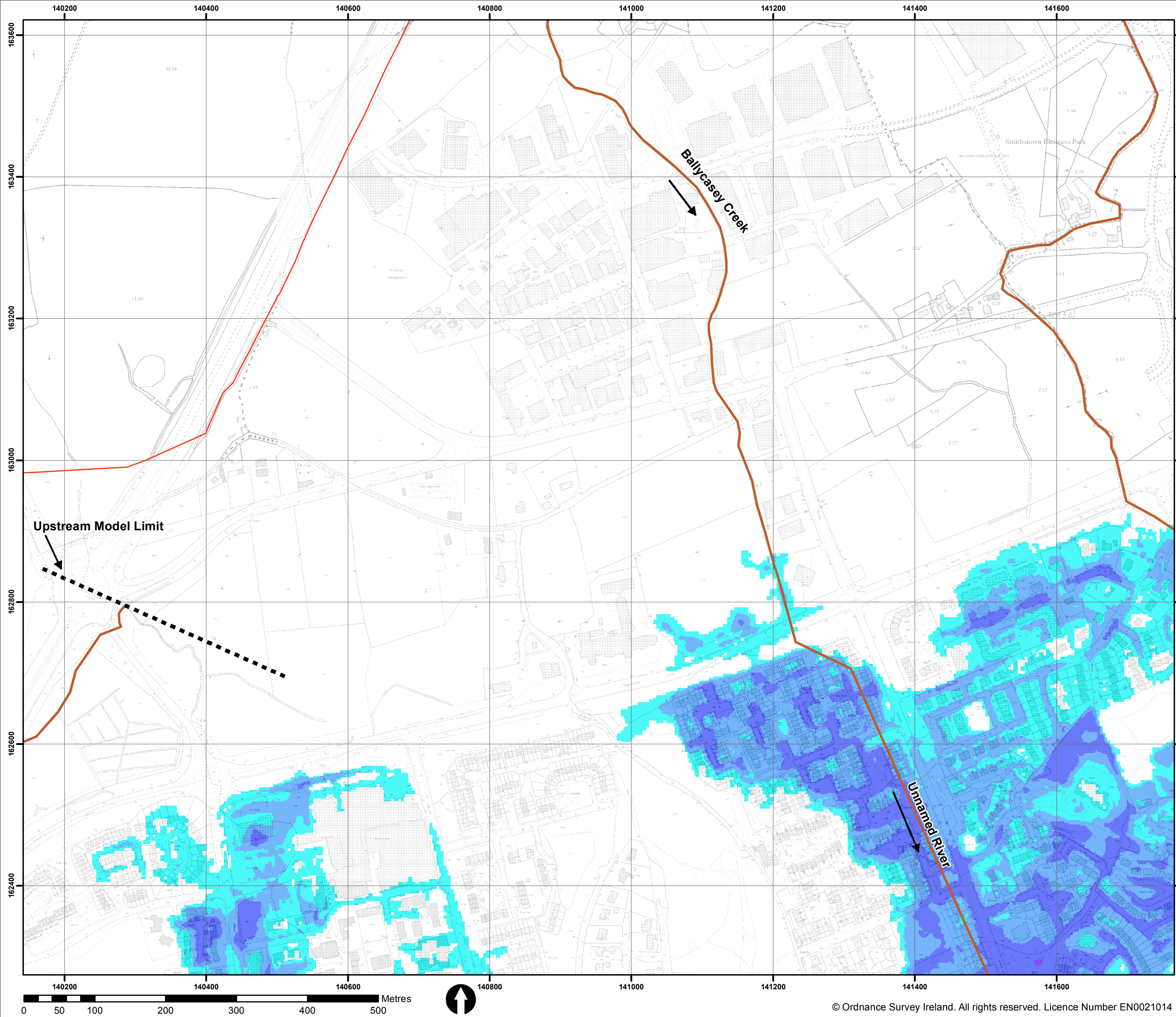
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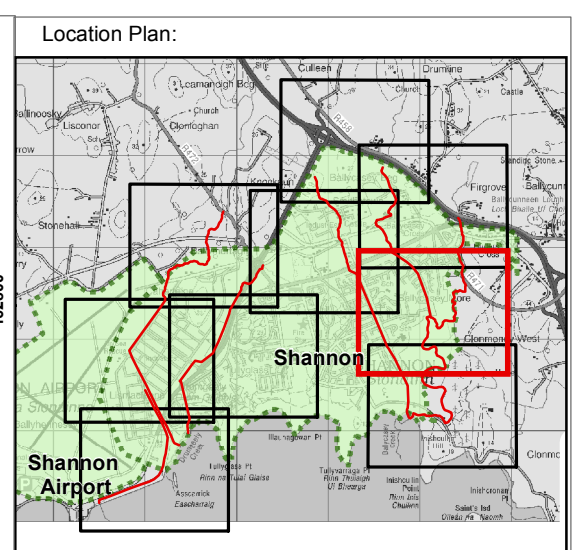
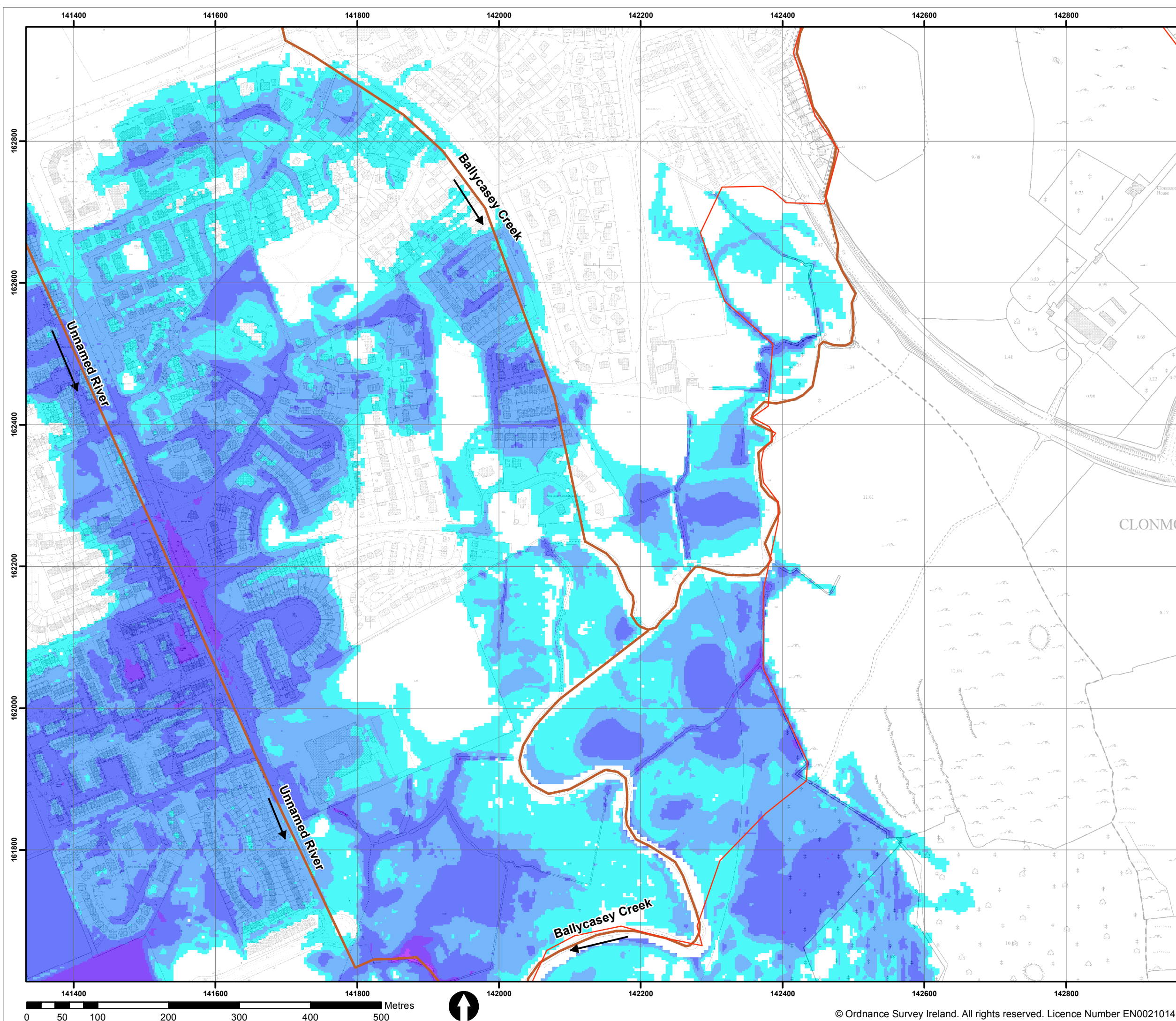
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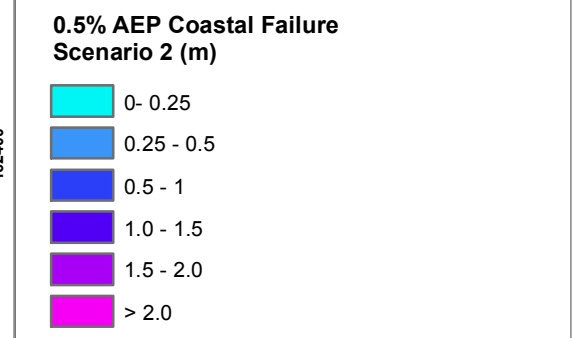
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Project: SHANNON CFRAM STUDY	
Map: SHANNON	
Map Type: DEFENCE FAILURE DEPTH MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2	
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Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Sheet: 4 of 10	Revision: 0
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- Legend:**
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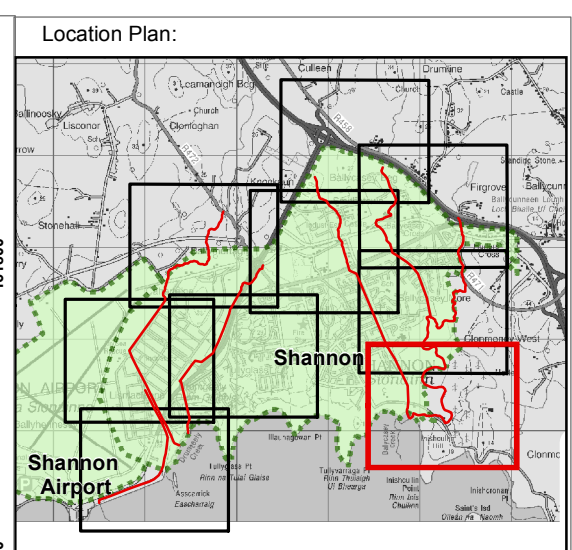
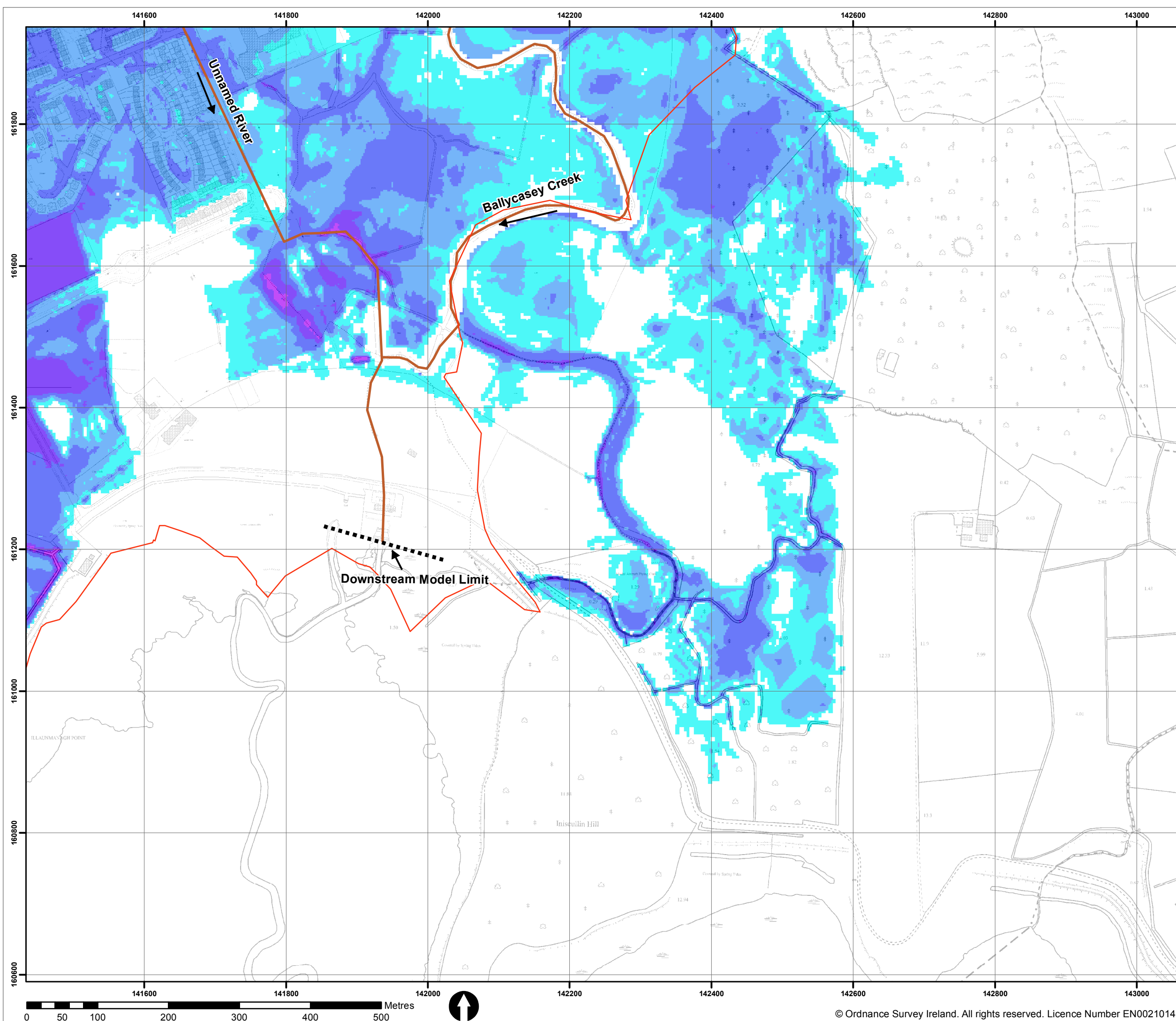


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Source: 0.5% AEP COASTAL FAILURE SCENARIO 2	
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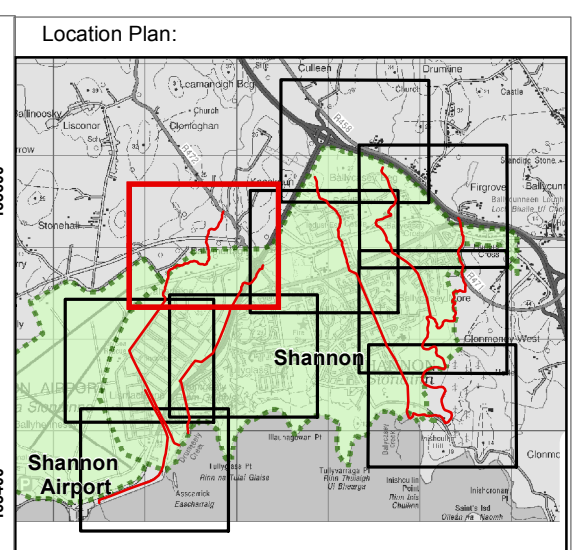
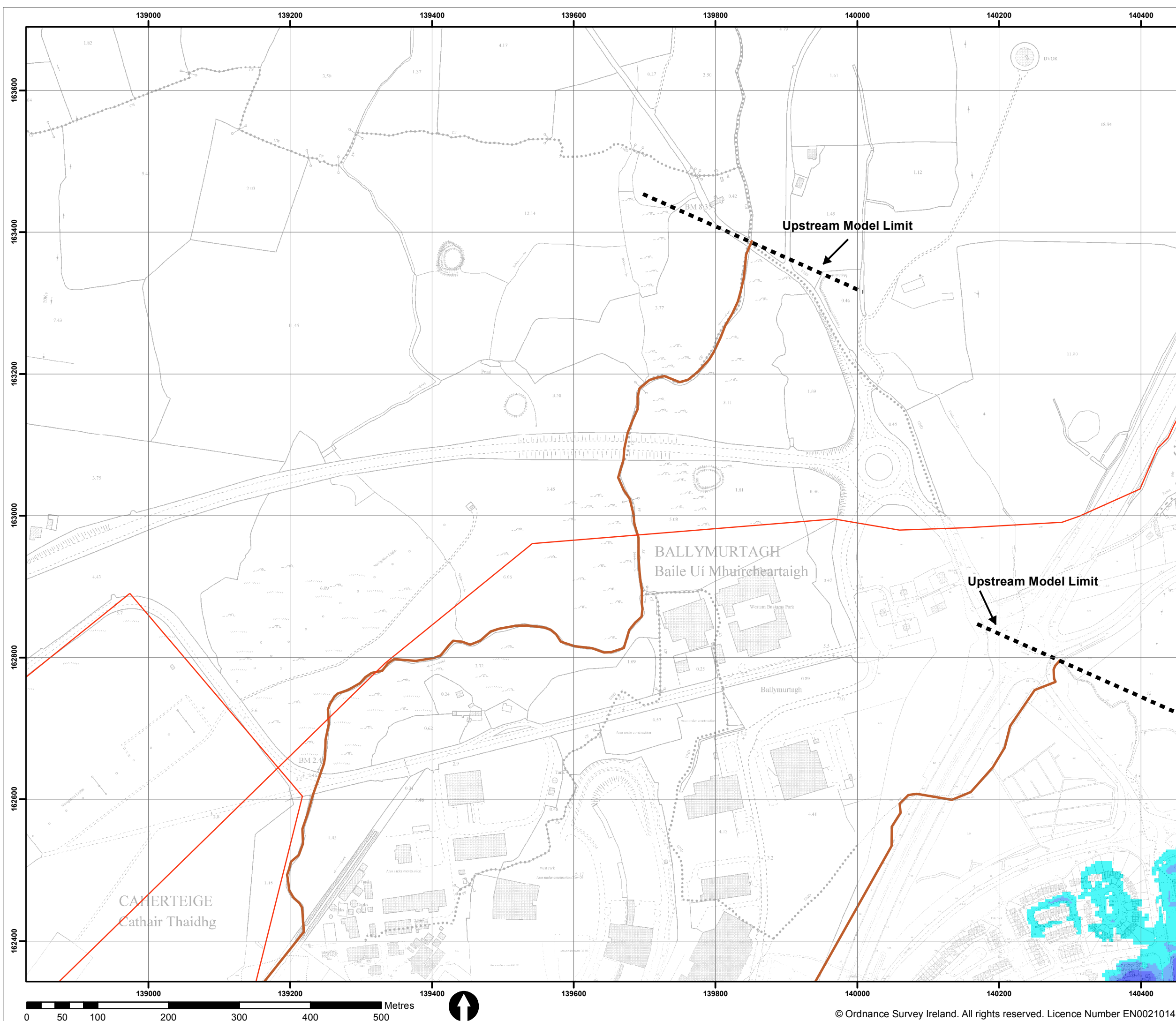
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Drawn by: EH	Date: November 2015
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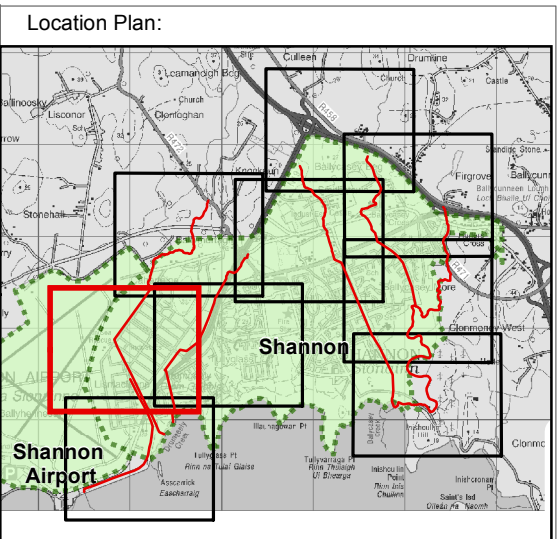
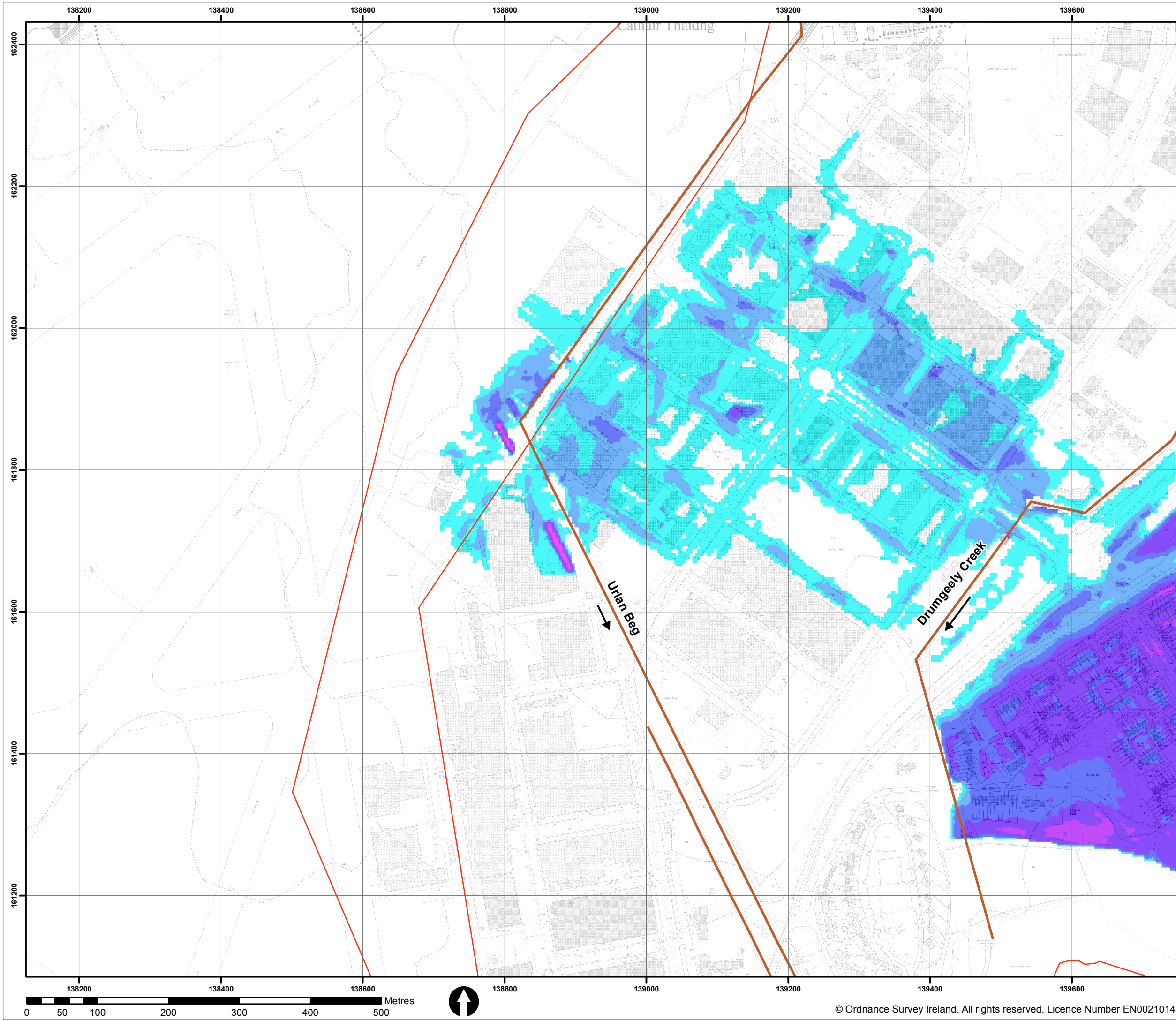
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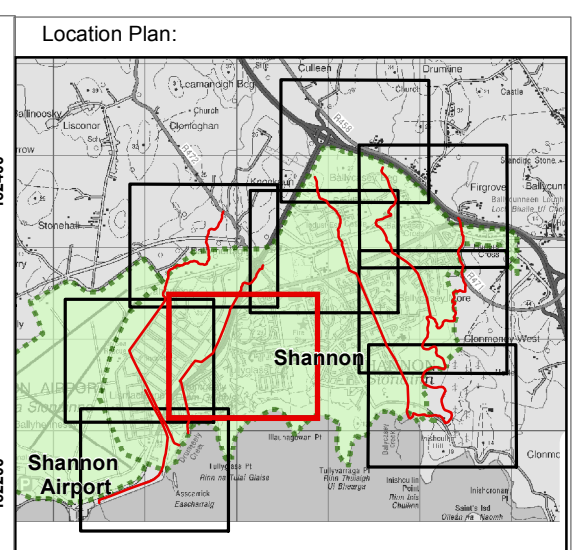
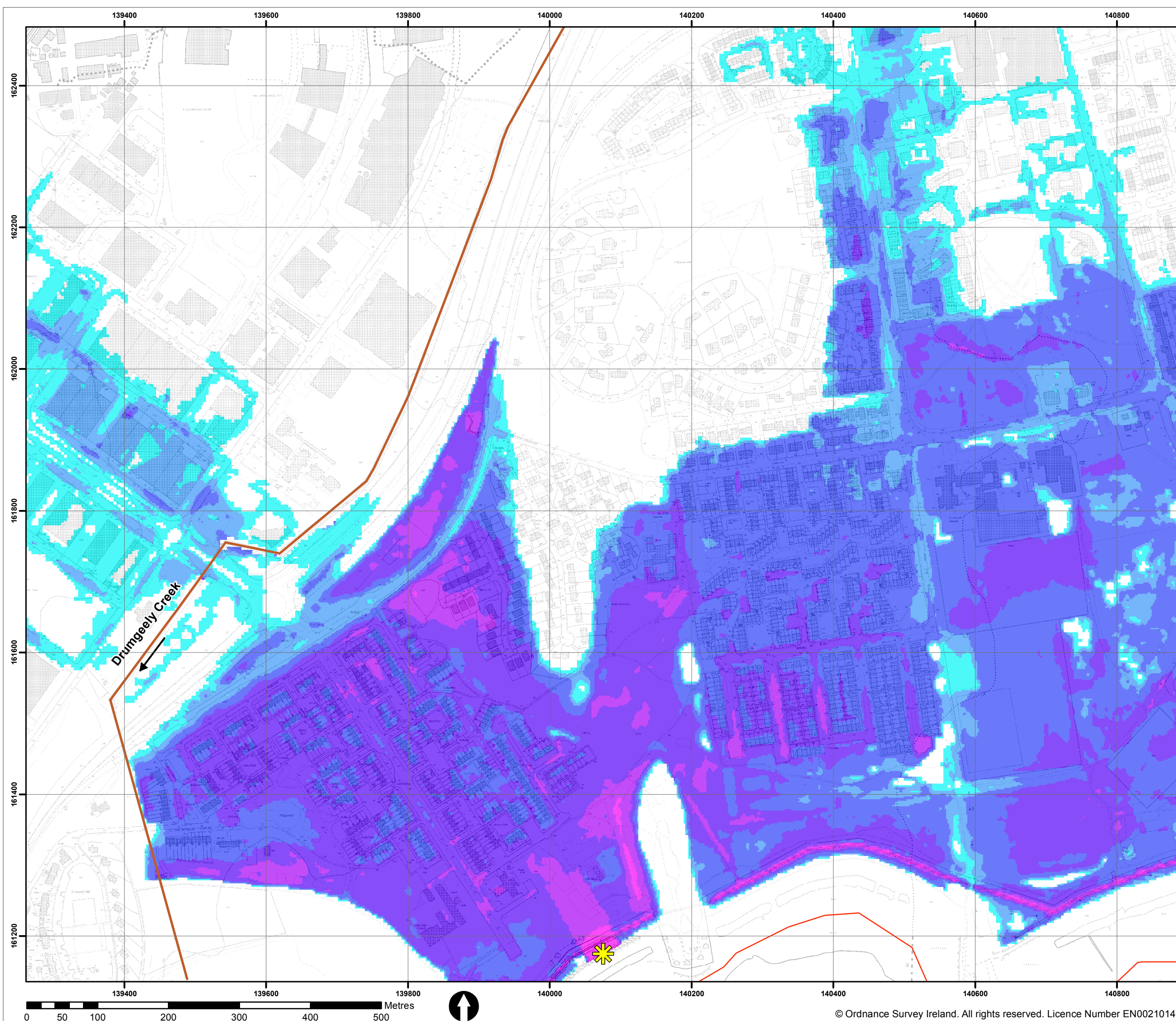
Map: **SHANNON**

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SHANNON
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: S04FDCCDC1

Sheet: 8 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 2 (m)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

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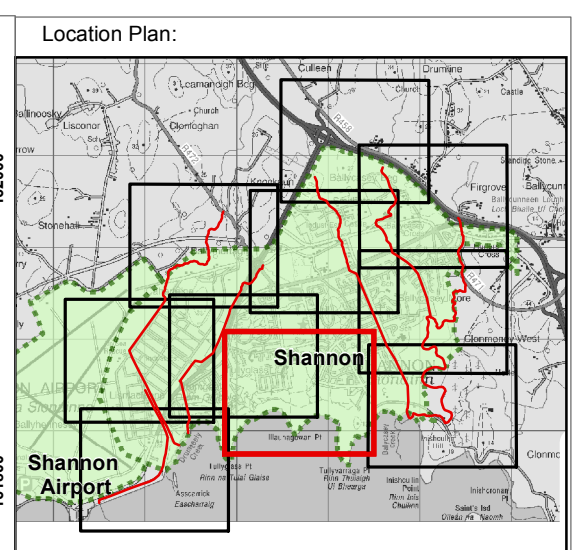
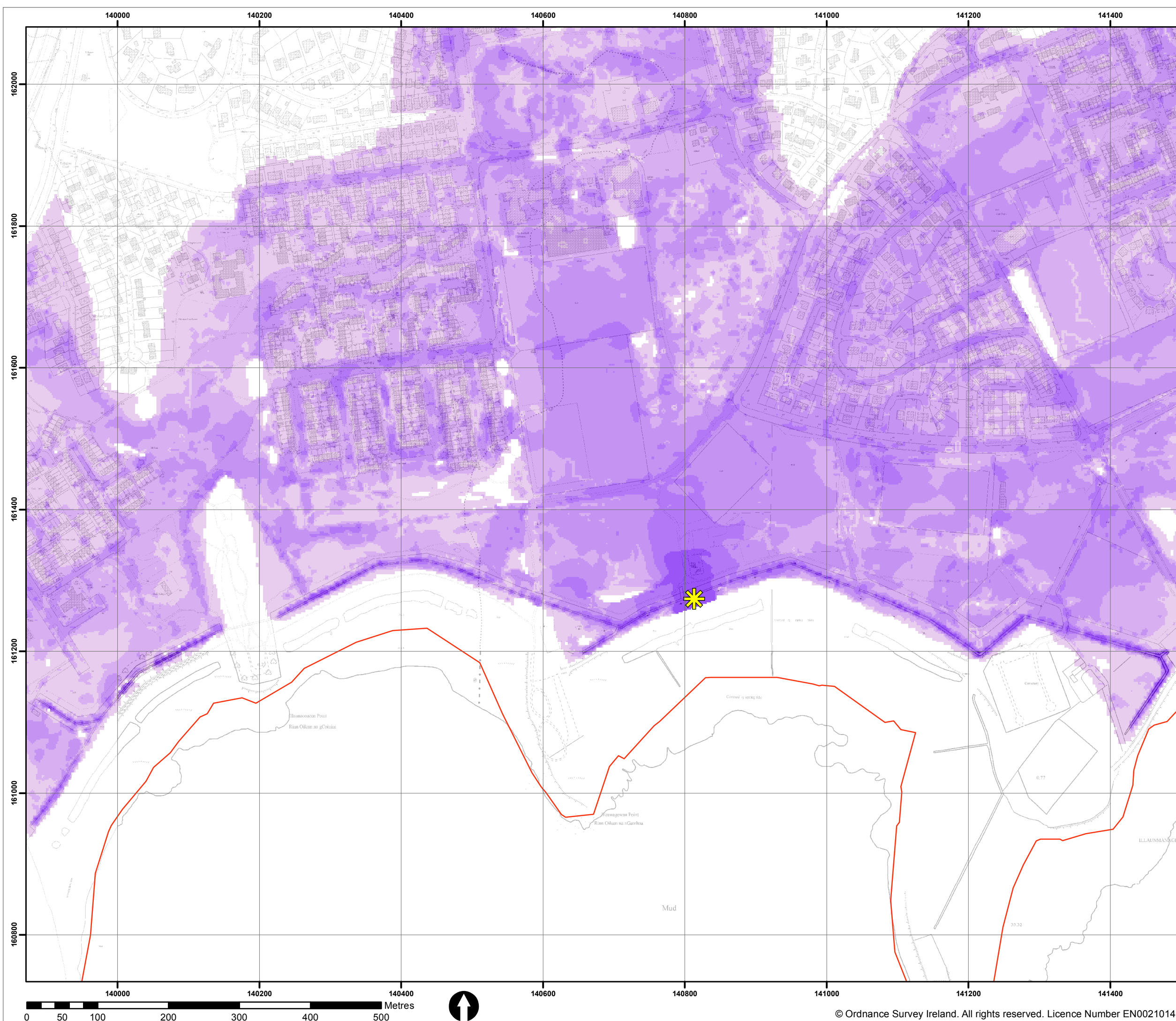
Map:
SHANNON

Map Type: DEFENCE FAILURE DEPTH MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SHANNON
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
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Approved by: PS	Date: November 2015

Map No.: S04FDCCDC1

Sheet: 9 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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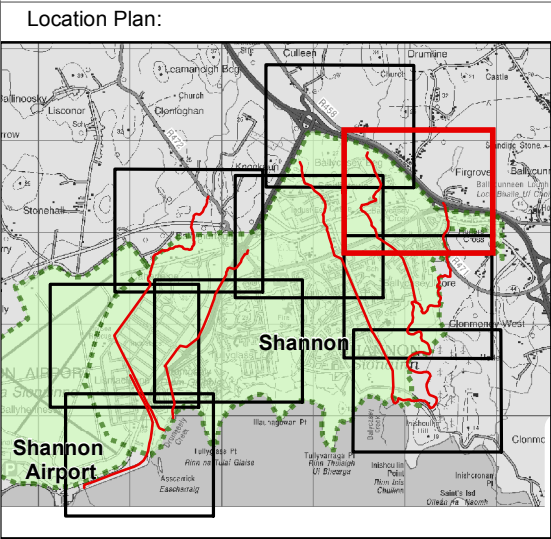
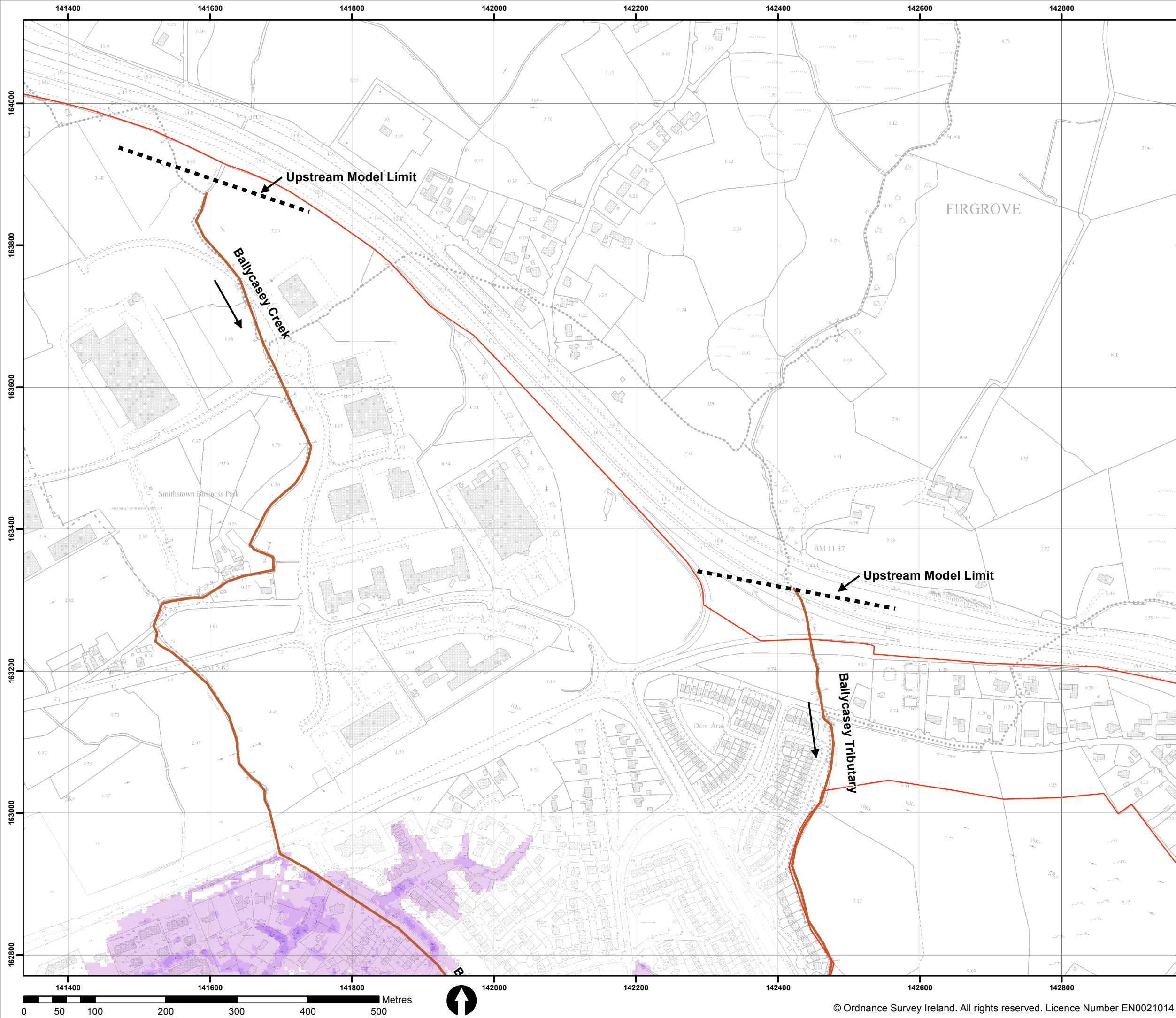
Map:
SHANNON

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON
Scenario: EXISTING

Drawn by: EH	Date: November 2015
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Map No.: S04FVCCDC1

Sheet: 2 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0


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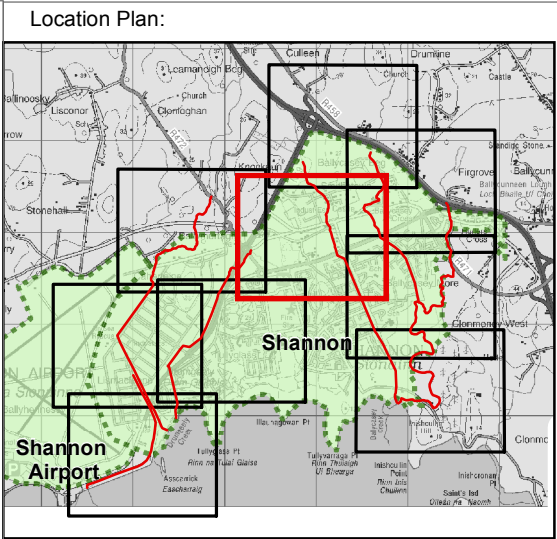
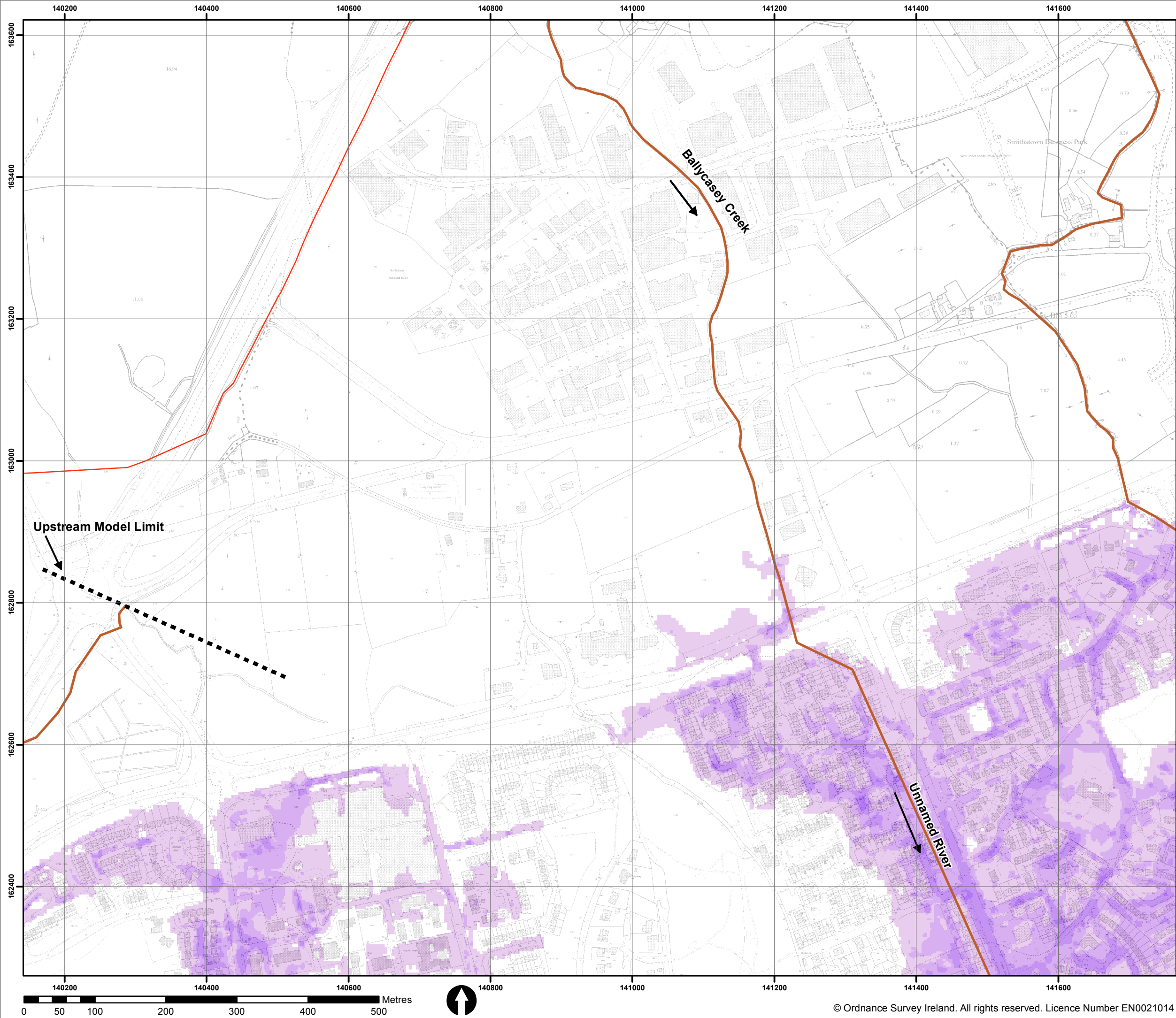
Map:
SHANNON

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON
Scenario: EXISTING

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Sheet: 3 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m/s)

0 - 0.25
0.25 - 0.5
0.5 - 1.0
1.0 - 2.0
> 2.0


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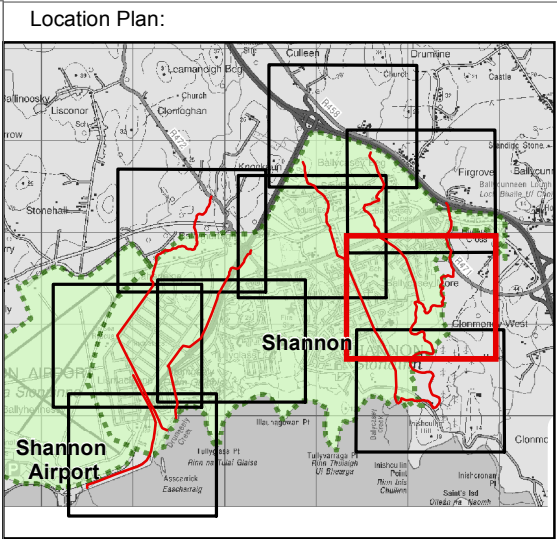
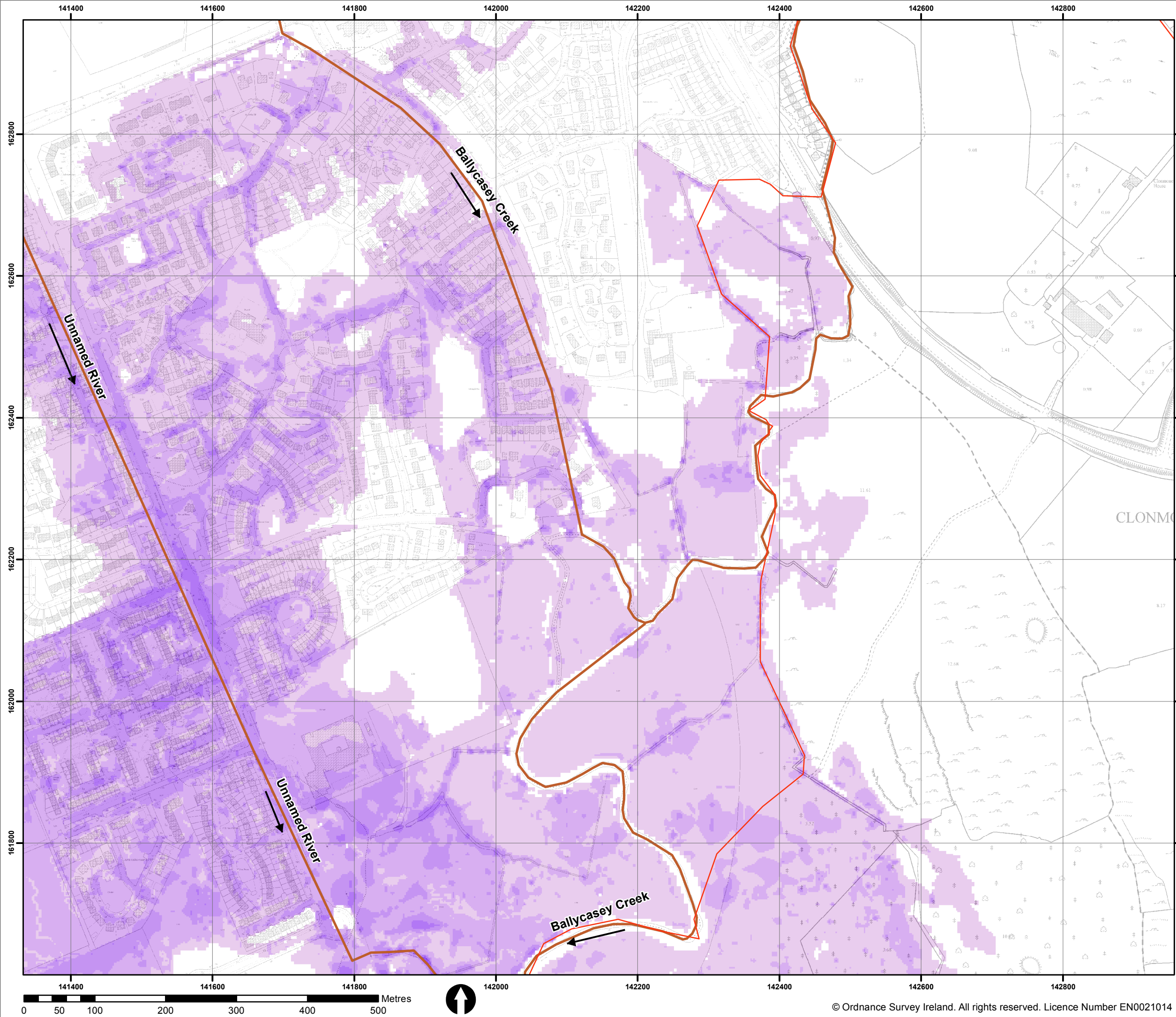
Map:
SHANNON

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON
Scenario: EXISTING

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Map No.: S04FVCCDC1

Sheet: 4 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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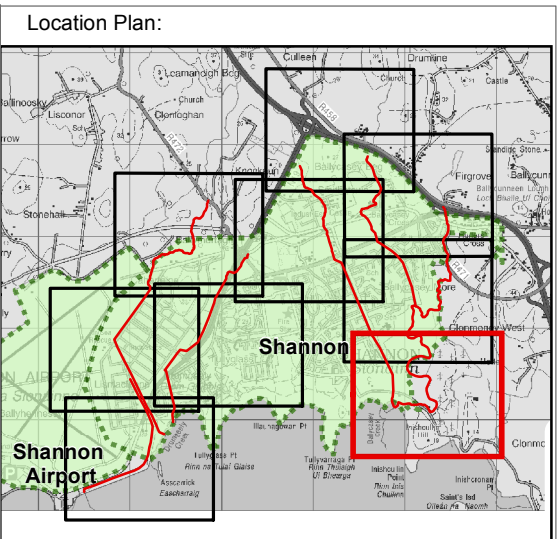
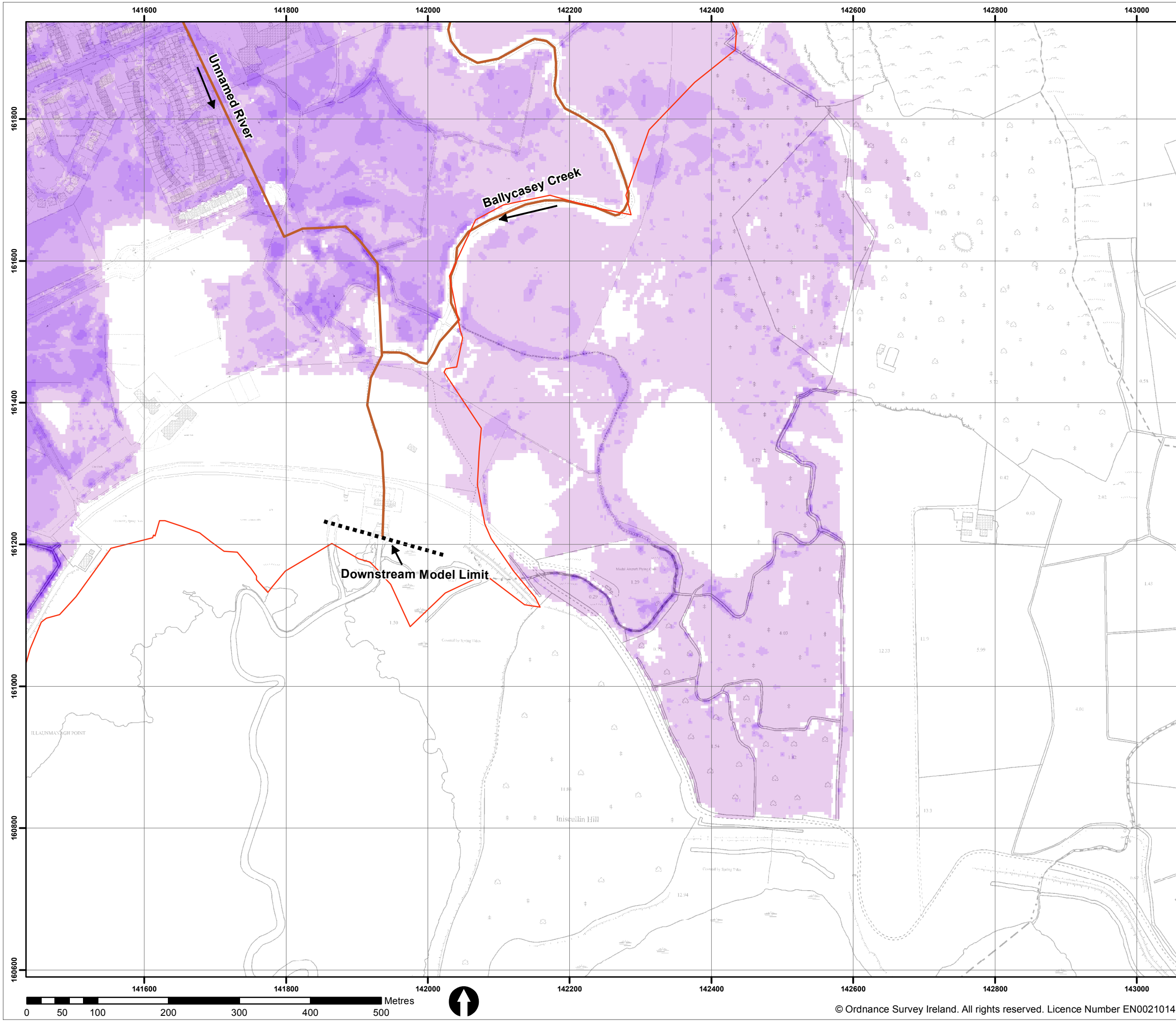


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Project: SHANNON CFRAM STUDY	
Map:	SHANNON
Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Sheet: 5 of 10	Revision: 0
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Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0


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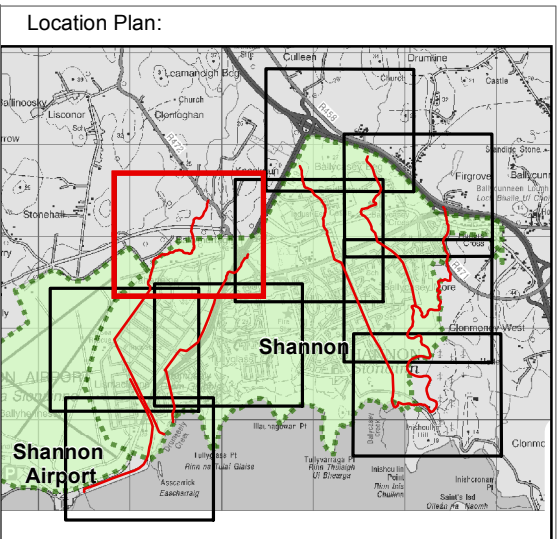
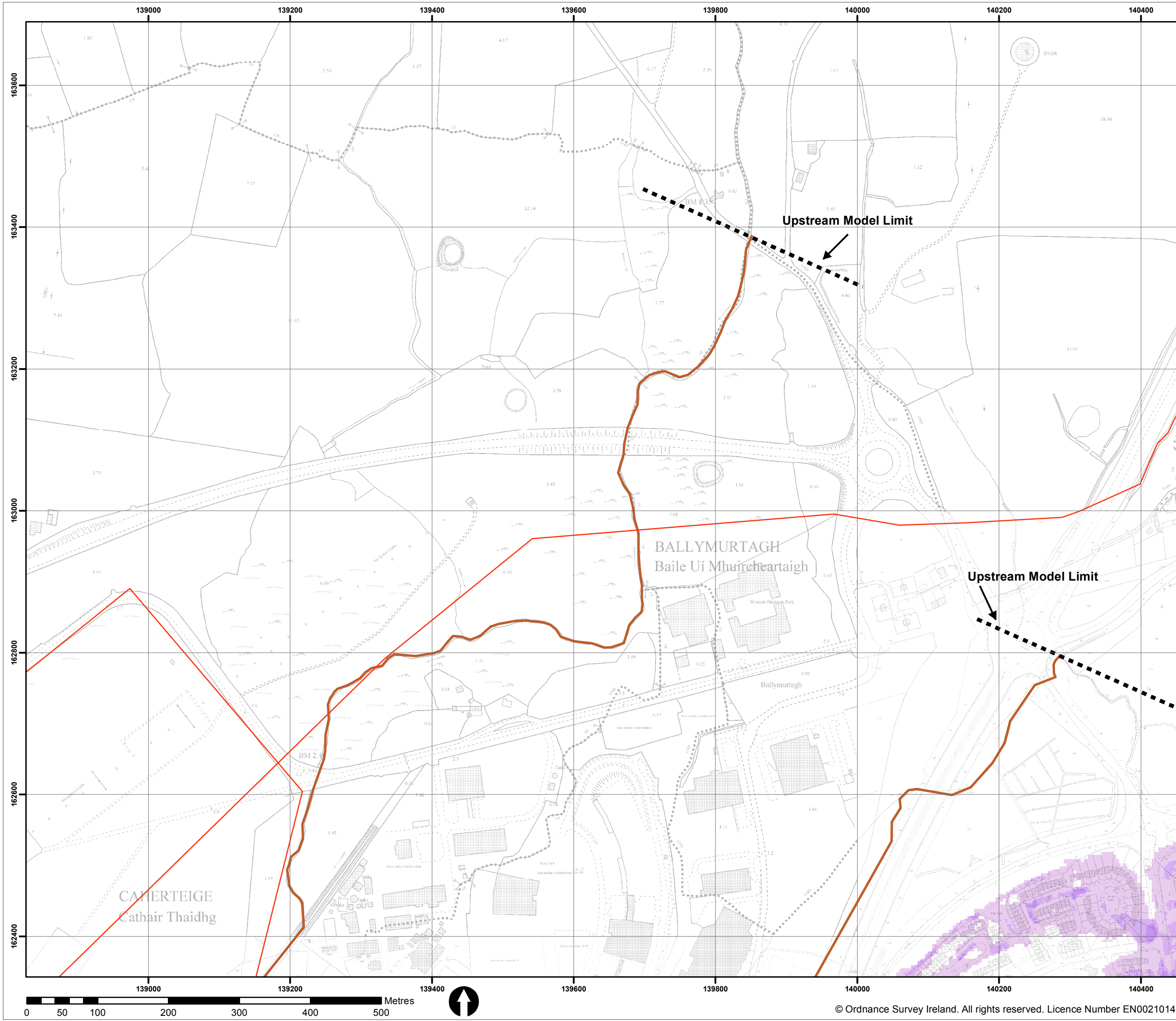
Map: **SHANNON**

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON
Scenario: EXISTING

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Sheet: 6 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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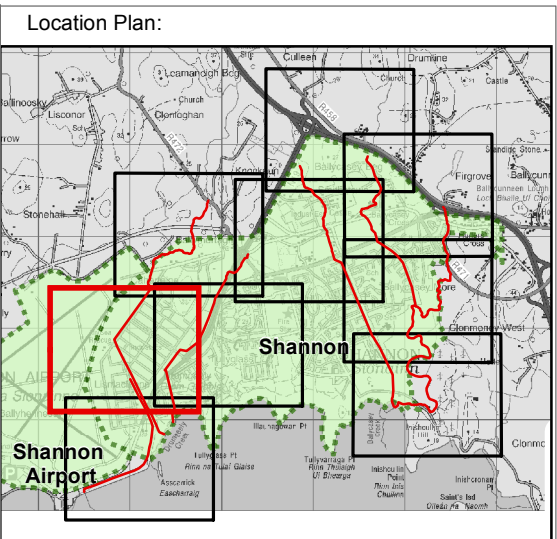
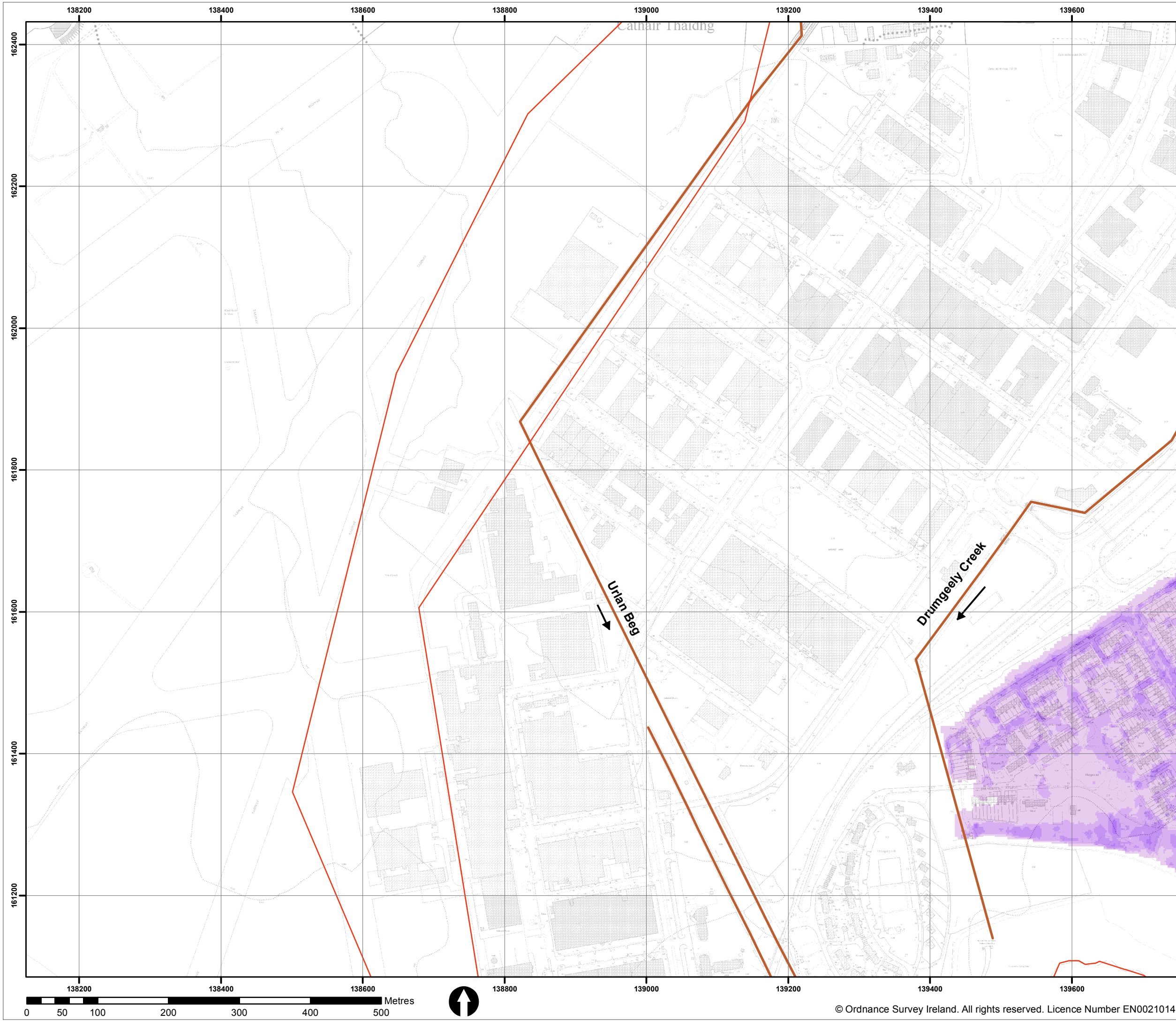
Map:
SHANNON

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON
Scenario: EXISTING

Drawn by: EH	Date: November 2015
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Map No.: S04FVCCDC1

Sheet: 7 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0


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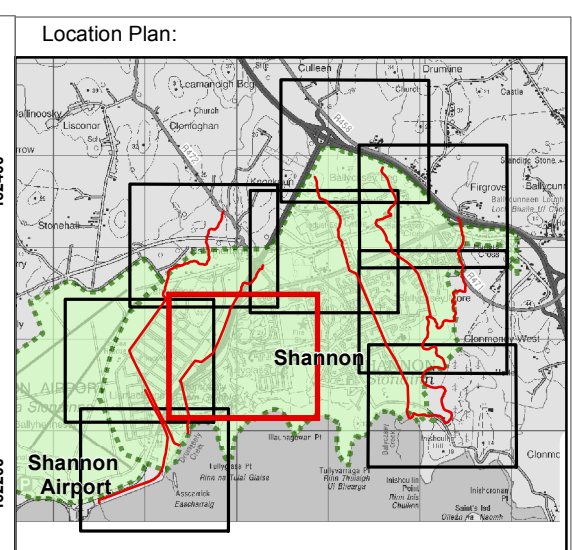
Map: **SHANNON**

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1
Map area: SHANNON
Scenario: EXISTING

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Map No.: S04FVCCDC1

Sheet: 8 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 1 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0


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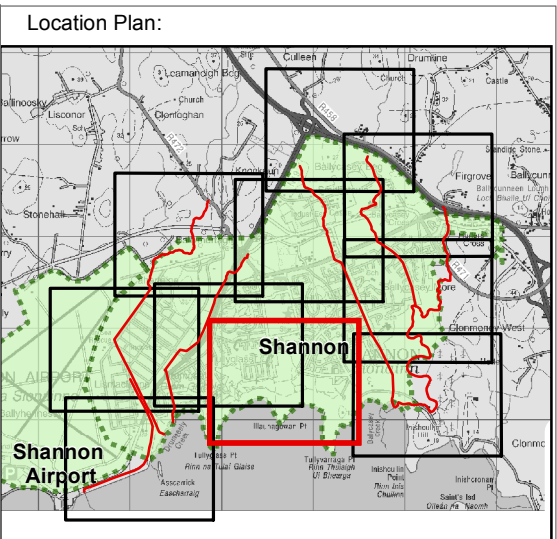
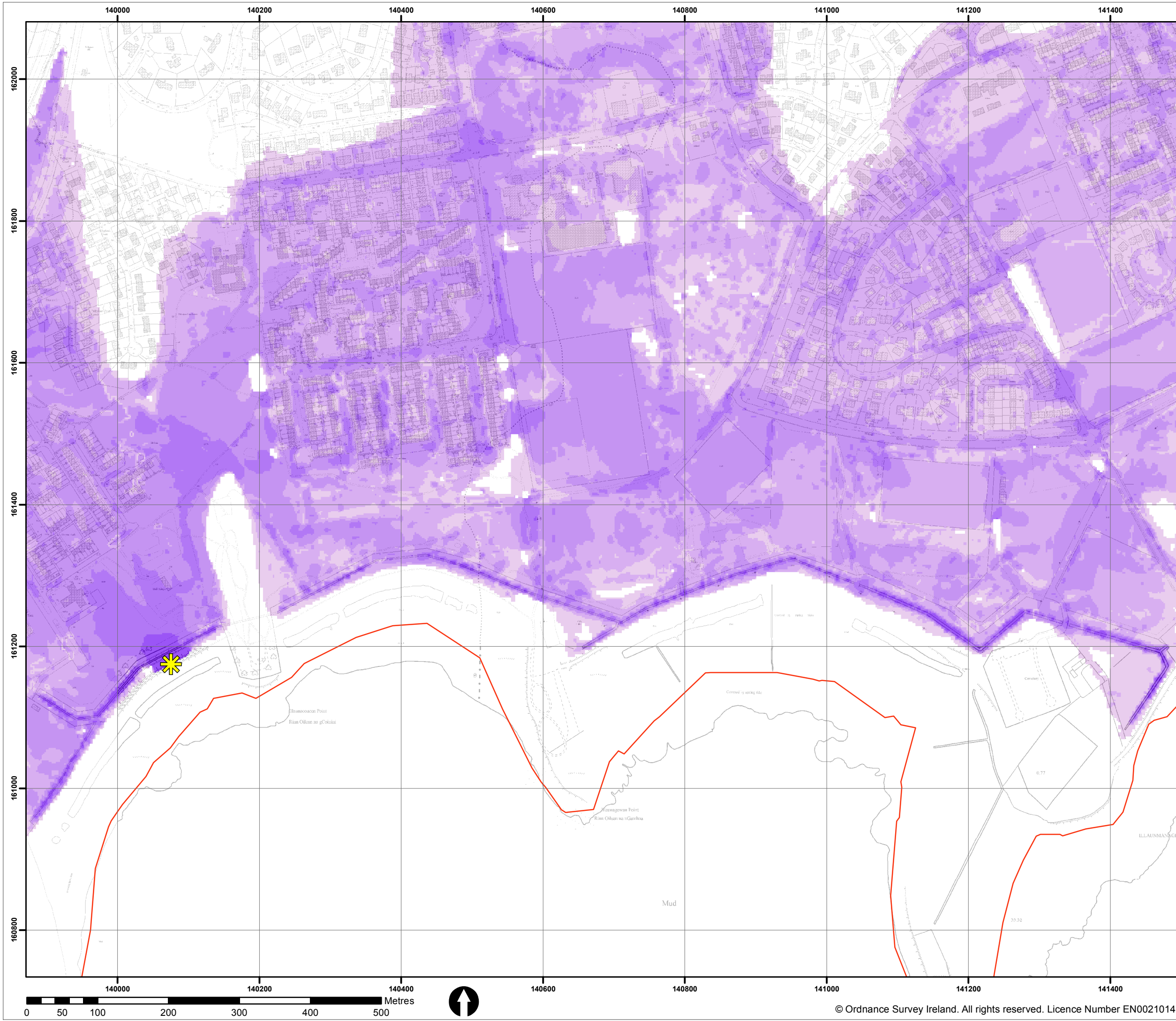


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Project:	
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Map:	SHANNON
Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 1	
Map area: SHANNON	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Approved by: PS	Date: November 2015
Map No.: S04FVCCDC1	
Sheet: 9 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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Project:
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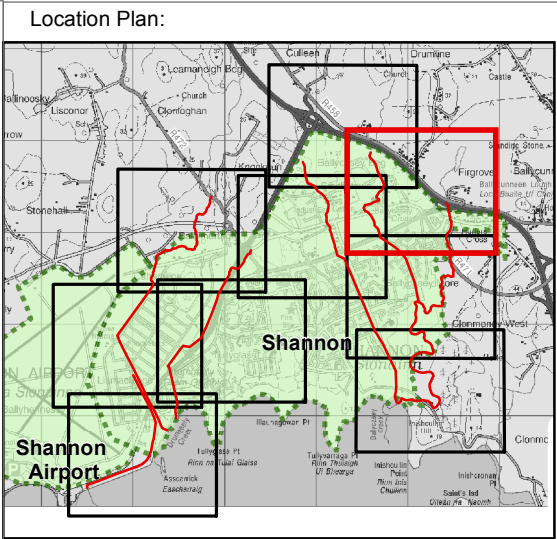
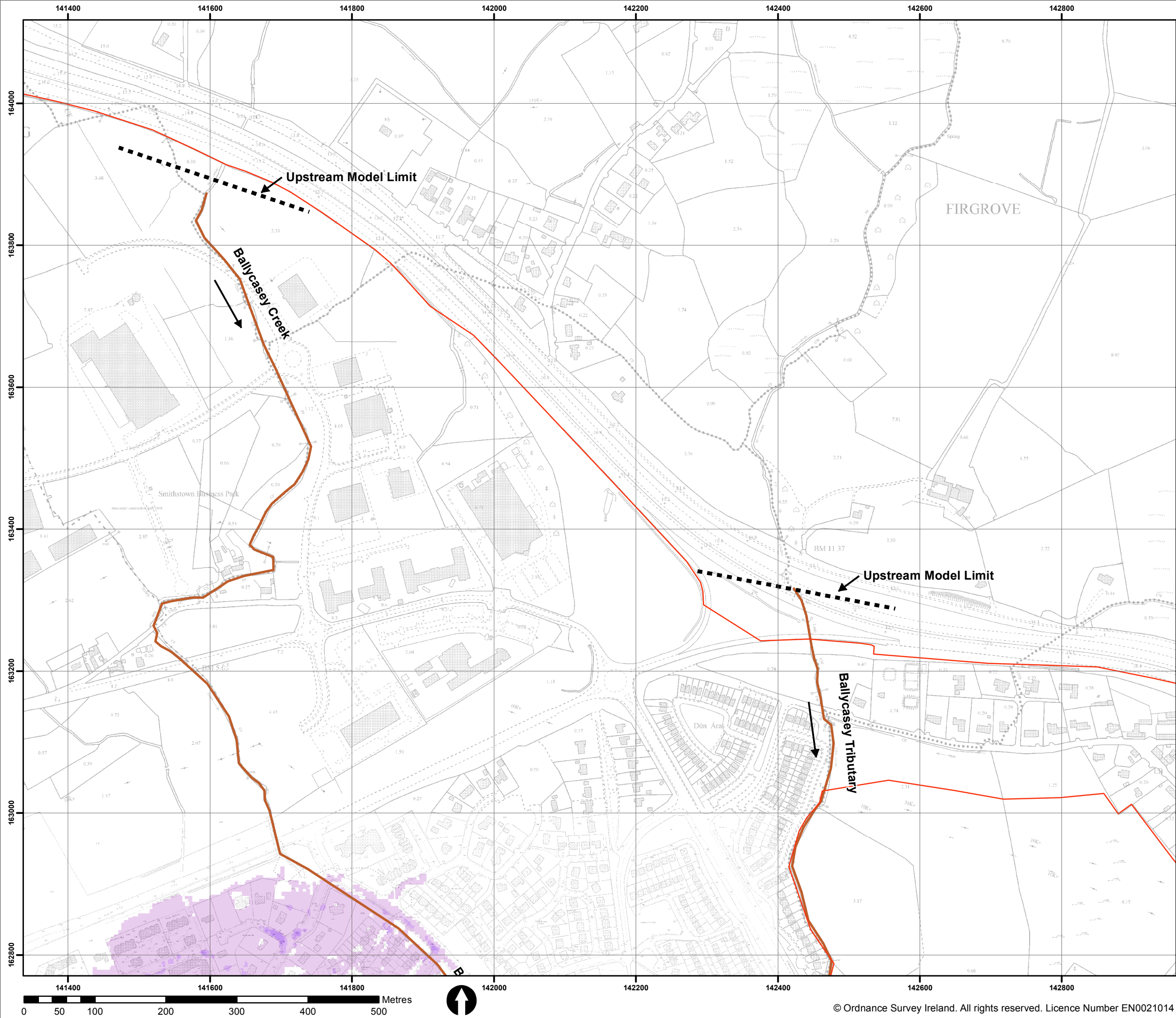
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Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SHANNON
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
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Map No.: S04FVCCDC1

Sheet: 2 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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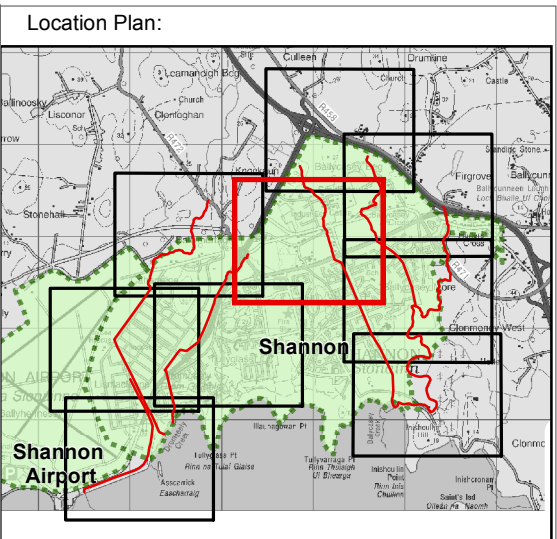
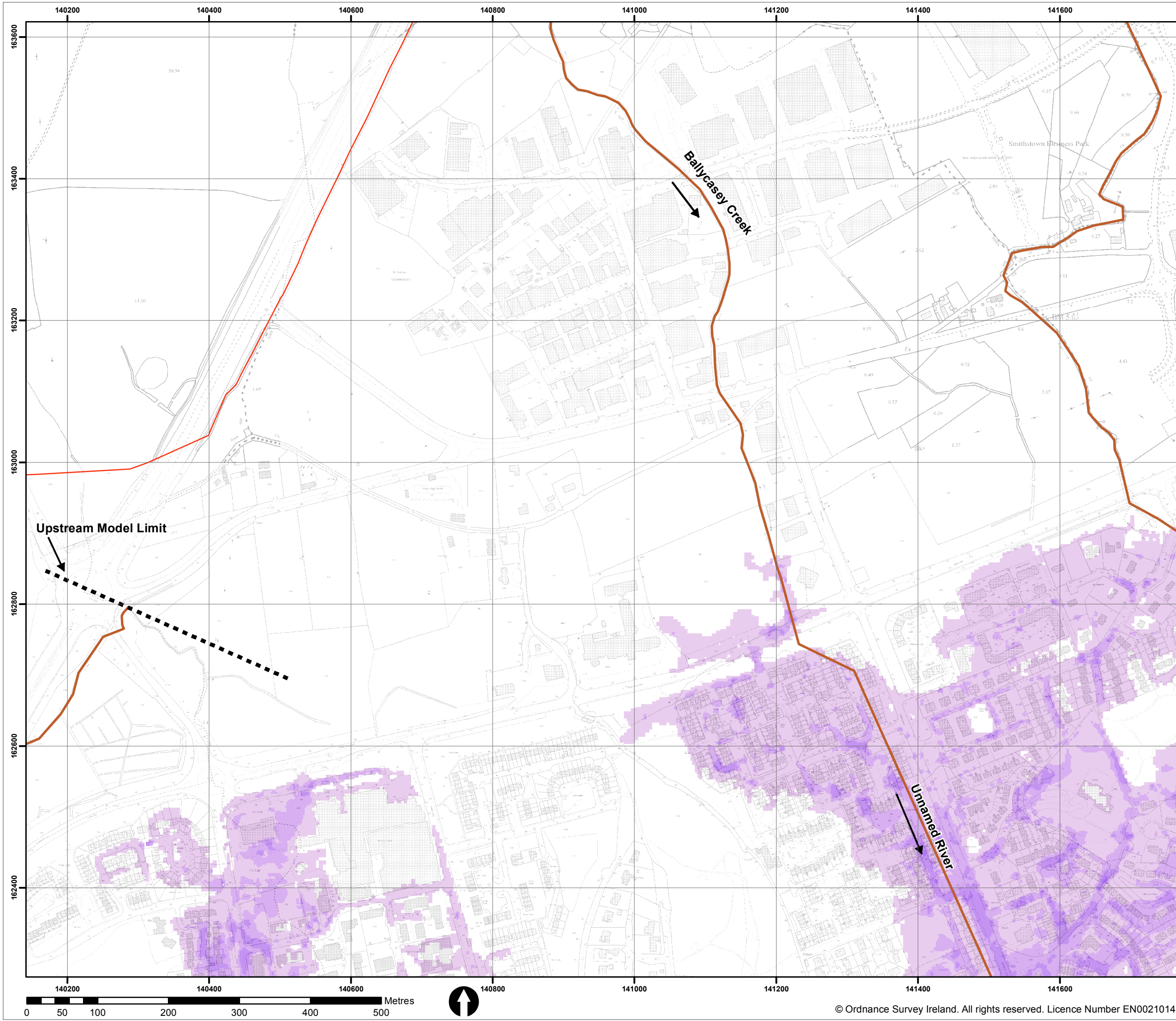


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Project: SHANNON CFram STUDY	
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Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2	
Map area: SHANNON	
Scenario: EXISTING	
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Map No.: S04FVCCDC1	
Sheet: 3 of 10	Revision: 0
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Legend:

- Model Reach
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- Defence Failure Location


0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
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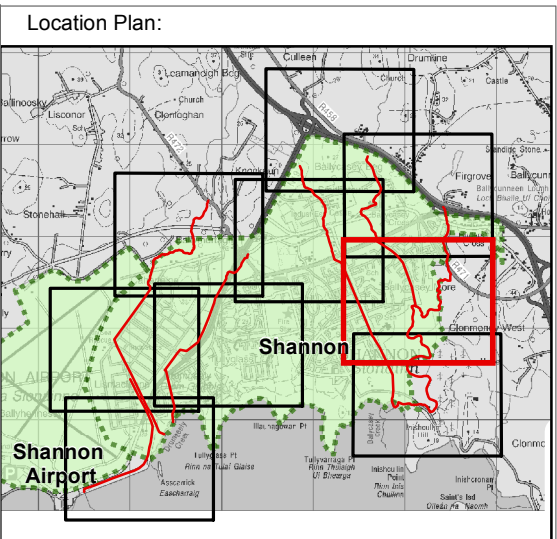
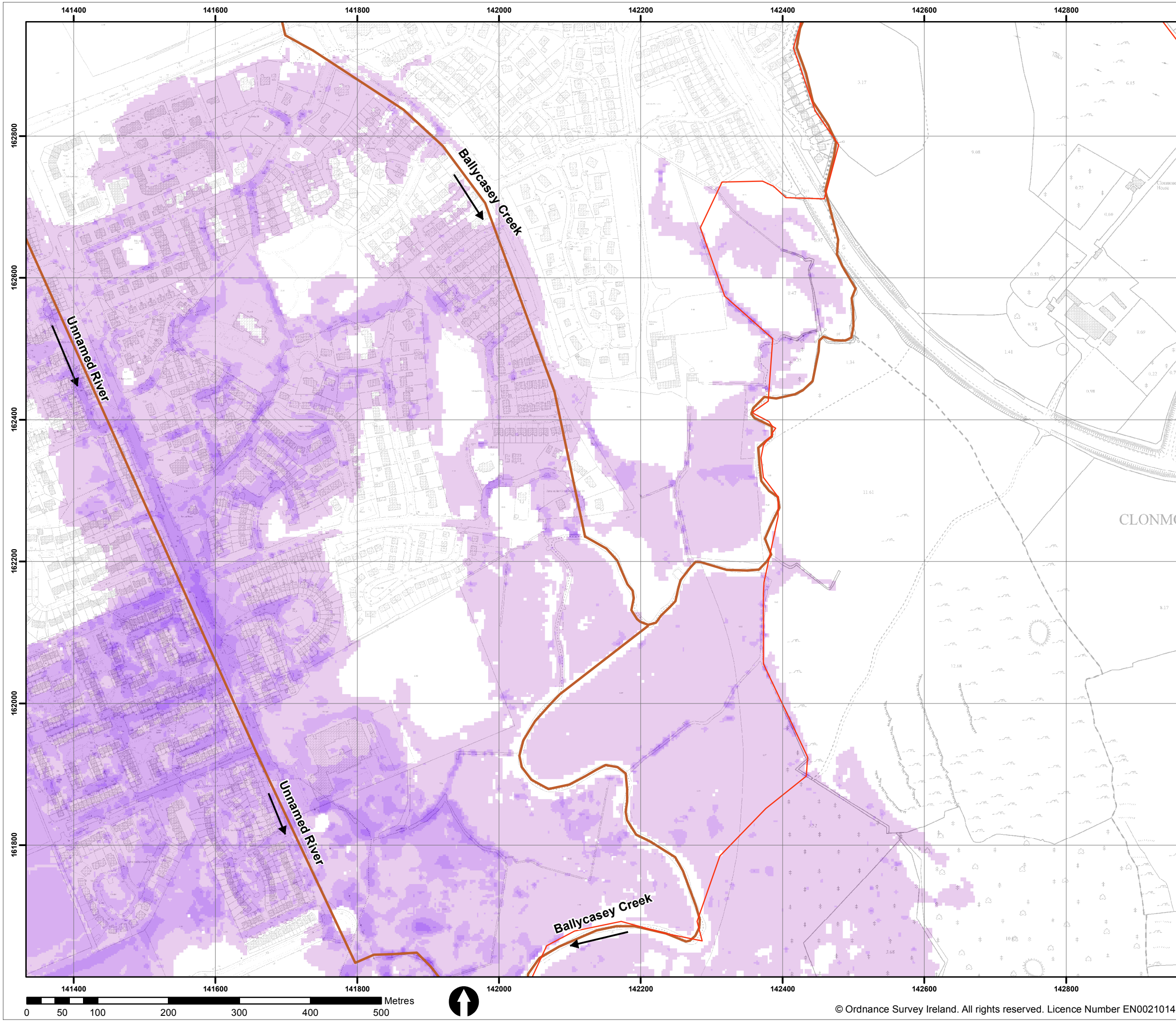
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SHANNON

Map Type: DEFENCE FAILURE VELOCITY MAP
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Map area: SHANNON
Scenario: EXISTING

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Map No.:
S04FVCCDC1

Sheet: 4 of 10	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location

0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

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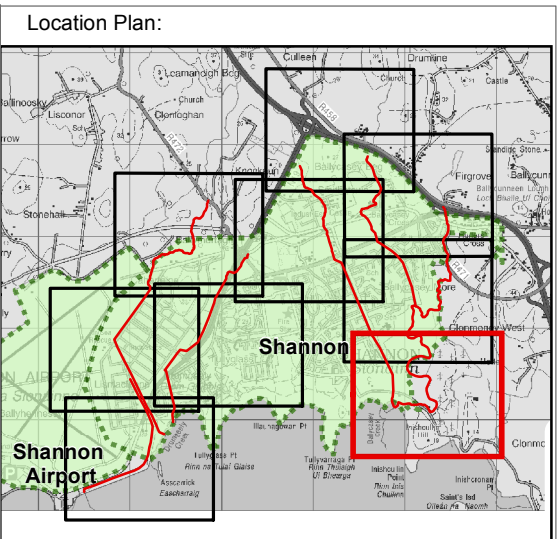
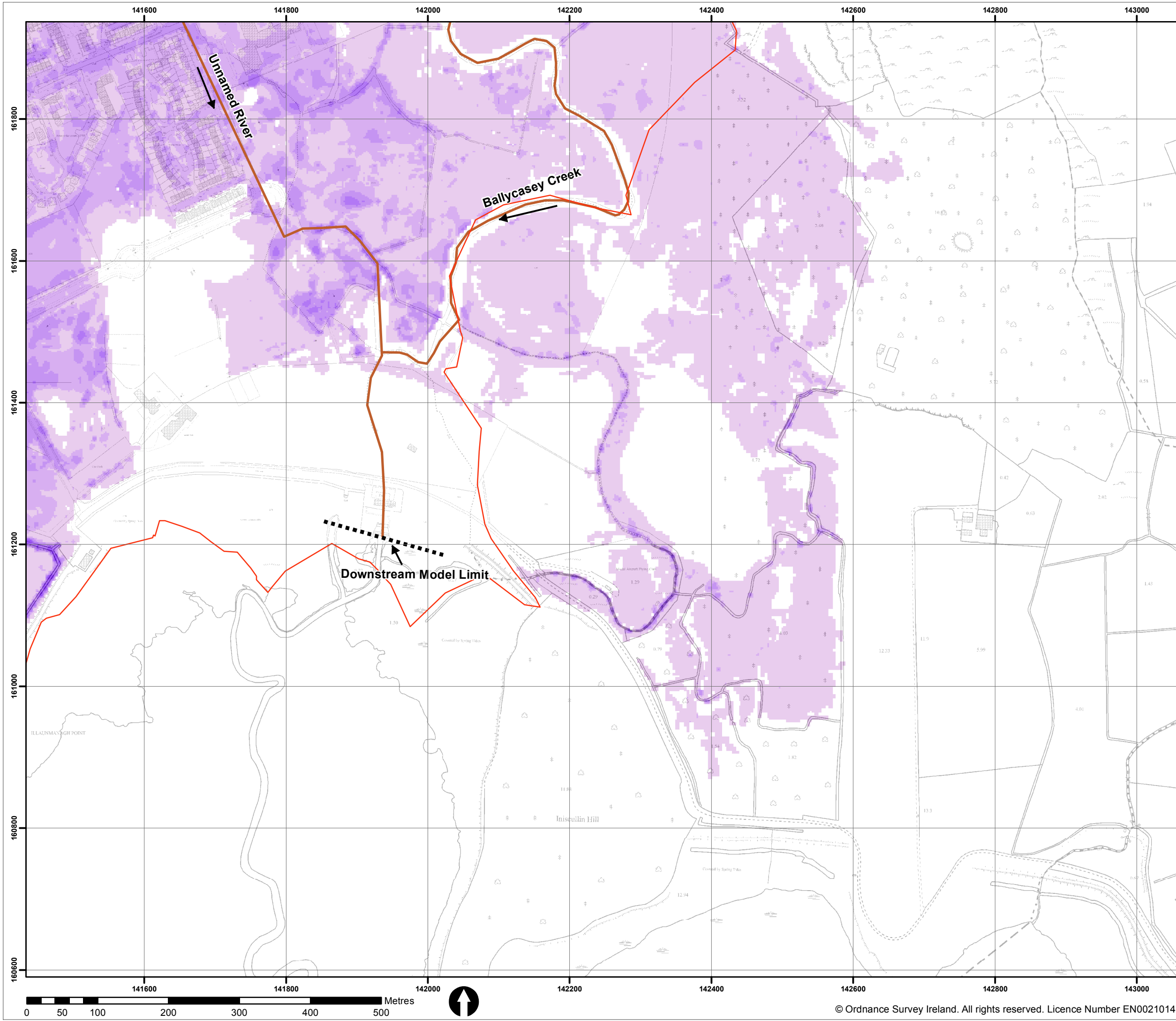


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Project: SHANNON CFRAM STUDY	
Map:	SHANNON
Map Type: DEFENCE FAILURE VELOCITY MAP	
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2	
Map area: SHANNON	
Scenario: EXISTING	
Drawn by: EH	Date: November 2015
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Sheet: 5 of 10	Revision: 0
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Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
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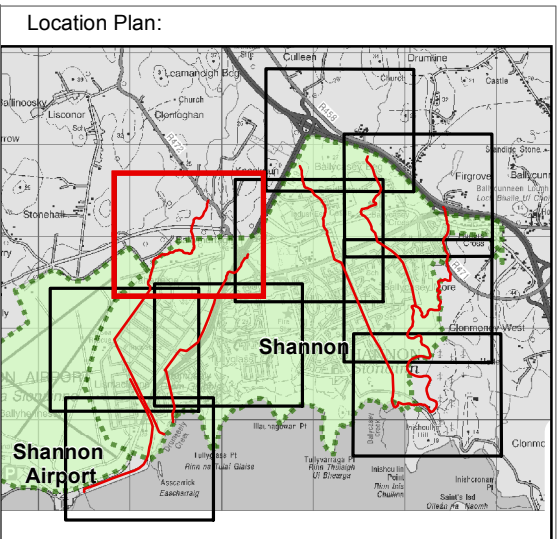
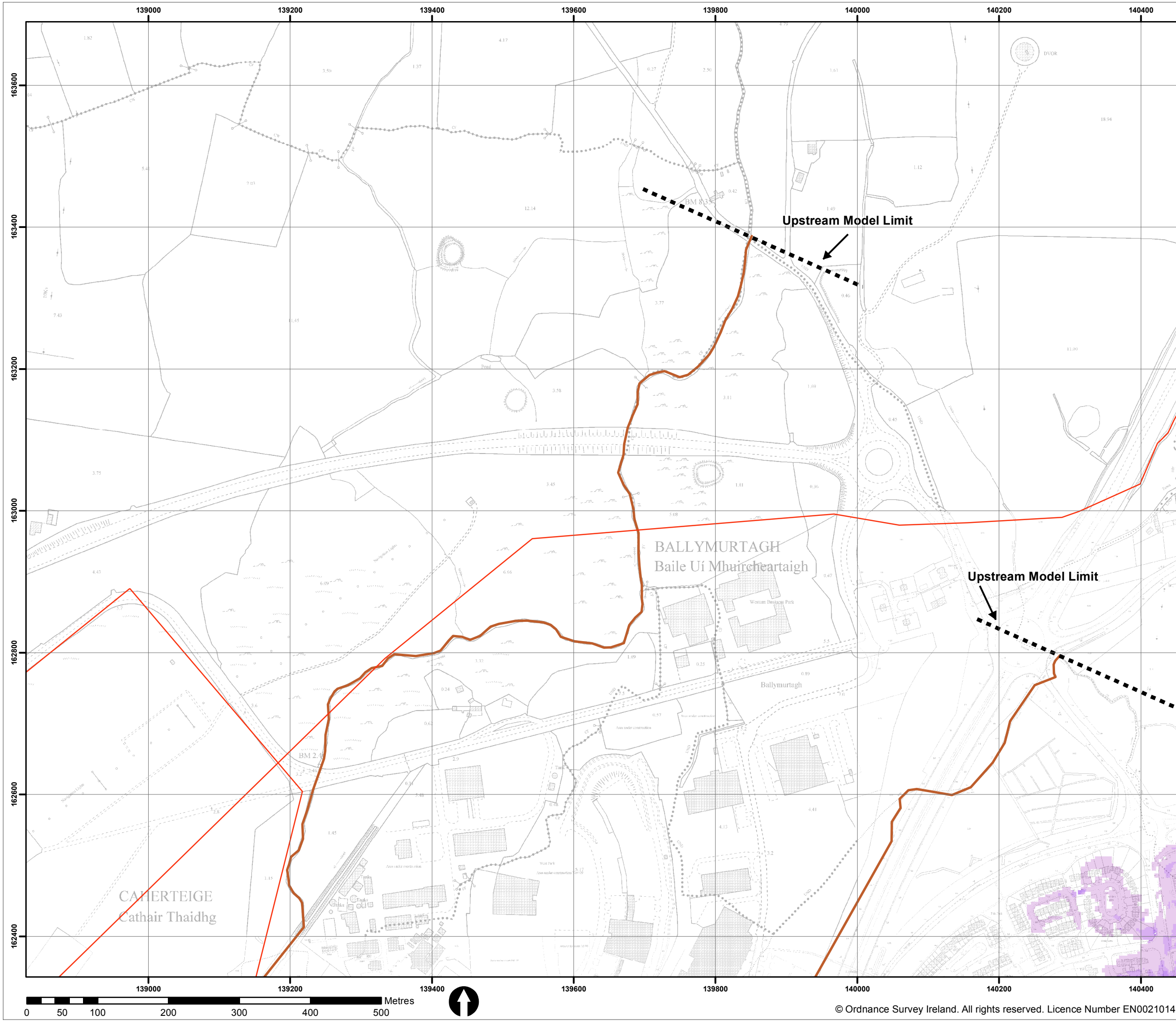
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Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SHANNON
Scenario: EXISTING

Drawn by: EH	Date: November 2015
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Map No.: S04FVCCDC1	Revision: 0
Sheet: 6 of 10	Plot Scale: 1:1 @ A3

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Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
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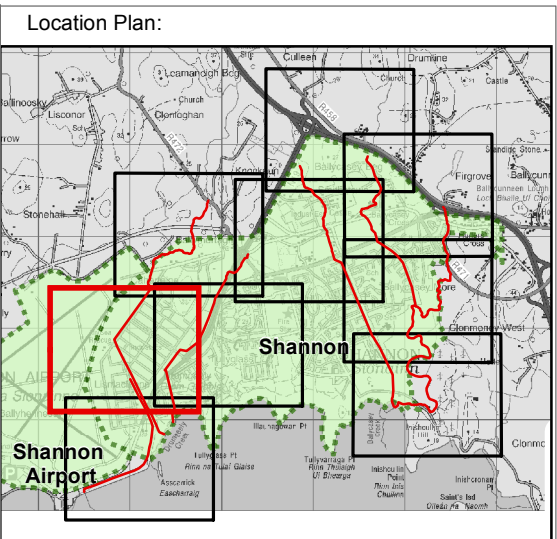
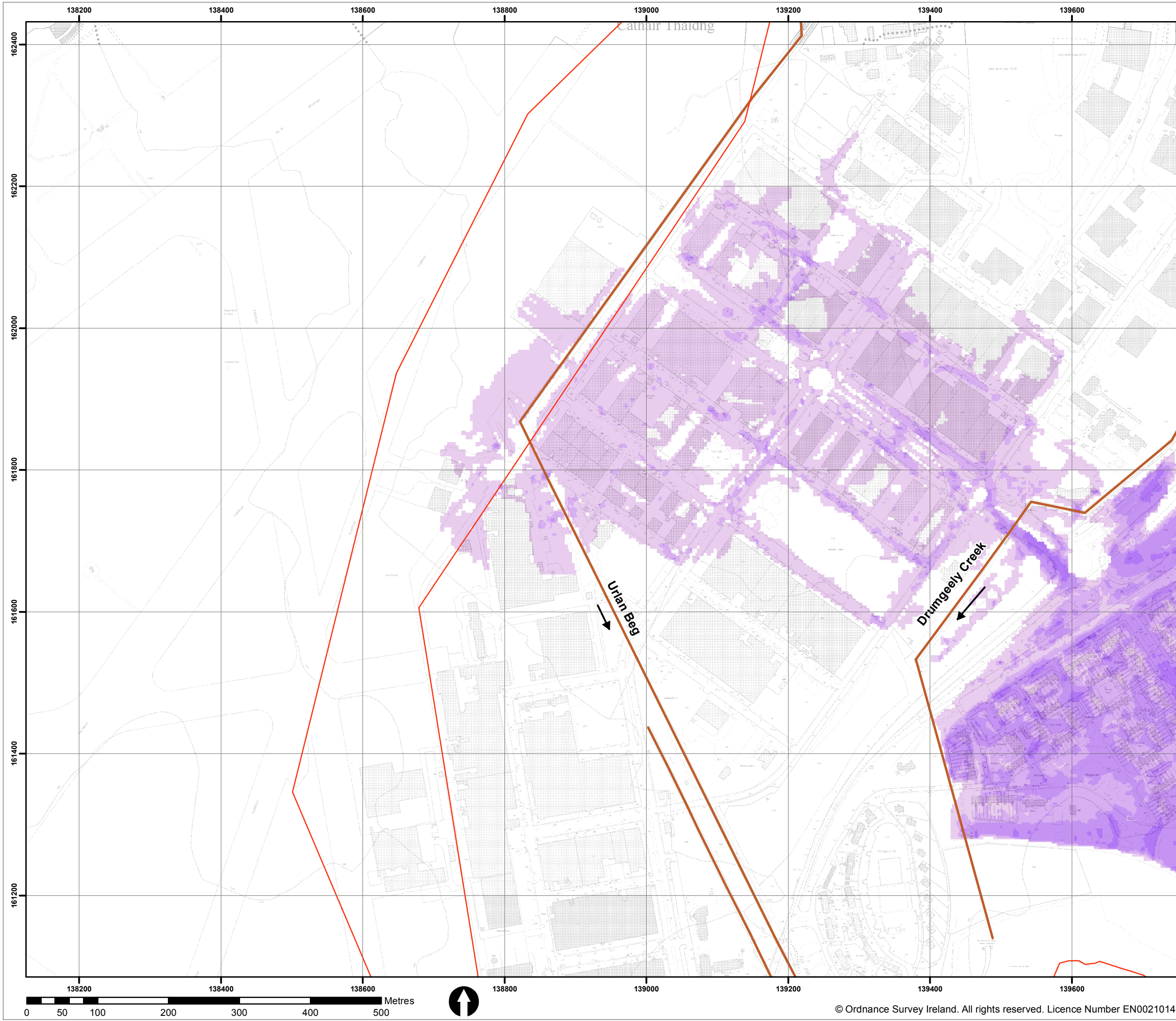
Map:
SHANNON

Map Type: DEFENCE FAILURE VELOCITY MAP
Source: 0.5% AEP COASTAL FAILURE SCENARIO 2
Map area: SHANNON
Scenario: EXISTING

Drawn by: EH	Date: November 2015
Checked by: PT	Date: November 2015
Reviewed by: MC	Date: November 2015
Approved by: PS	Date: November 2015

Map No.: S04FVCCDC1
Sheet: 7 of 10
Map Scale: 1: 5000

Revision: 0
Plot Scale: 1:1 @ A3



Legend:

- Model Reach
- AFA Boundary
- Defence Failure Location


0.5% AEP Coastal Failure Scenario 2 (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0


IMPORTANT USER NOTE:

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The Office of Public Works
Oifig na nOibreacha Poblai



JACOBS

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

Merrion House
Merrion Road
Dublin

Project:
SHANNON CFRAM STUDY

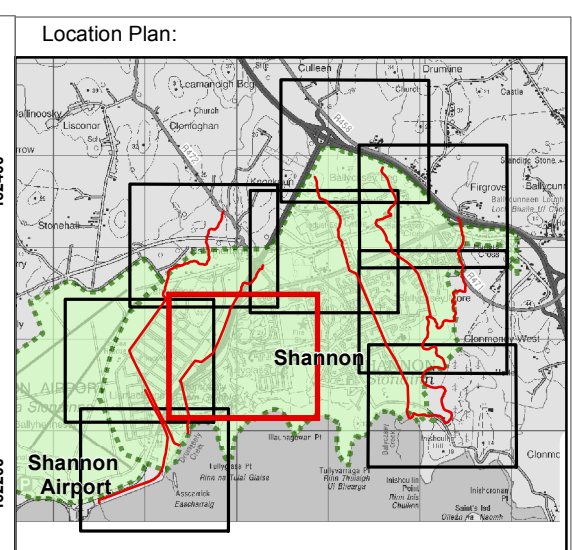
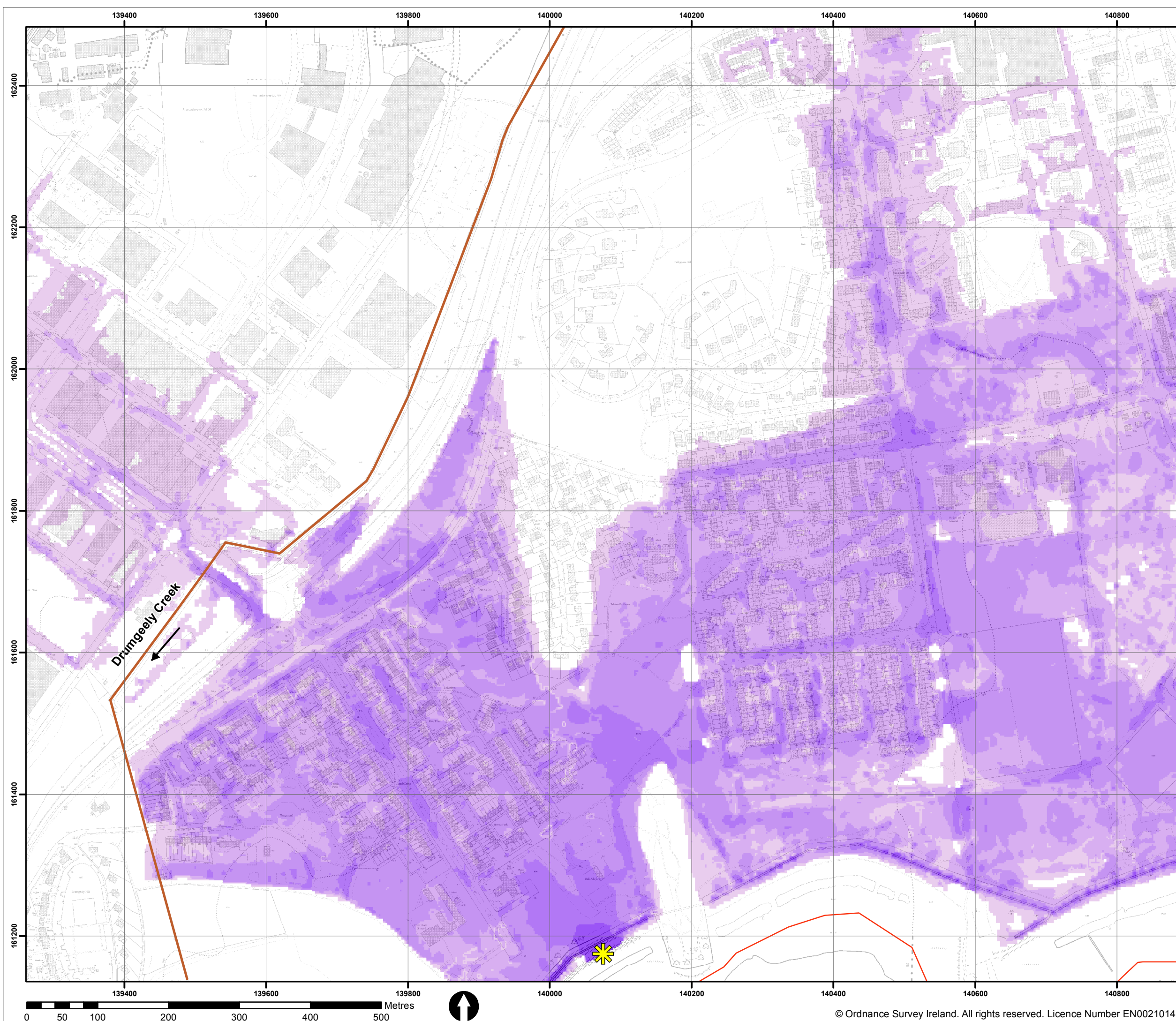
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Appendix J Relevant OPW Guidance Notes



CFRAM Guidance Note 24 – Breach Analysis

Originators: Sun Yan Evans and Marianne Piggott

Revision E Date: 19 June 2013



1.0 Overview

Flooding can be categorised as arising from two main sources: i) Coastal sources when extreme storm surges and/or waves overtop coastal defences or marine infrastructure inundating the areas inland of the coastal defences; (ii) Inland sources, i.e. overland flow from excess rainfall, excess river flows overflowing the river banks or defence; urban drainage flooding; excess groundwater; and, estuarial flooding.

Additionally, flooding can occur due to the failure of flood defence assets or infrastructure during a flood event. Because of the sudden onset, the impacts of this form of flooding can be severe and should be assessed where appropriate. Therefore, all CFRAM studies will assess flooding arising from flood defence asset failure in Areas for Further Assessment.

2.0 Purpose

This note aims to provide a consistent approach for all CFRAM studies to simulate the inundation of the failure of flood defence assets or infrastructure. The model outputs from the flood defence failure scenarios will inform the Preliminary Options Report in the CFRAM studies.

This note focuses on:

- (i) The selection of breach parameters;
- (ii) The selection of modelling techniques to simulate the inundation due to the failure of flood defence assets.

This guidance note does not address or cover the assessment of flooding from breaches of dams or reservoirs. The assessment of failure or breach scenarios of such structures is NOT included in the scope of the CFRAM Studies. If further information is required, please refer to specific guidelines for assessing dam breach inundation, such as the DEFRA National Reservoir Inundation Mapping Specification (Mott MacDonald June 2009)¹ for general information.

3.0 Requirements for CFRAM Studies

The requirements from the Stage I and Stage II CFRAM Briefs below are clarified in sections 4, 5 and 6 of this guidance note.

The CFRAM Studies Stage I Project Brief² Section 7.6 states:

“In the event of a failure of flood defence assets (such as the collapse of a section of wall or breach of an embankment), areas that would otherwise be defended against flooding during a given event severity might become subject to flooding. The Consultant shall undertake analysis to identify and assess the flood hazard and risk that may be caused or significantly increased (with due consideration for flow velocities, rate of onset of flooding, likely flood volumes and potential flood damage), by the occurrence of failures of defence assets providing protection to the areas at risk from flooding. The Consultant shall undertake such analysis using appropriate hydraulic modelling techniques in line with best practice using the models identified in Section 7.2, or the JFlow modelling software.”

The CFRAM Studies Stage II Project Brief³ states:

“The Consultant shall undertake such analysis for two (2) failure scenarios (comprising potential breach extents / breach development scenarios or locations) for each of the existing flood defence assets where the retained depth of water above ground level exceeds 1.0m during a flood event of a probability equal to the standard of defence of the asset, and only for defences providing some degree of protection to APSRs.

The Consultant shall also undertake such analysis for one (1) failure scenarios (comprising potential breach extents / breach development scenarios or locations) for up to two locations that may be at risk from future coastal erosion under either a current scenario or future scenario, and only for defences providing some degree of protection to APSRs.”

The required outputs from each defence failure scenario are as follows:

- Maximum flood extent map (excluding degrees of confidence, table of peak flows and levels and defended areas).
- Maximum flood depth map; and
- Maximum flow velocity map.

4.0 Breach Formation

4.1 Flood Defence Asset Types

Flood defence assets can be broadly classified into the following types:

- Flood embankments;
- Flood walls;
- Hydraulic structures, such as flood gates, adjustable weirs, pumps, flapped valves etc.;
- Other naturally occurring features that can provide flood protection; and
- Other infrastructure that can provide flood protection as a secondary purpose.

The type of flood defence asset is important to consider as it partly determines the mode of failure, rate of breach formation and breach dimensions. Other factors such as asset condition and the flood event characteristics also influence mode of failure, rate of breach formation and breach dimensions as discussed below. Naturally occurring and other informal defences, such as sand dunes, should be assessed on a case-by-case basis with OPW to establish the need of breach analysis that is in line with the definition of flood defences in Appendix C of CFRAM Framework Stage I Brief.

4.2 Mode of Failure

Generally speaking, there are two modes of failure: (i) overtopping^a and (ii) piping^b. The EU IMPACT study (WP 6, 2005)⁴ and Management of Flood Embankments Good Practice Review (FD2411/TR1, 2007)⁵ draw together over 100 European examples of historic breaches. Both these studies conclude that overtopping is the dominant failure mechanism for over 70% of cases reported. Analysis by the EU IMPACT study suggests that as flood embankments and walls are raised over time there is an increased risk of failure from piping as the join is exposed leading to the development of hydraulic soil failure or wall collapse.

4.3 Breach Location

The location of a breach depends on a number of factors as outlined by WP 2 of the EU Impact project⁶:

- Internal factors: Understanding of these factors needs a complete knowledge of the geotechnical properties of the interior of each specific asset such as potential lines of weakness in concrete, moisture content, cohesion, permeability, compaction, pore water pressure etc.
- External factors: These factors could be detected by a visual survey, including: settlement of the crest level, localised dipping of the crest, cracking of walls, bulging at the base of the asset, slumping, sink holes, vegetation changes etc.

^a Overtopping may be as a result of flood water overtopping the crest of an embankment, or through wave action resulting in periodic overflowing of a coastal defence.

^b Critical conditions resulting from piping (seepage or leakage) are, typically, when flow increases to a significant level causing erosion of material and progressively creating a larger hole through the embankment. Eventual subsidence of the bank material above the 'pipe' and rapid breaching of the embankment will follow.

CFRAM Guidance Note 24 – Breach Analysis

Originators: Sun Yan Evans and Marianne Piggott

Revision E Date: 19 June 2013



- Environmental factors: These factors correspond to the physical elements surrounding embankments and affecting their overall performance, such as, flow velocities, burrowing animals, scour holes at base of the wall or embankment, vegetation cover or vegetation growing in the wall etc.
- Human factors: These factors involve human actions and events and can include the presence of outfall structures through the embankment or wall, footpath erosion or loading by vehicles on roads, wash from boats, grazing animals and lack of maintenance.

There is insufficient research and understanding in the breach formation process to reliably predict breach location. The CFRAM Brief limits breach locations to existing flood defence assets within AFAs where the retained water level exceeds the adjacent ground level by 1.0m during a flood event (Section 2 of this note). However, interviews with expert local engineers and All Panel Reservoir Engineers during the NRIM pilot study¹ found that the setting of any threshold has the following effects;

- Exclusion of important flood defences that were critical to the receptors at risk, e.g. communities, properties and environmentally important sites.
- Inappropriate analysis of flood defences that were not critical to receptors at risk.

Therefore, the consultant is required to validate vulnerable locations and select the most appropriate breach locations based on the knowledge of the factors listed above. Additionally, the Irish Coastal Protection Strategy Study (ICPSS) has identified sections at risk from erosion in the future. This ICPSS data can be used to supplement expert engineering judgement to identify potential breach locations in coastal areas.

Recommendation: Selection of Breach Location

It is recommended that the Consultant identifies potential feasible breach locations considering the following aspects:

- Known problem embankments;
- Areas where failures have previously occurred;
- Current asset condition and rate of deterioration from the asset conditions survey where available;*
- Topographic survey data;
- Presence of strategic receptors at risk downstream such as; hospitals, garda stations, other emergency service stations, carehomes, nurseries, schools or areas of high population density relative to the rest of the AFA.

The most appropriate breach locations for each AFA should then be agreed with OPW prior to modelling.

* Good, fair and poor asset should all be considered in conjunction with estimated rate of deterioration.

4.4 Breach Parameters

4.4.1 Time of Failure

The time at which the breach forms can have a significant impact on the flood conditions downstream of the failure.

Laboratory and field tests by the EU IMPACT study and United States Department of Agriculture experiments⁷ indicate that failure may occur rapidly after the onset of overtopping. Conversely, the field data suggests piping failure is a relatively slower process, occurring over a period of weeks before eventual failure of the embankment. Once the piping flow through the embankment becomes turbulent (identifiable as cloudy with sediment), the failure can occur within minutes.

Therefore, any breach can be assumed to form rapidly within minutes of overtopping the defence or the presence of turbulent flow through the defence. These conditions may be formulated prior to the peak flow for an event.

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The time at which the failure occurs relative to the peak flow also determines the severity of flood risk to receptor in terms of velocity, hazard rating and flood extent. Mott MacDonald undertook a number of sensitivity tests on the time failure of flood embankments in Lincolnshire^{8,9} and found:

- The flood extent is often the greatest if the breach is assumed to occur during the rising limb or close to the peak of the hydrograph as this often provides the greatest volume during the breach.
- The flood velocities and hazard are often the greatest if the breach is assumed to occur at the peak of the hydrograph, especially in the vicinity of the breach. This often provides the greatest potential head for flow through the breach and onto the floodplain.

Recommendation: Selection of Time of Failure

The prediction of the likely time to failure during an event is best made through expert judgement by an experienced engineer familiar with construction of flood embankments, the relevant hydraulics and geotechnical theory and the purposes of the breach analysis⁵.

A simplified approach is recommended for the CFRAM studies. This assumes that the breach will initiate when the water level reaches the defence crest level or at its peak level if the peak water level is below the defence crest level.

4.4.2 Breach Dimension

A) Breach Height

The breach height or depth can be defined as the distance from the defence crest to minimum elevation through the breach. In most studies, a conservative estimate of the breach height is taken to be the defence crest to the floodplain level as this provides the largest head through the breach¹⁰.

Datasets compiled by Wahl¹¹ and IMPACT WP 6⁴ suggest that breach height varies in historic breach failures depending on the mode of failure, activity taken to repair the breach, and the potential head available.

B) Breach Width

The results from the laboratory and field tests undertaken as part of the EU IMPACT study¹⁰ suggest that: (i) the breach side walls are typically vertical during breach development; (ii) the typical breach width varies with defence type, material and many other factors; (iii) the breach width depends on the number of factors as summarized in the formula below:

$$L = L(H, G, R, S, Q, A, T)$$

Where:

- H - head through the breach
- G - the dimensions and geotechnical properties of the dike
- R - river flow conditions in the vicinity of breach
- S - topographic conditions on the protected side
- Q - the discharge of the river
- A - the activity of flood fighters
- T - the function of time

A range of models have been tested in the EU IMPACT project to estimate the breach dimensions and/or discharge hydrographs. The results suggest that all the models have limitations and associated uncertainties in the results predicted. Without local validation of these models, it was difficult to reliably predict breach width. Therefore, Morris et al. (2007)⁵ recommend that breach dimensions are estimated

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using engineering judgement based on historic failures and conditions surveys. A similar approach was taken to derive parameters for the Environment Agency's Anglian Region breach specification as used in the Northern Area Tidal Modelling Study⁸.

4.4.3 Breach Repair and Closure

The repair or closure of a breach during a flood event has not been well documented in historic defence failures⁵. The time it takes to repair or close a breach will ultimately determine the duration of the breach and flow into the floodplain. The time it takes to close a breach in a flood embankment or wall is dependent on the following:

- The discharge and velocities through the breach;
- The duration of high flows and levels in the river or sea;
- The soil conditions;
- Availability of material to repair the breach;
- Access to the breach site;
- Health and safety considerations; and
- The legislation and procedures in place for emergency teams to respond.

For example, a breach in a river embankment may be repaired relatively quickly once the water levels have receded. However, a breach in a coastal embankment may only be repaired during short period at low tide if water levels drop below the breach base level. Therefore, it may take several tidal cycles to repair a coastal breach.

Selection of Breach Dimension (Breach Height and Width) and Time to Closure

The following breach parameters are recommended to inform the selection of breach dimensions and time to closure for the CFRAM studies:

a) **Breach Height** – as a conservative estimate, the breach height is taken to be the difference between the defence crest and a representative floodplain level adjacent to the breach.

b) **Breach Width and Time to Closure as tabulated in the table below:**

Location	Defence type	Breach width (m)	Time to Closure (hrs)
Open coast	Earth embankment	200m or the total asset length where < 200m	72
	Dunes*	100 or the total asset length where < 100m	72
	Hard (walls)	50 or the total asset length where < 50m	72
Estuary and Tidal Rivers	Earth embankment	50 or the total asset length where < 50m	72
	Hard (walls)	20 or the total asset length where < 20m	72
Fluvial Rivers	Earth embankment	40 or the total asset length where < 40m	36
	Hard (walls)	20 or the total asset length where < 20m	36

Parameters based on those applied by the Environment Agency, UK.

* Sand dunes and other informal defences should be assessed on a case-by-case basis in consultation with OPW to establish the need for breach analysis that is in line with the definition of flood defences in Appendix C of CFRAM Framework Stage I Brief.

5 Breach Inundation Modelling

5.1 Approach

Flooding arising from a catastrophic failure of a defence is more difficult to simulate than fluvial or tidal flooding over a prolonged event. This is due to the presence of rapidly varying flow conditions including mixed sub, super and transcritical flows, 'shock-wave' propagation, interaction and reflections (EU IMPACT Project 2005).

There are three main approaches to the modelling of inundation resulting from a breach:

- Independent modelling
- Iterative modelling
- Dynamic modelling.

Both 1D and 2D hydraulic models can be used for modelling of flow conditions on the floodplain, but the 1D approach is limited in the prediction of variable floodplain velocities. Therefore, 2D modelling techniques would be the preferred approach to simulate the variable floodplain velocities and other flood conditions arising from a defence failure scenario.

5.2 Independent Modelling

Independent modelling is a simplistic approach that assumes that there is no interaction between the flow through the breach and the floodplain downstream.

Independent modelling was found to be appropriate for breach scenarios where the floodplain downstream does not limit the volume or head through the breach opening i.e. no backwater effect. This approach is applicable to simulate defence failure for the following locations in CFRAM studies:

- Coastal locations where the volume entering through the breach is predominately influenced by the tidal conditions; and,
- Locations where the floodplain topography is low-lying and expansive hence the storage on the floodplain does not limit inundation.

5.3 Iterative Modelling

Iterative modelling uses the same approach as the independent modelling (i.e. separate breach formation and hydraulic model) but attempts to consider scenarios where the floodplain influences flow through the breach by modifying the breach hydrograph based on iterative modelling of the breach formation model and hydraulic model. This approach is applicable to simulate defence failure for the following locations in CFRAM studies:

- Locations where the floodplain topography is constrained with limited storage on the floodplain thus limiting the discharge through the breach due to backwater effects; and
- Locations where the floodplain features form barriers to flow, such as raised roads and other urban infrastructure, thus limiting the discharge through the breach due to backwater effects.

5.4 Dynamic Modelling

Dynamic modelling seeks to dynamically solve the flow through the breach by linking the 1D or 2D model of the river channel to the 2D model of the floodplain. This enables full hydrodynamic calculations through the breach and taking into account any back water effects. This approach is applicable to simulate defence failure for the following locations in CFRAM studies:

- Locations where the floodplain topography is constrained with limited storage on the floodplain thus limiting the discharge through the breach due to backwater effects; and
- Locations where the floodplain features form barriers to flow, such as raised roads and other urban infrastructure, thus limiting the discharge through the breach due to backwater effects.

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In the context of the CFRAM studies, the dynamic modelling approach has the advantage of utilising the existing baseline 1D/2D models and only requiring one model simulation for each breach scenario. However, there might be an increased risk of model instability arising from the rapidly varying flow conditions through the breach.

Recommendation: Selection of Modelling Techniques for Breach Inundation Modelling

It is recommended that 2D modelling techniques are used to simulate the variable floodplain velocities and other flood conditions arising from a defence failure scenario. There should be existing 1D/2D models for breach analysis which have been developed for AFAs as part of the CFRAM studies.

The following three modelling techniques are recommended for the predicted of breach inundation:

- Independent modelling for locations where the water levels on the floodplain or floodplain features do not influence flow through breach;
- Iterative modelling for locations where the water levels on the floodplain or floodplain features influence flow through the breach; and
- Dynamic modelling for locations where the water levels on the floodplain or floodplain features influence flow through the breach.

Quality, time and cost implications should be taken into consideration when selecting between iterative and dynamic modelling techniques to effectively assess the impact of a breach. Dynamic modelling is the preferred choice if there is an existing dynamic model such as developed for AFAs in the CFRAM Studies. However, iterative modelling may be more appropriate if the existing dynamic model would take too long to run or has stability issues.

6 Selection of % AEP Flood Event

The discussion with OPW and the CFRAM consultants on the selection of %AEP Flood Event for breach analysis at the recent NTCG3 is summarised below.

The application of a single design %AEP flood event, such as the 1%AEP for fluvial locations and 0.5%AEP for coastal locations, provides a consistent approach and comparable results between different locations for planning purposes. However, this approach may result in inappropriate breach analysis for flood defence assets that are already overwhelmed in the selected %AEP flood event.

To avoid this problem, it was agreed that the %AEP flood event for breach analysis should be that which is closest to defence crest level but does not overtop the defence asset, with a limit of the 1%AEP for fluvial flooding and 0.5%AEP for tidal flooding. It is recognised that this will result in different %AEP events being selected at different breach locations.

Recommendation: Selection of %AEP Flood Event

It is recommended that the %AEP flood event for breach analysis should be that which is closest to defence crest level but does not overtop the defence asset, with a limit of the 1%AEP for fluvial flooding and 0.5%AEP for tidal flooding.

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References:

- ¹ Mott MacDonald (2009) National Reservoir Inundation Modelling Specification. United Kingdom DEFRA/ Environment Agency.
- ² Office of Public Works (2010) Catchment-based Flood Risk Assessment and Management (CFRAM) Studies Stage I Tender Documents: Project Brief.
- ³ Office of Public Works (2011) South Western River Basin District Catchment-based Flood Risk Assessment and Management (CFRAM) Studies Stage II Tender Documents: Project Brief.
- ⁴ Nagy-Toth (2005) EU IMPACT Project Work Package 6: Detailed Technical Report on the collation and analysis of dike breach data with regards to formation process and location factors. H-EURAqua Ltd.
- ⁵ Morris, Dyer and Smith (2007) Management of Flood Embankments: A good practice review. FD2411/TR1. United Kingdom DEFRA/Environment Agency.
- ⁶ EU IMPACT (2004) Work Package 2 Deliverable 2.4.1: Identifying Potential Breach Location. Investigation of Extreme Flood Processes & Uncertainty (IMPACT).
- ⁷ Damme et al (2012) WP 4.4 A new approach to rapid assessment of breach driven embankment failures. Flood risk management Research Consortium. United States Department of Agriculture - Agricultural Research Service (1999) Dam Breach Experiments.
- ⁸ Mott MacDonald (2010) Anglian Region Northern Area Tidal Modelling. Volume 4: Breach Hazard Mapping. Environment Agency.
- ⁹ Mott MacDonald (2013 ongoing) Lincoln Breach Hazard Mapping. Environment Agency.
- ¹⁰ Morris, Hassan and Vaskinn (2005) Conclusions and Recommendations from the IMPACT project WP2: Breach Formation. EU IMPACT Project.
- ¹¹ Wahl (1998) Prediction of embankment dam breach parameters – a literature review and needs assessment. US Bureau of Reclamation Dam Safety Report DSO-98-004.

NATIONAL CFRAM PROGRAMME

GUIDANCE NOTE NO. 27

Title:	Economic Damage and Benefit Calculation and Cost-Benefit Analysis
Version:	Rev. C – Final
Author:	Mark Adamson
Date:	21st July 2014
Issued to:	CFRAM Consultants
Date Issued:	21st July 2014

1.0	PURPOSE
	<p>The purpose of National CFRAM Programme Guidance Note No. 27 is to set out a common approach to the calculation of monetarised, economic flood damages and the economic benefits of flood risk management options, and for undertaking a cost-benefit analysis, with a view to ensuring that damages, benefits and benefit-cost calculations are determined in a nationally consistent manner, to enable inter-comparability of proposed measures across the country.</p>
2.0	SCOPE
	<p>GN 27 relates to the calculation of monetarised, economic flood damages and the potential economic benefits of options for flood risk management measures, for the purposes of:</p> <ul style="list-style-type: none"> – The calculation of the economic (monetary) benefit-cost ratio for options for flood risk management measures (to be used for option appraisal and economic flood risk mapping – see GP comment on Section 4.3) – Option appraisal against Objective 2.a (Minimise Economic Risk) under the Multi-Criteria Analysis (MCA) <p>Note that there are minor variations in the benefit / damage values to be used for the two purposes above (see Section 4.5 herein).</p> <p>GN 27 does <u>not</u> address to:</p> <ul style="list-style-type: none"> – The calculation of the costs of options for flood risk management measures, which is outlined in Guidance Note 32, with reference to the OPW Unit Cost Database – The application of the Multi-Criteria Analysis (MCA) to appraise flood risk management measures (except for Objective 2.a), for which guidance is produced in Guidance Note 28 (GN28)

	<p>A glossary of abbreviations / acronyms used for this GN is provided in Appendix A. An explanatory table is provided in Appendix B, that might be useful for clarity.</p>
3.0	CALCULATION OF ECONOMIC FLOOD DAMAGES
3.1	<p>General Requirements</p> <p>The requirements for the calculation of economic risk, and hence economic flood damages are as set out in Section 8 and Appendix I of the Generic CFRAM Project Brief.</p> <p>General Methodology</p> <p>The calculation of flood damages should be based on the Flood Hazard Research Centre Handbook of 2010 (FHRC, 2010) and the 'Multi-Coloured Manual' of 2005 (FHRC, 2005) as referred to in FHRC 2010, subject to caveats, amendments and clarifications set out herein</p> <p>Price Conversions</p> <p>Prices (damage costs) in the data provided by FHRC 2010 should be converted to euro rates applicable to Ireland in 2013 by:</p> <ul style="list-style-type: none"> - Applying a 'PPP' multiplication factor of 1.279. This is derived from the relative OECD Purchasing Price Parity values for the UK and for Ireland for 2010. The 'PPP' factor is net of currency conversion (i.e., already includes for exchange rates as well as price differences, and so no currency conversion rate should be applied in addition to this factor) - Applying an inflation multiplication factor of 1.051. This is derived from inflation rates based on the CPI in Ireland for the period 2010 - 2013 <p>Flood Duration</p> <p>The damages should be calculated assuming long duration (>12 hours) flooding for residential properties, except where shorter duration flooding (including the time required for the draining away of flood waters) would clearly be expected, e.g., in small, flashy catchments, where the duration of <12 hours should be applied instead. For non-residential properties, shorter duration flooding (<12 hours) should be assumed, as depth-damage data for longer duration flooding of non-residential properties is not provided in FHRC 2010.</p> <p>Coastal Flooding</p> <p>The addition of 10% on building fabric damages should be used when assessing flooding from coastal / tidal sources.</p>
3.2	<p>Scope of Assessment</p> <p>The calculation of flood damages should be undertaken for:</p> <ul style="list-style-type: none"> - AFAs and APMRs - The current scenario and MRFS based on each of the range of flood event probabilities as set out in Section 6.5.1 of the Generic CFRAM Project Brief

	<ul style="list-style-type: none"> - The HEFS in an indicative manner, making use of calculated damages for the 10%, 1% (0.5% for coastal flooding) and 0.1% damages for the HEFS, and using these values to shift the MRFS damage curve to derive an indicative damage curve for the HEFS.
3.3	<p>Residential Property Damages</p> <p><i>Residential Property Classifications</i></p> <p>For the purposes of determining the appropriate residential property damages, and the depth-damage curve / data to be used, account should be taken of:</p> <ul style="list-style-type: none"> - Property type (detached, semi-detached, terraced, bungalow, etc.) <p>but not:</p> <ul style="list-style-type: none"> - Property age - Social class (and without inclusion of the Distributional Impact Factor) - Property size <p>The use of properties marked as 'unknown' in the GeoDirectory can be confirmed through the site visits and/or by remote data such as Google Street Map</p> <p><i>Property Floor Levels and Flood Depths</i></p> <p>As set out in Section 5.4.2 (and 8.1.4) of the Generic CFRAM Project Brief, residential property floor levels (which is the base-line or zero-depth against for the calculation of flood damages) may be determined, subject to confirmation by the CFRAM Consultant through spot-checks, on the basis that doorstep / floor levels of ground-floor properties are a specific height above ground level as determined from the DTM data. The specific height of the doorstep / floor level adopted for each AFA should be based on observation / measurement for each AFA.</p> <p>Flood damages should be assumed to begin at flood depths of –0.3m relative to floor levels. This only applies however to properties whose foot-print lies within the flooded area, and does not need to be calculated for properties that are situated outside of the flood extents for the given event.</p> <p>For properties with basements, the flood damages for the property assuming a depth of 2.4m (typical ceiling height) should be applied once the flood depth exceeds the threshold level for the basement (i.e., the lowest level that allows significant flood waters to enter). This damage should be in addition to the normal depth-damage calculation for the ground floor of the property.</p>
3.4	<p>Non-Residential Property Damages</p> <p><i>Non-Residential Property Classifications</i></p> <p>The Indicative Susceptibility depth-damage curve / data should be used, unless there is a clear and specific reason to use the High or Low Susceptibility Band data for a given property.</p>

	<p>For the purposes of determining the appropriate non-residential property damages, and the depth-damage curve / data to be used, account should be taken of:</p> <ul style="list-style-type: none"> - Property type (i.e., sub-classes of the 'Bulk Code Class', and with a three-digit 'MCM Code', as referred to in FHRC 2005 & 2010) - Property area <p>Property Floor Levels and Flood Depths</p> <p>As set out in Section 5.4.2 (and 8.1.4) of the Generic CFRAM Project Brief, non-residential property floor levels may generally be determined, subject to confirmation by the Consultant through spot-checks and the exceptions as set out below, that doorstep / floor levels of ground-floor properties are a specific height above ground level as determined from the DTM data. The specific height adopted for each AFA should be based on observation / measurement for each AFA.</p> <p>Surveys of the threshold levels for flooding of major commercial properties (those with estimated potential damages greater or equal to €500,000 for an event of annual exceedence probability of 0.1% in the AFA), and also for entry points to significant basements or underground car-parks, are however required, and these levels where captured should be used.</p> <p>Flood damages should be assumed to begin at flood depths of 0m. For mixed-use properties, i.e., where the property includes both residential and (non-residential) commercial use, it could be assumed (unless otherwise verified through site visit / remote data) that the ground floor will typically be in non-residential (commercial) use, and so the non-residential approach should be applied, i.e., assume flood damages begin at 0m rather than -0.3m. For converted properties that are now non-residential, the non-residential approach should be applied.</p> <p>The 'with basements' or 'without basements' depth-damage data for non-residential properties should be used as appropriate. Where the existence or otherwise of a basement is unknown for a given property, then the 'without basement' depth-damage data should be used.</p> <p>In line with good practice, a 'reality-check' should be undertaken for any property that contributes more than 1% of the total PV damages for an AFA.</p>
3.5	<p>Other Damage Costs</p> <p>Principal Direct Damage (PDD) Costs</p> <p>The PDD Costs are calculated as the sum of the residential and non-residential property damages. The PDD Cost is used as the baseline for the calculation of other damage costs, as set out below.</p> <p>Infrastructural Utility Assets</p> <p>Economic damages to infrastructural utility assets (e.g., electrical sub-stations, gas installations and pipe-work, telecommunications assets, etc.) should be calculated as 20% of total PDD Costs for the AFA or SSA.</p> <p><i>(Note: 20% value has been derived from the analysis of damages of past floods in the UK).</i></p>

	<p>Infrastructural Utility Damage Costs should be included for the economic CBA, but should <u>not</u> be included in the appraisal against Objective 2.a under the MCA.</p> <p>Emergency Services Costs to emergency services (which include evacuation costs) should be included in the economic damages, and should be calculated as 8.1% of the total PDD Costs for the AFA or SSA.</p> <p><i>(Note: 8.1% value derived as average of the measured emergency services costs for the 2000 and 2007 floods in the UK).</i></p> <p>Traffic Disruption Costs of traffic disruption may typically be excluded from the calculation of the economic damages, as it will typically not be significant within the overall damages. This would be, for example, where the flooding would be of minor roads or local urban streets and where alternative local routes are available and/or traffic volumes will not be high. Traffic disruption costs may however be included where there are major (high volume) roads affected and / or where deviation routes are of significant distance.</p> <p>The inclusion or otherwise of traffic disruption costs is at the discretion of the CFRAM Consultants, subject to advice from the Steering / Progress Group.</p> <p>In the event that traffic disruption costs are calculated, then such damages / costs should be included for the economic CBA, but should <u>not</u> be included in the appraisal against Objective 2.a under the MCA.</p> <p>Risk to Life While clearly of significant importance in the overall appraisal under the MCA, the potential damage costs of loss of life in a flood event are <u>not</u> to be included in the assessment of economic damages.</p> <p><i>(Note: This is excluded because, while loss of life can occur in flood events, in Ireland loss of life in a community that might be classified as an APSR (AFA) is very rare. As such, it would not materially change the economic analysis.)</i></p> <p>Where risk to life is of potentially significant concern (e.g., where there is a prevalence of basements and / or by observation of the flood hazard (risk to life) mapping and the location of residential / high vulnerability properties), this should be noted in the description of flood risk for the AFA, and can be taken into account in option selection and justification.</p> <p>Other Excluded Damage Costs Damage costs can arise in relation to various other types of damage, impacts or costs arising in the event of a flood. However, these are either not economic losses (i.e., to the overall national economy), are provided for under another included cost, and / or are typically relatively small as a percentage of the overall damage and hence do not need to be considered in the economic appraisal at this strategic level of assessment.</p>
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	<p>Such excluded costs would include:</p> <ul style="list-style-type: none"> - Damage to roads - Damage to parked cars - Environmental damage - Personal evacuation costs - Temporary accommodation - Extra heating costs - Losses to businesses - Recreational losses <p>Many of the above costs are deemed to be included within the Intangible and Indirect Damages (see Item 3.6 below).</p>
3.6	<p>Intangible and Indirect Damages</p> <p>Flood events can cause significant stress, anxiety and ill health to potentially affected people, during and then after a flood. Individuals generally also incur some costs due to their properties flooding that are not directly related to damage, such as evacuation, temporary accommodation, loss of earnings, increased travel and shopping costs, etc.</p> <p>While these negative impacts are difficult to monetarise or quantify, it is recognised that these impacts are significant, and professional opinion (Chatterton, pers. comm) has indicated that they could well be greater than the direct damages to residential properties.</p> <p>For residential properties, the intangible and indirect flood damages shall together be set equal to the total (direct) property damage.</p> <p>Intangible damages may also be applied in the case of small, individually or family-owned businesses where the intangible impact would be personal and similar in nature to that which might be experienced were the property residential. The inclusion of intangible damages for non-residential properties (if included) shall however be justified on a property-by-property basis, and may not be generally applied across an entire sector or sub-sector.</p> <p>While recognising that there will be some impact to those living above ground floor level (e.g., in apartment buildings), the intangible impact will, in line with the economic damages, be quite limited relative to those in properties that are flooded, and so these damages should not be included at the CFRAM level of analysis.</p> <p>Intangible and indirect damages should be included for the economic CBA, but should <u>not</u> be included in the appraisal against Objective 2.a under the MCA (as they are provided for under other MCA objectives).</p>

3.7	<p>Calculation of Annual Average Damage</p> <p>The Annual Average Damage (AAD) shall be calculated using linear interpolation between damage values for each of the eight defined design event probabilities, i.e., with a damage value calculated for each 'slice' based on the average of the damages for the design event damages that form the probability boundaries for the 'slice', and the probability range of the 'slice'.</p> <p>The AAD is calculated as the sum of the damage values of each slice, up to and including the 'slice' with the 0.1% AEP event as the upper bounding event.</p>
3.8	<p>Calculation of the Present Value of Damages (PVd)</p> <p>The PVd should be calculated as the discounted sum of the annual average damages over the project horizon, where:</p> <ul style="list-style-type: none"> - The discount rate to be applied is 4% - The project horizon is 50 years <p>The discount rate is subject to sensitivity testing (see Section 5.1).</p>
4.0	<p>CALCULATION OF ECONOMIC BENEFITS OF FLOOD RISK MANAGEMENT OPTIONS</p>
4.1	<p>General Requirements</p> <p>The economic benefits of an option for a flood risk management measure, or of a proposed flood risk management measure, are calculated as the reduction in the economic damages the option or measure will provide. The benefits / damages should be calculated assuming protection to the defined / proposed Standard of Protection (SoP), i.e., <u>not</u> taking into account freeboard / factor of safety.</p> <p>Baseline Scenario</p> <p>The baseline scenario against which benefits of an option or measure should be compared is the current situation or 'continue with existing practice' in terms of arterial drainage maintenance, local authority maintenance regimes for urban channels, culvert inlets, etc.</p> <p><i>(Note: This is different from the usual 'Do Nothing' baseline scenario against which benefits of further action, or maintaining the status quo, are measured. This is necessary due to the nature of current activities, and the uncertainty associated with damages that would arise should those activities cease).</i></p> <p>Defence Options or Measures</p> <p>For options or measures involving direct flood defence of an area, such as a wall or embankment, the reduction in damages should be calculated as the damages avoided to up and including the standard of protection of the option or measure, with no benefit offered for events greater than standard of protection.</p> <p><i>(Note: This approach will tend to under-estimate the benefits of an option or measure, as it ignores the residual benefits for greater-than-design events. However, these residual benefits would be offset to some degree by increased damages that could arise in the event of the failure of the defence, and the above approach simplifies that analysis required.)</i></p>

	<p><i>Other Flood Hazard Reduction Options or Measures</i></p> <p>For options or measures that involve reducing flood flows or levels through the relevant area, such as flood water retention or increasing in-bank channel capacity, the reduction in damages will need to be calculated by running the model for the flood event probabilities for which flooding and damage will occur to determine the flood damages for those events, and hence the reduction in damages from the current scenario. The event of probability equal to the standard of protection, or for which no flooding or damages would arise, will also need to be run to demonstrate the effectiveness of the option or measure at the intended 'zero-damage' event probability.</p>
4.2	<p>Present Value of Benefits (PVb)</p> <p>The PVb of an option or measure is the reduction in the Present Value of damages (PVd) that would be achieved by implementing the option or measure (where the PVd is calculated as set out in Section 3.8 herein based on the discount rate and the project horizon), but also taking into account the capping of benefits as set out in Section 4.3 below.</p>
4.3	<p>Property Value Capping</p> <p>The costs of a measure or scheme (i.e., an option) with respect to a particular property should not exceed the total value of that property and, where relevant, the intangible damages that can be avoided through relocation; otherwise the State could end up investing more in protecting an asset than the value of that asset and associated intangible consequences, and a lower cost alternative measure (relocation) could be implemented instead. Capping values are hence applied to PVb of an option when undertaking an economic CBA.</p> <p>Capping should not be applied to the property damages for the appraisal against Objective 2.a under the MCA nor for the economic damage risk maps, as these should reflect the 'Do Nothing' or current situation.</p> <p><i>Residential Property Value Capping</i></p> <p>The capping value of the Principal Direct Damages (PDD) for a residential property is based on the value of that property. The value for a given property can be based on local or regional valuations of that type of property, i.e., a property-specific valuation is not required. Information on residential property prices is available from a number of publicly available sources (e.g., Residential Property Price Register, Daft.ie, etc.).</p> <p>The total capping value should however also take into account the PVd related to the intangible damages for a property, noting that these can be ongoing and not only the direct consequences of a given flood. The PVb capping value for intangible benefits of an option should be set equal to the capping value for the PDD for the property, representing the intangible damages avoided over the project horizon if the property (and its residents) were to be relocated, but taking into account the capping of the PDD of the property.</p>

	<p>The Total Capping Value for the PVb for a residential property is therefore calculated as the sum of the capping value for the PDD for a property and the capping value of the intangible damages for that property. As the latter is equal to the former, this value is effectively double the capping value for the PDD of a property (i.e., double the property value).</p> <p>Non-Residential Property Value Capping The capping value for the PVb for a given non-residential property can be derived from regional valuations of that type of property, taking account of typical stock, or as ten (10) times the current rateable value of the property.</p> <p>Capping of Other Damages Capping should be applied to property damages and intangible damages only. Capping should <u>not</u> be applied to damages calculated as a percentage of the Principal Direct Damages (PDD), such as emergency services costs.</p>
4.4	<p>Exclusions from Benefit Calculations</p> <p>Potential increases in property value (including land value) arising from the implementation of a scheme may not be counted as scheme benefits.</p>
4.5	<p>Reduction in Risk (Benefits) for Appraisal against MCA Objective 2.a</p> <p>The economic benefits used for the economic cost-benefit analysis (CBA) to determine the benefit-cost ratio should be as set out above.</p> <p>The economic benefits used for the appraisal of options or measures under the MCA against Objective 2.a (Minimise Economic Risk) are as set out above, but should not be capped (Section 4.3) and with certain exclusions as referred to above, including:</p> <ul style="list-style-type: none"> - Benefits to infrastructural utilities (Section 3.5) - Benefits in reduction of disruption to traffic (Section 3.5) - Intangible and indirect benefits (Section 3.6) <p>These exclusions are to avoid double-counting benefits within the MCA. Further guidance on scoring under the MCA against Objective 2.a is given in GN28.</p>
5.0	COST – BENEFIT ANALYSIS
5.1	<p>General Methodology</p> <p>The benefit-cost ratio (BCR) to be produced as the output of the cost-benefit analysis is calculated by dividing the PVb for an option or measure, capped as appropriate, by the whole life cost (PVC) of that option or measure.</p> <p>The Net Present Value of the benefits (NPVb) of the option should also be calculated by deducting the PVC from the capped PVb.</p>

	<p>Further guidance on deriving costs for options or measures is provided under the guidance on the use of Unit Cost Database. The whole life cost is determined from the sum of the costs over the project horizon, with future costs discounted by the set discount rate (see Section 3.8 herein).</p> <p>It should be noted that residual asset values of potential flood risk management measures (i.e., at the end of the project horizon) should be assumed to be zero.</p> <p>Measures are only likely to be recommended as measures to be put forward in the Flood Risk Management Plan if their BCR is greater than unity.</p> <p>As set out in the Generic CFRAM Project Brief, sensitivity tests should be undertaken to determine the BCR using higher or lower discount rates, which should be 5% and 3% respectively.</p>
6.0	ECONOMIC RISK MAPPING
	<p>For the economic risk mapping, the AAD should be calculated in the same way as calculating the economic damages to be used for the economic cost-benefit analysis (CBA) to determine the benefit-cost ratio (i.e., including damages related to infrastructure and traffic disruption (if relevant) and indirect and intangible damages).</p> <p>Capping (as used in calculating PVb – See Section 4.3) is not relevant to, and should <u>not</u> be applied for, the economic risk mapping.</p>
7.0	REFERENCES AND RESOURCES
	<p>References</p> <ul style="list-style-type: none"> – FHRC 2010: The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques – 2010, Flood Hazard Research Centre, Middlesex University – FHRC 2005: The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques – 2010, Flood Hazard Research Centre, Middlesex University <p>Resources</p> <ul style="list-style-type: none"> – GN28 – Option Appraisal and the Multi-Criteria Analysis Framework – GN32 – Calculation of the Costs of Flood Risk Management Options and Measures – OPW Unit Cost Database

APPENDIX A

GLOSSARY OF ABBREVIATIONS

AAD	Annual Average Damages
AEP	Annual Exceedance Probability
AFA	Area for Further Assessment
APMR	Area of Potentially Moderate Risk (associated with Medium Priority Watercourses, or 'MPWs')
BCR	Benefit – Cost Ratio (Benefits / Costs)
CBA	Cost – Benefit Analysis
CPI	Consumer Price Index
DTM	Digital Terrain Model
FHRC	Flood Hazard Research Centre (Middlesex University, London)
HEFS	High End Future Scenario
MCA	Multi-Criteria Analysis (see GN28)
MCM	Multi-Coloured Manual
MRFS	Mid-Range Future Scenario
NPVb	Net Present Value of the benefits of a potential Scheme (PVb - PVc)
OECD	Organisation of Economic Co-operation and Development
PPD	Principal Direct Damages (sum of direct damages to residential and non-residential damages)
PPP	Purchasing Power Parity
PVb	Net Present Value of Benefits (whole life, discounted benefits)
PVc	Net Present Value of Costs (whole life, discounted costs)
PVd	Net Present Value of Damages (whole life, discounted damages)

APPENDIX B

EXPLANATORY TABLE

The table below sets out which parameters are applicable for each use (Economic CBA, Economic Risk Mapping and appraisal against MCA Objective 2.a), and how some of the parameters (e.g., Total damages for a given event, AAD) are calculated based on previous parameters.

The relevant sections in the Guidance Note are given in parentheses after the comment on application.

Parameter		Application		
		Economic CBA	Economic Risk Mapping	MCA Appraisal: Objective 2.a
1	Residential Damages	Yes (3.3)	Yes (3.3)	Yes (3.3)
2	Non-Residential Damages	Yes (3.4)	Yes (3.4)	Yes (3.4)
3	Principal Direct Damages (PDD)	1 + 2	1 + 2	1 + 2
4	Intangible Damages	Yes (3.6)	Yes (3.6)	No
5	Infrastructural Utility Damages	Yes (3.5)	Yes (3.5)	No
6	Emergency Services	Yes (3.5)	Yes (3.5)	Yes (3.5)
7	Traffic Disruption	Possibly (3.5)	Possibly (3.5)	No
8	Event Damage	3 + 4 + 5 + 6 + 7	3 + 4 + 5 + 6 + 7	3 + 6
9	Annual Average Damage (AAD)	Annualise 8	Annualise 8	Annualise 8
10	Present Value of Damages (PVd)	Discounted sum of 9 over Project Horizon	N / A	Discounted sum of 9 over Project Horizon
11	Un-capped PVb	Reduction in PVd (10) provided by Option (4.2)	N / A	Reduction in PVd (10) provided by Option (4.2)
12	Capping Value	Double Residential Property Value, or, = Non-residential Property Value (4.3)	N / A	N / A
13	Capped PVb	11, but not > 12 (4.3)	N / A	11 (4.3)
14	PVc	Whole Life Scheme Cost	N / A	Whole Life Scheme Cost
15	BCR	13 / 14 (5.1)	N / A	13 / 14 (5.1)
16	NPVb	13 - 14 (5.1)	N / A	13 - 14 (5.1)

NATIONAL CFRAM PROGRAMME GUIDANCE NOTE NO. 28

Title:	Option Appraisal and the Multi-Criteria Analysis Framework
Version:	Rev. C
Author:	Mark Adamson, Richael Duffy, CFRAM Consultants
Date:	March 2015
Issued to:	CFRAM Consultants
Date Issued:	March 2015

1.0	PURPOSE
	The purpose of National CFRAM Programme Guidance Note (GN) No. 28 is to clarify certain requirements of the process for the development of flood risk management (FRM) options, including screening, and to set a common approach to the multi-criteria analysis (MCA) for option appraisal.
2.0	SCOPE
	<p>GN 28 relates to:</p> <ul style="list-style-type: none"> – Flood Risk Management Objectives (Section 8.4 and Appendix J), – Screening of Possible FRM Methods (Section 11.4 of the Stage I [Generic] Project Brief), – Appraisal of Potential Options (Sections 11.6) – Selection of Preferred Options (Section 11.7) <p>GN 28 does <u>not</u> address or cover:</p> <ul style="list-style-type: none"> – Defining the Spatial Scales of Assessment (SSAs) for urban areas, which is covered by GN 19 – Methods for the evaluation of adaptability to climate change, which is covered under GN 29. – Methods for undertaking the Strategic Environmental Assessment (SEA), as the requirements for this are set out in the Project Brief with the consultants employed as experts to undertake the SEA. – The development of flood risk management options (Section 11.5) from the methods that have been deemed potentially viable through the screening process. This is deemed to be a matter for the Consultants to determine in the manner they deem appropriate.

3.0	OVERVIEW OF SCREENING AND MCA OPTION APPRAISAL FRAMEWORK
3.1	<p>Framework Overview</p> <p>An objective of the CFRAM Projects is to:</p> <p><i>“Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk in the Areas of Potential Significant Risk (APSRs) and within the Study Area as a whole”</i> (Section 1.2.1, Generic Project Brief),</p> <p>where</p> <p><i>“The analysis, and method and option development and appraisal, to derive the set of actions and measures to be defined in the FRMP, as described herein, should form a robust and sound foundation for the future full development (after completion of this Project) of a measure to be taken to public exhibition or planning (as appropriate) and subsequent implementation.”</i> (Section 11.1, Generic Project Brief)</p> <p>and</p> <p><i>“The rejection of any method or option shall be robust and with clear and transparent reasoning, as rejected methods and options shall not be reconsidered in future projects.”</i> (Section 11.1, Generic Project Brief)</p> <p>The screening and MCA option appraisal process is intended to provide an efficient, staged approach to achieving the above stated objective in the robust manner required, taking into account the wide range of potential benefits and impacts that flood risk management measures can have, and in coordination with the SEA/AA processes.</p> <p>The MCA appraisal outcomes will also inform the national prioritisation of preferred options and measures. There is hence a strong need for consistency across the CFRAM Programme to ensure that all potential works are considered on an equal basis.</p>
3.2	<p>Robustness</p> <p>Appendix M of the Generic Project Brief sets out a non-exhaustive range of flood risk management (FRM) methods. The purpose of the screening and option appraisal process is to review all possible FRM methods, including those in Appendix M, and to identify the most appropriate suite of FRM options to be set out in the FRMP that the OPW, Local Authorities and other agencies can take forward to full scheme development, exhibition / planning and implementation.</p> <p>The processes <u>must</u> be sufficiently robust such that a re-evaluation of methods and options for a given location or for the Study Area as a whole, in terms of option selection, is <u>not</u> required for the implementing agency to move forward with the measures and strategies set out in the FRMP.</p>

<p>3.3</p>	<p><i>Application of Professional Judgement</i></p> <p>In the interests of efficiency, the screening process and option appraisal process should, as far as reasonably possible, be automated, making use of the measurable parameters. However, an automated system cannot always take account of specific or local issues or particular circumstances. It is therefore essential that the processes and all outcomes are subject to the application of professional review and judgement.</p> <p>With respect to all objectives, other than objective 2.A (Reduce Economic Damages), professional judgement needs to be applied within the requirements and guidance provided.</p> <p>Notwithstanding this, with a view to ensuring national consistency, the professional judgement should typically not change the calculated Local Weighting or scoring by more than 1 point, or by more than 2 points in exceptional circumstances. Any changes beyond this limit should be discussed and agreed with OPW (who will have a national overview of weighting and scoring).</p> <p>Wherever professional judgement forms the basis of an amendment to the Local Weighting or score, then the reasoning for this should be recorded and reported.</p>
<p>3.4</p>	<p><i>Design Standards</i></p> <p>Section 11.2 of the Generic Brief defines the 1% Annual Exceedance Probability (AEP) event and the 0.5% AEP event as the preferred design standards against which measures should provide protection for fluvial and coastal flooding respectively. However, the Brief also defines that other design standards should be considered under certain circumstances. The screening and option appraisal processes need to keep this potential flexibility in mind.</p> <p>It is not however expected that extensive work will be done at screening stage to re-screen each measure for alternative design standards where a measure fails to meet the screening criteria at the preferred standard, nor that extensive work will be done at appraisal stage to determine the optimum design standard for an option. It is expected that:</p> <ul style="list-style-type: none"> – Professional judgement be applied at screening to retain a measure that might fail at the preferred design standard, but that could be attractive and viable at other design standards – Professional judgement be applied at appraisal stage, and where it is considered that a scheme might be preferable and / or be more cost – beneficial at a higher or lower design standard then this should be noted in the Preliminary Options Report (and the FRMP if / as appropriate) – A measure be appraised at an alternative design standard if a potentially preferred (or the only potentially viable) option proves not to be viable at the preferred design standard, but, based on professional judgement and the risk information available, is likely to be viable at an alternative standard.

4.0	FLOOD RISK MANAGEMENT OBJECTIVES
4.1	<p>Section 8.4 of the Generic Project Brief introduces the FRM objectives, with provisional objectives then set out in Appendix J, along with indicators that act as a means by which achievement or otherwise of the objectives can be measured or assessed. The objectives are defined under four categories:</p> <ul style="list-style-type: none"> – Technical – Economic – Social – Environmental <p>Note that the environmental category includes cultural heritage, which is assessed as part of the SEA process.</p> <p>The objectives have been developed to broaden the range of potential impacts of flooding and FRM measures that are taken into account in the development and selection of FRM options and strategies, and their subsequent prioritisation.</p> <p>All four categories are deemed important criteria in the selection of flood risk management measures for a given location. However, only the latter three (i.e., excluding the 'Technical' category) refer to benefits, and so it is only these that should be used to provide an indication of benefit relative to cost, and be used for the purposes of prioritisation (of programme investment to maximise benefit).</p> <p>The OPW have reviewed the provisional objectives, taking into account the lessons learned from the pilot studies and further consultation. A revised set of objectives is set out in Appendix A.</p>
5.0	SCREEING PROCESS
5.1	<p><i>Overview of the Screening Process</i></p> <p>The purpose of the screening process is to filter out FRM methods that are not going to provide applicable, acceptable or viable options or measures, either alone or in combination with other methods, for a given flood problem for a given location in the SSA under consideration.</p> <p>The screening process requires an indicative appraisal of <u>all</u> possible FRM methods for <u>each</u> of the various SSAs against each of the criteria set out in Section 11.4 of the Generic Brief. Considerations for each of the criteria are set out below.</p> <p><i>A) Applicability to Relevant Area</i></p> <p>Certain FRM methods would simply not be applicable to certain flood risk circumstances, and may be rejected on this basis. Examples might include:</p> <ul style="list-style-type: none"> – Increasing conveyance or flow diversion in purely coastal flood situations – Rehabilitation of existing defences where no existing defences exist

Methods that may be applicable, even if unlikely to be viable or appropriate for other reasons, should not be rejected on the basis of applicability.

B) Economic

While the screening process is an indicative appraisal, it should make use of available information. The economic risk assessment previously undertaken (as part of the Flood Risk Assessment) will provide an envelope of potential economic benefits. Professional experience, and some simple costing using unit costs, can be used to estimate the possible minimum* costs of a method. On this basis, an indicative benefit – cost ratio for a method, in isolation or potential combination with other methods, can be determined.

In assessing the potential benefits of a method, the standard of protection and the effectiveness of the method in reducing risk should be considered (i.e., it should not be assumed all of that the damages up to the 0.1% AEP event will be prevented, unless that is the standard being considered, and a percentage degree of reduction in risk (e.g. option take-up rate and effectiveness) should be applied for non-structural measures such as flood forecasting and warning).

* On the basis of a precautionary approach to avoid rejecting methods that may prove economically viable, supplementary items used in detailed costing (unmeasured items, optimism bias, archaeology, land purchase / compensation, etc.) may be excluded from the costing at this stage. On the same basis, the threshold for the indicative benefit – cost ratio for rejection of a method should not be set equal to unity, and a threshold of 0.5 should be applied.

C) Environmental

The environmental screening should make use of the SEA scoping and any other environmental assessment work available at the time.

Methods should not be rejected only on the basis that a method may have a detrimental impact on an environmentally or culturally valuable or protected site, as mitigation measures may be available. Screening should take into account the degree of detrimental impact on the site, the scope for mitigation and whether there are apparently viable and acceptable alternative approaches available.

D) Social

In considering the social dimension during the screening process, outcomes of consultation processes previously undertaken (e.g., for start-up / SEA scoping and flood mapping) should be taken into account, along with the application of professional judgement and experience. Rejection of a method should only occur however where all variants of the measure would be unacceptable, for example, a permanent wall of 2m height may be unacceptable along the banks of a river through the middle of an urban area, but a permanent wall of 1.2m height topped with demountables to the 2m height may be acceptable.

	<p>E) Cultural</p> <p>The approach taken to the cultural criteria of the screening should be similar to that undertaken for the environmental criteria, whereby a method should not be rejected only on the basis of a potentially minor negative impact.</p> <p>Consideration of Criteria in Combination</p> <p>The screening process may need to consider the criteria in combination as well as individually, e.g., for the example given under social criteria above, the permanent plus demountable option may be rejected if there would be a requirement for extensive demountables and the urban area in question is in a flashy catchment where there would not possibly be adequate warning time (based on recorded rather than predicted rainfall) to permit erection of the demountables without an intolerable level of false warnings. As with all rejections, the justification of rejection on the basis of 'in combination' reasons should be robust.</p>
5.2	<p>Justification of Rejection of Methods at Screening</p> <p>In all cases where potential methods are rejected, justification should be provided which is robust, and with a clear and transparent reasoning. Such justification should be self-explanatory, but may vary in detail, with only brief text provided in some instances where the case for rejection is in itself self-evident (and would be so to the public and stakeholders) but with more detailed description required in other circumstances where the case for rejection is not so clear.</p>
5.3	<p>Automation</p> <p>There is only limited scope for automation in the screening process, as much of the decision-making is indicative and will rely heavily on professional judgement and non-numeric factors. The exception to this may be the economic criteria where use may be made of the economic risk outcomes and unit costs.</p> <p>If an automated process is used, consideration should be given to the use of lookup tables for values or parameters that are used frequently (e.g., for multiple locations or multiple methods) to facilitate a single point amendment approach that, based on experience, can make significant savings in time as consultation and review processes lead to amendments in such values or parameters.</p>
5.4	<p>Design Standards</p> <p>Given the potential for flexibility in the design standard, or standard or protection that may be adopted, methods or measures that might be effective and potentially viable at design standards other than those preferred, even if not so at the preferred standards, should not be rejected. This would apply in particular where:</p> <ul style="list-style-type: none"> – A certain method is very likely to form (part of) a preferred option, but needs to be to a higher or lower standard due to factors such as health and safety requirements, available space for the method, social factors, etc. – There appears to be no viable methods that could achieve the preferred standard of protection

	<p>– A method at a lower or higher standard of protection may become (part of) the preferred option overall, even if another option might (at this screening stage) appear to be more beneficial at the preferred standard.</p>
5.5	<p><i>Requirements for Modelling</i></p> <p>The screening process is intended to be indicative and the OPW does not require that hydraulic modelling of all methods be undertaken at this stage. However, modelling may be appropriate in some instances to provide the required sound and robust justification for rejection, or indeed may be desirable, depending on the approach taken, to reduce the work required at the appraisal stage.</p>
5.6	<p><i>Non-Structural FRM Methods</i></p> <p>Some non-structural FRM methods may be rejected during screening for various reasons. However, it should be noted that many non-structural methods are complimentary to structural methods in providing residual flood risk management, as well as providing stand-alone options in their own right, and some may represent the implementation of national policy (e.g., spatial planning, preparation of emergency response plans – See Section 6.6). As such, non-structural measures should not be rejected on the basis that other structural measures appear to be viable, but only on the basis that they are not applicable, appropriate or viable in the same manner as other methods.</p> <p>Land use management, natural flood management, green infrastructure, river restoration, etc. are terms used to cover (some of) a suite of measures that are intended to reduce flood risk by working with natural systems and, where possible, provide environmental benefits. While in small catchments they can effectively manage flood risk to a certain degree in their own right, in larger catchments they can work in a complimentary way with others measures to achieve flood risk management targets. At screening, such measures should not be rejected on the basis that other structural measures appear to be viable, but only on the basis that they are not applicable, appropriate or viable in the same manner as other methods.</p>
6.0	MCA OPTION APPRAISAL PROCESS
6.1	<p>Overview of MCA Option Appraisal Process</p> <p>The option appraisal process is set out in Section 11.6 of the Generic Brief, with reference made to Section 8.4 and Appendix J in relation to the FRM objectives that will form part of the appraisal process. Section 8 of the Generic Brief notes that both the Flood Risk Management Objectives set out in Appendix J, and the descriptions of the local weightings provided in Section 8.4, are subject to review and refinement, with guidelines to be issued by the OPW for consultation with the NTCG. As stated in Section 1 herein, the purpose of this GN is to clarify the requirements of the option appraisal process, and to set a common approach to the multi-criteria analysis (MCA) for option appraisal, and hence provide the guidelines referred to above.</p>

This section outlines the overall structure of the MCA framework, which forms the core of option appraisal, and provides a description of each component of the framework. The objectives are set out in Appendix A herein, with detailed guidance on the approach to be taken with respect to each objective then set out in Appendix B, including definition of global weightings and indicators, and guidance on assessing local weightings. Guidance on scoring the performance of different options under the MCA with respect to each objective is set out in Appendix C.

Overall Framework

The appraisal of flood relief scheme options in the past has been primarily based on economic costs and benefits, with an EIA undertaken to minimise negative impacts on the environment and public consultation undertaken to ensure social acceptability. The National Flood Policy Review (OPW, 2004) set a broader range of objectives for flood risk management in Ireland, that was subsequently reinforced by the EU 'Floods' Directive [2006/60/EC].

The MCA framework has been developed to broaden the range of potential impacts that flooding and the implementation of FRM measures can have that are taken into account in the development and selection of FRM options and strategies, and their subsequent prioritisation. It is based on the numeric, but non-monetarised assessment of options against a range of objectives, whereby indicators are set for each objective. These indicators are then used to define scores for that objective on the basis of the degree to which the option being appraised goes beyond the Basic Requirement for that objective towards meeting the Aspirational Target. Weightings are applied globally (nationally) for each objective, with local weightings then applied to reflect the local importance of that objective in the context of the respective SSA, and these weightings are applied to the scores derived as above.

The sums of the scores, set against the total costs of their achievement, represent the preference for a given option (using all criteria) or the net benefits of an option (using only the economic, social and environmental criteria). These total scores can be used to inform the decision on the selection of (a) preferred option(s) for a given location and the prioritisation of potential schemes between locations.

Each component of the MCA Framework is explained in more detail below.

Objectives

The FRM objectives reflect what the overall flood risk management programme is seeking to achieve, expanding on the requirements of the National Flood Policy Review and the EU 'Floods' Directive.

At a local level, and for the purposes of the MCA, the objectives set out an aim that each flood risk management option should be seeking to achieve, if possible. The degree to which an option achieves the objective is an indication of the 'success' of the option, and equally, the more an option achieves across all of the objectives, then the greater the preference that will be given to that option relative to others, taking account also of the cost of each of the options.

	<p>Indicators</p> <p>The indicators are parameters, measurable and numeric where possible, by which the ‘success’ of an option in meeting a particular objective can be gauged.</p> <p>Basic Requirements and Aspirational Targets</p> <p>The objectives are termed as general aims for the management or reduction of flood risk, or for other benefits that can be accrued through the implementation of flood risk management measures.</p> <p>To enable the assessment of the degree to which an option ‘succeeds’ in meeting the stated aims, a more defined aim needs to be set, along with a benchmark for neutral status (i.e., no impact).</p> <p>The Basic Requirements and Aspirational Targets are set in terms of the defined indicator, i.e., make use of the same parameter for setting target or threshold values as that used for scoring against the objective.</p> <p>Aspirational Targets</p> <p>The aim is defined as an Aspirational Target, whereby an option would be deemed as perfect with respect to the given objective if it were to meet the Aspirational Target. Typically this will represent complete removal of a risk, or the full achievement of another benefit, and it will be rare that any option will meet such Aspirational Targets for even one, let alone all, objectives.</p> <p>The Aspirational Targets are therefore NOT requirements that must be met, and very effective options may still fail to meet the Aspirational Targets.</p> <p>Basic Requirements</p> <p>The Basic Requirement represents a neutral status or ‘no change’, whereby if an option has no impact on the matter the objective relates to, or meets what might be termed for some objectives as minimum requirements for acceptability, then that option will have met the Basic Requirement. If an option performs worse than the Basic Requirement, i.e., has a negative impact (a dis-benefit) or does not meet the minimum requirements for acceptability, it will score a negative-value score for that objective, but might still be considered further, depending on the degree of the dis-benefit or failure to meet the requirements.</p> <p>The Basic Requirement is therefore NOT an absolute minimum requirement for acceptability, but a benchmark to define positive versus negative impacts or performance.</p> <p>Scoring Against Objectives</p> <p>An option may be scored against the objective by determining the degree to which it performs, measured using the defined indicator, in going beyond the Basic Requirement towards meeting the Aspirational Target (which are both expressed in the same terms as the indicator). The following generic rules should be applied in scoring, although specific guidance is given in Appendix B:</p>
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- An option that meets the Basic Requirement only should be given a score of zero.
- An option that meets the Aspirational Target should be given a score of five.
- An option that performs somewhere between the Basic Requirement and the Aspirational Target should be given a score proportional to the degree to which it achieves the objective beyond the Basic Requirement towards meeting the Aspirational Target.
- An option that performs better than the Aspirational Target (which for most objectives will not be possible) should still only be limited to a maximum score of five.
- An option that performs worse than the Basic Requirement, i.e., creates a dis-benefit or does perform to an acceptable standard, should be given a negative score down to –5 using, where possible, the same scoring mechanism as that used for scoring options that achieve between the Basic Requirement and the Aspirational Target.
- There are exceptions to the negative scoring where the performance or impact of the option becomes unacceptable, and the option should be rejected on the basis of its performance on the given objective alone. In such circumstances the option should be given a ‘-999’ score and be rejected from further consideration. The thresholds for unacceptability of an option are defined where relevant in the detailed objective description sheets in Appendix B.

The resultant scores should only be considered as initial guidance for decision-making, and the arithmetic calculation of scores can sometimes give misleading results that do not take account of all relevant issues. The application of professional judgement in reviewing and confirming or amending all of the derived scores is essential.

Justification of the score assigned should be provided which is robust, and with a clear and transparent reasoning that should include quantitative evidence where reasonably possible. Such justification should be self-explanatory, but may vary in detail, with only brief text (potentially a standard comment) provided in instances where the basis for score is clear (and would be so to the public and stakeholders) but with more detailed description required in other circumstances where the basis for the score assigned is not so clear, such as where amendments have been made to numerically-derived scores or where the scoring has varied from the guidance for certain reasons.

Global Weightings

Global Weightings are assigned to each objective to give it more or less weight in the overall assessment of the suitability or value of the option. The Global Weightings are fixed nationally to ensure a consistent approach and basis for prioritisation, and are intended to represent the ‘societal value’ for the objective relative to the others, i.e., with those of most weight representing the most important objectives.

	<p>Local Weightings</p> <p>The Local Weightings are assigned to each objective for each location under consideration (i.e., each SSA), and are intended to represent the local importance of that objective within the local context. They are very important within the framework as they provide scale to the process, whereby if the subject of a given objective is of much greater significance than another in the same location, and should have a greater influence on the choice of option, then this can be provided for through the Local Weightings. Similarly, the importance of an issue / objective in one location relative to another can also be provided for through the Local Weightings.</p> <p>Local Weightings for some objectives will be numerically determined according to the degree of risk (e.g., economic annual average damages, number of properties, etc.), but for some others will need to be set by professional judgement. In both instances however, the assignment should take into account local knowledge provided at the stakeholder and public consultation events (primarily for events during the mapping stage, but account may also need to be taken of significant issues raised during the optioneering stage PCDs).</p> <p>Guidance is provided on assigning Local Weightings in the detailed objective description sheets in Appendix B.</p> <p>Justification should be provided to the degree necessary to permit defence for the Local Weighting assigned in the face of public or stakeholder questioning. Such justification should be self-explanatory, but may vary in detail, with only brief text (potentially a standard comment) provided in instances where the basis for weighting is clear (and would be so to the public and stakeholders) but with more detailed description required in other circumstances where the basis for the weighting assigned is not so clear, and / or varies from the guidance provided or the numerical value derived.</p>
6.2	<p>MCA Outcomes</p> <p>Criteria Scores: Once the MCA has been applied, each option will have a weighted score for each objective. For each option, the scores for each of the four criteria should be summed to provide the Criteria Scores.</p> <p>MCA Benefit Score: To derive the MCA Benefit Score, the scores for the economic, social and environmental Criteria Scores should be summed. This score represents the net benefits of the option.</p> <p>Option Selection MCA Score: To derive the Option Selection MCA Score, the scores for all four of the criteria should be summed. This score compliments the MCA Benefit Score with the Technical Criteria Score, and hence includes all of the aspects that should be taken into account in considering the preferred option for a given location.</p>

	<p>MCA Benefit – Cost Ratio (BCR): The MCA Benefit Score should then be divided by the cost of the option to provide a numerical, but non-monetarised, MCA Benefit - Cost Ratio that provides an indication of the overall benefits that can be delivered per Euro invested.</p> <p>The Economic Benefit – Cost Ratio (BCR) should also be calculated using the more traditional techniques (i.e., the FHRC Multi-Coloured Manual, rather than the option appraisal MCA set out herein).</p> <p>The above scores and ratio can be used to inform decisions on which option might be preferred for each SSA, as set out in Section 7 herein.</p>
6.3	<p>Automation</p> <p>With the exception of most of the environmental objectives, there is significant scope for automation in the application of the MCA given the numeric nature of many of the indicators and function-based approach to scoring for many of the objectives.</p> <p>Where an automated process is used, serious consideration should be given to the use of lookup tables for values or parameters that are used frequently (e.g., for multiple locations or multiple methods) to facilitate a single point amendment approach that, based on experience, can make very significant savings in time in application of the MCA as consultation and review processes lead to amendments in such values or parameters.</p>
6.4	<p>Application of Professional Judgement</p> <p>As noted in Section 3.1, an automated system can be prone to error and cannot take always account of specific or local issues. It is therefore essential, particularly for the option appraisal process, that the processes and all outcomes are subject to the application of professional review and judgement. The decisions on recommendations for preferred options is one to be made by the consultant, not by the MCA process.</p>
6.5	<p>Design Standards</p> <p>As set out in Section 3.4, while the 1% AEP event and the 0.5% AEP event have been identified as the preferred design standards against which measures should provide protection for fluvial and coastal flooding respectively, other design standards should be considered under certain circumstances.</p> <p>In the event that professional judgement and / or consultation feedback indicates that alternative standards of protection might be preferred, then the appraisal should be undertaken for a sample alternative standard. It is not however expected that a full analysis be undertaken to optimise and define the alternative standard of protection for each option, but the appraisal should be undertaken on at least one alternative standard to demonstrate that alternative standards could provide (or</p>

	indeed would not provide) greater benefit or return on investment, or provide benefits / viability in a manner that is more socially or environmentally acceptable, which in turn should inform the outline design of the option and be reported in the FRMP. The post-CFRAM full scheme development process can then undertake the more detailed analysis to identify the optimal standard of protection for the preferred option.
6.6	<p>Measures Required under National Policy</p> <p>Certain non-structural flood risk management measures are required as matters of national policy. These would include:</p> <ul style="list-style-type: none"> - Application of the Guidelines on the Planning System and Flood Risk Management (DoECLG & OPW, November 2009) - Preparation of emergency response plans for severe weather events, including flood events (A Framework for Major Emergency Management, DoECLG) <p>As these measures are required to be applied regardless of other proposed measures, or of the outcomes of an appraisal under the MCA process, then they do not need to be subjected to an MCA appraisal, but may be assumed to be applicable and required for all AFAs and other SSAs. Standard texts can be prepared for the inclusion of these measures in the Preliminary Options Reports and the FRMPs.</p>
7.0	SELECTION OF PREFERRED OPTIONS AND PRIORITISATION
7.1	<p>Option Selection</p> <p>The option selection process is set out in Section 11.7 of the Generic Brief. The following outcomes of the MCA process should be used to guide the decision-making process, subject to the application of professional judgement and consultation with the Steering and Progress Groups (and subsequently stakeholder and public consultation):</p> <ul style="list-style-type: none"> – The Technical Criteria Score – The MCA Benefit Score – The Option Selection MCA Score – The MCA BCR – The Economic BCR <p>Noting other considerations outlined below, greatest weight should be given in the option selection to the MCA BCR, which provides a measure of the overall benefits per euro investment. However, professional judgement must be applied at this stage, taking into account local consultation outcomes. The reasoning for the selection of a given option should be recorded and reported.</p>

	<p>All proposed measures (i.e., options selected as preferred options for a given AFA or SSA) should have a economic BCR in excess of unity, unless clear and robust justification can be given as to why an option that is not economically cost-beneficial is being proposed for implementation.</p> <p>The options should also be considered across all SSAs to check for spatial coherence, as set out in Section 11.7 of the Generic Project Brief.</p> <p>The options should also be considered across the SSAs with consideration of the potential impacts of future changes, such as climate change, as set out in Section 11.7 of the Generic Project Brief, and is discussed in further detail in GN 29.</p>
7.2	<p>Prioritisation</p> <p>The prioritisation of recommended options across all SSAs will be lead by the OPW as an inter-project, i.e., national, assessment taking account of projected multi-annual budgets. This will make use of the following MCA outcomes:</p> <ul style="list-style-type: none"> – The MCA Benefit Score – The MCA BCR – The Economic BCR <p>While the national prioritisation process will be lead by the OPW, the consultants should annotate the preferred options during the option selection process with any particular factors that they consider should be taken into account in the prioritisation process. Such factors might include special risks that have not been properly accounted for in the standardised MCA process.</p>
8.0	DEFINITIONS
	No new definitions are established herein.
9.0	REFERENCES AND RESOURCES
	<p>References</p> <ul style="list-style-type: none"> – National CFRAM Programme – Stage I Tender Documents: Project Brief – 2149/RP/002/F, May 2010 – Report of the Flood Policy Review Group – OPW, 2009 – Directive on the assessment and management of flood risks (the EU ‘Floods’ Directive) – 2006/60/EC – Guidelines on the Planning System and Flood Risk Management (DoECLG & OPW, 2009) – A Framework for Major Emergency Management (DoECLG)

APPENDIX A TABLE OF FLOOD RISK MANAGEMENT OBJECTIVES

CRITERIA		OBJECTIVE		SUB-OBJECTIVE		GLOBAL WEIGHTING
1	Technical	a	Ensure flood risk management options are operationally robust	i)	Ensure flood risk management options are operationally robust	
		b	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options	i)	Minimise health and safety risks associated with the construction, operation and maintenance of flood risk management options	
		c	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	i)	Ensure flood risk management options are adaptable to future flood risk, and the potential impacts of climate change	
2	Economic	a	Minimise economic risk	i)	Minimise economic risk	
		b	Minimise risk to transport infrastructure	i)	Minimise risk to transport infrastructure	
		c	Minimise risk to utility infrastructure	i)	Minimise risk to utility infrastructure	
		d	Minimise risk to agriculture	i)	Minimise risk to agriculture	
3	Social	a	Minimise risk to human health and life	i)	Minimise risk to human health and life of residents	
				ii)	Minimise risk to high vulnerability properties	
		b	Minimise risk to community	i)	Minimise risk to social infrastructure and amenity	
				ii)	Minimise risk to local employment	

CRITERIA		OBJECTIVE		SUB-OBJECTIVE		GLOBAL WEIGHTING
4	Environmental	a	Support the objectives of the WFD	i)	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives.	
		b	Support the objectives of the Habitats Directive	i)	Avoid detrimental effects to, and where possible enhance, Natura 2000 network, protected species and their key habitats, recognising relevant landscape features and stepping stones.	
		c	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	i)	Avoid damage to or loss of, and where possible enhance, nature conservation sites and protected species or other know species of conservation concern.	
		d	Protect, and where possible enhance, fisheries resource within the catchment	i)	Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species.	
		e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	i)	Protect, and where possible enhance, visual amenity, landscape protection zones and views into / from designated scenic areas within the river corridor.	
		f	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting	i)	Avoid damage to or loss of features, institutions and collections of architectural value and their setting.	
				ii)	Avoid damage to or loss of features, institutions and collections of archaeological value and their setting.	

APPENDIX B DETAILED DESCRIPTIONS OF INDIVIDUAL OBJECTIVES

OBJECTIVE 1.A.	
Objective	Ensure flood risk management options are operationally robust
Indicator	Level of operational risk of option <ul style="list-style-type: none"> - Degree of reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision, for the option to operate or perform successfully
Scoring	By professional judgement, based on the guidance and criteria set out below
Basic Requirement	Moderate to high, but manageable, degree of operational risk, i.e., an option with a high degree of reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision, but which, with the allocation of adequate resources, could be operated with an acceptable degree of risk of failure
Aspirational Target	No operational risk, i.e., no reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision for the option to operate or perform successfully
Global Weighting	20
Local Weighting	Constant and equal to 5, i.e., no amendment to local weighting
Guidance on Assignment of Local Weightings	
The Local Weighting to be applied for this objective is constant, and should always be set equal to 5, as it always a consideration in option design and selection.	
Guidance on Scoring	
<p>Scoring is to be by professional judgement, based on the guidance and criteria set out below, taking into account the degree of reliance of the option on mechanical, electrical or electronic systems ('systems'), or on human intervention, action or decision ('intervention') to operate or perform successfully (i.e., to design). The scoring should also consider and be adjusted where necessary other relevant factors, such as:</p> <ul style="list-style-type: none"> - The risks / consequences of failure of the system or intervention (with a higher risk, and hence lower score, being given where failure would result in total or major failure and resultant flooding, as opposed to partial failure leading to only localised or minor flooding) - Whether the interventions required are during times of flood (e.g., erection of demountables) or at other times (e.g., routine maintenance), where interventions required during a flood event would be deemed to represent a higher risk, and hence be assigned a lower score, due to potential travel or communications difficulties 	

- The frequency that interventions would be required, with a higher risk, and hence lower score, being assigned to measures that require frequent interventions
- Whether institutional changes will be required to effectively implement and operate a measure, with a higher risk, and hence lower score, if change is required
- Other locally context-specific issues that should give cause to deviate from the guidance below

Indicative Scoring for Objective 1.A

Description of operational risk for relevant score, with examples given in italics

Score	Description / Examples
5	No operational risk, i.e., no reliance on systems or intervention, with limited monitoring / maintenance requirements <i>Fixed flood defence walls, Increased conveyance in self-cleansing rivers or diversion channels, Relocation</i>
4	Negligible operational risk, i.e., no reliance on systems or intervention, with more regular monitoring and intermittent, but potentially substantial, maintenance requirements <i>Fixed flood defence embankments, Uncontrolled storage, Increased conveyance measures (incl. diversion channels) where maintenance required</i>
3	Very low operational risk, i.e., there is a requirement for simple systems or interventions for the option to operate, with regular monitoring and maintenance required, but a very low likelihood of system / operation failure <i>Pumping systems, Tidal barriers, Storage with controlled inflow / outflow mechanisms, Simple flood forecasting and warning systems with long advance warning periods available (appx. 12 hours+)</i>
2	Low risk, i.e., there is a requirement for systems or interventions for the option to operate, with regular monitoring and maintenance required, and / or a low to moderate likelihood of system / operation failure <i>Complex flood forecasting and warning systems with long advance warning periods available, with a limited number of rapidly deployed in-situ flood defences (e.g., flood gates, tipping defences)</i>
1	Low / moderate risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a low to moderate likelihood of system / operation failure <i>Simple flood forecasting and warning systems with medium-range advance warning periods available (appx. 6 hours), with several rapidly deployed in-situ flood defences (e.g., flood gates, tipping defences)</i>

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| 0 | <p>Moderate, but manageable, risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a moderate likelihood of system / operation failure</p> <p><i>Complex flood forecasting and warning systems with medium-range advance warning periods available (appx. 6 hours), with several rapidly deployed in-situ flood defences (e.g., flood gates, tipping defences) or limited demountable defences that are stored on-site</i></p> |
| -1 | <p>Moderate / high risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a moderate to high likelihood of system / operation failure</p> <p><i>Flood forecasting and warning system of long advance warning periods with substantial demountable defences requiring transport from off-site</i></p> |
| -3 | <p>High risk, i.e., options that are fully reliant on systems or interventions for the option to operate, with regular monitoring and maintenance required, and a high likelihood of system / operation failure</p> <p><i>Flood forecasting and warning systems of medium-range advance warning periods with substantial demountable defences requiring transport from off-site</i></p> |
| -5 | <p>Foreseeable likelihood of failure that would render the measure ineffective</p> <p><i>Flood forecasting and warning systems with short advance warning periods available (appx. 3 hours or less) and interventions or actions by the public required for damage to be avoided</i></p> |
| -999 | <p>Unacceptable risk, i.e., options that are fully reliant on systems or interventions for the option to operate that will be difficult to achieve, and for which failure of the system / intervention is likely and would have unacceptable consequences</p> |

Note: Where systems / interventions are required, it is assumed that redundancy and / or back-up systems will be included as part of the option design, e.g., manual overrides for automated systems, duplicate telemetry / communication systems, etc.

OBJECTIVE 1.B	
Objective	Minimise health and safety risk in construction, maintenance and operation of the flood risk management option
Indicator	Degree of health and safety risk during construction, maintenance and operation
Scoring	By professional judgement, taking into account the guidance and criteria set out below, with review of candidate preferred options by PSDP
Basic Requirement	Moderate to high, but acceptable and manageable, level of health and safety risk during construction, maintenance or operation
Aspirational Target	Negligible risk to health and safety during construction, maintenance or operation
Global Weighting	20
Local Weighting	Constant and equal to 5, i.e., no amendment to local weighting
Guidance on Assignment of Local Weightings	
The Local Weighting to be applied for this objective is constant, and should always be set equal to 5, as it always a consideration in option design and selection.	
Guidance on Scoring	
<p>Scoring is to be by professional judgement, taking into account the guidance and criteria set out below.</p> <p>The indicative score under this objective should be set at five, and then have a point deducted for each specific risk (as defined under the Safety, Health and Welfare at work (Construction) Regulations) likely to be encountered in a) construction and then again in b) operation and maintenance.</p> <p>As an example, a measure requiring deep excavation and working near water during construction, and then working near water during operation / maintenance, would have a score of 2 ($5 - 2$ (construction stage) $- 1$ (operation / maintenance stage) = 3).</p> <p>Professional judgement needs then to be applied to take into account any locally or context-specific issues, e.g., specific hazards, or a potentially higher risk for construction in an urban environment.</p> <p>The PSDP (or person assigned the duties of PSDP where a company is nominated as PSDP) should review the scoring afforded to the preferred option(s) and other options that would be realistically in contention to be adopted as a preferred option based on other objectives, to ensure that the scoring is appropriate and reasonable.</p> <p>Note: It should be assumed in assigning scores that good construction health and safety practices will be implemented.</p>	

OBJECTIVE 1.C	
Objective	Ensure flood risk can be managed effectively and sustainably into the future, and the potential impacts of climate change
Indicator	Sustainability and adaptability of the flood risk management measure in the face of potential future changes, including the potential impacts of climate change
Scoring	By professional judgement, based on the guidance and criteria set out below
Basic Requirement	Option should not hinder future interventions that may be required to manage potential future increases in risk
Aspirational Target	Option to provide for, or be adaptable to, the HEFS in terms of maintaining the standard of protection at no or negligible cost
Global Weighting	20
Local Weighting	Constant and equal to 5, i.e., no amendment to local weighting
Guidance on Assignment of Local Weightings	
<p>The Local Weighting to be applied for this objective is constant, and should always be set equal to 5, as it always a consideration in option design and selection.</p> <p>It is recognised that the impacts of, and vulnerability to, potential future changes will vary significantly from community to community. However, this objective is used only for option selection, and is not used for prioritisation, and so the relative significance of the impacts and vulnerability to potential future change between communities is not relevant. As promoting adaptability is always important, the local weighting is to be kept constant.</p>	
Guidance on Scoring	
<p>Scoring is to be by professional judgement, taking into account the guidance and criteria set out below.</p> <p>The scoring for a given measure should reflect the cost and the degree of difficulty and potential impacts (technically, socially, environmentally, legislatively, etc.) of potential future adaptations that would be necessary to maintain the Standard of Protection of the measure under the MRFS and/or HEFS, whereby the greater the cost, difficulty and impact, the lower the score.</p> <p>This assignment of a score should reflect the findings of the application of GN29 on climate change adaptation, and account should be taken of the robustness of the option in terms of the need for possible future interventions that may be through additional measures as well direct adaptation of the option under consideration. For example, an option may not be, nor need to, adaptable itself, but may nonetheless score highly if it is shown through a decision-tree analysis this it is very robust in terms of options for future interventions.</p>	

The guidance given below gives examples for certain scores. Other scores (between 5 and -5) should also be used, where appropriate, interpolating between the scores for which examples are given, where the costs and degree of difficulty and impact may be at the high or low relative to the examples given.

Score	Description / <i>Examples</i>
5	<p>Option is inherently adaptable at no / negligible cost, difficulty and impact and provides no impediment to future interventions to address new potential future risk areas (i.e., that are separate from the area benefitting from the option in question).</p> <p>This would include Non-Structural measures, and Structural measures designed using the assumptive approach to the HEFS and / or that would be able to maintain the standard of protection / risk reduction under the HEFS with no or negligible further cost or intervention</p>
4	<p>Option is readily adaptable at limited cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.:</p> <ul style="list-style-type: none"> • <i>Walls where the foundations and wall are built to permit an extension in height to maintain the required level of protection / risk reduction for the HEFS, which would be acceptable locally (e.g., typically less than 1.2-1.5m height in public areas after being raised)</i> • <i>Structural measures (e.g., walls) designed using the assumptive approach to the MRFS and / or that would be able to maintain the standard of protection / risk reduction under the MRFS with no or negligible further cost or intervention</i> • <i>Embankments, earth flow diversion channels or other such structures that could be readily topped-up / enhanced</i>
3	<p>Option is adaptable at moderate cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.:</p> <ul style="list-style-type: none"> • <i>Walls where the foundations and wall are built to permit an extension in height to maintain the required standard of protection / risk reduction for :</i> <ul style="list-style-type: none"> ○ <i>the HEFS, which would be acceptable locally but where adaptation would have other negative implications / costs (e.g., more than 1.2-1.5m height in public areas after being raised, but with demountable defences necessary to provide protection above 1.2-1.5m)</i> ○ <i>the MRFS, which would be acceptable locally (e.g., typically less than 1.2-1.5m height in public areas after being raised)</i> • <i>Conveyance enhancement, major earth storage structures or similar measures where substantial earthworks would be required to enhance performance, but where adaptation would not require replacement of structural works</i>

Score	Description / <i>Examples</i>
2	<p>Option is adaptable at moderate to significant cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.:</p> <ul style="list-style-type: none"> <i>Walls where the foundations and wall are built to permit an extension in height to maintain the required standard of protection / risk reduction for the MRFS, which would be acceptable locally but where adaptation would have other negative implications / costs (e.g., more than 1.2-1.5m height in public areas after being raised, but with demountable defences necessary to provide protection above 1.2-1.5m)</i>
1	<p>Option is adaptable only at significant cost, difficulty and impact, and provides no impediment to future interventions to address new potential future risk areas, e.g.:</p> <ul style="list-style-type: none"> <i>Conveyance enhancement (including flow diversions), flow retention or similar measures where significant structural replacement works would be required</i> <i>Protection measures which, once adapted, would exceed 1.2-1.5m in height in public areas with no scope for demountable barriers</i>
0	<p>Option is not adaptable, but provides no impediment to future interventions to address new potential future risk areas.</p> <p><i>Options that are not adaptable, although additional works (e.g., separate measures) may need to be undertaken to address potential future increases in risk to the area benefitting from the option in question, e.g.:</i></p> <ul style="list-style-type: none"> <i>Coastal / tidal defence walls that can not be raised (e.g., due to visual impact, and / or where demountables are not a viable option), but where a tidal barrage could be implemented as a separate future intervention</i> <p><i>Option does not hinder future interventions to address new potential future risk areas</i></p>
-1	<p>Option is not adaptable, and will create a minor interference or impediment to with potential future measures</p> <p><i>Options that will cause a minor impediment and some additional cost to future interventions that may be needed to address the MRFS or HEFS.</i></p>
-3	<p>Option is not adaptable, and will create a moderate interference with or impediment to potential future measures</p> <p><i>Options that will cause a moderate impediment and additional cost to future interventions that may be needed to address the MRFS or HEFS.</i></p>
-5	<p>Option is not adaptable, and will create a major interference with or impediment to potential future measures</p> <p><i>Options that will cause a major impediment and substantial additional cost to future interventions that may be needed to address the MRFS or HEFS.</i></p>
-999	Unacceptable interference with potential future measures

OBJECTIVE 2.A	
Objective	Reduce economic damages
Indicator	Annual Average Damage (AAD) expressed in Euro / year, calculated in accordance with the economic risk assessment methods, but with no allowance for social / intangible benefits
Scoring	0.05 X percentage reduction in AAD
Basic Requirement	AAD is not increased
Aspirational Target	100% reduction in AAD
Global Weighting	30
Local Weighting	AAD for the SSA / €75,000
Guidance on Assignment of Local Weightings	
<p>The Local Weighting should be calculated as:</p> $\text{Local Weighting} = \text{AAD for the SSA} / \text{€75,000}$ <p>Where:</p> <p>The Local Weighting may not exceed the ceiling value of 5, and,</p> <p>AAD is the Annual Average (economic) Damages, excluding any allowances for social and intangible benefits</p> <p>‘€75,000’ is a factor that has been selected to set the Local Weighting equal to 5 in SSAs / AFAs where economic damages are among the highest typically encountered in Ireland, i.e., it has been set to ensure that there will not be a large number of locations where the ceiling value of 5 is exceeded. This factor has been selected based on trial application on a number of test cases to ensure that the factor meets the above criteria.</p> <p>The above calculation process is automated, and in this instance the outcome should be used as calculated. Professional judgement does however need to be applied within the requirements and guidance provided in relation to the calculation of the Annual Average Damages.</p>	
Guidance on Scoring	
<p>Indicator Calculation</p> <p>The indicator should be calculated on the basis of the economic damage analysis, to be undertaken in accordance with Appendix I of the Generic Project Brief and guided by Guidance Note 27, but with no allowance for social / intangible benefits as these are provided for under other objectives within the MCA.</p>	

Option Scoring

The score for a given option should be calculated as:

$$\text{Score} = 0.05 \times \text{Percentage Reduction in AAD}$$

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

The following values should apply as the percentage reduction in AAD for non-structural options (i.e., those that do not reduce hazard, but can reduce risk):

Non-Structural Measure	% Reduction in AAD
Flood Forecasting and Warning: Warning Period > 12 hrs	10%
Flood Forecasting and Warning: Warning Period 6 - 12 hrs	6%
Flood Forecasting and Warning: Warning Period 2 - 6 hrs	4%
Flood Forecasting and Warning: Warning Period < 2 hrs	0%

OBJECTIVE 2.B

Objective	Minimise risk to transport infrastructure
Indicator	Number and type of transport routes at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	No increase in risk to transport infrastructure
Aspirational Target	Reduce risk to transport infrastructure to zero
Global Weighting	10
Local Weighting	Based on calculated assessment, adjusted by professional judgement

Guidance on Assignment of Local Weightings

The local weightings should be calculated based on a score derived from the number and type of transport routes potentially blocked by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that route, taking account of the duration of flooding and the diversion time (in relation to road flooding).

Route and Airport Scoring

Each type of transport route and airport is assigned a score. The types of transport routes and airports are categorised and scored as follows:

Type	Road	Rail	Airports	Score
IRR			International	500
A	Motorway	Main line / DART / Luas		250
B	National Primary		Regional	150
C	National Secondary	Branch Line		75
D	Regional			25
E	Local Rural			10
F	Local Urban (Street)			See below

Local Urban Roads (Streets)

Within an AFA there may be multiple local roads (streets) at risk from flooding, and the flooding of these does not necessarily have a proportional cumulative effect in terms of impact on transport. As such, a maximum value of 25 should be applied with respect to the flooding of urban streets, with professional judgement applied in determining the score up to this maximum score.

Note that each road joining a junction should be treated as an individual road, and similarly train stations / rail junctions prone to flooding might reflect interruption to multiple routes.

Probability Factoring

For each route, the score is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that route, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1% / 100-yr)

For example, a National Primary road at risk from flooding in events of probability of 0.02 and less, then the factored score would be = $150 \times 0.02 = 3$

Other Factors

Duration of Flooding

The damages associated with the flooding of transport routes are related to the duration of the flooding. It is assumed that substantive flooding of the route will last approximately 6 to 12 hours. However, if the duration of flooding, and hence disruption, is significantly greater or less than this, then professional judgement should be applied to increase or decrease the score accordingly, noting amended or compensatory behaviours when flooding is known but also the impact of long-term isolation of properties.

Diversion Time for Road Flooding

The damages associated with the flooding of roads are related to the length of diversion in terms of additional journey time. It is assumed that diversion would typically increase journey time by approximately 15 to 30 minutes. However, if the duration of flooding, and hence disruption, is significantly greater or less than this, then professional judgement should be applied to increase or decrease the score accordingly. In determining diversion time, advice should be sought on which routes are likely to remain open during a flood.

Calculation of Other Factors

Note that the factors for duration and diversion time do **NOT** need to be calculated based on distance, speed, etc., but may be estimated based on professional judgement taking into account local anecdotal information derived from local authority staff and public observations.

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for each transport route at risk from flooding, subject to a maximum score of 5.

For example, an AFA with a national secondary road and regional road at risk from flooding in events of probability of 0.01 and 0.05 respectively, and multiple urban streets at risk from flooding in events of probability from 0.1, then the factored score would be:

(National secondary road: $75 \times 0.01 = 0.75$) + (Regional road: $= 25 \times 0.05 = 1.25$) + (Multiple urban streets) $= 25 \times 0.1 = 2.5$ = Total AFA Score (i.e., Local Weighting) = 4.50

Note that final local weighting taking into account the application of the factors for duration and diversion time should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3, taking account of other local factors.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring

Options are scored based on the degree of reduction in the risk to transport routes, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

$$\text{Option Score} = 5 \times [(\text{Local Weighting} - \text{Residual Risk Score}) / \text{Local Weighting}]$$

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

Flood warning does not reduce hazard, but generally can reduce risk. While transport routes will still be blocked in the event of a flood regardless of the advance warning of the flooding, the negative impact (delay and disruption) could be slightly reduced if advance warning were available. As such, non-structural measures should be afforded the percentage reduction in score as set out below:

Non-Structural Measure	% Reduction in Factored Score
Flood Forecasting and Warning: Warning Period > 12 hrs	10%
Flood Forecasting and Warning: Warning Period 6 - 12 hrs	6%
Flood Forecasting and Warning: Warning Period 2 - 6 hrs	4%
Flood Forecasting and Warning: Warning Period < 2 hrs	0%

Professional judgement should be applied to review and confirm scores as per Section 3.3.

OBJECTIVE 2.C																			
Objective	Minimise risk to utility infrastructure																		
Indicator	Number and type of infrastructure assets at risk from flooding																		
Scoring	Based on calculated assessment, adjusted by professional judgement																		
Basic Requirement	No increase in risk to utility infrastructure																		
Aspirational Target	Reduce risk to utility infrastructure to zero																		
Global Weighting	10																		
Local Weighting	Based on calculated assessment, adjusted by professional judgement																		
Guidance on Assignment of Local Weightings																			
<p>The local weightings should be calculated based on a score derived from the number and type of utility infrastructure receptors potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that receptor.</p> <p>Receptor Scoring</p> <p>Each type of utility receptor is assigned a score. The types of utility receptors are categorised and scored as follows:</p> <table border="1"> <thead> <tr> <th>Receptor Type</th><th>Score</th></tr> </thead> <tbody> <tr> <td>Power Stations</td><td>500</td></tr> <tr> <td>HV Sub-Stations</td><td>250</td></tr> <tr> <td>Gas Assets – High Priority</td><td>100</td></tr> <tr> <td>Gas Assets – Medium Priority</td><td>25</td></tr> <tr> <td>Water Treatment Plants & Primary Pumping Facilities</td><td>250</td></tr> <tr> <td>Waste Water Treatment Plants & Primary Pumping Facilities</td><td>250</td></tr> <tr> <td>Core Telecommunication Exchanges</td><td>100</td></tr> <tr> <td>Non-Core Telecommunication Exchanges</td><td>25</td></tr> </tbody> </table> <p>Probability Factoring</p> <p>For each receptor, the score is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that receptor, where the factor applied is calculated as:</p> <p>Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)</p>		Receptor Type	Score	Power Stations	500	HV Sub-Stations	250	Gas Assets – High Priority	100	Gas Assets – Medium Priority	25	Water Treatment Plants & Primary Pumping Facilities	250	Waste Water Treatment Plants & Primary Pumping Facilities	250	Core Telecommunication Exchanges	100	Non-Core Telecommunication Exchanges	25
Receptor Type	Score																		
Power Stations	500																		
HV Sub-Stations	250																		
Gas Assets – High Priority	100																		
Gas Assets – Medium Priority	25																		
Water Treatment Plants & Primary Pumping Facilities	250																		
Waste Water Treatment Plants & Primary Pumping Facilities	250																		
Core Telecommunication Exchanges	100																		
Non-Core Telecommunication Exchanges	25																		

For example, a Water Treatment Plant at risk from flooding in events of probability of 0.02 and less, then the factored score would be:

$$\text{Factored score} = 250 \times 0.02 = 5$$

Other Factors

Service Area / Population

The impact of flooding of a utility asset, and the associated damage and disruption of service, is related to the population and/or area it serves. It is assumed that an asset would be typical of its classification. However, if the population and/or area served is significantly greater or less than this, then professional judgement should be applied to increase or decrease the score accordingly.

Calculation of Other Factors

Note that the factors for service area / population do **NOT** need to be calculated based on the area or population served, but may be estimated based on professional judgement taking into account local anecdotal information derived from local authority staff and public observations. (Note: The OPW will seek industry standard data re typical service numbers).

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for each receptor at risk from flooding, subject to a maximum score of 5.

Note that final local weighting taking into account the application of the factors for service area / population should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring

Options are scored based on the degree of reduction in the risk to utility receptors, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

$$\text{Option Score} = 5 \times [(\text{Local Weighting} - \text{Residual Risk Score}) / \text{Local Weighting}]$$

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

Flood warning does not reduce hazard, but generally can reduce risk. While utility receptors could still be flooded in the event of a flood regardless of the advance warning of the flooding, the negative impact (damage to the utility and disruption to the service the utility provides) could be slightly reduced if advance warning were available. As such, non-structural measures should be afforded the percentage reduction in score as set out below:

Non-Structural Measure	% Reduction in Factored Score
Flood Forecasting and Warning: Warning Period > 12 hrs	10%
Flood Forecasting and Warning: Warning Period 6 - 12 hrs	6%
Flood Forecasting and Warning: Warning Period 2 - 6 hrs	4%
Flood Forecasting and Warning: Warning Period < 2 hrs	0%

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 2.D	
Objective	Manage risk to agriculture
Indicator	Agricultural production
Scoring	By professional judgement, taking account of local advice
Basic Requirement	No increase in the negative impact of flooding on agricultural production
Aspirational Target	Provide the potential for enhanced agricultural production
Global Weighting	10
Local Weighting	By professional judgement, taking account of local advice
Guidance on Assignment of Local Weightings	
Setting of the Local Weighting is to be by professional judgement, taking account of the value and social importance of the agricultural industry in the area guided by advice from the steering and progress groups and via submissions from the public.	
Guidance on Scoring	
<p>Option Scoring</p> <p>Scoring is to be professional judgement, taking into account local advice.</p> <p>Consideration in setting the scores for an option should include:</p> <ul style="list-style-type: none"> - An increase or decrease in the area of agricultural land subject to flooding - The frequency and seasonality of flooding, and the seasonality of agricultural production and land use in the area - The duration of flooding - The source of floodwaters, noting that salt water flooding can cause significantly more damage to agricultural production than river flooding - The overland flow velocity - The existing and potential other agricultural uses of the land - The potential for flood warning to mitigate the impacts of flooding on agriculture - Factors that may not affect the area of land flooding but that could otherwise impact positively or negatively on agricultural production (e.g., risk to local dairy factory, long-term isolation of farms, etc.) - The potential to enhanced agricultural production, such as through the reduction of the frequency or extent of flooding of agricultural land. 	

OBJECTIVE 3.A (i)	
Objective	Minimise risk to human health and life – Residents
Indicator	Annual Average Number of residential properties at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	Number of properties at risk is not increased
Aspirational Target	100% reduction in number of residential properties at risk
Global Weighting	30
Local Weighting	Based on calculated assessment, adjusted by professional judgement
Guidance on Assignment of Local Weightings	
<p>The local weightings should be calculated based on a score derived from the number of residential properties potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of each property.</p> <p>Receptor Scoring</p> <p>All residential properties should be treated as equal for the purposes of the calculated score. To ensure that the local weighting on this category is appropriately scaled, each ground floor property should be afforded a score of 2, and each property above ground floor should be afforded a score of 1.</p> <p>Probability Factoring</p> <p>For each property, the score (2) is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that property, where the factor applied is calculated as:</p> <p style="padding-left: 40px;">Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)</p> <p>Total AFA Score (Local Weighting)</p> <p>For the given AFA, the total AFA score is calculated as the sum of the factored scores for all of the residential properties at risk from flooding, subject to a maximum score of 5.</p> <p>Other Factors</p> <p><i>Known Areas of Highly Vulnerable People</i></p> <p>The risk to life associated with the flooding of residential properties is related to the vulnerability of the people living in that property, with the elderly and very young particularly vulnerable.</p>	

The scoring should typically assume that a reasonable cross section of society exists in those that inhabit all of the properties at risk within an AFA. However, if it is known that an area is occupied by particularly vulnerable or resilient set of people then professional judgement should be applied to increase or decrease the score accordingly.

Rate of Onset

The risk to health and life is associated with the flooding of residential properties is related to the rate of onset of flooding and hence the time available to evacuate the vulnerable people. It is assumed that typically it will be evident that flooding may occur with a 1 to 2 hours available to then evacuate the vulnerable people before the depth / velocity of flood water creates difficulties for evacuation and / or a moderate risk to life. However, if the rate of onset is significantly greater or less than this, then professional judgement should be applied to decrease or increase the score accordingly.

Flood Depths and Velocities (Risk to Life)

The risk to life associated with the flooding of residential properties is related to the projected depths of flooding and the velocity of overland flood flow (i.e., the risk to life). It is assumed that typically a Low risk to life will exist for the community in general and residential areas within a community in particular. However, if the risk to life is greater than this, then professional judgement should be applied to increase or the score accordingly.

Existing Flood Warning Schemes

Where an existing flood warning scheme is in place, then the local weighting should be multiplied by a factor of 0.5, 0.7 and 0.9 for effective advance warning periods in excess of 6 hours, 4 hours and 2 hours respectively.

Final Local Weighting

Note that final local weighting taking into account the application of the factors for known areas of highly vulnerable people, the rate of onset, flood depths and velocities and the presence of existing flood warning schemes should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3, and should take into account other factors that may influence the risk to life, such as the presence of basement properties.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring

Options are scored based on the degree of reduction in the risk to residential properties, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

$$\text{Option Score} = 5 \times [(\text{Local Weighting} - \text{Residual Risk Score}) / \text{Local Weighting}]$$

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

Flood warning does not reduce hazard, but generally can reduce risk. In the case of risk to people in residential properties, advance warning of an impending flood can be vital in providing sufficient time to evacuate the residents, and so flood forecasting and warning can significantly reduce the risk to life. The option score for non-structural measures involving advance warning should therefore be 4, 2 and 1 for effective advance warning periods in excess of 6 hours, 4 hours and 2 hours respectively.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 3.A (ii)													
Objective	Minimise risk to human health and life – High vulnerability properties												
Indicator	Number and type of high vulnerability properties at risk from flooding												
Scoring	Based on calculated assessment, adjusted by professional judgement												
Basic Requirement	Number of high vulnerability properties at risk not increased												
Aspirational Target	100% reduction in number of high vulnerability properties at risk												
Global Weighting	10												
Local Weighting	Based on calculated assessment, adjusted by professional judgement												
Guidance on Assignment of Local Weightings													
<p>The local weightings should be calculated based on a score derived from the number and type of high vulnerability properties potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of that property.</p> <p>Property Scoring</p> <p>Each type of high vulnerability property is assigned a score. The types of high vulnerability properties are categorised and scored as follows:</p> <table border="1"> <thead> <tr> <th>Property Type</th><th>Score</th></tr> </thead> <tbody> <tr> <td>Hospitals</td><td>500 (IRR)</td></tr> <tr> <td>Nursing / Residential Homes</td><td>250</td></tr> <tr> <td>Prisons</td><td>250</td></tr> <tr> <td>Camping / Caravan / Halting Sites</td><td>100</td></tr> <tr> <td>Schools</td><td>50</td></tr> </tbody> </table> <p>Probability Factoring</p> <p>For each property, the score is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that property, where the factor applied is calculated as:</p> <p>Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)</p>		Property Type	Score	Hospitals	500 (IRR)	Nursing / Residential Homes	250	Prisons	250	Camping / Caravan / Halting Sites	100	Schools	50
Property Type	Score												
Hospitals	500 (IRR)												
Nursing / Residential Homes	250												
Prisons	250												
Camping / Caravan / Halting Sites	100												
Schools	50												

Other Factors

Rate of Onset of Flooding

The risk to life associated with the flooding of high vulnerability properties is related to the rate of onset of flooding and hence the time available to evacuate the vulnerable people. It is assumed that typically it will be evident that flooding may occur with 1 to 2 hours advance warning available to evacuate the vulnerable people before the depth / velocity of flood water creates difficulties for evacuation and / or a moderate risk to life. However, if the rate of onset is significantly greater or less than this, then professional judgement should be applied to decrease or increase the score accordingly.

Flood Depths and Velocities (Risk to Life)

The risk to life associated with the flooding of high vulnerability properties is related to the projected depths of flooding and the velocity of overland flood flow (i.e., the risk to life). It is assumed that typically a Low risk to life will exist for high vulnerability properties. However, if the risk to life is greater than this, then professional judgement should be applied to increase or the score accordingly.

Calculation of Other Factors

The rate of onset of flooding and the risk to life at the high vulnerability property can be determined from the outputs of the hydraulic modelling and flood mapping.

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for each property at risk from flooding, subject to a maximum score of 5.

Note that final local weighting taking into account the application of the factors for Rate of Onset of Flooding and Flood Depths and Velocities (Risk to Life) should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring

Options are scored based on the degree of reduction in the risk to high vulnerability properties, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

$$\text{Option Score} = 5 \times [(\text{Local Weighting} - \text{Residual Risk Score}) / \text{Local Weighting}]$$

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

Flood warning does not reduce hazard, but generally can reduce risk. In the case of high vulnerability properties, advance warning of an impending flood can be vital in providing sufficient time to evacuate the vulnerable people, and so flood forecasting and warning can significantly reduce the risk to life. The option score for non-structural warnings involving advance warning should therefore be 4, 2 and 1 for effective advance warning periods in excess of 6 hours, 4 hours and 2 hours respectively.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 3.B (i)	
Objective	Minimise risk to community – Social Infrastructure and Amenity
Indicator	Number of social infrastructure assets at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	Number of social infrastructure assets at risk not increased
Aspirational Target	100% reduction in number of social infrastructure assets at risk
Global Weighting	5
Local Weighting	Based on calculated assessment, adjusted by professional judgement
Guidance on Assignment of Local Weightings	
<p>The local weightings should be calculated based on a score derived from the number of social infrastructure and amenity assets potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of each asset.</p> <p>Receptor Scoring</p> <p>All social infrastructure and amenity assets should be treated as equal for the purposes of the calculated score. To ensure that the local weighting on this category is appropriately scaled, each asset should be afforded a score of 25.</p> <p>A weighing has not been applied to the scores, as all social infrastructure and amenity assets (where included) were designated during the PFRA vulnerability assessment as being of 'moderate' vulnerability, except for schools where a 'high' vulnerability classification was assigned due to elevated risk to human health and life arising from the concentration of children, which is provided for under Objective 3.A. (ii).</p> <p>The relevant social infrastructure and amenity assets include:</p> <ul style="list-style-type: none"> – Schools and educational facilities – Libraries – Community centres – Local and central government offices, including post offices – Emergency services facilities (fire, Garda, civil defence, RNLI and coast guard stations) – Health centres (other than hospitals and nursing homes) – Churches and other religious centres 	

- Parks and public gardens, sports facilities, playgrounds
- Local cultural heritage sites or collections, sites of ecological interest or other sites of social amenity

Probability Factoring

For each asset, the score (25) is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that asset, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for all of the social infrastructure and amenity assets at risk from flooding, subject to a maximum score of 5.

Other Factors

Assets of Particular Social Value

A particular social infrastructure and amenity asset may be of exceptional local importance, i.e., where the loss of the asset (permanently or over a long period of time) would have a very severe detrimental impact on the functioning of the community as a whole and on the day-to-day lives of the people in the community (i.e., well beyond the normal expected impact that the loss of one of the listed social infrastructure assets might have. In such cases, professional judgement should be applied to increase the weighting accordingly.

Note that final local weighting taking into account the application of the factors for assets of particular social value should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring

Options are scored based on the degree of reduction in the risk to social infrastructure and amenity, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

$$\text{Option Score} = 5 \times [(\text{Local Weighting} - \text{Residual Risk Score}) / \text{Local Weighting}]$$

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

Flood warning does not reduce hazard, but generally can reduce risk. However, social infrastructure and amenity assets will still be damaged in the event of a flood regardless of the advance warning of the flooding (unless combined with individual protection measures), and so the negative impact (damage to the fabric and disruption to the service the asset provides) will still occur. While it is recognised that advance warning gives more time to prepare damage reduction measures, etc., it is considered that such mitigation measures should be part of a well-formed flood event emergency response plan, and so the advance warning will bring limited benefit. As such, a zero degree of reduction of risk to social infrastructure and amenity should be assumed in relation to non-structural options.

Enhancement or Creation of Social Amenity Sites

Where an option would enhance an existing social amenity site, or involve the creation of a new site, then professional judgement should be used to increase the score afforded that option under this Objective, taking account of the number and value of the sites involved.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 3.B (ii)	
Objective	Minimise risk to community - Local Employment
Indicator	Number of non-residential (i.e., commercial) properties at risk from flooding
Scoring	Based on calculated assessment, adjusted by professional judgement
Basic Requirement	Number of non-residential properties at risk not increased
Aspirational Target	100% reduction in number of non-residential properties at risk
Global Weighting	10
Local Weighting	Based on calculated assessment, adjusted by professional judgement
Guidance on Assignment of Local Weightings	
<p>The local weightings should be calculated based on a score derived from the number of non-residential properties (taken as a place of employment) potentially affected by flooding, and the highest probability (lowest magnitude) of flood event that causes flooding of each property.</p> <p>Receptor Scoring</p> <p>All non-residential properties that are not derelict should be treated as equal for the purposes of the calculated score. To ensure that the local weighting on this category is appropriately scaled, each property should be afforded a score of 5.</p> <p>A differential weighting has not been applied to the count, as reliable information would not be available as to the number of employees for any given property, nor of the indirect employment associated with that property / business</p> <p>The relevant non-residential properties include:</p> <ul style="list-style-type: none"> – Offices – Shops – Services (Restaurants, Pubs, Hotels, etc.) – Factories, Workshops and other Manufacturing Facilities – Warehouses – Health Centres (including hospitals and nursing homes) – Other places of employment 	

Probability Factoring

For each property, the score (5) is then factored by the probability of the highest probability (least severe) flood event that causes flooding of that property, where the factor applied is calculated as:

Factor = Probability of flooding (expressed as the AEP, e.g., 0.01 for 1%)

Total AFA Score (Local Weighting)

For the given AFA, the total AFA score is calculated as the sum of the factored scores for all of the non-residential properties at risk from flooding, subject to a maximum score of 5.

Other Factors

Properties of Particular Importance for Local Employment

A particular non-residential property may be of exceptional local importance, i.e., where the property is the location for the employment of a particularly large number of people or a very high proportion of the people employed within the local area. Flooding of such a property (and the interruption to business and potential closure) would have a very severe detrimental impact on the community and could lead to a significant rise in local unemployment. In such cases, professional judgement should be applied to increase the weighting accordingly.

Local Employment Generated through Tourism

Local employment may be generated through local features and assets that are not based in particular buildings (and hence not included as non-residential properties). Such features may include local angling sites, tourist features or walks, sites of ecological value, heritage sites, etc. Flooding of such features and assets may negatively impact on local employment. In such cases, professional judgement should be applied to increase the weighting accordingly.

Note that final local weighting taking into account the application of the factors for properties of particular importance for local employment should still not exceed a maximum of 5.

The above provides guidance on the setting of local weightings for this objective. However, professional judgement should also be applied as per Section 3.3.

Guidance on Option Scoring

Residual Risk Score

The residual risk score for a flood risk management option should be calculated in the same manner as the local weighting, but based on the flood hazard with the option applied.

In the case of measures providing flood defence, then the residual risk score can be calculated simply by adjusting the factor for probability to that of the standard of protection (following the simplistic assumption that once the standard of protection is exceeded for a given flood defence, then no defence is provided).

Option Scoring

Options are scored based on the degree of reduction in the risk to local employment, calculated using the residual risk score as determined for the relevant option, and the final local weighting, and multiplied by a factor of 5.

The score for a given option should be calculated as:

$$\text{Option Score} = 5 \times [(\text{Local Weighting} - \text{Residual Risk Score}) / \text{Local Weighting}]$$

The other factors detailed under the guidance on the assignment of Local Weighting should also be taken into account in assigning the score for a measure.

Standard of Protection Factor

A Standard of Protection Factor is not applicable to this objective, as it is implicit within the scoring process.

Non-Structural Option Risk Reduction

Flood warning does not reduce hazard, but generally can reduce risk. However, non-residential properties will still be damaged in the event of a flood regardless of the advance warning of the flooding (unless combined with individual property protection measures), and so the negative impact (damage to the fabric and disruption to the employment the property provides) will still occur. While it is recognised that advance warning gives more time to prepare damage reduction measures, etc., it is considered that such mitigation measures should be part of a well-formed flood event emergency response plan, and so the advance warning will bring limited benefit. As such, a zero degree of reduction of risk to local employment should be assumed in relation to non-structural options.

The above provides guidance on the setting of local weightings and scoring for this objective. However, professional judgement should also be applied as per Section 3.3.

OBJECTIVE 4.A	
Objective	Support the objectives of the WFD
Sub-Objective	Provide no impediment to the achievement of water body objectives and, if possible, contribute to the achievement of water body objectives.
Scoring	<p>Likelihood to impact on water body status elements:</p> <ul style="list-style-type: none"> – Biology; – Physico-chemical; – Hydrology and morphology; – Priority substances and priority hazardous substances.
Basic Requirement	Provide no constraint to the achievement of water body objectives.
Aspirational Target	Contribute to the achievement of water body objectives.
Global Weighting	15
Local Weighting	5
Guidance on Assignment of Local Weightings	
The Local Weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	
Guidance on Option Scoring	
<p>Scoring should be guided by professional judgement with reference to the scoring guidance below and the generic description of the likely impacts of measures on water body status.</p> <p>The scoring of the options for this objective should take into account the <u>duration and permanence</u> of the likely impact(s) of the options on water body status elements, the <u>sensitivity</u> of the receiving water bodies, and the <u>potential sources of pollution</u> in the flood extent area.</p> <div> <div> <p>Duration is defined in terms of:</p> <ul style="list-style-type: none"> • long term; • medium term; • short term. </div> <div> <p>Permanence is defined in terms of:</p> <ul style="list-style-type: none"> • permanent; • recurring; • intermittent. </div> </div>	

Sensitive water bodies include:

- water bodies listed in the register of protected areas;
- high status water bodies.

Significant polluting sources include:

- plants licensed under Directives 96/61/EC and 91/271/EC;
- septic tanks greater than 500 PE;
- significant slurry storage facilities.
- establishments defined under Directive 2012/18/EU

Combining positive and negative scores

Most options will have the potential for both positive and negative impacts on water body status as, regardless of the nature of the options, they will all be designed to reduce flood risk which in turn will reduce pollution risk (by reducing the occurrence of flood waters carrying pollutants from inundated areas back into the river – the significance of this positive impact varies depending on the potential sources of pollution within the inundated area and the sensitivity of the water body). Therefore, the overall score applied should be a combination of the best case positive score and the worst case negative score.

Example of combining scores

Option = hard defences and flow diversion

- +2 due to reduction of pollution risk to sensitive water bodies
- -2 due to construction stage impacts associated with walls
- -5 associated with diversion of flow into another river

In this case, the overall score should be '-3', combining the best case positive score and the worst case negative score.

Comparing options

When scoring multiple options for one AFA, it may happen that the options score the same even if they have varying degrees of impact. Professional judgement should be used to ensure that the scores reflect the varying degrees of impact between the options i.e. the scores should be manually adjusted to reflect the different degrees of impact associated with the different options.

Example of manual adjustment

Option 1 = flow diversion

- +2 due to reduction of pollution risk to sensitive water bodies
- -5 associated with diversion of flow into another river

Overall score = -3

Option 2 = flow diversion plus walls

- +2 due to reduction of pollution risk to sensitive water bodies
- -2 due to construction stage impacts to sensitive water bodies associated with walls
- -4 due to excavation and restoration of natural banks in sensitive water bodies
- -5 associated with diversion of flow into another river

Overall score = -3 (combining best case positive score and worst case negative score)

These options score the same even though Option 2 has more negative impacts associated with it. In this example, using professional judgement, Option 2 should be manually adjusted downwards by 1 point to reflect the comparative difference in impacts between the options. If more than two options are being compared, and all differ in terms of the severity of their likely impacts on this objective, but all score the same using this methodology, the options should be manually adjusted upwards or downwards by a maximum of two points in either direction to reflect the comparative difference in impacts between the options. Such adjustments will ensure that the overall MCA scores for the options reflect their differing degree of potential impact on this objective and will therefore ensure that this objective will have an influence in terms of the choice of a preferred option. In such cases a clear rationale should be recorded for the adjustment. It should be noted that such adjustments may have a significant impact on the overall MCA score of the preferred option (perhaps up to 10% of the overall MCA score).

Scoring Table

Score	Duration of impact	WB sensitivity	Examples
5	Permanent or long-term contribution to the achievement of wb objectives	All	Reinstatement of natural hydrological or morphological regime.
4	Medium-term or recurring contribution to the achievement of wb objectives	Sensitive	Reduced flooding in area with significant polluting sources in 1% AEP extent.
3		Non-sensitive	
2	Short-term or intermittent contribution to the achievement of wb objectives	Sensitive	Reduced flooding in area with no significant polluting sources in 1% AEP extent.
1		Non-sensitive	
0	No constraint to the achievement of wb objectives	All	No connectivity between measure and channel or flow.
-1	Short-term or intermittent impediment to the achievement of wb objectives	Non-sensitive	Construction phase impacts. In-stream or on-bank maintenance impacts. Overland floodways. Off-line storage. Rehabilitation of existing in-stream or on-bank defences.
-2		Sensitive	
-3	Medium-term or recurring impediment to the achievement of wb objectives	Non-sensitive	Excavation and restoration of banks. Flow diversion within the same river. One-off or very occasional dredging. Short culverts (e.g. under a road).
-4		Sensitive	
-5	Permanent or long-term impediment to the achievement of wb objectives	All	Channelisation / realignment that does not constitute a reinstatement of natural hydrological or morphological regimes. Regular dredging. Flow diversion to a different river (See further guidance in table below). Extensive culverting. Tidal barrage. On-line storage (dams and reservoirs). Improvement of channel conveyance. Permanent removal of natural banks.
-999	Unacceptable negative impact where feasible alternative exists		

The table below describes the likely impacts of flood risk management measures on the objectives of the WFD. It sets out a description of likely impacts that can be referred to when undertaking the scoring process to help ensure consistency between studies.

Category	Measure	Code	Likely Impacts (WFD)
NFM Protect	Land Use Management	LM	Effective land use management has the potential for positive impacts on water body status through the reduction of pollutants entering rivers and the restoration of natural hydrological and morphological regimes.
Protect	Maintenance Programme	MP	The maintenance of existing in-stream or on-bank flood defences has the potential for short-term and intermittent negative impacts on water status.
Protect	Upstream storage / Storage	S	<p>On-line storage: creation of a dam and reservoir across the floodplain of a river, often with an outlet control structure such as an undershot culvert or sluices, to control outlet flow, and with an overflow weir and spillway.</p> <p>Positive impacts include reduced flooding and therefore reduced pollution. Negative impacts include permanent changes to hydrological and morphological regimes, barrier to migration. There is also the potential for eutrophication within the reservoir which can affect the channel downstream.</p> <p>Off-line storage: area of floodplain embanked to prevent or control flooding within the storage area or wash-land during minor events.</p> <p>Positive impacts include reduced flooding and therefore reduced pollution. Negative impacts include changes to hydrological (and to a lesser extent morphological) regimes.</p>
Protect	Tidal Barrage	TB	Tidal barrages have the potential for significant negative impacts on migratory fish and other water dependent species and are a permanent change to hydrological and morphological regimes.
Protect	Improvement of Channel Conveyance	IC	<p>Increased conveyance improves the efficiency of the channel, and thereby reduces the water levels for a given flow. This is often done by deepening or widening a channel, cutting berms to take more flow during flood events, realigning the bed profile (e.g. removing outcrops) or lining the channel with an artificial or soft (but low resistance) material (ranging from concrete or steel piles to low grass over geotextile).</p> <p>These measures all have the potential for negative effects to hydrological and morphological regimes (permanent or long term), physico-chemical conditions (short-term during construction), biology (arising from other impacts described).</p>

Category	Measure	Code	Likely Impacts (WFD)
Protect	Hard Defences	D	<p>Embankments are unlikely to have negative impacts upon water bodies except in areas where embankments extend right up to the channel bank in which case there may be short-term construction phase impacts.</p> <p>Flood walls have the potential for impacts depending on the distance of the wall from the channel. Some walls will require excavation of the bank during the construction phase followed by bank restoration – with short-term effects associated with construction and medium-term associated with bank recovery. There would also potentially be long-term hydrological or morphological impacts. In some areas, walls may replace natural banks and this would represent a permanent impact on the hydrological and morphological regime of the channel.</p>
Protect	Culverting	C	<p>Culverting represents a permanent morphological and hydrological impact. The extent of culverting is important in assessing the impact.</p>
Protect	Diversion of Flow	DF	<p>Flow diversion measures include realigning the entire river or creating by-pass channels.</p> <p>Realigning a river in a way that does not constitute a reinstatement of more natural hydrological or morphological regimes constitutes a permanent negative impact to the hydrological and morphological regime of a river and is also associated with short term construction-related water status impacts.</p> <p>Flow diversion via a bypass channel from one point of a river to another point of the same river would have short-term and intermittent negative impacts to the hydrological and morphological regime of a river during periods of overflow. However, it represents a significant change to the river regime, even when the diversion is not taking place.</p> <p>Flow diversion from one river to another is an interbasin transfer and can therefore affect the flow regime in both the contributing and receiving rivers and can also affect water quality in the receiving river. When scoring this option consider the quality of the water in receiving river versus the quality of water in the contributing river, the quantity of water being transferred and whether there is any contaminant/invasive species in the contributing water that isn't present in the receiving water.</p>
Protect	Overland Floodways	OF	<p>Overland floodways constitute a short-term and intermittent negative impact to the hydrological and morphological regime of the river and could also impact on the physico-chemical condition of the river as well as on the biology due to pollutants on the floodways being carried into the river during periods of operation.</p>

Protect	Rehabilitation of Existing Defences	ED	Rehabilitation of existing in-stream and on-bank defences has the potential for short-term and occasional impacts of the physico-chemical conditions of the river associated with the works phase.
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OBJECTIVE 4.B	
Objective	Support the objectives of the Habitats and Birds Directives
Sub-Objective	Avoid detrimental effects to, and where possible enhance, Natura 2000 network, protected species and their key habitats, recognising relevant landscape features and stepping stones
Scoring	Area of Natura 2000 site at risk of flooding and qualitative assessment of impact (flooding may have a positive, neutral or negative impact) Loss of, or significant changes to habitat of, riverine and wetland species associated with Natura 2000 sites.
Basic Requirement	No deterioration in the conservation status of designated sites as a result of flood risk management measures
Aspirational Target	Improvement in the conservation status of designated sites as a result of flood risk management measures
Global Weighting	15
Local Weighting	By professional judgement, taking account of local advice
Guidance on Assignment of Local Weightings	
<p>The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.</p> <p>The presence of Annex IV (Habitats Directive) species of flora and fauna, and their key habitats, which are strictly protected wherever they occur, whether inside or outside the SAC/SPA, will have an impact on this weighting.</p>	
Guidance on Option Scoring	
<p>Scoring by professional judgement, based upon the following key datasets:</p> <ul style="list-style-type: none"> - Natura 2000 sites (SACs, SPAs) - Ramsar Sites - Annex IV (Habitats Directive) species of flora and fauna, and their key habitats <p>Note that the scoring allows a negative score of -5 to reflect the importance of avoiding environmental impacts. The positive scores reflect the opportunities for environmental enhancement. <u>The network of sites must also be considered together with the impact upon the individual site.</u></p>	

Score	Description
+5	Potential to create new candidate SAC, SPA or Ramsar sites or enhance NHA sites to SAC, SPA or Ramsar status, which extend the existing network of international and European designations as a result of flood risk management measures.
+3	Improvement or enhancement of the condition or management of existing SAC, SPA or Ramsar sites and network as a result of flood risk management measures.
+1	Localised improvement or enhancement of the condition or management of existing SAC, SPA or Ramsar sites and network as a result of flood risk management measures.
0	No impact on existing SAC, SPA or Ramsar sites as a result of flood risk management measures.
-1	Any detrimental impact upon existing SAC or SPA site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
-3	Any detrimental impact upon existing SAC or SPA site, including a delay in recovery of the site, but excluding impacts on the conservation objectives of the site, as a result of flood risk management measures, where there are no suitable mitigation measures.
-5	Any detrimental impact upon conservation objectives of existing SAC, SPA or Ramsar site, including a delay in recovery of the site, as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
-999	Any detrimental impact upon existing conservation objectives of SAC, SPA or Ramsar site, as a result of flood risk management measures, where there are no suitable mitigation measures.

OBJECTIVE 4.C	
Objective	Avoid damage to, and where possible enhance, the flora and fauna of the catchment
Sub-Objective	Avoid damage to, and where possible enhance, legally protected sites / habitats and other sites / habitats of national, regional and local nature conservation importance
Scoring	<p>Area of national, regional or local conservation designations at risk of flooding and qualitative assessment of impact (flooding may have a positive, neutral or negative impact)</p> <p>Loss of, or significant changes to habitat of, riverine and wetland species associated with national, regional and local conservation designations.</p>
Basic Requirement	No deterioration of in condition of existing sites due to the implementation of flood risk management option
Aspirational Target	Creation of new or improvement in condition of existing sites due to the implementation of flood risk management option
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice
Guidance on Assignment of Local Weightings	
<p>The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.</p>	
Guidance on Option Scoring	
<p>Scoring by professional judgement, based upon the following key datasets:</p> <ul style="list-style-type: none"> - Natural Heritage Areas (& proposed Natural Heritage Areas) - Nature Reserves - Wildfowl Sanctuary - OSPAR - National Parks <p>Note that the scoring allows a negative score of -5 to reflect the importance of avoiding environmental impacts. The positive scores reflect the opportunities for environmental enhancement. The network of sites must also be considered together with the impact upon the individual site.</p>	

Score	Description
+5	Potential to create new national, regional and local conservation sites as a result of flood risk management measures.
+3	Improvement or enhancement of the condition or management of existing national, regional and local sites as a result of flood risk management measures.
+1	Potential for localised improvement of flora/fauna
0	No impact on existing national, regional and local sites as a result of flood risk management measures.
-1	Potential localised loss of or disturbance to flora/fauna limited by the already modified nature of the channel/shoreline.
-3	Potential localised loss of or disturbance to flora/fauna
-5	Any detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.
-999	Any detrimental impact upon national, regional or local sites as a result of flood risk management measures, where there are no suitable mitigation measures.

OBJECTIVE 4.D	
Objective	Protect and where possible enhance fisheries resource within the catchment
Sub-Objective	Maintain existing and where possible create new fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species.
Scoring	<ul style="list-style-type: none"> • Area of suitable habitat supporting salmonid and other fish species • Number of upstream barriers
Basic Requirement	<ul style="list-style-type: none"> • No loss of integrity of fisheries habitat • Maintenance of upstream accessibility
Aspirational Target	<ul style="list-style-type: none"> • No loss of fisheries habitat • Improvement in habitat quality / quantity • Enhanced upstream accessibility
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice
Guidance on Assignment of Local Weightings	
<p>The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.</p> <p>The following weighting system may be adopted.</p>	
Weighting	Description
5	Where there are designated waters (e.g. under EU Shellfish Waters Directive; EU Freshwater Fish Directive)
4	Waterbody supports substantial salmonid fisheries/shellfisheries and is of national value for fishing/angling
3	Waterbody supports substantial fisheries/shellfisheries and is of regional value for fishing/angling
2	Waterbody supports fisheries/shellfisheries and is of local value for fishing/angling
1	Fisheries could be present but unlikely given the modified nature of the channel/presence of barriers to movement; no known angling/fishing activities
0	No fisheries or angling areas present

Guidance on Option Scoring

Scoring by professional judgement with reference to the scoring guidance below and the generic description of the likely impacts of measures.

It is noted that this objective only relates to inland fisheries and not marine fisheries. Shellfish waters in particular are included under the register of protected areas under the WFD and as such are included in Objective 4a.

The scoring of the options for this objective should take into account the duration and permanence of the likely impact(s) of the options on on fisheries and fisheries potential, the sensitivity of the receiving water bodies, and species e.g. salmonid sp. and designated salmonid waters.

Duration is defined in terms of:

- long term;
- medium term;
- short term.

Permanence is defined in terms of:

- permanent;
- recurring;
- intermittent.

Sensitive waters include:

- designated salmonid waters

Sensitive species include*:

- Atlantic Salmon
- Lamprey
- Shad
- Pollan
- Arctic Char
- Smelt

*Based on 2011 IFI National Programme: Habitats Directive and Red Data Book Fish species

Combining positive and negative scores

Instream and bank options have the greatest potential to impact negatively on fisheries, however some options may offer improvements and as such the overall score applied should be a combination of the positive and negative scores with reference to the worst case and best case scores.

Example of combining scores

Option = hard defences and flow diversion

- +2 due to reduction of pollution risk to sensitive water bodies and sensitive species
- -2 due to construction stage impacts associated with walls
- -5 associated with diversion of flow into another river

In this case, the overall score should be '-3', combining the best case positive score and the worst case negative score.

Comparing options

When scoring multiple options for one AFA, it may happen that the options score the same even if they have varying degrees of impact. Professional judgement should be used to ensure that the scores reflect the varying degrees of impact between the options i.e. the scores should be manually adjusted to reflect the different degrees of impact associated with the different options.

Example of manual adjustment

Option 1 = flow diversion

- +2 due to improved fisheries potential as a result of reduction of pollution risk to sensitive water bodies and species
- -5 associated with diversion of flow into another river

Overall score = - 3

Option 2 = flow diversion plus walls

- +2 due to improved fisheries potential as a result of reduction of pollution risk to sensitive water bodies and species
- -2 due to construction stage impacts to sensitive water bodies and species associated with walls
- -4 due to excavation and restoration of natural banks in sensitive water bodies
- -5 associated with diversion of flow into another river

Overall score = - 3 (combining best case positive score and worst case negative score)

These options score the same even though Option 2 has more negative impacts associated with it. In this example, using professional judgement, Option 2 should be manually adjusted downwards by 1 point to reflect the comparative difference in impacts between the options. If more than two options are being compared, and all differ in terms of the severity of their likely impacts on this objective, but all score the same using this methodology, the options should be manually adjusted upwards or downwards by a maximum of two points in either direction to reflect the comparative difference in impacts between the options. Such adjustments will ensure that the overall MCA scores for the options reflect their differing degree of potential impact on this objective and will therefore ensure that this objective will have an influence in terms of the choice of a preferred option. In such cases a clear rationale should be recorded for the adjustment. It should be noted that such adjustments may have a significant impact on the overall MCA score of the preferred option.

Scoring Table

Score	Duration of impact	Sensitivity	Examples
5	Creation of fisheries habitat or removal of barrier to upstream migration for wb where sensitive species are known to be present e.g. salmonids	Any wb	Reinstatement of natural hydrological or morphological regime.
4	Creation of fisheries habitat or removal of barrier to upstream migration for wb where other species are present e.g. coarse fish	Any wb	Reinstatement of natural hydrological or morphological regime.
3			
2	Creation of fisheries potential	Any wb	Land Use Management
1			
0	No change to fisheries potential of the wb	Any wb	Measures with no connection to channel, flow, bank side vegetation
-1	Short-term minor impacts to fisheries habitat	Non-sensitive wb	Construction phase impacts.
-2		Sensitive wb	
-3	Medium to long-term alternation of fisheries habitat	Non-sensitive wb	In-stream or on-bank maintenance impacts. Walls that require excavation and restoration of banks. Flow diversion within the same river. Rehabilitation of existing in-stream or on-bank defences. Dredging
-4		Sensitive wb	
-5	Permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.	Any wb	Channelisation/realignment. Regular dredging. Extensive culverting. Tidal barrage. On-line storage (dams). Improvement of channel conveyance. Walls that replace natural banks. Flow diversion to a different river.
-999	Unacceptable negative impact where feasible alternative exists		

The table below describes the likely impacts flood risk management measures fisheries. It can be referred to when undertaking the scoring process to help ensure consistency between studies.

Category	Measure	Code	Likely Impacts (Fisheries)
NFM Protect	Land Use Management	LM	Effective land use management has the potential for positive impacts on fisheries through the reduction of pollutants entering rivers and the restoration of natural hydrological and morphological regimes with the possibility of restoration and / or creation of fisheries potential.
Protect	Maintenance Programme	MP	The maintenance of existing flood defense measures is likely to result in some positive impacts to fisheries through removal of debris and other physical obstructions etc, particularly following flood events. There is however potential for negative impacts where management of vegetation leads to loss of habitat or disturbance to species. All in-stream works have potential to negatively impact directly on fish species and as such would have to be carried out with due care and attention. On-bank works also have potential for negative impacts, particularly with regard to release of sediment and other organic matter.
Protect	Upstream storage / Storage	S	On-line storage refers to creating a dam and reservoir across the floodplain of a river, often with an outlet control structure such as an undershot culvert or sluices, to control outlet flow, and with an overflow weir and spillway. Such a measure has the potential to negatively impact on fisheries through disturbance or loss of habitat and blockage to migratory routes. This will be particularly significant in sensitive waters and for sensitive species. Creation of eutrophic conditions in the reservoirs could also impact on fisheries down-stream. Off-line storage refers to an area of floodplain that is embanked to prevent or control flooding within the storage area or wash-land during minor events. This can produce positive effects including creation of new habitat. Negative impacts may occur where the storage interferes with the existing riparian zone.
Protect	Tidal Barrage	TB	Tidal barrages have the potential for significant negative impacts on migratory fish and other water dependent species and are a permanent change to hydrological and morphological regimes.
Protect	Improvement of Channel Conveyance	IC	Increased conveyance improves the efficiency of the channel, and thereby reduces the water levels for a given flow. This is often done by deepening or widening a channel, cutting berms to take more flow during flood events, realigning the bed profile (e.g. removing outcrops) or lining the channel with an artificial or soft (but low resistance) material (ranging from concrete or steel piles to low grass over geotextile). This measure includes primarily in-stream work elements and as such represents one of the measures with most negative possibility in terms of fisheries potential.

Protect (cont'd)	Improvement of Channel Conveyance (cont'd)	IC (cont'd)	<p>All aspects are likely to result in short-term construction related impacts however, some, over the medium to long term will have significant potential to cause loss of habitat, disturbance of species through changes to hydrological and morphological regimes (permanent or long term), physico-chemical conditions (short-term during construction) and biology .</p> <p>In the medium to long-term there may be the possibility for positive impacts where new habitat can be generated.</p>
Protect	Hard Defences	D	<p>Flood walls have the potential for impacts for fisheries depending on the distance of the wall from the channel. Some walls will require excavation of the bank during the construction phase followed by bank restoration – with short-term effects associated with construction and medium-term associated with bank recovery. There would also potentially be long-term hydrological or morphological impacts. In some areas, walls may replace natural banks and this would represent a permanent impact on the hydrological and morphological regime of the channel and in turn on the habitats and species present.</p>
Protect	Culverting	C	<p>Culverting represents a permanent morphological and hydrological impact with has the potential to permanent impact on fisheries habitat and species particularly with regard to upstream movement of fish species. The extent of culverting is important is assessing the impact.</p>
Protect	Diversion of Flow	DF	<p>Realigning a river constitutes a permanent negative impact to the hydrological and morphological regime of a river which have potential for both short and medium term impacts to fisheries through loss of habitat and disturbance to species.</p> <p>Flow diversion via a bypass chanell from one point of a river to another point of the same river would have short-term and intermittent negative impacts to the hydrological and morphological regime of a river and consequently fish species during periods of overflow but this impact may have longer term consequences on fisheries habitat also.</p> <p>Flow diversion from one river to another is an interbasin transfer and can therefore affects the flow regime in both the contributing and receiving rivers and can also affect water quality in the receiving river. Such a measure should always be considered of maximum significance with respect to fisheries protection.</p>
Protect	Overland Floodways	OF	<p>Overland floodways consitute a short-term and intermittent negative impact to the hydrological and morphological regime of the river and could also impact on the physico-chemical condition of the river as well as on the biology due to pollutants on the floodways being carried into the river during periods of operation.</p>

Protect	Rehabilitation of Existing Defences	ED	The rehabilitation of existing flood defense measures is likely to result in some negative impacts to fisheries where management of vegetation leads to loss of habitat or disturbance to species. All in-stream works have potential to negatively impact directly on fish species and as such would have to be carried out with due care and attention. On-bank works also have potential for negative impacts, particularly with regard to release of sediment and other organic matter. This measure has the potential for short-term and occasional impacts to the physico-chemical conditions of the river associated with the works phase.
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OBJECTIVE 4.E															
Objective	Protect, and where possible enhance, landscape character and visual amenity within the zone of influence.														
Sub-Objective	Protect, and where possible enhance, visual amenity, landscape protection zones and views into/from designated scenic areas within the zone of influence.														
Scoring	<ol style="list-style-type: none"> 1. Length of waterway corridor qualifying as a landscape protection zone within urban areas 2. Change of quality in existing scenic areas and routes 3. Loss of public landscape amenities 														
Basic Requirement	<ol style="list-style-type: none"> 1. No significant impact on landscape designation (protected site, scenic route/amenity, natural landscape form) within zone of visibility of measures 2. No significant change in the quality of existing landscape characteristics of the receiving environment 														
Aspirational Target	<ol style="list-style-type: none"> 1. No change to the existing landscape form 2. Enhancement of existing landscape or landscape feature 														
Global Weighting	10														
Local Weighting	By professional judgement, taking account of local advice														
Guidance on Assignment of Local Weightings															
<p>The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning this weighting. After consultations with progress group, steering group and members of the stakeholder group, and with the local community, this weighting may change.</p> <p>Consideration may be given to the public use of landscape and cultural associations, history and memories. The following weighting system may be adopted.</p> <table> <thead> <tr> <th>Weighting</th><th>Description</th></tr> </thead> <tbody> <tr> <td>5</td><td>Landscape designated as a internationally/nationally important landscape and potentially affected</td></tr> <tr> <td>4</td><td>Landscape character type designated at a county level as highly sensitive and/or exceptional/high value and potentially affected</td></tr> <tr> <td>3</td><td>Landscape character type designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected</td></tr> <tr> <td>2</td><td>Landscape character type designated at a county level as low sensitivity and/or low value and potentially affected</td></tr> <tr> <td>1</td><td>No specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected</td></tr> <tr> <td>0</td><td>No specific landscape designation, and no landscape value/sensitivity</td></tr> </tbody> </table>		Weighting	Description	5	Landscape designated as a internationally/nationally important landscape and potentially affected	4	Landscape character type designated at a county level as highly sensitive and/or exceptional/high value and potentially affected	3	Landscape character type designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected	2	Landscape character type designated at a county level as low sensitivity and/or low value and potentially affected	1	No specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected	0	No specific landscape designation, and no landscape value/sensitivity
Weighting	Description														
5	Landscape designated as a internationally/nationally important landscape and potentially affected														
4	Landscape character type designated at a county level as highly sensitive and/or exceptional/high value and potentially affected														
3	Landscape character type designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected														
2	Landscape character type designated at a county level as low sensitivity and/or low value and potentially affected														
1	No specific landscape sensitivity/value, but landscape features/views are important at a local level and potentially affected														
0	No specific landscape designation, and no landscape value/sensitivity														

Guidance on Option Scoring

Scoring should be guided by professional judgement with reference to the scoring guidance below and the generic description of the likely impacts of measures.

The scoring of the options for this objective should take into account the duration and permanence of the likely impact(s) of the options on landscape value and the sensitivity of the landscape to change.

Duration is defined in terms of; <ul style="list-style-type: none"> • Long term; • Medium term; • Short term. 	Permanence is defined in terms of; <ul style="list-style-type: none"> • Permanent; • Recurrent; • Intermittent.
Range of Sensitivities include; <ul style="list-style-type: none"> • High (International/National); • Moderate (Regional/County/City); • Low (County/City/Local) 	Permanence is defined in terms of; <ul style="list-style-type: none"> • Permanent; • Recurrent; • Intermittent.

Examples of Sensitive Landscapes include;

- World Heritage Sites (International);
- National Parks (International/National);
- Sensitive/Vulnerable Landscapes (National/Regional/County);
- High Amenity Landscapes/Areas (County);
- Scenic Views/Prospects and Routes (County/Local);
- Sensitive Riverscapes/Seascapes/Streetscapes/Local Amenity Walks (County/City/Local).

Combining Positive and Negative Scores

Constructing hard defences adjacent to watercourses has the potential to impact positively and negatively on landscape. A negative impact may arise from the construction of a visible man-made structure on the opposite bank of a river with a scenic walkway. A positive impact may arise from the removal of invasive species encroaching on the river bank.

+2 due to enhancement of local landscape feature (e.g. removal of invasive vegetative species)

-5 due to construction of hard defence where no defence existed prior

In the above example the overall score should be '-3', combining the best positive score with the worst negative score.

Comparing Options

When scoring multiple options for one AFA, it may happen that the options score the same even if they have varying degrees of impact. Professional judgement should be used to ensure that the scores reflect the varying degrees of impact between the options, i.e. the scores should be manually adjusted to reflect the different degrees of impact associated with the different options.

Example of manual adjustment

Option 1 = flood storage

- +1 due to clearance of natural flood storage area
- -1 short term construction stage impacts
- -4 due to change in existing landscape form in the locality

Overall Score = -3 (highest positive added to highest negative)

Option 2 = river morphology changes

- -3 due to construction stage impacts in a riverscape recognised as being of high value in a County/City Development Plan

Overall Score = -3

The above options score the same even though Option 2 is more likely to be perceived to have the more significant negative impact arising from the inclusion of the riverscape in a County or City Development Plan. Option 2 should then be manually adjusted downwards by 1 point to reflect the comparative difference in impacts between the options. If more than two options are being compared, and all differ in terms of the severity of their likely impacts on this objective, but all score the same using this methodology, the options should be manually adjusted upwards or downwards by a maximum of 2 points in either direction to reflect the comparative difference between the options.

Scoring Table

Score	Duration of Impact	Sensitivity	Examples
5	Permanent significant enhancement of high sensitivity landscape character/feature in the zone of visibility of the selected measure	High	Reinstatement of natural river corridor morphology in a riverscape recognised as being of high value included in a County/City Development Plan
4	Permanent significant enhancement of moderate sensitivity landscape character/feature in the zone of visibility of the selected measure	Moderate	Clearance of significant extent of riparian vegetation/man-made obstructions in a river corridor of high landscape/amenity value included in a County/City Development Plan
3	Permanent localised enhancement of high value landscape/feature in the zone of visibility of the selected measure	High	Channel widening and deepening at specific location on a watercourse of high landscape value removing risk of flow restriction and visual impacts from blockages with detritus (vegetative/rubbish).
2	Permanent localised enhancement of moderate value landscape character/feature in the zone of visibility of the selected measure	Medium	Clearance of local area for use as temporary overland flow storage returning land-use to natural function.
1	Permanent localised enhancement of local sensitivity landscape character/feature in the zone of visibility of the selected measure	Low	Removal of artificial visible man-made flow restriction from local amenity view (screens from under bridge on local amenity walk).
0	No change to existing landscape character/feature in the zone of influence of the selected measure	-	No change to existing landscape character or features.
-1	Short term impact (construction) on local sensitivity landscape character/feature in the zone of visibility of the selected measure.	Low	Construction or extension to local flood embankment prior to establishment of vegetative mitigation (i.e. screening).
-2	Short term impact (construction) on moderate sensitivity landscape character/feature in the zone of visibility of the selected measure.	Low	Construction of significant flood storage area in large area of natural landscape prior to mitigation establishment
-3	Short term impact (construction) on high/moderate value landscape character/feature in the zone of visibility of the selected measure	Medium	Re-establishment of natural river corridor morphology in a riverscape recognised as being of high value in a County/City Development Plan
-4	Permanent impact on local/moderate value landscape character/feature in the zone of influence of the selected measure	Medium	Construction of permanent hard defences (flood walls) adjacent to a local amenity walkway in a historic garden/demesne
-5	Permanent impact on high value landscape character/feature in the zone of influence of the selected measure	High	Construction of tidal barrage in high amenity seascape which is the subject matter of a protected view/prospect
-999	Unacceptable negative impact where feasible options exist	High	Site specific.

OBJECTIVE 4.F.i	
Objective	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.
Sub-Objective	Avoid damage to or loss of features, institutions and collections of architectural value and their setting, and improve their protection from extreme floods where this is beneficial.
Scoring	a) The number of architectural features, institutions and collections subject to flooding. b) The impact of flood risk management measures on architectural features, institutions and collections.
Basic Requirement	a) No increase in risk to architectural features, institutions and collections at risk from flooding. b) No detrimental impacts from flood risk management measures on architectural features, institutions and collections.
Aspirational Target	a) Complete removal of all relevant architectural features, institutions and collections from the risk of harm by extreme floods. b) Enhanced protection and value of architectural features, institutions and collections importance arising from the implementation of the selected measures.
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice
Guidance on Assignment of Local Weightings	
<p>The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning a value to this weighting but some guidance has been provided below. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.</p> <p>Reference should be made to the PRFA Methodology for Classifying the Vulnerability of National Monuments from Flooding in the Republic of Ireland (OPW, 2011).</p>	

Score	Description
5	Internationally important feature(s) (i.e. Structures or sites of sufficient architectural heritage importance to be considered in an international context. These are exceptional structures that can be compared to and contrasted with the finest architectural heritage in other countries) present and potentially affected.
4	Nationally important feature(s) (e.g. Structures or sites that make a significant contribution to the architectural heritage of Ireland. These are structures and sites that are considered to be of great architectural heritage significance in an Irish context) present and potentially affected with a high to moderate vulnerability.
3	A number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a high to moderate vulnerability.
2	A number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.
1	No architectural features are at risk from flooding but potential effects on the settings of designated architectural features.
0	No sites/features at risk.

Guidance on Option Scoring

FRM measures may have both positive and negative effects on features of cultural heritage, and these need to be taken into account when identifying and scoping potential effects. Scoring should be based on professional judgement guided by the criteria provided below.

Score	Description / Examples		
5	No negative effects on architectural features and a number of architectural features (Internationally and Nationally important features) completely saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which significantly enhance the setting of architectural features (Internationally and Nationally important features).	Creation of amenity value for a number of architectural features (Internationally and Nationally important features) which was previously not present.
4	Architectural features (Nationally important features, Record of Protected Structures and NIAH) partially saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which enhance the setting of architectural features (Nationally important features, Record of Protected Structures and NIAH).	Creation of amenity value for a number of architectural features (Nationally important features, Record of Protected Structures and NIAH) which was previously not present.
3	Increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are substantially less vulnerable to flood damage.	Removal of negative elements from the setting of architectural features (Record of Protected Structures and NIAH) so that the setting of the features is significantly enhanced.	Protection of the existing amenity for a number of architectural features (Record of Protected Structures and NIAH).
2	Increase in the level of protection for a number of architectural features (Record of Protected Structures and NIAH) from flooding, such that they are significantly less vulnerable to flood damage.	Removal of negative elements from the setting of a number architectural features (Record of Protected Structures and NIAH) so that the setting of the architectural features is noticeably enhanced.	Partial protection of the existing amenity for a number architectural features (Record of Protected Structures and NIAH).
1	Increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.	Removal of negative elements from the setting of architectural features (Record of Protected Structures and NIAH) so that its setting is enhanced.	Protection of the existing amenity for architectural features (Record of Protected Structures and NIAH).
0	No effects on architectural features		

-1	No physical effects on architectural features (Record of Protected Structures and NIAH)	Changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is slightly changed.	Partial loss of access to architectural features (Record of Protected Structures and NIAH) which does not affect their existing amenity value.
-2	Multiple effects which score -1 individually and/or Physical effects on architectural features (Record of Protected Structures and NIAH) such that the structure is partially removed.	Changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is clearly modified.	Loss of access to architectural features (Record of Protected Structures and NIAH) such that its current amenity value is altered.
-3	Multiple effects which score -2 individually and/or Physical effects on architectural features (Record of Protected Structures and NIAH) such that the structure is completely removed.	Changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is completely altered.	Loss of access to architectural features (Record of Protected Structures and NIAH) such that its current amenity value is completely lost.
-4	Multiple effects which score -3 individually and/or Physical effect on architectural features (Nationally important features, Record of Protected Structures and NIAH) such that the structure is partially removed.	Changes to the setting of architectural features (Nationally important features, Record of Protected Structures and NIAH) such that it is clearly modified.	Loss of access to architectural features (Nationally important features, Record of Protected Structures and NIAH) such that its current amenity value altered.
-5	Physical effect on architectural features (Nationally important features, Record of Protected Structures and NIAH) such that the structure is completely removed.	Changes to the setting of architectural features (Nationally important features, Record of Protected Structures and NIAH) such that it is completely altered.	Loss of access to architectural features (Nationally important features, Record of Protected Structures and NIAH) such that its current amenity value is completely lost.
-999	Physical effects on architectural features (Internationally important) such that its Outstanding Universal Value (OUV) is altered.	Effects on the setting of an architectural features (Internationally important) such that its Outstanding Universal Value (OUV) is altered.	

OBJECTIVE 4.F.ii	
Objective	Avoid damage to or loss of features, institutions and collections of cultural heritage importance and their setting, and improve their protection from extreme floods.
Sub-Objective	Avoid damage to or loss of features, institutions and collections of archaeological value and their setting, and improve their protection from extreme floods where this is beneficial.
Scoring	a) The number of archaeological features, institutions and collections subject to flooding. b) The impact of flood risk management measures on archaeological features, institutions and collections.
Basic Requirement	a) No increase in risk to archaeological features, institutions and collections at risk from flooding. b) No detrimental impacts from flood risk management measures on archaeological features, institutions and collections.
Aspirational Target	a) Complete removal of all relevant archaeological features, institutions and collections from the risk of harm by extreme floods. b) Enhanced protection and value of archaeological features, institutions and collections arising from the implementation of the selected measures.
Global Weighting	5
Local Weighting	By professional judgement, taking account of local advice
Guidance on Assignment of Local Weightings	
<p>The local weighting may not exceed a ceiling value of 5. Professional judgement should be applied in assigning a value to this weighting but some guidance has been provided below. After consultations with progress group, steering group and members of the stakeholder group, this weighting may change.</p> <p>Reference should be made to the PRFA Methodology for Classifying the Vulnerability of National Monuments from Flooding in the Republic of Ireland (OPW, 2011).</p>	

Score	Description
5	Internationally important archaeological feature(s) (i.e. World Heritage Site including those on the tentative list present and potentially affected.
4	Nationally important archaeological feature(s) (e.g. National Monument in State Care, sites on which Preservation Orders or Temporary Preservation Orders have been served) present and potentially affected.
3	A number of sites listed on the RMP/RPS present and potentially affected. (high to moderate vulnerability)
2	A number of sites listed on the RMP/RPS present and potentially affected. (moderate to low vulnerability)
1	Limited potential for effects on archaeological features and their setting.
0	No archaeological features at risk.

Guidance on Option Scoring

FRM measures may have both positive and negative effects on archaeological features, and these need to be taken into account when identifying and scoping potential effects. Scoring should be based on professional judgement guided by the criteria provided below

Score	Description / Examples		
5	No negative effects on archaeological features, and, A number of archaeological features (Recorded Monuments or National Monuments) completely saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which significantly enhance the setting of archaeological features (Recorded Monuments or National Monuments).	Creation of amenity value for a number of archaeological features (Recorded Monuments or National Monuments) which was previously not present.
4	Archaeological features (Recorded Monuments or National Monuments) partially saved from what would otherwise have been inevitable loss from flooding.	Creation of elements which enhance the setting of an archaeological feature (Recorded Monuments or National Monuments).	Creation of amenity value for a number archaeological feature (Recorded Monuments or National Monuments) which was previously not present.
3	Increase in the level of protection for a number of archaeological features (Recorded Monuments) from flooding, such that they are substantially less vulnerable to flood damage.	Removal of negative elements from the setting of archaeological features (Recorded Monuments) so that the setting of the features is significantly enhanced.	Protection of the existing amenity for a number of archaeological features (Recorded Monuments).
2	Increase in the level of protection for a number of archaeological features (Recorded Monuments) from flooding, such that they are significantly less vulnerable to flood damage.	Removal of negative elements from the setting of a number archaeological features (Recorded Monuments) so that the setting of the archaeological features is noticeably enhanced.	Partial protection of the existing amenity for a number of archaeological features (Recorded Monuments).
1	Increase in the level of protection for archaeological features (Recorded Monuments) from flooding, such that it is less vulnerable to flood damage.	Removal of negative elements from the setting of archaeological features (Recorded Monuments) so that it's setting is enhanced.	Protection of the existing amenity for archaeological features (Recorded Monuments).
0	No effects on archaeological features		

-1	No physical effects on archaeological features (Recorded Monuments or National Monuments)	Changes to the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.	Partial loss of access to archaeological features (Recorded Monuments or National Monuments) which does not affect their existing amenity value.
-2	Multiple effects which score -1 individually and/or Physical effects on archaeological features (Recorded Monuments) such that the monument is partially removed.	Changes to the setting of archaeological features (Recorded Monuments) such that it is clearly modified.	Loss of access to archaeological features (Recorded Monuments) such that its current amenity value is altered.
-3	Multiple effects which score -2 individually and/or Physical effects on archaeological features (Recorded Monuments) such that the monument is completely removed.	Changes to the setting of archaeological features (Recorded Monuments) such that it is completely altered.	Loss of access to archaeological features (Recorded Monuments) such that its current amenity value is completely lost.
-4	Multiple effects which score -3 individually and/or Physical effect on archaeological features (National Monuments) such that the monument is partially removed.	Changes to the setting of archaeological features (National Monuments) such that it is clearly modified.	Loss of access to archaeological features (National Monuments) such that its current amenity value altered.
-5	Physical effect on archaeological features (National Monuments) such that the monument is completely removed.	Changes to the setting of archaeological features (National Monuments) such that it is completely altered.	Loss of access to archaeological features (National Monuments) such that its current amenity value is completely lost.
-999	Physical effects on archaeological features (a World Heritage Site) such that its Outstanding Universal Value (OUV) is altered.	Effects on the setting of an archaeological feature (a World Heritage Site) such that its Outstanding Universal Value (OUV) is altered.	

Appendix K Option Appraisal Report - Sub-catchment Spatial Scale



Appendix K1 Option Appraisal Report - Shannon Town and Airport Sub-catchment

1. Preliminary Report: Summary of Current Flood Risk					
1.1 Sub-catchment and Watercourse Details					
Sub-catchment	Shannon and Shannon Airport				
Unit of Management:	27				
Primary Watercourse(s):	Ballycasey Creek, Unnamed River, Ballycasey Tributary, Urlan Beg, Drumgeely Creek, Unnamed Tributary, Shannon Estuary.				
1.2 Summary of Flood Risk in 1% Fluvial / 0.5% Coastal AEP Event					
Source of flood risk	Fluvial		Coastal		Both
Total Number of Properties at risk in AFA in 1% Fluvial / 0.5% Coastal AEP Event:		Residential	Non-Residential	Total	
	Fluvial	86	47	133	
	Coastal	6	37	43	
	Combined	86	50	136	
Relevant Comments:	The Shannon and Shannon Airport sub-catchment is at risk of flooding from both fluvial and coastal sources. Shannon Town and Shannon Airport are hydraulically connected for coastal flood events and the flood risk cannot be isolated to either site. The ground levels within Shannon Town and Shannon Airport are less than the tide level in a 50% AEP coastal event, if the defences in Shannon Airport were not in existence, properties within Shannon town would be at risk of flooding in a 50% AEP event. Likewise if the Shannon town defences were not in existence, Shannon Airport would be at risk of flooding in the 50% AEP event, There is significant increase in the number of properties at risk in the 0.1% AEP Coastal flood event, than during the 0.5% AEP flood event. Although the CFRAM preferred design standard is the 0.5% AEP event, in accordance with the Project Brief, we believe that assessing a 0.1% AEP design standard would provide significant additional economic benefit to the sub-catchment. Therefore, the 1% Fluvial/ 0.1% Coastal AEP design standard is being adopted.				
1.2 (a) Summary of Flood Risk in 0.1% AEP Coastal and 1% AEP Fluvial Event					
Total Number of Properties at risk in AFA in 1% Fluvial / 0.1% Coastal AEP Event:		Residential	Non-Residential	Total	
	Fluvial	86	47	133	
	Coastal	1008	146	1154	
	Combined	1023	149	1172	
AFA Flood Cells:	Total Number:	5			
	Flood Cell Titles:	SubSHN_A, SubSHN_B, SubSHN_C, SubSHN_D, SubSHN_E			
Breakdown of properties at (combined) risk per Flood Cell:	Flood Cell Ref	Residential	Non-Res	Total	
	SubSHN_A	0	14	14	
	SubSHN_B	1	103	104	
	SubSHN_C	936	19	955	
	SubSHN_D	86	4	90	
	SubSHN_E	0	9	9	
Relevant Figure Ref:	Figure 1.1 to 1.11				

1.3 Summary of Existing Flood Risk Management Measures						
Arterial Drainage	Storage		Flow Diversion	Flood Defences	Level Control	Other
None	None		None	Yes	None	None
Relevant Figure Ref:		Fig 1.1 to 1.10				
1.4 Summary of PV Damages/Potential PV Benefits for 0.1% SOP Coastal & 1% SOP Fluvial Event						
Total PV Damages:			Uncapped		Capped	
		Fluvial	€ 40,130,880		€ 26,394,884	
		Coastal Direct Damages *	€ 164,865,160		€ 154,012,290	
		Coastal Indirect Damage **	€ 100,000,000		€ 100,000,000	
		Combined	€ 305,191,192		€ 270,802,132	
Max Combined Capped Benefits for 1% Fluvial / 0.1% Coastal AEP Event***:		€ 268,242,673				
Breakdown of Max Capped PV benefits per Flood Cell for 1% Fluvial / 0.1% Coastal AEP Event		Flood Cell Ref	Residential	Non-Res	Total	
		SubSHN_A	€ 0	€ 3,237,626	€ 3,237,626	
		SubSHN_B	€ 574	€ 37,251,679	€ 37,252,253	
		SubSHN_C	€ 2,251,638	€ 246,693	€ 2,499,331	
		SubSHN_D	€ 596,375	€ 6,727	€ 603,102	
		SubSHN_E	€ 0	€ 4,650,361	€ 4,650,361	
Relevant Comments:		<p>* Based on consultation with the Capital and Engineering Projects Manager of Shannon Airport Authority (SAA) (email dated 22/10/15) the total airport infrastructural value is in the region of €605M. Using professional judgement, it is estimated that damages during a flood event will be 20% of the total airport infrastructural value, this has been added to the direct damages already calculated.</p> <p>** As detailed above, following consultation with SAA (email dated 09/12/15), a figure in excess of €100M has been estimated for operation disruption costs to the airport. This has been included as indirect damages for this IRR.</p>				
Relevant Figure Ref:		Figure 1.1 to 1.11				

*** These are the maximum benefits available if a FRM option with a 1% Fluvial / 0.1% Coastal AEP SOP is provided to all properties within the AFA.

1.5 Social Risk		
	Type	Description
High Vulnerability Properties at risk:	School	0.1% AEP Coastal Flood Risk
		2 No. National Schools
		2 No. Other Schools
Social Infrastructure Assets:	Fire Station	0.1% AEP Coastal Flood Risk
		Shannon Airport Fire Station
	OPW Building	0.1% AEP Coastal Flood Risk
		Shannon Driving Test Centre

		Shannon Customs & Excise
Social Amenity Sites:	None	N/A
Relevant Figure Ref:	General Risk - Social	
1.6 Risk to the Environment		
	Type	Description
Risk to WFD Annex IV:	Licensed IPPC Facilities	0.1% AEP Coastal Flood Extent
		Lufthansa Technik Painting Shannon Limited
		Element Six
		Heraeus Metal Processing Limited
		UCB Manufacturing Ireland Limited
Risk to SACs:	Proposed National Heritage Areas	Fergus Estuary and Inner Shannon, North Shore
	Special Area of Conservation	Lower River Shannon
	Special Protection Area	River Shannon and River Fergus Estuaries SPA
Relevant Figure Ref:	General Risk - Environment	
1.7 Risk to Cultural Heritage		
	Type	Description
Risk to Sites of Cultural Heritage:	Clare National Monuments	1% AEP Fluvial Flood Extent
		Enclosure, Ballycasey Beg
	NIAH	0.1% AEP Coastal Flood Extent
		Airport terminal, regionally important
Relevant Figure Ref:	General Risk – Cultural Heritage	
1.8 Risk to the Economy		
	Type	Description
Risk to Transport Infrastructure:	Airport	0.1% AEP Coastal Flood Extent
		Shannon Airport
	National Road	20% AEP Fluvial Flood Extent
		N19
	Regional Road	20% AEP Fluvial Flood Extent
		R471
		5% AEP Fluvial Flood Extent
		R472
	Local (Urban) Road	20% AEP Fluvial Flood Extent
		Drumgeely Road
		Ballycasey Grove
		10% AEP Fluvial Flood Extent
		Bothar na Luachra
		5% AEP Fluvial Flood Extent
		Tullyvaraga Road
0.1% AEP Coastal Flood Extent		
Gort Road		
Drumgeely Road		

		Bóthar Sioda
		Bóthar na Luachra
		Bealach Brí
Risk to Utility Infrastructure:	None	N/A
Relevant Figure Ref:	General Risk - Economy	

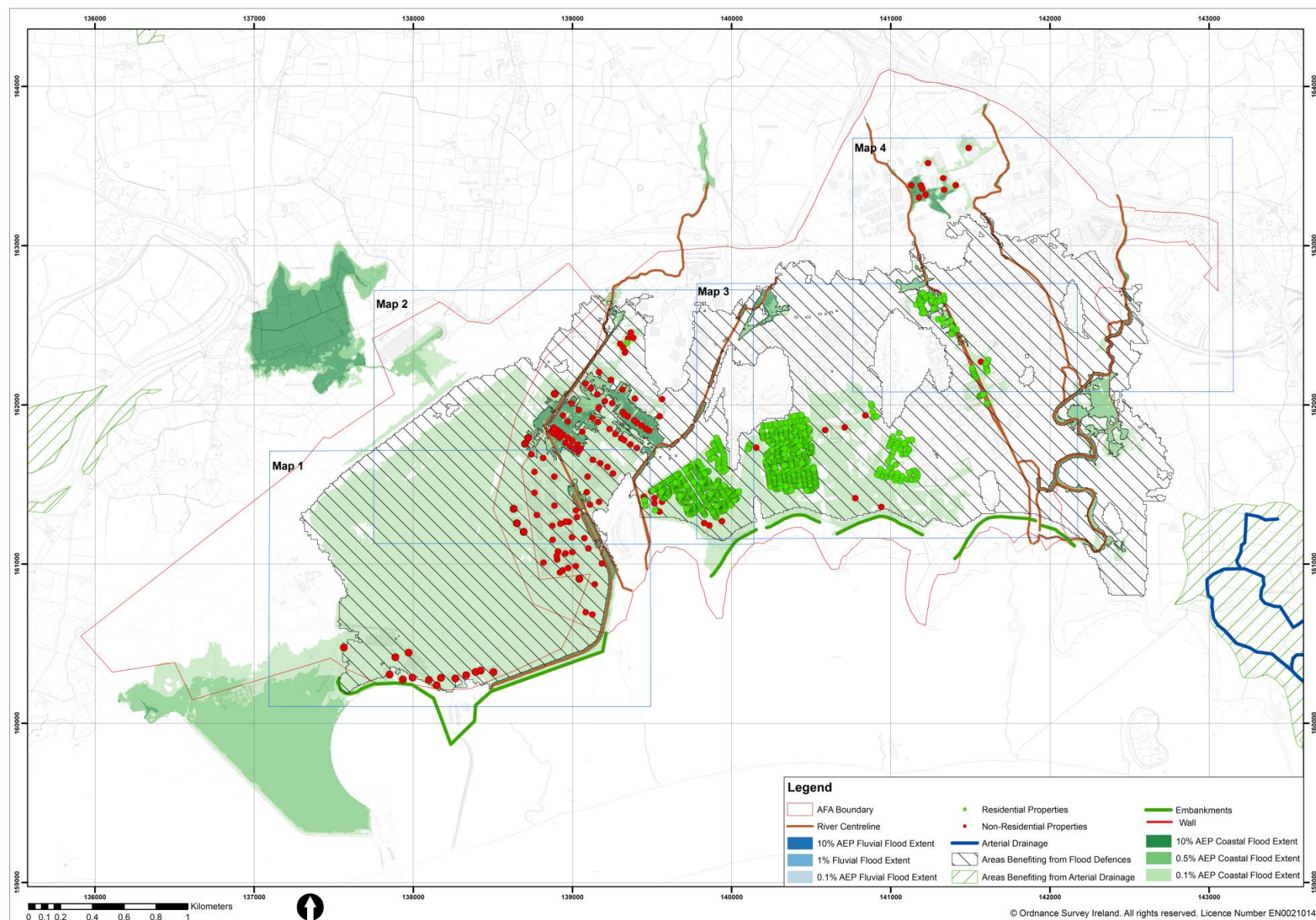


Figure 1.1 – Shannon and Shannon Airport Coastal Flood Risk to Properties - Overview

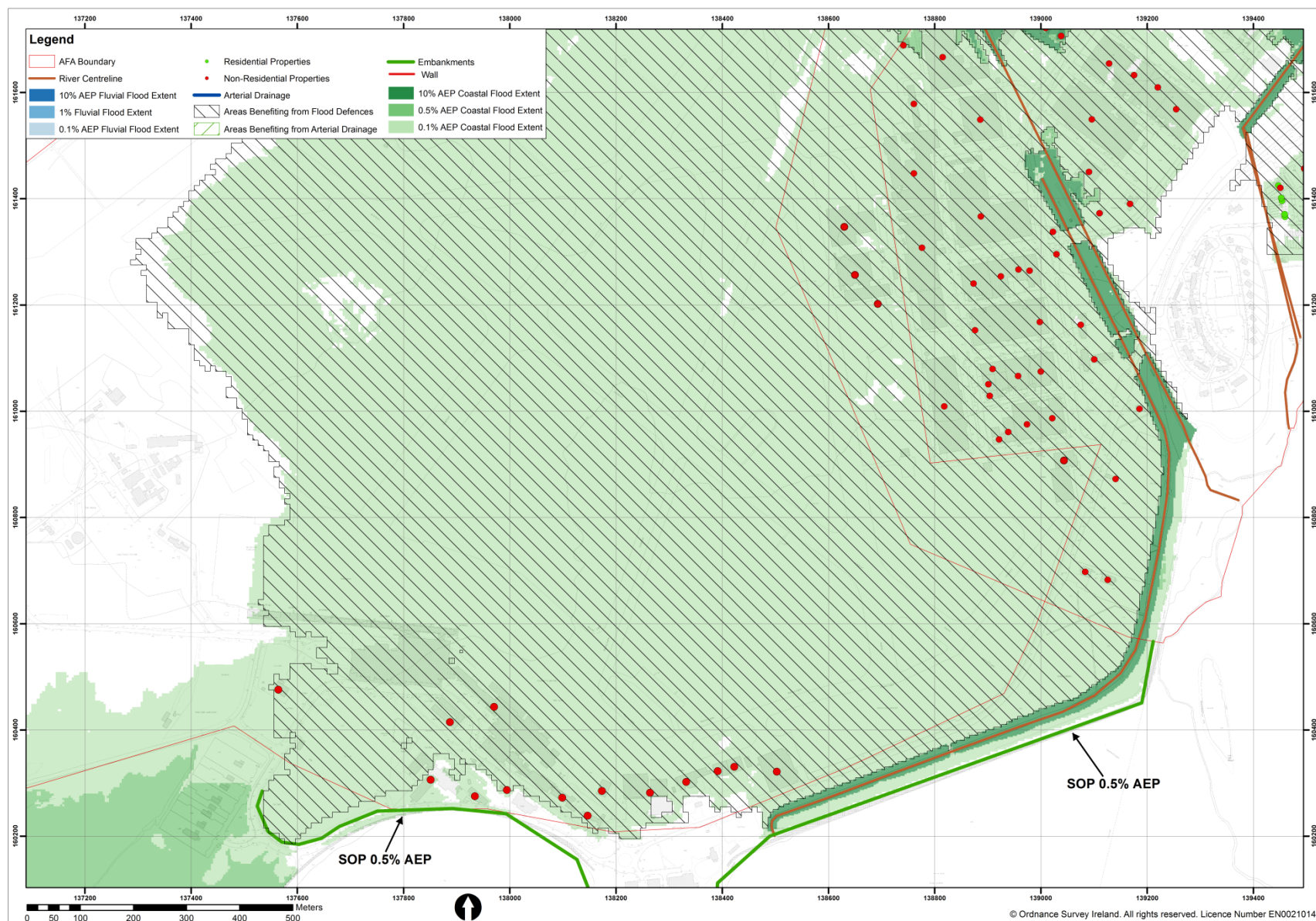


Figure 1.2 – Shannon and Shannon Airport Coastal Flood Risk to Properties - Map1

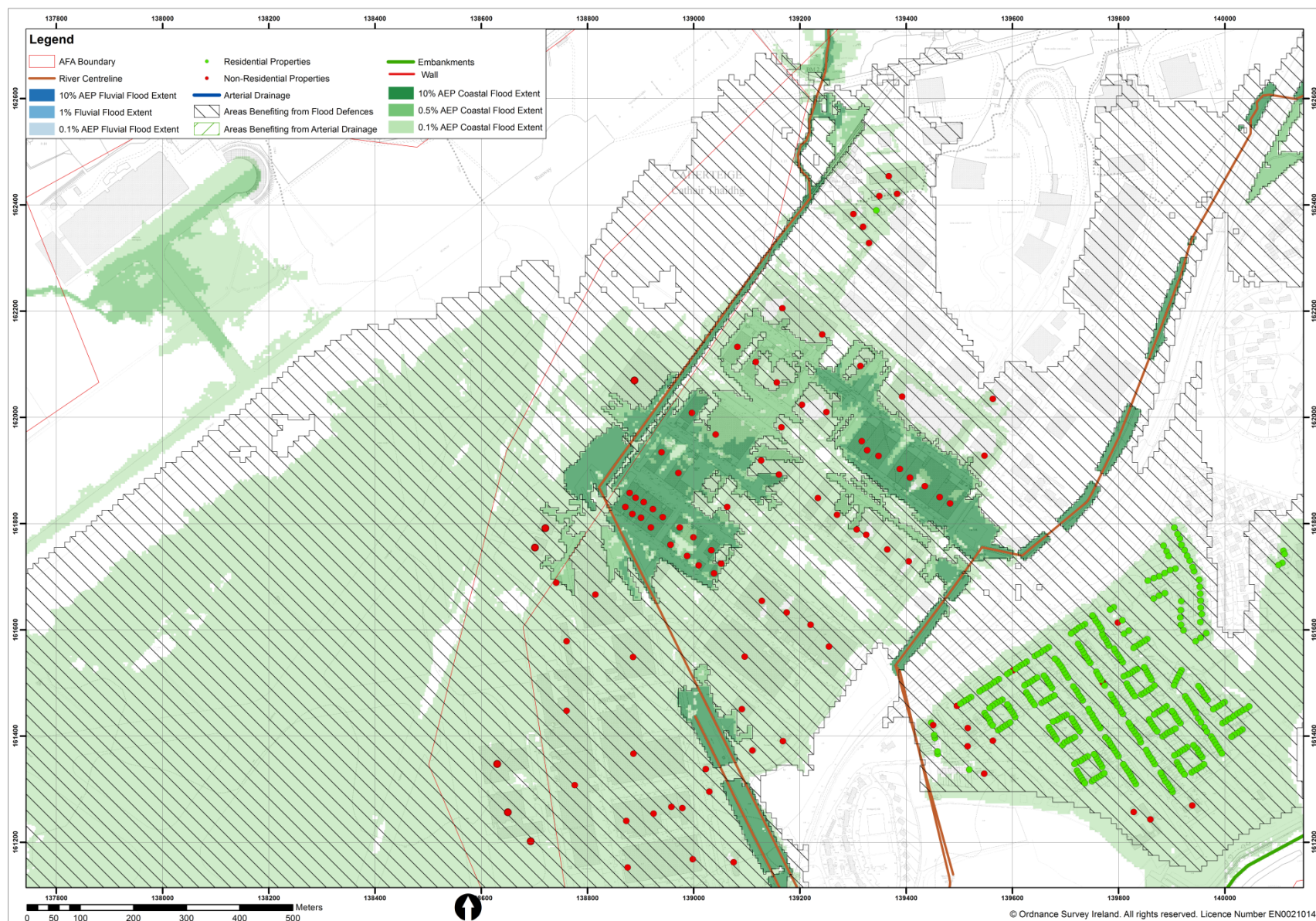


Figure 1.3 – Shannon and Shannon Airport Coastal Flood Risk to Properties - Map2



Figure 1.4 – Shannon and Shannon Airport Coastal Flood Risk to Properties - Map3

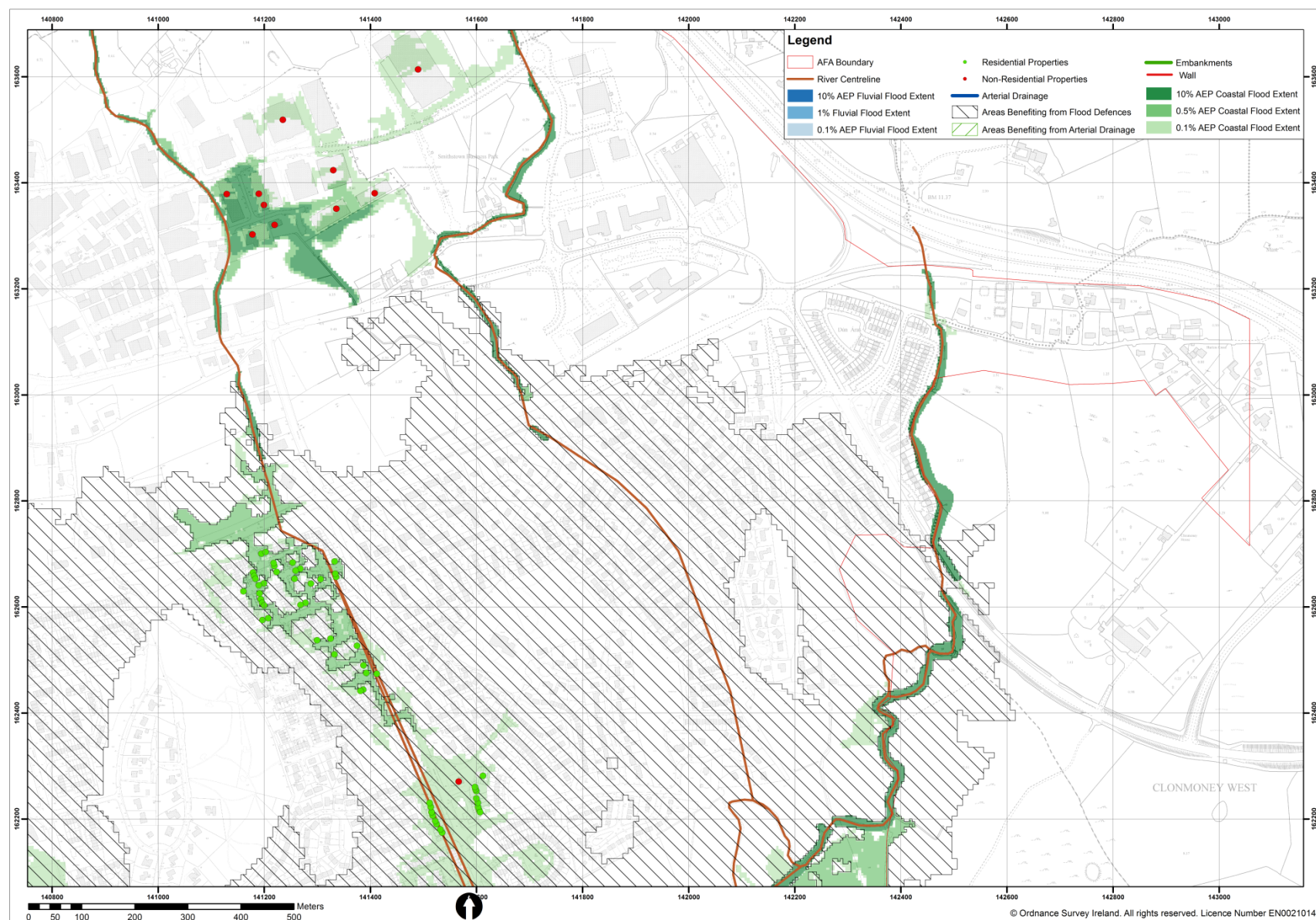


Figure 1.5 – Shannon and Shannon Airport Coastal Flood Risk to Properties - Map4

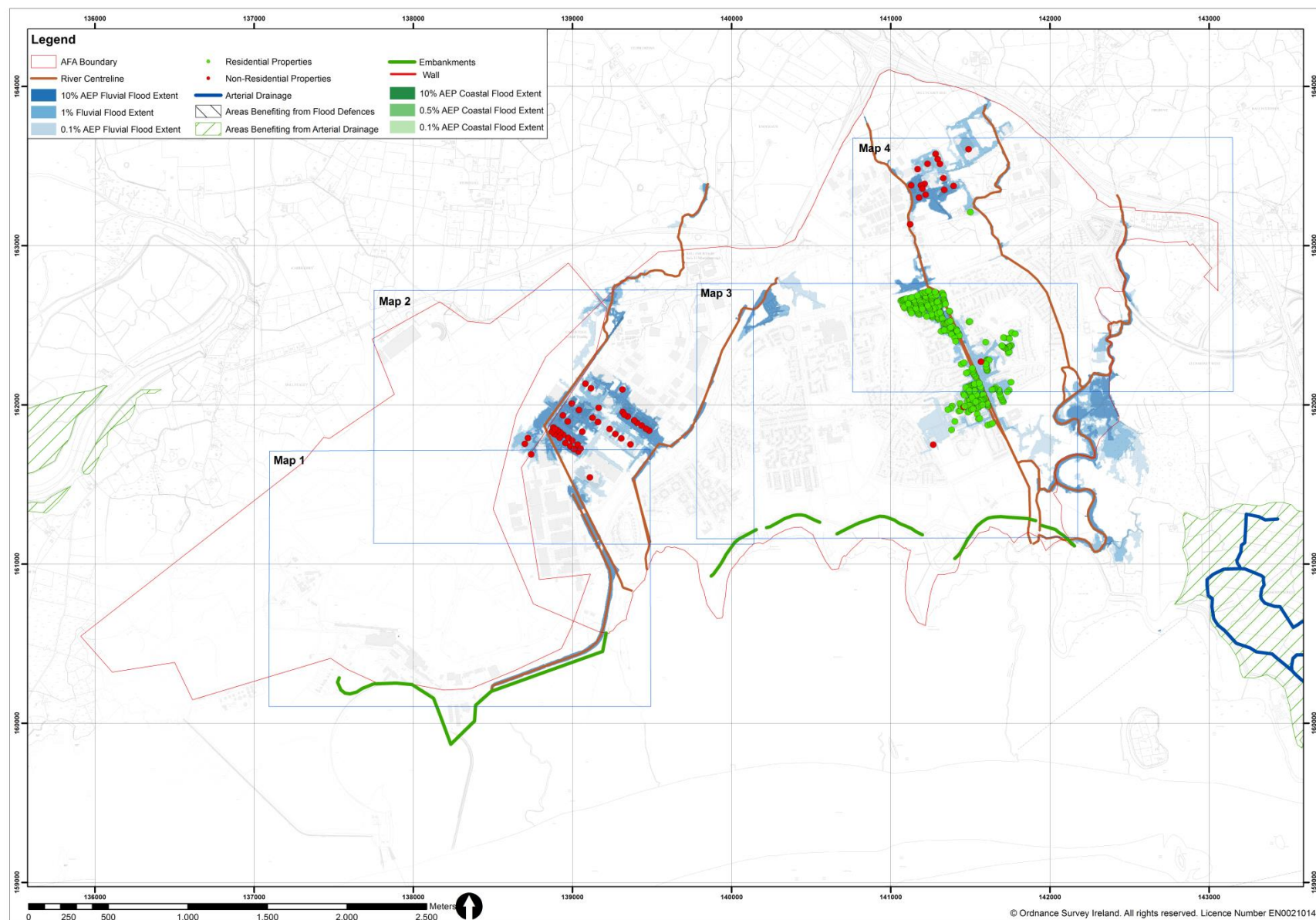


Figure 1.6 – Shannon and Shannon Airport Fluvial Flood Risk to Properties - Overview

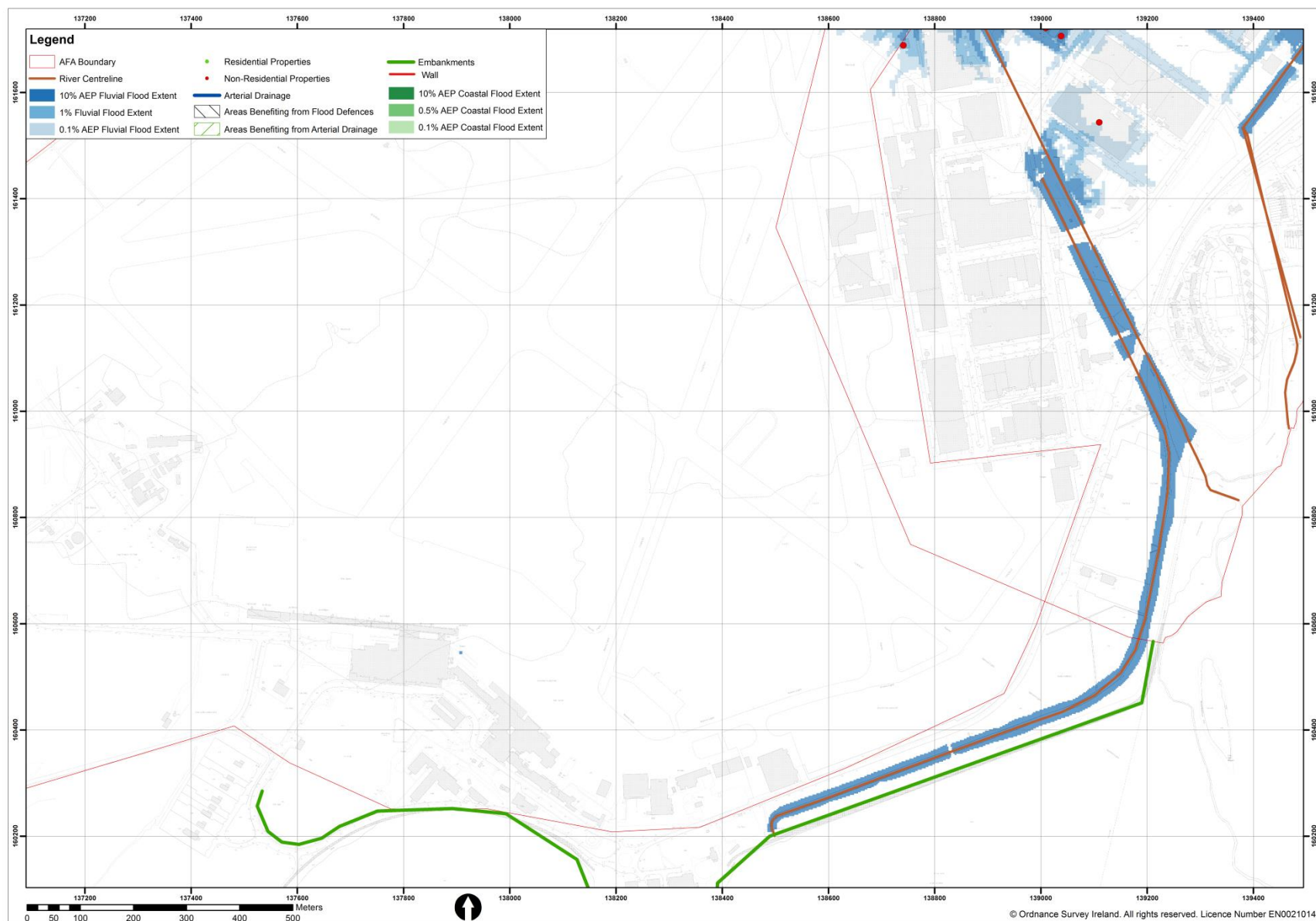


Figure 1.7 – Shannon and Shannon Airport Fluvial Flood Risk to Properties - Map1

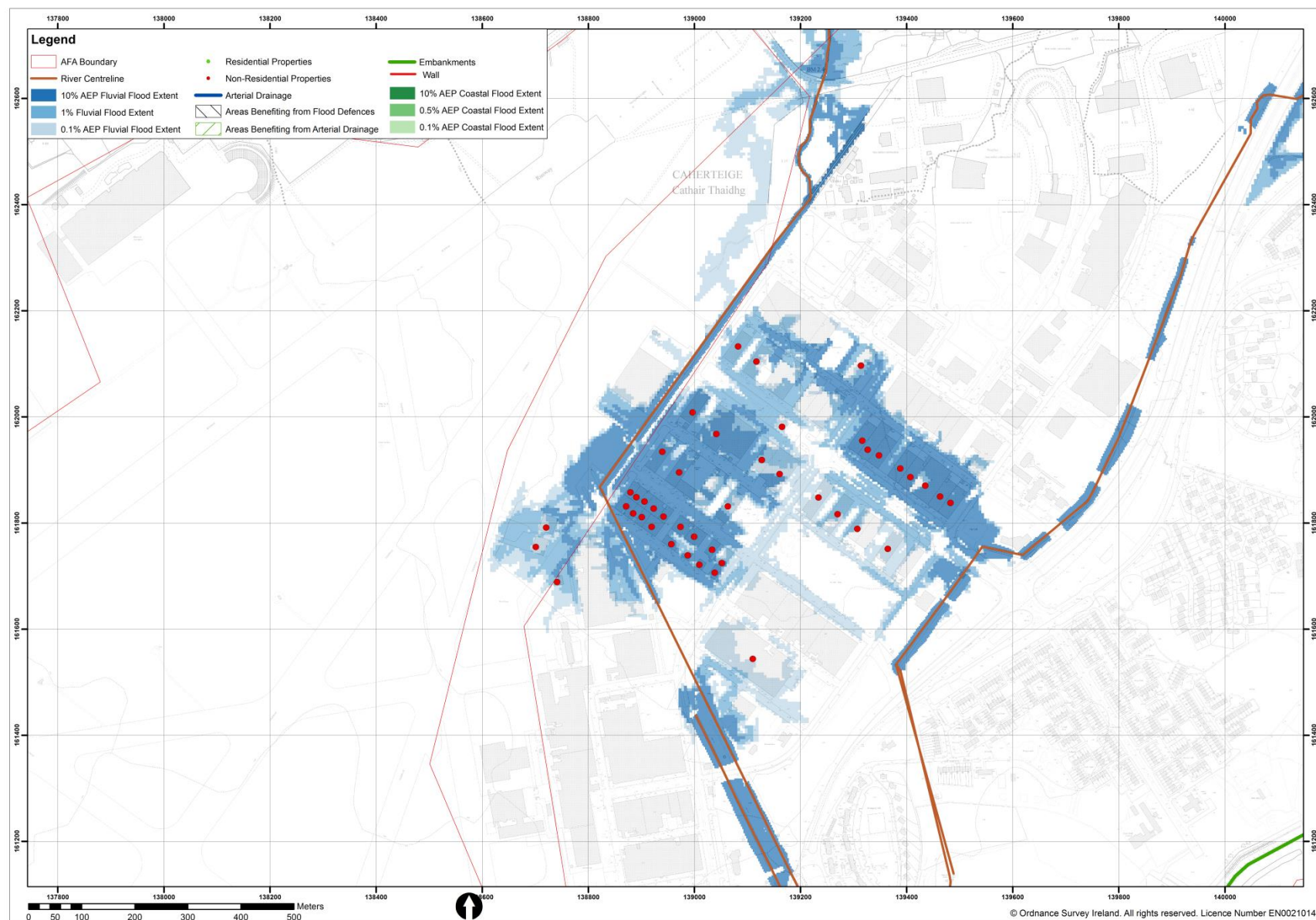


Figure 1.8 – Shannon and Shannon Airport Fluvial Flood Risk to Properties - Map2

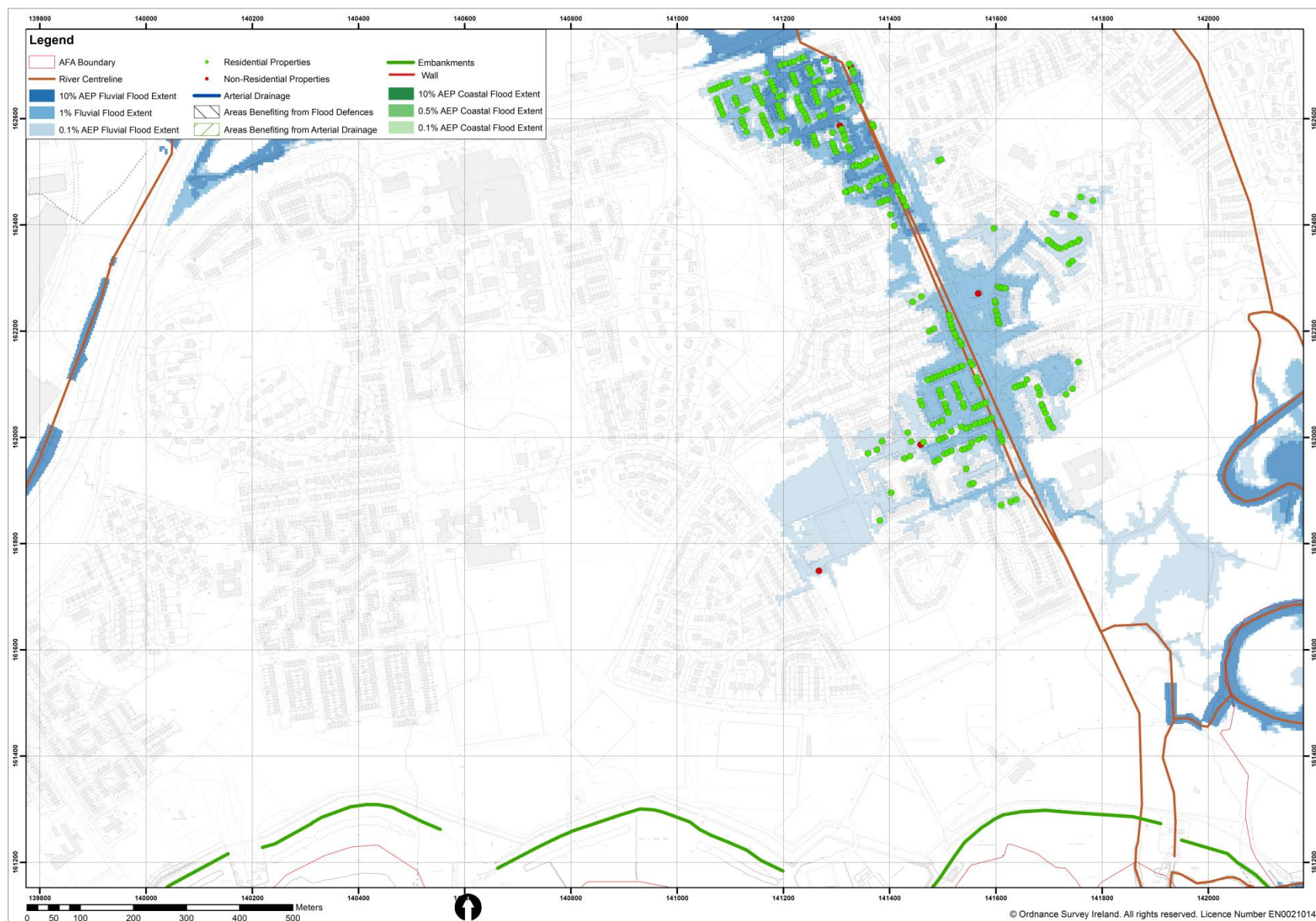


Figure 1.9 – Shannon and Shannon Airport Fluvial Flood Risk to Properties - Map3

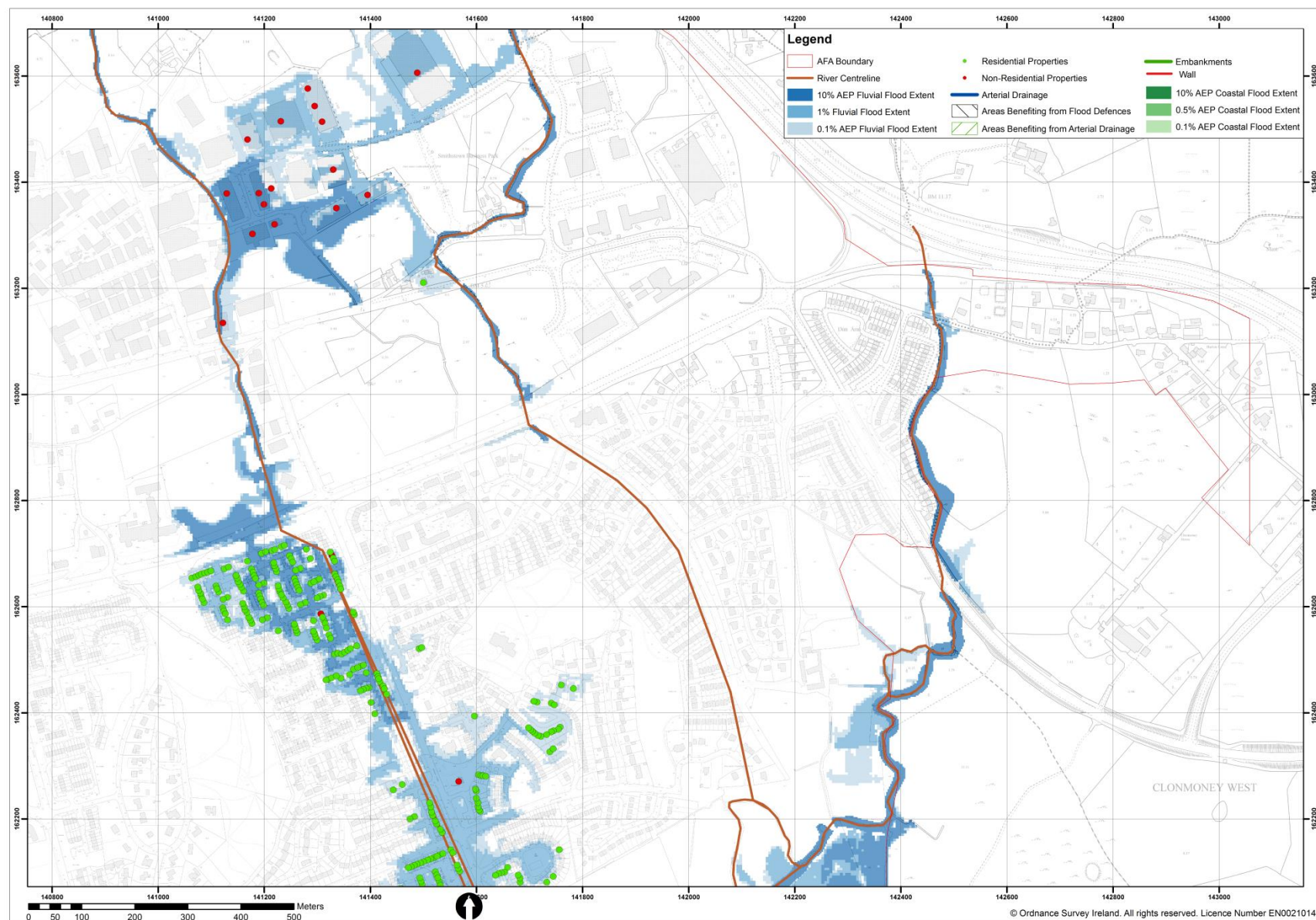


Figure 1.10 – Shannon and Shannon Airport Fluvial Flood Risk to Properties - Map4

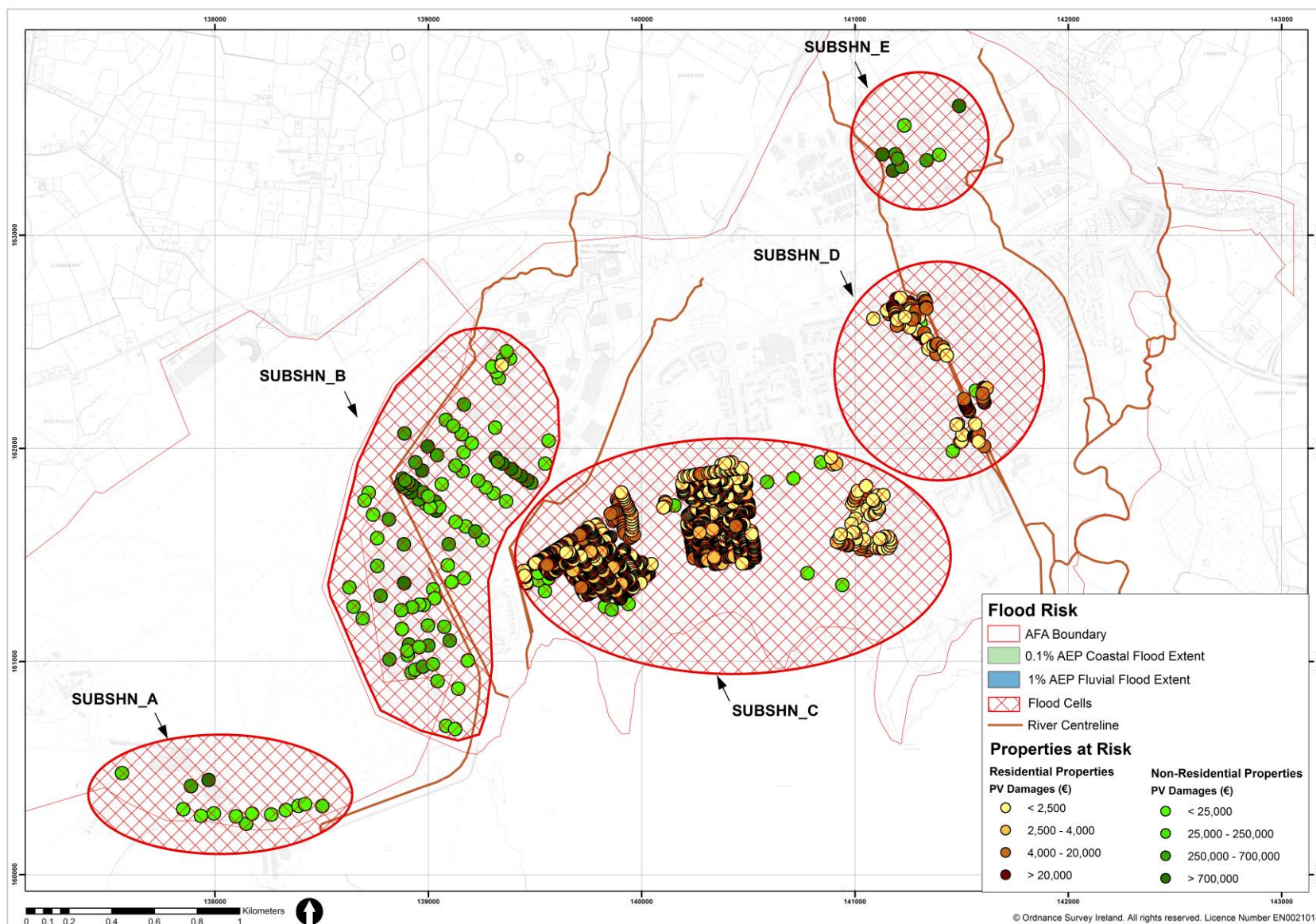


Figure 1.11 – Shannon Town and Airport Total Combined PV Damages for Properties in the 1% Fluvial & 0.1% Coastal AEP Flood Event and Flood Cells. Flood Cells are groupings of properties that are likely to be hydraulically linked.

2. STAGE 2: Screening of the Measures

2.1 Baseline, Structural and Non-Structural Measures

Each Measure has been screened for viability using the following criteria: i) Applicability to Relevant Area; ii) Economic; iii) Environmental; iv) Social; v) Cultural. A Measure needs to be viable for all of the criteria to remain within the process. Failure on any of criteria results in the Measure being screened out.

Measures		Appl.	Econ.	Envir.	Soc.	Cult.	Overall Viability
Baseline							
A	Do Nothing	Unviable	Viable	Viable	Viable	Viable	Screened Out
B	Existing Regime	Viable	Viable	Viable	Viable	Viable	Screened In
C	Do Minimum	Unviable	Viable	Viable	Viable	Viable	Screened Out
Structural							
D	Storage	Viable	Viable	Viable	Viable	Viable	Screened In
E	Flow Diversion	Viable	Viable	Viable	Viable	Viable	Screened In
F	Increase Conveyance	Viable	Viable	Viable	Viable	Viable	Screened In
G	Flood Defences	Viable	Viable	Viable	Viable	Viable	Screened In
H	Relocation of Properties	Unviable	Unviable	Unviable	Unviable	Unviable	Screened Out
I	Other Measures	Unviable	Unviable	Unviable	Unviable	Unviable	Screened Out
Non-Structural							
J	Flood Forecasting / Warning / Response	Viable	Viable	Viable	Viable	Viable	Screened In
K	Public Awareness	Viable	Viable	Viable	Viable	Viable	Screened In
L	Individual Property Resistance	Viable	Viable	Viable	Viable	Viable	Screened In
M	Individual Property Resilience	Viable	Viable	Viable	Viable	Viable	Screened In
2.2 Justification for Screened Out Baseline and Structural Measures							
The following provides justification on Measures with an overall viability 'Screened Out' categorisation.							
A	Do Nothing	Applicability	Economic	Environmental	Social	Cultural	Screened out due to the number of properties currently at risk of flooding.
C	Do Minimum	Applicability	Economic	Environmental	Social	Cultural	Screened out, as the "Do Minimum" FRM measure would have a negligible impact to the existing flood risk.
H	Relocation of Properties	Applicability	Economic	Environmental	Social	Cultural	The relocation of Shannon Airport and 1,172 properties is not applicable to the area as it would be economically, socially and culturally unviable.
I	Other Measures	Applicability	Economic	Environmental	Social	Cultural	No other measures have been identified.

2.3 Summary of 'Screened In' Measures

The following summarises the Measures – both 'Baseline and Structural' and 'Non-structural' which have been Screened In and will be taken forward and used in the Development of Options Phase.

Baseline Measures		Non-Structural Measures	
B	Existing Regime	J	Flood Forecasting / Warning / Response
Structural Measures		M	Public Awareness
D	Storage	L	Individual Property Resistance
E	Flow Diversion	M	Individual Property Resilience
F	Increase Conveyance		
G	Construct Flood Defences		

3 STAGE 3: Selection of Options								
3.1 Consideration of Options The following are the agreed combination of 'Screened In' measures that comprise each of the Options being taken forward for further consideration. Where appropriate, the 'Screened In' measures have been sub-divided into separate specific measures to ensure applicability to site conditions.								
Measures		Different composition of measures per option						
Baseline Measures								
B	Existing Regime	✓						
Structural Measures								
D	Storage							
Di	Online Storage	✓	✓					
Dii	Offline Storage							
Diii	Other Storage	✓	✓					
E	Flow Diversion							
Ei	Full Diversion							
Eii	Flood Relief Channel	✓						
Eiii	Other Diversion							
F	Increase Conveyance							
Fi	Channel Dredging							
Fii	Channel Widening							
Fiii	Structure Enhancement/Works	✓	✓					
G	Flood Defences							
Gi	New Flood Defences	✓	✓					
Gii	Raise Existing Flood Defences							
Giii	Demountable Defences							
Giv	Other Defences							
Non-Structural Measures								
J	Flood Forecasting / Warning / Response							
K	Public Awareness							
L	Individual Property Resistance							
M	Individual Property Resilience							
Option Reference		SUBSHN_01	SUBSHN_02					

Measures not screened out but not included in options		
Measures		Justification
J	Flood Forecasting / Warning / Response	Flood Forecasting was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 0.1% Coastal AEP standard of protection. Flood Forecasting does not improve the viability of the options under consideration.
K	Public Awareness	Public Awareness was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 0.1% Coastal AEP standard of protection. Public Awareness does not improve the viability of the options under consideration.
L	Individual Property Resistance	Individual property resistance was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 0.1% Coastal AEP standard of protection. Individual property resistance does not improve the viability of the options under consideration.
M	Individual Property Resilience	Individual property resilience was not considered as either an independent measure or in combination with other measures, as the options being appraised would provide the required 0.1% Coastal AEP standard of protection. Individual property resilience does not improve the viability of the options under consideration.

4 STAGE 4: Appraisal of Options

4.1 Options Appraisal

Each option taken forward for Multi-Criteria Assessment (MCA) analysis is to be discussed at the Option Development Meeting. Below describes this concept design of each options and provides a summary of any significant comments/issues which were raised by LA staff at the Options Development Meetings. These comments will be considered in the local weightings and the MCA scores.

Option Ref:		SUBSHN_01			
Option Measures	Baseline	B	Existing Regime		
	Structural	Di	Online Storage		
		Diii	Other Storage		
		Eii	Flood Relief Channel		
		Fiii	Structure Enhancement/Works		
		Gi	New Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Option Description:		<p>This option will provide a 0.1% Coastal AEP Design standard to all properties and it will also protect the properties from the 1% Fluvial event.</p> <ul style="list-style-type: none"> Construct new flood defence walls and embankments as shown in Figure 5.1. Diversion of flow, from Unnamed River to a natural storage located between Unnamed River and Ballycasey Creek, north of the R471 Road (see figure 5.1). Two culverts, one north of the Storage area and one under the R471 Road are required. Natural storage areas, balancing pond and flood plain to be located as shown on Figure 5.1. Replace existing 90m culvert as shown on Figure 5.1. Replace existing 35m culvert as shown on Figure 5.1. Construct new coastal defences as shown on Figure 5.1. 			
Option Development Meeting:		Date:	16/09/2015		
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting.		

Option Ref:		SUBSHN_02			
Option Measures	Baseline	B	Existing Regime		
	Structural	Di	Online Storage		
		Diii	Other Storage		
		Fiii	Structure Enhancement/Works		
		Gi	New Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Option Description:		<p>This option will provide a 0.1% Coastal AEP Design standard to all properties and it will also protect the properties from the 1% Fluvial event.</p> <ul style="list-style-type: none"> Construct new flood defence walls and embankments as shown in Figure 5.2. Natural online storage areas, balancing pond and natural flood plain areas to be located as shown on Figure 5.2. Replace existing 90m culvert as shown on Figure 5.2. Replace existing 1500m culvert as shown on Figure 5.2. Replace existing 35m culvert as shown on Figure 5.2. Construct new coastal defences as shown on Figure 5.2. 			
Option Development Meeting:		Date:	16/09/2015		
		Summary:	The Minutes from this meeting are provided in Appendix E. The final options provided in this report have been developed taking into consideration issues raised at the Option Development Meeting		

5 STAGE 5: Multi Criteria Assessment

5.1 Options selected for the Multi Criteria Assessment

Following the Option Development Meeting, the following options are the refined options for the Multi-Criteria Assessment (MCA) stage. This is the final of a five stage MCA process.

Option Reference		SUBSHN_01	SHN_02
Baseline			
B	Existing Regime	Maintain existing coastal defences.	Maintain existing coastal defences.
Structural Measures			
Di	Online Storage	Natural storage areas, balancing pond and flood plain to be located as shown on Figure 5.1.	Natural storage areas to be located as shown on Figure 5.2.
Diii	Other Storage		Balancing pond and natural flood plain areas to be located as shown on Figure 5.2.
Eii	Flood Relief Channel	Diversion of flow, from Unnamed River to a natural storage located between Unnamed River and Ballycasey Creek, north of the R471 Road (see figure 5.1). Floodway to be created by re-profiling the natural ground.	
Fiii	Structure Enhancement/Works	Two culverts, one north of the Storage area and one under the R471 Road are required. Replace existing 90m culvert as shown on Figure 5.1. Replace existing 35m culvert as shown on Figure 5.1.	Replace existing 90m culvert as shown on Figure 5.2. Replace existing 1500m culvert as shown on Figure 5.2. Replace existing 35m culvert as shown on Figure 5.2.
Gi	New Flood Defences	Construct new flood defence walls and embankments as shown in Figure 5.1.	Construct new flood defence walls and embankments as shown in Figure 5.2.
Table reference			
A summary of the outcome from the MCA is presented in the following table		Table 5.1	Table 5.2

Table 5.1: Multi Criteria Assessment Outcome for Option SUBSHN_01

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Shannon and Shannon Airport Sub-Catchment		Option Ref: SUBSHN_01
Option Measures			
Baseline	B	Existing Regime	
Structural	Di	Online Storage	
	Diii	Other Storage	
	Eii	Flood Relief Channel	
	Fiii	Structure Enhancement/Works	
	Gi	New Flood Defences	
Non-Structural	N/A		
Criteria Scores			
Technical		800	
Economic		837	
Social		1021	
Environmental		-779	
Economic Values			
Economic PV Benefits		€ 268,925,432	
PV Cost		€ 39,423,702	
NPV Benefits		€ 229,501,730	
Economic BCR		6.82	
Outcome Scores			
MCA PV Benefits		€ 153,318,516	
MCA Benefit Score		1079	
MCA Benefit Score Ratio		27.36	
Option Selection MCA		1879	
Relevant Figure		Figure 5.1	

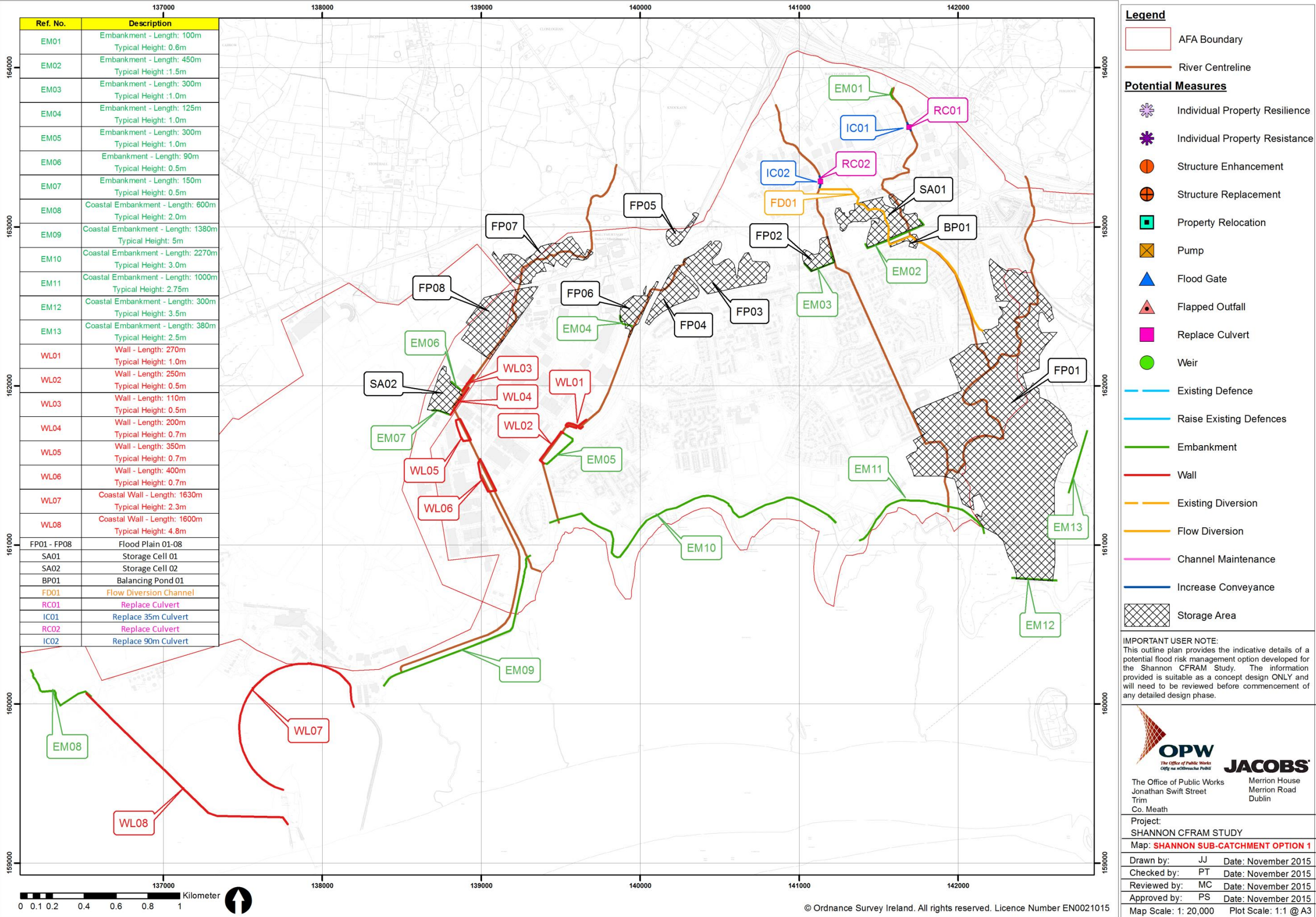


Figure 5.1 Option SUBSHN_01

Table 5.2: Multi Criteria Assessment Outcome for Option SUBSHN_02

Multi Criteria Assessment			
The detailed MCA appraisal process is provided in Appendix F of this Report. The summary MCA Outcome Scores for the defined option is provided in the table below.			
AFA	Shannon and Shannon Airport Sub-Catchment		Option Ref: SUBSHN_02
Option Measures			
Baseline	B	Existing Regime	
Structural	Di	Online Storage	
	Diii	Other Storage	
	Fiii	Structure Enhancement/Works	
	Gi	New Flood Defences	
Non-Structural	N/A		
Criteria Scores			
Technical		560	
Economic		837	
Social		1021	
Environmental		-806	
Economic Values			
Economic PV Benefits		€ 268,925,432	
PV Cost		€ 46,185,365	
NPV Benefits		€ 222,740,067	
Economic BCR		5.82	
Outcome Scores			
MCA PV Benefits		€ 153,318,516	
MCA Benefit Score		1052	
MCA Benefit Score Ratio		22.75	
Option Selection MCA		1612	
Relevant Figure		Figure 5.2	

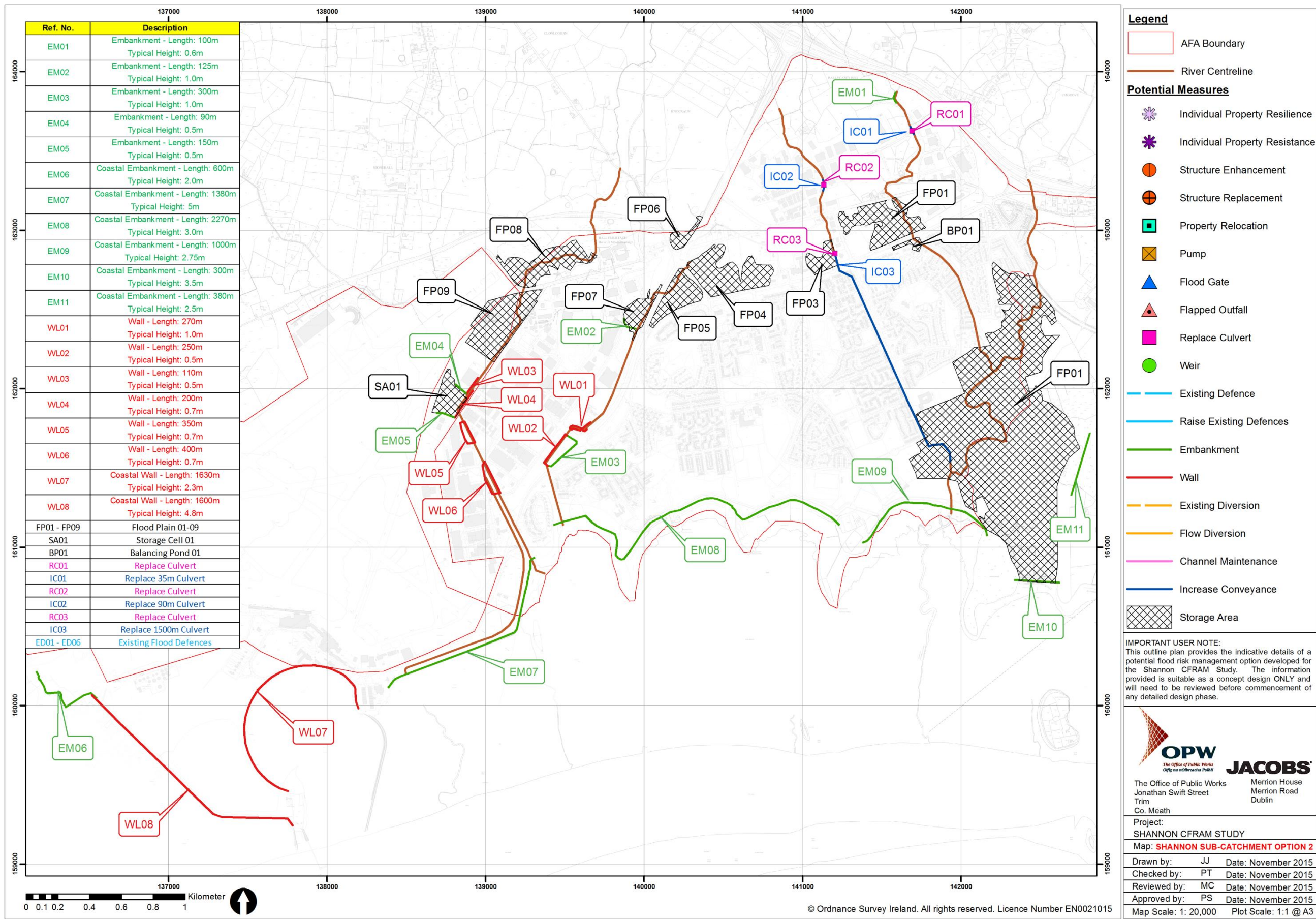


Figure 5.2 Option SUBSHN_02

5.2 Comparison of Multi Criteria Assessment Scores		
Each option taken forward for further consideration through the Option Development Meeting, has been developed into a simple concept design to consider applicability to site. Below describes this concept design and whether through the Option Development Meeting, the option has been recommended suitable for a Multi-Criteria Assessment (MCA).		
Categories	Option Reference and Results	
	SUBSHN_01	SUBSHN_02
Criteria Scores		
Technical	800	560
Economic	837	837
Social	1021	1021
Environmental	-779	-806
Economic Values		
Economic PV Benefits	€ 268,925,432	€ 268,925,432
PV Cost	€ 39,423,702	€ 46,185,365
NPV Benefits	€ 229,501,730	€ 222,740,067
Economic BCR	6.82	5.82
Outcome Scores		
MCA PV Benefits	€ 153,318,516	€ 153,318,516
MCA Benefit Score	1079	1052
MCA BCR	27.36	22.75
Option Selection MCA	1879	1612

5.3 Recommendation of Preferred Option					
<p>It forms part of the CFRAM process for the recommendation of a preferred option for each AFA. The prioritised selection criteria used in this recommendation process is detailed in Section 3.7.3 of the Main Report.</p> <p>Therefore, following the five stage Multi Criteria Assessment process, the preferred option is as outlined below</p>					
Option Ref:		SUBSHN_01			
Option Measures	Baseline	B	Existing Regime		
	Structural	Dii	Offline Storage		
		Eii	Flood Relief Channel		
		Fiii	Structure Enhancement/Works		
		Gi	New Flood Defences		
	Non Structural	J Flood Forecasting	K Public Awareness	L Property Resistance	M Property Resilience
Comments		<p>This option has been designed to protect all properties at risk of flooding in the sub-catchment in the 0.1% AEP coastal event and the 1% Fluvial AEP event.</p> <p>There are no fluvial gauges in Shannon and as such there is uncertainty associated with the predicted fluvial flood risk to the town. It is recommended that gauges are installed and used to calibrate the predicted flood risk before the fluvial FRM are designed.</p> <p>The economic BCR is greater than 1 and the MCA BCR is 27.36 for SUBSHN_01 therefore this is a viable emerging preferred option.</p>			

Annex A - Multi-Criteria Analysis Summary and Whole Life Cost Summaries for FRM Option(s)

CRITERIA		OBJECTIVE		Global Weighting	Local Weighting	Comments	SUBSHN_01				Option Score	Weighted score	SUBSHN_02				Option Score	Weighted Score				
							B	Existing Regime					B	Existing Regime								
							Di	Online Storage			Di	Online Storage										
							Diii	Other Storage			Diii	Other Storage										
							Eii	Flood Relief Channel			Fiii	Structure Enhancement / Works										
							Fiii	Structure Enhancement / Works			Gi	New Flood Defences										
							Gi	New Flood Defences														
1	Technical	a	Ensure flood risk management options are operationally robust	20	5.00	The option scores are determined based on the level of operational risk to operate or perform successfully. Each measure is scored independently and the average of the measure scores is used as the score for the option.	No risks	Manageable	B	5.00	4.33	433	No risks	Manageable	B	5.00	4.20	420				
									Di	3.00					Di	3.00						
							Negligible	Moderate / high	Diii	4.00			Negligible	Moderate / high	Diii	4.00						
									Eii	5.00					Fiii	5.00						
							Very low	High	Gi	4.00			Very low	High	Gi	4.00						
							Low	Failure likely					Low	Failure likely								
							Low / moderate	Unacceptable					Low / moderate	Unacceptable								
b		Minimise health and safety risks associated with the construction and operation of flood risk management options	20	5.00	H&S risks are considered for construction and maintenance of flood risk management measures. The indicative aspirational score is set at five, with a point then deducted for each specific H&S risk in either construction or maintenance.	No risks	Moderate	Work near/in water		No risks	Moderate	Work near/in water		-1.00	-100							
						Negligible	Moderate / high	Work near services or buildings		Negligible	Moderate / high	Deep or complex excavations										
						Very low	High			Very low	High											
						Low	Very High			Low	Very High											
						Low / moderate	Unacceptable			Low / moderate	Unacceptable											
c		Ensure flood risk management options are adaptable to future flood risk	20	5.00	The options scores are determined based on the sustainability and adaptability of the flood risk management measures in the face of potential future changes, including the potential impact of climate change. Each measure is scored independently and the average of the measure scores is used as the score for the option.	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.		B	2.00	Option can be adapted at negligible to limited cost and difficulty, and provides no impediment to future interventions.		B	2.00	2.40	240							
							Di	3.00		Di	3.00											
							Diii	3.00		Diii	3.00											
						Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.		Eii	2.00	Option can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.		Fiii	1.00									
							Fiii	3.00		Gi	3.00											
						Impediment to future interventions.				Impediment to future interventions.												
						Option cannot be adapted, but provides no to minor impediment to potential future interventions.				Option cannot be adapted, but provides no to minor impediment to potential future interventions.												
	Option cannot be adapted, and provides moderate to major impediment to potential future interventions.								Option cannot be adapted, and provides moderate to major impediment to potential future interventions.													
	TECHNICAL CRITERIA SCORE											800										
	2					Economic	a	Minimise economic risk	24	5.00		The score is calculated based on the reduction in AAD, following the full implementation of option.				4.94	593	The score is calculated based on the reduction in AAD, following the full implementation of option.		4.94	593	
b		Minimise risk to transport infrastructure	10	5.00			Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.		4.88	244	Scoring is based on the reduction in flood risk to transport routes, following the full implementation of option.		4.88	244								
c		Minimise risk to utility infrastructure	14	0.00			No risk to utility infrastructure in the existing scenario.		0.00	0	No risk to utility infrastructure in the existing scenario.		0.00	0								
d	Minimise risk to agriculture	12	1.19		Comments		Both Fresh & Salt Water	Area of Agricultural Land Flooded	No Change	Area of Agricultural Land Flooded	No Change	0.00	0									
					Percentage of AFA that is rural land		23.78%	Frequency & Seasonality of Flooding	No Change	Frequency & Seasonality of Flooding	No Change											
								Duration of Flooding	No Change	Duration of Flooding	No Change											
								Risk to Agricultural Infrastructure	No Change	Risk to Agricultural Infrastructure	No Change											
								Flood Warning	Not Applicable	Flood Warning	Not Applicable											
							Agricultural Production Enhanced	No Change	Agricultural Production Enhanced	No Change												
							Other (Please Specify)	Not Applicable	Other (Please Specify)	Not Applicable												
ECONOMIC CRITERIA SCORE											837											
3	Social	a i)	Minimise risk to human health and life - Residents	27.00	5.00		Flood Depths & Velocities	Medium to high risk to life	4.60	621	The baseline conditions are assumed to apply to this option. The option score is assessed based on the reduction in flooding of residential properties.		4.60	621								
							Known Areas of Highly Vulnerable People	Reasonable Cross Section of Society														
		a ii)	Minimise risk to human health and life - High vulnerability properties	17.00	0.20		Rate of Onset of flooding	Significantly Greater Rate of Onset	5.00	17	The baseline conditions are assumed to apply to this option. The score is assessed based on the reduction in flooding of high vulnerability flooding.		5.00	17								
		b i)	Minimise risk to community - Social Infrastructure & Amenity	9.00	0.18		Assets of Particular Social Value	Yes	5.00	8	The option score is based on the reduction in flood risk to social infrastructure assets, following the full implementation of option.		5.00	8								
b ii)		Minimise risk to community - Local employment	7.00	5.00		Asset of Particular Employment Value	Yes	4.98	174	The option score is calculated based on the reduction in flood risk to social infrastructure assets, following the full implementation of the option.		4.98	174									
SOCIAL CRITERIA SCORE											820											
4		Environmental	a	Support the objectives of the WFD	16	5.00	There are six waterbodies within the AFA. The WFD status for waterbodies sampled by the EPA ranges from good to high. There are 2 polluting sources within or partly within the 0.5% AEP Coastal and 1% AEP Fluvial. There are a number of Annex IV areas within the AFA. There are 3 SPA/SAC waterbodies including the Shannon Estuary and 2 salmonid waterbodies. Local weighting to be applied for this objective is constant, and should always be set equal to 5 as WFD objectives must be achieved and are relevant to all waterbodies.	5 of the 6 pollution sources will potentially be removed from the 0.1% AEP Coastal/Fluvial. One IPPC facility will remain partially within the flood extent.		-2.00	-160	5 of the 6 pollution sources will potentially be removed from the 0.1% AEP Coastal/Fluvial. One IPPC facility will remain partially within the flood extent.		-2.50	-200							
	Construction related impacts due to significant construction works in and adjacent to watercourses including construction of walls, embankments, storage options, balancing ponds, culvert replacement and flow diversion channels.							Construction related impacts due to significant construction works in and adjacent to watercourses including construction of walls, embankments, storage options, balancing ponds, culvert replacement and flow diversion channels.														
	Permanent impact related to flow diversion channels, storage areas and replacement of natural banks with flood defence walls. All these measures could cause potential changes to the hydrological and morphological regime of the watercourses.							Permanent impact related to flow diversion channels, storage areas and replacement of natural banks with flood defence walls. All these measures could cause potential changes to the hydrological and morphological regime of the watercourses.														
	b		Support the objectives of the Habitats Directive	10	5.00	The Lower Shannon cSAC [002165] is within the AFA. Lough Gash Turlough cSAC [000051] is located c. 5 km from the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] is within the AFA. Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (e.g. SCA/SPA/Ramsar) is present (within AFA) and potentially affected.	Potential significant effects are related to works within the boundary of the Lower River Shannon cSAC and River Shannon and River Fergus Estuary SPA in relation to construction of a flood embankments and sea walls. However, it is noted in relation to the proposed embankment works within the designated areas much of these are increasing existing embankments and are highly unlikely to be qualifying habitat.		-5.00	-250	Potential significant effects are related to works within the boundary of the Lower River Shannon cSAC and River Shannon and River Fergus Estuary SPA in relation to construction of a flood embankments and sea walls. However, it is noted in relation to the proposed embankment works within the designated areas much of these are increasing existing embankments and are highly unlikely to be qualifying habitat.		-5.00	-250								
							There are also significant construction works proposed to improve/replace culverts, provide a flow diversion channel, provide wall and embankments. Due to the proximity to the cSAC and SPA there is the potential for significant effects				There are also significant construction works proposed to improve/replace culverts, provide a flow diversion channel, provide wall and embankments. Due to the proximity to the cSAC and SPA there is the potential for significant effects											
							Potentially significant effects during construction are: - Pollution risks to the cSAC/SPA - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC. Therefore a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.				Potentially significant effects during construction are: - Pollution risks to the cSAC/SPA - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC. Therefore a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.											
	c		Avoid damage to, and where possible enhance, the flora and fauna of the catchment	5	5.00	The River Estuary and Inner Shannon Estuary - North Shore pNHA [002048] is within the sub catchment. Lough Gash Turlough pNHA [000051], Ballycar Lough pNHA [000015] and Inner Shannon Estuary - South Shore pNHA [000435] are within c. 6 km from the sub catchment. Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc.) is present (within the sub catchment) and potentially affected.	Potential significant effects are related to works within the boundary of the Inner Shannon, North Shore pNHA in relation to works on the existing flood defence earth embankments.		-5.00	-125	Potential significant effects are related to works within the boundary of the Inner Shannon, North Shore pNHA in relation to works on the existing flood defence earth embankments.		-5.00	-125								
							Potential impacts include: - Pollution risks to the pNHA - Disturbance to protected species Therefore, a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.				Potential impacts include: - Pollution risks to the pNHA - Disturbance to protected species Therefore, a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.											
	d		Protect, and where possible enhance, fisheries resource within the catchment	13	2.00	The Shannon Estuary North 1 Cleagh and Shannon Estuary North 1 Drumlinae are designated as a Salmonid river. There is Medium angling activity in the area. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.	Construction works adjacent to and in the waterbodies may impact water quality and cause access issues. Part of the natural banks will be replaced by walls on the WFD Salmonid waterbodies. Operational impact may include changes to angling access or locations. Therefore, a potential for permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.		-5.00	-130	Construction works adjacent to and in the waterbodies may impact water quality and cause access issues. Part of the natural banks will be replaced by walls on the WFD Salmonid waterbodies. Operational impact may include changes to angling access or locations. However, no flow diversion for this option. Therefore, a potential for permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.		-4.50	-117								
e	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	8	3.00	Working landscape, Vulnerable Landscape and Heritage Landscape as designated within Clare County Council Development Plan 2011 fall within 1% AEP Fluvial & the 0.5% AEP Coastal. The Estuary Walk, West Shannon, Estuary Walk East Shannon and Free Zone / Estuary Walkway Shannon are local walking trails along the Shannon Estuary within the AFA but outside the 1% AEP Fluvial & the 0.5% AEP Coastal. Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are landscape character types designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected.	Construction related impacts and replacement of natural banks with flood walls and the creation of embankments. Construction related impacts due to construction works associated with, storage options, balancing ponds, culvert replacement and flow diversion channels. Some of which are in the vicinity of designated landscape features; the heritage landscape and the walkways. Permanent impact on high value landscape character/feature in the zone of influence of the selected measure.		-5.00	-120	Construction related impacts and replacement of natural banks with flood walls and the creation of embankments. Construction related impacts due to construction works associated with, storage options, balancing ponds, culvert replacement and flow diversion channels. Some of which are in the vicinity of designated landscape features; the heritage landscape and the walkways. Permanent impact on high value landscape character/feature in the zone of influence of the selected measure.		-5.00	-120										
f i)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of architectural value	4	2.00	Shannon is not a heritage town. There is one protected feature of architectural value within the sub catchment; an NIAH/RPS: Shannon Airport. This is at risk in the 0.1%AEP Fluvial/Coastal. Local weighting of 2 set by professional judgement. Weighting of 2 applied where a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.	The Shannon NIAH/RPS will no longer be at risk in the 0.1%AEP Fluvial/Coastal. Potential for changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is slightly changed. Therefore, overall a potential increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.		0.50	4	The Shannon NIAH/RPS will no longer be at risk in the 0.1%AEP Fluvial/Coastal. Potential for changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is slightly changed. Therefore, overall a potential increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.		0.50	4										
f ii)	Avoid damage to or loss of features of cultural heritage importance and their setting - loss of archaeological value	4	1.00	Shannon is not a heritage town. There are 2 RMPs within or partially within the 0.1% AEP Fluvial/Coastal within the sub catchment. Local weighting of 1 set by professional judgement. Weighting of 1 applied where there is limited potential for effects on archaeological features and their setting.	2 RMPs will potentially be removed from the 0.1% AEP Fluvial/Coastal within the sub catchment. Potential impacts to the setting of one RMP due to embankments. Therefore, overall a potential to change the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.		0.50	2	2 RMPs will potentially be removed from the 0.1% AEP Fluvial/Coastal within the sub catchment. Potential impacts to the setting of one RMP due to embankments. Therefore, overall a potential to change the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.		0.50	2										
ENVIRONMENTAL CRITERIA SCORE											-779											
Economic Values	Economic PV Benefits								€268,925,432			€268,925,432										
	Cost								€39,423,702			€46,237,655										
	NPV Benefits								€229,501,730			€222,687,777										
	Economic BCR								6.82			5.82										
Outcome Scores	MCA PV Benefits								€153,318,516			€153,318,516										
	MCA Benefit Score								878			851										
	MCA BCR								22.28			18.41										
	Option Selection MCA								1678			1411										

Objective	Global Weightings (fixed)	Local Weightings		Baseline Comments	Option 1 Comments	Option 2 Comments
1.A	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.	This score is determined for this option as it has negligible operational risks to operate or perform successfully.
1.B	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it has low/moderate health and safety risks associated with the construction and operation of flood risk management option.	This score is determined for this option as it has moderate/high health and safety risks associated with the construction and operation of flood risk management option.
1.C	20	5.00	fixed	Local weighting is fixed.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.	This score is determined for this option as it can be adapted only at moderate to significant cost and difficulty, but provides no impediment to future interventions.
2.A	24	5.00	calculated	Local weighting is calculated based on the baseline AAD.	This score is calculated based on the reduction in AAD, following the full implementation of option.	This score is calculated based on the reduction in AAD, following the full implementation of option.
2.B	10	5.00	calculated but adjusted by professional judgement	Local weighting is calculated based on the baseline risk to transport infrastructure. Local weighting capped at maximum of 5.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.	This score is calculated based on the reduction in flood risk to transport routes, following full implementation of option.
2.C	14	0.00	calculated but adjusted by professional judgement	There is no risk to utility infrastructure within this AFA.	There is no risk to utility infrastructure within this AFA.	There is no risk to utility infrastructure within this AFA.
2.D	12	0.00	Professional judgement	Local weighting is calculated based on the percentage of rural land within the AFA.	This option has no effect on agriculture.	This option has no effect on agriculture.
3.A (i)	27	5.00	calculated but adjusted by professional judgement	Local weighting is calculated based on the baseline risk to residential properties. Local Weighting is capped at a maximum value of 5.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.	This score is calculated based on a reduction in flooding to residential properties, following full implementation of the option.
3.A (ii)	17	0.20	calculated but adjusted by professional judgement	There are no high vulnerability properties at risk.	There are no high vulnerability properties at risk.	There are no high vulnerability properties at risk.
3.B (i)	9	0.18	calculated but adjusted by professional judgement	Local weighting is calculated based on the baseline risk to social infrastructure. Local Weighting is capped at a maximum value of 5.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.	This score is calculated based on a reduction in flood risk to social infrastructure assets, following full implementation of the option.
3.B (ii)	7	5.00	calculated but adjusted by professional judgement	Local weighting is calculated based on the baseline risk to local employment. The local weighting is capped at the maximum value of 5.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.	This score is calculated based on the reduction in flood risk to assets of local employment, following full implementation of the option.
4.A	16	5.00	fixed	<p>The Lower Shannon cSAC [002165] is within the AFA. Lough Gash Turlough cSAC [000051] is located c. 5 km from the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] is within the AFA.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SCA/SPA/Ramsar) is present (within AFA) and potentially affected.</p>	<p>5 of the 6 pollution sources will potentially be removed from the 0.1% AEP Coastal/Fluvial. One IPPC facility will remain partially within the flood extent.</p> <p>Construction related impacts due to significant construction works in and adjacent to watercourses including construction of walls, embankments, storage options, balancing ponds, culvert replacement and flow diversion channels.</p> <p>Permanent impact related to flow diversion channels, storage areas and replacement of natural banks with flood defence walls. All these measures could cause potential changes to the hydrological and morphological regime of the watercourses.</p> <p>Overall a potential short-term or intermittent impediment to the achievement of waterbody objectives.</p>	<p>5 of the 6 pollution sources will potentially be removed from the 0.1% AEP Coastal/Fluvial. One IPPC facility will remain partially within the flood extent.</p> <p>Construction related impacts due to significant construction works in and adjacent to watercourses including construction of walls, embankments, storage options, balancing ponds, culvert replacement and flow diversion channels.</p> <p>Permanent impact related to flow diversion channels, storage areas and replacement of natural banks with flood defence walls. All these measures could cause potential changes to the hydrological and morphological regime of the watercourses.</p> <p>Overall a potential short-term or intermittent impediment to the achievement of waterbody objectives.</p>
4.B	10	5.00	Professional judgement	<p>The Lower Shannon cSAC [002165] is within the AFA. Lough Gash Turlough cSAC [000051] is located c. 5 km from the AFA. The Rivers Shannon and River Fergus Estuaries SPA [004077] is within the AFA.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where an internationally important site (e.g. SCA/SPA/Ramsar) is present (within AFA) and potentially affected.</p>	<p>Potential significant effects are related to works within the boundary of the Lower River Shannon cSAC and River Shannon and River Fergus Estuary SPA in relation to construction of a flood embankments and sea walls. However, it is noted in relation to the proposed embankment works within the designated areas much of these are increasing existing embankments and are highly unlikely to be qualifying habitat.</p> <p>There are also significant construction works proposed to improve/replace culverts, provide a flow diversion channel, provide wall and embankments. Due to the proximity to the cSAC and SPA there is the potential for significant effects</p> <p>Potentially significant effects during construction are:</p> <ul style="list-style-type: none"> - Pollution risks to the cSAC/SPA - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC. <p>Therefore a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>	<p>Potential significant effects are related to works within the boundary of the Lower River Shannon cSAC and River Shannon and River Fergus Estuary SPA in relation to construction of a flood embankments and sea walls. However, it is noted in relation to the proposed embankment works within the designated areas much of these are increasing existing embankments and are highly unlikely to be qualifying habitat.</p> <p>There are also significant construction works proposed to improve/replace culverts, provide a flow diversion channel, provide wall and embankments. Due to the proximity to the cSAC and SPA there is the potential for significant effects</p> <p>Potentially significant effects during construction are:</p> <ul style="list-style-type: none"> - Pollution risks to the cSAC/SPA - Disturbance to bird species within and outside the SPA - Disturbance to otter within and outside the cSAC. <p>Therefore a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>
4.C	5	5.00	Professional judgement	<p>The River Estuary and Inner Shannon Estuary - North Shore pNHA [002048] is within the sub catchment .Lough Gash Turlough pNHA [000051], Ballycar Lough pNHA [000015] and Inner Shannon Estuary - South Shore pNHA [000435] are within c. 6 km from the sub catchment.</p> <p>Local weighting of 5 set by professional judgement. Weighting of 5 applied where a nationally important site (pNHA, NHA etc.) is present (within the sub catchment) and potentially affected.</p>	<p>Potential significant effects are related to works within the boundary of the Inner Shannon, North Shore pNHA in relation to works on the existing flood defence earth embankments.</p> <p>Potential impacts include:</p> <ul style="list-style-type: none"> - Pollution risks to the pNHA - Disturbance to protected species <p>Therefore, a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>	<p>Potential significant effects are related to works within the boundary of the Inner Shannon, North Shore pNHA in relation to works on the existing flood defence earth embankments.</p> <p>Potential impacts include:</p> <ul style="list-style-type: none"> - Pollution risks to the pNHA - Disturbance to protected species <p>Therefore, a potential detrimental impact upon the condition of existing national, regional or local sites as a result of flood risk management measures, where suitable mitigation measures are technically feasible.</p>
4.D	13	2.00	Professional judgement	<p>The Shannon Estuary North 1 Clenagh and Shannon Estuary North 1 Drumline are designated as a Salmonid river. There is Medium angling activity in the area.</p> <p>Local weighting of 2 set by professional judgement. Weighting of 2 applied where a waterbody supports fisheries/shellfisheries and is of local value for fishing/angling.</p>	<p>Construction works adjacent to and in the waterbodies may impact water quality and cause access issues. Part of the natural banks will be replaced by walls on the WFD Salmonid waterbodies. Operational impact may include changes to angling access or locations.</p> <p>Therefore, a potential for permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.</p>	<p>Construction works adjacent to and in the waterbodies may impact water quality and cause access issues. Part of the natural banks will be replaced by walls on the WFD Salmonid waterbodies. Operational impact may include changes to angling access or locations. However, no flow diversion for this option.</p> <p>Therefore, a potential for permanent loss or removal of fisheries habitat and / or introduction of barriers to upstream migration.</p>
4.E	8	3.00	Professional judgement	<p>Working landscape, Vulnerable Landscape and Heritage Landscape as designated within Clare County Council Development Plan 2011 fall within 1% AEP Fluvial & the 0.5% AEP Coastal.</p> <p>The Estuary Walk West Shannon, Estuary Walk East Shannon and Free Zone / Estuary Walkway Shannon are local walking trails along the Shannon Estuary within the AFA but outside the 1% AEP Fluvial & the 0.5% AEP Coastal.</p> <p>Local weighting of 3 set by professional judgement. Weighting of 3 applied where there are landscape character types designated at a county level as moderate sensitivity and/or medium value; protected views present that could be affected.</p>	<p>Construction related impacts and replacement of natural banks with flood walls and the creation of embankments. Construction related impacts due to construction works associated with, storage options, balancing ponds, culvert replacement and flow diversion channels. Some of which are in the vicinity of designated landscape features; the heritage landscape and the walkways.</p> <p>Permanent impact on high value landscape character/feature in the zone of influence of the selected measure.</p>	<p>Construction related impacts and replacement of natural banks with flood walls and the creation of embankments. Construction related impacts due to construction works associated with, storage options, balancing ponds, culvert replacement and flow diversion channels. Some of which are in the vicinity of designated landscape features; the heritage landscape and the walkways.</p> <p>Permanent impact on high value landscape character/feature in the zone of influence of the selected measure.</p>
4.F(i)	4	2.00	Professional judgement	<p>Shannon is not a heritage town. There is one protected feature of architectural value within the sub catchment; an NIAH/RPS: Shannon Airport. This is at risk in the 0.1%AEP Fluvial/Coastal.</p> <p>Local weighting of 2 set by professional judgement. Weighting of 2 applied where a number of sites/features listed on the Record of Protected Structures and/or Recorded by NIAH are present and potentially affected with a moderate to low vulnerability.</p>	<p>The Shannon NIAH/RPS will no longer be at risk in the 0.1%AEP Fluvial/Coastal.</p> <p>Potential for changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is slightly changed.</p> <p>Therefore, overall a potential increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.</p>	<p>The Shannon NIAH/RPS will no longer be at risk in the 0.1%AEP Fluvial/Coastal.</p> <p>Potential for changes to the setting of architectural features (Record of Protected Structures and NIAH) such that it is slightly changed.</p> <p>Therefore, overall a potential increase in the level of protection for architectural features (Record of Protected Structures and NIAH) from flooding, such that it is less vulnerable to flood damage.</p>
4.F(ii)	4	1.00	Professional judgement	<p>Shannon is not a heritage town. There are 2 RMPs within or partially within the 0.1% AEP Fluvial/Coastal within the sub catchment.</p> <p>Local weighting of 1 set by professional judgement. Weighting of 1 applied were there is limited potential for effects on archaeological features and their setting.</p>	<p>2 RMPs will potentially be removed from the 0.1% AEP Fluvial/Coastal within the sub catchment.</p> <p>Potential impacts to the setting of one RMP due to embankments.</p> <p>Therefore, overall a potential to change the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.</p>	<p>2 RMPs will potentially be removed from the 0.1% AEP Fluvial/Coastal within the sub catchment.</p> <p>Potential impacts to the setting of one RMP due to embankments.</p> <p>Therefore, overall a potential to change the setting of archaeological features (Recorded Monument or National Monument) such that it is slightly changed.</p>

Option 1 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis						Notes to CFRAM Consultants
			€	€	€	
(1) Basic Construction Costs (Estimate)					18,322,368	Construction Cost of each measure <u>including</u> Method Factor and CPI Adjustment but <u>excluding</u> Preliminaries
(2) Preliminaries	5.1%				931,241	Refer to UCD for selecting Preliminaries. %
	Sub-Total:				19,253,609	
(3) Optimism Bias	40.0%				7,701,444	Refer to UCD for selecting OB %
(4) Construction Costs (Excl VAT)					26,955,052	
(5) Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)	13.0%				3,504,157	Set at 13%
Construction Costs and Fees					30,459,209	
(6) Other Items						
(a) Allowance for Archaeology & Environmental Mitigation Measures	10.0%			2,695,505		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b) Allowance for compensation and land acquisition	15.0%			4,043,258		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c) Site investigation	4% assumed			1,078,202		Professional judgement to be applied in estimating a suitable sum.
(d) Art Allowance				64,000		See “Guidance E – Per Cent for Art Note”
(e) Est. NPV Operation & Maintenance						From PVC Summary sheet: PVC – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
			773,948			
	Optimism Bias	40.0%	309,579	1,083,528	8,964,493	Refer to UCD for selecting OB %
Option Cost for Cost Benefit Analysis					39,423,702	



CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by:	M Cairns	Date:	27.08.15
Checked by:		Date:	

Project reference	S04
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Project name:	Shannon Option 1
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Base date for estimates (year 0)	Oct-2013
Scaling factor (e.g. €m, €k, €)	€

Construction Price Index (CPI)	0.987
Method Factor - to take into account particular site issues /constraints	1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		
Capital costs	Cost (€)	Comment
Total wall costs	€9,833,440	urban, stone cladding, no piles
Total embankment costs	€8,096,163	imported material, no piles
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs	€71,190	Flow diversion Channel
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs	€321,576	
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€18,322,368	
Apply update to unit rate (CPI) if appropriate (cell N15)	€18,084,177	
Enter appropriate preliminaries estimate (%)	5%	
Enter other applicable costs (€)	0	
Total capital cost (€)	€19,253,609	
Consider amendments based on site issues/constraints (cell N16)	€19,253,609	
Total capital cost (€)	€19,253,609	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€1,815	average O&M costs
Total embankment O&M costs	€20,849	average O&M costs
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs	N/A	
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€13,601	average O&M costs
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€36,265	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€20,027,557	
Optimism bias rate (from external sheet)	40%	
Total Cost including Optimism Bias	€28,038,580	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€19,253,608.8
Annual maintenance cost (€)	€36,265.0
Other cost (€)	€0.0
Other works frequency (years)	

Key	
	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVc (€k):		20027557
Cash sum		0	19253609	1776985	0	21030594	20027557
year	Discount Factor	Cost Elements				TOTALS:	
		Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	19253609			19253608.8	19253608.8
1	0.962			36265		36265.0	34870.2
2	0.925			36265		36265.0	33529.0
3	0.889			36265		36265.0	32239.4
4	0.855			36265		36265.0	30999.5
5	0.822			36265		36265.0	29807.2
6	0.790			36265		36265.0	28660.8
7	0.760			36265		36265.0	27558.4
8	0.731			36265		36265.0	26498.5
9	0.703			36265		36265.0	25479.3
10	0.676			36265		36265.0	24499.3
11	0.650			36265		36265.0	23557.0
12	0.625			36265		36265.0	22651.0
13	0.601			36265		36265.0	21779.8
14	0.577			36265		36265.0	20942.1
15	0.555			36265		36265.0	20136.7
16	0.534			36265		36265.0	19362.2
17	0.513			36265		36265.0	18617.5
18	0.494			36265		36265.0	17901.4
19	0.475			36265		36265.0	17212.9
20	0.456			36265		36265.0	16550.9
21	0.439			36265		36265.0	15914.3
22	0.422			36265		36265.0	15302.2
23	0.406			36265		36265.0	14713.7
24	0.390			36265		36265.0	14147.8
25	0.375			36265		36265.0	13603.6
26	0.361			36265		36265.0	13080.4
27	0.347			36265		36265.0	12577.3
28	0.333			36265		36265.0	12093.6
29	0.321			36265		36265.0	11628.4
30	0.308			36265		36265.0	11181.2
31	0.296			36265		36265.0	10751.1
32	0.285			36265		36265.0	10337.6
33	0.274			36265		36265.0	9940.0
34	0.264			36265		36265.0	9557.7
35	0.253			36265		36265.0	9190.1
36	0.244			36265		36265.0	8836.6
37	0.234			36265		36265.0	8496.8
38	0.225			36265		36265.0	8170.0
39	0.217			36265		36265.0	7855.7
40	0.208			36265		36265.0	7553.6
41	0.200			36265		36265.0	7263.1
42	0.193			36265		36265.0	6983.7
43	0.185			36265		36265.0	6715.1
44	0.178			36265		36265.0	6456.9
45	0.171			36265		36265.0	6208.5
46	0.165			36265		36265.0	5969.7
47	0.158			36265		36265.0	5740.1
48	0.152			36265		36265.0	5519.3
49	0.146			36265		36265.0	5307.1

Option 2 Costs for CBA

CFRAM Programme – Option Costs for Cost Benefit Analysis					Notes to CFRAM Consultants
		€	€	€	
(1) Basic Construction Costs (Estimate)				23,218,760	Construction Cost of each measure <u>including</u> Method Factor and CPI Adjustment but <u>excluding</u> Preliminaries
(2) Preliminaries	4.0%			932,643	Refer to UCD for selecting Preliminaries. %
	Sub-Total:			24,151,403	
(3) Optimism Bias	35.0%			8,452,991	Refer to UCD for selecting OB %
(4) Construction Costs (Excl VAT)				32,604,394	
(5) Design Team Fees and Expenses (Incl Site Supervision, and Environmental fees)	13.0%			4,238,571	Set at 13%
Construction Costs and Fees				36,842,965	
(6) Other Items					
(a) Allowance for Archaeology & Environmental Mitigation Measures	10.0%		3,260,439		Professional judgement to be applied in estimating a suitable % Typical values are 10% - 15% of (4) Construction Costs depending on the archaeological and environmental sensitivity of the site
(b) Allowance for compensation and land acquisition	10.0%		3,260,439		Professional judgement to be applied in estimating a suitable %. Typical values are 10% - 15% of (4) Construction Costs depending on the likely level of interference with private property
(c) Site investigation	4% assumed		1,304,176		Professional judgement to be applied in estimating a suitable sum.
(d) Art Allowance			64,000		See “Guidance E – Per Cent for Art Note”
(e) Est. NPV Operation & Maintenance					From PVC Summary sheet: PVC – Capital Cost (excluding OB). Includes enabling costs and other whole life costs e.g. pump replacement
		1,115,286			
	Optimism Bias	35.0%	390,350	1,505,636	Refer to UCD for selecting OB %
Option Cost for Cost Benefit Analysis				46,237,655	



CFRAM Unit Cost Development Project

Whole Life Cost Tool

Prepared by: M Cairns Date: 27.08.15
Checked by: Date:

Project reference: S04

Project name: Shannon Option 1

Base date for estimates (year 0): Oct-2013
Scaling factor (e.g. €m, €k, €): €

Construction Price Index (CPI): 0.987
Method Factor - to take into account particular site issues /constraints: 1.00

This sheet has been provided to group asset types to generate a whole life cost for a portfolio of flood risk management methods

Combined Method Whole Life Cost Tool

Enabling costs	Cost (€)	Comment
Total enabling costs (if applicable, may be sunk cost)		

Capital costs	Cost (€)	Comment
Total wall costs	€9,833,440	urban, stone cladding, no piles
Total embankment costs	€7,951,177	imported material, no piles
Total demountable barrier costs		
Total demountable gate costs		
Total in-channel excavation costs		
Total excavation on land costs		
Total weir construction costs		
Total weir removal costs		
Total bridge construction costs		
Total bridge removal costs		
Total bridge underpinning costs		
Total culvert costs	€5,434,144	
Total sluice gate costs		
Total road raising costs		
Total individual property protection costs		
Total hydrometric gauging station costs		
Total flood forecasting costs		
Total pumping station costs		
Total channel maintenance costs		
Total bank protection costs		
Total manhole sealing costs		
Total user specified method costs		
Total Construction costs	€23,218,760	
Apply update to unit rate (CPI) if appropriate (cell N15)	€22,916,916	
Enter appropriate preliminaries estimate (%)	4%	
Enter other applicable costs (€)		
Total capital cost (€)	€24,151,403	
Consider amendments based on site issues/constraints (cell N16)	€24,151,403	
Total capital cost (€)	€24,151,403	

Operation and Maintenance Cost Tool	Cost (€)	Comment
Total wall O&M costs	€1,815	average O&M costs
Total embankment O&M costs	€21,181	average O&M costs
Total demountable barrier O&M costs		
Total demountable gate O&M costs		
Total in-channel excavation O&M costs		
Total excavation on land O&M costs	N/A	
Total weir O&M costs		
Total weir removal O&M costs		
Total bridge O&M costs		
Total bridge removal O&M costs		
Total bridge underpinning O&M costs		
Total culvert O&M costs	€29,263	
Total sluice gate O&M costs		
Total road raising O&M costs		
Total individual property protection O&M costs		
Total hydrometric gauging station O&M costs		
Total flood forecasting O&M costs		
Total pumping station O&M costs		
Total channel maintenance O&M costs		
Total bank protection O&M costs		
Total manhole sealing O&M costs		
Total user specified method O&M costs		
Total Operation and Maintenance costs	€52,259	

Other costs	Cost (€)	Comment
Other costs (consider the need for additional longer term or intermittent costs)		

Total PV Cost	Cost (€)	Comment
Total PVc costs (see PVc calculator below)	€25,266,689	
Optimism bias rate (from external sheet)	35%	
Total Cost including Optimism Bias	€34,110,030	

Whole life cost and PVc analysis - for Whole Life Cost Tool

Enter applicable costs (enabling, capital and O&M)
Enter year of capital works (all other costs start after this year)
Enter 'other' costs and frequency (e.g. replacement costs) if applicable
Enabling costs assume to start in year 0 (amend manually if required)

Enabling cost (€) (if applicable, may be sunk cost)	
Year of capital works (year)	0
Capital cost (€)	€24,151,402.9
Annual maintenance cost (€)	€52,259.1
Other cost (€)	€0.0
Other works frequency (years)	

Key	
	Information
	Calculation
	Cost input
	User information

Discount rate:	4.0%	Present Value Factor:		22.341	Total PVc (€k):		#####
Cash sum		0	24151403	2560695	0	26712098	25266689
year	Discount Factor	Cost Elements				TOTALS:	
		Enabling	Capital	Maint.	Other	Cash	PV
0	1.000	0	24151403			24151402.9	#####
1	0.962			52259		52259.1	50249.1
2	0.925			52259		52259.1	48316.5
3	0.889			52259		52259.1	46458.1
4	0.855			52259		52259.1	44671.3
5	0.822			52259		52259.1	42953.2
6	0.790			52259		52259.1	41301.1
7	0.760			52259		52259.1	39712.6
8	0.731			52259		52259.1	38185.2
9	0.703			52259		52259.1	36716.5
10	0.676			52259		52259.1	35304.4
11	0.650			52259		52259.1	33946.5
12	0.625			52259		52259.1	32640.9
13	0.601			52259		52259.1	31385.4
14	0.577			52259		52259.1	30178.3
15	0.555			52259		52259.1	29017.6
16	0.534			52259		52259.1	27901.5
17	0.513			52259		52259.1	26828.4
18	0.494			52259		52259.1	25796.6
19	0.475			52259		52259.1	24804.4
20	0.456			52259		52259.1	23850.4
21	0.439			52259		52259.1	22933.0
22	0.422			52259		52259.1	22051.0
23	0.406			52259		52259.1	21202.9
24	0.390			52259		52259.1	20387.4
25	0.375			52259		52259.1	19603.3
26	0.361			52259		52259.1	18849.3
27	0.347			52259		52259.1	18124.3
28	0.333			52259		52259.1	17427.2
29	0.321			52259		52259.1	16756.9
30	0.308			52259		52259.1	16112.4
31	0.296			52259		52259.1	15492.7
32	0.285			52259		52259.1	14896.9
33	0.274			52259		52259.1	14323.9
34	0.264			52259		52259.1	13773.0
35	0.253			52259		52259.1	13243.3
36	0.244			52259		52259.1	12733.9
37	0.234			52259		52259.1	12244.1
38	0.225			52259		52259.1	11773.2
39	0.217			52259		52259.1	11320.4
40	0.208			52259		52259.1	10885.0
41	0.200			52259		52259.1	10466.3
42	0.193			52259		52259.1	10063.8
43	0.185			52259		52259.1	9676.7
44	0.178			52259		52259.1	9304.5
45	0.171			52259		52259.1	8946.7
46	0.165			52259		52259.1	8602.6
47	0.158			52259		52259.1	8271.7
48	0.152			52259		52259.1	7953.6
49	0.146			52259		52259.1	7647.7

Appendix M Economic Sensitivity Analysis

Only AFAs with options are displayed below.

AFA/IRR	Option	3%	4%	5%
Shannon Airport	Option 1	€55,638,692	€55,408,580	€55,233,087
Ennis	N/A	-	-	-
Quin	N/A	-	-	-
Bunratty	Option 1	€764,841	€758,255	€753,231
Sixmilebridge	N/A	-	-	-
Shannon Town	Option 1	€6,107,778	€6,003,635	€5,924,211
	Option 2	€21,351,206	€21,164,137	€21,021,469
Kilrush	Option 1	€175,176	€173,082	€171,485
Kilkee	Option 1	€4,445,155	€4,438,063	€4,432,654
	Option 2	€3,297,911	€3,240,290	€3,196,346
Sub Shannon	Option 1	€39,634,919	€39,423,702	€39,262,618
	Option 2	€46,531,155	€46,237,655	€46,013,819

AFA/IRR	Total Capped CBA								
	3%			4%			5%		
	Coastal	Fluvial	Combined	Coastal	Fluvial	Combined	Coastal	Fluvial	Combined
Shannon Airport	224,840,515	-	-	224,237,626	-	-	223,114,507	-	-
Ennis	1,274,564	28,822,961	29,846,181	1,113,845	25,230,136	26,092,714	991,379	22,406,579	23,146,802
Quin	-	20,286	-	-	17,102	-	-	14,675	-
Bunratty	2,859,658	1,920,332	3,391,236	2,628,754	1,836,885	3,076,884	2,452,801	1,773,296	2,837,344
Sixmilebridge	-	436,279	-	-	367,792	-	-	315,603	-
Shannon Town	33,627,140	29,524,430	52,285,387	29,826,398	26,545,337	46,555,772	26,718,169	24,244,196	42,149,671
Kilrush	6,139	305,461	311,601	5,175	257,510	262,691	4,439	220,970	225,406
Kilkee	4,295,628	6,648,124	8,536,320	3,914,961	6,014,333	7,667,125	3,603,104	5,495,800	6,993,879