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ST GILES CIRCUS

CONCEPTUAL DESIGN STATEMENT FOR CROSSRAIL

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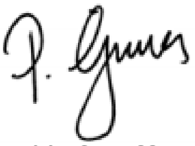

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EXECUTIVE SUMMARY

This Conceptual Design Statement has been prepared for Crossrail in support of the Planning Application for the St Giles Circus Development near Tottenham Court Road Underground Station. The proposed development includes the construction of a deep basement above the Eastbound Crossrail running tunnel, refurbishment of existing buildings on Denmark Street and Endell Street and the construction of a single storey basement below the existing buildings at 4 Flitcroft Street and 1 Book Mews.

Part of the site is currently occupied by London Underground for the upgrading works to Tottenham Court Road Station which include the construction of a new escalator box to provide improved access to the Northern Line. The development is governed by an Agreement between the Secretary of State for Transport and the developer which identifies the construction of a future basement on the site. The site will be returned to the developer by London Underground when they complete the structural works to the escalator box, it is understood that this will be after the construction of the Eastbound Crossrail tunnel below the site, but before the tunnels are fully commissioned.

The principle interface of the development with Crossrail is the construction of the new deep basement above the Eastbound running tunnel to form a new Event Gallery. The construction of deep basement will result in the removal of considerable overburden above the tunnel. In order to control movements of the tunnel a basement construction sequence is proposed that installs tension walls either side of the Crossrail tunnel and adit beams above the Crossrail tunnel prior to excavating above the Crossrail tunnel. The system of tension walls and adit beams will then resist the heave forces that result from the excavation and reduce the movements that the tunnel would otherwise experience. Since the last issue of this report this system has been extended under the building at 22 Denmark Place by the proposed installation of three under-reamed caissons that will act as tension piles.

The approach outlined above has been discussed with Crossrail's 3rd Party developments team during the development of the design and this document has been prepared to respond to the requirements of "Crossrail: Information for Developers, February 2008" and the proposed amendments to the Developer Information Pack.

Two approaches have been used to validate the concept design: A 'static' structural engineering assessment of the maximum heave forces that could be applied to the system of adit beams and tension walls, based on the weight of overburden removed and the hydraulic pressure on the base slab, this is used to validate the stresses in the structure. The second approach includes a finite element model of the ground conditions at each stage of construction to assess the movements that the tunnel will experience as a result of the basement construction. A parametric study is included to assess the sensitivity of changing different parameters such as depth of wall, skin friction, beam spacing on the tunnel movements.

The results of both these studies show that the predicted movements of the tunnel are within the limits identified by Crossrail. A system of monitoring is then outlined to verify that the actual movements are in line with the predicted movements and interventions are suggested if the movements are greater than predicted. The residual risk to both the travelling public and the operation of the railway is considered to be low.

For the other buildings on the site an assessment of change in surcharge loadings as a result of the development has been made together with a settlement damage assessment of the impact of the construction of the Crossrail tunnels on the existing buildings. In all cases the depth of the tunnels is such that the predicted damage is class 0 (negligible) in accordance with the Burland method.

After the planning stage a further site investigation will be commissioned to confirm the ground conditions over the part of the site currently occupied by London Underground. Detailed design and method statements will then be prepared for all the ground floor and sub-structures for approval by Crossrail so that the planning conditions that relate to Crossrail can be discharged.

1 INTRODUCTION

This Conceptual Design Statement (CDS) describes the proposed design for the St Giles Circus project and its interface with Crossrail. The objective of the document is to demonstrate the following:

- The future construction of Crossrail is not prejudiced by the proposed building.
- The building itself is not adversely affected to an acceptable degree by the construction of Crossrail.
- The design complies with the principles set out in the Developer Agreement.

2 OVERVIEW

2.1 The Nature of the Development

The St Giles Circus project involves the redevelopment of this Central London site adjacent to Tottenham Court Road station and is bounded by Charing Cross Road, Andrew Borde Street, St Giles Circus and Denmark Street. The project also includes the refurbishment of some properties to the south of Denmark Street and the refurbishment of a property on Endell Street. Refer to figure 2.1 for a site plan. The development will include Retail, Hotel, Residential, Commercial and Leisure facilities.

Part of the site is currently occupied by London Underground (LUL) as part of the upgrade works at Tottenham Court Road that include the construction of a new escalator box and associated tunnels for access to the Northern Line beneath the Charing Cross Road frontage of the site. An Agreement is in place between the Secretary of State for Transport and the Project Sponsor that allows LUL to utilise the part of the site and divert Charing Cross Road across the site during the construction of the escalator box and new ticket hall at Tottenham Court Road station.

As part of this Agreement LUL installed 7 piles (known as the 'Consolidated Piles') which will support part of the new build element of the St Giles Circus project where it extends above the new escalator box. The Agreement also requires LUL, Crossrail and the Project Sponsor to proactively work together and share information regarding over-site development on the St Giles Circus site.

The scheme for the St Giles Circus project involves the construction of four new buildings on the site (known as Buildings A, B, C and D), the refurbishment of the existing building stock on Denmark Street and the construction of a new basement below Buildings A, B, C and D. Refer to figure 2.2 for the relative locations of the buildings.

The project falls within the Crossrail Safeguarding zone (see Appendix A) and lies directly above the Eastbound Crossrail running tunnel, approximately 100m to the east of the proposed Tottenham Court Road Crossrail station. Refer to the section on 'Design Assumptions' for the assumptions made about the construction of the tunnel.

2.2 Asset Summary

The following Crossrail assets interface with the proposed St Giles Circus project:

The contract C300 Eastbound running tunnel approximately between chainage points 5050m and 5140m (see Appendix A, Crossrail drawings).

The contract C300 Westbound running tunnel approximately between chainage points 5050m and 5130m.

The St Giles Circus project also interfaces with the LUL Tottenham Court Road station upgrade works, particularly the new Escalator box structure to the Northern Line, which forms the subject of a separate report.

2.3 Discipline Interfaces

The interface between the St Giles Circus project and Crossrail is the construction of a basement and new foundations near the Crossrail tunnels which may give rise to ground movements resulting in potentially unacceptable distortion of the tunnel lining. A consultation process has been undertaken with Crossrail, which has included meetings with Crossrail's 3rd Party Developments Manager. The minutes from these meetings are shown in appendix H.

During the consultation process with Crossrail, a list of constraints on tunnel movements was provided by Crossrail, which is presented in Appendix D and summarised below:

1. The tunnel segments and joints do not become overstressed.
2. Waterproofing of tunnel segment joints (is unaffected) remains within Specified performance criteria.
3. Minimum 50mm gauge clearance between the tunnel lining/ (also "structure gauge") and dynamic kinematic envelope of Crossrail trains are not breached.
4. Clearance between track and overhead conductors are not affected unduly.
5. Track geometry does not suffer undue movement or distortion, i.e. movements predicted are below the 'No Mandated Requirement' thresholds, described for various geometry faults in Appendix A of the Network Rail Standard NR/L2/TRK/001/C01.

6. No adverse impact on the track drainage system.
7. No adverse impact on Mechanical and Electrical equipment, cables, track and internal structures.

3 THE PARTIES

3.1 Project Sponsor

The Project Sponsor is Consolidated Developments Ltd who own the freehold for the site. Contact details are:

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Consolidated Developments Limited

26 Soho Square

London W1D 4 NU

Tel 020 7437 4372

Fax 020 7437 3800

www.26sohosq.com

3.2 Infrastructure Manager (IM)

This CDS relates to the interface of the St Giles Circus project with the Crossrail Infrastructure below the site. A separate CDS is provided for the interface of the St Giles Circus project with the London Underground Infrastructure. This CDS has been developed with the guidance of the Crossrail 3rd Party Developments Manager:

Geoff Rankin

3rd Party Developments Manager

Desk Location CS30/G3/07

25 Canada Square

Canary Wharf

London E14 5LQ

Tel 020 3229 9600

geoffrankin@crossrail.co.uk

3.3 Design Co-Ordination Organisation

The lead designer for the St Giles Circus project is ORMS Architecture Design who are responsible for co-ordinating the design and the planning application. Contact details are:

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ORMS Designers + Architects Ltd

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London EC1N 0JH

Tel 020 7833 8533

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3.4 CDS Design Organisation

The structural engineer for the St Giles Circus project is Engenuiti who are also responsible for compiling the CDS. Engenuiti are working with geotechnical engineering specialist Donaldson Associates who are advising on the foundation design and ground movements and who are co-authoring the CDS. Contact details are:

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3.5 Third Party Approvals

Aside from Crossrail, the St Giles Circus project will also be obtaining approvals from the following bodies for the basement works:

London Underground Limited.

London Borough of Camden.

The Environment Agency.

3.6 Organisation responsible for Detailed Design

The organisations responsible for the detailed design of structures that interface with Crossrail will be the structural and geotechnical engineers identified in the section 3.4 'CDS Design Organisation.' Whilst elements of the St Giles Circus project may become Contractor Design, the design of the adits, basement slab, retaining walls and tension piles/walls either side of the Crossrail tunnel will be traditionally designed.

3.7 Control Points and Controlling Authorities in Design

In common with all developments that occur within the Safeguarding Limits, the Planning authority will condition approval of the development to ensure that:

The detailed design and method statements for all ground floor structures, foundations and basements and for any other structures below ground level, including piling (temporary and permanent), have been submitted to and approved in writing by the Local Planning Authority which:

- Accommodate the proposed location of the Crossrail structures and tunnels.
- Accommodate ground movement arising from the construction thereof, and
- Mitigate the effects of noise and vibration arising from the operation of the Crossrail railway within the tunnels.

This CDS identifies the approach that is taken towards the design at the Planning Application stage. Once a conditional planning approval is obtained for the development the design will be developed to RIBA stage E. At RIBA stage E proposed construction method statements and checked calculations will be submitted with an updated CDS to Crossrail for review and comment. Once these have been agreed with Crossrail they will be included as a requirement within the Tender documents.

The Tender documents will also require the successful contractor to submit and obtain approval from Crossrail for all final Construction Method statements for the ground floor structures, foundations and basements prior to works commencing on site so that the planning conditions can be discharged.

All structures that form the envelope of the basement construction and associated piles (ie basement slab, piles, pile caps, diaphragm and secant pile retaining walls, adit beams) will be traditionally designed and procured so that the consultant team maintains full design responsibility for the structure that interfaces with Crossrail.

4 OUTLINE PROJECT PROGRAMME

4.1 Proposed Start and Completion Dates

The St Giles Circus project is currently at RIBA stage C as the scheme is going to planning. Figure 4.1 shows the anticipated design and construction programme. As the site will not be handed back from LUL until mid 2013/early 2014 construction is not anticipated to start until late 2013/early 2014 with an estimated completion date for the basement and superstructure works of late 2016/early 2017.

It is noted that the eastbound Crossrail TBM is due to pass under the site in early 2013 before any Project Sponsor works on site and that the basement and superstructure works are due to be completed before train running is due to commence in 2018.

5 PROPOSED WORKS

5.1 Description and Scope

Building A:

Building A comprises a 7 storey steel framed structure that houses a mixed use development that could include retail, hotel and leisure facilities. Steel is used as the framing system to minimise the weight of the structure that is imposed on the transfer structures and the foundations. The floor structure is formed of composite metal deck slabs which act compositely with steel beams. A main feature of the building is the 4 storey high covered Plaza on the Andrew Borde Street and Charing Cross Road sides of the building. Above the plaza is a 3 storey leisure facility that is supported on long span transfer trusses that transfer the gravity loads to a limited number of columns on the building's facade. On the Charing Cross Road facade these columns are supported by the existing Consolidated Piles.

Around the Plaza a moveable facade is provided that enables the area to be screened off from the surrounding streets for certain events. This moveable facade is supported at the top by the structure of the leisure facility and restrained approximately 4m above ground level by a horizontal beam or transom that spans between the main facade columns. At the corner of Charing Cross Road and Andrew Borde Street a 'dummy column' is provided which is actually hung from the leisure facility above. This dummy column supports and restrains the corner of the moveable facade rail without imposing vertical foundation loads at its base. This is because the dummy column is located too close to the Escalator Box, Crossrail Tunnel and new Tottenham Court Road ticket hall to enable an independent foundation to be constructed.

To the south side of the Plaza is a 4 storey mixed use building which provides vertical circulation and stability to the leisure facility above. Stability is provided by the diaphragm action of the floor plates transferring horizontal loads back to the stability cores where vertical bracing around the stairs, lifts and risers transfers the horizontal loads to the ground floor slab which is itself restrained by the retaining walls of the basement box.

The positions of the columns at ground floor have been co-ordinated with the below ground infrastructure to avoid the footprint of the Eastbound Crossrail tunnel and the exclusion zone around it identified in the Agreement between Consolidated Developments and the Secretary of State for Transport.

Building B:

Building B is a 5 storey mixed use building that is similar in form and construction to Building A. A single storey covered Plaza is formed at ground floor with a two storey pub and a single storey restaurant above. Steel transfer structures span between the main supporting columns on the west and east sides of the building.

A top hung moveable facade runs along the Andrew Borde Street side of the building and is restrained by a transom approximately 4m above ground level. The transom spans between the superstructure columns.

Stability is provided by vertical bracing behind the riser, on the Andrew Borde Street facade and behind the fixed screens on the east side of the Plaza. The transfer trusses and superstructure columns on the west side of the Plaza also contribute to the stability system of the building. At ground floor level the horizontal loads are transferred by the ground floor slab to the basement retaining walls. At the third floor level an interconnecting floor slab is provided between buildings A and B, it is proposed that a movement joint is provided between the buildings to keep the stability systems separate and control differential movements.

The footprint of the building is clear of the Escalator box, however the Eastbound Crossrail tunnel runs diagonally across the building. Column positions at ground floor level have been planned to avoid landing on the Crossrail tunnels and exclusion zones as far as possible, however some columns land close to the exclusion zone and are transferred around it by the basement box structure.

Building C:

The 4 storey building C provides bedroom accommodation for the hotel and is linked to Building A by a lightweight glazed bridge structure. The regular arrangement of the structure and spans of up to 8m allow for the use a concrete flat slab structure that minimises the depth of the structural zone and allows for the horizontal distribution of services.

Stability is provided by concrete shear walls that go to the ground floor where horizontal loads are transferred by the ground floor slab to the basement retaining walls.

Building D:

Building D is a 4 storey concrete framed structure that houses the building services plant that serves the majority of the project. A concrete flat slab structure spanning up to 7m between columns is utilised to provide the maximum clear height for the services and provide a robust structure with sufficient mass to void vibration problems.

The concrete structure also restrains the retained facade on St Giles High Street. Stability is provided by a combination of concrete shear walls and sway frame action of the closely spaced columns behind the existing facade.

The northern part of the building houses kitchens and plant associated with building B and is connected to building B. As this part of the building is above the box in box construction it is proposed to frame this building in steel with composite floors to minimise the loads that need to be transferred over the box in box structure.

Basement Box:

A new basement is proposed beneath buildings A, B, C and D which will form an Event Gallery for up to 2,000 people. The central part of the Event Gallery is a column free space of approximately 18m x30m with the maximum clear height possible. A mezzanine is provided around the Event Gallery to accommodate bars and ancillary activities. On the south side of the site, adjacent to Denmark Place, the depth of the basement is increased to accommodate the foul drainage sump and pump, lift pits and sprinkler tanks. This area of deeper basement is clear of both Crossrail and the Escalator Box.

The footprint of the basement is constrained by the Escalator Box to the West, Andrew Borde Street to the North, the retained facade on St Giles High Street to the East and retained (some listed) buildings to the South on Denmark Place.

As the Event Gallery is located directly above the Eastbound Crossrail tunnel the depth of the basement is constrained by the exclusion zone around the Tunnel as detailed in the Crossrail Information for Developers (February 2008) which puts a 6.0m clearance between the outside of the tunnel and the development above. The Crossrail Information for Developers also allows for an 'Alignment adjustment zone' of 3.0 m above and to the sides of the tunnel, however at the site location the tunnel is constrained by passing under the Escalator Box so its position is fixed at this location. As part of the Agreement between the Secretary of State for Transport and the Project Sponsor, it was agreed that the exclusion zone between the Crossrail tunnel and the oversite development could be reduced to a minimum of 1.0m at the Escalator Box, increasing to 3.0m where the centre of the tunnel alignment crosses the Eastern boundary of the site. Furthermore the drawings in the Agreement note that 'the exclusion zone shown on this drawing allows for the development of the Crossrail alignment to the East of the safeguarding tunnel. Subject to agreement with Crossrail, piling may be permitted in this zone once the alignment is fixed. However, no piles closer than 1.0m clear from outside of tunnel will be allowed, and no piles within the exclusion zone may be closer than the pile diameter from the tunnel.' The drawings from the Agreement are shown in Appendix B.

The design for the basement has therefore been progressed on the basis that no foundation structures will be allowed closer than 1.0m clear (including allowances for construction tolerances) from the outside of the tunnel, and that the basement structure should be 6m above the tunnel crown. After consideration of the construction method (see section 7.1) a minimum dimension of 2.0m between the outside of the pile and the outside of the tunnel is proposed. The minimum dimension allows for pile construction tolerances.

As a significant amount of the existing overburden above the Eastbound Crossrail tunnel will be removed by the basement excavation, a concept for the basement structure has been developed that will restrain the ground movements, particularly heave, caused by the removal of the overburden. The concept involves the installation of diaphragm walls or tension piles either side of the Eastbound Crossrail tunnel and the construction of 'adit' beams between the diaphragm walls or tension piles prior to the basement excavation above the tunnel. This system of 'adit' beams and tension piles is designed to resist the heave forces generated by the basement excavation and therefore control the movements experienced by the Eastbound Crossrail tunnel. The principle has been previously discussed with Crossrail in meetings in 2011 and preliminary static design checks for the structural system are included in Appendix K. Section 7 describes development of the Concept Design to further control ground movements, particularly heave.

Given the relative proximity of the Event Gallery to both Crossrail and the Northern Line, an acoustic assessment of the noise from the trains has been made and is included in Appendix C. This has resulted in the adoption of a box in box structure around the Event Gallery.

No 22 Denmark Place

This building (at the rear of 26 Denmark Street) is a single storey timber framed building with brick infill that is grade II listed. Part of the building sits above the proposed Eastbound Crossrail tunnel. Initially it was proposed to construct the basement around this building, however this creates a discontinuity in the heave restraint system described above and also results in significant movements due to both the basement construction and the Crossrail tunnelling. The Basement Impact Assessment has identified that the movement would result in 'severe' damage to this building in accordance with the Burland damage classification (see figure 5.1), whereas the assessment of movements due to Crossrail alone (see Appendix L) show that the damage caused would be negligible. As a result it is proposed to extend the basement under No. 22 Denmark Place in order to maintain a consistent heave restraint system. In order to mitigate the effects of movement it is proposed to support the existing building on a grillage of steel beams installed between piles. An initial excavation to 3m clear depth below the footprint of the retained building will then be undertaken before installing hand dug caissons that will act as tension piles to hold down the adit beams. Basement construction will then proceed in the same way as the rest of the basement box.

Nos. 21 to 25 Denmark Street:

These existing buildings are to be retained and refurbished as part of the development. The principle structural alterations are the addition of a new floor with a mansard roof. In order to minimise the change in foundation loads associated with the new floor it is proposed to replace the existing roof construction with a lightweight steel and timber floor construction and form the mansard roof out of similar lightweight construction.

The existing first floor structure at No. 21 Denmark Street will also be removed to improve access to the development from Denmark Street. Steel frames will be provided between ground and second floor at No. 21 to restrain the party walls and support the lightwell above.

An assessment of the movements caused to these buildings by the construction of the Crossrail tunnels has been made and shown that the effects are 'negligible' according to the Burland method. As the change in existing load on these building is very minor no impact is anticipated on the Crossrail tunnels.

No. 4 Flitcroft Street and No.1 Book Mews:

These existing buildings are to be refurbished as part of the development. The existing lower ground floor in 4 Flitcroft Street will be lowered to connect to a new basement below the existing yard and No. 1 Book Mews. Underpinning of existing party walls is proposed to form the perimeter retaining walls to the basement and a new ground bearing raft slab founded on the terrace gravels will be constructed between the retaining walls to support the internal column loads. Tension piles will be utilised to resist heave and water pressure under the centre of the slab.

The existing upper ground floor in 4 Flitcroft Street will be removed and reconstructed at street level to prop the top of the retaining wall and align with the level of adjacent properties.

The basement excavation to formation level is proposed to be approximately 5m below ground and the closest part of the basement to the Crossrail works is approximately 12m from the centreline of the Westbound running tunnel.

An assessment of the movements caused to these buildings by the construction of the Crossrail tunnels has been made and shown that the effects are 'negligible' according to the Burland method.

Nos. 6, 7, 9, 10 Denmark Street:

The structural refurbishment of these buildings is limited to change of use from commercial to residential, some internal modifications to create new openings in load bearing walls and replacement of the existing mansard roof at No. 10. As this refurbishment does not materially affect the existing loads supported by the foundations, no impact is anticipated on the Crossrail tunnels.

An assessment of the movements caused to these buildings by the construction of the Crossrail tunnels has been made and shown that the effects are 'negligible' according to the Burland method.

Nos. 4 Denmark Street:

This existing buildings is to be retained and refurbished as part of the development. The principle structural alteration is the addition of a new floor with a mansard roof. In order to minimise the change in foundation loads associated with the new floor it is proposed to replace the existing roof construction with a lightweight steel and timber floor construction and form the mansard roof out of similar lightweight construction.

An assessment of the movements caused to this buildings by the construction of the Crossrail tunnels has been made and shown that the effects are 'negligible' according to the Burland method. As the change in existing load on these building is very minor no impact is anticipated on the Crossrail tunnels.

Nos. 126 to 136 Charing Cross Road, Nos. 18 to 20, 26 to 28 Denmark Street, No. 59 St Giles High Street:

No significant structural alterations are proposed to these buildings. An assessment of the movements caused to these buildings by the construction of the Crossrail tunnels has been made and shown that the effects are 'negligible' according to the Burland method.

No 71 Endell Street

This existing buildings is to be retained and refurbished as part of the development. The existing roof structure is to be replaced and some internal alterations are proposed to load bearing walls.

An assessment of the movements caused to this buildings by the construction of the Crossrail tunnels has been made and shown that the effects are 'negligible' according to the Burland method. As the change in existing load on these building is very minor no impact is anticipated on the Crossrail tunnels.

6 ASSUMPTIONS

6.1 Existing Conditions

The site is located within the London Borough of Camden at National Grid Reference TQ 298 812. The Northern part of the site is bound to the west by the Charing Cross Road, to the south by Denmark Street and to the north and east by St Giles Street. A further portion of the site is located to the south of Denmark Street, at numbers 4, 6,7, 9 and 10 Denmark Street, number 4 Flitcroft Street and number 1 Book Mews. No. 71 Endell Street is also included within the development.

The site currently comprises several commercial buildings. There is an existing single level basement at 144 Charing Cross Road and basements are present below a number of the properties that line Denmark Place and Denmark Street.

Existing London Underground Northern Line station tunnels (Northbound and Southbound) are located immediately to the west of the site and lie in a north-south direction. The Southbound Northern Line tunnel is the nearer of the two to the proposed location of the piles. One of the Crossrail tunnels will run below the site from west to east.

An initial site investigation has been carried out at the site by STATS Ltd on behalf of Consolidated Developments Ltd. The works were carried out during the period between 8th April and 16th May 2008.

The investigation included the sinking of two cable percussive boreholes (BH) to a depth of 7.6mbgl. BH101 was extended to 63.5mbgl by rotary coring and BH102 was extended to 54.0mbgl using open hole rotary drilling. Nine self-boring pressuremeter tests were carried out within BH102 and further in-situ and laboratory testing was conducted. Four piezometers were installed to depths of 15.0, 24.1, 35.05 and 55.0mbgl.

Full details of the Ground Investigation are presented within the STATS Factual Report on Ground Investigation (STATS, 2008), included in Appendix G.

The investigation revealed the following strata:

Table 6.1 Design Stratum Levels

Stratum	**Top Of Stratum Level**		**Thickness (m)**	**Description**
	mOD	**mOD +100**		
Made Ground	+25.10	125.10	4.4	Brick rubble and ceramic fragments changing with depth to slightly sandy gravely Clay.
Terrace Gravel	+20.70	120.70	1.6	Dense to very dense, slightly silty sandy fine to coarse angular to subrounded Gravel.
London Clay	+19.10	119.10	24.1	Firm, becoming stiff and very stiff with depth, fissured locally thinly laminated Clay. Weak mudstone bands present between +12.70 and +3.55mOD.
Cohesive Lambeth Group	-5.00	95.00	11.1	Very stiff and hard, locally laminated, Clay becoming very dense laminated, locally silty, fine Sand with depth.
Cohesionless Lambeth Group	-16.1	83.90	7.6	
Thanet Sand	-23.70	76.30	4.7	Very dense silty fine Sand. A 0.7m thick layer of flint cobbled present at the base interface.
Chalk	-28.40	71.60	Proven to 10.7	Weak to moderately weak, medium density structured Chalk.

Geotechnical parameters for each stratum, and a design ground water profile, are given in the modelling report.

The factual results of the STATS site investigations are shown in appendix G. A site investigation is currently being procured for the South of Denmark Street site to support the Basement Impact Assessment. Once the site is returned to the Project Sponsor by London Underground following completion of the initial phase of the Tottenham Court Road station upgrade works a further intrusive site investigation will be undertaken to confirm the ground conditions over the remainder of the site and enable detailed design to commence.

6.2 Design Assumptions

The following assumptions have been made with respect to the Crossrail Tunnel:

Item	Assumption	Source
1. Outside diameter of tunnel	7.0m diameter	Fig. 1, Crossrail Information for Developers, February 2008.
2. Vertical clearance requirement	6.0m	Fig. 1, Crossrail Information for Developers, February 2008.
3. Horizontal clearance requirement	Varies 1.0m to 3.0m	Drawing 009942 S020-003 rev P3, Agreement between the Secretary of State for Transport and Consolidated Developments
4. Volume loss during tunnel construction	1.0% from EPB TBM	Minutes of meeting with Crossrail on 31/10/11.
5. Track base construction	Floating slab in Eastbound tunnel. Floating slab in Westbound tunnel returns to standard track slab at chainage 5177m	Minutes of meeting between with Crossrail on 31/10/11. Crossrail comments on draft CDS dated 17/08/12.
6. Rail head level	Varies between 101.882mATD at chainage 5,070m and 102.202mATD at chainage 5,030m	Drawing C122-OVE-C4-DDA-CR001_Z-21115 Rev C01
7. Distance between tunnel centreline and rail head	1.935m (+/-100mm)	Minutes of meeting with Crossrail on 26/9/11.
8. Design line speed	100km/h (62.5mph)	
9. Noise and Vibration	Refer to Appendix C	Annex 2, Crossrail Information for Developers, February2008.

The following design assumptions have been made with respect to the geotechnical modelling:

Item	Assumption	Source
1. Geotechnical parameters	Use same parameters as agreed with LUL for the design of the Consolidated Piles.	STATS investigation
2. Basement construction period	18 months.	To be verified by Construction Methodology Consultant
3. Adit spacing	Modelled as different % stiffness of tunnel length.	
4. Diaphragm wall constructed under bentonite.	No plane strain wall construction movements included.	

6.3 Proposed Method of Design Reviews, Analysis and Independent Checks

Prior to submission to Crossrail this CDS has been reviewed internally by both Donaldson Associates and Engenuiti in accordance with our QA procedures. At RIBA Stage E a category 2 check of the design will be undertaken following the initial review and incorporation of any comments on the RIBA stage E CDS from Crossrail.

6.4 Design Check Category Specified

Category 2

7 EFFECTS OF PROPOSED CONSTRUCTION ON CROSSRAIL

7.1 Risk Based Approach

The design approach has generated a concept for the basement box in which the tunnel movements are acceptable in terms of overall movement. In order to identify the risk of poor installation, a parametric study has been carried out in order to identify the most effective location for the elements and sizing to reduce the associated risk to the tunnel.

The parametric study has covered variations in:

- ground parameters and strata levels
- adit size, location and spacing
- heave restraint wall size, construction method and length

As noted in section 6, it is recommended that further SI is carried out in order to ensure that the parametric study includes all reasonable variation in ground properties.

A selection of appropriate adit, heave restraint wall and slab locations and sizes has been made in order to limit the risk of construction problems causing movement of the tunnel. The following table summarises the parameters considered and the proposed design, for further details refer to Appendix J.

Parameter	Options considered	Risk	Recommendation
Toe level of wall.	80m, 85m, 90m, 95m, 100m above LUL datum.	The change on toe level has a noticeable effect on tunnel movements.	Proceed with toe level of +80m above LUL datum to minimise tunnel movement.
Adit spacing	2.4m, 3.0m, 3.6m	Changes in adit spacing have little impact on tunnel movements	Proceed with maximum adit spacing (revised to 3.46m) to minimise length of hand dug adits and provide safer means of construction.
Adit heights	0.5m, 1.5m, 1.8m	Changes in adit height (and stiffness) have little impact on tunnel movements	Proceed with 1.8m high adit so that it is simpler and safer to hand dig and excavation is open for minimum period. Increased depth also required to reduce shear reinforcement requirements for static design check.
Spacing between embedded wall and Crossrail tunnel	1.0m, 2.0m, 3.0m clear.	The closer the wall is the to Crossrail tunnel, the less the predicted tunnel movement is due to heave. Closer walls also reduce the span of the adit beams, further reducing movement and adit construction risk. Closer walls increase the risk that construction of the wall will cause movement to Crossrail due to relaxation of earth pressure and face losses.	Decision linked to type of embedded wall and wall cross section below. Based on 900mm dia secant wall a minimum clear distance of 2.0m is proposed so that the pile is at least 2 pile diameters away from the nearest part of the Crossrail tunnel. It is noted that the construction of the large diameter Consolidated Piles 1.1m clear of the Northern Line tunnel had a predicted movement of 1mm.
Type of embedded wall either side of	Diaphragm wall Secant wall	Assuming wall is sized for same stiffness, selection comes down to construction risk. Diaphragm walls require	Secant wall proposed to reduce working space required on site, reduce length of excavation open at any one time, enable

Crossrail tunnel		more construction space, larger rigs and larger bentonite plant. Diaphragm walls also have a longer face of open excavation (typically 3m) and would need careful co-ordination between reinforcement cages and the soft spot for adit breakthrough.	co-ordination between pile positions and adit locations (larger pile used at adit location with toe level just above top of adit), reduce need for hand breaking out of concrete.
Tension reinforcement to embedded wall	External steel casing Plunge column Conventional reinforcement	External steel casing can provide larger cross-sectional area to pile, but limits reinforcement to every other pile and is subject to section loss due to corrosion. Plunge column provides a large area of reinforcement within a relatively small element, but is difficult to accurately construct at depth and local connection to adit beams is problematic. Cross-sectional area of reinforcement is constrained by pile diameter, but is a tried and tested technique for tension piles and easier to connect adit beams to.	Conventional reinforcement to minimise construction risk.
Wall cross section	900mm dia, 1050mm dia, 1200mm dia, 1600mm dia, 2100mm dia	Smaller diameter piles will have a smaller zone of influence and will provide a larger surface area for a given concrete volume. In order to allow hit and miss construction either 1 or 3 piles between adits are recommended. One pile between adits would require a 2.1m dia pile to provide sufficient surface area per metre run, three piles would require 900mm dia piles to give sufficient surface area per metre run.	Proceed with 3No. 900mm dia piles between adits to enable piles to be constructed closer to Crossrail tunnel.
Connection between basement slab and adit beams	Slab cast between adit beams. Slab cast on top of adit beams.	Slab cast between adit beams would require shear connection between side of adit beams and discontinuous reinforcement, taking longer to excavate and fix. Adit beam depth would be less. Slab cast on top of adit beams allows speedy excavation and reinforcement placement, design of slab as a continuous member, requires tie bars between adit beam and slab to resist heave.	Proceed with basement slab cast on top of adit beams to minimise construction period and hence control heave between adit beams. Extra depth of adit beam to be used to reduce deflection (shrinkage of second pour would also help deflected shape) and accommodate post-tensioning tendons. Simpler and therefore quicker and safer construction of adit beams.
Excavation of	Timber	Timber headings require	Excavate adits with timber

adits	headings Pipe jacking	manual excavation in confined spaces and their use should be minimised (see adit spacing above). Pipe jacking would reduce risk to operatives, however the space and forces needed undertake the pipe jacking are more than can be accommodated in the basement either side of the Crossrail tunnel. There is also a risk that pipe jacking would be difficult to align with the opening for the adit in the piles opposite.	headings as it's a tried and tested technique (eg Westminster Station) and it reduces the risk of construction problems with alignment and connection to the embedded wall.
Connection between adit beam and tension pile	Analyse as fixed. Analyse as simply supported.	A fixed connection would reduce the deflection and peak moments experienced by the adit beam, but is harder to achieve as the adit and piles as cast at separate times. A simply supported connection will result in increased deflections and mid span moments, but can be more easily achieved with appropriate reinforcement.	Analyse as simply supported as moment continuity between the adit beams and the piles is difficult to achieve and could potentially result in an optimistic assessment of deflections in the adit beam.
Bending stiffness of adit beam	Consider beam as acting compositely with basement slab. Consider beam as non-composite.	Composite action of the basement slab with the adit beam would add to the stiffness and reduce the deflection experienced by the adit beam. Non-composite action would conservatively model the beam stiffness.	As the adit beam is modelled as simply supported the basement slab would go into tension as a result of composite action between the basement slab and the adit beam. The design is therefore progressed on the basis that any composite action is limited to the tension reinforcement provided in the basement slab directly above the adit beam.

7.2 Summary of Predicted Settlements

Appendix J identifies the modelling assumptions and the results of the parametric modelling report, the following table summarises the tunnel movements predicted by this modelling report during the construction of the basement.

Location	Movement	Comments
Tunnel crown	10mm upwards	
Tunnel invert	6mm upwards	
Tunnel sidewalls	3mm inwards (relative to centre)	
Relative movement between tunnel invert and crown	4mm extension	

Taking into account the long term effects of heave, the following total long term tunnel movements are predicted.

Location	Movement	Comments
Tunnel crown	12mm upwards	
Tunnel invert	8mm upwards	
Tunnel sidewalls	1.5mm inwards (relative to centre)	
Relative movement between tunnel invert and crown	4mm extension	

7.3 Summary of Surcharge Loading Changes

The change in surcharge on the site is based on subtracting an assessment of the self weight of demolished buildings on the site and the weight of existing strata excavated on the site from the self weight the proposed new building structures with spread footings. Where proposed buildings are founded on deep pile foundations (as is the case for Buildings A, B and C) the weight of the new structure in the assessment is limited to the basement slab as the remainder of the loads will be supported by strata below the mid axis of the Crossrail tunnel. It should be noted that this load assessment is preliminary based on the current status of the design, as the design develops allowances for the self weight of finishes and different structural systems may vary slightly.

Figure 7.1 and table 7.1 show the preliminary assessment of the change in surcharge.

7.4 Summary of Predicted Construction Interface Impacts

7.4.1 Tunnel segments and segment joints.

Based on the movements predicted in the settlement analysis (from Plaxis modelling) a preliminary assessment of stresses in the segmental tunnel lining has been made and is included in Appendix K. This demonstrates that the movements that result from heave reduce the axial and bending stresses in the tunnel lining compared with a base case of the tunnel constructed prior to excavation of the basement on the site.

The assessment considers active earth pressures applied to the tunnel lining and validates a 2D analysis model of the tunnel lining against Ilya Mikhelson's classic formulae for forces in a tunnel. In order to model the effects of the segmental tunnel construction two bending stiffnesses for the tunnel lining are considered:

1. A continuous concrete lining 300mm thick.
2. A continuous concrete lining 300mm thick, but with a second moment of area reduced by 50% to allow for the staggered segments.

A vertical UDL ('heave' load) is then applied to these models to generate the 4mm movement predicted predicted by the Plaxis model. The resulting axial forces and bending moments in the tunnel lining are then assessed for the Eurocode load combinations and verified against the ultimate strength capacity of the section. The maximum compressive stress is assessed to be at 70% utilisation at the bearing between segments, and tension is only generated in the section prior to excavation of the basement.

It is therefore concluded that the construction of the basement will not cause overstressing of the tunnel segments and tunnel joints.

7.4.2 Waterproofing of tunnel segment joints.

The vertical movement of the tunnel below the site will result in relative vertical movement between the tunnel under the site and the tunnel either side of the site. As the circumferential joints between the segment rings are only connected with plastic dowel connectors, it is assumed that these joints are not capable of transmitting significant tensile forces that would result from bending the tunnel about a horizontal axis. The relative vertical movement must therefore be accommodated by the relative rotation of adjacent segment rings over a transition length from no relative movement to the full 12mm relative movement predicted under the basement.

Based on a transition length of 6.0m (depth between basement and tunnel crown) either side of a change in overburden pressure, and an intermediate situation where the overburden removed is less below the escalator box and building D, an assessment of the rotation between adjacent segments has been made. This has demonstrated that the predicted rotation between adjacent rings is in the order of 0.02 degrees, which would result in a closing or opening up of the joint by 1.2mm. This compares favourably with the planned 3.0mm gap between segment rings.

At the time of writing the selected water-proofing product (KH11.3112) is yet to be confirmed, as is the size of the rebate for the gasket. However, given the specification requirement for the hydrophilic rubber to 'exhibit at least four times volumetric swelling when immersed for a period of 28 days in a salt water solution containing 1% chloride ions and 0.5% sulphate ions' and the typical hydrophilic strip size of 10mm, it is not anticipated that an opening up of the joint by 1.2mm will cause a problem for the hydrophilic seal.

7.4.3 Clearance between tunnel lining and dynamic kinematic envelope

The information provided by Crossrail (Appendix D) states that the minimum gauge clearance between the tunnel lining and the dynamic kinematic envelope is to be 50mm. Note 3 on drawing C122-OVE-C4-DDD-CR001_Z-23123/C01 indicates that 100mm is provided between the kinematic swept envelope and the structural envelope. Allowing for the predicted 4mm movement of the tunnel crown and side walls leaves 46mm of allowance for other construction tolerances.

7.4.4 Clearance between track and overhead conductors

The tolerance on the dimension between the top of the rail and the roof mounted bracket supporting the OHE is -0 to +10mm (item 3.3 of meeting minutes from 31 October 2011). Therefore the predicted long term extension between tunnel invert and crown of 4mm is within these limits.

7.4.5 Track geometry movement or distortion

The predicted horizontal movements of the tunnel lining are symmetrical, therefore any impacts on track geometry would be related to vertical movement of the tunnel invert that supports the track bed. The maximum predicted movement of the tunnel invert is 8mm (long term). As the track is likely to be installed part way through the basement construction the actual figure after installation of the track is likely to be less than this, however the 8mm figure is used to mitigate the effect of any delays in the construction.

From NR/L2/TRK/001/C01 Appendix A, the following limits for 'No mandated action' apply for a line speed between 51 and 75mph:

3m twist limit: 12mm

Top limit: 18mm

Line limits: 13mm.

Therefore by inspection the predicted movement of 8mm (albeit over a length much greater than the 3m length limit for twist) falls well within the no mandated action limits.

7.4.6 Track drainage systems

The predicted movements of the tunnel invert (8mm) will not adversely affect the track drainage system which has a minimum depth much greater than this. Assuming a minimum fall of 1in 80 (fall not shown on drawings), the change in fall of 1 in 450 that results from the predicted longitudinal profile will not affect the water flow within the drainage system. As the waterproofing of the tunnel segments is not adversely affected by the predicted movements the amount of water ingress into the tunnel will not be adversely affected.

7.4.7 Mechanical and Electrical equipment, internal structures

The relative movements and curvatures identified in the earlier sections of this report are less than the limiting values that buildings and infrastructure are normally designed for. In building structures with brittle finishes deflections after construction are typically limited to span/500. Assuming that the movements occur after the installation of the above equipment and that the equipment (such as the walkway structures) is potentially brittle, an allowable movement across the 7.0m OD tunnel would be 14mm, this is significantly more than the 4mm relative movement predicted.

As there is at least 6 metres between the outside of the running tunnel and the Mechanical and Electrical services in the development there is no interface between the Mechanical and Electrical services of the development and the Eastbound running tunnel.

As there is at least 6 metres between the outside of the running tunnel and services in the development there is no interface between communications and control equipment in the tunnel and the basement.

8 EFFECTS OF CROSSRAIL ON PROPOSED DEVELOPMENT

8.1 Approach

The approach to the design of the new basement has been to locally control the effects of heave on the tunnel by enclosing it with tension piles and adit beams that transfer the uplift forces generated by the heave to the strata below the Crossrail tunnel.

8.2 Predicted settlement damage assessment

The effect of Crossrail on the development can be divided into two distinct zones:

1. The new buildings and basement that are constructed above and around the Eastbound Crossrail tunnel.

2. The existing buildings that are to be refurbished as part of the development, including the addition of a mansard roof to some properties on Denmark Street and the construction of an enlarged basement at 4 Flitcroft Street.

The new buildings will be founded on deep piled foundations that extend well below the mid axis depth of the Crossrail tunnel, therefore the principle effect of the Crossrail tunnel is the need to control movements on the tunnel that result from the basement excavation and the planning of the foundations to avoid foundations that are too close to the tunnel. As the new buildings are steel or concrete framed the sub and superstructures will be designed to accommodate relative movements between the piled foundations.

The existing buildings that are retained and modified are assessed in Appendix L

8.3 Noise and Vibration Assessment

The noise and vibration assessment is presented in Appendix C. As can be seen the proximity of the development to both Crossrail and the Northern Line, coupled with the proposed use of the basement Event Gallery results in the adoption of a box in box structure for the Event Gallery. The use of deep piled foundations elsewhere on the development provides sufficient isolation from noise and vibration for the proposed uses of the building.

9 PROPOSED CONSTRUCTION METHOD

9.1 Description of the works and method of construction

The works described are those required to excavate a deep basement on site. These consist of both temporary and permanent works as follows:

Element	Purpose	Construction method(s)
Basement wall	Temporary and permanent retention on outer boundary of basement	Secant and contiguous walls formed by piling OR diaphragm walls formed by panel excavation under bentonite. Next to LUL Northern line escalator, re-use of the existing piled wall as temporary works is anticipated.
Ground floor slab	Parts of the slab cast prior to excavation to prop retaining walls and heave restraint walls	Cast-in-situ reinforced concrete
Heave restraint walls	To confine and limit the heave experienced by the CRL tunnel during excavation of the basement outside the tunnel zone. To provide permanent heave protection in conjunction with horizontal beams and slab over the tunnel area.	Secant and contiguous walls formed by piling OR diaphragm walls formed by panel excavation under bentonite.
Tunnelled adits	Provide temporary tunnels and formwork for temporary and permanent horizontal heave-reduction beams across the tunnel, connected to the basement slab and the heave restraint walls	Timber headings constructed across the tunnel zone prior to excavation. Reinforced concrete beams to be constructed within the adits.
Basement slab	Provide additional heave control above tunnel.	Cast-in-situ reinforced concrete connected to heave restraint walls and adit beams.

The construction method and proposed construction sequence has been reviewed and commented on by the following specialist contractors: Keltbray, Mace and Bauer.

The anticipated construction sequence is illustrated in the modelling report and the following steps are illustrated on 029-S-501 to 029-S-529 in Appendix I.

01: Demolition, Enabling Works and Facade Retention

1. Site set up.
2. Install monitoring system to Eastbound Crossrail tunnel.
3. Install monitoring system to NLEB.
4. Utility diversions/capping for those utilities that cross the site.
5. Install facade retention to York and Clifton Mansions (fill under-street vaults for kentledge, provide external steel frame retention system through windows with possible site accommodation above street, tie back through 59 St Giles High Street to avoid props across basement footprint).
6. Demolish York and Clifton Mansions.
7. Recover and store facades to 17 to 21 Denmark Place (provide steel frame around single storey sections of each facade, diamond saw cut facade from rear, lift out and store off-site. All subject to condition survey and assessment of facades to be retained).
8. Demolish 17 to 21 Denmark Place and buildings to North site of Denmark Place.

Note: Steps 07, 08 and 09 below can be constructed concurrently with steps 02 to 06 below.

02: LUL Escalator Box breakout and stage 1 excavation

1. Remove temporary road slab to NLEB and excavate to +123.5m.

03: LUL Escalator Box capping beam props installation

1. Install temporary steel propping system at +124.5m

04: LUL Escalator Box stage 2 excavation

1. Excavate NLEB to +119.0m, maintaining 2.0m overburden to top of inclined concrete box.

05: LUL Escalator Box stage 2 props installation

1. Install temporary propping to NLEB at +120.0m.

06: LUL Escalator Box stage 3 excavation (also see 029-S-560 to 029-S-564 incl.)

1. Excavate NLEB to +114.0m and install blinding and compressible void former.
2. Construct basement slab above NLEB with discreet connection through LUL temporary secant wall to new secant wall to East of NLEB. West side supported off Consolidated Piles. Outer steel casing of Consolidated Piles to be burnt back to reveal de-bonding layer and inner steel casing.
3. Construct retaining wall to West side of NLEB, spanning between Consolidated Piles.
4. Construct retaining wall to underside of mezzanine slab, supported by retaining wall to West side of NLEB and discreet connection through LUL temporary secant wall to new secant wall to East of NLEB.
5. Backfill outside retaining wall to underside mezzanine slab.
6. Construct mezzanine slab above NLEB.
7. Remove temporary propping to NLEB at +120.0m.
8. Construct retaining wall to underside of ground floor slab, supported by retaining wall to West side of NLEB and discreet connection through LUL temporary secant wall to new secant wall to East of NLEB.
9. Backfill outside retaining wall to below temporary props.
10. Remove temporary props at 124.5m
11. Backfill NLEB to underside of ground floor slab.
12. Construct ground floor slab above NLEB, supported off Consolidated Piles and new secant wall to East of NLEB.

07: Piled Wall construction to Crossrail Tunnel

1. Install secant pile wall either side of Crossrail tunnel, including 'adit' piles.

08: Piled Wall construction to basement perimeter

1. Install secant pile wall around basement footprint, starting at East side of NLEB and basement over link tunnel to Northern Line platforms.

09: Main Piles and Tension Piles installation

1. Install tension and load bearing piles over remainder of basement footprint, piles to be cast to just above basement slab level.
2. Construct capping beam around basement perimeter.

Note: The construction of the basement at the rear of 26 Denmark Street can occur concurrently with steps 10 to 16.

Basement at rear of 26 Denmark Street (refer to 029-S-550 to 029-S-556)

1. Construct temporary foundations either side of existing walls above basement and needle through.

2. Underpin existing wall immediately outside basement footprint to depth of 1.5m below existing footing.
3. Install grillage of supporting steel beams below existing walls and support on underpins/temporary piles.
4. Excavate to 1.5m depth within underpins and secant piled wall below 22 Denmark Place.
5. Underpin again to 3.0m depth below existing footings below rear of 22 Denmark Place.
6. Excavate to 3.0m depth below 22 Denmark Place.
7. Underpin again to 4.5m depth below existing footing below 22 Denmark Place.
8. Commence Caisson excavation under rear of 22 Denmark Place.
9. Complete Caisson excavation and under-ream to required toe level.
10. Cast RC tension 'pile' within Caisson to underside of Adit beam.
11. Excavate adit beams to Caissons as step 17 below.

Note: the sequencing of the Northern and Southern basement excavations in steps 10 to 16 below can be amended to have either the Northern excavated first or the Southern excavated first to suit site logistics.

10: Excavation of Northern Basement Stage 1

1. Excavate Northern Basement to +122.5m around.
2. Install temporary propping to Northern Basement at +123.5m.

11: Install temporary props in Northern Basement

1. Excavate Northern Basement to +119.0m.
2. Install temporary propping to Northern Basement at +120.0m.

12: Excavation of Southern Basement Stage 1

1. Excavate Southern Basement to +122.5m.
2. Install temporary propping to Southern Basement at +123.5m.

13: Install temporary props in Southern Basement

1. Excavate Southern Basement to +119.0m.
2. Install temporary propping to Southern Basement at +120.0m.

14: Excavation of Northern Basement Stage 2

1. Excavate Northern Basement to formation level, breaking piles down to cut off level.

15: Northern Basement Slab and Adit breakouts

1. Install blinding and heave protection layer and then cast Northern Basement slab with openings for adit beam construction.

16: Southern Basement Excavation and cast slab

1. Excavate Southern Basement to formation level, breaking piles down to cut off level.
2. Install blinding and heave protection layer and then cast Southern Basement slab with openings for adit beam construction.

17: Adit beam construction over Crossrail Tunnel

1. Excavate and construct adit beams from North to South over Crossrail Tunnel in hit and miss. Cast concrete blinding at the base of each adit at the end of each working day to reduce softening of the London Clay below the adit.

18: Crossrail over-basement excavation stage 1

1. Excavate Crossrail over-basement to 122.5m.

19: Crossrail over-basement propping stage 1

1. Install temporary propping to Crossrail over-basement at +123.5m.

20: Crossrail over-basement excavation stage 2

1. Excavate Crossrail over-basement to +119.0m.

21: Crossrail over-basement propping stage 2

1. Install temporary propping to Crossrail over-basement at +120.0m.

22: Excavation to adit level and construct base slab

1. Excavate Crossrail over-basement to formation level, exposing top of adit beams and removing any biodegradable formers to the top of the adit.
2. Cast continuous Crossrail over-basement slab direct against blinding to control future heave.

23: Construct basement liner walls and install raking props

1. Construct retaining wall liner walls, (excluding box in box construction) to below mezzanine slab.
2. Install raking props between liner wall and basement slab at underside of mezzanine slab and below capping beam to prop retaining wall.

24: Remove temporary horizontal props

1. Remove temporary props installed at +120.0m and +123.5m.

25: Demolish Crossrail over-basement temporary piles.

1. Breakdown secant pile wall either side of Crossrail tunnel to basement slab level except where wall buttresses NLEB.

26: Construct basement to mezzanine level walls and columns.

1. Internal walls and columns to underside of mezzanine slab.

27: Construct basement mezzanine in situ concrete slab.

1. Construct mezzanine slab (excluding where raking props pass through structure).
2. Commence steel frame for Event Gallery roof slab.

28: Construct mezzanine to ground floor walls and columns.

1. Construct internal walls and columns to underside of ground floor slab.
2. Complete basement retaining wall liner wall.

29: Construct mezzanine to ground floor walls and columns.

1. Construct ground floor slab, including box in box structure with pre-compressed acoustic bearings to transfer propping forces across box in box slab.
2. Breakdown secant pile wall between basement above NLEB and main basement.
3. Remove raking props.
4. Complete box in box structure.
5. Superstructure.

The construction methodology for each element is intended to minimise any risk of tunnel displacement, during the detailed design stage further consideration will be given to an alternative top down method of construction now that the extent of the Event's Gallery and associated box in box has been established.

10 SAFETY

10.1 Key Safety Issues

During construction, the design and construction methodology is aimed to protect against:

- Movement of adjacent structures
- Temporary and permanent stability of basement walls
- Safe excavation of basement area
- Movement of CRL tunnel
- Excavation of timber headings
- Safe installation of reinforcement and concrete for walls and adit beams

10.2 Safety Critical Structures

The safety critical structures relevant to this CDS are:

- Retaining structures
- Basement floor slab
- CRL Tunnel lining

10.3 Hazards

Hazards associated with normal construction processes are not included here. The following table indicates the hazards that the design has addressed:

Hazard	Design Issue
Excessive movement and collapse of retaining structures	Propping and wall loading
Excessive movement of CRL tunnel	Movement during construction of heave restraint wall and adits Movement during basement excavation
Adit construction	Sequencing of construction to limit amount of exposed faces, confined space, specialist personnel required.

During construction, the sequence should be strictly adhered to, including timing where relevant. A series of trigger levels and relevant monitoring shall be agreed with CRL, LUL, local owners and Camden as required.

10.4 Site Specific Hazards

Proximity of excavation to major thoroughfare requiring vehicle protection.

Proximity of excavation to Northern Line Escalator box requiring tight control of wall movements to comply with limits on escalator movement.

Construction of embedded retaining walls above Crossrail Tunnel and LUL access tunnels to Northern Line platforms requiring strict limits on pile toe depth and additional propping during excavation.

10.5 Construction Hazards

Construction of heave retaining wall – movement of tunnel if tolerance not met or construction method inadequate.

Construction of timber headings – heave of tunnel

10.6 Maintenance and Future Demolition Hazards

The slab, adit beams and heave retaining wall all have a permanent heave retention function in order to ensure the tunnel heave is restricted. During building life, the monitoring of the slab movement may need to be continued. Inclusion of ducting to enable the future installation of post-tensioning wires in order to further stiffen the slab if necessary to retain the slab movement within acceptable limits is included in design.

Future demolition will need to ensure that the slab, adit beams and heave retaining wall are not removed or their function impaired. The need for preserving the heave retention system will be recorded on the structural drawings, the Health and Safety File and the O&M manuals. It is noted that a legal agreement may be required to record the need to maintain the heave retention system.

10.7 Operational Hazards

The CDS has been prepared on the basis that the basement construction will take place after the tunnel is bored, but before it is fully commissioned and operational. Therefore the operational hazard is larger than predicted long term movement of the Crossrail tunnel resulting in disruption to train services due to track movement, impact on kinematic envelope or clearance between OHE and train. This hazard is mitigated by designing the structure to controll the movements to significantly less than the limits. The hazard is controlled by real time monitoring of tunnel movements during construction of the basement and for a period after completion of the structural works to give early warning as soon as any movements are larger than predicted. Should the movements be larger than predicted there is sufficient margin between the predicted movements and the acceptable movement limit for remedial measures to be undertaken. These remedial measures will be identified in the Emergency Preparedness Plan that will be finalised with Crossrail along with the Construction Method Statement prior to any works commencing. Depending on the stage of construction, remedial measures could include backfilling the excavation with a dense fill, pre-stressing the adit beams (empty ducts will be provided and tendons will be un-grouted to allow for inspection and re-tensioning/replacement if required) or increasing the surcharge loads.

Based on the LU standard on customer safety (5-534, A1) the risk of injury to the travelling public has been preliminary assessed as follows:

	Extremely likely	Very likely	Likely	Unlikely	Very Unlikely
Fatal	Very High	High	High	High	Medium
Severe	High	High	High	Medium	Medium
Major	High	High	Medium	Medium	Low
Serious	High	Medium	Medium	Low	Low
Minor	Medium	Medium	Low	Low	Very Low

Extreme movement of the tunnel lining (several times beyond that predicted) could cause line-side equipment to enter the kinetic envelope which a train could then strike leading to major injury.

The risk of damage to the tunnel or disruption to service has been preliminary assessed as follows:

	Extremely likely	Very likely	Likely	Unlikely	Very Unlikely
Collapse	Very High	High	High	High	Medium
Extended Closure	High	High	High	Medium	Medium
Major disruption	High	High	Medium	Medium	Low
Some disruption	High	Medium	Medium	Low	Low
Minor disruption	Medium	Medium	Low	Low	Very Low

Extreme movement of the tunnel lining (several times beyond that predicted) could cause speed restrictions and the need for adjustment of line-side equipment to be moved outside the kinematic envelope resulting in major disruption while adjustments are made during engineering hours.

10.8 Consideration of Railway Safety Principles and Guidance

The requirements of the Construction (Design and Management) Regulations 2007 have been addressed through the review of the design proposal and the consideration of alternative methods of construction. The buildability of the proposed basement box has been reviewed within the Consultant team and with specialist contractor Keltbray who are providing construction advice to the team. The proposed construction sequence has been developed taking into account the need to minimise movements of the adjacent structures. A Design Hazard Checklist is presented in this section and will be maintained and updated as the design develops so that hazards are recorded and eliminated as far as reasonably practical.

10.9 Monitoring plan

A real time monitoring system will be required prior to construction commencing on site. This system will be linked to and supplement the systems installed by Crossrail to the project sponsors buildings on site (some already monitored) and monitor tunnel movements in the Eastbound Crossrail tunnel. The monitoring system will also cover the Northern Line Escalator Box structure.

It is proposed that the monitoring system is installed 6 months prior to any works starting on site so that the existing trend of any movements resulting from the construction of the NLEB or the Crossrail tunnel can be established prior to the influence of the St Giles Circus project.

During construction of the adits and excavation of the ground above the Crossrail tunnel real time monitoring of the movements against the predicted movements will be required. A series of pre agreed alert levels will be used to determine the actions that need to be taken by the contractor and the design team. The following are proposed, based on Crossrail's generally adopted levels for the protection of assets:

Green: The movements recorded are within 75% to 100% of the predicted movements at this time. Work may continue although the Engineer may call for the work to stop while an engineering review of current trends is undertaken.

Amber: Where movements recorded are within 100% to 125% of the predicted movements at this time. The contractor must stop work immediately to allow the situation to be assessed by the Engineer and preparations should be made to implement the Emergency Preparedness Plan.

Red: Where movements recorded exceed 125% of the predicted movements at this time. Implementation of the Emergency Preparedness Plan to prevent future movements reaching the movement limit of the tunnel.

It is anticipated that monitoring of the tunnel will continue for a minimum of 12 months beyond practical completion of the project to ensure that the trends of actual movements are in line with the predicted movements. If the trends differ by more than 25% over this period then the monitoring period will be extended until such time as both Crossrail and the Project Sponsor agree that any movement is acceptable.

11 STANDARDS AND REFERENCES

11.1 Civil Engineering Design

The concept design of the construction methodology and element sizing has been carried out using numerical modelling in order to mitigate the risk of tunnel movement during basement construction. Plaxis V2010 has been used, and this is further described in the modelling report. The anticipated movement of the heave restraint walls and basement slab has been checked using a simple structural model.

The detailed design of each element, sized to ensure that tunnel movements are restricted, will be according to the relevant Eurocodes.

Element	Design codes	Anticipated methodology
General	BSEN 1990:2004 BSEN 1991:2009	Basis of structural design Actions on structures
Basement wall	BSEN 1997-1 BSEN 1992	Identification of internal stresses and allowable ground movements from f.e. or retaining wall design software
Ground floor slab, Basement slab	BSEN 1997-1 BSEN 1992	Identification of temporary case prop requirements from f.e. or retaining wall design software. Permanent works loads from structural load requirement and permanent heave loading from f.e.
Heave restraint walls	BSEN 1997-1 BSEN 1992	Identification of internal stresses and allowable ground movements from f.e.
Tunnelled adit beams	BSEN 1997-1 BSEN 1992	Permanent works beams, loads identified by f.e. and structural modelling

In all cases the UK National Annex shall be used.

Reference has also been made to the following documents when preparing this CDS:

Author	Title	Reference	Date	Purpose
Network Rail	Level 2 Module Inspection and maintenance of permanent way – Geometry and gauge clearance	NR/L2/TRK/001/C01	5 Dec 2009	Design
Network Rail	Level 2 Module Inspection and maintenance of permanent way – Installation requirements, maintenance limits and intervention limits	NR/L2/TRK/001/E01	5 Dec 2009	Design
Crossrail	Information for Developers		February 2008	Design
Crossrail	Proposed amendments to the Developer Information Pack	G. Rankin	30 Aug 2011	Design
Secretary of State for Transport	Agreement Relating to the Crossrail project and proposed works at Charing Cross Road London WC2		3 April 2008	Design

Ilya Mikhelson	Structural Engineering Formulas			Preliminary Design
Buro Happold	Consolidated Piles – Design Statement	009942 Denmark Place Rev 06	Oct 2008	Information

11.2 Accompanying drawings and supporting documents

The architect's concept (RIBA stage C) general arrangement drawings for the proposed development are shown in Appendix E. The structural and civil engineering concept drawings are shown in Appendix F.

FIGURES

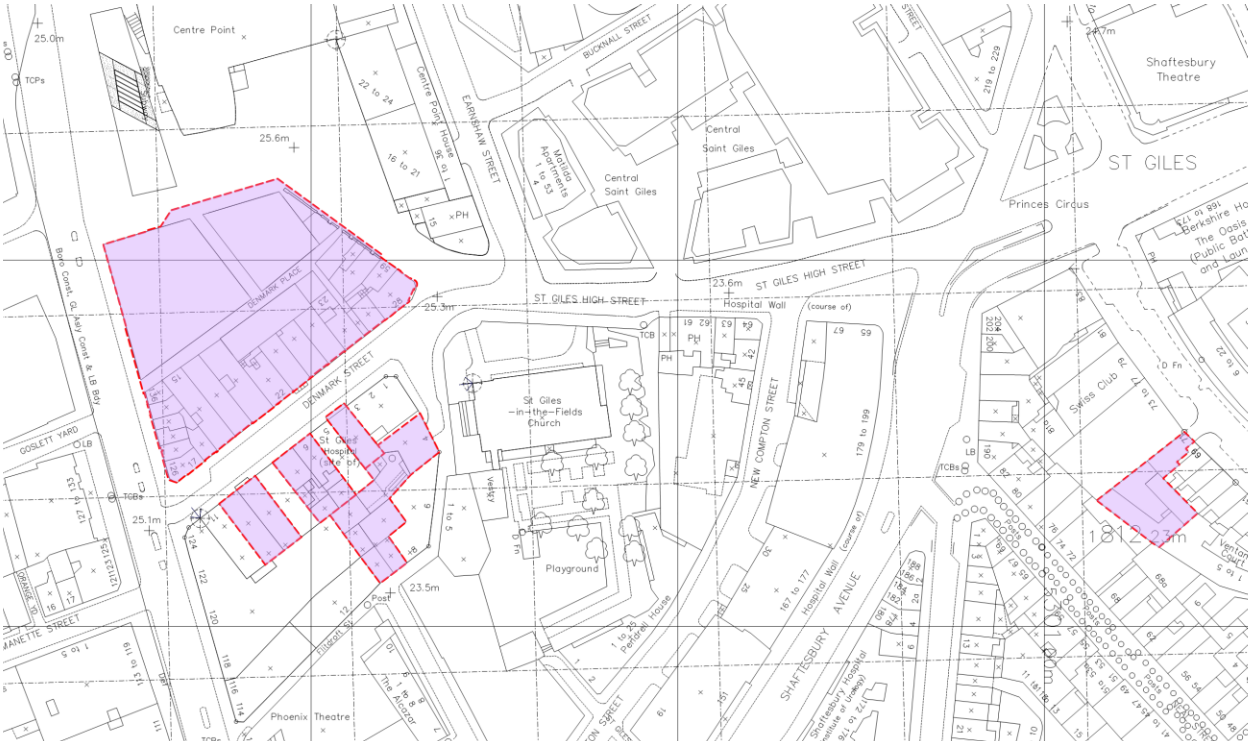

Figure 2.1: Site Plan.

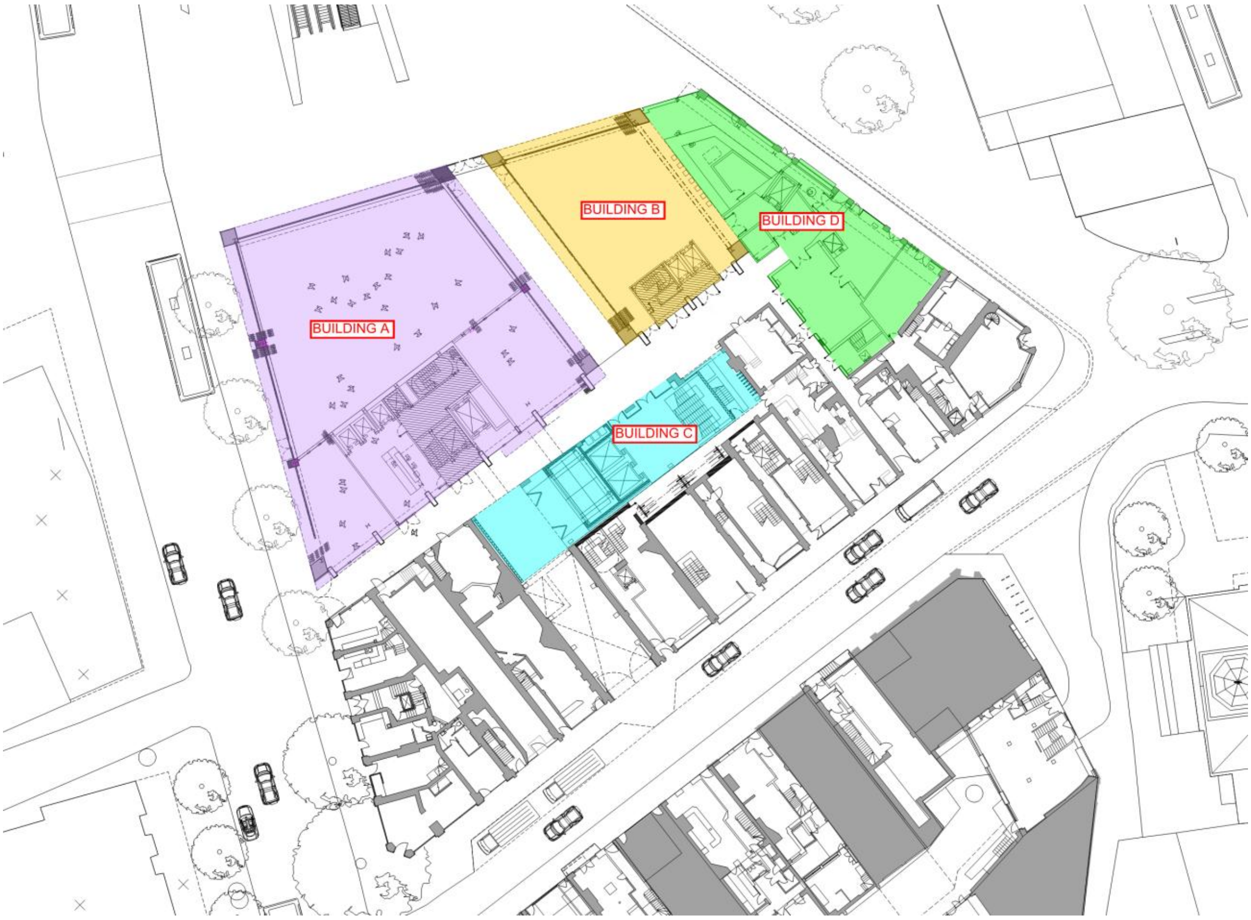

Figure 2.2: Buildings A, B, C, D.

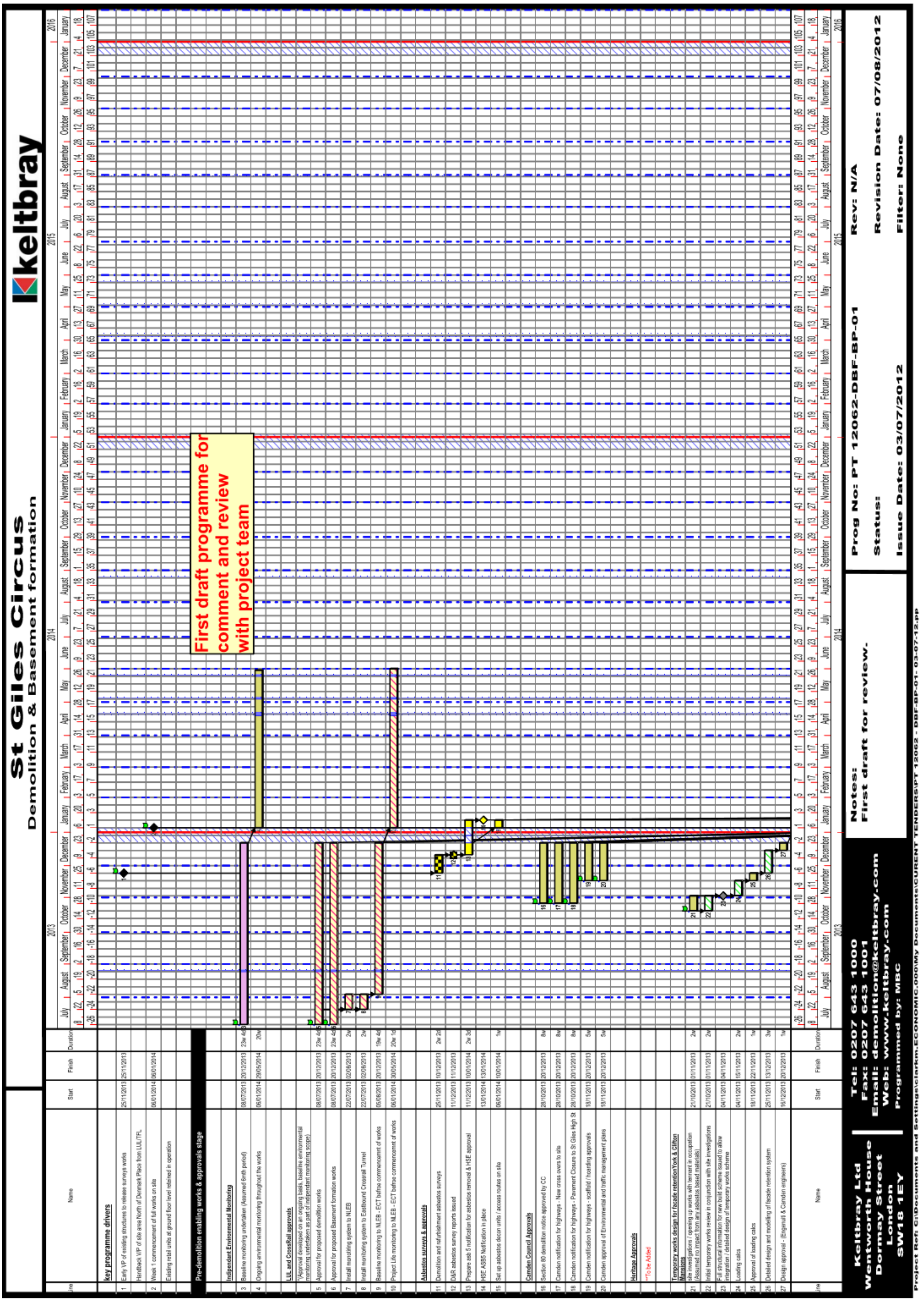

Figure 4.1: Anticipated design and construction programme.

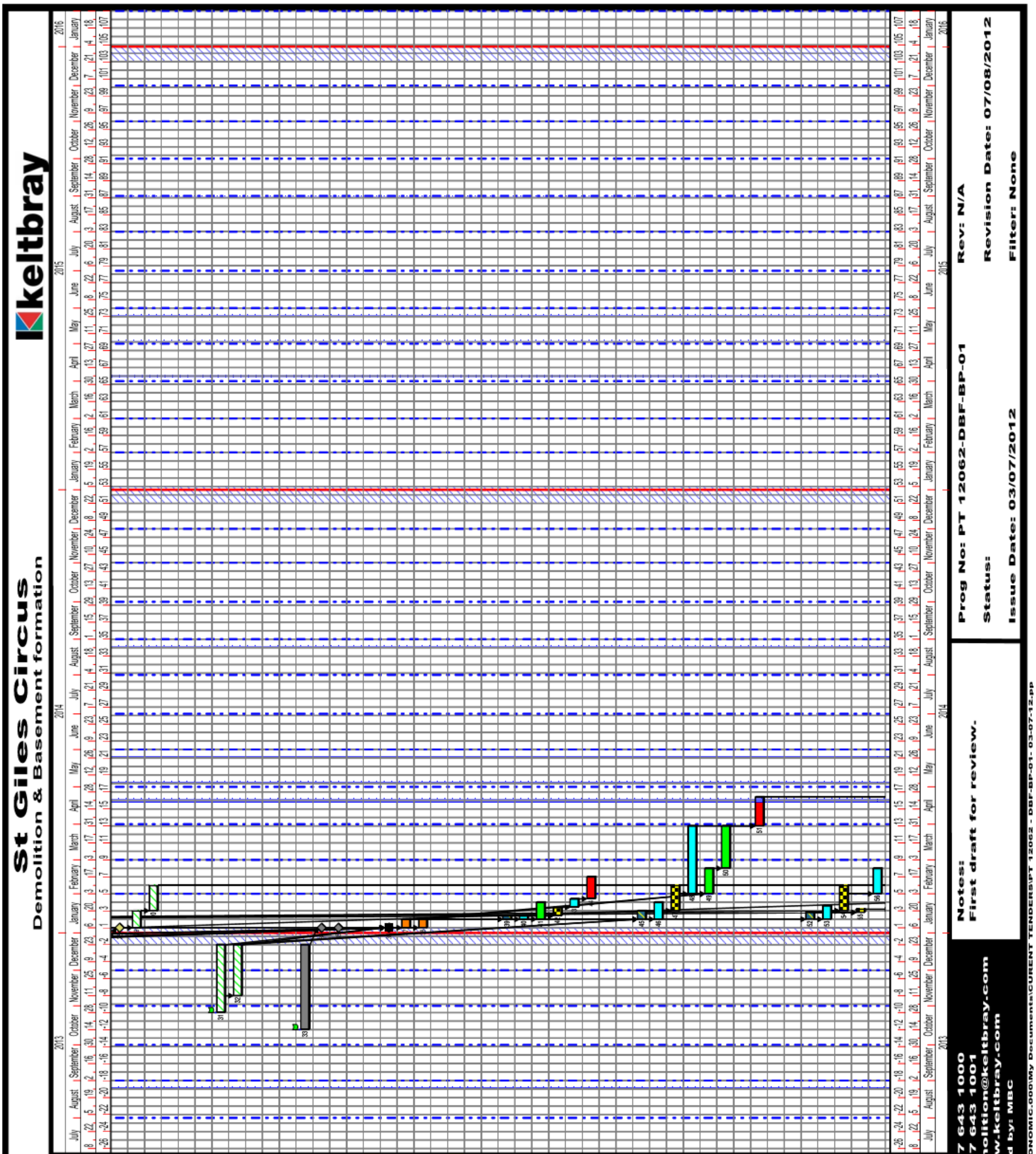

Figure 4.1(cont): Anticipated design and construction programme.

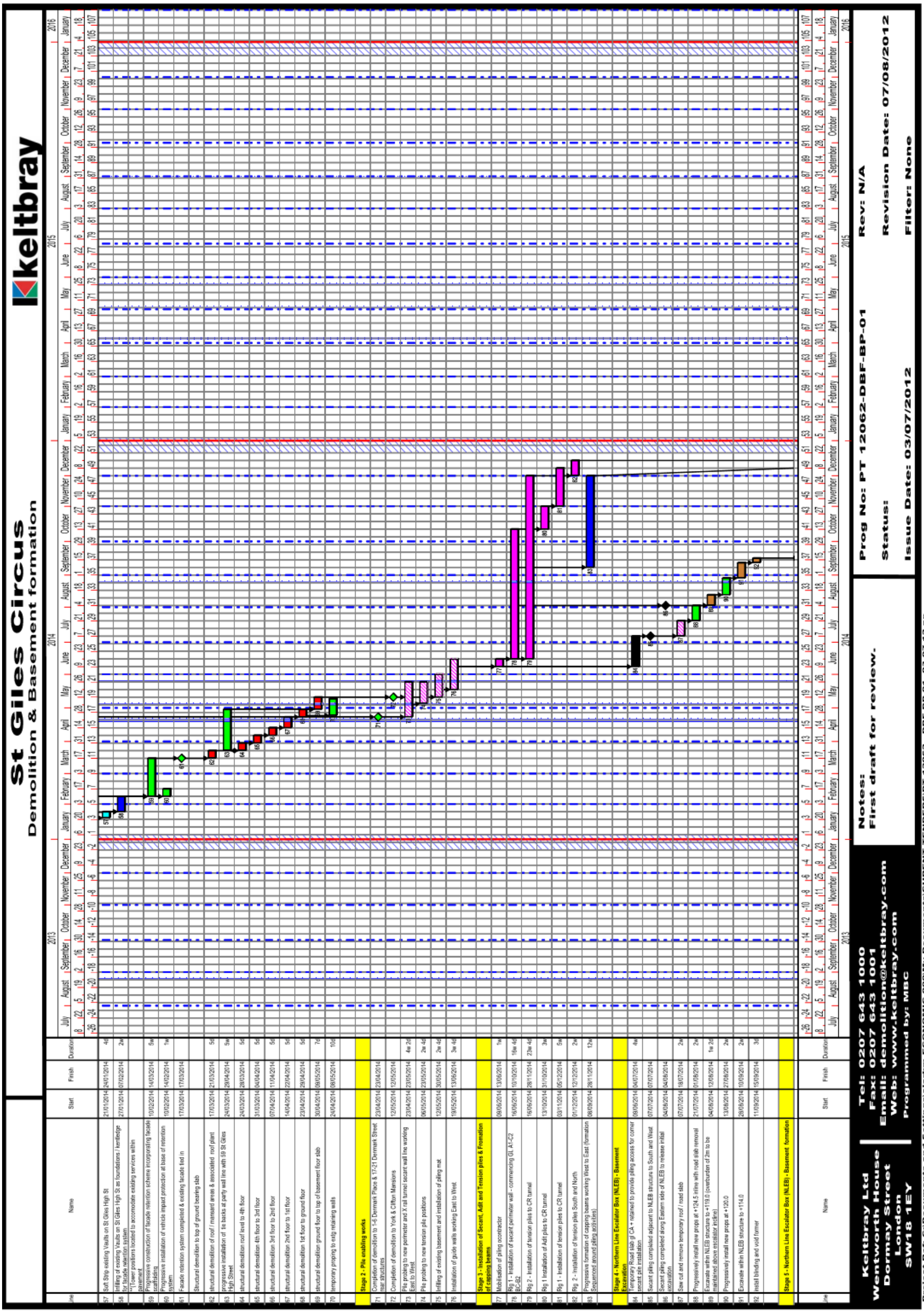

Figure 4.1 (cont): Anticipated design and construction programme.

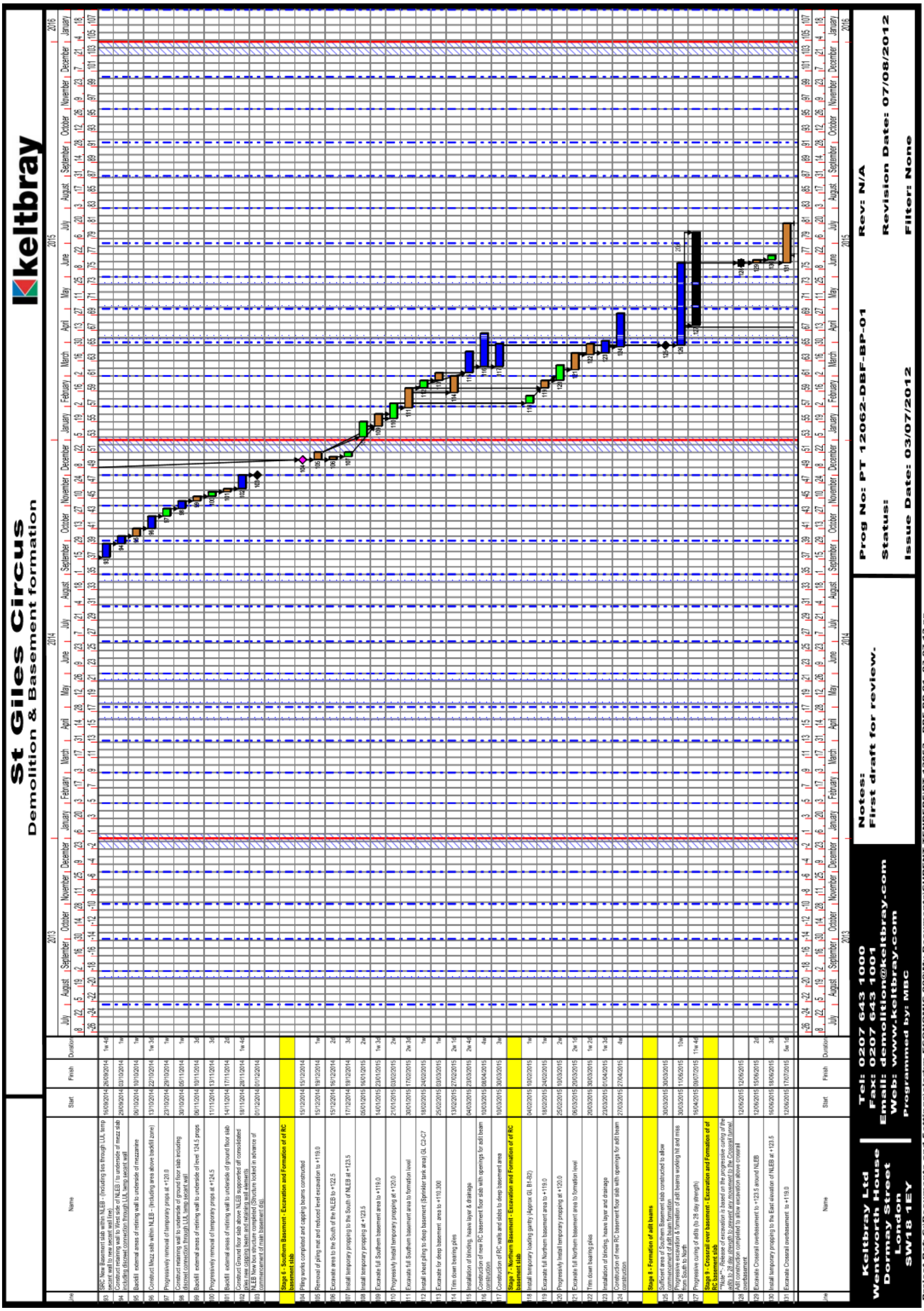

Figure 4.1 (cont): Anticipated design and construction programme.

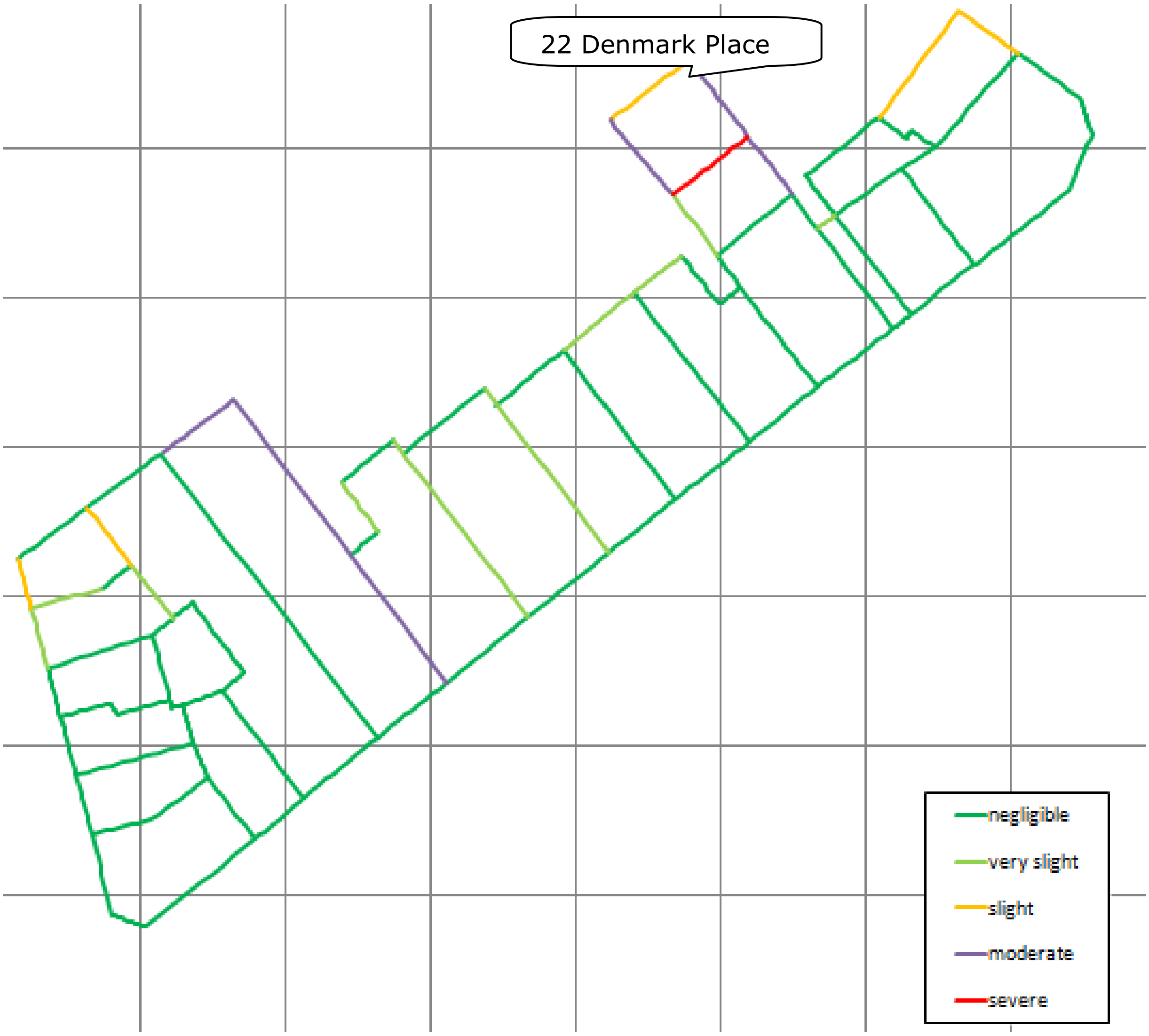

Figure 5.1: Damage categories for the buildings along the south side of the proposed development due to both Crossrail tunnelling and basement construction, without mitigation to 22 Denmark Place.

Figure 7.1: Preliminary assessment of the change in surcharge.

CROSSRAIL CHANGE IN SURCHARGE ASSESSMENT

engenuiti
IMAGINE + CREATE + ENGINEER

Project name: St Giles Circus

Document no: Rev: 0

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Prepared by: CF Date: 12/07/2012
Checked by: PG

Summary	Area	Wall load	Floor load	Excavation Depth	Overburden Removed	Total Removed	Less SW of basement sla	Net decrease in surcharge
	m2	kN/m2	kN/m2	m	kN/m2	kN/m2	kN/m2	kN/m2
52 St Giles High St	76	32.2	20.5	8.1	145.8	198.5	16.8	**181.7**
53 St Giles High St	48	32.2	20.5	8.1	145.8	198.5	16.8	**181.7**
54 St Giles High St	31.1	44	20.5	8.1	145.8	210.6	16.8	**193.8**
55 St Giles High St	51.4	38	20.5	8.1	145.8	204.1	16.8	**187.3**
56 St Giles High St	65.3	25	20.5	8.1	145.8	190.8	28.8	**162.0**
57 St Giles High St	24.6	34	20.5	8.1	145.8	200.1	28.8	**171.3**
58 St Giles High St	92.1	36	20.5	8.1	145.8	201.9	28.8	**173.1**
1 Denmark Place	18.9	34	18.5	8.1	145.8	198.2	16.8	**181.4**
2 Denmark Place	29.9	31	18.5	8.1	145.8	195.5	16.8	**178.7**
3 Denmark Place	29.5	31	18.5	8.1	145.8	195.2	16.8	**178.4**
4 Denmark Place	31.6	30	18.5	8.1	145.8	194.4	16.8	**177.6**
5 Denmark Place	33.4	29	18.5	8.1	145.8	193.7	16.8	**176.9**
6 Denmark Place	33	26	10.65	8.1	145.8	182.6	16.8	**165.8**
17 Denmark Place	57	28	32.4	12.0	216	276.7	16.8	**259.9**
18 Denmark Place	69.3	17	10.65	14.8	266.4	293.7	16.8	**276.9**
19 Denmark Place	64.5	23	19.7	11.7	210.6	253.6	16.8	**236.8**
20 Denmark Place	61.7	25	39.2	11.8	212.4	276.8	16.8	**260.0**
21 Denmark Place	45.4	29	48.1	11.8	212.4	289.3	16.8	**272.5**
21 Denmark Street	94.6	5	15.7	0.0	0	20.3	0.0	**20.3**
4 Flitcroft Street			15.7	3.3	59.4	75.1	20.4	**54.7**
1 Book Mews			7.85	4.5	81	88.9	12.0	**76.9**
Existing ground level				11	198	198	16.8	**181.2**
Basement extension				4.5	81	81	20.4	**60.6**

Table 7.1: Preliminary assessment of the change in surcharge.