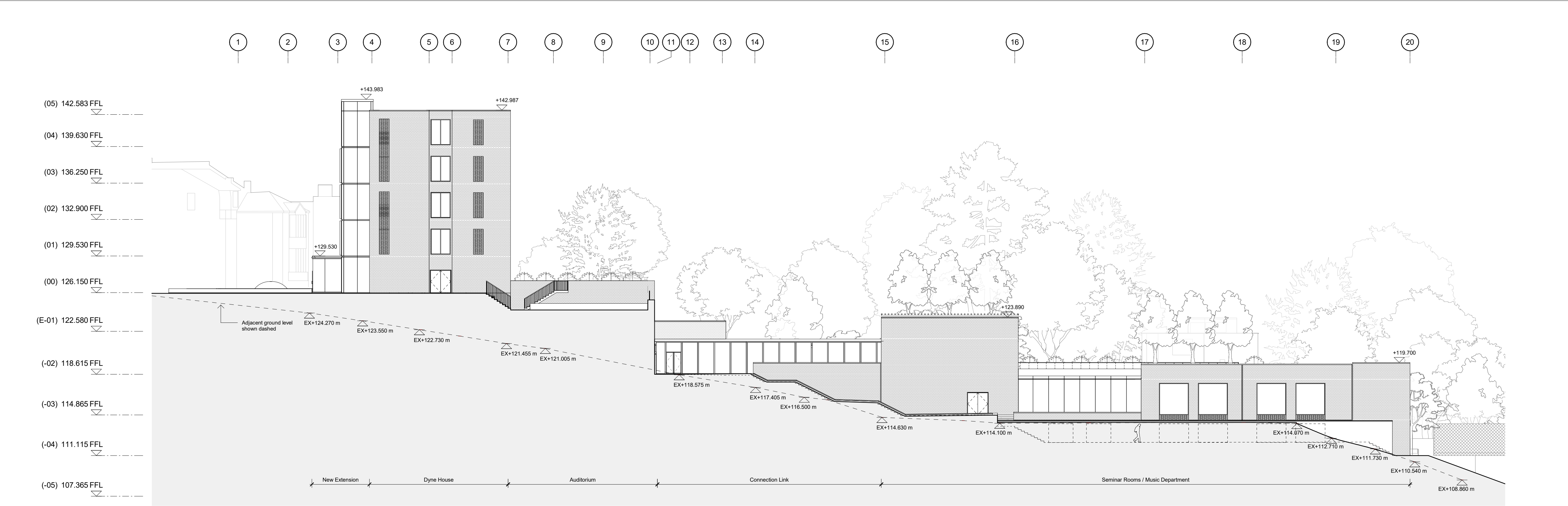
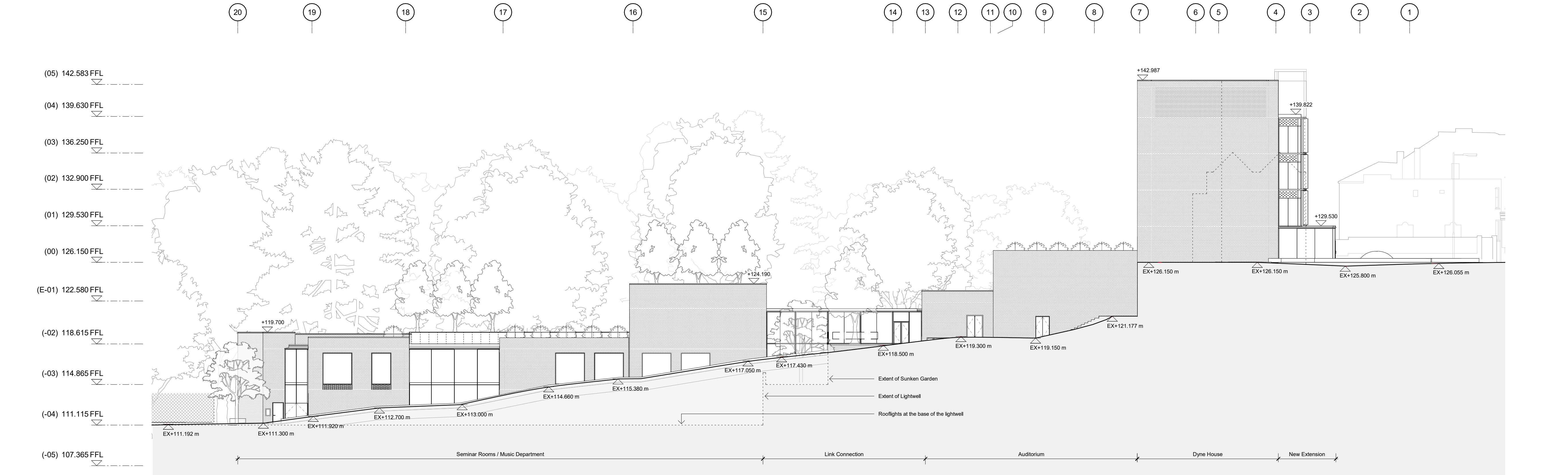




1 Dyne House - South Elevation
2520 1:200



2 Dyne House - North Elevation
2520 1:200

General Notes:

G1 All Levels are above ordnance datum (AOD)
New Levels are shown thus: [Symbol] +20.345
Retained Existing Levels thus: [Symbol] EX+20.345
Existing Levels are shown: [Symbol] EX+20.345

G2 Door tags are shown thus: [Symbol] DG-011 [Symbol] DRS-XXX [Symbol] FR-XXX
Door number
Instance of doors per room
Door type
Fire rating, 'V' denotes smoke seal

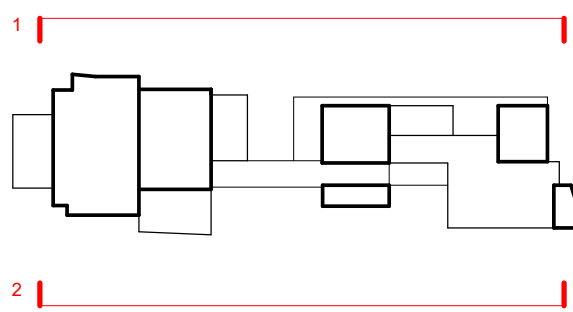
G3 Abbreviations:

GN/AWC: Gender Neutral / Accessible WC
CS: Cleaner's Store
PH: Printer hub
ST: Store
RWP: Rain water pipe

Notes:

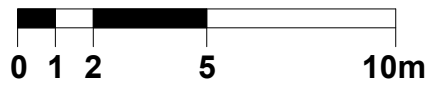
- Topography and contextual information shown indicatively, refer to Ordinance Survey drawings for further information.

[Symbol] Spot height taken from OS information



DRAFT PLANNING

Scale at 1:200

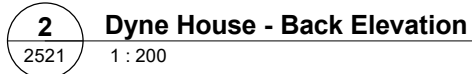


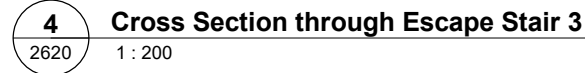
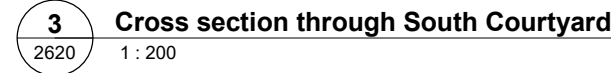
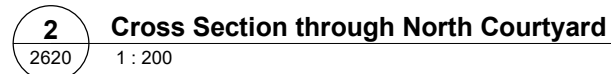
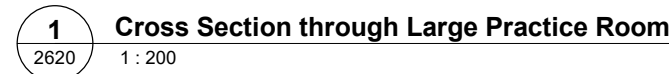
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Date	Rev.	Description	Approved By
31.05.2018	A	Memo 0001 Draft GA Issue for Interim Cost Check	JG
29.06.2018	B	Memo 0002 Update GA Progress Issue	JG
20.07.2018	C	Memo 0003 Draft Stage 2 Backgrounds Issue	JG
27.07.2018	D	Memo 0004 Stage 2 Backgrounds and Costing Issue	JG
21.09.2018	E	Memo 0006 Stage 2 Issue	JG
11.07.2019	F	Draft Planning Issue to Client	JW

Date	Rev.	Description	Approved By

Project	Highgate School Dyne House 3	Sort Code	A/Hs-DH3	Drawing Number	2520	Rev.	F
Subject	Dyne House - GA South and North Elevation Proposed Elevations						
Architects	Hopkins Architects Limited 27 Broadley Terrace, London, NW1 6LG T: 020 7724 1751 E: mail@hopkins.co.uk	Date: 05/16/18	Scale: 1 : 200	at A1			

 Spot height taken from OS information[illegible]



General Notes:

G1 All Levels are above ordnance datum (AOD)
 New Levels are shown thus: +20.345
 Retained Existing Levels thus: EX+20.345
 Existing Levels are shown: EX+20.345

G2

Door tags are shown thus:



The diagram shows a door tag with the following components and labels:

- Door number:** DG-01
- Instance of doors per room:** Indicated by an arrow pointing left from the door number.
- Door type:** DRS-XXX
- Fire rating, 'S' denotes smoke seal:** FR-XXS

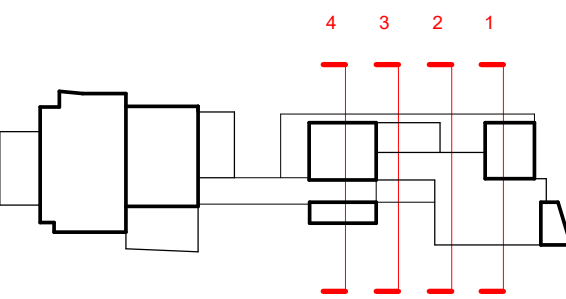
G3 Abbreviations

GN/AWC: Gender Neutral / Accessible WC
CS: Cleaner's Store
PH: Printer hub
ST: Store
RWP: Rain water pipe

Notes:

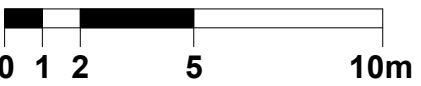
- Topography information shown indicatively, refer to Ordinance Survey drawings for further information.

 Spot height taken from OS information



DRAFT PLANNING

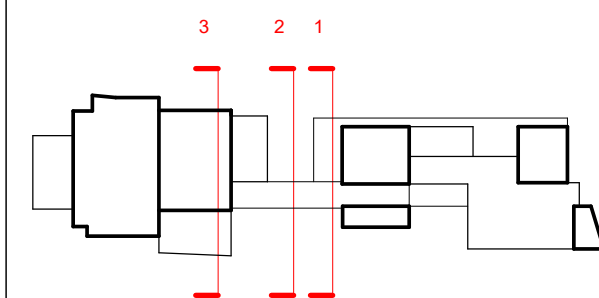
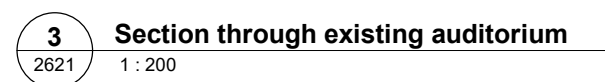
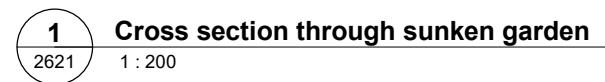
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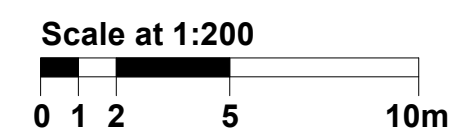
Date	Rev.	Description	Approved By
31.05.2018	A	Memo 0001 Draft GA Issue for Interim Cost Check	JG
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21.09.2018	E	Memo 0006 Stage 2 Issue	JG
11.07.2019	F	Draft Planning Issue to Client	JW

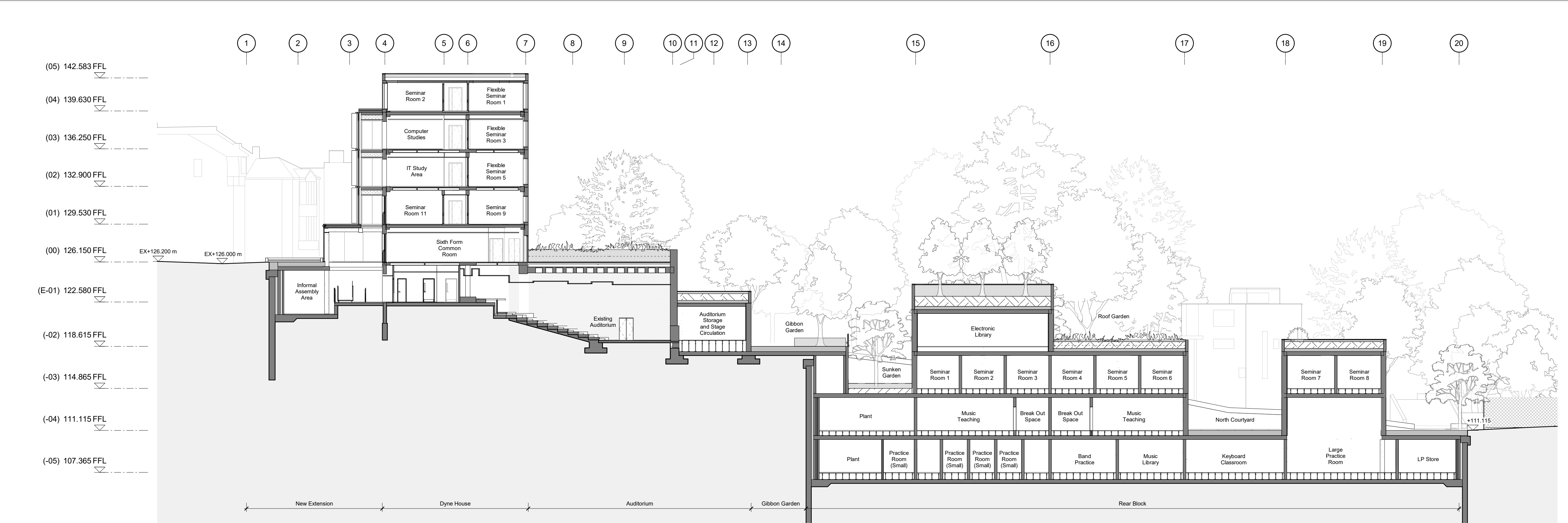
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Project	Highgate School Dyne House 3	Sort Code	Drawing Number	Rev.
Subject	Dyne House - Cross Sections Proposed Sections	A/Hs-DH3	2620	F
Architects	Hopkins Architects Limited 27 Broadway Terrace, London, NW1 6LG T: 020 7724 1751 E: mail@hopkins.co.uk	Date: 07/16/18	Scale: 1 : 200	at A1

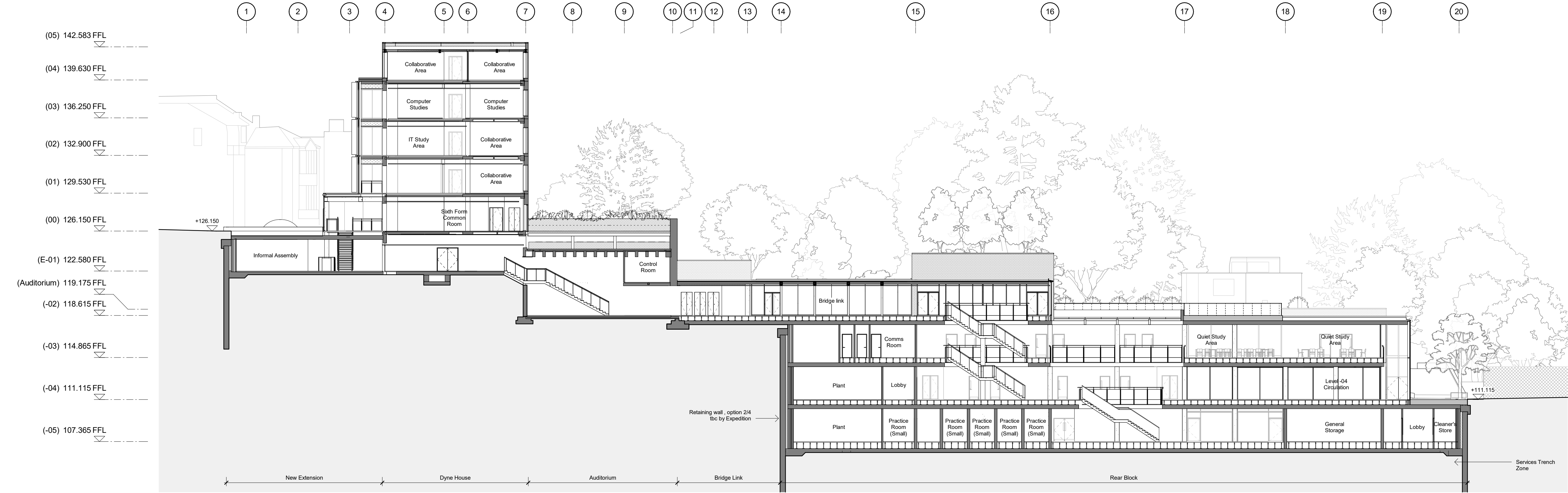


DRAFT PLANNING

[illegible]



3 Long Section through Auditorium
2622 1 : 200



4 Long Section through Circulation Route
2622 1 : 200

General Notes:

G1 All Levels are above ordnance datum (AOD)
New Levels are shown thus: [Symbol] EX+20.345
Retained Existing Levels thus: [Symbol] EX+20.345
Existing Levels are shown: [Symbol] EX+20.345

G2 Door tags are shown thus: [Symbol] DG-011 (Door number)
[Symbol] DRS-XXX (Door type)
[Symbol] FR-XXX (Fire rating, 'V' denotes smoke seal)

G3 Abbreviations:
GN/AWC: Gender Neutral / Accessible WC
CS: Cleaner's Store
PH: Printer hub
ST: Store
RWP: Rain water pipe

Notes:

- Topography information shown indicatively, refer to Ordnance Survey drawings for further information.

[Symbol] Spot height taken from OS information

DRAFT PLANNING

Scale at 1:200
0 1 2 5 10m

Work Package	Cost Check	Info/Briefing	Tender	Contract	Construction	Date	Rev.	Description	Approved By	Date	Rev.	Description	Approved By	Project	Highgate School Dyne House 3	Sort Code	Drawing Number	Rev.
						31.05.2018	A	Memo 0001 Draft GA Issue for Interim Cost Check	JG					Subject	Dyne House - Long Sections Proposed Sections	A/H-S-DH3	2622	F
						29.06.2018	B	Memo 0002 Update GA Progress Issue	JG									
						20.07.2018	C	Memo 0003 Draft Stage 2 Backgrounds Issue	JG									
						27.07.2018	D	Memo 0004 Stage 2 Backgrounds and Costing Issue	JG									
						21.09.2018	E	Memo 0006 Stage 2 Issue	JG									
						11.07.2019	F	Draft Planning Issue to Client	JW									
														Architects	Hopkins Architects Limited 27 Broadway Terrace, London, NW1 6LG T: 020 7724 1751 E: mail@hopkins.co.uk	Date: 10/18/16	Scale: 1 : 200	at A1



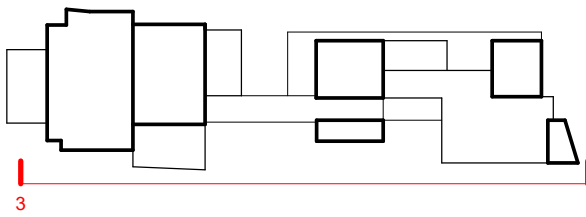
3 Long Section through Plant Rooms
2623 1 : 200

- General Notes:**
- G1** All Levels are above ordnance datum (AOD)
New Levels are shown thus: [Symbol] 20.345
Retained Existing Levels thus: [Symbol] EX+20.345
Existing Levels are shown: [Symbol] EX+20.345
- G2** Door tags are shown thus: [Symbol] DG-011 [Symbol] DRS-XXX [Symbol] FR-XXG
Door number
Instance of doors per room
Door type
Fire rating, 'V' denotes smoke seal
- G3** Abbreviations:
GN/AWC: Gender Neutral / Accessible WC
CS: Cleaner's Store
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Notes:

- Topography information shown indicatively, refer to Ordnance Survey drawings for further information.

[Symbol] Spot height taken from OS information



DRAFT PLANNING

Scale at 1:200
0 1 2 5 10m

Work Package	Cost Check	Info/Briefing	Tender	Contract	Construction

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11.07.2019	E	Draft Planning Issue to Client	JW

Date	Rev.	Description	Approved By

Project	Highgate School Dyne House 3
Subject	Dyne House - Long Sections Proposed Sections
Architects	Hopkins Architects Limited 27 Broadley Terrace, London, NW1 6LG T: 020 7724 1751 E: mail@hopkins.co.uk

Sort Code	Drawing Number	Rev.
A/Hs-DH3	2623	E
Date: 05/25/18	Scale: 1 : 200	at A1

Appendix C. Ground Movement and Damage Impact Assessment



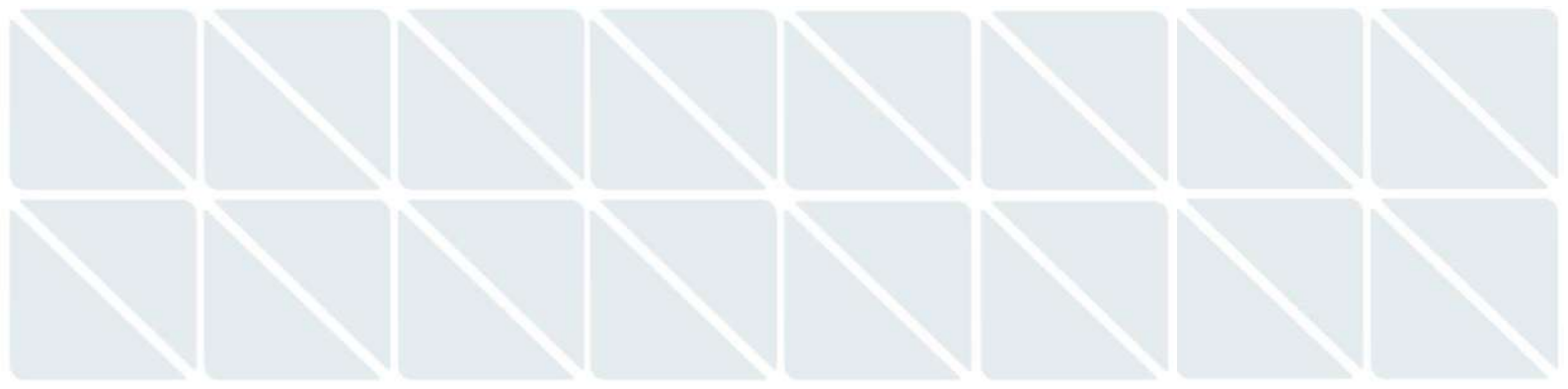
A-squared Studio

Highgate School - Dyne House and Island Site

Ground Movement Assessment Report

December 2019

1157-A2S-XX-XX-RP-Y-0002-00





Project Name	Highgate School - Dyne House and Island Site
Project Number	1157
Client	Expedition Engineering Ltd
Document Name	Ground Movement Assessment Report

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2.	The Site & Development	2
3.	Ground Conditions	4
4.	Impact Assessment Methodology	6
5.	Conclusions & Closing Remarks	16



1. Introduction

A-squared Studio Engineers Ltd (A-squared) has been appointed by Expedition Engineering Ltd (Expedition) to undertake a Ground Movement Assessment (GMA) for the Dyne House and Island development in Highgate, London.

The A-squared scope comprises an assessment of the potential impact of the proposed redevelopment works on the various neighbouring properties.

1.1. Study Aims & Objectives

A ground movement and impact assessment has been carried out in order to estimate the potential damage induced by the proposed redevelopment at the Dyne House and Island sites of Highgate School on the neighbouring properties.

The scheme includes the renovation and extension of the existing Dyne House, and the demolition of the existing structures, excavation of one- to three-level basements, and construction of one- to two-storey structures on both the Island plot and the eastern section of the Dyne House plot.

The assessment encompasses properties located within the *zone of influence* of the proposed scheme. The GMA assessment is based on *greenfield* ground movements which are unlikely to be exceeded. The adopted assessment methodology provides a robust and conservative assessment, representative of current industry best practice, as detailed in Section 5.

The assessment carried out and described herein aims to:

- Assess the impact on ground movements induced by the proposed works on properties adjacent to the development under consideration.
- Provide performance criteria and inform aspects of substructure construction and design.

This report provides a detailed description of the:

- Site and proposed development.
- Modelling parameters and input.
- Analyses and results.



2. The Site & Development

2.1. Site Location and Proposed Development

The proposed development is located within the Highgate School campus along Southwood Lane, Highgate, London, N6 5EE, as shown in Figure 2.1, and is comprised of the Dyne House and Island plots in the east and west, respectively. The entire site falls within the administrative boundaries of the London Borough of Haringey. Highgate Underground Station is located approximately 620m north of the site.

The Island plot is generally flat, with ground elevation of approximately +126.0mOD. The Dyne House plot slopes downwards from west to east, with elevations ranging from approximately +126.0mOD to +111.0mOD.



Figure 2.1 Dyne House and Island development locations

The Island plot is currently occupied by a two-storey structure directly adjacent to the Central Hall and Big School buildings of Highgate School. This structure will be demolished, and a two-storey building with one-level basement will be constructed in its place. The approximate depth to formation level of the one-level basement is 4.5mBGL (+121.5mOD).

The Dyne House plot is currently occupied by several structures. Dyne House is a five-storey school building with a one- to two-level basement occupying the western section of the site. The Gym and Geography Building is a two-storey 'L'-shaped structure occupying the centre of the plot. A 1m- to 2m-deep disused swimming pool is located directly south of the Gym and Geography Building. The eastern section of the plot, referred to as the 'Parade Grounds', is covered in asphalt and is currently used as a playground.

The current proposal involves the expansion of the existing Dyne House structure to the west towards Southwood Lane through the construction of an adjacent one- to five-storey structure and excavation of a one-level basement to depths of approximately 4.0mBGL (+121.0mOD). This is referred to as the 'Dyne House front extension'. The existing Dyne House structure will be extensively redeveloped; however, it is understood that this will not affect the current building height, basement depth and anticipated building loads. The existing Gym and Geography Building will be demolished and a one- to two-level teaching facility with a one- to three-level basement, referred to as the 'Rear Block', will be constructed in its place. Excavation depths for this proposed basement range between 4.0mBGL and 11.0mBGL, due to the sloping nature of the plot (approximate basement formation level at +107.0mOD for

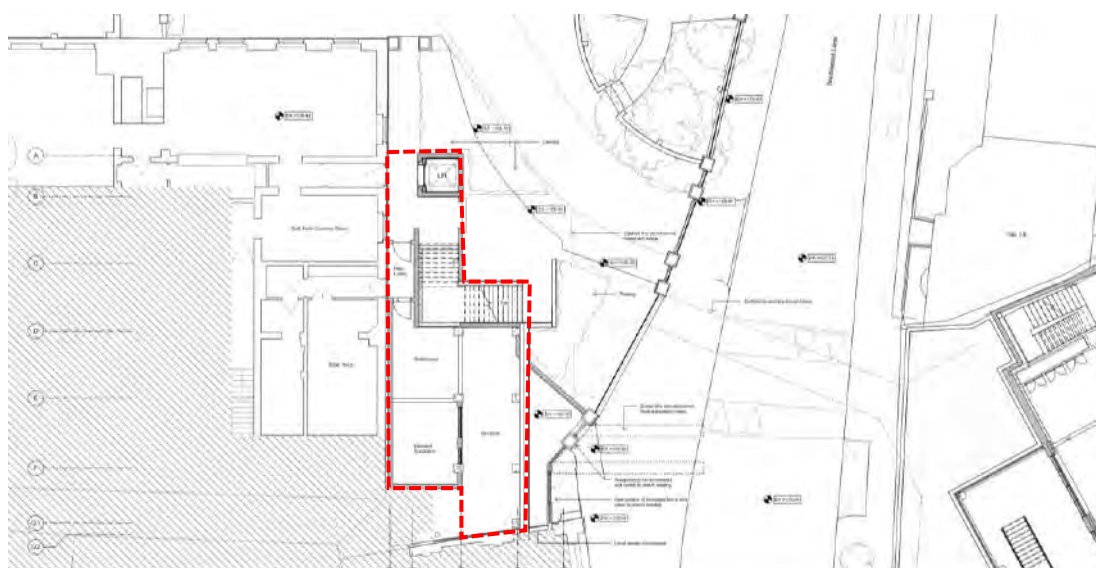


the Rear Block). A one-level bridge link structure, referred to as the 'Bridge Link', is also proposed to connect the redeveloped Dyne House and new teaching facility. No construction is expected to take place within the Parade Grounds.

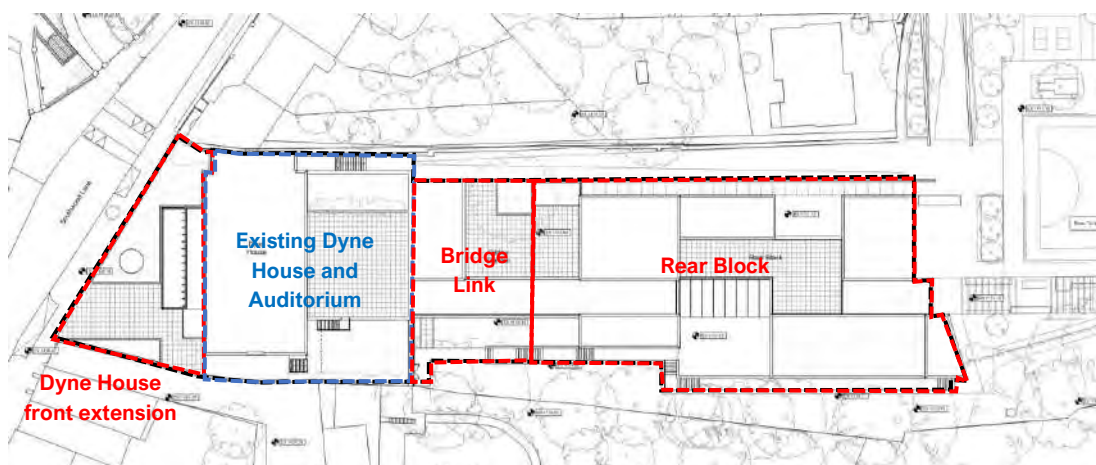
The Dyne House and Island plots are connected via an existing underground link tunnel crossing beneath Southwood Lane. It is understood that no construction works are proposed for this tunnel. The tunnel will be accessible through the proposed one-level basement at the Island plot and the proposed one-level basement underneath the Dyne House extension.

Based on the *Highgate School Dyne House III: RIBA Stage 2 Report* prepared by Expedition in October 2018, it is understood that the proposed structures on the Island plot will be supported by 10m-long pile foundations. The Bridge Link and Rear Block are understood to be supported by 15m-long piles, while the existing Dyne House structure and proposed Dyne House front extension will be supported by shallow pad foundations. The excavations are understood to be supported by embedded retaining walls.

The proposed building footprints for the Dyne House and Island plots are shown in Figure 2.2.



(a) Island plot



(b) Dyne House plot

Source: *Highgate Schools Dyne House 3* drawings provided by Expedition Engineering Ltd (04/11/2019).

Proposed building footprints shown in red.

Figure 2.2 Proposed building footprints



3. Ground Conditions

Site-specific ground investigation works were carried out on the project site by Geotechnical & Environmental Associates Ltd (GEA) between March and May 2015. The ground conditions at the site were generally found to comprise the following (in order of succession):

- Made Ground – topsoil and anthropogenic deposits of undifferentiated clays, sands and gravels.
- Bagshot Formation – firm light brown to brown silty sandy gravelly CLAY / SAND with sand partings.
- Claygate Member – firm to stiff brown / orange slightly silty CLAY with occasional silt partings.
- London Clay Formation – stiff to very stiff fissured brown CLAY with occasional rare bands of silty sand.

The above include the strata of engineering interest and significance, taking cognisance of the scale of the proposed development and zone of influence. The thickness of the Bagshot Formation was observed to reduce from west to east, following the slope of the ground surface. In the eastern sections of the site (i.e. underneath the Rear Block and Parade Grounds), the Bagshot Formation was no longer observed, and the Made Ground stratum was found to directly overlie the Claygate Member.

The entire site has been simplified and discretised and into two separate soil zones, as shown in Figure 3.1, to take into account the changes in elevation of the ground surface and differences in observed strata: Zone A, representing the western portions of the site (including the Island plot), and Zone B, representing the eastern portions of the site. The Bagshot Formation is absent in Zone B.

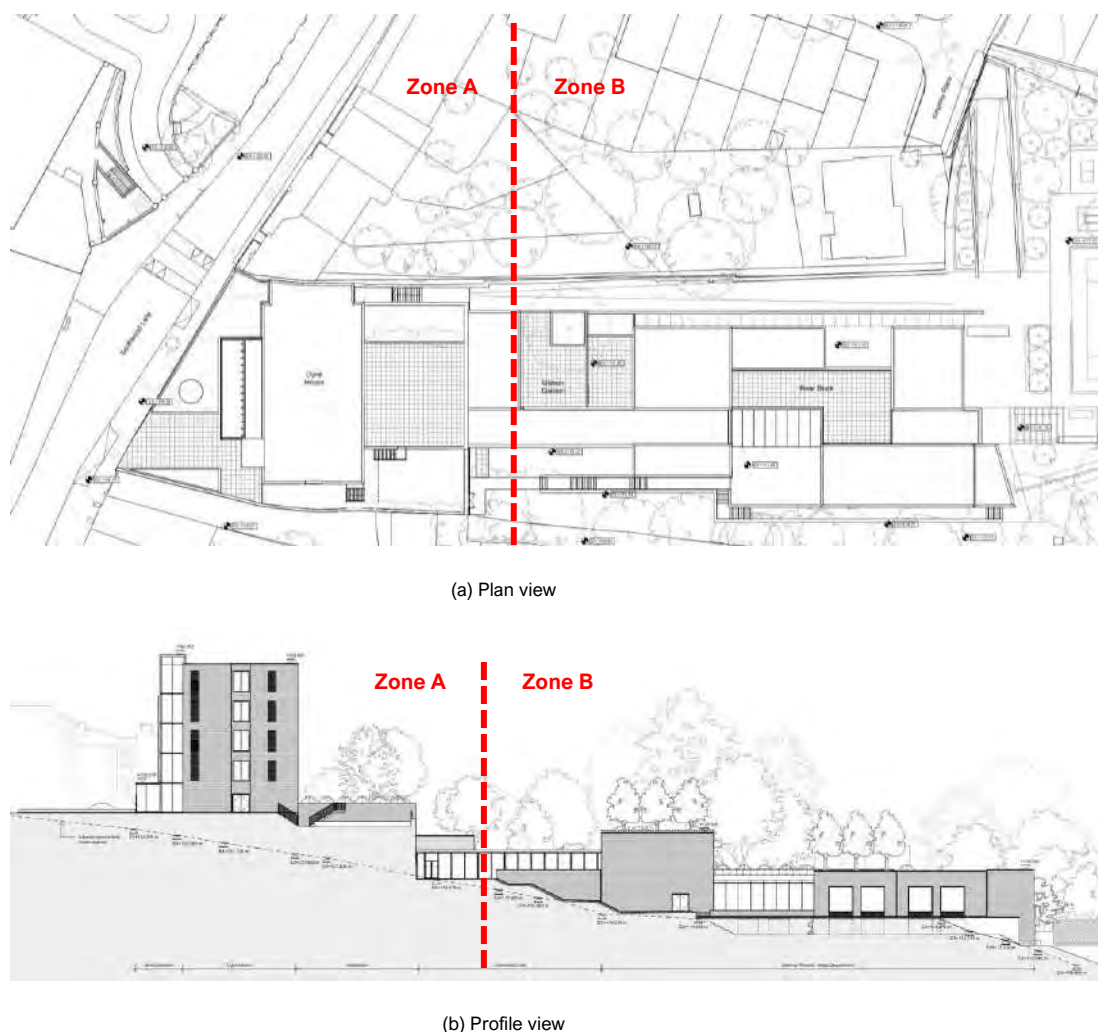


Figure 3.1 Plan and profile views showing Zone A and Zone B



The two ground models adopted for this assessment are presented in Table 3.1 and Table 3.2. The strength and stiffness profiles of the Bagshot Formation and Claygate Member were found to be consistent with respect to depth below ground level, regardless of ground surface elevation, indicating that the site may be located on an anticline.

Table 3.1 Zone A ground model and geotechnical parameters adopted for analysis purposes

Stratum	Depth (mBGL)	Thickness (m)	Undrained Young's Modulus, E_u ^[2] (MPa)	Drained Young's Modulus, E' ^[2] (MPa)
Made Ground	0.0	1.5	-	10.0
Bagshot Formation	1.5	11.5	-	34.0
Claygate Member + London Clay ^{[3][4]}	13.0	45.0 ^[5]	$9.2 + 3.2z^{[6]}$	$7.4 + 2.6z^{[6]}$

1. Ground model based on previous site-specific ground investigation undertaken by GEA. This data has been interpreted specifically for the scope of the GMA presented herein.
2. Stiffness data (E_u and E') has been evaluated empirically from in-situ testing data taking into consideration the nature of the geotechnical/soil-structure interaction mechanisms and level of anticipated strain within the soil mass.
3. The closest deep BGS boreholes show that the London Clay formation extends to depths of approximately 129.0mBGL. The entire excavation is thus assumed to take place within the Bagshot Formation, Claygate Member, and London Clay.
4. The Claygate Member and London Clay strata were assumed to follow a continuous stiffness profile.
5. *Rigid boundary* was assumed at 58.0mBGL for analytical purposes.
6. z refers to the depth in metres below the top of the Claygate Member and London Clay formation. Lower bound stiffness values adopted for GMA purposes only.

Table 3.2 Zone B ground model and geotechnical parameters adopted for analysis purposes

Stratum	Depth (mBGL)	Thickness (m)	Undrained Young's Modulus, E_u ^[2] (MPa)	Drained Young's Modulus, E' ^[2] (MPa)
Made Ground	0.0	1.0	-	10.0
Claygate Member + London Clay ^{[3][4]}	1.0	57.0 ^[5]	$9.2 + 3.2z^{[6]}$	$7.4 + 2.6z^{[6]}$

1. Ground model based on previous site-specific ground investigation undertaken by GEA. This data has been interpreted specifically for the scope of the GMA presented herein.
2. Stiffness data (E_u and E') has been evaluated empirically from in-situ testing data taking into consideration the nature of the geotechnical/soil-structure interaction mechanisms and level of anticipated strain within the soil mass.
3. The closest deep BGS boreholes show that the London Clay formation extends to depths of approximately 129.0mBGL. The entire excavation is thus assumed to take place within the Bagshot Formation, Claygate Member, and London Clay.
4. The Claygate Member and London Clay strata were assumed to follow a continuous stiffness profile.
5. *Rigid boundary* was assumed at 58.0mBGL for analytical purposes.
6. z refers to the depth in metres below the top of the Claygate Member and London Clay formation. Lower bound stiffness values adopted for GMA purposes only.



4. Impact Assessment Methodology

4.1. Assessment Details

The assessment has been undertaken using proprietary spreadsheets and the commercially available software Oasys Pdisp and Xdisp, which consider the three-dimensional ground movement field induced by the proposed excavation works.

Ground movements will arise as a result of various mechanisms which are mobilised as part of the construction works for the proposed scheme. The demolition of the existing buildings and basement excavations will induce ground movements arising from the overburden removal and installation of the proposed retention system. The permanent condition loading will partially reinstate a portion of the removed overburden, yielding settlements across the foundation system. The induced ground movements will extend over a given zone of influence surrounding the building/excavation footprint.

A series of three-dimensional models of the proposed scheme have been developed in Oasys Xdisp/Pdisp and combined by means of superposition in order to enable ground movement assessments to be carried out representing the various construction stages. The ground movement displacement fields were separated in two groups (A & B) based on the approach followed, as detailed below:

Group A – Unloading/Loading ground movements

- A1. Building demolition and basement excavation (short-term).
- A2. Building demolition, basement excavation, and application of the proposed building loading (long-term).

Group B – CIRIA-based ground movements

- B1. Embedded retaining wall installation and basement excavation.
- B2. Embedded retaining wall installation, basement excavation, and application of the proposed building loading (long-term).

The Group A assessments are based on *greenfield* ground movements evaluated from linear half-space (Pdisp) analyses and focus on vertical ground movements induced by the overburden removal unloading and reloading processes.

A demolition pressure of 30kPa has been applied over the footprints of the three existing buildings to be demolished on both sites (approximately 15kPa/storey), as shown in Figure 4.1.



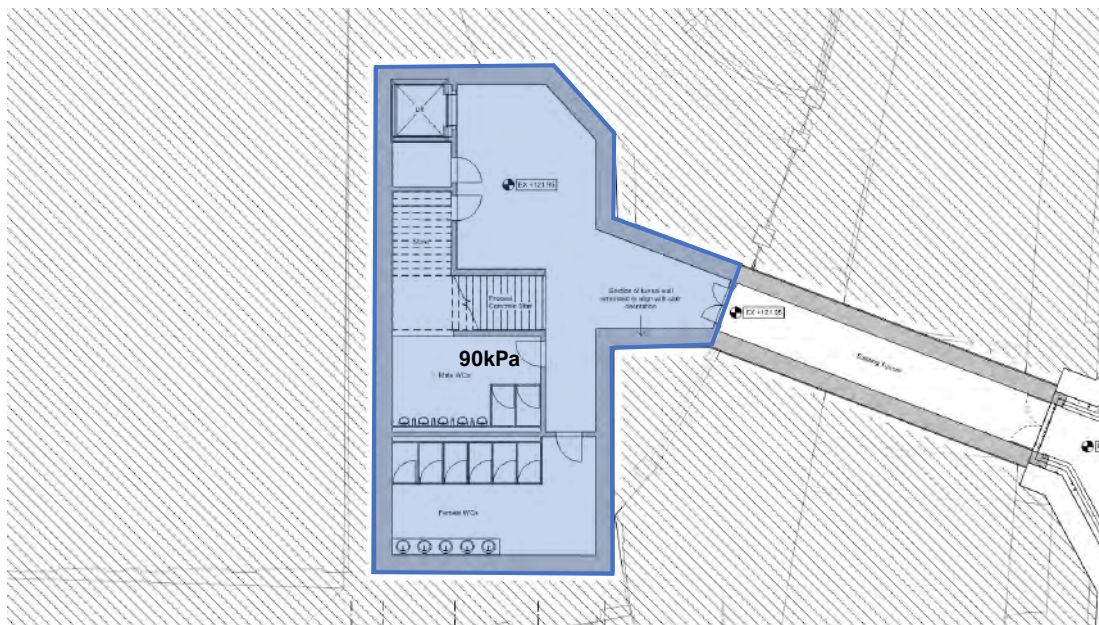
(a) Island plot



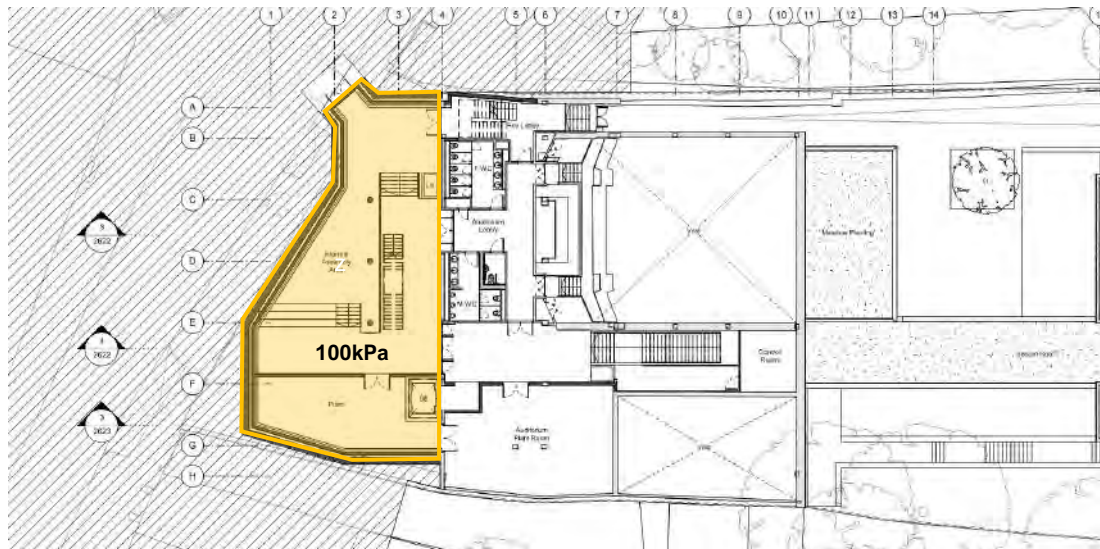
(b) Dyne House plot

Figure 4.1 Modelled demolition area in Pdisp

Excavation unloading pressures have been modelled at the basement formation levels representing the removal of approximately 4.5m (90kPa) of overburden at the Island plot and 4.0m (80kPa) to 11.0m (220kPa) of overburden at the Dyne House plot. The modelled excavation geometries are shown in Figure 4.2.



(a) Island plot



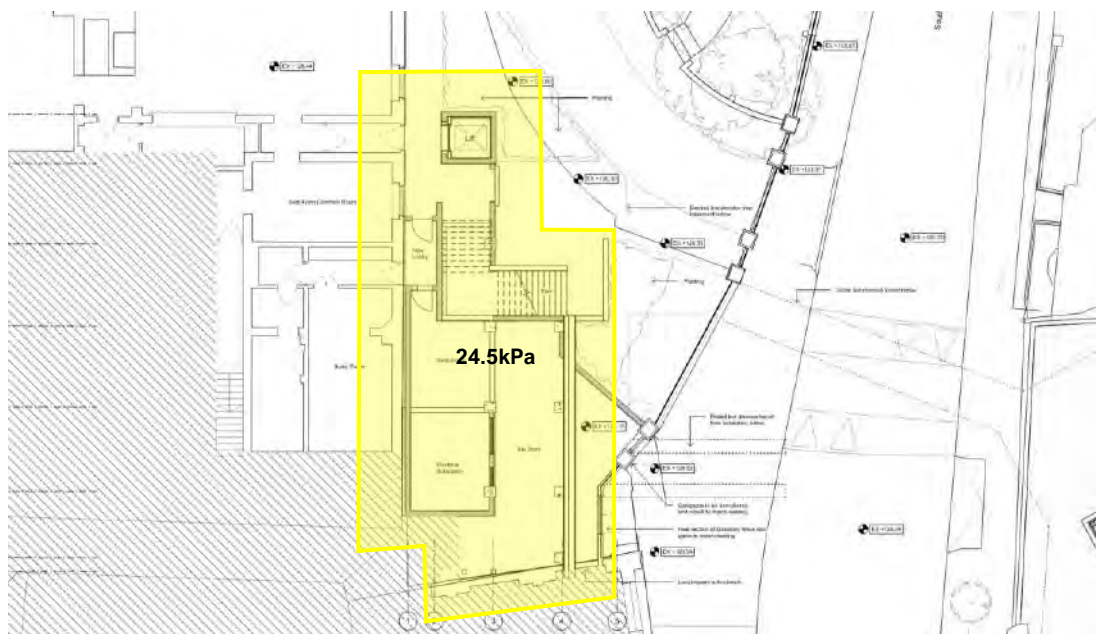
(b) Dyne House plot – Dyne House front extension



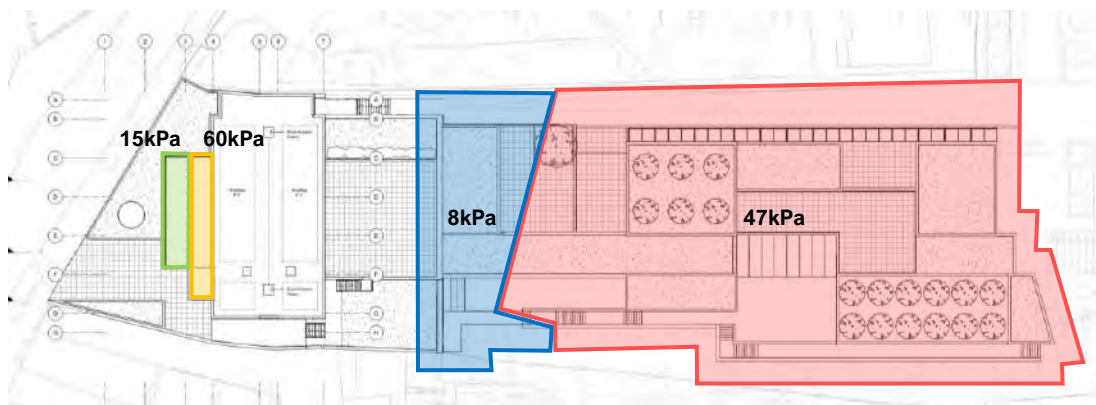
(c) Dyne House plot – Rear block

Figure 4.2 Modelled excavation areas in Pdisp

The proposed structure on the Island plot will have two storeys and will be supported by 10m-long piles. The proposed one- to five-storey Dyne House front extension will be supported by shallow foundations, while the one-storey Bridge Link and one- to three-storey Rear Block will be supported by 15m-long piles. Based on an assumed surcharge of 15kPa/storey, uniformly distributed loading pressures have been modelled either at basement formation level (for structures on shallow foundations) or as an equivalent pressure at depths equal to 2/3 of the proposed bearing pile lengths, assuming a 1:4 (horizontal:vertical) load spread distribution with depth (for structures supported by pile foundations). Foundation types and pile lengths have been assumed based on the *Highgate School Dyne House III: RIBA Stage 2 Report* provided by Expedition. Figure 4.3 shows the modelled loading pressures for the various proposed structures.



(a) Island plot



(b) Dyne House plot

Figure 4.3 Modelled loading areas in Pdisp

The Group B assessments adopt the normalised ground displacement curves reported in CIRIA C760. In addition to the effects arising from the basement excavation, the ground movement effects associated with the installation of the embedded retaining wall have been considered. The following CIRIA C760 normalised ground movement curves were adopted to assess ground movements due to retention system installation and excavation works:

- *Embedded retaining wall:* Installation of contiguous bored pile wall in stiff clay.
- *Excavation to formation:* Excavation in front of a high stiffness wall in stiff clay.

The modelling of the contiguous pile wall curve has been deemed suitable for calculating the installation effects of secant piled walls, contiguous piled walls, and/or sheet pile walls (assuming pre-boring or jetting installation aids, which may be required).

In the B2 assessment, the CIRIA ground movements are combined with the long-term settlements induced by the loading redistribution (evaluated in Pdisp).

The two sets of analyses enabled the evaluation of an envelope of damage classification results, with the worst-case results presented herein. A representative geometry has been adopted for defining the excavation/installation geometry implemented in the 3D modelling efforts, as shown in Figure 4.4.

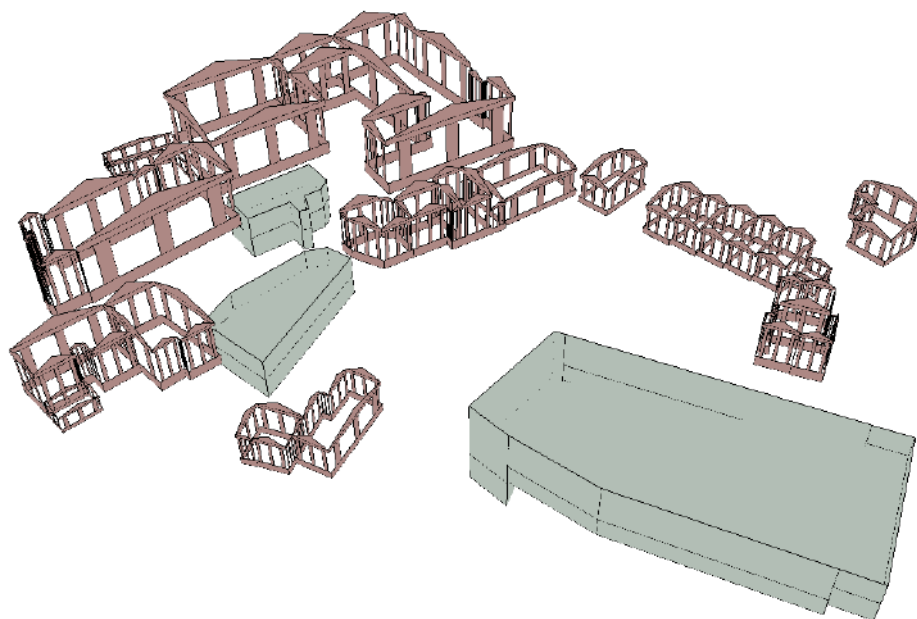


Figure 4.4 Indicative plot of the three-dimensional analytical model using the Oasys Xdisp software suite

4.2. Impact Assessment

4.2.1. General

The potential impact/damage induced on primary façade/wall elements of the buildings surrounding the proposed scheme have been evaluated on the basis of the calculated ground movement fields. Façades of the existing Dyne House building and auditorium were not considered in this analysis. The masonry walls of concern are shown in Figure 4.5, including the wall nomenclature/reference system adopted. The arrangement is based on the currently available survey information and presents an array of masonry façades running both perpendicular and parallel to the proposed basements (covering the key deformation mechanisms). In total, 142 façades of the neighbouring buildings were considered for the current study and these are grouped in the following manner:

- BS-01 – BS-18: Highgate School – Big School Building
- SB-01 – SB-14: Highgate School – Science Building
- HL-01 – HL-03: Highgate School – Link Building
- CH-01 – CH-11: Highgate School – Central Hall
- 10S-01 – 10S-11: 10 Southwood Lane
- 12S-01 – 12S-06: 12 Southwood Lane
- 14S-01 – 14S-12: 14 Southwood Lane
- 16S-01 – 16S-06: 16 Southwood Lane
- 18S-01 – 18S-05: 18 Southwood Lane
- 20S-01 – 20S-07: 20 Southwood Lane
- 22S-01 – 22S-04: 22 Southwood Lane
- HT-01 – HT-04: Highgate Tabernacle
- 23K-01 – 23K-19: 23-27 Kingsley Place
- 23AB-01 – 23AB-15: 23A & 23B Kingsley Place
- 28K-01 – 28K-07: 28 Kingsley Place