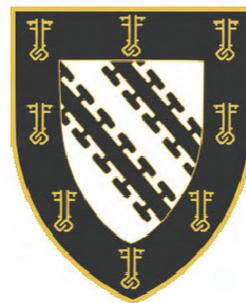


**SUPERSEDED**  
SEE AMENDED REPORT



**EXETER  
COLLEGE  
OXFORD**

**A New Quad at Walton Street  
Flood Risk Assessment, Including Basement Hydrological  
Assessment and Drainage Statement**

March 2013

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**Exeter College, Oxford, Walton Street Quadrangle**  
**Flood Risk Assessment and Drainage Strategy**

<b>Prepared by</b>	NC	NC		
<b>Checked by</b>	JB	JB		
<b>Date:</b>	18/3/13	25/03/13		
<b>Revision:</b>	P01	P02		
<b>Reason for issue:</b>	Preliminary	Planning		

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## Drawings

Existing Site Plan

Existing Sections

Proposed Basement Plan

Proposed Ground Floor Plan

Proposed Sections

Existing Drainage Plan

Proposed Drainage Plan

## Appendices

Card Geotechnics Report - Basement Hydrological Assessment

## **1 Introduction**

Exeter College Oxford is developing a new college campus as an addition to the existing Turl Street site. The site is that of Ruskin College, who vacated the site in October 2012. The site is located on the junction of Worcester Place and Walton Street in Oxford City Centre, and is referred to in this report as the Walton Street Quadrangle site.

Stockley were appointed in January 2012 by Exeter College Oxford to provide structural and civil engineering services for the redevelopment of the Walton Street Quadrangle site. Alison Brooks Architects are the Lead Consultant appointed by the College, with Northcroft acting as the Project Manager.

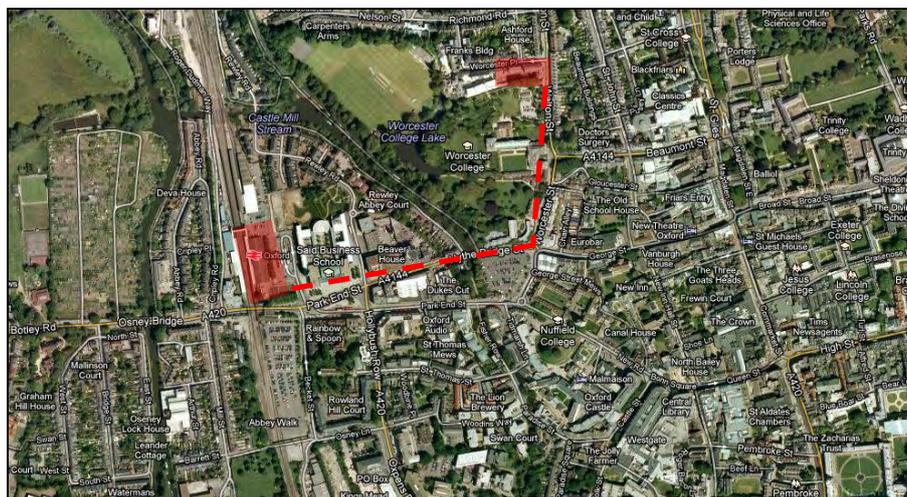
The proposals are to transform the site into a new college facility for Exeter College including residential, teaching, cultural and social accommodation for students and faculty staff. Existing structures will be carefully demolished, with the exception of the existing façade to the original Ruskin building facing Walton Street and Worcester Place which will be retained.

This Flood Risk Assessment (FRA) has been prepared in line with PPS25 to support the planning application for the redevelopment of the Walton Street Quadrangle site. According to the online EA flood maps for the area, approximately half of the proposed site sits within flood zone 1 and the remaining area sits within flood zone 2.

## 2 Proposed Development

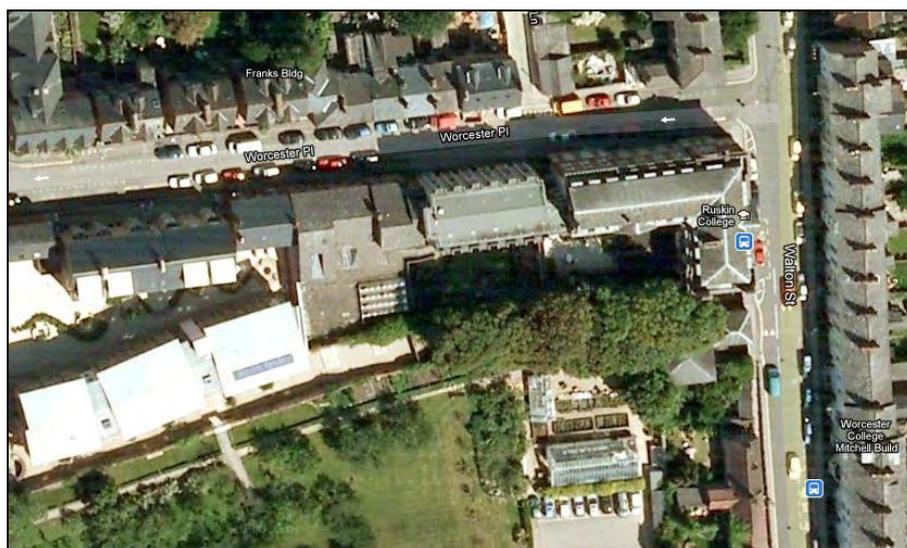
### 2.1 The Existing site

The site is located at the junction of Walton Street and Worcester Place in Oxford. The site sits on the northern edge of the city centre and is approximately 10 minutes' walk from Oxford Train Station.



**Figure 1 - Site Location Plan**

The site is bounded on its northern edge by Worcester place which is a residential scale road and is home to residential properties along its entire length. To the east the site is bounded by Walton Street which is a distributor road and is also lined with residential properties in the vicinity of the site. To the south the site is bounded by Worcester Lane which is a private lane within the grounds of Worcester College. To the west the site is bounded by Worcester College properties providing residential accommodation for Worcester College.



**Figure 2 - Existing Site Aerial View**

## **2.2 Development**

The development proposals are to create a structure which varies from three to five storeys in height and includes rebuilding the existing basement which covers approximately 70% of the site area. The new building will house student and Fellows accommodation on the upper levels whilst the ground floor and basement areas will house teaching, dining and communal areas along with archive storage, plant space, cycle parking and back of house areas.

## **2.3 Classification**

The new building will house student and Fellows accommodation on the upper levels whilst the ground floor and basement areas will house teaching, dining and communal areas along with archive storage, plant space, cycle parking and back of house areas. The upper floors would be classified in accordance with PPS25, annex D, table D.2 as more vulnerable uses and the ground floor and basement areas are classified as less vulnerable uses.

## **2.4 Planning Background**

In principle, planning policy at the local level is supportive of the redevelopment of sites already in use for higher education, increasing density whilst being respectful to the character and setting of Oxford's historic core (Policy CS29 : The Universities). Redevelopment of the former Ruskin College site, for use by Exeter College, is considered wholly consistent with this policy and with the wider policies of the Core Strategy. The proposals are also in accordance with the aims of the National Planning Policy Framework (NPPF). In particular, the scheme will adhere to the principles of sustainable development, seeking to deliver good quality design which makes a positive contribution to the surrounding area whilst conserving significant aspects of the buildings' heritage in an appropriate manner.

### 3 Potential Sources of Flooding

#### 3.1 Historical Flooding Information

Oxford is located at the confluence of the Rivers Thames and Cherwell and as such is at risk of flooding by both watercourses. The Oxford SFRA1 report details dates of the historical flood events back to 1947 as follows;

Spring 1947  
 Summer 1977  
 Winter 1979  
 Autumn 1992  
 Autumn 1993  
 Easter 1998  
 Winter 2000  
 New Year 2003  
 Summer 2007

The mapping for these events taken from the SFRA appendix C is attached as Appendix A of this document.

None of these historical flood events resulted in flooding of the proposed development site on Walton Street.

#### 3.2 Tidal / Coastal Flooding

Tidal or Coastal flooding is not applicable to this site in Oxford.

#### 3.3 Flooding from Sewers

The Oxford City SFRA Level 2 (February 2012) contains data on historic incidences of flooding from sewers in the last 10 years. This data, which was gathered from Thames Water, shows that there were 16 flood incidents recorded in the last ten years. 13 of these incidents were attributed to flooding from foul water sewers and it is therefore assumed that the surface water flood risk from the surface water sewer network within the city is low;

Table 4-1: Thames Water Sewer Flooding Incidents

Postcode	Properties flooded by surface water sewers in last ten years	Properties flooded by foul water sewers in the last ten years	Properties flooded by combined sewers in the last ten years	Total
OX1 2	1	0	0	1
OX2 0	1	6	0	7
OX2 6	0	2	1	3
OX2 8	0	1	0	1
OX4 3	0	1	0	1
OX4 4	0	1	0	1
OX4 6	0	1	0	1
OX4 7	0	1	0	1
Total	2	13	1	16

Figure 3 - Incidents of Flooding from SFRA2

Further to that the incidents of flooding within the same postcode area as the proposed development site (OX1 2) was limited to only one incident, which occurred from a surface water sewer. This shows that the foul water flood risk in the vicinity of the site is also low. The mapping of the flooding events from sewers is contained within appendix A of this report.

### 3.4 Flooding from Surface Water

The Area Susceptible to Surface Water Flooding (AStSWF) maps taken from the Oxford SFRA2 show that the site is unlikely to be susceptible to surface water flow or ponding, below is an abstract from the mapping which is also contained within appendix A of this report.



Figure 4 - Area at Risk of Flooding Map

### 3.5 Flooding from Groundwater

The Oxford SFRA shows that there have been no historical events of groundwater flooding in proximity of the site, refer to Appendix A for the mapping of historical groundwater flooding events. The closest groundwater flooding event occurred in New Botley over 1km to the west-southwest of the site.

A Hydrogeology assessment has been prepared by Card Geotechnics for the proposed development. This report was commissioned in order to assess the impact on groundwater of reconstructing the new basement on the site. The report is included in Appendix B of this report.

A maximum increase in groundwater level of 5.5cm is predicted at the up-gradient (north east) site boundary, reducing to 3.8cm at 20m distance. The impact of such a rise is considered to be negligible, given that the nearest upstream structures are some 10m to 15m away, and given that conservative assumptions were made in the modelling.

### **3.6 Fluvial Flooding**

The site sits to the north east of the River Thames and Castle Mill Stream. The eastern half of the site sits in Flood zone 1 which gives a less than 0.1% annual probability (1 in 1000 year) of flooding occurring. The western half of the site sits within flood zone 2 which gives a 0.1% annual probability (1 in 1000 year) of flooding occurring. The Oxford SFRA flood zone map is contained within Appendix C of this report

As detailed in the Oxford SFRA1 the historical flooding events have been mapped, refer to appendix A of this report for the mapping of these flood events. None of these events resulted in fluvial flooding of the proposed site.

### **3.7 Climate Change**

PPS25 gives anticipated increases in rainfall intensities to account for climate change. The design of the new drainage system at the Walton Street development site will account for climate change and although there is little space available on the site due to the constrained nature of the site SUDS in the form of attenuation tanks will be provided to attenuate against climate change increases in rainfall and also to reduce the peak flow rates compared to the existing peak flow rates from the existing site.

## **4 Design Response**

The new building will house student and Fellows accommodation on the upper levels whilst the ground floor and basement areas will house teaching, dining and communal areas along with archive storage, plant space, cycle parking and back of house areas. The upper floors would be classified in accordance with PPS25, annex D, table D.2 as more vulnerable uses and the ground floor and basement areas are classified as less vulnerable uses. The basement is to be constructed using a secant piled wall to create a complete box around the basement in conjunction with a watertight concrete method which together will ensure that the basement cannot be inundated by any way other than water overtopping the capping beam which is set at ground floor level (approximately +60.485m AOD) The surface water drainage system within the basement is a pumped system which ensures that water cannot re-enter the basement from the sewer network due to the presence of non-return valves.

The ground floor level will be set at the threshold level at Walton Street (+60.485m AOD) which relates to a level above the 0.1% annual probability (1 in 1000 year) of flooding occurring this is generally raised from the existing ground floor level in the existing situation which currently follows ground level, this raised ground floor will ensure safe access from the residential parts of the development in the upper floors if required.

## **5 Flood Risk Management Measures**

Exeter College will sign up to the Environment Agency's flood warning system, Floodline Warnings Direct (FWD). FWD is a multimedia flood warning system that is used to issue flood warnings to specific areas by telephone, mobile, fax or pager. The aim of this service is to provide flood warnings at least two hours in advance of a flood event to properties that lie within flood zone 2 or flood zone 3.

## **6 Off-site Impacts**

The redevelopment of the Walton Street site is not anticipated to cause any adverse effects to surrounding or downstream sites. The design of a new SUDS drainage system will reduce peak water flows from the sites which will help to reduce the risk of flooding from sewers and flash flooding in the locality of the site. A detailed hydrology report has been produced to test the impacts of the reconstructed basement on groundwater in the area and this has shown that the effects on groundwater are not considered to be significant.

## **7 Residual Risks**

The new ground floor of the redeveloped Walton Street site will be set at threshold level and will be level throughout the site this has the effect of raising ground floor levels generally to those as existing, this increase in ground floor levels will ensure safe access from the site in the event of a flood event.

## **8 Drainage Strategy**

### **8.1 Existing Condition**

#### The Site

The existing site is mainly covered with existing structures and hard standing although there is a small grassed quadrangle within the site which is presently not formally drained. The existing hard standing area is 1600m<sup>2</sup> and the existing soft landscaping area is 100m<sup>2</sup>.

#### The drainage System

The existing complex of buildings on the site were home to Ruskin College, the existing drainage network carries the surface water from all hard standing and roofs to the surface water sewer within Worcester Place under gravity, there is currently no provision for attenuation or any form of SUDS system.

The existing foul water also drains under gravity to the foul water sewer within Worcester Place.

The as surveyed existing drainage layout is appended to this report.

### **8.2 Proposed Condition**

The below ground drainage layout is shown indicatively on (DR) 001. The proposed hard standing area is 1700m<sup>2</sup> although planting areas are to be provided these will generally be on top of structure and will require positive drainage.

#### Surface Water

The surface water from the majority of the 1150m<sup>2</sup> roof areas will be drained into water harvesting tanks for re-use within the building as a grey water supply. Where collection is unfeasible from the roof due to the proximity of the boundary and the space restrictions the surface water from the roofs and hard standing will be drained under gravity to the existing sewer within Worcester Place.

The external hardstanding areas will drain to basement level and will need to be pumped to the surface water sewer in Worcester Place due to the reduced level of the existing basement. The pump chambers will conform to building regulations and provide 24 hour storage in case of malfunction.

The proposed development should be designed so that there is no flooding to the development in a 1 in 30 year (3.33% AEP) event and so that there is no property flooding in a 1 in 100 year (1% AEP) plus climate change event.

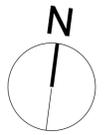
The increase in hard standing area of 100m<sup>2</sup> will be attenuated for along with a target reduction of 30% of existing peak flows up to a 1 in 100 year plus climate change event as outlined in

Oxford City Councils SFRA2. The rainwater harvesting tanks will double up as attenuation tanks which will be further supplemented by the storage capacity within the Hydrobrake manhole by providing a free board within the tanks itself with flow being regulated by a Hydrobrake or similar flow control.

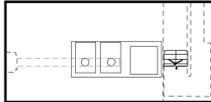
#### Foul Water

Foul water will generally be collected below the basement of the new building and will be pumped to the foul sewer on Worcester Place. The pump chambers will conform to building regulations and provide 24 hour storage in case of malfunction.

## **DRAWINGS**



Boiler Room Part Plan



A-A  
EX010

B-B  
EX010

D-D  
EX011

C-C  
EX011

E-E  
EX012

Cavity wall with masonry external skin and loadbearing blockwork internal skin.

TP11 58.664

59.006

57.619

57.615

58.559

57.925

Structure of staircase to be confirmed (assumed RC).

RC blade columns. 59.001

Masonry infill wall with RC retaining wall under.

Column (construction T.B.C.) picking up steel section above. 59.346

Concrete stair access to basement.

Perimeter loadbearing masonry walls.

Ground bearing concrete floor slab throughout basement areas.

Internal loadbearing masonry piers picking up steel beams.

TP15

58.905

TP16

TP10 Abandoned 57.793

TP9

58.206

TP7

TP5

TP14

TP19

57.462

59.030

TP19

59.039

TP21

Masonry boundary wall.

Low level masonry retaining wall.

Garden area.

Banked landscaping down to library floor level.

Worcester College stone wall.

Assumed RC retaining wall

Lane separating Worcester College site from existing Ruskin College site.

Internal loadbearing masonry walls pick up filler joist ground floor above.

Internal loadbearing masonry pier picking up steel column section above.

TP3

TP2

59.002

TP1

59.809

TP25

TP24

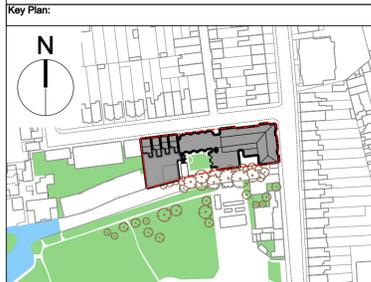
TP23

Concrete stair structure.

Electricity substation.

Masonry piers within boundary wall.

Perimeter loadbearing masonry walls act as retaining structure below adjacent ground level.



**Notes:**  
This drawing is to be read in conjunction with all relevant Architect's and Engineer's drawings and the specification.  
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**Notes Continued:**  
This drawing has been produced using a combination of survey information supplied at competition stage and on site visual inspections.  
All information shown on these drawings is to be checked on site for verification.  
The accuracy of the information contained on these drawings can not be guaranteed.

**Key**

	Existing RC element
	Existing brickwork
	Existing blockwork
	Existing stonework
	Existing structure under
59.039	Existing levels

**Key**

	Trial pit location
--	--------------------

07.12.12	P03	Issued for Information	IS	NC
07.06.12	P03	Trial pit locations added	IS	NC
30.03.12	P02	Issued for Information	IS	NC
02.03.12	P01	Issued for Information	IS	NC
Date:	Rev:	Description:	Drawn:	Chkd:

**Project:**  
Exeter College Oxford

**Title:**  
Existing Plan at 59.5m Basement Level

Scale: 1:100@A1  
1:200@A3

Date: Mar 2012

Drawn: IS  
Checked: NC

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Notes Continued:  
 This drawing was produced using survey information from The Downland Partnership Ltd - April 2011 and relevant Ordnance Survey information.

Notes Continued:  
 Key:  
 - - - Site boundary  
 - - - Existing pavement line  
 Existing pavement line  
 Existing grassed area

Notes Continued:

Notes Continued:

30.03.12	PO1	Issued for Information	IS	NC
Date:	Rev:	Description:	Drawn:	Chk'd:

Project:  
 Exeter College  
 Oxford  
 Title:  
 Site Plan

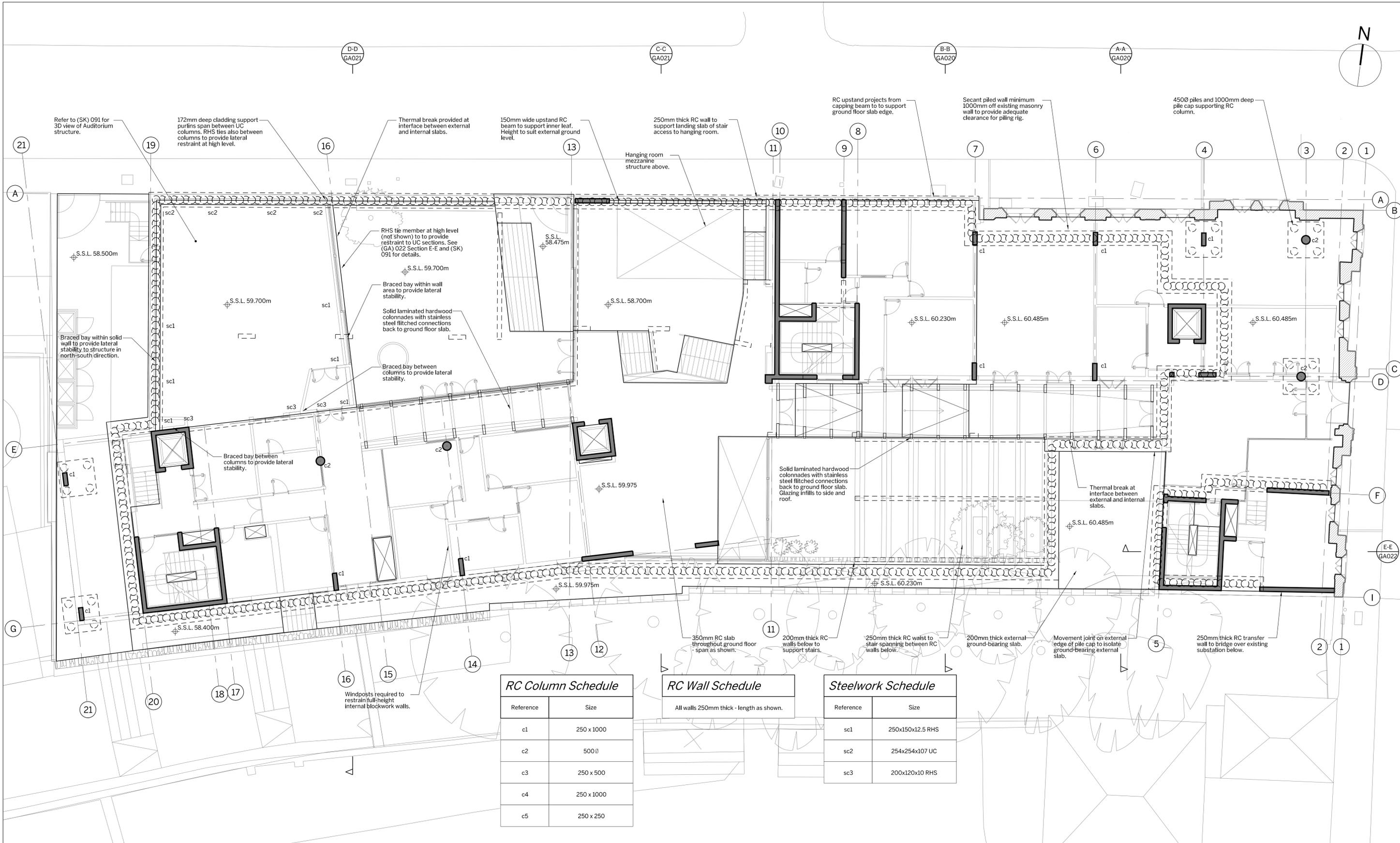
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1:200@A1 1:400@A3	Jan 12	IS	NC	521/01	(GA) 001	P01





**RC Column Schedule**

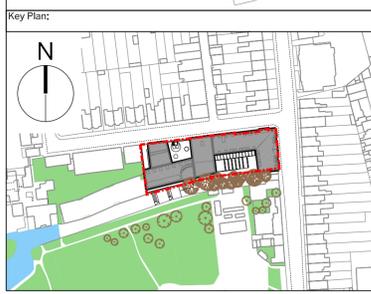
Reference	Size
c1	250 x 1000
c2	500Ø
c3	250 x 500
c4	250 x 1000
c5	250 x 250

**RC Wall Schedule**

All walls 250mm thick - length as shown.

**Steelwork Schedule**

Reference	Size
sc1	250x150x12.5 RHS
sc2	254x254x107 UC
sc3	200x120x10 RHS



**Notes:**

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**Notes Continued:**

1. Concrete special finish to be achieved through the use of limiting percentage of coarse aggregate and a controlled permeability formwork.

**Notes Continued:**

**Key**

- RC element in section
- RC element below
- RC element under
- Span of slab

**Notes Continued:**

07.12.12	PO2	Issued for Stage D	IS	NC	Scale:	Date:	Drawn:	Checked:	Job Number:	Drawing Number:	Revision:
04.05.12	PO1	Issued for Stage C	IS	NC	1:100@A1	Nov 2012	IS	NC	521/01	(GA) 012	PO2
Date:	Rev:	Description:	Drawn:	Chkd:	1:200@A3						

**Project:**  
Exeter College Oxford

**Title:**  
Proposed Ground Floor Plan

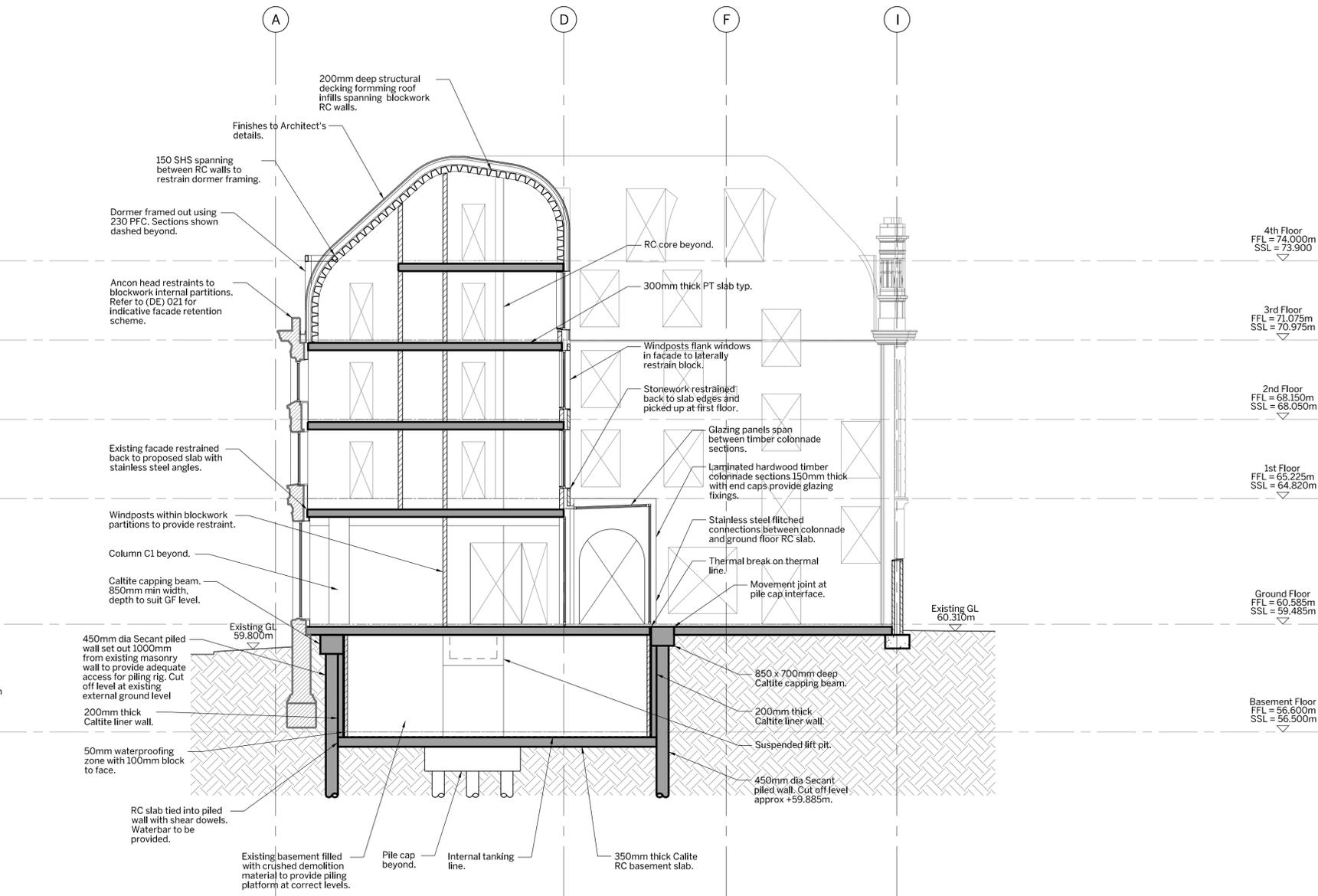
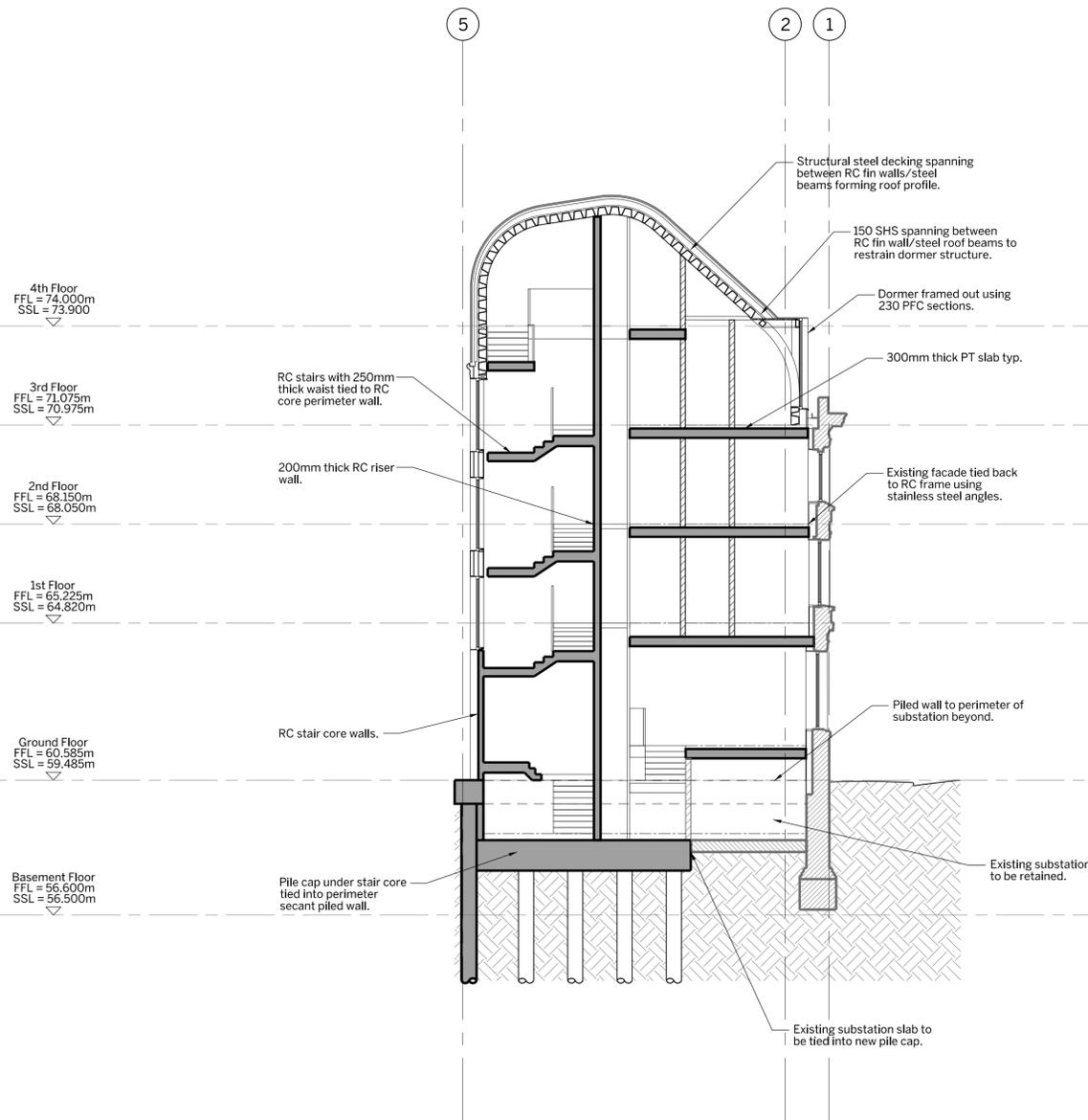
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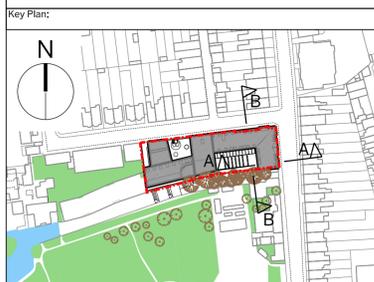
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**INFORMATION**



Section A - A

Section B - B



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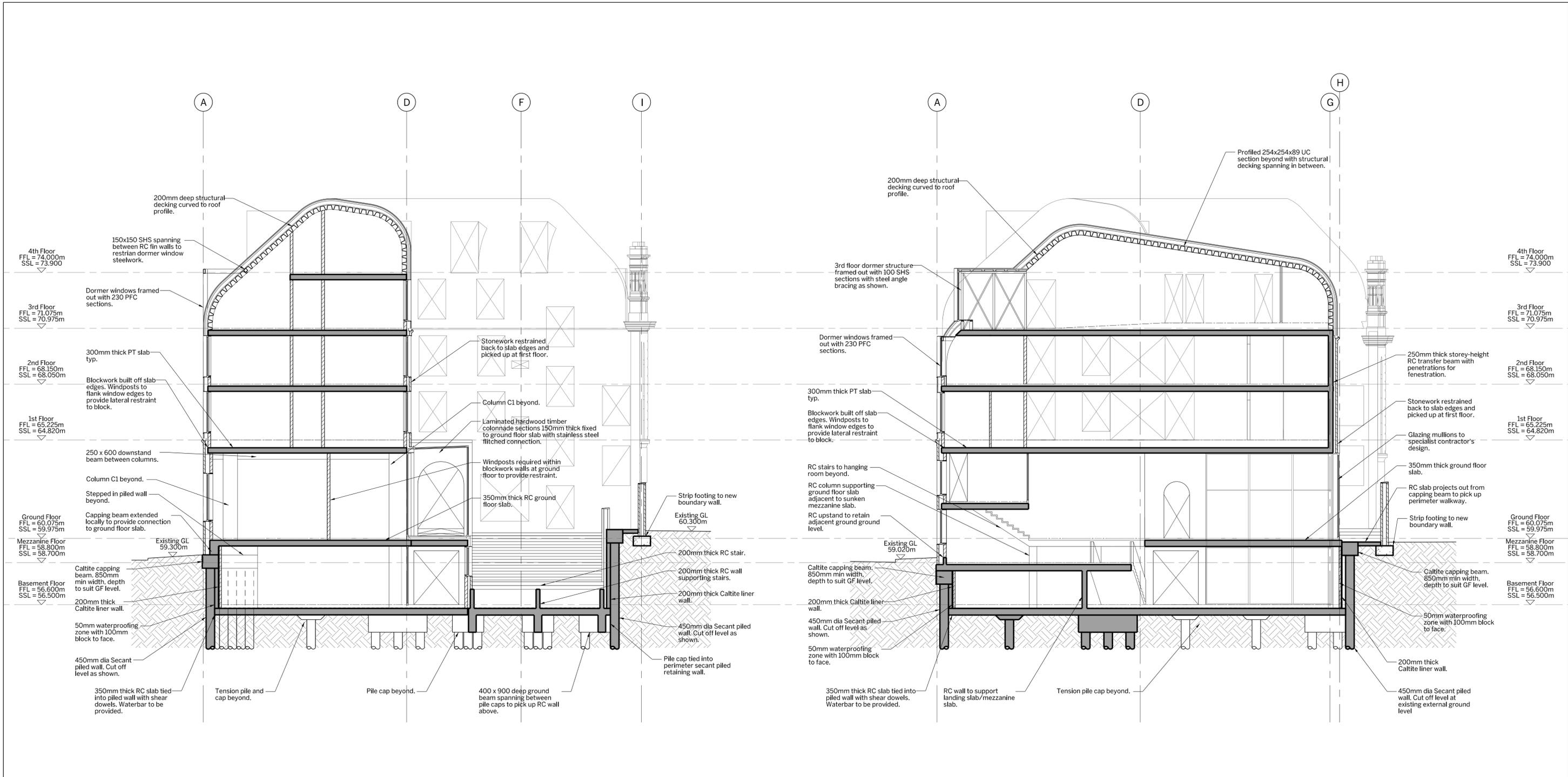
Notes Continued:

Notes Continued:

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Date:	Rev:	Description:	Drawn:	Chkd:

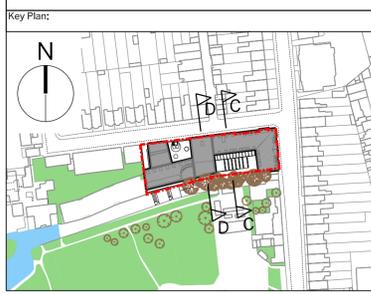
Project: Exeter College Oxford			
Title: Proposed Sections A-A and B-B			
Scale:	Date:	Drawn:	Checked:
1:100@A1 1:200@A3	Dec 2012	IS	NC

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Job Number:	Drawing Number:	Revision:
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Section C - C

Section D - D



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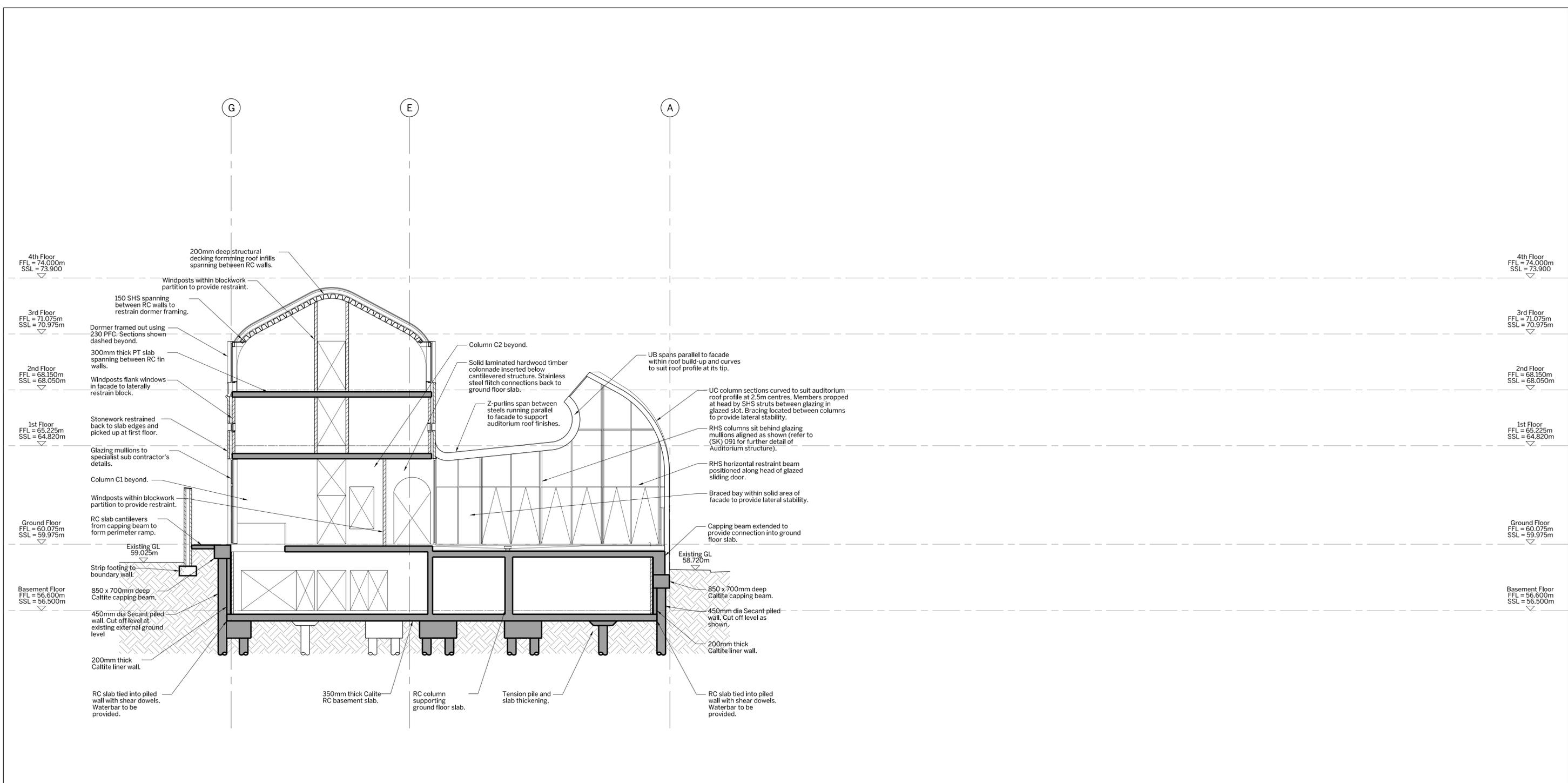
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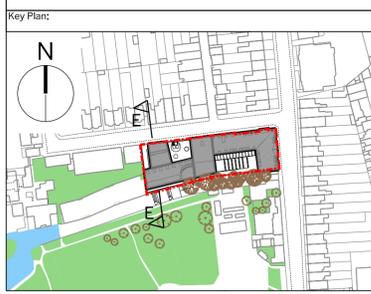
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 Title:  
 Proposed  
 Sections C-C and D-D



Section E - E



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Notes Continued:	Notes Continued:	Notes Continued:
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Date:	Rev:	Description:	Drawn:	Chkd:

Project: Exeter College Oxford
Title: Proposed Sections E-E
Scale: 1:100@A1 1:200@A3
Date: Dec 2012
Drawn: IS
Checked: NC
Job Number: 521/01
Drawing Number: (GA) 022
Revision: P01

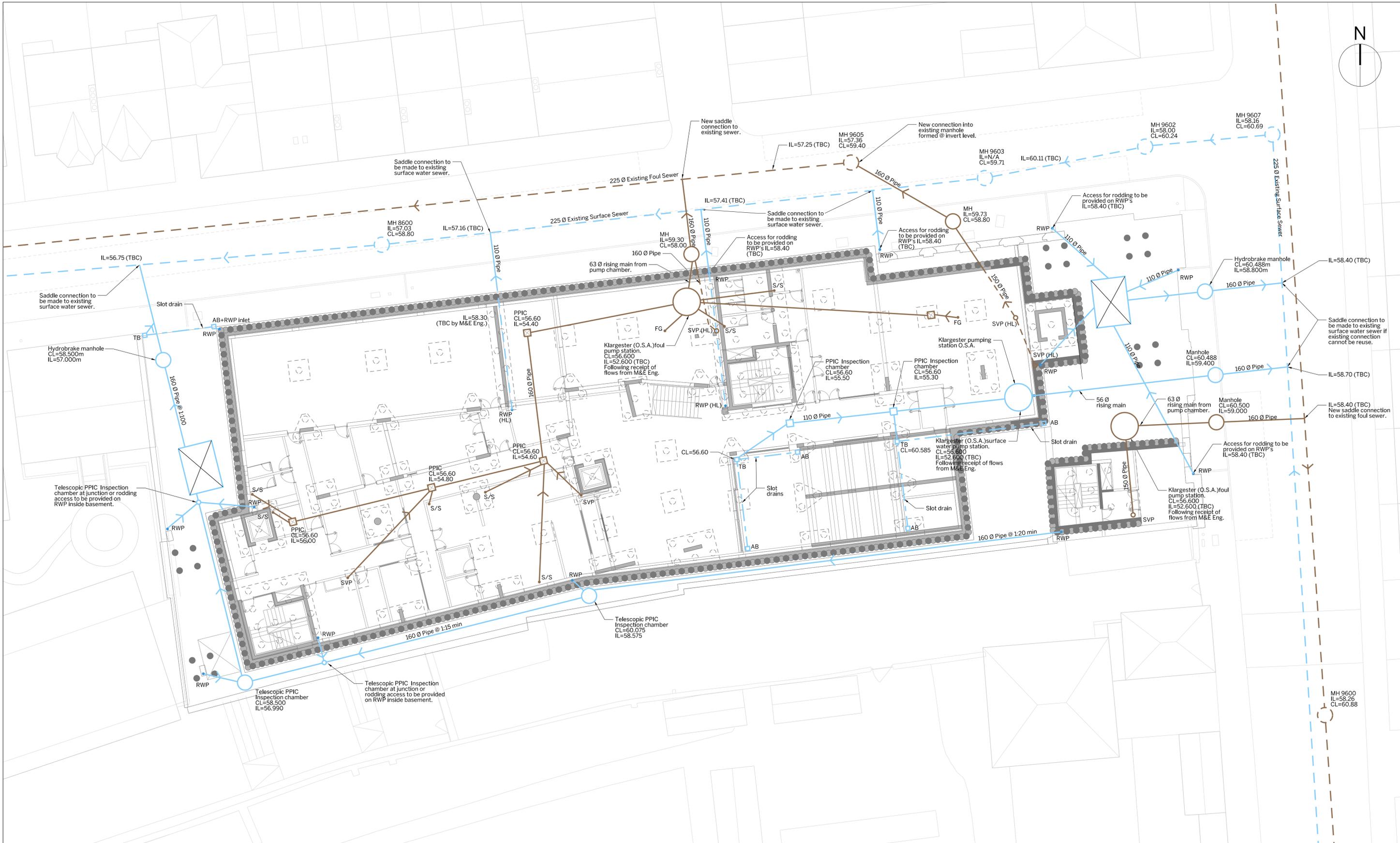
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**Notes Continued:**

**Notes Continued:**

**Key**

- Slot drain
- Access box
- TB
- RE
- FG
- ☐ Pump and storage chamber

**Notes Continued:**

**Key**

- - - High level above slab drainage to M & E Engineers specifications.
- - - Existing foul
- - - Existing Surface

15.02.13	P03	General Updates	GB	NC
07.12.12	P02	Issued for Stage D	GB	NC
04.05.12	P01	Issued for Stage C	IS	NC
Date:	Rev:	Description:	Drawn:	Chk'd:

**Project:**  
Exeter College Oxford

**Title:**  
Proposed Drainage Plan

**Status:**  
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Drawing Number: (DR) 001  
Revision: P03



  
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 Revision:

■	SURFACE WATER SURVEYED
■	FOUL WATER SURVEYED

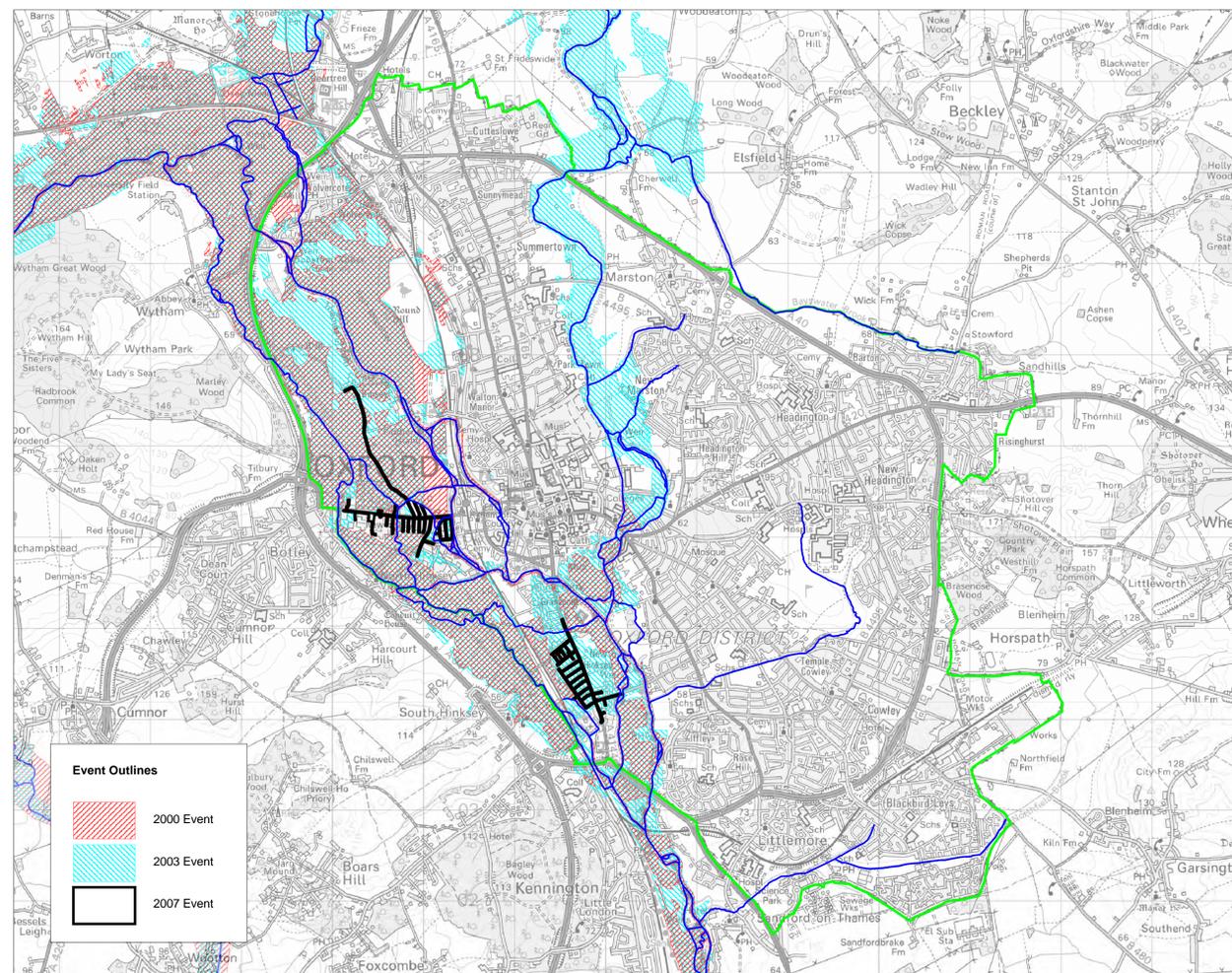
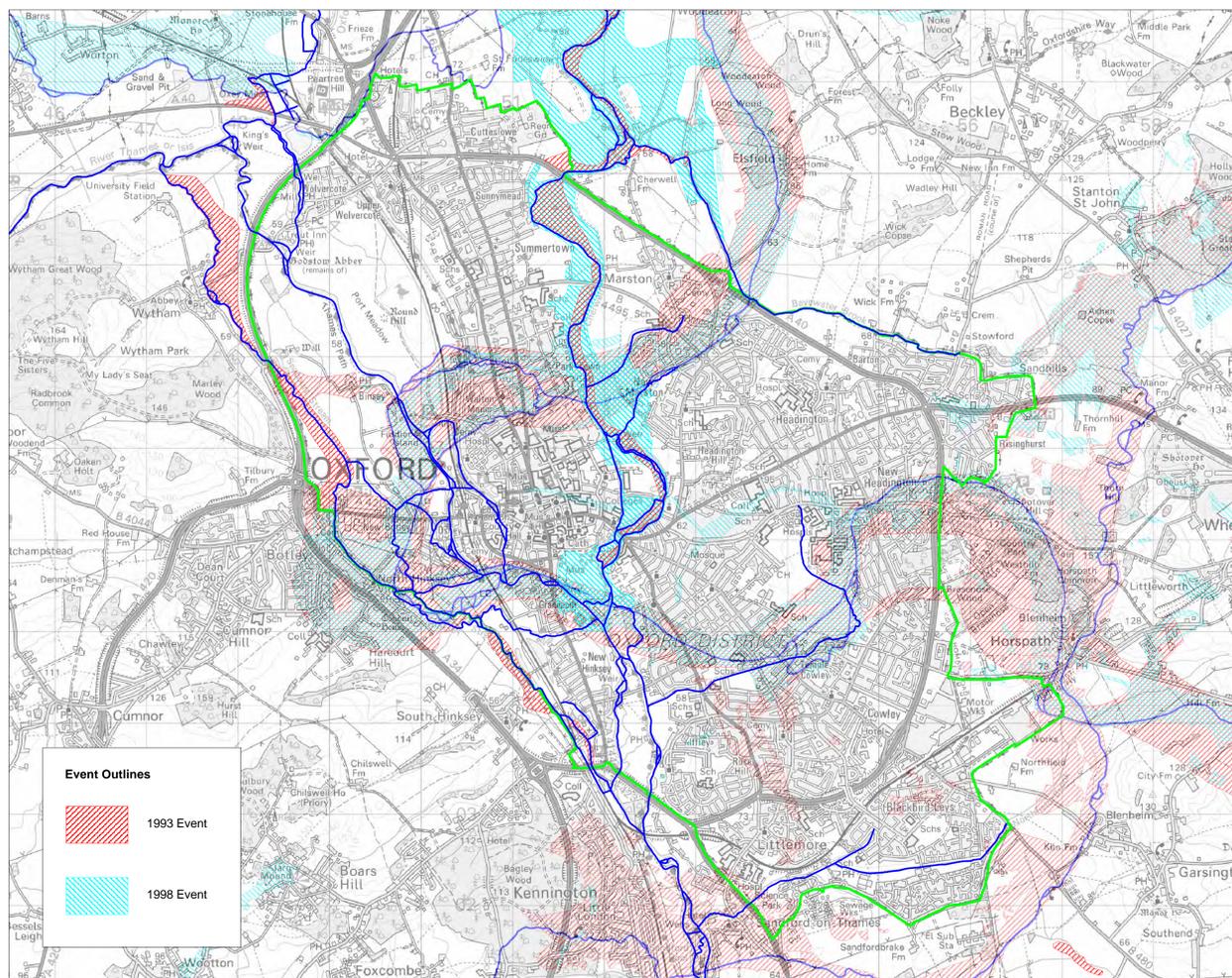
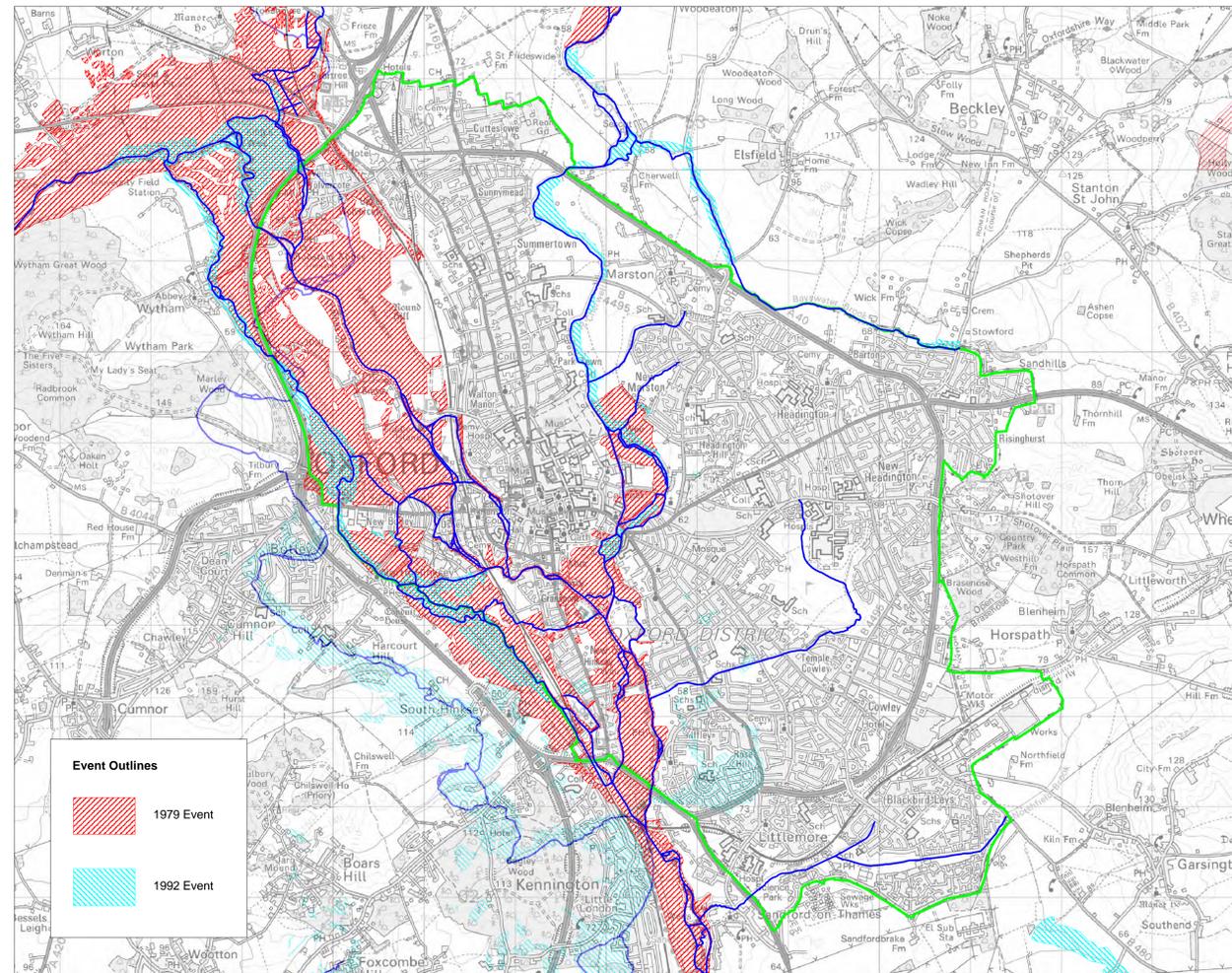
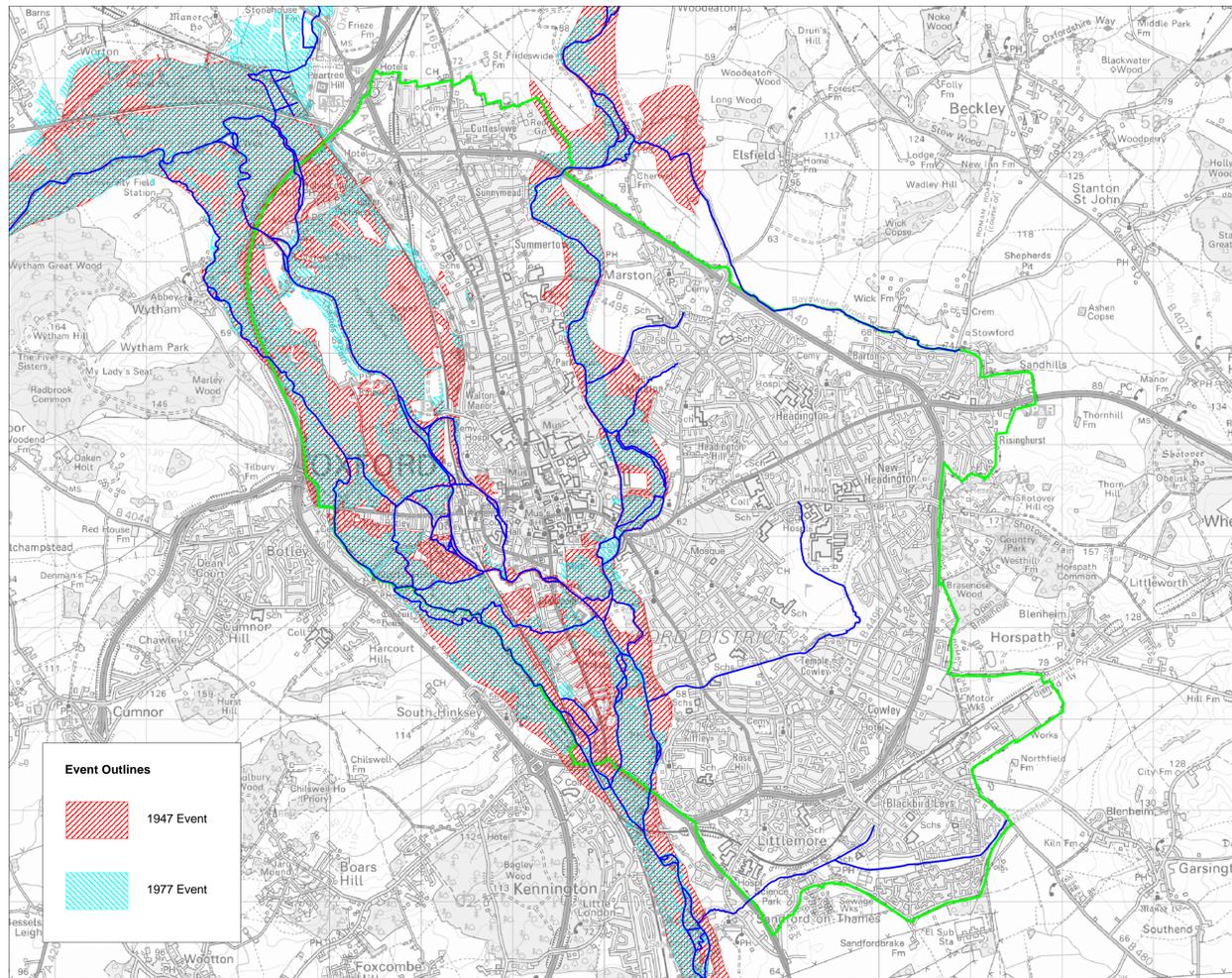
Lames Group Plc  
 West Midlands Division

Easter College  
 Oxford

WG	
28-04-12	
NTS	1402-001634

## **APPENDICES**

## **APPENDIX A – Historical Flood Event Mapping**



**Legend**

- River Centreline
- Study Boundary

SCALE: NTS



Project Title:  
Oxford City SFRA - March 2011

Figure Title:  
Historical Flood Outlines

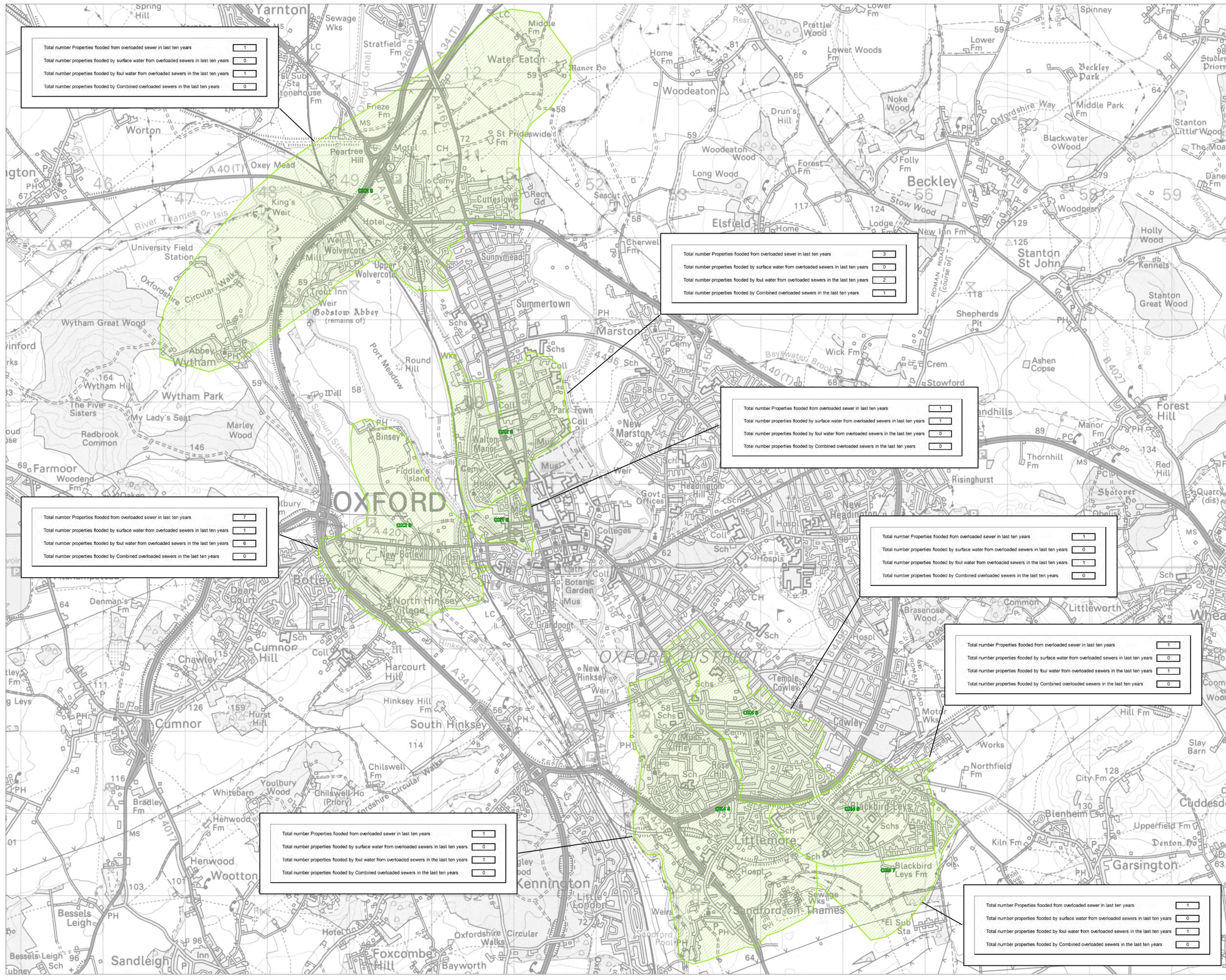
Document Reference: 5093353/62/DWG/003

Figure Number:  
Appendix C

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ATKINS



**Legend**

Postcode Areas



SCALE: NTS

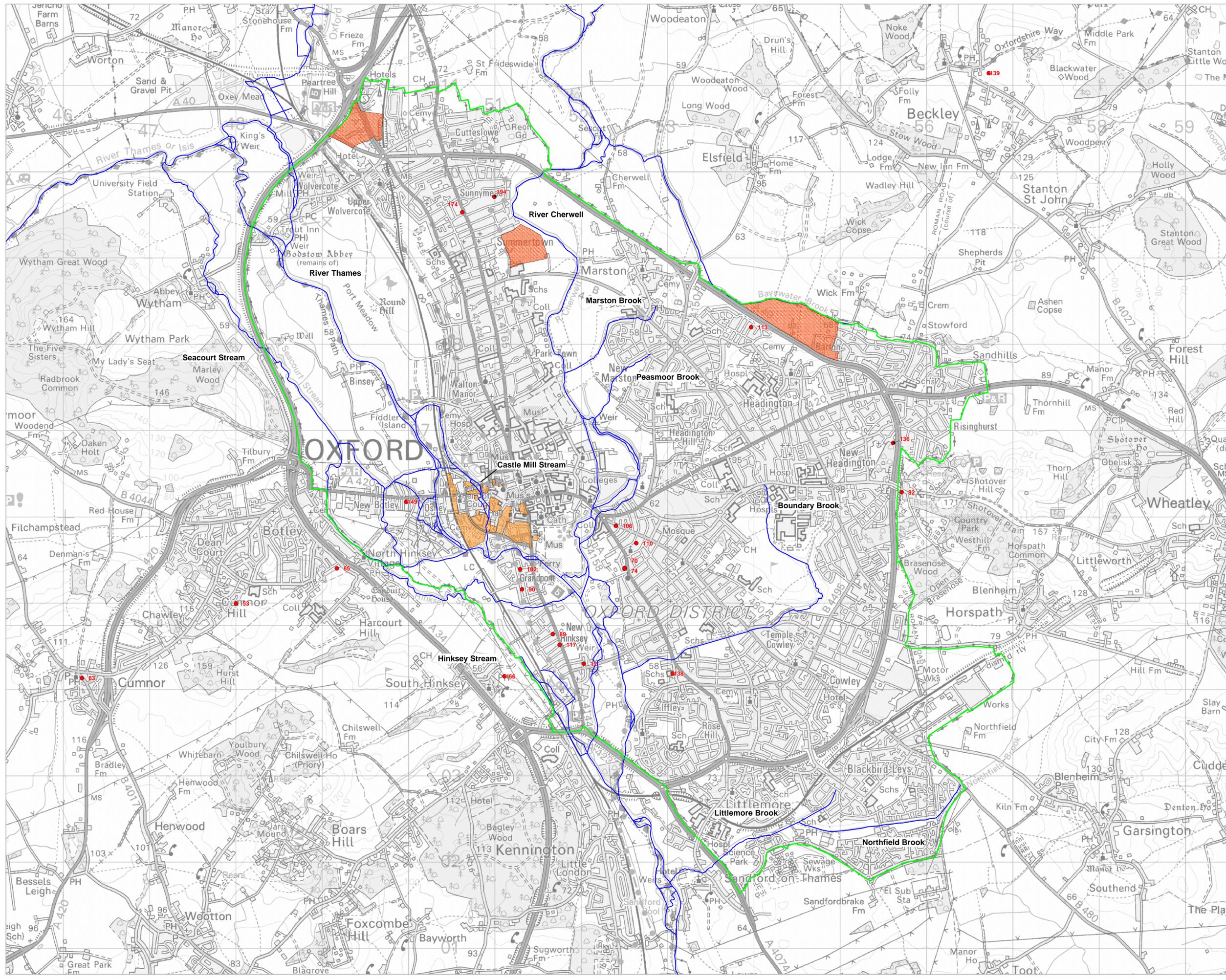
Project Title:  
Oxford City SFRA - March 2011

Figure Title:  
Thames Water Sewer Flooding Incidents by Postcode Area

Document Reference: 5093353/62/DWG/001  
Figure Number: Appendix A

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- Legend**
- River Centreline
  - Study Boundary
  - Strategic Development Sites
  - Indicative Sites within the West End
  - Ground Water Flooding Incidents (Labelled with call reference number)

SCALE: NTS



Project Title:  
Oxford City SFRA - March 2011

Figure Title:  
Registered Groundwater Flooding Incidents

Document Reference: 5093353/62/DWG/002      Figure Number: Appendix B

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## **APPENDIX B – Card Geotechnics Hydrology Report**



Exeter College

**Ruskin College, Oxford**  
*Basement hydrological  
assessment report*

October, 2012



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Card Geotechnics Limited ("CGL") has prepared this report in accordance with the instructions of Stockley on behalf of Exeter College ("the Client") under the terms of its appointment for consulting engineering services by the Client dated 30<sup>th</sup> August 2012. The report is for the sole and specific use of the Client, and CGL shall not be responsible for any use of the report or its contents for any purpose other than that for which it was prepared and provided. Should the Client require to pass copies of the report to other parties for information, the whole of the report should be so copied, but no professional liability or warranty shall be extended to other parties by CGL in this connection without the explicit written agreement thereto by CGL.

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Reference	CG/8069	Revision 0.0 Issue Date October 2012

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- B Proposed development plans**
- C Underground infrastructure**

## 1. INTRODUCTION

---

Exeter College, Oxford, is proposing to redevelop part of Ruskin College, including the demolition of existing buildings and construction of 4 to 6 storey buildings with a single storey basement level. The façades of the original college along Walton Street and Worcester Place are to be retained.

Card Geotechnics Limited (CGL) has been commissioned to undertake a review of the groundwater information available for the site and environs to provide an appropriate groundwater level for the proposed basement design, in accordance with the design philosophy set out in BS 8102:2009 – *Code of practice for protection of structures against water from the ground*, and to assess the potential impact of the basement on local groundwater levels.

This report presents the findings of a desk based study of the available ground and groundwater conditions in the surrounding area taking into account published and unpublished geological records from the British Geological Survey and council records. Site investigation data for the site has also been reviewed, along with information available from CGLs recent work at Oxford University Press (OUP) and publicly available information for the recent Radcliffe Observatory Quarter (ROQ) development in central Oxford.

The report assesses the impact of the proposed basement on the local and regional groundwater regimes and the risk associated with the potential for increased groundwater levels as a result of the proposed basement. This report also includes a 2 dimensional groundwater flow analysis using FLAC finite difference software to assess the change in flow regime and upstream porewater pressures generated by construction of the new basement.

## **2. SITE CONTEXT**

---

### **2.1 Site location**

The site is located at Ruskin College, at the junction between Walton Street and Worcester Place, Oxford, OX1 2HE. The OS Grid Reference of the site is approximately 450919, 206638 and the site location is shown in Figure 1. Figure 1 also shows the nearby OUP and ROQ basement sites, from which information has been derived to support groundwater modelling.

### **2.2 Site Layout**

The site is approximately rectangular in shape, with dimensions of 75m by 25m.

The site is currently occupied by the buildings of Ruskin College, providing student accommodation and teaching facilities. The buildings range from two to five storeys in height, with variable levels of part to full single storey basements. There is also a relatively small open space/courtyard in the central and southern portion of the site. The site is bounded by Walton Street and Worcester Lane to the north and east of the site, respectively. To the south and west are the grounds and buildings of Worcester College.

Plans and sections showing the existing site layout are provided in Appendix A.

### **2.3 Proposed development**

It is proposed to demolish the existing buildings on site whilst retaining the façades of the original Ruskin College buildings along the north eastern and eastern boundaries. A single storey basement is to be constructed across the majority of the site footprint, excavated within a secant piled wall to a floor level of 56.4mOD. Existing basements will need to be deepened by between 1.5m and 3.0m whilst in other areas new basement excavations will extend to a maximum depth of 4.0m below ground level (bgl). The secant wall does not extend fully to the eastern edge of the site, where the existing basement and floor levels of the Ruskin buildings are being largely retained. An open courtyard area steps up to ground level from the basement along the southern boundary.

Plans of the proposed site layout are provided in Appendix B and proposed excavation levels and depths are shown in Figure 4.

### **3. GROUND AND GROUNDWATER CONDITIONS**

---

#### **3.1 Introduction**

This section of the report collates desk based information, historical boreholes and on-site and off-site intrusive investigation data. Public and private sources have been consulted to supplement the site specific data and establish the hydrogeological regime of the site and surrounding area.

Borehole locations and derived groundwater levels and contours are summarised in Figure 2.

#### **3.2 Published geology**

According to British Geological Map Sheet 236<sup>1</sup> the site is underlain by the Northmoor Sand and Gravel Formation (terrace gravels of the River Thames) and the Oxford Clay at depth. More recent alluvial deposits outcrop approximately 100m to the south west of the site.

#### **3.3 Historical boreholes**

There are limited BGS borehole records in the near vicinity of the site. The nearest of these include several boreholes at the former Radcliffe Infirmary approximately 350m north of the site, a single borehole on Cardigan Street 350m north west of the site, and a series of boreholes along Rewley Abbey Court 250m south west of the site and Worcester College Pond.

The BGS borehole records largely coincide with the geological map of the area and show that, under a thin veneer of Made Ground (typically <1.0m), siliceous sands and gravels are encountered representative of the Northmoor Sand and Gravel Formation and Summertown-Radley Sand and Gravel Formation. These soils are, however, characterised by intermittent soft to firm clay horizons perhaps representative of historical flood plains. The river terrace gravels are overlain by soft alluvium in those boreholes closer to the River Thames.

---

<sup>1</sup> Witney, England and Wales Sheet 236. 1:50,000 Series. Solid and Drift Geology. British Geological Survey, 1982.

The Oxford Clay was encountered in the majority of the boreholes where depths of investigation were sufficient, and comprised firm becoming stiff to hard blue/grey clay.

### **3.4 On-site Intrusive Investigations**

#### **3.4.1 Ground conditions**

A previous ground investigation has been undertaken at the site by Geotechnical and Environmental Associates Limited (GEA) in May 2012<sup>2</sup>, and comprised the following works:

1. A desk study;
2. An intrusive investigation comprising a single cable percussion borehole to 20m depth, including in-situ standard penetration testing and disturbed/undisturbed sampling. The borehole was excavated outside the site perimeter on Worcester Place. 20 hand dug trial pits were also excavated to expose existing foundations;
3. Geotechnical and geoenvironmental laboratory testing;
4. Interpretative reporting for both geotechnical and geoenvironmental requirements.

A second phase of investigation was being undertaken at the time of writing, including the excavation of 3 additional boreholes with monitoring installations. Preliminary logs have been provided along with the results groundwater monitoring. The locations of the boreholes are illustrated in Figure 2.

Based on the four boreholes completed, the ground conditions on site are summarised below in Table 1:

---

<sup>2</sup> GEA (23 May 2012) *Ruskin College Oxford – Desk Study and Ground Investigation Report*

**Table 1: Summary of ground conditions**

Stratum	Depth to top (mbgl)	Thickness (m)
	Level [mOD]	
MADE GROUND comprising dark brown to orangebrown sandy gravelly clay/clayey gravelly sand with fragments of brick, concrete, ash and coal.	0 [59.83 – 57.90]	0.50 – 1.70
Soft orange light brown silty sandy gravelly CLAY / loose to medium dense brown clayey silty SAND with occasional gravel / loose orange brown clayey silty sandy GRAVEL. [NORTHMOOR SAND AND GRAVEL]	0.50 – 1.70 [56.20 - 59.33]	1.90 – 5.80
Initially soft becoming very stiff dark blue grey fissured silty CLAY with occasional sandy partings. [OXFORD CLAY]	2.40 - 6.80 [52.2 – 57.43]	Proven to 20mbgl

The Northmoor Sand and Gravel at the site is characterised by both cohesive and granular units, possibly representing cyclical depositions of terrace deposits during flood events. In the trial pits the Northmoor Sand and Gravel was typically encountered as a clayey silty sand and gravel. Similarly variable superficial ground conditions were encountered at the OUP and ROQ sites (see below).

It is noted that gravel was encountered to a depth of 6.8mbgl in borehole BH1, and to a depth of 6.5mbgl in borehole BH4. Gravel was not encountered in boreholes BH2 and BH3, with the alluvial deposits in this area comprising silts and clays. It is possible that the presence of the gravels represents a former river channel across the western half of the site.

### **3.4.2 Groundwater**

A groundwater strike was recorded during the first phase of investigation in borehole BH1 in the granular Northmoor Sand and Gravel at a depth of 6.2m (52.80mOD), which rose to 3.1mbgl (55.90mOD) after a period of 20 minutes. Groundwater strikes were recorded within trial pits TP1 – TP7 at levels of between 57.2mOD and 57.4mOD generally in the north and eastern areas of the site. Trial pits TP9 – TP25 did not encounter groundwater, no log was provided for trial pit TP8.

During the second phase of investigation, groundwater strikes were recorded as fast inflows in boreholes BH2 and BH4 at depths of 2.3m and 6.3m, respectively. A seepage was recorded in borehole BH3 at 3.0m during the site works.

Subsequent monitoring of boreholes BH2, BH3, and BH4 on four occasions recorded water levels between 57.9mOD and 55.1mOD across the site, typically lower in borehole BH4. Groundwater monitoring records are summarised Table 2 below (provided by GEA).

**Table 2: Groundwater monitoring results**

Date	Borehole BH2 Depth to water (m) (level m OD)	Borehole BH3 Depth to water (m) (level m OD)	Borehole BH4 Depth to water (m) (level m OD)
11/9/2012	2.15 (57.68)	1.52 (57.38)	2.67 (55.23)
20/9/2012	2.20 (57.63)	1.58 (57.32)	2.84 (55.06)
27/9/2012	1.96 (57.87)	1.35 (57.55)	2.39 (55.51)
8/10/2012	1.90 (57.93)	1.28 (57.62)	2.26 (55.64)

The results indicate a fall in groundwater levels to the south and west, consistent with the broad regional trend. It is noted that there is an approximate 2.5m drop in water level across the site in boreholes BH1 and BH4. It is considered that this is due to the presence of a substantial thickness of gravels across the western half of the site acting as a preferential flow path for groundwater in this area. This corresponds to groundwater observations within the trial pits, with water present in the north and east at shallow depth only.

### 3.5 Off-site intrusive investigations

A site investigation was completed at the OUP site approximately 200m north of the site, comprising 2 boreholes to 20.45m and 16.45m bgl. Here both cohesive and granular units of the Northmoor Sand and Gravel were encountered, again indicative of the variability of this formation over relatively small spatial scales. The Northmoor Sand and Gravel was underlain by stiff to very stiff sandy clays of the Oxford Clay Formation at levels varying between 57mOD and 54mOD.

A large scale investigation was completed at the Radcliffe Observatory Quarter (ROQ, formerly the Radcliffe Infirmary) some 350m north of the site, with information from this investigation partly available through the Oxford City Council planning website (ref. 09/02535/FUL). The site investigation comprised excavation of 9 cable percussive

boreholes. Again the ground conditions comprise Made Ground over variable River Terrace Deposits with thicknesses recorded between 4.1m and 5.2m. The River Terrace Deposits generally comprise medium dense to very dense orange silty sandy gravel varying to silty gravelly sand with occasional pockets or layers of sandy gravelly clay.

The Oxford Clay was encountered in all of the boreholes, generally described as stiff becoming very stiff blue grey and green grey calcareous clay, thinly laminated and very closely to closely fissured in parts, with occasional fossils.

### **3.6 Local topography**

The local topography is characterised by the higher level river terraces sitting above the adjacent floodplains of the River Thames and River Cherwell. Oxford City centre is thus situated on relatively high ground between the major rivers to the west and east of the city. The site is located on the western slope of this river terrace plateau.

The natural slope of the site drops from east to west towards the Oxford Canal and the River Thames located 300m and 500m west of the site, respectively. The ground level drops from 60.5mOD on Walton Street to 58mOD at the site's western boundary, representing a local gradient of 1:30 or 2°.

### **3.7 Hydrogeology**

#### **3.7.1 EA aquifer designations**

The Environment Agency<sup>3</sup> has produced an aquifer designation system consistent with the requirements of the Water Framework Directive. The designations have been set for superficial and bedrock geology and are based on the importance of aquifers for potable water supply and their role in supporting surface water bodies and wetland ecosystems.

The Northmoor Sand and Gravel underneath the site is classified as Secondary A aquifer. Secondary A aquifers are 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. The alluvium is also classified as a Secondary A aquifer.

---

<sup>3</sup> [www.environment-agency.gov.uk](http://www.environment-agency.gov.uk) (September 2012)

The Oxford Clay encountered at depth is classified as an Unproductive Strata. Unproductive Strata are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

### **3.7.2 Hydrogeological flow**

Both BGS and publicly available data have been consulted to establish the local hydrogeological regime and groundwater flow direction. A recent report commissioned by the Environment Agency on groundwater flooding in Oxford<sup>4</sup> has also been consulted.

The hydrogeological regime in Oxford and the surrounding area is characterised by shallow groundwater levels, across the floodplain areas to the west of the site, groundwater is typically less than 1mbgl in winter and 2mbgl in summer. The older river terrace deposits form a relatively higher ridge between the River Cherwell and the Oxford Canal and as such, groundwater levels, which are considered to be in continuity with both, are slightly deeper across the urbanised Oxford area.

The site itself is approximately 4m to 5m above the water level in Castle Mill Stream and the River Thames. The recent alluvial deposits of the Thames and Cherwell floodplains typically comprise 1m of silty clay underlain by 5m of sands and gravels<sup>4</sup> across the western area of the site, with up to 5.3m of mixed silty clay and sand in the east. As such, the older river terraces are likely to be in hydraulic continuity with the alluvium and the rivers.

The Oxford Clay represents a regional aquiclude, inhibiting the vertical movement of groundwater from the overlying superficial deposits. Therefore, groundwater is likely to flow laterally through the superficial deposits and radially outwards from the river terrace plateau towards the floodplains of the River Thames to the west and River Cherwell to the east, and also towards the confluence of the two rivers approximately 1.8km south east of the site. It is likely that confined water bearing units are present within the Northmoor Sand and Gravel..

Monitoring data has been combined with groundwater data from BGS and publicly available information, including data from the OUP and ROQ sites, to derive local groundwater flow directions as shown in Figure 2. The results broadly conform to the hydrogeological interpretation of the study, which is summarised conceptually in Figure 3.

---

<sup>4</sup> Macdonald DMJ. Et al (2007) Groundwater and flooding in Oxford. Defra 42<sup>nd</sup> Flood and Coastal Management Conference, York, 2007. Available online : [http://www.groundwateruk.org/downloads/Oxford\\_Defra\\_Paper\\_2007.pdf](http://www.groundwateruk.org/downloads/Oxford_Defra_Paper_2007.pdf)

The groundwater information available for the site suggests that groundwater is discontinuous, broadly flowing towards the south and west, with flow likely to be occurring within sand channels and lenses between more silty/clayey horizons. There is a considerable increase in thickness of the gravels in the south of the site, which appears to be acting as a local drain, causing groundwater levels to drop considerably in this area. It is concluded that groundwater flow across the site will be generally slow through the eastern areas, with velocity controlled by low permeability silts and clays, with lenses and sand channels where present. The slow flow creates a limited supply to the gravels, which are capable of draining much faster, causing the drop in groundwater level evident from monitoring.

A conceptual model of the deduced flow regime is summarised in Figure 3b.

### 3.8 Hydrology

The floodplain of the River Thames is located to the west of the site and the course of the river is some 500m west of the site at its nearest point. Castle Mill stream branches off from the Thames and flows parallel to Oxford Canal, 300m south west of the site at its nearest point (see Figure 2).

*Worcester College Lake* is located some 80m south west of the site. The lake is understood to be connected by a sluice to the canal and is at the same level as the canal. It is considered likely that the lake is in hydraulic continuity with local groundwater.

Records from the EA<sup>3</sup> indicate that a Zone 3 floodplain is located immediately adjacent to the site's south western boundary. Zone 3 floodplains are areas that could be affected by flooding of rivers if there were no flood defences. This area could be flooded from a river by a rainfall event that has a 1 per cent (1 in 100) or greater chance of happening each year.

A Zone 2 floodplain extends partly onto the western half of the site. Zone 2 floodplains represent the additional extent of an extreme flood from rivers. These areas are likely to be affected by a major rainfall event, with up to a 0.1 per cent (1 in 1000) chance of occurring each year.

The extent of historical extreme floods may account for the presence of soft cohesive horizons within the Northmoor Sand and Gravel close to the superficial boundary with the alluvium.

## 4. RECOMMENDATIONS FOR GROUNDWATER

---

### 4.1 Impact of proposed basement construction on groundwater

Borehole records indicate that the basement formation at 56mOD (to include excavation for 350mm slab) will be within the Northmoor Sand and Gravel, some 4m above the Oxford Clay. Monitoring indicates that groundwater levels fall from some 57.9mOD to 55.6mOD across the site and as such the basement formation will be at or below groundwater level.

The excavations required across the site are summarised diagrammatically in Figure 4, showing the existing basement levels and additional excavations required to achieve the new formation level.

A secant pile wall is proposed around the basement perimeter to form the basement walls. Toe levels for the piles are expected to penetrate into the Oxford Clay, which will intercept the groundwater table and effectively create a fully impermeable basement box.

### 4.2 Recommended design groundwater level

BS 8102:2009 – *Code of practice for protection of structures against water from the ground* recommends a risk assessment to be undertaken to establish design groundwater levels where monitoring data is available. Monitoring results indicate groundwater levels from some 57.9mOD to 55.6mOD across the site, with higher values in the north. Flood levels inferred from the EA maps represent transient groundwater levels at or close to ground level at the site and as such a groundwater level of 58mOD is recommended for persistent conditions, with a design water level at ground surface for 'extreme' flood events as a transient, emergency loading condition.

Enquiries to Thames Water assets indicate that there is a 3" distribution main situated along the eastern boundary of the site beneath Walton Street and a 5" distribution main along the northern boundary along Worcester Place. A 10" trunk main also runs in a north south alignment on the eastern side of Walton Street. Foul and surface water drains also run along both these highways. Rupture of any of this infrastructure would be unlikely to generate a transient groundwater level greater than ground surface as stipulated for extreme flood events and, as such, no additional measures are recommended in this regard. Details of Thames Water infrastructure are included in Appendix C.

## 5. GROUNDWATER MODELLING

---

### 5.1 Previous hydrogeological modelling

A number of sites in close proximity to Ruskin College have been subject to groundwater modelling to assess the impact of basement construction on the local hydrogeological regime. These are summarised in the following sections.

#### 5.1.1 Radcliffe Observatory Quarter – 2009

The ROQ project is located some 350m to the north of Ruskin College and includes the excavation of a 4.3ha two storey basement. Given the size of the basement, Pell Frischmann Ltd. undertook groundwater modelling to assess the impact of the basement on the local hydrogeology and hydrology as part of the Environmental Impact Assessment for that site in 2009. Their report is available on the Oxford City Council planning website (ref. 09/02535/FUL) and relevant findings/conclusions are summarised below:

- a. Groundwater levels were found to decrease from the east of the site (59.2mOD) to the west (58.7mOD (SW) to 58.2mOD (NW)); with an average gradient of 1:600 falling to the west.
- b. In-situ testing recorded the permeability of the local gravels to be of the order of  $1.07 \times 10^{-4}$  m/s and a conservative mean value of  $3 \times 10^{-3}$  m/s was used in the analysis with reference to the Environment Agency's R&D publication 120<sup>5</sup>.
- c. The groundwater regime was found to be relatively stable on site over a 12 month monitoring period.
- d. The Pell Frischmann analysis considered regional hydrogeology/hydrology in terms of the very large Observatory Quarter basement's potential impact on the River Cherwell and the Oxford Canal. It concluded that the basement would not have an impact on the regional hydrogeology or hydrology.
- e. Local variations in groundwater level were not considered.

---

<sup>5</sup> LandSim. Landfill performance assessment: Simulation by Monte Carlo method R&D Publication 120. Environment Agency (1996).

### **5.1.2 Oxford University Press – 2012**

A groundwater modelling exercise using FLAC software was completed by CGL at a site 200m north of Ruskin College (planning ref 12/00371/FUL). A single storey basement is proposed across the entire site footprint.

The results suggest a negligible groundwater rise and is based on typical hydraulic gradients assumed for the area for a local hydrological and hydrogeological study undertaken for the ROQ site to the north and east of the site.

### **5.1.3 Summary**

Both of the modelling exercises completed by CGL and Pell Frischmann suggest that basement construction in similar ground conditions and in close proximity to the site do not have a significant impact on the local hydrogeology. It is therefore considered likely that the proposed Ruskin College development will have a similarly low impact on local groundwater levels and flow rates – however analysis will be undertaken to assess this effect.

In terms of infiltration/water supply, it is noted that the proposed development footprint is currently occupied by impermeable hard-standing or buildings and, as such, the new construction will not materially affect the infiltration characteristics of the site.

## **5.2 Analysis**

The construction of the new basement will create an impermeable barrier to groundwater flow and calculations have been undertaken to assess the impact of the basement on local groundwater levels. The analysis has been undertaken using two-dimensional finite difference software, (FLAC), to compute groundwater flow rates and pore pressures based on Darcy's Law.

Historical borehole data and site monitoring records have been combined to establish the regional groundwater gradient in the vicinity of the site as illustrated in Figure 2. The flow gradient is input into the FLAC model and steady state conditions established. FLAC's calculated pore pressure gradient is illustrated in Figure 3 and is consistent with contouring based on available data.

A permeability of  $1 \times 10^{-3}$  m/s was used for the entire site as a highly conservative value in order to establish worst case responses to changes in flow conditions should a gravel channel become obstructed by the construction of the basement. The basement area was 'excavated' within the model by applying a permeability of 0m/s in the basement area, and setting initial pore pressures to 0kPa, allowing for the basement to be dewatered and to create a long-term watertight box.

Flow vectors before and after basement construction are illustrated in Figures 6 and 7, showing the obstruction caused by the new basement.

Pore pressure changes have been assessed along lines broadly orthogonal to the regional flow direction (typically SW) with lines intersecting the site boundary, 10m to the northeast, and 20m to the northeast. The results are summarised in Figure 8 and indicate a maximum increase in groundwater pressure of some 0.55kPa at the basement perimeter, corresponding to an increase in groundwater levels of some 5.5cm above existing levels at the site perimeter, reducing to 3.8cm at 10m distance, and 2.9cm at 20m distance.

The FLAC analysis indicates that groundwater rises around the basement perimeter are minimal, with the maximum occurring toward the upstream side of the basement. The effects reduce rapidly with distance away from the basement. These values are considered to be worst-credible estimates as they assume a uniform high permeability within the gravels and unobstructed existing flow. In reality there will be clay lenses/layers within the gravels that significantly reduce the vertical permeability of the soils, forcing groundwater to dissipate laterally around the perimeter of the basement, rather than rising vertically.

On the basis of the analysis, the impact of the basement on local groundwater levels is considered to be minor and is very unlikely to affect local properties, even those with basements.

## 6. SUMMARY AND CONCLUSIONS

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1. It is proposed to construct a new basement at Ruskin College, Oxford with a secant piled wall around its perimeter that will obstruct local groundwater flow.
2. Studies undertaken for major new basements in the area indicate that groundwater flows generally toward the south and west in the vicinity of the site (towards the River Thames). This observation is supported by historical borehole data.
3. Groundwater levels drop by some 2m to 2.5m across the site and it is considered that this is due to a significant increase in the gravel thickness in the west of the site. It is considered that groundwater flow rates are likely to be controlled by the mixed/low permeability silt, clay and sand deposits in the east, with the deep gravels providing under-drainage in the west and reducing groundwater levels accordingly.
4. A design ground water level of 58mOD is recommended for persistent conditions based on available monitoring data. Groundwater should be taken at ground level for transient, extreme conditions given the site's location in the floodplain of the River Thames.
5. A finite difference model has been constructed to assess the impact of the basement on local groundwater levels. The model takes worst case permeability assumptions, effectively assuming that a sand channel becomes blocked, to determine the maximum likely groundwater rise caused by the basement. The result is a maximum increase of 5.5cm at the up-gradient (north east) site boundary, reducing to 3.8cm at 20m distance. The impact of such a rise is considered to be negligible, given that the nearest upstream structures are some 10m to 15m away, and given the conservative assumptions made in the modelling. It is also recognised that existing foundations and basements to the northeast of the site will reduce existing flow rates, and correspondingly reduce the impact of the current basement on groundwater levels.