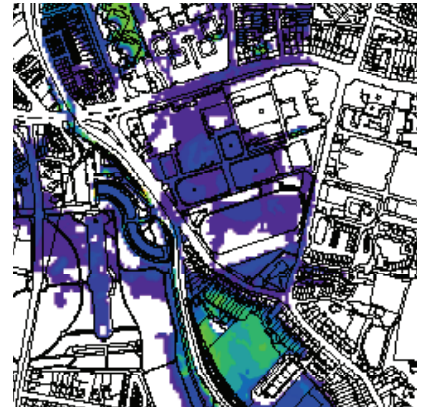
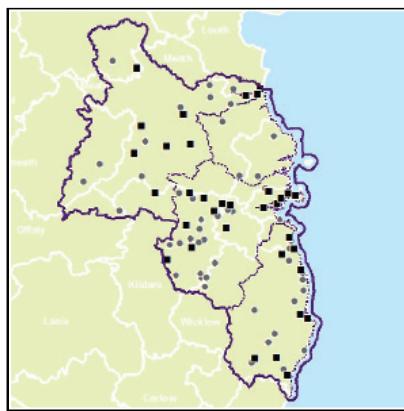




Eastern CFRAM Study

Camac Options Report

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Eastern CFRAM Study Camac Options Report

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TABLE OF CONTENTS

APPENDICES	V
ABBREVIATIONS.....	VI
1 INTRODUCTION.....	7
1.1 GENERAL INFORMATION ON THE EASTERN CFRAM STUDY	7
1.2 EASTERN CFRAM STUDY ACTIVITIES.....	8
1.2.1 Preliminary Flood Risk Assessment.....	9
1.2.2 Data Collection	9
1.2.3 Flood Risk Review.....	9
1.2.4 Surveys.....	10
1.2.5 Hydrological Analysis	10
1.2.6 Hydraulic Analysis	10
1.2.7 Flood Risk Assessment.....	10
1.2.8 Development of Flood Risk Management Options.....	10
1.2.9 Environmental Assessment.....	10
1.2.10 Communications Activities	11
1.2.11 Preparation of Flood Risk Management Plan	11
1.3 PURPOSE OF THE OPTIONS REPORT	11
1.4 INTRODUCTION TO THE OPTIONEERING PROCESS.....	12
2 DATA COLLECTION	14
2.1 BACKGROUND MAPPING	14
2.2 RECEPTORS	14
2.3 FLOOD HAZARD	15
2.4 SURVEY DATA.....	15
2.5 ECONOMIC ASSESSMENT	16
3 SPATIAL SCALES OF ASSESSMENT.....	17
3.1 UNIT OF MANAGEMENT SSA.....	17
3.2 SUB-CATCHMENT SSA	17
3.3 AFA SSA.....	17
3.4 IRR SSA	18
3.5 SPATIAL SCALE OF ASSESSMENT FOR THE RIVER CAMAC	18
4 FLOOD RISK ASSESSMENT	21
4.1 FLOOD RISK MAPS.....	21
4.2 FLOOD RISK FROM THE RIVER CAMAC.....	23
5 DAMAGE ASSESSMENT.....	25
5.1 DAMAGE ASSESSMENT GUIDELINES.....	25
5.2 RECORDING DAMAGE ASSESSMENT DATA	27
5.3 CATEGORISATION OF PROPERTIES	27
5.4 PROPERTY THRESHOLD LEVEL.....	29
5.5 FLOOD DEPTH OF PROPERTIES	30
5.6 FLOOD DAMAGE TO PROPERTIES	30
5.7 INTANGIBLE DAMAGES AND EMERGENCY COSTS	31
5.8 ANNUAL AVERAGE DAMAGE AND PRESENT VALUE DAMAGE	32
5.9 CAPPING DAMAGES	34
5.10 DAMAGE ASSESSMENT REVIEW	34
5.11 SUMMARY OF DAMAGES ON THE RIVER CAMAC STUDY.....	34
6 FLOOD RISK MANAGEMENT METHODS.....	35
6.1 STANDARD OF PROTECTION.....	35
6.1.1 Residual Risk.....	35
6.2 LIST OF FRM METHODS	35
6.3 BASELINE CONDITION	37
7 ASSESSMENT OF FRM METHODS.....	38
7.1 SCREENING FRM METHODS	38
7.1.1 Shortlisting FRM Methods	39
7.1.2 Technical Screening.....	39
7.1.3 Environmental and Social Screening	39
7.1.4 Economic Screening	40

	7.1.5	Construction Costs	40
7.2		DEVELOPING POTENTIAL FRM OPTIONS	40
	7.2.1	Economic Review of Potential FRM Options	41
7.3		ASSESS POTENTIAL FRM OPTIONS (MCA PROCESS)	41
	7.3.1	Criteria and Objectives	42
	7.3.2	Scoring Options	43
	7.3.3	Weighting Objectives	44
7.4		PREFERRED FRM OPTIONS	44
	7.4.1	Refining Options	44
	7.5	PREFERRED FRM OPTIONS FOR THE RIVER CAMAC	45
8		CONSULTATION AND UPDATING FRM OPTIONS	46
	8.1	OUTCOMES OF CONSULTATION FOR THE RIVER CAMAC	46
	8.2	CULVERT BLOCKAGE ANALYSIS AND FLOW RESTRICTION REVIEW	46
	8.3	MAINTENANCE REVIEW	51
	8.4	MODIFICATION OF BOW'S BRIDGE	56
	8.5	REMOVAL OF KEARNS PLACE BRIDGE	56
	8.6	LOWERING THE CAMAC BED LEVEL	57
	8.7	ATTENUATION OF FLOW	57
	8.8	ALTERNATIVE STANDARDS OF PROTECTION	58
	8.9	EMERGENCY RESPONSE PLAN	58
	8.10	UPDATING PREFERRED OPTIONS	58
	8.10.1	Option 1 - Hard defences and sealing manholes	59
	8.10.2	Option 2 - Hard defences, storage and sealing manholes	59
	8.10.3	Future Flood Risk	60
9		SUMMARY OF FRM OPTIONS FOR THE RIVER CAMAC	61
	9.1	LIMITATIONS AND RECOMMENDATIONS	62
	9.1.1	Hydraulics	62
	9.1.2	Optioneering	62

LIST OF FIGURES

Figure 1.1 - Eastern CFRAM Study Area	8
Figure 1.2 – Eastern CFRAM Study activities	8
Figure 1.3 - Optioneering process	13
Figure 3.1 - River Camac Spatial Scale of Assessment	20
Figure 4.1 - Example cultural heritage, social, environmental risk maps	22
Figure 4.2 - Example economic risk density maps	22
Figure 5.1 - MCM's depth damage data for detached houses	26
Figure 5.2 - Example shapefile with attribute table showing damage assessment data	27
Figure 5.3 - Camac direct damage curve	33
Figure 7.1 - Assessment of FRM methods flow chart	38
Table 7.3 - Potential FRM Options	45
Figure 8.1 - Culverts at risk of blockage and restrictions in the River Camac	47
Figure 8.2 - Culverts at risk of blockage and restrictions in the River Camac	48
Figure 8.3 - Maintenance areas on the River Camac	52
Figure 8.4 - Maintenance areas on the River Camac	52

LIST OF TABLES

Table 1.1 - Outputs of study activities	9
Table 2.1 - Background Mapping data	14
Table 2.2 - Receptor data	14
Table 2.3 - Flood Hazard data	15
Table 2.4 - Survey data	15
Table 2.5 - Economic Assessment data	16
Table 3.1 - Spatial Scales of Assessment for the River Camac	19
Table 4.1 - Flood risk receptor groups	21
Table 4.2 - Flood risk from the River Camac	23
Table 5.1 - MCM property types	27
Table 5.2 - Categorisation of properties data	29
Table 5.2 - Property threshold data	29
Table 5.3 - Flood depth of properties data	30
Table 5.4 - Converting pound sterling to euro using the PPP 2010 values from OECD website	31
Table 5.5 - Conversion rates to current year prices using CPI from CSO Ireland website	31
Table 5.6 - Flood damage to properties data	31
Table 5.7 - Intangible damages and emergency cost data	32

Table 5.8 - AAD and pvD data	33
Table 5.9 - Capping damages data	34
Table 5.10 - Summary of damages on the River Camac Study.....	34
Table 7.1 - Additional costs to FRM options.....	41
Table 7.2 - Criteria and Objectives of the MCA.....	42
Table 7.4 - Preferred FRM Options MCA score breakdown	45
Table 8.1 - Recommended action on the River Camac	48
Table 8.2 - Recommended maintenance on the River Camac	53
Table 8.3 - Economic change from Bow Bridge modification.....	56
Table 8.4 - Economic change from Kearns Place Bridge removal.....	57
Table 8.5 - Economic change from attenuating flow	57
Table 8.6 - BCR of option 1 providing a 2%AEP SoP	58
Table 8.7 - Summary of recommendations considered to update potential FRM Options	58
Table 8.8 - Impact of future scenarios to Option 1	60
Table 9.1 - Potential FRM options for the River Camac.....	61

APPENDICES

APPENDIX A Flood Risk Maps

APPENDIX B Assessment of FRM Methods Datasheets

APPENDIX C Costing of Options

APPENDIX D Flood Defence Maps

APPENDIX E Stage 1 Culvert Blockage Results

ABBREVIATIONS

AEP	Annual Exceedance Probability
AFA	Area for Further Assessment
BCR	Benefit Cost Ratio
CFRAM	Catchment Flood Risk Assessment and Management
CPI	Consumer Price Index
DEHLG	Department of Environment, Community and Local Government (previously known as the Department of Environment, Heritage and Local Government)
FCERM	Flood or Coastal Erosion Risk Management
FFL	Finished Floor Level
FHRC	Flood Hazard and Research Centre
FRA	Flood Risk Assessment
FRM	Flood Risk Management
FRMP	Flood Risk Management Plan
HA	Hydrometric Area
HEFS	High end future scenario
HPW	High Priority Watercourse
IRR	Individual Risk Receptor
MCM	Multi Coloured Manual
MRFS	Mid range future scenario
OPW	Office of Public Works
PFRA	Preliminary Flood Risk Assessment
pvD	present value Damage
RBD	River Basin District
RMP	Record of Monuments and Places
SAC	Special Area of Conservation
SMR	Sites and Monuments Record
SI	Statutory Instrument
SoP	Standard of Protection
SPA	Special Protection Area
SSA	Spatial Scale of Assessment
UoM	Unit of Management

1 INTRODUCTION

The Office of Public Works (OPW) commissioned RPS to undertake the Eastern Catchment-based Flood Risk Assessment and Management Study (Eastern CFRAM Study) in June 2011. The Eastern CFRAM Study was the second River Basin District (RBD) level CFRAM study to be commissioned in Ireland under the EC Directive on the Assessment and Management of Flood Risks 2007, the EU Floods Directive, (Reference 1) as implemented in Ireland by SI 122 of 2010 European Communities (Assessment and Management of Flood Risks) Regulations 2010 (Reference 2). The Eastern CFRAM Study will culminate in 2016 with the development of Flood Risk Management Plans (FRMPs) which will include Flood Risk Management Measures designed to deal with identified flood risk.

The Camac catchment is located within the Eastern CFRAM study area (Figure 1.1). Due to the very significant recent flooding in the Camac catchment, it was prioritised within the Eastern CFRAM Study programme and an advance project has been carried out during 2013. The purpose of this advance project was to accelerate the identification of Preferred Flood Risk Management Options for the catchment to be taken forward to implementation by the Local Authorities within which the catchment is located (i.e. Dublin City Council and South Dublin County Council).

The Camac Options Report details the generic methodology for the flood risk assessment and the development of flood risk management options for all study areas in the Eastern CFRAM Study while providing the specific findings for the River Camac study area. While it is usual to prepare a preliminary options report to be used for the consultation stage of the process this report, due to its accelerated nature, includes the consultation and presents the final Flood Risk Management Options to be taken forward to detailed design. Due to no cost beneficial Flood Risk Management Option being identified the report details the recommendations to refine the options in order to make it cost-beneficial, or identify in a manner that is socially acceptable, discrete areas where works are cost-beneficial.

1.1 GENERAL INFORMATION ON THE EASTERN CFRAM STUDY

As shown in figure 1.1 the Eastern CFRAM Study Area covers approximately 6,250 km² and includes four Units of Management; Hydrometric Area (HA) 07 (Boyne), HA08 (Nanny – Delvin), HA09 (Liffey-Dublin Bay) and HA10 (Avoca-Vartry). There is historical evidence of a high level of flood risk within certain areas of the Eastern CFRAM Study area with significant coastal and fluvial flooding events having occurred in the past. A detailed account of historical flooding can be found in the Eastern CFRAM Study inception reports in which can be downloaded from the Eastern CFRAM Study website at www.eastcfрамstudy.ie.

The objectives of the Eastern CFRAM Study are to:

- Identify and map the existing and potential future flood hazard within the Study Area.
- Assess and map the existing and potential future flood risk within the Study Area.
- Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk within the Study Area.
- Prepare a set of Flood Risk Management Plans (FRMPs) for the Study Area, and associated Strategic Environmental and, as necessary, Habitats Directive (Appropriate) Assessment, that set out the policies, strategies, measures and actions that should be pursued by the relevant bodies, including OPW, Local Authorities and other stakeholders, to achieve the most cost effective and sustainable management of existing and potential future flood risk within the Study Area, taking account of environmental plans, objectives and legislative requirements and other statutory plans and requirements.

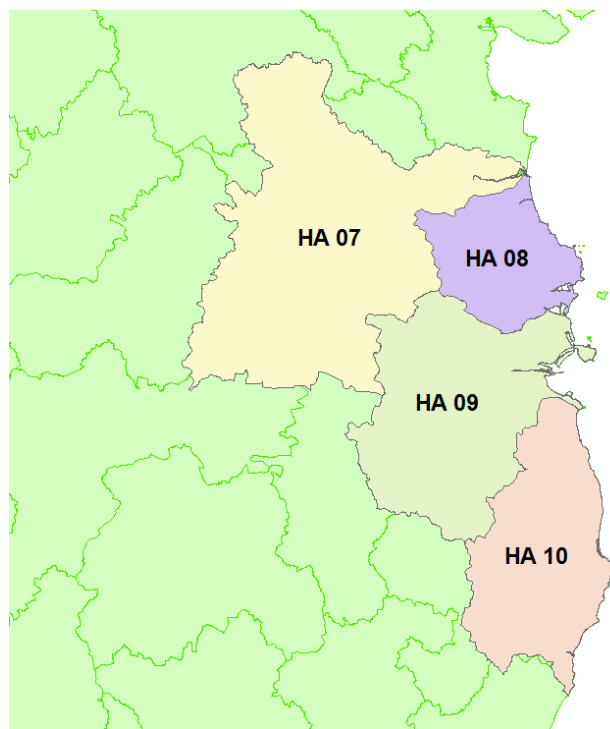


Figure 1.1 - Eastern CFRAM Study Area

1.2 EASTERN CFRAM STUDY ACTIVITIES

To achieve the study objectives the Eastern CFRAM Study has carried out a range of activities. Each activity, while focusing on a specific task, is connected to and informs the other activities. Figure 1.2 summarises the activities involved in the study and how they relate to each other.

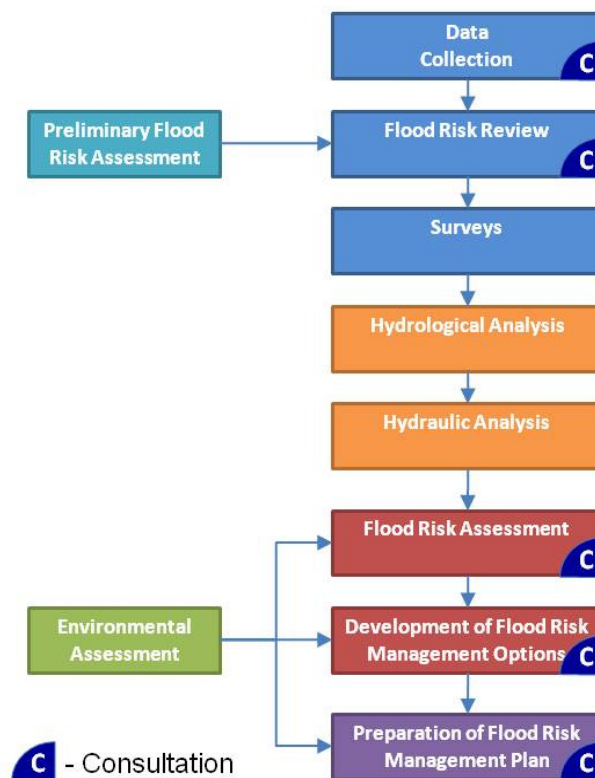


Figure 1.2 – Eastern CFRAM Study activities

The main outputs and reports associated with the study activities are listed in the table below. An explanation of each activity's output(s) are summarised in sections 1.1.1 to 1.1.11.

Table 1.1 - Outputs of study activities

Activity	Output
Preliminary Flood Risk Assessment	<ul style="list-style-type: none"> National fluvial flood maps Identification of Areas for Further Assessment
Data Collection	<ul style="list-style-type: none"> -
Flood Risk Review	<ul style="list-style-type: none"> Confirmation of Areas for Further Assessment
Surveys	<ul style="list-style-type: none"> Survey data for all watercourses identified for assessment
Hydrological Analysis	<ul style="list-style-type: none"> Estimation of flows for all watercourses for all flood events Hydrology report
Hydraulic Analysis	<ul style="list-style-type: none"> Flood hazard maps Hydraulics report
Flood Risk Assessment	<ul style="list-style-type: none"> Flood risk maps Preliminary options report
Development of Flood Risk Management Options	<ul style="list-style-type: none"> Identification of flood risk management measures and options Preliminary options report
Environmental Assessment (including Strategic Environmental Assessment (SEA) and Appropriate Assessment (AA))	<ul style="list-style-type: none"> SEA Screening Statement, SEA Scoping Report, SEA Environmental Report, SEA Statement AA Screening Statement, Natura Impact Statement
Communications Activities	<ul style="list-style-type: none"> Influence on draft maps, options and FRMPs Communications synthesis reports
Preparation of Flood Risk Management Plan	<ul style="list-style-type: none"> Flood Risk Management Plan

1.2.1 Preliminary Flood Risk Assessment

In 2011 the OPW completed a Preliminary Flood Risk Assessment (PFRA) in accordance with the EU Floods Directive. The objective of the PFRA is to identify areas where the risks associated with flooding might be significant. The PFRA provides maps showing areas deemed to be at risk. The PFRA identified Areas for Further Assessment (AFAs) which were then taken forward in the CFRAM programme. The documentation associated with the PFRA including the flood maps can be accessed through the national CFRAM website www.CFRAM.ie/pfra.

1.2.2 Data Collection

An initial data collection was carried out to capture the relevant information to meet the objectives of the project. This main proportion of this activity was carried out at the start of the project but is also ongoing as new information is made available and new data requirements identified. Details of the initial data collection process can be found in the Eastern CFRAM Study inception reports which can be accessed through the Eastern CFRAM Study website www.eastcfрамstudy.ie.

1.2.3 Flood Risk Review

The Flood Risk Review (FRR) was completed in September 2011 for the Eastern CFRAM Study. RPS was required to review the output of the preliminary flood risk assessment and all other information

and knowledge readily available during the initial stages of the Eastern CFRAM Study. The data was assessed and identified AFAs where potential significant flood risk exists or might be considered likely to exist including areas other than those identified through the PFRA. Areas where significant flood risk does not exist and no further assessment required were also identified as part of the FRR. The findings of the FRR can be found in the Flood Risk Review Report and maps which can be accessed through the Eastern CFRAM Study website www.eastcfframstudy.ie.

1.2.4 Surveys

Before progressing to the hydrological and hydraulic analysis activities the topographical data for each watercourse and associated floodplains identified for assessment was required. This activity started in 2011 and was completed in October 2012. The outputs of the survey were LiDAR information of floodplains, river channel cross sections and geometrical data for structures located in the river channel or influencing the hydraulic nature of the river.

1.2.5 Hydrological Analysis

The hydrological analysis encompasses all aspects of flood hydrology including review of historic flood events within the AFAs, flood frequency analysis and design flow estimation. The review of historic flood events and initial flood frequency analysis (to determine the statistical frequency / severity of historic flood events within the AFAs) was completed for the Eastern study area in August 2012 and is contained within the Inception Reports. The second stage of the hydrological analysis focuses on design flow estimation such that design flows for various risk scenarios can be defined and used as inputs for hydraulic modelling. The approach to design flow estimation relies heavily on defining the index flood, equivalent to the statistical median from a series of annual peak flood flows (equivalent to a 50% chance of occurring in any given year). The design flow estimation includes a more detailed flood frequency analysis to define appropriate flood growth behaviour for each catchment / sub-catchment in order to define design events based on scaling of the index flood flow. The hydrological analysis also includes consideration of the factors which will affect future changes in flows such as catchment changes and climate change. The hydrological analysis stage overlaps with the hydraulic analysis as design flow estimates are tested and refined through the models against observed data. Details of the hydrological analysis can be found in Eastern CFRAM Study HA09 Hydrology Report.

1.2.6 Hydraulic Analysis

Dynamic hydraulic models have been developed for all the areas of assessment. These models simulated how each watercourse will react to various sizes of floods and its interaction with the surrounding floodplain. The output of this analysis is a Hydraulics Report in addition to a series of flood extent, zone, depth, velocity and risk-to-life maps known collectively as flood hazard maps which are generated based on the model results. Details of the hydraulic analysis can be found in the Eastern CFRAM Study HA09 Hydraulics Report.

1.2.7 Flood Risk Assessment

The Flood Risk Assessment (FRA) is detailed in this report and its main output is to achieve one of the CFRAM study objectives; assess and map the existing and potential future flood risk within the Study Area. The FRA focuses on the receptors at risk from flooding and are categorised as either social (including risk to people), environmental, cultural heritage or economic receptors.

1.2.8 Development of Flood Risk Management Options

The development of Flood Risk Management Options is detailed in this report and its main output is to achieve one of the CFRAM study objectives; identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk within the Study Area. The output of this activity is to present FRM options for the receptors identified during the FRA. This is achieved through a screening process and analysis of the options in order to identify which are the most appropriate.

1.2.9 Environmental Assessment

Strategic Environmental Assessment (SEA) is a process to evaluate, at the earliest appropriate stage, the environmental effects of a plan or programme before it is adopted. It also gives the public and other interested parties an opportunity to comment and to be kept informed of decisions and how they were made. The outputs of the process include an SEA Screening Statement notifying the decision to carry out SEA, an SEA Scoping Report outlining the environmental issues considered by the SEA, an SEA Environmental Report outlining the assessment of the potential effects of the measures in the

Flood Risk Management Plans on aspects of the environment, and an SEA Statement detailing how the SEA process influenced the development of the Flood Risk Management Plans.

It has been concluded that, given the nature of the options proposed, the Camac work is more appropriately considered a 'project' under the definition of the EIA Directive than a 'plan' or 'programme' under the SEA Directive. Therefore, the SEA process does not apply to the Camac works. It is however strongly recommended that the Part VIII route is followed and that an Environmental Impact Report is completed to support the Part VIII planning application. This should include an assessment of the potential impacts of the project on flora and fauna, cultural heritage and landscape as a minimum and should be carried out by suitable qualified specialists. The report should also contextualize the works within the Eastern CFRAM Study and where possible use similar and compatible assessment criteria to ensure there is no potential for conflict with the Eastern CFRAM Study process. The Eastern CFRAM Study will address these advanced works in the context of baseline conditions which will reflect the flood relief works for this catchment. In this way the cumulative impacts associated with the wider CFRAM Study will be captured more appropriately at the CFRAM Study level of assessment.

Appropriate Assessment (AA) is a process which ascertains if there are internationally important sites whose integrity could be significantly adversely affected by the implementation of a plan or project. Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) together form the Natura 2000 network of protected areas. Outputs of the process include an AA Screening Statement notifying the decision to carry out AA and a Natura Impact Statement outlining the assessment of the potential effects on Natura 2000 sites of the measures contained in the Flood Risk Management Plans.

AA screening has been undertaken in relation to the Camac preferred options. It was concluded that the implementation of any of the preferred options within the Camac catchment would not have the potential to result in adverse impacts to the Natura 2000 network, either alone or in combination with other plans or projects. Therefore, the process did not proceed to Stage 2, Appropriate Assessment.

1.2.10 Communications Activities

Communications activities include elected member briefings, public consultation days, stakeholder workshops, website consultations and consultation with progress group members and other key stakeholders. Stakeholder input influences the technical review of flood maps, flood risk management options and Flood Risk Management Plans.

1.2.11 Preparation of Flood Risk Management Plan

This is the last activity of the Eastern CFRAM Study and will follow the Preliminary Options Report. The report will detail the work carried out during the entire study including the outcomes of the PFRA, flood hazard assessment, flood risk assessment, FRM objectives, environmental considerations, FRM options, programme or work and plan monitoring and review.

1.3 PURPOSE OF THE OPTIONS REPORT

The main objectives of the preliminary options report are to detail the activities associated with Flood Risk Assessment and the development of Flood Risk Management Options and to present the outcomes of each.

The report first details the flood risk to the area being studied based on the following four groups of receptors:

- Society (including risk to people);
- The Environment;
- Cultural Heritage;
- The Economy.

This assessment informs how best to manage the present and future flood risk to the area being studied.

The second part of this report details the decision making process in identifying the most appropriate FRM options and details of the options to be taken forward to consultation.

1.4 INTRODUCTION TO THE OPTIONEERING PROCESS

As discussed in section 1.1, optioneering is a process where the flood risk to an area is identified and quantified which informs what the most appropriate FRM options are. This is carried out through a series of activities summarised in figure 1.3.

The activities shown in the blue boxes aim to identify and assess the flood risk. The starting point in this process is to identify the spatial scale of assessment (SSA). The following SSAs are defined:

- Unit of Management SSA - refers to a hydrometric area. There are four Units of Management within the Eastern CFRAM study area;
- Sub-Catchment SSA - refers to the catchment of the principle river on which an AFA sits;
- AFA SSA - refers to the individual AFA being considered only;
- IRR SSA - refers to Individual Risk receptor.

Identifying the SSA informs the FRM method screening process by assuring that only methods appropriate to the spatial scale are considered.

The next step in the optioneering process is the review of the flood hazard maps. The output of the hydraulic modelling is the flood hazard maps. The flood hazard maps are then used to assess the flood risk and produce flood risk maps. The flood risk receptors as defined in section 1.1 are assessed in order to ascertain where flood risk management will be required and to what extent. These activities are detailed in chapter 4 of this report.

On quantifying the flood risk the FRM methods are screened to rule out unacceptable methods. The remaining methods are then developed further and combined to make potential FRM options. This process is described further in chapter 7 and illustrated in the orange boxes.

The FRM options are assessed against a set of criteria and objectives and scored in order to identify the preferred options (maroon box). These options are then presented for consultation with the OPW, progress group and steering group (consisting of local authorities and key stakeholders) and the preferred options identified are taken forward to public consultation, thereby allowing the public the opportunity to influence the options (purple box). Comments from the public consultation are then considered and if appropriate used in updating preferred options which in turn becomes the FRM Measure to be presented in the draft Flood Risk Management Plan (FRMP). Environmental assessment (SEA and AA) feeds into the screening of the FRM methods, the development of potential FRM options, the Multi Criteria Analysis (see section 7.3) and consultation activities (green box).

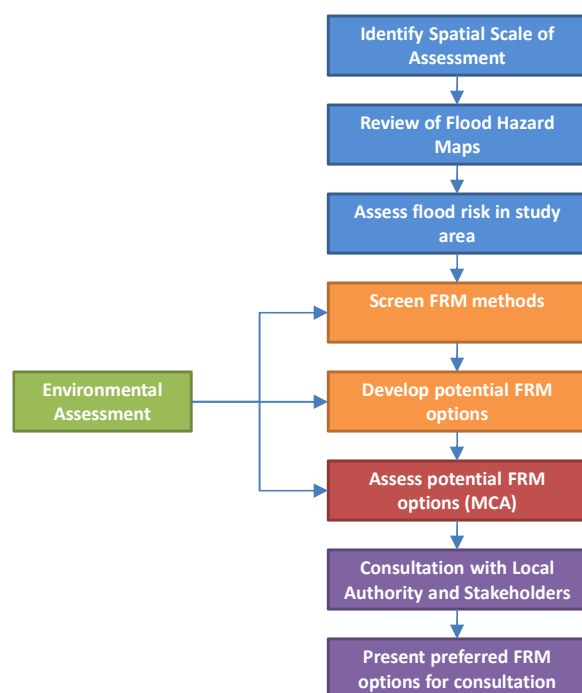


Figure 1.3 - Optioneering process

2 DATA COLLECTION

This section details the data used in the optioneering process. The data was received primarily from the OPW or produced by RPS through the hydraulic analysis within Eastern CFRAM Study activities. Supplementary data was also received from Local Authorities and stakeholders. The data was received in various formats including GIS, AutoCAD, MS Excel and MS Word. The following sections list the data used for the various activities in the optioneering process.

2.1 BACKGROUND MAPPING

Mapping was used throughout to aid the various tasks. This included assessing the flood risk in the study area and identifying the receptors at risk. The maps were used to locate and inform the alignment of proposed FRM options and to reference the options being displayed in the various maps produced. The table below summarises the maps that were used.

Table 2.1 - Background Mapping data

Data	Use
OSi 210,000 scale raster map	Various tasks
OSi 50,000 scale raster map	Various tasks
OSi 10,000 scale Digi-City map	Various tasks
OSi 6 inch scale map	Historical review
OSi Ortho Photography	Various tasks
OSi 5,000, scale vector map	Various tasks
OSi 2,500, scale vector map	Various tasks
OSi 1,000, scale vector map	Various tasks
Google maps	Identification of receptors and location of FRM measures
Bing maps	Identification of receptors and location of FRM measures

2.2 RECEPTORS

The following data was used to identify and assess the social, environmental, cultural heritage and economic receptors at flood risk within the study area.

Table 2.2 - Receptor data

Data	Use
Primary Schools, Post Primary Schools, Third Level	Flood Risk Assessment
Fire Stations	Flood Risk Assessment
Garda Stations	Flood Risk Assessment
Civil Defence	Flood Risk Assessment
OPW buildings	Flood Risk Assessment
Nursing Homes, Hospitals, Health Centres	Flood Risk Assessment
Geo-Directory (Oct 2010)	Flood Risk Assessment and Damage Assessment
Utility Infrastructure Assets	Flood Risk Assessment
Road	Flood Risk Assessment
Rail	Flood Risk Assessment

Data	Use
Ports	Flood Risk Assessment
Airports	Flood Risk Assessment
Architectural Heritage	Flood Risk Assessment
National Monuments	Flood Risk Assessment
National Heritage Area	Flood Risk Assessment
Proposed National Heritage Area	Flood Risk Assessment
Special Area of Conservation	Flood Risk Assessment
Special Protected Area	Flood Risk Assessment
Pollution Sources	Flood Risk Assessment
Development and Local Area Plans	Assessment of FRM methods
Historical Flood Data	Flood Risk Assessment
OPW Channels	Assessment of FRM methods
OPW Embankments	Assessment of FRM methods
OPW Benefiting Land	Assessment of FRM methods
River Centrelines	Various tasks
Lakes	Various tasks

2.3 FLOOD HAZARD

The output of the hydraulic analysis provides details on the flood extent, depth, velocity, risk to life and flood zones. This was used to inform the flood risk assessment, the screening of FRM methods, developing and assessing potential FRM options. The following datasets were used.

Table 2.3 - Flood Hazard data

Data	Use
Camac flood extent raster (50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.1% AEP flood events)	Establish flood extent and depth for Flood Risk Assessment and developing FRM options
Camac HEFS (10%, 1%, 0.1% AEP flood events)	Developing FRM options
Camac MRFS (50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.1% AEP flood events)	Developing FRM options

2.4 SURVEY DATA

Surveys were carried out by Murphy Surveys for the Eastern CFRAM Study. This consisted of surveying river cross sections, and specified structures such as culverts, bridges and weirs. Existing defences were surveyed and their geometric data recorded along with condition assessment being carried out. LiDAR surveys were flown for all relevant areas within the study area providing detail of the topography of the flood plain.

Table 2.4 - Survey data

Data	Use
Channel and Structure survey	Flood Risk Assessment and developing FRM options
Defence asset condition survey	Flood Risk Assessment and developing FRM options

Data	Use
Property survey	Flood Risk Assessment
Floodplain survey	Various tasks

2.5 ECONOMIC ASSESSMENT

The following data was used during the economic assessment. This involved assigning damage to receptors during different flood events and providing costs to FRM options.

Table 2.5 - Economic Assessment data

Data	Use
Cost Database	Costing FRM options
Depth Damage Database	Damage Assessment
Consumer Price Index data	Damage Assessment and costing FRM options
Market value of house data	Damage Assessment
Purchasing Power Parity	Damage Assessment and costing FRM options
OSi Building polygons	Damage Assessment

3 SPATIAL SCALES OF ASSESSMENT

When considering which FRM methods to assess it is accepted that certain methods will be more appropriate at larger spatial scales and others at smaller spatial scales. It is important therefore to define what spatial scale is being assessed at the beginning of the screening process. This is to avoid a situation where the full impact of a FRM method is missed due to the spatial scale of assessment (SSA) being too small, or the FRM method being considered is ineffective as the SSA is too large. OPW have defined a minimum of four SSAs and these are described in the following sections.

3.1 UNIT OF MANAGEMENT SSA

The Unit of Management SSA refers to a full hydrometric area. For the Eastern CFRAM Study there are four hydrometric areas; Hydrometric Area (HA) 07 (Boyne), HA08 (Nanny – Delvin), HA09 (Liffey-Dublin Bay) and HA10 (Avoca-Vartry).

At this scale, methods that could provide benefits to multiple AFAs within the Unit of Management and other areas should be considered, along with the spatial and temporal coherence of methods being considered at smaller SSAs.

FRM methods and options that might typically be applicable at this scale might include (but are not necessarily limited to):

- Policy requirements;
- Flood forecasting and warning systems;
- Land Use Management, where applicable;
- Methods implemented under other legislation;
- Requirements for additional monitoring (rain and river level / flow gauges).

3.2 SUB-CATCHMENT SSA

The sub-catchment SSA refers to the catchment of the principal river on which an AFA sits, including areas upstream and areas downstream to the river's discharge into another, larger river or into the sea. This SSA would generally not be applicable to AFAs that are only at risk from coastal flooding, except where multiple AFAs are at risk around an estuarine area, where the estuary area may be treated as a Sub-Catchment SSA.

At this scale, methods that could provide benefits to multiple AFAs within the sub-catchment and other areas should be considered, such as upstream storage or tidal barrages, along with the spatial and temporal coherence of methods being considered at smaller SSAs.

3.3 AFA SSA

The AFA SSA refers to an individual AFA; such areas would include towns, villages, areas where significant development is anticipated and other areas or structures for which the risk that could arise from flooding is understood to be significant. At this scale, methods benefitting only the particular AFA in question are considered, even if the implementation of a given method includes works or activities outside of the AFA, i.e., elsewhere in the sub-catchment or UoM. Examples of where this might apply would be storage options upstream of the AFA, or flood forecasting and warning systems, that provide benefits to no other AFAs than the AFA under consideration, as well as all other FRM methods and options, such as protection methods, conveyance improvement, etc.

There are however instances where considering only single methods to address all risk within the AFA SSA will not be appropriate, and options for many AFAs are likely to comprise a range of methods as necessary to address the risk in different parts of the AFA. Such instances might include:

- Areas along the same watercourse but which could benefit from independent FRM methods and where whole AFA methods, which would attempt to provide flood protection to all flood prone areas, might not be appropriate or viable. These would be discrete areas of flood risk within an AFA (e.g., a large urban area).
- Single or multiple areas along one or more watercourses within the AFA where the cause or mechanism of flooding are physically or effectively hydraulically independent from each other. Examples might include AFAs where:
 - Floods can occur due to different sources (i.e., coastal and fluvial);
 - A steep tributary gives rise to flood risk that causes flooding in an area where the tributary is hydraulically independent of flooding that could be caused by the main river running through the AFA;
 - Two separate watercourses run through and give rise to separate areas of flood risk in a single AFA and discharge to the sea (or another river).

It is therefore essential that the discrete areas of flood risk within an AFA be identified to inform the screening of FRM methods and avoid duplicate work. It is preferable to incorporate methods into options which will address the flood risk to the entire AFA. However, where this is not viable the preferred option for the AFA may comprise separate methods addressing only individual discrete areas of flood risk, with, where appropriate, recommendations for local / community action and / or the pursuit of minor works to address the flood risk in areas where no viable methods have been identified.

3.4 IRR SSA

The IRR SSA refers to Individual Risk Receptors, such as water treatment works or power stations. This SSA does not need to be considered for significant receptors that are within a broader AFA, as the receptor is then considered as an integral part of that AFA, and analysis of individual receptors within a given AFA is considered to be beyond the scope of the CFRAM studies.

At this scale, methods benefitting only the IRR are to be considered, even if the implementation of a given method includes works or activities outside of the boundary of the IRR i.e., elsewhere in the sub-catchment or UoM. All FRM methods and options are potentially applicable at the IRR SSA.

3.5 SPATIAL SCALE OF ASSESSMENT FOR THE RIVER CAMAC

The River Camac flows through Dublin City. Dublin City has been identified as an AFA. However, due to its size and the complexity of the densely populated and urbanised area, high priority watercourses (HPWs) have been designated within it. The following HPWs are located within the Dublin City AFA.

- Lower Liffey
- River Camac
- River Poddle
- River Santry
- River Carysfort/Maretimo

Each HPW named above is assessed at an AFA scale. The River Camac has therefore been assessed as an AFA and AFA appropriate FRM methods have been considered. For further details on the FRM methods see chapter 6.

The River Camac is part of UoM 09 (Liffey-Dublin Bay) and will be assessed within this spatial scale. The next SSA is sub-catchment, however due to the unique circumstances where the whole River

Camac catchment is being assessed at AFA scale the sub-catchment SSA is not relevant or duplicates the AFA SSA and therefore is not required. The River Camac is therefore also assessed at AFA scale as discussed. The River Camac was reviewed for discrete areas of flood risk and it was found that all areas influence all other areas and therefore the smallest SSA being considered is at AFA scale. The following SSAs, as summarised in table 3.1 are therefore to be considered for the River Camac.

Table 3.1 - Spatial Scales of Assessment for the River Camac

SSA	Name
UoM	Liffey-Dublin Bay
Sub-Catchment	<i>Not required</i>
AFA	River Camac
IRR	<i>Not required</i>

Due to the River Camac being prioritised within the Eastern CFRAM Study, FRM methods appropriate at UoM scale have not been assessed. This will be completed in 2016 as part of the deliverables for the Eastern CFRAM Study. The Liffey-Dublin Bay UoM will consider FRM methods which will benefit multiple AFAs and HPWs of which the River Camac is one. The following AFAs and HPWs are part of the Liffey-Dublin Bay UoM:

- Lower Liffey HPW
- River Camac HPW
- River Poddle HPW
- River Santry HPW
- River Carysfort/Maretimo HPW
- Baldonnel
- Blessington
- Celbridge
- Clane
- Clontarf
- Dublin
- Hazelhatch
- Kilcock
- Leixlip
- Lucan to Chapelizod
- Maynooth
- Naas
- Newbridge
- Raheny
- Sandymount
- Santry
- Sutton & Baldoyle
- Sutton & Howth North
- Turnings/Kileenmore

The extent of the River Camac being studied is dictated by its catchment and is presented in figure 3.1 below. The upstream extent of the area being studied starts in the foothills of the Wicklow Mountains north of Saggart and flows through Clondalkin, Fox & Geese, Bluebell, Drimmagh and Kilmainham before discharging to the River Liffey at Heuston Station.

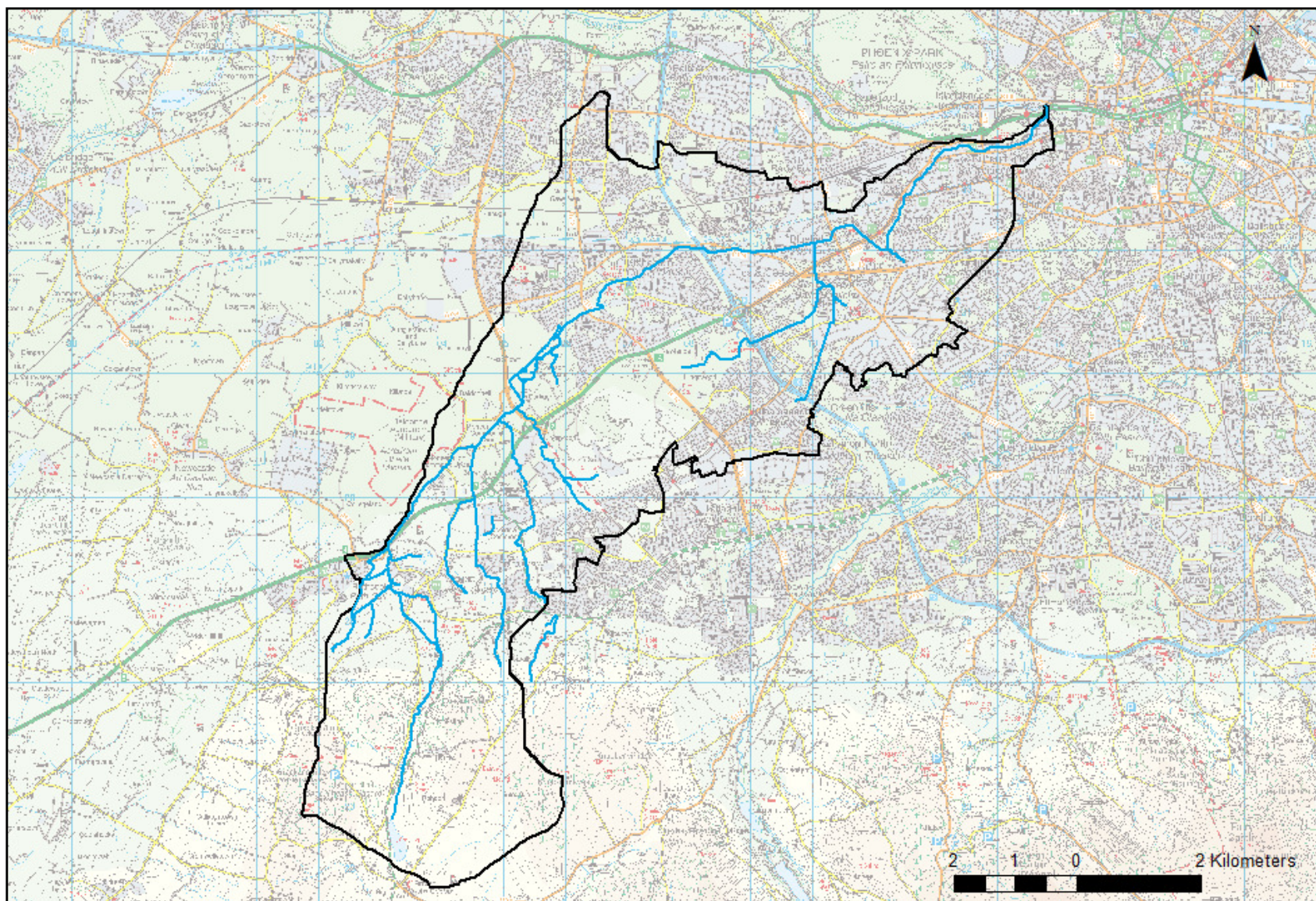


Figure 3.1 - River Camac Spatial Scale of Assessment

4 FLOOD RISK ASSESSMENT

The aim of the Flood Risk Assessment is to assess and map the potential adverse consequences (risk) associated with flooding in the study area to the four receptor groups as described in the table below. The level of flood risk to a receptor can be affected by its location within the flood extent or the proportion of the receptor within the flood extent, the depth to which it floods, the velocity of the water adjacent to the receptor and the receptors' vulnerability to flooding.

Table 4.1 - Flood risk receptor groups

Flood Risk Receptor Group	Receptor Dataset	Indicator
Social	Residential Properties	Location and number of residential properties
	Residential Homes (children, disabled, elderly)	Location, type and number
	Prisons, Schools (primary, post-primary, third level education), fire stations, garda stations, civil defence, ambulance stations, hospitals, health centres, OPW buildings, government buildings, local authority buildings.	Location, type and number
	Social amenity sites	
Environment	Special Area of Conservation, Special Protected Area, Groundwater Abstraction for Drinking Water, Pollution Sources, Recreational water including bathing water	Location, extent and nature
Cultural Heritage	Architectural Heritage, National Monuments, National Heritage Area, Proposed National Heritage Area, Sites and Monument Records, Record of Monuments and Places	Location, type and number
Economic	Residential and Commercial Properties	Location, type, number, depth-damage data
	ESB power stations, ESB HV substations, Board Gais assets, Eircom assets, Water supply, Data centres	Location, type and number
	Road networks, Rail networks & Stations, Ports and Harbours	Location, type, number and length

4.1 FLOOD RISK MAPS

The clearest way to present the flood risk within a study area is through flood risk maps. These maps detail the source of the risk and the receptors at risk. The following flood risk maps were produced:

- Social Risk map
- Environmental Risk map
- Cultural Heritage Risk map
- Economic Activity map
- Economic Risk Density map
- Number of Inhabitants map

In areas where there are few receptors it may be possible to combine the social, environmental and cultural heritage receptors together in one map. An example of the social, environmental and cultural heritage risk maps are shown in figure 4.1 below. The economic activity map presents the receptors with a monetary damage according to their type as listed in table 4.1. The economic risk density maps present the annual average damage (AAD) calculated from the damage assessment, for further details on the damage assessment see chapter 5. The AAD is represented by the total damage occurring from all receptors in a square grid. This grid varies from 1km² in urban areas to 5km² in rural area. An example of Economic Risk Density map is shown in figure 4.2. The flood risk maps are presented in appendix A.

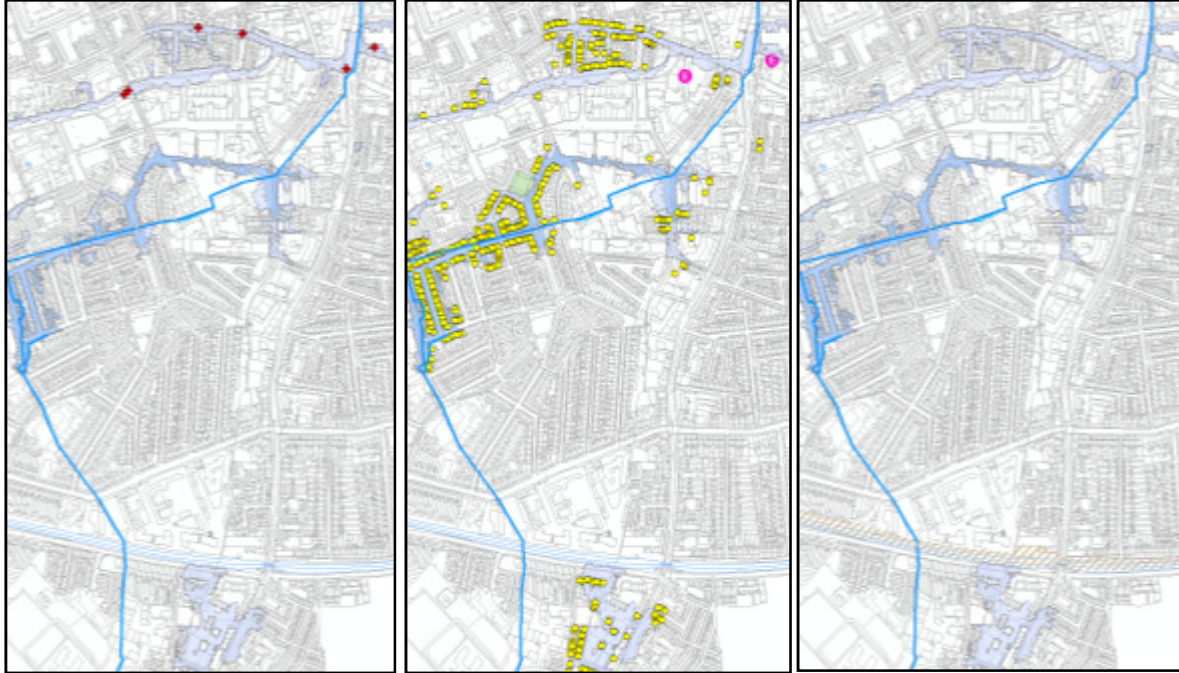


Figure 4.1 - Example cultural heritage, social, environmental risk maps

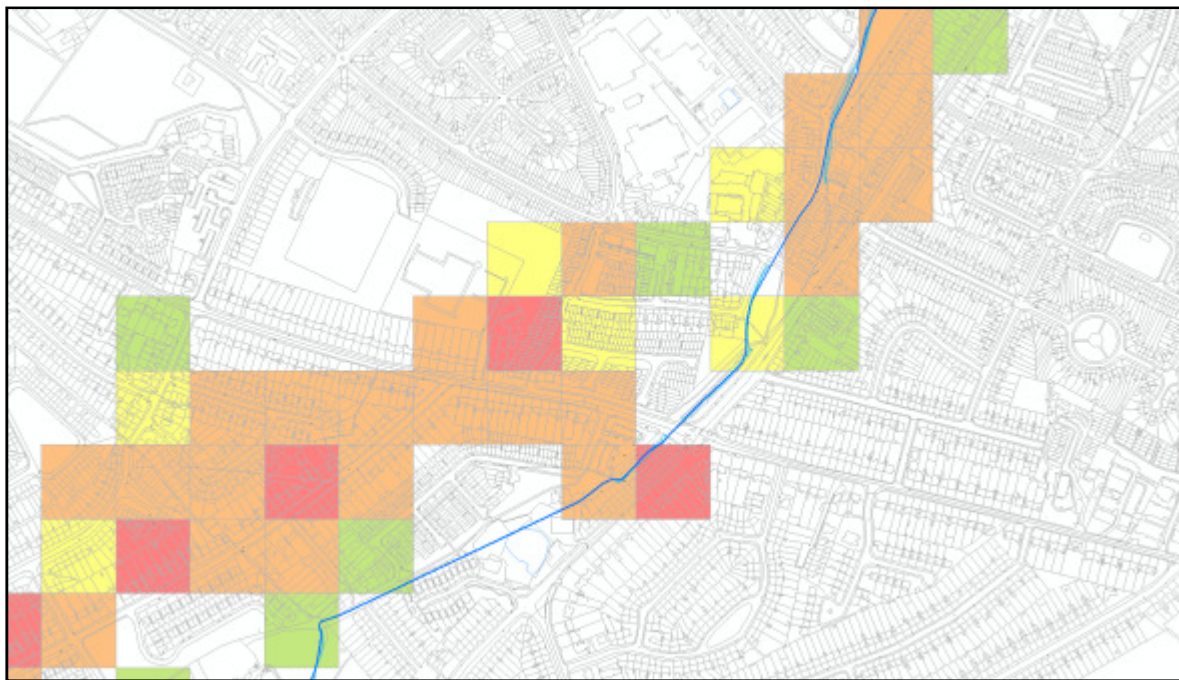


Figure 4.2 - Example economic risk density maps

4.2 FLOOD RISK FROM THE RIVER CAMAC

The following table summarises the flood risk to the study area from the River Camac.

Table 4.2 - Flood risk from the River Camac

Flood Risk Receptor Group	Receptor	Risk
Social	Residential Properties	899 residential properties are a risk from the 0.1% AEP flood event. 407 residential properties are a risk from the 1% AEP flood event. 113 residential properties are a risk from the 10% AEP flood event.
	Residential Homes (children, disabled, elderly)	None at risk within the 0.1% AEP flood event.
	Prisons, Schools (primary, post-primary, third level education), fire stations, garda stations, civil defence, ambulance stations, hospitals, health centres, OPW buildings, government buildings, local authority buildings.	1 school is at risk from the 0.1% AEP flood event. None at risk within the 1% AEP flood event.
	Social amenity sites	Multiple parks and open amenity spaces including Clondalkin and Lansdowne Valley Parks are at risk from the 10%, 1% and 0.1% AEP flood events, however the risk is deemed to be low as the use of the amenity sites return after the flood event and areas vulnerability to flood damage is low.
Environment	Special Area of Conservation, Special Protected Area, Groundwater Abstraction for Drinking Water, Pollution Sources, Recreational water including bathing water	Part of the Grand Canal and the Slade of Saggart and Crooksling Glen, pNHA's, are at risk from the 1% and 0.1% AEP events. 3 Licensed PPC facilities are at risk from the 10%, 1% and 0.1% AEP events. 2 licensed waste facilities are at risk from the 1% and 0.1% AEP events.
Cultural Heritage	Architectural Heritage, National Monuments, National Heritage Area, Proposed National Heritage Area, Sites and Monument Records, Record of Monuments and Places, UNESCO sites	The following 10 structures designated by DEHLG as monuments are at risk: <ul style="list-style-type: none"> • 3 bridges • 16th/17th century house • 2 water mills • ringfort • 3 burnt spreads or fulacht fia
Economic	Residential and Commercial Properties	The total AAD from residential and commercial properties is €3,640,570
	ESB power stations, ESB HV substations, Board Gais assets, Eircom assets, Water supply, Data centres	No receptors identified

Flood Risk Receptor Group	Receptor	Risk
	Road networks, Rail networks & Stations, Ports and Harbours	Heuston Railway Station and associated railway lines are at risk from the 0.1% AEP flood event Parts of the N4, N7 and M50 are at risk from the 0.1% AEP flood event
	Agricultural land	1.8km ² of agricultural land is at risk from the 0.1% AEP flood event

5 DAMAGE ASSESSMENT

As part of the economic risk assessment a monetary damage is assigned to certain receptors at risk. This damage represents the costs to the nation if the flood events being considered were to occur. The following receptors are assigned a monetary damage value:

- Residential properties
- Commercial properties
- National road network and rail network
- Utility infrastructure

The total damage to an area being studied is used to quantify the economic risk and provide the amount of potential benefit that would occur if a FRM measure is put in place which would prevent the damage from occurring.

5.1 DAMAGE ASSESSMENT GUIDELINES

The damage assessment methodology for the CFRAM study follows the guidance in "The Benefits of Flood and Coastal Defence: A Manual of Assessment Techniques" (Flood Hazard Research Centre, Middlesex University, UK, 2005) This document is often referred to as the Multi Coloured Manual (MCM).

The MCM results from research carried out by Middlesex University Flood Hazard Research Centre and provides data and techniques for assessing the benefits of flood risk management in the form of flood alleviation. The MCM has focused on the benefits that arise from protecting residential property, commercial property, and road disruption amongst other areas as experience has shown that these sectors constitute the vast majority of the potential benefits of capital investment.

Based on this research the MCM provides depth damage data for both residential and commercial properties. For certain depths of flood water a damage has been assigned to a property. This damage is a combination of the likely items within the building and the building structure itself. The damage to each property is dependent on the property type, as such the MCM has categorised both the residential and commercial properties. An example of the depth damage data is shown in figure 5.1 overleaf.

	DETACHED LAND USE CODE 11														
	2010 PRICES						FLOOD DURATION MORE THAN 12 HOURS								
Components of damage	DEPTH ABOVE UPPER SURFACE OF GROUND FLOOR														
	-0.3	0	0.05	0.1	0.2	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3
1 Paths and paved areas	0	54.32	58.38	73.32	162.24	360.86	413.33	455.09	503.6	604.25	695.98	824.35	859.62	902.05	949.92
2 Gardens/fences/sheds	0	0	102.7	202.5	705.95	1308.73	2248.7	2948.95	3755.38	5856.54	6811.11	8088.28	9415.97	10109.3	10487.34
3 External main building	935.51	1223.52	1430.1	1763.94	2321.56	2647	3129	3808.85	4520.47	5913.69	8082.01	9828.87	12058.9	15251.18	19279.72
4 Plasterwork	176.84	487.74	1124.95	1712.61	2592.26	3917.47	4739.55	5016.94	5913.36	7178.64	8142.19	9363.46	9918.23	10305.43	10860.2
5 Floors	0	1756.48	6399.48	7457.37	8453.96	9270.39	9344.44	9418.48	9455.5	9603.59	9751.68	9899.77	9899.77	9899.77	9899.77
6 Joinery	0	357.66	1572.85	4443.87	6055.64	7510.61	7534.94	7853.8	7951.63	8025.14	8220.27	11396.54	11396.54	11396.54	11396.54
7 Internal decorations	209.19	241.8	374.99	1716.8	2753.95	2833.64	2931.01	3104.93	3234.52	3348.56	3462.6	3480.28	3480.28	3480.28	3480.28
8 Plumbing and electrical	0	0	962.99	1726.05	2669.08	4106.08	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48	4395.48
Building Fabric Damage	1321.54	4121.52	12026.44	19096.46	25714.63	31954.78	34736.44	37002.52	39729.95	44925.9	49561.33	57277.02	61424.8	65740.04	70749.25
1 Domestic appliances	0	0	2.76	194.14	903.63	1657.79	1798.06	1906.38	1907.06	1907.74	1910.12	1911.61	1911.61	1911.61	1911.61
2 Heating equipment	0	0	35.91	68.21	118.1	161.3	697.84	955.69	1149.08	1149.08	1149.08	1149.08	1149.08	1149.08	1149.08
3 Audio/video	0	0	163.71	479.77	686.43	959.78	1287.64	1682.48	1718.91	1718.91	1718.91	1718.91	1718.91	1718.91	1718.91
4 Furniture	0	0	194.6	334.79	2140.23	2175.78	2207.94	2251.35	2335.43	2361.77	2361.77	2361.77	2361.77	2361.77	2361.77
5 Personal effects	0	0	57.37	143.14	281.24	430.58	642.4	785.56	859.81	974.85	1058.12	1058.12	1058.12	1058.12	1058.12
6 Floor coverings/curtains	0	0	1360.09	1432.05	1432.05	1474.94	1654.79	1667.42	1688.06	1702.99	1702.99	1702.99	1702.99	1702.99	1702.99
7 Garden/DIY/leisure	0	0	32.38	96.52	126.4	203.42	233.81	266.64	269.59	277.21	278.09	278.09	278.09	278.09	278.09
8 Domestic clean-up	0	0	4820.2	4820.2	5915.8	5915.8	6884.9	6884.9	6884.9	6884.9	8666.9	8666.9	8666.9	8666.9	8666.9
Household Inventory Damag	0	0	6667.02	7568.82	11603.87	12979.4	15407.39	16400.42	16812.85	16977.46	18845.97	18847.46	18847.46	18847.46	18847.46
Total Damage	1321.54	4121.52	18693.46	26665.28	37318.5	44934.18	50143.83	53402.95	56542.8	61903.35	68407.3	76124.49	80272.26	84587.5	89596.71
Total Damage/Square Metre	17.07	52.5	247.12	353.18	495.36	597.03	666.9	711.58	751.92	821.18	908.61	1013.84	1068.33	1123.67	1188.23

Figure 5.1 - MCM's depth damage data for detached houses

5.2 RECORDING DAMAGE ASSESSMENT DATA

The damage assessment is carried out in order to quantify the economic risk to the area being studied. This requires a lot of details to be recorded such as background data, interim calculations and final damage results. As such RPS have created geo-referenced shapefiles, known as economic risk shapefiles, with the relevant data recorded in their attribute tables, an example is shown in figure 5.2. The damage data for residential properties, commercial properties and utility infrastructure have been grouped into a single point file for each area being studied and polyline file for road networks. The following sections detail how the damage assessment is carried out and the data that is recorded during various processes within the shapefile attribute tables.

The River Camac study has produced a shapefile detailing the economic risk to properties called "H09PE_EcRisk_Prop".

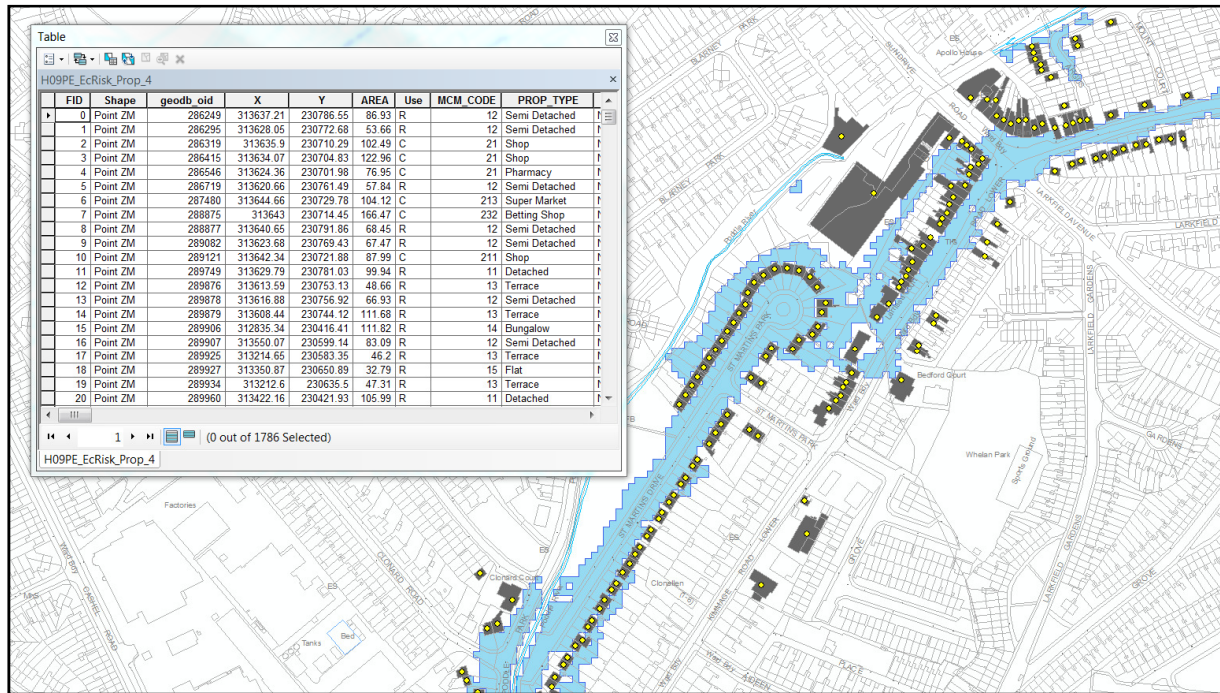


Figure 5.2 - Example shapefile with attribute table showing damage assessment data

5.3 CATEGORISATION OF PROPERTIES

All properties identified as at risk during the flood risk assessment were included in the damage assessment. The first task in this process is to identify the property use. This was carried out according to MCM guidelines, table 5.1 details the various property types. The MCM assigns a code to each property type to aid the damage calculations where a number can more readily be used in calculations rather than a description in text format.

Table 5.1 - MCM property types

Property Type	MCM code	Property Type	MCM code
Detached House	11	Leisure	51
Semi Detached House	12	Hotel	511
Terrace House	13	Boarding House	512
Bungalow	14	Caravan Mobile	513
Flat	15	Caravan Static	514
Shop/Store	21	Self catering Unit	515
(High Street) Shop	211	Hostel (including prisons)	516
Superstore/Hypermarket	213	Bingo hall	517
Retail Warehouse	214	Theatre/Cinema	518

Property Type	MCM code	Property Type	MCM code
Showroom	215	Beach Hut	519
Kiosk	216	Sport	52
Outdoor market	217	Sports Grounds and Playing Fields	521
Indoor Market	218	Golf Courses	522
Vehicle Services	22	Sports and Leisure centres	523
Vehicle Repair Garage	221	Amusement Arcade/Park	524
Petrol Filling Station	222	Football Ground and Stadia	525
Car Showroom	223	Mooring/Wharf/Marina	526
Plant Hire	224	Swimming Pool	527
Retail Services	23	Public Building	6
Hairdressing Salon	231	School/College/University/Nursery	610
Betting Shop	232	Surgery/Health Centre	620
Landrette	233	Residential Home	625
Pub/Social club/wine bar	234	Community Centres/Halls	630
Restaurant	235	Library	640
Café/Food Court	236	Fire/Ambulance station	650
Post Office	237	Police Station	651
Garden Centre	238	Hospital	660
Office	3	Museum	670
Offices (non specific)	310	Law court	680
Computer Centres (Hi-Tech)	311	Church	690
Bank	320	Industry	8
Distribution/Logistics	4	Workshop	810
Warehouse (including store)	410	Factory/Works/Mill	820
Land Used for Storage	420	Extractive/heavy Industry	830
Road Haulage	430	Sewage treatment works	840
Warehouse (electrical goods)	411	Laboratory	850
Warehouse (ambient goods)	412	Miscellaneous	9
Warehouse (frozen goods)	413	Car Park	910
		Public Convenience	920
		Cemetery/Crematorium	930
		Bus Station	940
		Dock Hereditament	950
		Electricity Hereditament	960

For each area being studied all properties found within the 0.1% AEP flood extent were categorised. This was carried out using data gained from site visits, surveys, OSi mapping, An post geo-directory and online mapping. The OSi building polygon layer was used initially to locate all the properties and provide their floor area. Sheds and garages which have no depth damage data in the MCM guidelines were then removed and the remaining building categorised. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.2 - Categorisation of properties data

Data type	Attribute name	Data details
Property ID	geodb_oid	An Post geo-directory database ID
Location	"X" and "Y"	X Y coordinates to Irish National Grid
Floor Area or Road Length	"Area" or "Length"	Floor area of the property or the length of road
Property Use	Use	"R" for residential and "C" for commercial
MCM code	MCM_CODE	As per MCM guidelines
Property type	PROP_TYPE	As per MCM guidelines

Within the River Camac's 0.1% AEP flood extent 1280 residential and commercial properties were categorised.

5.4 PROPERTY THRESHOLD LEVEL

The damage assigned to a property relates to the depth of water above floor level. As such the threshold level of all properties is required as part of the damage assessment. As a general rule of thumb most properties are constructed with the floor level raised 300mm above the adjacent ground level. This was assumed for the Eastern CFRAM Study and is consistent with the assumptions made in the MCM, however it is recognised that this is not always the case as some properties contain basements, while others have a half basement and a raised ground floor. To account for this a survey was carried out using data gained from site visits, surveys, OSi mapping and online mapping. The properties found to have basements were recorded along with properties with a raised ground floor level. For the purposes of this study a conservative approach was assumed and where a basement was found the threshold level was dropped 2.5m below ground level and all raised properties were still assumed to be 300mm above ground level. This accounts for the MCM's methodology of assigning damage which assumes that damage will start at ground level, i.e. -300mm, where the external building structure and plasterwork would be damaged.

To assign a finished floor level (FFL) to properties 300mm was added to the ground level or where a basement was present 2.5m was taken from the ground level. In order to calculate this the ground level at each property is required. For each area being studied a LiDAR survey was carried out capturing the ground level to an accuracy of 0.2m. This survey data was extract at the centre point of each property using the spatial analysis tool within the ARC GIS model package. This was data was attributed to each property as the ground level and the FFL calculated accordingly. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.2 - Property threshold data

Data type	Attribute name	Data details
Basement present?	BASEMENT	"Yes" basement present, "No" no basement
Is ground floor raised	RAISED	"Yes" ground floor is raised, "No" ground floor is not raised
Ground level	GRND_LVL	LiDAR data extracted at each property, measured in mOD
Finished Floor Level	FFL	Ground level plus 300mm for properties without basement, ground level minus 2.5m for properties with basement

Within the River Camac's 0.1% AEP flood extent 30 properties were identified as having a basement and 28 properties identified as having raised FFLs.

5.5 FLOOD DEPTH OF PROPERTIES

To estimate the damage to a property the depth that it floods to is required. This will vary depending on the size of the flood event. As part of the Eastern CFRAM Study the depths to which the properties flood during the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP flood events were calculated. The depth of flooding is calculated by finding the difference between the flood water elevation and the FFL. To achieve this the maximum flood depth at each property is required. It is recognised that as flood water passes around a structure such as a building the water will be pushed against the upstream face and be forced around the structure. This creates an uneven distribution of water levels around the structure. This was simulated in the hydraulic analysis where buildings were placed in the floodplain forcing the modelled flood to flow around them. To maintain a conservative approach the maximum flood level adjacent to the building was extracted and recorded in the attribute table of the economic risk shapefile. This process was achieved by carrying out a statistical analysis in ARC GIS and was carried out for each property and for each flood event. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.3 - Flood depth of properties data

Data type	Attribute name	Data details
Flood level for all flood events	Q1000_ELEV, Q200_ELEV, Q100_ELEV, Q50_ELEV, Q20_ELEV, Q10_ELEV, Q5_ELEV, Q2_ELEV,	The maximum flood level adjacent to the building (mOD)
Flood depth for all flood events	Q1000_Dp, Q200_Dp, Q100_Dp, Q50_Dp, Q20_Dp, Q10_Dp, Q5_Dp, Q2_Dp,	Difference between the flood level and FFL

5.6 FLOOD DAMAGE TO PROPERTIES

Once the depths of flooding are known the damage can be calculated using the MCM depth damage data. This is known as direct damage in that the flooding directly damages assets, it does not account for indirect damages such as heating costs to dry out the house, etc. For each property type a typical damage based on historical data has been assigned to a depth of flooding, an example of which is shown in figure 5.1. Depth of flooding and therefore damage is measured relative to the FFL of the property in question and starts at a depth of -0.3m which is the surrounding ground level to the property (please refer to sections 5.4 and 5.5 for more details). These direct damage figures have been updated to 2010 pound sterling prices and are based on the floor area of the building an example of this data is present in figure 5.1. A GIS tool has been developed which provides the direct damage in each flood event for each building in pound sterling 2010 prices per square metre by interpolating between the depth damage figures provided in the MCM guidance. This damage figure is then multiplied by the floor area of the property to give the total damage. This figure is converted to Euro and updated to 2013 prices using the OECD's purchasing power parities (PPP) records and CSO Ireland's consumer price index (CPI). The overall adjustment factor used in the Eastern CFRAM Study was 1.345, the conversion rates are shown below.

Table 5.4 - Converting pound sterling to euro using the PPP 2010 values from OECD website

	PPP
US - UK	0.667
US - Ire	0.853
UK - Ire	1.278861

Table 5.5 - Conversion rates to current year prices using CPI from CSO Ireland website

	CPI
2006	100
2010	101.2
Apr-13	106.4
2010 - 2013	1.051383

The following details the information and calculations described above were recorded within the economic risk shapefile attribute tables:

Table 5.6 - Flood damage to properties data

Data type	Attribute name	Data details
Direct damage per meter square	Q1000_M2Dm, Q200_M2Dm, Q100_M2Dm, Q50_M2Dm, Q20_M2Dm, Q10_M2Dm, Q5_M2Dm, Q2_M2Dm	Damage per meter square to each property according to the depth of flooding from each flood event as per MCM data. Values in pound sterling updated to 2010 costs.
Damage to property over full floor area	1000_Dm£10, Q200_Dm£10, Q100_Dm£10, Q50_Dm£10, Q20_Dm£10, Q10_Dm£10, Q5_Dm£10, Q2_Dm£10	Damage per meter square multiplied by floor area of building.
Damage conversion to euro and 2013 prices	1000_Dm€13, Q200_Dm€13, Q100_Dm€13, Q50_Dm€13, Q20_Dm€13, Q10_Dm€13, Q5_Dm€13, Q2_Dm€13	Conversion rate (1.345) applied to damage to property over full floor area.

5.7 INTANGIBLE DAMAGES AND EMERGENCY COSTS

Apart from the material damages to the building structure and the goods inside the property, it is recognised that there are monetary damages associated with clean up costs, temporary accommodation, stress, etc. To account for this it is OPW policy to assigned intangible damages to all residential properties equal to its direct damages. No intangible damages are assigned to commercial properties as these costs do not apply at the same level with the exception of small family run businesses. To achieve this a survey is carried out identifying these small businesses and an intangible damage equal to the direct damage assigned to the property as well.

Intangible damages are also considered due to road disruption of national roads. Within the area affected by the River Camac no national roads were impacted and therefore no damages considered.

A cost will be associated with emergency services dealing with the flood events. Following the Environment Agency's Flood or Coastal Erosion Risk Management (FCERM) appraisal guidance, which the MCM guidance has been adapted to comply with, a value of 10.7% of the residential damages has been assigned to the emergency services costs. This percentage of the residential damages has been used in this damage assessment also. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.7 - Intangible damages and emergency cost data

Data type	Attribute name	Data details
Intangible Damage	Q1000_IntD, Q200_IntD, Q100_IntD, Q50_IntD, Q20_IntD, Q10_IntD, Q5_IntD, Q2_IntD,	Set equal to the direct damage of residential properties and small family run businesses.
Emergency costs	1000_emerg, Q200_emerg, Q100_emerg, Q50_emerg, Q20_emerg, Q10_emerg, Q5_emerg, Q2_emerg,	Equal to 10.7% of the residential damages.

5.8 ANNUAL AVERAGE DAMAGE AND PRESENT VALUE DAMAGE

So far in the process damages have been assigned to each property for each flood event. In order to gain an appreciation of the economic risk the overall damage needs to be calculated. This is represented by assessing the likelihood of each of these flood events occurring in any given year and applying this as a percentage to the damage, this is known as the Annual Average Damage (AAD). This can then be taken over the lifetime of the project which has been set at 50 years and discounted back to present day costs, this is known as present value damage (pvd).

Calculating the AAD can best be described by considering the graph shown in figure 5.3. The points shown represent the flood events where the damage has been calculated in the Camac area. Their position on the graph is dictated by the damage caused and the frequency of the flood event occurring in any given year. These points are joined together to create a damage curve. This curve represents all the other flood events that could occur in between the flood events shown, for example the damage that would occur in a 33%AEP event is estimated by the damage curve that is drawn from the 50%AEP event to the 20%AEP event. The area under the curve is therefore a function of the damage and the frequency and gives the AAD. It can be seen then that for many areas being considered the majority of the damage occurs from the smaller yet more frequent flood events rather than the larger flood events that appear at first glance to contribute most to the flood damage. Because the AAD is calculated by the area under the damage curve the more flood events included in the assessment the more accurate the AAD figure will be. However a minimum of three events are required to create a curve but the less events there are the more likely you are to overestimate the AAD. It is also essential to identify the threshold event. This is the event where damage starts to occur. Failure to do this will cut the damage curve short and reduce the area under the graph. The events that were considered for this study were the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP flood events.

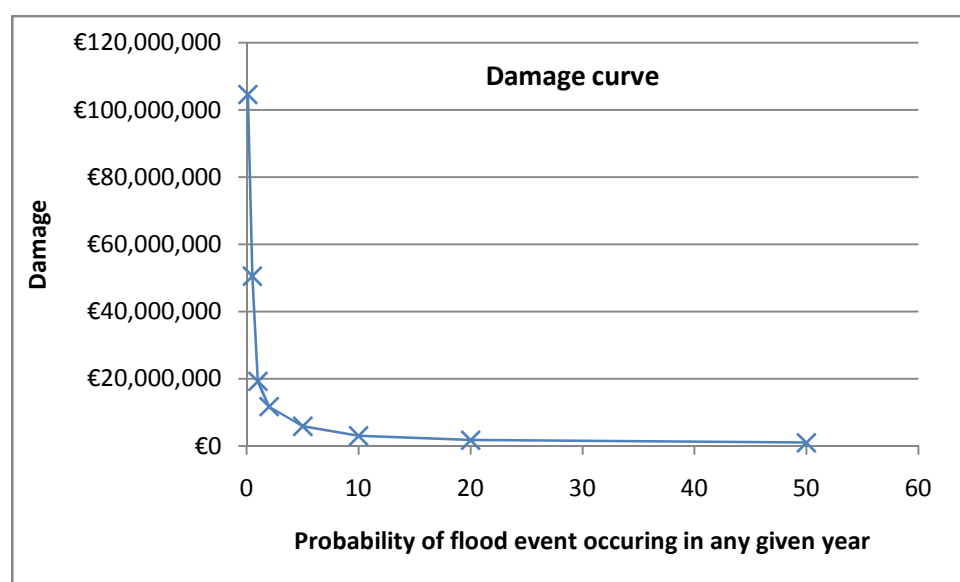


Figure 5.3 - Camac direct damage curve

Once the AAD is calculated the present value damage is calculated. The present value damage calculation sums the AAD that is expected to occur for each of the 50 years being considered in this study. However in order for the damage value in each year to be comparable with each other they are discounted to represent the equivalent present damage value. Discounting damage values in the future is based on the principle that generally people prefer to receive goods or services now rather than later. This is known as time preference. The cost therefore of providing a flood management option will also be discounted to present day values. It is therefore best practice to discount the AAD figure for any given year by the distance in years it is away from the present day. The OPW has set this discount rate at 4% and this figure has been used in this study. Over the 50 years being considered this amount to factoring the AAD by 22.341. The AAD and PVD are calculated for the direct damages, intangible damages and the emergency costs separately and totalled to give the overall damage available.

The AAD calculations consider damages up to the 0.1% AEP flood event. However when considering the FRM methods to alleviate this risk the standard of protection will usually be to the 1% AEP flood event. It is therefore useful to calculate the AAD up to the 1% AEP flood event as well. This becomes useful when considering residual risk. For more details on FRM methods and standards of protection see chapter 6. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.8 - AAD and pvD data

Data type	Attribute name	Data details
Annual Average Damage for direct damages, intangible damages and emergency costs	AAD, AAD_Int, AAD_emerg, AAD_Q100, AAD_Int100, AAD_eme100	The equation to calculate the AAD is as follows: $(Q2_Dm€13+Q5_Dm€13)/2*(0.5-0.2)+(Q5_Dm€13+Q10_Dm€13)/2*(0.2-0.1)+(Q10_Dm€13+Q20_Dm€13)/2*(0.1-0.05)+(Q20_Dm€13+Q50_Dm€13)/2*(0.05-0.02)+(Q50_Dm€13+Q100_Dm€13)/2*(0.02-0.01)+(Q100_Dm€13+Q200_Dm€13)/2*(0.01-0.005)+(Q200_Dm€13+1000_Dm€13)/2*(0.005-0.001)$
Present value damage	pvD, pvD_Int, pvD_emerg, pvD_Q100, pvD_Int100, pvD_eme100	The AAD factored by 22.341

5.9 CAPPING DAMAGES

It is recognised that for certain properties the overall damage associated with it can far exceed the market value of the property. This can be due to either the depth to which it floods or the frequency with which it floods or more likely a combination of both. Where such a situation occurs it is necessary to cap the damages at the market value. The market value was calculated at a regional level with the market value data sourced from CSO.

Residential properties affected by the River Camac have been assigned a market value of €320,728 which is the regional average market value of second hand properties for Dublin taken during the first quarter of 2013. Damage to commercial properties were reviewed to ascertain the proportion any individual commercial property has on the overall damage. For properties contributing to 1% of the total damage or more a detailed assessment was carried out. This involved confirming the amount of floor area that would flood, the FFL assumed and the valuation of the property as set by the Valuation Office. A number of commercial properties contributed 1% of the damage or greater and were therefore reviewed. While the floor area and FFL remained unchanged the damage for some of these properties had to be capped.

The approach taken in this study is to cap the direct damages and the intangible damages separately before totalling up the overall damages with the emergency costs. The following details were recorded within the economic risk shapefile attribute tables:

Table 5.9 - Capping damages data

Data type	Attribute name	Data details
Capped damages for direct and intangible	pvD_Cap, pvDInt_Cap, pvD_Q100cp, Int100_cap	Any damages over €320,728 are capped at this value
Valuation of commercial properties	Valuation	Value of each property reviewed on a case by case basis. Information of each property value found from the Valuation Office (valoff.ie)

5.10 DAMAGE ASSESSMENT REVIEW

A review of the damage assessment was carried out to quality check the data being used. This was carried out by reviewing the properties that contribute over 1% of the capped pvD. The review consists of checking the property type and the finished floor level including split levels, the footprint areas and the depth damage being applied.

5.11 SUMMARY OF DAMAGES ON THE RIVER CAMAC STUDY

The last field in the attribute table of the economic risk shapefile is the total damage which sums the capped present value direct damages, the capped present value intangible damages and the present value emergency costs. This gives the overall present value damage. The table below summarises the damages associated with the River Camac Study.

Table 5.10 - Summary of damages on the River Camac Study

Total AAD	Total AAD up to 1% AEP event	Total pvD	Total pvD up to the 1% AEP event
€3,460,983	€2,720,698	€42,593,196	€30,440,033

6 FLOOD RISK MANAGEMENT METHODS

There are various ways to manage the flood risk within any area being studied. These methods can be grouped into 4 areas.

- Protect methods - reduce the likelihood of flooding. Methods include flood walls, flow diversion and upstream storage.
- Prepare methods - reduce the impact of flooding. Methods include individual property protection, flood forecasting and public awareness campaigns.
- Prevent methods - avoids future flood risk. Methods include planning and development control.
- Permit methods - accepts that flooding will occur. Methods include maintaining the existing regime and doing a minimal amount of maintenance.

The CFRAM study has set an objective to identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk within the Area being studied. With this being said it is an aspiration of the study to provide the highest standard of flood risk management that is cost beneficial. This would, in general, entail providing 'protect' methods over 'prepare' methods and avoiding 'permit' methods where possible. Prevent methods, which consider future flood risk, should always be included.

6.1 STANDARD OF PROTECTION

The standard of flood risk management is also dependant on the design standard being applied i.e. the maximum level of protection that the FRM methods provide. The preferred design standard for this study is the 1% AEP event for fluvial flood risk and the 0.5% AEP event for coastal flood risk or the appropriate combination for areas of joint fluvial-coastal influence. The FRM method achieving the design standard must also have provision for adaptability to the mid range future scenario (MRFS) flood risk.

Where there is a clear technical, economic, social or environmental case as to why the preferred standards would not be appropriate or acceptable, or where the adoption of alternative standards would provide significant additional benefit in relation to costs and impacts, this is also considered.

6.1.1 Residual Risk

For any FRM measure the flood risk to an area being studied can never be totally eliminated as a flood event greater than the design standard can occur, this is referred to as residual risk. In calculating residual damage it is assumed that for any design standard less than the 0.1% AEP flood event, residual damage will occur. In most cases the design standard will be to the 1% AEP event and there will therefore be residual damage for the 0.5% and 0.1% AEP flood events. For the purposes of this study it is assumed that for FRM methods that contain the flow within the river channel, such as flood walls, the residual damage for flood events greater than the design standard will be the same as the present day current damages. For FRM methods that reduce the flow, such as upstream storage, a benefit will be provided during flood events greater than the design standard event and therefore should be calculated.

6.2 LIST OF FRM METHODS

The following table lists the FRM methods being considered in the Eastern CFRAM Study. This list is not exhaustive and additional FRM methods may become apparent which are specific to an area being studied. Where this is the case the additional FRM methods will be added to the long list of methods to be screened.

Table 6.1 FRM Methods

FRM Method	Method type	Description
Do Nothing	Permit	Implement no new flood risk management measures and abandon any existing practices.
Maintain Existing Regime	Permit	Continue any existing flood risk management practices, such as reactive maintenance.
Do Minimum	Permit	Implement additional minimal measures to reduce the flood risk in specific problem areas without introducing a comprehensive strategy.
Planning and Development Control	Prevent	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.
Building Regulations	Prevent	Regulation relating to floor levels, flood proofing, flood resilience, sustainable drainage systems, prevention of reconstruction, or redevelopment in flood risk areas.
Catchment Wide SuDS	Prevent	Implement attenuating infrastructure to the existing drainage system in order to reduce the flow entering the river network. This may consist of swales, french drains, soak aways, larger culverts, underground storage tanks, ponds, green roofs, etc.
Emergency Response Plan	Prevent	Using the Flood mapping, various reports and proposed flood risk management measure to review and update their Emergency Response Plans
Land Use Management	Protect	Changing how the land is used in order to store or slow surface water runoff and slow in channel and out of bank flow along the river in order to store flood water in suitable locations. This may consist of the creation of wetlands, restoring river meanders, increasing the amount of boulders and vegetation in channel, perpendicular hedges or ditches in the floodplain, tree rows and planting in floodplain to either slow flow or direct flow, planting along banks parallel to flow, fencing off livestock from riparian strip, changing agricultural practices to decrease soil compaction and increase water infiltration.
Strategic Development Management	Prevent	Management of necessary floodplain development (proactive integration of structural measures into development designs and zoning, regulation on developer-funded communal retention, drainage and/or protection systems.
Maintenance Programme	Protect	Increased frequency of routine maintenance, targeting of problem culverts, bridges or other control structures, removal of debris and rubbish tipping, desilting of sedimentation prone areas.
Upstream Storage/Storage	Protect	Large scale dam and reservoir, offline washlands (embanked areas of floodplain to store water during larger flood events.
Tidal Barrage	Protect	A fixed or moveable barrier across the river to prevent tidal water progressing upstream.
Improvement of Channel Conveyance	Protect	Deepening of channel bed, widening of channel, realigning long section profile, removal of constraints, lining or smoothing channel.
Hard Defences	Protect	Reinforced concrete walls, earth embankments, demountable barriers.
Relocation of Properties	Protect	Abandoning flood risk area and properties within and providing alternative properties in suitable area.

FRM Method	Method type	Description
Culverting	Protect	Routing the watercourse underground through culvert to prevent out of bank flooding along a specific stretch.
Diversion of Flow	Protect	Removing flow from the watercourse via a diversion and discharging to a suitable river or coastline or reintroducing the flow further downstream. This may consist of a culvert or an open channel.
Overland Floodways	Protect	Using topographical features of the floodplain to convey out of bank flow and discharge to other suitable rivers, the coast line or further downstream on the same river. This may consist of fields, park land, roads, etc.
Sealing Manholes		Preventing pressurised culverts from surcharging through manholes and flooding the surrounding area.
Rehabilitation of Existing Defences	Protect	Improvement of existing flood defences.
Localised Protection Works	Protect	Minor raising of existing defences/levels, infilling gaps in defences, etc.
Flood Warning/Forecasting	Prepare	Installation of flood forecasting and warning system and development of emergency flood response procedures.
Public Awareness Campaign	Prepare	Informing public who live, work or use a flood risk area on risks of flooding and how to prepare for flooding.
Individual Property Protection	Prepare	Flood protection and resilience measures such as flood gates, vent covers, use of flood resilient materials, raising electrical power points, etc

6.3 BASELINE CONDITION

The FRM method "maintain existing regime" is considered the baseline condition as is described in table 6.1 above. This represents the current scenario which all other scenarios, created by the implementation of other FRM methods, are compared to. This is realised by the reduction in receptors at risk, as described in chapter 4, and the reduction in monetary damage (see chapter 5) also known as benefit.

7 ASSESSMENT OF FRM METHODS

In order to ensure a consistent approach across the whole Eastern CFRAM study area, a process to assess the FRM methods for each SSA has been standardised as summarised in the flow chart below.

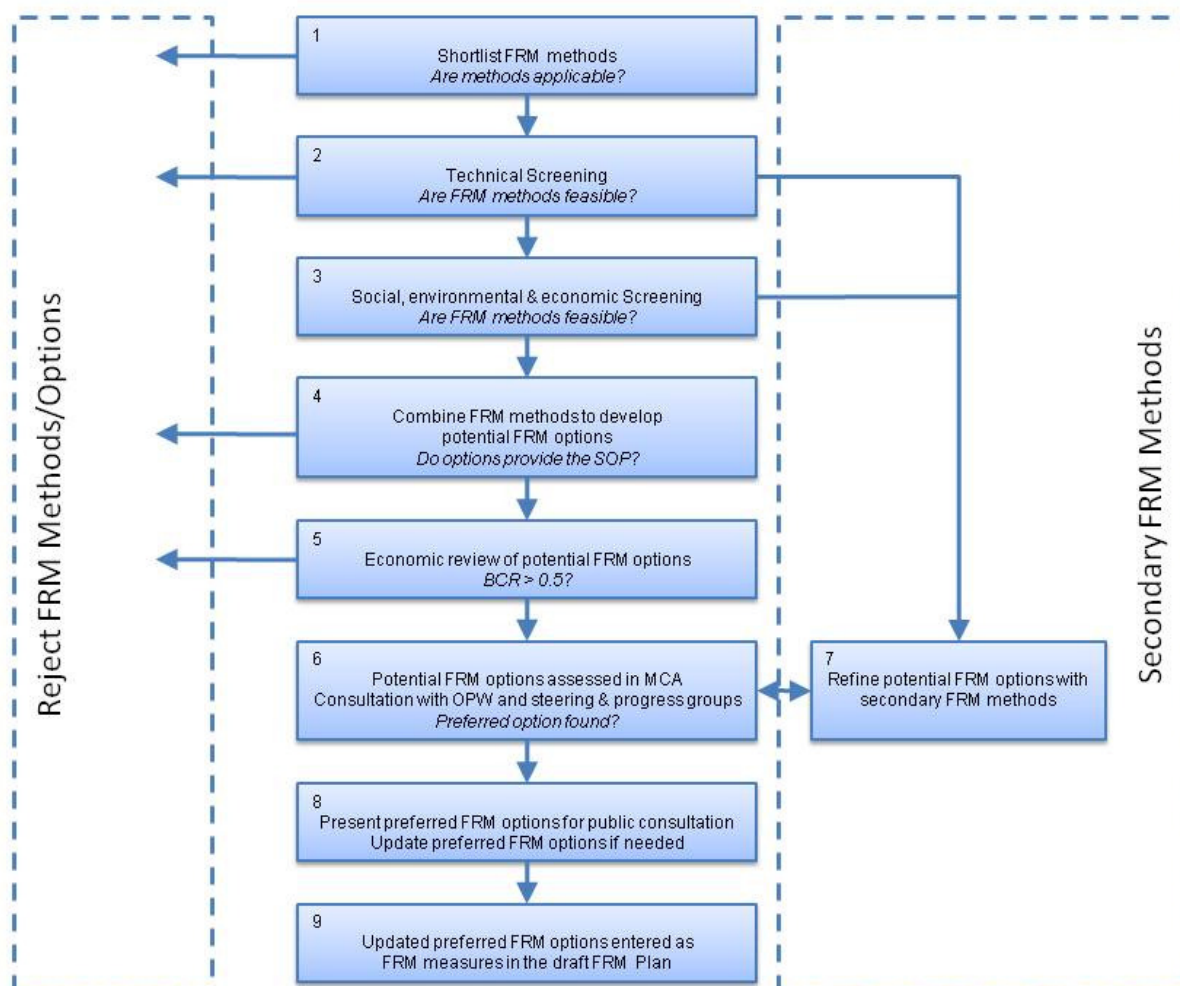


Figure 7.1 - Assessment of FRM methods flow chart

The flow chart summarises in boxes 1 to 3 how the screening of FRM methods is carried out. Boxes 4 and 5 describe how the feasible FRM methods that come through the screening are developed into potential FRM options and box 6 shows how the potential FRM options are assessed to identify the preferred FRM options. This process is carried out in consultation with the OPW and the steering group and progress groups of the Eastern CFRAM Study. If however no preferred FRM option is identified, box 7 shows how the options can be refined with additional or other FRM methods and reassessed. The preferred FRM options are then taken forward to public consultation and, if required, updated to reflect the comments and issues raised before presenting the final FRM measure in the FRM Plan as shown in boxes 8 and 9. Appendix B provides a record of the assessments and decisions made when this process was applied to the Camac.

7.1 SCREENING FRM METHODS

The aim of the screening process is to ensure the widest possible range of FRM methods are considered in the assessment process while the rejection of any methods shall be robust and with

clear and transparent reasoning. The following section details how the screening process achieves this.

7.1.1 Shortlisting FRM Methods

A long list of FRM methods (Table 6.1) has been developed by OPW and RPS and includes FRM methods which reduce the likelihood of flooding (protect measures), reduce the impact of flooding (prepare measures) and avoid future flood risk (prevent measures).

This long list is reviewed for each SSA in terms of applicability. Measures which are not applicable to the specific SSA are rejected and a shortlist of FRM methods created to be considered further. An example of this is considering flood forecasting at an AFA SSA. If the flood forecasting were to benefit multiple AFAs, the full benefit of the FRM method would not be captured at an AFA scale of assessment and would therefore be considered only at UoM scale or Sub-Catchment scale. For more information on SSAs see chapter 3. The full list of possible FRM methods along with a description of each is presented in chapter 6.

7.1.2 Technical Screening

Although an FRM method may be applicable, it may not be feasible from a technical point of view. This may be due to the method providing no reduction in flood risk. An example of this is where a high level of maintenance and operation is currently being carried out on the watercourse and to implement the "do minimum" method, (a reduction on maintenance and operation) would result in increased flood risk with little cost savings. Where such methods are identified they are rejected at this stage and not considered any further in the process.

Other methods may have little impact in reducing the flood risk. A flood warning system on a flashy watercourse may not be effective, and though it may be beneficial to some degree, it would not be effective as a primary method. Where such methods are identified they are classed as a secondary method. Secondary methods are methods which have been identified as unsuitable to manage the flood risk as a primary method but do not merit complete rejection from the assessment process. These secondary methods are "parked" until the primary options refinement stage. A situation where this could arise is when hard defences have been identified as the primary method but, for example due to complex access along the watercourse, it may be better to culvert a short reach where hard defences would be unsuitable.

The technical screening also identifies methods which would be excessively complex to implement. This may be due to restrictions on construction methods or obstacles such as bridges and underground services. These methods may be effective in reducing the flood risk but due to their complex nature do not merit further consideration until all other more straightforward methods have been exhausted. These methods are also classed as secondary methods.

Methods which upon review are found to be relatively straightforward and have a noticeable impact in reducing the flood risk are classed as primary methods and are taken through to the next stage of the assessment process.

7.1.3 Environmental and Social Screening

It is important to ensure that methods being brought through the assessment process will not have significant detrimental environmental, social/cultural or economic impacts. To this end each primary method progressing through the technical screening is assessed from an environmental, social/cultural and economic criteria in turn.

The following rationale are considered when developing the methodology for screening methods in relation to their potential to impact on environmental, social and cultural receptors:

- The methodology must be robust and defensible;
- The methodology must be rapid and replicable;
- The methodology must be precautionary to avoid rejecting methods at an early stage which might prove to be the best available method manage flood risk;
- The methodology must not overlap the multi-criteria analysis and environmental assessment processes.

In order to fulfil these aims, the methodology considers whether the method is likely to have a direct or indirect negative effect on Special Areas of Conservation (SACs), Special Protection Areas (SPAs) or Unesco sites.

- If there are no SACs, SPAs or Unesco sites within the footprint of the proposed method, directly adjacent to the proposed method, or directly upstream or downstream of the proposed method, then the method can continue through the screening process as a primary method.
- If an SAC, SPA or Unesco site is within the footprint of the proposed method, directly adjacent to the proposed method or directly upstream or downstream of the proposed method, then the method cannot be considered as a standalone method at this stage and is classed as a secondary method.

This methodology ensures that when a method has been flagged as potentially having a negative impact on an SAC, SPA or Unesco site, the optioneering team will put the method aside and consider other methods which have not been flagged in terms of environmental, social or cultural impacts first.

7.1.4 Economic Screening

The economic screening aims to ensure that only methods likely to be cost beneficial will progress to the more detailed assessment. This is carried out by calculating the benefit available and comparing that to the cost of implementing the method. The benefit available is quantified through the damage assessment as described in chapter 5. Benefit is a monetary measurement and considers the reduction in damage between the baseline condition (maintain existing regime, see chapter 6) and the FRM method or option being considered. In practice the benefit usually equates to the baseline condition damage up to the design standard of the FRM method/option being considered plus the reduction in residual risk beyond the design standard, see chapter 6 for details on residual risk.

In order to ensure that the screening process is conservative, only the construction cost associated with the FRM method in question is considered. Costs associated with other works such as design and maintenance of the FRM method are excluded at this stage. This allows more FRM methods to pass through the economic review to be assessed in more detail later. A ratio between the benefit and construction cost provides the basis for screening out methods. FRM methods achieving a benefit cost ratio (BCR) of 0.5 or greater are considered further. Setting the minimum BCR at 0.5 recognises that when FRM methods are developed into FRM options, the quantities (i.e. length of flood wall etc) of any given FRM method can change and therefore the BCR. A BCR of 0.5 is therefore a conservative approach while still identifying excessively expensive methods. FRM methods achieving less than 0.5 are classed as secondary methods as they are unlikely to result in a cost beneficial scheme. The following section details how the construction costs of FRM methods are estimated.

7.1.5 Construction Costs

The cost of constructing FRM methods is calculated using data from OPW, local authorities, the Environment Agency and RPS. This data is based on previous schemes using real costs and is presented as rates to be applied to the FRM methods depending on the quantities involved.

As such the first stage in this process is to quantify the FRM methods. This information included wall lengths and heights, lengths of culvert, volume of embankments, etc. This is carried out by hydraulic modelling and using the GIS software ESRI ArcMap. The location and extent of FRM methods are delineated in GIS using OSi mapping with consideration of the flood risk receptors. Once finalised the design standard flood event is simulated with each FRM method in place in a hydraulic model and the heights required calculated. This can sometimes be an iterative process.

Once the quantities are calculated, the construction rates can be applied to estimate the cost. For details of the Camac FRM methods costs see appendix C.

7.2 DEVELOPING POTENTIAL FRM OPTIONS

The primary FRM methods which are progressed through the technical, environmental, social and economic screening are combined to create potential FRM options. Most methods, while providing significant reductions in flood risk, will not manage the flood risk entirely by themselves. Methods are therefore required to be combined into options so that they will manage the flood risk and achieve the objectives set by the study. In most cases the FRM options are required to provide a design standard of the 1% AEP flood event although this can vary depending on the requirements of the SSA. All

possible combinations of FRM methods are considered as potential FRM options, however, only options that can provide the required design standard are progressed further.

7.2.1 Economic Review of Potential FRM Options

A further economic review is carried out to ensure that a BCR of greater than 0.5 is still being achieved as it is possible that combining FRM methods can lead to an excessively costly option being created that is unlikely to be cost beneficial. This economic review is similar to that described in section 7.14 using the same benefit value as previously calculated. The costing of the option is carried out in more detail. Costs additional to those for construction are included to give a more accurate estimate of the overall cost of the option. The following items are included in the option costing.

Table 7.1 - Additional costs to FRM options

Item	% of construction cost
Provision for unmeasured items	20
Provision for optimism bias	60
Maintenance costs (PVD over 50yrs)	-
Detailed design (design fees)	6
Construction supervision	5
Allowance for archaeological and/or environmental monitoring/exploration	21
Cost of land acquisition/compensation	12.5
Allowance for art	1

Details of the costing of the FRM options are presented in appendix C

7.3 ASSESS POTENTIAL FRM OPTIONS (MCA PROCESS)

The potential FRM options which are progressed to this stage are found to be technically, socially, environmentally and economically feasible. In assessing the potential FRM options the best, most appropriate option which has been found feasible by the preceding stages is identified.

The assessment of FRM 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 associated with flooding and the implementation of FRM options considered 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. Indicators are used to assign scores for each objective on the basis of the degree to which the option being appraised goes beyond a specified basic requirement for that objective towards meeting a specified aspirational target for that objective. Weightings are applied globally (nationally) for each objective, with local weightings 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 described above.

The sums of the weighted 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.

The following section describes the MCA process in more detail.

7.3.1 Criteria and Objectives

Each option is assessed against four criteria; Technical, Economic, Social and Environmental. Scoring against these criteria helps to achieve the CFRAM Study objective of achieving the most cost effective and sustainable management of existing and potential future flood risk within the area being studied. A set of objectives are associated with each criteria and are an expansion on the requirements of the National Flood Policy Review and the EU Floods Directive. The degree to which an option achieves each objective is an indication of the success of the option in managing the flood risk, the more the option achieves across all the objectives, the greater preference it will be given.

Generally each objective focuses on a flood risk receptor type and how the flood risk is to be reduced with the exception of the technical objectives which focus on how the options would be constructed and operated during their lifetime. In some cases the flood risk receptor type is wide reaching and sub-objectives are required to focus on a specific group within the receptor type. The table below presents the objectives and sub-objectives set for each of the criteria in the MCA.

Table 7.2 - Criteria and Objectives of the MCA

Criteria	Objective	Sub-Objective
Technical	Ensure flood risk management options are operationally robust	Ensure flood risk management options are operationally robust
	Minimise health and safety risks associated with the construction and operation of flood risk management options	Minimise health and safety risks associated with the construction and operation of flood risk management options
	Ensure flood risk management options are adaptable to future flood risk	Ensure flood risk management options are adaptable to future flood risk
Economic	Minimise economic risk	Minimise economic risk
	Minimise risk to transport infrastructure	Minimise risk to transport infrastructure
	Minimise risk to utility infrastructure	Minimise risk to utility infrastructure
	Manage Risk to agricultural land	Manage Risk to agricultural land
Social	Minimise risk to human health and life	Minimise risk to human health and life of residents
		Minimise risk to high vulnerability properties
	Minimise risk to community	Minimise risk to social infrastructure
		Minimise risk to local employment
	Minimise risk to flood-sensitive social amenity sites	Minimise risk to flood-sensitive social amenity sites
Environmental	Support the objectives of the WFD	Prevent deterioration in status, and if possible contribute to the achievement of good ecological status / potential of water-bodies
	Minimise the risk to potential sources of environmental pollution	Minimise the risk to potential sources of environmental pollution
	Support the objectives of the Habitats Directive	Avoid damage to, and where possible enhance, European protected Natura 2000 sites
	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	Avoid loss/damage to, and where possible enhance, nationally protected sites of nature conservation importance i.e. (p)NHA, Ramsar
		Avoid loss / damage and where possible enhance, legally protected species and other known species of conservation concern

Criteria	Objective	Sub-Objective
	Protect, and where possible enhance, fisheries resource within the catchment	Maintain existing, and where possible create new, fisheries habitat including the maintenance or improvement of conditions that allow upstream migration for fish species
		Protect, and where possible enhance, the quality of shellfish waters
	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	Protect, and where possible enhance, visual amenity
	Avoid damage to or loss of features of cultural heritage importance and their setting	Avoid damage to or loss of features of architectural value and their setting
		Avoid damage to or loss of features of archaeological value and their setting
	Protect soil function	Avoid loss of soil from erosion
	Minimise detrimental impacts of climate change on the environment resulting from flood risk management activities	Minimise detrimental impacts of climate change on the environment resulting from flood risk management activities

7.3.2 Scoring Options

A scoring system is devised for the MCA to assess each option in a robust, clear and transparent way. A score is given for how well an option achieves an objective but also accounts for the importance of the objective relative to other objectives and how important the receptors within the area being studied are relative to the receptor group being considered.

To enable the scoring of the objectives, indicators are set. Indicators are parameters, measurable and numeric where possible, by which the success of the option in meeting a particular objective can be gauged. For example a social objective is to "minimise risk to human health and life of residents" and the indicator is "the number of residential properties at risk from flooding during the 0.1% AEP event". The difference that the option being assessed makes to the number of residential properties at risk can be calculated as a percentage and applied to the maximum score value to give the score.

The success of the option in achieving the objective in question is quantified by how much it goes beyond a specified basic requirement and achieves a specified aspirational target. As such basic requirements and aspirational targets have been set in terms of the defined indicator.

The basic requirement represents a neutral status or 'no change', whereby 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. If an option performs less well 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. The basic requirement is therefore not an absolute minimum requirement for acceptability, but a benchmark to define positive versus negative impacts or performance.

The aim of an objective is defined by the aspirational target, whereby an option would be deemed as performing optimally 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. The aspirational targets are therefore not requirements that must be met, and it should be noted that very effective options may still fail to meet the aspirational targets.

The following rules have been applied to the MCA scoring:

- An option achieving the basic requirement is given a score of zero
- An option meeting the aspirational target is given a score of five. Options achieving more than the aspirational target still score a maximum of five.

- An option achieving somewhere in between the basic requirement and the aspirational target is given a score proportional to the degree to which it achieves the objective beyond the basic requirement towards meeting the aspirational target.
- An option failing to meet the basic requirement is given a negative score of -1 to -5 depending on the impacts associated with the options.
- Where the performance or impact of the option becomes unacceptable a score of -999 is given and the option is rejected from further consideration.

Justification for each objective score has been included within the MCA tables providing the rationale for each score.

7.3.3 Weighting Objectives

It is appreciated that some objectives are more important than others and to give them all equal importance would not reflect the real benefit, or lack thereof, achieved. For example, an objective considering risk to life is more important than one considering social amenity sites. To reflect this in the scoring a global weighting has been applied. This gives an objective more or less weight in the overall assessment of the suitability or value of the option. Global weightings will remain constant nationally and were derived following consultation carried out on previous pilot studies and with OPW and a number of environmental stakeholders.

It is further appreciated that for any given objective its importance will depend on the SSA and the type of receptor it is considering. For example, an objective considering the impact to environmentally designated sites may have more significance if the site is of international importance than of local importance. To account for this a local weighting is applied to the objective. The local weighting has been determined numerically according to the degree of risk (e.g. annual average damage, number of properties, etc) but some have been set by professional judgment. Details of the local weighting rationale are included within the MCA tables.

7.4 PREFERRED FRM OPTIONS

Identification of the preferred FRM options is based on the following:

- Benefit Cost Ratio (BCR) - The ratio between the monetary benefit of adopting a FRM option and the overall cost of constructing, operating and maintaining the option. A ratio of one or greater must be achieved for an option to be considered further.
- MCA score - The sum weighted score of all of the objectives set in the MCA. This score represents the non-monetary benefit of adopting the FRM option
- Overall Net Benefit/Cost - This is a ratio between the non-monetary benefit of adopting a FRM option and the overall cost of constructing, operating and maintaining the option.

Professional judgement is required to identify the preferred options as some options may have a good monetary BCR but a poor overall net benefit/cost or vice versa and comparison between options may not always be clear. Where preferred options are identified the baseline condition can be removed from further consideration. If no preferred options are identified the baseline condition will remain as a preferred option.

Preferred FRM options are reviewed by OPW and the Eastern CFRAM Study progress group and steering group members. Recommendations can be made at this point by these groups to improve the options.

7.4.1 Refining Options

If no preferred option is identified, or recommendations are made during the consultation with the OPW and the Eastern CFRAM Study progress group and steering group members, a refinement of the potential FRM options can be carried out. This process allows for secondary methods, previously "parked" as shown in figure 7.1, to be considered in strategic places in order to reduce the costs, or address particular social, environmental or technical issues. The refinement process also allows for a lower SoP to be considered if it is clear that no options are feasible to protect to the preferred SoP. For

each refined option considered, an MCA and cost benefit analysis are carried out and the revised score assessed to see if a preferred FRM option is achieved.

7.5 PREFERRED FRM OPTIONS FOR THE RIVER CAMAC

The table below details the potential FRM options and the FRM methods that each option consists of. The potential FRM options were reviewed by OPW and the progress and steering groups. No preferred FRM options were identified due to both BCR's being below unity. These options were reviewed with the purpose of refining them in order to achieve a favourable BCR, however all other FRM methods considered increased the complexity of the option and consequently the costs. While no preferred option was identified, the two most cost beneficial options were presented for consultation as options that could be examined further in a subsequent study.

Table 7.3 - Potential FRM Options

	FRM Methods		
Option 1	Hard defences	Sealing manholes	
Option 2	Hard defences	Sealing manholes	Upstream storage/storage

The breakdown of how each FRM option scored during the MCA is detailed in table 7.4 below

Table 7.4 - Preferred FRM Options MCA score breakdown

	Option 1	Option 2
Technical score	500	300
Economic score	540	540
Social score	400	400
Environmental score	122.5	77.5
Overall score	1562.5	1317.5

Both options are similar in the methods proposed to manage the flood risk and the MCA scores can therefore also be expected to be similar. Where the scores vary it reflects the differences between the two options which are namely the addition of a storage area in Lansdowne Valley Park and the resulting reduction in walls heights and length downstream of the park.

It can be seen that both options achieved the same economic and social scores. This is due to all options protecting the same receptors to the same standard of protection. Each option would however impact on the environment to varying degrees and their technical scores represent the differing complexity during construction, operation and maintenance.

Details of the screening of FRM methods, developing FRM options and assessing FRM options are presented in appendix B. Sketches of these options are presented in the appendix D.

8 CONSULTATION AND UPDATING FRM OPTIONS

An important element of the Eastern CFRAM Study is consultation with all interested parties including the public. This is carried out at strategic points in the study, including the identification of preferred FRM options. This gives the interested parties an opportunity to communicate local knowledge and how they are currently affected, and to give their views on the preferred FRM options, thereby influencing the decision-making process.

The consultation includes a wide range of interested parties with general or specific interests such as impact on society, the environment, cultural heritage or the economy. All comments are considered and, where relevant, further updates to the options can be carried out before the final FRM measure are presented in the FRM Plans.

8.1 OUTCOMES OF CONSULTATION FOR THE RIVER CAMAC

Consultation was carried out through elected members briefings, a stakeholders workshop, public consultation days and correspondence with the Local Authorities and the OPW. Web-based consultation was also undertaken. Details of the consultation can be found in the Camac Poddle HPWs Consultation Synthesis Report. The following summarises the main findings from the consultation activities regarding the options proposed.

- Most people who attended events had experienced flooding to their private dwellings or commercial property and are keen to get something in place as soon as possible. Most are experiencing difficulties in getting their property insured.
- Bow Bridge and Kearns Place Bridge were identified as structures causing restrictions and should be considered for removal or modification.
- It was suggested that lowering the bed level along the lower reach of the Camac should be considered.
- It was suggested that attenuation of the lower reach be considered.
- A number of maintenance and blockage concerns were raised along with pluvial flooding issues.
- It was noted that properties flooded from the Bluebell stream during the Oct 2011 flood but this stream is excluded from the Eastern CFRAM study.
- Concern was expressed that no cost beneficial option had been identified and required to know what the next steps would be.

The comments from the consultation process were reviewed and the following was carried out:

- OPW commissioned RPS to carry out an additional culvert blockage analysis study. This study aims to identify the culverts at risk of blocking. In addition to this structures identified as causing restrictions to the in channel flow were also identified.
- A maintenance review of the River Camac was also carried out to identify any maintenance measures required.
- The effect of modifying Bow Bridge and removing Kearns Place Bridge was carried out.
- Lowering the bed level along the lower reach of the Camac was assessed.
- Attenuating flow from the lower reach tributaries was assessed.
- Alternative standards of protection were considered.

8.2 CULVERT BLOCKAGE ANALYSIS AND FLOW RESTRICTION REVIEW

A risk based Method Statement to identify the culverts where significant risks could arise and determine the degree of potential risk arising is summarised below:

- **Stage 1 – Applicability Test.** This stage is to identify those culverts where significant risks might arise due to blockage.

- **Stage 2 – Significance Test.** This stage is a high-level assessment of the degree to which the overall AFA/HPW analysis may depend on considering a particular culvert identified through the Stage 1 screening process.
- **Stage 3 – Assessment.** This stage sets out the approach to determining the degree of potential risk arising from culvert blockages and a proposal to map the resulting flood extents.

Stage 1 of the culvert blockage analysis was carried out to identify the number of culverts on the River Camac network at risk of blockage. It was found that 75 culverts are at risk and are mainly located in the upper reaches of the River Camac and along its tributaries. This is mainly due to the structures being smaller relative to the culverts located along the lower reaches of the River Camac and therefore more likely to block. The details of the stage 1 screening process are recorded in appendix B. Stage 2 and 3 were not carried out as part of this study but it is recommended that they be considered during a subsequent study in the detailed design.

In light of stages 2 & 3 not being completed a review was carried out which assessed the state of culvert inlets in relation to the debris and vegetation accumulating upstream of them along with any other structures in the river channel which may cause restrictions to flow. This was carried out based on the channel survey and Local Authority knowledge. Culverts identified were deemed to be at risk of being partially or fully blocked within the culvert or at the inlet structure. In addition to this two manhole shafts were found to be protruding from the river bed which will restrict the flow acting as a partial weir. The following culverts and restrictions were identified and are shown in table 8.1 and figures 8.1 and 8.2 below.

Ten areas have been identified requiring screen upgrades, or the removal of a restriction. All but two culverts identified in this review were identified in the stage 1 blockage analysis. These two culverts are at the end of the Robinhood Stream and were found to have a large enough cross sectional areas (CSAs) to remove it from the stage 2 analysis. However in light of this review this has been updated. It is recommended that any subsequent study tasked with the identification of a cost beneficial preferred option include an examination of the installation of properly designed screens and removal of the restrictions in flow, including the costs of those works. Alternatively, the Local Authorities could pursue those works under the OPW Minor Works funding scheme as an interim measure.

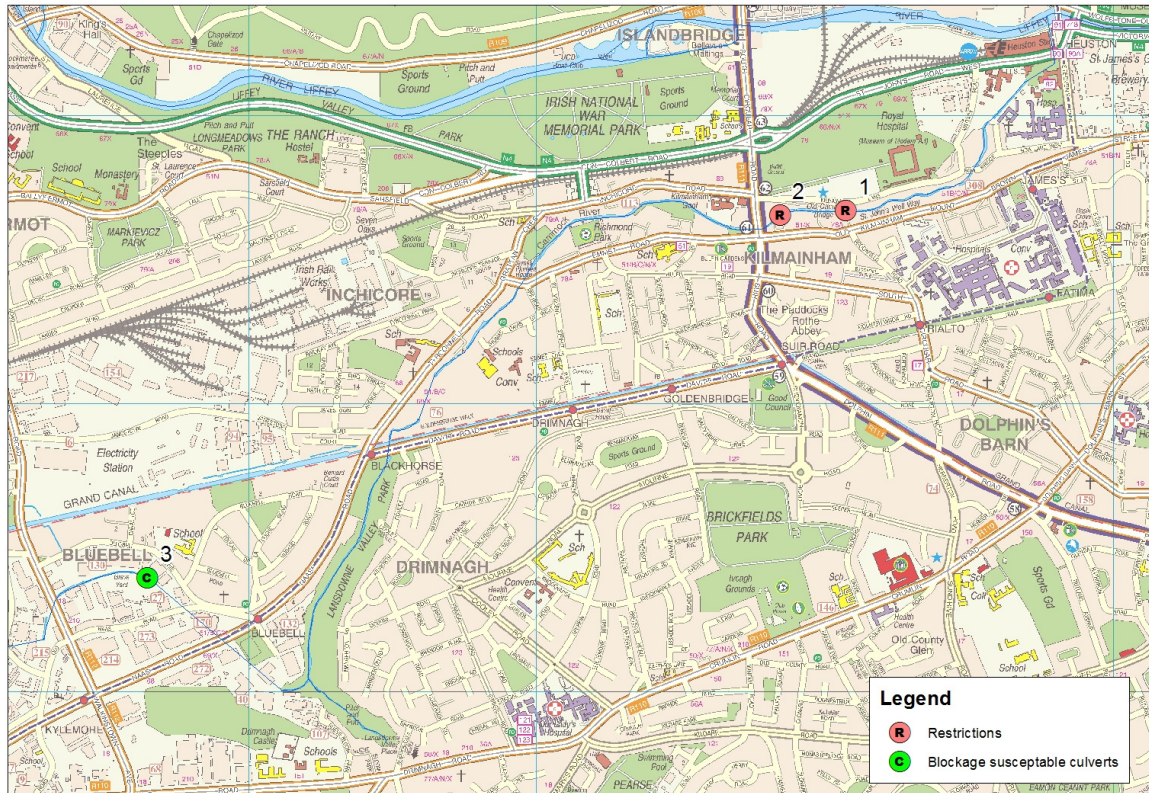


Figure 8.1 - Culverts at risk of blockage and restrictions in the River Camac

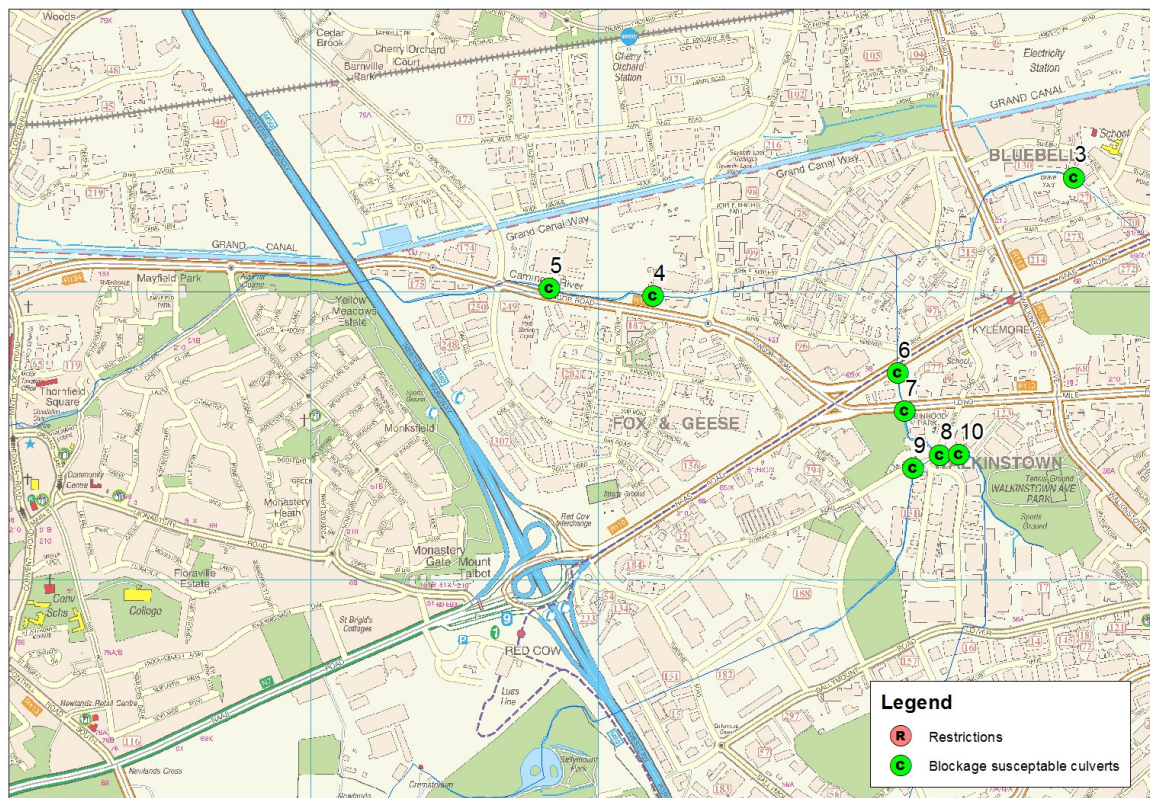











Figure 8.2 - Culverts at risk of blockage and restrictions in the River Camac

Table 8.1 - Recommended action on the River Camac

Culvert/Restriction in Flow	Comment	Recommended Action
<p>R Areas 1 & 2</p> <p>48° 53' 20" 28.67" N 10° 01' 18" 44.09" W</p> 	<p>At two locations there are protruding manholes coming up from the river bed which cause a significant restriction.</p>	<p>Lower manhole shaft and covers to bed level and seal.</p>

Culvert/Restriction in Flow	Comment	Recommended Action
<p>C Area 3</p> 	<p>The culvert travelling under Naas Road has been identified as at risk of blocking. Dense vegetation has been identified as potentially restricting flow.</p>	<p>Carry out an full economic assessment to quantify the benefit from managing this flood risk. Consider the following:</p> <ul style="list-style-type: none"> • Construct screen. • Extend head and wing walls to contain the water. • Secondary Screen upstream
<p>C Area 4</p> 	<p>Course screen attached to footbridge near the Nangor road is in disrepair. Further upstream the staff at the gauge station is damaged</p>	<ul style="list-style-type: none"> • Carry out an assessment for the need for a course screen. • Upgrade course screen if required/remove screen if required • Replace staff gauge
<p>C Area 5</p> 	<p>The culvert at the Diageo Site on the Nangor Road has been identified as at risk of blocking. In places upstream overhanging branches have the potential to restrict flow</p>	<p>Carry out an full economic assessment to quantify the benefit from managing this flood risk. Consider the following:</p> <ul style="list-style-type: none"> • Construct screen. • Extend head and wing walls to contain the water.

Culvert/Restriction in Flow	Comment	Recommended Action
<p>C Area 6</p> 	<p>The culvert on the Robinhood Stream at the Naas Road has been identified as at risk of blocking. The reach of watercourse approaching this culvert is heavily vegetated and full of debris increasing the potential for restricting the flow and blocking the culvert</p>	<p>Carry out an full economic assessment to quantify the benefit from managing this flood risk. Consider the following:</p> <ul style="list-style-type: none"> • Construct screen. • Extend head and wing walls to contain the water.
<p>C Area 7</p> <p>66°1' 59" E, 23.55" N 66°1' 59" E, 23.54" N</p> 	<p>The culvert on the Robinhood Stream at the Long Mile Road has been identified as at risk of blocking. The reach of watercourse approaching this culvert is heavily vegetated and full of debris increasing the potential for restricting the flow and blocking the culvert</p>	<p>Carry out an full economic assessment to quantify the benefit from managing this flood risk. Consider the following:</p> <ul style="list-style-type: none"> • Construct screen. • Extend head and wing walls to contain the water.
<p>C Area 8</p> 	<p>The culvert on the Robinhood Stream at the Robinhood Road has been identified as at risk of blocking. The reach of watercourse approaching this culvert is heavily vegetated and full of debris increasing the potential for restricting the flow and blocking the culvert</p>	<p>Carry out an full economic assessment to quantify the benefit from managing this flood risk. Consider the following:</p> <ul style="list-style-type: none"> • Construct screen. • Extend head and wing walls to contain the water.

Culvert/Restriction in Flow	Comment	Recommended Action
<p>C Area 9</p> 	<p>The culvert on the Robinhood Stream upstream of the Robinhood Road has been identified as at risk of blocking. The reach of watercourse approaching this culvert is heavily vegetated and full of debris increasing the potential for restricting the flow and blocking the culvert</p>	<p>Carry out an full economic assessment to quantify the benefit from managing this flood risk. Consider the following:</p> <ul style="list-style-type: none"> • Construct screen. • Extend head and wing walls to contain the water. • OR removal of structure
<p>C Area 10</p> <p>Lat: 53° 15' 17.42" N Long: 6° 20' 55.18" W</p> 	<p>The culvert on the Kingstown Stream at the Robinhood Road has been identified as at risk of blocking. The reach of watercourse approaching this culvert is heavily vegetated and full of debris increasing the potential for restricting the flow and blocking the culvert</p>	<p>Carry out an full economic assessment to quantify the benefit from managing this flood risk. Consider the following:</p> <ul style="list-style-type: none"> • Construct screen. • Extend head and wing walls to contain the water.

8.3 MAINTENANCE REVIEW

It was highlighted during the consultation process that many members of the public have a perception that there is an ongoing maintenance issue along the River Camac corridor. Problems with rubbish tipping and debris blocking stretches of the open channel and culverts is a recurring problem. While the impact of this is difficult to quantify, it was appreciated that it is a real risk that had not been managed within the preferred FRM options. It was therefore recommended that maintenance be included to the preferred FRM options.

A review of the watercourse was carried out based on the channel survey and correspondence with the relevant Local Authorities. The review has been based on three maintenance criteria which contribute to the flood risk. These three criteria are:

- sedimentation,
- debris,
- vegetation,

In general it was found that there was evidence of rubbish entering the river network and being caught by the vegetation and at culverts, bridges and weirs. This problem is recurrent along the full length of the River Camac and associated tributaries located within the urban extent of Dublin.

Dublin City Council and South Dublin County Council both proactively maintain the River Camac and have provided additional maintenance measures since the October 2011 flood. These measures include debris removal and vegetation control which help to improve the free flow of water.

Ten areas have been identified as areas requiring vegetation and debris control and monitoring and are detailed in the figures and table below. The recommendations mainly consist of measures already installed by the Local Authorities or is a recommendation for use of already existing resources. It is therefore assumed that there will be no additional costs to consider. This review can be progressed by the Local Authorities in incorporating it into their Maintenance Plan without the need for a subsequent study.

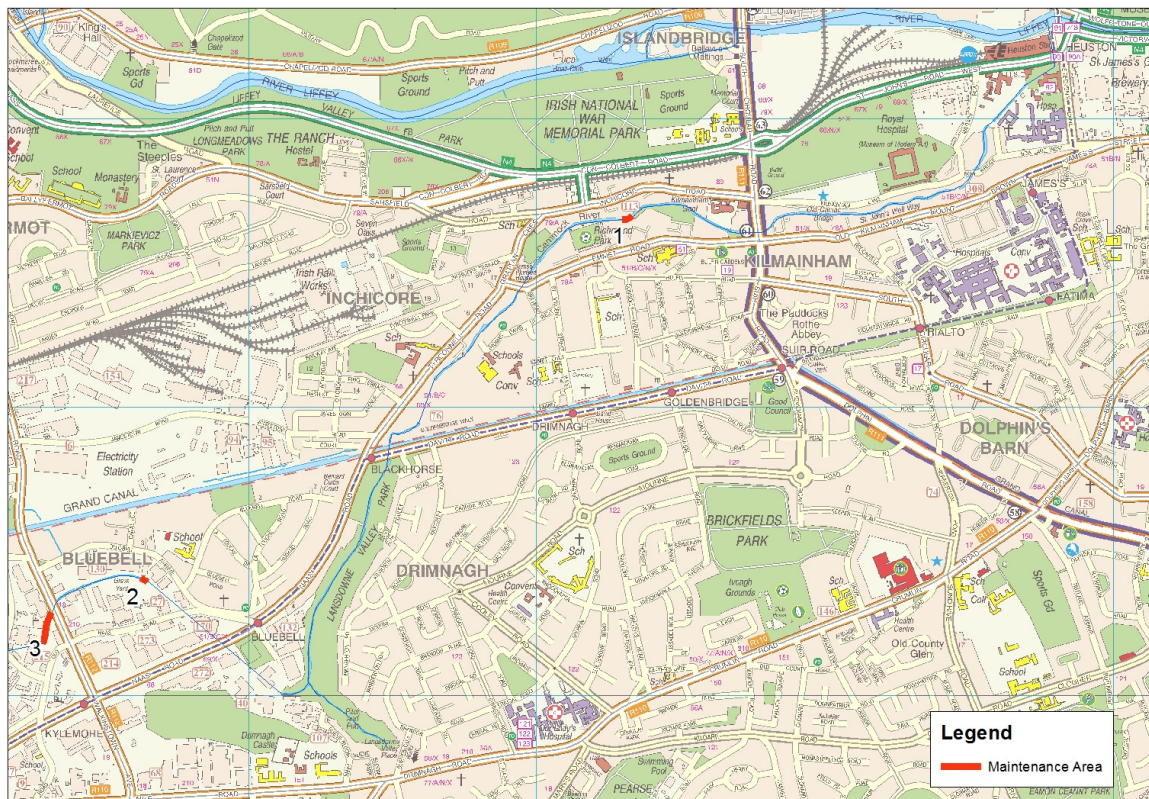


Figure 8.3 - Maintenance areas on the River Camac

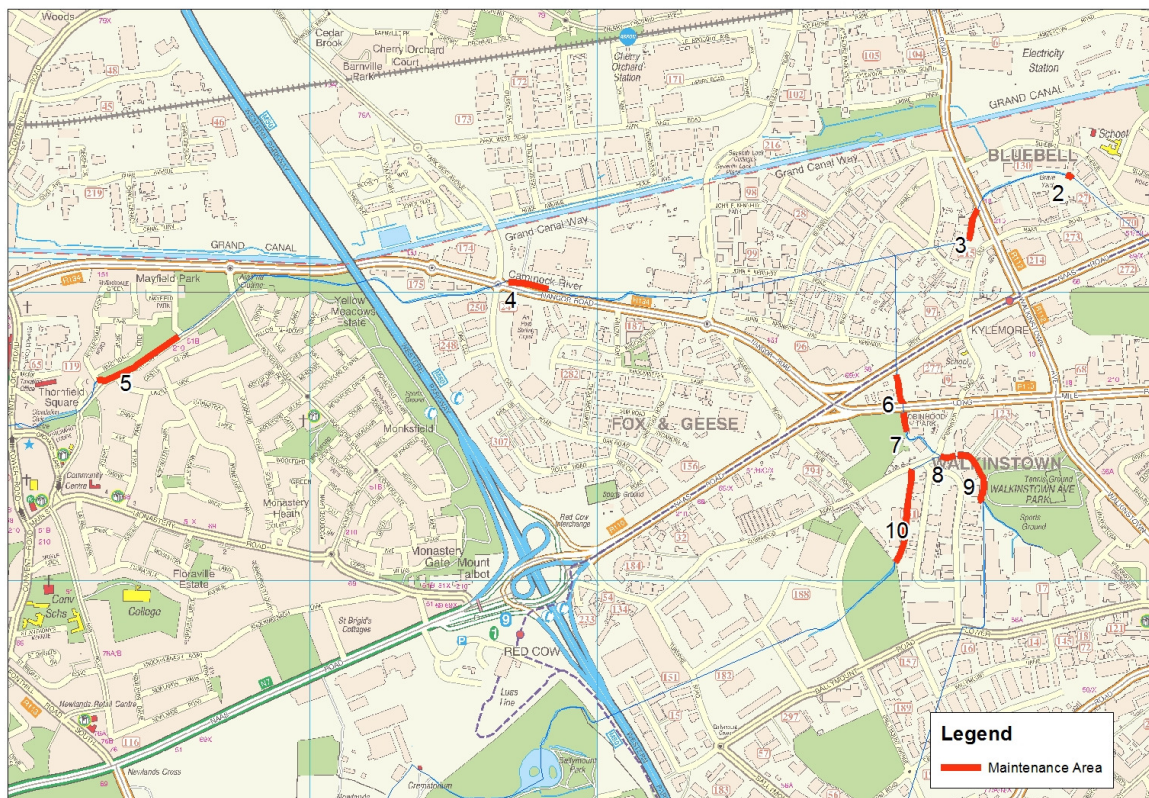







Figure 8.4 - Maintenance areas on the River Camac

Table 8.2 - Recommended maintenance on the River Camac

Maintenance Issue	Comment	Recommended Action
Maintenance Area 1 	Tree protruding from gabion retaining structure	Maintained by riparian owner. Recommended LA monitor the state of the gabion structure and the protruding trees with a view to carry out emergency maintenance works if necessary.
Maintenance Area 2 	Dense vegetation has been identified as potentially restricting flow to the channel upstream of the culvert travelling under Naas Road.	Maintained by riparian owner. Recommended LA monitor vegetation with a view to carry out emergency maintenance works if necessary.
Maintenance Area 3 	Protruding Leylandii trees have the potential to restrict flow and low hanging branches from deciduous trees have the potential to restrict flow and show evidence of trapping debris which could exacerbate the problem.	<ul style="list-style-type: none"> • Cut back low Leylandii trees • Cut back low hanging branches from deciduous trees.

Maintenance Issue	Comment	Recommended Action
 <p>Maintenance Area 4</p>	<p>In places upstream of the culvert at the Diageo Site on the Nangor Road overhanging branches have the potential to restrict flow</p>	<p>Cut back overhanging branches and vegetation</p>
 <p>Maintenance Area 5 Lat: 53° 19' 38.26" N Lon: 6° 23' 15.03" W</p>	<p>Heavy vegetation in places along the River Camac has the potential to catch debris. Debris has been deposited under the bridge at Riversdale Road</p>	<p>Manage vegetation along this reach and remove debris from under bridge.</p>
 <p>Maintenance Area 6</p>	<p>The reach of watercourse approaching the culvert on the Robinhood Stream at the Naas Road is heavily vegetated and full of debris increasing the potential for restricting the flow and blocking the culvert</p>	<p>Manage vegetation and debris.</p>

Maintenance Issue	Comment	Recommended Action
<div data-bbox="196 241 323 275" style="background-color: red; width: 80px; height: 15px; margin-bottom: 5px;"></div> Maintenance Area 7 <div data-bbox="196 275 387 309" style="font-size: 0.8em; color: red;"> 6561.54° 48' 23.55" N 1005.6° 00' 48.54" W </div> 	<p>The channel upstream of the culvert on the Robinhood Stream at the Long Mile Road is heavily vegetated and full of debris increasing the potential for restricting the flow and blocking the culvert</p>	<p>Manage vegetation and debris.</p>
<div data-bbox="196 745 323 779" style="background-color: red; width: 80px; height: 15px; margin-bottom: 5px;"></div> Maintenance Area 8 	<p>The channel upstream of the culvert on the Robinhood Stream at the Robinhood Road is heavily vegetated and full of debris increasing the potential for restricting the flow and blocking the culvert</p>	<p>Manage vegetation and debris.</p>
<div data-bbox="196 1249 323 1283" style="background-color: red; width: 80px; height: 15px; margin-bottom: 5px;"></div> Maintenance Area 9 	<p>The channel upstream of the culvert on the Robinhood Stream at the Robinhood Road is heavily vegetated and full of debris increasing the potential for restricting the flow and blocking the culvert</p>	<p>Manage vegetation and debris.</p>

Maintenance Issue	Comment	Recommended Action
<p>Maintenance Area 10</p> 	<p>The channel upstream of the culvert on the Kingstown Stream at the Robinhood Road is heavily vegetated and full of debris increasing the potential for restricting the flow and blocking the culvert</p>	<p>Manage vegetation and debris.</p>

8.4 MODIFICATION OF BOW'S BRIDGE

On review of option 1 for the River Camac (Hard defences) it was noted that Bow's Bridge causes a significant restriction and therefore the heights of walls required upstream of the bridge are in the order of 4m in height. An assessment was carried out which considered the affect of removing the parapet walls and allowing the water to spill over the bridge and continue downstream. A review of the streets adjacent to Bow Bridge found that if water were allowed onto the bridge deck it would want to flow into these streets and pond adjacent to properties putting them at risk. For this measure to work it would also require demountable barriers to be erected to direct the flow back into the river.

A hydraulic model was constructed to simulate the scenario and the impact of the flood wall heights and length assessed. It was found that by modifying Bow's Bridge as described it would lower the water level as far upstream at Kearns Place by 400mm on average. The water level downstream did not change significantly. The economic change is detailed in the table below.

Table 8.3 - Economic change from Bow Bridge modification

Original Project Whole Life Cost and BCR	Modified Project Whole Life Cost and BCR
€41,049,267- BCR 0.74	€40,776,149 - BCR 0.75

Although the effect of modifying Bow's Bridge is to reduce the height of walls required upstream the cost of removing the parapet walls and fixing demountables effectively costs the same as the original option so as to achieve nearly the same BCR (see appendix C for more details). Added to this the social impact of erecting demountable barriers and the increased residual flood risk to properties it is recommended that this refinement to option 1 be rejected from further consideration.

8.5 REMOVAL OF KEARNS PLACE BRIDGE

Similar to Bow Bridge it was noted on review of option 1 for the River Camac (Hard defences) that the bridge at Kearns Place causes a significant restriction and therefore the heights of walls required upstream of the bridge are over 4.5m. An assessment was carried out which considered the effect of removing the bridge at Kearns Place. The refinement to option 1 would therefore also involve the demolition and removal of the existing bridge.

A hydraulic model was constructed to simulate the scenario and the impact of the flood wall heights and length assessed. It was found that removing the bridge lowered the water levels as far upstream as the South Circular Road and had the effect of reducing the wall length by 114m and the height from 4.5m to 3.5m. Removing the bridge also had the effect of increasing the water level as far downstream as the bridge at St John's Well and increased the height of the wall from 2m to 3.5m. The economic change to option 1 is detailed in the table below.

Table 8.4 - Economic change from Kearns Place Bridge removal

Original Project Whole Life Cost and BCR	Modified Project Whole Life Cost and BCR
€41,049,267- BCR 0.74	€40,915,407 - BCR 0.74

The effect of removing the bridge is to decrease the cost of the walls required upstream but to increase the cost of the walls downstream. Added to that the cost of removing the bridge and the BCR remains at 0.74 (see appendix C for more details). There are positives and negatives to removing the bridge at Kearns Place but on balance the overall length of wall would be reduced and its maximum height resulting in a reduced residual risk and providing a more favourable social aspect. It is therefore recommended that removing Kearns Place bridge be considered as an update to option 1. However if it is required that a footbridge be constructed to replace this bridge it is likely to reduce the BCR and make the original option preferable.

8.6 LOWERING THE CAMAC BED LEVEL

A significant contribution to the cost of option 1 and 2 is due to the height of the walls required along the lower reach of the River Camac. This also has negative social aspects. It was therefore proposed to investigate the effect of lowering the bed of the River Camac in an effort to keep the flood water in bank and reduce the need for flood walls.

A hydraulic model was constructed to simulate this option and the amount of walls required assessed. The bed level was lowered 2m downstream on Lansdowne Valley Park to the inlet of the final culvert before discharging the River Liffey. It was found that the length of wall required was reduced from 10.2km to 7.9km with 200m of wall required along the lower reach where the bed level was lowered. The cost of the wall was recalculated accordingly and the cost of associated works required to lower the bed was also considered. These works include the underpinning or reconstruction of the walls located on the left and right hand bank. These walls consist of reinforced concrete, block work, brick work, stone and gabions and the majority of them retain buildings which are situated at the water's edge, some of which are multi-storey. Ten culverts or bridges would have to be underpinned or lowered some of which have archaeological importance. The outfalls to the Camac would need to be lowered accordingly. There are services which run underneath the River Camac that would need to be lowered or re-located. And the river itself would need to be dredged and the material disposed of, this would ultimately be an ongoing maintenance issue as sedimentation is likely to reoccur.

Reducing the amount of walls required by lowering the bed level makes approximately €2m of benefit available to carry out all the other works and keep the option cost beneficial. However considering the amount of associated works as described above this is unlikely to be feasible. It is recommended therefore that this option not be considered any further.

8.7 ATTENUATION OF FLOW

As an alternative to lowering the bed level it was recommended that attenuation of the flow the River Camac be assessed. On review of the flow distribution along the River Camac it was noted that there was a relatively modest flow contribution from the upper reaches and therefore limited scope to attenuate the flow in order to produce flood protection. The most effective area to consider attenuation was found to be along the lower reaches of the River Camac. This option would involve retrospectively fitting SuDS to the storm drainage network along the lower reaches of the Camac and the tributaries located within the urban areas.

A hydraulic model was constructed to simulate this option which resulted in the flow being reduced from 39m³/s to 28m³/s just upstream of Walkinstown Road. It was found that the height and length of the walls required along the lower reach of the River Camac would be reduced. The resulting economic change is summarised in the table below.

Table 8.5 - Economic change from attenuating flow

Original Project Whole Life Cost and BCR	Modified Project Whole Life Cost and BCR
€41,049,267- BCR 0.74	€199,226,690 - BCR 0.15

The volume of water required to attenuate the flow as represented in the model was calculated to be 200,916m³. This is a significant volume of water to be stored in a heavily urbanised area where space is restricted. To estimate a cost a series of storage pipes were assumed which would provide the capacity required. This would result in 79km of pipe to be laid in suitable areas (open areas and along existing service lines such as roads). The cost to do this reduced the overall BCR to 0.15 making this FRM option unfeasible economically. Added to this the technical difficulty in laying the storage pipes in a heavily urbanised areas and accommodating the existing services around these pipes makes this option unfeasible. It is recommended therefore that this option not be considered any further.

8.8 ALTERNATIVE STANDARDS OF PROTECTION

A high level assessment for the 2%AEP SoP was carried out to investigate whether an alternative SoP would provide a potential solution. The pvD was reduced from €30.4m to €26.7m representing a modest reduction in the benefit available. As defended model runs for the 2%AEP event have not been carried out at this stage, comparison of the undefended flood extents between the 2%AEP and 1%AEP was used to determine areas where walls would no longer be needed resulting in the overall length of defences reducing by 500m. To test what effect this would have on the BCR, 500m was deducted from the option 1 cost calculations and a BCR calculated as shown in table 8.5.

Table 8.6 - BCR of option 1 providing a 2%AEP SoP

Damage/Benefit	€26,726,134
Construction Cost	€15,581,656
Project Whole Life Cost	€36,645,493
BCR	0.73
MCA	1762.5
MCA BCR	48.1

While the heights of walls would also be lowered and the cost marginally reduced, given that mobilisation, foundation and services elements would be less sensitive to wall height, the initial results show that the BCR would not be significantly improved.

8.9 EMERGENCY RESPONSE PLAN

The Local Authorities have emergency response plans which are updated when new information is made available. These plans can now be updated in light of the flood risk and hazard mapping produced as part of the Camac CFRAM study. This can be progressed by the Local Authorities without the need for a subsequent study.

8.10 UPDATING PREFERRED OPTIONS

The preceding sections considered the recommendations resulting from the consultation process. These recommendations were applied to Option 1 to assess their effectiveness in producing a cost beneficial solution. Some of the recommendations were found to be economically, technically or socially unfeasible and others while reducing the cost slightly did not improve the BCR. As such no preferred option was found and hence it is recommended that a subsequent study be carried out in order to examine the potential options in greater detail, to see whether a cost-beneficial option can be found. A summary of the findings are presented in table 8.7 below.

Table 8.7 - Summary of recommendations considered to update potential FRM Options

Outcome of Consultation	Recommendation
Culvert Blockage Analysis and Restrictions review	Stage 1 culvert blockage analysis complete, 75 culverts identified of which 8 are recommended for screen upgrades along with removal of manhole shafts causing restrictions. This is to be considered during subsequent study.
Maintenance review	10 areas identified, no additional cost associated with maintenance. This can be progressed as a preferred option.
Modification of Bow's Bridge	Little improvement to the BCR and increases

	residual risk. Recommendation rejected.
Removal of Kearns Place Bridge	Slight reduction in cost but no change to the BCR. Social impact improved by wall height being reduced. Recommendation to be considered during subsequent study.
Lowering the Camac bed level	Recommendation found to be economically and technically unfeasible. Recommendation rejected.
Attenuation of flow	Recommendation found to be economically and technically unfeasible. Recommendation rejected.
Alternative standard of protection	No improvement to BCR. Recommendation can be re-visited during subsequent study if required.
Emergency response plan	Data available for this to be progressed

It is recommended that the maintenance (section 8.3) and review of the emergency response plan (section 8.9) be progressed as preferred options by the Local Authorities in the near term, subject to availability of resources. Addressing the risk of culvert blockage and removal of restrictions in flow (section 8.2) can either be progressed by Local Authorities under the OPW Minor Works funding scheme in the near term, or be included along with assessment of the removal of Kearns Place Bridge and alternative standards of protection in a subsequent study. Both potential options, Options 1 and 2, remain unchanged until such a study is carried out. Options 1 and 2 are summarised in the following sections.

8.10.1 Option 1 - Hard defences and sealing manholes.

The hard defences would consist of flood walls and earth embankments located where the 1%AEP flood waters need to be prevented from leaving the watercourse. Approximately 10.25km of flood defence would be required. Flood walls would be in excess of 4m in height in certain downstream locations, but would typically range from 1.4 to 2.5m in height. Typically, there can be difficulty in the construction of hard defences of such heights. For example, the community can be cut-off from the watercourse resulting in a negative social impact, and the retention of large volumes of water during a flood event can present a high residual risk.

There is a significant flood risk from the Robinhood stream within the Robinhood Industrial Estate, where the stream flows through a culvert before joining the Camac River. Out of manhole flooding occurs along the John F Kennedy Drive and the study found that sealing manholes would be required to address this flood risk.

Option 1 would consist of:

- Hard defences - 7950m of retaining wall and 2300m of earth embankment.
- Sealing manholes - manholes to be sealed along John F Kennedy Drive.

8.10.2 Option 2 - Hard defences, storage and sealing manholes.

Option 2 considered the benefit of adding flood storage to Option 1. Lansdowne Valley Park has been identified as a potential storage area using the existing topography of the park and controlling flow through the Grand Canal embankment.

The addition of storage at Lansdowne Valley Park reduces the flow from the catchment above the park, resulting in a reduction of downstream flood levels of approximately 0.4 m. This in turn reduces the required length and height of hard defences downstream in comparison to Option 1; however the cost to construct the storage dam in Lansdowne Valley Park outweighs the reduction in cost to the hard defences, with lengths of wall remaining in the order of 4m in height. Again, such wall heights could result in negative social and technical impacts, in terms of the community being cut-off from the watercourse and residual flood risk.

Approximately 10km of hard flood defence would be required with this storage measure. Sealing manholes will also be required to address flood risk in the industrial area.

Option 2 would consist of:

- Storage - 120m of sheet piled core earth embankment averaging 5m in height and overflow weir.
- Hard defences - 7700m of retaining wall and 2300m of earth embankment.
- Sealing manholes - manholes to be sealed along John F Kennedy Drive

8.10.3 Future Flood Risk

Part of the objective of the CFRAM studies is to consider the management of potential future flood risk. This was carried out in part through the MCA of potential FRM options which assesses the options adaptability or provision of protection up to the mid range future scenario (MRFS) and the high end future scenario (HEFS).

The MRFS represents the likely future scenario based on the wide range of predictions available and with allowances for increased flow, sea level rise, etc within the bounds of widely accepted projections. The HEFS represents a more extreme potential future scenario, but one that is nonetheless not significantly outside the range of accepted predictions available, and with allowances for increased flow, sea level rise, etc at the upper bounds of widely accepted projections.

Additional hydraulic model runs were carried out to represent the MRFS and HEFS in order to assess the potential impact to the proposed FRM options. The impact is summarised in table 8.8 below.

Table 8.8 - Impact of future scenarios to Option 1

	Present Day Scenario	MRFS	HEFS
Maximum height of defence (inc freeboard)	4.77m (Tyrconnell Road)	5.3m (Kearns Place)	5.56m (Kearns Place)
Increase in water level	-	0.53m	0.79m

When considering Option 1 the results from the hydraulic analysis show that the maximum increase in water depth resulting from the MRFS and HEFS is 0.53m and 0.79m respectively. This changes the location of the highest walls from Tyrconnell Road to Kearns Place. While the proposed wall and embankment heights are suitable for the present day 1%AEP flood event it is anticipated that upgrading and modification will be required in the future to accommodate the MRFS and HEFS. The MCA reflects that this adaptation in the future is possible but would be considered difficult to carry out. Subsequent study should assess the best option for dealing with the increased capacity.

9 SUMMARY OF FRM OPTIONS FOR THE RIVER CAMAC

As no cost-beneficial preferred options were identified during the option development process the two potential FRM options were presented for consultation. No clear preference for either option1 or option2 was expressed during the consultation however potential improvements to the options were highlighted in order to update either option in an effort to reduce the length and height of walls required and subsequently its cost. No recommendations were found to significantly improve the BCR of options 1 or 2; however the following options were identified as being able to be progressed in the near-term by the Local Authorities, subject to the availability of resources:

- Maintenance plan (see section 8.3)
- Review of Emergency Response Plan (see section 8.9)

As no preferred option was identified (see table 9.1 for details) it is recommended that a further study be carried out. This study is to include the recommendations found to have potential in improving the overall option. The following FRM Methods are therefore recommended to be considered in a further detailed study:

- Culvert inlet screens and removal of restrictions in flow (see sections 8.2 & 8.3)¹
- Hard defences (flood walls and embankments) (see appendix A & D)
- Flood storage (see appendix A & D)
- Sealing manholes (see appendix A & D)
- Removal of Kearns Place Bridge (see section 8.5)

Table 9.1 - Potential FRM options for the River Camac

Option	1	2
	Hard defences and sealing manholes	Hard defences, flood storage and sealing manholes
Benefit	€30,440,033	€30,440,033
Project whole life cost	€41,049,267	€43,037,370
Multi Criteria Analysis Score	1562.5	1317.5
Benefit Cost Ratio	0.74	0.71
Overall Net Benefit/Cost (€m)	38	31

In addition the following FRM methods will be considered at UoM scale (Liffey and Dublin Bay) and Sub-Catchment scale (Liffey):

- Planning and development control
- Building Regulations
- Catchment wide SuDS
- Land use management
- Strategic development management
- Flood warning/forecasting

¹ Culvert inlet screens and removal of restrictions in flow can be progressed either by Local Authorities under OPW Minor Works funding scheme or as part of the subsequent study recommended in this report.

9.1 LIMITATIONS AND RECOMMENDATIONS

The overall recommendations resulting from this study is:

- to examine the two potential options identified in a subsequent detailed study to see whether the economic, technical and social issues can be addressed.
- Without prejudice to the outcome of the examination recommended above, identify in a manner that is socially acceptable, discrete areas where works are cost-beneficial.
- to examine other measures at UoM scale as described in section 9 as part of the CFRAM Study
- For the interim period between now and the conclusion of the further study the baseline condition should continue (maintain existing regime) along with assessing the possibility of implementing recommendations made in the maintenance review (Section 8.3)
- The emergency response plan which does not rely of being cost beneficial can be progressed as a preferred option without waiting on further studies.

In order to progress the potential options, it is important to record the following limitations, assumptions and recommendations for detailed design.

9.1.1 Hydraulics

- An integrated catchment model including the main storm sewer network could be used to better distribute the inflows along the lower reach of the River Camac.

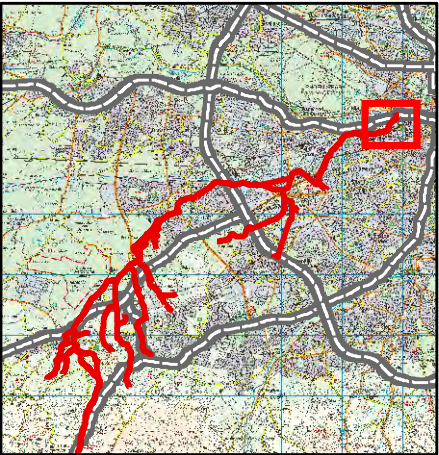
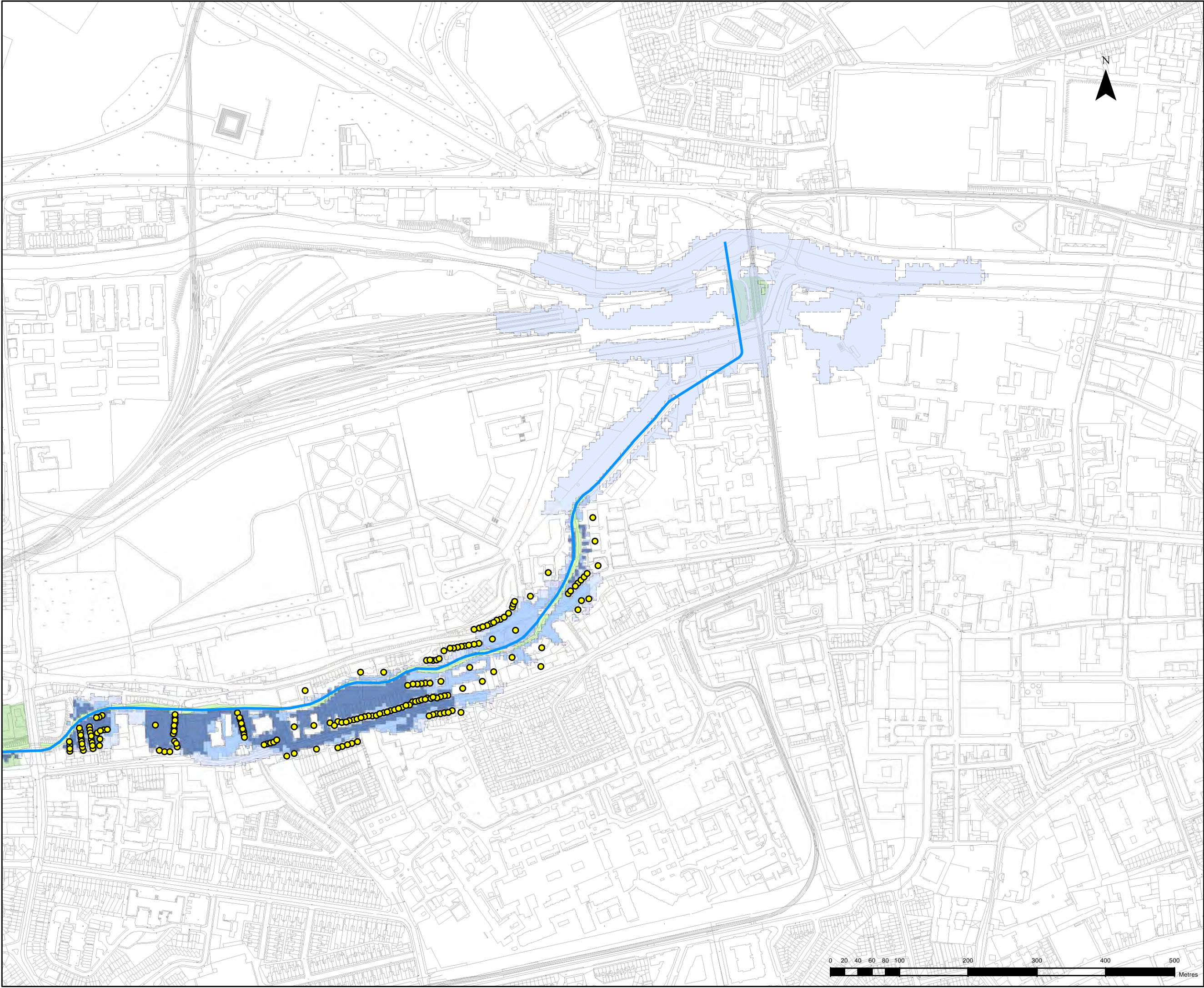
9.1.2 Optioneering

- Property classification included type only. There is scope to refine the damage assessment by including property age and social class as per MCM guidance recommendations. A distributional impact analysis will be required and weighted factor applied to social class groups as per MCM guidance recommendations (see section 5.3).
- A review of the conversion rates (2010 values to present day and Pound sterling to Euro) may be required when the detailed assessment is due to be carried out (see section 5.6).
- 10.7% of residential damages was assumed to account for emergency service costs (see section 5.7).
- A review of the housing capping value may be required when the detailed assessment is due to be carried out (see section 5.9).
- It is recommended that pluvial flood risk be considered along with the fluvial flood risk due to their integrated nature. This would require an additional pluvial flood risk and management study.
- A more detailed costing of flood measures is recommended. A survey along the line of the flood walls and embankments will provide details to cost the defences more accurately. The survey can also be used to provide information in order to answer some unknowns which are accounted for in the optimism bias and contingencies, such as land acquisition, site conditions, etc (see sections 7.1.5 & 7.2.1).
- As no cost beneficial option was found for the River Camac it is recommended that the study area be reviewed. This would involve looking at a smaller area in order to reduce the amount of defences required while still keeping the majority of the benefit available.
- It is recommended that the attenuation FRM measure as described in section 4.7 to be progressed further to assess its feasibility.
- It is recommended that the Lansdowne Valley Park storage option be considered, separate from flood walls. Although this measure will not provide the full 1%AEP standard of protection it should be assessed if it is cost beneficial to carry out.
- It is recommended that the Bluebell Stream be considered in the detailed design with a view to providing flood risk management measures.

- It was noted that the most sensitive area to the MRFS and HEFS is downstream of Lansdowne Valley Park. While the proposed defences do not provide protection against these scenarios special consideration should be given to the adaptability of defences along this reach given the already large heights proposed.
- Consideration of alternative SoPs should be given in further studies as larger BCR may be possible (see section 8.8)

Appendix A

Flood Risk Maps



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Legend

- Residential Properties
- High Vulnerability Sites**
 - Ⓜ Schools
 - Ⓝ Residential Care
- Valuable Social Infrastructure**
 - 🚒 Fire Stations
 - 🚒 Civil Defence HQs
 - 🚒 Garda Stations
 - 🏥 Hospitals
 - 🏥 Health Centres
- Social Amenity Sites**
 - 🌳 Open space and Recreational Amenities
 - 🌳 Green Belt
- Flood Extents**
 - 0.1% AEP Event
 - 1% AEP Event
 - 10% AEP Event
 - River Centreline

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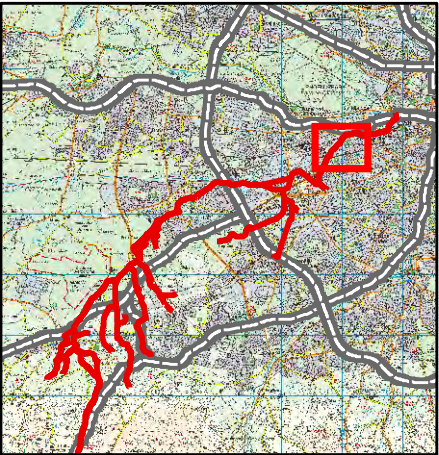
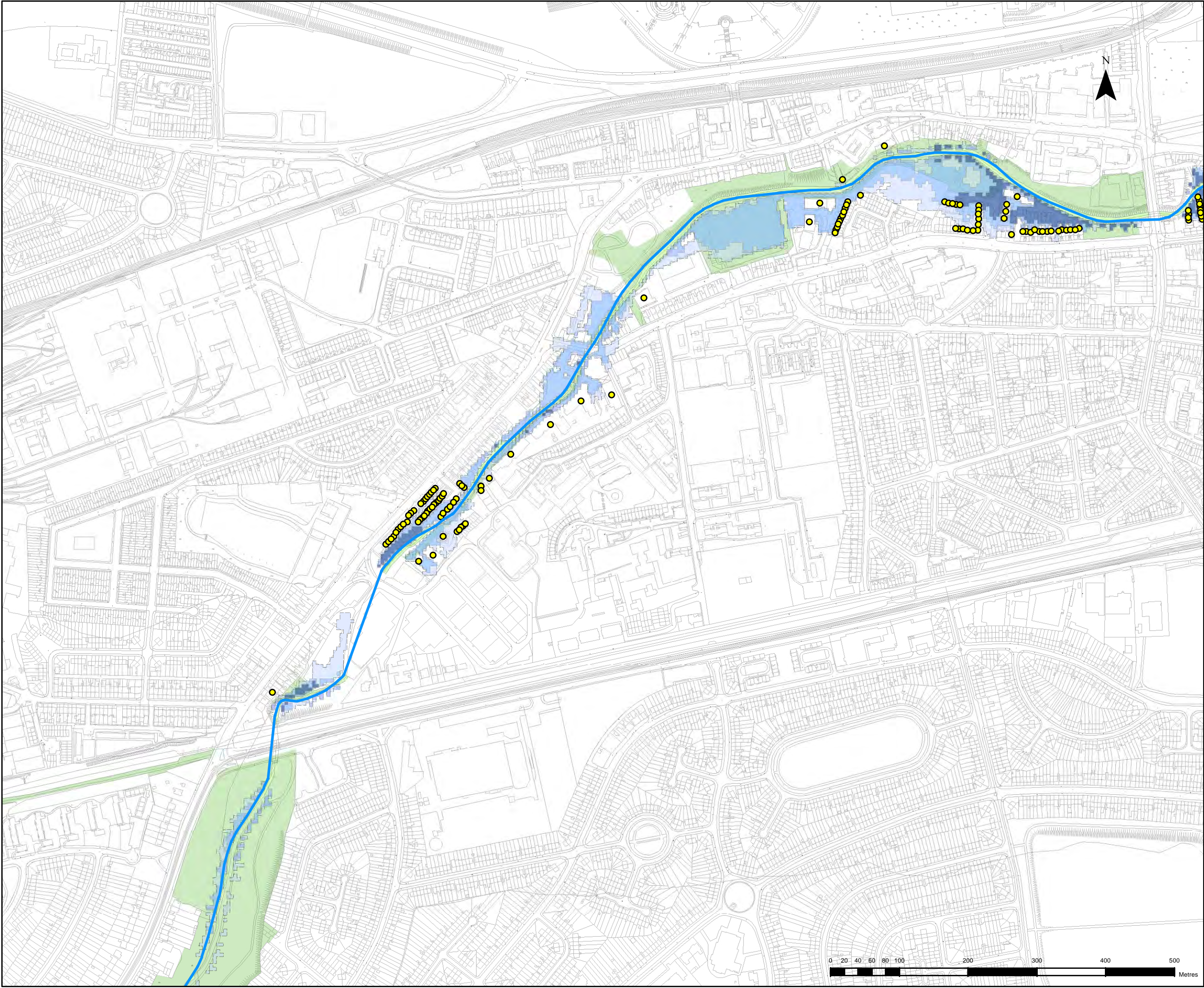
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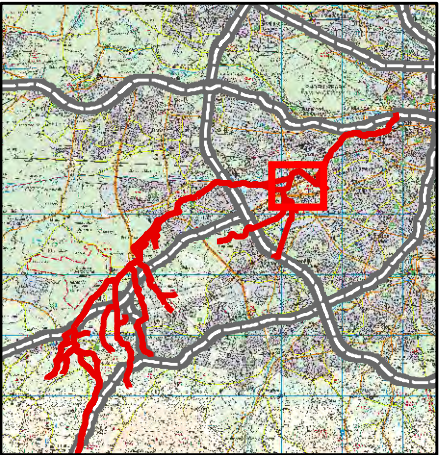
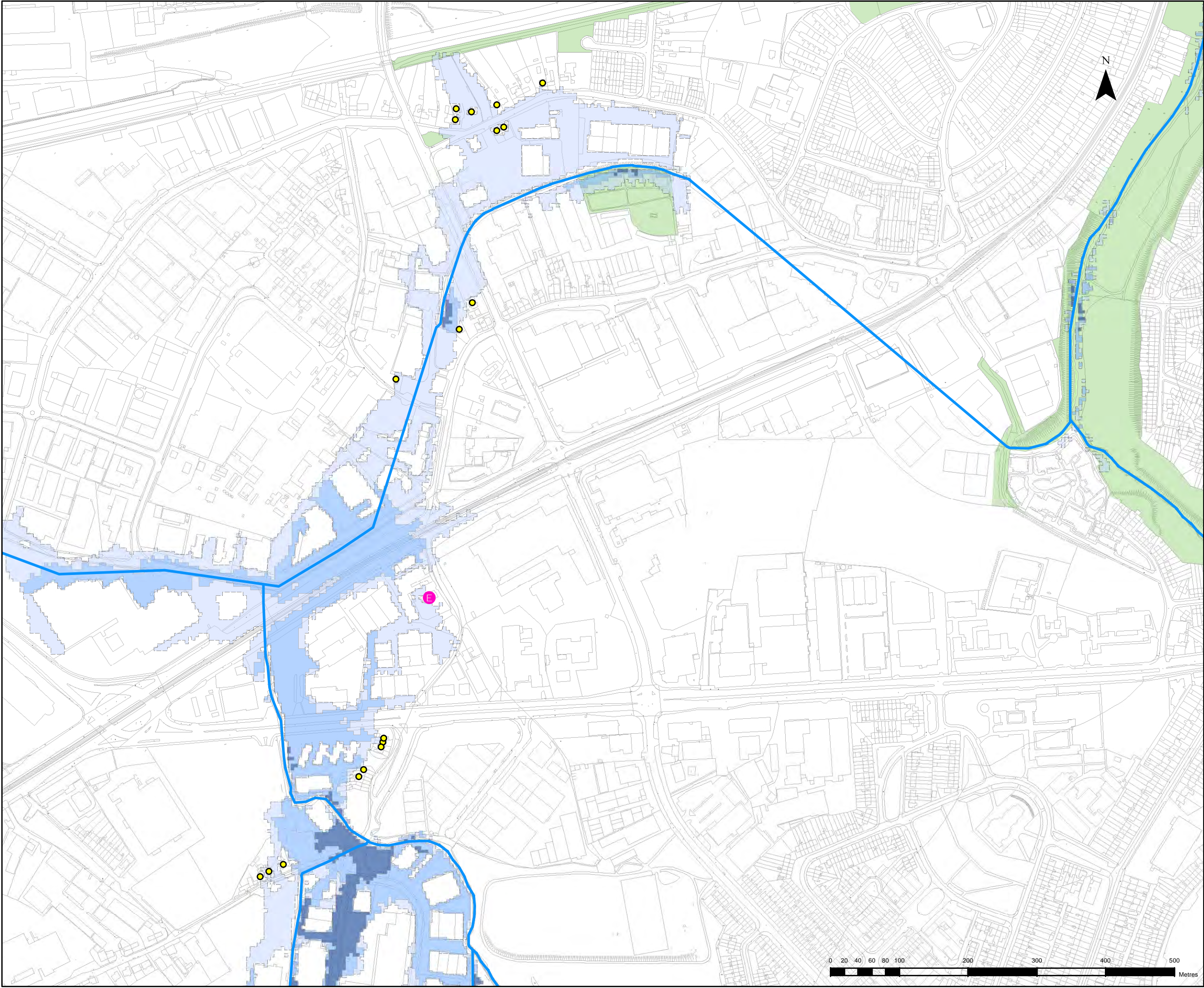
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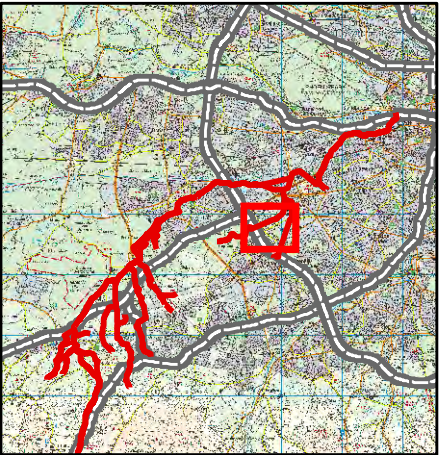
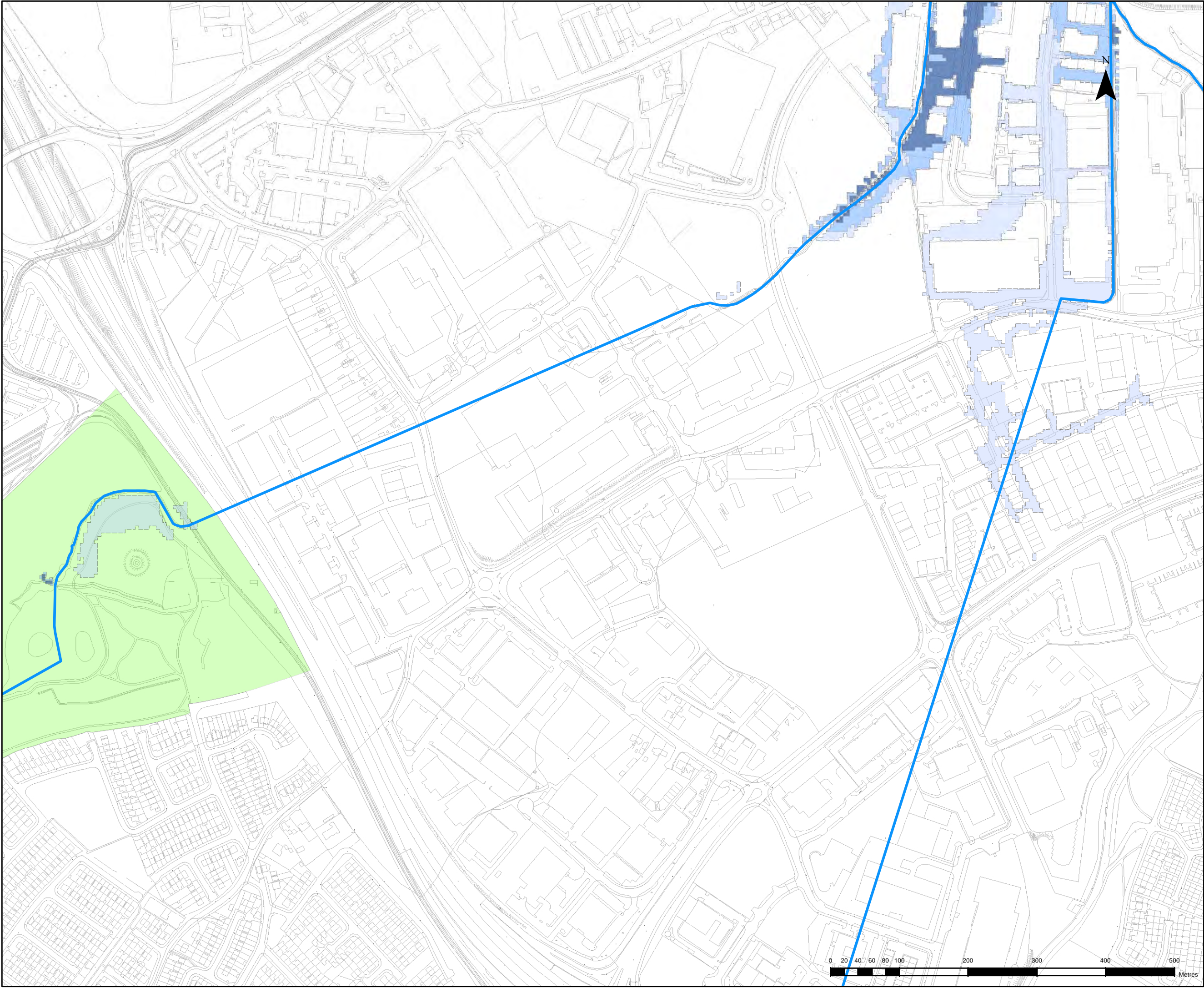
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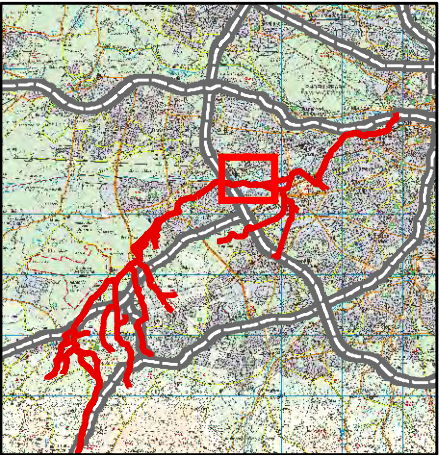
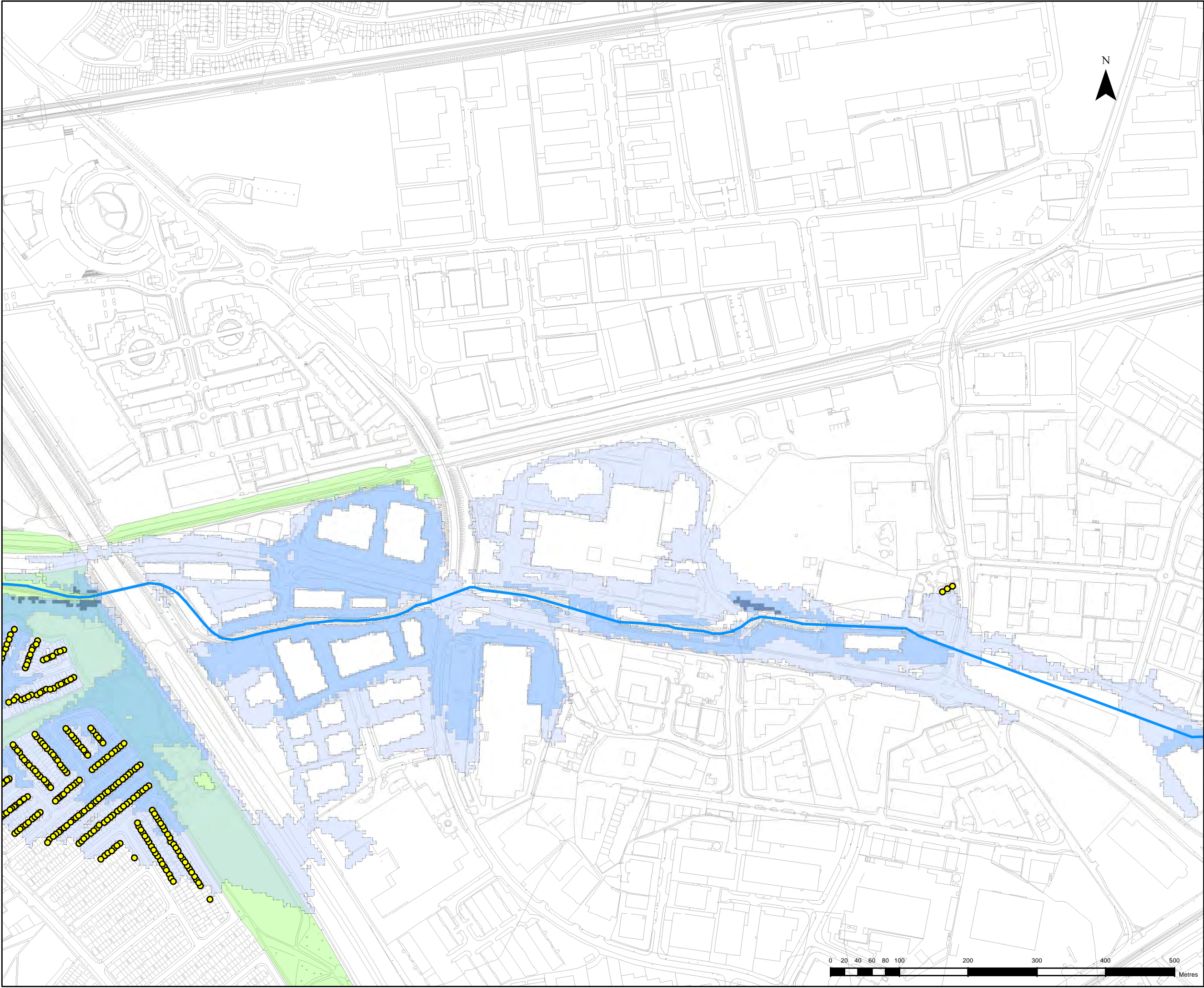
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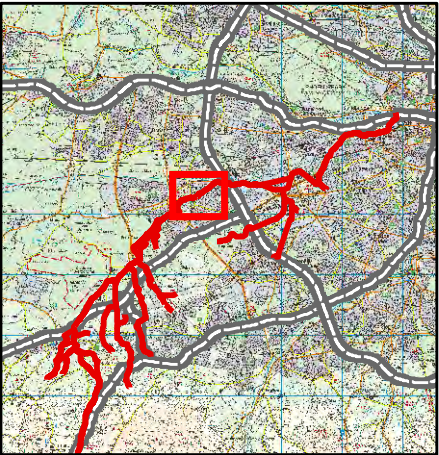
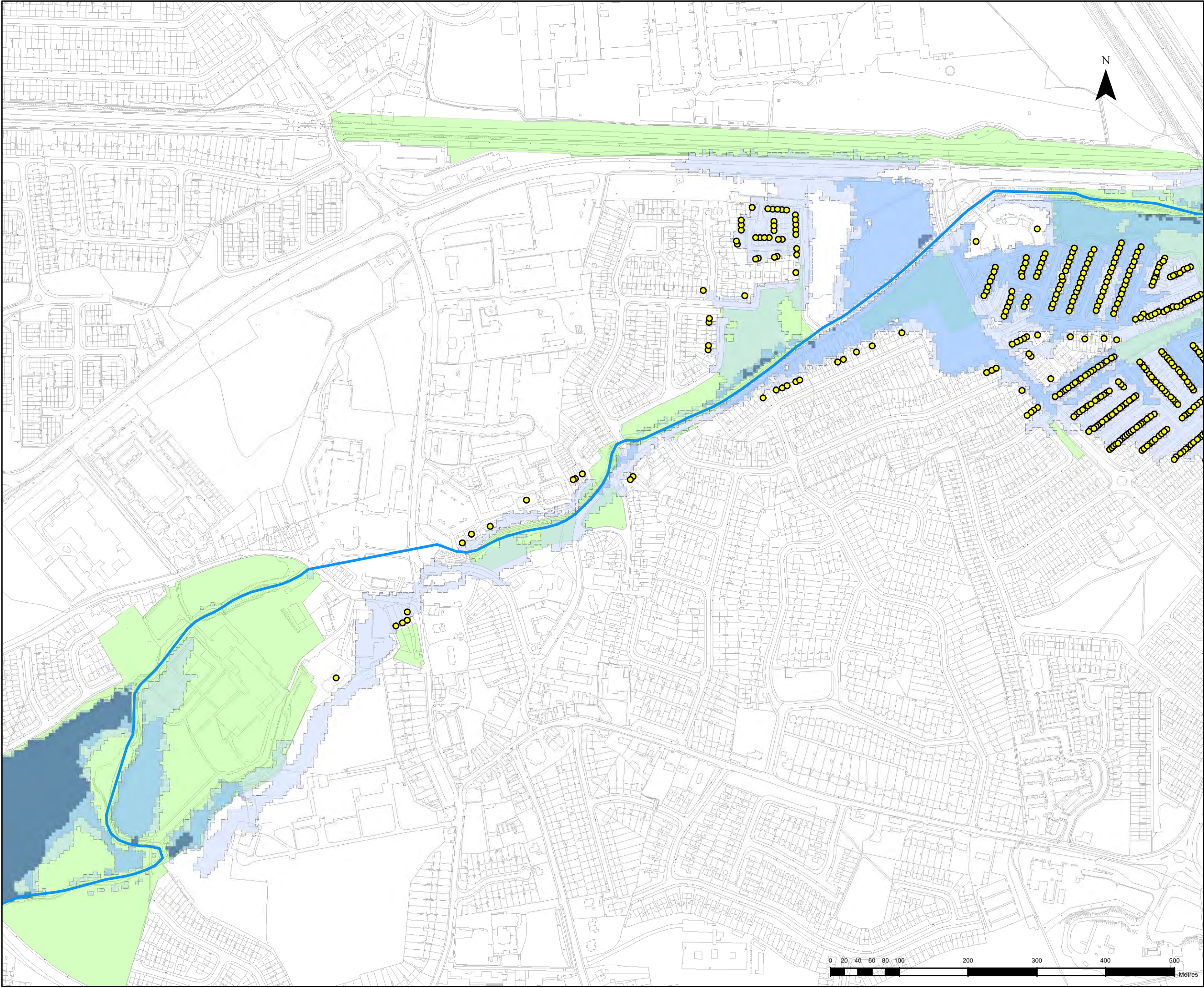
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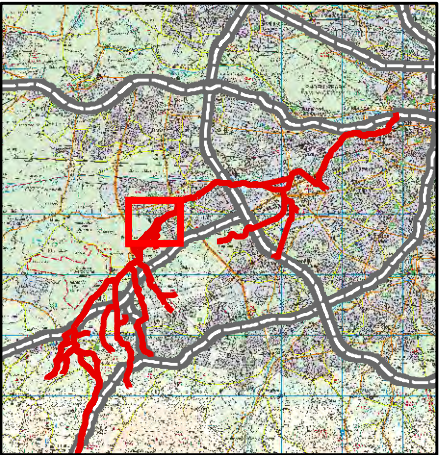
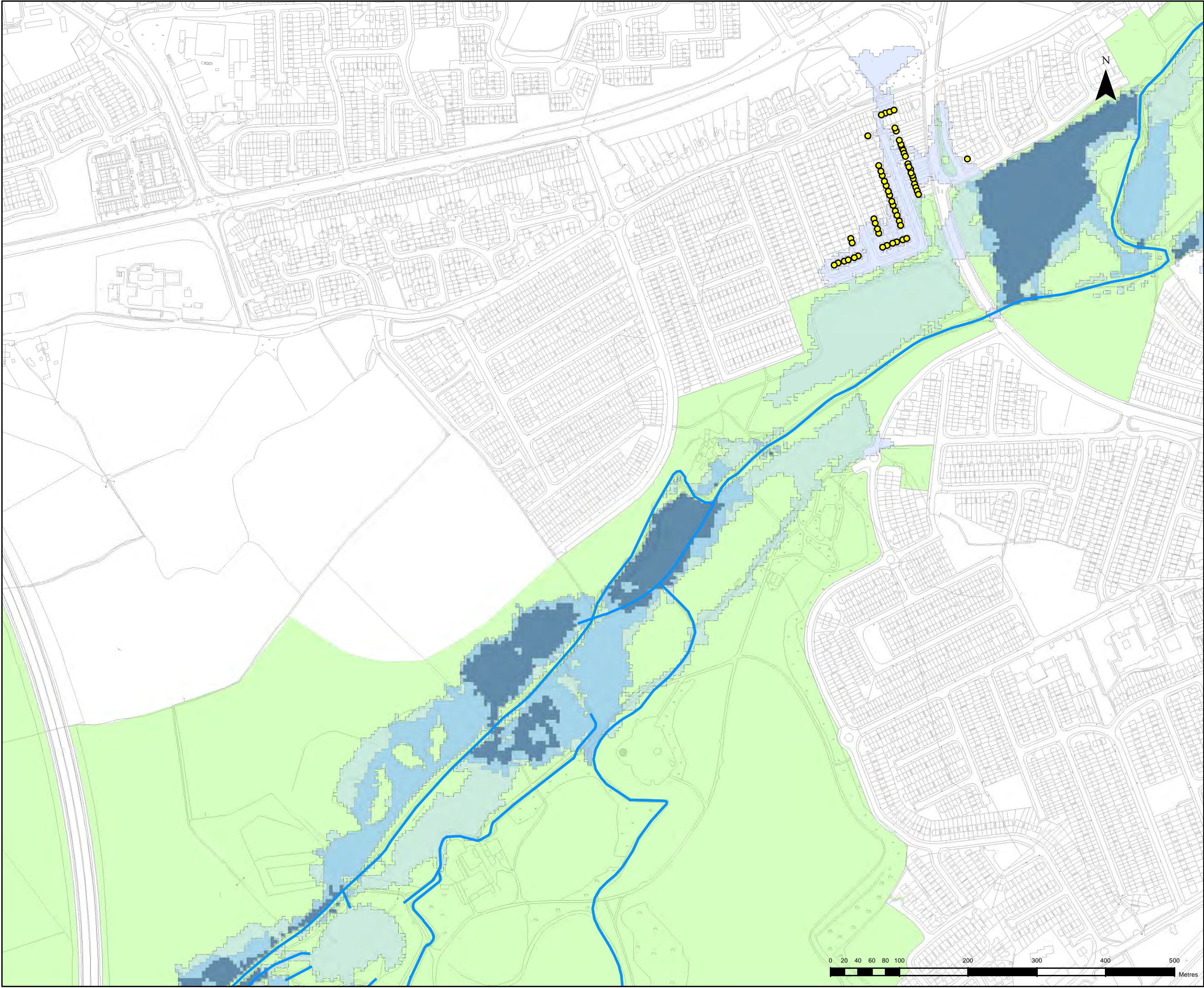
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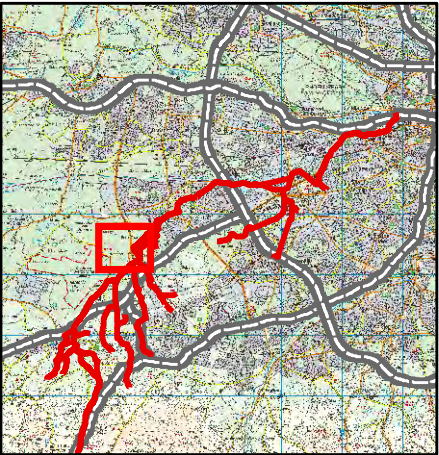
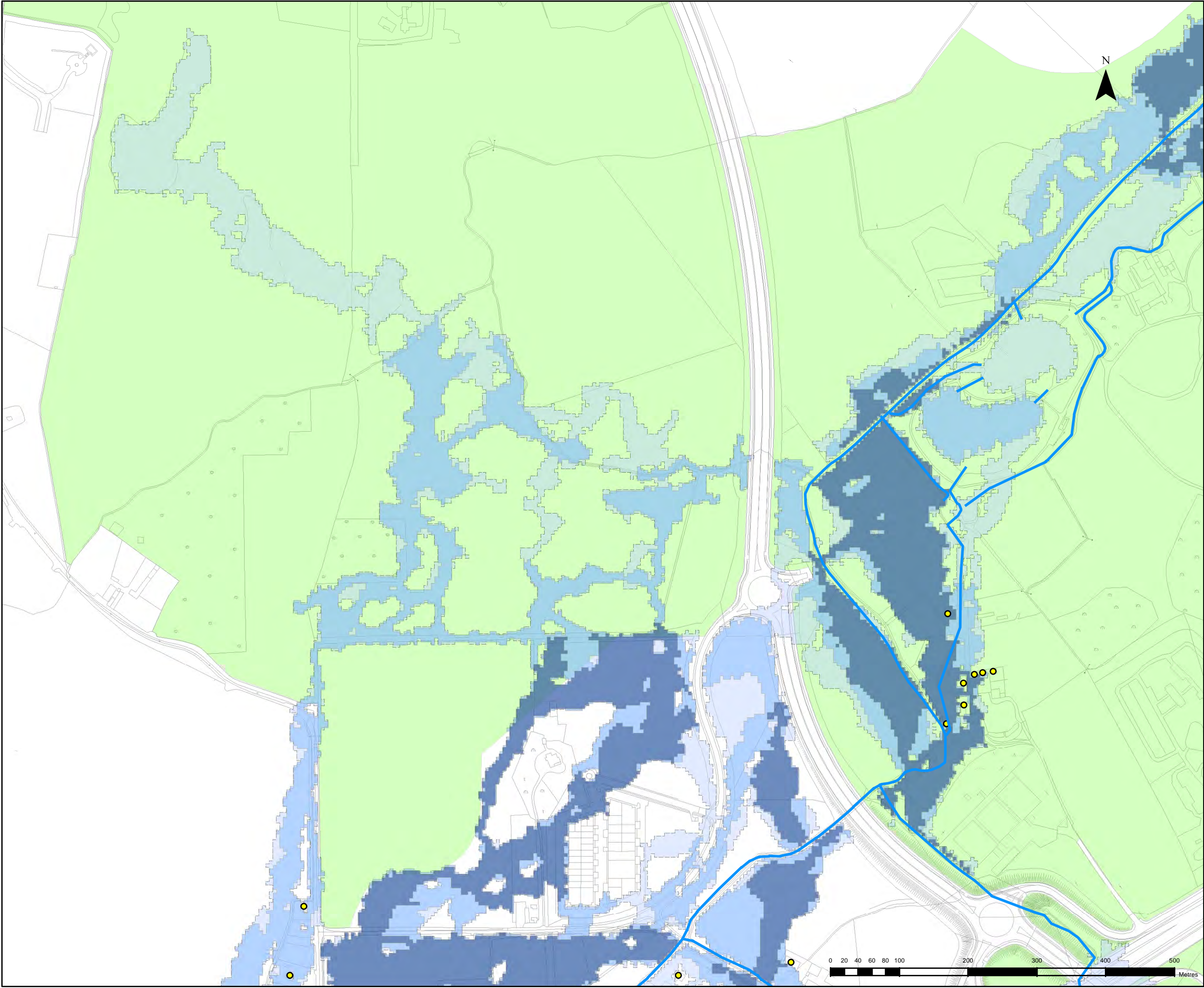
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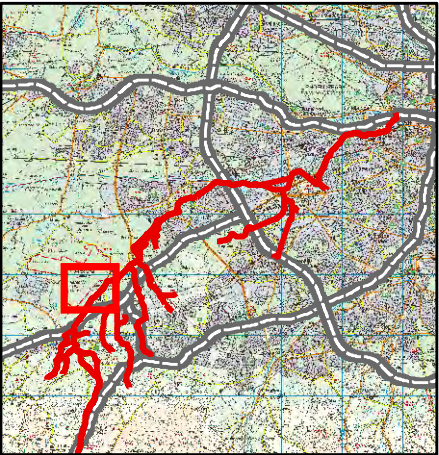
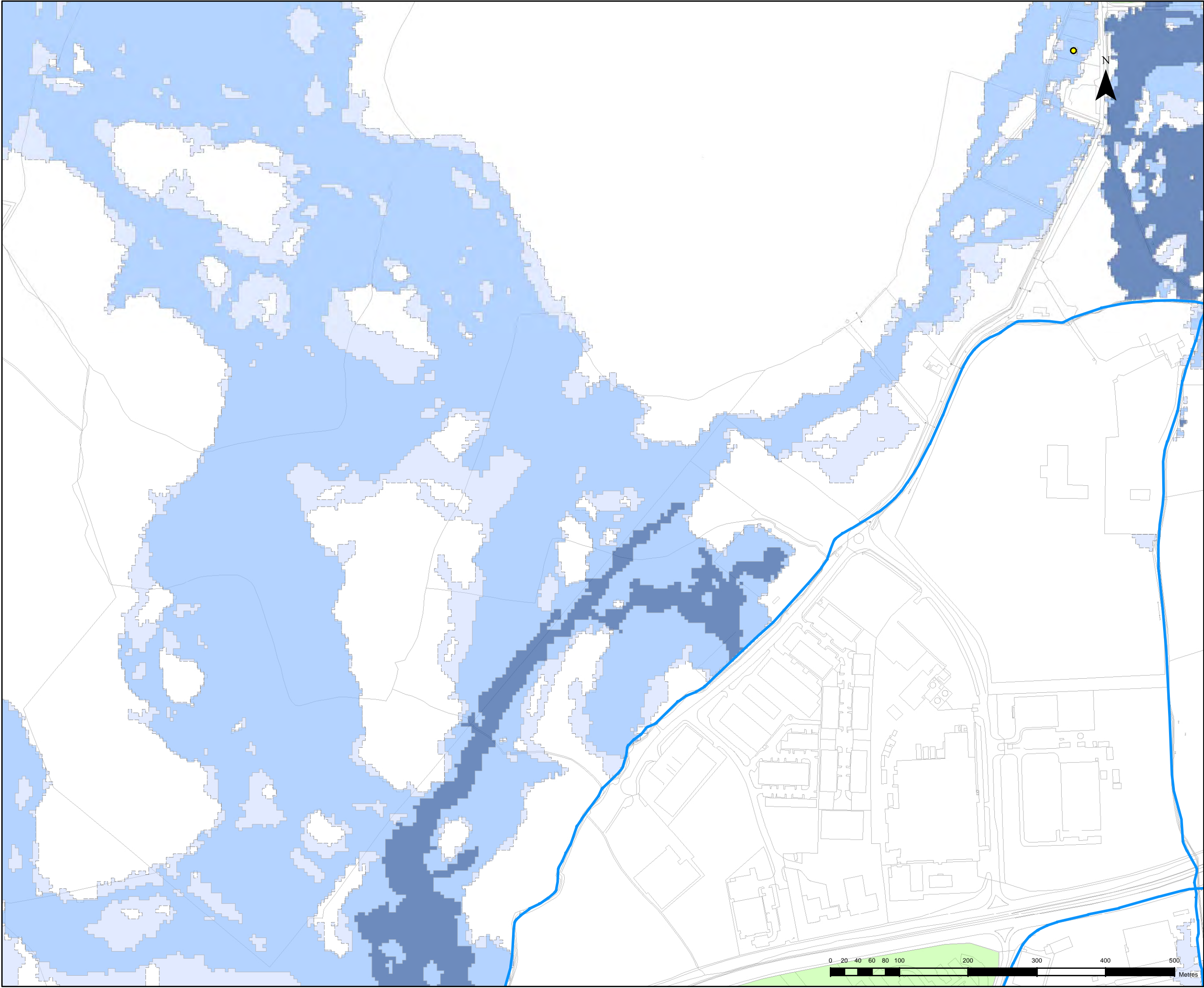
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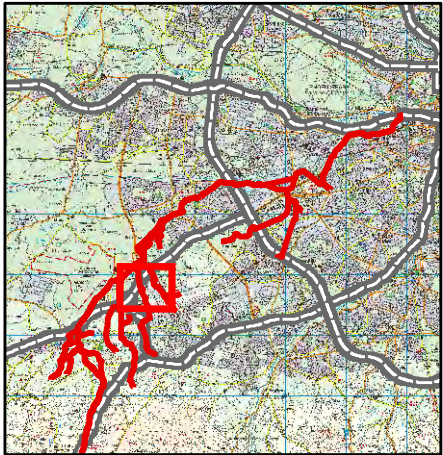
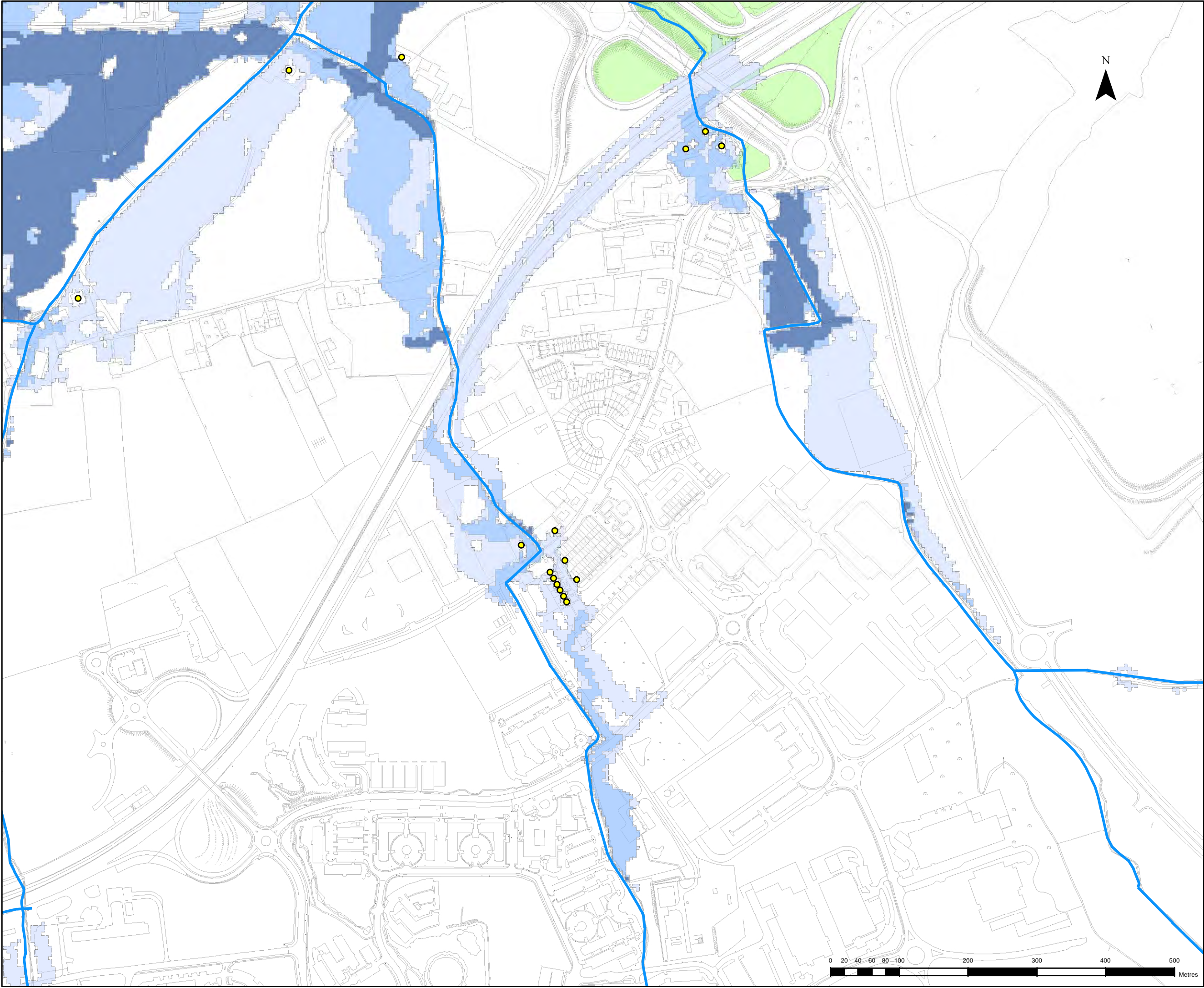
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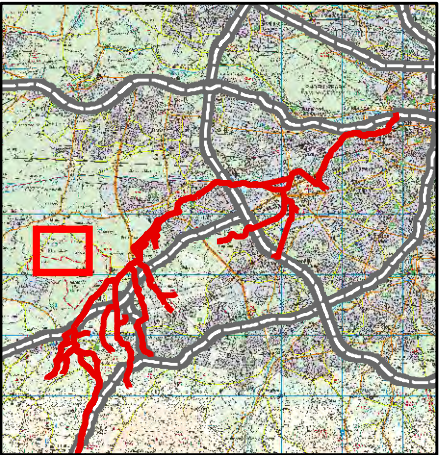
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09CC_SOC_009a

Drawn By : RC
Checked By : MW
Approved By : GG
Date : 21/10/2013

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Legend

- Residential Properties
- High Vulnerability Sites**
 - Schools
 - Residential Care
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 - Fire Stations
 - Civil Defence HQs
 - Garda Stations
 - Hospitals
 - Health Centres
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 - Open space and Recreational Amenities
 - Green Belt
- Flood Extents**
 - 0.1% AEP Event
 - 1% AEP Event
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 - River Centreline

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TITLE

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Draft - General Risk - Social

ELMWOOD HOUSE
74 BOUCHER ROAD
BELFAST BT12 6RZ

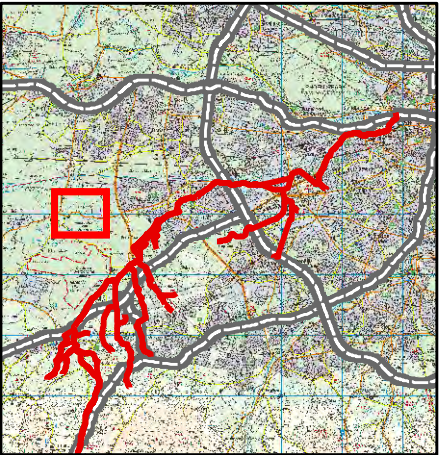
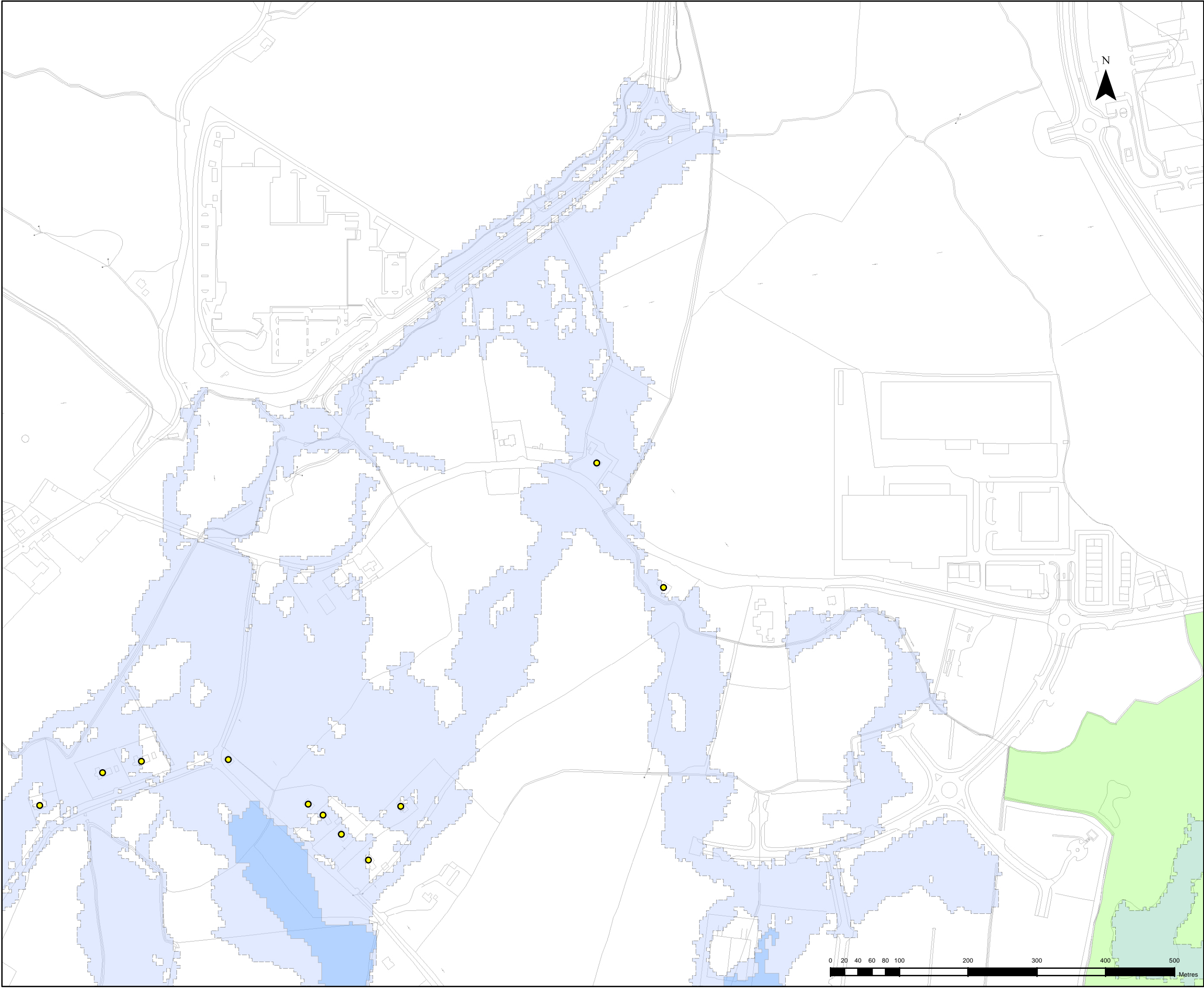
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TITLE

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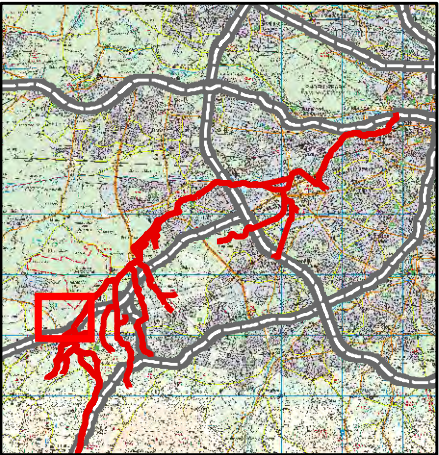
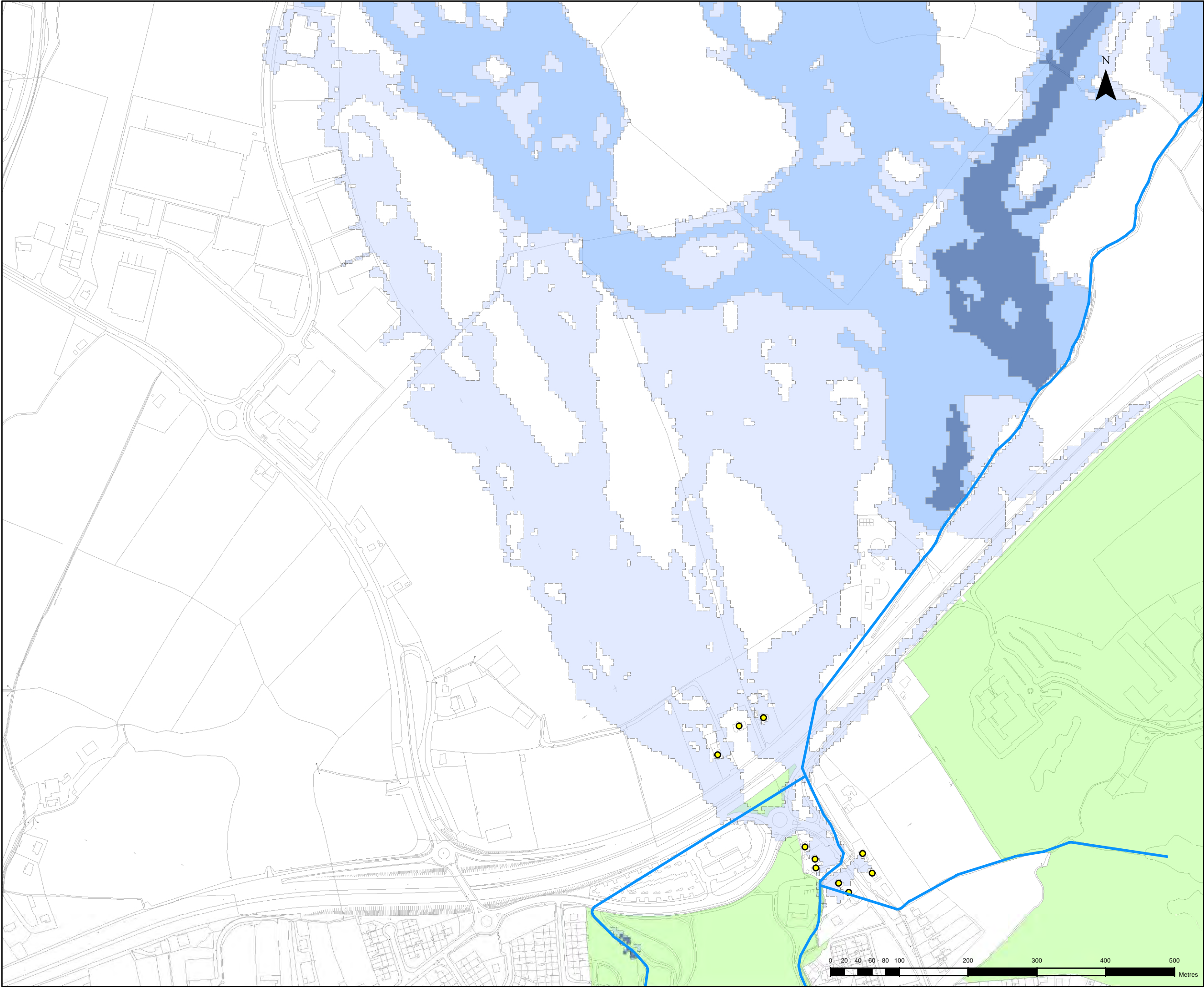
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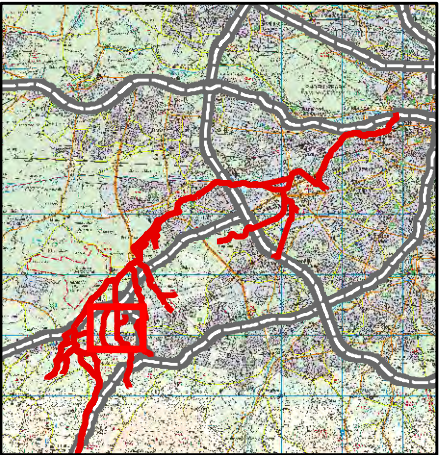
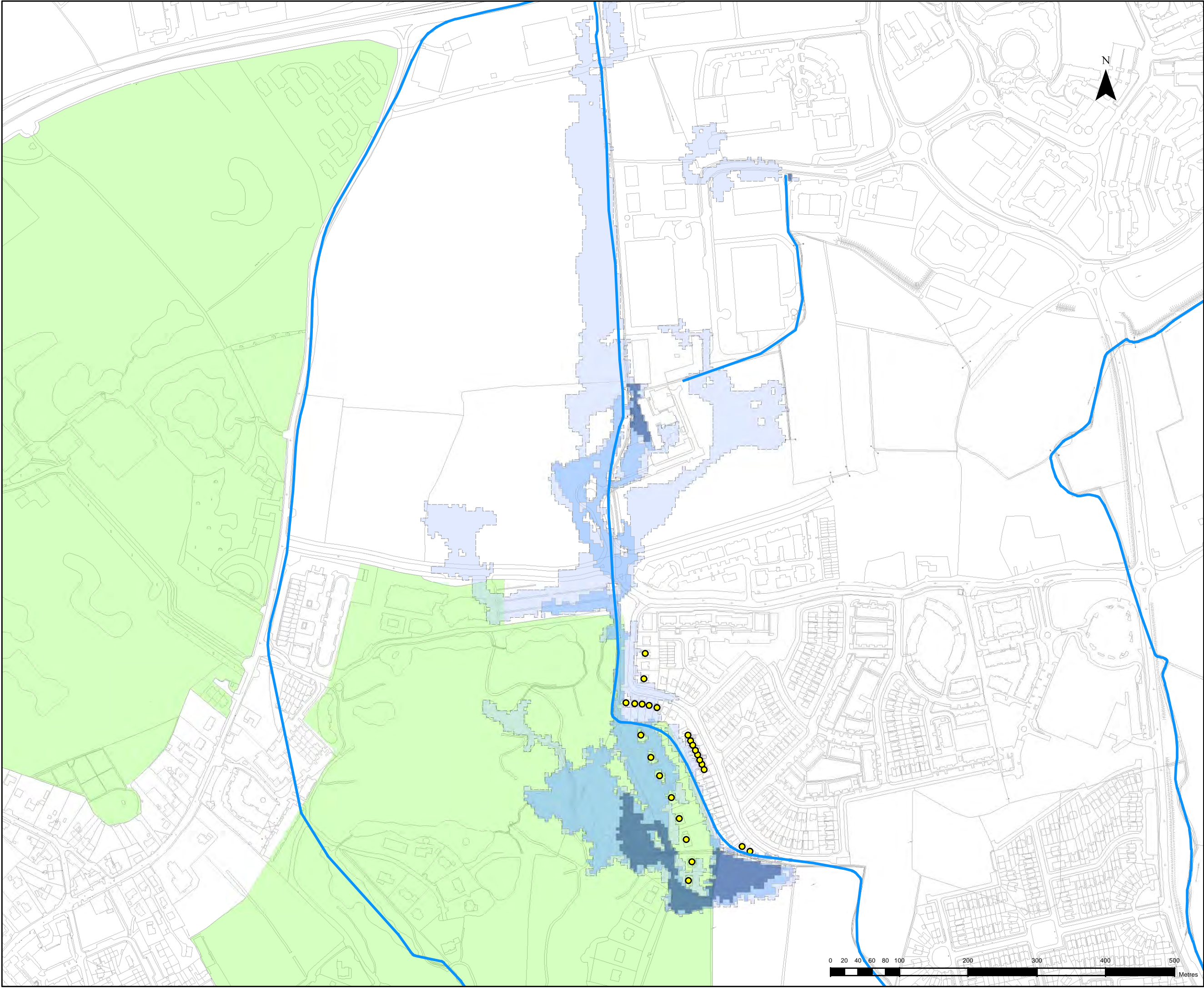
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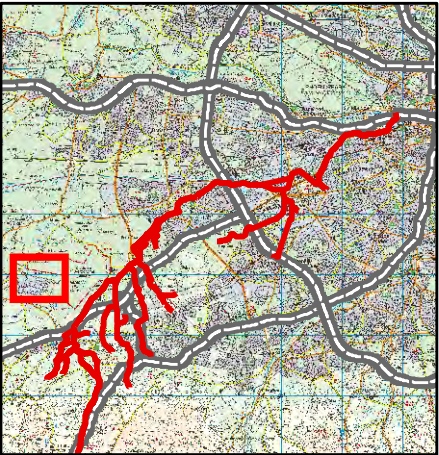
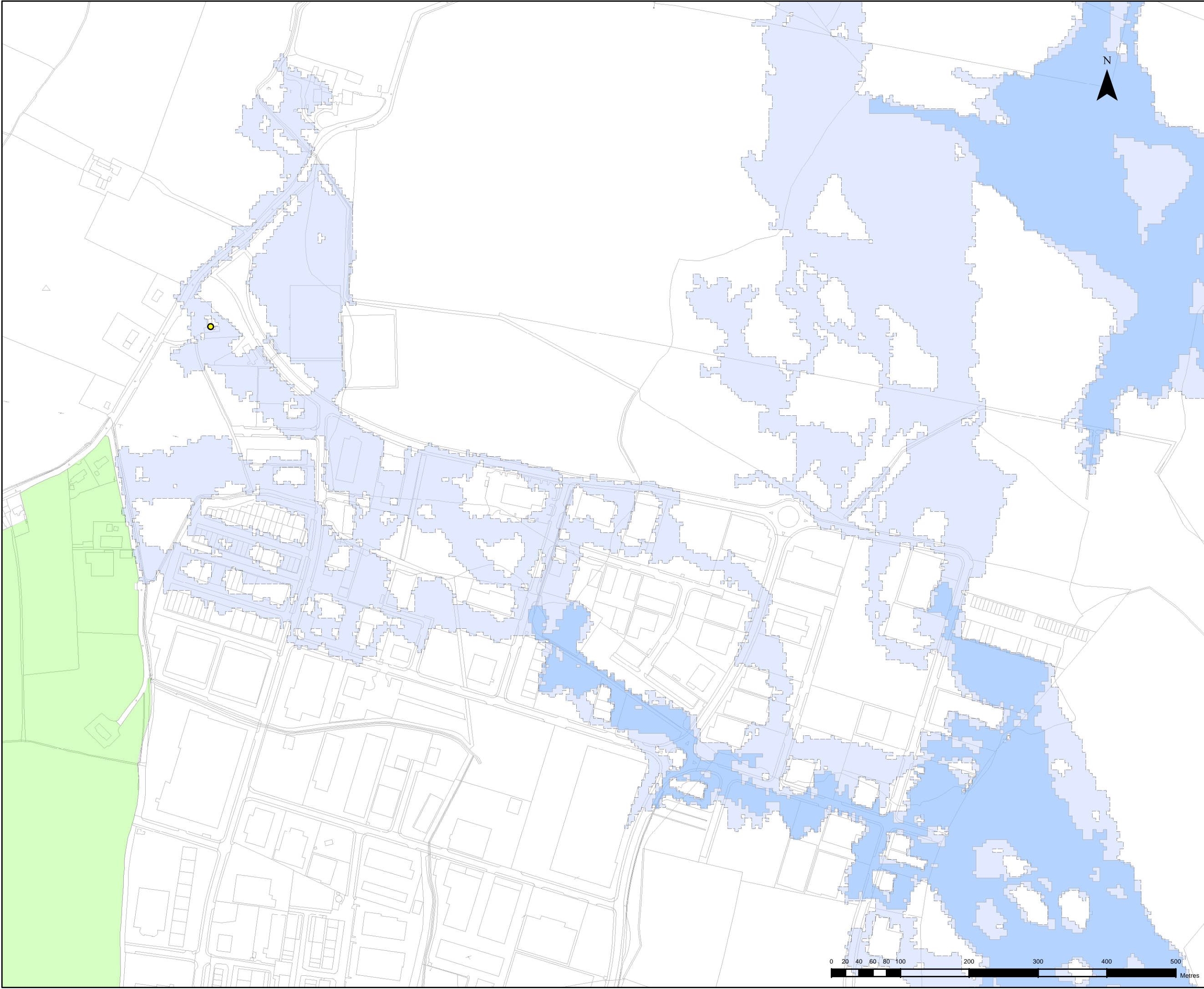
RPS	ELMWOOD HOUSE 74 BOUCHER ROAD BELFAST BT12 6RZ	TEL : 028 9066 7914 FAX : 028 9066 8286 www.rpsgroup.com/ireland
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	Date :	21/10/2013

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Legend

● Residential Properties

High Vulnerability Sites

● Schools

● Residential Care

Valuable Social Infrastructure

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● Civil Defence HQs

● Garda Stations

● Hospitals

● Health Centres

Social Amenity Sites

● Open space and Recreational Amenities

● Green Belt

Flood Extents

■ 0.1% AEP Event

■ 1% AEP Event

■ 10% AEP Event

— River Centreline

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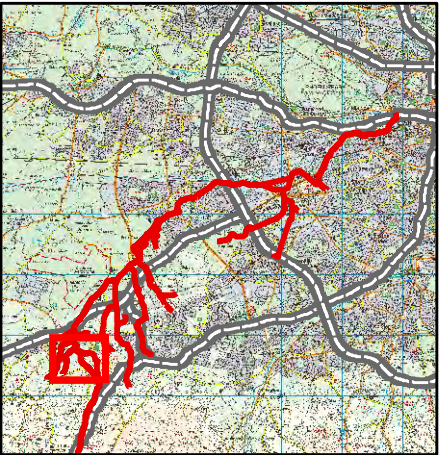
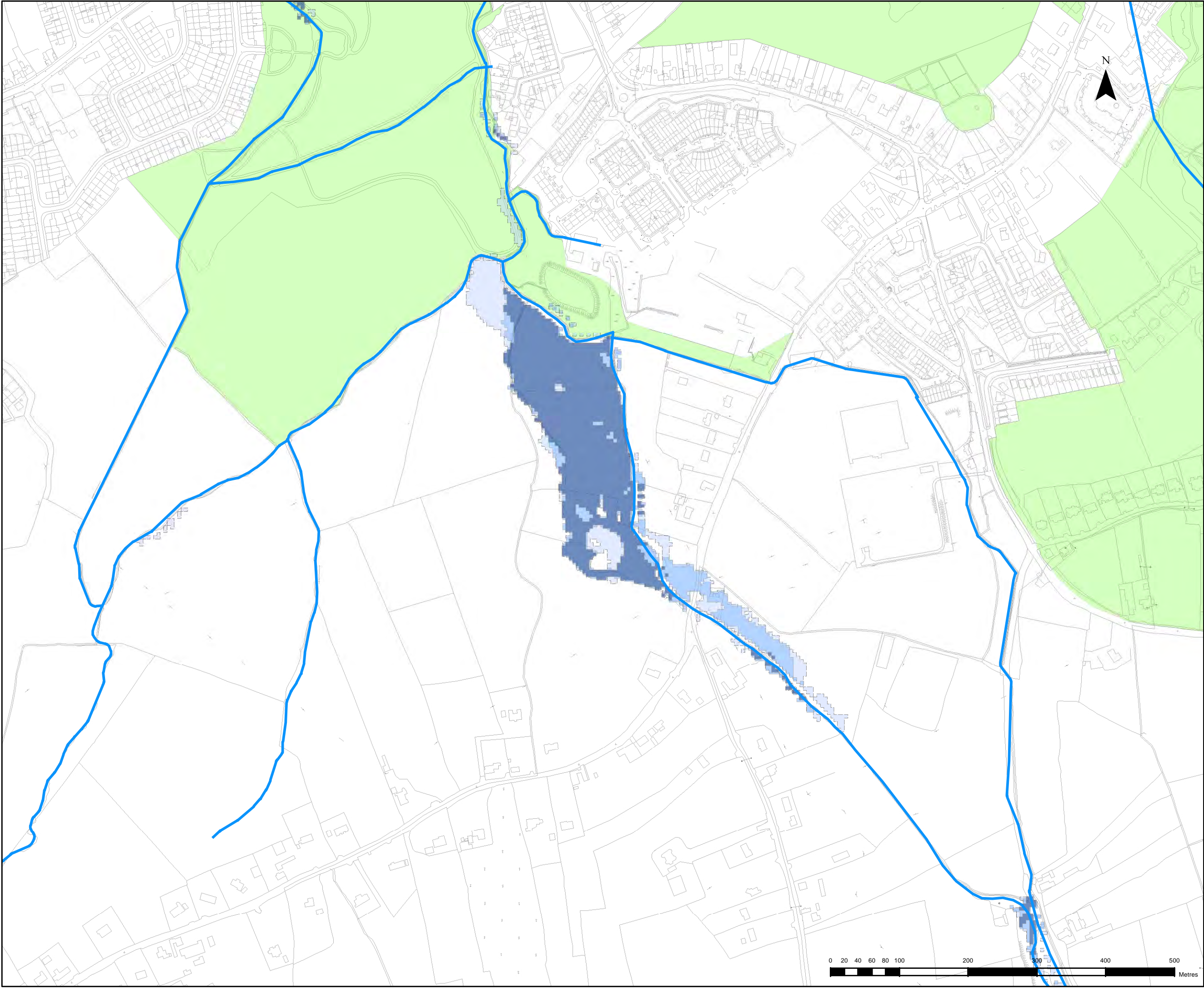
TEL : 028 9066 7914
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Drawing No.:

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Drawn By : RC
Checked By : MW
Approved By : GG
Date : 21/10/2013

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EASTERN CFRAMS

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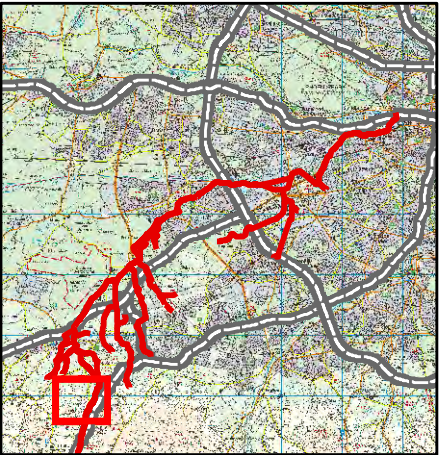


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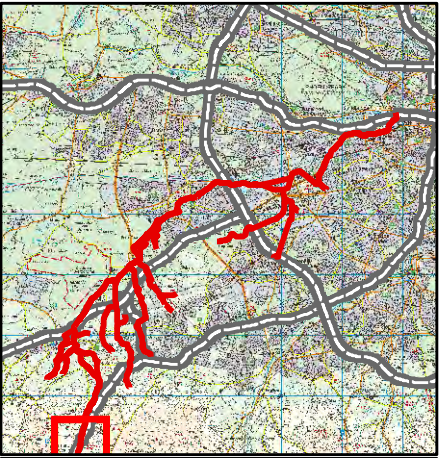
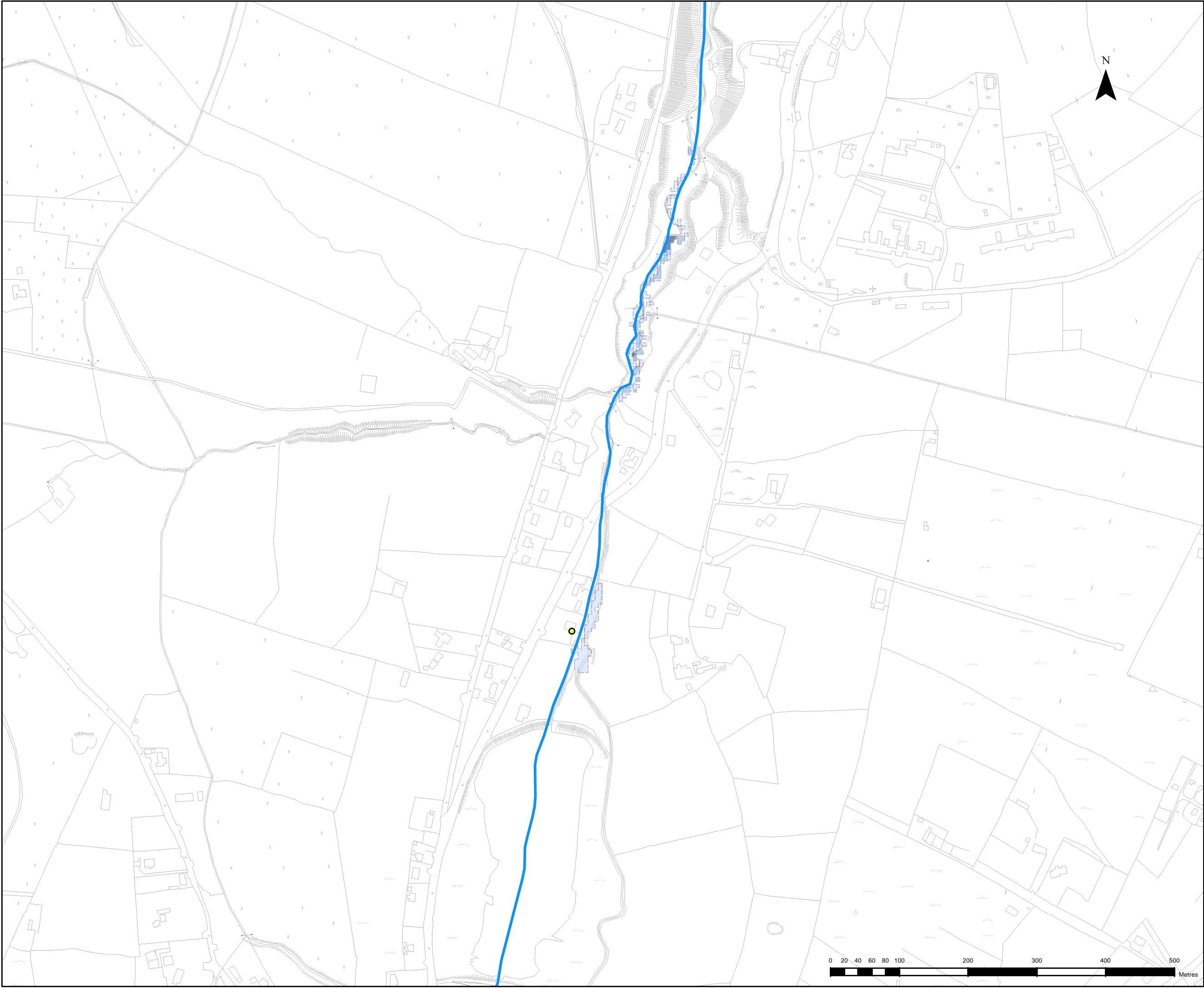
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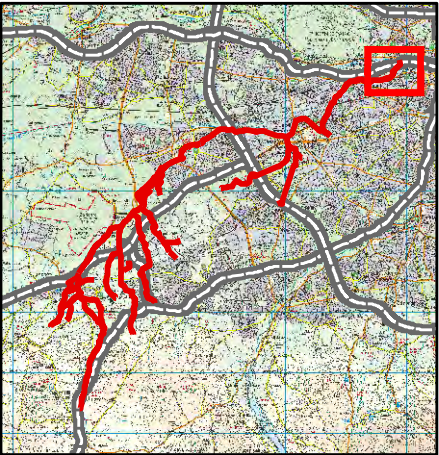
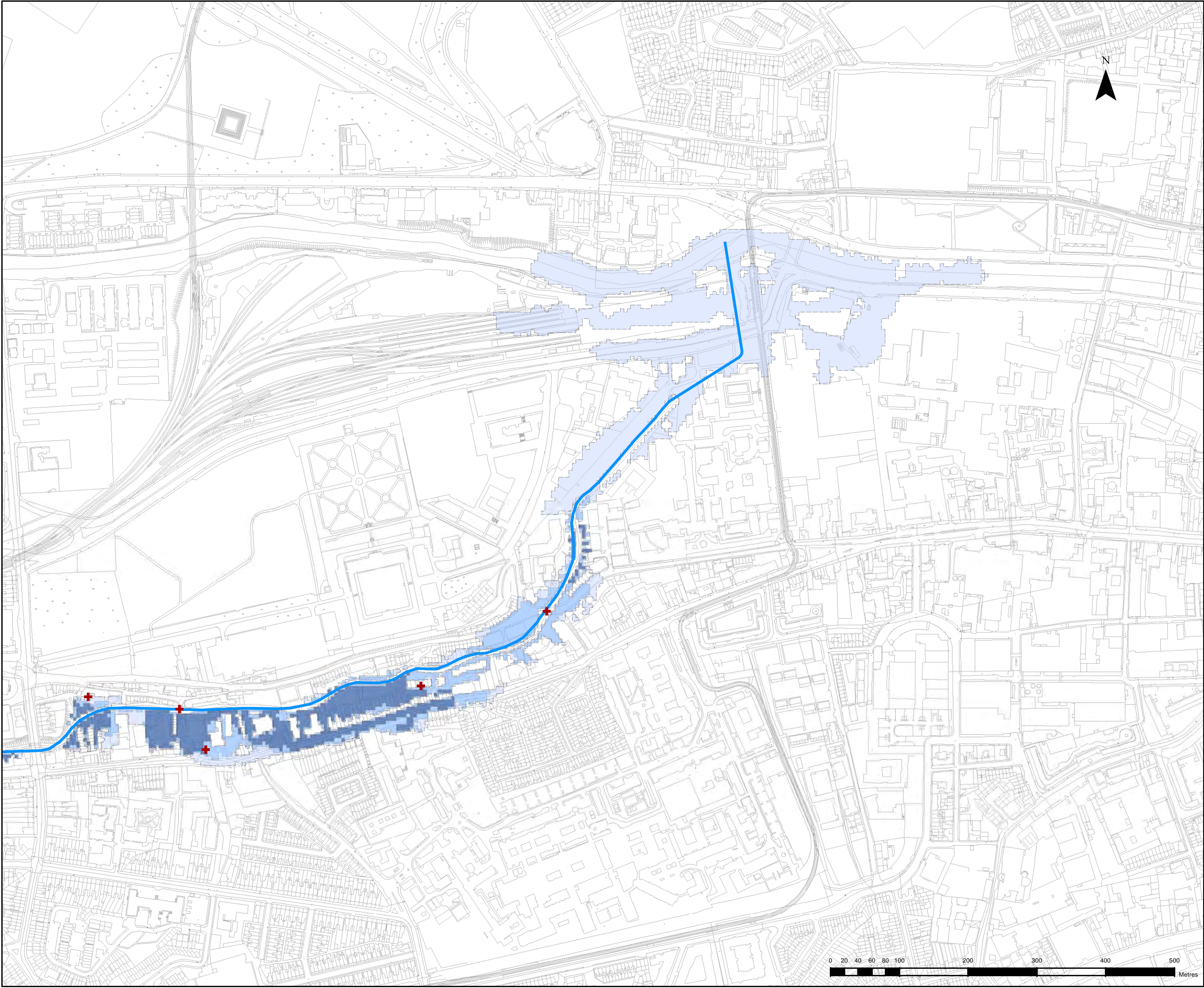
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- Architctural / Archaeological Heritage
 - UNESCO Sites
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 - 0.1% AEP Event
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 - River Centreline

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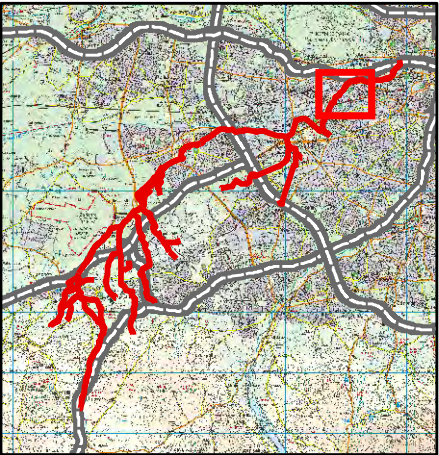
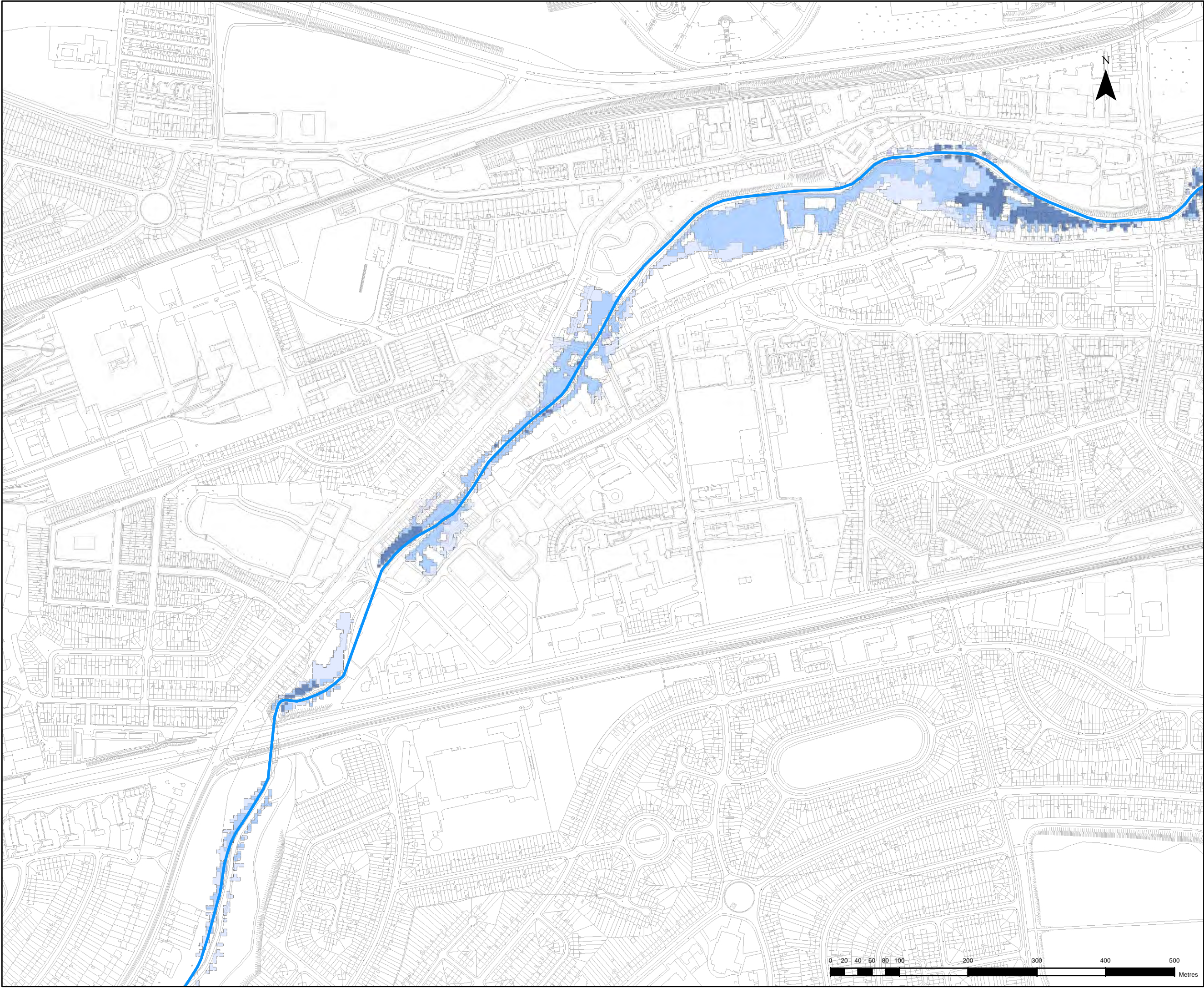
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	Date :	21/10/2013
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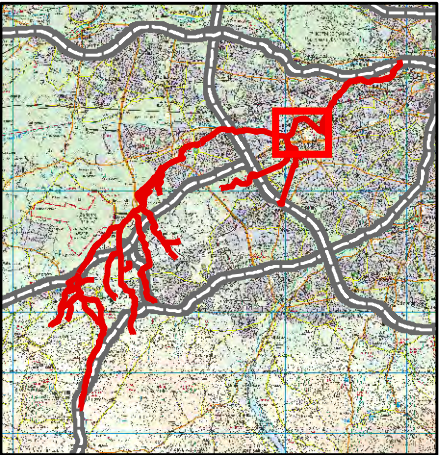
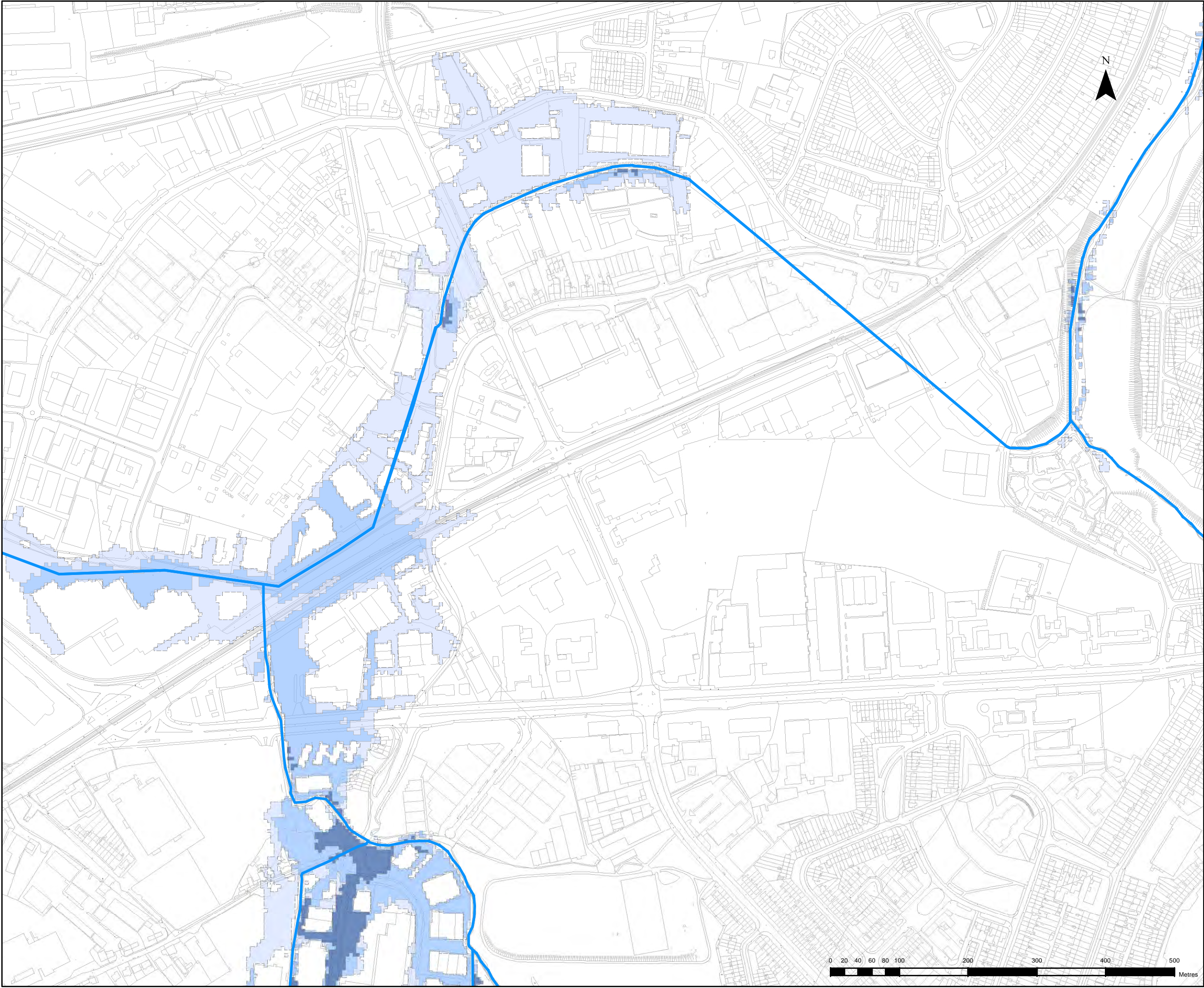
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Drawing No.: 09CC_HER_002
Drawn By: RC
Checked By: MW
Approved By: GG
Date: 21/10/2013

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TITLE

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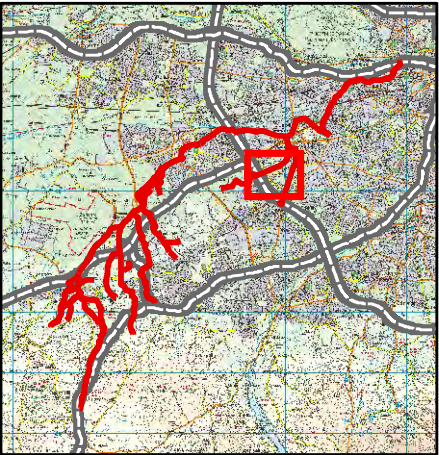
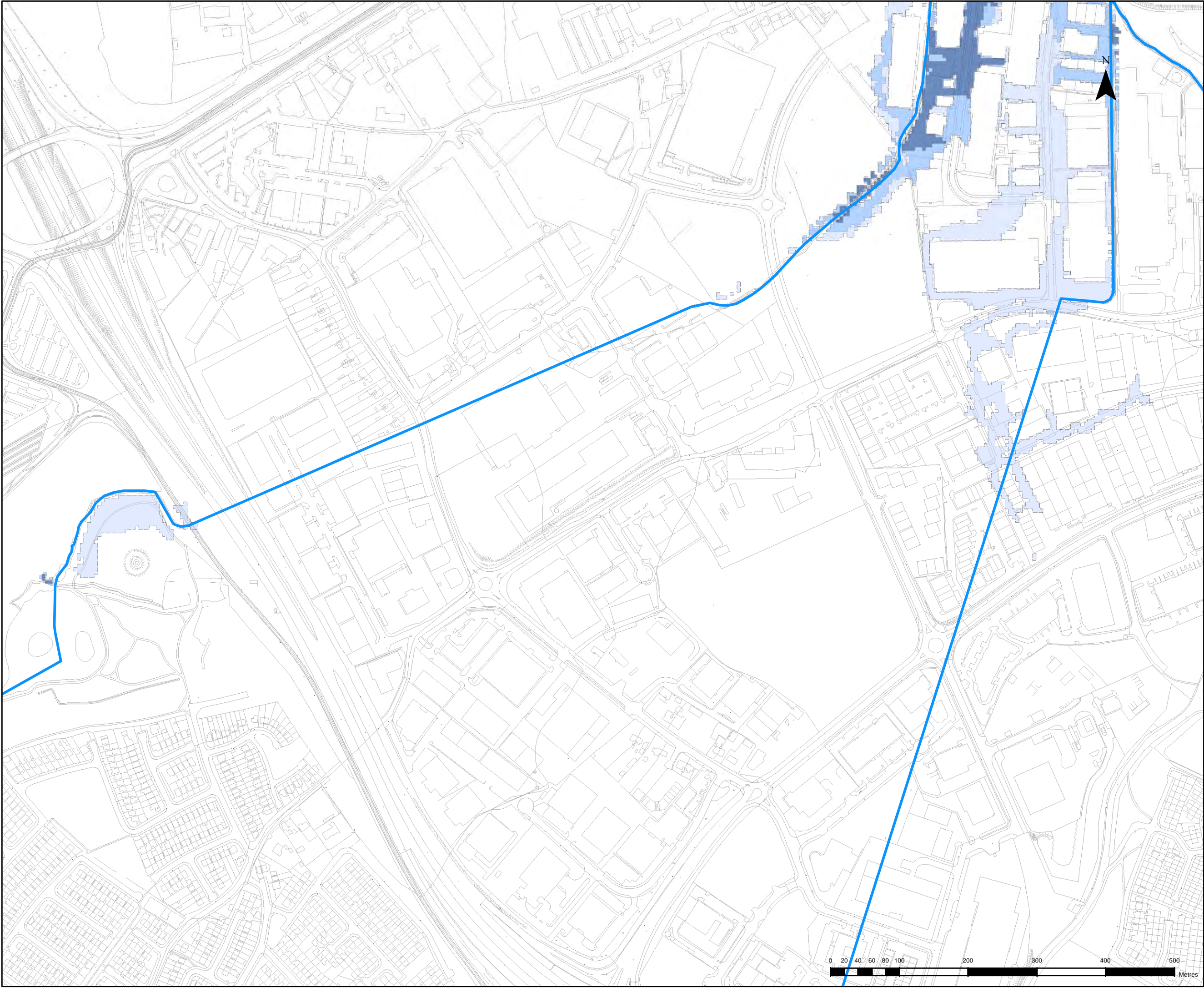
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	Checked By :	MW
	Approved By :	GG
	Date :	21/10/2013

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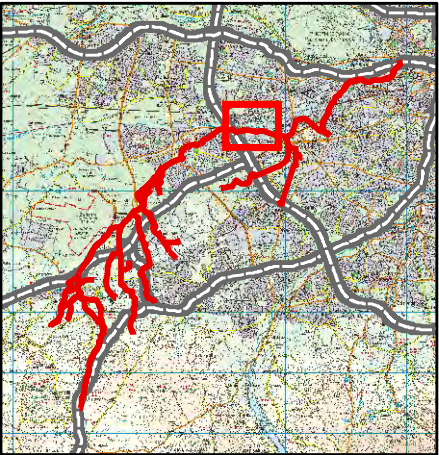
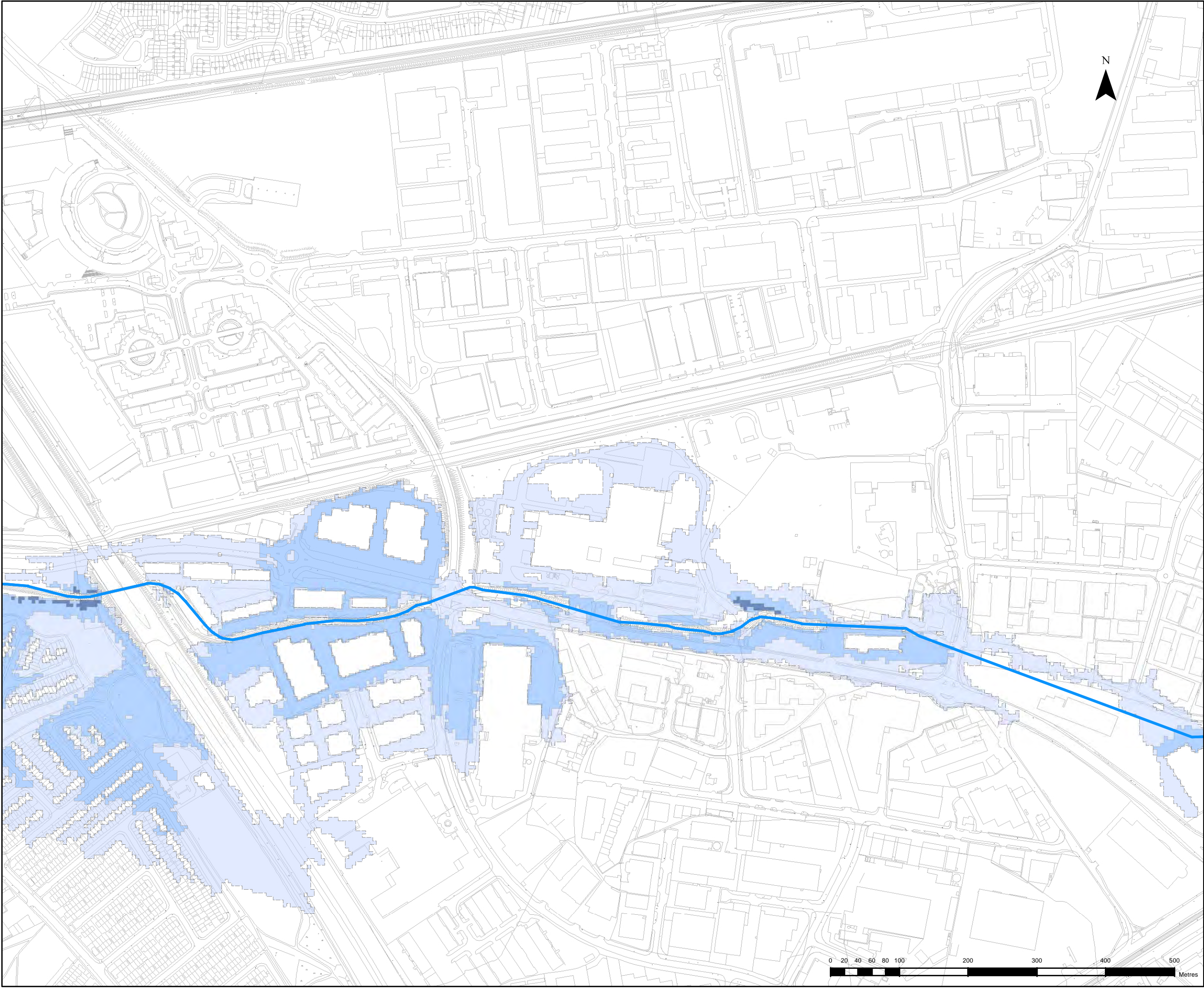
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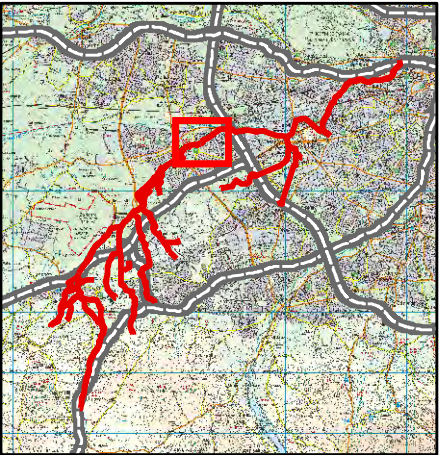
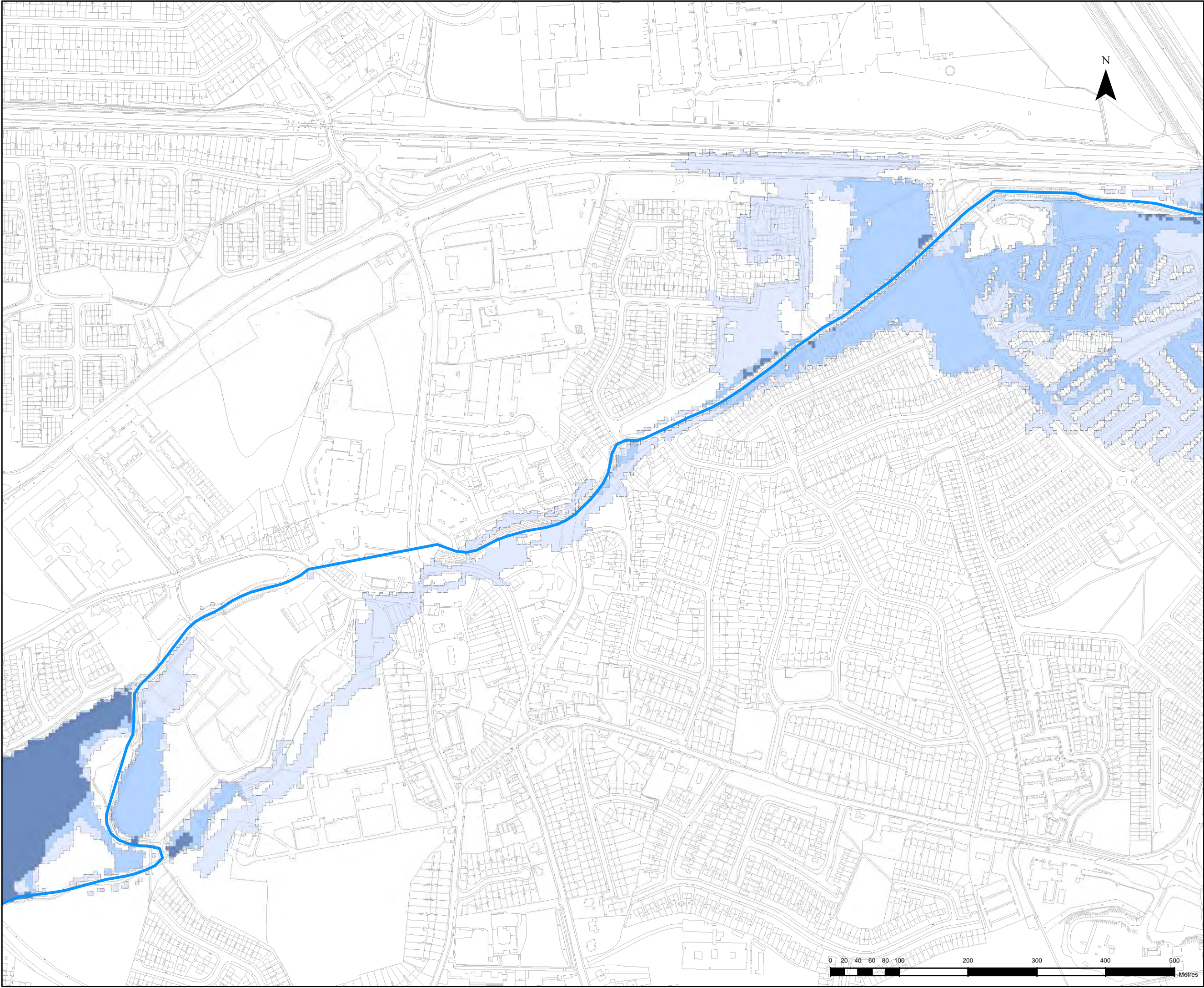
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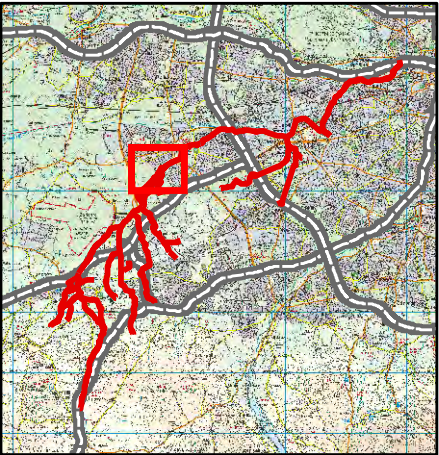
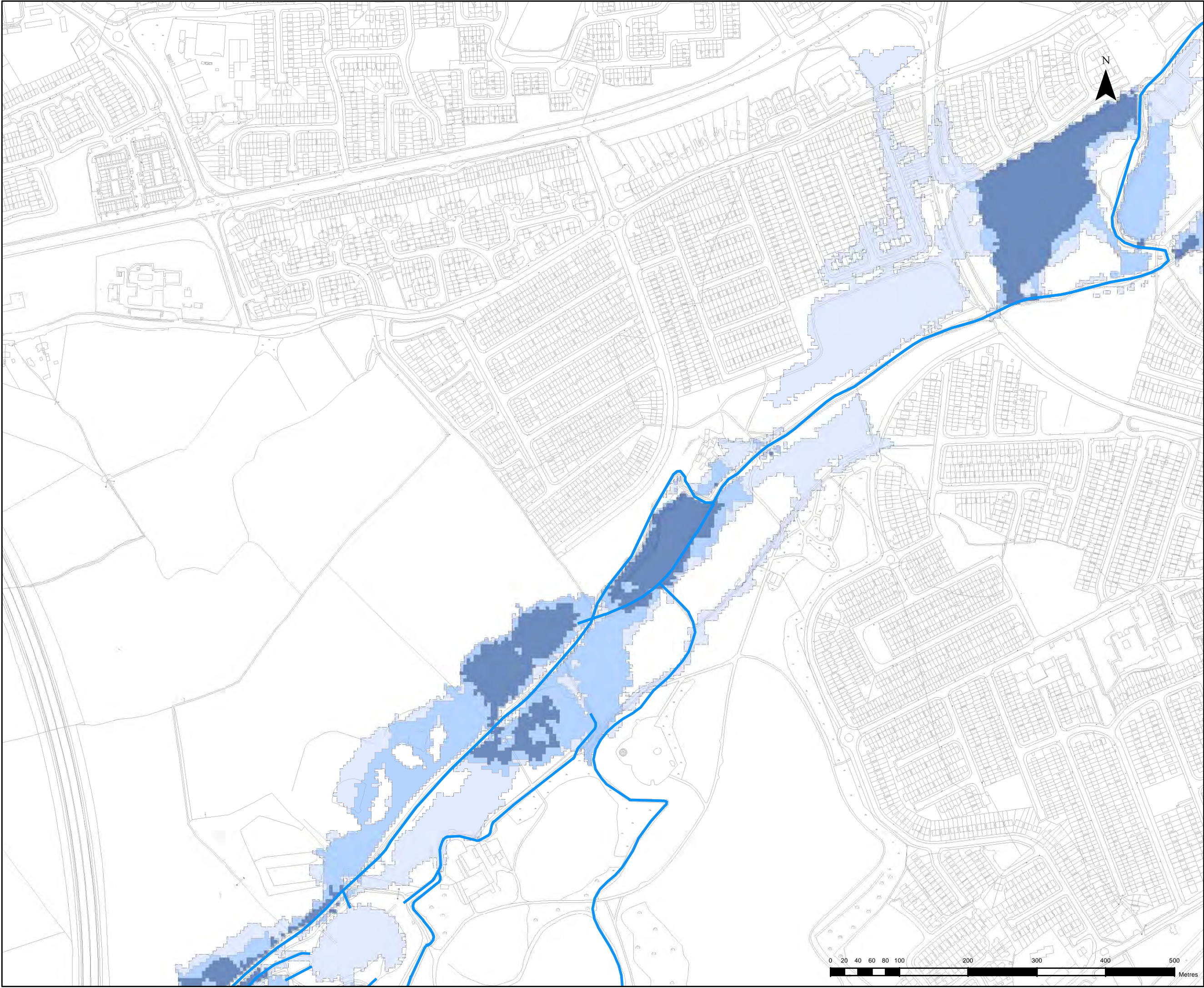
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Drawing No.:

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Drawn By : RC
Checked By : MW
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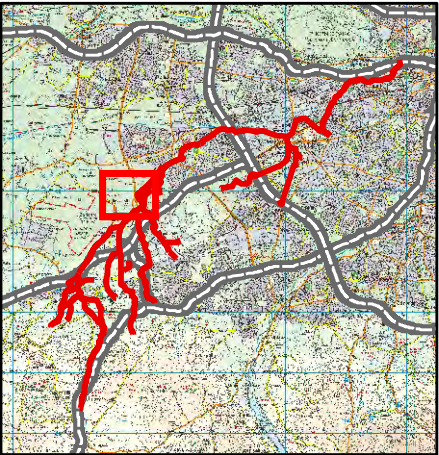
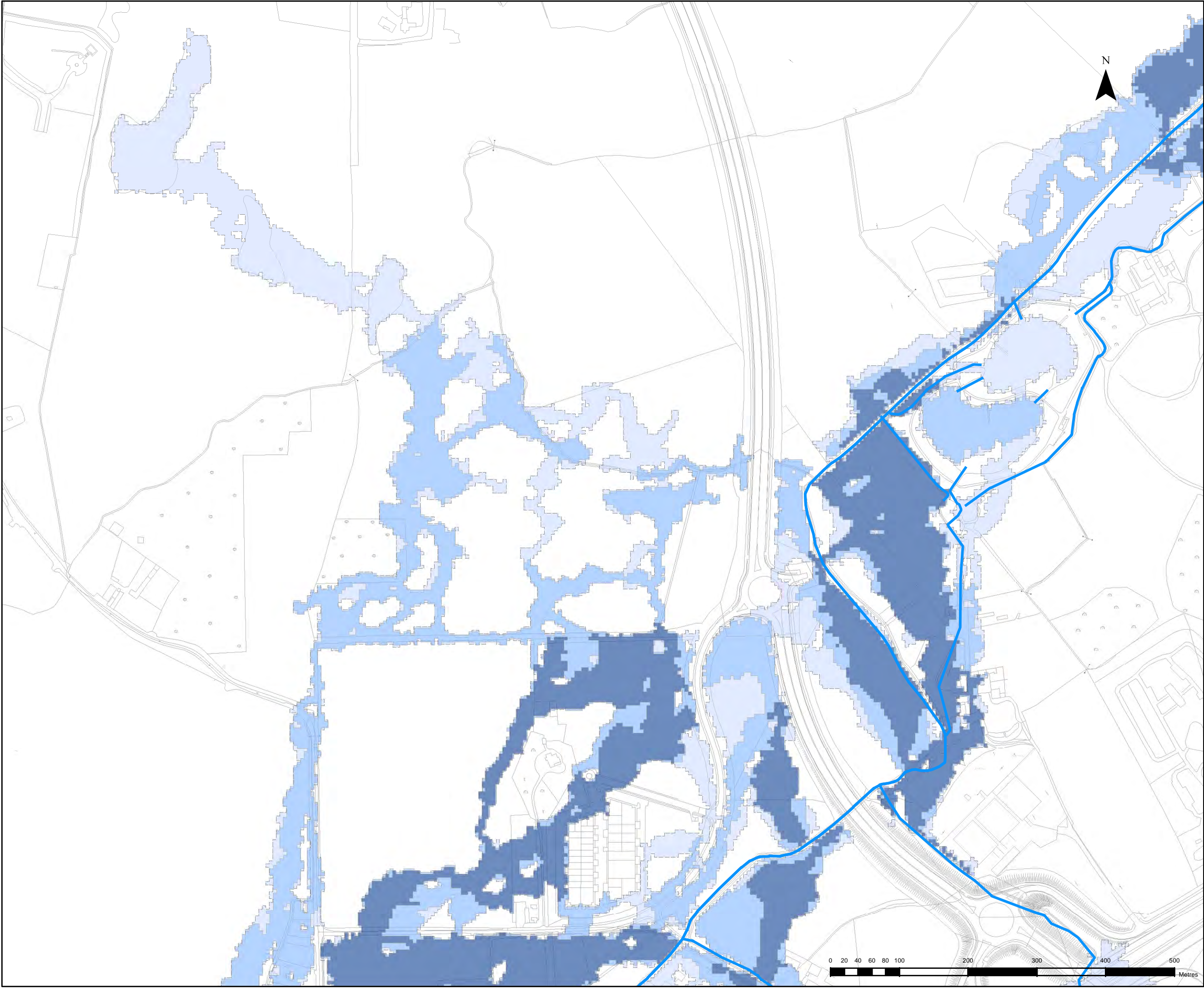
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Drawn By : RC
Checked By : MW
Approved By : GG
Date : 21/10/2013

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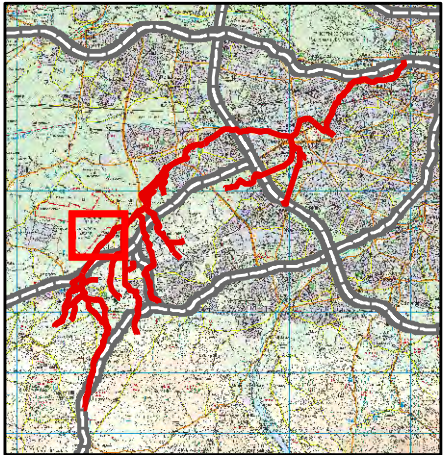
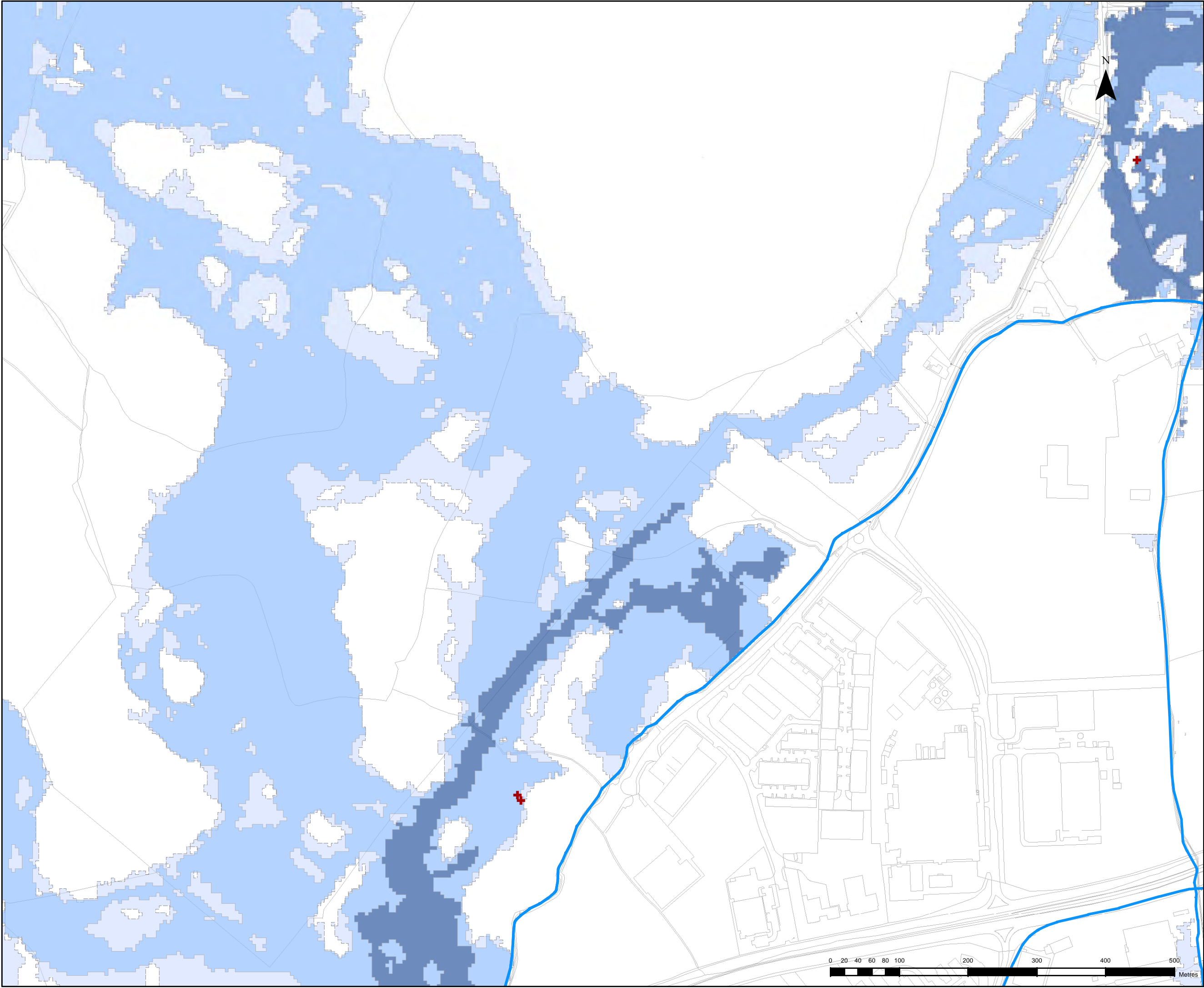
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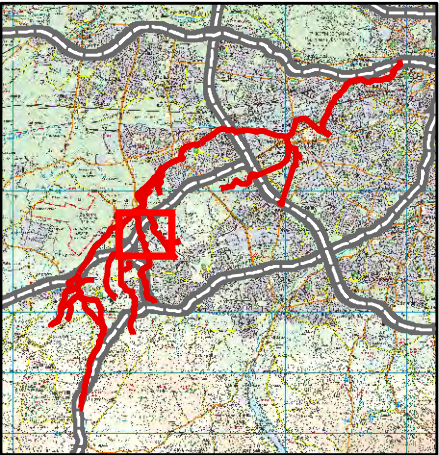
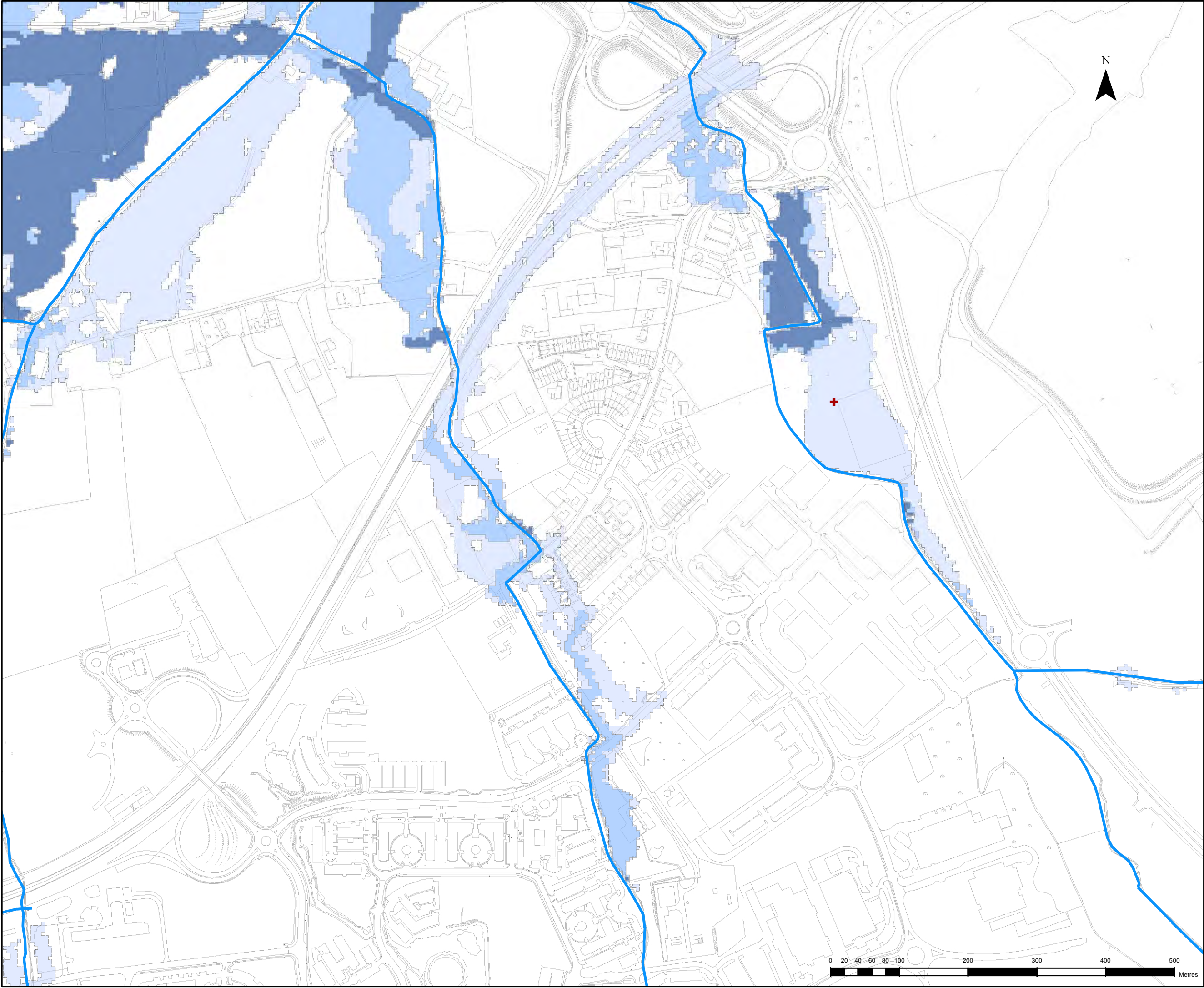
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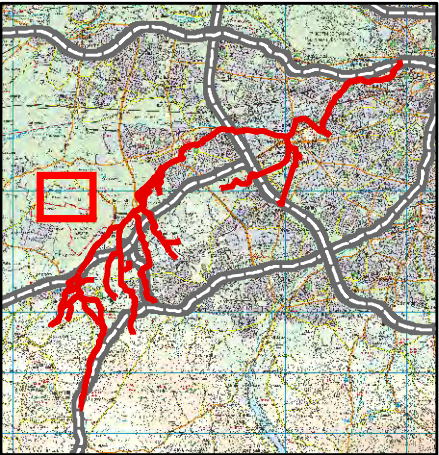
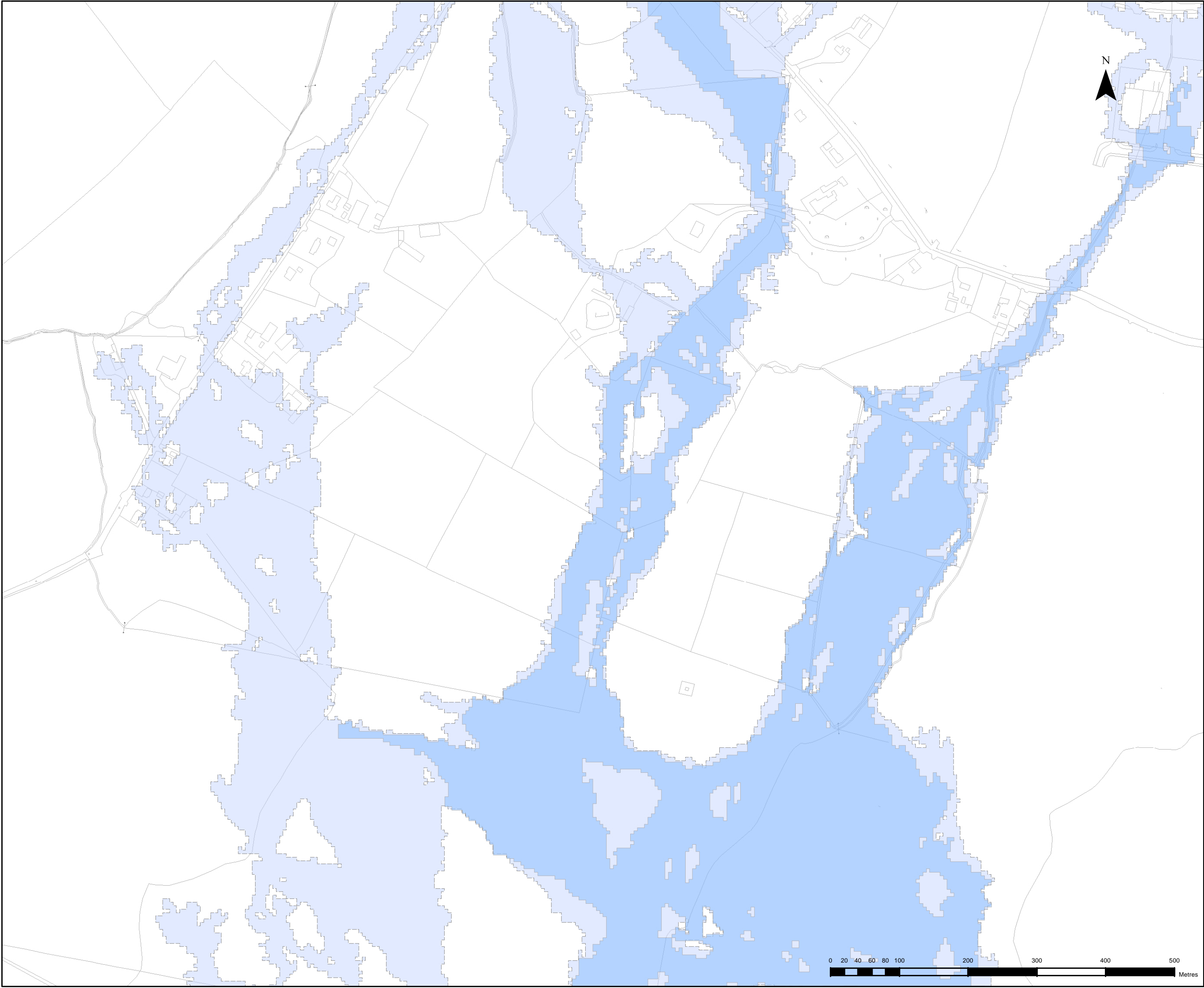
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 - UNESCO Sites
 - Flood Extent**
 - 0.1% AEP Event
 - 1% AEP event
 - 10% AEP event
 - River Centreline

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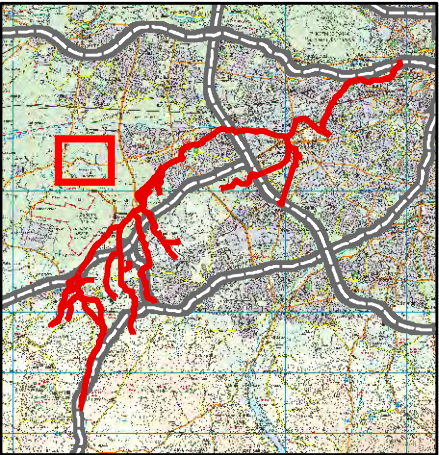
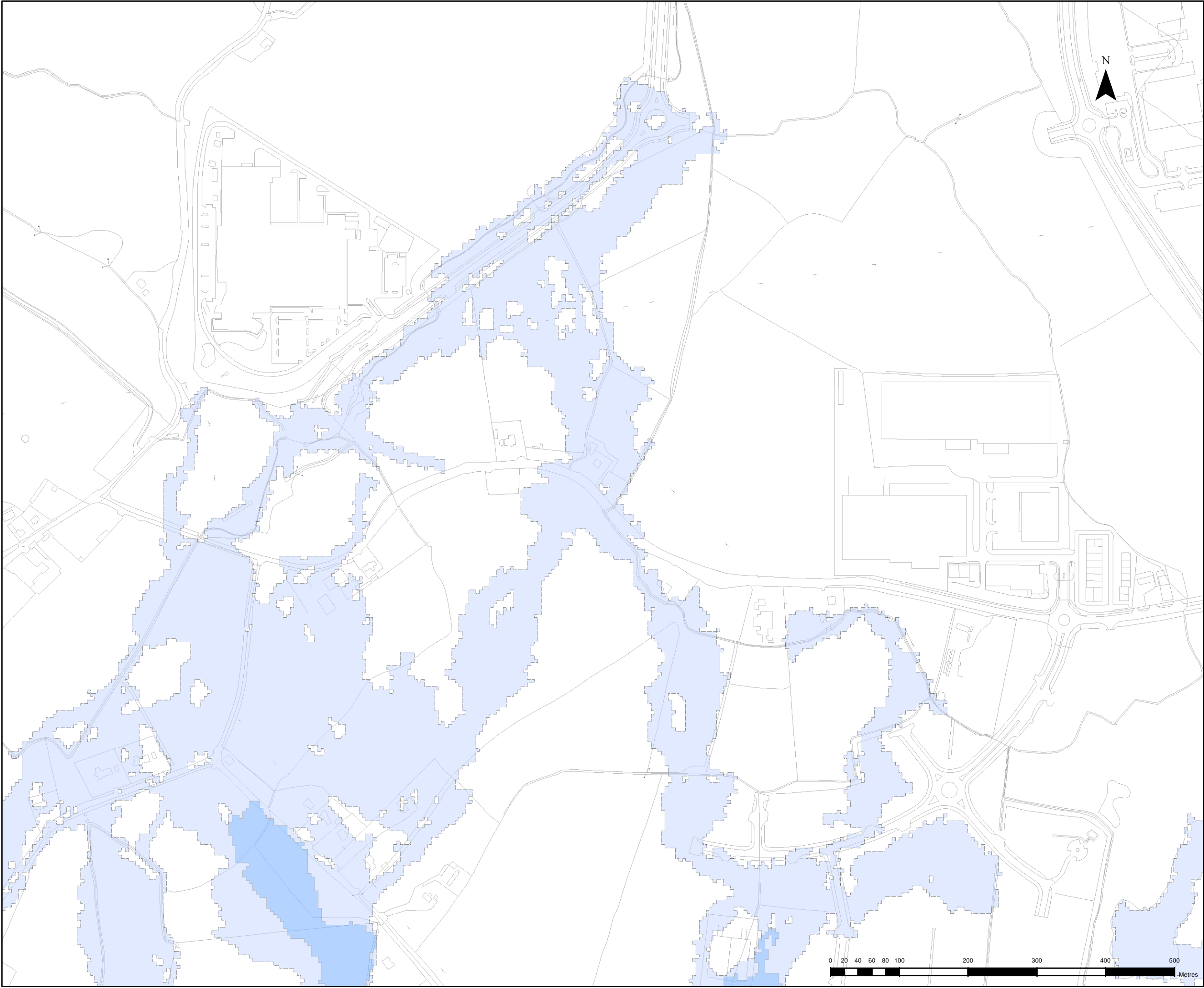
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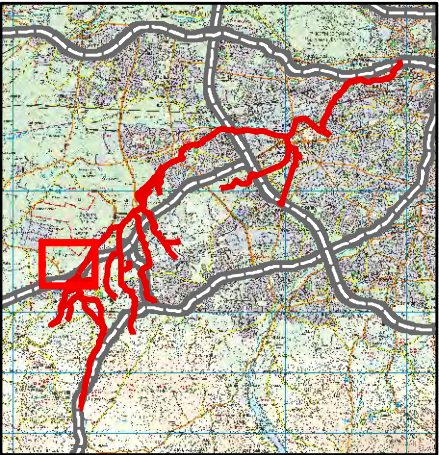
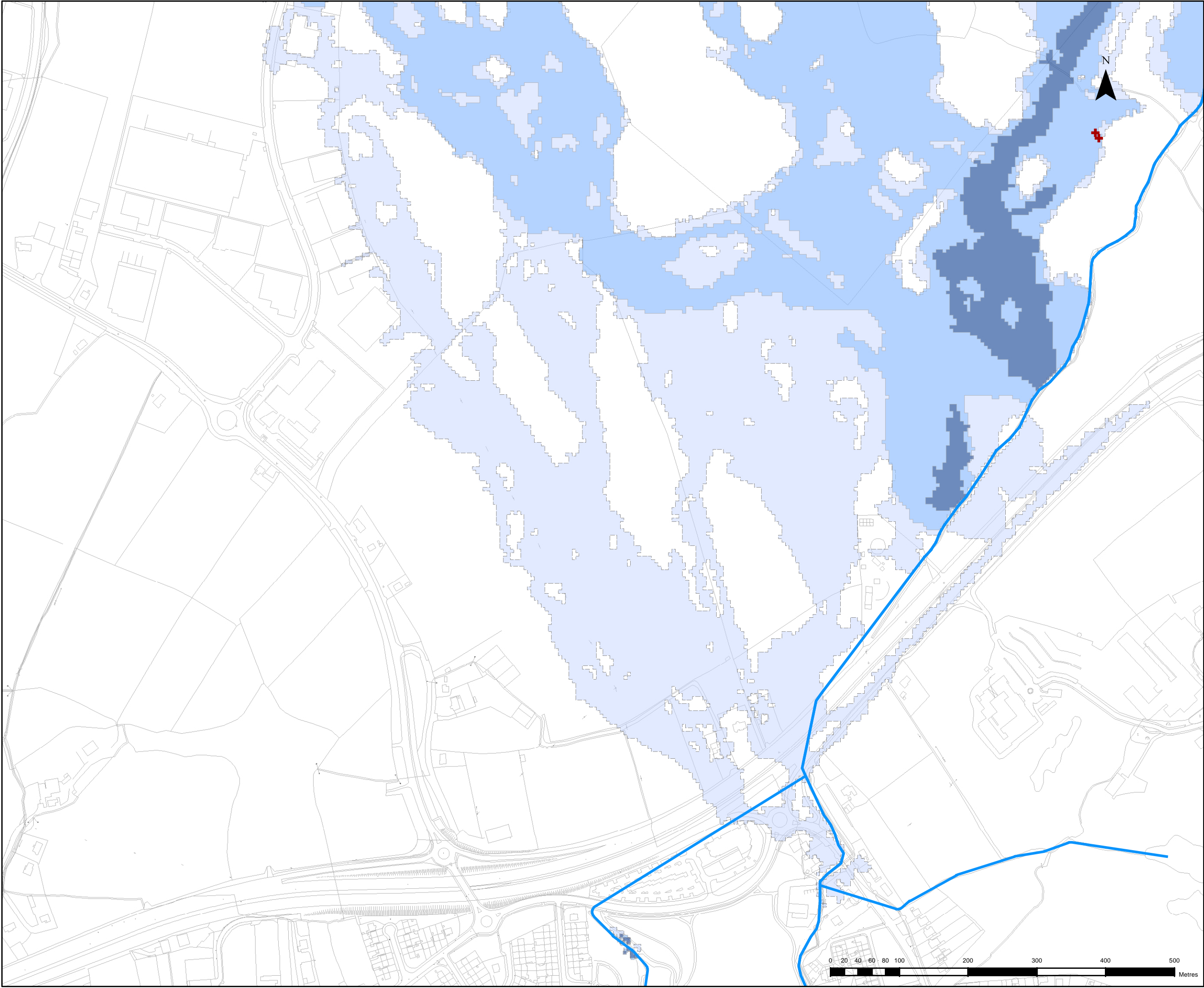
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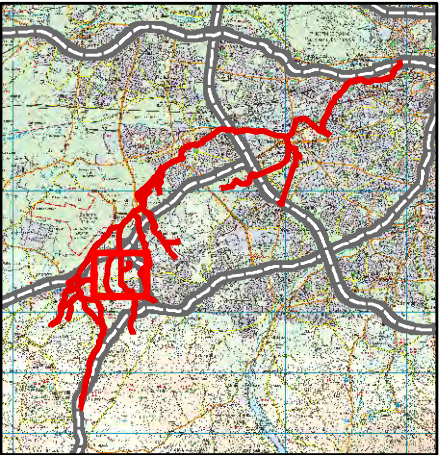
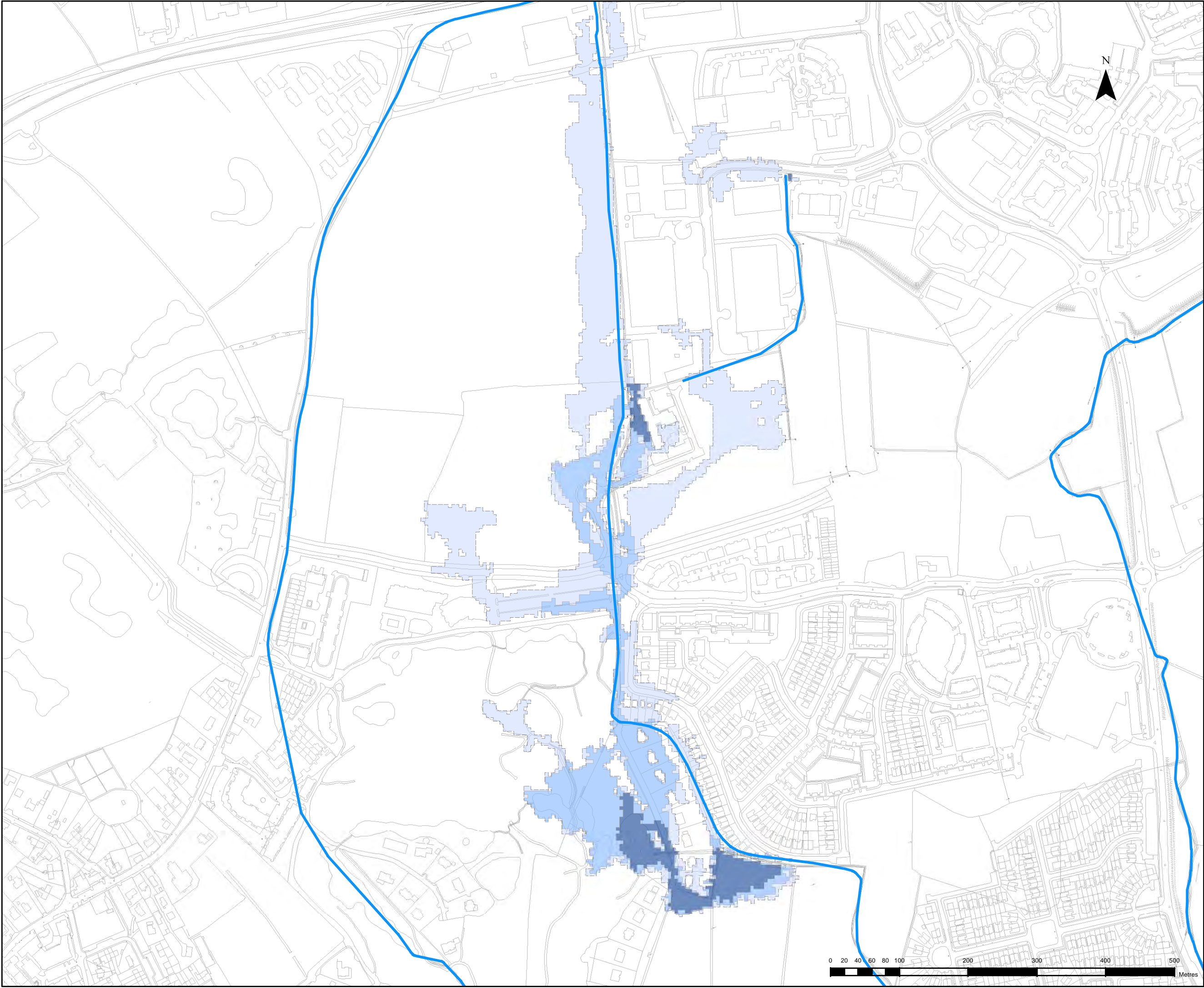
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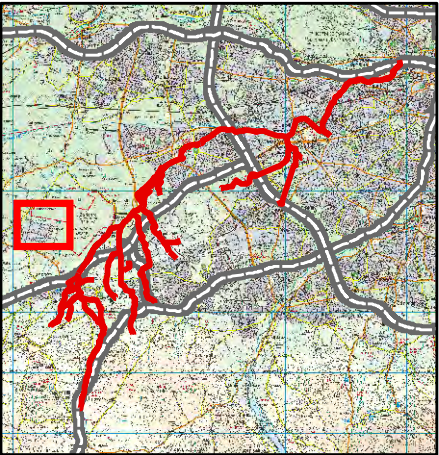
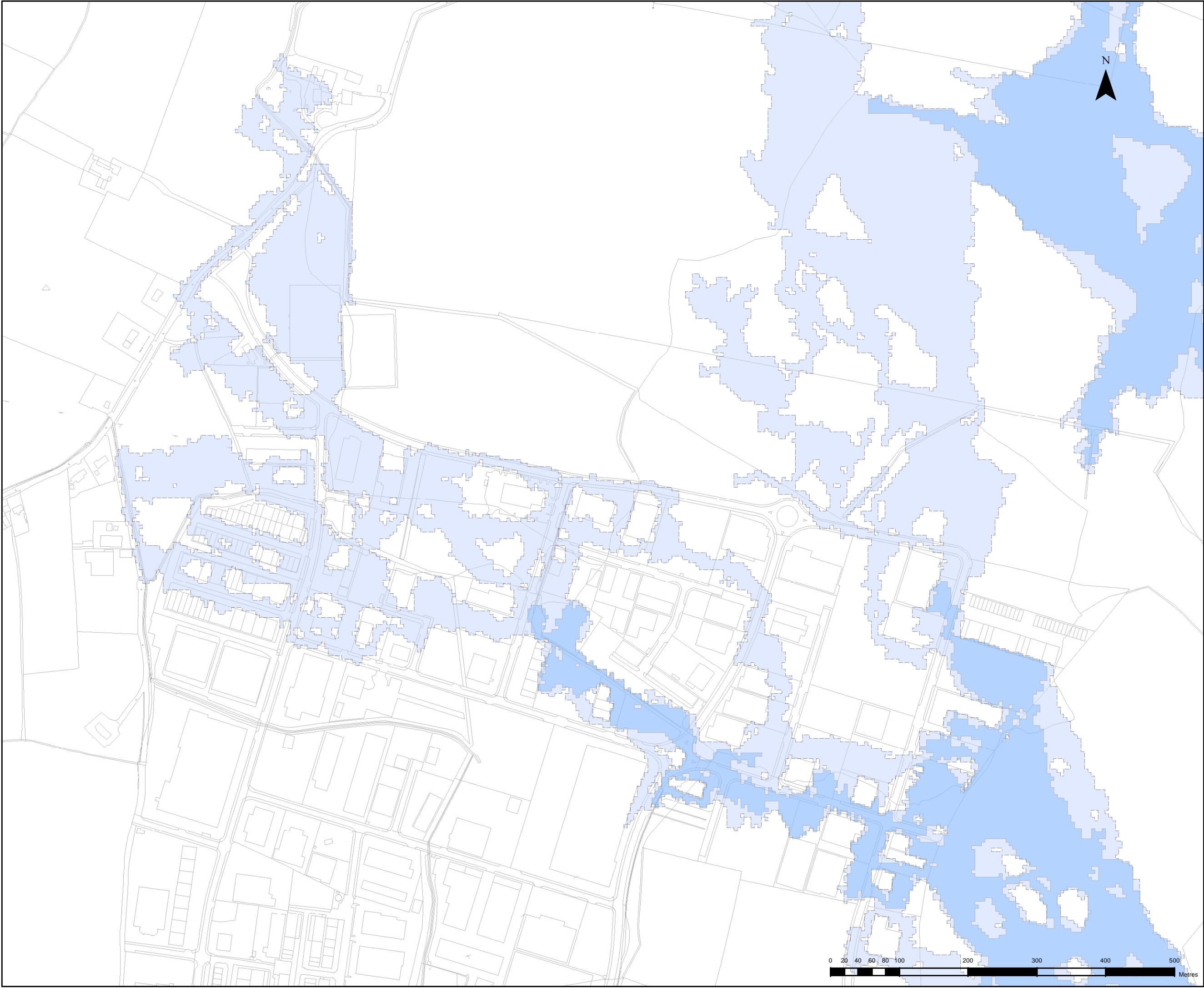


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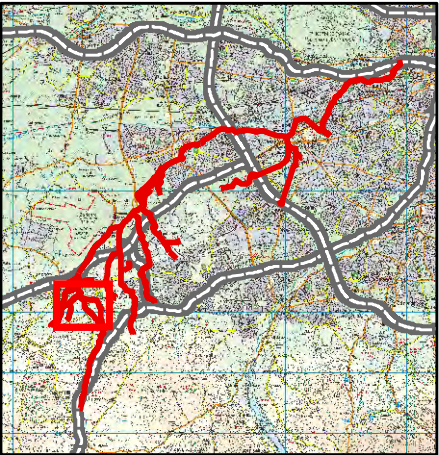
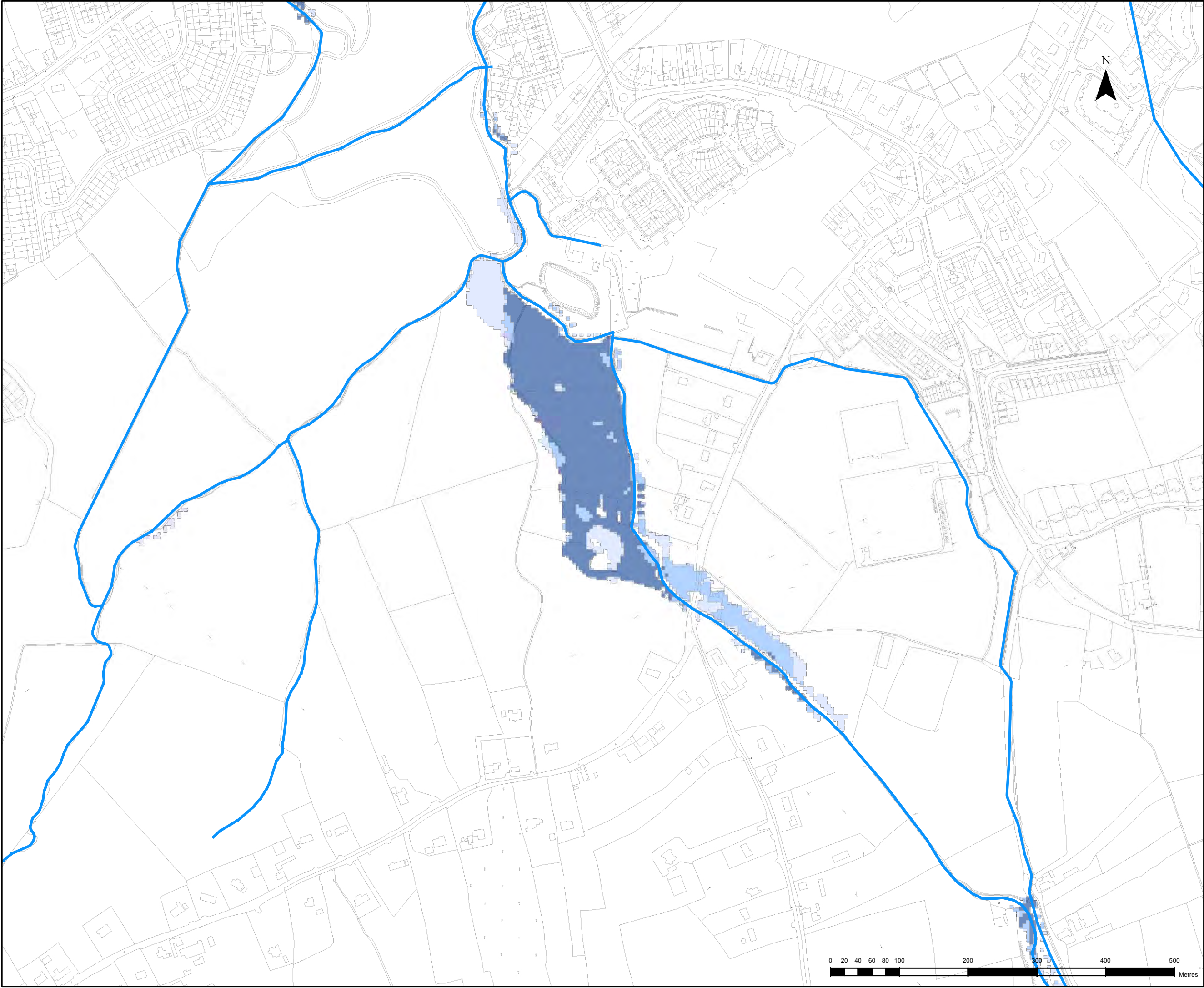
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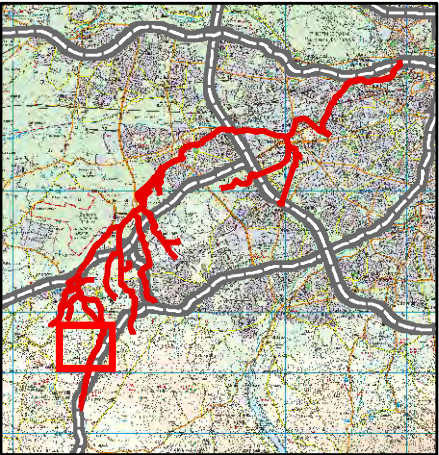
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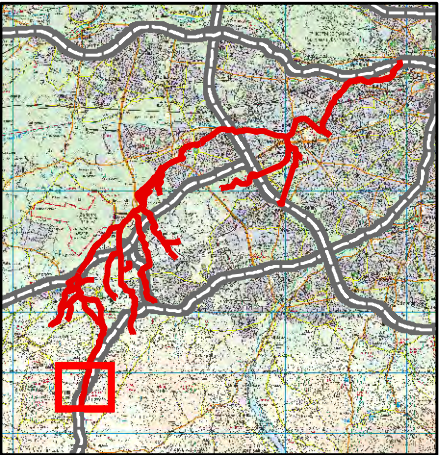
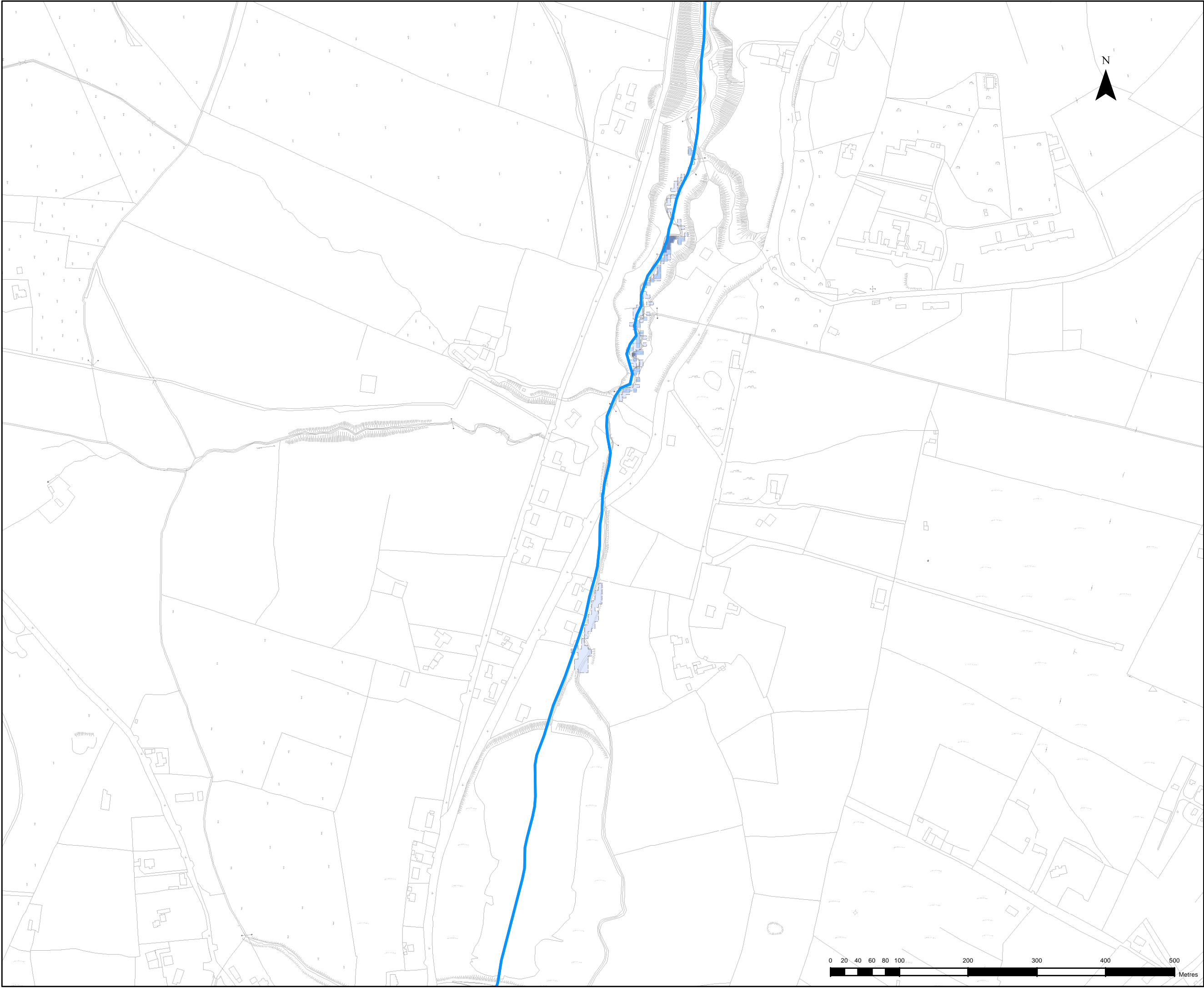
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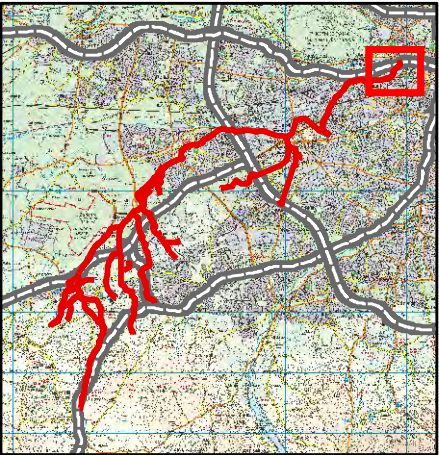
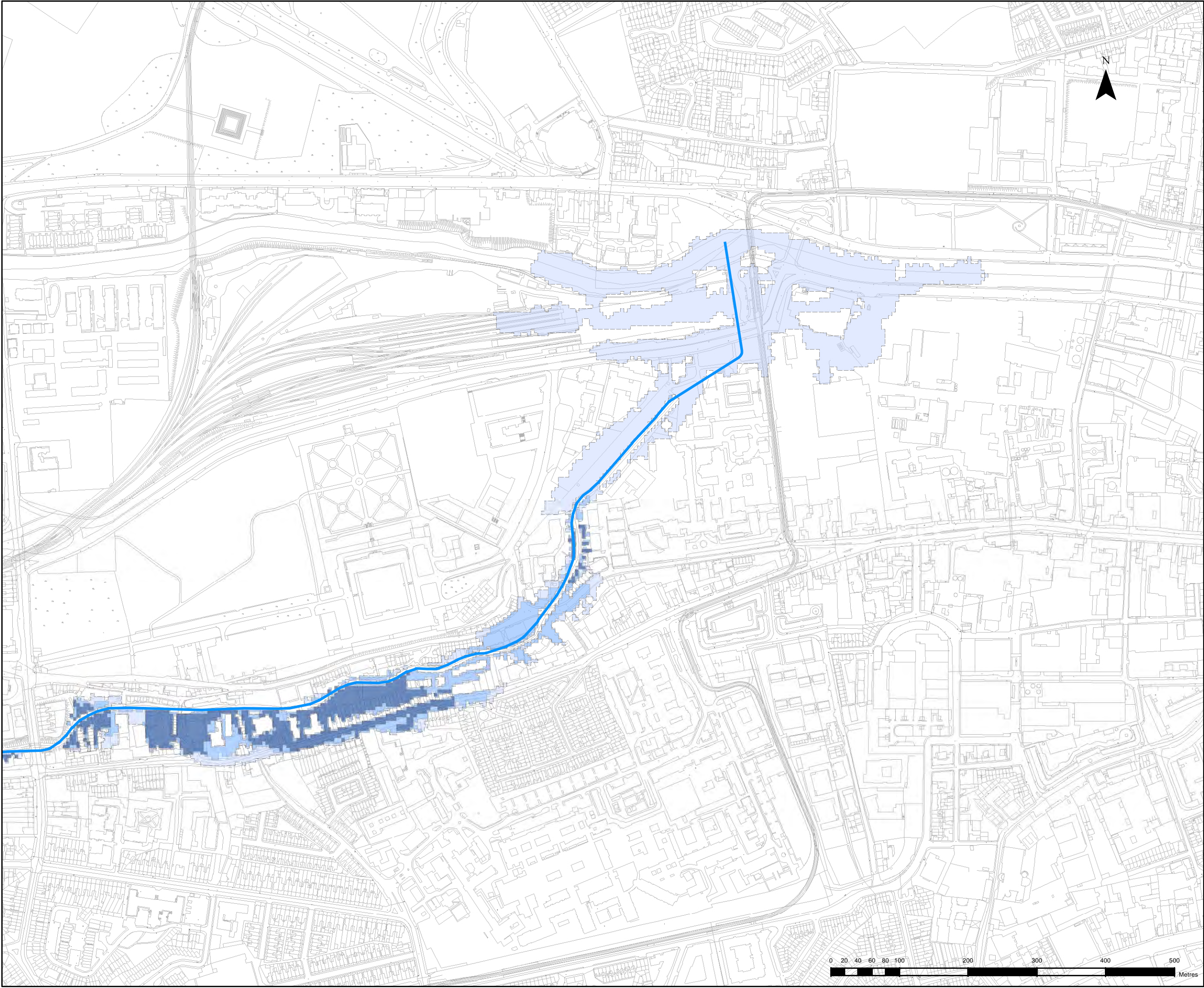
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- Licensed Waste Facilities
 - Licensed PPC Facilities
 - Special Areas for Conservation
 - Special Protection Areas
 - Proposed Natural Heritage Areas
 - Natural Heritage Sites
 - Freshwater Pearl Mussel Habitats
- Flood Extent**
- 0.1% AEP Event
 - 1% AEP event
 - 10% AEP event
 - River Centreline

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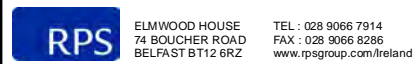


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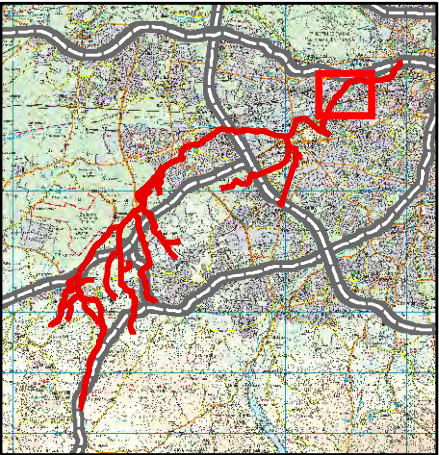
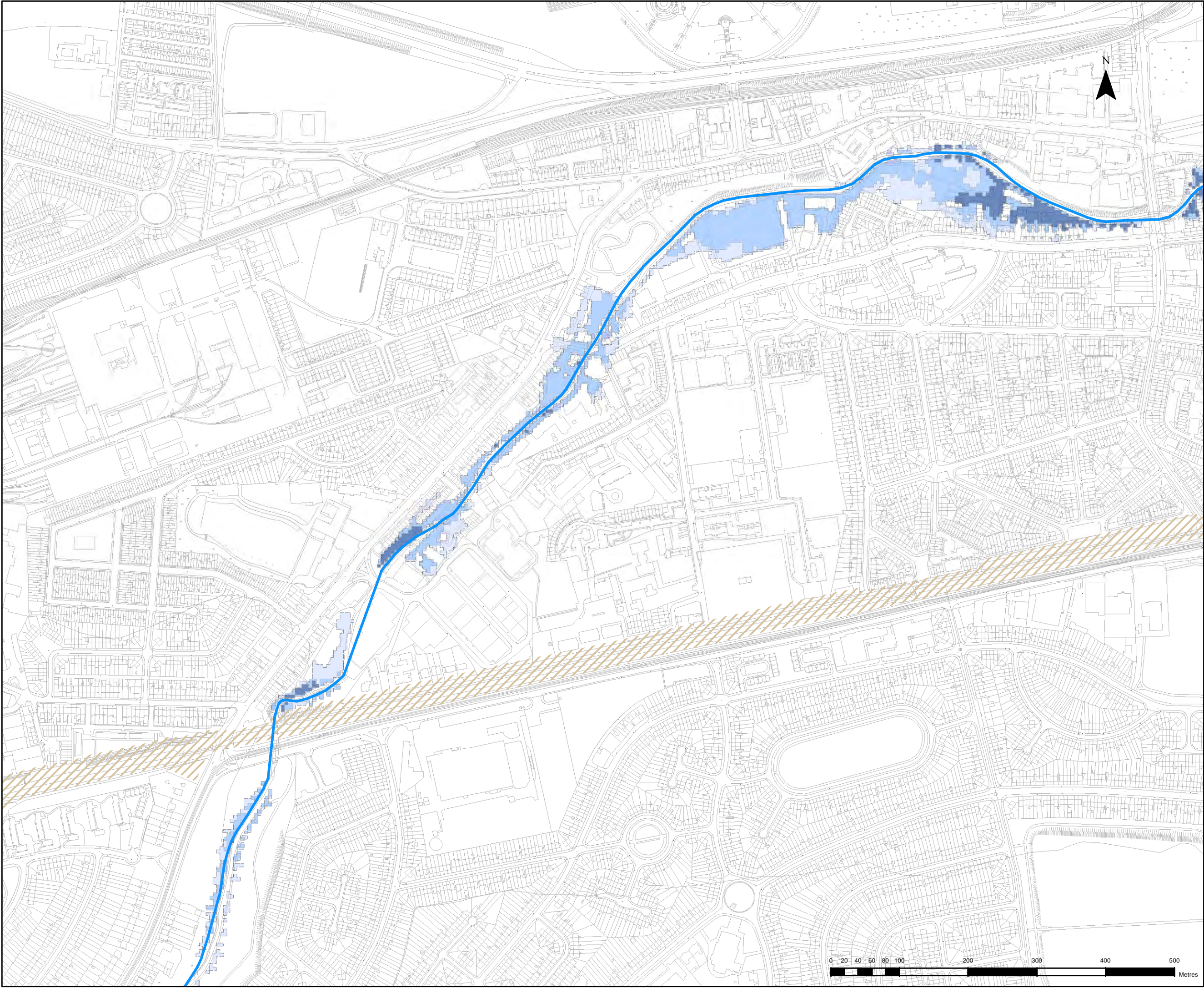
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-  Licensed PPC Facilities
-  Special Areas for Conservation
-  Special Protection Areas
-  Proposed Natural Heritage Areas
-  Natural Heritage Sites
-  Freshwater Pearl Mussel Habitats
- Flood Extent**
-  0.1% AEP Event
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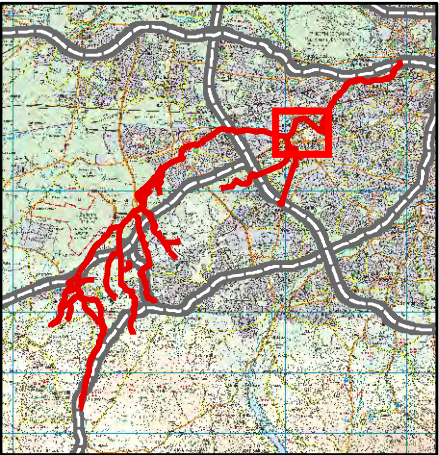
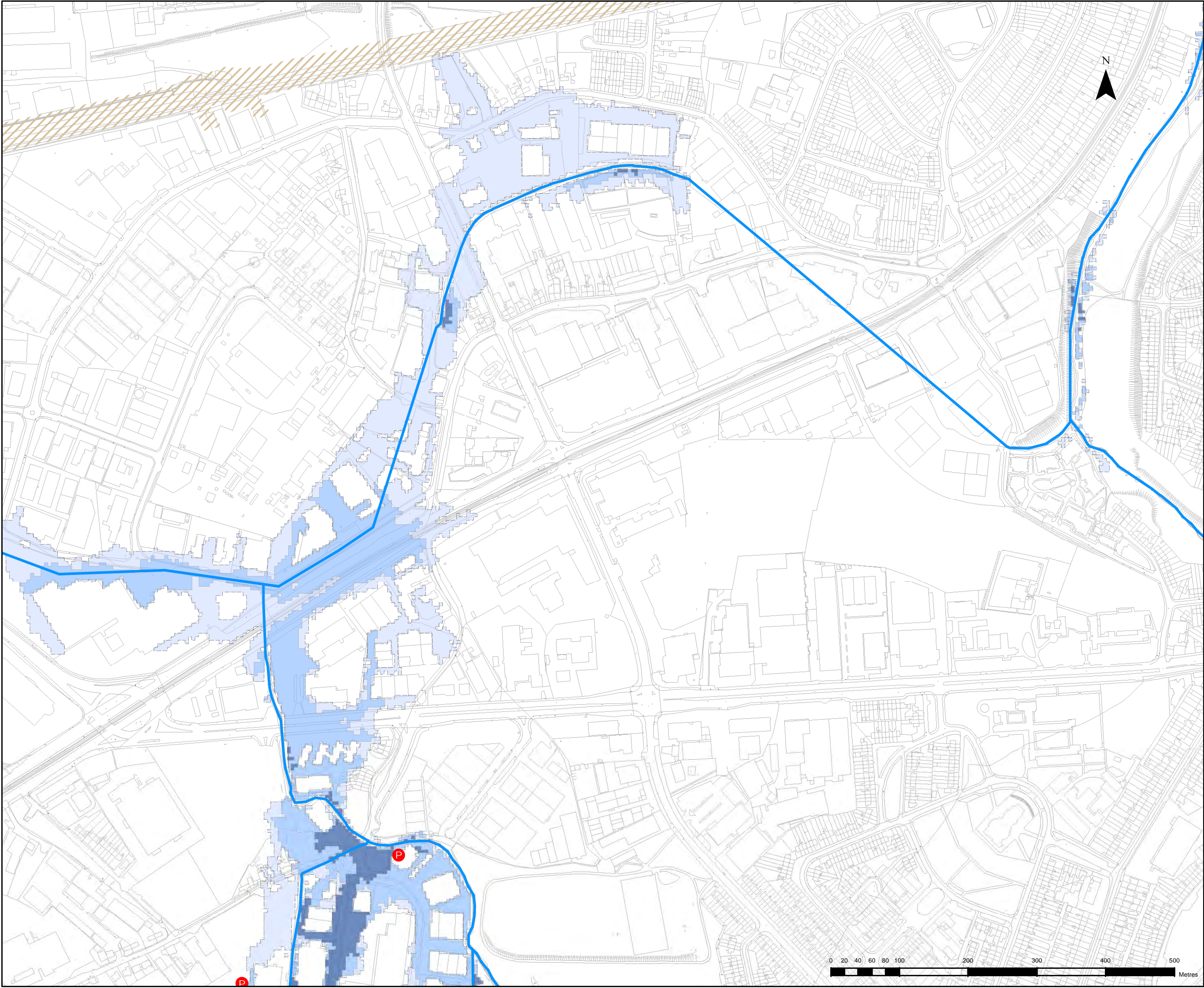
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- Legend**
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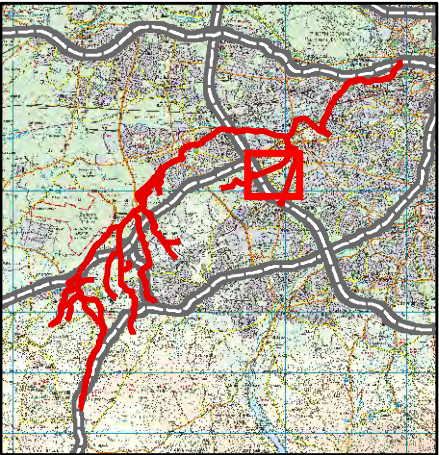
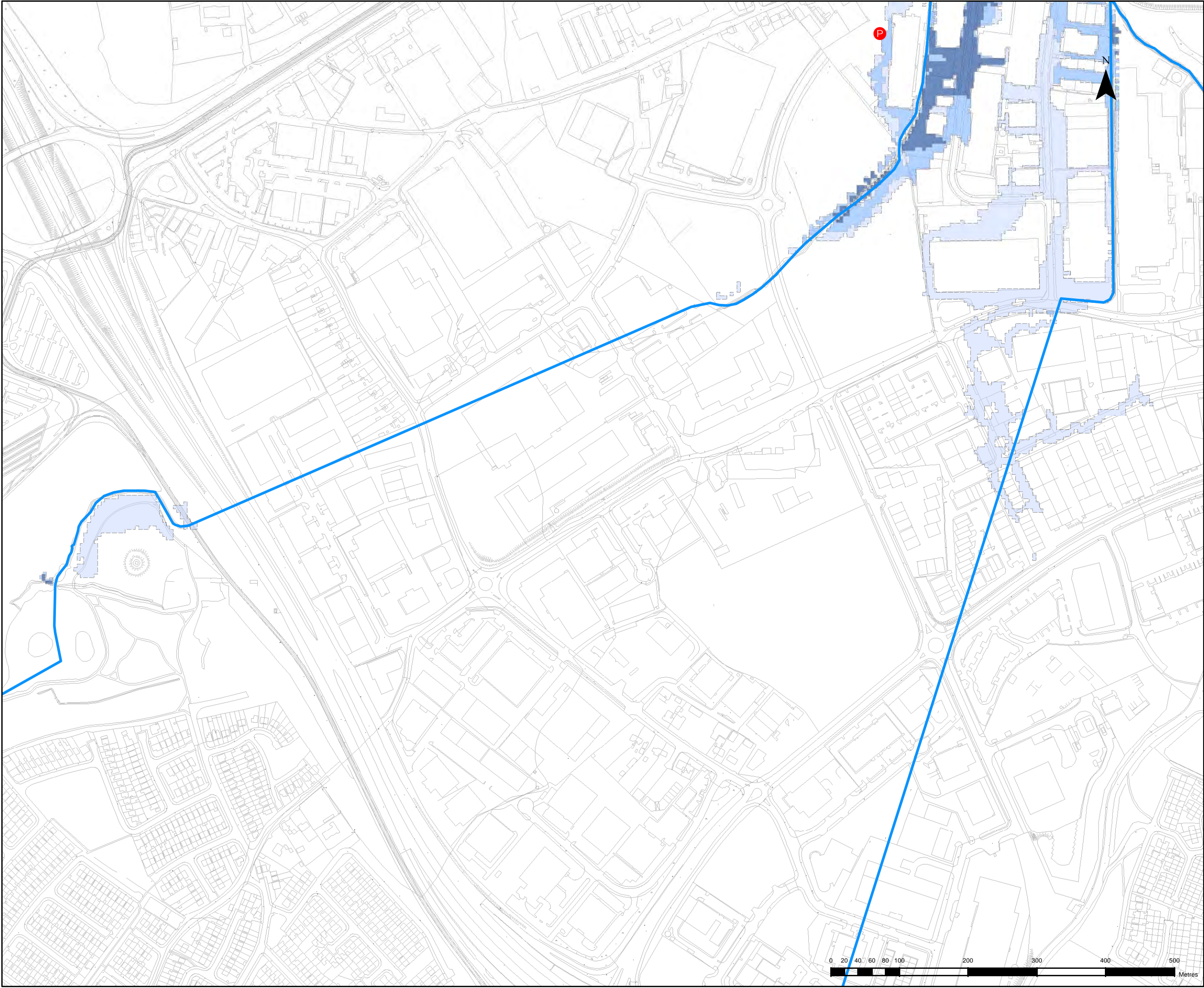
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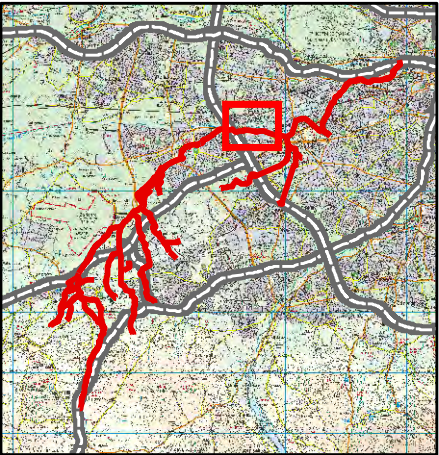
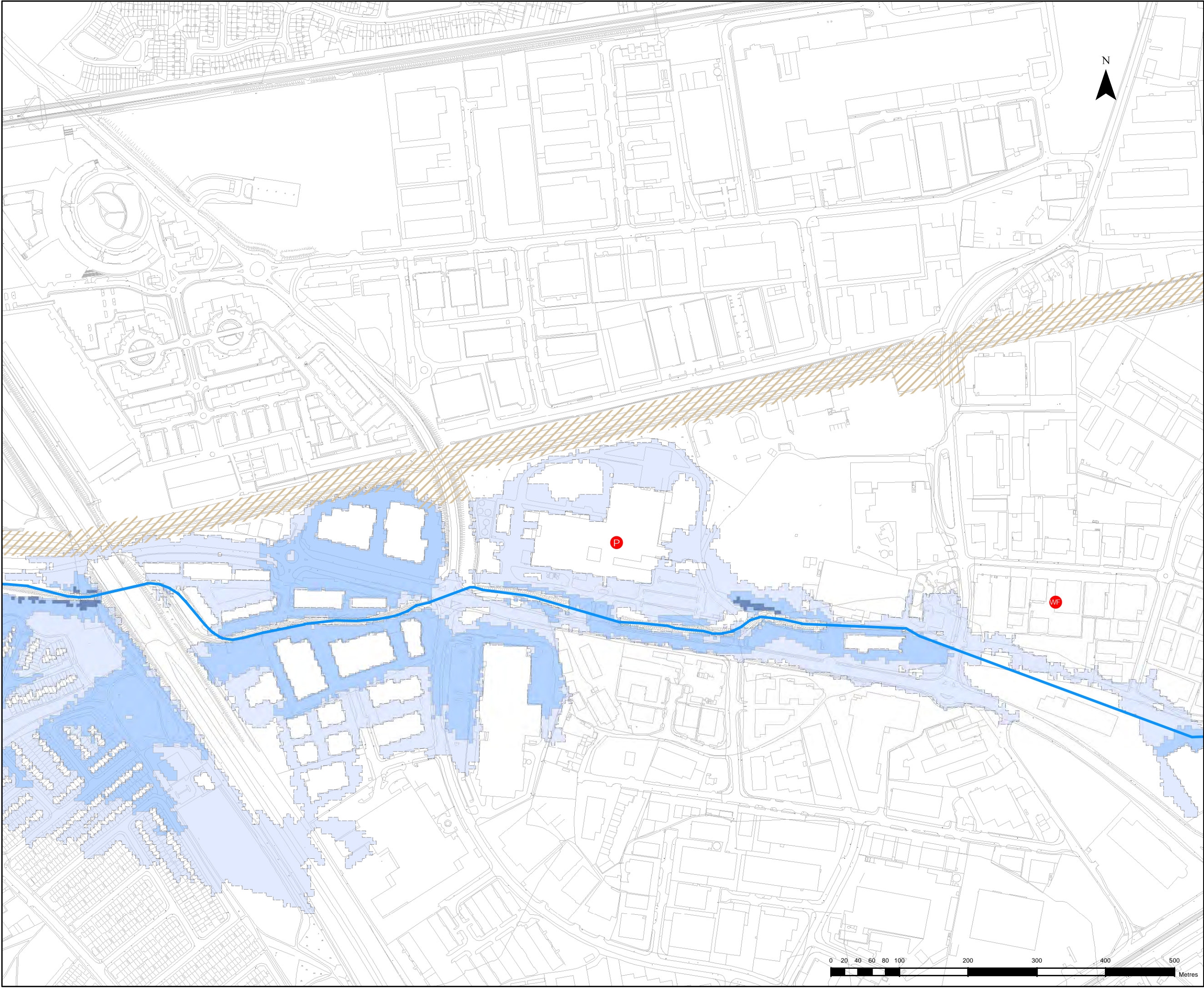
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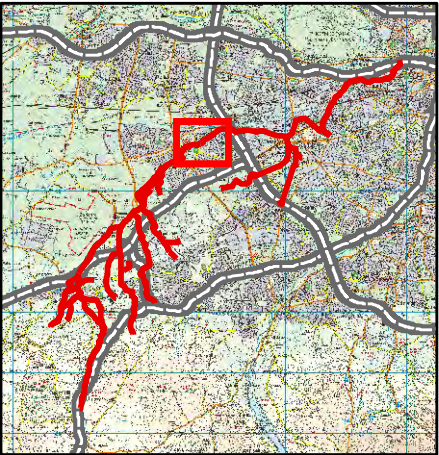
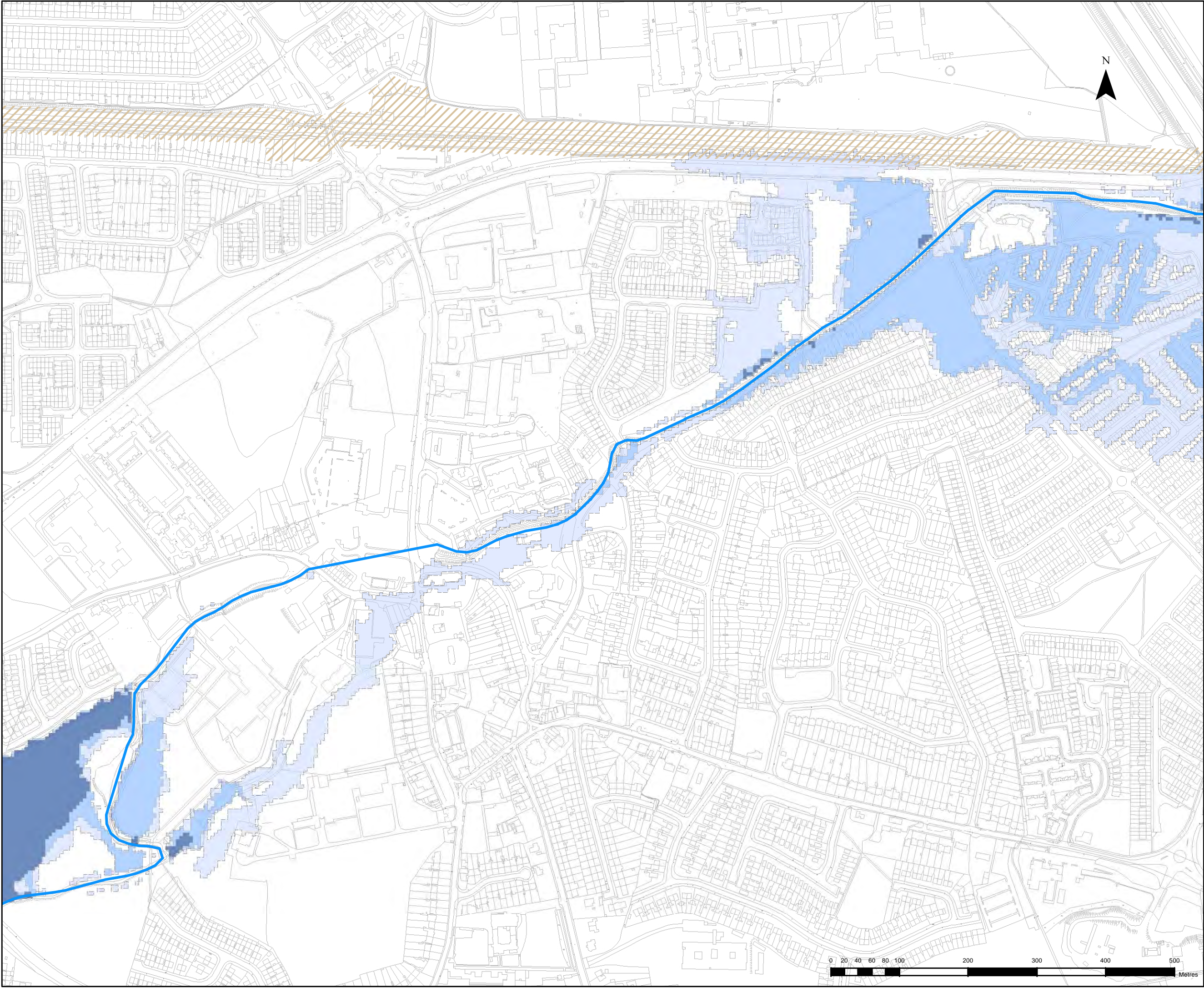
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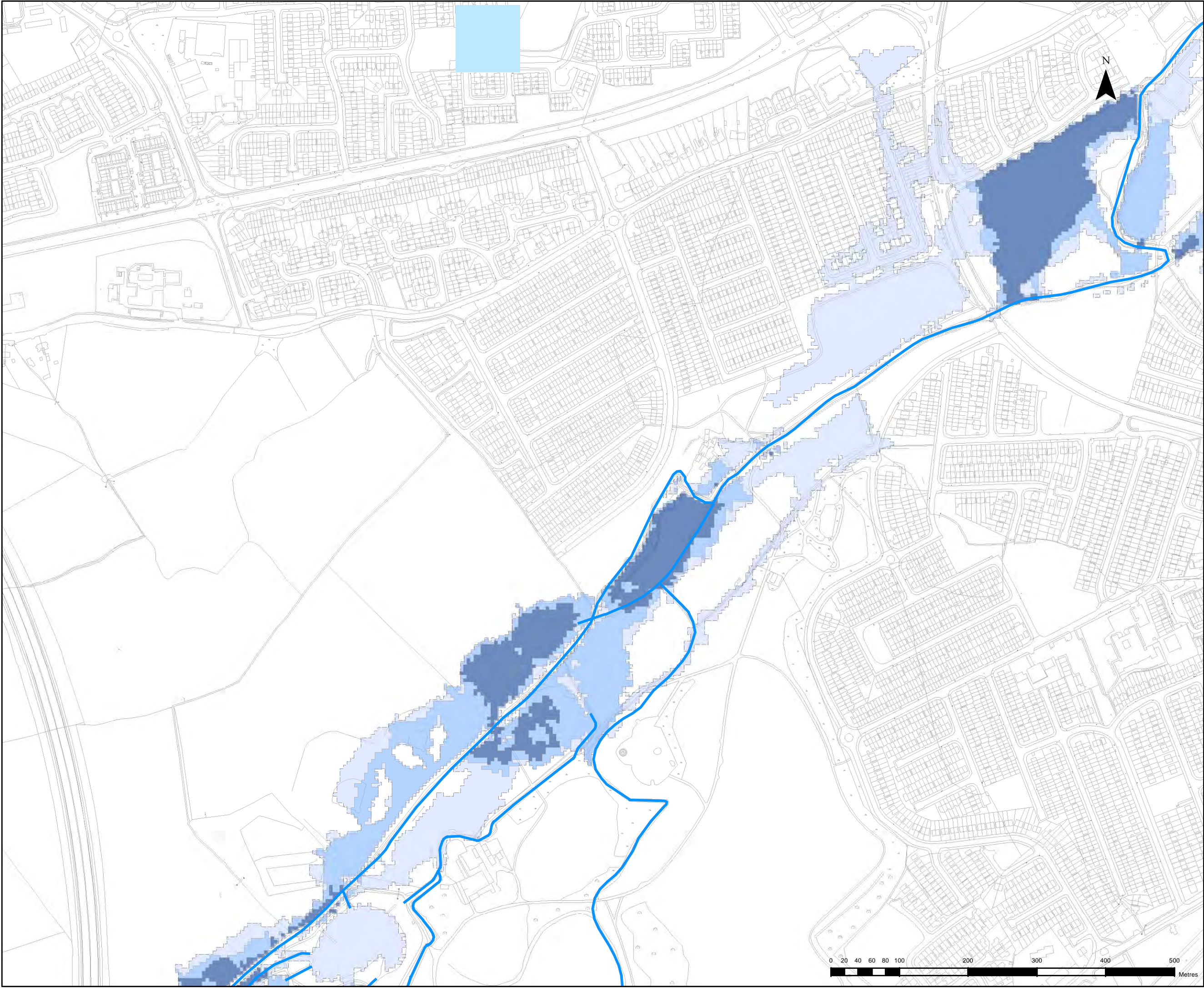
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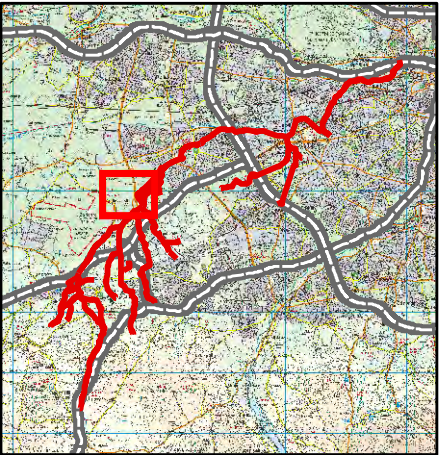
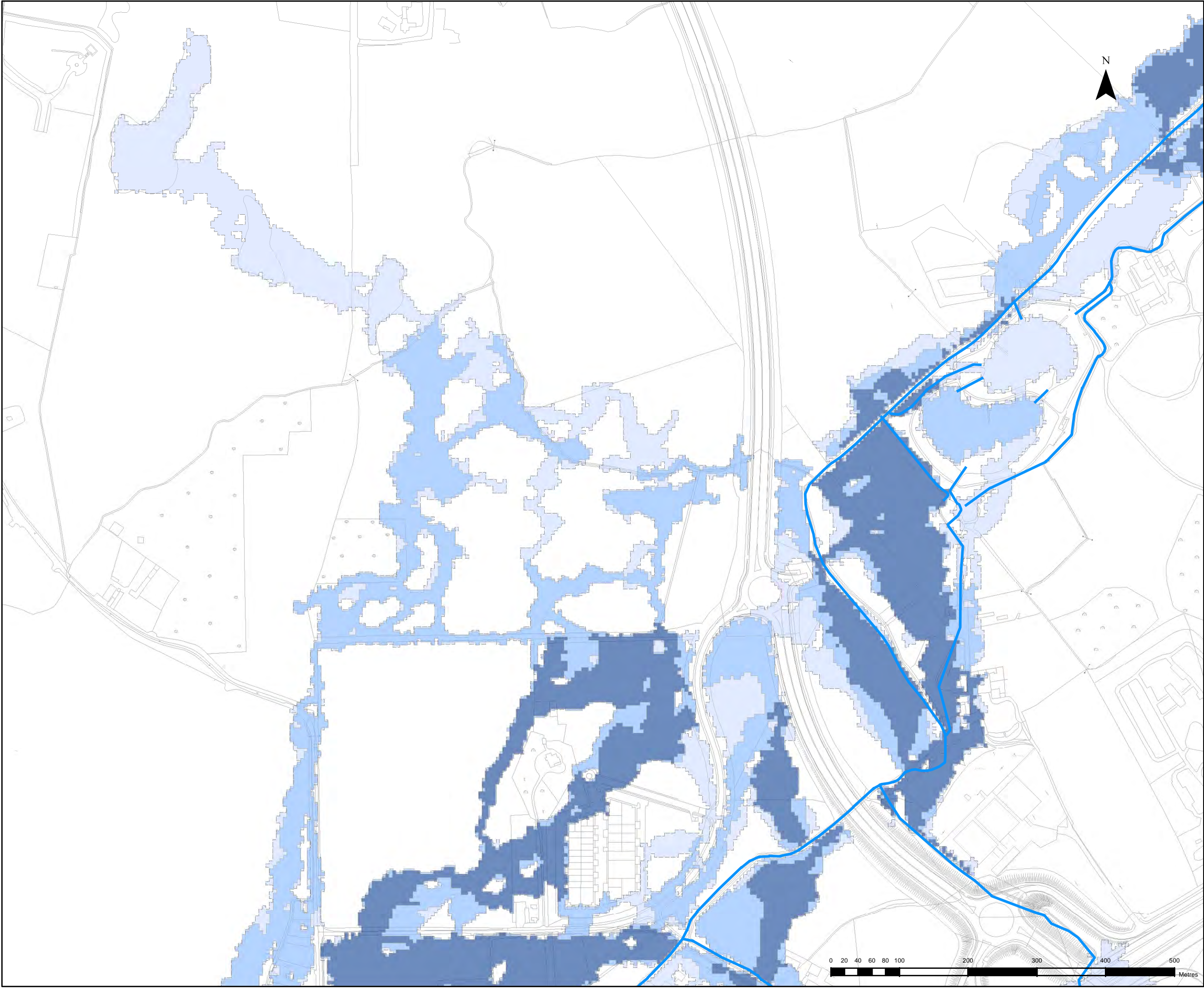
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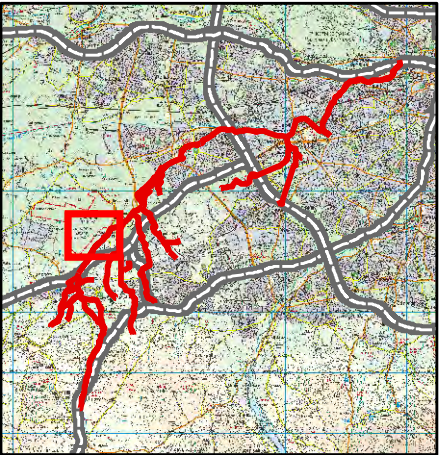
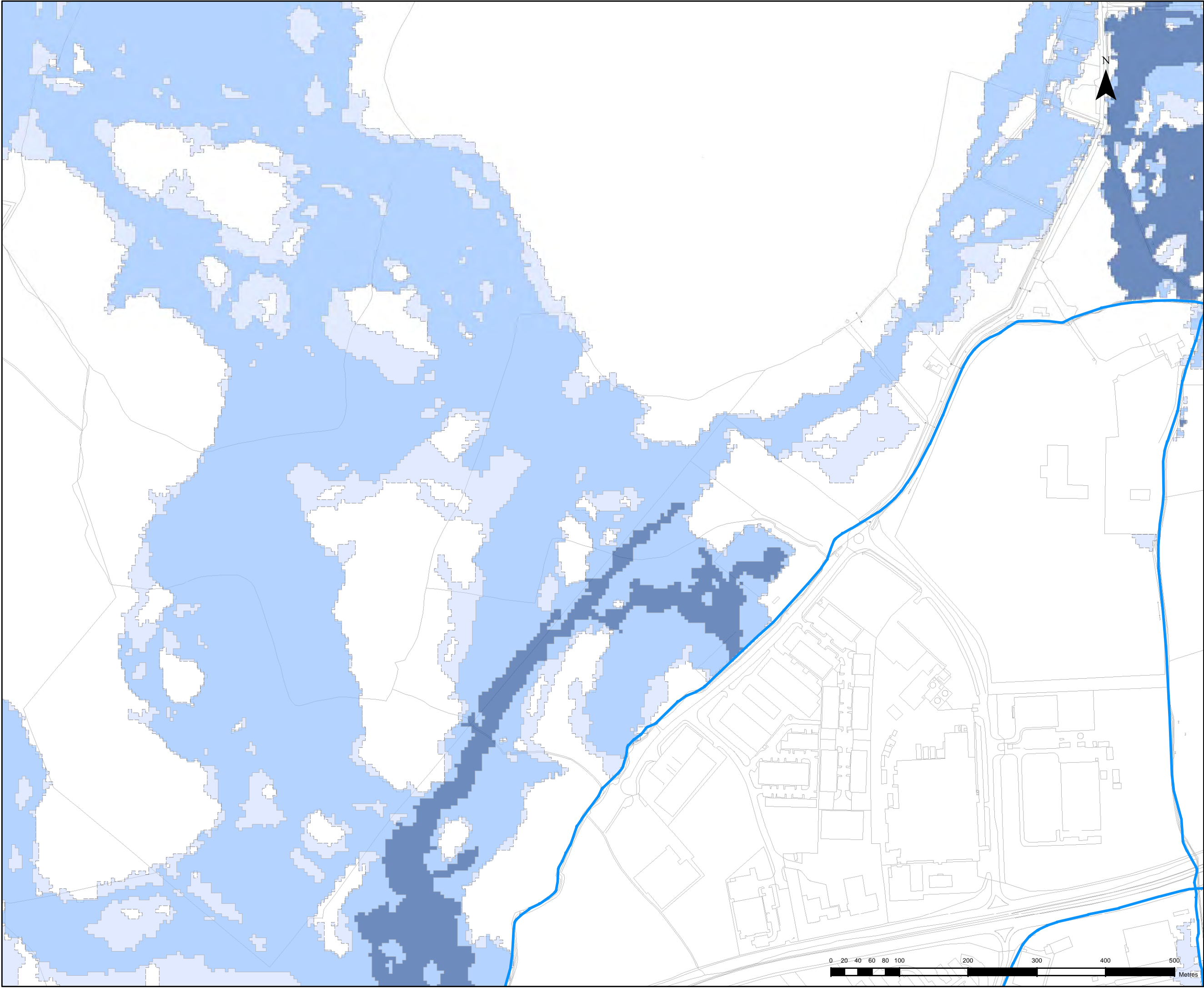
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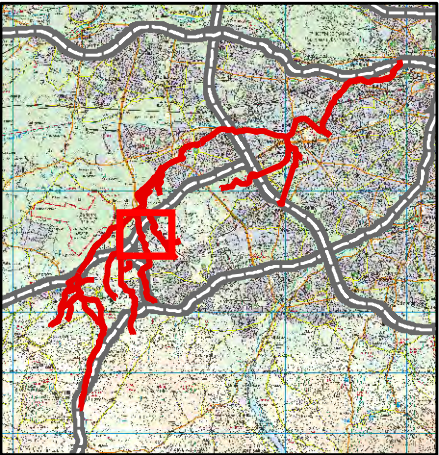
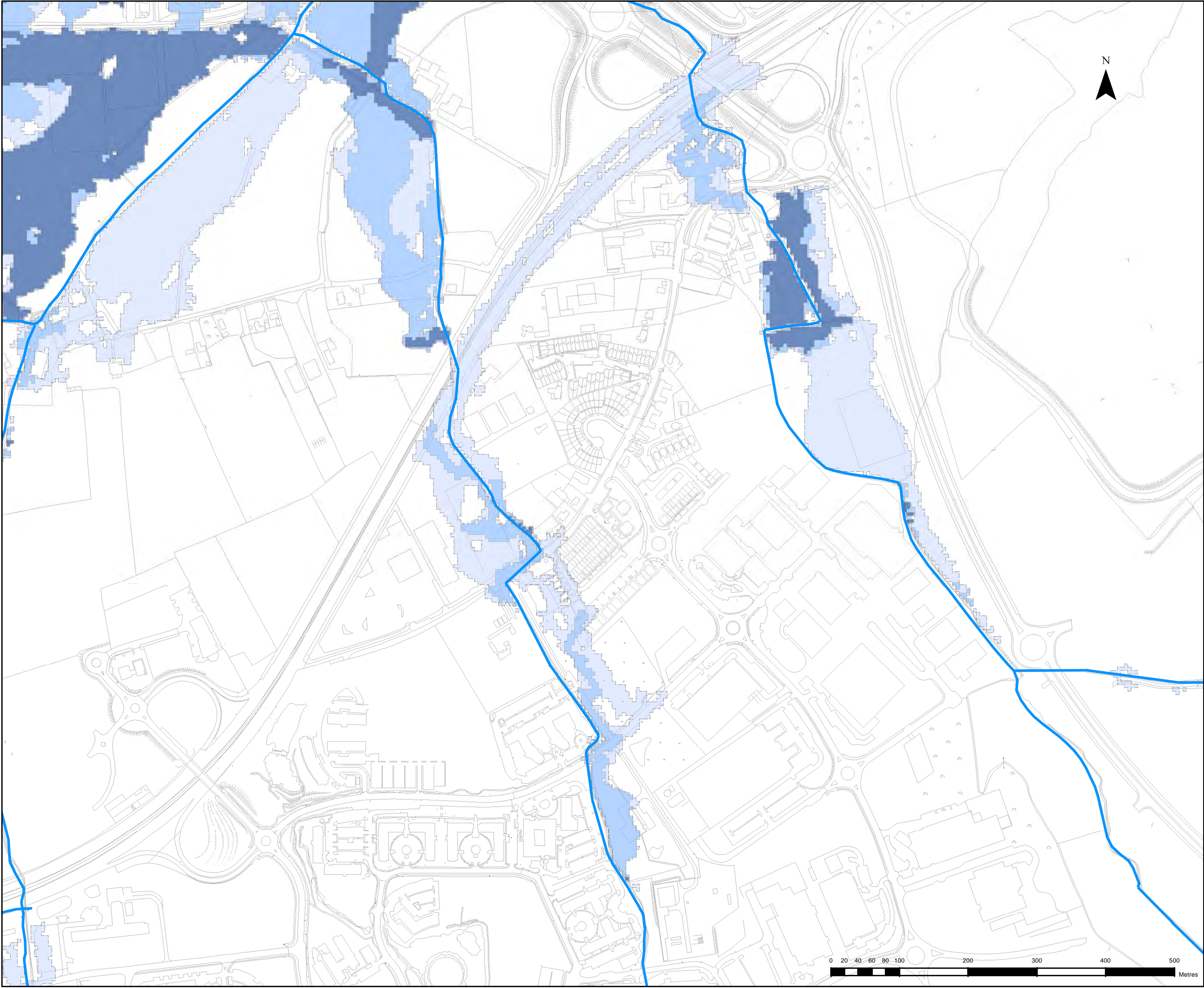


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-  Natural Heritage Sites
-  Freshwater Pearl Mussel Habitats
- Flood Extent**
-  0.1% AEP Event
-  1% AEP event
-  10% AEP event
-  River Centrelines

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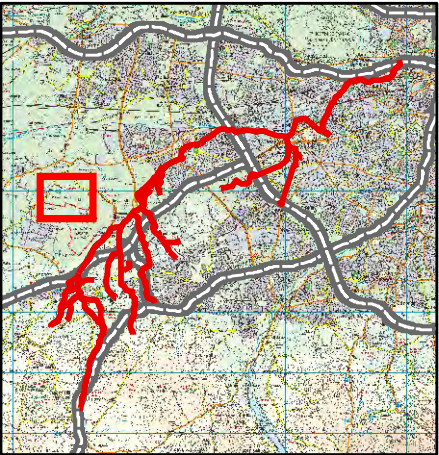
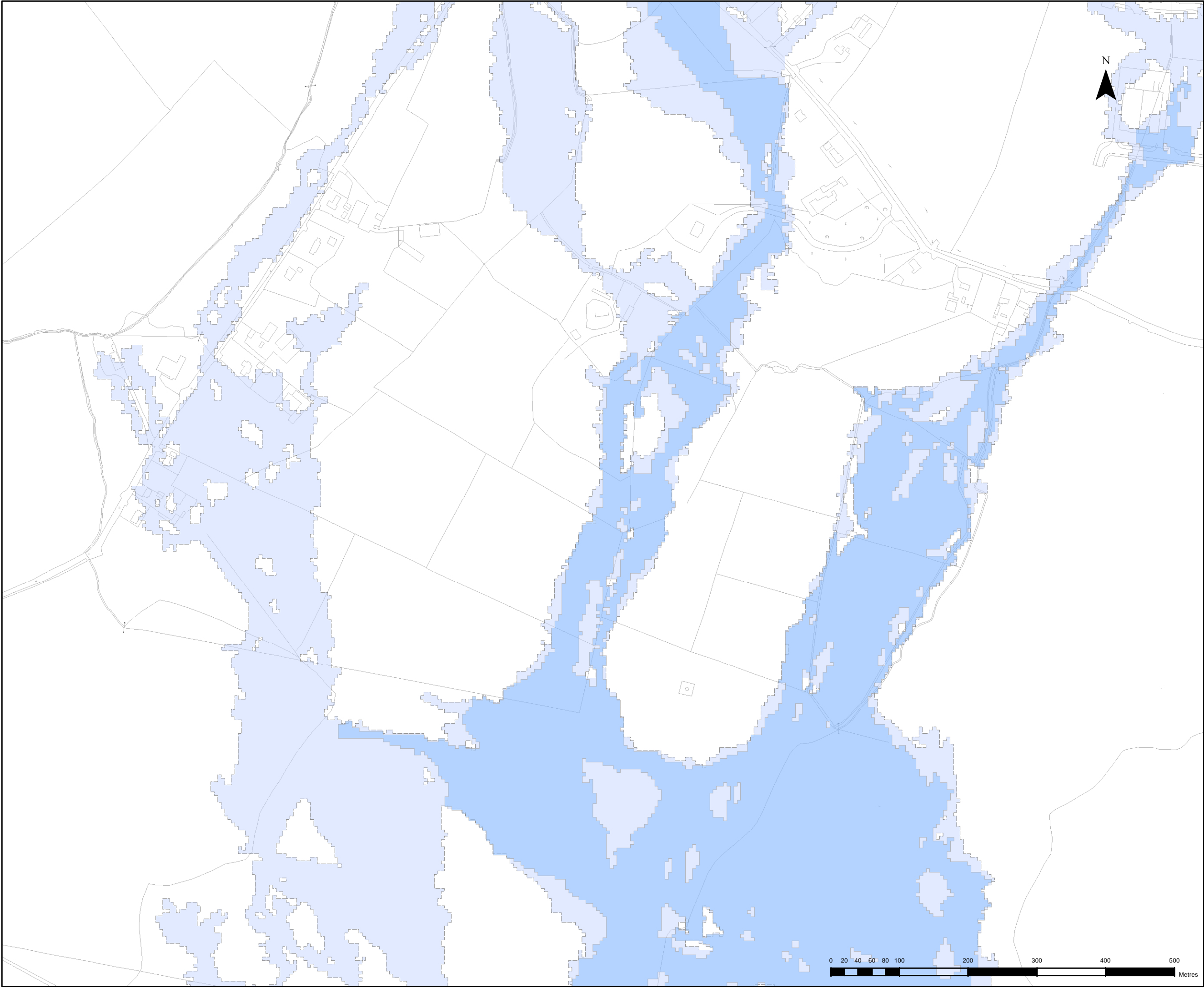
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RPS ELMWOOD HOUSE 74 BOUCHER ROAD BELFAST BT12 6RZ
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Drawing No.: 09CC_ENV_009a
Drawn By: RC
Checked By: MW
Approved By: GG
Date: 21/10/2013

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- Legend**
- Licensed Waste Facilities
 - Licensed PPC Facilities
 - Special Areas for Conservation
 - Special Protection Areas
 - Proposed Natural Heritage Areas
 - Natural Heritage Sites
 - Freshwater Pearl Mussel Habitats
- Flood Extent**
- 0.1% AEP Event
 - 1% AEP event
 - 10% AEP event
 - River Centreline

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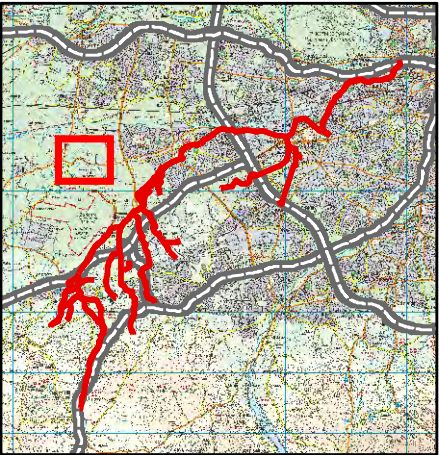
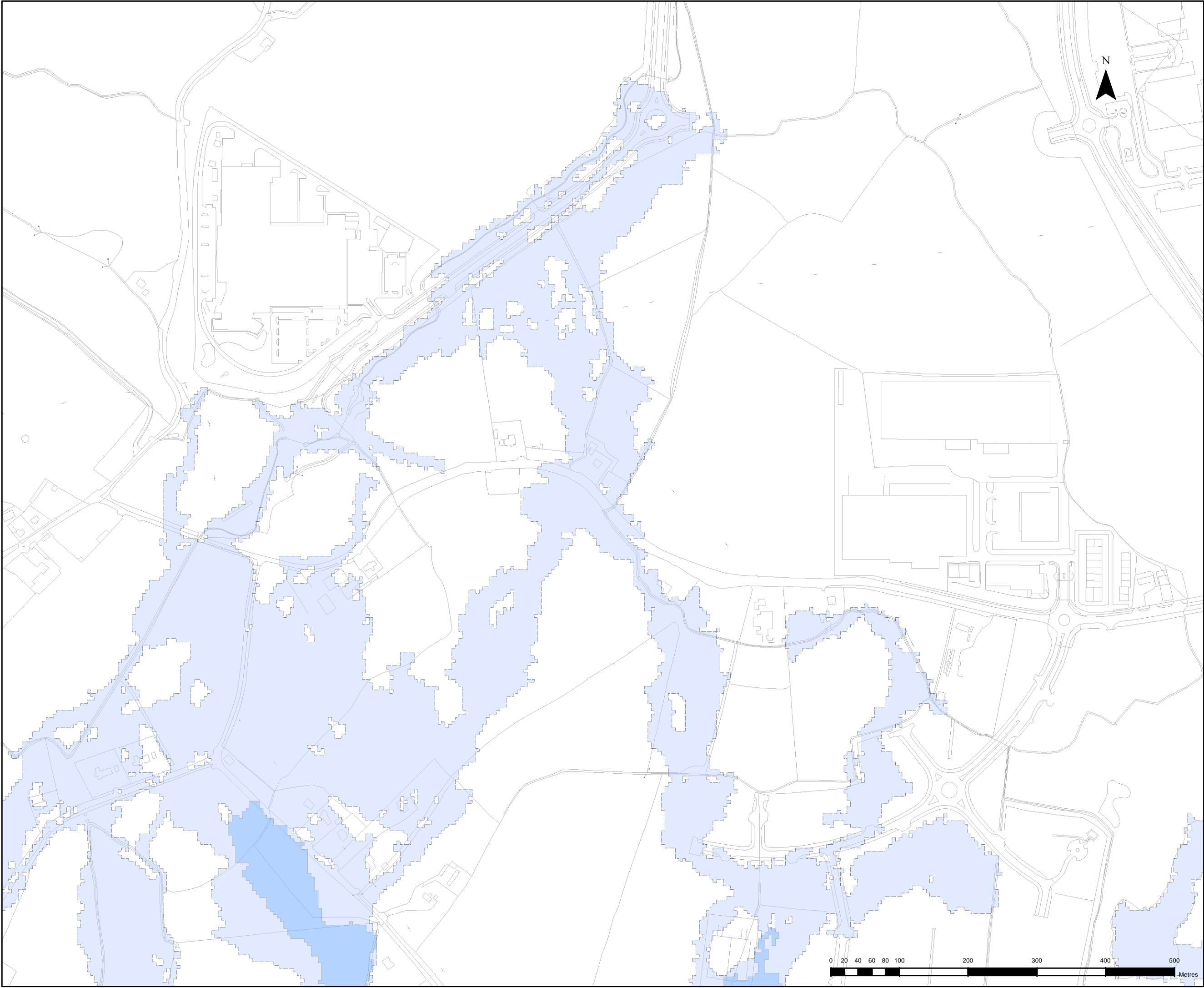
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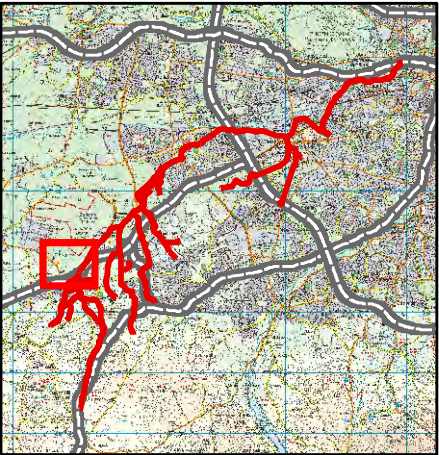
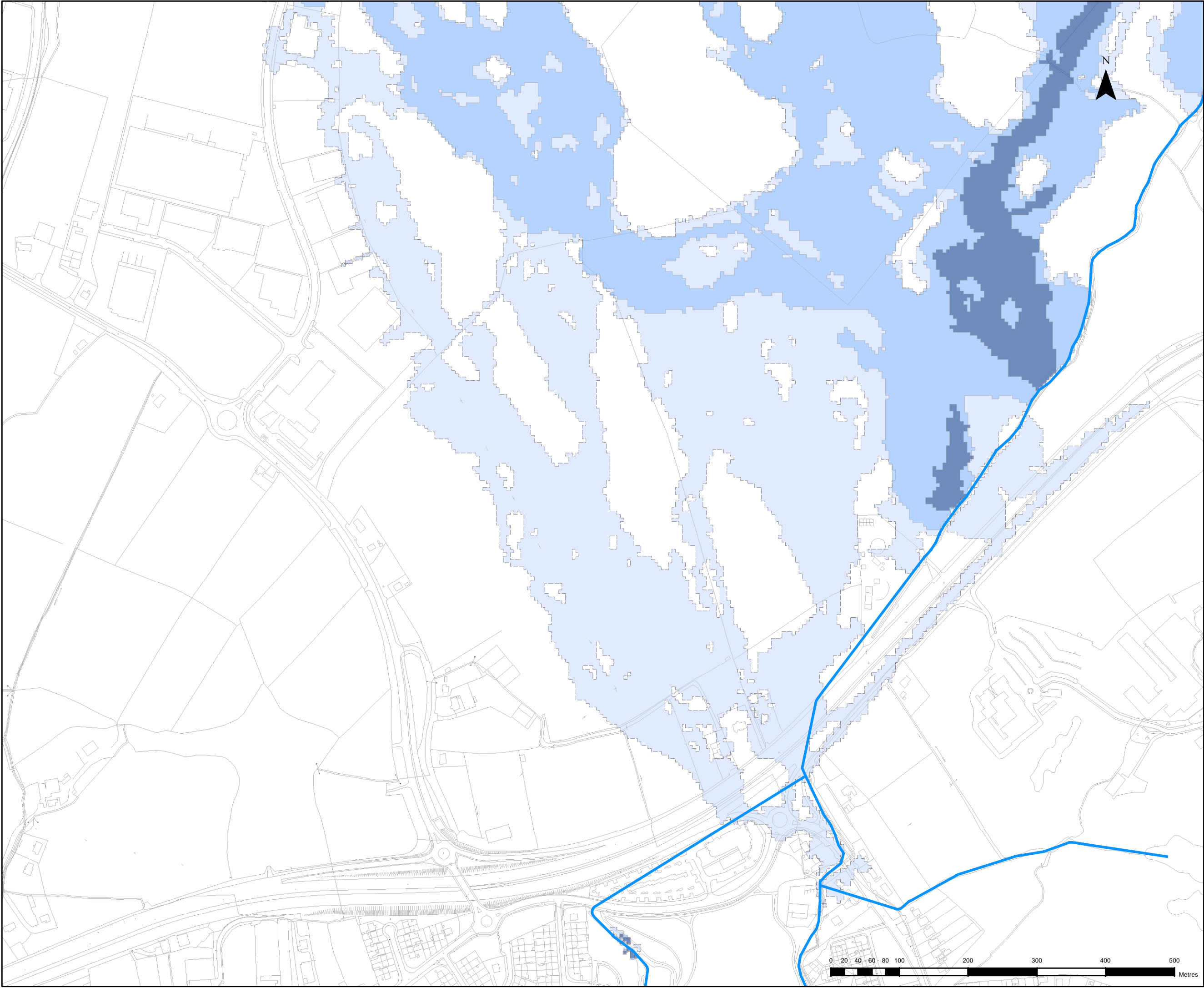
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Drawing No.: **09CC_ENV_009c** **Drawn By :** **RC**
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Legend

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- 0.1% AEP Event
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 - 10% AEP event
 - River Centrelines

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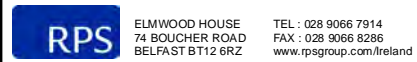


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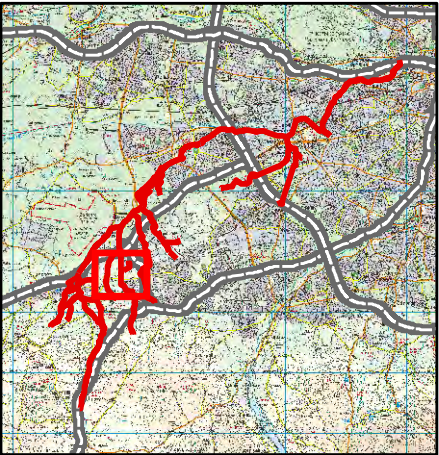
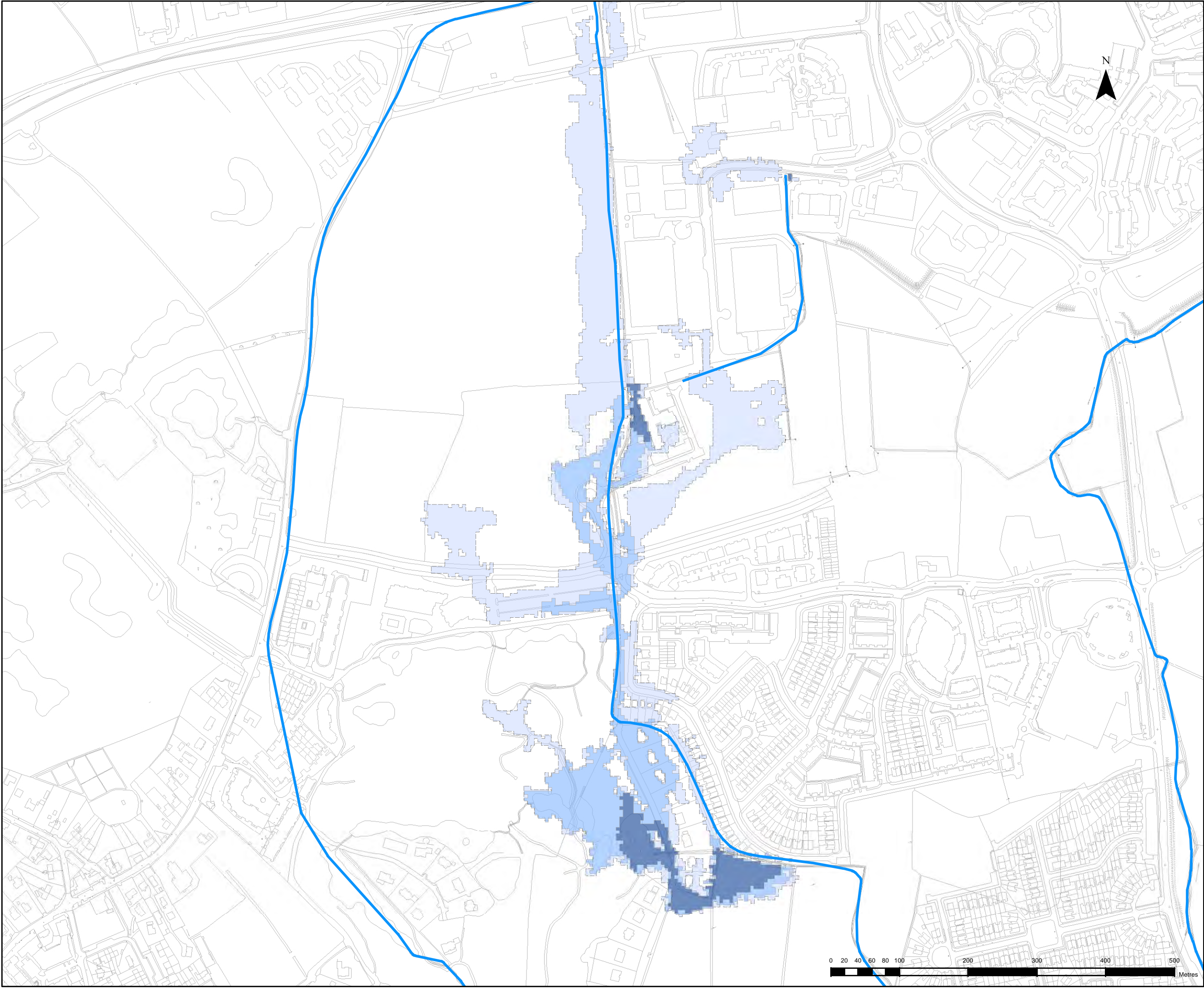
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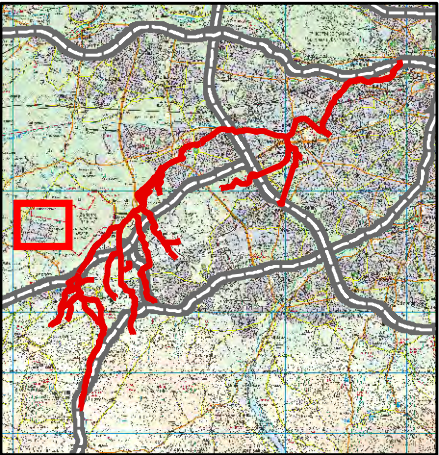
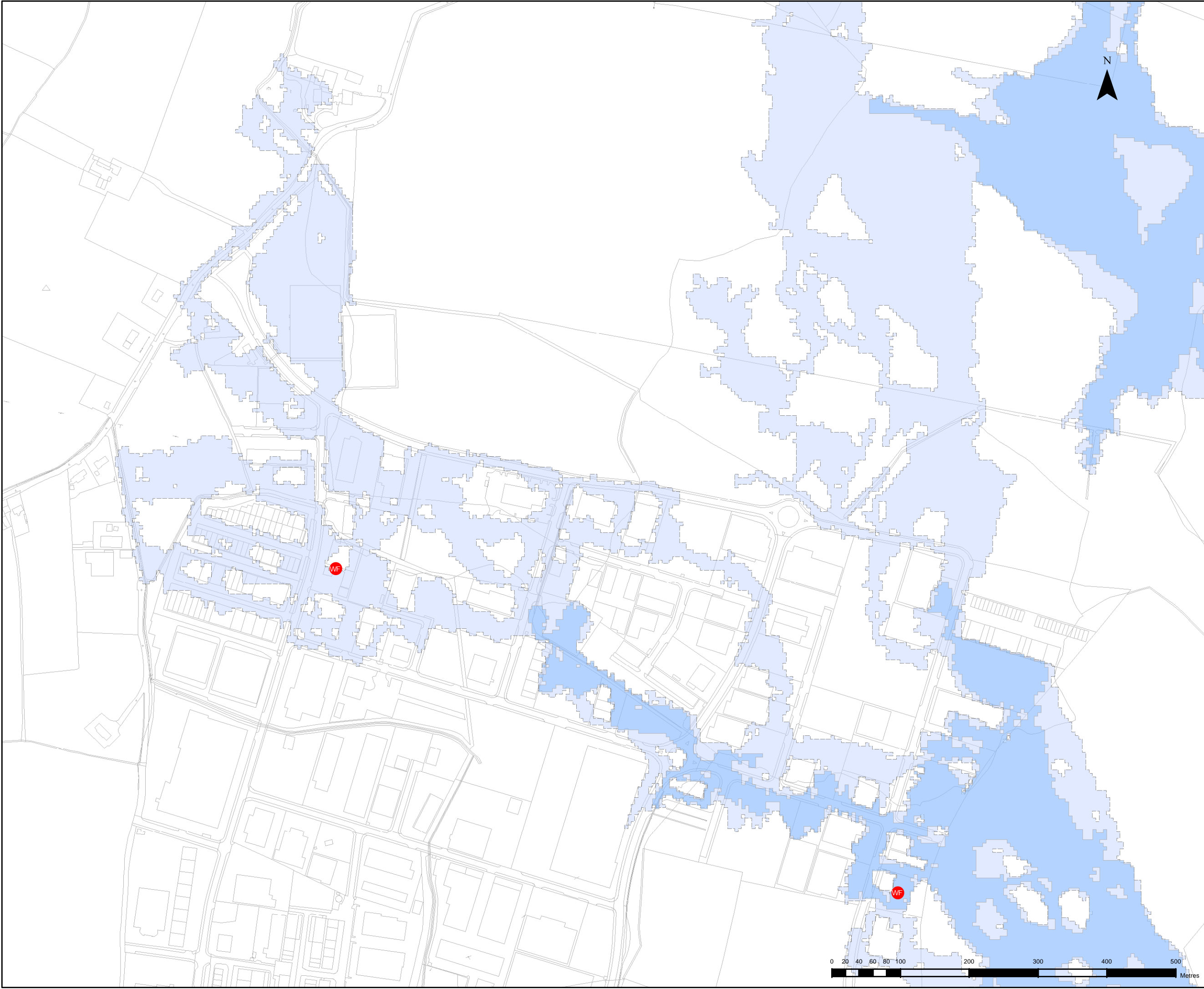
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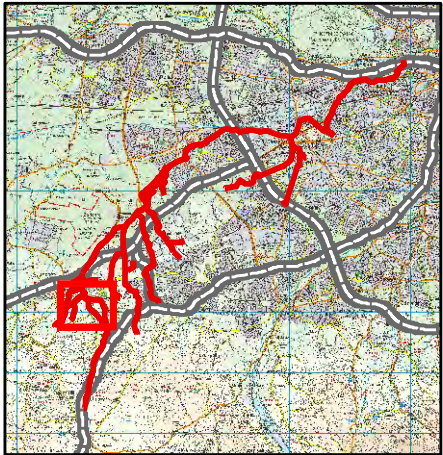
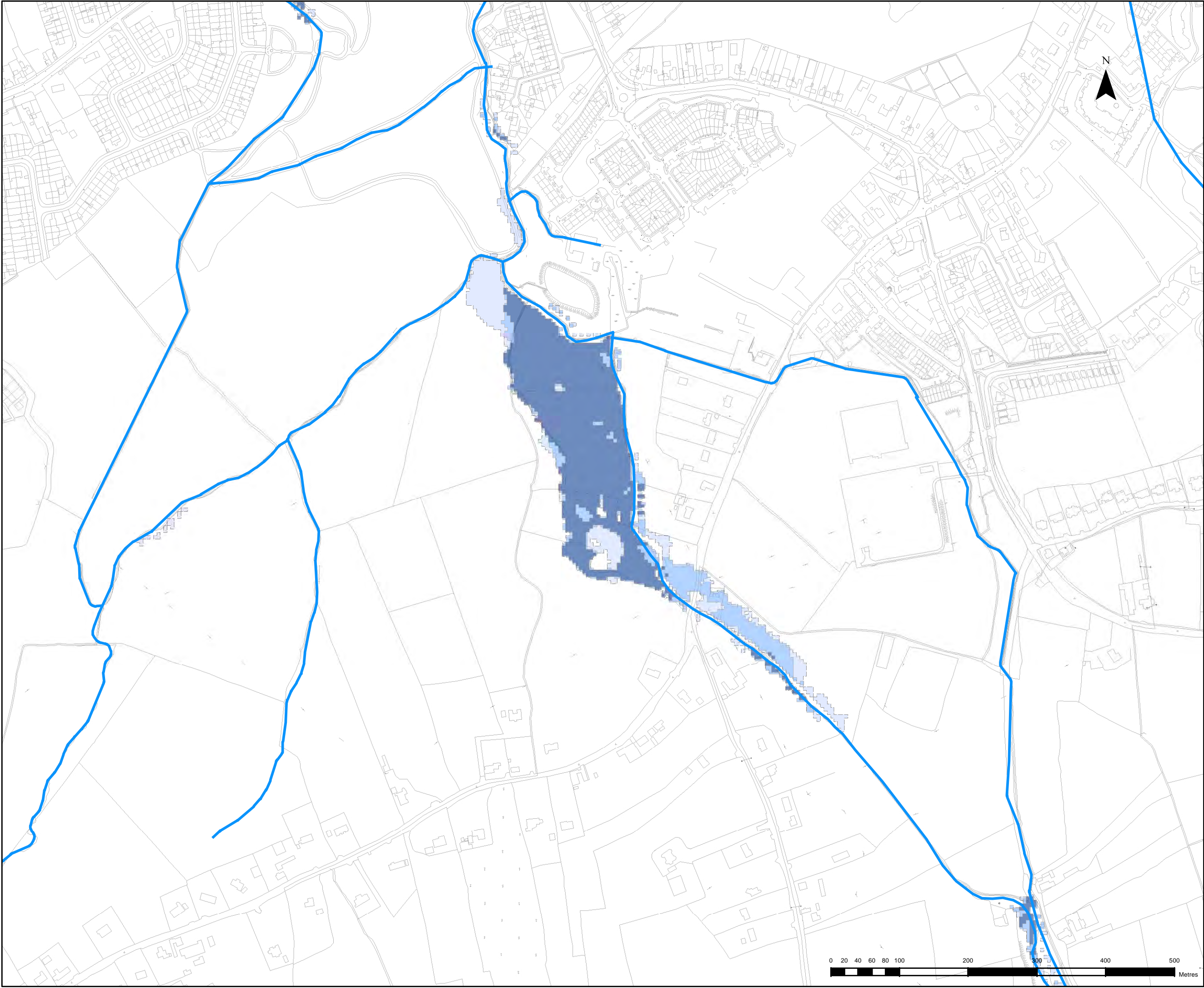
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Legend

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- Flood Extent**
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 - 10% AEP event
 - River Centrelines

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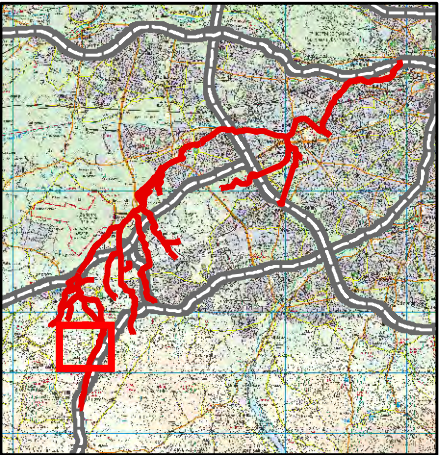
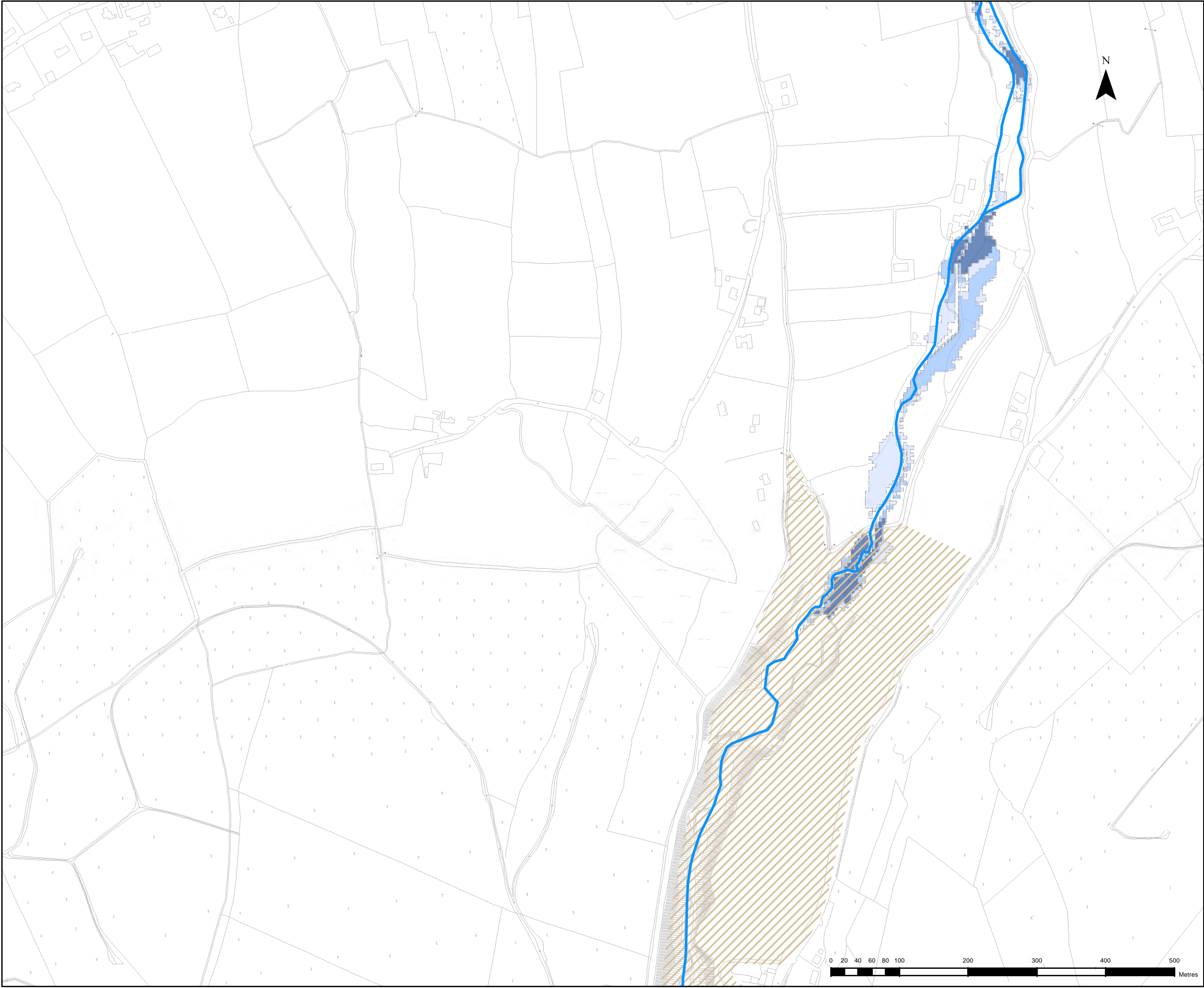


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 - 10% AEP event
 - River Centreline

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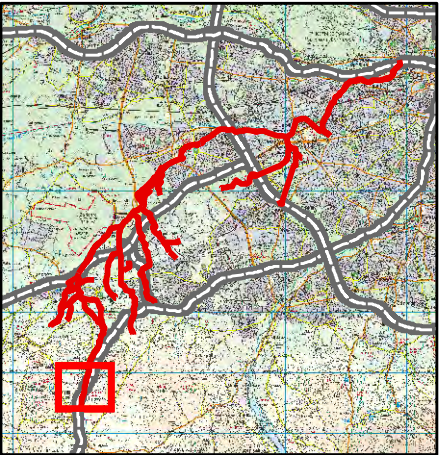
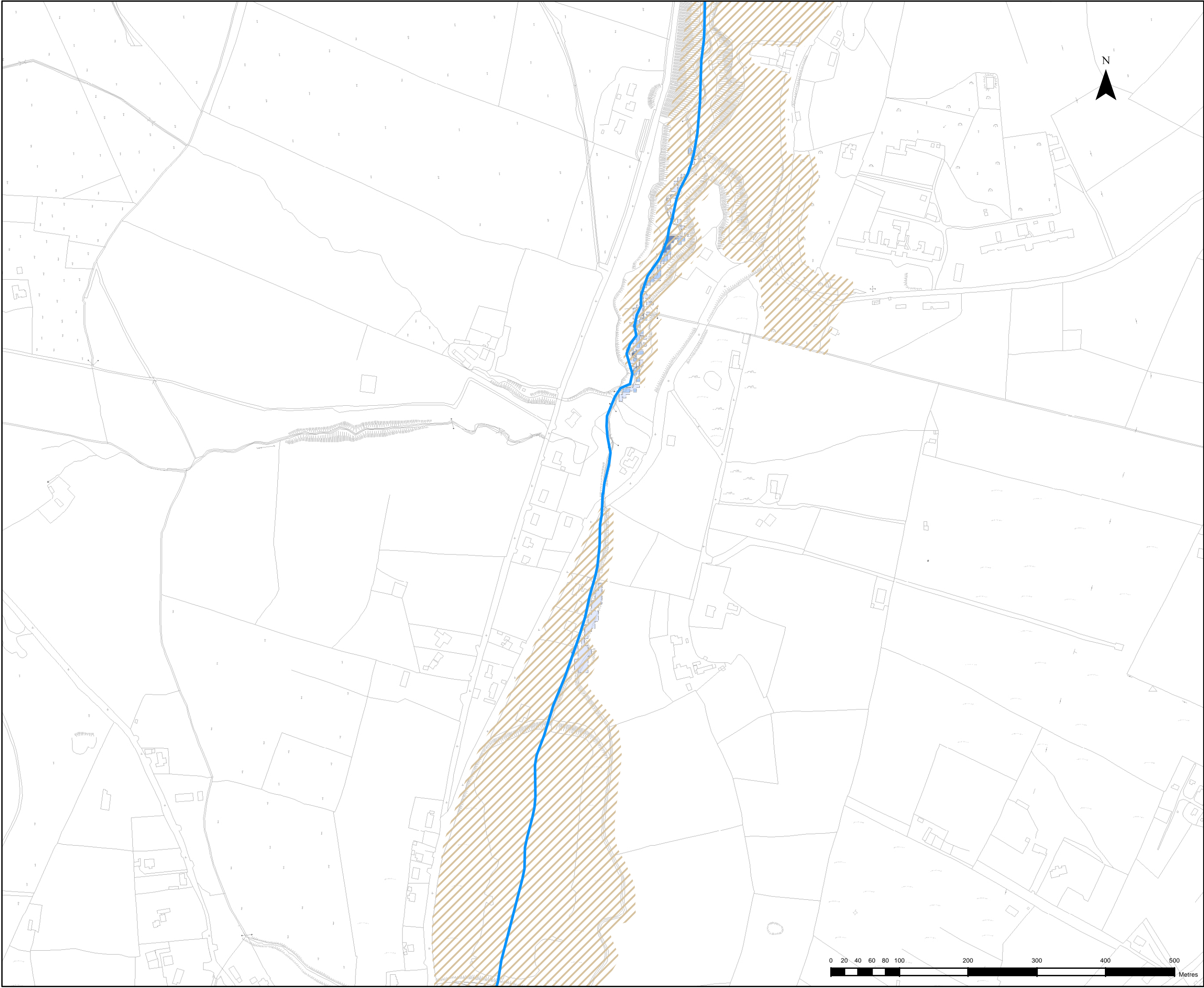
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 - River Centreline

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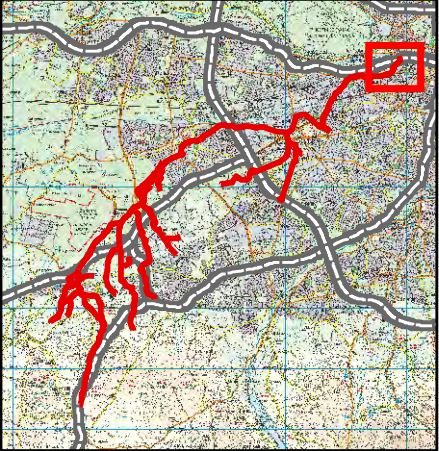
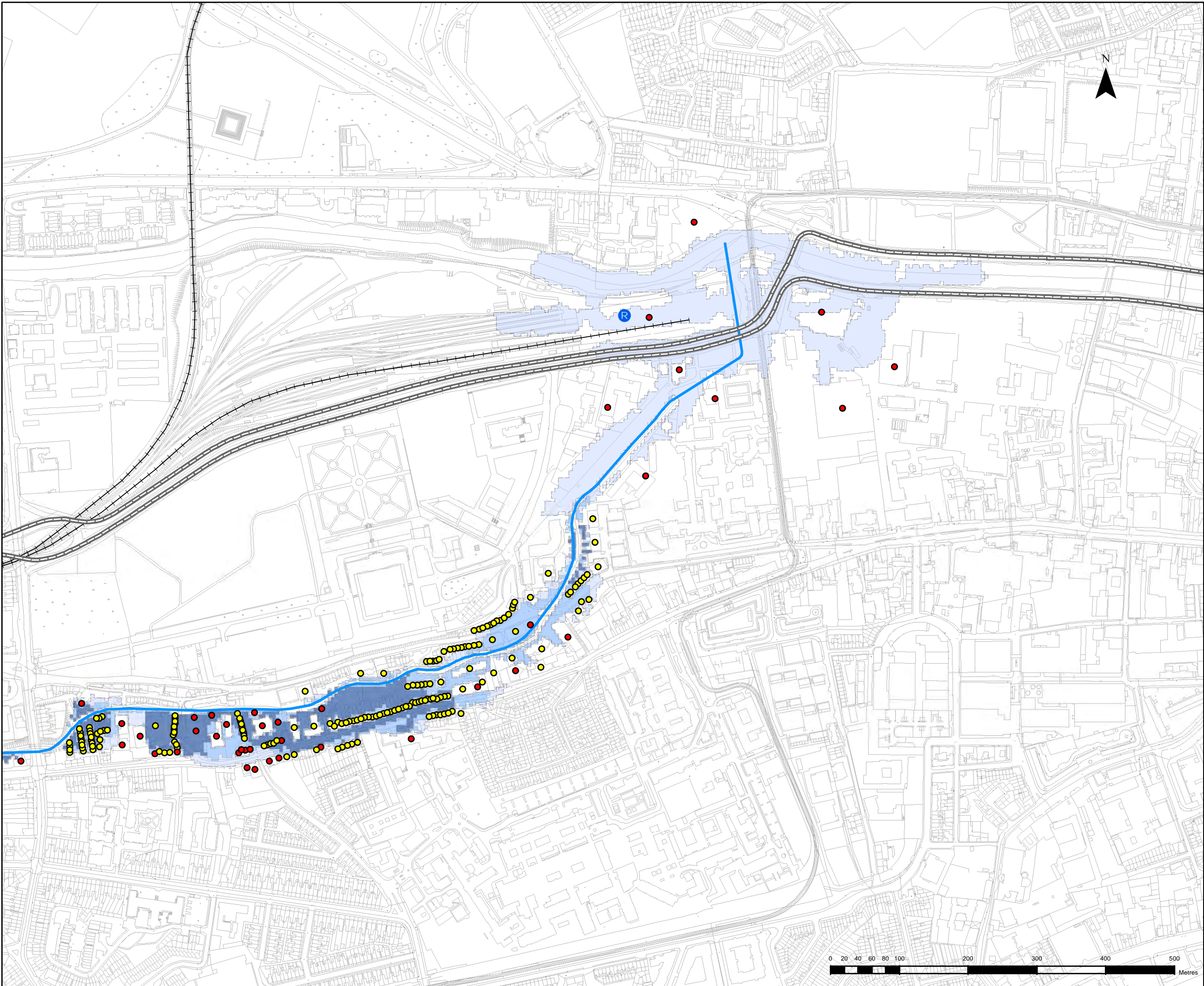


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Legend

Properties

- Residential Properties
- Non-Residential Properties

Infrastructure

- Airports
- Road Network
- Rail Stations
- Railways
- Ports and Harbours
- Utility
- Water Treatment Works
- Waste Water Treatment Works
- ESB BG EC Infrastructure

Agricultural Land

- Rural/Agricultural Areas

Flood Extent

- 0.1% AEP Event
- 1% AEP event
- 10% AEP event
- River Centreline

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TITLE

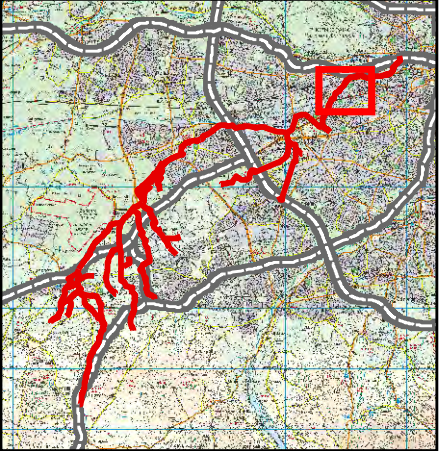
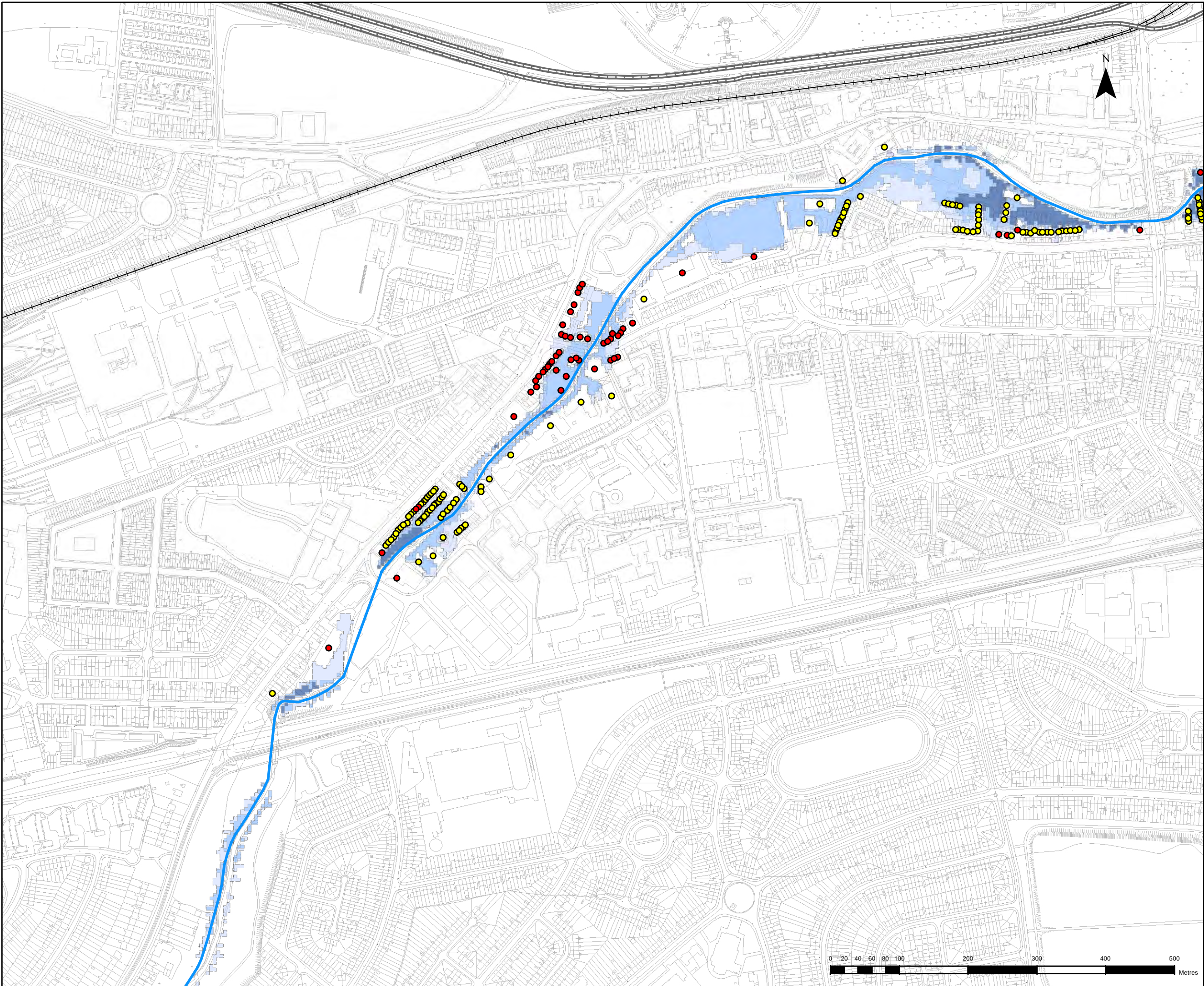
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Legend

Properties

- Residential Properties
- Non-Residential Properties

Infrastructure

- ✈ Airports
- Road Network
- Ⓡ Rail Stations
- Railways
- ⚓ Ports and Harbours
- ⚙ Utility
- ⚙ Water Treatment Works
- ⚙ Waste Water Treatment Works
- ⚡ ESB BG EC Infrastructure

Agricultural Land

- Rural/Agricultural Areas

Flood Extent

- 0.1% AEP Event
- 1% AEP event
- 10% AEP event
- River Centreline

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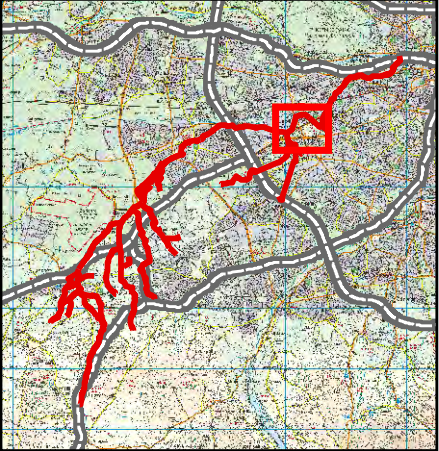
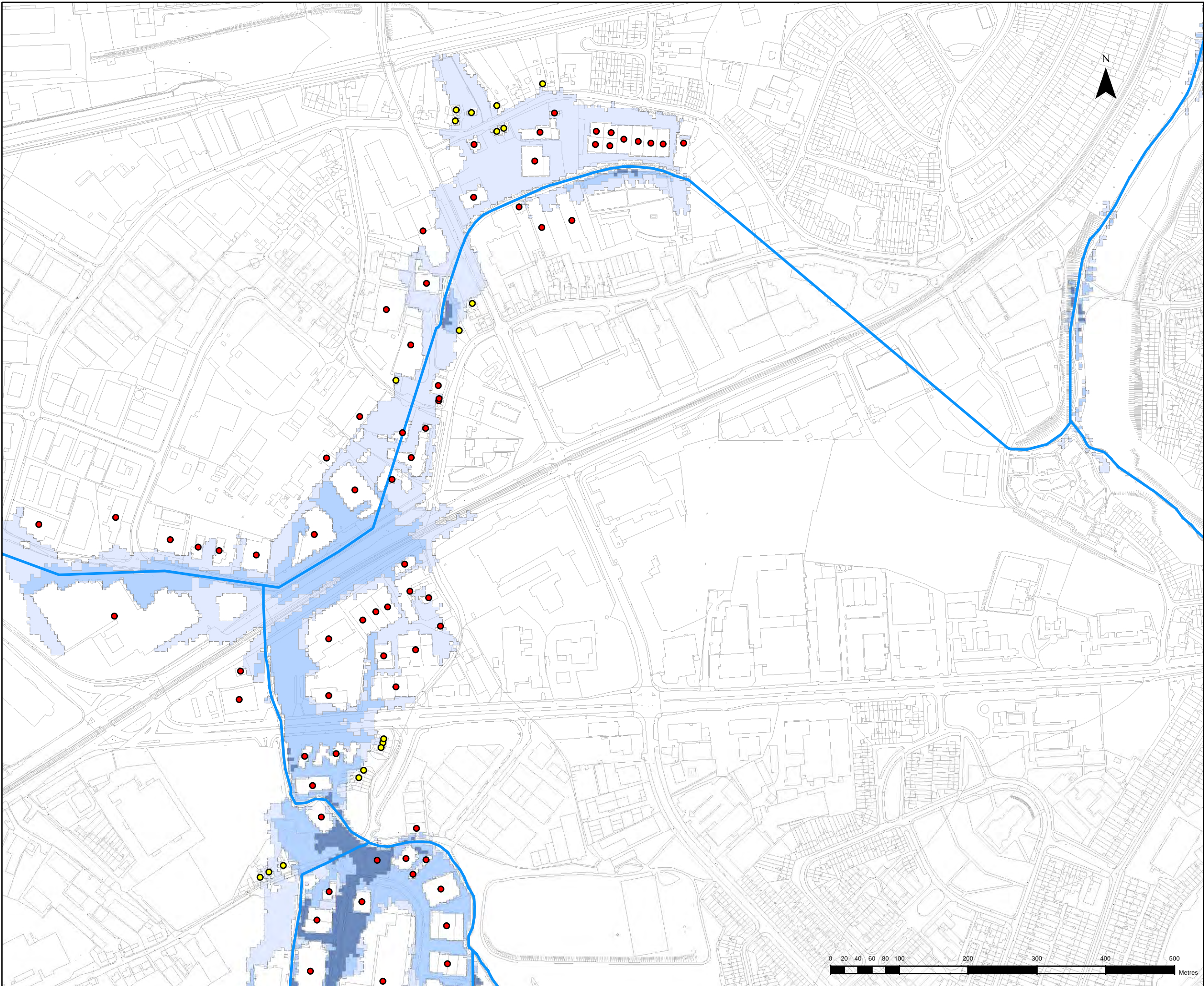
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Date : 21/10/2013

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Legend

Properties

- Residential Properties
- Non-Residential Properties

Infrastructure

- Airports
- Road Network
- Rail Stations
- Railways
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- Utility
- Water Treatment Works
- Waste Water Treatment Works
- ESB BG EC Infrastructure

Agricultural Land

- Rural/Agricultural Areas

Flood Extent

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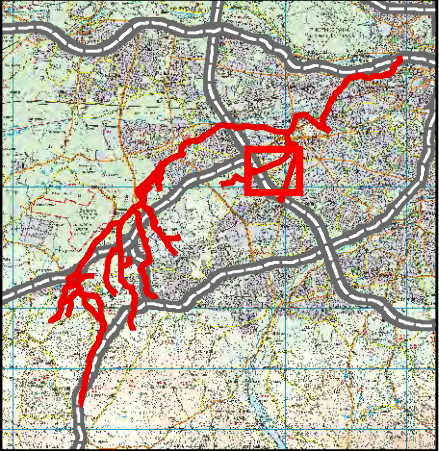
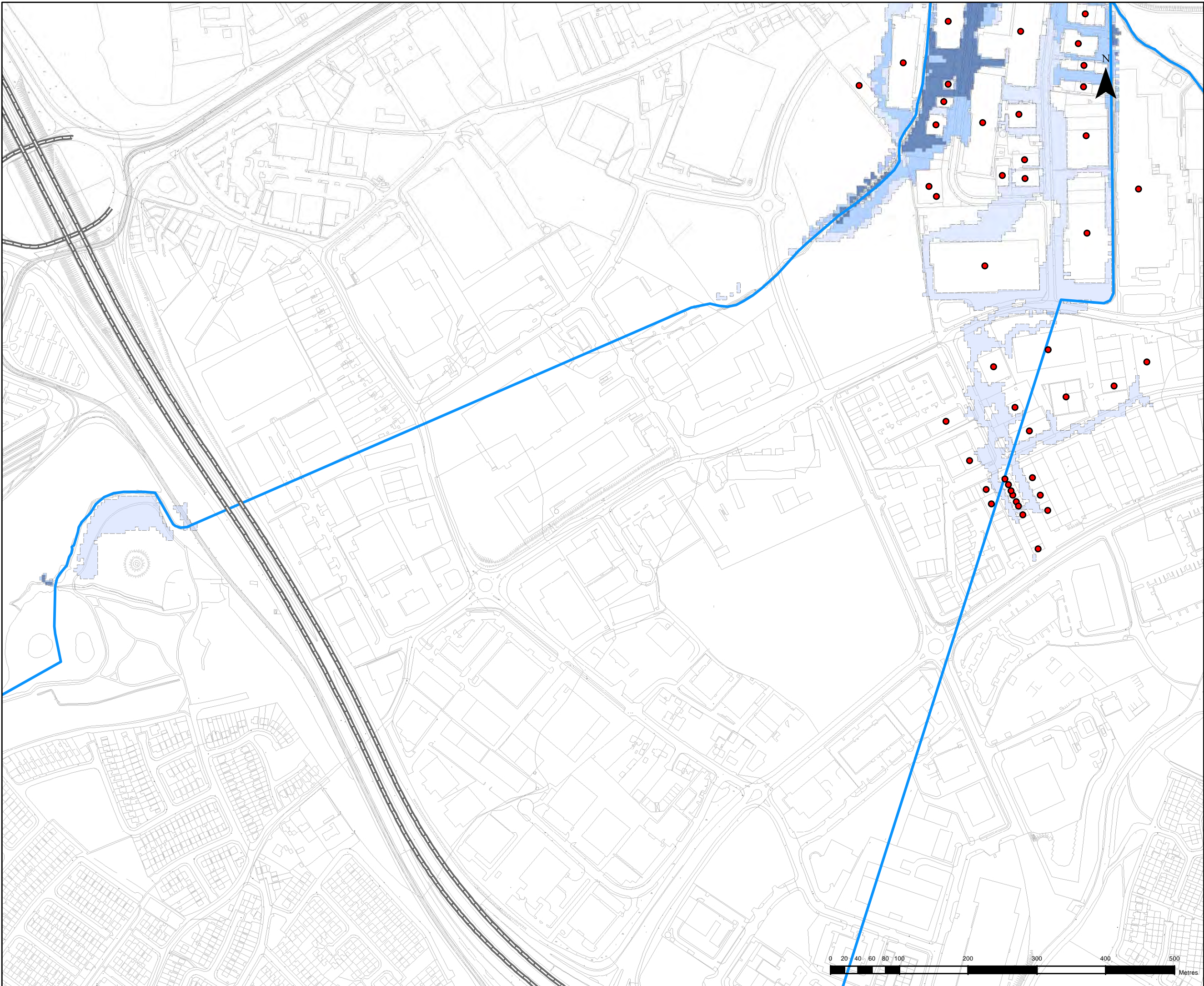
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Legend

Properties

- Residential Properties
- Non-Residential Properties

Infrastructure

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- Utility
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Agricultural Land

- Rural/Agricultural Areas

Flood Extent

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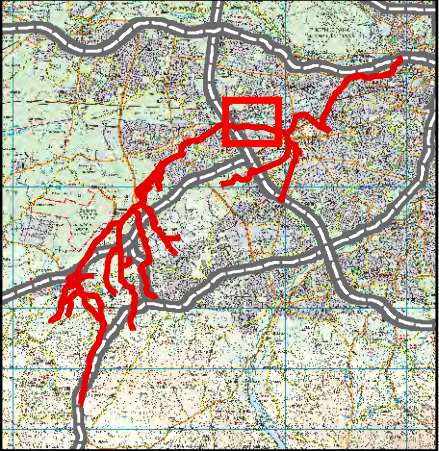
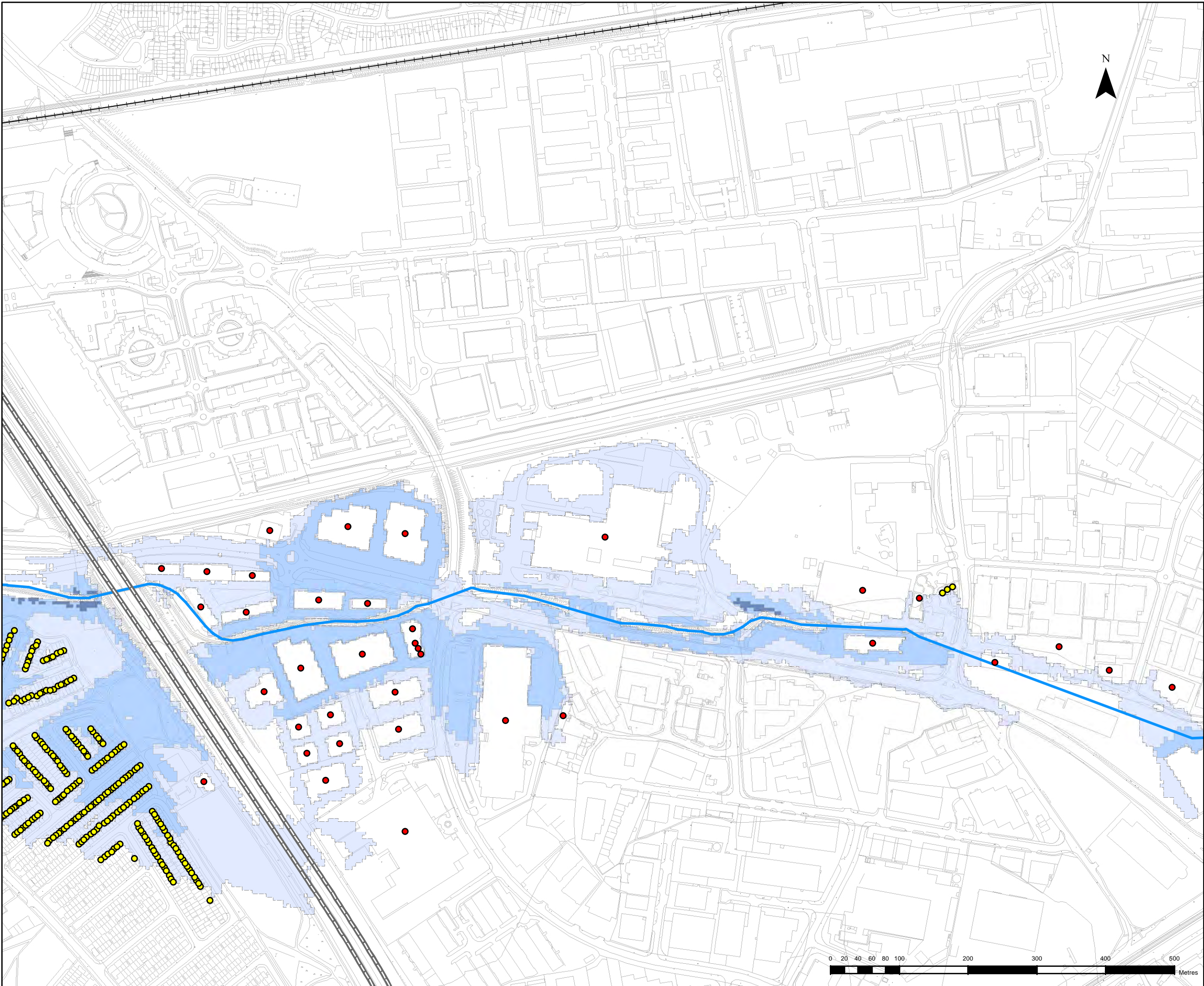
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- ESB BG EC Infrastructure

Agricultural Land

- Rural/Agricultural Areas

Flood Extent

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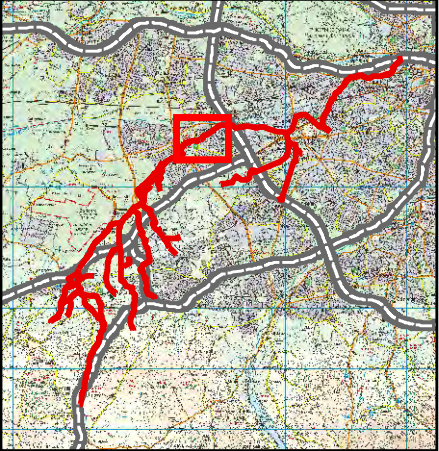
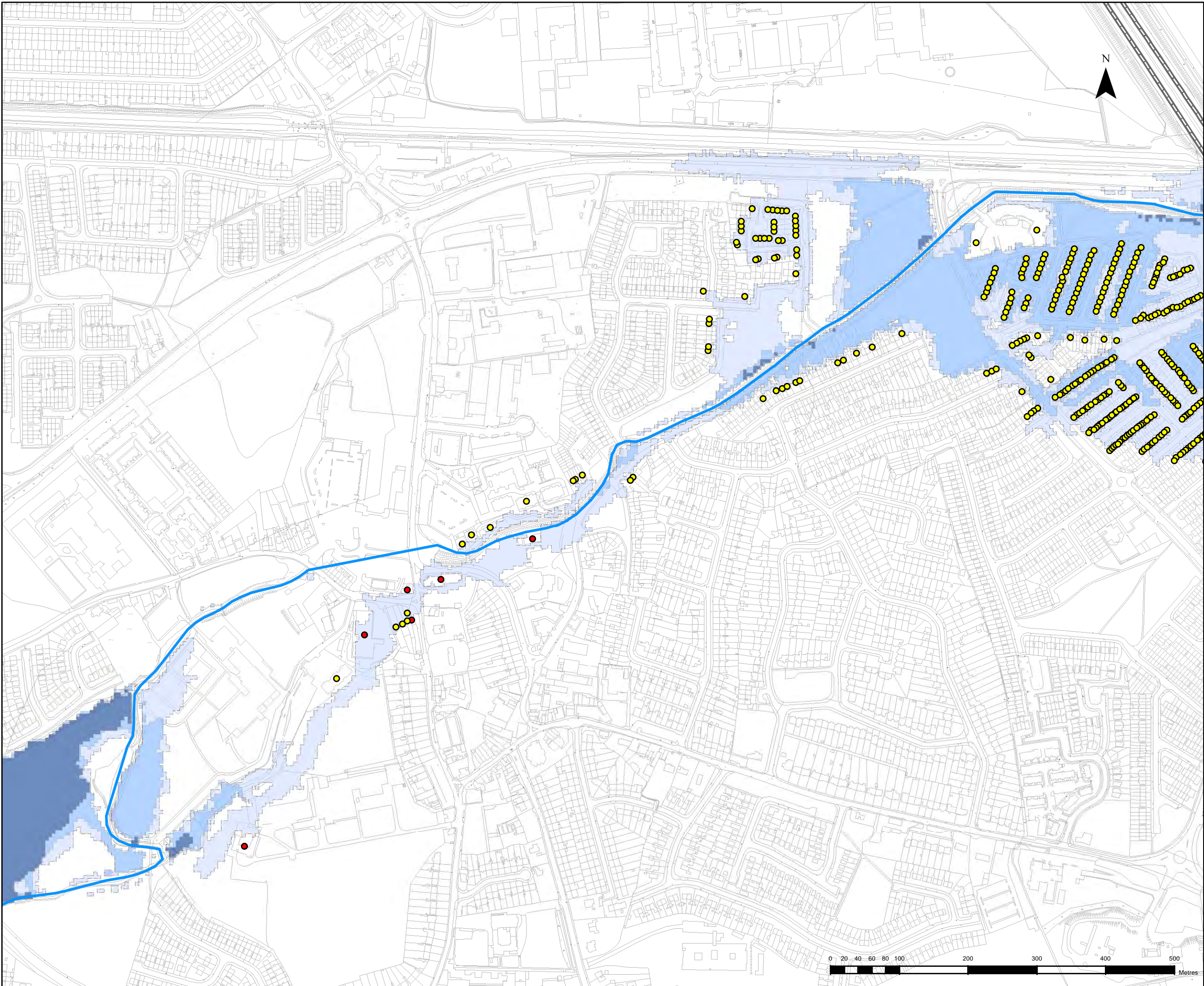
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Legend

Properties

- Residential Properties
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Infrastructure

- ✈ Airports
- 🛣 Road Network
- 🚉 Rail Stations
- 🚊 Railways
- ⚓ Ports and Harbours
- ⚙ Utility
- 🌊 Water Treatment Works
- 🗑 Waste Water Treatment Works
- ⚡ ESB BG EC Infrastructure

Agricultural Land

- 🌱 Rural/Agricultural Areas

Flood Extent

- 🌊 0.1% AEP Event
- 🌊 1% AEP event
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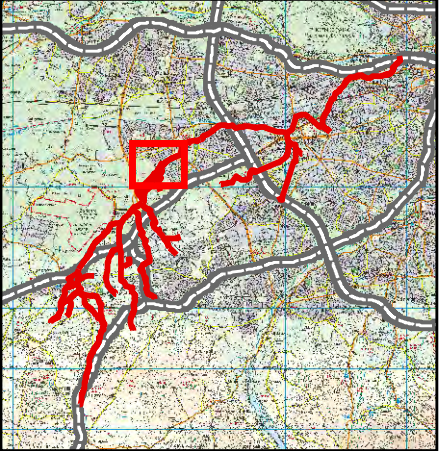
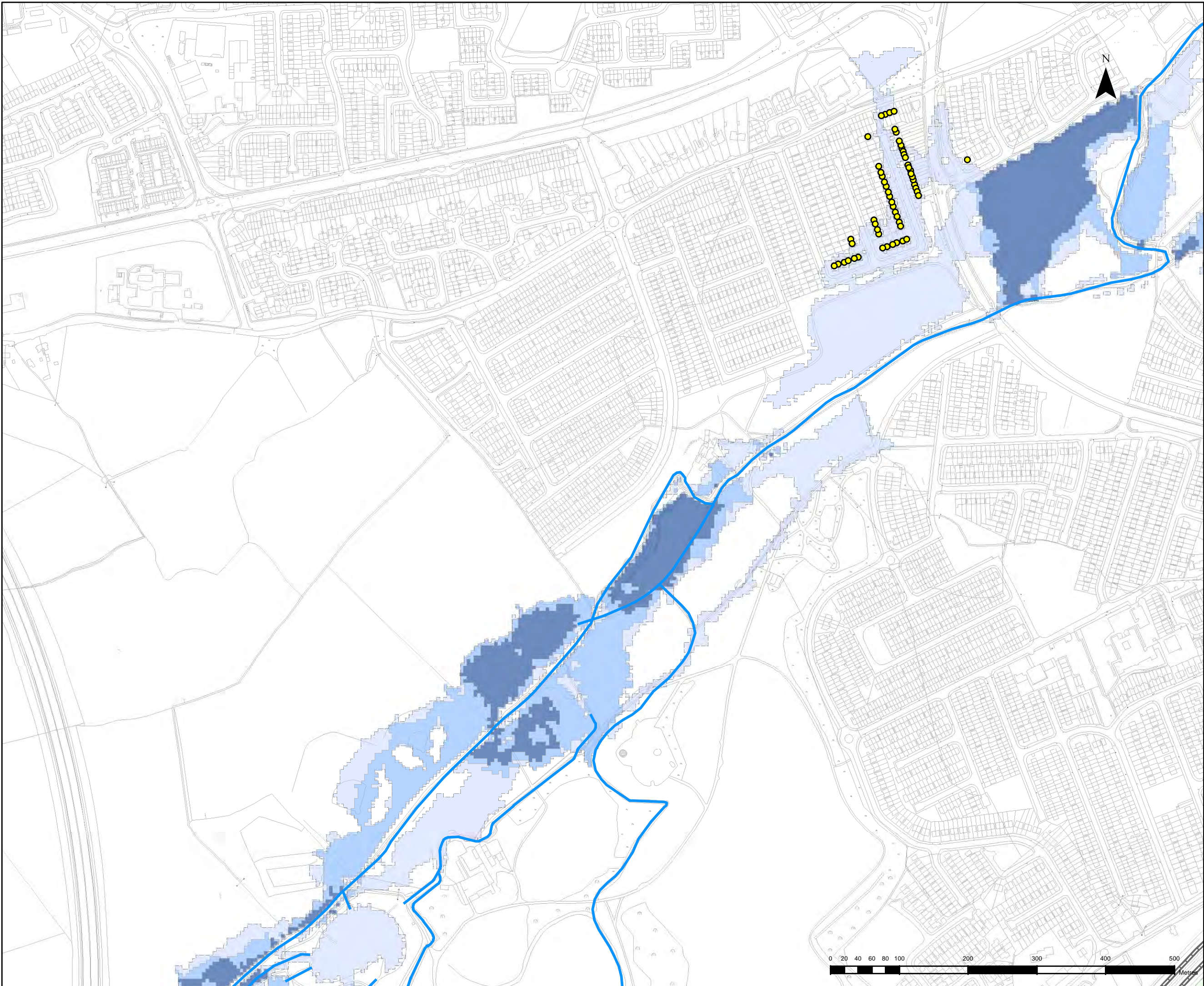
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Drawn By : RC
Checked By : MW
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Legend

Properties

- Residential Properties
- Non-Residential Properties

Infrastructure

- ✈ Airports
- Road Network
- Ⓡ Rail Stations
- Railways
- ⚓ Ports and Harbours
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- Ⓜ Water Treatment Works
- Ⓜ Waste Water Treatment Works
- ⚡ ESB BG EC Infrastructure

Agricultural Land

- Rural/Agricultural Areas

Flood Extent

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- 10% AEP event
- River Centreline

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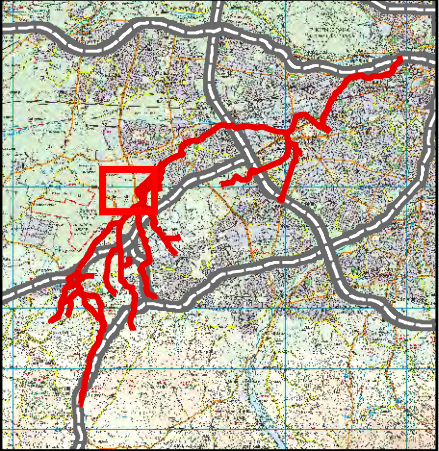
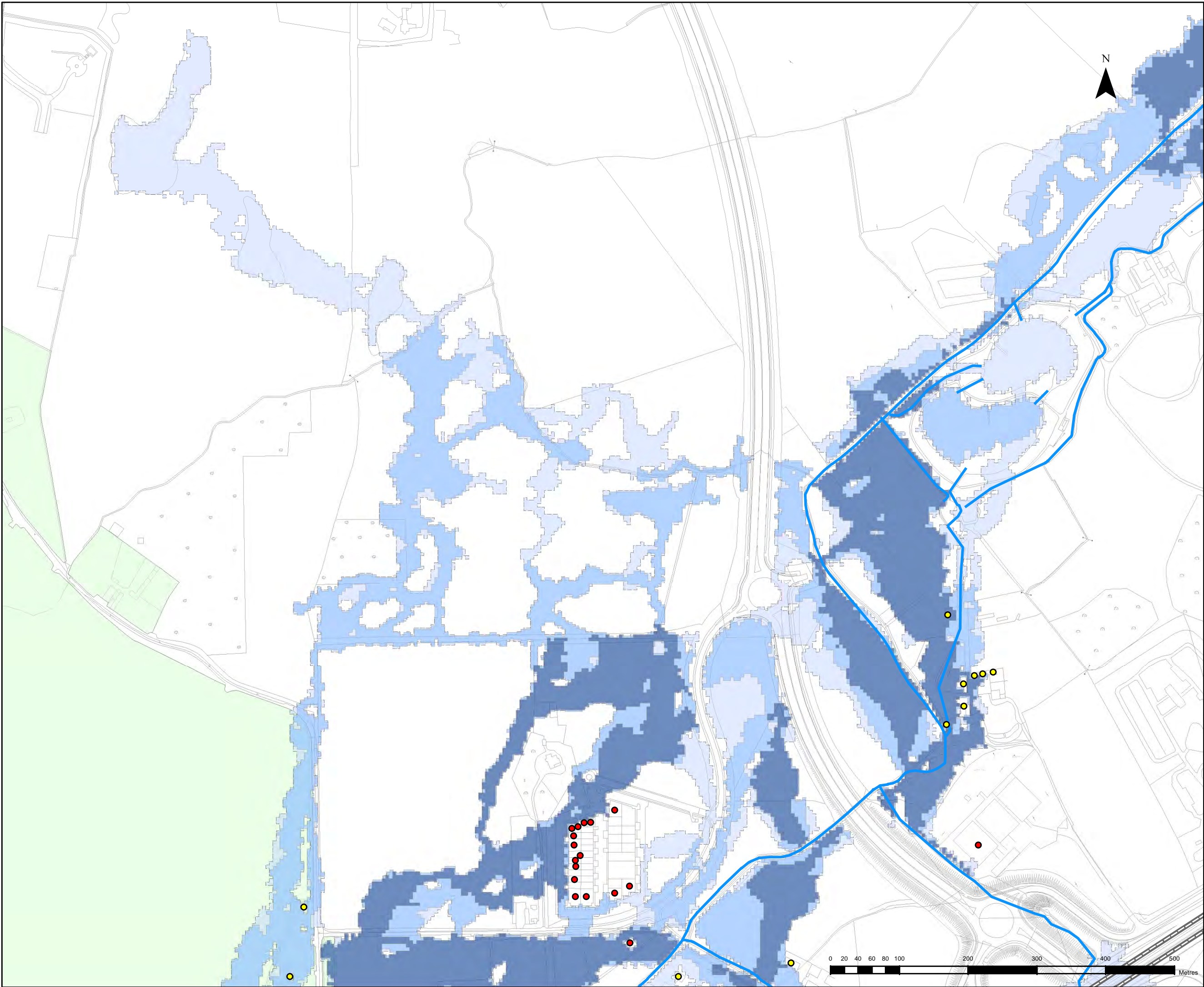
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Legend

Properties

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Infrastructure

- ✈ Airports
- Road Network
- Ⓡ Rail Stations
- Railways
- ⚓ Ports and Harbours

Utility

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- Ⓜ Waste Water Treatment Works
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Agricultural Land

- Rural/Agricultural Areas

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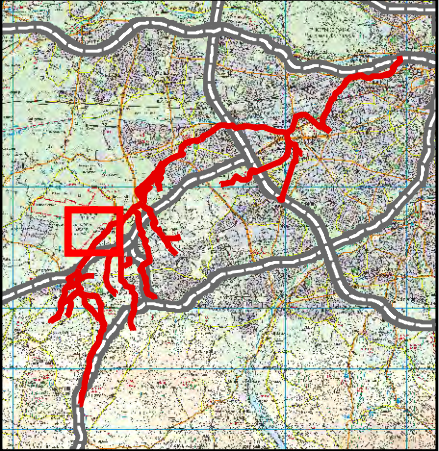
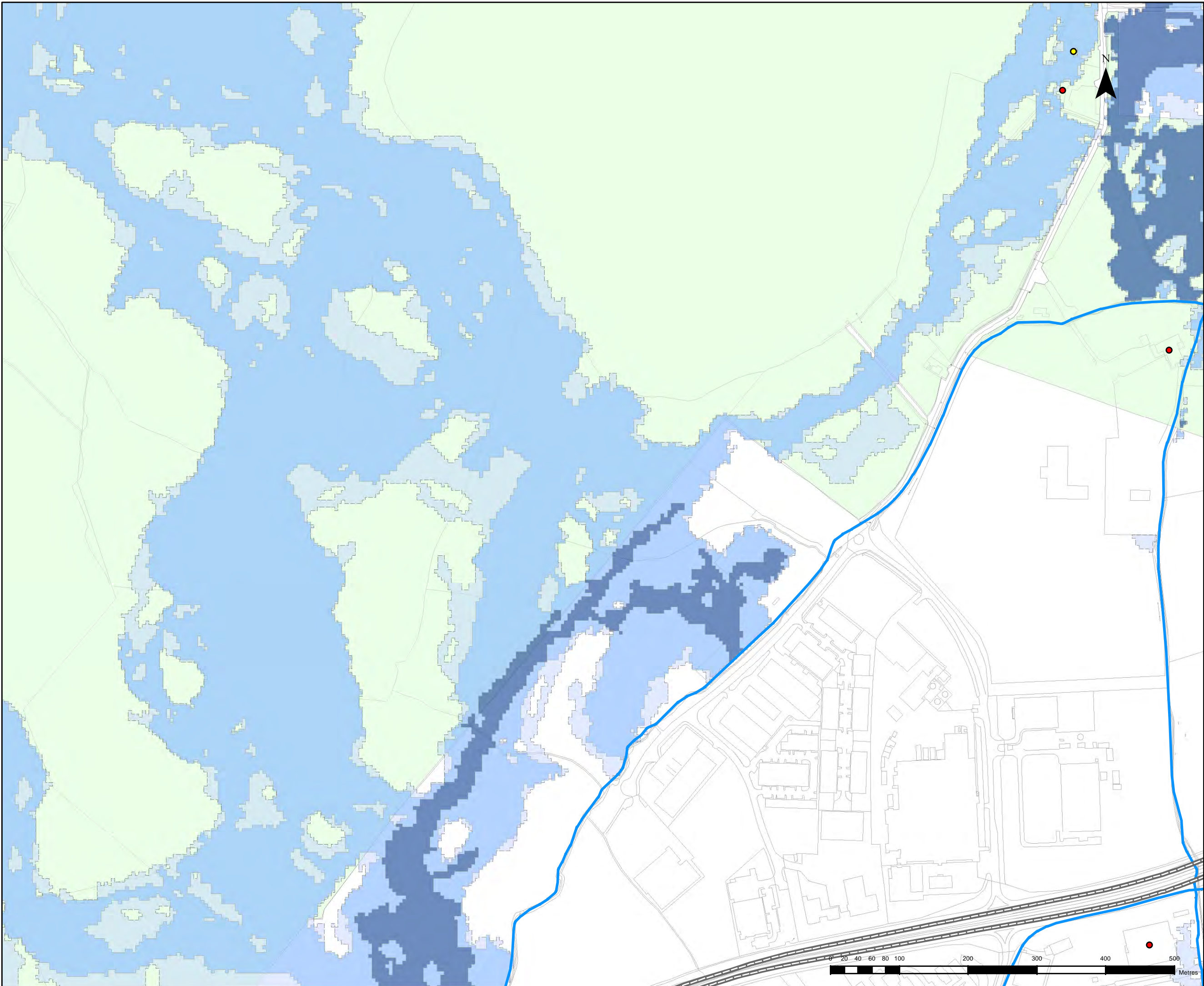
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Legend

Properties

- Residential Properties
- Non-Residential Properties

Infrastructure

- ✈ Airports
- 🛣 Road Network
- 🚉 Rail Stations
- 🚊 Railways
- ⚓ Ports and Harbours
- Utility**
- 💧 Water Treatment Works
- 🗑 Waste Water Treatment Works
- ⚡ ESB BG EC Infrastructure

Agricultural Land

- 🌱 Rural/Agricultural Areas

Flood Extent

- 🌊 0.1% AEP Event
- 🌊 1% AEP event
- 🌊 10% AEP event
- 📏 River Centreline

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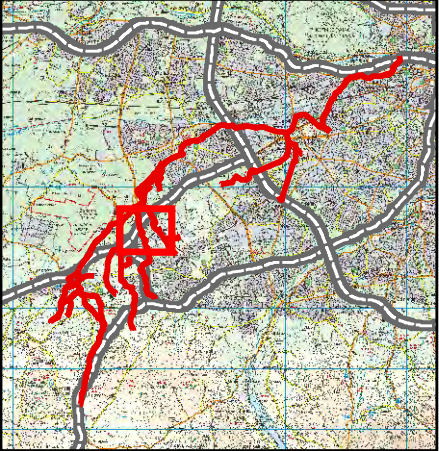
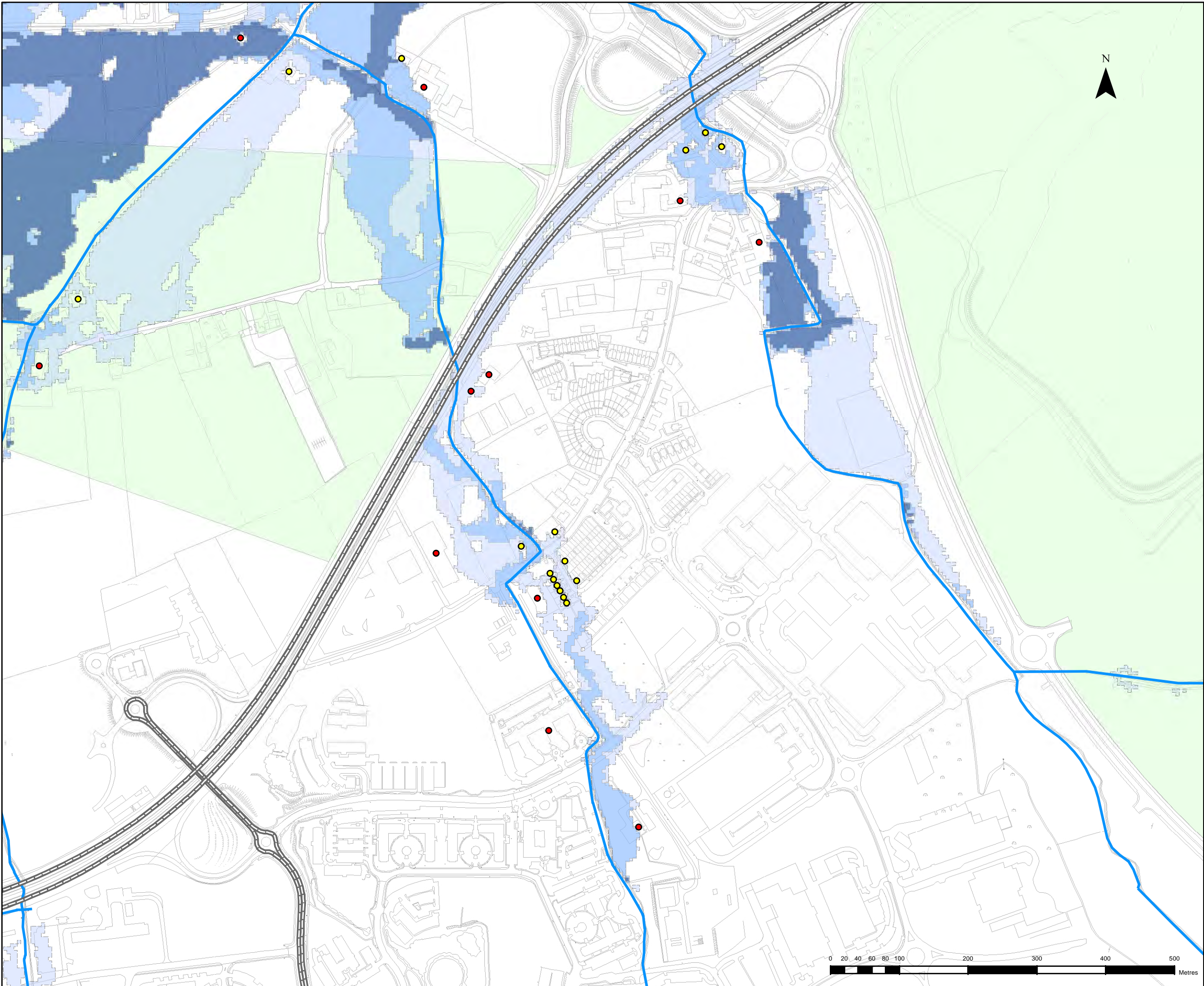
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Legend

Properties

- Residential Properties
- Non-Residential Properties

Infrastructure

- ✈ Airports
- ⚡ Road Network
- Ⓡ Rail Stations
- ⚡ Railways
- ⚓ Ports and Harbours

Utility

- ⚡ Water Treatment Works
- ⚡ Waste Water Treatment Works
- ⚡ ESB BG EC Infrastructure

Agricultural Land

- Rural/Agricultural Areas

Flood Extent

- 0.1% AEP Event
- 1% AEP event
- 10% AEP event
- River Centreline

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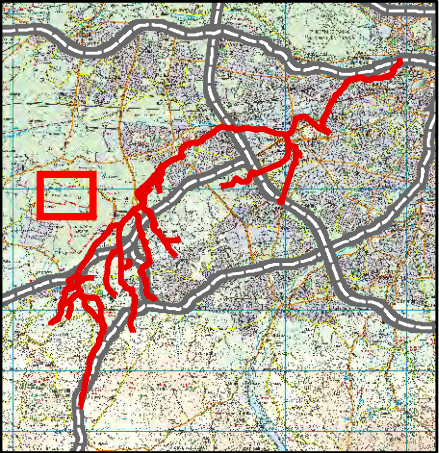
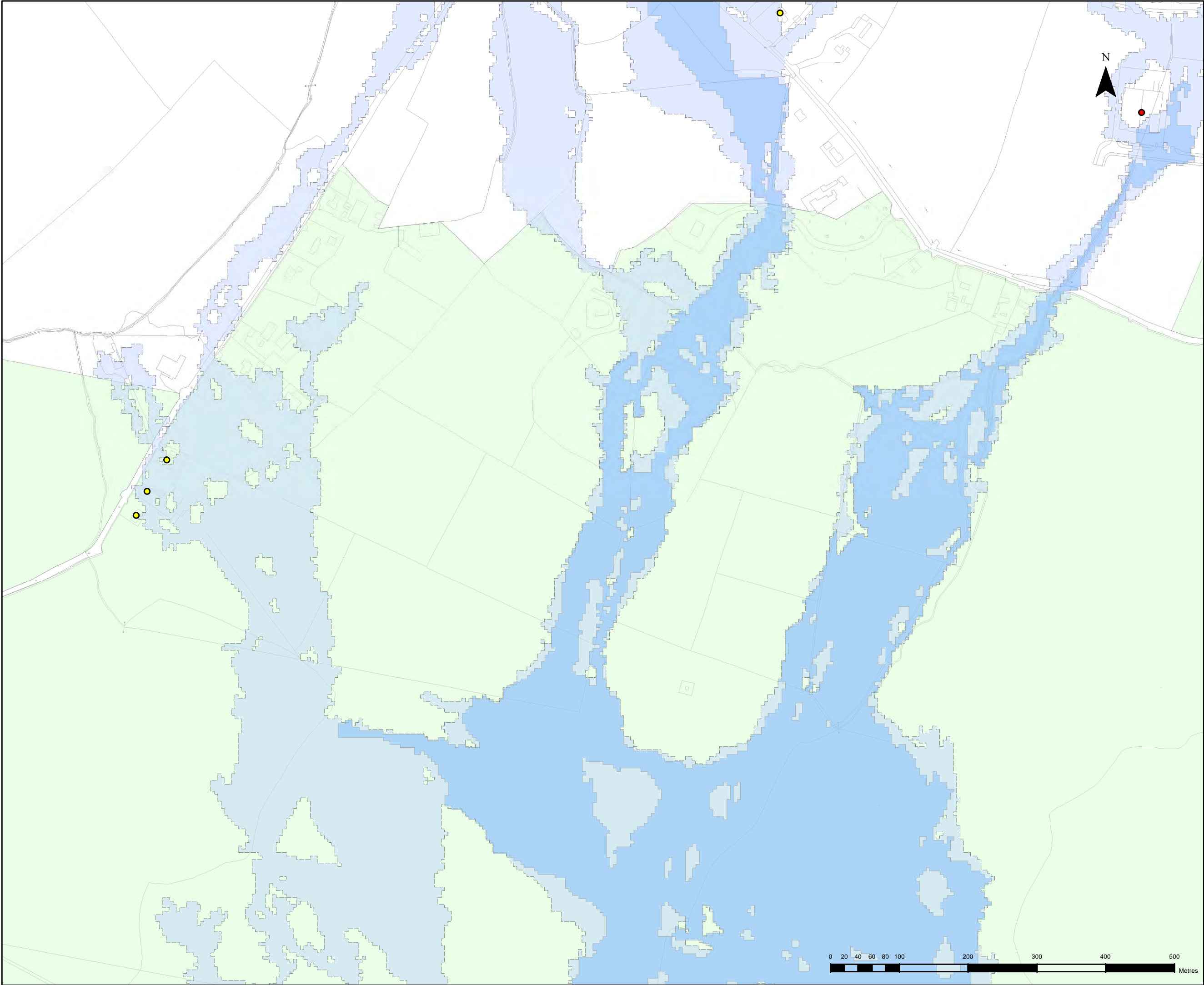
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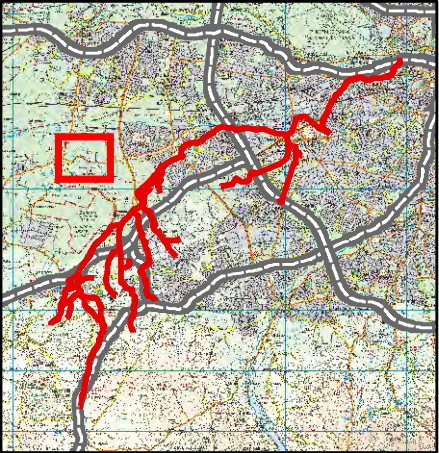
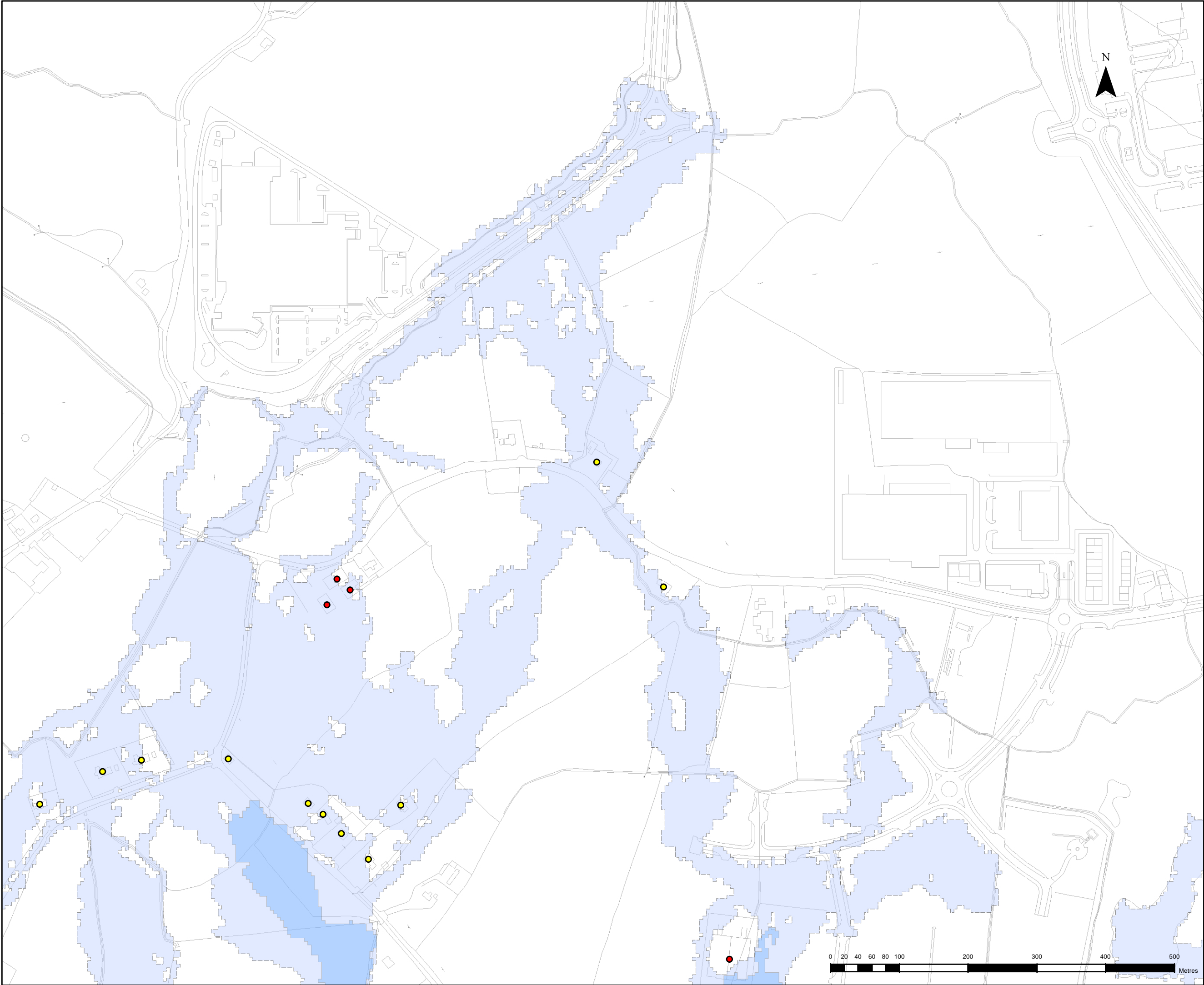
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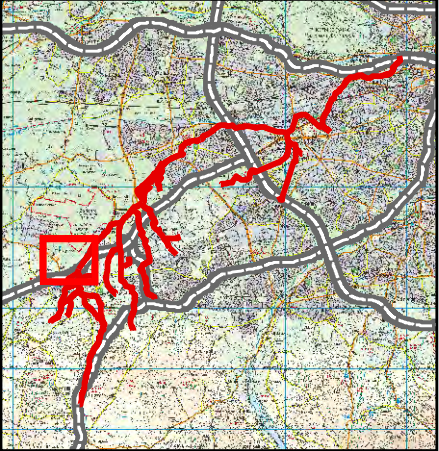
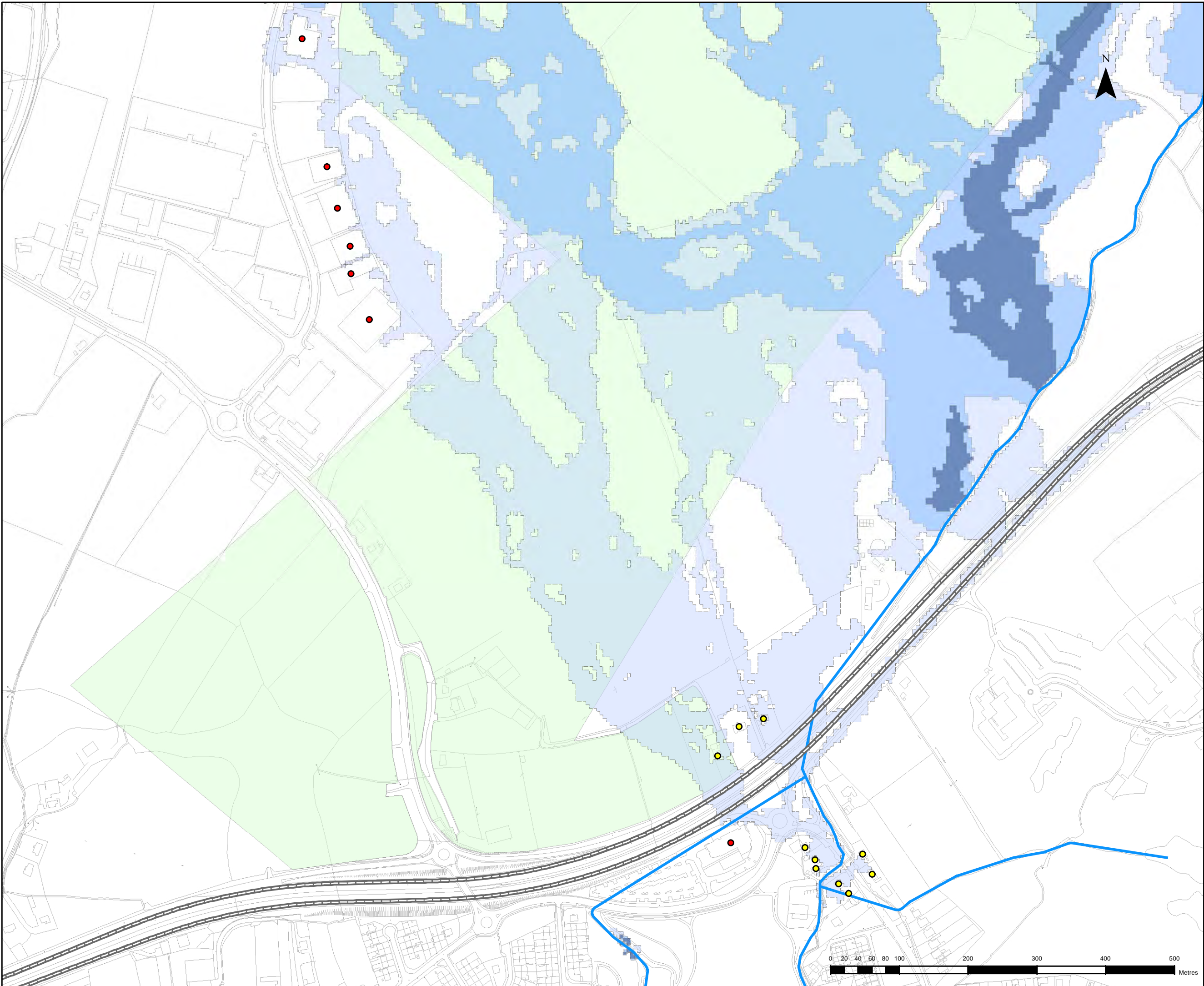
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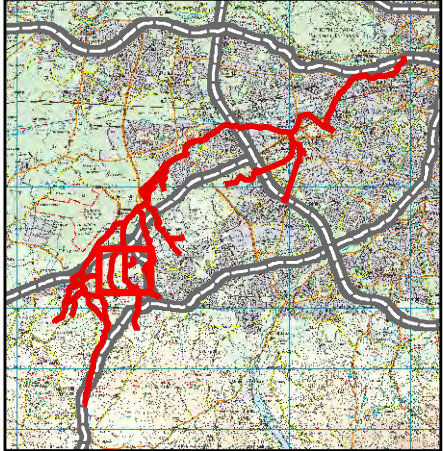
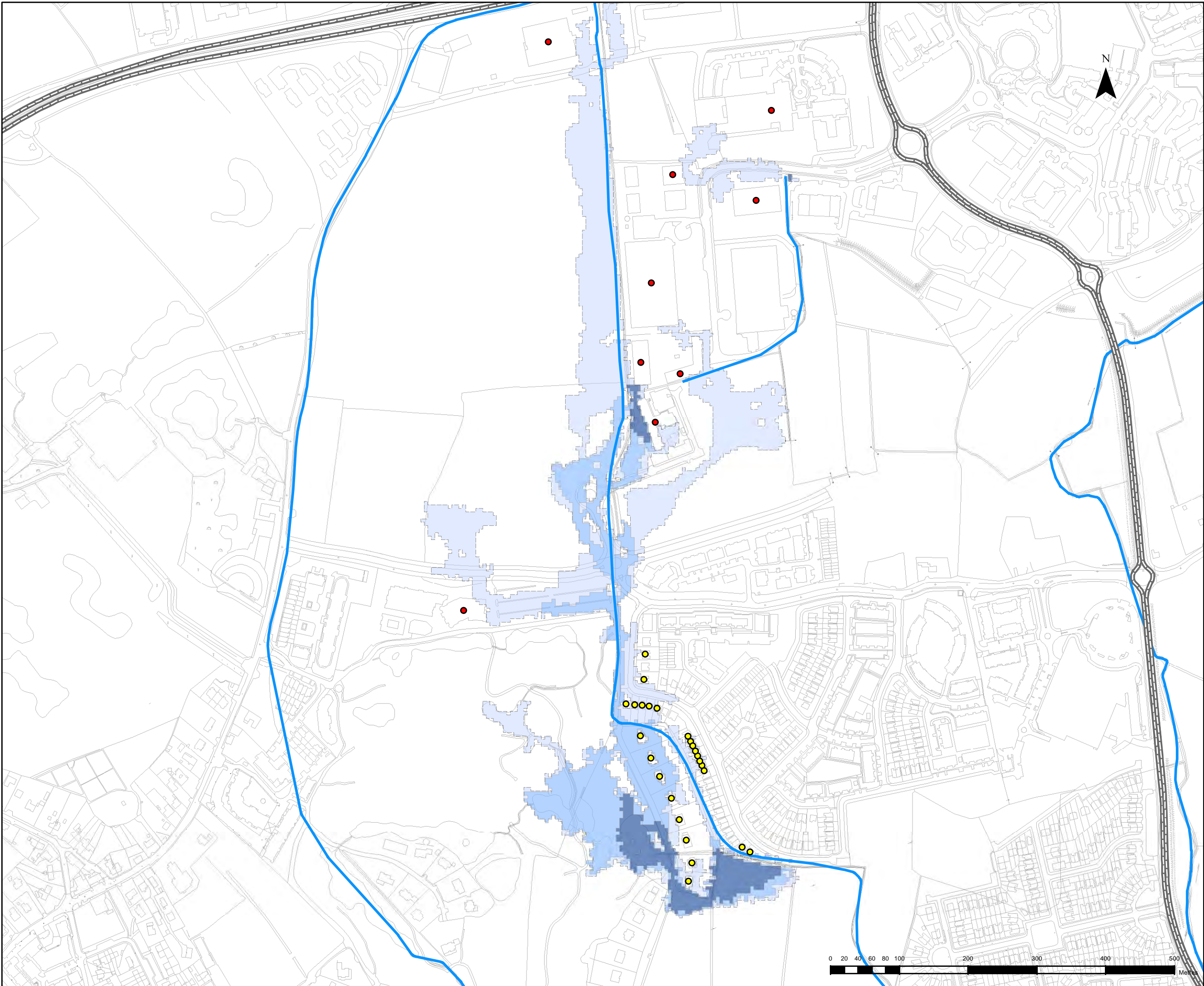
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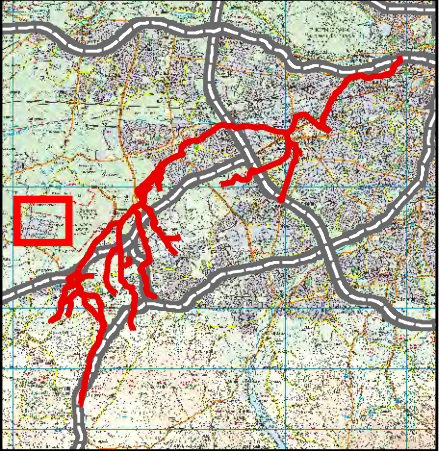
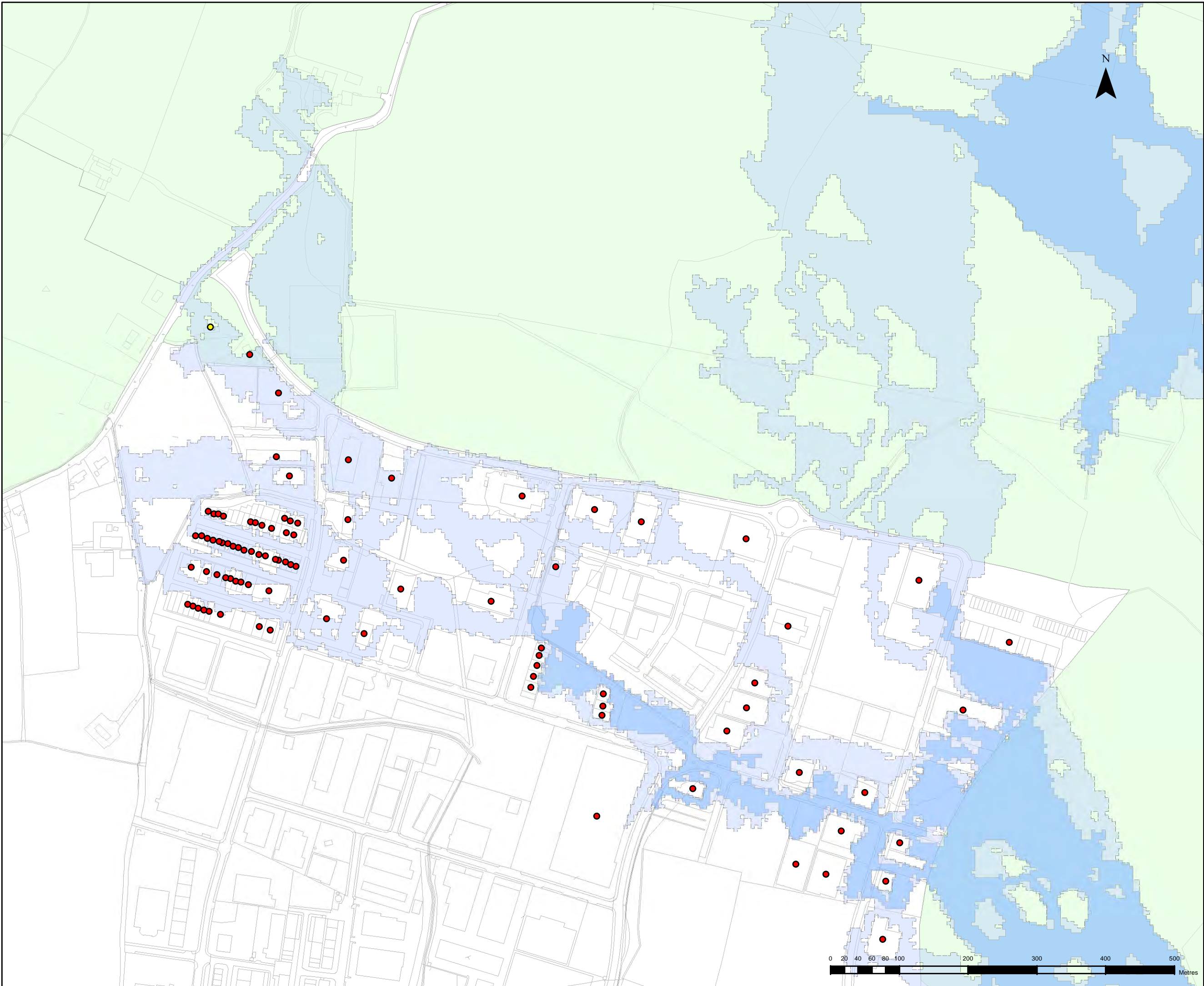
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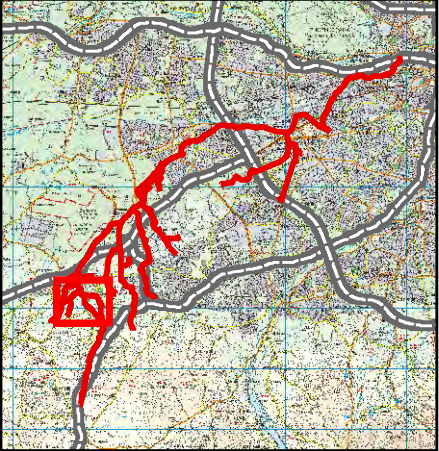
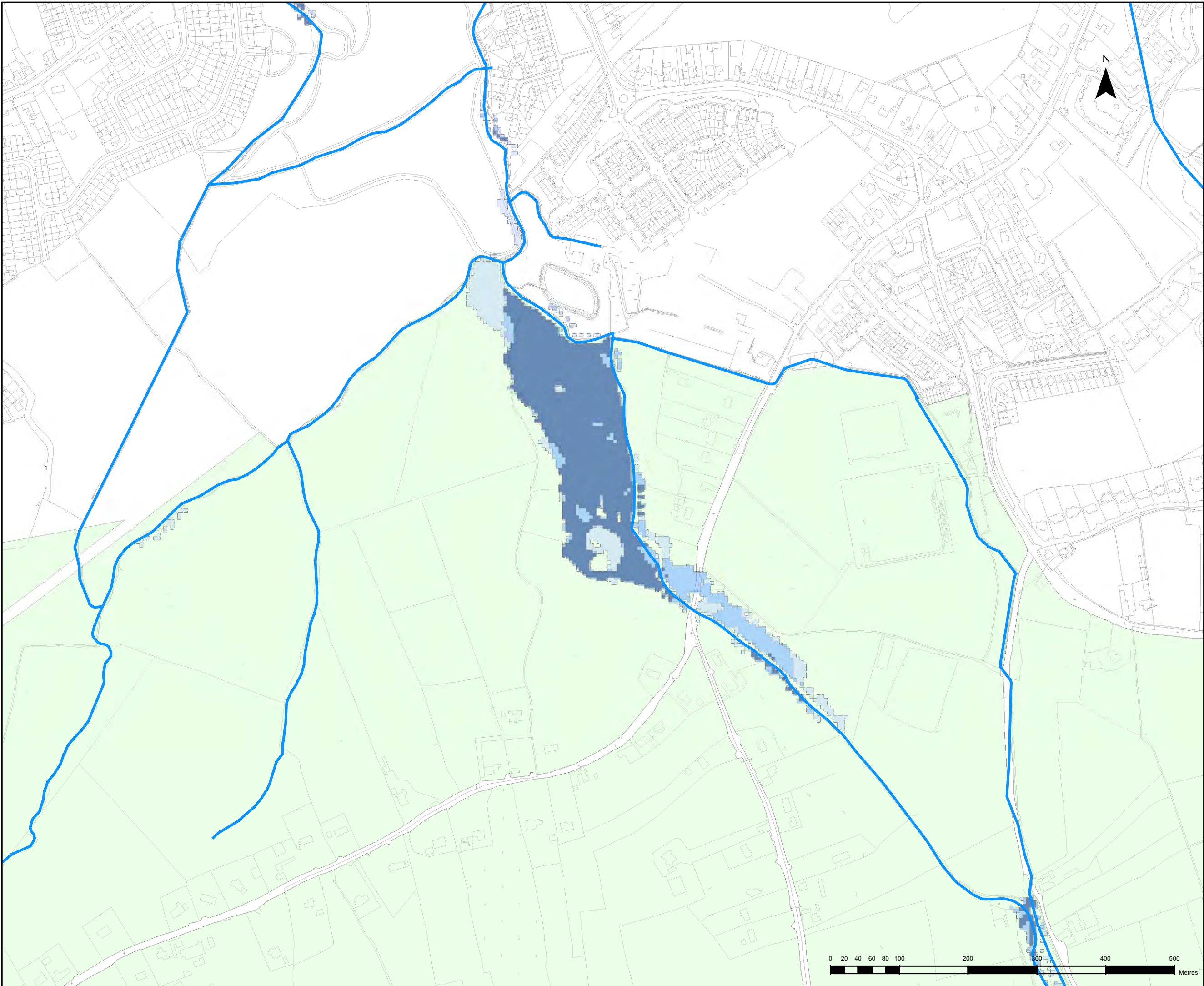
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- 🌱 Rural/Agricultural Areas

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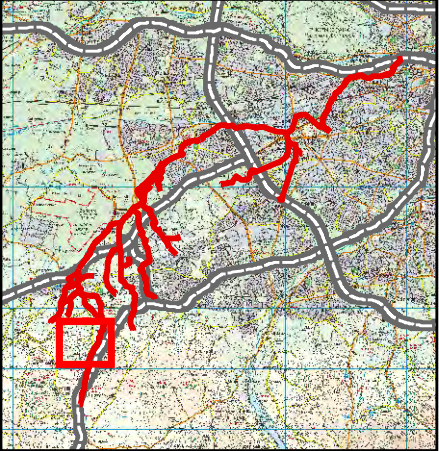
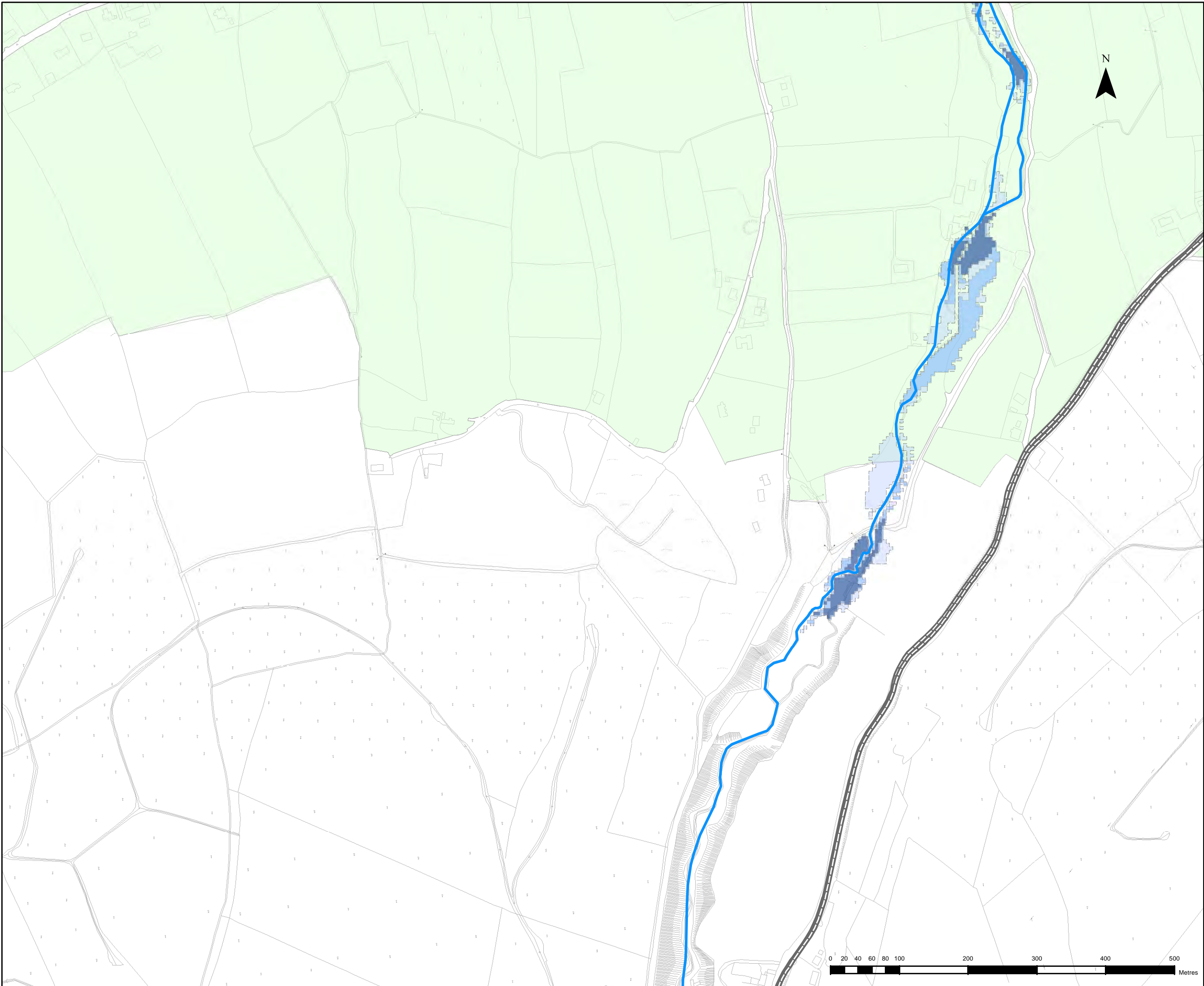
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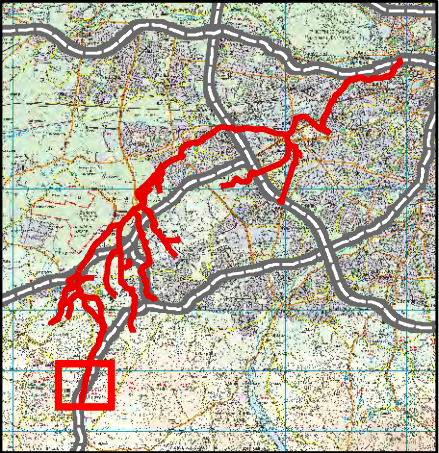
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Appendix B

Assessment of FRM Methods

Datasheet

Appendix B

Assessment of FRM Methods Datasheets

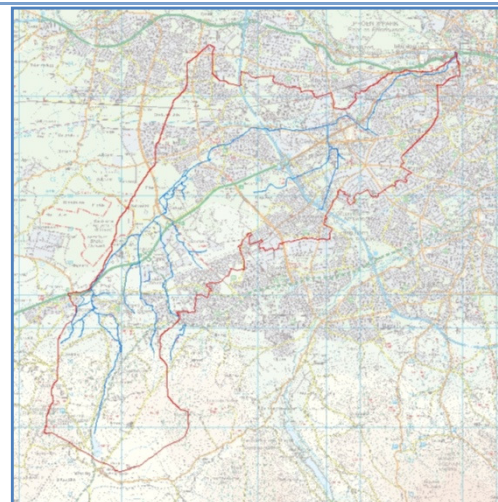
RPS

Name	Local Authority	Unique ID	SSA	Status	Date
Camac	Dublin City & South Dublin	-	HPW	Draft	30/10/2013

Flood Risk Receptor summary

During a 1% AEP event (i.e. often referred to as 100 year flood) the following receptors are at risk on the Camac:

Receptor	Item	Unit
Residential Property	407	No.
Commercial Property	165	No.
pNHA	2	No.
SMR	3	No.
NIAH	1	No.
ACA	1	No.



- The majority of risk is to residential properties along the lower reach of the Camac along with commercial properties to a lesser extent.
- The two pNHAs (proposed Natural Heritage Area) within the 1% AEP flood extent are the Grand Canal and Slade of Saggart and Crooksling Glen.
- There are 3 SMRs (Sites and Monument Record) and 1 NIAH (National Inventory of Architectural Heritage) sites within the 1% AEP flood extent.
- There is an Architectural Conservation Area (ACA) within the 1% AEP flood extent.
- There are amenity areas with development plan amenity objectives within the 1% AEP flood extent.

1. Short listing of measures - applicability review

Measure	Review comment	Applicable?
Do Nothing	No maintenance. Consider further	✓
Maintain Existing Regime	Baseline Condition. Consider further	✓
Do Minimum	Consider further	✓
Planning and development control	To be considered at UoM and Sub-Catchment SSA	✗
Building regulations	To be considered at UoM and Sub-Catchment SSA	✗
Catchment wide SuDS	To be considered at UoM and Sub-Catchment SSA	✗
Land use management	To be considered at UoM and Sub-Catchment SSA	✗
Strategic Development Management	To be considered at UoM and Sub-Catchment SSA	✗
Maintenance programme	Consider further	✓
Upstream storage/storage	Consider further	✓
Tidal barrage/flap valve	Consider further	✓
Improvement of channel conveyance	Consider further	✓
Hard defences	Consider further	✓
Relocation of properties	Consider further	✓
Culverting	Consider further	✓
Diversion of flow	Consider further	✓
Overland floodways	Consider further	✓
Rehabilitation of existing defences	Consider further	✓
Localised protection works	Consider further	✓
Flood warning/forecasting	To be considered at UoM and Sub-Catchment SSA ¹	✗
Public awareness campaign	Consider further	✓
Individual property protection	Consider further	✓
Sealing manholes	Consider further	✓

¹ In order to provide an effective flood warning and forecast system it would require monitoring that will benefit the entire Liffey UoM and therefore should be looked at that SSA. See Liffey Flood Controls and Flood Forecasting System Option Report for more details.

2. Technical Review*

Measure	Review comment	Feasible?
Do Nothing	Measure can continue through screening process	✗
Maintain Existing Regime	Measure can continue through screening process	✓
Do Minimum	Measure unacceptable	✗
Maintenance programme	Consider as a secondary measure	✗
Upstream storage/storage	Measure can continue through screening process	✓
Tidal barrage	Consider as a secondary measure	✗
Improvement of channel conveyance	Consider as a secondary measure	✗
Hard defences	Measure can continue through screening process	✓
Relocation of properties	Consider as a secondary measure	✗
Culverting	Consider as a secondary measure	✗
Diversion of flow	Measure can continue through screening process	✓
Overland floodways	Consider as a secondary measure	✗
Rehabilitation of existing defences	Do not consider any further	✗
Localised protection works	Do not consider any further	✗
Public awareness campaign	Consider as a secondary measure	✗
Individual property protection	Consider as a secondary measure	✗
Sealing manholes	Measure can continue through screening process	✓

* refer to section A1 for further details on review comments

3.1 Environmental Review*

Measure	Review comment	Continue?
Maintain Existing Regime	Measure can continue through screening process	✓
Upstream storage/storage	Measure can continue through screening process	✓
Hard defences	Measure can continue through screening process	✓
Diversion of flow	Measure can continue through screening process	✓!
Sealing manholes	Measure can continue through screening process	✓

* refer to section B2 for further details on review comments with explanation marks

3.2 Social/Cultural Review*

Measure	Review comment	Continue?
Maintain Existing Regime	Measure can continue through screening process	✓
Upstream storage/storage	Measure can continue through screening process	✓
Hard defences	Measure can continue through screening process	✓!
Diversion of flow	Measure can continue through screening process	✓!
Sealing manholes	Measure can continue through screening process	✓

* refer to section B2 for further details on review comments with explanation marks

3.3 Economic Review*

Measure	Construction cost and comment	Continue?
Maintain Existing Regime	No construction cost associated with measure	✓
Upstream storage/storage	Approx €2,050,128 - cost acceptable	✓
Hard defences	Approx €16,947,181 - cost acceptable	✓
Diversion of flow	Approx €43,000,000 ⁺ - cost unacceptable	✗
Sealing manholes	Minimal construction cost to implement measure	✓

* damage available - €31,234,367 ⁺ diversion only protects downstream portion and will still require extensive defences upstream therefore overall BCR will not reach unity

4. List of measure combinations providing 1% AEP flood event standard of protection*

Option

1	Hard defences
2	Hard defences and storage

* refer to section B3 for details of option matrix

5. Economic Review

Option	Damage/Benefit	Construction Cost	pBCR*	Acceptable?
1	€30,440,033	€17,831,705	1.7	✓
2	€30,440,033	€19,059,975	1.6	✓

* BCR is the ratio between the benefit and the construction cost

6. Summary of MCA*

Option	Description	Damage/Benefit	Project whole life cost ⁺	MCA score	BCR	Overall Net Benefit /Cost (€m)
1	Hard defences	€30,440,033	€41,049,267	1562.5	0.74	38
2	Hard defences and storage	€30,440,033	€43,037,370	1317.5	0.71	31

* refer to appendix A4 for the full MCA tables

⁺ costs include for unmeasured items, optimism bias, maintenance, design, supervision and monitoring

7. Assessment of FRM Methods Summary

The assessment has identified two possible options with favourable MCA scores but with BCRs below unity. Both options comprise elements of hard defences and accompanying works including sealing manholes. The addition of upstream storage at Lansdowne Valley Park reduces flow from before reaching Dublin city centre and reduces the length and height of hard defences downstream. However the cost to construct the storage dam in Lansdowne Valley Park outweighs the reduction in cost to the hard defences.

As both options (hard defences with and without storage), have low BCRs and excessively high sections of proposed floodwall downstream (around Kilmainham), it appears that a whole High Priority Watercourse solution is not economically or technically viable.

A more detailed analysis of localised measures may, however, be beneficial. It is therefore envisaged that a subsequent study be commissioned to carry out more detailed examinations of the types of options considered under the CFRAM Study, at a much more localised scale, in order to examine the potential for improving the technical or economic viability of those options, and the feasibility of implementing more localised options.

8. Refinement of options

No preferred options identified from refinement.

9. Updated Potential Options

Post consultation recommendations were considered and the updated Potential FRM options is as follows:

- Hard defences (flood walls and embankments)
- Sealing manholes
- Culvert inlet screens
- Removal of culverts and screens (as per maintenance review)
- Removal of Kearns Place Bridge
- Maintenance Plan

While the recommendations improve the potential FRM option it is still not cost beneficial. Maintaining the existing regime is therefore recommended while further study is ongoing in the Camac area.

Section B1 - Comments on the technical review

Measure	Comment
Do Nothing	Due to the existing flood risk in the River Camac study area the Do Nothing FRM method is deemed unacceptable socially and economically.
Maintain Existing Regime	This measure is to be kept as the baseline condition. DCC and SDCC maintain the Camac. All screens are checked and cleared on a weekly cycle and when bad weather warnings occur. Important structures on the Camac are also monitored..
Do Minimum	This measure is considered unacceptable socially and economically as increased risk and damage may result from a less effective maintenance programme than is currently being implemented with insignificant cost saving.
Maintenance programme	There is currently a high level of maintenance already occurring on the Camac. While measures to improve the maintenance programme would be beneficial in reducing the flood risk there would be limited effect in reducing the overall flood risk. This measure should therefore be placed in the secondary measures list and considered further at detailed design phase or if the primary measures are found to be unsuitable.
Upstream storage/storage	Lansdowne Valley Park has been identified as one potential storage area using the existing topography of the park and controlling flow through the Grand Canal embankment to create further storage. Another storage area at Corkagh Park has been identified requiring a linear dam across the downstream end. A hydraulic model was used to assess the effect of these two storage areas. It was found that the storage at Corkagh had minimal effect on water levels downstream and would need to be combined with another measure such as hard defences to provide the SOP. The effect of adding the Corkagh storage to hard defences would be a slight reduction in length and height of hard defences so this measure should therefore be considered as a secondary option. The Lansdowne Valley Park Storage model found that there is a significant reduction of around 400mm to the water level downstream of the park. This measure will require other measures such as hard defences to be combined with it to provide the SOP but should be considered as a primary measure.
Tidal barrage/Flap valve	The Camac is influenced by the Liffey water levels which are affected by the tide although no receptors are at risk from coastal flooding. A flap valve at the end of the Camac culvert could prevent this influence occurring although the principle source of flood risk is fluvial and therefore will have minimal impact. This measure should therefore be placed in the secondary measures list and considered further if the primary measures are found to be unsuitable.
Improvement of channel conveyance	There are no structures along the main Camac that significantly restrict the flow and cause flood risk. Increasing the conveyance through any of the structures along the Camac would have minimal impact. A twin culvert structure on the Robinhood stream within the Robinhood estate has been identified where increasing the conveyance would reduce the flood risk. However the reduction in flood risk would be localised and would not address all the flood risk in the Robinhood estate. This measure should therefore be placed in the secondary measures list and considered further if the primary measures are found to be unsuitable.
Hard defences	Hard defences would consist of flood walls and earth embankments located where the river banks are low relative to water level. Approximately 8.5km of flood defence would be required and could be implemented either without the need of any additional measures or along with certain other measures.
Relocation of properties	572 properties would be required to be relocated. It is considered that this would be an excessively socially complex measure to implement in practice and while technically feasible should be placed in the secondary measures list and considered further, in localised places, only if the primary measures are found to be unsuitable.
Culverting	This measure is feasible but is considered an excessively technically complex measure to implement in practice due to the numerous existing culverts, bridges, weirs and utility services to remove or incorporate some of which have archaeological significance. The pumping of the Camac during construction in restricted spaces would add to the complexity also while dealing with large flows.

Measure	Comment
Diversion of flow	A suitable diversion route has been identified from the Camac to the Liffey diverting at a park on the Tyrconnell Road and then following the Tyrconnell Road, Sarsfield Road and Memorial Road before entering Memorial Park and discharging downstream of the weir on the Liffey. In order to be effective the flow needs to be reduced to less than the 20%AEP flood event. This will require a flow of 25 cumecs to be diverted. At the location of the flow diversion the 1%AEP event flow is approx 50 cumecs. The diversion route is approximately 1km and falls 8m. A 5m x 3m box culvert or equivalent other would be required to convey 25 cumecs of water. Flow diversion will reduce the flood risk significantly but not entirely during the design event and therefore this measure will need to be used along with another measure.
Overland floodways	Overland floodways may be feasible in certain localised areas along the Camac however this measure is deemed to be an excessively technically complex measure to implement in practice due to the heavily urbanised nature of the catchment. Finding suitable roads to use as floodways without increasing the flood risk or disruption to traffic and property owners/users would be technically and socially difficult as would finding a suitable discharge point back into the Camac. This measure would reduce the flood risk along particular reaches of the river and would therefore have limited impact. This measure should therefore be placed in the secondary measures list and considered further, in localised places, only if the primary measures are found to be unsuitable.
Rehabilitation of existing defences	Existing defences, which are all flood walls, are located at Lady's Lane and in the Robinhood Industrial Estate. The defence at Lady's Lane and Diageo are relatively new and do not require rehabilitation. The walls in Robinhood estate have gaps throughout, are missing cover causing the reinforcement to be exposed leaving the potential for cracks forming and further deterioration and the foundation quality is unknown. All things considered it is questionable whether anything other than full removal and replacement with new flood walls would be suitable. As this is incorporated into another measure this measure should be rejected as unsuitable.
Localised protection works	Along certain reaches of the Camac low river banks result in a flood risk. There is potential to infill in these gaps albeit with limited impact on the overall flood risk. This measure should therefore be placed in the secondary measures list and considered further, in localised places, only if the primary measures are found to be unsuitable.
Public awareness campaign	The public awareness campaign could be effective in reducing the impact of flooding but will not reduce the flood risk itself. This measure should be kept as a possible Unit of Management 09 scale measure in order to minimise impact and address residual flood risk. This measure should therefore be placed in the secondary measures list and considered further, through MCA, at plan stage.
Individual property protection	It would be deemed to be ineffective to implement this measure for all 527 properties as the full standard of flood protection could not be assured and a high social impact would still remain. This measure may become effective on a local scale where isolated properties could benefit from it. This measure should therefore be placed in the secondary measures list and considered further, in localised places, only if the primary measures are found to be unsuitable.
Sealing manholes	The Robinhood stream flows through a culvert before joining the Camac River. Out of manhole flooding occurs along the John F Kennedy Drive. This is due to high flow being conveyed through the culvert and not from water backing up from the Camac. No flow attenuating measure is available to the Robinhood stream upstream of this location therefore sealing manholes will be required to address this flood risk. This measure will therefore be required for all FRM options being considered further.

Section B2 - Comments on the environmental and social review

Environmental review – presence or absence of Natura 2000 site within or directly adjacent to footprint of measure

Social/cultural review – presence or absence of Unesco site within or directly adjacent to footprint of measure

Measure	Environmental Comment	Social Comment
Hard defences	No internationally designated sites	Potential impacts to the tentative Unesco designation in the Camac catchment must be considered. Downstream flood walls are in the order of 4m in height which would result in social issues in terms of residual flood risk and also the community being cut-off from the watercourse.
Diversion of flow	Potential impacts to Natura 2000 sites in or directly adjacent to the receiving catchment must be considered.	Potential impacts to Unesco sites in or directly adjacent to the receiving catchment must be considered.

Section B3 - Developing potential FRM options

Full list of measures after stage 4 review

FRM Method		Abbreviation
Maintain Existing Regime	Baseline	ER
Upstream storage/storage	Current flood risk	S
Hard defences	Current flood risk	D
Sealing manholes	Current flood risk	SM

Notes:

- Hard defences will be required to some degree for all options as no other option can provide the required SOP (Standard of Protection) alone.
- Sealing manholes will be required for all options and this is the only measure to address the flooding along the John F Kennedy Drive.
- All options must provide the preferred SOP (1% AEP Event).
- The baseline FRM method will carry on through the process for comparative purposes

Potential FRM options can consist of a single or multiple FRM methods. The tables below display the matrices used to identify the various FRM methods other than the baseline condition. Each table identifies FRM options with one, two and three FRM methods respectively. An "x" denotes where a combination of FRM methods is unacceptable by failing the meeting the requirements as set out in the bullet points above. A "o" denotes an acceptable FRM option to be assessed further. Where a box has been greyed out it is due to the FRM option already being considered elsewhere in the matrix or where same FRM method is being considered twice.

1 FRM Method	S	D	SM
	x	x	x

2 FRM Methods	S	D	SM
S			
D	x		
SM	x	o	

3 FRM Methods	D SM
S	o
D	x
SM	x

Potential FRM Options

	FRM Methods		
Baseline Option	Maintain Existing Regime		
Option 1	Hard defences	Sealing manholes	
Option 2	Hard defences	Sealing manholes	Upstream storage/storage

CRITERIA	OBJECTIVE	SUB-OBJECTIVE	INDICATOR	BASIC REQUIREMENT	ASPIRATIONAL TARGET	GLOBAL WEIGHTING	LOCAL WEIGHTING	LOCAL WEIGHTING COMMENT	SCORE	SCORE COMMENT			WEIGHTED SCORE
							Local Importance	International Importance		Does not meet Basic Requirement	Meets Basic Requirement	Meets Aspirational Target	
							1	5	-5		0	5	
1	Technical	a	Ensure flood risk management options are operationally robust	i) Ensure flood risk management options are operationally robust	Level of operational risk of option • Degree of reliance on mechanical, electrical or electronic systems or on human intervention, action or decision, for the option to operate or perform successfully • Non-numeric	Manageable degree of operational risk, i.e., degree of reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision can be met and is acceptable given the risks / consequences of failure			Constant at 5			For the majority of this option there is no operational risk minimal maintenance will be required for the flood embankments	
							20	5		4			400
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	i) Minimise health and safety risks associated with the construction and operation of flood risk management options	Degree of health and safety risk during construction and operation	Acceptable and manageable level of health and safety risk	No risk to health and safety during either construction or operation		Constant at 5			Options involved: construction work (heavy plant) (-1) restricted access (-1) Working near water (-1) Deep excavations/working at height (-1)	100
		c	Ensure flood risk management options are adaptable to future flood risk	i) Ensure flood risk management options are adaptable to future flood risk	Sustainability and adaptability of the flood risk management measure in the face of potential future changes, including the potential impacts of climate change	Option to provide for, or be adaptable to, the MRFS in terms of maintaining the standard of protection OR Option avoids any additional flood risk under the MRFS	Option to provide for, or be adaptable to, the HEFS in terms of maintaining the standard of protection OR Option avoids any additional flood risk under the HEFS		Constant at 5			0 - option adaptable to MRFS with difficulty 1 - option adaptable to MRFS 2 - option provides MRFS 3 - option adaptable to HEFS with difficulty 4 - option adaptable to HEFS 0 5 - option provides HEFS	0
2	Economic	a	Minimise economic risk	i) Minimise economic risk	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	AAD is not increased	100% reduction in AAD		Constant at 5			Scoring considers the percentage of AAD under the scheme option during the 1% AEP event compared to the AAD during the 0.1% AEP event with a max score of 5 for 100%	450
		b	Minimise risk to transport infrastructure	i) Minimise risk to transport infrastructure	Number of transport routes (road, rail, navigation) at risk from flooding (0.1% AEP Event)	No increase in the number of transport routes at risk	All transportation routes protected		Up to a Regional road at risk (Inc Luas line) National Primary - 5 National Secondary - 4 Regional - 3 Third Class - 2 Minor Road - 1			Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	90
		c	Minimise risk to utility infrastructure	i) Minimise risk to utility infrastructure	Number of utility infrastructure assets (power stations, WWTWs, WTWs, telecom exchanges, etc) at risk from flooding (0.1% AEP Event)	No increase in the number of utility infrastructure assets at risk	All utility infrastructure assets protected		1 ESB substation at risk with a "low" vulnerability			Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
		d	Manage Risk to Agricultural Land	i) Manage Risk to Agricultural Land	Area of agricultural land at risk from flooding (based on CORINE data or other)	No increase on agricultural land at risk	All agricultural land protected		No significant area of agricultural land at risk			Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
							10	1		0			
3	Social	a	Minimise risk to human health and life	i) Minimise risk to human health and life of residents	Number of residential properties at risk from flooding (0.1% AEP Event)	No additional (or substitution of) residential properties at risk from flooding	No residential properties at risk from flooding		due to high population			Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	300
				ii) Minimise risk to high vulnerability properties	Number of high vulnerability properties (hospitals, residential homes for the sick, elderly, infirm and children) at risk from flooding (0.1% AEP Event)	No additional (or substitution of) vulnerable properties at risk from flooding	No vulnerable properties at risk from flooding		No high vulnerability properties at risk during the 1% AEP event			Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
		b	Minimise risk to community	i) Minimise risk to social infrastructure	Number of high value soical infrastructural assets (first responders, govt buildings) at risk from flooding (0.1% AEP Event)	No additional (or substitution of) high value social infrastructural assets at risk from flooding	No high value social infrastructural assets at risk from flooding		no first reponders, no major govt offices at risk during the 1% AEP event			Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
				ii) Minimise risk to local employment	Number of non-residential properties (fire stations, Garda stations) at risk from flooding (0.1% AEP Event)	No additional (or substitution of) non-residential properties at risk from flooding	No non-residential properties at risk from flooding		high density of commerical activity			Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	100
		c	Minimise risk to flood-sensitive social amenity sites	i) Minimise risk to flood-sensitive social amenity sites	Number of amenity sites at risk from flooding (0.1% AEP Event)	No additional (or substitution of) amenity sites at risk from flooding	No amenity sites at risk from flooding		1 community centre, 2 sports club/leisure centre and playing fields at risk			Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
							5	3		0			
4	Environmental	a	Support the objectives of the WFD	i) Prevent deterioration in status, and if possible contribute to the achievement of good ecological status / potential of water-bodies	Ecological status of water bodies	Provide no constraint associated with flood risk management options to the achievement of good status/potential	Significant contribution of flood risk management options to the achievement of good status/potential		WFD objectives must be achieved in all water bodies so this objective should always have the maximum local weighting			Reduction in flooding will reduce input of contaminants from the catchment which could have benefits for water status	150
		b	Minimise the risk to potential sources of environmental pollution	i) Minimise the risk to potential sources of environmental pollution	Number of potential pollution sources at risk from flooding (including those licensed under Directives 96/61/EC and 92/271/EC)	No additional (or substitution of) potential pollution sources at risk from flooding due to the implementation of the flood risk management option	No potential pollution sources at risk from flooding due to the implementation of the flood risk management option		No receptors in 1% AEP flood extent			Achieves basic target in that no additional receptors are put at risk	0
		c	Support the objectives of the Habitats Directive	i) Avoid damage to, and where possible enhance, European protected Natura 2000 sites	Reported conservation status of Natura 2000 sites relating to flood risk management	No deterioration in conservation status of Natura 2000 sites due to the implementation of the flood risk management option	Improvement in conservation status of Natura 2000 sites due to the implementation of the flood risk management option		No receptors in 1% AEP flood extent, AA has screened out any impacts			Achieves basic target in that no additional receptors are affected	0
		d	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	i) Avoid loss/damage to, and where possible enhance, nationally protected sites of nature conservation importance i.e. (p)NHA, Ramsar	Reported conservation status of designated sites relating to flood risk management	No deterioration in conservation status of sites due to the implementation of the flood risk management option	Improvement in conservation status of sites due to the implementation of the flood risk management option		2 PNHAS. Grand Canal and Slade of Saggart and Crooksling Glen.			Option does not impact directly on either pNHA site. Potential positive impacts to canal due to reduced flooding	15
				ii) Avoid loss / damage and where possible enhance, legally protected species and other known species of conservation concern	Presence and/or extent of suitable habitat supporting legally protected species and other known species of conservation concern ("target species")	No loss of integrity of suitable habitat supporting legally protected species and other known species of conservation concern due to the implementation of the flood risk management option	No loss of suitable habitat supporting legally protected species and other known species of conservation concern due to the implementation of the flood risk management option		Habitats of interest in catchment and within 1% AEP including trees and woodland with protection objectives in development plan			Habitat protected from flooding and not impacted by walls.	22.5
		e	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	Area of suitable habitat supporting salmonid and other fisheries and number of upstream barriers	No loss of integrity of fisheries habitat, maintenance of upstream accessibility	No loss of fisheries habitat, improvement in habitat quality and/or quality, enhanced upstream accessibility		River culverted for significant stretches in lower reaches. Fishery habitat and fish are present including brown trout. Stocking has taken place.			Walls could affect access and care should be taken to avoid in-stream works and hydromorphological changes	-15
				ii) Protect, and where possible enhance, the quality of shellfish waters	Classification of shellfish waters	No deterioration in shellfish water quality parameter values due to the implementation of the flood risk management option	Improvement in shellfish water quality parameter values due to the implementation of the flood risk management option		Nearest shellfish area is geographically remote at the other side of Howth Head			Achieves basic target in that receptors are not negatively affected by implementation of the option	0
		f	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	i) Protect, and where possible enhance, visual amenity	Compliance with Landscape Character Objectives for the catchment	Protection of the Landscape Character of the Catchment	Enhancement of the Landscape Character within the Catchment		Landscape objectives outlined in development plans			Walls are likely to have a negative effect on landscape and views	-45
		g	Avoid damage to or loss of features of cultural heritage importance and their setting	i) Avoid damage to or loss of features of architectural value and their setting	No. of Architectural Conservation Areas (ACAs), Record of Protected Structures (RPS) in the County Development Plans and NIAH sites of regional and above rating at risk from flooding .	No additional architectural areas / structures at risk from flooding and no detrimental impacts on the architectural heritage setting as a result of implementation of the option.	No architectural heritage at risk from flooding and enhanced protection of sites due to the implementation of the option.		NIAH and ACA in 1% AEP flood extent.			Both NIAH and ACA protected from flooding. However walls could impact on ACA.	-10
				ii) Avoid damage to or loss of features of archaeological value and their setting	Number of UNESCO World Heritage Sites (including candidate UNESCO World Heritage Sites), National Monuments including Temporary Preservation Orders and Register of Historic Monuments, Potential National Monuments in Local Authority Ownership where known), and Recorded Archaeological Sites/Monuments (RMP sites) at risk from flooding .	No additional archaeological sites / features at risk from flooding and no detrimental impacts on the archaeological heritage setting as a result of implementation of the option.	No archaeological heritage at risk from flooding and enhanced protection of sites due to the implementation of the option.		Parts of catchment are proposed unesco site, 3 SMR features in 1% AEP. Archeological objectives in development plans.			All features will be prevented from flooded. One SMR is in close proximity to the walls. Also walls could affect potential Unesco area.	-10
		h	Protect soil function	i) Avoid loss of soil from erosion	The area of land which is at risk or currently experiencing erosion from flooding	No increase in the quantity of land at risk from soil erosion from flooding	A reduction in the quantity of land at risk from soil erosion		Rural areas upstream.			Reduced flooding and walls will reduce risk of erosion	20
		i	Minimise detrimental impacts of climate change on the environment resulting from flood risk management activities	i) Minimise detrimental impacts of climate change on the environment resulting from flood risk management activities	Number of flood sensitive environmental receptors at risk during climate change flood events	No increase in number of environmental receptors at risk during the MRFS	Reduction in number of environmental receptors at risk during the HEFS		2 additional environmental receptors are at risk during the MRFS and 4 in the HEFS			Where the environmental receptors are located there are no proposed defences	-5
							5	1		-1			1562.5

CRITERIA	OBJECTIVE	SUB-OBJECTIVE	INDICATOR	BASIC REQUIREMENT	ASPIRATIONAL TARGET	GLOBAL WEIGHTING	LOCAL WEIGHTING	LOCAL WEIGHTING COMMENT	SCORE	SCORE COMMENT			WEIGHTED SCORE
							Local Importance 1	International Importance 5		Does not meet Basic Requirement -5	Meets Basic Requirement 0	Meets Aspirational Target 5	
1	Technical	a	Ensure flood risk management options are operationally robust	i) Ensure flood risk management options are operationally robust	Level of operational risk of option • Degree of reliance on mechanical, electrical or electronic systems or on human intervention, action or decision, for the option to operate or perform successfully • Non-numeric	Manageable degree of operational risk, i.e., degree of reliance on mechanical, electrical or electronic systems, or on human intervention, action or decision can be met and is acceptable given the risks / consequences of failure	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	20	5	Constant at 5	2	For the majority of this option there is no operational risk however the dam across Lansdowne Park will require regular maintenance along with maintenance of proposed embankments.	200
		b	Minimise health and safety risks associated with the construction and operation of flood risk management options	i) Minimise health and safety risks associated with the construction and operation of flood risk management options	Degree of health and safety risk during construction and operation	Acceptable and manageable level of health and safety risk	No risk to health and safety during either construction or operation	20	5	Constant at 5	1	Options involved: construction work (heavy plant) (-1) restricted access (-1) Working near water (-1) Deep excavations/working at height (-1)	100
		c	Ensure flood risk management options are adaptable to future flood risk	i) Ensure flood risk management options are adaptable to future flood risk	Sustainability and adaptability of the flood risk management measure in the face of potential future changes, including the potential impacts of climate change	Option to provide for, or be adaptable to, the MRFS in terms of maintaining the standard of protection OR Option avoids any additional flood risk under the MRFS	Option to provide for, or be adaptable to, the HEFS in terms of maintaining the standard of protection OR Option avoids any additional flood risk under the HEFS	20	5	Constant at 5	0	0 - option adaptable to MRFS with difficulty 1 - option adaptable to MRFS 2 - option provides MRFS 3 - option adaptable to HEFS with difficulty 4 - option adaptable to HEFS 5 - option provides HEFS	0
2	Economic	a	Minimise economic risk	i) Minimise economic risk	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	AAD is not increased	100% reduction in AAD	30	5	Constant at 5	3	Scoring considers the percentage of AAD under the scheme option during the 1% AEP event compared to the AAD during the 0.1% AEP event with a max score of 5 for 100%	450
		b	Minimise risk to transport infrastructure	i) Minimise risk to transport infrastructure	Number of transport routes (road, rail, navigation) at risk from flooding (0.1% AEP Event)	No increase in the number of transport routes at risk	All transportation routes protected	10	3	Up to a Regional road at risk (Inc Luas line) National Primary - 5 National Secondary - 4 Regional - 3 Third Class - 2 Minor Road - 1	3	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	90
		c	Minimise risk to utility infrastructure	i) Minimise risk to utility infrastructure	Number of utility infrastructure assets (power stations, WWTWs, WTWs, telecom exchanges, etc) at risk from flooding (0.1% AEP Event)	No increase in the number of utility infrastructure assets at risk	All utility infrastructure assets protected	10	2	1 ESB substation at risk with a "low" vulnerability	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
		d	Manage Risk to Agricultural Land	i) Manage Risk to Agricultural Land	Area of agricultural land at risk from flooding (based on CORINE data or other)	No increase on agricultural land at risk	All agricultural land protected	10	1	No significant area of agricultural land at risk	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
3	Social	a	Minimise risk to human health and life	i) Minimise risk to human health and life of residents	Number of residential properties at risk from flooding (0.1% AEP Event)	No additional (or substitution of) residential properties at risk from flooding	No residential properties at risk from flooding	30	5	due to high population	2	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	300
				ii) Minimise risk to high vulnerability properties	Number of high vulnerability properties (hospitals, residential homes for the sick, elderly, infirm and children) at risk from flooding (0.1% AEP Event)	No additional (or substitution of) vulnerable properties at risk from flooding	No vulnerable properties at risk from flooding	10	1	No high vulnerability properties at risk during the 1% AEP event	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
		b	Minimise risk to community	i) Minimise risk to social infrastructure	Number of high value soical infrastructural assets (first responders, govt buildings) at risk from flooding (0.1% AEP Event)	No additional (or substitution of) high value social infrastructural assets at risk from flooding	No high value social infrastructural assets at risk from flooding	5	1	no first responders, no major govt offices at risk during the 1% AEP event	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
				ii) Minimise risk to local employment	Number of non-residential properties (fire stations, Garda stations) at risk from flooding (0.1% AEP Event)	No additional (or substitution of) non-residential properties at risk from flooding	No non-residential properties at risk from flooding	10	5	high density of commerical activity	2	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	100
		c	Minimise risk to flood-sensitive social amenity sites	i) Minimise risk to flood-sensitive social amenity sites	Number of amenity sites at risk from flooding (0.1% AEP Event)	No additional (or substitution of) amenity sites at risk from flooding	No amenity sites at risk from flooding	5	3	1 community centre, 2 sports club/leisure centre and playing fields at risk	0	Scoring considers the percentage of receptors protected under the scheme option during the 1% AEP event compared to the existing receptors at risk during the 0.1% AEP event with a max score of 5 for 100%	0
4	Environmental	a	Support the objectives of the WFD	i) Prevent deterioration in status, and if possible contribute to the achievement of good ecological status / potential of water-bodies	Ecological status of water bodies	Provide no constraint associated with flood risk management options to the achievement of good status/potential	Significant contribution of flood risk management options to the achievement of good status/potential	10	5	WFD objectives must be achieved in all water bodies so this objective should always have the maximum local weighting	3	Reduction in flooding will reduce input of contaminants from the catchment which could have benefits for water status	150
		b	Minimise the risk to potential sources of environmental pollution	i) Minimise the risk to potential sources of environmental pollution	Number of potential pollution sources at risk from flooding (including those licensed under Directives 96/61/EC and 92/271/EC)	No additional (or substitution of) potential pollution sources at risk from flooding due to the implementation of the flood risk management option	No potential pollution sources at risk from flooding due to the implementation of the flood risk management option	10	1	No receptors in 1% AEP flood extent	0	Achieves basic target in that no additional receptors are put at risk	0
		c	Support the objectives of the Habitats Directive	i) Avoid damage to, and where possible enhance, European protected Natura 2000 sites	Reported conservation status of Natura 2000 sites relating to flood risk management	No deterioration in conservation status of Natura 2000 sites due to the implementation of the flood risk management option	Improvement in conservation status of Natura 2000 sites due to the implementation of the flood risk management option	10	1	No receptors in 1% AEP flood extent, AA has screened out any impacts	0	Achieves basic target in that no additional receptors are affected	0
		d	Avoid damage to, and where possible enhance, the flora and fauna of the catchment	i) Avoid loss/damage to, and where possible enhance, nationally protected sites of nature conservation importance i.e. (p)NHA, Ramsar	Reported conservation status of designated sites relating to flood risk management	No deterioration in conservation status of sites due to the implementation of the flood risk management option	Improvement in conservation status of sites due to the implementation of the flood risk management option	2.5	3	2 PNHAS. Grand Canal and Slade of Saggart and Crooksling Glen.	2	Option does not impact directly on either pNHA site. Potential positive impacts to canal due to reduced flooding	15
				ii) Avoid loss / damage and where possible enhance, legally protected species and other known species of conservation concern ("target species")	Presence and/or extent of suitable habitat supporting legally protected species and other known species of conservation concern ("target species")	No loss of integrity of suitable habitat supporting legally protected species and other known species of conservation concern due to the implementation of the flood risk management option	No loss of suitable habitat supporting legally protected species and other known species of conservation concern due to the implementation of the flood risk management option	2.5	3	Habitats of interest in catchment and within 1% AEP including trees and woodland with protection objectives in development plan	-1	Habitat protected from flooding and not impacted by walls but could be negatively impacted by storage (loss of habitats area due to footprint of dam structure as well as intermittent drowning of parkland).	-7.5
		e	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	Area of suitable habitat supporting salmonid and other fisheries and number of upstream barriers	No loss of integrity of fisheries habitat, maintenance of upstream accessibility	No loss of fisheries habitat, improvement in habitat quality and/or quality, enhanced upstream accessibility	2.5	3	River culverted for significant stretches in lower reaches. Fishery habitat and fish are present including brown trout. Stocking has taken place.	-2	Walls could affect access and care should be taken to avoid in-stream works and hydromorphological changes	-15
				ii) Protect, and where possible enhance, the quality of shellfish waters	Classification of shellfish waters	No deterioration in shellfish water quality parameter values due to the implementation of the flood risk management option	Improvement in shellfish water quality parameter values due to the implementation of the flood risk management option	2.5	1	Nearest shellfish area is geographically remote at the other side of Howth Head	0	Achieves basic target in that receptors are not negatively affected by implementation of the option	0
		f	Protect, and where possible enhance, landscape character and visual amenity within the river corridor	i) Protect, and where possible enhance, visual amenity	Compliance with Landscape Character Objectives for the catchment	Protection of the Landscape Character of the Catchment	Enhancement of the Landscape Character within the Catchment	5	3	Landscape objectives outlined in development plans	-4	Walls are likely to have a negative effect on landscape and views. The dam structure associated with the storage is also likely to have a negative effect on the landscape of the park as well as views.	-60
		g	Avoid damage to or loss of features of cultural heritage importance and their setting	i) Avoid damage to or loss of features of architectural value and their setting	No. of Architectural Conservation Areas (ACAs), Record of Protected Structures (RPS) in the County Development Plans and NIAH sites of regional and above rating at risk from flooding .	No additional architectural areas / structures at risk from flooding and no detrimental impacts on the architectural heritage setting as a result of implementation of the option.	No architectural heritage at risk from flooding and enhanced protection of sites due to the implementation of the option.	2.5	4	NIAH and ACA in 1% AEP flood extent.	-1	Both NIAH and ACA protected from flooding. However walls could impact on ACA.	-10
				ii) Avoid damage to or loss of features of archaeological value and their setting	Number of UNESCO World Heritage Sites (including candidate UNESCO World Heritage Sites), National Monuments including Temporary Preservation Orders and Register of Historic Monuments, Potential National Monuments in Local Authority Ownership where known), and Recorded Archaeological Sites/Monuments (RMP sites) at risk from flooding .	No additional archaeological sites / features at risk from flooding and no detrimental impacts on the archaeological heritage setting as a result of implementation of the option.	No archaeological heritage at risk from flooding and enhanced protection of sites due to the implementation of the option.	2.5	4	Parts of catchment are proposed unesco site, 3 SMR features in 1% AEP. Archeological objectives in development plans.	-1	All features will be prevented from flooded. SMR is in close proximity to the walls and embankment. Also walls could affect potential Unesco area.	-10
		h	Protect soil function	i) Avoid loss of soil from erosion	The area of land which is at risk or currently experiencing erosion from flooding	No increase in the quantity of land at risk from soil erosion from flooding	A reduction in the quantity of land at risk from soil erosion	5	2	Rural areas upstream.	2	Reduced flooding and walls will reduce risk of erosion. Storage could have erosion implications.	20
		i	Minimise detrimental impacts of climate change on the environment resulting from flood risk management activities	i) Minimise detrimental impacts of climate change on the environment resulting from flood risk management activities	Number of flood sensitive environmental receptors at risk during climate change flood events	No increase in number of environmental receptors at risk during the MRFS	Reduction in number of environmental receptors at risk during the HEFS	5	1	2 additional environmental receptors are at risk during the MRFS and 4 in the HEFS	-1	Where the environmental receptors are located there are no proposed defences	-5
													1317.5

Appendix C

Costing of Options

Costing of: Option 1 Hard Defences

Construction Costs

Costing of walls and embankments

Cost of walls and embankments based on previous schemes in association with RPS

Shapefile ID:

Option1_HardD

ef	Type	Length	Height	Freeboard	Height with FB	Cost £/m2007	Cost €/m 2013
H9CC_Opt1_01	Wall	233.28	1.76	0.30	2.06	403,454.18	570,887.67
H9CC_Opt1_02	Wall	231.06	1.70	0.30	2.00	391,981.63	554,654.01
H9CC_Opt1_03	Wall	70.83	0.84	0.30	1.14	86,621.29	122,569.12
H9CC_Opt1_04	Wall	163.24	0.78	0.30	1.08	194,241.11	274,851.17
H9CC_Opt1_05	Embankment	426.87	0.57	0.50	1.07	72,356.80	102,384.87
H9CC_Opt1_06	Embankment	369.27	0.97	0.50	1.47	81,753.98	115,681.88
H9CC_Opt1_07	Embankment	597.48	0.91	0.50	1.41	127,601.22	180,555.72
H9CC_Opt1_08	Embankment	66.43	0.22	0.50	0.72	8,264.08	11,693.67
H9CC_Opt1_09	Wall	84.07	1.09	0.30	1.39	114,385.02	161,854.80
H9CC_Opt1_10	Wall	130.15	0.70	0.30	1.00	149,134.25	211,024.97
H9CC_Opt1_11	Wall	170.41	0.81	0.30	1.11	205,587.53	290,906.35
H9CC_Opt1_12	Wall	60.95	0.26	0.30	0.56	55,074.84	77,930.90
H9CC_Opt1_13	Wall	109.75	0.17	0.30	0.47	93,732.46	132,631.43
H9CC_Opt1_14	Wall	29.00	0.53	0.30	0.83	30,515.68	43,179.69
H9CC_Opt1_15	Wall	71.65	0.80	0.30	1.10	86,046.13	121,755.27
H9CC_Opt1_16	Wall	197.70	2.32	0.30	2.62	402,875.50	570,068.84
H9CC_Opt1_17	Embankment	350.86	0.98	0.50	1.48	78,135.52	110,561.76
H9CC_Opt1_18	Embankment	177.82	0.99	0.50	1.49	39,854.08	56,393.53
H9CC_Opt1_19	Embankment	234.18	0.40	0.50	0.90	34,544.99	48,881.16
H9CC_Opt1_20	Embankment	72.13	0.58	0.50	1.08	12,348.05	17,472.49
H9CC_Opt1_21	Wall	70.42	0.95	0.30	1.25	90,384.82	127,894.52
H9CC_Opt1_22	Wall	737.98	0.79	0.30	1.09	882,193.89	1,248,304.35
H9CC_Opt1_23	Wall	283.97	1.49	0.30	1.79	448,907.35	635,203.90
H9CC_Opt1_24	Wall	288.89	0.91	0.30	1.21	364,431.06	515,669.95
H9CC_Opt1_25	Wall	164.43	1.12	0.30	1.42	226,438.23	320,410.09
H9CC_Opt1_26	Wall	90.55	1.80	0.30	2.10	158,599.06	224,417.66
H9CC_Opt1_27	Wall	41.19	1.18	0.30	1.48	58,083.88	82,188.70
H9CC_Opt1_28	Wall	141.54	2.50	0.30	2.80	302,459.33	427,979.95
H9CC_Opt1_29	Wall	91.54	1.90	0.30	2.20	165,373.11	234,002.94
H9CC_Opt1_30	Wall	96.64	1.44	0.30	1.74	150,110.66	212,406.59
H9CC_Opt1_31	Wall	109.90	1.04	0.30	1.34	146,503.66	207,302.68
H9CC_Opt1_32	Wall	76.66	2.67	0.30	2.97	170,991.45	241,952.89
H9CC_Opt1_33	Wall	29.36	1.31	0.30	1.61	43,503.34	61,557.22
H9CC_Opt1_34	Wall	98.58	4.33	0.30	4.63	309,983.68	438,626.90
H9CC_Opt1_35	Wall	85.04	2.14	0.30	2.44	164,867.65	233,287.72
H9CC_Opt1_36	Wall	182.08	1.93	0.30	2.23	331,947.16	469,705.23
H9CC_Opt1_37	Wall	100.30	3.00	0.30	3.30	241,944.69	342,351.73
H9CC_Opt1_38	Wall	37.69	3.52	0.30	3.82	101,707.01	143,915.42
H9CC_Opt1_39	Wall	37.65	1.95	0.30	2.25	69,053.71	97,711.00
H9CC_Opt1_40	Wall	131.61	1.87	0.30	2.17	235,588.35	333,357.52
H9CC_Opt1_41	Wall	567.98	1.17	0.30	1.47	797,807.10	1,128,897.05
H9CC_Opt1_42	Wall	51.54	0.66	0.30	0.96	57,922.77	81,960.71
H9CC_Opt1_43	Wall	113.52	0.52	0.30	0.82	118,828.09	168,141.75
H9CC_Opt1_44	Wall	65.59	1.22	0.30	1.52	93,935.94	132,919.36
H9CC_Opt1_45	Wall	302.56	0.68	0.30	0.98	343,361.03	485,855.86
H9CC_Opt1_46	Wall	80.71	0.30	0.30	0.60	74,707.63	105,711.29
H9CC_Opt1_47	Wall	81.92	0.27	0.30	0.57	74,474.52	105,381.45
H9CC_Opt1_48	Wall	191.94	1.64	0.30	1.94	319,275.77	451,775.21
H9CC_Opt1_49	Wall	291.07	0.23	0.30	0.53	258,205.11	365,360.23
H9CC_Opt1_50	Wall	40.30	0.01	0.30	0.31	30,868.21	43,678.52
H9CC_Opt1_51	Wall	84.45	4.47	0.30	4.77	272,061.62	384,967.20
H9CC_Opt1_52	Wall	96.43	2.14	0.30	2.44	186,949.52	264,533.57
H9CC_Opt1_53	Wall	57.04	2.92	0.30	3.22	135,080.04	191,138.26
H9CC_Opt1_54	Wall	67.58	3.32	0.30	3.62	174,923.90	247,517.32
H9CC_Opt1_55	Wall	65.22	3.71	0.30	4.01	182,819.86	258,690.10
H9CC_Opt1_56	Wall	65.47	3.51	0.30	3.81	176,311.28	249,480.46
H9CC_Opt1_57	Wall	93.80	2.65	0.30	2.95	208,189.61	294,588.30
H9CC_Opt1_58	Wall	69.53	2.83	0.30	3.13	161,213.01	228,116.41
H9CC_Opt1_59	Wall	59.59	1.69	0.30	1.99	100,763.34	142,580.12
H9CC_Opt1_60	Wall	55.63	3.57	0.30	3.87	151,649.82	214,584.49

H9CC_Opt1_61	Wall	104.61	1.71	0.30	2.01	178,041.56	251,928.80
Shapefile ID:							
Option1_HardDef							
ef	Type	Length	Height	Freeboard	Height with FB	Cost £/m2007	Cost €/m 2013
H9CC_Opt1_62	Wall	120.34	1.59	0.30	1.89	196,862.42	278,560.33
H9CC_Opt1_63	Wall	44.13	3.37	0.30	3.67	115,440.85	163,348.80
H9CC_Opt1_64	Wall	85.04	3.09	0.30	3.39	209,348.32	296,227.87
H9CC_Opt1_65	Wall	86.55	1.97	0.30	2.27	159,694.06	225,967.09
H9CC_Opt1_66	Wall	60.07	2.43	0.30	2.73	126,049.49	178,360.03
H9CC_Opt1_67	Wall	80.21	2.41	0.30	2.71	167,427.55	236,909.98
H9CC_Opt1_68	Wall	137.07	2.17	0.30	2.47	268,002.63	379,223.73
						17,930,590.58	

Costing of sealing of manholes

Approximately €1000 per manhole required

Number of manholes to be sealed	7
Cost of sealing manholes €	7,000.00

Project Whole Life Cost

Construction cost	€17,937,590.58
Provision for unmeasured items (20%)	€3,587,518.12
Provision for optimism bias (60%)	€10,762,554.35
Maintenance costs (NPV over 50yrs)	€600,000.00
Detailed design (design fees) (6%)	€1,076,255.43
Construction supervision (5%)	€896,879.53
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€3,766,894.02
Cost of land acquisition/compensation (12.5%)	€2,242,198.82
Allowance for art (1%)	€179,375.91
Project Whole Life Cost	€41,049,266.75

Summary

Total Damage/Benefit	30,440,033.00
Total Construction Cost	€17,937,590.58
Project Whole Life Cost	€41,049,266.75
BCR	0.74
MCA score	1762.5
MCA BCR	42.94

Costing of: Option 2 Hard Defences and Storage

Construction Costs

Costing of walls and embankments

Cost of walls and embankments based on previous schemes in association with RPS

Shapefile ID: Option 2 Hard Defences and Storage								
	Type	Length	Height	Freeboard	Height with FB	Cost £/m2007	Cost €/m2013	
H9CC_Opt2_01	Wall	233.28	1.37	0.30	1.67	353,362.39	500,007.78	
H9CC_Opt2_02	Wall	231.06	1.70	0.30	2.00	391,981.63	554,654.01	
H9CC_Opt2_03	Wall	70.83	0.84	0.30	1.14	86,621.29	122,569.12	
H9CC_Opt2_04	Wall	163.24	0.78	0.30	1.08	194,241.11	274,851.17	
H9CC_Opt2_05	Embankment	426.87	0.57	0.50	1.07	72,356.80	102,384.87	
H9CC_Opt2_06	Embankment	369.27	0.97	0.50	1.47	81,753.98	115,681.88	
H9CC_Opt2_07	Embankment	597.48	0.91	0.50	1.41	127,601.22	180,555.72	
H9CC_Opt2_08	Embankment	66.43	0.22	0.50	0.72	8,264.08	11,693.67	
H9CC_Opt2_09	Wall	84.07	1.09	0.30	1.39	114,385.02	161,854.80	
H9CC_Opt2_10	Wall	130.15	0.70	0.30	1.00	149,134.25	211,024.97	
H9CC_Opt2_11	Wall	170.41	0.81	0.30	1.11	205,587.53	290,906.35	
H9CC_Opt2_12	Wall	60.95	0.26	0.30	0.56	55,074.84	77,930.90	
H9CC_Opt2_13	Wall	109.75	0.18	0.30	0.48	94,336.72	133,486.46	
H9CC_Opt2_14	Wall	29.00	0.53	0.30	0.83	30,515.68	43,179.69	
H9CC_Opt2_15	Wall	71.65	0.80	0.30	1.10	86,046.13	121,755.27	
H9CC_Opt2_16	Wall	197.70	2.32	0.30	2.62	402,875.50	570,068.84	
H9CC_Opt2_17	Embankment	350.86	0.74	0.50	1.24	67,214.34	95,108.29	
H9CC_Opt2_18	Embankment	177.82	0.99	0.50	1.49	39,854.08	56,393.53	
H9CC_Opt2_19	Embankment	234.18	0.40	0.50	0.90	34,544.99	48,881.16	
H9CC_Opt2_20	Embankment	72.13	0.58	0.50	1.08	12,348.05	17,472.49	
H9CC_Opt2_21	Wall	70.42	1.21	0.30	1.51	100,465.60	142,158.82	
H9CC_Opt2_22	Wall	737.98	0.79	0.30	1.09	882,193.89	1,248,304.35	
H9CC_Opt2_23	Wall	283.97	1.49	0.30	1.79	448,907.35	635,203.90	
H9CC_Opt2_24	Wall	288.89	0.91	0.30	1.21	364,431.06	515,669.95	
H9CC_Opt2_25	Wall	164.43	1.12	0.30	1.42	226,438.23	320,410.09	
H9CC_Opt2_26	Wall	90.55	1.80	0.30	2.10	158,599.06	224,417.66	
H9CC_Opt2_27	Wall	41.19	1.18	0.30	1.48	58,083.88	82,188.70	
H9CC_Opt2_28	Wall	141.54	1.97	0.30	2.27	261,156.52	369,536.48	
H9CC_Opt2_29	Wall	91.54	1.50	0.30	1.80	145,212.88	205,476.22	
H9CC_Opt2_30	Wall	96.64	1.44	0.30	1.74	150,110.66	212,406.59	
H9CC_Opt2_31	Wall	84.10	0.94	0.30	1.24	107,480.21	152,084.49	
H9CC_Opt2_32	Wall	76.66	2.36	0.30	2.66	157,907.01	223,438.42	
H9CC_Opt2_33	Wall	29.36	1.11	0.30	1.41	40,270.30	56,982.48	
H9CC_Opt2_34	Wall	88.90	4.33	0.30	4.63	279,545.03	395,556.22	
H9CC_Opt2_35	Wall	64.62	1.74	0.30	2.04	111,047.72	157,132.53	
H9CC_Opt2_36	Wall	182.08	1.89	0.30	2.19	327,937.14	464,031.05	
H9CC_Opt2_37	Wall	100.30	2.77	0.30	3.07	229,243.24	324,379.18	
H9CC_Opt2_38	Wall	37.69	3.20	0.30	3.50	95,066.52	134,519.12	
H9CC_Opt2_39	Wall	37.65	1.78	0.30	2.08	65,529.69	92,724.51	
H9CC_Opt2_40	Wall	131.61	1.75	0.30	2.05	226,892.85	321,053.39	
H9CC_Opt2_41	Wall	567.98	1.17	0.30	1.47	797,807.10	1,128,897.05	
H9CC_Opt2_42	Wall	51.54	0.66	0.30	0.96	57,922.77	81,960.71	
H9CC_Opt2_43	Wall	113.52	0.52	0.30	0.82	118,828.09	168,141.75	
H9CC_Opt2_44	Wall	65.59	1.22	0.30	1.52	93,935.94	132,919.36	
H9CC_Opt2_45	Wall	302.56	0.68	0.30	0.98	343,361.03	485,855.86	
H9CC_Opt2_46	Wall	80.71	0.30	0.30	0.60	74,707.63	105,711.29	
H9CC_Opt2_47	Wall	81.92	0.27	0.30	0.57	74,474.52	105,381.45	
H9CC_Opt2_48	Wall	191.94	1.64	0.30	1.94	319,275.77	451,775.21	
H9CC_Opt2_49	Wall	291.07	0.23	0.30	0.53	258,205.11	365,360.23	
H9CC_Opt2_50	Wall	40.30	0.01	0.30	0.31	30,868.21	43,678.52	
H9CC_Opt2_51	Wall	84.45	3.95	0.30	4.25	247,883.23	350,754.77	
H9CC_Opt2_52	Wall	42.71	0.45	0.30	0.75	43,061.00	60,931.31	
H9CC_Opt2_53	Wall	57.04	2.52	0.30	2.82	122,517.89	173,362.82	
H9CC_Opt2_54	Wall	67.58	2.90	0.30	3.20	159,296.31	225,404.29	
H9CC_Opt2_55	Wall	65.22	3.17	0.30	3.47	163,428.91	231,251.91	
H9CC_Opt2_56	Wall	65.47	3.15	0.30	3.45	163,334.43	231,118.21	
H9CC_Opt2_57	Wall	93.80	2.13	0.30	2.43	181,334.27	256,587.99	
H9CC_Opt2_58	Wall	69.53	2.44	0.30	2.74	146,282.96	206,990.38	
H9CC_Opt2_59	Wall	59.59	1.26	0.30	1.56	86,655.31	122,617.26	
H9CC_Opt2_60	Wall	55.63	3.39	0.30	3.69	146,136.59	206,783.27	
H9CC_Opt2_61	Wall	104.61	1.34	0.30	1.64	156,730.77	221,774.04	
H9CC_Opt2_62	Wall	120.34	1.48	0.30	1.78	189,574.11	268,247.36	
H9CC_Opt2_63	Wall	44.13	3.06	0.30	3.36	107,908.68	152,690.78	

Shapefile ID: Option 2 Hard								
Defences and Storage	Type	Length	Height	Freeboard	Height with FB	Cost £/m2007	Cost €/m2013	
H9CC_Opt2_64	Wall		85.04	2.91	0.30	3.21	200,920.40	284,302.37
H9CC_Opt2_65	Wall		86.55	1.80	0.30	2.10	151,593.02	214,504.13
H9CC_Opt2_66	Wall		60.07	2.32	0.30	2.62	122,411.39	173,212.11
H9CC_Opt2_67	Wall		80.21	2.26	0.30	2.56	160,803.18	227,536.50
H9CC_Opt2_68	Wall		137.07	2.00	0.30	2.30	255,172.95	361,069.73
H9CC_Opt2_69	Embankment		54.33	1.20	0.50	1.70	13,695.73	19,379.46
							17,026,335.25	

Costing of storage embankments

Shapefile ID: Option2_Tymon_					
Storage	Type	Length (m)	Height (m)	Volume (m2)	
H9CC_Opt2_Store_01	Embankment	4.853	0.51	28.54	
H9CC_Opt2_Store_02	Embankment	4.853	1.32	89.43	
H9CC_Opt2_Store_03	Embankment	4.853	2.18	174.99	
H9CC_Opt2_Store_04	Embankment	4.853	2.81	251.33	
H9CC_Opt2_Store_05	Embankment	4.853	3.83	399.43	
H9CC_Opt2_Store_06	Embankment	4.853	4.46	506.05	
H9CC_Opt2_Store_07	Embankment	4.853	5.2	646.03	
H9CC_Opt2_Store_08	Embankment	4.853	6.63	961.72	
H9CC_Opt2_Store_09	Embankment	4.853	7.23	1111.91	
H9CC_Opt2_Store_10	Embankment	4.853	8.1	1348.31	
H9CC_Opt2_Store_11	Embankment	4.853	8.78	1548.42	
H9CC_Opt2_Store_12	Embankment	4.853	6.23	867.42	
H9CC_Opt2_Store_13	Embankment	4.853	5.69	747.50	
H9CC_Opt2_Store_14	Embankment	4.853	4.48	509.62	
H9CC_Opt2_Store_15	Embankment	4.853	3.84	401.04	
H9CC_Opt2_Store_16	Embankment	4.853	3.49	346.70	
H9CC_Opt2_Store_17	Embankment	4.853	3.35	325.96	
H9CC_Opt2_Store_18	Embankment	4.853	2.76	244.85	
H9CC_Opt2_Store_19	Embankment	4.853	1.64	118.75	
H9CC_Opt2_Store_20	Embankment	4.853	0.97	60.77	
				10688.76	

EA Flood Risk Management Estimating Guide

Cost per m2 fill volume (£/m2)

Volume	500-5000m2	5000-15000m2	>15000m2
Average	65	46	24
Min	31	29	17
Max	116	53	31
Number	23	8	9

EA Flood Risk Management Estimating Guide

Sheet piling, average depth 10m

	Average cost	Min cost	Max cost
Urban < 100m length £/m	6459	2421	13342
Urban > 100m length £/m	2081	1271	3006
Rural £/m	1357	300	3330

Cost of embankment £/m 2013	491,683.08
Cost of embankment €/m 2013	755,716.89

Costing of overflow weir

Control structure to regulate the discharge from the flood storage in Lansdowne Valley Park

Type	fixed weir
Width (m approx)	30

EA Flood Risk Management Estimating Guide

Fixed weir - average - £/m	6,050.00
Narrow fixed - average - £/m	29,100.00
Movable weir - average - £/m	61,100.00

Cost of weir (£ 2007)	181,500.00
Cost of weir (€ 2013)	278,965.50

Downstream Channel lining and scour protection

Channel	705,000.00
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Costing of sealing of manholes

Approximately €1000 per manhole required

Number of manholes to be sealed	7
Cost of sealing manholes €	7,000.00

Project Whole Life Cost	
Construction cost	€18,766,017.64
Provision for unmeasured items (20%)	€3,753,203.53
Provision for optimism bias (60%)	€11,259,610.59
Maintenance costs (NPV over 50yrs)	€720,000.00
Detailed design (design fees) (6%)	€1,125,961.06
Construction supervision (5%)	€938,300.88
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€3,940,863.70
Cost of land acquisition/compensation (12.5%)	€2,345,752.21
allowance for art (1%)	€187,660.18
Project Whole Life Cost	€43,037,369.78
Summary	
Total Damage/Benefit	30,440,033.00
Total Construction Cost	€18,766,017.64
Project Whole Life Cost	€43,037,369.78
BCR	0.71
MCA	1417.5
MCA BCR	32.94

Costing of: Hard Defences with removal of Bow's Bridge

Construction Costs

Costing of walls and embankments

Cost of walls and embankments based on previous schemes in association with RPS

Shapefile ID: Hard

Defences and Bow Br

removal	Type	Length	Height	Freeboard	Height with FB	Cost £/m2007	Cost €/m2013
H9CC_Bow_01	Wall	233.28	1.37	0.30	1.67	353,362.39	500,007.78
H9CC_Bow_02	Wall	231.06	1.70	0.30	2.00	391,981.63	554,654.01
H9CC_Bow_03	Wall	70.83	0.84	0.30	1.14	86,621.29	122,569.12
H9CC_Bow_04	Wall	163.24	0.78	0.30	1.08	194,241.11	274,851.17
H9CC_Bow_05	Embankment	426.87	0.57	0.50	1.07	72,356.80	102,384.87
H9CC_Bow_06	Embankment	369.27	0.97	0.50	1.47	81,753.98	115,681.88
H9CC_Bow_07	Embankment	597.48	0.91	0.50	1.41	127,601.22	180,555.72
H9CC_Bow_08	Embankment	66.43	0.22	0.50	0.72	8,264.08	11,693.67
H9CC_Bow_09	Wall	84.07	1.09	0.30	1.39	114,385.02	161,854.80
H9CC_Bow_10	Wall	130.15	0.70	0.30	1.00	149,134.25	211,024.97
H9CC_Bow_11	Wall	170.41	0.81	0.30	1.11	205,587.53	290,906.35
H9CC_Bow_12	Wall	60.95	0.26	0.30	0.56	55,074.84	77,930.90
H9CC_Bow_13	Wall	109.75	0.17	0.30	0.47	93,732.46	132,631.43
H9CC_Bow_14	Wall	29.00	0.53	0.30	0.83	30,515.68	43,179.69
H9CC_Bow_15	Wall	71.65	0.80	0.30	1.10	86,046.13	121,755.27
H9CC_Bow_16	Wall	197.70	2.32	0.30	2.62	402,875.50	570,068.84
H9CC_Bow_17	Embankment	350.86	0.98	0.50	1.48	78,135.52	110,561.76
H9CC_Bow_18	Embankment	177.82	0.99	0.50	1.49	39,854.08	56,393.53
H9CC_Bow_19	Embankment	234.18	0.40	0.50	0.90	34,544.99	48,881.16
H9CC_Bow_20	Embankment	72.13	0.58	0.50	1.08	12,348.05	17,472.49
H9CC_Bow_21	Wall	70.42	0.95	0.30	1.25	90,384.82	127,894.52
H9CC_Bow_22	Wall	737.98	0.79	0.30	1.09	882,193.89	1,248,304.35
H9CC_Bow_23	Wall	283.97	1.49	0.30	1.79	448,907.35	635,203.90
H9CC_Bow_24	Wall	288.89	0.91	0.30	1.21	364,431.06	515,669.95
H9CC_Bow_25	Wall	164.43	1.12	0.30	1.42	226,438.23	320,410.09
H9CC_Bow_26	Wall	90.55	1.80	0.30	2.10	158,599.06	224,417.66
H9CC_Bow_27	Wall	41.19	1.18	0.30	1.48	58,083.88	82,188.70
H9CC_Bow_28	Wall	141.54	2.50	0.30	2.80	302,459.33	427,979.95
H9CC_Bow_29	Wall	91.54	1.90	0.30	2.20	165,373.11	234,002.94
H9CC_Bow_30	Wall	96.64	1.44	0.30	1.74	150,110.66	212,406.59
H9CC_Bow_31	Wall	109.90	1.04	0.30	1.34	146,503.66	207,302.68
H9CC_Bow_32	Wall	76.66	2.67	0.30	2.97	170,991.45	241,952.89
H9CC_Bow_33	Wall	29.36	1.31	0.30	1.61	43,503.34	61,557.22
H9CC_Bow_34	Wall	98.58	4.33	0.30	4.63	309,983.68	438,626.90
H9CC_Bow_35	Wall	85.04	2.14	0.30	2.44	164,867.65	233,287.72
H9CC_Bow_36	Wall	182.08	1.93	0.30	2.23	331,947.16	469,705.23
H9CC_Bow_37	Wall	100.30	2.58	0.30	2.88	218,750.74	309,532.30
H9CC_Bow_38	Wall	37.69	2.98	0.30	3.28	90,501.17	128,059.16
H9CC_Bow_39	Wall	37.65	1.83	0.30	2.13	66,566.16	94,191.12
H9CC_Bow_40	Wall	131.61	1.88	0.30	2.18	236,312.98	334,382.86
H9CC_Bow_41	Wall	567.98	1.17	0.30	1.47	797,807.10	1,128,897.05
H9CC_Bow_42	Wall	51.54	0.66	0.30	0.96	57,922.77	81,960.71
H9CC_Bow_43	Wall	113.52	0.52	0.30	0.82	118,828.09	168,141.75
H9CC_Bow_44	Wall	65.59	1.22	0.30	1.52	93,935.94	132,919.36
H9CC_Bow_45	Wall	302.56	0.68	0.30	0.98	343,361.03	485,855.86
H9CC_Bow_46	Wall	80.71	0.30	0.30	0.60	74,707.63	105,711.29
H9CC_Bow_47	Wall	81.92	0.27	0.30	0.57	74,474.52	105,381.45
H9CC_Bow_48	Wall	191.94	1.64	0.30	1.94	319,275.77	451,775.21
H9CC_Bow_49	Wall	291.07	0.23	0.30	0.53	258,205.11	365,360.23
H9CC_Bow_50	Wall	40.30	0.01	0.30	0.31	30,868.21	43,678.52
H9CC_Bow_51	Wall	84.45	4.47	0.30	4.77	272,061.62	384,967.20
H9CC_Bow_52	Wall	96.43	2.14	0.30	2.44	186,949.52	264,533.57
H9CC_Bow_53	Wall	57.04	2.92	0.30	3.22	135,080.04	191,138.26
H9CC_Bow_54	Wall	67.58	3.32	0.30	3.62	174,923.90	247,517.32
H9CC_Bow_55	Wall	65.22	3.70	0.30	4.00	182,460.77	258,181.99
H9CC_Bow_56	Wall	65.47	3.51	0.30	3.81	176,311.28	249,480.46
H9CC_Bow_57	Wall	93.80	2.65	0.30	2.95	208,189.61	294,588.30
H9CC_Bow_58	Wall	69.53	2.83	0.30	3.13	161,213.01	228,116.41

Shapefile ID: Hard Defences and Bow Br removal	Type	Length	Height	Freeboard	Height with FB	Cost £/m2007	Cost €/m2013
H9CC_Bow_59	Wall	59.59	1.21	0.30	1.51	85,014.84	120,296.00
H9CC_Bow_60	Wall	55.63	3.30	0.30	3.60	143,379.97	202,882.66
H9CC_Bow_61	Wall	104.61	1.56	0.30	1.86	169,402.05	239,703.90
H9CC_Bow_62	Wall	120.34	1.53	0.30	1.83	192,886.98	272,935.08
H9CC_Bow_63	Wall	44.13	2.85	0.30	3.15	102,806.24	145,470.83
H9CC_Bow_64	Wall	85.04	2.77	0.30	3.07	194,365.36	275,026.98
H9CC_Bow_65	Wall	86.55	1.82	0.30	2.12	152,546.09	215,852.71
H9CC_Bow_66	Wall	60.07	2.35	0.30	2.65	123,403.60	174,616.09
H9CC_Bow_67	Wall	80.21	2.41	0.30	2.71	167,427.55	236,909.98
H9CC_Bow_68	Wall	137.07	2.17	0.30	2.47	268,002.63	379,223.73
							17,703,259.05

Costing of sealing of manholes

Approximately €1000 per manhole required

Number of manholes to be sealed	7
Cost of sealing manholes €	7,000.00

Costing of modifying Bow's Bridge

Removing parapet walls €	20,000
Demountable barriers €*	33,000

*Based on EA unit cost database

Project Whole Life Cost	
Construction cost	€17,763,259.05
Provision for unmeasured items (20%)	€3,552,651.81
Provision for optimism bias (60%)	€10,657,955.43
Maintenance costs (NPV over 50yrs)	€720,000.00
Detailed design (design fees) (6%)	€1,065,795.54
Construction supervision (5%)	€888,162.95
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€3,730,284.40
Cost of land acquisition/compensation (12.5%)	€2,220,407.38
allowance for art (1%)	€177,632.59
Project Whole Life Cost	€40,776,149.15
Summary	
Total Damage/Benefit	30,440,033.00
Total Construction Cost	€17,763,259.05
Project Whole Life Cost	€40,776,149.15
BCR	0.75
MCA	1762.5
MCA BCR	43

Costing of: Hard Defences with removal of Kearns Place Bridge

Construction Costs

Costing of walls and embankments

Cost of walls and embankments based on previous schemes in association with RPS

Shapefile ID:

Hard Defences and Kearns Br removal	Type	Length	Height	Freeboard	Height with FB	Cost £/m2007	Cost €/m2013
H9CC_Opt1_01	Wall	233.28	1.37	0.30	1.67	353,362.39	500,007.78
H9CC_Opt1_02	Wall	231.06	1.70	0.30	2.00	391,981.63	554,654.01
H9CC_Opt1_03	Wall	70.83	0.84	0.30	1.14	86,621.29	122,569.12
H9CC_Opt1_04	Wall	163.24	0.78	0.30	1.08	194,241.11	274,851.17
H9CC_Opt1_05	Embankment	426.87	0.57	0.50	1.07	72,356.80	102,384.87
H9CC_Opt1_06	Embankment	369.27	0.97	0.50	1.47	81,753.98	115,681.88
H9CC_Opt1_07	Embankment	597.48	0.91	0.50	1.41	127,601.22	180,555.72
H9CC_Opt1_08	Embankment	66.43	0.22	0.50	0.72	8,264.08	11,693.67
H9CC_Opt1_09	Wall	84.07	1.09	0.30	1.39	114,385.02	161,854.80
H9CC_Opt1_10	Wall	130.15	0.70	0.30	1.00	149,134.25	211,024.97
H9CC_Opt1_11	Wall	170.41	0.81	0.30	1.11	205,587.53	290,906.35
H9CC_Opt1_12	Wall	60.95	0.26	0.30	0.56	55,074.84	77,930.90
H9CC_Opt1_13	Wall	109.75	0.17	0.30	0.47	93,732.46	132,631.43
H9CC_Opt1_14	Wall	29.00	0.53	0.30	0.83	30,515.68	43,179.69
H9CC_Opt1_15	Wall	71.65	0.80	0.30	1.10	86,046.13	121,755.27
H9CC_Opt1_16	Wall	197.70	2.32	0.30	2.62	402,875.50	570,068.84
H9CC_Opt1_17	Embankment	350.86	0.98	0.50	1.48	78,135.52	110,561.76
H9CC_Opt1_18	Embankment	177.82	0.99	0.50	1.49	39,854.08	56,393.53
H9CC_Opt1_19	Embankment	234.18	0.40	0.50	0.90	34,544.99	48,881.16
H9CC_Opt1_20	Embankment	72.13	0.58	0.50	1.08	12,348.05	17,472.49
H9CC_Opt1_21	Wall	70.42	0.95	0.30	1.25	90,384.82	127,894.52
H9CC_Opt1_22	Wall	737.98	0.79	0.30	1.09	882,193.89	1,248,304.35
H9CC_Opt1_23	Wall	283.97	1.49	0.30	1.79	448,907.35	635,203.90
H9CC_Opt1_24	Wall	288.89	0.91	0.30	1.21	364,431.06	515,669.95
H9CC_Opt1_25	Wall	164.43	1.12	0.30	1.42	226,438.23	320,410.09
H9CC_Opt1_26	Wall	90.55	1.80	0.30	2.10	158,599.06	224,417.66
H9CC_Opt1_27	Wall	41.19	1.18	0.30	1.48	58,083.88	82,188.70
H9CC_Opt1_28	Wall	141.54	2.50	0.30	2.80	302,459.33	427,979.95
H9CC_Opt1_29	Wall	91.54	1.90	0.30	2.20	165,373.11	234,002.94
H9CC_Opt1_30	Wall	96.64	1.44	0.30	1.74	150,110.66	212,406.59
H9CC_Opt1_31	Wall	109.90	1.04	0.30	1.34	146,503.66	207,302.68
H9CC_Opt1_32	Wall	76.66	2.67	0.30	2.97	170,991.45	241,952.89
H9CC_Opt1_33	Wall	29.36	1.31	0.30	1.61	43,503.34	61,557.22
H9CC_Opt1_34	Wall	75.59	3.35	0.30	3.65	196,905.53	278,621.32
H9CC_Opt1_35	Wall	85.04	1.68	0.30	1.98	143,329.64	202,811.43
H9CC_Opt1_36	Wall	187.09	3.52	0.30	3.82	504,865.08	714,384.09
H9CC_Opt1_37	Wall	100.30	3.05	0.30	3.35	244,705.87	346,258.81
H9CC_Opt1_38	Wall	37.69	3.52	0.30	3.82	101,707.01	143,915.42
H9CC_Opt1_39	Wall	37.65	1.95	0.30	2.25	69,053.71	97,711.00
H9CC_Opt1_40	Wall	131.61	1.87	0.30	2.17	235,588.35	333,357.52
H9CC_Opt1_41	Wall	567.98	1.17	0.30	1.47	797,807.10	1,128,897.05
H9CC_Opt1_42	Wall	51.54	0.66	0.30	0.96	57,922.77	81,960.71
H9CC_Opt1_43	Wall	113.52	0.52	0.30	0.82	118,828.09	168,141.75
H9CC_Opt1_44	Wall	65.59	1.22	0.30	1.52	93,935.94	132,919.36
H9CC_Opt1_45	Wall	302.56	0.68	0.30	0.98	343,361.03	485,855.86
H9CC_Opt1_46	Wall	80.71	0.30	0.30	0.60	74,707.63	105,711.29
H9CC_Opt1_47	Wall	81.92	0.27	0.30	0.57	74,474.52	105,381.45
H9CC_Opt1_48	Wall	191.94	1.64	0.30	1.94	319,275.77	451,775.21
H9CC_Opt1_49	Wall	291.07	0.23	0.30	0.53	258,205.11	365,360.23
H9CC_Opt1_50	Wall	40.30	0.01	0.30	0.31	30,868.21	43,678.52
H9CC_Opt1_51	Wall	84.45	4.47	0.30	4.77	272,061.62	384,967.20
H9CC_Opt1_52	Wall	57.04	2.92	0.30	3.22	135,080.04	191,138.26
H9CC_Opt1_53	Wall	67.58	3.32	0.30	3.62	174,923.90	247,517.32
H9CC_Opt1_54	Wall	65.22	3.70	0.30	4.00	182,460.77	258,181.99
H9CC_Opt1_55	Wall	65.47	3.51	0.30	3.81	176,311.28	249,480.46
H9CC_Opt1_56	Wall	93.80	2.65	0.30	2.95	208,189.61	294,588.30
H9CC_Opt1_57	Wall	69.53	2.83	0.30	3.13	161,213.01	228,116.41
H9CC_Opt1_58	Wall	59.59	1.80	0.30	2.10	104,372.37	147,686.90
H9CC_Opt1_59	Wall	55.63	3.57	0.30	3.87	151,649.82	214,584.49
H9CC_Opt1_60	Wall	104.61	1.71	0.30	2.01	178,041.56	251,928.80
H9CC_Opt1_61	Wall	120.34	1.38	0.30	1.68	182,948.37	258,871.94

Shapefile ID: Hard Defences and Kearns Br removal								
	Type	Length	Height	Freeboard	Height with FB	Cost £/m2007	Cost €/m2013	
H9CC_Opt1_62	Wall	44.13	3.37	0.30	3.67	115,440.85	163,348.80	
H9CC_Opt1_63	Wall	85.04	3.09	0.30	3.39	209,348.32	296,227.87	
H9CC_Opt1_64	Wall	86.55	1.97	0.30	2.27	159,694.06	225,967.09	
H9CC_Opt1_65	Wall	60.07	2.43	0.30	2.73	126,049.49	178,360.03	
H9CC_Opt1_66	Wall	80.21	2.41	0.30	2.71	167,427.55	236,909.98	
H9CC_Opt1_67	Wall	137.07	2.17	0.30	2.47	268,002.63	379,223.73	
							17,638,191.46	

Costing of sealing of manholes

Approximately €1000 per manhole required

Number of manholes to be sealed	7
Cost of sealing manholes €	7,000.00

Costing of removing Kearns Bridge

Demolition and removal of bridge €	100,000.00
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Project Whole Life Cost	
Construction cost	€17,745,191.46
Provision for unmeasured items (20%)	€3,549,038.29
Provision for optimism bias (60%)	€10,647,114.88
Maintenance costs (NPV over 50yrs)	€900,000.00
Detailed design (design fees) (6%)	€1,064,711.49
Construction supervision (5%)	€887,259.57
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€3,726,490.21
Cost of land acquisition/compensation (12.5%)	€2,218,148.93
allowance for art (1%)	€177,451.91
Project Whole Life Cost	€40,915,406.75
Summary	
Total Damage/Benefit	€30,440,033.00
Total Construction Cost	€17,745,191.46
Project Whole Life Cost	€40,915,406.75
BCR	0.74
MCA	1762.5
MCA BCR	43

Costing of: Hard Defences and Attenuation

Construction Costs

Costing of walls and embankments

Cost of walls and embankments based on previous schemes in association with RPS

Shapefile ID:

Hard Defences and Attenuation	Type	Length	Height	Freeboard	Height with FB	Cost £/m2007	Cost €/m2013
H9CC_Atten_01	Wall	233.28	1.37	0.30	1.67	353,362.39	500,007.78
H9CC_Atten_02	Wall	231.06	1.70	0.30	2.00	391,981.63	554,654.01
H9CC_Atten_03	Wall	70.83	0.84	0.30	1.14	86,621.29	122,569.12
H9CC_Atten_04	Wall	163.24	0.78	0.30	1.08	194,241.11	274,851.17
H9CC_Atten_05	Embankment	426.87	0.57	0.50	1.07	72,356.80	102,384.87
H9CC_Atten_06	Embankment	369.27	0.97	0.50	1.47	81,753.98	115,681.88
H9CC_Atten_07	Embankment	597.48	0.91	0.50	1.41	127,601.22	180,555.72
H9CC_Atten_08	Embankment	66.43	0.22	0.50	0.72	8,264.08	11,693.67
H9CC_Atten_09	Wall	84.07	1.09	0.30	1.39	114,385.02	161,854.80
H9CC_Atten_10	Wall	130.15	0.70	0.30	1.00	149,134.25	211,024.97
H9CC_Atten_11	Wall	170.41	0.81	0.30	1.11	205,587.53	290,906.35
H9CC_Atten_12	Wall	90.45	0.26	0.30	0.56	81,731.25	115,649.72
H9CC_Atten_13	Wall	109.75	0.18	0.30	0.48	94,336.72	133,486.46
H9CC_Atten_14	Wall	29.00	0.53	0.30	0.83	30,515.68	43,179.69
H9CC_Atten_15	Wall	71.65	0.80	0.30	1.10	86,046.13	121,755.27
H9CC_Atten_16	Wall	197.70	2.32	0.30	2.62	402,875.50	570,068.84
H9CC_Atten_17	Embankment	350.86	0.74	0.50	1.24	67,214.34	95,108.29
H9CC_Atten_18	Embankment	177.82	0.99	0.50	1.49	39,854.08	56,393.53
H9CC_Atten_19	Embankment	234.18	0.40	0.50	0.90	34,544.99	48,881.16
H9CC_Atten_20	Embankment	72.13	0.58	0.50	1.08	12,348.05	17,472.49
H9CC_Atten_21	Wall	70.42	1.21	0.30	1.51	100,465.60	142,158.82
H9CC_Atten_22	Wall	737.98	0.79	0.30	1.09	882,193.89	1,248,304.35
H9CC_Atten_23	Wall	283.97	1.49	0.30	1.79	448,907.35	635,203.90
H9CC_Atten_24	Wall	288.89	0.91	0.30	1.21	364,431.06	515,669.95
H9CC_Atten_25	Wall	164.43	1.12	0.30	1.42	226,438.23	320,410.09
H9CC_Atten_26	Wall	90.55	1.80	0.30	2.10	158,599.06	224,417.66
H9CC_Atten_27	Wall	41.19	0.60	0.30	0.90	44,930.29	63,576.37
H9CC_Atten_28	Wall	70.52	2.30	0.30	2.60	142,929.98	202,245.92
H9CC_Atten_29	Wall	39.91	0.85	0.30	1.15	49,027.53	69,373.95
H9CC_Atten_30	Wall	96.64	1.42	0.30	1.72	149,046.49	210,900.79
H9CC_Atten_31	Wall	76.66	2.22	0.30	2.52	151,997.91	215,077.04
H9CC_Atten_32	Wall	29.36	0.88	0.30	1.18	36,552.31	51,721.52
H9CC_Atten_33	Wall	75.59	3.54	0.30	3.84	204,813.09	289,810.52
H9CC_Atten_34	Wall	56.36	1.59	0.30	1.89	92,198.49	130,460.86
H9CC_Atten_35	Wall	182.08	0.58	0.30	0.88	196,608.93	278,201.63
H9CC_Atten_36	Wall	108.00	2.25	0.30	2.55	215,921.31	305,528.65
H9CC_Atten_37	Wall	37.69	2.59	0.30	2.89	82,408.07	116,607.42
H9CC_Atten_38	Wall	37.65	1.48	0.30	1.78	59,310.83	83,924.82
H9CC_Atten_39	Wall	131.61	1.51	0.30	1.81	209,501.85	296,445.12
H9CC_Atten_40	Wall	567.98	1.17	0.30	1.47	797,807.10	1,128,897.05
H9CC_Atten_41	Wall	51.54	0.80	0.30	1.10	61,895.57	87,582.23
H9CC_Atten_42	Wall	113.52	0.27	0.30	0.57	103,202.48	146,031.51
H9CC_Atten_43	Wall	65.59	1.22	0.30	1.52	93,935.94	132,919.36
H9CC_Atten_44	Wall	302.56	0.68	0.30	0.98	343,361.03	485,855.86
H9CC_Atten_45	Wall	80.71	0.30	0.30	0.60	74,707.63	105,711.29
H9CC_Atten_46	Wall	81.92	0.27	0.30	0.57	74,474.52	105,381.45
H9CC_Atten_47	Wall	191.94	1.64	0.30	1.94	319,275.77	451,775.21
H9CC_Atten_48	Wall	291.07	0.23	0.30	0.53	258,205.11	365,360.23
H9CC_Atten_49	Wall	40.30	0.01	0.30	0.31	30,868.21	43,678.52
H9CC_Atten_50	Wall	84.45	3.60	0.30	3.90	231,609.31	327,727.17
H9CC_Atten_51	Wall	57.04	2.15	0.30	2.45	110,897.90	156,920.53
H9CC_Atten_52	Wall	67.58	2.42	0.30	2.72	141,436.21	200,132.24
H9CC_Atten_53	Wall	65.22	2.72	0.30	3.02	147,269.79	208,386.75
H9CC_Atten_54	Wall	65.47	2.78	0.30	3.08	149,997.11	212,245.91
H9CC_Atten_55	Wall	93.80	1.69	0.30	1.99	158,610.52	224,433.89
H9CC_Atten_56	Wall	69.53	2.05	0.30	2.35	131,352.90	185,864.36

Shapefile ID: Hard Defences and Attenuation								
Attenuation	Type	Length	Height	Freeboard	Height with FB	Cost £/m2007	Cost €/m2013	
H9CC_Atten_57	Wall	26.73	0.27	0.30	0.57	24,300.58	34,385.33	
H9CC_Atten_58	Wall	104.61	1.08	0.30	1.38	141,755.63	200,584.21	
H9CC_Atten_59	Wall	120.34	1.29	0.30	1.59	176,985.20	250,434.06	
H9CC_Atten_60	Wall	44.13	2.50	0.30	2.80	94,302.18	133,437.58	
H9CC_Atten_61	Wall	56.43	2.48	0.30	2.78	119,964.87	169,750.30	
H9CC_Atten_62	Wall	38.10	1.62	0.30	1.92	62,956.54	89,083.51	
H9CC_Atten_63	Wall	60.07	2.12	0.30	2.42	115,796.66	163,852.27	
H9CC_Atten_64	Wall	80.21	2.02	0.30	2.32	150,204.20	212,538.94	
H9CC_Atten_65	Wall	137.07	1.68	0.30	1.98	231,022.97	326,897.50	
							15,278,086.43	

Costing of Attenuation

Cost of storage pipes as a upgrade to the existing storm network based on the EA Flood Risk Management Estimating Guide

Volume of water required to be attenuated is xxxm3 requiring a pipe network of xxm diameter pipes or equivalent for xkm

Volume to attenuate (m3)	Diameter of pipe (m)	Pipe area (m2)	Total length of network (km)	Volume provided	Cost of culverts per km (£ 2007)*	Total cost (£ 2007)	Total cost (€ 2013)
200,916	1.8	2.54	79	201,031	598,500	47,281,500.00	72,671,665.50

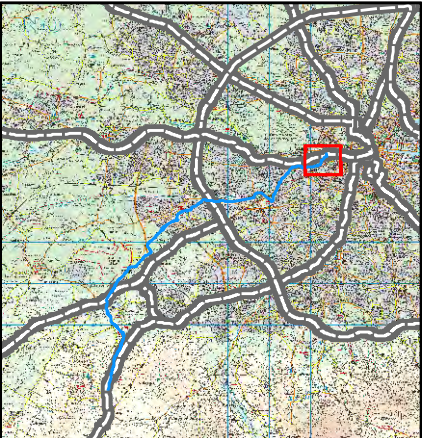
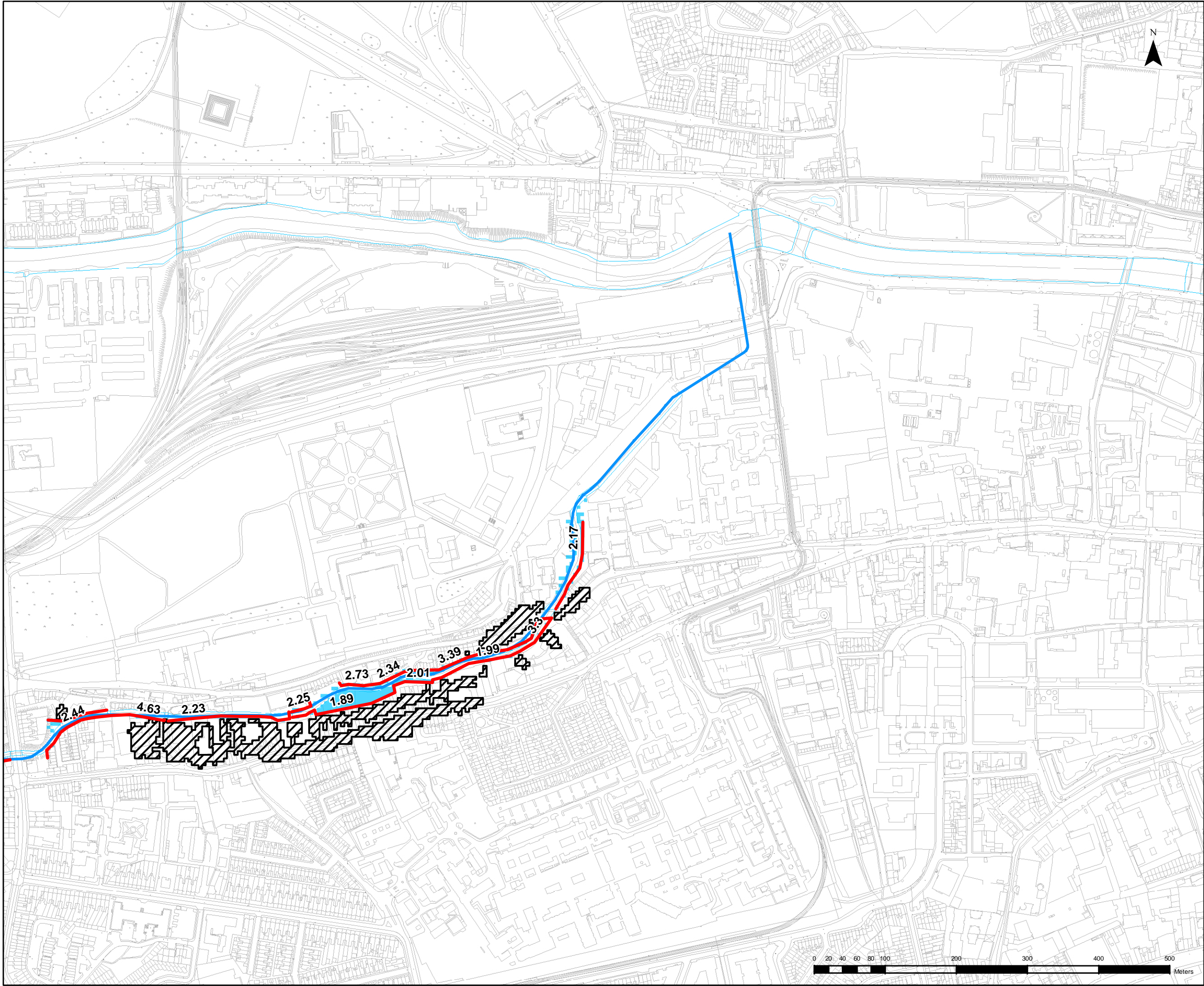
* EA unit cost of culvert construction is ±50%. Due to construction being in heavily urbanised area the unit cost + 50% was assigned

Project Whole Life Cost	
Construction cost	€87,949,751.93
Provision for unmeasured items (20%)	€17,589,950.39
Provision for optimism bias (60%)	€52,769,851.16
Maintenance costs (NPV over 50yrs)	€900,000.00
Detailed design (design fees) (6%)	€5,276,985.12
Construction supervision (5%)	€4,397,487.60
Allowance for archaeological and/or environmental monitoring/exploration (21%)	€18,469,447.91
Cost of land acquisition/compensation (12.5%)	€10,993,718.99
allowance for art (1%)	€879,497.52
Project Whole Life Cost	€199,226,690.60
Summary	
Total Damage/Benefit	€30,440,033.00
Total Construction Cost	€87,949,751.93
Project Whole Life Cost	€199,226,690.60
BCR	0.15
MCA	1562.5
MCA BCR	8

Appendix D

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Potential Options



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Legend

- MH Manhole
- Embankment
- Wall
- River Centreline
- 1% AEP Residual Flooding
- Area benefiting from Defences

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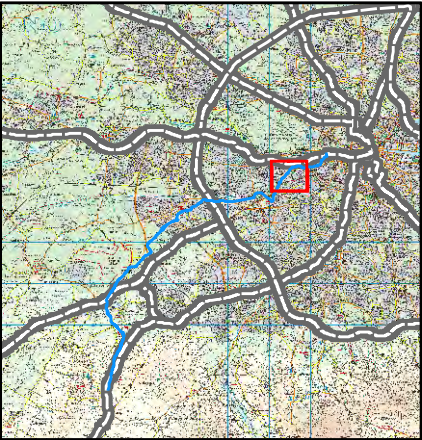
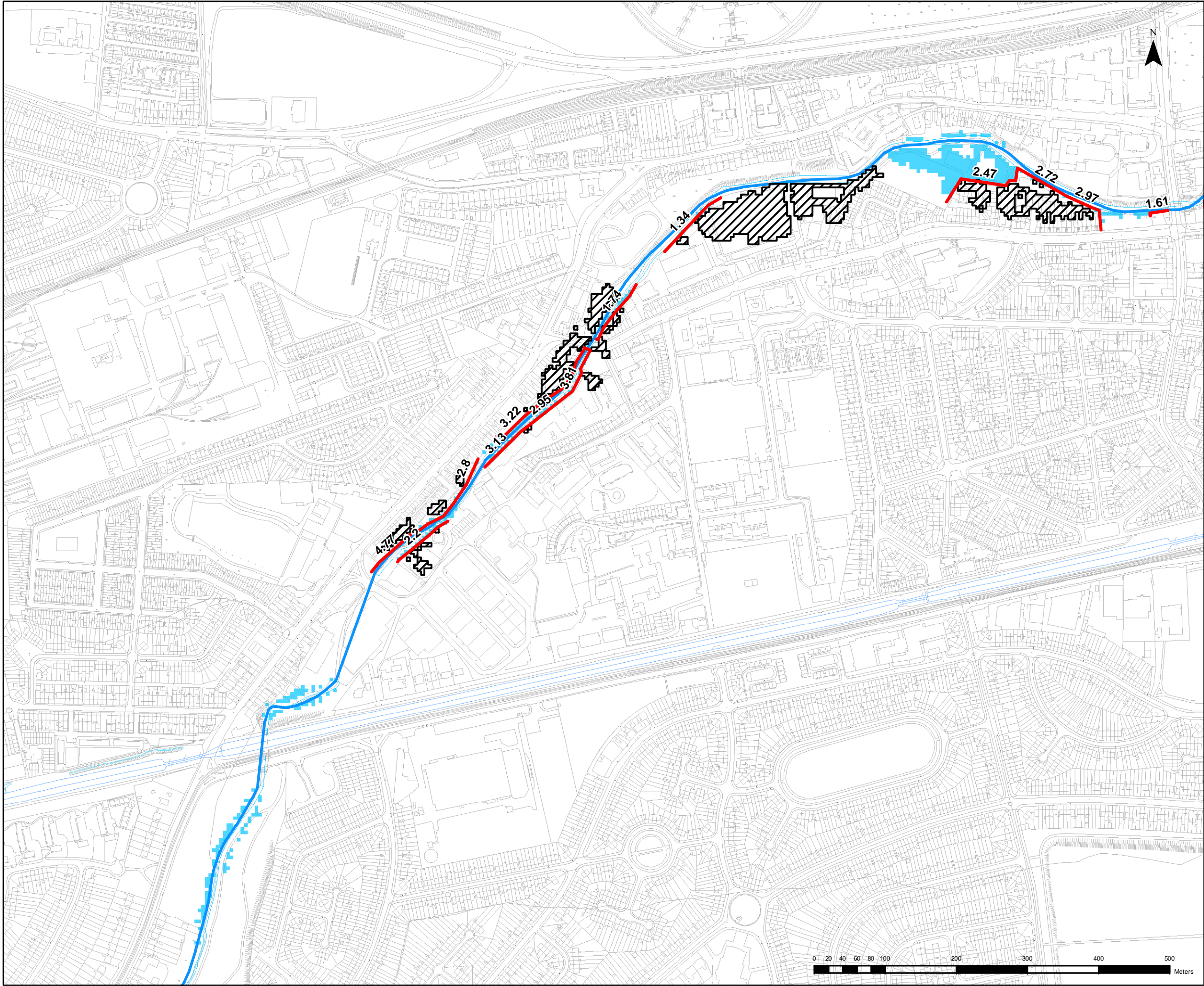
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	BELFAST BT12 6RZ	www.rpsgroup.com/ireland

Drawing No.:	Drawn By:	RC
09CC_DEF_OPT 1_001	Checked By:	MW
	Approved By:	GG
	Date:	13/02/2014

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TITLE

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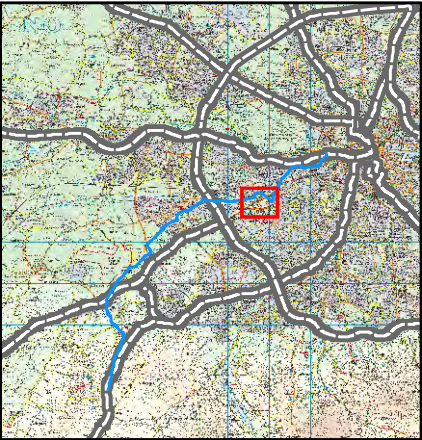
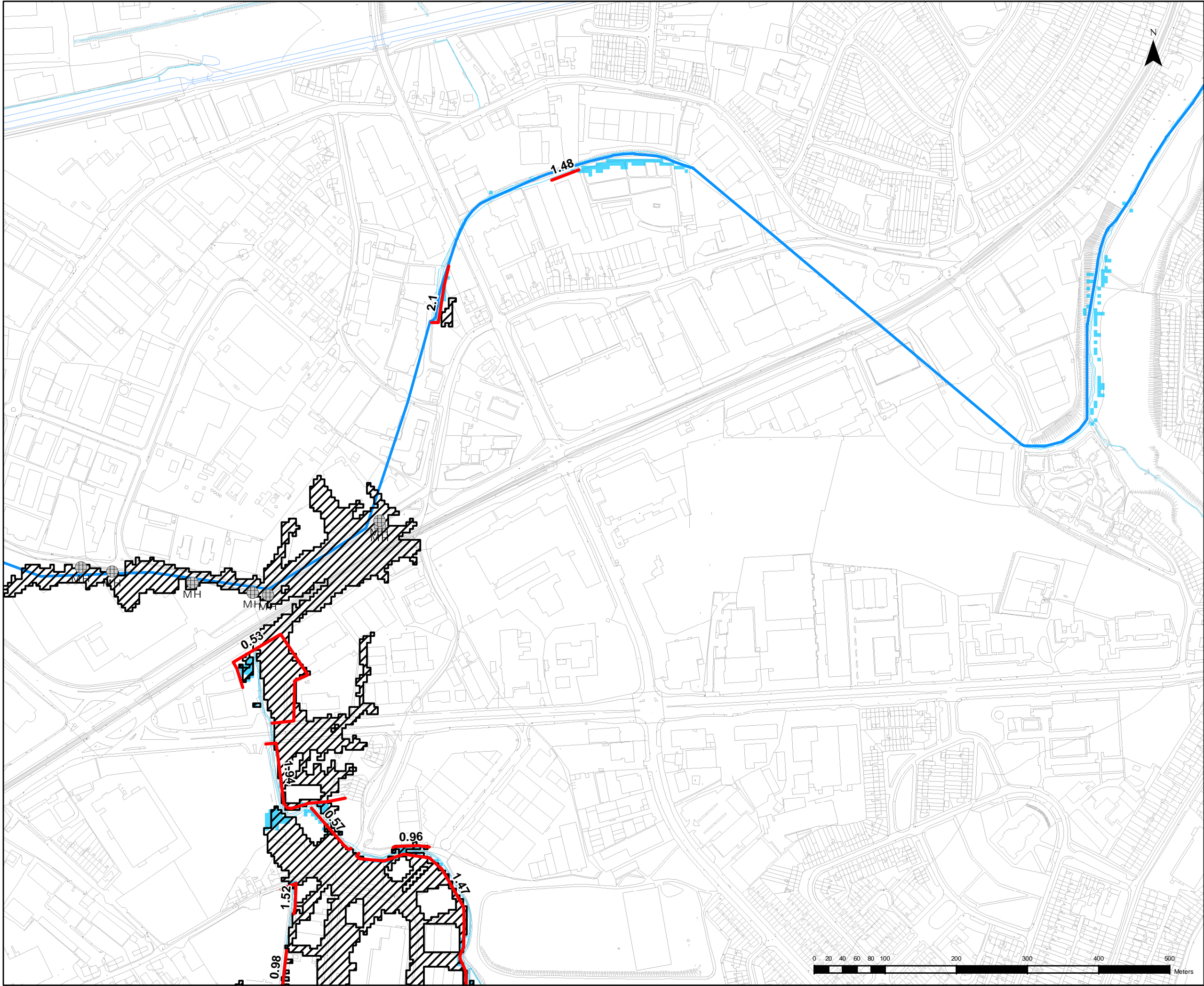
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Legend

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MW

Approved By :

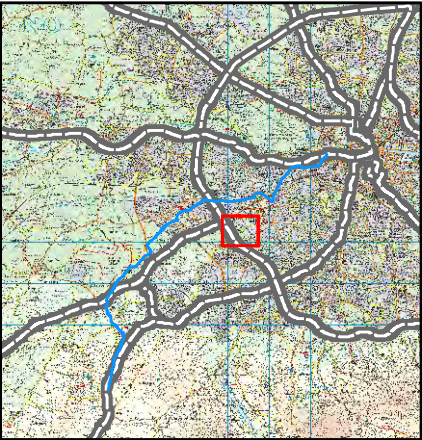
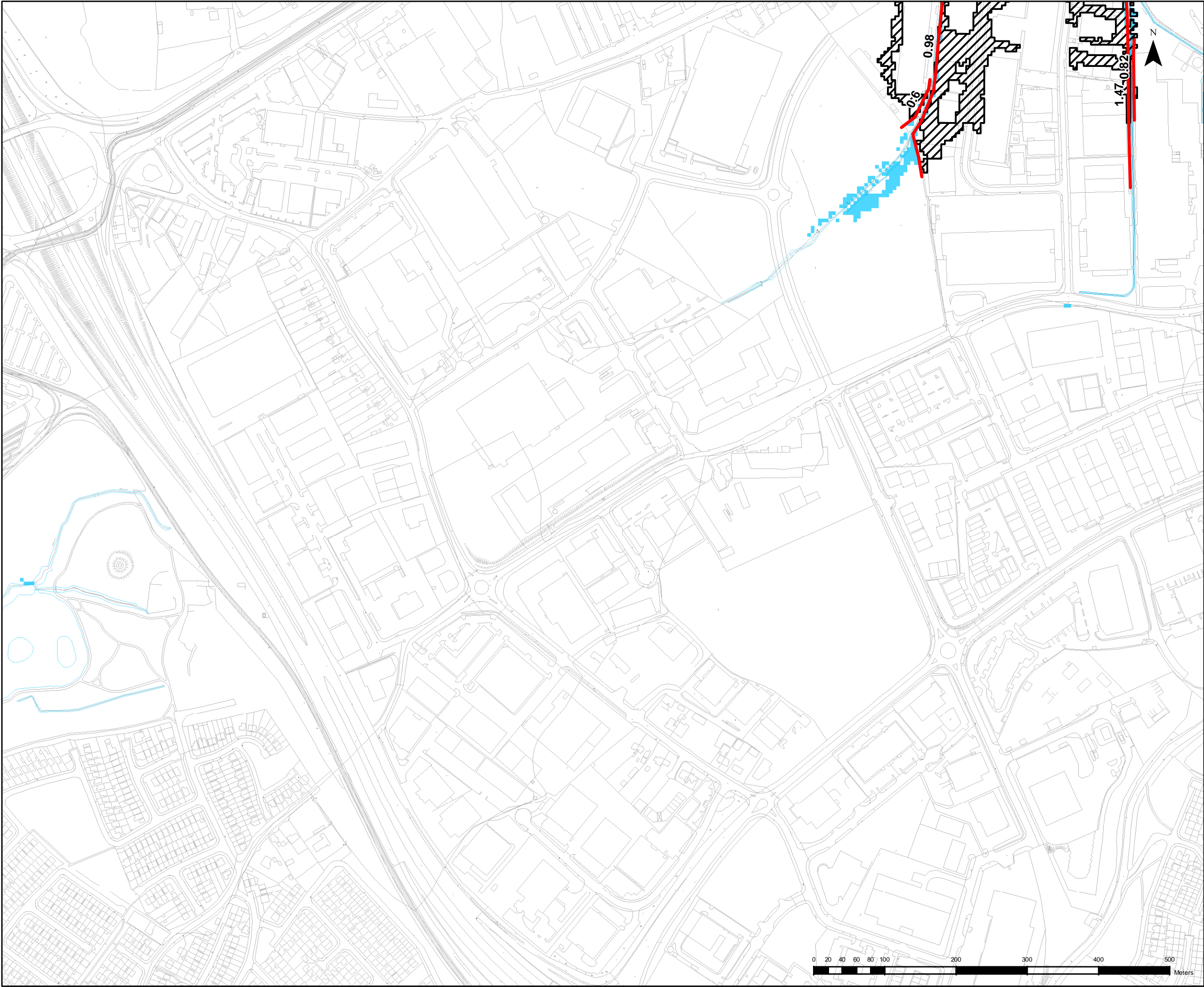
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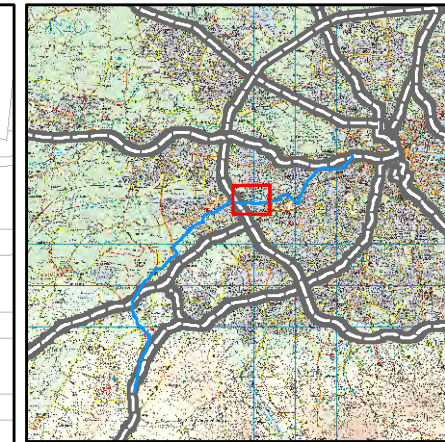
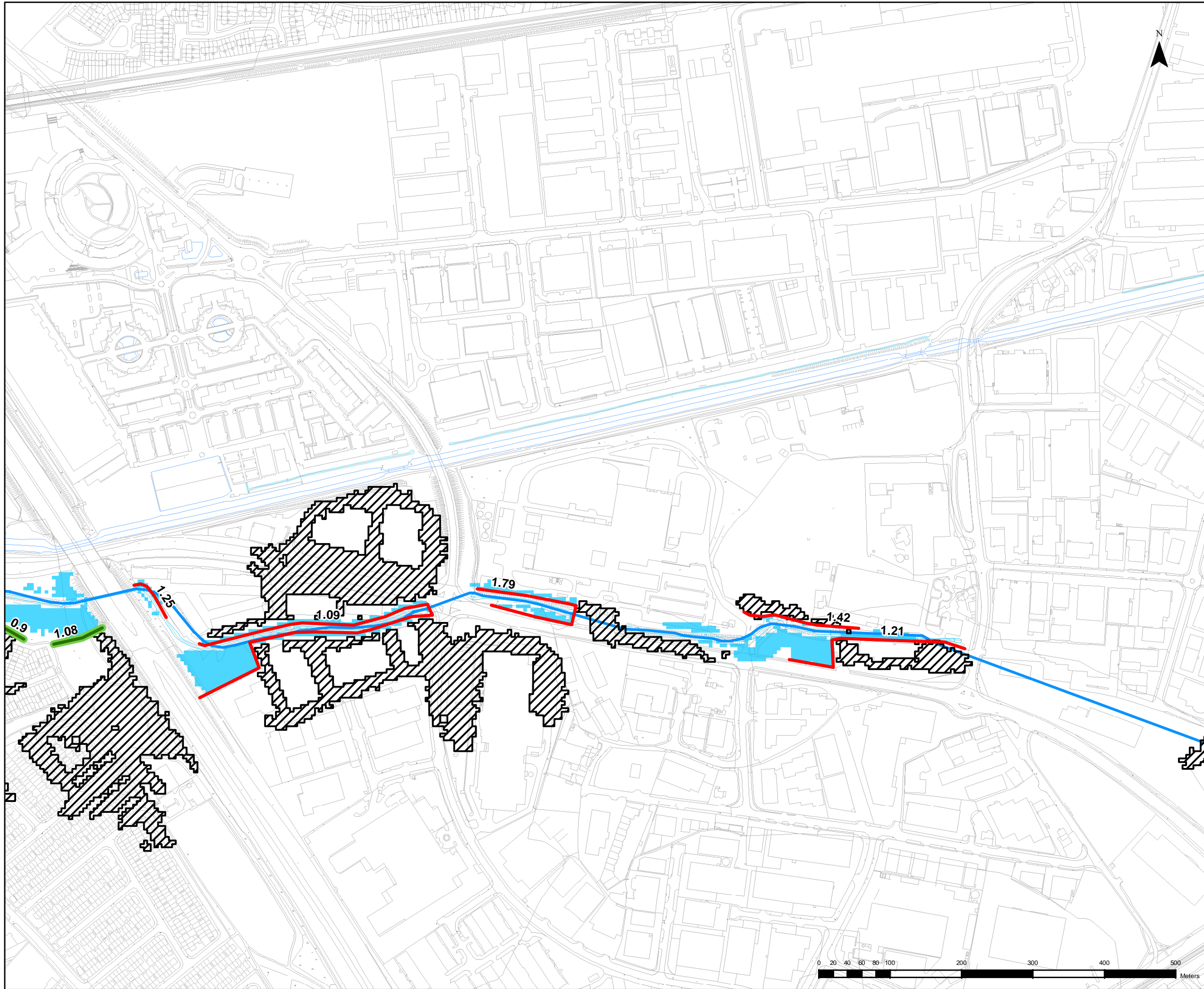
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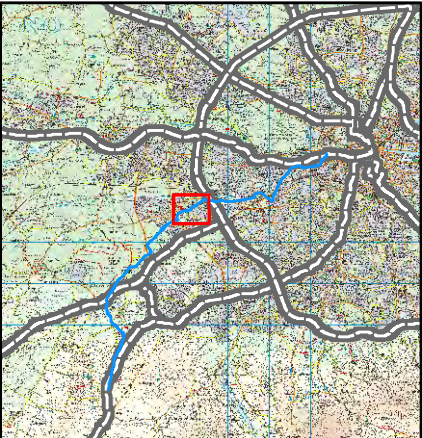
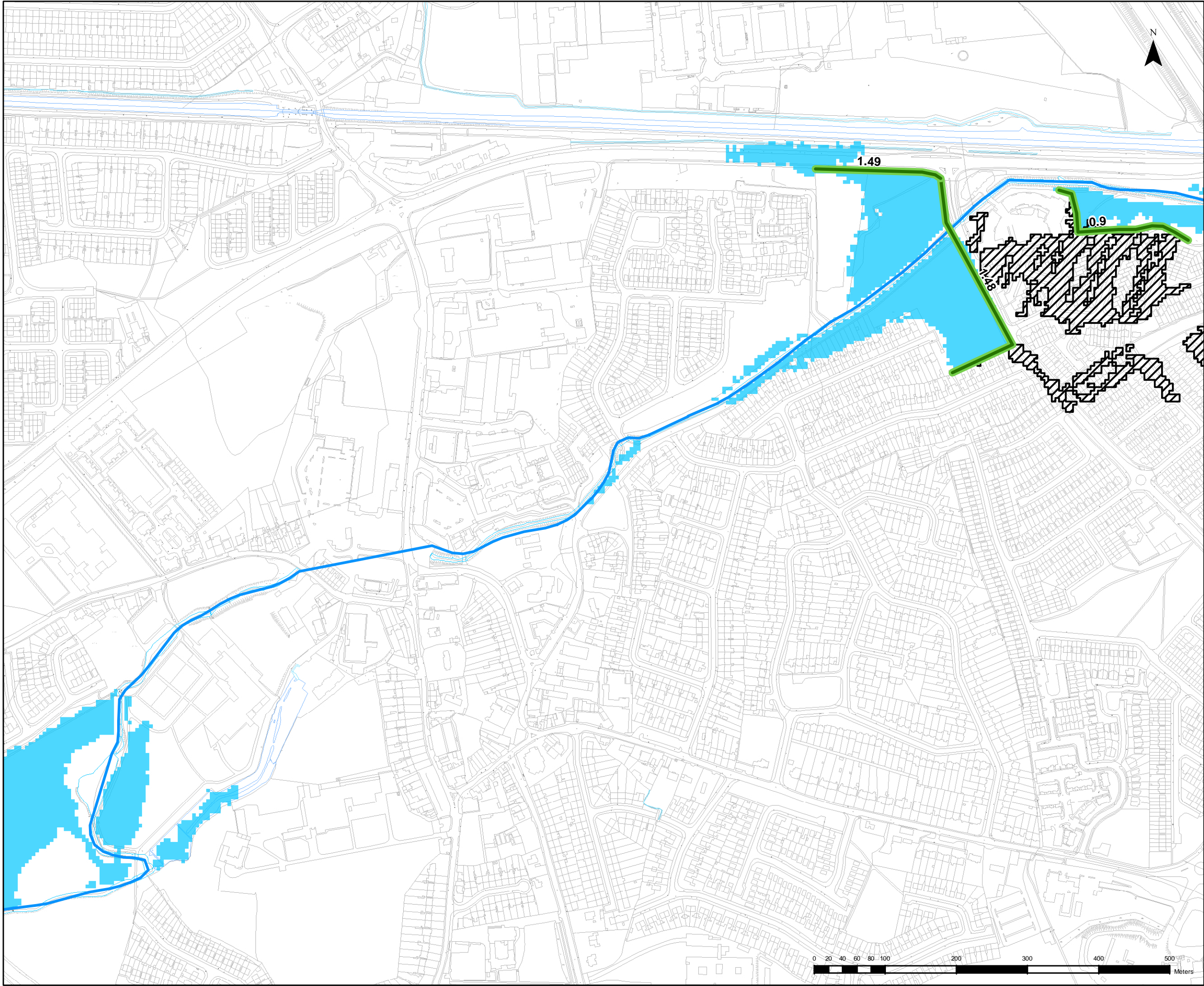
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 - Area benefiting from Defences

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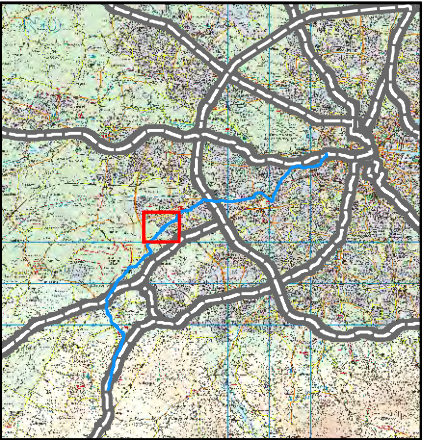
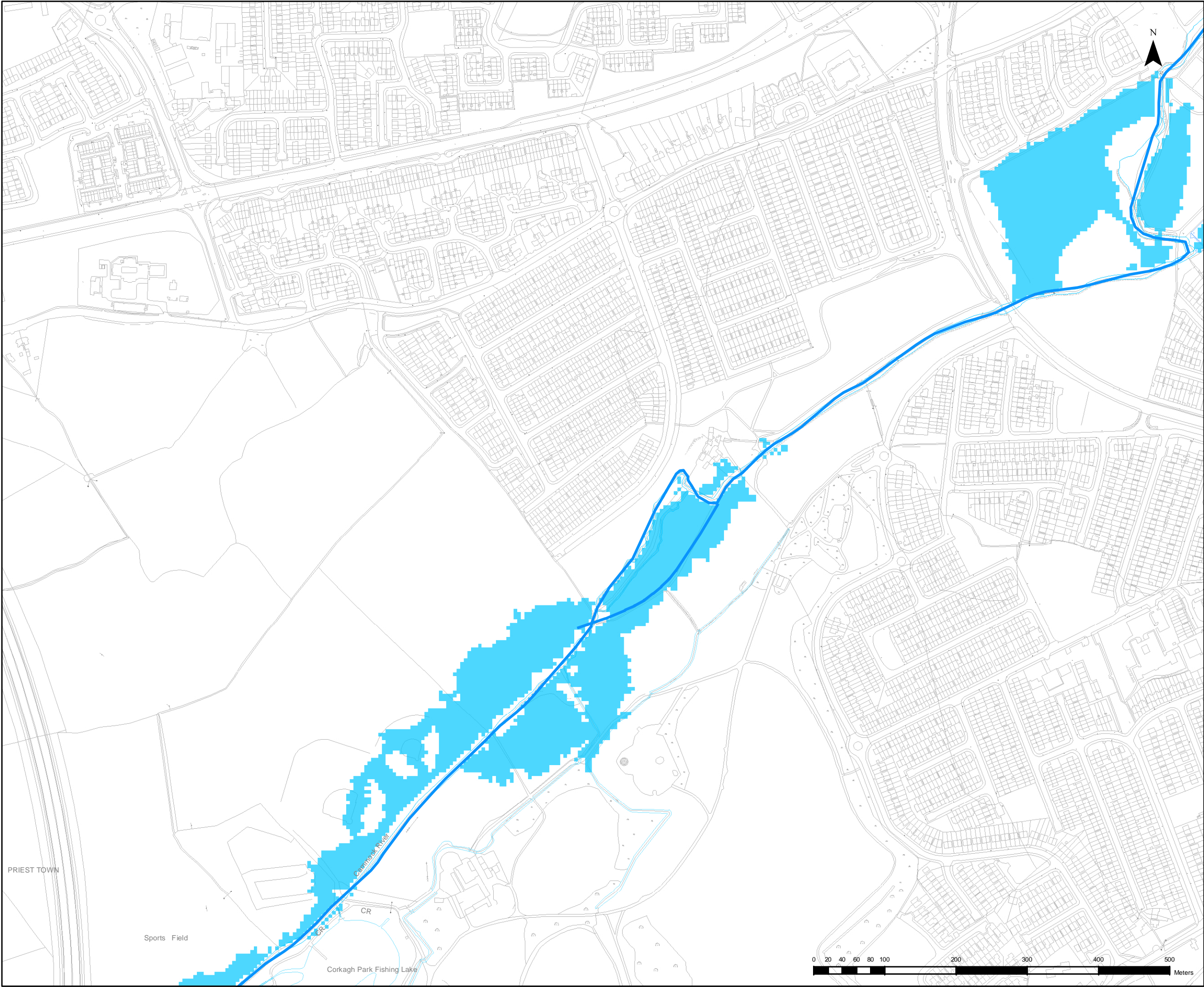


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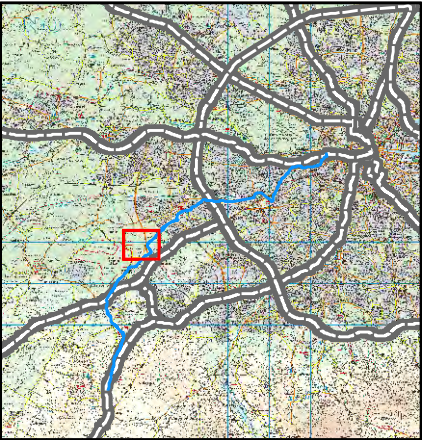
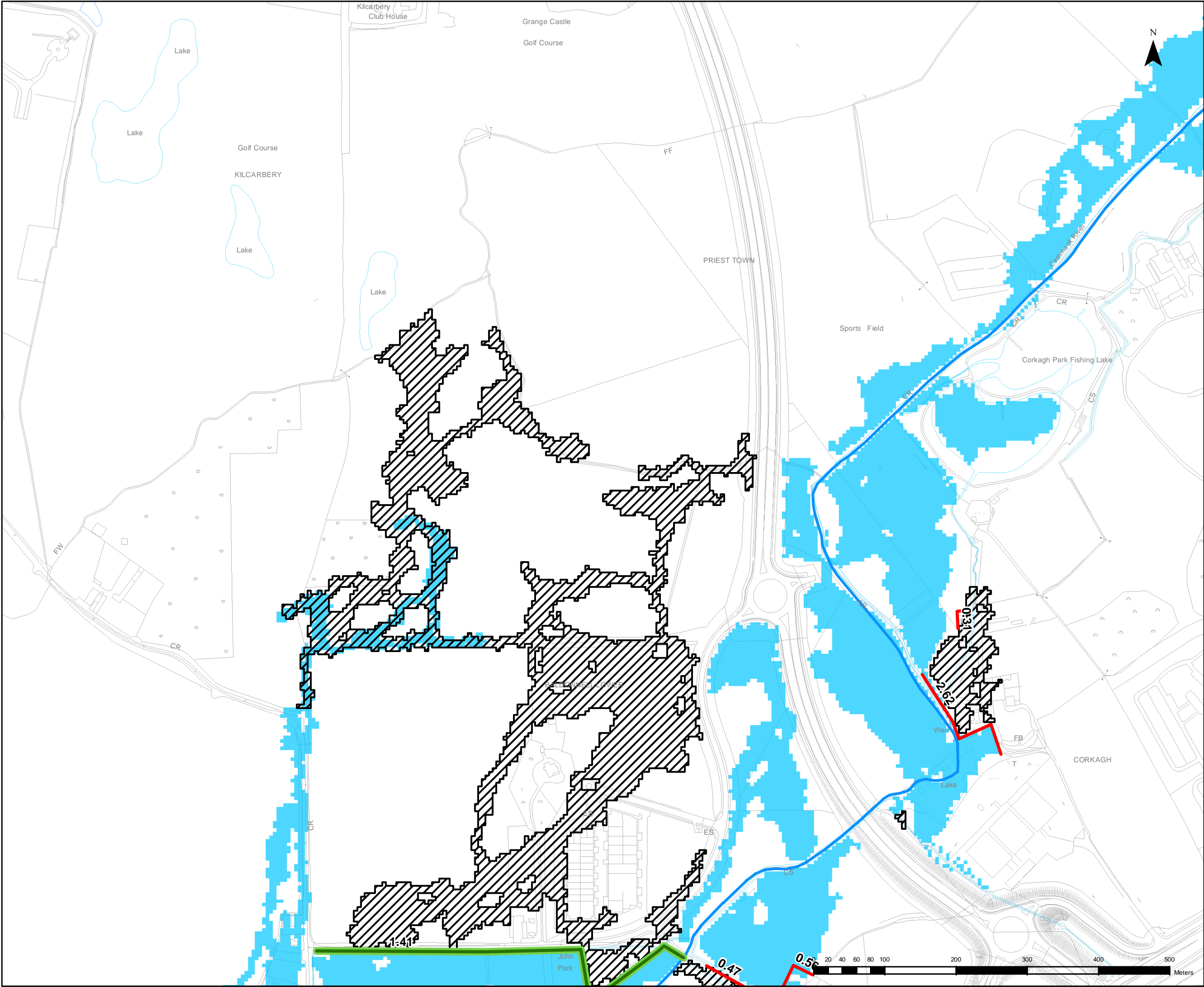
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Legend



Manhole

Defences

Embankment

Wall

River Centreline

1% AEP Residual Flooding

Area benefiting from Defences

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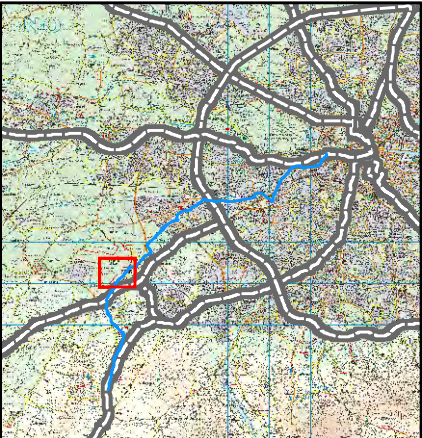
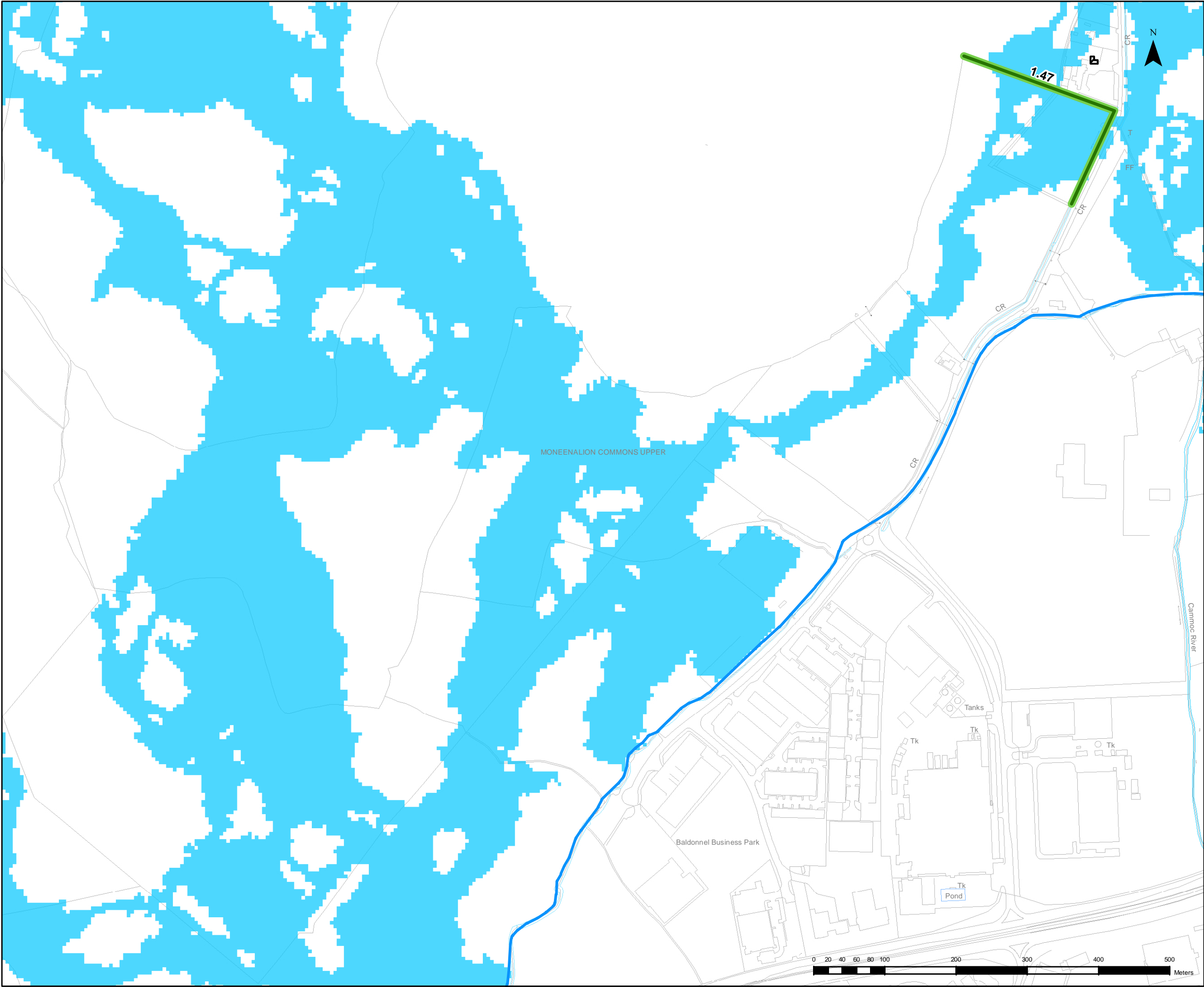
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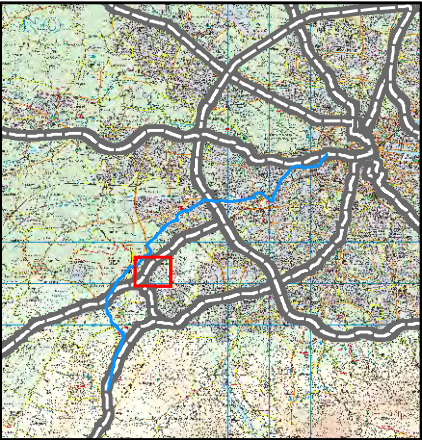
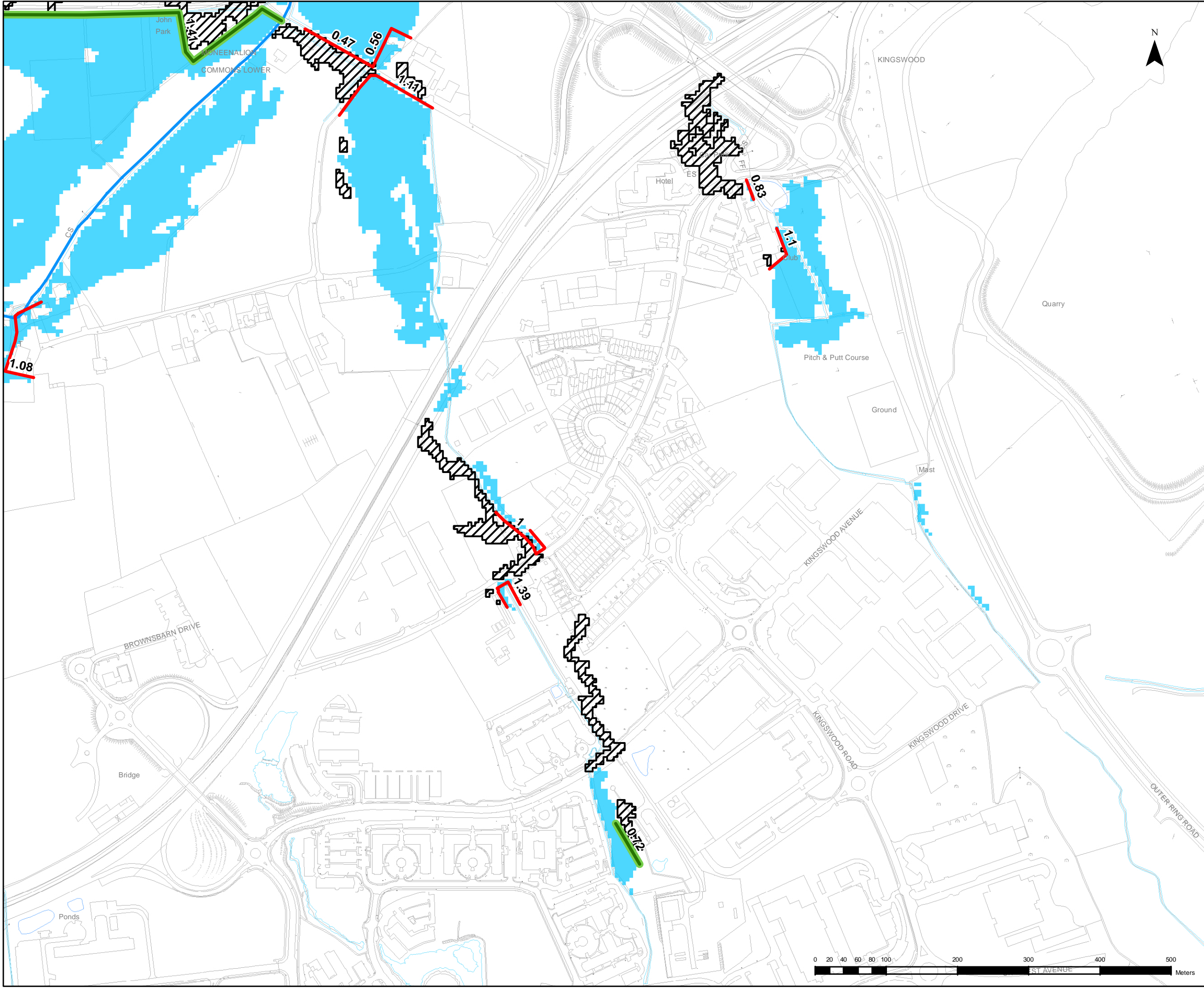
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Legend



Manhole

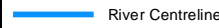
Defences



Embankment



Wall



River Centreline



1% AEP Residual Flooding



Area benefiting from Defences

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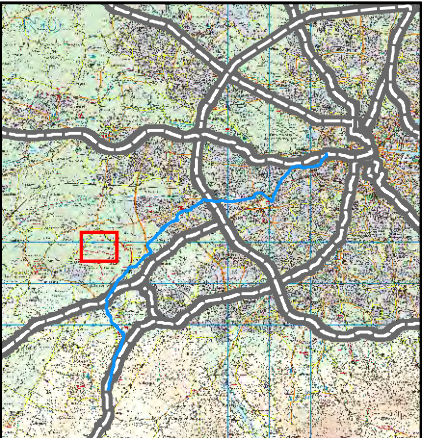
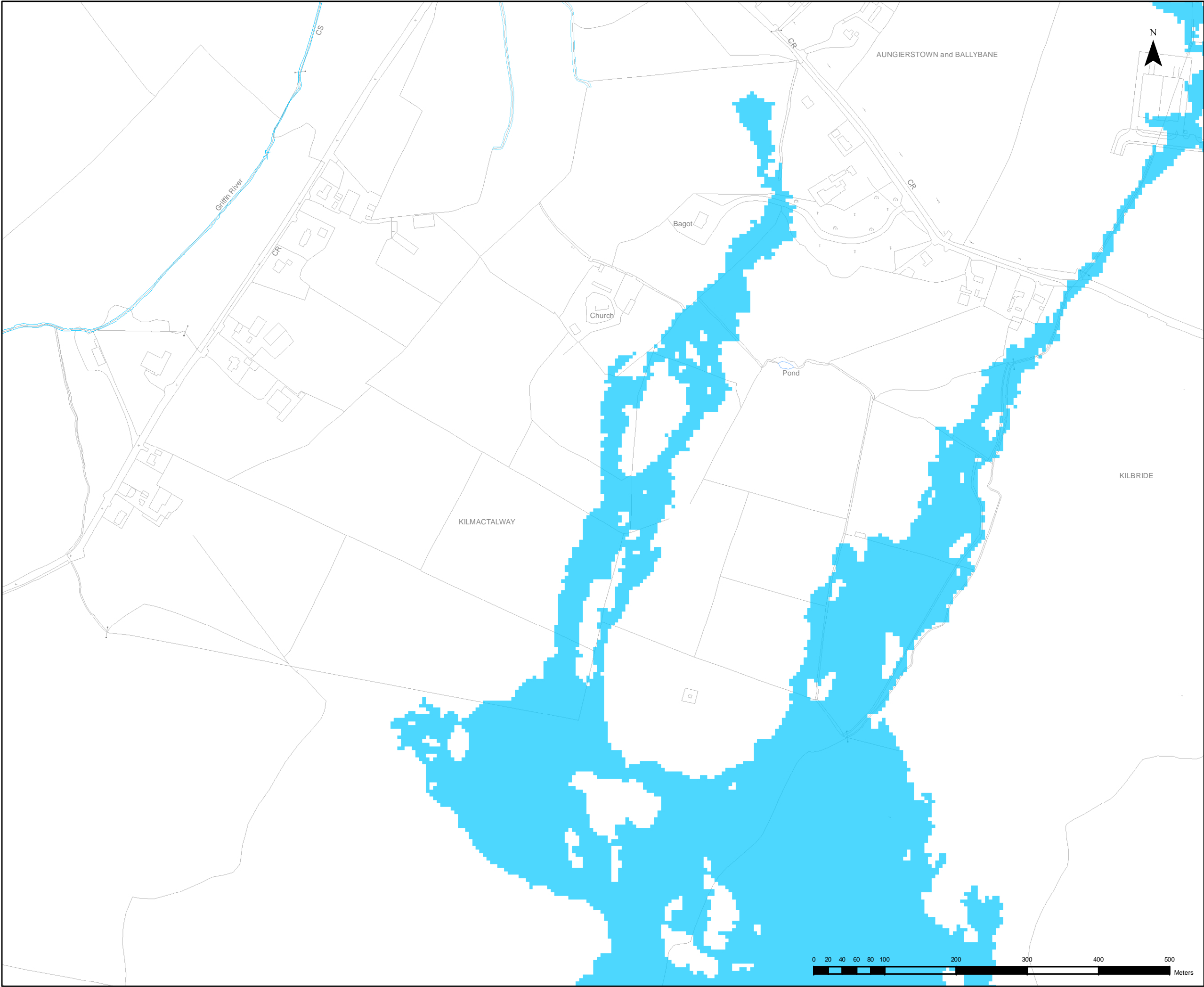
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Legend

MH Manhole

Defences

Embankment

Wall

River Centreline

1% AEP Residual Flooding

Area benefiting from Defences

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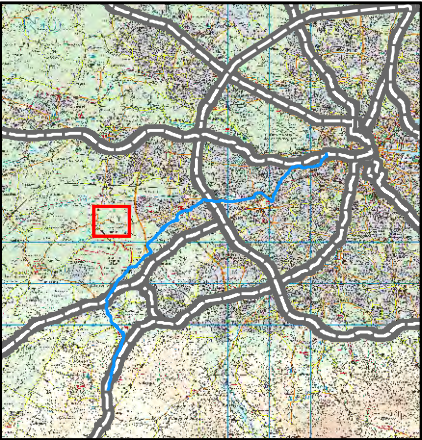
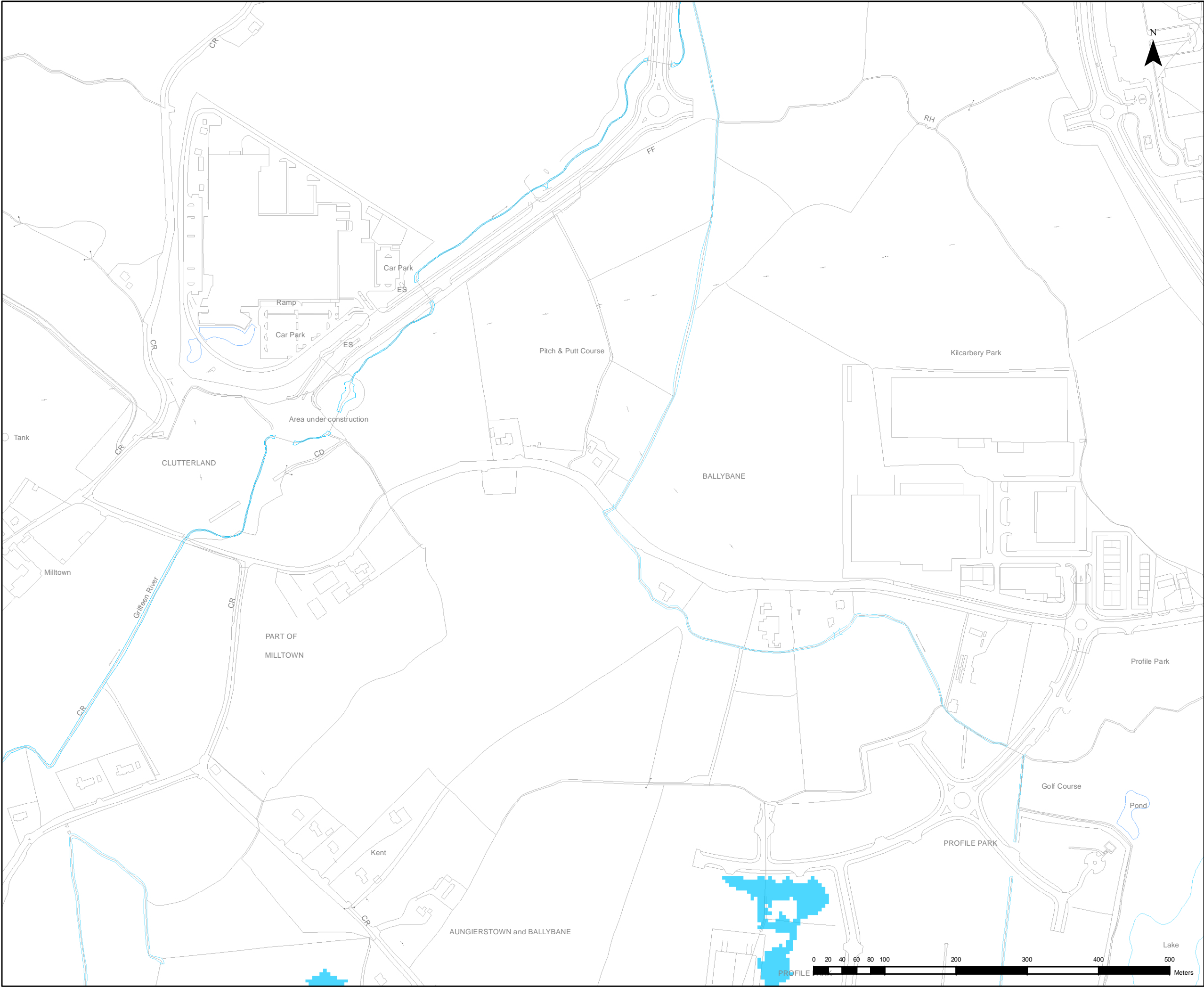
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Legend

 MH Manhole


Defences

 Embankment

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 River Centreline

 1% AEP Residual Flooding

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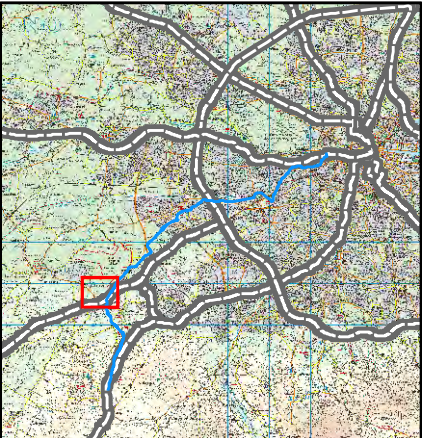
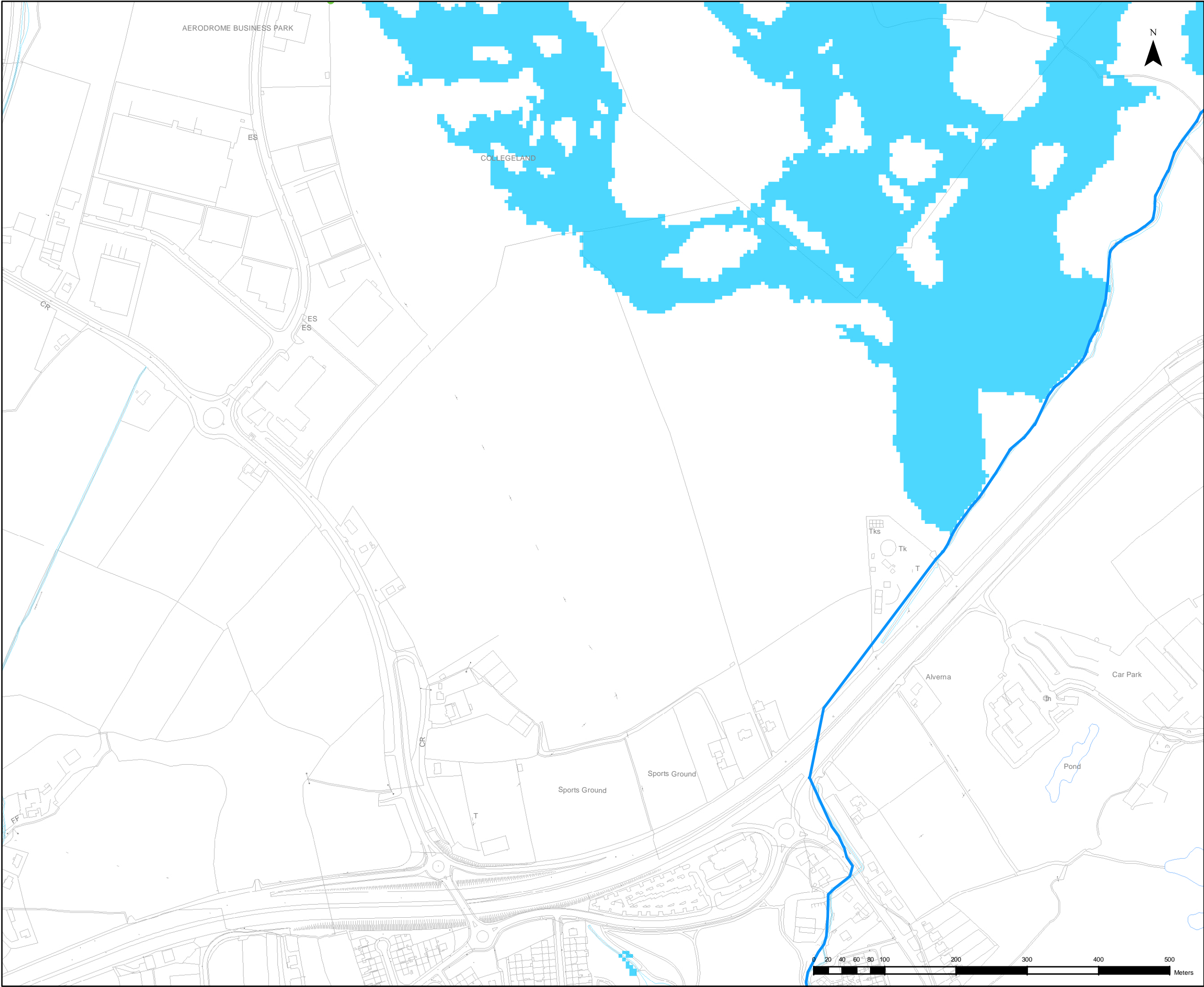
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TITLE

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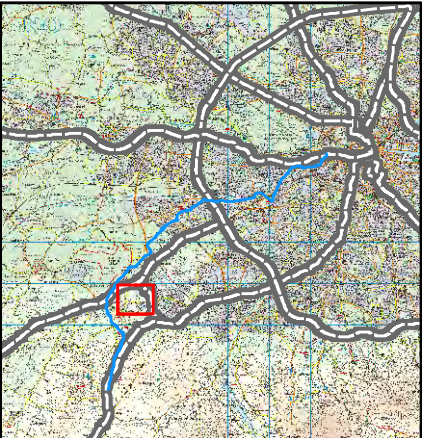
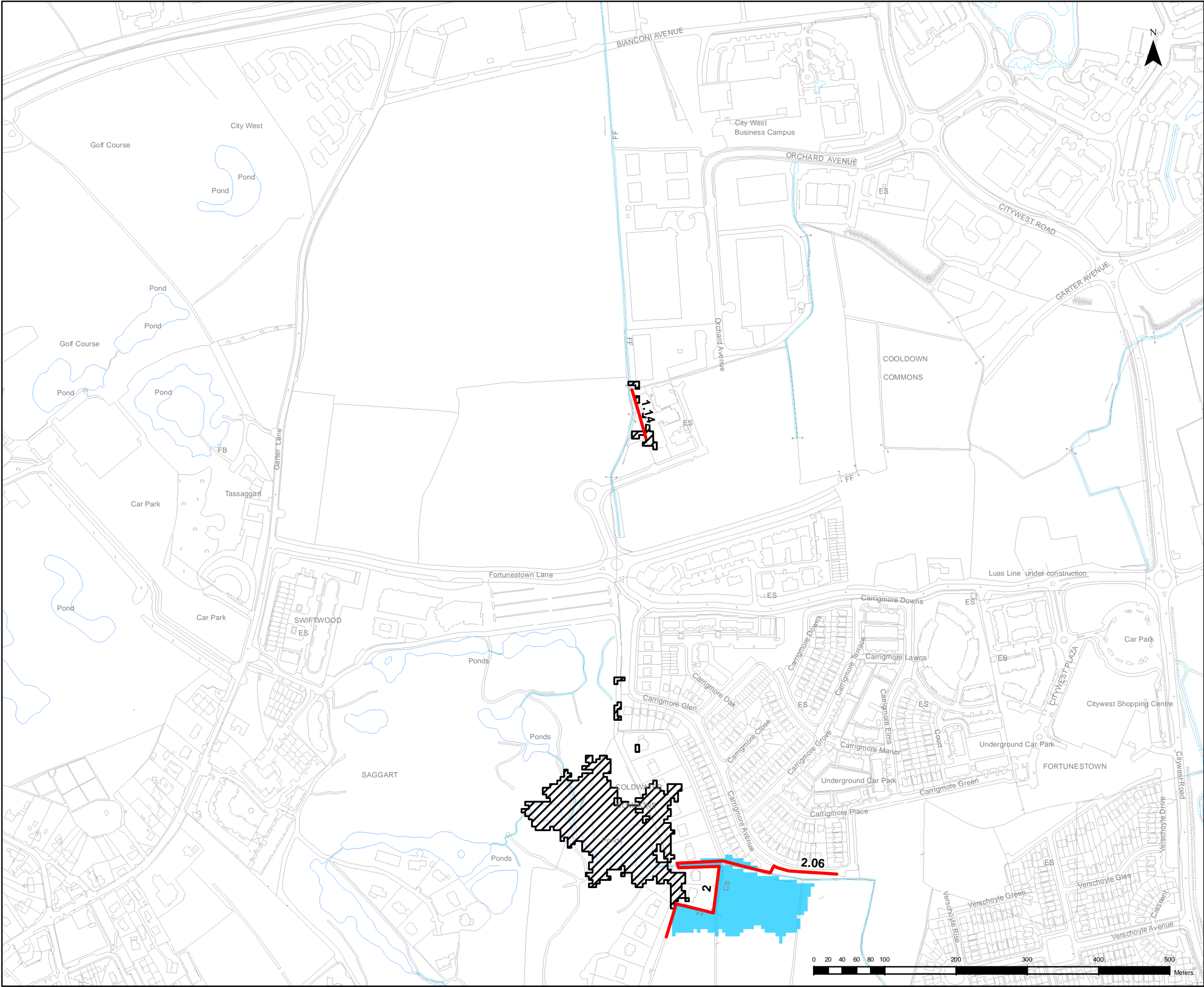
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TITLE

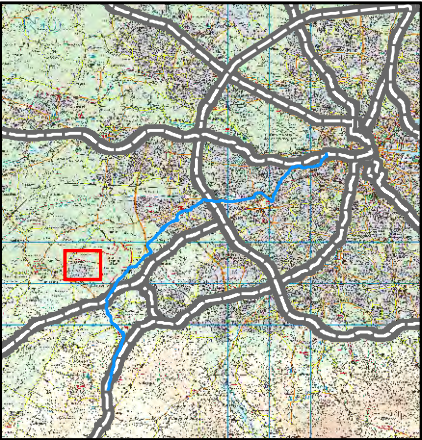
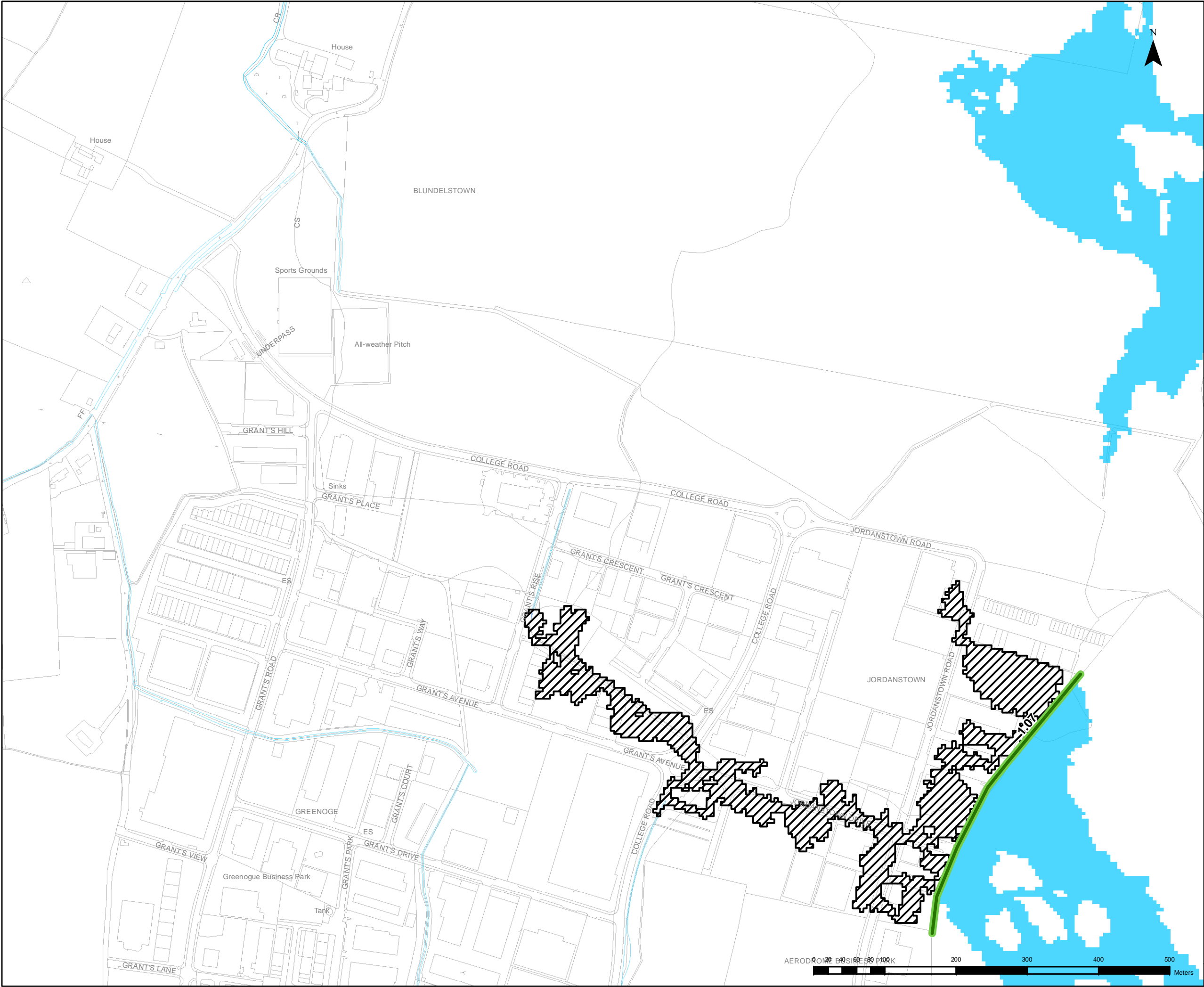
CAMAC
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Legend

 MH Manhole


Defences

 Embankment

 Wall

 River Centreline

 1% AEP Residual Flooding

 Area benefiting from Defences

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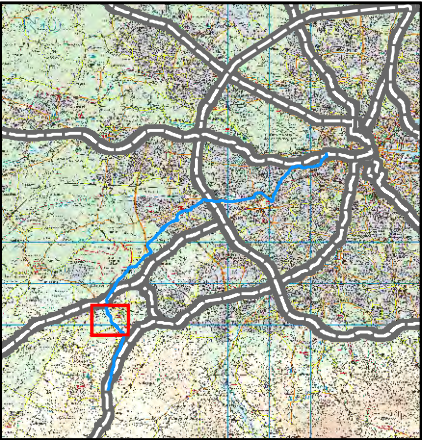
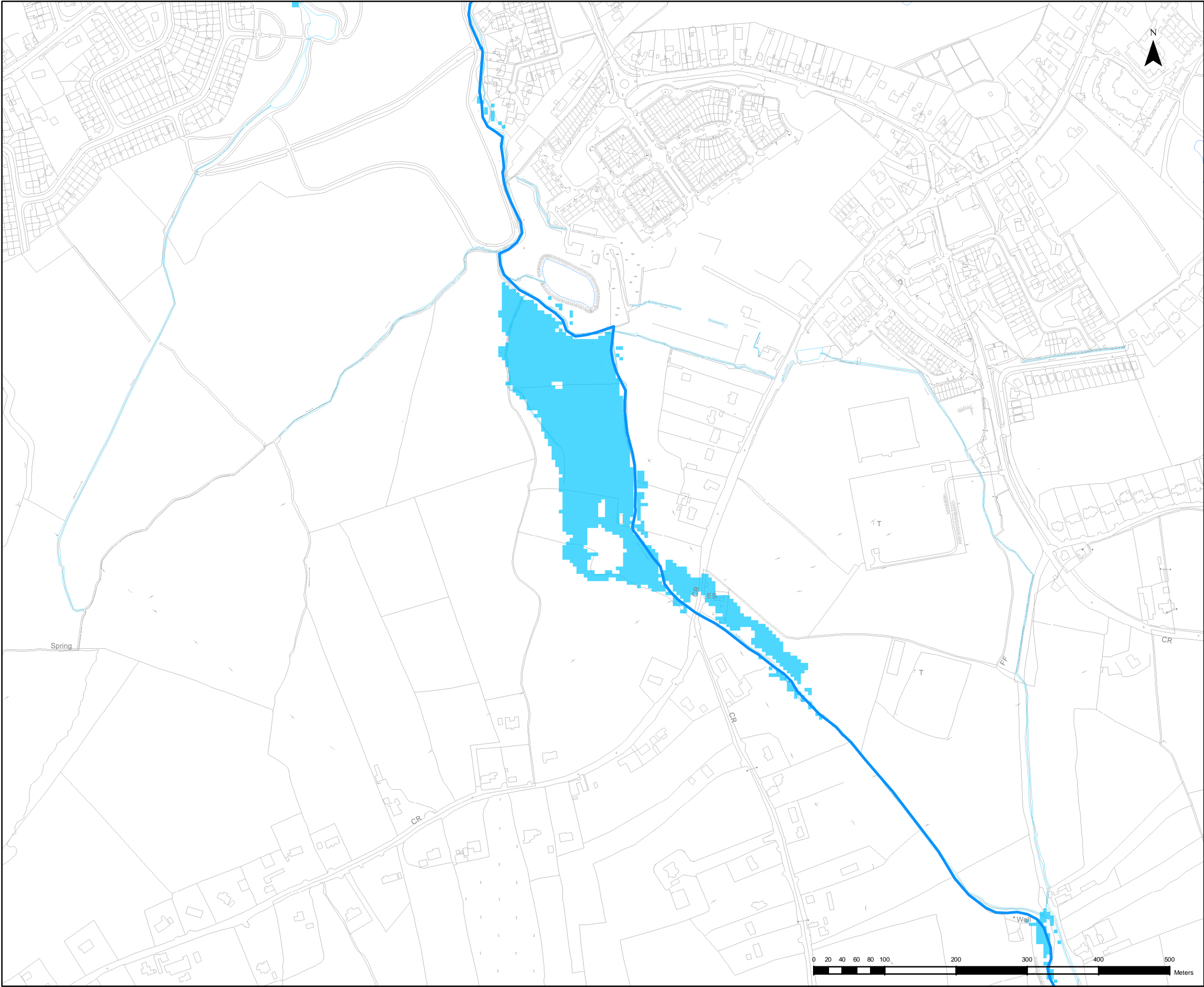
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Checked By : MW

Approved By : GG







Date : 13/02/2014

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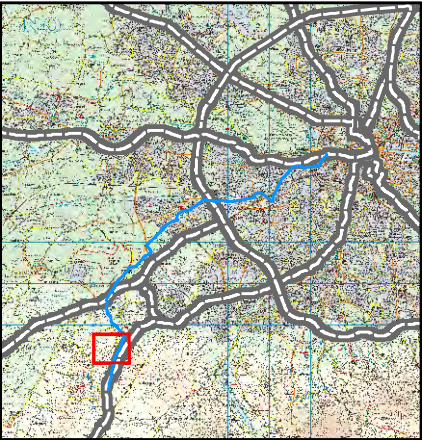
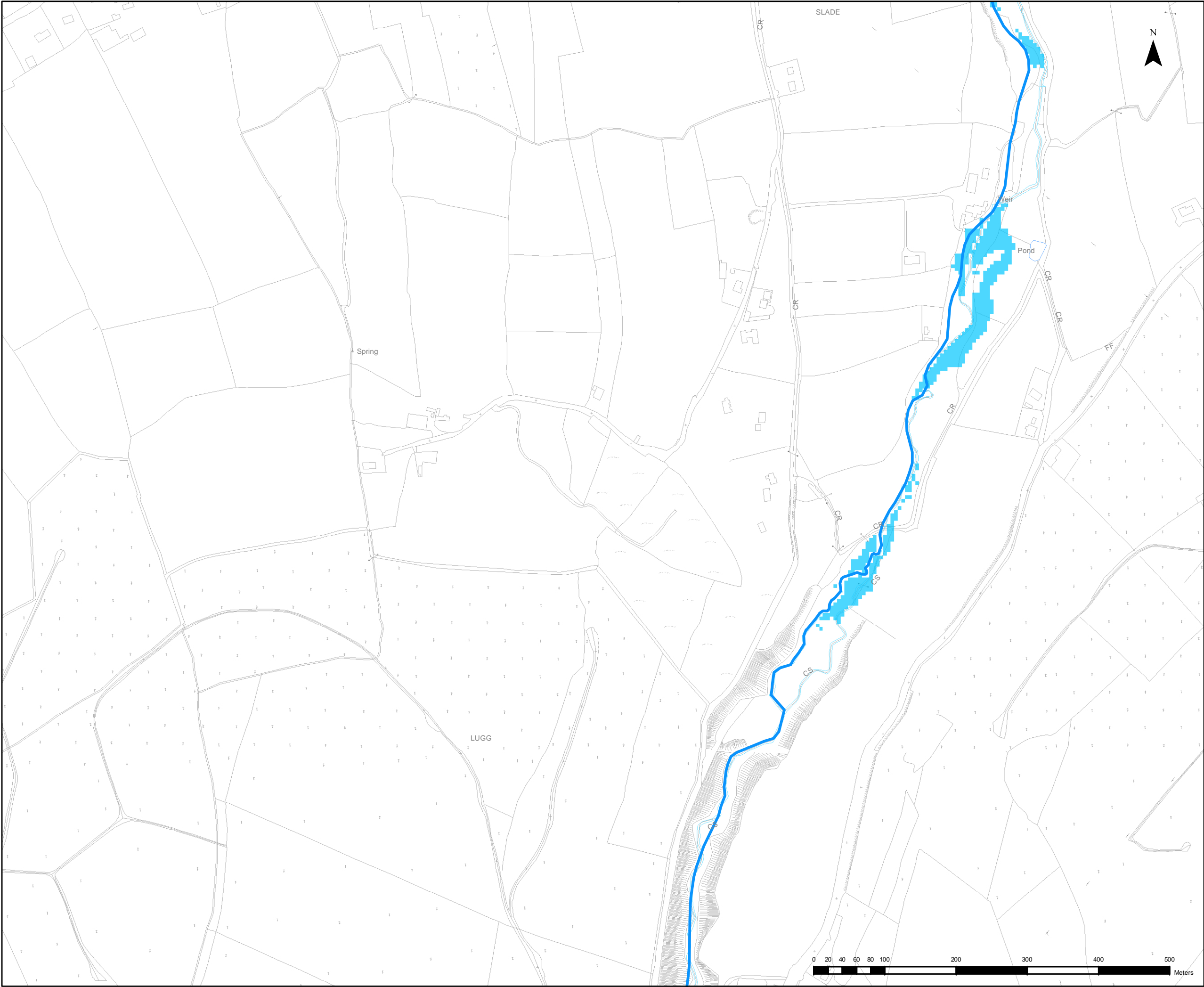
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 - Wall
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EASTERN CFRAMS

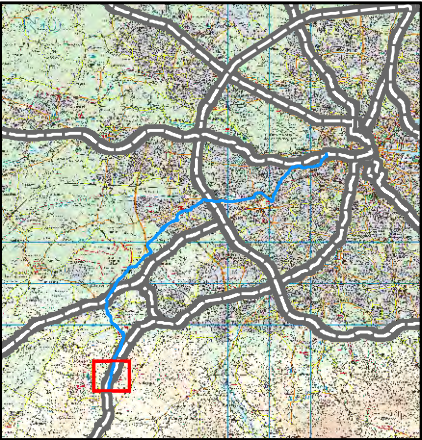
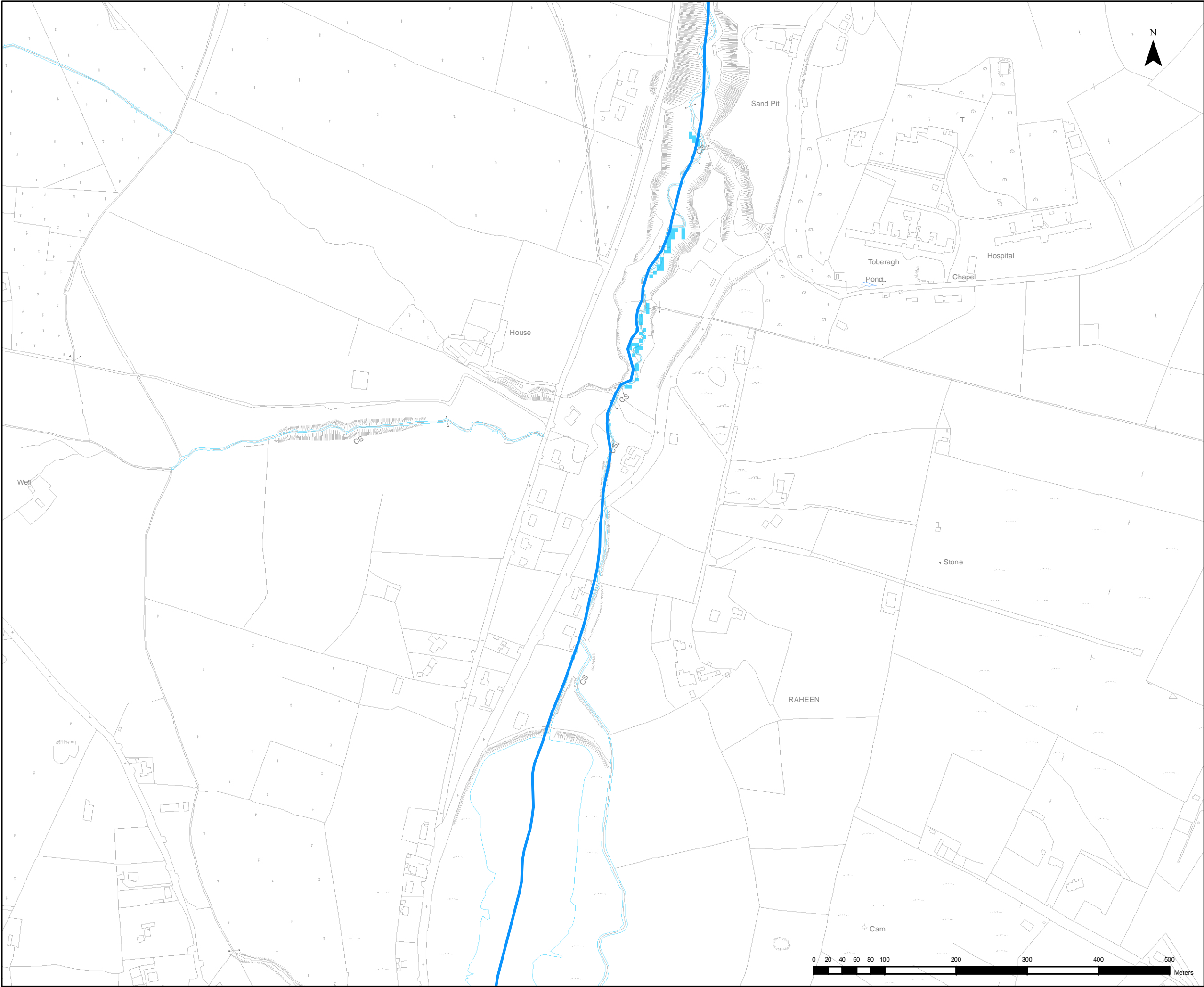
TITLE

CAMAC
Hard Defences and Manholes

ELMWOOD HOUSE
74 BOUCHER ROAD
BELFAST BT12 6RZ


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Drawing No.:	Drawn By :	RC
09CC_DEF_OPT 1_012	Checked By :	MW
	Approved By :	GG
	Date :	13/02/2014
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Legend

 MH Manhole


Defences

 Embankment

 Wall

 River Centreline

 1% AEP Residual Flooding

 Area benefiting from Defences

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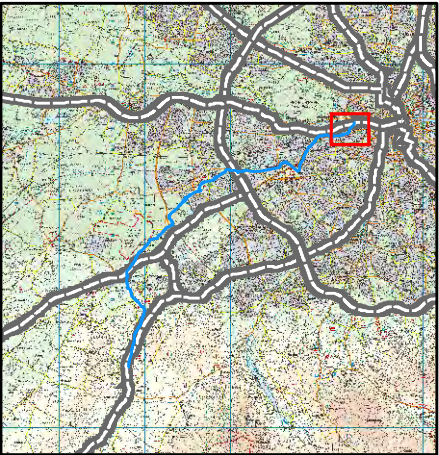
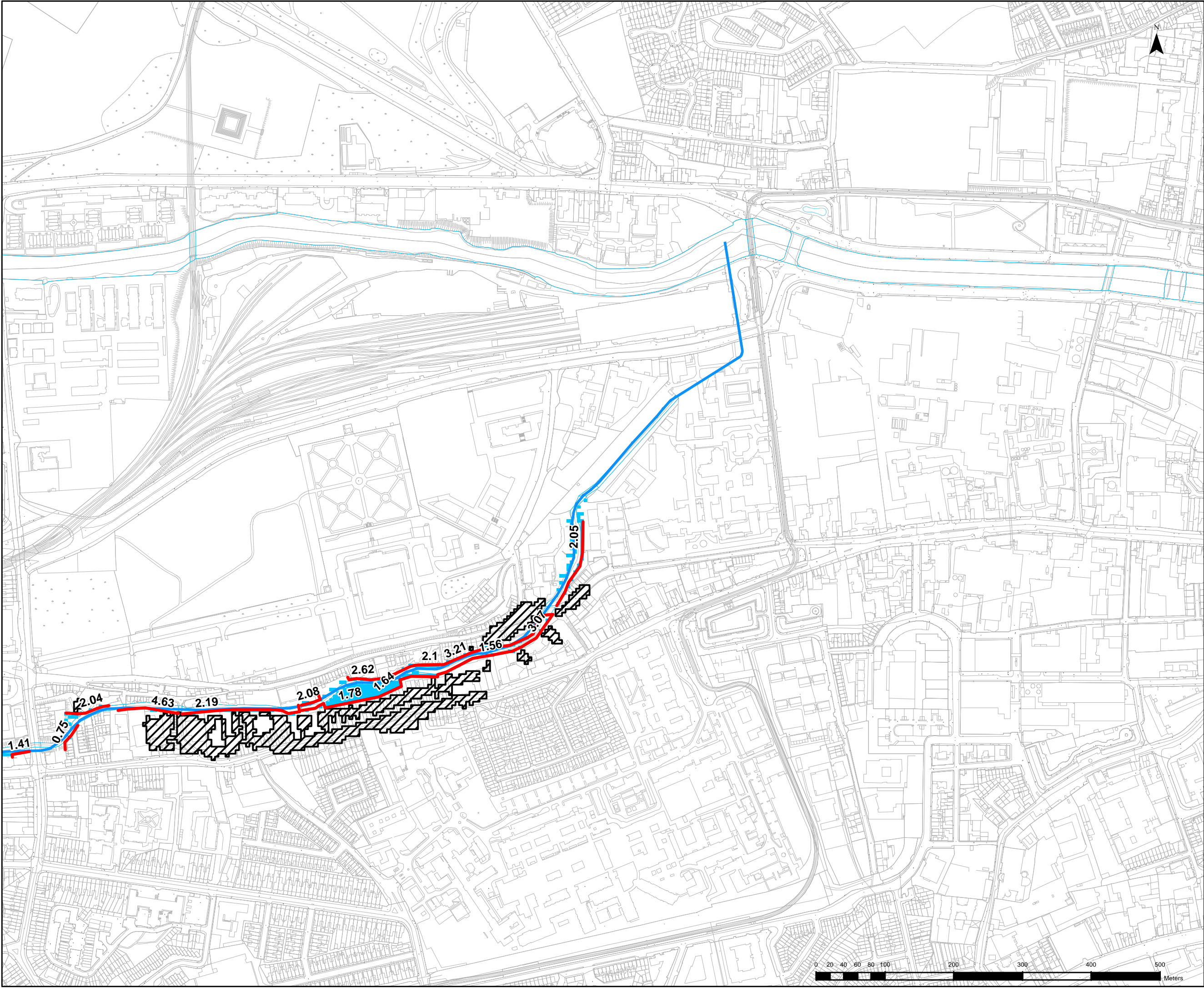
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Drawn By : RC
Checked By : MW
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Date : 13/02/2014

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- Legend**
- MH Manhole
 - Defences
 - Embankment
 - Wall
 - River Centreline
 - Landsowne Embankment
 - 1% AEP Residual Flooding
 - Area benefiting from Defences

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PROJECT

EASTERN CFRAMS

TITLE

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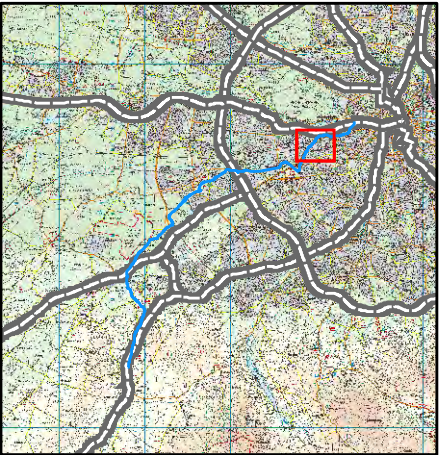
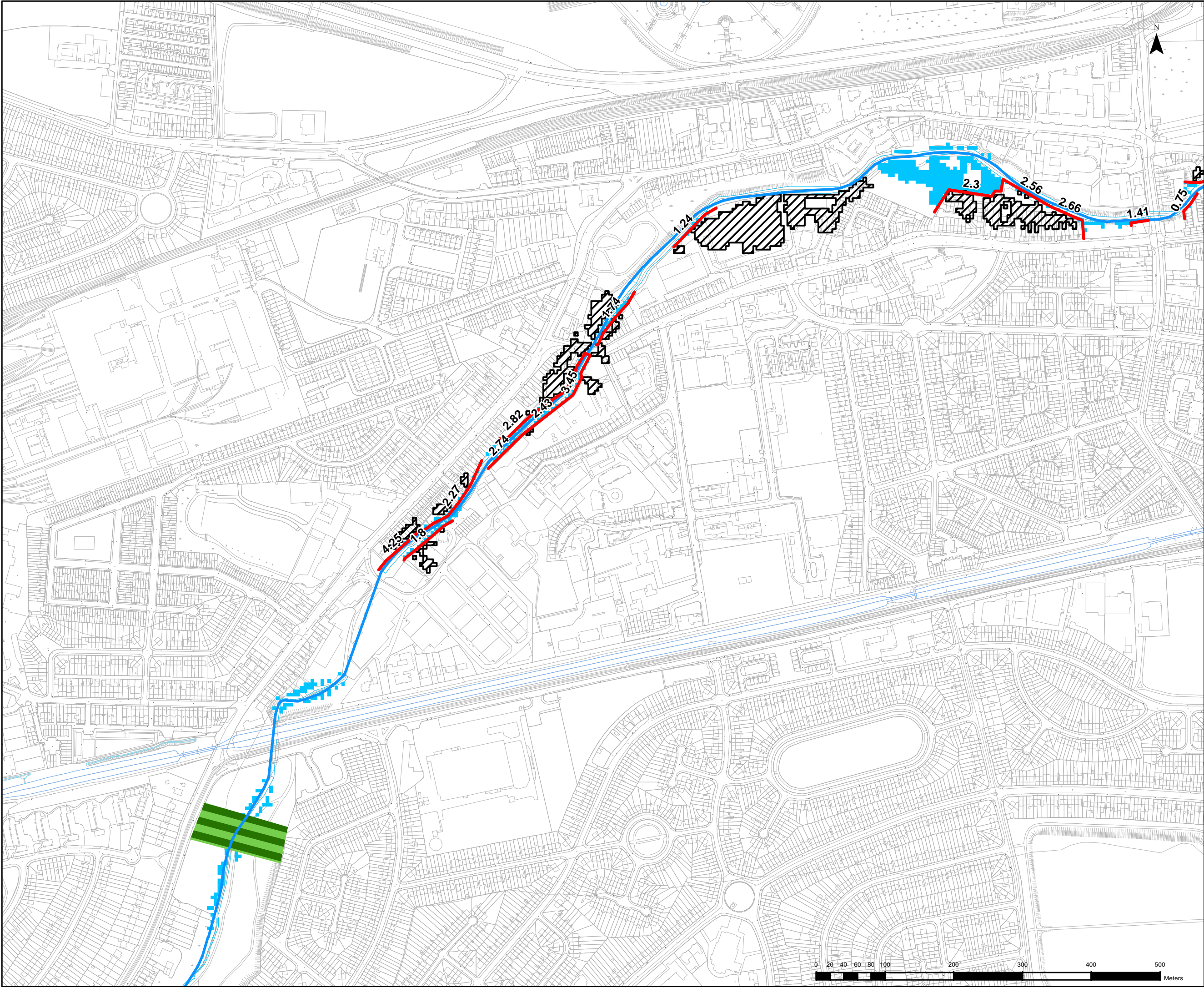
ELMWOOD HOUSE
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BELFAST BT12 6RZ

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- Legend**
- MH Manhole
 - Defences**
 - Embankment
 - Wall
 - River Centreline
 - Landsdowne Embankment
 - 1% AEP Residual Flooding
 - Area benefiting from Defences

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TITLE

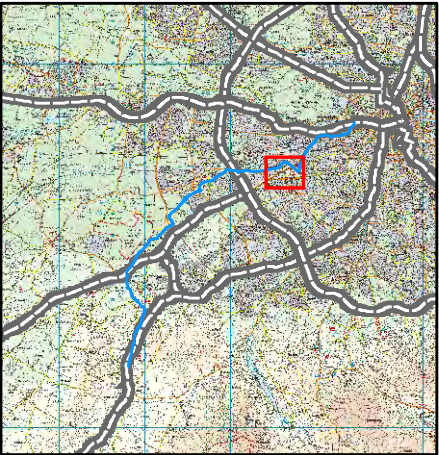
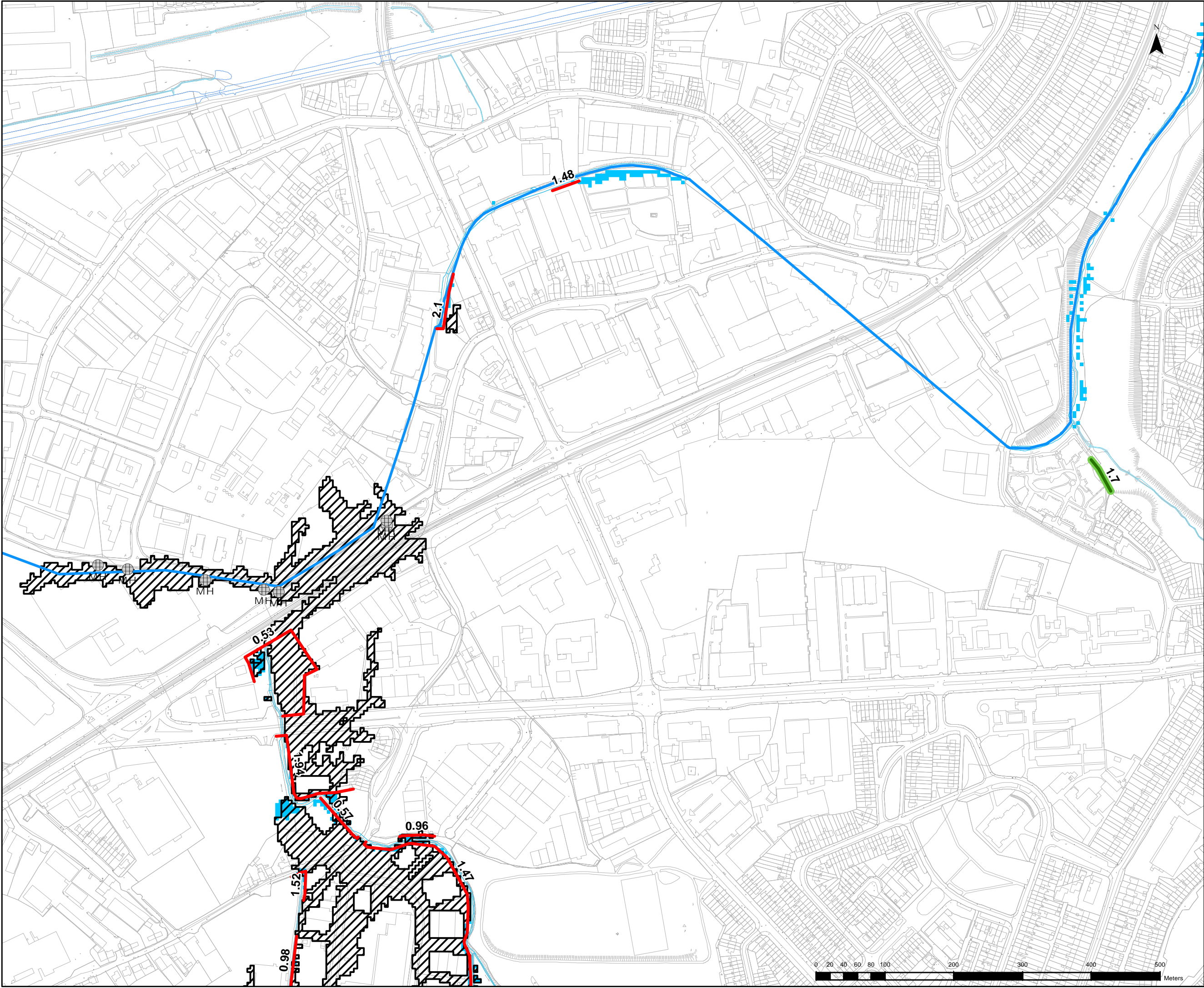
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Legend

- MH Manhole
- Defences**
 - Embankment
 - Wall
 - River Centreline
 - Landsdowne Embankment
 - 1% AEP Residual Flooding
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TITLE

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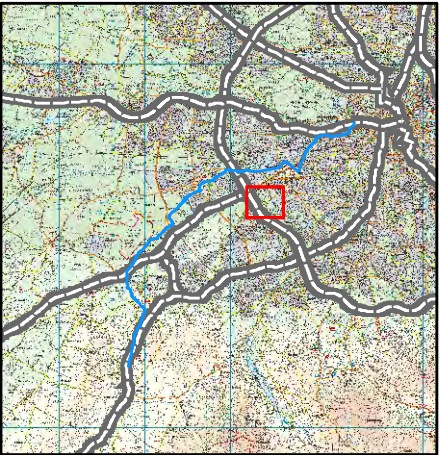
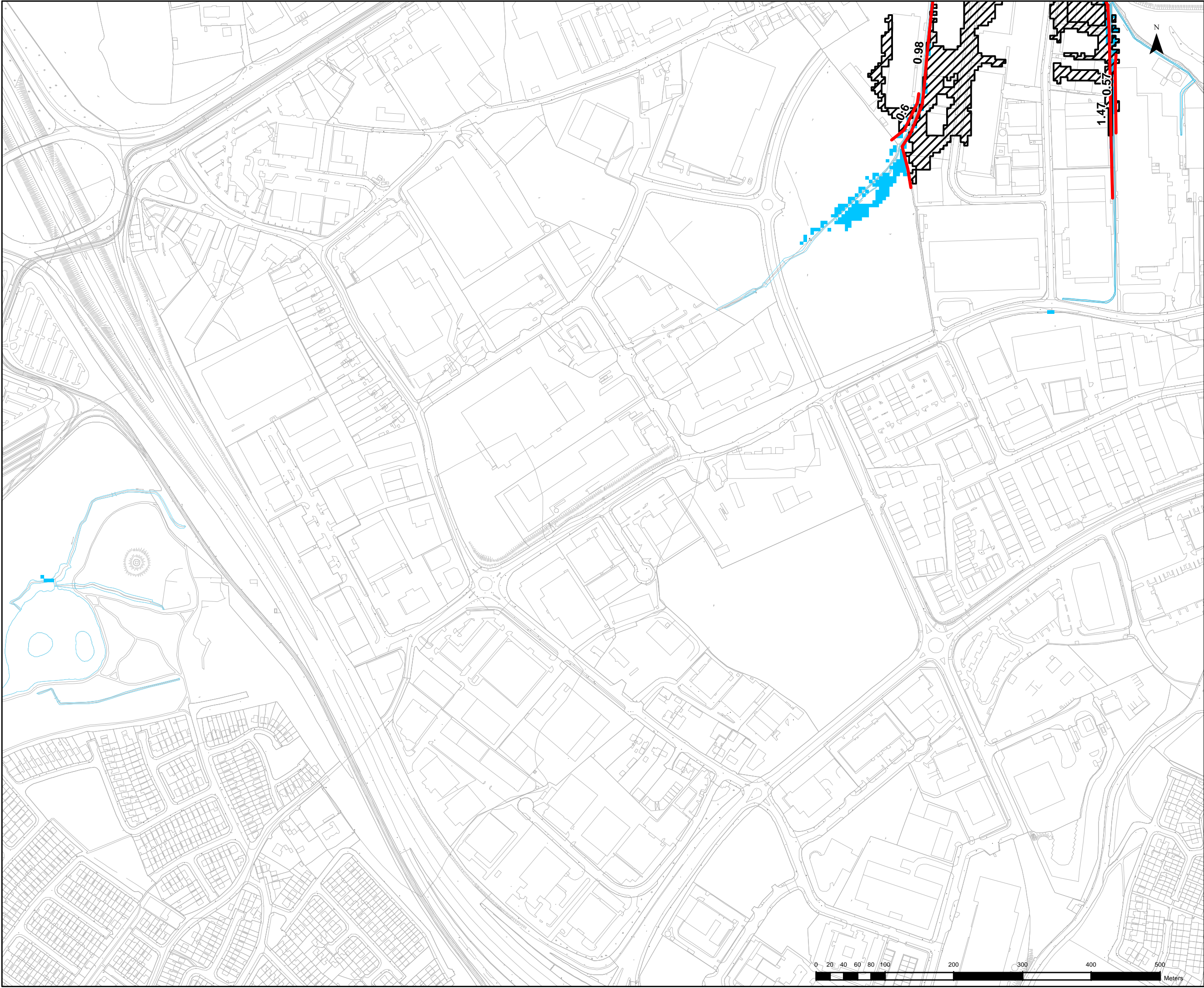
ELMWOOD HOUSE
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- MH Manhole
 - Defences**
 - Embankment
 - Wall
 - River Centreline
 - Landsowne Embankment
 - 1% AEP Residual Flooding
 - Area benefiting from Defences

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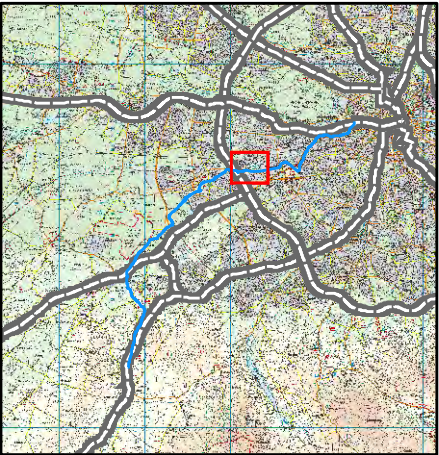
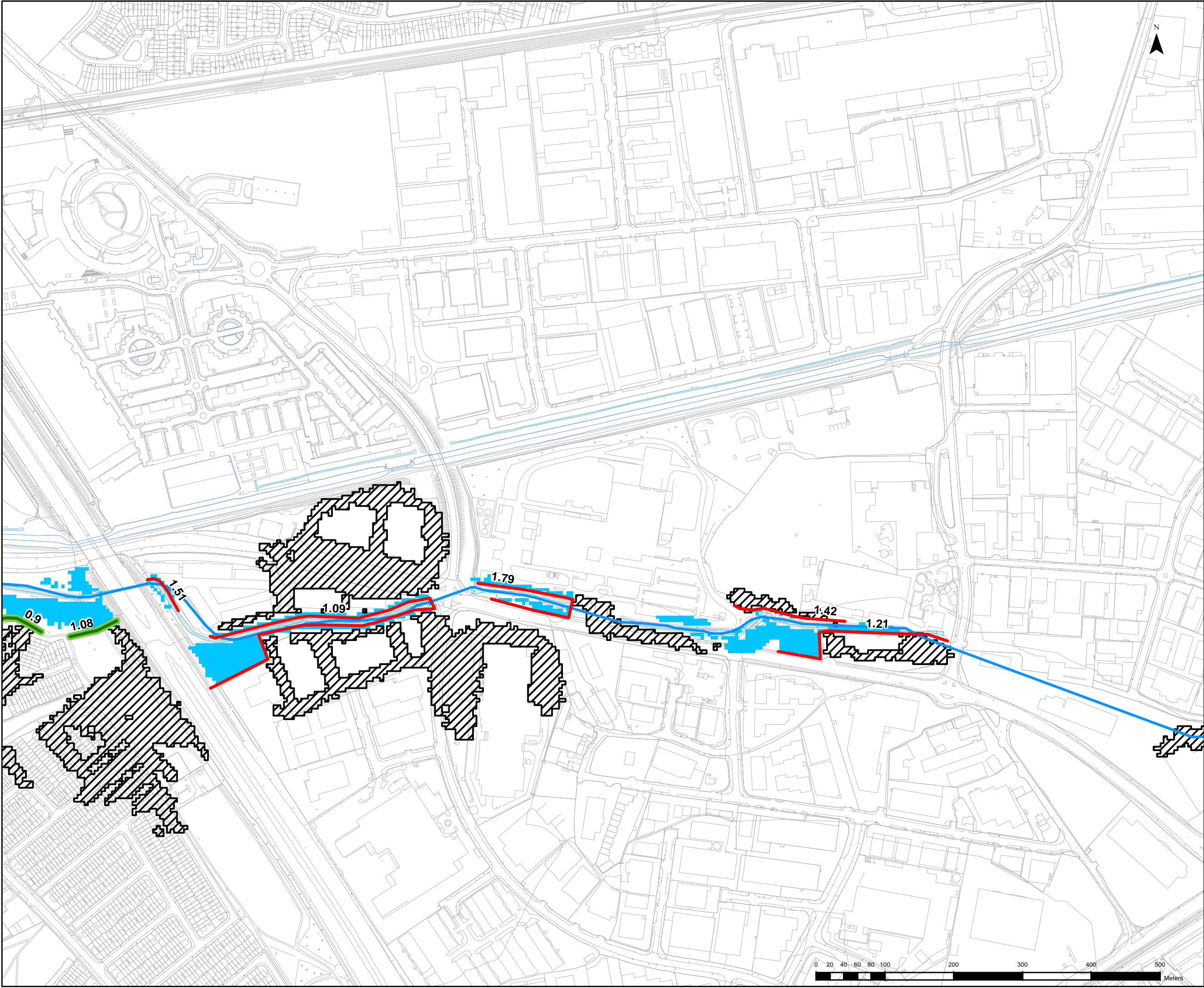
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Legend

-  MH Manhole
- Defences**
-  Embankment
-  Wall
-  River Centreline
-  Landsdowne Embankment
-  1% AEP Residual Flooding
-  Area benefiting from Defences

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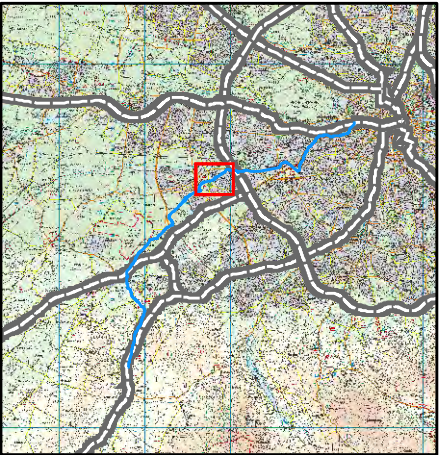
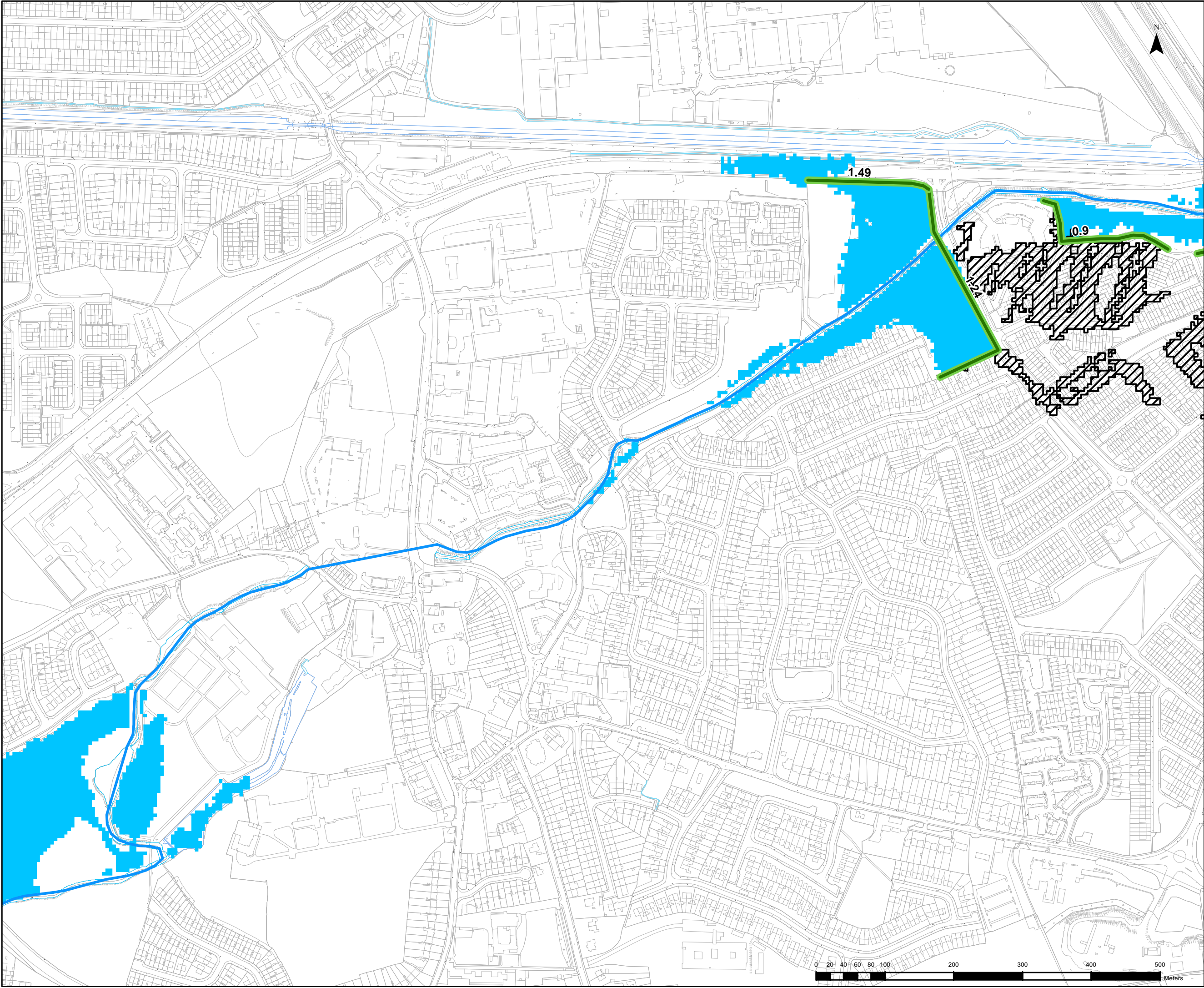
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Drawing No.: 09CC_DEF_OPT 2_005 Drawn By: RC Checked By: MW Approved By: GG Date: 13/02/2014

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- Legend**
- MH Manhole
 - Defences
 - Embankment
 - Wall
 - River Centreline
 - Landsdowne Embankment
 - 1% AEP Residual Flooding
 - Area benefiting from Defences

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TITLE

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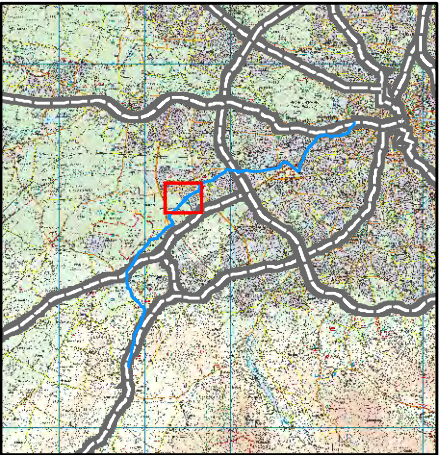
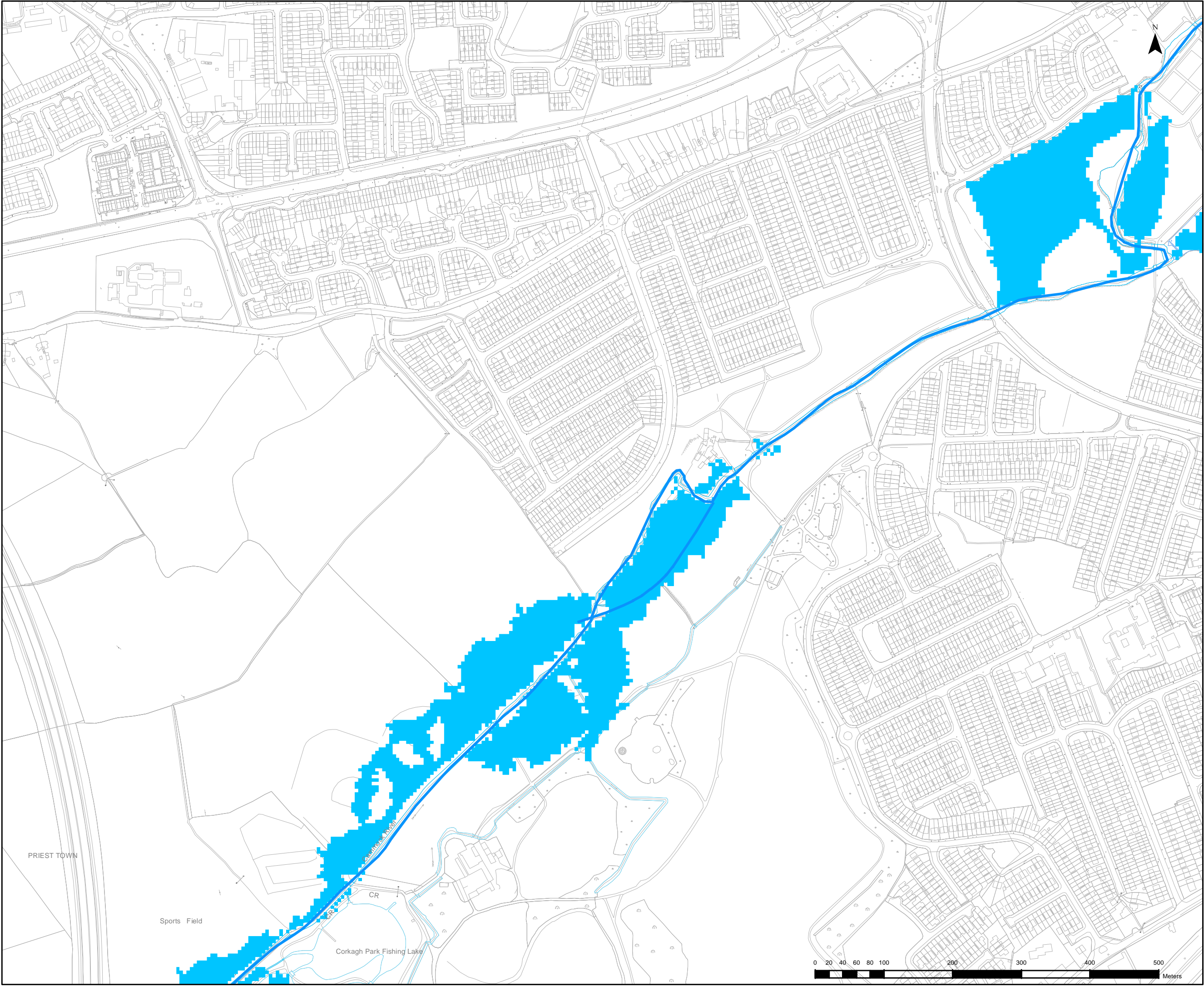
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Legend

MH Manhole

Defences

Embankment

Wall

River Centreline

Landsdowne Embankment

1% AEP Residual Flooding

Area benefiting from Defences

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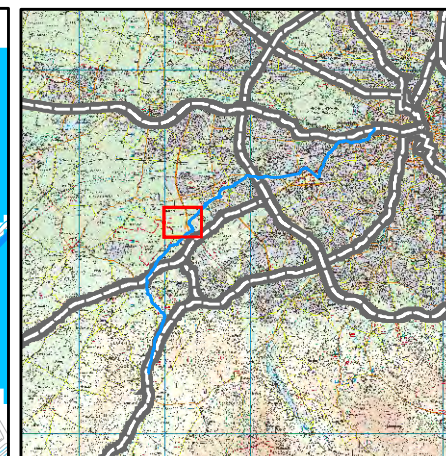
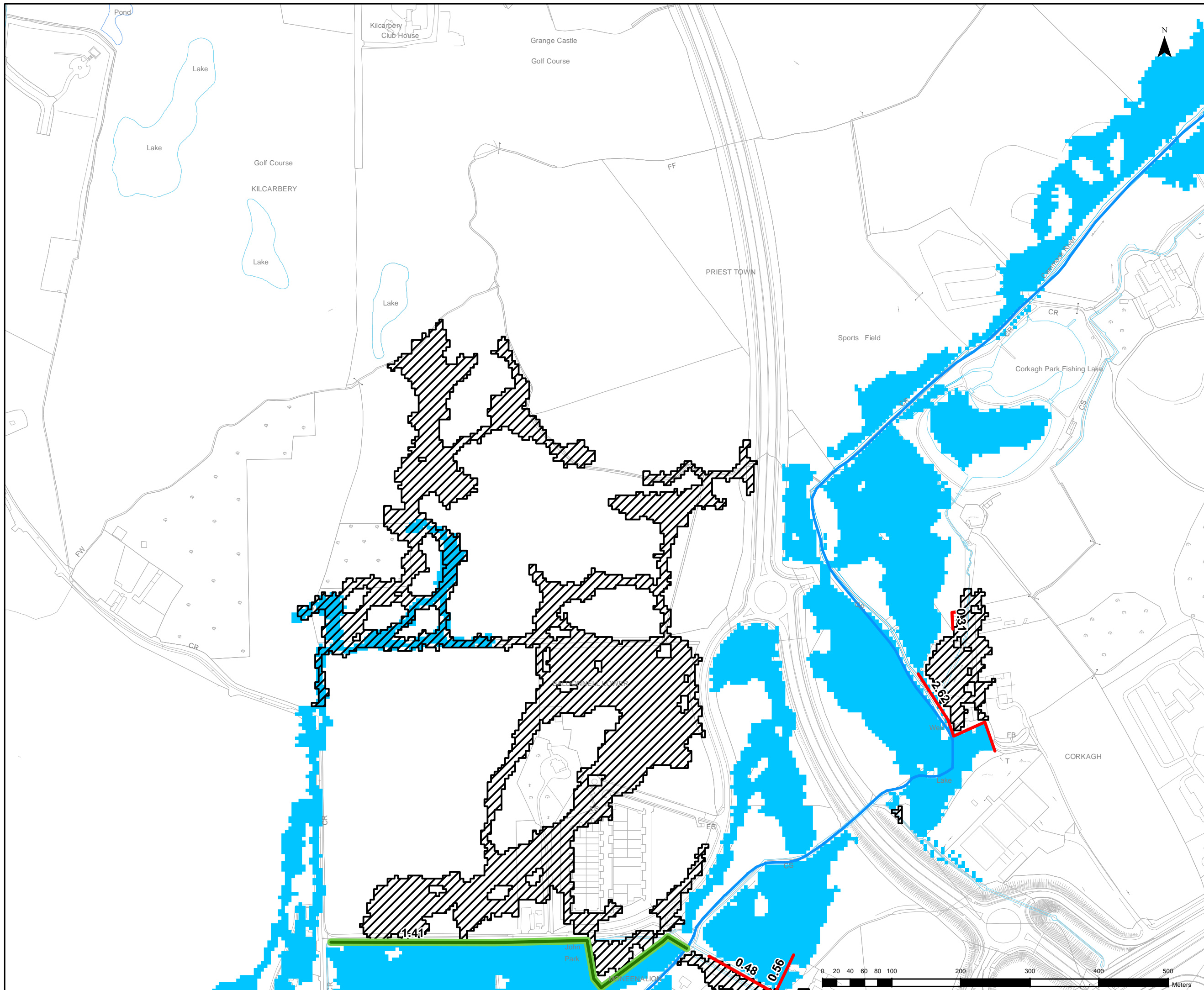
EASTERN CFRAMS

TITLE

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		Approved By :	GG
		Date :	13/02/2014
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Legend



Manhole

Defences



Wal



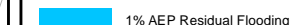
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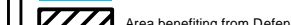
Landsdowne Embankment



1% AEP Residual Flooding



Area benefiting from Defor



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TITLE	CAMAC Hard Defences, Manholes and Upstream Storage
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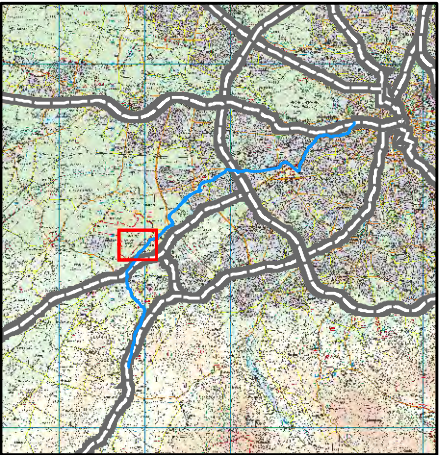
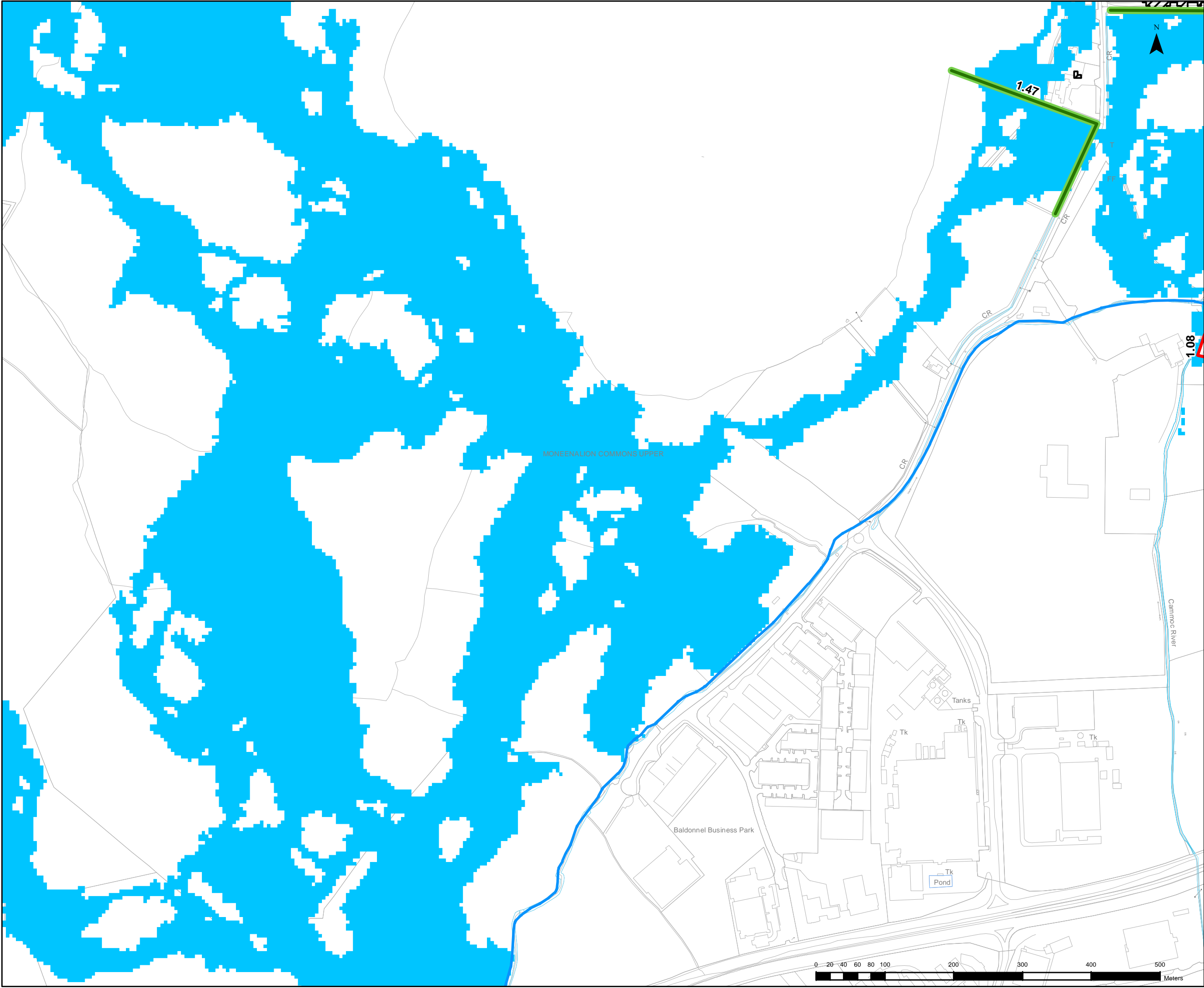
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Drawing No. :

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- Legend**
- MH Manhole
 - Defences**
 - Embankment
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 - River Centreline
 - Landsdowne Embankment
 - 1% AEP Residual Flooding
 - Area benefiting from Defences

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TITLE

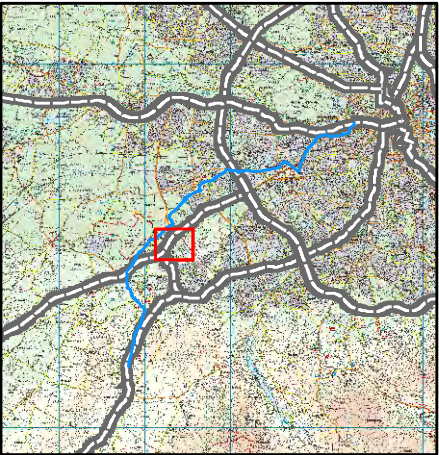
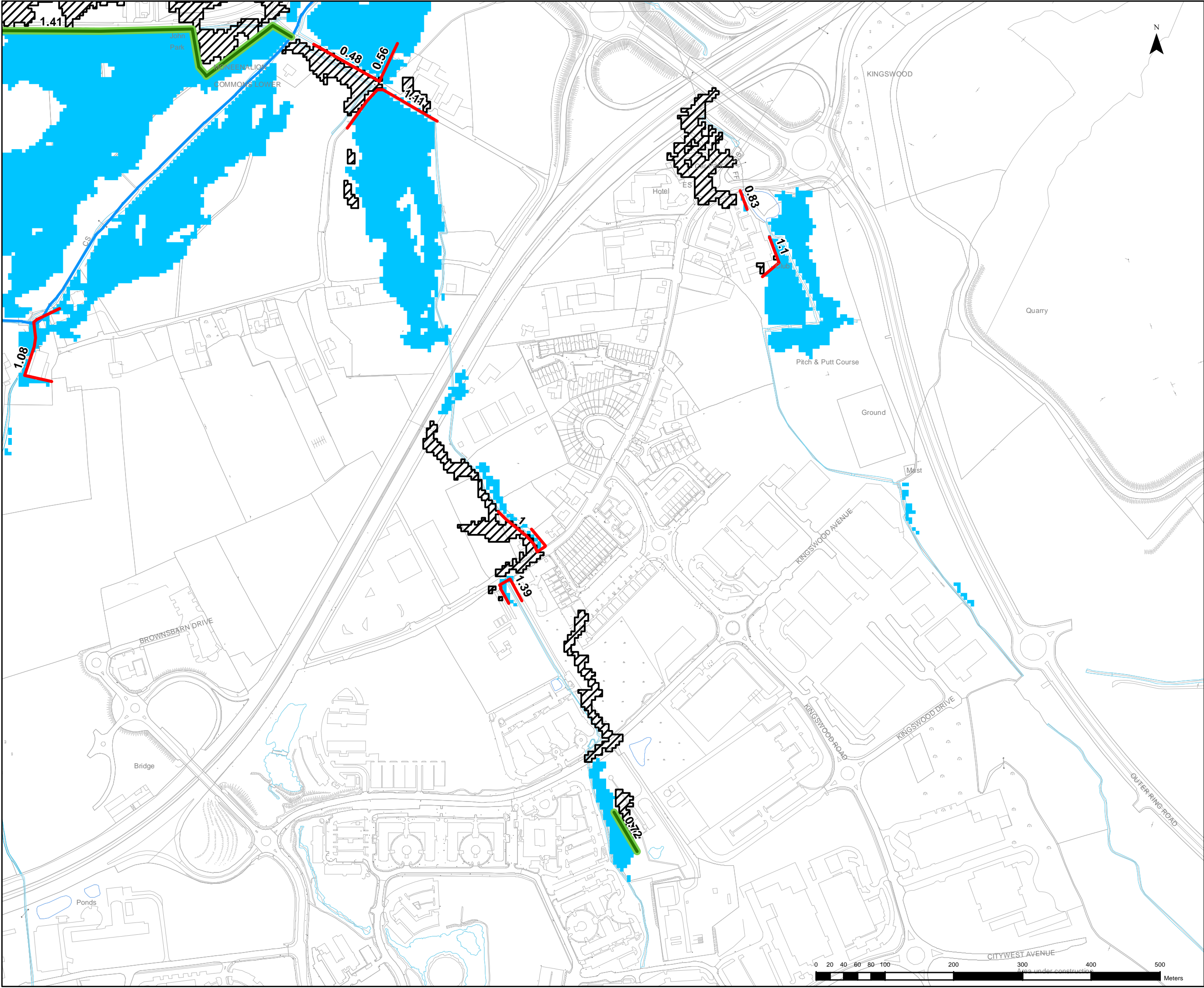
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- Legend**
- MH Manhole
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 - 1% AEP Residual Flooding
 - Area benefiting from Defences

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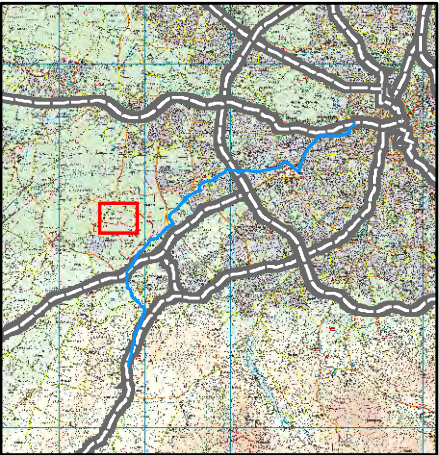
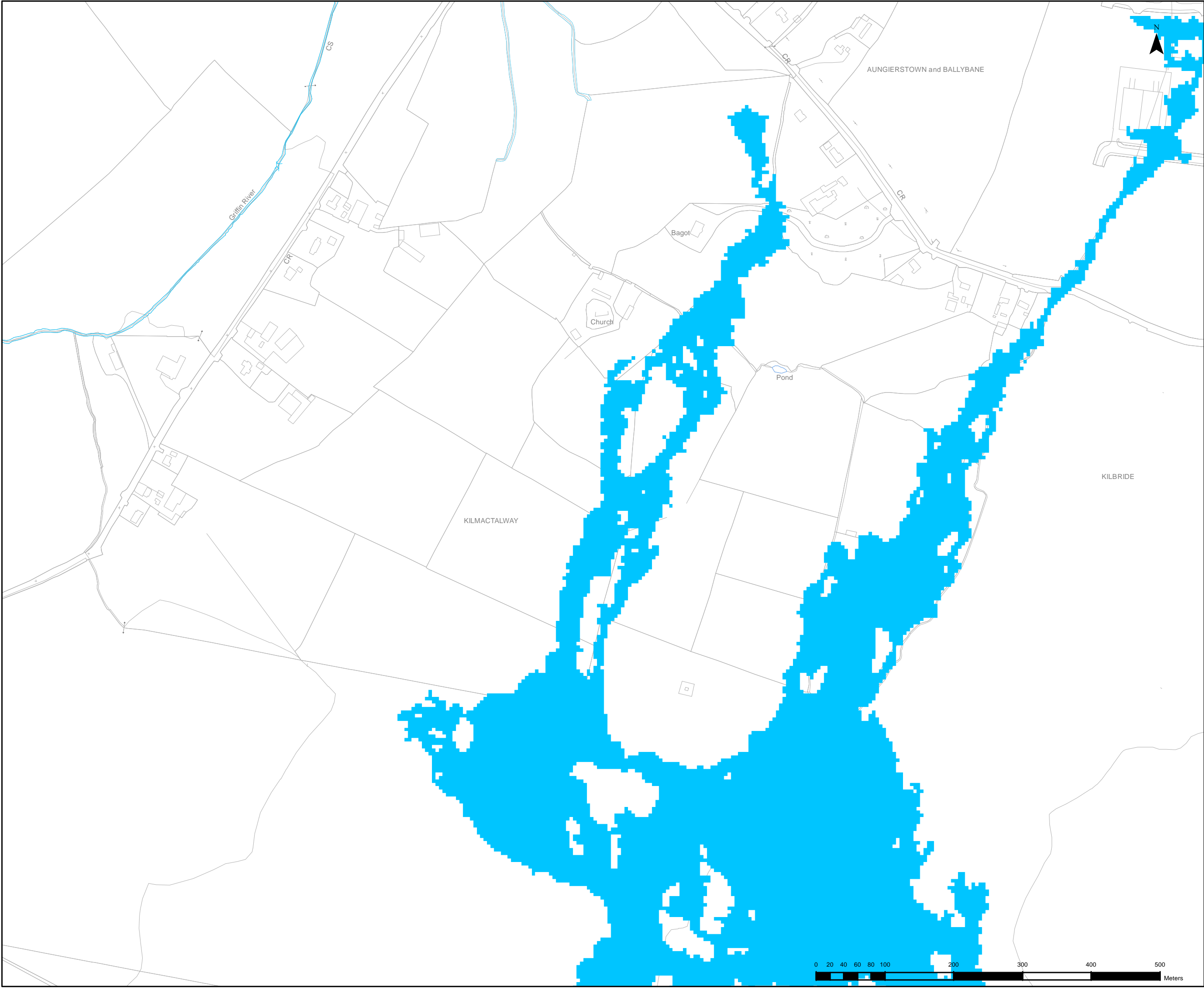
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09CC_DEF_OPT 2_009a	Date :	13/02/2014
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Legend

- MH Manhole
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- Landsdowne Embankment
- 1% AEP Residual Flooding
- Area benefiting from Defences

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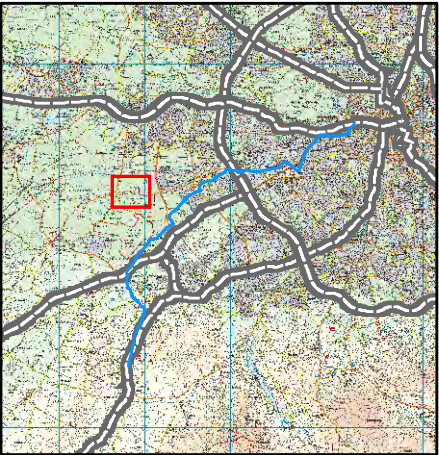
TITLE

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09CC_DEF_OPT 2_009b	Date :	13/02/2014
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Legend

- MH Manhole
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 - Area benefiting from Defences

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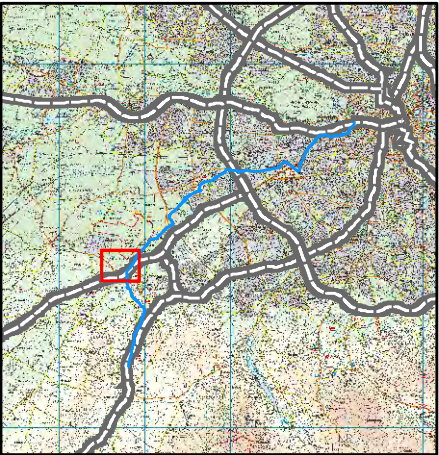
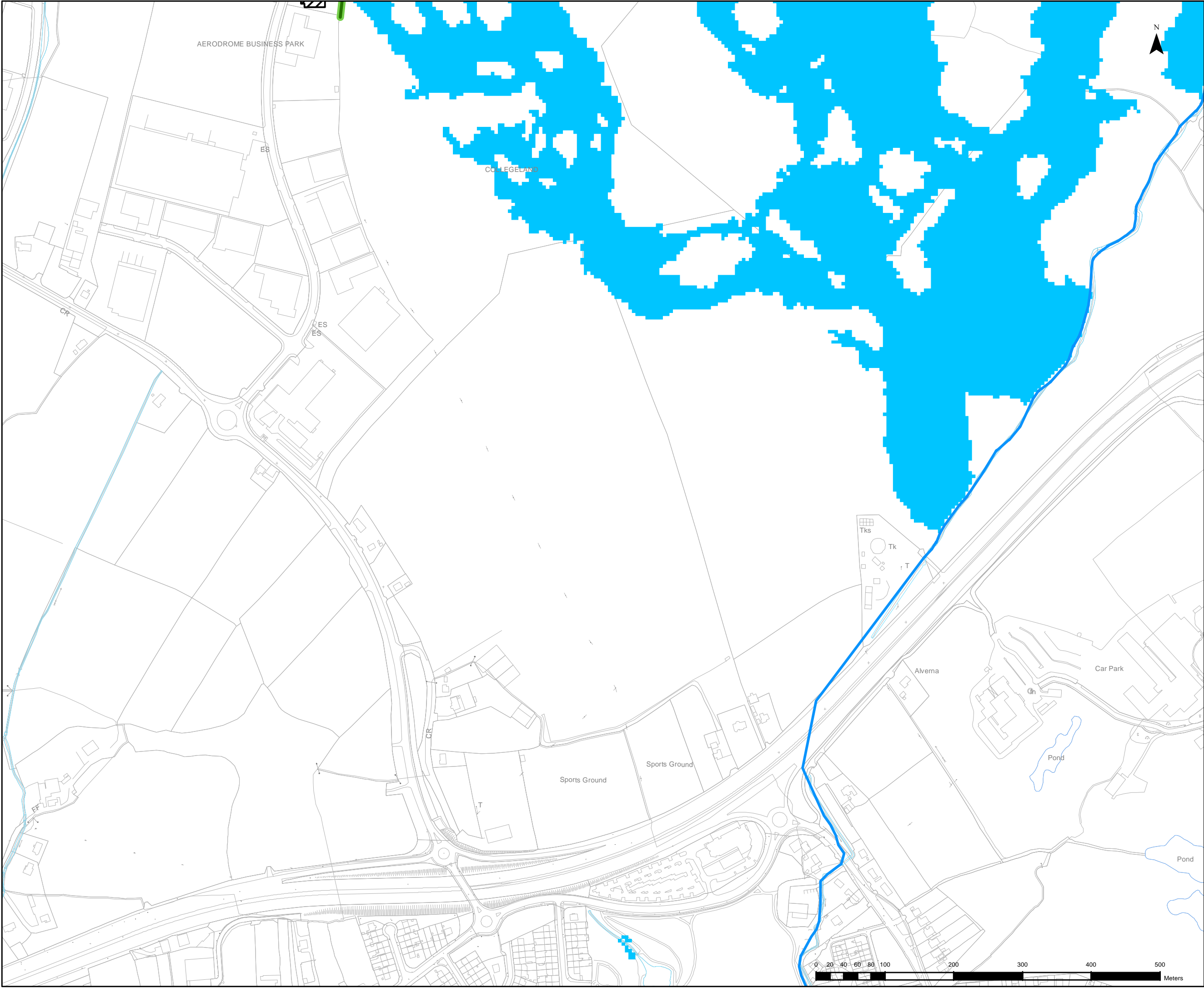
TITLE

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- Legend**
-  MH Manhole
 - Defences**
 -  Embankment
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 -  River Centreline
 -  Landsdowne Embankment
 -  1% AEP Residual Flooding
 -  Area benefiting from Defences

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TITLE

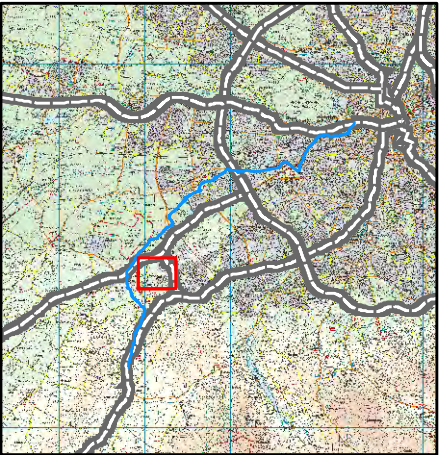
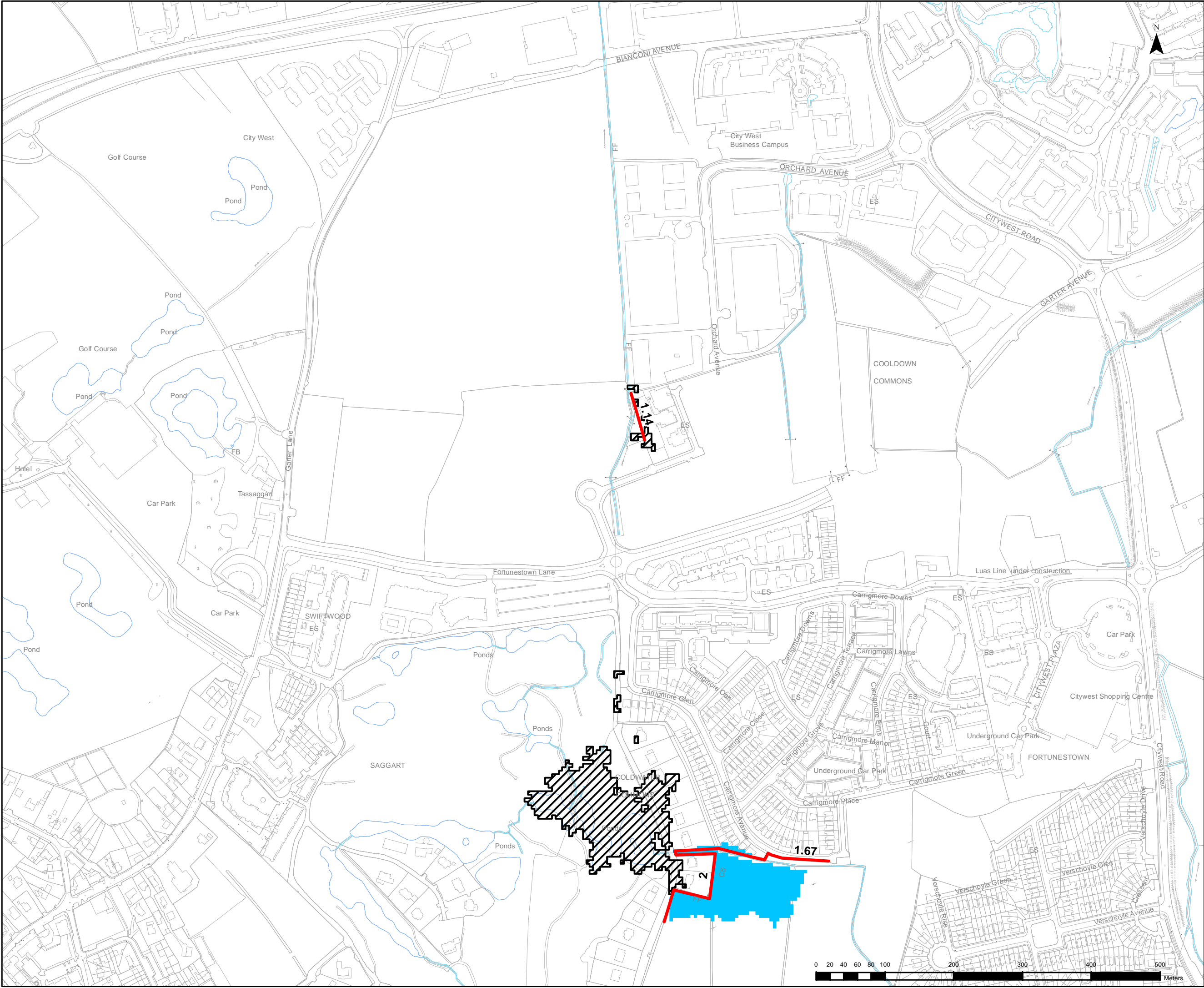
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Legend

- MH Manhole
- Embankment
- Wall
- River Centreline
- Landsdowne Embankment
- 1% AEP Residual Flooding
- Area benefiting from Defences

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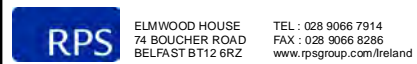


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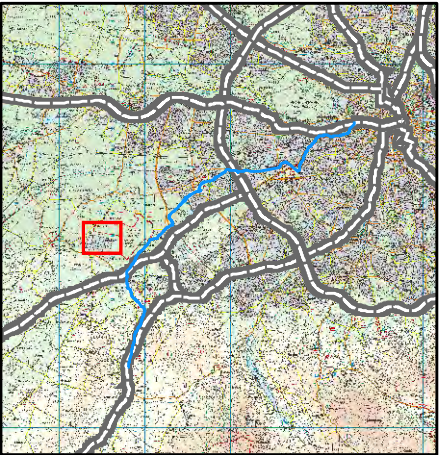
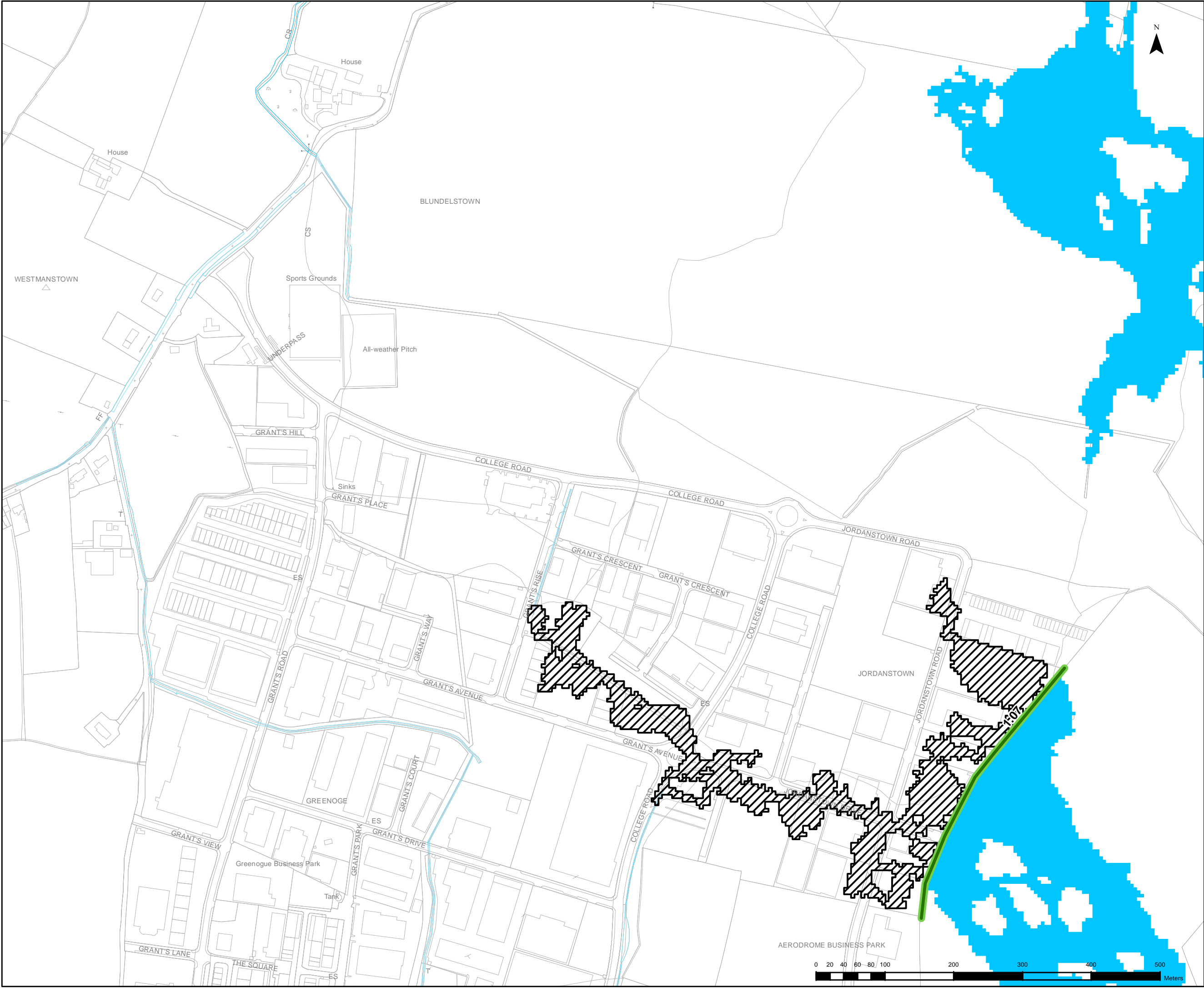
TITLE

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- Legend**
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 -  1% AEP Residual Flooding
 -  Area benefiting from Defences

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TITLE

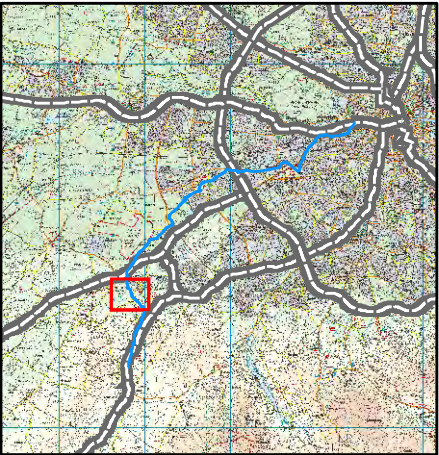
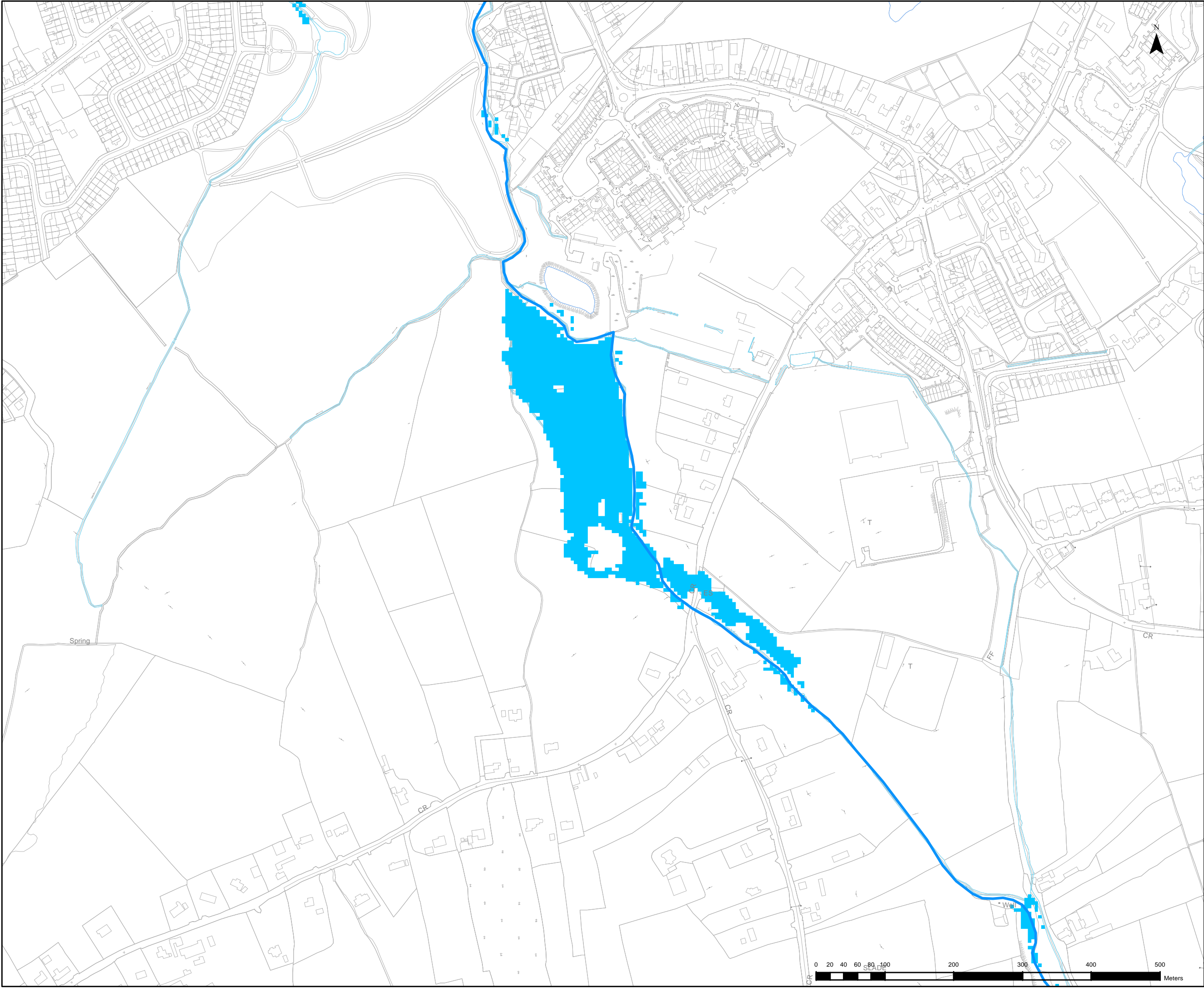
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Legend

- MH Manhole
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 - River Centreline
 - Landsdowne Embankment
 - 1% AEP Residual Flooding
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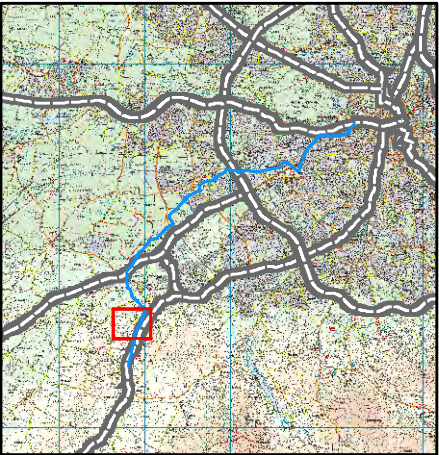
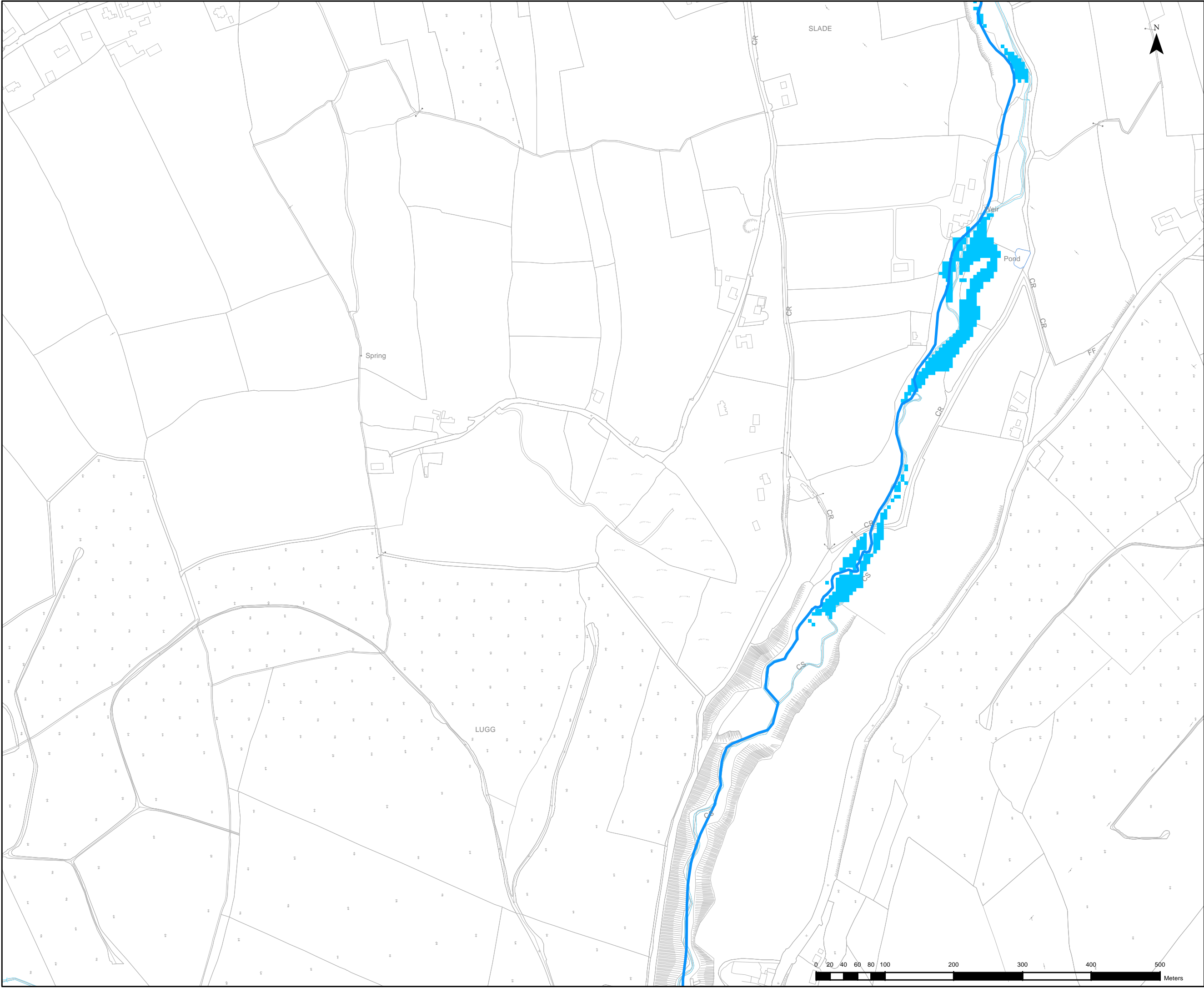
TITLE

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Legend

MH Manhole

Defences

Embankment

Wall

River Centreline

Landsdowne Embankment

1% AEP Residual Flooding

Area benefiting from Defences

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EASTERN CFRAMS

TITLE

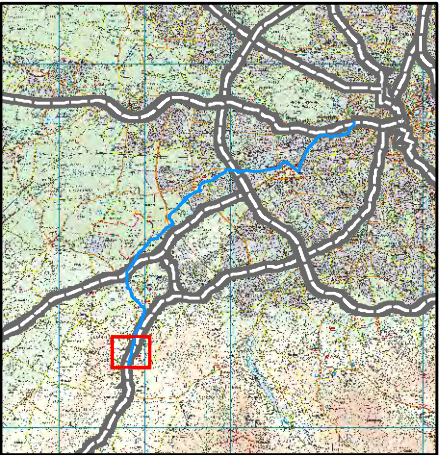
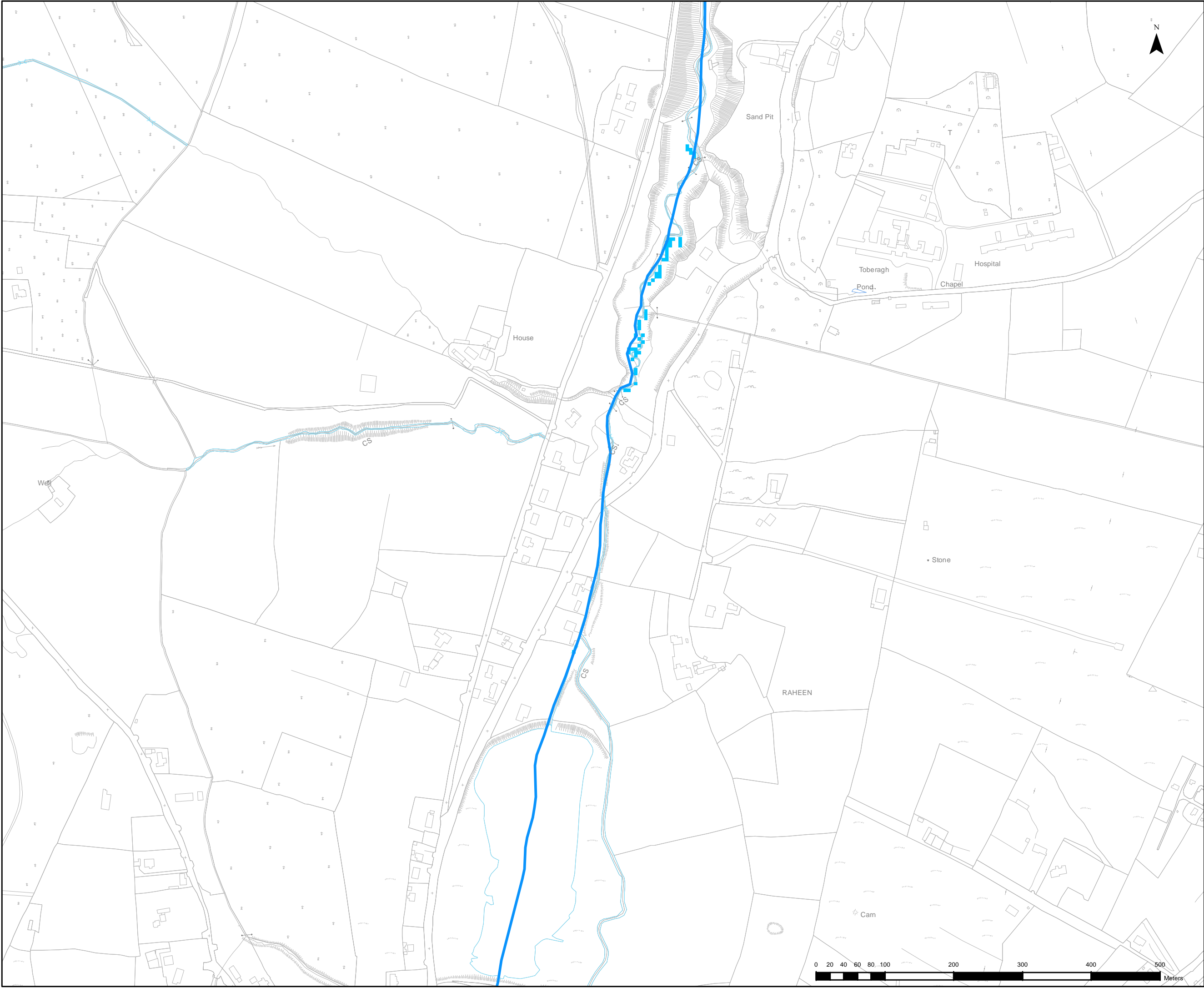
CAMAC
Hard Defences, Manholes and Upstream Storage

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Drawing No.: 09CC_DEF_OPT_2_012

Drawn By : RC
Checked By : MW
Approved By : GG
Date : 13/02/2014

SCALE AT A3: 1:5,000



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- Legend**
- MH Manhole
 - Defences**
 - Embankment
 - Wall
 - River Centreline
 - Landsdowne Embankment
 - 1% AEP Residual Flooding
 - Area benefiting from Defences

DRAFT FINAL



CLIENT

PROJECT

EASTERN CFRAMS

TITLE

CAMAC
Hard Defences, Manholes and Upstream Storage

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SCALE AT A3 : 1:5,000		

Appendix E

Stage 1 Culvert Blockage Results

Culvert Ref	Watercourse Name	Length (m)	Stage 1 Status	Comment	Trash Screen Present
02020I	Camac	7.09	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
01987I	Camac	14.84	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
01800I	Camac	5.7	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
01752I	Camac	11.55	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
01669I	Camac	4.92	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
01568I	Camac	9.46	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
01549I	Camac	Unknown	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
01526J	Camac	5	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
01386I	Camac	52.18	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
01336I	Camac	7.85	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
01227I	Camac	50.49	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
01175I	Camac	10.99	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
01070I	Camac	10.83	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00994I	Camac	17.34	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00961I	Camac	8.54	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00904I	Camac	193.39	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00750I	Camac	71.29	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00677I	Camac	75.98	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00653I	Camac	17.82	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00638I	Camac	108.82	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00627I	Camac	41.87	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00622I	Camac	934.99	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00520I	Camac	63.12	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00479I	Camac	Unknown	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00417J	Camac	17.3	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00325I	Camac	17.49	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00303I	Camac	161.51	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00275I	Camac	26.21	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00047I	Camac	27.73	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00027I	Camac	Unkown	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00150I	Rathcool	34.46	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00101I	Fitzmaurice	8.36	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00078I	Fitzmaurice	8.36	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00037I	Fitzmaurice	Unknown	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
00172I	Saggart 1a	4.78	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00160I	Saggart 1a	19.51	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00153J	Saggart 1a	6.34	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00127I	Saggart 1a	7.47	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00095I	Saggart 1a	22.37	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00053I	Saggart 1a	14.04	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00004I	MILJ	Unknown	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00013I	Alverna	Unknown	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00013I	Link WP6A11	13.23	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00043I	Link WP6A12	6.69	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00172I	New Saggart	4.3	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00219I	Verschoyles	528.53	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00160I	Verschoyles	16.83	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00149I	Verschoyles	14.3	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00144I	Verschoyles	82.5	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
00111I	Verschoyles	119.98	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
00098I	Verschoyles	21.99	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00086I	Verschoyles	55.89	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00047I	Verschoyles	4.83	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00036I	Verschoyles	4.76	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00009I	Verschoyles	47.42	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
00004I	Verschoyles	47.42	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00023J	CityWest	4.04	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00009I	CityWest	14.96	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00000I	CityWest	4.04	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00002I	Spring	Unknown	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00323J	Fortunestown	Unknown	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00272I	Fortunestown	114.04	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
00251I	Fortunestown	22.46	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
00230J	Fortunestown	4.89	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00219I	Fortunestown	30.5	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00181I	Fortunestown	31.9	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
00176I	Fortunestown	166.66	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
00130I	Fortunestown	22.89	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00097I	Fortunestown	62.84	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00059J	Fortunestown	86.16	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00057I	Fortunestown	Unknown	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00045I	Fortunestown	6.95	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00024I	Fortunestown	4.6	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00015I	Fortunestown	9.93	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00007I	Fortunestown	5.92	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00449I	Tallaght	12.34	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00421I	Tallaght	20.85	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00402I	Tallaght	4.18	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00009J	Brookeview	Unknown	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00144J	Tallaght	3.11	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00094I	Tallaght	4.42	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00088I	Tallaght	7.82	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00083I	Tallaght	3.39	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00077I	Tallaght	6.03	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00072I	Tallaght	3.24	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00068I	Tallaght	5.78	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00063I	Tallaght	18.06	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00056I	Tallaght	20.35	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO

Culvert Ref	Watercourse Name	Length (m)	Stage 1 Status	Comment	Trash Screen Present
00049I	Tallaght	103.64	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00029I	Tallaght	103.55	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00044J	Core B	65(approx)	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00019I	Core B	17.12	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00018I	Core B	19.39	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00017I	Core B	7.23	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00002I	Core A	8.23	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00007I	CORF	8.33	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00001I	CORC	7.84	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00044I	CORA	92.42	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00001I	CORA	14.03	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00010I	CORB	4.8	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00059I	CORK	5.03	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00017I	CORK	8.44	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00008I	CORK	7.44	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00001I	CORK	Unknown	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
01057I	Camac	5.82	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
01044I	Camac	10	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	No Receptors	NO
00354I	Kingswood	320.99	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
00228I	Kingswood	830	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
00136I	Kingswood	41.84	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00074I	Kingswood	102.43	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00066I	Kingswood	16.11	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00054I	Kingswood	35.23	GO TO STAGE 2 FOR SELECTED CULVERT	Large Culvert CSA but recommend stage 2 assessment from site inspection findings	NO
00042I	Kingswood	8.55	GO TO STAGE 2 FOR SELECTED CULVERT	Large Culvert CSA but recommend stage 2 assessment from site inspection findings	NO
00197J	Kilnamanagh	Unknown	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00182I	Kilnamanagh	1313	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	YES
00019I	Walkinstown	8.64	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO
00035J	Crumlin	Unknown	NO FURTHER ASSESSMENT OF CULVERT REQUIRED	Large Culvert CSA	NO
00013I	Crumlin	15.68	GO TO STAGE 2 FOR SELECTED CULVERT	N/A	NO

