Basement Impact Assessment – 3A Mornington Crescent, London NW1 7RH

Hydrogeology, Land Stability and Ground Movement Assessment

1 December 2017

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Contents

Summary

A basement impact assessment (BIA) has been undertaken for hydrogeology and land stability in general accordance with CPG4 (2015) for the site 3A Mornington Crescent, London NW1 7RH, in the London Borough of Camden.

The proposed basement is an extension to the existing basement toward the garden area at the rear of the property. The proposed basement will include the encapsulation of an existing basement patio area, with a net increased area at the existing basement level of circa 5 m^2.

The BIA report considered relevant information from existing sources included in the 'Guidance for subterranean development' produced for the London Borough of Camden' (November 2010) and a Groundsure Enviro/Geo insight Report with historical maps and BGS records.

A ground investigation at the site was undertaken by Maund Geo-Consulting Ltd in November 2017 which comprised one No. cable percussive borehole and two No. hand dug trial pits to expose party wall footings. The borehole (BH01) was drilled to 9.50m below ground level (bgl), while the trial pits were excavated to a depth of 0.5m bgl.

The ground investigation confirmed the ground conditions as Made Ground of clayey gravel composition to a depth of approximately 0.4m which overlies firm to stiff silty clay of the London Clay Formation to a depth of at least 9.5m bgl. Groundwater was encountered at 5.45m and 7.1m during drilling and up to a minimum depth of 4.17m in two rounds of post investigation monitoring.

An assessment of hydrogeology has shown that the strata underlying site is considered non-productive strata of very low permeability and is not designated as an aquifer within Environment Agency (EA) guidelines. It is not anticipated that the development will have any significant impact on groundwater, which has been monitored at 1.17 m below the basement formation. As the basement is at a similar level as the existing basement no further mitigation measures are proposed for groundwater.

An assessment of land stability has been made from the excavation and construction of the basement. It has been calculated that heave in the centre of the basement is not expected to exceed 6 mm resulting from the excavation and construction. The foundation formation will be able to accommodate an imposed load from the retaining wall of 87 kPa with net settlement of < 25 mm.

A ground movement assessment was undertaken in relation to 3 Mornington Crescent. It was determined that there is negligible impact from the basement construction with Damage Assessment Category 0 to No. 3 Mornington Crescent and adjacent properties No. 2 and No. 4 Mornington Crescent.

1 Introduction

1.1 Terms of Reference

Maund Geo-Consulting Ltd was instructed on 8 November 2017 by Croft Structural Engineers Ltd to undertake the hydrogeology and geology sections of a Basement Impact Assessment (BIA) including a Ground Movement Assessment (GMA) for a proposed development at 3A Mornington Crescent, London NW1 7RH.

1.2 Scope and Objective

This report has been written in general accordance with 'Camden geological, hydrogeological and hydrological study - Guidance for subterranean development' produced for the London Borough of Camden (LBC) by Arup (November 2010), hereafter referred to as the GSD. The guidance sets out the methodology for a risk-based impact assessment to be undertaken with regard to hydrology, hydrogeology and land stability in support of planning policy DP27. The BIA comprises stages in which information is obtained to enable LBC to decide on the impact of the development for the planning application. The LBC Guidance CPG4 (July 2015) requires a BIA to be undertaken for new basements in 5 stages:

1. Screening
2. Scoping
3. Site investigation
4. Impact assessment
5. Review and decision making (By LBC)

This report includes stages 1 to 4 and has been undertaken by Dr Julian Maund, director of Maund Geo Consulting Ltd, who is a chartered engineer and chartered geologist with over 30 years' experience.

As a site investigation has already been undertaken as part of the BIA for 3A Mornington Crescent on 02/11/2017 (Report included in Appendix D) the screening part of the assessment has been assessed based on existing information including the site investigation, so the project has been completed in the following sequence:

1. Background information
2. Site Investigation
3. Screening
4. Scoping
5. Impact Assessment

This report considers the hydrogeological and land stability elements of the BIA only. Hydrology is considered in a separate report by Croft Structural Engineers Ltd.

2 Background Information on the Site

2.1 Information Sources

Background information has been derived from a Groundsure report obtained on 31/10/17 for the site (Appendix B). Geological information has been derived from on-line BGS sources (Geology of Britain Viewer) and the GSD. Mapping and aerial photography have been obtained from Streetmap and Google Earth. Information is also derived from the site investigation undertaken specifically for the proposed development by Maund Geo-Consulting Ltd on 2 November 2017.

2.2 Location

The site is located at 3A Mornington Crescent, at approximate National Grid Reference TQ 29116 83144 and Post Code NW1 7RH in the Kings Cross area of the London Borough of Camden.

2.3 Description

The existing building comprises a four storey terraced brick and plaster building occupying the Western side of Mornington Crescent at it's southern end, as shown on the Street View image below in Figure 2.1.

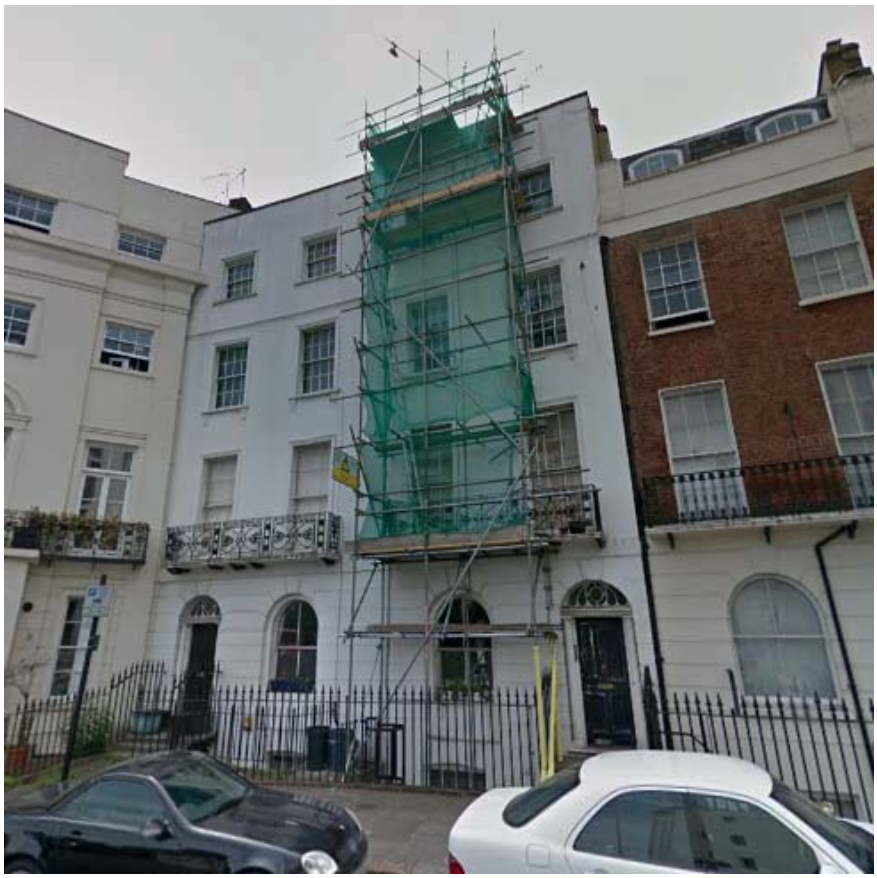

Figure 2.1 Street View Image of the site October 2015

2.4 Present use

The site is a residential dwelling and is currently occupied by the owners/tenants

2.5 Proposed use

The proposed development relevant to this BIA is understood to comprise the construction of a single storey extension to the rear of the existing house, including an extension of the current basement. The extension will measure approximately 5 m in a W – E direction and 4.5 m in a N – S direction as shown on Drawings TIA-MSC-0053 PA-A 2001 - 4002 by Twist In Architecture Ltd in Appendix A. The new basement extensions with cover the same footprint.

2.6 Topography, geomorphology and drainage

The ground level at the site is level at approximately 25 m AOD. The land in the vicinity of the site is level.

There are no discernible geomorphological features in the vicinity of the site. There are no open watercourses within at least 100 m of the site.

2.7 Geology

Geological information obtained from Figure 4 of the GSD at 1: 10 000 and the BGS website geological mapping at 1 50 000 scale shows the site to be directly underlain by the London Clay Formation. No superficial deposits are shown. A review of boreholes in the vicinity available from the BGS Geology of Britain Viewer indicates shows comparable geology.

2.8 Hydrogeology/groundwater

The property is located on the London Clay, which is classified as an unproductive stratum. (Section of the GSD) confirms this classification.

The site does not lie within the any source ground water protection zones. The closest protection zone is approximately 1.3km to the North West.

The London Clay underlying the site is not classified as a groundwater vulnerability zone, as designated by the Environment Agency. The Groundsure Enviroinsight Report (Appendix B) indicates the nearest ground water vulnerability zone is located approximately 480 m south of the site in the Lynch Hill Gravel Member, classified as a Minor Aquifer of High Vulnerability.

2.9 Natural Hazards

The Groundsure report (Appendix B) findings on natural hazards are summarised in Table 2.1

Table 2.1 Natural Hazards

Natural Hazard	Risk (Stated by BGS in Groundsure report)	Comment
Shrink Swell	Moderate	The site is underlain by the London Clay Formation (LFC) which comprises potentially moderate to high plasticity clays. This material has potential shrink swell properties.
Landslides	Low	Not applicable to the topography of the site
Soluble Rocks	Negligible	Not applicable to the site geology
Compressible Ground	Negligible	Clay soil of the LCF is subject to consolidation from additional imposed loads, which are limited by appropriate foundation design
Collapsible Deposits	Very Low	Not applicable to the site geology
Running sand	Negligible	Not applicable to the site geology
Radon	Not in a Radon affected area	No Radon protection measures are necessary

2.10 History of site

The Groundsure Insights Maps in Appendix C includes historical mapping surveys from 1882 to 2014.

From the earliest record provided the site appears to be occupied by a residential dwelling. The building on the site itself and the surrounding area, appear little changed from 1882 to the present day.

2.11 Underground features

The London Underground Northern line passes within 37 m to the east of the site. An extrapolation from known station depths estimates the tunnel to be at an approximate depth of 22 m bgl, at its closest point to the site. There are no rail or other tunnels within 250 m of the site.

Information from Street View and Google Earth indicate a railway cutting approximately 30m west of the house. This appears to be supported by 2 – 3m concrete retaining wall.

The Groundsure Geoinsight Report (Appendix B) has not identified any mining, underground workings or natural cavities within at least 500 m of the site.

2.12 Other factors e.g. contamination and archaeology

The Groundsure Enviroinsight Report (Appendix B) has not identified any 'Environmental Permits, Incidents and Registers' or 'Landfill and Other Waste Sites' within at least 100 m of the site boundary.

No specific archaeological investigation has been undertaken. The 'Groundsure' survey has not identified any known 'Environmentally Designated Sensitive Sites' within 250 m of the site (Appendix B).

2.13 Flooding

The Groundsure report (Appendix B) has not identified any flooding issues within 250 m of the site. The risk of surface flooding is shown as 'Very Low'. The UK Government Flood Maps for Planning services categorise the site in "Flood Zone 1", which has a flooding probability of 'low.

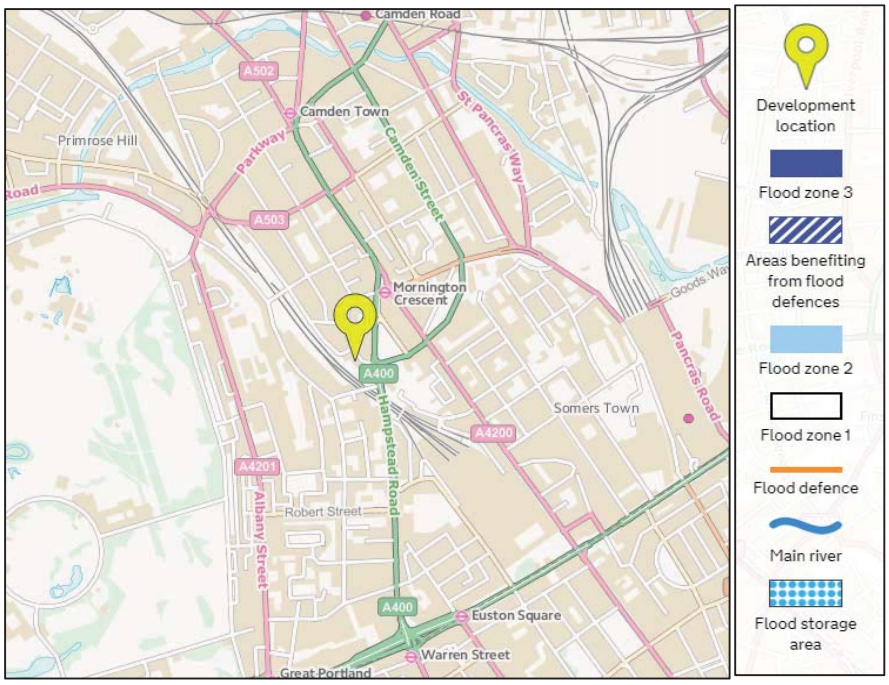

Figure 2.1 Flood risk from surface water flooding

3 Site Investigation

A ground investigation was undertaken by Maund Geo-Consulting Ltd on 02/11/2017. A report of the ground investigation comprising exploratory hole records and laboratory testing is included in Appendix D.

The ground investigation comprised:

- 1 No. borehole (BH01) carried out using cable percussive methods to a depth of 9.5 m bgl,
- 2 No. hand dug trial pits to expose party wall footings,
- The in-situ strengths of the subsoil encountered were assessed by means of SPTs in BH01 at 1 m intervals,
- Disturbed soil samples were obtained from BH01 for laboratory geotechnical testing and further examination.
- A 50 mm diameter groundwater monitoring well was installed to a depth of 8.0 m in BH01

The locations of the above exploratory holes are shown in Figure 3.1 below. The exploratory hole records and laboratory test results are shown in Appendix D.

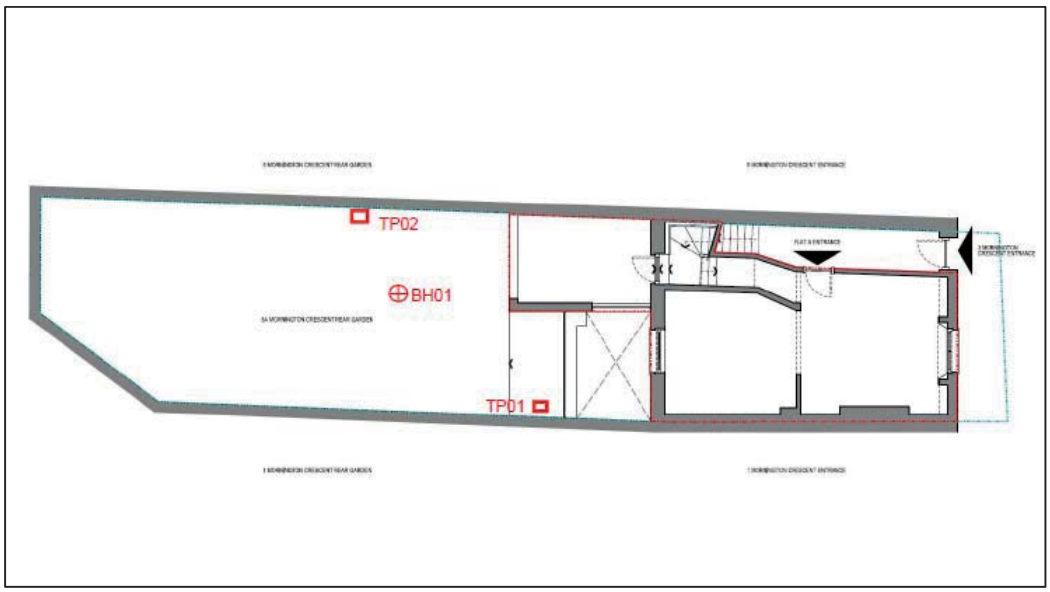

Figure 3.1 Maund Geo-Consulting Ltd borehole locations

3.1 Details of laboratory tests

Laboratory tests to determine the geotechnical properties of the soil were scheduled by Maund Geo-Consulting Ltd and carried out by I2 Analytical Ltd generally in accordance with BS1377:1990 and BRE Special Digest 1 2005. The tests included:

- 5 moisture content and plasticity tests
- 1 Water soluble sulphate and pH (BS1377:1990)

4 Ground Conditions

4.1 Stratigraphy

The ground conditions encountered in BH01 are summarised in Table 4.1 below. For a full description refer to borehole records in Appendix D.

Table 4.1 Summary of ground conditions

Stratum	General description of Stratum	Depth at top of Strata (m)	Approx. level (m AOD)	Thickness of Strata (m bgl)
MADE GROUND	Concrete paving slabs	0	26.0	0.05
MADE GROUND	Fine sandy clayey Gravel of brick and flint.	0.05	25.95	0.35
London Clay Formation	Firm to Stiff yellow brown silty CLAY with occasional bands of sand or claystone gravel	0.4	25.6	9.5 proven

4.2 Groundwater

Groundwater was encountered during drilling at depths of 5.45 m bgl and 7.1 m bgl, both slow seepages.

Groundwater readings from post investigation monitoring on the site are shown in Table 4.2 indicating a minimum groundwater depth of 4.17 m.

Table 4.2 Groundwater monitoring in BH01

Date of monitoring	Groundwater Depth (metres below ground level – Approximately 26.00 m AOD)	Approximate Groundwater level (m AOD)
14/11/17	4.47	21.53
21/11/17	4.17	21.86

4.3 Consideration of the individual strata in detail, with reference to any proposed foundations.

The anticipated formation level of the basement floor slab will be approximately 2.79 m bgl at approximately 23.21 m AOD, within the London Clay. An overall excavation depth of 3.00 m is assumed for a ground movement assessment.

The overall ground model is illustrated in the conceptual model in Section 6.2 below.

4.3.1 Made Ground

Below the existing concrete floor slab the made ground has been described as a sandy, clayey Gravel of brick and flint. Made ground was encountered to be approximately 0.4m thick. No SPT results were obtained in this material.

The made ground is described as an inert material with no visual or olfactory indications of contamination.

The risk of the onset of contamination leaching from the site is considered to be negligible considering the thickness of the made ground, the lack of indication of contaminants, and the impermeability of the underlying strata.

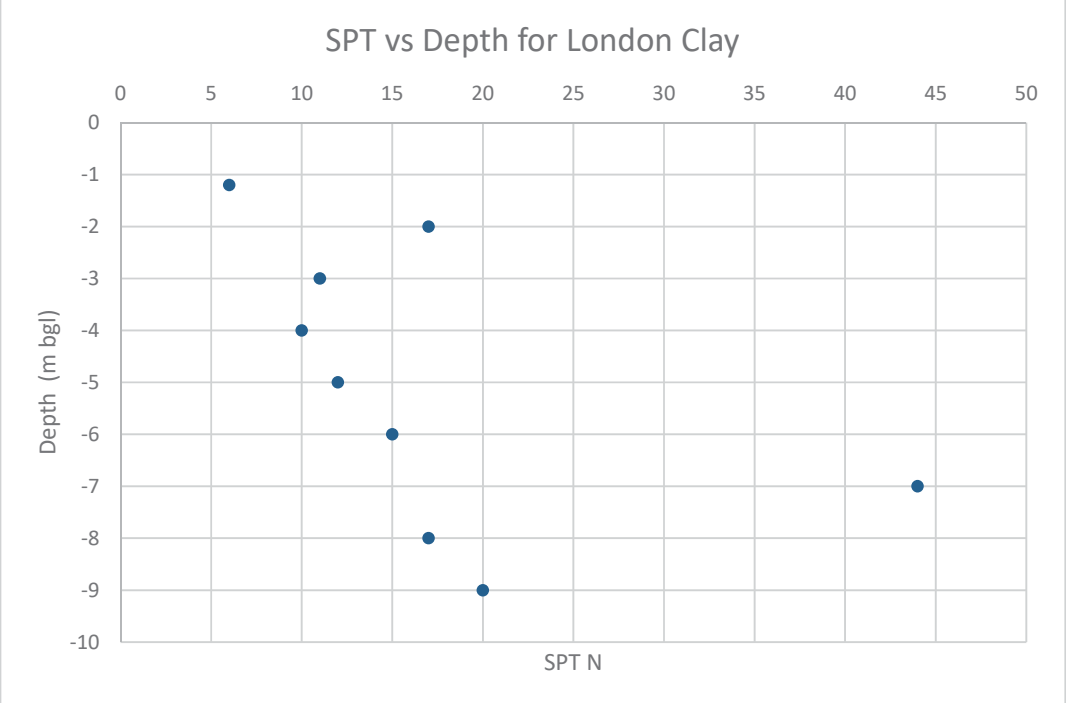

Figure 4.1 SPT N values for all strata

4.3.2 London Clay

The London Clay Formation (LCF) was encountered during the site investigation at a depth of 0.4 m bgl to termination of BH01 at 9.5 m bgl. A plot of SPT N values against depth is shown for in figure 4.1 above, which shows N values ranging between 6 and

20, with a clear pattern of N values increasing with depth. A single, anomalously high result of 44 was recorded at 7.0 m bgl. This coincided with a band of claystone, encountered at this depth.

5 No. Atterberg Limit tests, carried out on samples of London Clay showed very high to extremely high plasticity. Given a F1 of 4.5 (Stroud and Butler 1975) the recorded SPTN values correlate to undrained strengths of 27 kPa to 90 kPa.

The deformation modulus (E') of the LCF is assessed to increase linearly with depth from 12.15 MPa at the interface with made ground to 40.50 MPa at 16.5 m AOD, for purposes of settlement / heave modelling in Section 5 in accordance with published data on the LCF (e.g. Burland et al. 2001). Poisson Ratio is taken as v_u = 0.5 undrained and v' = 0.2 drained.

4.4 A review and summary of the derived values of geotechnical parameters.

The geotechnical parameters assessed based on the data obtained from the ground investigation (Appendix D) have been summarised in Table 4.3 as follows:

Table 4.3 Geotechnical Design Parameters

	Design Level	Class	Undrained Cohesion	Effective angle of shearing resistance	Bulk unit weight*	Deformation Modulus E_u (E')	K_a	K_p
Strata	**m bgl**		**Cu (kPa)**	**MPa**	**kN/m^3**	**MPa**		
London Clay Formation	0.4 (25.6)	CH	27 – 90 (19.6 +7.2z)	24	20	11.7 + 4.5z** (8.8 +3.4z)	0.35	2.5

Notes:

* BS8004 2015

** b: E' based on 0.75E_u. E_u is based on 600 C_u. Burland, Standing J.R., and Jardine F.M. (eds.) (2001), Building response to tunneling, case studies from construction of the Jubilee Line Extension London, CIRIA Special Publication 200.

Active and Passive pressure coefficients k_a and k_p from BS EN 1997-1 Annex C

The parameters in Table 4.3 are unfactored (Serviceability Limit State) and considered to be 'moderately conservative' design values.

Groundwater is assumed to be below formation level, at 4.17 m bgl.

5 Geotechnical Assessment of Ground Conditions

5.1 Introduction

The information obtained from the ground investigation on the soil conditions in relation to the proposed basement construction has been assessed for impacts on existing building structures. The principle impacts are ground movements from the excavation for the basement. These movements are vertical movements of the foundation formation level from isostatic readjustment from the excavation and possible impacts of existing structures from the basement wall construction.

5.2 Presumed Bearing resistance

The foundation formation level of the basement will be at approximately 23.00 m AOD or 3.0 m below ground level. At the formation level an undrained shear strength of approximately 50 kPa has been evaluated from the SPT profile. A dead load of 47 kN and live load of 7 kN, acting over a 0.6 m wide base of retaining wall (the retaining wall being cast onto slab) will utilise 51% of available resistance (EC7 DA1 Combination 2). This indicates the ground will easily accommodate the imposed load without significant (<25 mm) settlement.

5.3 Effect of Heave from soil excavation

The proposed basement will require the excavation from the exiting ground level of approximately 26.0 m AOD to approximately 23.00 m AOD (3.0 m depth). For purposes of this assessment it is assumed the unit weight of the soil (γ_k) to be removed is 20 kN/m^3 giving an overall negative load of 60 kPa.

Dimension of the excavation is based on Drawing PA-A-2002 in TIA-MCS-0053-PROPOSED included Appendix A.

The ground model is based on the ground conditions assessment in Section 4.

The heave has been evaluated using Pdisp version 19.3, which shows a maximum heave of < - 2.8 mm[1] under short term undrained conditions as shown in Figure 5.1 below in which location of 2, 3 and 4 Mornington Crescent are diagrammatically indicated. Long term drained conditions are shown in Figure 5.2 where up to – 2.75 mm was determined. As can be seen from the figures the heave affect becomes less than 0.5 mm at the nearest property of 3 Mornington Crescent. Nos. 2 and 4 are showing a displacement range of between 0.5 and 0 mm. The combined movements are discussed further in section 9 and 10.

[1] Please note that heave is stated as a negative number in PDISP, but is a positive number in the Ground Movement Assessment in Section 9

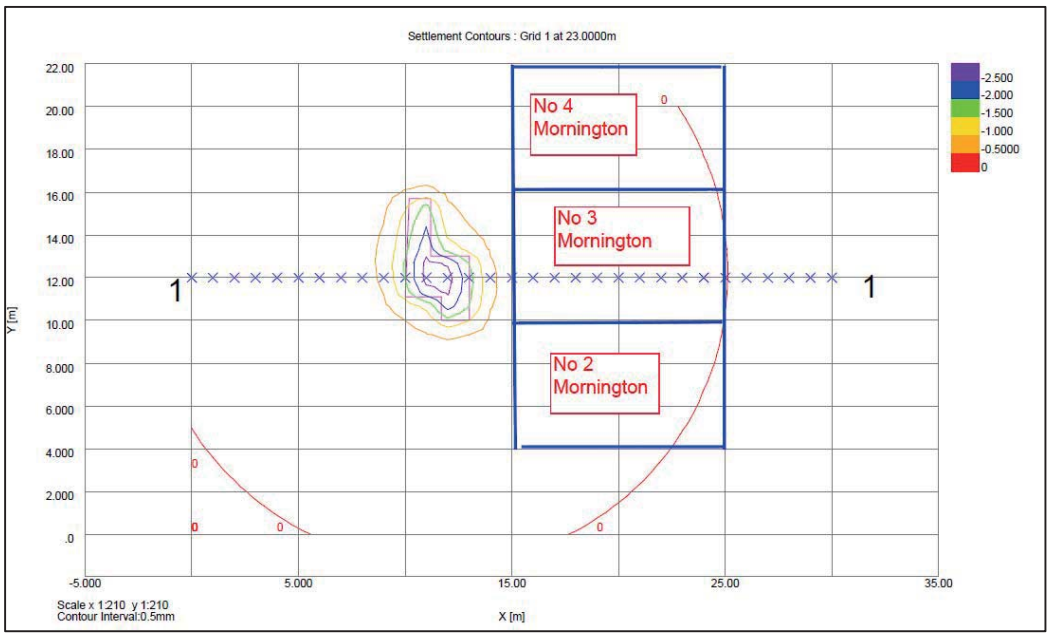

Figure 5.1 Heave- short term undrained condition

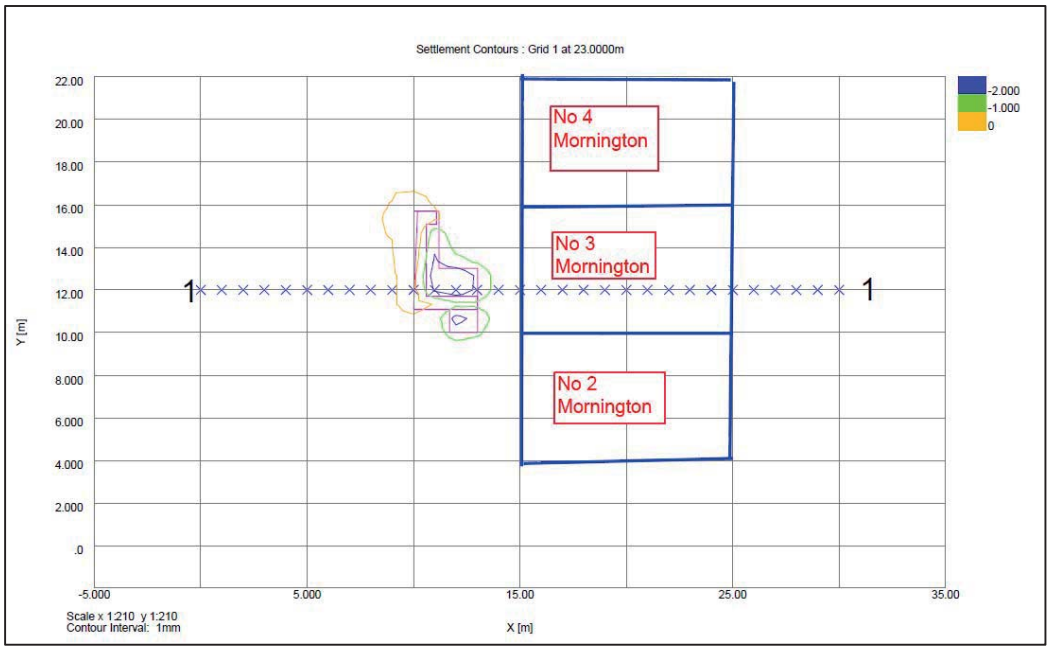

Figure 5.2 Heave- long term drained condition

Cross sections of the effects of the basement excavation and construction are shown in Figures 5.3 and 5.4, in which the location of 2, 3 and 4 Mornington crescent are diagrammatically indicated. These models have been used as a basis for the ground movement assessment and damage assessment in Section 9 and 10 respectively.

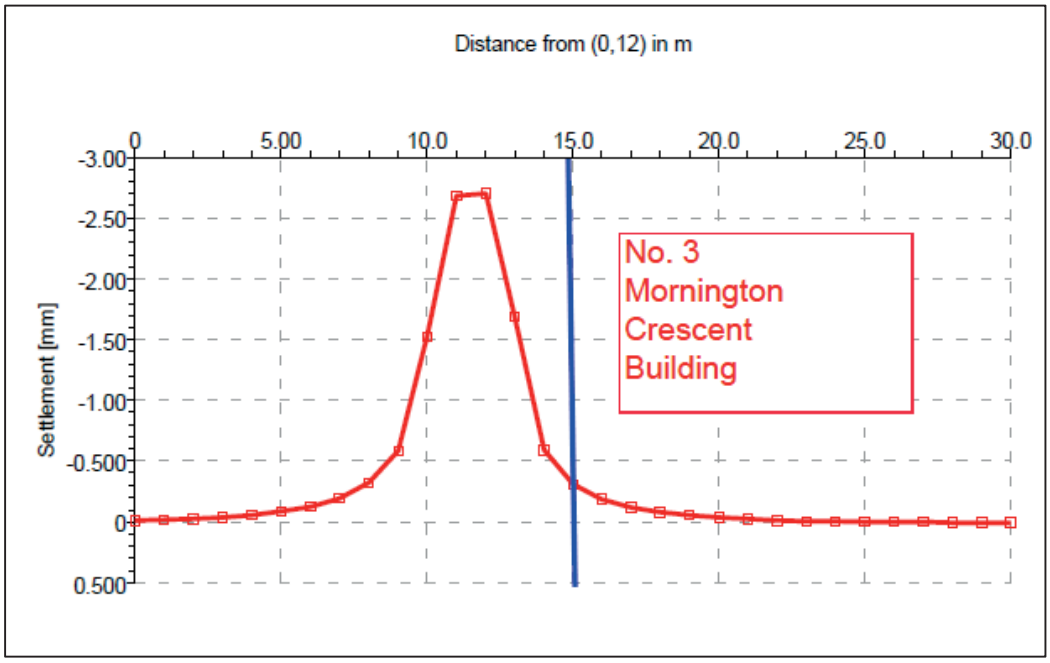

Figure 5.3 Heave- long term undrained condition- Section 1-1

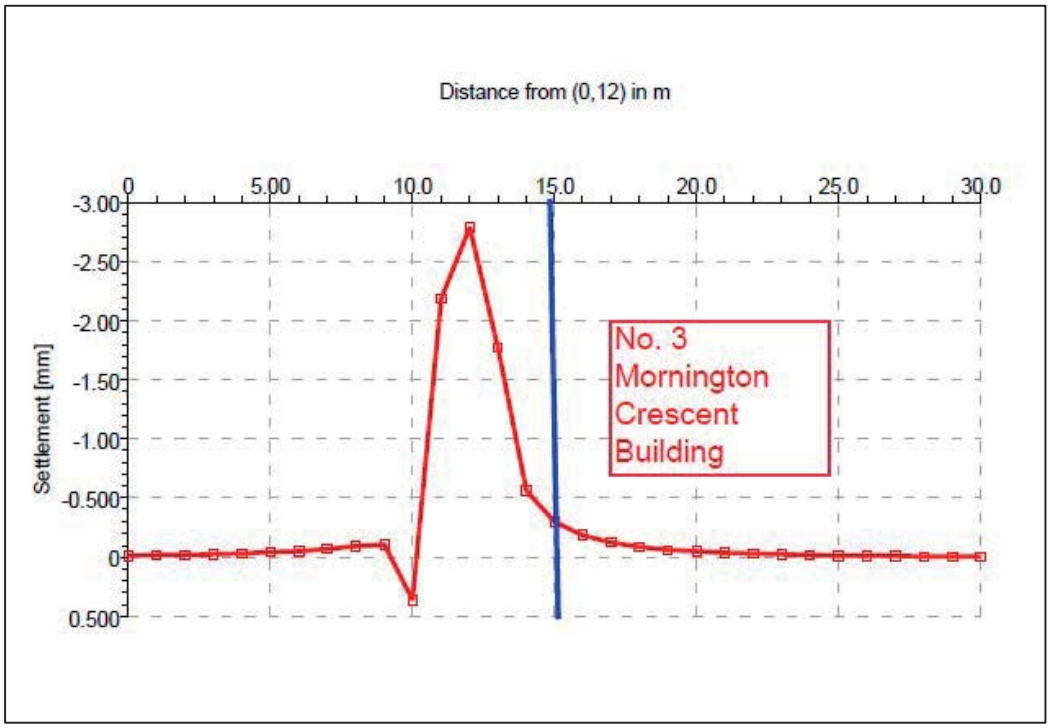

Figure 5.4 Heave- long term drained condition- Section 1-1

Full output of the PDISP model is included in Appendix D.

5.4 Sub –surface Concrete

The results of lab testing for sulphate and pH are summarised below in Table 5.1. The full analysis is included in Appendix D.

Table 5.1 Sulphate and pH categories

Sample depth	Soil Type	Sulphate S04 2:1 extract	pH	Sulphate Class (DS)	ACEC Class
1.2	London Clay Formation	0.10 g/l	7.0	DS-1	AC2

It is recommended that an overall design sulphate class of DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) class of AC2 is adopted.

6 Screening

6.1 Introduction

Screening is undertaken as outlined in Section 6.2 of the GSD recommendations. It identifies if there are hydrogeological and land stability issues associated with the proposed development that requires detailed analysis and investigation. If there are no significant issues identified in the screening stage, then further stages are not required. The report follows the flow charts set out in CPG4, and makes reference to the GSD.

6.2 Subterranean (Groundwater) flow

This section answers questions in Figure 1 of CPG4:

The source of information for the assessment of subterranean flow is from the GSD and a site-specific Groundsure Environmental Insight Report obtained in October 2017 for 3A Mornington Crescent (Appendices B and C) along with the ground investigation undertaken at 3A Mornington Crescent on 2nd November 2017 (Appendix D).

Table 5.1: Responses to Figure 1, CPG4

Question	Response	Action required
1a. Is the site located directly above an aquifer	No. The site is underlain by the London Clay Formation. This is considered and unproductive strata.	None
1b. Will the proposed basement extend beneath the water table surface.	Unlikely. Preliminary groundwater monitoring show groundwater is 4.17 m bgl (21.83 m AOD) which is below the basement formation level of at 2.87m bgl (23.21 m AOD).	The basement is at the same level to the existing basement in the property and neighbouring properties. Monitor groundwater levels to determine the if ground water level is affected by seasonal variations.
2. Is the site within 100m of a watercourse, well, or potential spring line.	No. There are no known wells or spring-lines within 100 m of the site[b,c].	None
3. Is the site within the catchment of the pond chains on Hampstead Heath	No. The site is not within the catchment of the ponds [b]	None

Question	Response	Action required
4. Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas.	Yes The new extension will increase the net hard surfaced area by approximately 5 m^2. (increase of basement area of 8.9 m^2 less loss of existing paved area)	None Net increase of 5 m^2 is not significant
5. As part of site drainage, will more surface water than at present be discharged to ground (e.g. via soakaways and/or SUDS).	No	None
6. Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local pond or spring lines.	No. There are no recorded local ponds or spring lines within 250 m of the site	None

a. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 8).*
b. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 11).*
c. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 14).*

In summary, the site is located on the London Clay Formation. Post investigation monitoring of 1 No. boreholes drilled at the site to a depth of 9.5 m bgl indicated that maximum groundwater level was encountered at 4.17 m bgl or approximately 1.17 m below the basement excavation. For further details, refer to Section 4 of this report.

6.3 Slope / Land Stability

This section answers questions posed by Figure 2 in CPG4.

Table 5.2: Responses to Figure 2, CPG4

Question	Response	Action required
1. Does the site include slopes, natural or man-made, greater than about 1 in 8?	No The site is on level ground at approximately 26.0 m AOD	None
2. Will the proposed re-profiling of the landscaping at site change slopes at the property boundary to greater than about 1 in 8?	No.	None
3. Does the development neighbour land including railway cuttings and the like with a slope greater than about 1 in 8?	Yes. A railway cutting exists directly west of the property, approximately 30 m from the house. The cutting appears to comprise a vertical concrete retaining wall, with a fall of approximately 2.5 from the site down to the railway.	None. At a distance of 30 m from the property, works will not have any impact on the railway cutting
4. Is the site within a wider hillside setting in which the general slope is greater than about 1 in 8?	No.	None
5. Is the London Clay the shallowest stratum on site?	Yes. Below a thin layer (≤0.4m) of made ground, the site bears directly onto London Clay. .	Determine heave and ground movement from the excavation of the clay and construction of basement walls.
6. Will any trees be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained?	No.	None

Question	Response	Action required
7. Is there a history of shrink/swell subsidence in the local area and/or evidence of such at the site.	No records.	None The basement construction will be below any seasonal variation from shrink and swell movements
8. Is the site within 100 m of a watercourse or a potential spring line?	No [a,b].	None
9. Is the site within an area of previously worked ground?	No. Natural soil occurs less than 0.5 m below the surface of the site. Historical mapping shows no change in land use from at least 1882 to the present day.	None
10. Is the site within an aquifer?	No. The site is underlain by the London Clay. This is considered and unproductive strata in EA classifications.	None
11. Is the site within 50m of the Hampstead Heath Ponds?	No.	None
12. Is the site within 5 m of a highway or pedestrian right of way?	No. The basement will be at the rear of the property over 5 m from the street.	None

Question	Response	Action required
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	No Neighbouring properties also have basements to the same depth.	A ground movement assessment will be undertaken to demonstrate impact.
14. Is the site over (or within the exclusion zone of) any tunnels?	No. The London Underground – Northern Line passes at 37 m of the site to the east [d].	None. The tunnel is estimated to be at a depth of 22 m bgl. Works required for the basement will not be expected to impact the tunnel at this distance and depth

Table 5.2 (continued): Responses to Figure 2, CPG4

a. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 8).*

b. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 11).*

c. *Camden Geological, Hydrogeological, and Hydrological Study, Arup, 2010. (Fig. 14).*

d. Groundsure Report (Appendix C) September 2016

In summary, the proposed basement is located on level ground and will be founded within the London Clay Formation, which is present from 0.4 m depth below the site surface.

7 Scoping

7.1 Introduction

This section considers the output from the screening survey where further actions are required. It considers the scope of information required in addressing these actions and what the potential impacts are of the basement construction. The existing ground conditions and the location of the basement can be summarised in a conceptual site model as indicated in Figure 7.1.

Figure 7.1 Conceptual Site Model (Not to scale, numbers are approx. m AOD)

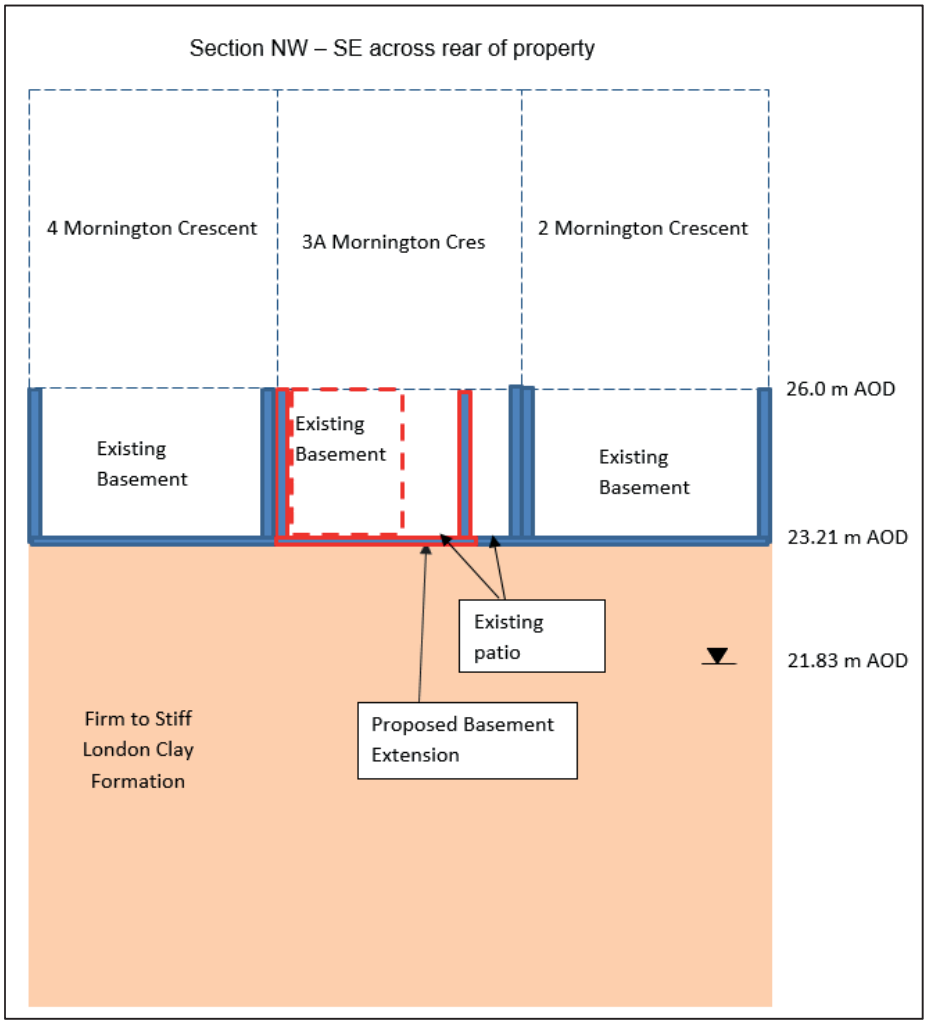

Table 7.1 Summary of Scoping Requirements - Hydrogeology

Screening questions of concern - Hydrogeology	Potential Impact	Mitigation
1b. Will the proposed basement extend beneath the water table surface?	No. Monitoring indicates the basement level does not extend below the water table surface.	The basement is at the same level to the existing basement in the property and neighbouring properties. Monitor groundwater levels to determine the if ground water level is affected by seasonal variations.

Table 7.2 Summary of Scoping Requirements – Land Stability

Screening questions of concern – Land Stability	Potential Impact	Mitigation
5. Is the London Clay the shallowest stratum on site?	Yes. Below a thin layer (≤0.4m) of made ground, the site bears directly onto London Clay. .	Determine heave and ground movement from the excavation of the clay and construction of basement walls.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	No Neighbouring properties also have basements to a similar depth.	A ground movement assessment will be undertaken to demonstrate impact (in section 9 of this report).

8 Impact Assessment

8.1 Groundwater

8.1.1 Groundwater level

The screening process has shown from preliminary borehole information that groundwater occurs at a depth of 4.17 m bgl, or approximately 21.83 AOD. At this level groundwater will be 1.17 m below the excavation depth of 3.0 m or 23.00 m AOD (this assumes total excavation allowing for blinding and basement floor slab).

As the proposed basement is a minor extension (circa 5 m^2 additional area) to the existing basement at the same level, it is not proposed that any mitigation measures are required in respect to groundwater.

8.1.2 Impact on groundwater by any contamination from the made ground

The made ground encountered on the site is described as an inert material with no visual or olfactory indications of contamination.

The natural strata underlying the site is of very low permeability and classified as non-water bearing. The risk of leaching into ground water is therefore considered negligible.

8.2 Land Stability

8.2.1 Is the site within an aquifer?

The site is situated over the London Clay Formation, which is not classified as an aquifer. The screening process has shown from preliminary borehole information that groundwater occurs at a depth of 4.17 m bgl, or approximately 21.83 AOD. At this level groundwater will be 1.17 m below the excavation depth of 3.0 m or 23.00 m AOD (this assumes total excavation allowing for blinding and basement floor slab).

As the proposed basement is a minor extension (circa 5 m^2 additional area) to the existing basement at the same level it is not proposed that any mitigation measures are required.

8.2.2 Proximity to adjacent buildings

3A Mornington Crescent is situated in a terrace with party wall either side of the site.

The adjacent properties also have basements. The basements are assumed to be at a similar level to 3 Mornington Crescent as the properties form part on a single terrace constructed at the same time. The proposed basement extension (scheme drawings included in Appendix B) will be to the rear of the property extending out by 5 m^2 into the garden. The basement retaining wall will be principally to support the garden excavation.

8.2.3 Soil removal / Excavations

The ground investigation indicates that the soil can be readily excavated using conventional plant appropriate for the access constraints imposed by the location of the property. Groundwater is not anticipated to be encountered, based on monitoring records from the site investigation for the full depth of the excavation.

The impact of the excavation on ground heave has been assessed in Section 5 of this report, which concludes that total heave will be less than 6 mm, which is considered within normal construction tolerance. For evaluation of all ground movements both short term during excavation and long term after construction refer to the Ground Movement Assessment in Section 9.

8.2.4 Stability of Temporary Excavations

It is proposed that the basement retaining walls will be constructed using a hit and miss underpinning technique, with temporary propping supporting the excavation, which is set out in the Basement Method Statement issued by Croft Structural Engineers Ltd.

8.2.5 Groundwater Control

As discussed in Section 8.1.1 groundwater is not anticipated to affect the construction works. Groundwater has been measured at 4.17 m bgl, below the basement formation level of 3.0 m bgl within a low permeability clay. If localised seepages are encountered of groundwater that is likely to impact the works, groundwater could be controlled by pumping to a tank prior to disposal by tanker to an approved facility. Alternatively discharge of the groundwater could be made to the sewer subject to an agreement at detailed design stage from the local water company in terms of water quality, flow rate and quantity.

8.2.6 Monitoring of groundwater and ground movements

Groundwater levels should be monitored before the works. Monitoring of adjacent structures and the highway should be carried out before, during and after construction.

9 Ground Movement Assessment

9.1 Introduction

This section provides an assessment of ground movement that may result from the construction of the basement and to determine how these may affect the adjacent building structures.

The proposed construction sequence for the basement is summarised as:

1. Excavate soil mass and prop side walls as excavation progresses
2. Cast stems for RC retaining wall in bays not exceeding 1000mm width on a sacrificial concrete strip
3. Install below slab drainage
4. Construct RC slab
5. Construct internal basement to load bearing walls
6. Proceed with ground floor construction and structure above

The full details of the construction are included in the Basement Method Statement by Croft.

Ground movements resulting from underpinning are not well documented, and there is no specific method for assessing their magnitude. It should be noted that CIRIA C580 (recently superseded by C760 in 2017), which is often used as a reference for ground movement assessments, is for embedded retaining walls and not concrete underpins. Therefore, although this assessment makes reference to C760, the assessment can only refer to empirical data.

When underpinning is carried out in a well-controlled manner, movements are typically small. The quality of workmanship and on site monitoring are key factors in minimising ground movements. The ground conditions at 3 Mornington Crescent is predominantly London Clay, which will display heave from excavation.

It should be noted that in in this proposed basement extension the new retaining wall will be predominantly to the rear of the property within the exiting garden. Consequently, vertical and horizontal movement associated with the retaining wall have not been included in the ground movement assessment. These movement will be predominantly acting out into the garden and have no effect on existing buildings. A boundary brick garden wall will be affected by the movement and this has been evaluated in an assessment of heave from unloading.

The following ground movements have been assessed:

- Short term vertical heave / settlement movements: London Clay and is susceptible to short term heave and time dependent swelling on unloading, which will occur because of basement excavation, generating upward ground

movements. Short term heave has been analysed by PDIP in the undrained condition.

- Long term vertical ground movement in the drained condition: The net loading / unloading on formation soils will generate ground movement, which could affect adjacent foundations which will happen over a period after construction. This has been modelled with Pdisp. This takes into account existing stress conditions, and the weight of soil removed, but does not take into account the weight of existing adjacent buildings.

9.2 Modelling of movements due to vertical stress changes

The predicted ground response due to vertical unloading of the ground through excavation for the proposed basement has been modelled using the OASYS program PDISP version 9.3.

PDISP assumes a linear elastic behaviour of the soil and a flexible structure. The finite stiffness of the structures will tend to redistribute or smooth out the movements, when compared to those predicted by PDISP. The settlement calculations therefore represent free field movements unaffected by the stiffness of the structures and are likely to be conservative (i.e. the distortions of the structure would be less than those obtained from the predicted movements).

The analysis was undertaken for the combination of short term undrained movements and long term drained movements. The 'hard layer' base to the analysis was taken as 26 m below ground level.

9.2.1 Vertical Movements due to excavation (Undrained/short term)

The excavation level was assumed at 3.0 m below ground level. Demolition and excavation of 3.0 m of soil will therefore produce an unload at new formation level of 60 kPa. Poisson's Ratio for London Clay as v_u = 0.5.

A short term (undrained) analysis was undertaken using parameters in Table 4.4 above to determine the heave movements likely to arise as a result of the excavation (i.e., the movements likely to occur prior to the construction of the new structural elements and the consequential vertical loading of the soil). The analysis indicated a maximum heave of 2.8 mm occurring centrally within the excavation (Figure 5.2). Predicted heave at the rear wall of 3 Mornington Crescent is less than 0.5 mm, decreasing linearly to zero at circa 5 m from the wall.

9.2.2 Vertical movements following construction of the new development (drained/long-term)

The movements of the ground following construction are assessed for the long term (drained) case using parameters in Table 4.4 above.

The PDISP assessment indicates that peak heave movements in the long term again occur under the centre of the basement, with a magnitude of 2.75 mm (Figure 5.3). The PDISP model indicated heave extends beyond the neighbouring properties at less than 0.5 mm.

It should be reiterated that the movements due to vertical stress changes do not occur in isolation to the other movements resulting from the basement construction process and the actual ground movements, particularly around and beyond the perimeter of the proposed basement, will be from the quality of workmanship. Furthermore, vertical installation movements are considered to affect only the underpinned foundation itself.

9.3 Horizontal Ground movements due to gravity retaining wall deflection.

Horizontal ground movement due to underpin deflection will not affect the main properties of Mornington Crescent as the retaining wall from the proposed extension to the existing basement predominantly faces into the garden

10 Damage Category Assessment

10.1 Introduction

The calculated ground movements have been used to assess potential 'damage categories' that may apply to neighbouring properties due to the proposed basement construction. The methodology proposed by Burland and Wroth and later supplemented by the work of Boscardin and Cording has been used, as described in *CIRIA Special Publication 200* and *CIRIA C760*. General damage categories are summarised in Table 10.1 below:

Table 10.1: Classification of damage visible to walls (reproduction of Table 6.4, CIRIA C760)

Category	Description	Approx. Crack Width (mm)	Limiting tensile Strain (ε_{lim})
0 (Negligible)	Negligible – hairline cracks	<0.1	0.0 – 0.05
1 (Very slight)	Fine cracks that can easily be treated during normal decoration	<1	0.05 – 0.075
2 (Slight)	Cracks easily filled, redecoration probably required. Some repointing may be required externally.	<5	0.075 – 0.15
3 (Moderate)	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced.	5 -15 or a number of cracks > 3	0.15 – 0.3
4 (Severe)	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows.	15-25 but also depends on number of cracks	> 0.3
5 (Very Severe)	This requires a major repair involving partial or complete re-building.	> 25 but also depends on number of cracks	

A ground movement for a single section through 3 Mornington Crescent is included in Figure 10.1. For this wall section, the combined impact of short term heave and long term settlement/ heave has been shown. The location of the section is shown diagrammatically on Figures 5.1/5.2.

.

Table 10.2 incorporates superimposed horizontal and vertical movements derived from the wall deflection and heave/settlement due to excavation. It should be noted that due

to the position of the retaining wall relative to the existing building there will be no horizontal movement, consequentially the only movements affecting the existing buildings will be vertical movements from excavation / construction.

Table 10.2: Summary of ground movements and corresponding damage category

Adjacent Property	3 Mornington Crescent
Building length - L (m)	13
Building height - H (m)	12
L/H (approximated for plotting)	1.1 (1.00)
max deflection (Δ) in metres (from GMA charts)	0.0005
Δ/L (%)	0.0038
εlim	0.00
Δ/L/εlim	0.00
length to negligible horizontal movement (table 6.3 C760)	10
δh	0.000
δh/L (%) = εh	0.00
Damage Category	**0**

10.2 Damage Category

Based on the above, the estimated maximum damage category imposed on the building of 3 Mornington Crescent is 'Category 0'. As the neighbouring buildings numbers 2 and 4 Mornington Crescent are further from the proposed basement extension they will have lower Damage Category ratings, posing negligible risk. The building damage category chart for 3 Mornington Crescent is shown in Figure 10.2.

10.3 Impact on the Highway

There will be no impact from the proposed basement development on the highway as the basement will be to the rear of the property.

11 Monitoring Strategy

The results of the ground movement analysis show that with good construction control, damage to adjacent structures generated by the assumed construction methods and sequence can be controlled to be within Category 0 ‘negligible’ damage. A formal monitoring strategy should be implemented on site in order to observe and control ground movements during construction.

The system should operate broadly in accordance with the ‘Observational Method’ as defined in CIRIA Report 185. Monitoring can be undertaken by installing survey targets to the top of the wall and face of the adjacent building. Baseline values should be established prior to commencement of works. Monitoring of these targets should be carried out at regular time intervals and the results should be analysed to determine if any horizontal translation of the wall or tilt/settlement of the neighbouring structure is occurring. Regular monitoring of these targets will allow ground movement trends to be detected early and a mitigation strategy can be implemented to control further movement. Monitoring data should be checked against predefined trigger limits and can also be further analysed to assess and manage the damage category of the adjacent buildings as construction progresses.

It is recommended that a condition survey is undertaken on all adjacent property facades prior to the works commencing and ideally when monitoring baseline values are established. Existing cracks or structural defects should be carefully recorded, documented and regularly inspected as construction progresses.

12 Conclusions

The results of this Basement Impact Assessment are supported by site investigation data and outline construction methods and sequence provided by the structural engineer.

The maximum damage category for the adjacent properties has been calculated to be within Category 0 (negligible damage).

An appropriate monitoring regime should be adopted and maintained throughout construction to manage risk and potential damage to the neighbouring structures as construction progresses onsite.

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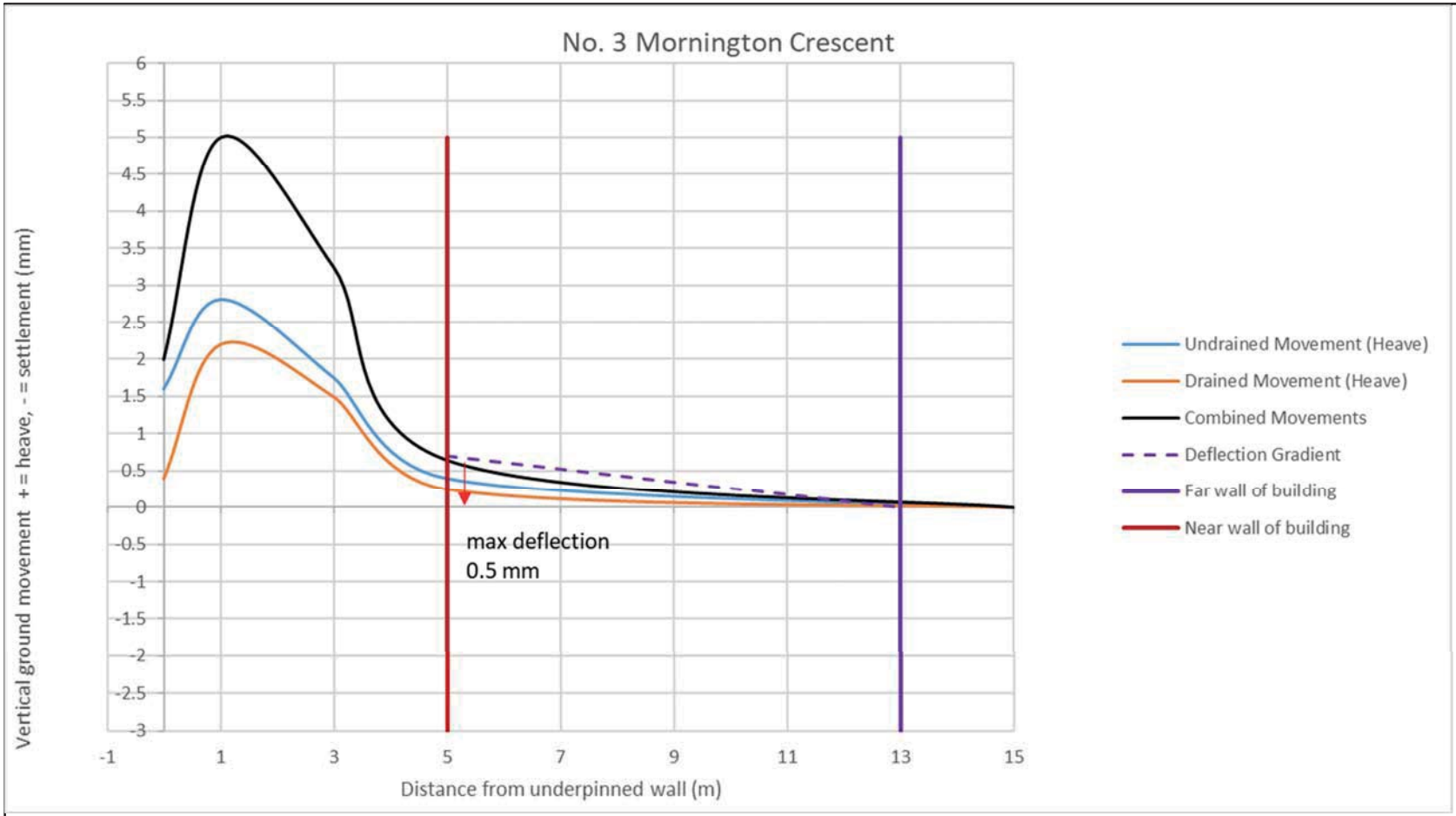
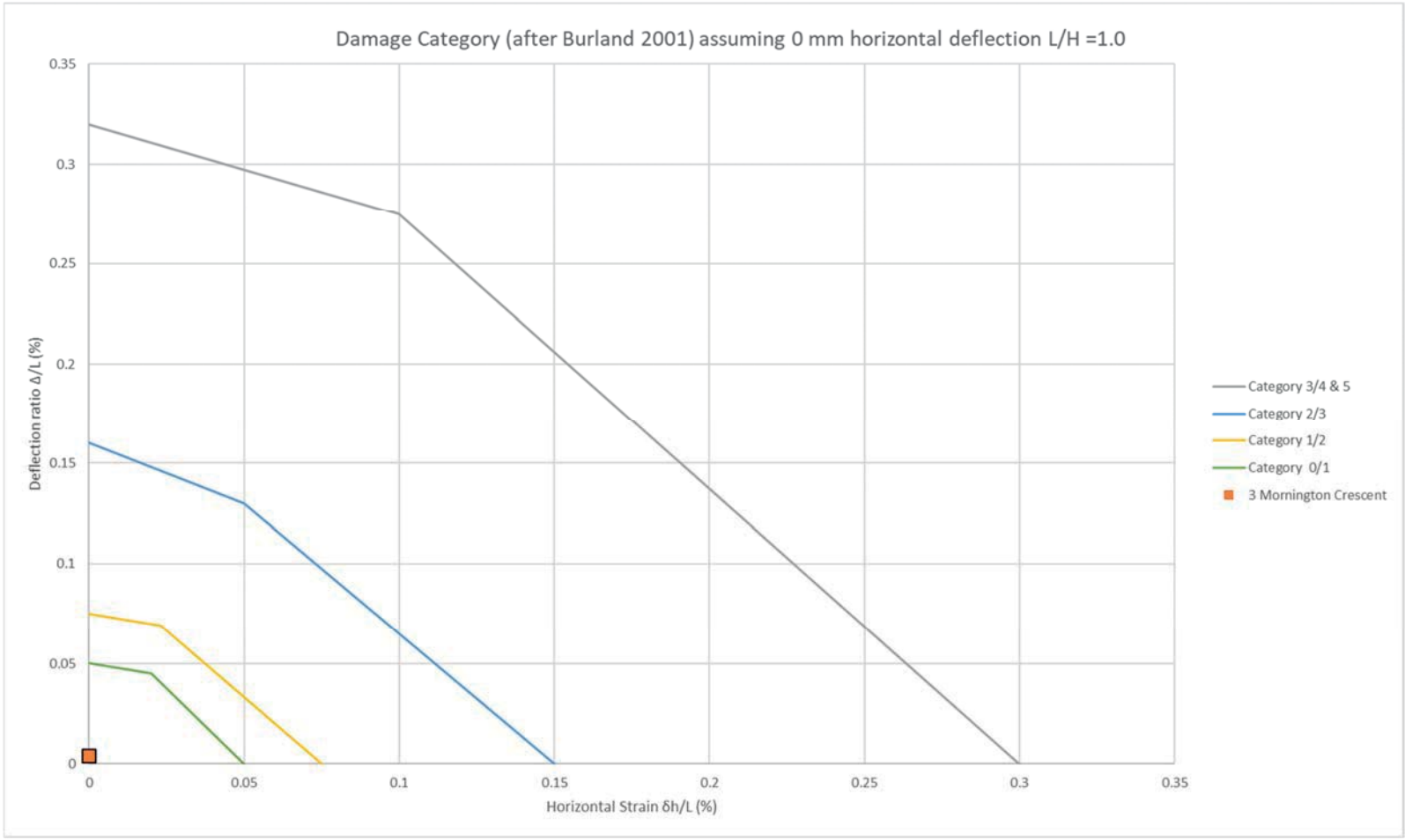
Figures



Client Croft Structural Engineers Ltd.	MAUND GEO-CONSULTING	Project 3A Mornington Crescent
Job No. MGC/17/27	Title Combined Vertical Movements Section 1-1 3 Mornington Crescent	Figure 10.1



Client Croft Structural Engineers Ltd.	MAUND GEO-CONSULTING	Project 3A Mornington Crescent
Job No. MGC/17/26	Title Damage Category Chart - 3 Mornington Crescent	Figure 10.2

Appendix A Proposed Basement Drawings

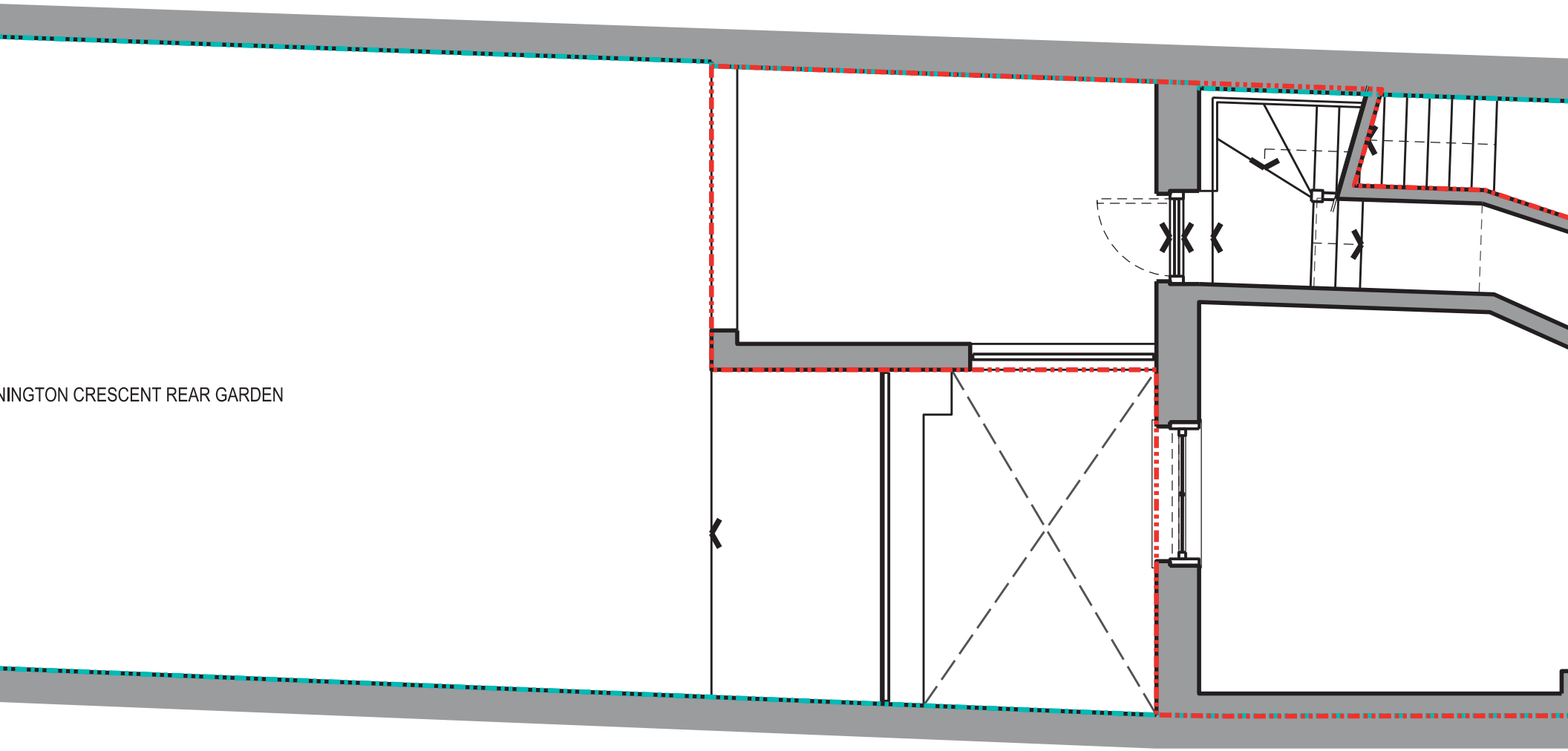
on Crescent

A MORNINGTON CRESCENT

MORNINGTON CRESCENT

INGTON CRESCENT REAR GARDEN

5 MORNINGTC



INGTON CRESCENT REAR GARDEN

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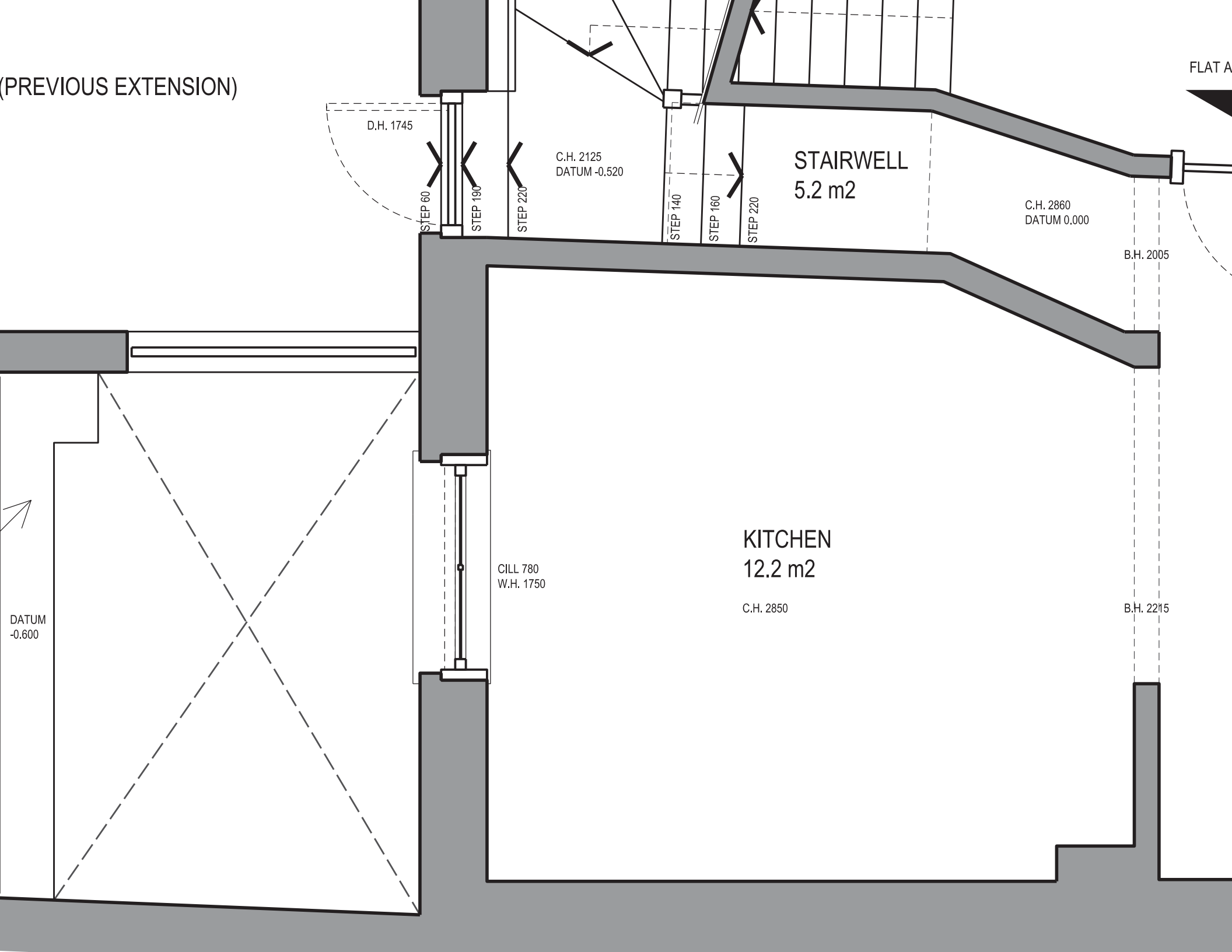
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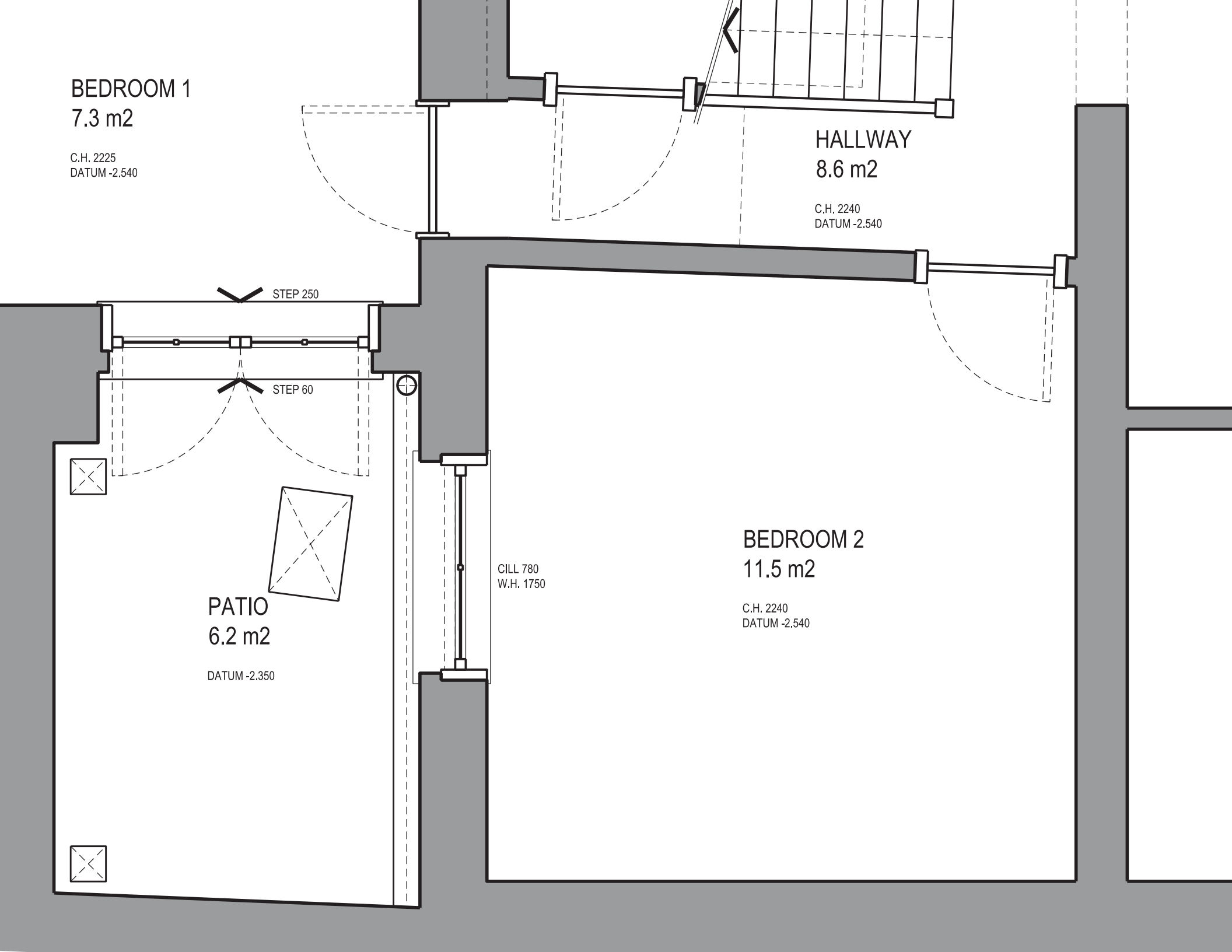
STEP 190
STEP 220
C.H. 2125
DATUM -0.520
STEP 140
STEP 160
STEP 220
STAIRWELL
5.2 m2
C.H. 2860
DATUM 0.000
B.H. 2005
CILL 780
W.H. 1750
KITCHEN
12.2 m2
C.H. 2850
B.H. 2215
DATUM
-0.600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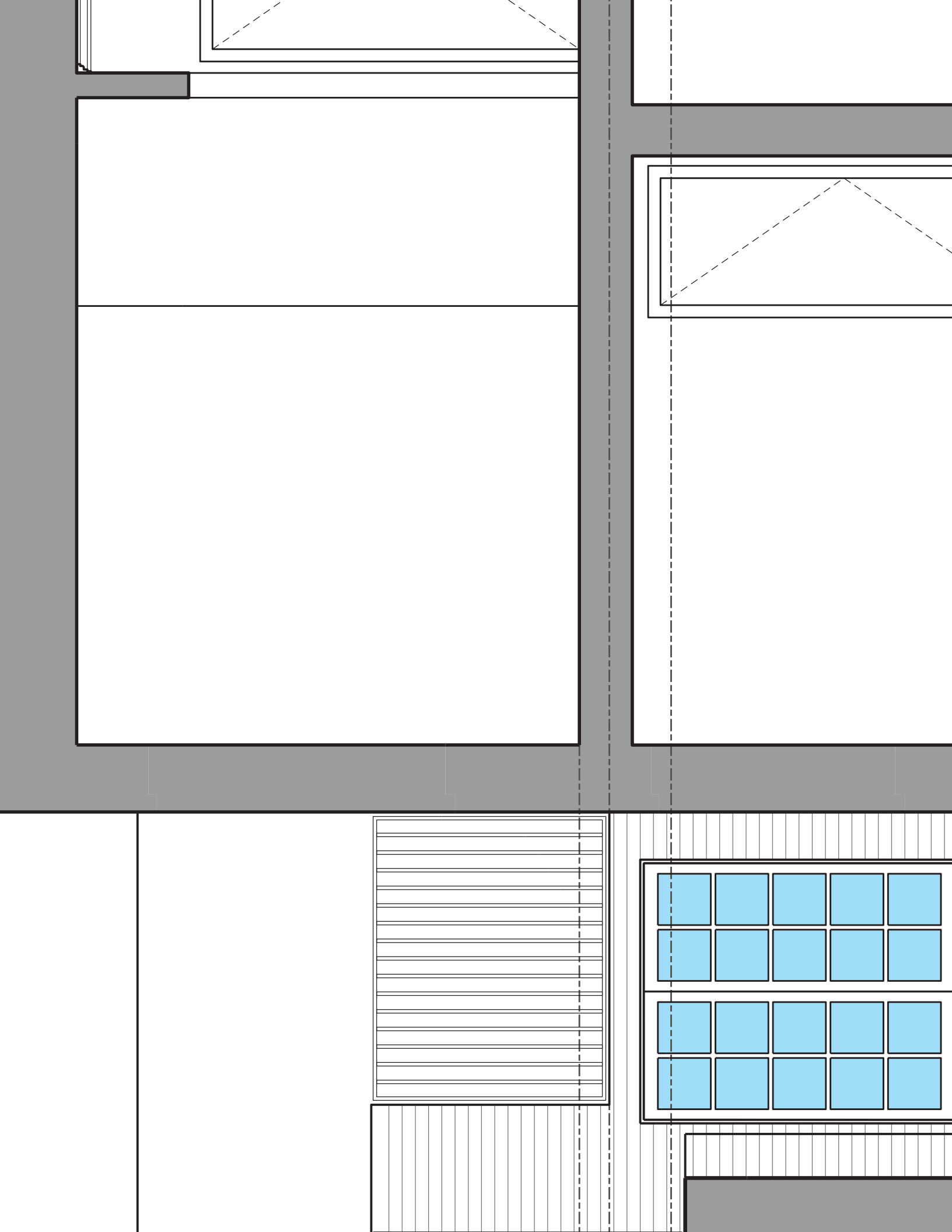
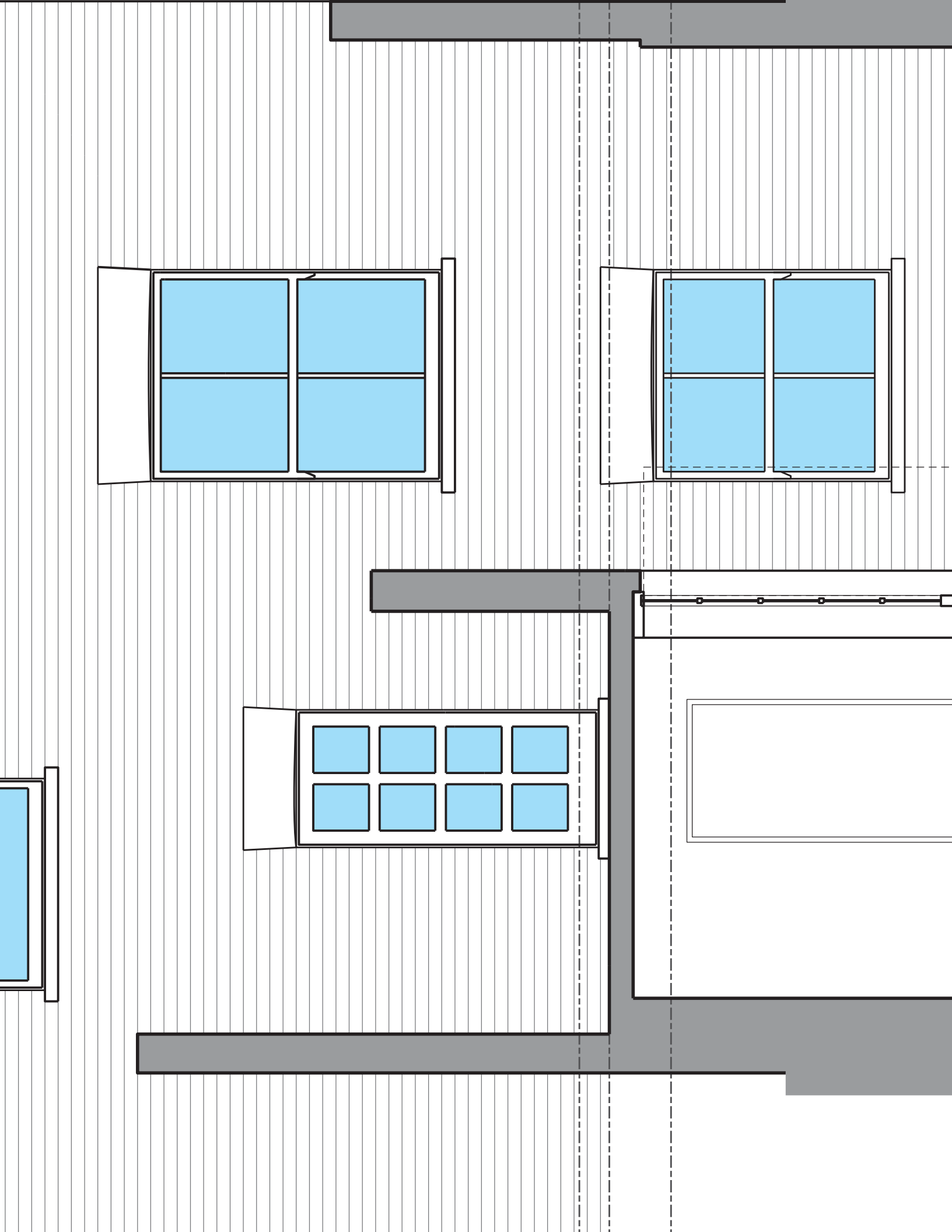
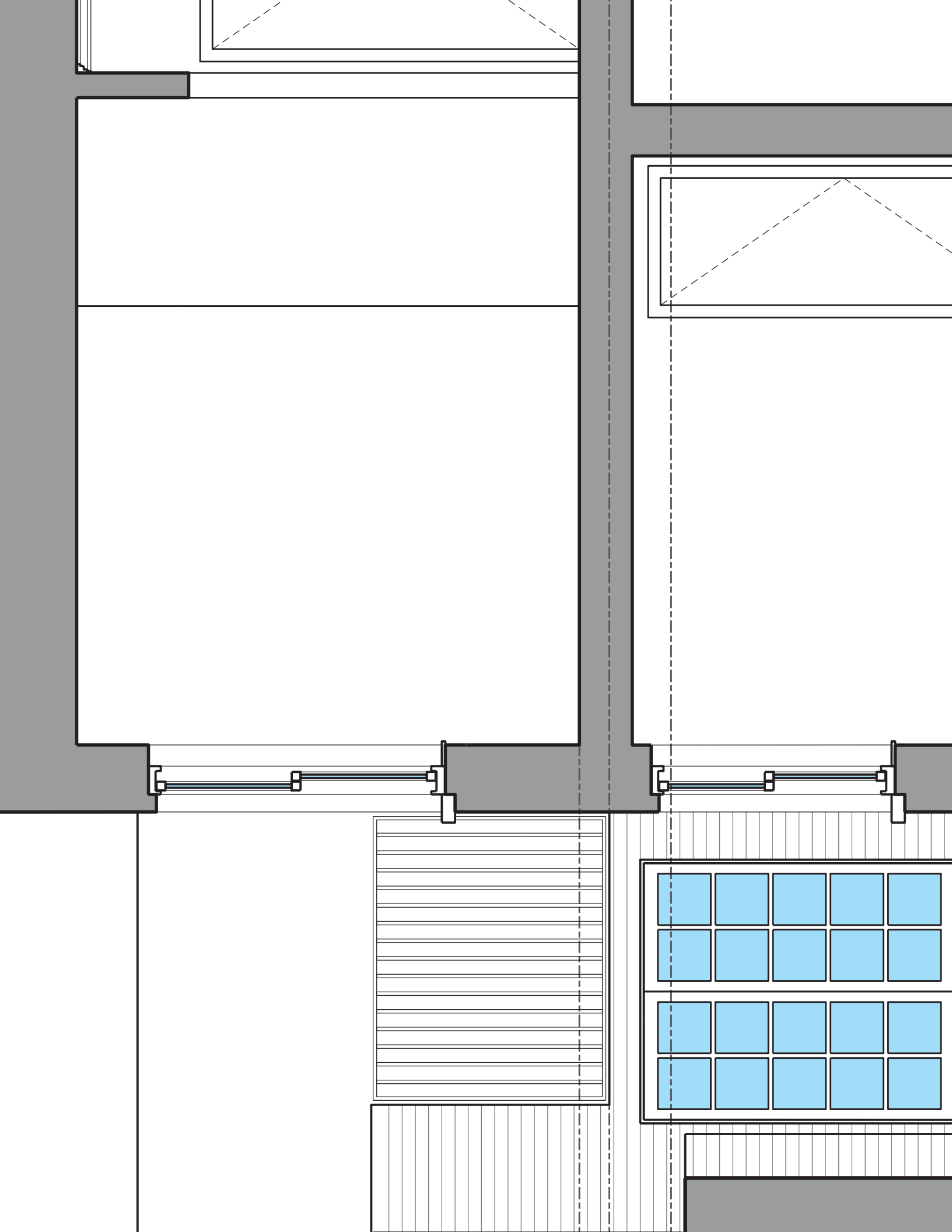
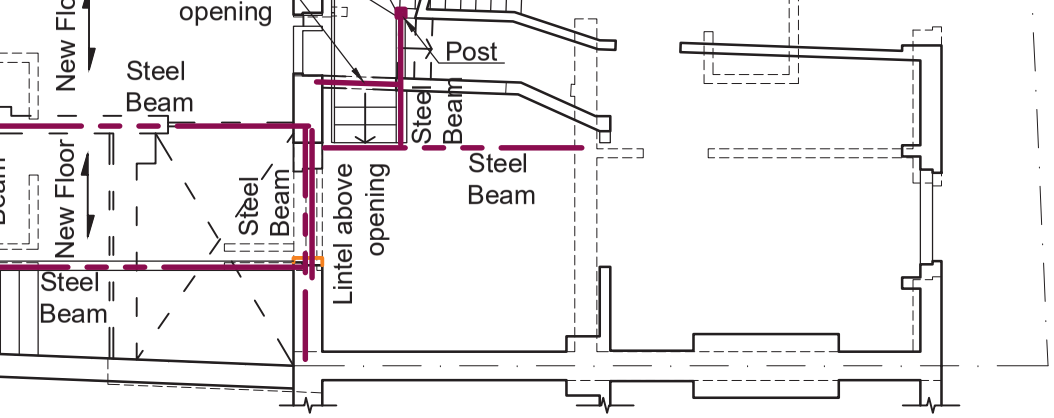
7.3 m2
C.H. 2225
DATUM -2.540
HALLWAY
8.6 m2
C.H. 2240
DATUM -2.540
STEP 250
STEP 60
PATIO
6.2 m2
DATUM -2.350
CILL 780
W.H. 1750
BEDROOM 2
11.5 m2
C.H. 2240
DATUM -2.540









Ground Floor Plan

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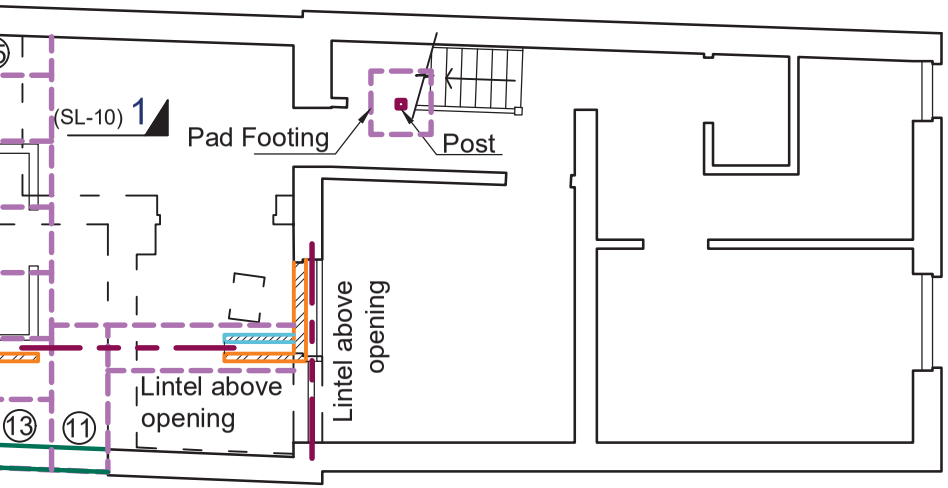
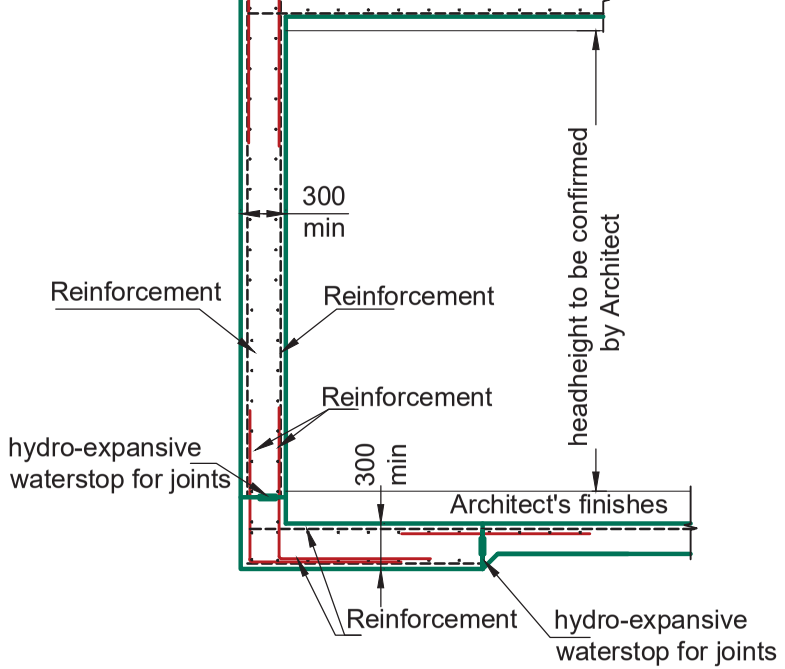


Lower Ground Floor Plan

Scale 1:100



Section 1-1

Scale 1:50

For Calc

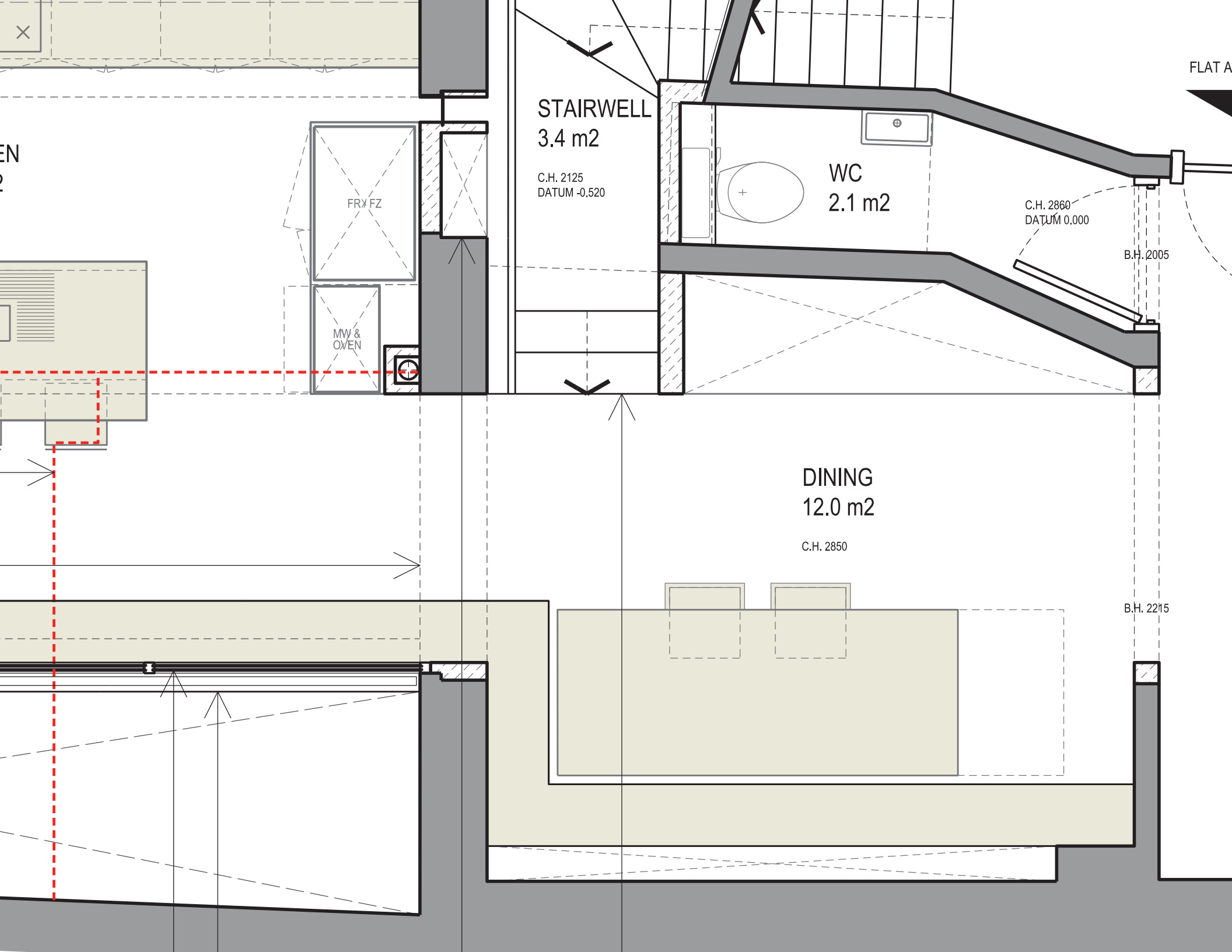
Rev	Date
-	21/11/2017

Job Number	Date
170938	Nov '17
Dwg Number	Rev
SL-10	-

Client: Dilhan Sebastian

Project: 3a Mornington Crescent

Crof
Structura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WC
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FRIDGE FZ
MW & OVEN
DINING
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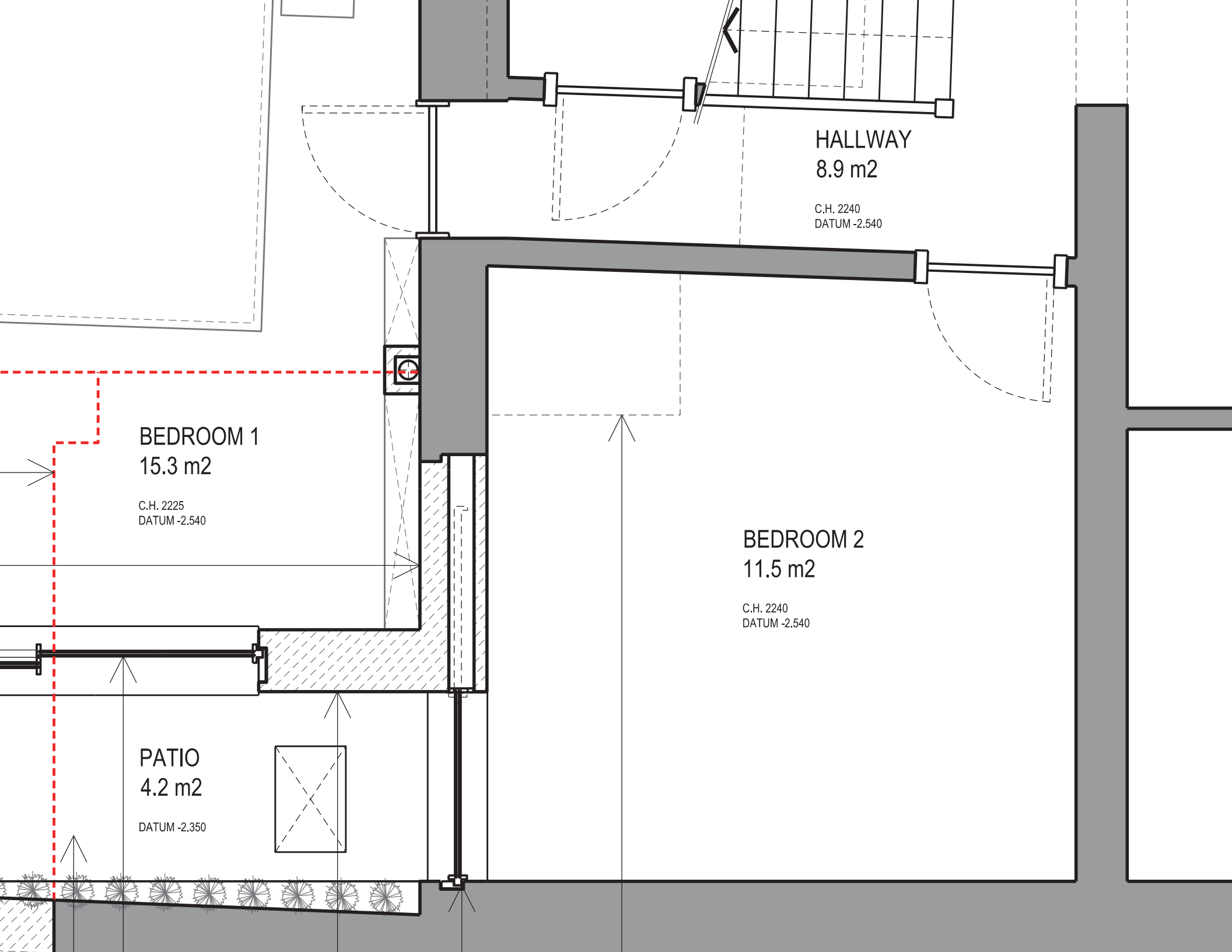
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BEDROOM 1
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C.H. 2225
DATUM -2.540
BEDROOM 2
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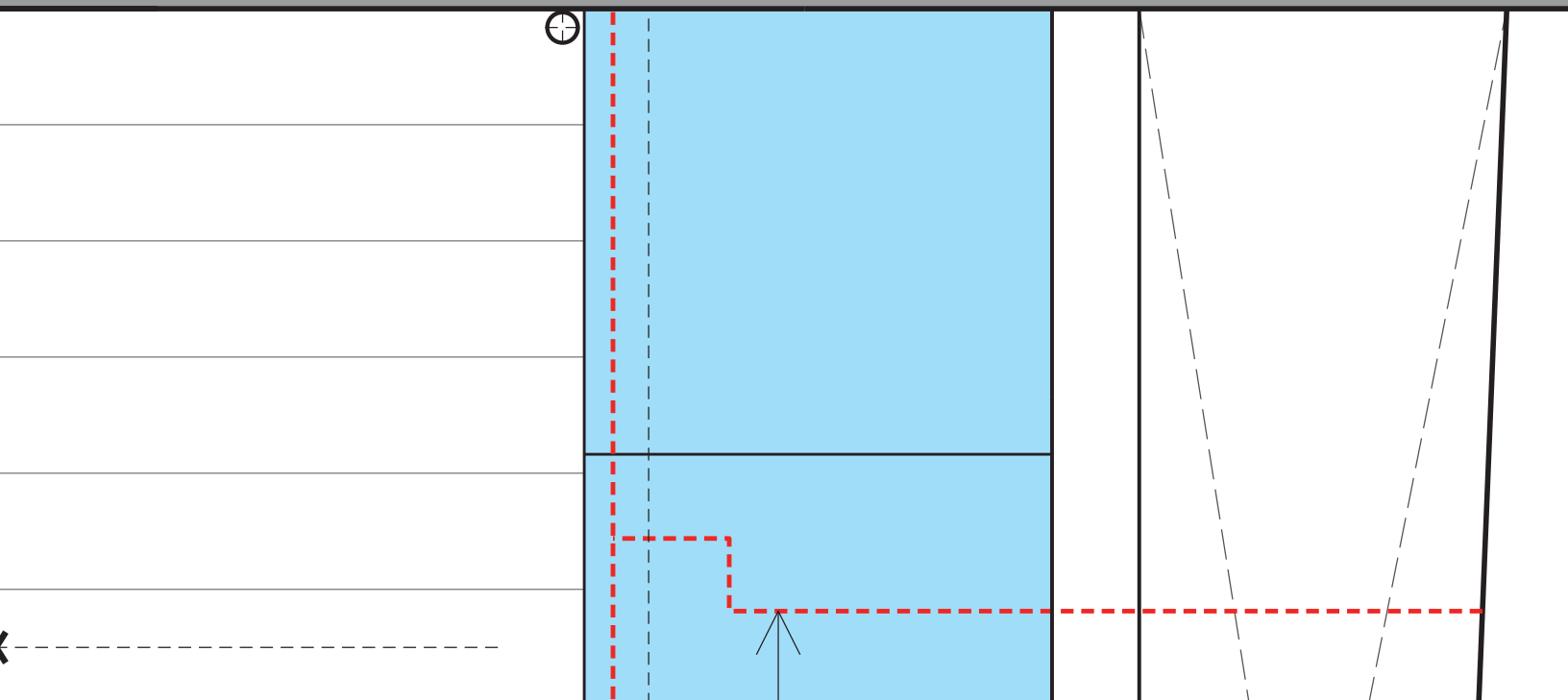
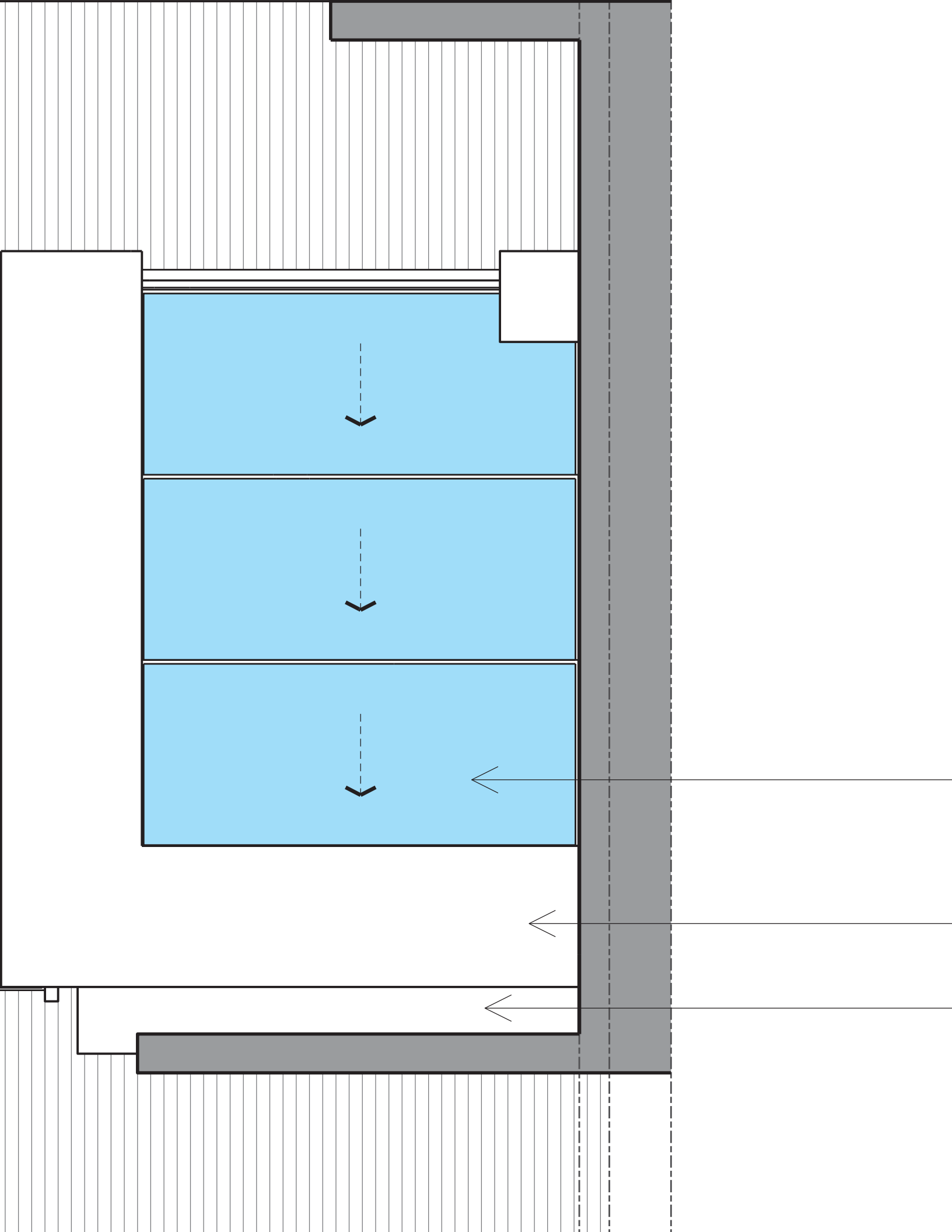
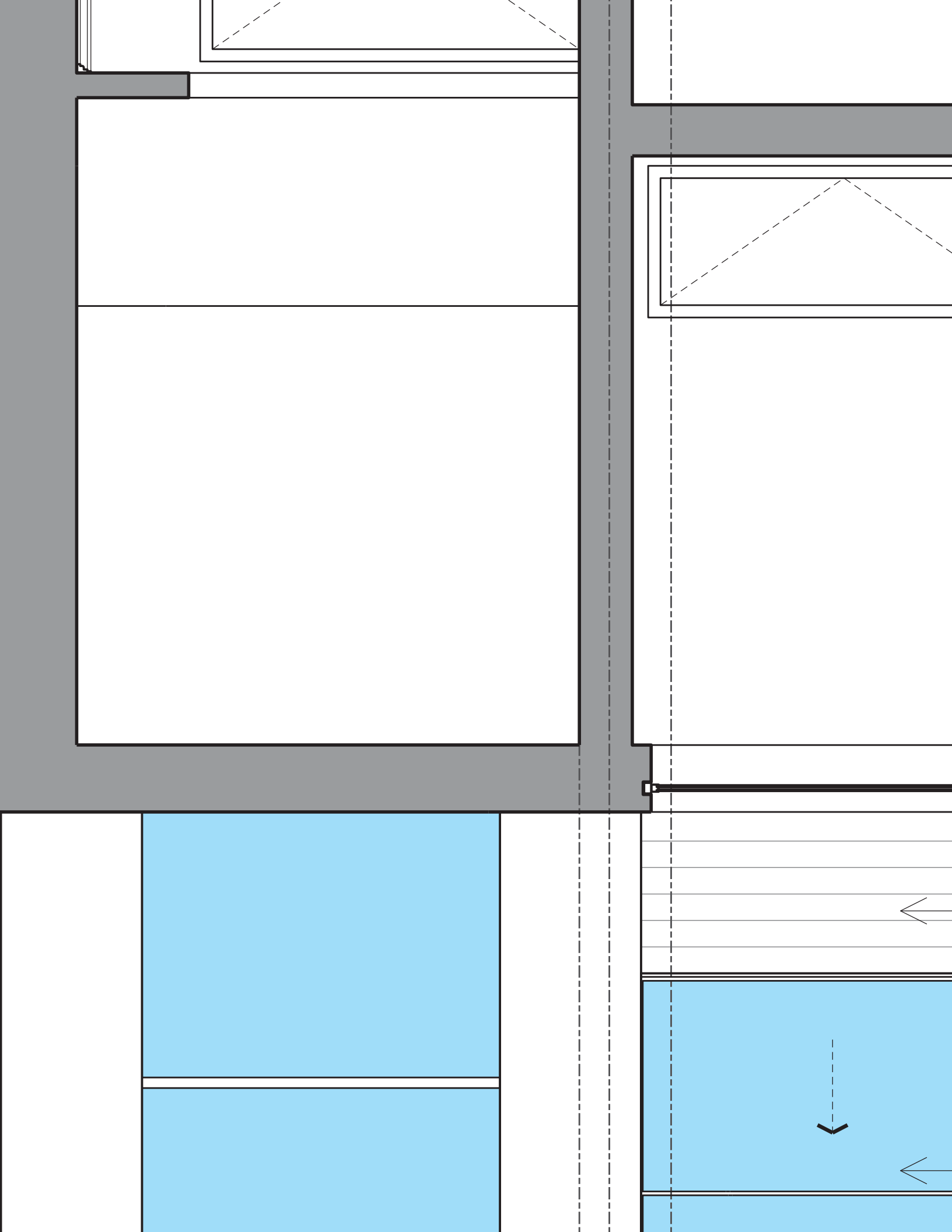
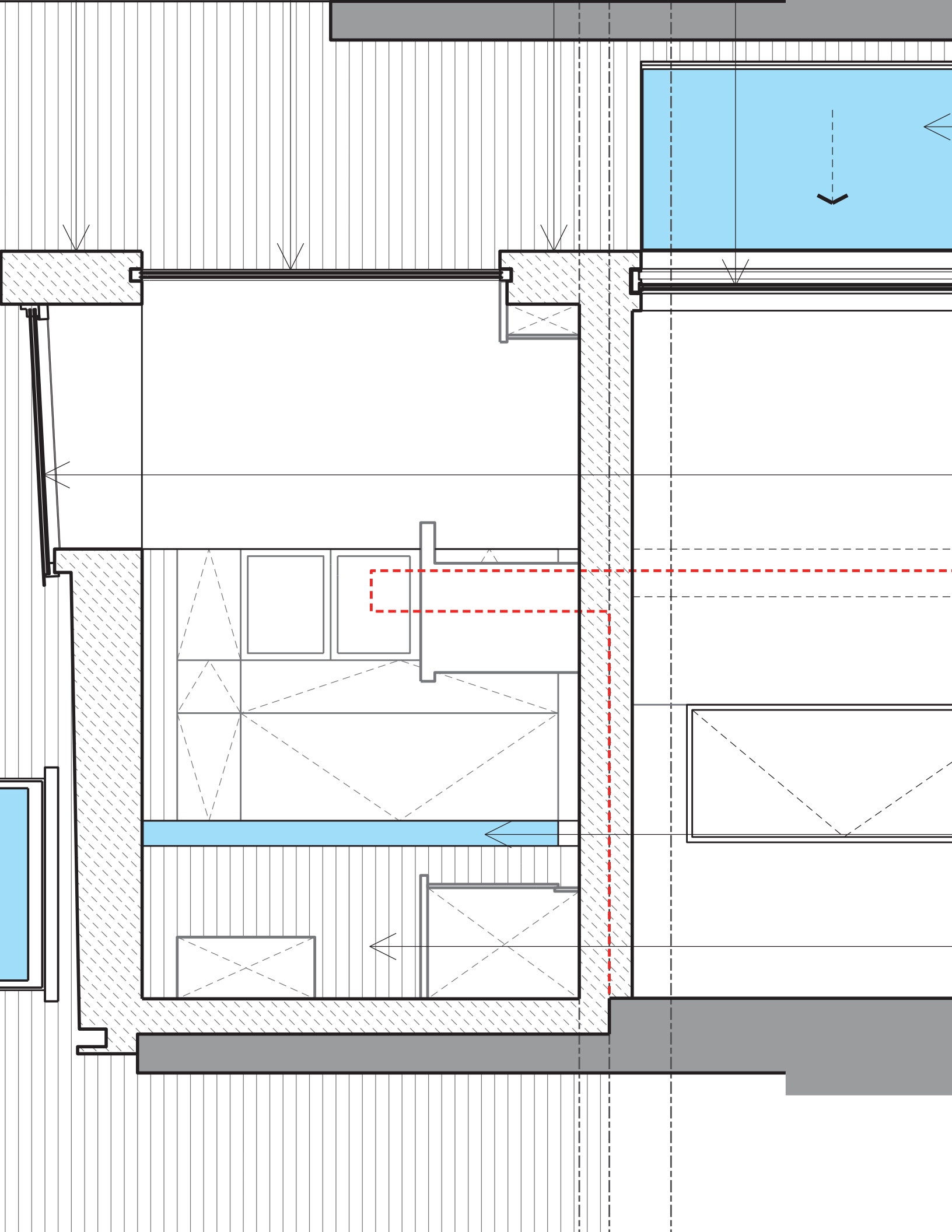
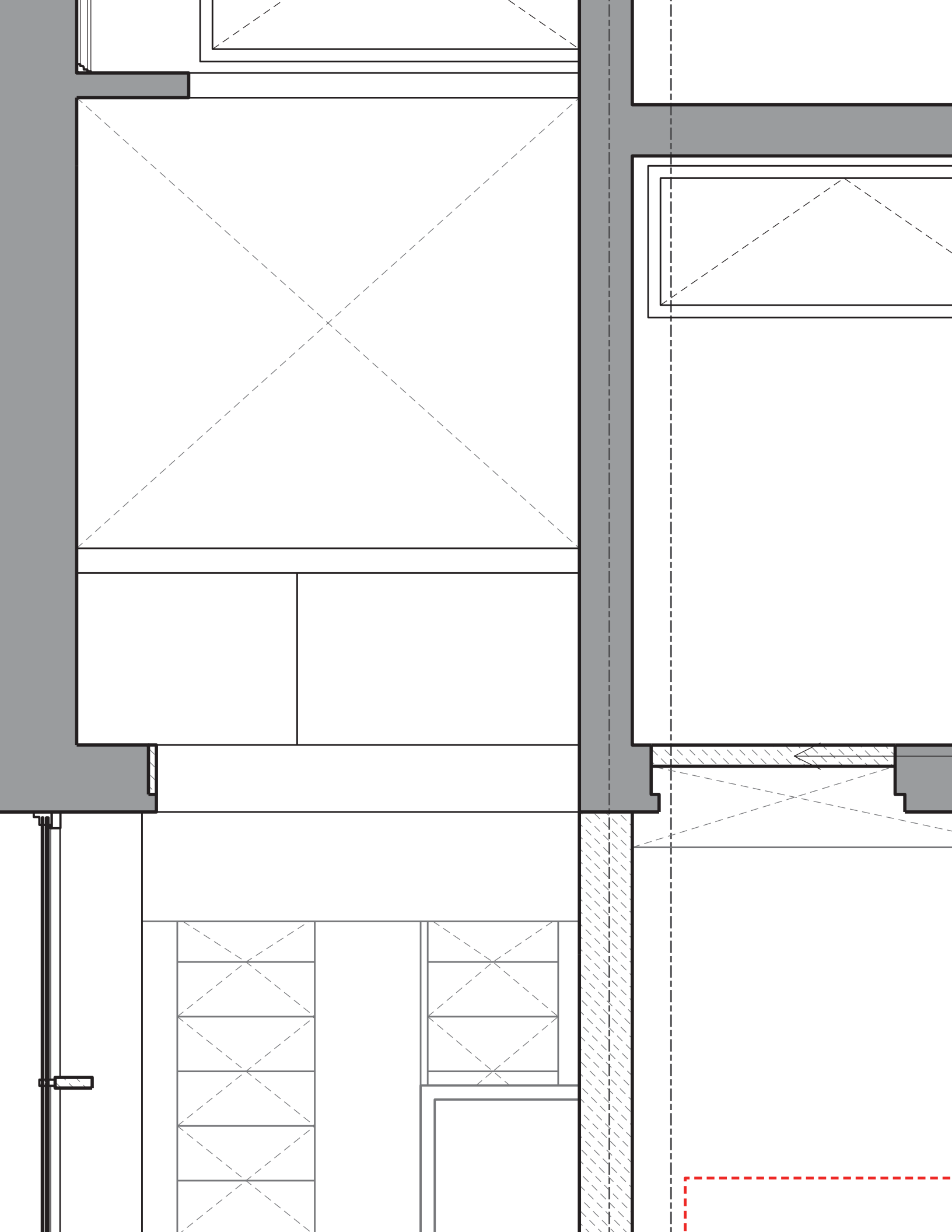
DATUM -2.540
PATIO
4.2 m2
DATUM -2.350











Appendix B Groundsure Geo and Enviro Insight Reports

Maund Geo- Consulting Ltd

20, Mortlake Avenue,
Worcester, WR5 IQD

Groundsure Reference:	HMD-4431152
Your Reference:	3A_Mornington_Crescent
Report Date	31 Oct 2017
Report Delivery Method:	Email - pdf

Enviro Insight

Address: FLAT A, 3, MORNINGTON CRESCENT, LONDON, NW1 7RH

Dear Sir/ Madam,

Thank you for placing your order with Groundsure. Please find enclosed the **Groundsure Enviro Insight** as requested.

If you need any further assistance, please do not hesitate to contact our helpline on 08444 159000 quoting the above Groundsure reference number.

Yours faithfully,

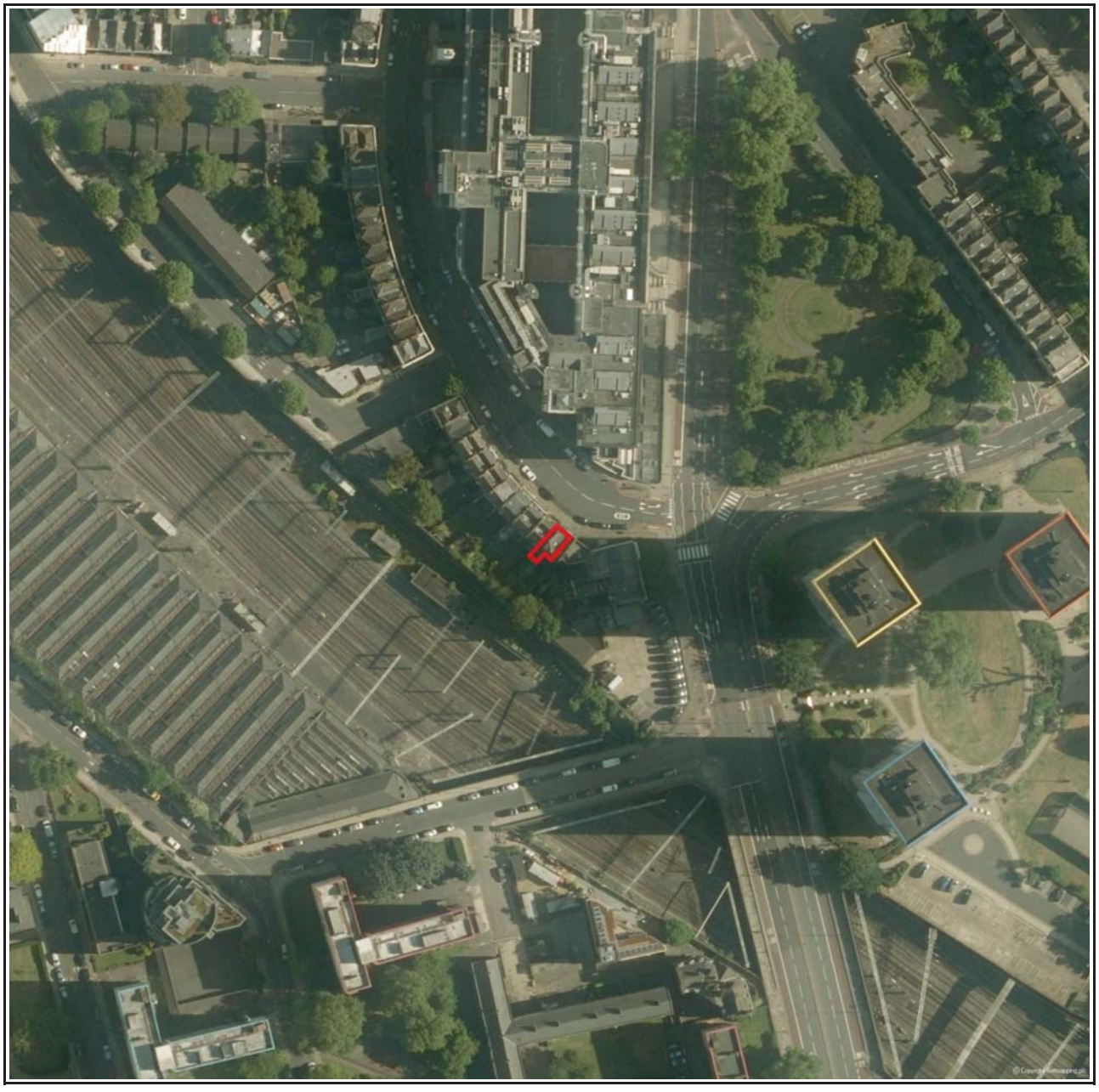
Managing Director
Groundsure Limited

Enc.
Groundsure Enviroinsight

Enviro Insight

Address:	**FLAT A, 3, MORNINGTON CRESCENT, LONDON, NW1 7RH**
Date:	**31 Oct 2017**
Reference:	**HMD-4431152**
Client:	**Maund Geo- Consulting Ltd**

NW N NE



W E

SW S SE

Aerial Photograph Capture date:	07-Jun-2015
Grid Reference:	529115,183144
Site Size:	0.01ha

Report Reference: HMD-4431152
Client Reference: 3A_Mornington_Crescent

Contents Page

Overview of Findings

For further details on each dataset, please refer to each individual section in the main report as listed. Where the database has been searched a numerical result will be recorded. Where the database has not been searched '-' will be recorded.

Section 1: Historical Industrial Sites	On-site	0-50	51-250	251-500
1.1 Potentially Contaminative Uses identified from 1:10,000 scale mapping	0	10	31	39
1.2 Additional Information – Historical Tank Database	0	4	6	23
1.3 Additional Information – Historical Energy Features Database	0	0	8	39
1.4 Additional Information – Historical Petrol and Fuel Site Database	0	0	0	0
1.5 Additional Information – Historical Garage and Motor Vehicle Repair Database	0	2	15	35
1.6 Potentially Infilled Land	0	0	4	0

Section 2: Environmental Permits, Incidents and Registers	On-site	0-50m	51-250	251-500
2.1 Industrial Sites Holding Environmental Permits and/or Authorisations				
2.1.1 Records of historic IPC Authorisations	0	0	0	0
2.1.2 Records of Part A(1) and IPPC Authorised Activities	0	0	0	0
2.1.3 Records of Red List Discharge Consents	0	0	0	0
2.1.4 Records of List 1 Dangerous Substances Inventory sites	0	0	0	0
2.1.5 Records of List 2 Dangerous Substances Inventory sites	0	0	0	0
2.1.6 Records of Part A(2) and Part B Activities and Enforcements	0	0	0	8
2.1.7 Records of Category 3 or 4 Radioactive Substances Authorisations	0	0	0	10
2.1.8 Records of Licensed Discharge Consents	0	0	0	0
2.1.9 Records of Water Industry Referrals	0	0	0	0
2.1.10 Records of Planning Hazardous Substance Consents and Enforcements within 500m of the study site	0	0	0	0
2.2 Records of COMAH and NIHHS sites	0	0	0	0
2.3 Environment Agency/Natural Resources Wales Recorded Pollution Incidents				
2.3.1 National Incidents Recording System, List 2	0	0	0	0
2.3.2 National Incidents Recording System, List 1	0	0	0	0
2.4 Sites Determined as Contaminated Land under Part 2A EPA 1990	0	0	0	0