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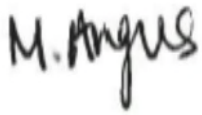
OUR TOWN HALL, MANCHESTER

Flood Risk Assessment

Document ref: OTH-RAM-XX-XX-RPT-C-0005

Revision History

Revision	Date	Purpose / Status	Comments
P01	15/04/2019	Planning Application/ S3	Draft for comment
P02	01/05/2019	Planning Application/ S3	Final

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CONTENTS

OUR TOWN HALL, MANCHESTER		1
FLOOD RISK ASSESSMENT		1
1.	INTRODUCTION	1
1.1	Scope and Objectives	1
2.	SITE CONTEXT	3
2.1	Application Site Description	3
2.2	Site Topography	4
2.3	Geological Setting	4
2.4	Hydrological Settings	6
2.5	Hydrogeological Settings	6
2.6	Existing Drainage Regime and Surface Water Runoff	6
3.	EXISTING FLOOD RISK	8
3.1	Fluvial and Tidal Flood Risk	8
3.2	Surface Water and Sewer Drainage Flood Risk	8
3.3	Groundwater Flood Risk	9
3.4	Risk from Reservoirs, Canal and Other Artificial Sources	9
3.5	Flood Risk Summary	11
4.	ASSESSMENT OF NEW DEVELOPMENT	12
4.1	Development Proposal	12
4.2	Flood Risk Vulnerability	12
4.3	Sequential Test	12
4.4	Surface Water Runoff & Drainage Strategies	12
5.	SUMMARY	16

TABLES

Table 2.1: BGS Borehole Records Summary
Table 2.2: Runoff Rate Calculations
Table 2.3: Flooding Sources at the Proposed Development Site
Table 3.3: Sustainable Drainage Options

FIGURES

Figure 1 Site Location Plan
Figure 2 Site Topography
Figure 3 Environment Agency Risk Of Flooding From Rivers And The Sea
Figure 4 Environment Agency Risk Of Flooding From Surface Water

APPENDICES

Appendix A
Aquifer Type – EA Definitions

Appendix B
Surface Water Runoff Rates

Appendix C
Flood Risk Zones – Technical Guidance to the NPPF Definitions

APPENDIX D
Magic Site Check Report

1. INTRODUCTION

1.0.1 Ramboll UK Limited trading as Ramboll (Ramboll) was appointed by Manchester City Council to undertake a Flood Risk Assessment (FRA) for the refurbishment of the 1877 Alfred Waterhouse Town Hall building, the redevelopment of Albert Square, and the associated surrounding areas of the public realm in Manchester England.

1.0.2 The key sources of information used to prepare this report include:

i. Environment Agency (EA) database of indicative floodplain, hydrogeological maps, and Light Detection and Ranging (LiDAR) data provided under the Open Government licence v3.0 for public sector information;
ii. Environment Agency – Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities (last update published in March 2016);
iii. Environment Agency – Product 4 Data (obtained on 24 March 2017);
iv. Sewers for Adoption – A Design and Construction Guide for Developers – Seventh Edition (August 2012);
v. CIRIA – C753 The SuDS Manual (2015);
vi. The British Geological Survey (BGS) Geology of Britain Viewer. http://www.bgs.ac.uk/data/mapViewers/home.html (accessed March 2019);
vii. National Planning Policy Framework (NPPF, last updated July 2018);
viii. National Planning Practice Guidance (NPPG): Flood Risk and Coastal Change (April 2015);
ix. Hidden Manchester Map. https://hidden-manchester.org.uk/waterways/river-tib.html (accessed March 2019);
x. Magic Site Check Report – generated 12/03/2019 grid ref: SJ83889807;
xi. RIBA Stage 3 Civil & Structural Report – Our Town Hall for Manchester City Council. OTH-RAM-XX-ZZ-RPT-Z-0002 Rev: 1 (December 2018);
xii. RIBA Stage 2 Civil and Structural Report – Our Town Hall for Manchester City Council. OTH-RAM-XX-ZZ-RPT-Z-0002 (April 2018);
xiii. Below Ground Surface Water Drainage Strategy – Early Works Package. OTH-RAM-XX-XX-RPT-C-0015 (April 2019).

1.0.3 The references for the key source of information used to prepare this document are included in the reference section at the rear of this report. Ramboll cannot accept liability for the accuracy or otherwise of any information derived from third party sources.

1.1 Scope and Objectives

1.1.1 This document considers the risks of various sources of flooding to the site and the consequent risk of flooding to downstream receptors (such as people, property, habitats, infrastructure and statutory sites) from the proposed development as a result of surface water runoff. A comparison is made between the current situation and the proposed future development.

1.1.2 This FRA has been carried out in accordance with the National Planning Policy Framework (NPPF)[1]. It is to be used to assist the Local Planning Authority (LPA) and Environment Agency (EA), when considering the flooding issues of the proposed development, as part of a planning application. An FRA is required as the developable area larger than 1 hectare (ha), at 1.58ha. This document will assess the flood risk for the full project area encompassing both the early and main works.

1.1.1 This report provides the following information:

[1] Department of Communities and Local Government – National Planning Policy Framework (March 2018)

i. An assessment of the flood risk to the site based upon flood data and the flood maps provided by the EA and Strategic Flood Risk Assessment (SFRA) and;
ii. An assessment of the impact of the new development in terms of surface water runoff;
iii. Proposals for measures to mitigate the generation of surface water runoff water generated by the proposed development; and
iv. Proposals to mitigate any residual flood risks to the development (if any).

1.1.2 This report does not consider the flood risks associated with localised flooding within the site boundary; for example, gully sections prone to blockages. The objective of this document is too provide a holistic assessment of flood risk to the entire project area from external sources of flooding.

2. SITE CONTEXT

2.1 Application Site Description

2.1.1 The Our Town Hall (OTH) project site is situated in Manchester city centre, encompassing the 1877 Alfred Waterhouse Town Hall building, Albert Square and the associated surrounding areas of the public realm. The site is located at Manchester Town Hall, Albert Square, City Centre, Manchester M2 5DB at National Grid Reference (NGR) 83887 98081, with an area of 1.58ha. The site location and red line boundary is show in Figure 1.

2.1.2 In advance of the main applications, a number of early works will be undertaken to ensure the contractor is in the strongest position to commence the main in line with the overall project programme in January 2020. The site for the early works includes the Town Hall courtyard and elevations; it partly extends into Albert Square to the west and Lloyd Street to the south.

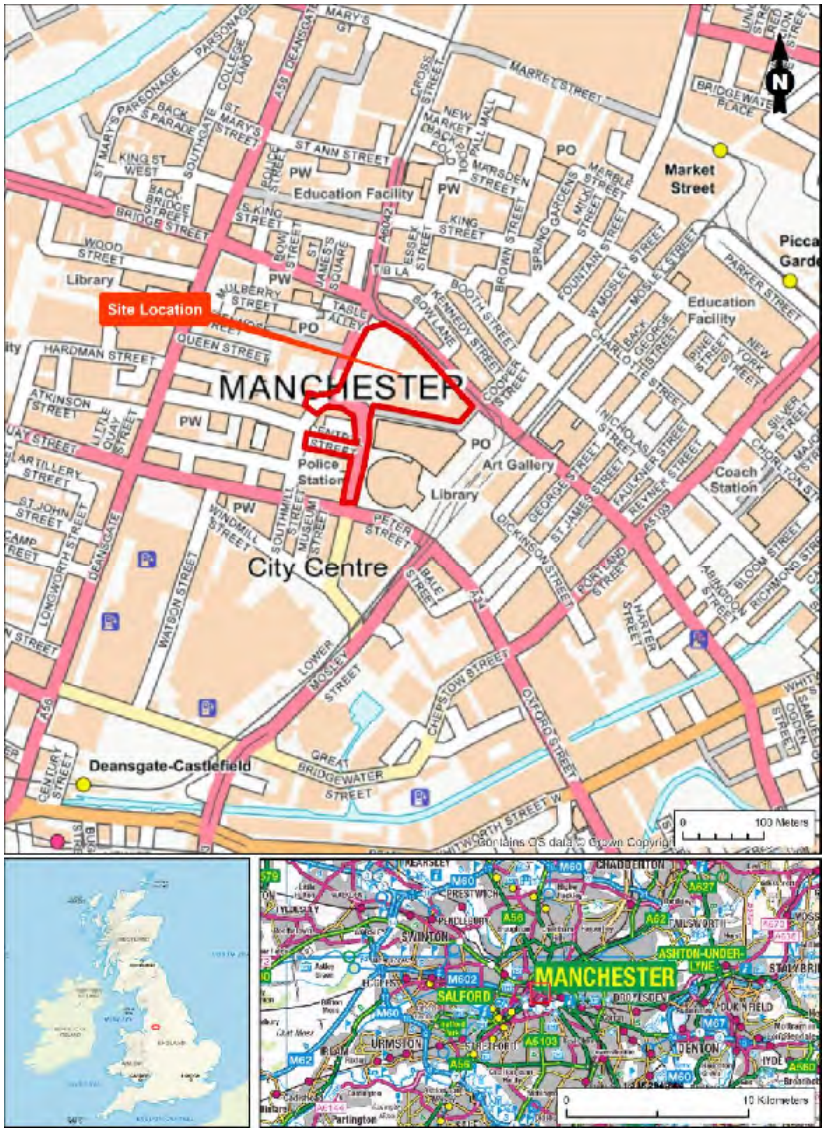


Figure 1: Site Location

2.2 Site Topography

2.2.1 Figure 2 shows the digital terrain model (DTM) for the site. This data was sourced from the Environment Agency under the Open Government Licence, showing the 25 cm composite filtered LiDAR data. The DTM data shows the site is generally level, between 39 mAOD and 40 mAOD. Within the vicinity of the OTH building, the LIDAR data shows the lower building level as opposed to the lower ground level which is approximately 1m lower than the surrounding streets, measured at 38 mAOD. The lowest level of the building is a half storey below the surrounding ground level; a number of the lowest building levels are historic moats with no water in. The Our Town Hall building courtyard within the building footprint are also at the lower building level.

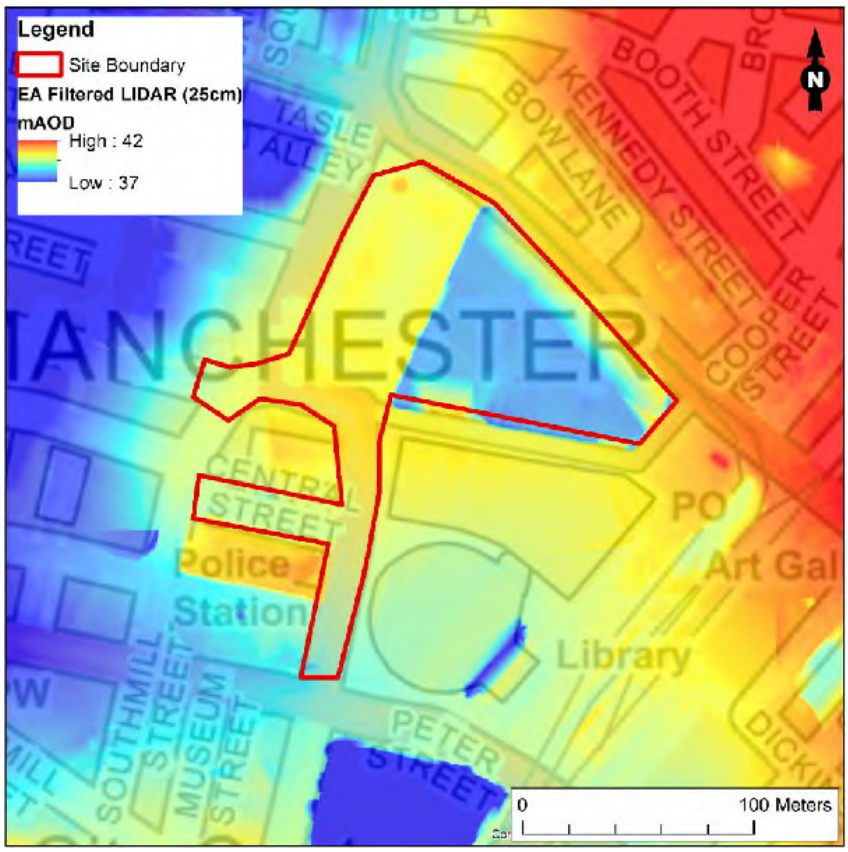


Figure 2: Site Topography

2.3 Geological Setting

2.3.1 The British Geological Survey (BGS) map of the area (1:50,000 scale map series), accessed via online digital mapping[2], indicates the site is underlain with the Chester Formation (Sandstone) Bedrock geology. This is a Sedimentary Bedrock formed approximately 247 to 250 million years ago in the Triassic Period, where the local environment was previously dominated by Rivers. This Bedrock geology is overlain with Till, Devensian (Diamicton) superficial deposits. These superficial deposits were formed up to 2 million years ago in the Quaternary Period, where the local environment was previously dominated by ice age conditions.

2.3.2 Ground investigation was undertaken by Geotechnics in March 2019. Borehole results are summarised in Table 2.1.

[2] The British Geological Survey (BGS) Geology of Britain Viewer. http://www.bgs.ac.uk/data/mapViewers/home.html (accessed March 2018)

Table 2.1: Borehole Records Summary

Strata	Description	Depth (mbgl)
Made Ground	Orangish brown fine to medium sand – dark brown gravelly slightly clayey fine to coarse sand	0.6
Made Ground	Greyish brown sandy angular fine to coarse gravel of concrete and brick fragments	0.6 - 1.60
Clay	Stiff reddish brown slightly sandy slightly gravelly CLAY	0.7 - 1.50

2.4 Hydrological Settings

2.4.1 The site lies between the River Irwell, located 580 m northwest of the site, and the River Medlock which lies 480m to the southeast. The River Tib is the closest hydrological feature to the Out Town Hall site. The River Tib had a history of overtopping its banks until 1783 when it was culverted. The River Tib is now culverted along most of its course and is often a dry ditch[3]. The culverted River Tib watercourse flows under the adjacent town hall extension and does not flow beneath the proposed development site.

2.4.2 There is a network of canals in the Manchester City centre area, the nearest of which is the Bridgwater/Rochdale Can which lies approximately 400 m south of the site. The Bridgewater and Rochdale Canals meet at Castlefield and are supplied by the River Medlock which lies just to the south of the site. The Canal is owned by the Manchester Ship Canal Company.

2.5 Hydrogeological Settings

2.5.1 The EA has developed Groundwater Source Protection Zones (SPZs) to assist in the assessment of risk to groundwater supplies taken from an abstraction point. The site does not lie within a Groundwater Source Protection Zone.

2.5.2 The EA website shows aquifers and provides designations which are in line with the Water Framework Directive and are based on maps produced by the BGS. Definitions for the aquifer types are provided in Appendix A.

2.5.3 According to EA mapping the underlying superficial deposit is designated as a Secondary Undifferentiated Aquifer, assigned where it has not been possible to attribute either alternative aquifer categories to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.

2.5.4 The underlying bedrock is designated as a Principal Aquifer, defined as layers of rock or drift deposits that have high intergranular and/ or fracture permeability – meaning they usually provide a high level of water storage. They may support water and/ or river base flow on a strategic scale.

2.6 Existing Drainage Regime and Surface Water Runoff

2.6.1 Existing and proposed development runoff rates have been calculated in Tedds (2017) using the Wallingford Procedure. The results of the calculations are shown in Table 2.1 below. The outputs from Tedds are provided in Appendix B, at the rear of this report.

2.6.2 As the proposed development comprises of refurbishment work to the Town Hall building and surrounding areas it is unlikely that the impermeable area will change. The increase in runoff rates reflects the climate change allowance of 40% that has been included is post-development runoff rates. The critical storm duration for runoff is 15 minutes.

2.6.3 For further modelling information and calculations of the multiple drainage systems within the Our Town Hall project site, please see the document Below Ground Surface Water Drainage Strategy – Early Works Package (OTH-RAM-XX-XX-RPT-C-0015).

Table 2.2: Runoff Rate Calculations

[3] Hidden Manchester Map – River Tib. https://hidden-manchester.org.uk/waterways/river-tib.html (accessed March 2018)

Return Period (years)	1-in-1	1-in-2	1-in-10	1-in-30	1-in-100
Pre-development runoff rates (l/s)	120	155	239	293	377
Post-development runoff rates (l/s) including 40% CC	170	219	340	419	547
Post-development increase	50	64	101	126	170

3. EXISTING FLOOD RISK

3.1 Fluvial and Tidal Flood Risk

3.1.1 The EA floodplain maps identify areas in England and Wales at risk of flooding by allocating them into flood risk zones. The Flood Risk Zones are defined in Table 1 (Flood Zones) of the Technical Guidance to the NPPF, provided in Appendix B of this report.

3.1.2 Figure 3 shows the site lies within Flood Zone 1 and therefore has low probability flood risk. According to the Technical Guidance to the NPPF, land in this zone is considered to have less than 1-in-1000 annual probability of river or sea flooding in any year, less than 0.1%. The flood risk from fluvial and tidal sources is considered to be low.

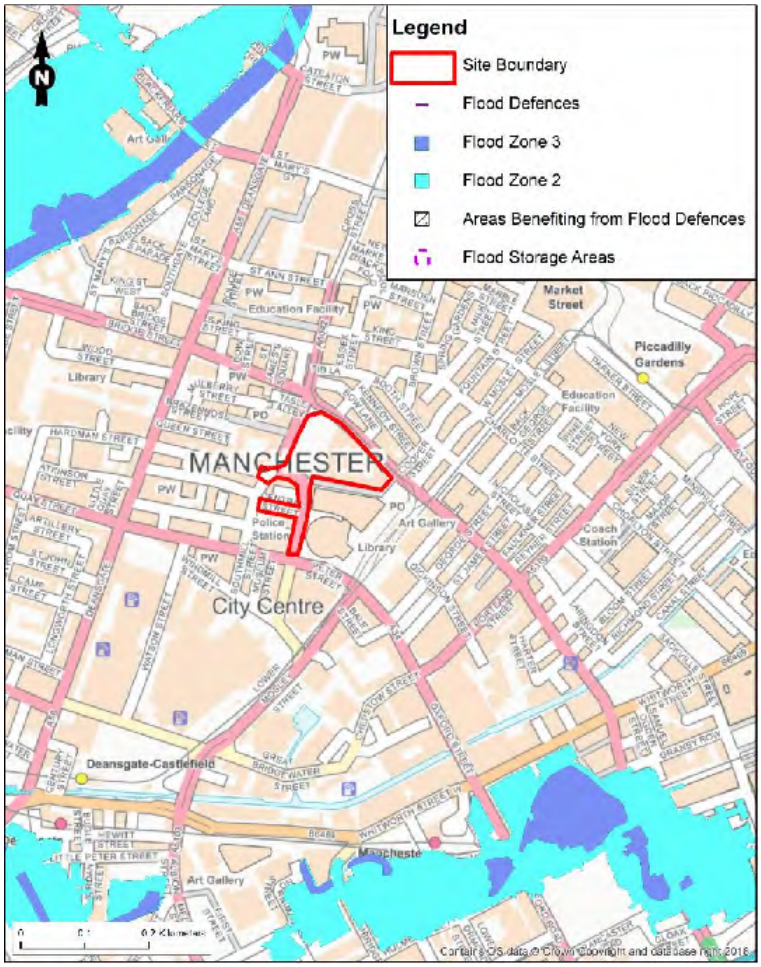


Figure 3: Environment Agency Risk of Flooding from Rivers and the Sea

3.2 Surface Water and Sewer Drainage Flood Risk

3.2.1 The Flood and Water Management Act 2010 defines surface water flooding as flooding that takes place when surface runoff generated by rainwater falls on the surface of the ground and has not yet entered a watercourse, drainage system or public sewer. It is important to note that flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding. The EA's indicative surface water maps identify areas in England and Wales at potential risk of surface water flooding. Figure 4 shows the surface water flood risk map for the site.

3.2.2 The EA indicative surface water flood risk map (Figure 4) indicates a surface water flood risk exists for the OTH Building, varying in risk from high to low. This risk is related to the topography of the OTH building, found to be approximately 1m lower than the surrounding streets. This topographical low point allows water to accumulate, causing the surface water flood risk shown in Figure 4.

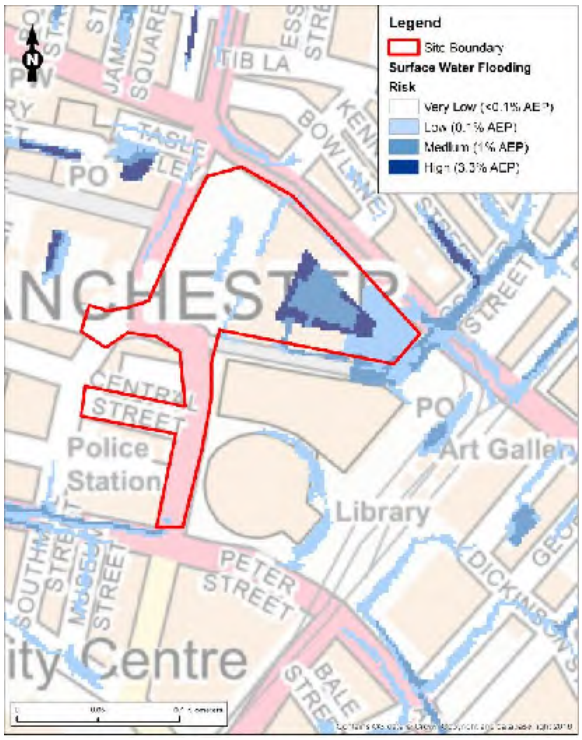


Figure 4: Environment Agency Risk of Flooding from Surface Water

3.3 Groundwater Flood Risk

3.3.1 Groundwater flooding is caused by the emergence of water originating from sub-surface permeable strata. A groundwater flood event results from a rise in groundwater level sufficient for the water table to intersect the ground surface and inundate low lying land. Groundwater floods may emerge from either point or diffuse locations. They tend to be long in duration developing over weeks or months and prevailing for days or weeks.

3.3.2 As discussed in Section 2.5, the underlying superficial deposit is designated as a Secondary Undifferentiated Aquifer, assigned where it has not been possible to attribute either alternative aquifer categories to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.

3.3.3 A site check report generated from Magic describes the typical soilscape of this area as 'slowly permeable seasonally wet acid loamy and clayey' resulting in low permeability and naturally impeded drainage. The geological formation present at the site can be described as an aquitard. The Magic site check report can be found in Appendix B.

3.3.4 On this basis, the risk of flooding from groundwater is low.

3.4 Risk from Reservoirs, Canal and Other Artificial Sources

3.4.1 Reservoirs in the UK have an extremely good safety record. The EA is the enforcement authority for the Reservoirs Act 1975 in England and Wales. All large reservoirs must be

inspected and supervised by reservoir panel engineers. It is assumed that these reservoirs are regularly inspected, and essential safety work is carried out. Reservoirs therefore present a minimal risk.

3.5 Flood Risk Summary

3.5.1 A summary of the risk of flooding from all sources is provided in Table 3.1.

Table 3.1: Flooding Sources at the Proposed Development Site

Sources of Flooding	High	Medium	Low	Comments
Tidal/ fluvial			√	Flood Zone 1 therefore the site has a low probability and low risk of flooding.
Surface water and drainage flood risk		√		Flood risk from surface water runoff due to the lowest levels of the Town Hall building.
Groundwater			√	Low permeability of the soil means that groundwater flooding is anticipated to present low risk of flooding to site.
Reservoirs, canals and other artificial sources			√	Regular inspection means that reservoirs present a minimal risk.

4. ASSESSMENT OF NEW DEVELOPMENT

4.1 Development Proposal

4.1.1 The Our Town Hall project comprises of the refurbishment of the 1877 Alfred Waterhouse Town Hall building, the redevelopment of Albert Square, and the associated surrounding areas of public realm. The structural alterations for the town hall building area split into key areas:

i. Entrances;
ii. Catering provisions;
iii. Lifts and stairs;
iv. Central block; and
v. Plantrooms, roof top plant and distribution – including the replacement of heat, power and pipe work systems.

4.1.2 In advance of the main applications, a number of early works will be undertaken to ensure the contractor is in the strongest position to commence the main works (described above) in line with the overall project programme in January 2020. The Below Ground Surface Water Drainage Strategy – Early Works Package (OTH-RAM-XX-XX-RPT-C-0015) references in section 4.4.3 of this document forms part of the early works.

4.2 Flood Risk Vulnerability

4.2.1 According to Table 2 (Flood Risk Vulnerability Classification) in the Planning Practice Guidance to NPPF, buildings used for professional and other service purposes are classified as "Less Vulnerable".

4.2.2 Table 3 (Flood Risk Vulnerability and Flood Zone Compatibility) in the Planning Practice Guidance to NPPF, states that all classifications of development are appropriate to locate in Flood Zones 1.

4.3 Sequential Test

4.3.1 The Sequential Test aims to steer development to areas with the lowest probability of flooding.

4.3.2 In accordance with the NPPF "Less Vulnerable" developments are suitable for location in Flood Zone 1; therefore, the sequential test is deemed to have been passed and the Exception Test is not required for the proposed development.

4.4 Surface Water Runoff & Drainage Strategies

4.4.1 The NPPF identifies that rainfall intensities will increase in the future as a result of CC, thereby increasing surface water runoff rates and volumes. The updated EA CC allowance guidance (2016) shows the recommended national precautionary sensitivity ranges for various parameters including peak rainfall intensity. The design life of the new development is considered to be 50-years; the recommended allowance for CC has a range between 20% (central) and 40% (upper end).

4.4.2 Consultations with Manchester City Council confirmed the requirement for discharge restrictions in separate areas within the redline boundary[4]. The restrictions are summarised below:

[4] RIBA Stage 3 Civil & Structural Report – Our Town Hall for Manchester City Council. OTH-RAM-XX-ZZ-RPT-Z-0002 Rev: 1

- Town Hall building, courtyard and moats - no betterment required on existing discharge rates, but surface water would need to be designed to 1 in 100-year storm event plus 40% climate change (or where existing drainage utilised evidence provided on when the system floods and its affect).
- Albert Square public realm – 50% betterment on existing drainage rates with surface water designed up to 1-in-100-year storm event plus 40% climate change.
- Lloyd Street, Cooper Street, Mount Street, Clarence Street, Southmill Street and Central Street drainage changes are minimal therefore no restrictions are to be imposed.

4.4.3 For the Our Town Hall building, it is proposed to utilise all of the existing above ground rainwater downpipe locations in the scheme; with a small number of additional downpipes being installed where the existing system is overwhelmed. Please refer to Below Ground Surface Water Drainage Strategy – Early Works Package (OTH-RAM-XX-XX-RPT-C-0015) for the detailed drainage design for the Our Town Hall building.

4.4.4 The detailed drainage design for the Albert Square public realm area will be part of a separate planning submission at a later date. The outline drainage strategy for this area proposes a combination of tree pit retention and below ground geo-cellular storage in Albert Square for attenuation; please note the detailed drainage design is yet to be completed for the Albert Square public realm area.

5. SUMMARY

i. The Our Town Hall (OTH) project site is situated in Manchester city centre, encompassing the 1877 Alfred Waterhouse Town Hall building, Albert Square and the associated surrounding areas of the public realm with an approximate area of 1.58 ha.

ii. Within the internal vicinity of the Town Hall building, the elevation is approximately 1 m lower
(38 mAOD) than the surrounding site levels. The site is generally flat with elevations ranging from 39 mAOD to 40 mAOD.

iii. The site lies between the River Irwell, and the River Medlock. The culverted River Tib watercourse flows beneath the adjacent town hall extension (it does not flow beneath the proposed development site) discharging into the River Medlock.

iv. The site is located in Flood Zone 1, therefore has a low probability of flooding. The site is at a low risk of flooding from fluvial, tidal, groundwater and artificial sources (reservoirs).

v. The Our Town Hall project comprises of the refurbishment of the 1877 Alfred Waterhouse Town Hall building, the redevelopment of Albert Square, and the associated surrounding areas of public realm. This type of development classifies as 'Less Vulnerable' according to NPPF guidance.

vi. Following consultations with Manchester City Council in November 2017, varying discharge restrictions have been put on areas within the redline boundary. As such, the detailed drainage designs for the Our Town Hall building and Albert Square public realm areas have been separated for two independent planning submissions. For the Our Town Hall building detailed drainage designs, please refer to document OTH-RAM-XX-XX-RPT-C-0015; the detailed drainage designs for Albert Square public realm area are yet to be created.

vii. In summary, the flood risk to the Our Town Hall project site is low, and post development off site flood risk will be reduced as a result of implementing attenuation on site.

FIGURES

FIGURE 1 SITE LOCATION PLAN
FIGURE 2 SITE TOPOGRAPHY
FIGURE 3 ENVIRONMENT AGENCY RISK OF FLOODING FROM RIVERS AND THE SEA
FIGURE 4 ENVIRONMENT AGENCY RISK OF FLOODING FROM SURFACE WATER







Figure Title: Site Location	Project Name: Our Town Hall, Manchester FRA	Date: March 2019	
		Scale: As shown	
Project Number: 1620003165	Client: Manchester City Council	Issue: 1	Prepared By: HTH

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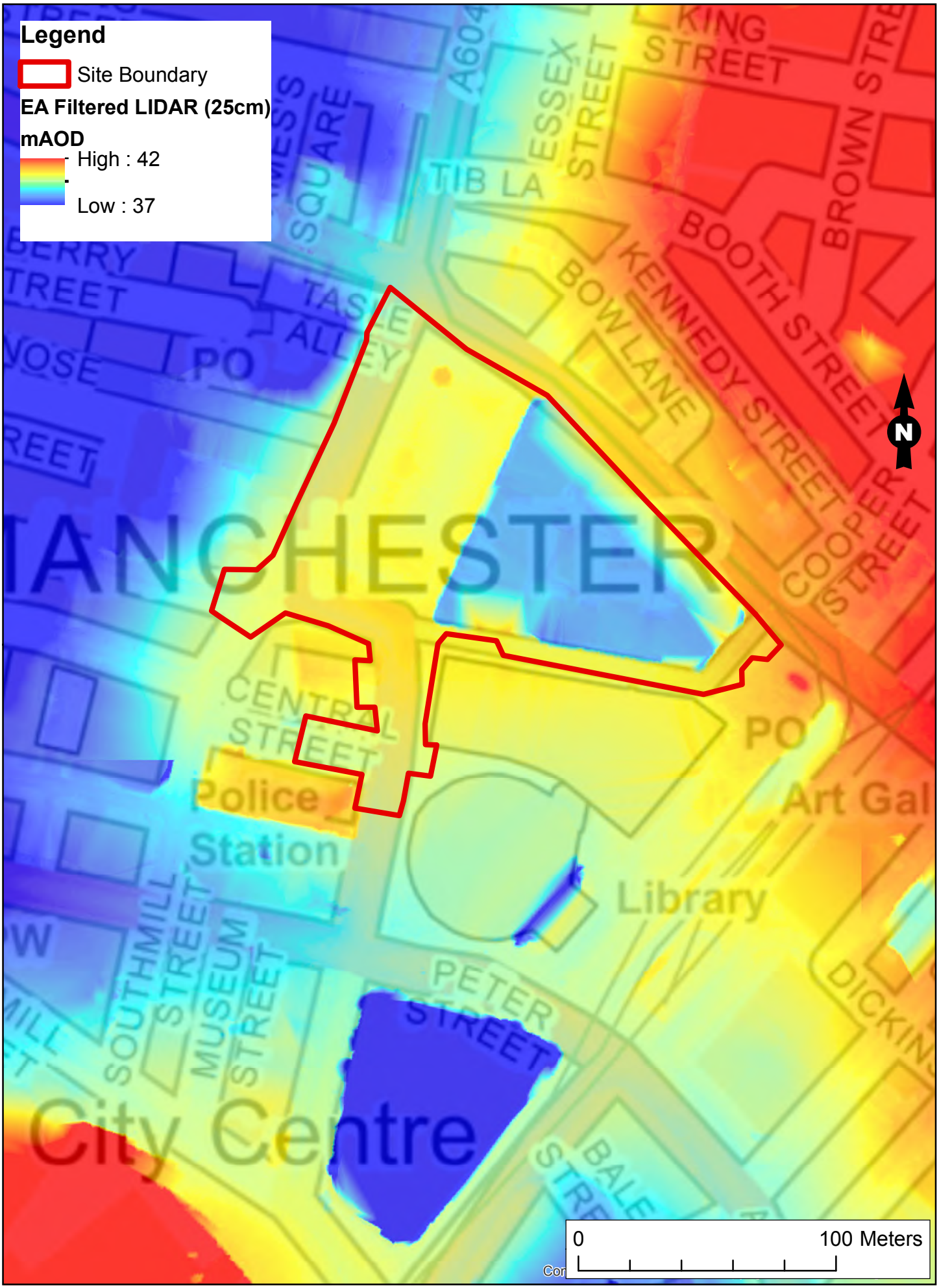


Figure Title: Digital Terrain EA Composite 25cm LIDAR	Project Name: Our Town Hall, Manchester FRA	Date: March 2019 Scale: As shown	RAMBOLL
Project Number: 1620003165	Client: Manchester City Council	Issue: 1	Prepared By: HTH

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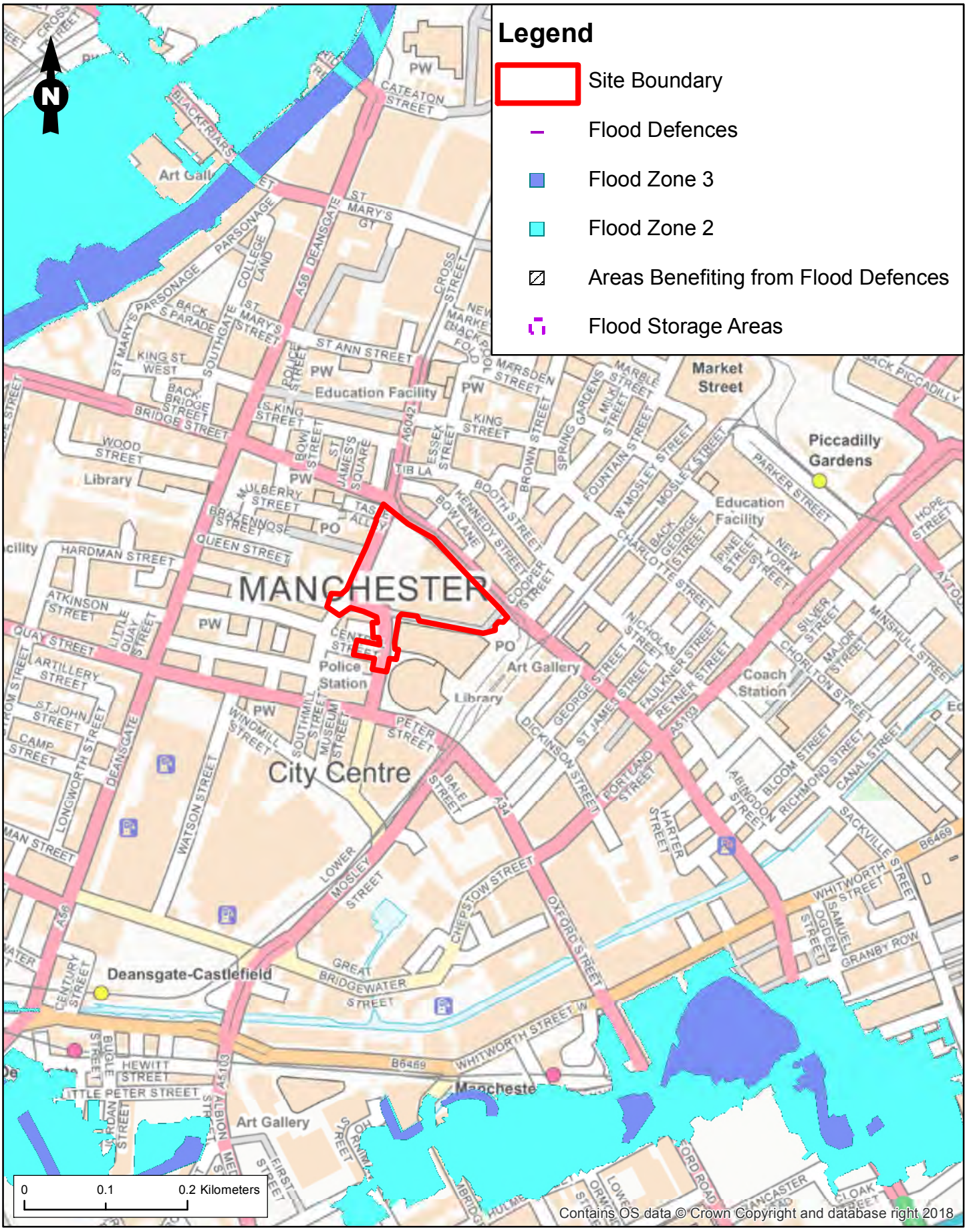


Figure Title Environment Agency - Risk of Flooding from Rivers and Sea	Project Number 1620003165		Client **Manchester City Council**
	Date March 2019	Prepared By HTH	
Project Name Our Town Hall, Manchester	Scale As shown	Issue 1	RAMBOLL

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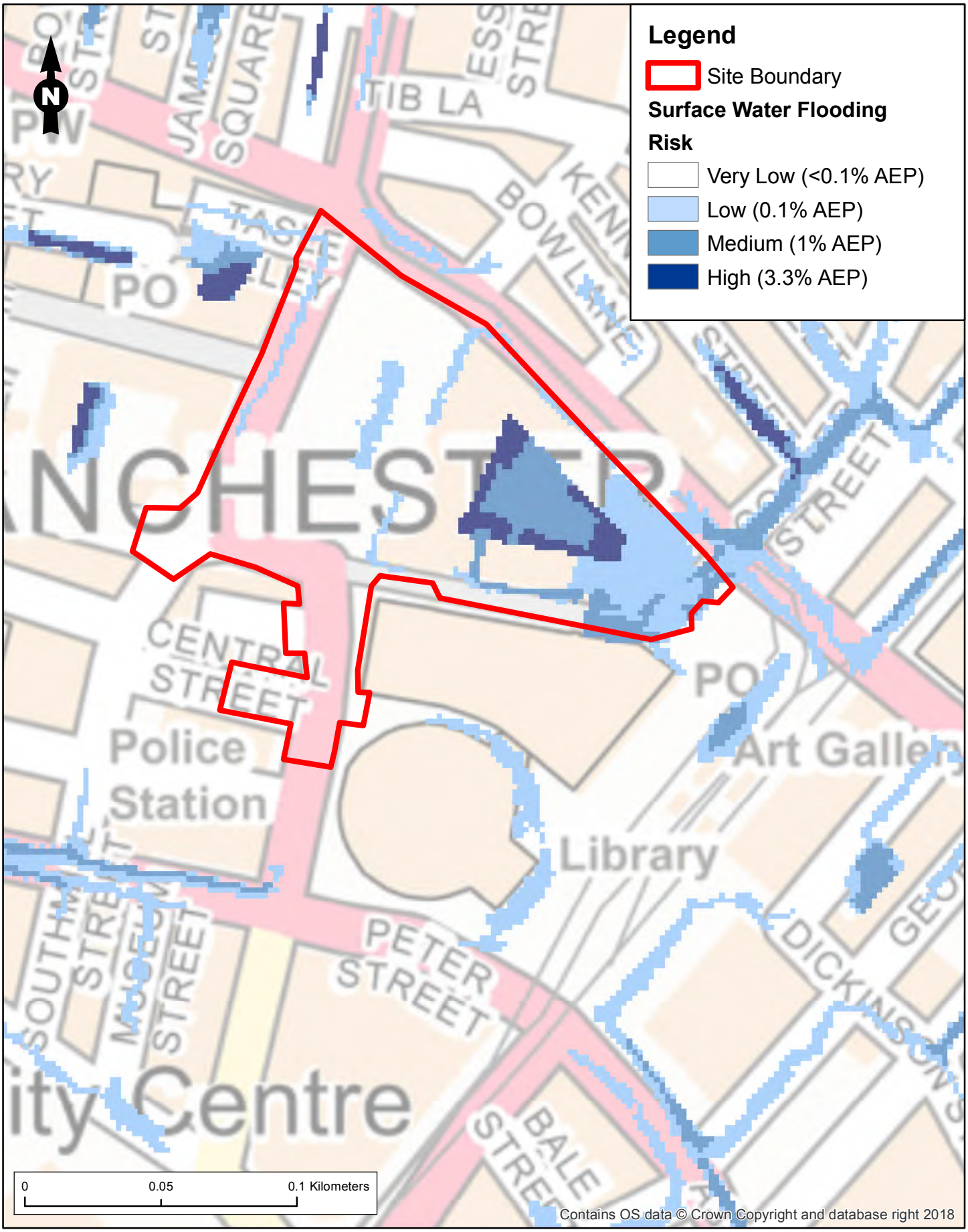


Figure Title Environment Agency - Risk of Flooding from Surface Water	Project Number 1620003165		Client **Manchester City Council**
	Date March 2019	Prepared By HTH	
Project Name Our Town Hall, Manchester	Scale As shown	Issue 1	RAMBOLL

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APPENDIX A
AQUIFER TYPE – EA DEFINITIONS

The EA website shows aquifers and provides designations which are in line with the Water Framework Directive and are based on maps produced by the BGS. Definitions for the aquifer types are provided below based on the EA website:

Principal Aquifer: "*layers of rock or drift deposits that have high intergranular and/ or fracture permeability – meaning they usually provide a high level of water storage. They may support water and/ or river base flow on a strategic scale."*

Secondary A Aquifer: *"permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers."*

Secondary B Aquifer: *"predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering."*

Secondary Undifferentiated Aquifer: "*assigned where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.*"

APPENDIX B
SURFACE WATER RUNOFF RATES

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Manchester
Storm duration	D = **15** min
Return period	Period = **1** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.360**
5-year return period rainfall of 60 minutes duration	M5_60min = **18.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **0** %
Factor Z1 (Wallingford procedure)	Z1 = **0.62**
Rainfall for 15min storm with 5 year return period	$M5_15min_i$ = Z1 × M5_60min = **11.2** mm
Factor Z2 (Wallingford procedure)	Z2 = **0.61**
Rainfall for 15min storm with 1 year return period	M1_15min = Z2 × $M5_15min_i$ = **6.8** mm
Design rainfall intensity	I_{max} = M1_15min / D = **27.3** mm/hr

Maximum surface water runoff

Catchment area	A_{catch} = **15800** m^2
Percentage of area that is impermeable	p = **100** %
Maximum surface water runoff	Q_{max} = A_{catch} × p × I_{max} = **120.0** l/s

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Manchester
Storm duration	D = **15** min
Return period	Period = **2** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.360**
5-year return period rainfall of 60 minutes duration	M5_60min = **18.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **0** %
Factor Z1 (Wallingford procedure)	Z1 = **0.62**
Rainfall for 15min storm with 5 year return period	$M5_15min_i$ = Z1 × M5_60min = **11.2** mm
Factor Z2 (Wallingford procedure)	Z2 = **0.79**
Rainfall for 15min storm with 2 year return period	M2_15min = Z2 × $M5_15min_i$ = **8.8** mm
Design rainfall intensity	I_{max} = M2_15min / D = **35.4** mm/hr

Maximum surface water runoff

Catchment area	A_{catch} = **15800** m^2
Percentage of area that is impermeable	p = **100** %
Maximum surface water runoff	Q_{max} = A_{catch} × p × I_{max} = **155.2** l/s

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Manchester
Storm duration	D = **15** min
Return period	Period = **10** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.360**
5-year return period rainfall of 60 minutes duration	M5_60min = **18.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **0** %
Factor Z1 (Wallingford procedure)	Z1 = **0.62**
Rainfall for 15min storm with 5 year return period	$M5_15min_i$ = Z1 × M5_60min = **11.2** mm
Factor Z2 (Wallingford procedure)	Z2 = **1.22**
Rainfall for 15min storm with 10 year return period	M10_15min = Z2 × $M5_15min_i$ = **13.7** mm
Design rainfall intensity	I_{max} = M10_15min / D = **54.7** mm/hr

Maximum surface water runoff

Catchment area	A_{catch} = **15800** m^2
Percentage of area that is impermeable	p = **100** %
Maximum surface water runoff	Q_{max} = A_{catch} × p × I_{max} = **239.9** l/s

	Project				Job no.	
	Calcs for				Start page no./Revision 1	
	Calcs by M	Calcs date 28/03/2019	Checked by	Checked date	Approved by	Approved date

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Manchester
Storm duration	D = **15** min
Return period	Period = **30** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.360**
5-year return period rainfall of 60 minutes duration	M5_60min = **18.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **0** %
Factor Z1 (Wallingford procedure)	Z1 = **0.62**
Rainfall for 15min storm with 5 year return period	$M5_15min_i$ = Z1 × M5_60min = **11.2** mm
Factor Z2 (Wallingford procedure)	Z2 = **1.50**
Rainfall for 15min storm with 30 year return period	M30_15min = Z2 × $M5_15min_i$ = **16.7** mm
Design rainfall intensity	I_{max} = M30_15min / D = **66.9** mm/hr

Maximum surface water runoff

Catchment area	A_{catch} = **15800** m^2
Percentage of area that is impermeable	p = **100** %
Maximum surface water runoff	Q_{max} = A_{catch} × p × I_{max} = **293.6** l/s

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Manchester
Storm duration	D = **15** min
Return period	Period = **100** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.360**
5-year return period rainfall of 60 minutes duration	M5_60min = **18.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **0** %
Factor Z1 (Wallingford procedure)	Z1 = **0.62**
Rainfall for 15min storm with 5 year return period	$M5_15min_i$ = Z1 × M5_60min = **11.2** mm
Factor Z2 (Wallingford procedure)	Z2 = **1.93**
Rainfall for 15min storm with 100 year return period	M100_15min = Z2 × $M5_15min_i$ = **21.5** mm
Design rainfall intensity	I_{max} = M100_15min / D = **86.1** mm/hr

Maximum surface water runoff

Catchment area	A_{catch} = **15800** m^2
Percentage of area that is impermeable	p = **100** %
Maximum surface water runoff	Q_{max} = A_{catch} × p × I_{max} = **377.8** l/s

	Project				Job no.	
	Calcs for				Start page no./Revision 1	
	Calcs by M	Calcs date 28/03/2019	Checked by	Checked date	Approved by	Approved date

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Manchester
Storm duration	D = **15** min
Return period	Period = **1** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.360**
5-year return period rainfall of 60 minutes duration	M5_60min = **18.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **40** %
Factor Z1 (Wallingford procedure)	Z1 = **0.62**
Rainfall for 15min storm with 5 year return period	$M5_15min_i = Z1 \times M5_60min \times (1 + p_{climate})$ = **15.6** mm
Factor Z2 (Wallingford procedure)	Z2 = **0.62**
Rainfall for 15min storm with 1 year return period	$M1_15min = Z2 \times M5_15min_i$ = **9.7** mm
Design rainfall intensity	I_{max} = M1_15min / D = **38.9** mm/hr

Maximum surface water runoff

Catchment area	A_{catch} = **15800** m^2
Percentage of area that is impermeable	p = **100** %
Maximum surface water runoff	$Q_{max} = A_{catch} \times p \times I_{max}$ = **170.7** l/s

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Manchester
Storm duration	D = **15** min
Return period	Period = **2** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.360**
5-year return period rainfall of 60 minutes duration	M5_60min = **18.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **40** %
Factor Z1 (Wallingford procedure)	Z1 = **0.62**
Rainfall for 15min storm with 5 year return period	$M5_15min_i = Z1 \times M5_60min \times (1 + p_{climate})$ = **15.6** mm
Factor Z2 (Wallingford procedure)	Z2 = **0.80**
Rainfall for 15min storm with 2 year return period	$M2_15min = Z2 \times M5_15min_i$ = **12.5** mm
Design rainfall intensity	I_{max} = M2_15min / D = **50.1** mm/hr

Maximum surface water runoff

Catchment area	A_{catch} = **15800** m^2
Percentage of area that is impermeable	p = **100** %
Maximum surface water runoff	$Q_{max} = A_{catch} \times p \times I_{max}$ = **219.8** l/s

	Project				Job no.	
	Calcs for				Start page no./Revision 1	
	Calcs by M	Calcs date 28/03/2019	Checked by	Checked date	Approved by	Approved date

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Manchester
Storm duration	D = **15** min
Return period	Period = **10** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.360**
5-year return period rainfall of 60 minutes duration	M5_60min = **18.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **40** %
Factor Z1 (Wallingford procedure)	Z1 = **0.62**
Rainfall for 15min storm with 5 year return period	$M5_15min_i = Z1 \times M5_60min \times (1 + p_{climate})$ = **15.6** mm
Factor Z2 (Wallingford procedure)	Z2 = **1.24**
Rainfall for 15min storm with 10 year return period	$M10_15min = Z2 \times M5_15min_i$ = **19.4** mm
Design rainfall intensity	I_{max} = M10_15min / D = **77.5** mm/hr

Maximum surface water runoff

Catchment area	A_{catch} = **15800** m^2
Percentage of area that is impermeable	p = **100** %
Maximum surface water runoff	$Q_{max} = A_{catch} \times p \times I_{max}$ = **340.1** l/s

	Project				Job no.	
	Calcs for				Start page no./Revision 1	
	Calcs by M	Calcs date 28/03/2019	Checked by	Checked date	Approved by	Approved date

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Manchester
Storm duration	D = **15** min
Return period	Period = **30** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.360**
5-year return period rainfall of 60 minutes duration	M5_60min = **18.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **40** %
Factor Z1 (Wallingford procedure)	Z1 = **0.62**
Rainfall for 15min storm with 5 year return period	$M5_15min_i = Z1 \times M5_60min \times (1 + p_{climate})$ = **15.6** mm
Factor Z2 (Wallingford procedure)	Z2 = **1.53**
Rainfall for 15min storm with 30 year return period	$M30_15min = Z2 \times M5_15min_i$ = **23.9** mm
Design rainfall intensity	I_{max} = M30_15min / D = **95.5** mm/hr

Maximum surface water runoff

Catchment area	A_{catch} = **15800** m^2
Percentage of area that is impermeable	p = **100** %
Maximum surface water runoff	$Q_{max} = A_{catch} \times p \times I_{max}$ = **419.3** l/s

	Project				Job no.	
	Calcs for				Start page no./Revision 1	
	Calcs by M	Calcs date 28/03/2019	Checked by	Checked date	Approved by	Approved date

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

Location of catchment area	Manchester
Storm duration	D = **15** min
Return period	Period = **100** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.360**
5-year return period rainfall of 60 minutes duration	M5_60min = **18.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **40** %
Factor Z1 (Wallingford procedure)	Z1 = **0.62**
Rainfall for 15min storm with 5 year return period	$M5_15min_i = Z1 \times M5_60min \times (1 + p_{climate})$ = **15.6** mm
Factor Z2 (Wallingford procedure)	Z2 = **1.99**
Rainfall for 15min storm with 100 year return period	$M100_15min = Z2 \times M5_15min_i$ = **31.2** mm
Design rainfall intensity	I_{max} = M100_15min / D = **124.7** mm/hr

Maximum surface water runoff

Catchment area	A_{catch} = **15800** m^2
Percentage of area that is impermeable	p = **100** %
Maximum surface water runoff	$Q_{max} = A_{catch} \times p \times I_{max}$ = **547.2** l/s

APPENDIX C
FLOOD RISK ZONES – TECHNICAL GUIDANCE TO THE NPPF DEFINITIONS

The flood risk zones shown on the flood maps are defined in Table 1 (Flood Zones) of the Guidance (NPPG):

Zone 1: Low Probability
According to the NPPG, land in this zone is considered to have less than 1-in-1000 annual probability of river or sea flooding in any year. This is <0.1%.

Zone 2: Medium Probability
According to the NPPG, land in this zone is considered to have between a 1-in-100 and 1-in-1000 annual probability of river flooding in any year (between 1% and 0.1%) or between a 1-in-200 and 1-in-1000 annual probability of sea flooding in any year (0.5% to 0.1%).

Zone 3a: High Probability
According to the NPPG, land in this zone is considered to have a 1-in-100 or greater annual probability of river flooding in any year (>1%) or a 1-in-200 or greater annual probability of flooding from the sea in any year (>0.5%).

Zone 3b: The Functional Floodplain
According to the NPPG, land in this zone is used for water flow or storage in times of flood. This flood zone should be identified by a Strategic Flood Risk Assessment (SFRA). It is considered to have a 1-in-20 or greater chance of river flooding in any year which is >5%. Another probability, however, can also be agreed between the Local Planning Authority (LPA) and the EA.

APPENDIX D
MAGIC SITE CHECK REPORT

Site Check Report Report generated on Tue Mar 12 2019
You selected the location: Centroid Grid Ref: SJ83889807
The following features have been found in your search area:

Aquifer Designation Map (Bedrock) (England)

Typology	Principal

Aquifer Designation Map (Superficial Drift) (England)

Typology	Secondary (undifferentiated)

Groundwater Vulnerability Map (England)

Classification	MAJOR_H

Geological Descriptions (England)

Name	Greater Manchester (Wigan, Bolton, Salford, Trafford, Bury, Rochdale, Stockport, Manchester, Tameside and Oldham Districts)
Hyperlink	http://www.naturalengland.org.uk/ourwork/conservation/geodiversity/englands/counties/area_ID15.aspx

Soilscape (England)

Reference	17
Name	SLOWLY PERMEABLE SEASONALLY WET ACID LOAMY AND CLAYEY SOILS
Main Surface Texture Class	LOAMY
Natural Drainage Type	IMPEDED DRAINAGE
Natural Fertility	LOW
Characteristic Semi-natural Habitats	SEASONALLY WET PASTURES AND WOODLANDS MAINLY, BUT NOT EXCLUSIVELY, ON THE UPLAND FRINGE
Main Land Cover	GRASSLAND WITH SOME ARABLE AND FORESTRY
Hyperlink	/Metadata_for_magic/soilscape_summary.pdf

Geological Places to Visit (England)
No Features found