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29 October, 2015

Mr Peyrouz Modarres
Walsh
32 Lafone Street
London
SE1 2LX

Our ref: CG/18067A

Please reply to: Adam Cadman

Dear Peyrouz,

Camden Lock Village, London: Area D and E Thames Water asset impact assessment

Further to your instruction, we have undertaken a ground movement analysis and impact assessment to assess potential for damage to Thames Water assets in the area of the area D and E development at the above site. We present our methodology, results of analysis and findings below.

1. Introduction

It is proposed to demolish the existing buildings and some of the road infrastructure at Camden Lock Village and replace them with a number of medium to high rise developments with basement levels ranging in depth between approximately 4 metres below ground level (mbgl) and 16mbgl.

CGL has been instructed to undertake calculations to assess the impact of the proposed development on Thames Water infrastructure running adjacent to the eastern site boundary of development areas D and E, located in south-eastern area of the wider Camden Lock Village site. The calculations have been undertaken using a combination of *Pdisp*, WALLAP, and empirical methods (CIRIA C580[1]) to calculate lateral and vertical ground movement profiles along the lengths of the respective utilities. This data has been used to assess the risk to the utilities with reference to assessment criteria provided by Thames Water.

CGL has previously completed an extensive ground investigation for the entire Camden Lock Village site, which is reported within a geotechnical and geoenvironmental interpretative report[2] (GGIR), including data for Block D, and a separate GGIR for Block E[3].

2. Site context

2.1. *Site location and layout*

The area D and E 'site' is situated off Kentish Town Road in Camden, northwest London. The Ordnance Survey grid reference for the approximate centre of the site is 528908N, 184195E. A site location plan is presented as Figure 1.

The site is approximately triangular in shape and is bordered by a National Rail viaduct to the north, Kentish Town Road to the east, the Grand Union Towpath and Regent's Canal to the south and Camden

[1] CIRIA C580, Embedded retaining walls, guidance for economic design, CIRIA 2003.
[2] Card Geotechnics Limited. (February 2015). Camden Lock Village: *Geotechnical and Geoenvironmental Interpretative Report*. Ref: CG/18067A. Rev 1.
[3] Card Geotechnics Limited. (March 2015). Camden Lock Village, *Proposed Block E: Geotechnical and Geoenvironmental Interpretative Report*. Ref: CG/18067C. Rev 2.

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Lock Village Market to the west. The northern region of the site (Building D site) area currently comprises office buildings with associated car parking. The southern region of the site (Building E site) comprises open land covered with grass and light vegetation. A site layout plan is presented within Figure 2.

The site is generally flat, although some minor variation in level is noted. Ground levels within the pavement of Kentish Town Road increase from around 25.8mOD in the north to 27mOD in the south, where a bridge is present over the Regents Canal .Ground levels adjacent to the eastern site boundary in the southern area of the site indicate a shallow slope up towards the pavement. In the south-eastern most area of area E, where the pavement is some 1m higher than typical site levels, a small wall (<0.5m high) and a shallow slope is present.

For the purposes of this assessment, a ground level of 26.1mOD has been assumed.

2.1.1. *Thames Water infrastructure position and geometry*

Based on information provided by Walsh, the structural engineers for the project, it is understood that one piece of Thames Water infrastructure is within the site's zone of influence and is therefore the subject of this impact assessment.

A 16 inch (406.4mm) water main runs beneath the pavement of Kentish Town Road, running parallel with the eastern site boundary adjacent to the proposed single storey basement beneath Blocks D and E. The crown of the pipe is at approximately 0.8m below ground level (mbgl). It is assumed that the depth of the pipe remains constant along the Kentish Town Road. A pipe crown level of 25.3mOD has been used within the assessment, assuming a design ground level of 26.1mOD.

The water main is typically around 2.4m to 2.8m from the back face of the piled walled.

2.2. *Proposed development*

The proposed development comprises a series of multi-storey buildings with a combined single-storey basement below the entire development footprint.

The proposed basement is typically 4.6m deep (assuming design ground level of 26.1mOD) with a formation level at approximately 21.5mOD. A contiguous piled wall of 0.6m diameter at 0.75m spacing is currently proposed to support the basement excavation along the eastern site boundary. Pile wall capping beam level is assumed to be at 26.1mOD.

The above information is taken from current detailed drawings provided by Walsh Associates and presented within Appendix A.

3. Ground and groundwater conditions

3.1. *Summary*

The ground conditions in the eastern sides of areas D and E encountered during the intrusive investigation are summarised in Table 1. Full details are provided within the GGIR's[2, 3].

Table 1. Summary of ground conditions (eastern side of areas D and E).

Stratum	Level to top of stratum (mOD) [mbgl]	Typical thickness (m)
(MADE GROUND) Comprising topsoil/hardstanding over soft to firm, becoming firm to stiff, silt and clay or loose to medium dense slightly clayey to clayey gravelly to very gravelly sand. *Obstructions were identified at 1.0 to 1.4mbgl within WS11, WS11A, WS14, WS14A and WS14B.*	25.79 to 25.8 [0.0 to 0.2]	0.5 to 1.0
Firm to very stiff, medium to high strength, very occasionally low strength, light brown occasionally mottled grey slightly silty occasionally slightly sandy CLAY. [WEATHERED LONDON CLAY FORMATION]	24.64 to 24.94 [0.85 to 1.4]	7.4 Base only proven in BH7
Stiff closely fissured dark grey silty CLAY. Frequent fine selenite crystals noted. *BH7 only*. [LONDON CLAY FORMATION]	16.89 [8.9]	>21.6 (Base not encountered in boreholes)

a. Based on ground conditions encountered in eastern side of area D and E. Excludes WS9, WS10 and WS13 located in western side of area D and E.

A plot of SPT 'N' versus level (mOD) is presented in Figure 3 and a plot of undrained shear strength, c_u (kPa) versus level (mOD) is presented in Figure 4.

The Made Ground was found to be relatively inconsistent across the site, comprising hardstanding/topsoil over soft to firm and firm to stiff silt/clay or loose to medium dense sand. Several concrete obstructions were encountered in the window sampler boreholes in area E, at depths of between 1.0m to 1.4m bgl.

The London Clay Formation was proven to a level of -4.71mOD. The upper 7.4m of the clay was found to consist of firm silty clay (Weathered London Clay Formation), becoming stiff (unweathered) from 16.89mOD. SPT 'N' values in this stratum ranged from 7 to 44 increasing with depth, corresponding to values of undrained shear strength (c_u) in range from 31.5kPa to >198kPa (where $f_1 = 4.5$).

Laboratory testing on samples of the London Clay Formation recorded c_u values of 64kPa to 344kPa, increasing with depth.

3.2. *Groundwater*

The monitoring records indicate that standing groundwater in the eastern area of the site is at approximately 7.45m bgl in area D and between 3.3m and 4.8m bgl in area E. Whilst shallower water was recorded in WS9 (at 1.25m bgl), this is located in the western side of area D, further away from the piled wall on the eastern boundary of the proposed basement. On the basis that BH7 is located between the piled wall and WS9, shallow groundwater (i.e. <2m bgl) is not anticipated within excavations for high level capping beams on the eastern site boundary (i.e. for the piled retaining wall basement box).

Notwithstanding this, a design groundwater level of 1m bgl is recommended for geotechnical design (i.e. hydrostatic pressure behind piled walls).

3.3. *Geotechnical design parameters*

Geotechnical design parameters are recommended based on the information from the intrusive investigation and published data from the well-studied London geology. These are summarised in Table 2.

The values are unfactored (Serviceability Limit State) parameters and are considered to be characteristic values for the local soils.

Table 2. Geotechnical design parameters

Stratum	Depth (mbgl) Level [mOD]	Bulk Unit Weight γ_b (kN/m^3)	Undrained Cohesion c_u (kPa) [c']	Friction Angle ϕ' (°)	Young's Modulus E_u (MPa) [E']
Made Ground	0 [26.1]	18	30 [0]	26[a]	18[a] [10.8][a]
London Clay Formation	1.5 [24.6]	20	50 + 6z[c] [5]	24[a]	30 + 3.6z[d] [22.5 + 2.7z][d]

a. BS 8002:1994 Code of practice for Earth retaining structures, British Standards institution.

b. Eu is based on 600c_u and E' is based on 0.6Eu – Padfield, C.J., and Sharrock, M.J. (1983). Settlement of structures on clay soils.

c. z = depth below surface of London Clay Formation.

d. Eu is based on 600c_u and E' is based on 0.75Eu . Burland, Standing J.R., and Jardine F.M. (eds) (2001), Building response to tunnelling, case studies from construction of the Jubilee Line Extension London, CIRIA Special Publication 200. Increased to 1000 c_u for London Clay Formation within retaining wall deflection calculations.

Whilst the Made Ground was encountered as both granular and cohesive soils, cohesive Made Ground has been assumed in the ground movement analysis. Given the relatively thin nature of the Made Ground (<1.5m thick), the consistency of this material is not considered to have a significant effect on the outputs of the analysis. Notwithstanding this, the granular Made Ground, if encountered during pile construction, is likely to be more susceptible to flighting and this will require careful consideration by the specialist contractor to control ground movements.

4. Ground movement assessment

The following report sections detail the analytical approach undertaken and discuss the results of calculations undertaken to predict ground movements that may occur due to the construction of the proposed basement. The impact of these ground movements on the water main is later assessed against criteria set by Thames Water (Appendix B).

A conceptual site model (CSM) is presented in Figure 5 and graphically illustrates the geometry of the water main in relation to the proposed basement.

4.1. Ground movements due to piling

4.1.1. *Movements due to piled wall installation*

With reference to CIRIA C580[4], vertical and horizontal surface movements due to installation of a contiguous piled wall have been reported to be in the region of 0.04% of the wall depth assuming a good standard of workmanship. The distance behind the wall at which negligible movement exists is taken as 1.5 times wall depth for lateral movements and 2 times wall depth for vertical movements.

[4] CIRIA C580 (2003) *Embedded Retaining Walls – guidance for economic design*

Assuming a pile length in the region of 7.0m, this would give rise to a predicted lateral and vertical movement of 2.8mm immediately adjacent to the piled wall.

Predicted installation movements and corresponding ground movement at the location of adjacent constraint are summarised in Table 3. A profile of lateral movements along the pipe is presented in Figure 6.

Table 3. Vertical movement due to contiguous pile installation

Section 1	Ground movement [a] (mm)	Distance behind wall to negligible movement (m)	Deflection at water main adjacent to piled wall [b] (mm)
Vertical movement	2.8	14	2.24 to 2.32
Lateral movement	2.8	10.5	2.06 to 2.16

[a] Ground movement immediately behind piled wall
[b] Water main located approximately 2.4m to 2.8m from the basement wall

Predicted installation movements are not modelled to abruptly reduce to negligible beyond the line of the piled wall. On this basis, it is assumed in the pile installation movement profiles that the installation that movements extend 1.5 (lateral) or 2.5 (vertical) times pile length in all directions from each pile.

It is assumed that all piling will be undertaken within the site boundary and that temporary loading of the underlying soils from the piling rig will not impact upon the water main.

4.1.2. *Retaining wall deflection analysis results*

Deflections of the retaining wall have been calculated using *WALLAP* embedded retaining wall analysis software. Serviceability limit state (SLS) criteria have been used to determine wall deflections.

The piled wall will be propped in the temporary condition with struts and in the final condition by the basement and ground floor slabs. The calculations model the presence of a nominal 20kPa surcharge behind the wall (Kentish Town Road) along the eastern boundary.

Calculation sheets are provided within Appendix C and summarised within Table 4. A profile of lateral movements along the pipe is presented in Figure 6.

Table 4. Results of WALLAP analysis for contiguous piled wall

Section	Maximum predicted wall deflection (mm)	Level of maximum deflection (mOD)	Max Lateral deflection at location/level of constraint (mm)	Vertical settlement below location of constraint (mm)
TW Water main	4.0	20 to 25.3	2.6	2.0

The results indicate 4mm of deflection at the centre point of the retaining wall. The thick capping beam along the length of the wall and the structural support of the pile walls perpendicular to the eastern site boundary will reduce the magnitude of deflections at the corners of the basement wall. In this regard,

predicted movements reduce along the pipe as it passes the corner area have been calculated based on the approach proposed by Fuentes & Devriendt (2010). These movements are included in the profile of lateral movement presented as Figure 6.

The distance to negligible lateral movements behind the wall has been calculated assuming the ground movement occurs within a soil wedge based on a 45° zone of plastic deformation from the base of the excavation depth. Vertical ground movement has been calculated by taking 50% of the displacement profile predicted from *WALLAP*. This is in line with the results of finite element analysis reported within *CIRIA C580 – Embedded retaining wall design 2003.*

In regard to indicative wall displacements that may be expected during excavation, it should be noted that *WALLAP* uses a Winkler spring analysis to determine the wall displacements. In a Winkler medium, springs are used to represent a continuum and there is no transfer of shear stresses between the springs. In general, the application of this concept leads to an overestimation of structural deformations; hence the resulting wall displacements and corresponding impact on the nearby structures and infrastructure may be over-predicted by the *WALLAP* program. Notwithstanding this, the *WALLAP* predictions are consistent with CIRIA deflection predictions.

4.2. Movements due to trench sheet deflections

It is anticipated that trench sheeting will be used to support the temporary excavation for the capping beam. This is likely to be formed adjacent to the pavement for Kentish Town Road.

Deflections have been calculated using *WALLAP* and assuming the sheets will be embedded into the Made Ground and/or London Clay and will be propped at high level, a summary is presented in Table 5. Given that the sheets are likely to be placed during excavation of the capping beam and in small sections, heave due to installation (ground displacement due to pushing) is considered to be negligible and will not be further assessed.

Given the increasing level of the Kentish Town Road in a southerly direction, the excavation required for the capping beam will become deeper, ranging from around 0.8m in the north to 1.7m in the south. In order to limit deflections to those provided within Table 5 where the excavation is at the deepest, a further low level temporary strut will be required.

Table 5. Results of WALLAP analysis for trench sheets

Section	Wall deflection at asset level (mm)	Lateral deflection at location/level of constraint (mm)	Vertical settlement below location of constraint (mm)
TW Water main	1.0	0.0 to 0.41	0.5

4.3. Ground movements due to basement excavation (*Pdisp* analysis)

The construction of the basement will result in stress changes in the ground due to the demolition of the existing building and the excavation of the basement. Analyses have therefore been undertaken in stages to capture the historical movement of the TW utilities, and to predict future movements and corresponding risks to this infrastructure that may occur as a result of the proposed basement development.

The magnitude of these movements has been calculated using OASYS Limited *Pdisp* analysis software. *Pdisp* assumes that the ground behaves as an elastic material under loading, with movements calculated based on the applied loads and the soil stiffness (Eu and E') for each stratum input. Details of the stages analysed are provided below, and loading assumptions are summarised in Figure 7 (Stages 1 & 2) and Figure 8 (Stages 4 & 5).

Contour plots for each analysis stage are presented in Appendix D. Full *Pdisp* outputs are available on request.

4.3.1. *Stage 1: Historical loading*

Based on the historical mapping, the existing building (*Waterside House*) is likely to post-date the construction of the water main. Therefore the construction of the existing building would have caused the infrastructure to settle. As the infrastructure remains serviceable, it follows that these movements did not damage it, and were sustainable.

For the purposes of the analysis it is assumed that the existing building is supported on a raft foundation applying a bearing pressure of 50kPa (12.5kPa per floor level) over its footprint at an assumed level of 25.1mOD. This is considered to be a conservative assumption.

Pdisp analysis was undertaken for both the undrained (short-term) and drained (long-term) conditions to assess the impacts on the Thames Water infrastructure due to historical loading and to determine its pre-construction profile.

4.3.2. *Stage 2: Demolition*

At this stage the existing structure is demolished, giving rise to an unloading of -50kPa, applied at an elevation of 25.1mOD to assess the impacts on the Thames Water infrastructure due to demolition of the existing structure. *Pdisp* analysis was undertaken for the undrained (short-term) condition only.

4.3.3. *Stage 3: Excavation*

The proposed bulk basement excavation gives rise to a net unloading of the underlying strata both during construction and over the long term. The excavation will unload the soils at the basement formation level by some 90kPa. This value assumes a typical bulk unit weight of 18kN/m^3 for 1.5m of Made Ground and 20kN/m^3 for the London Clay.

Part of the proposed piled wall capping beam will extend some 1.4m beyond the rear of the piled wall, towards the water main. Whilst this will not result in loading to the underlying soils (it is assumed to be cantilevered and that the load is taken down the retaining wall), a temporary excavation will unload the soils in the short term to cast the beam. Given the proximity to the existing pavement, it is assumed that sheet trenching will be used to support the temporary excavation. This excavation will result in some minor unloading adjacent to the water main, of the order of 15kPa (assumed excavation depth of approx. 0.8m) in the northern area to around 25kPa in the southern area (assumed excavation depth of approx. 1.4m), based on a unit weight of 18kN/m^3 (i.e. assuming all Made Ground).

Pdisp analysis was undertaken for the undrained (short-term) condition only.

4.3.4. *Stage 4: Final condition*

The proposed development will be piled, and, on this basis, the load case for the final condition is similar to the Stage 3 analysis. The unloading due to the demolition of the existing building in area D is also

applied to this stage to assess the long-term (drained) response due to stress relief in this area. Additionally, load is applied as the capping beam excavation is backfilled. *Pdisp* analysis was undertaken for the drained (long-term) condition only.

4.4. Results

The results of the analysis are summarised below in Table 6, and include vertical movements based on *Pdisp* outputs and cumulative movements including vertical movements due to pile installation and deflection. Data have been derived from displacement lines drawn within *Pdisp* at the level and location of the relevant TW infrastructure. Plots of cumulative horizontal and vertical displacement are provided in and Figure 6 and Figure 9, respectively. Plots of cumulative vector displacements and curvature profiles (based on 1/r where r is expressed in mm) for each analysis stage are presented as Figure 10 and Figure 11, respectively.

Table 6. Summary of ground movements at TW water main (per analysis stage)

Stage	Vertical displacements per stage [a] (mm)	Cumulative vertical displacements [a] (mm)	Max cumulative lateral displacements [b] (mm)
1. Historical	-0.04 to 2.58	-0.04 to 2.58	-
2. Demolition	-0.64 to 0.05	0.01 to 1.94	-
3. Pile installation	0.0 to +2.32	0.13 to 4.24	0.0 to 2.16
4. Excavation	-1.9 to 0.4	0.45 to 3.80	0.0 to 4.68
5. Final	-6.55 to -0.4	-2.79 to 0.22	0.0 to 4.68

[a] (+) values indicate settlement; (-) values indicate heave.
[b] Lateral movements are towards the excavation.

5. Infrastructure damage assessment

The calculated displacement profiles have been used to assess the potential impact of the proposed development on the TW infrastructure in accordance with guidance and advice provided by Thames Water. Limits for the TW infrastructure are summarised in Appendix B.

5.1. Bending strain

The displacement profiles discussed in Section 4 of this report have been used to determine the resulting tensile strains in the pipe based on vector movements (i.e. combined lateral and vertical profiles). A profile of tensile strain is presented in Figure 12 and indicates a maximum change in tensile strains of 83με.This is based on a 406.4mm diameter pipe with the neutral axis taken as half of the diameter. These values are below the assessment criteria of 100με for a cast iron pipe.

5.2. Axial strain

With regard to axial strains, the influence of the wall running perpendicular to the water pipe is initially zero, increasing slightly as the pipe passes beyond the corner. This has limited effect on axial strain because the pipe runs away from the wall beyond the corner and axial movements decrease rapidly away from the wall. Axial movements (based on the proportional component of the perpendicular wall at angles from the corner) along the pipe range from 0.0mm to 0.21mm (i.e. are extremely low). This is without accounting for the axial stiffness/rigidity of the pipe which would be expected to allow the soils to displace axially along the sides of the pipe.

On this basis, no further assessment of axial strain or combined bending/axial strain is considered to be necessary.

5.3. Joint rotation

Joint rotation has been calculated assuming a typical section length of 3.66m (12 feet). The centre point of the section length (*j*), i.e. the joint between pipe spans, has been taken as the point at 58m (see **Error! Reference source not found.** and Figure 9). This point was chosen as the differential movement on either side is most pronounced. The differential movement between point *j* and 1.83m either side (points *k* and *i*) have been calculated, corresponding to Stage 3 (excavation) vertical movements and combined lateral contiguous pile deflections due to installation and excavation.

The results indicate joint rotation of 0.0002°, which is below the assessment criteria of 0.1° for a cast iron pipe. A maximum predicted joint rotation of 0.021° was calculated using Stage 3 vertical movements and lateral movements from pile deflection only. The joint rotation calculations are presented in Appendix E.

6. Conclusions

The proposed development comprises the demolition of the existing structures, excavation of a single storey basement and the construction of an apartment block. The potential impacts of ground movements caused by the construction on the Thames Water infrastructure, a 16" water main, have been assessed.

The current analysis and pipe damage assessment is considered to be suitably conservative and represent the worst case. Detailed temporary works design should be undertaken to comply with the calculated deflection limits contained in this report.

The results of the analysis indicate that with good construction control and workmanship, the ground movements and corresponding damage to the pipe can be controlled and are likely to be less than predicted and within the assessment criteria as set out by Thames Water.

7. Closure

We trust we this meets your current requirements, but should you have any queries, please do not hesitate to contact us.

Yours sincerely,

Adam Cadman, Chartered Senior Engineer
Card Geotechnics Limited

Figures

Appendices

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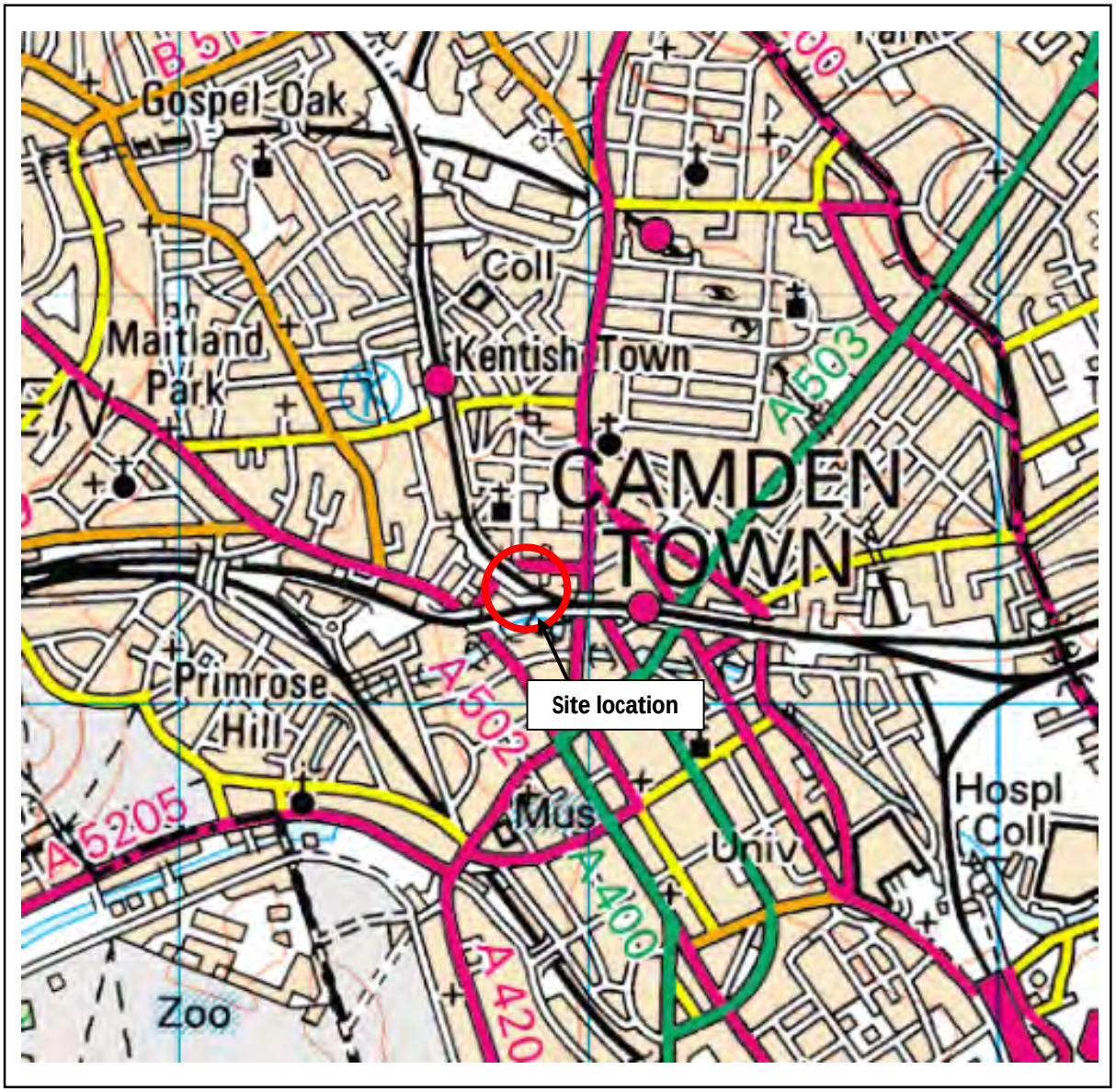
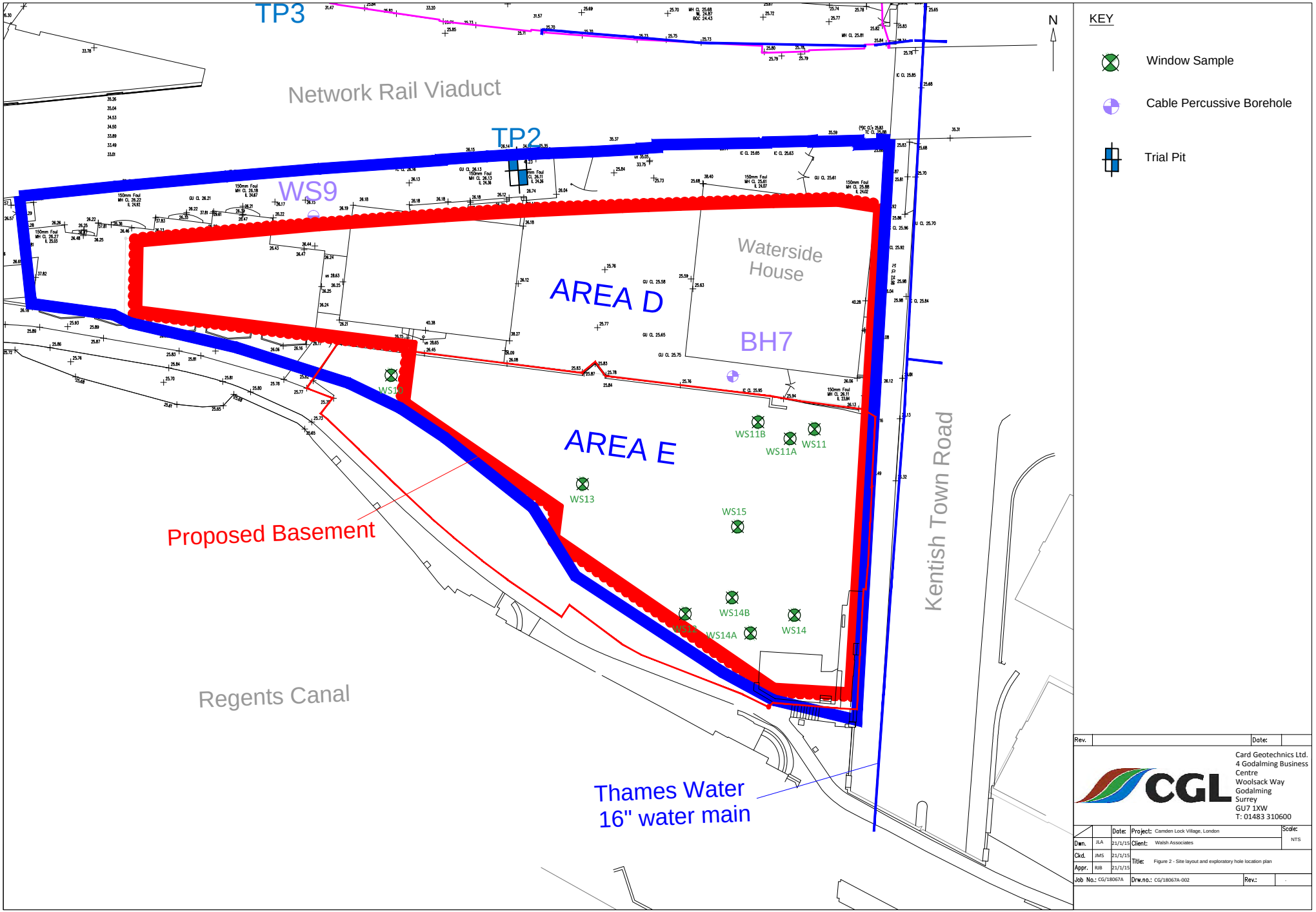
Reference	CG/18067a	Revision	0	Issue Date	August 2015
			1		September 2015

FIGURES



Client	Project	Job No
Walsh Associates	**Camden Lock Village, London**	**CG/18067A**
CGL	Title **Site location plan**	**Figure 1**



Rev.		Date:	

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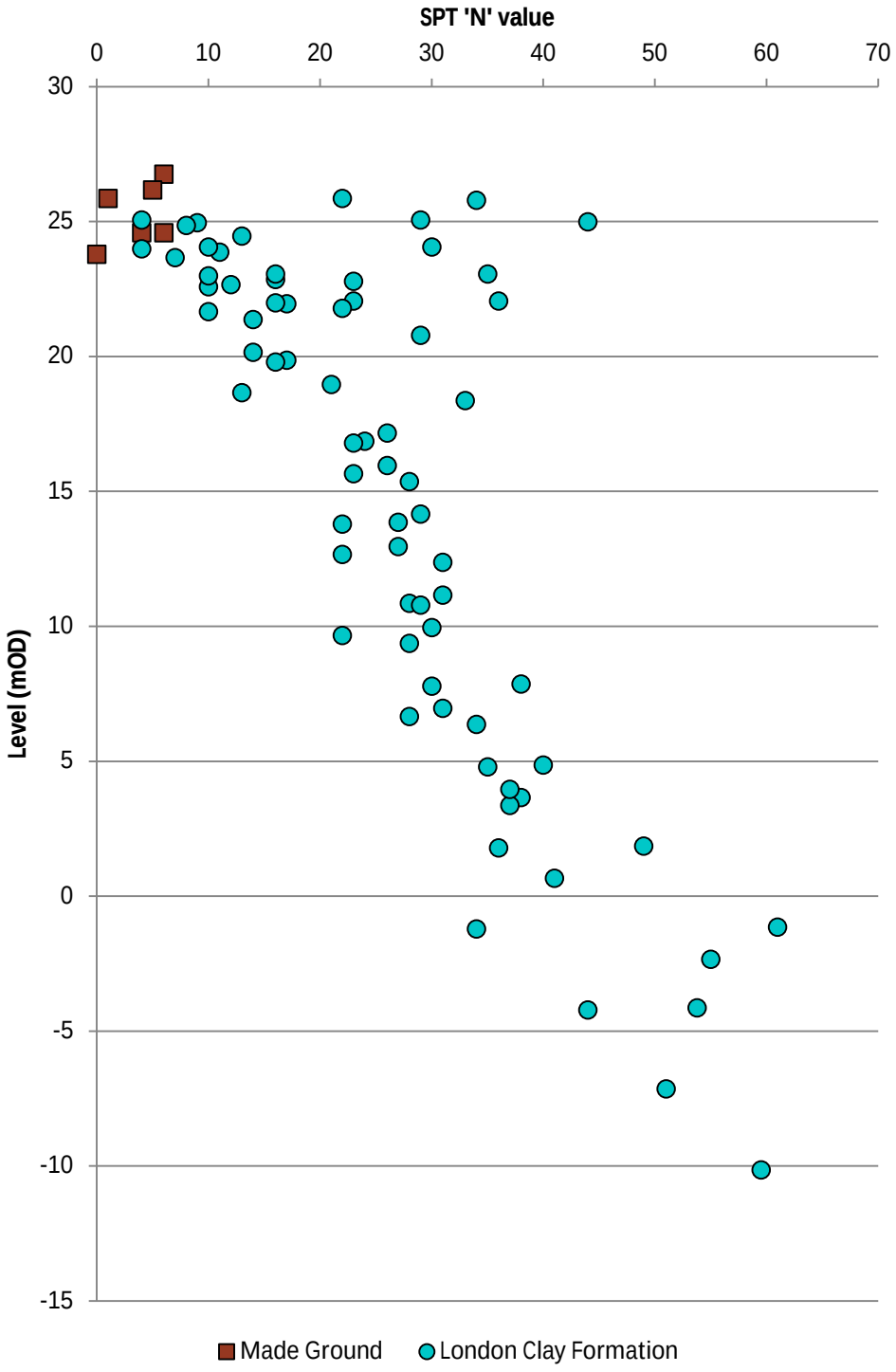
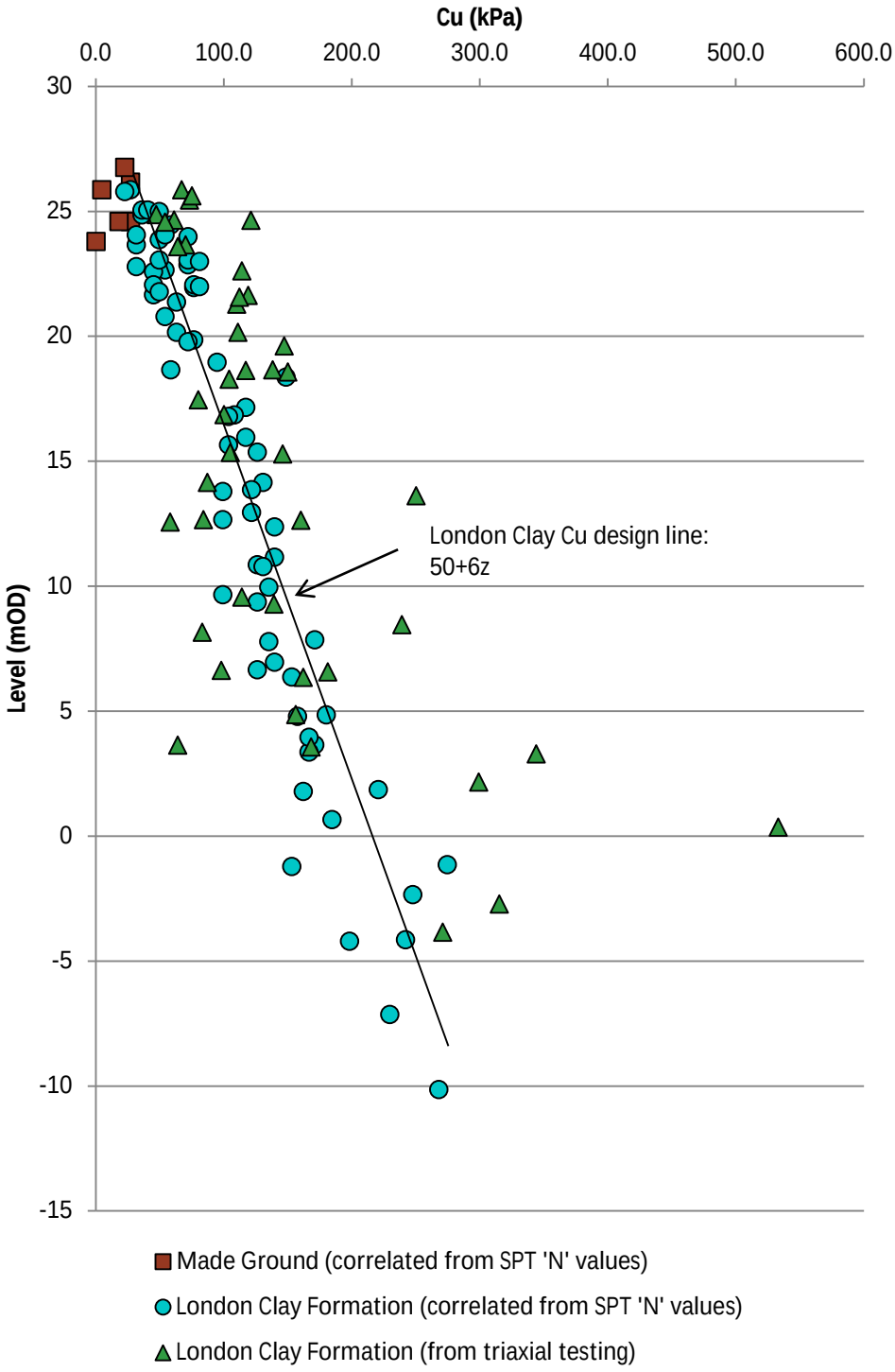
		Date:	Project: Camden Lock Village, London	Scale:
Dwn.	JLA	21/1/15	Client: Walsh Associates	NTS
Ckd.	JMS	21/1/15	Title: Figure 2 - Site layout and exploratory hole location plan	
Appr.	RJB	21/1/15		
Job No.: CG/18067A			Drw.no.: CG/18067A-002	Rev.:

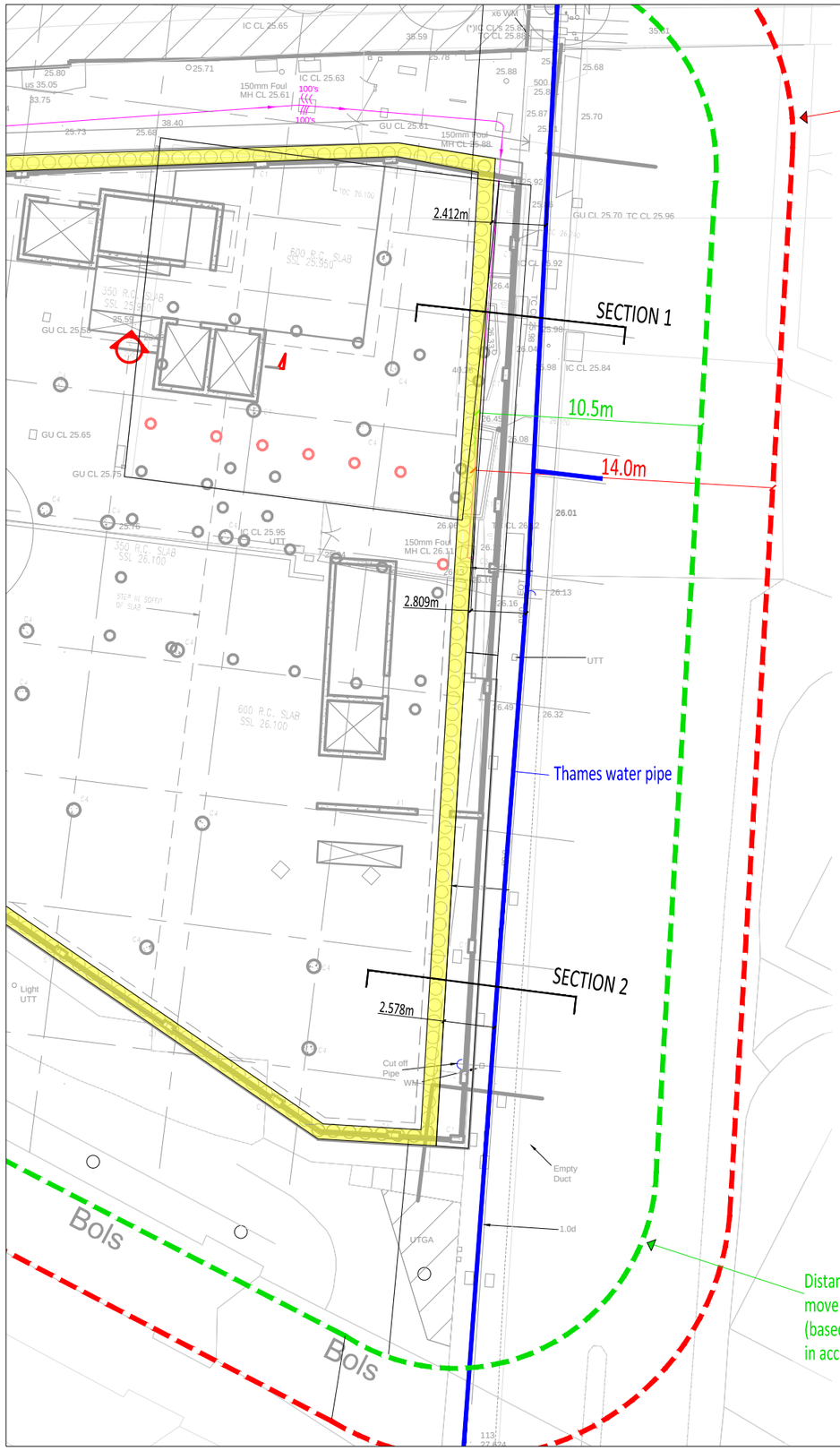


Client	Project	Job No
Walsh Associates	**Camden Lock Village, London**	**CG/18067A**
CGL	Title **SPT 'N' versus level**	**Figure 3**

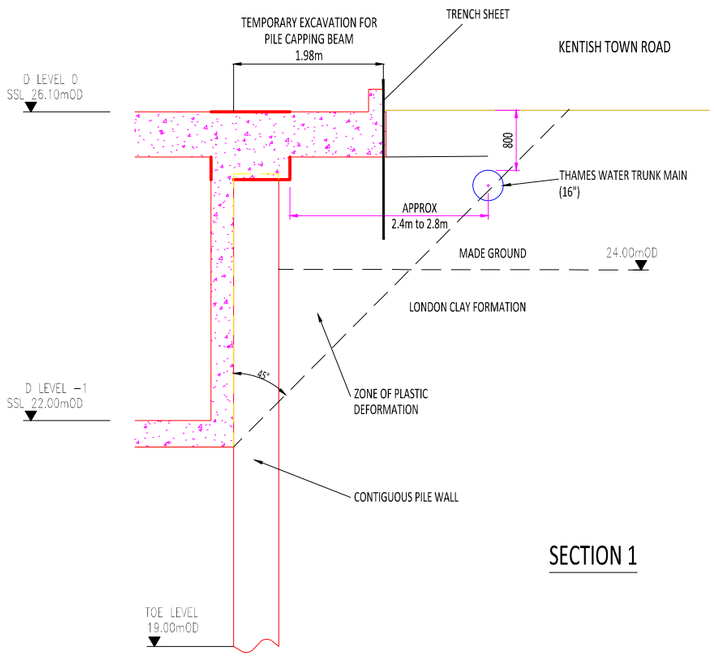


Data is from all of Camden Lock Village site.

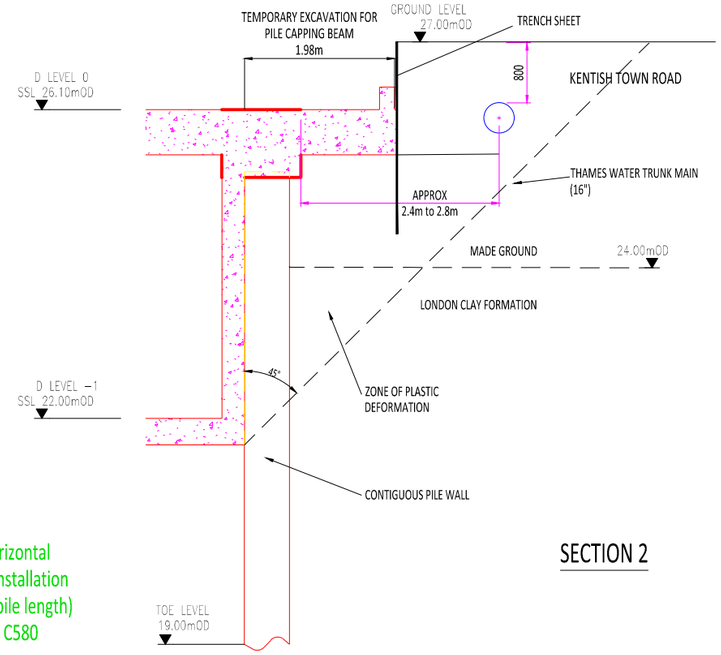
Client	Project	Job No
Walsh Associates	**Camden Lock Village, London**	**CG/18067A**
CGL	Title: **c_u versus level**	**Figure 4**



Distance to negligible vertical movements due to pile installation (based on 2 times the pile length) in accordance with CIRIA C580



SECTION 1



SECTION 2

KEY

*	*	*
Rev	Date	Comments

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Project
Camden Lock Village Phase 2, London

Client
Walsh Associates

Drawing title
Conceptual Site Model

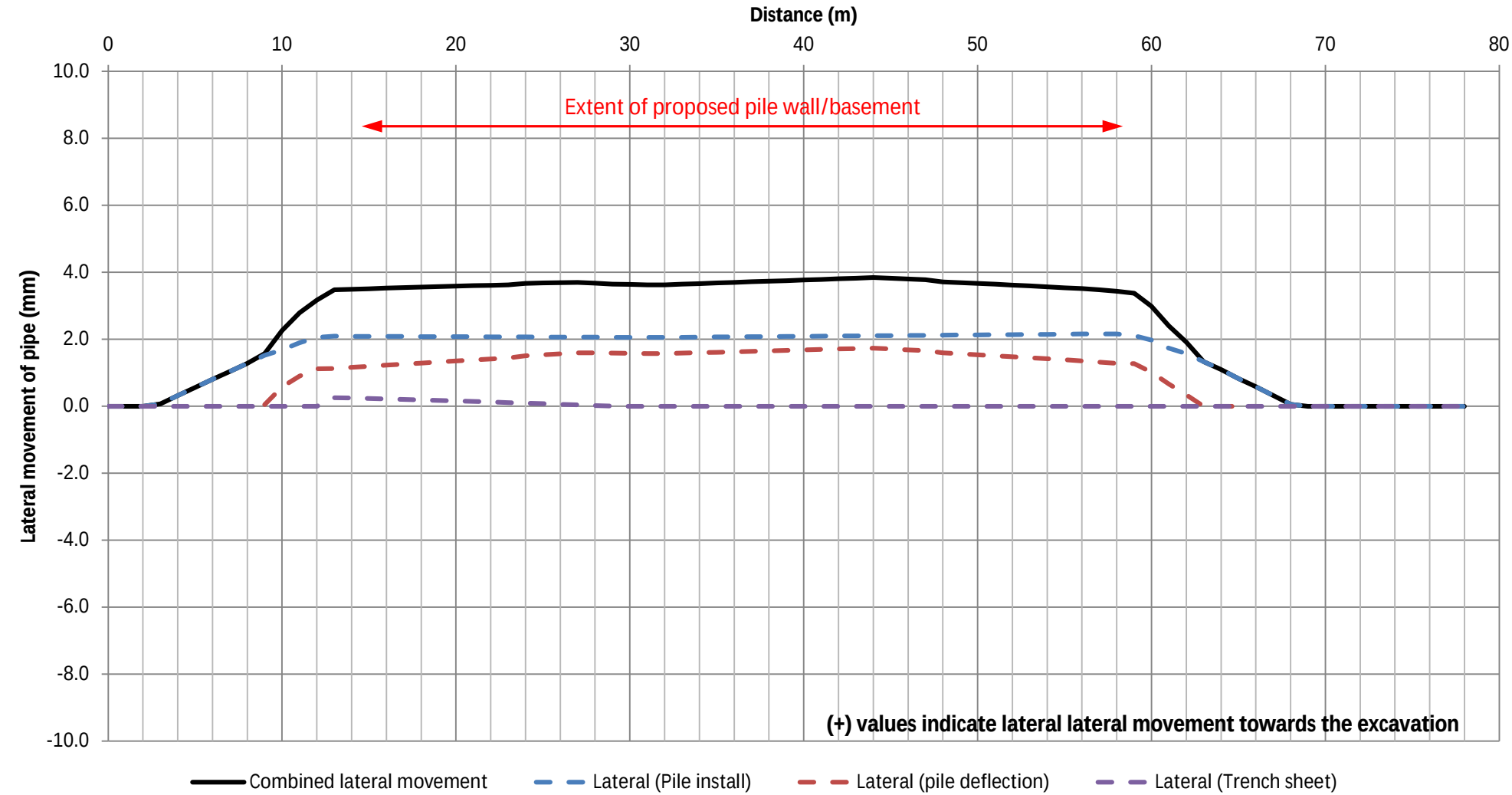
Scale(s)
NTS

Job No.
CG/18067a

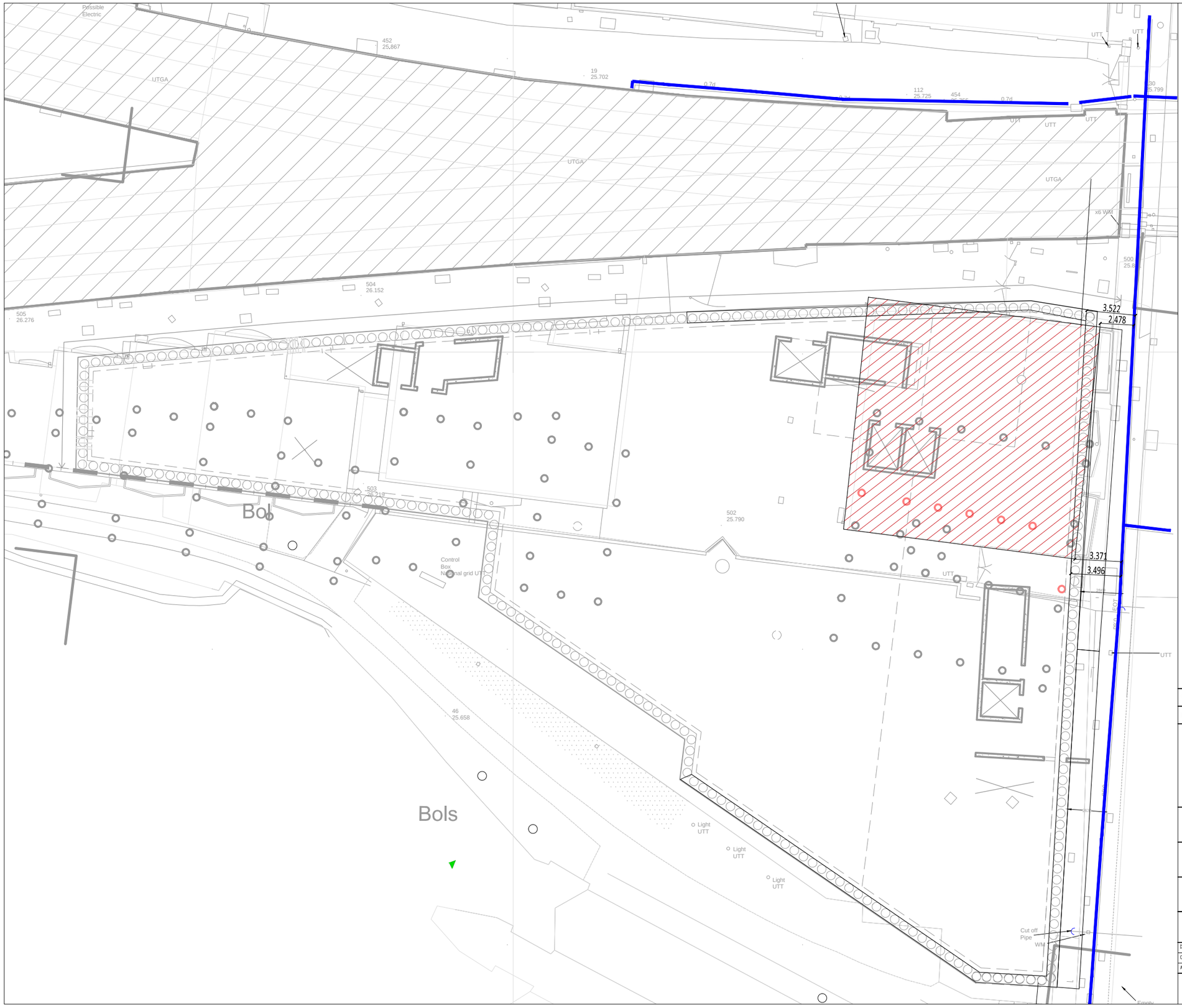
Drawn	TSB	29/07/15
Checked	ADC	04/08/15
Approved	RJB	04/08/15

Dwg No.
Figure 5

Rev.
0



Client	Project	Job No
Walsh Associates	**Camden Lock Village, London**	**CG/18067A**
CGL	Title: **Lateral displacement**	**Figure 6**



KEY

Stage 1 (Existing): +50kPa load (undrained and drained); and
Stage 2 (Demolition): -50kPa unload (undrained only).

Rev	Date	Comments
*	*	*

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Project
Camden Lock Village Phase 2, London

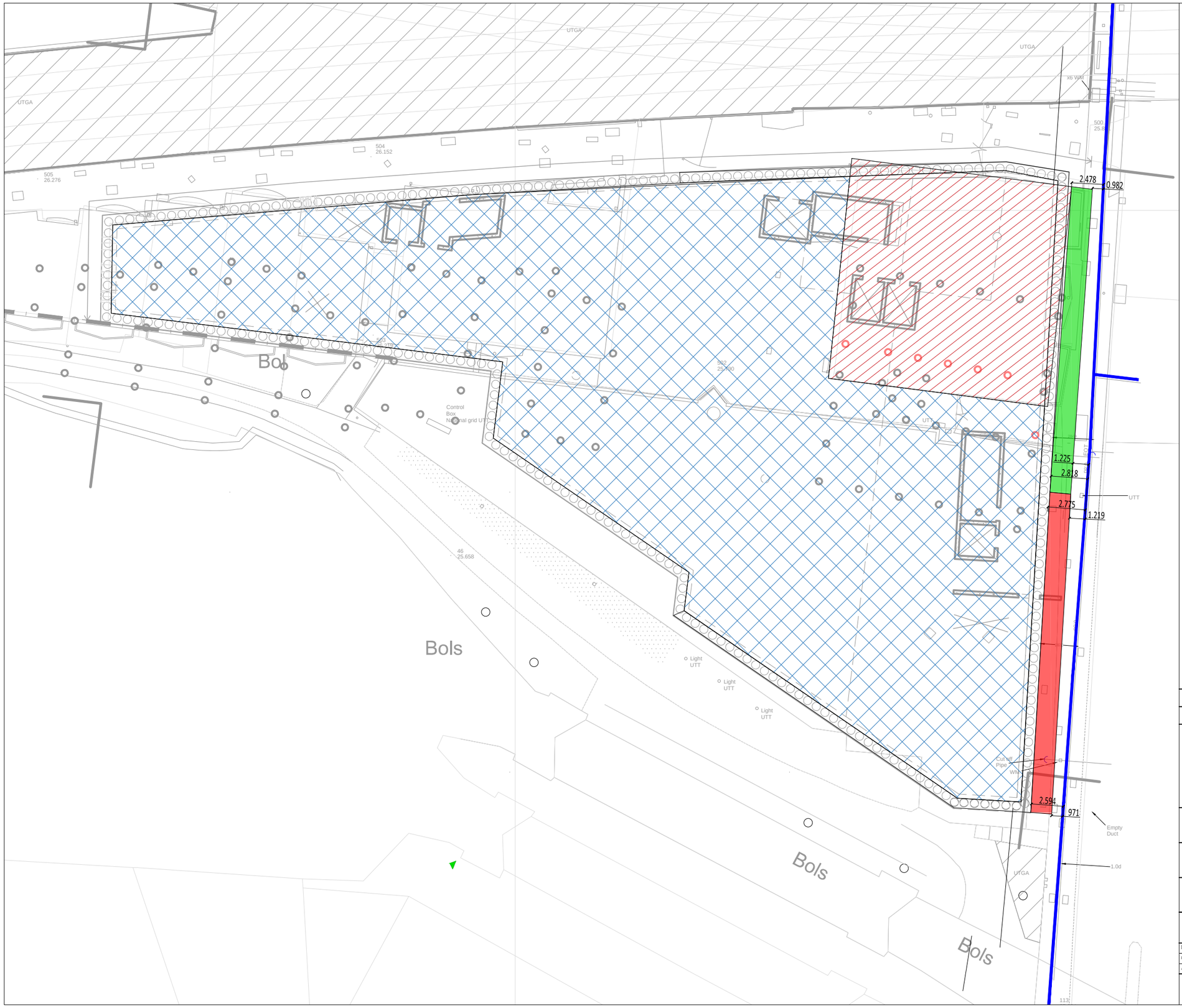
Client
Walsh Associates

Drawing title
Stage 1&2: Historical and demolition

Scale(s)	Job No.
NTS	**CG/18067a**

Drawn	TSB	04/08/15
Checked	ADC	04/08/15
Approved	RJB	04/08/15

Dwg No. **Figure 7**
Rev. **0**



*	*	*
Rev	Date	Comments

Card Geotechnics Ltd
4 Godalming Business Centre
Woolsack Way
Godalming
Surrey
GU7 1XW
T: 01483 310600

Project
Camden Lock Village Phase 2, London

Client
Walsh Associates

Drawing title
Stage 3&4: Excavation and final loading

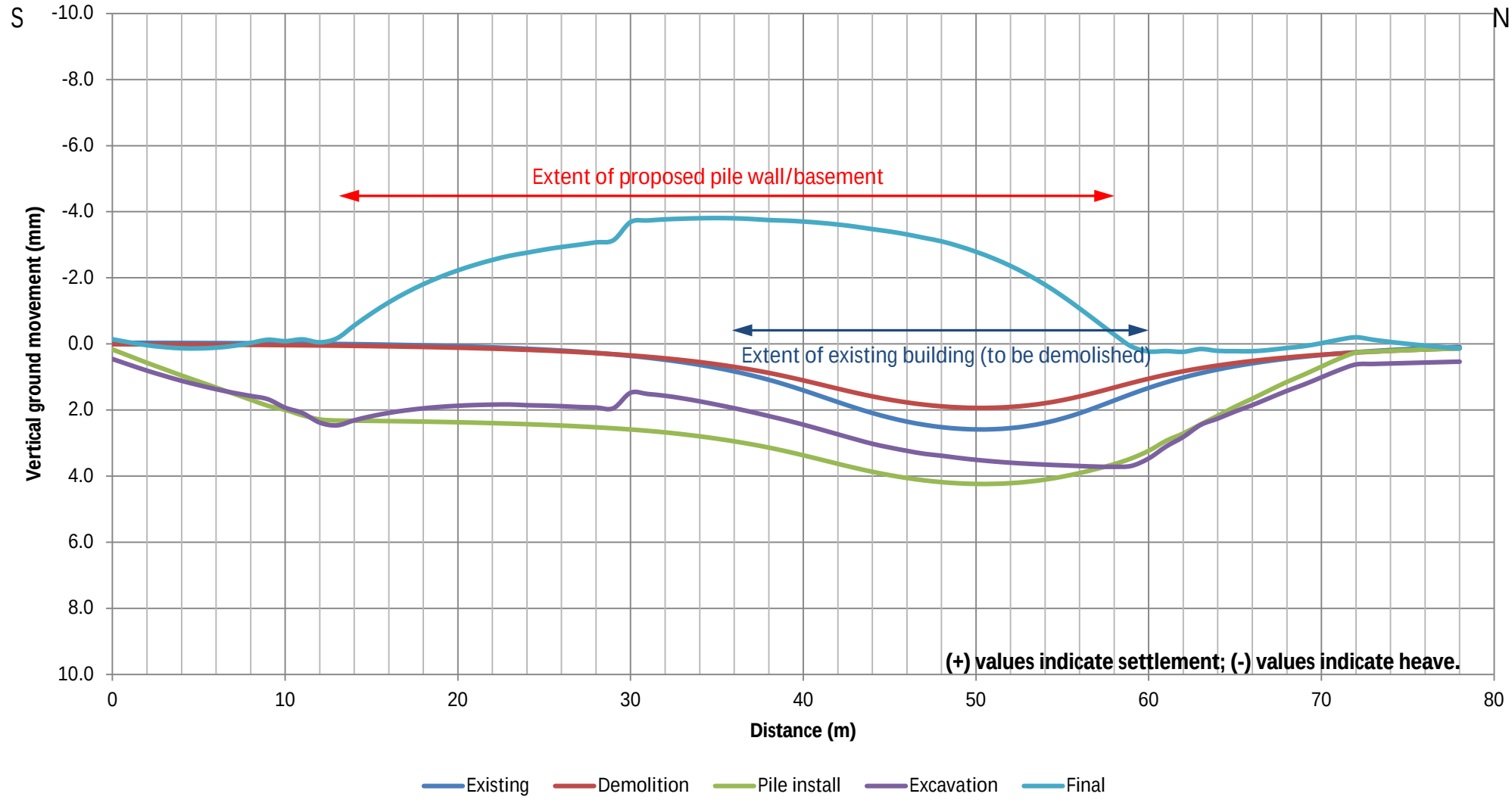
Scale(s)
NTS

Job No.
CG/18067a

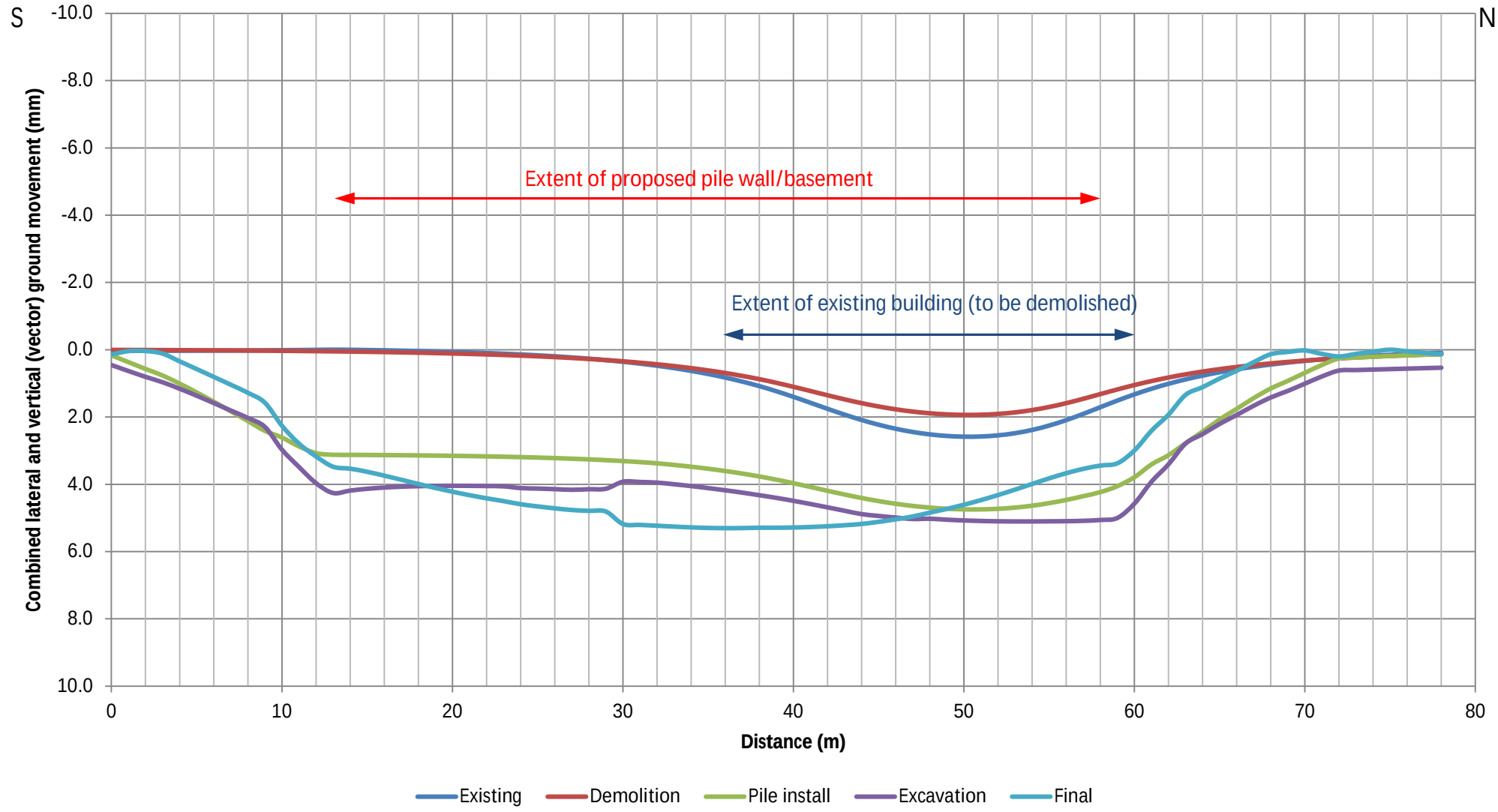
Drawn	TSB	04/08/15
Checked	ADC	04/08/15
Approved	RJB	04/08/15

Dwg No.
Figure 8

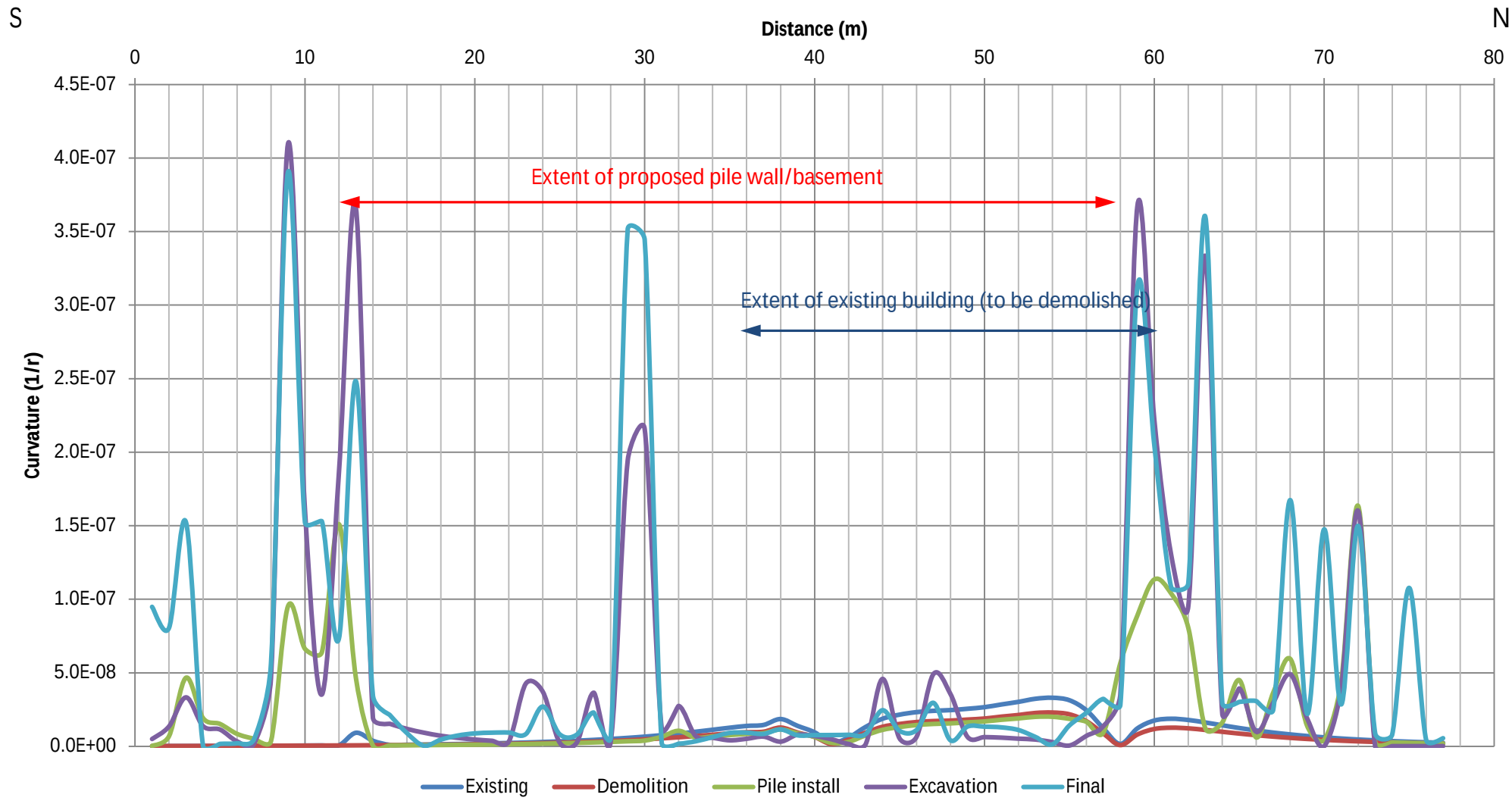
Rev.
0



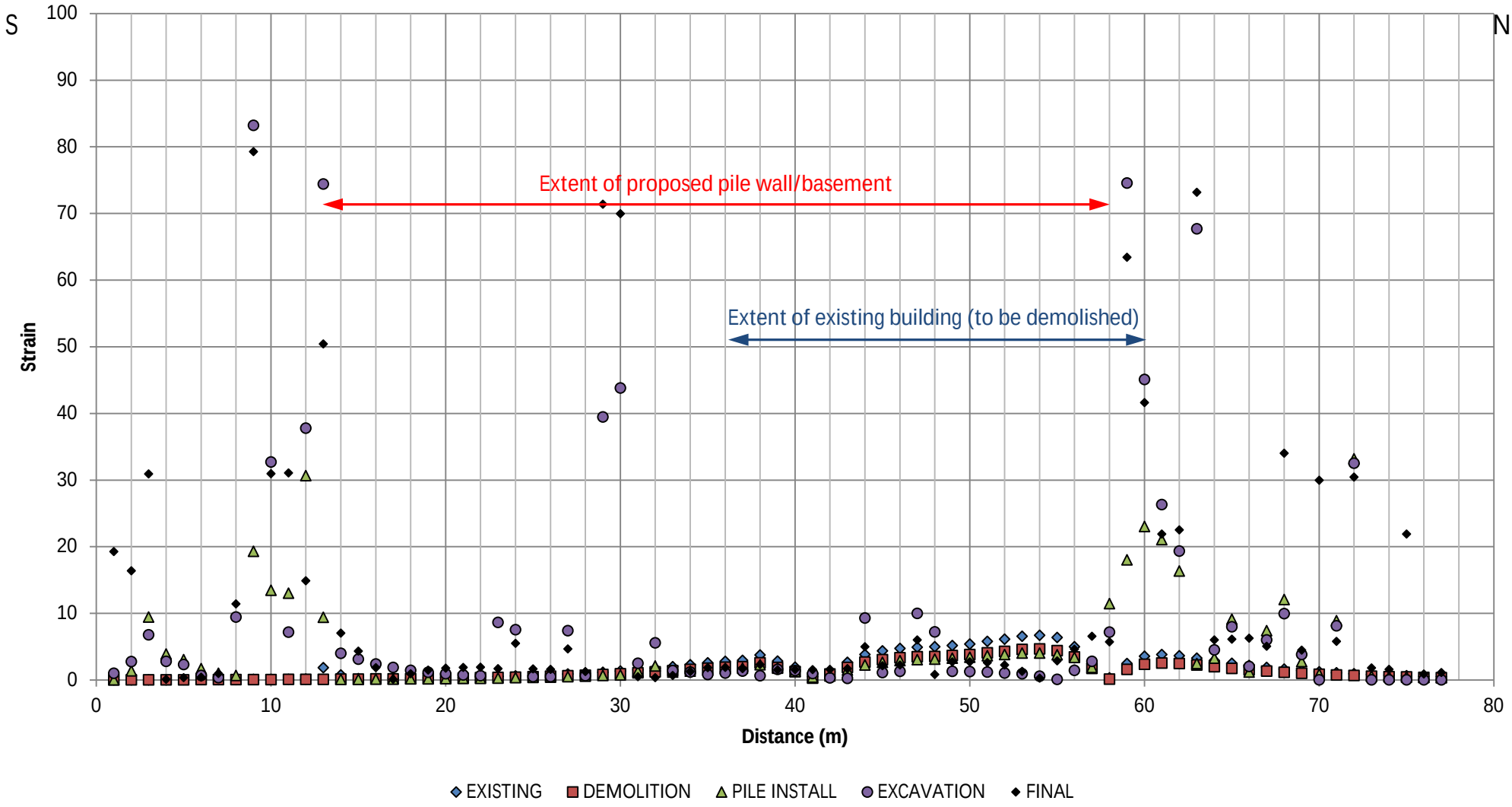
Client	Project	Job No
Walsh Associates	**Camden Lock Village, London**	**CG/18067A**
CGL	Title: **Cumulative vertical displacement**	**Figure 9**



Client	Project	Job No
Walsh Associates	**Camden Lock Village, London**	**CG/18067A**
CGL	Title: **Cumulative vector displacement**	**Figure 10**



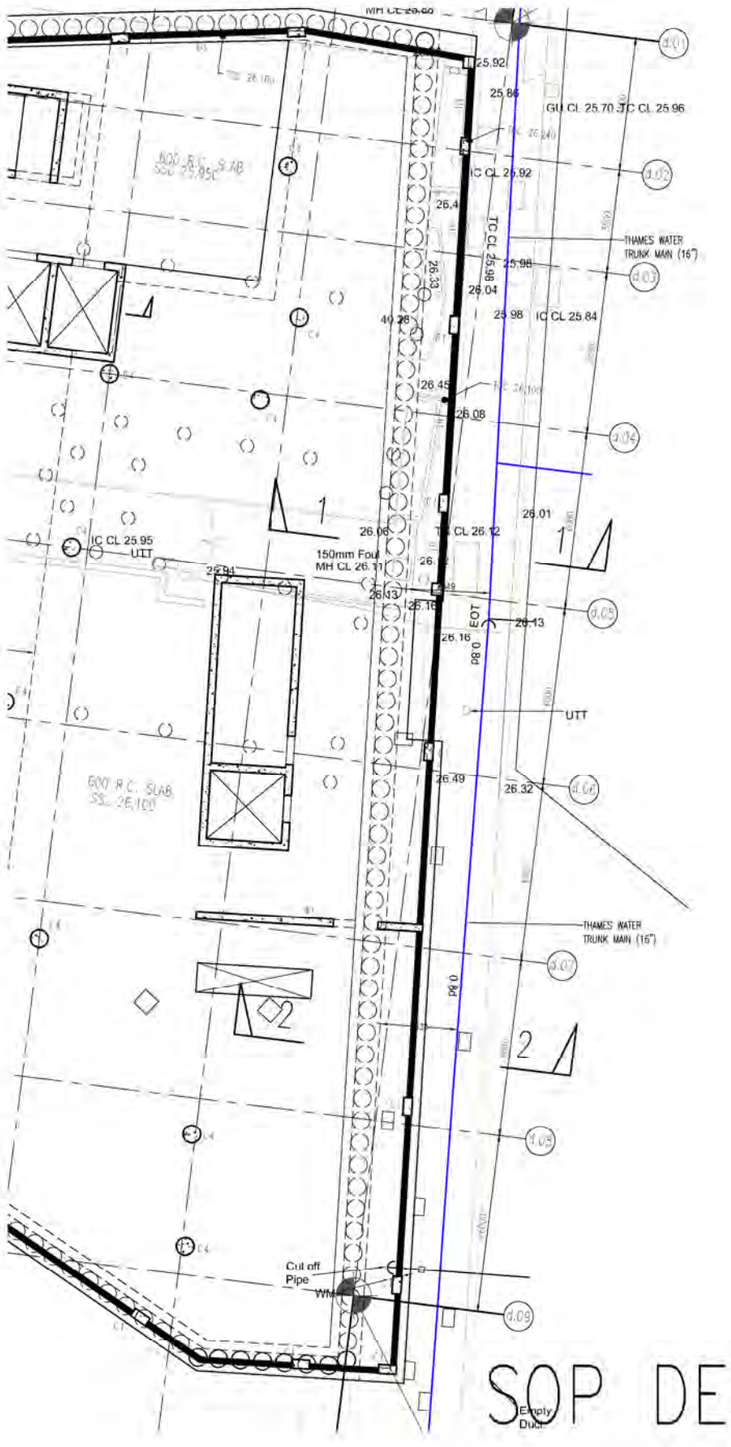
Client	Project	Job No
Walsh Associates	**Camden Lock Village, London**	**CG/18067A**
CGL	Title: **Curvature profiles**	**Figure 11**



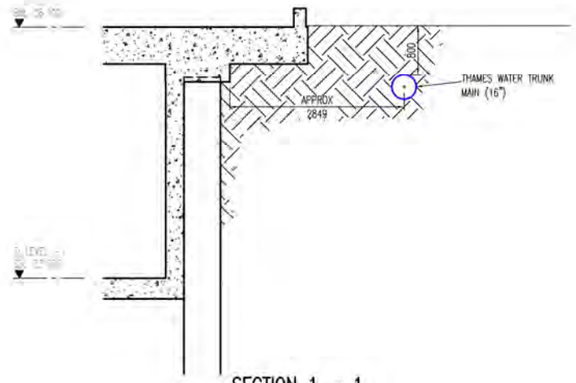
Client	Project	Job No
Walsh Associates	**Camden Lock Village, London**	**CG/18067A**
CGL	Title: **Combined tensile strain profile**	**Figure 12**

APPENDIX A

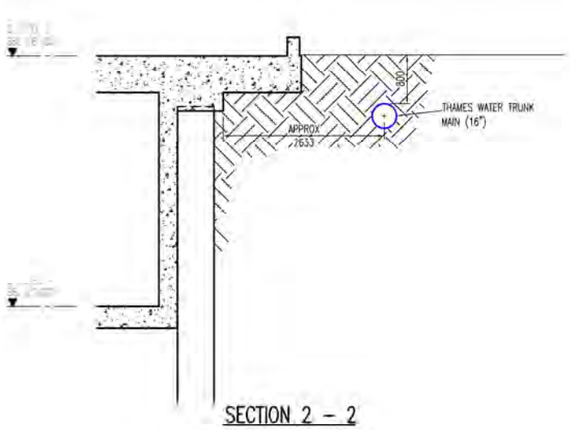
Proposed development plans



SOP DE3



SECTION 1 – 1
GRID LINE d.04
SCALE 1:50



SECTION 2 – 2
GRID LINE d.07
SCALE 1:50

Notes

1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS IN METRES.

2. THIS DRAWING TO BE READ IN CONJUNCTION WITH RELEVANT ARCHITECT'S AND ENGINEER'S DRAWINGS AND SPECIFICATIONS.

3. THIS DRAWING HAS BEEN PRODUCED ELECTRONICALLY AND MAY HAVE BEEN PHOTO REDUCED OR ENLARGED WHEN COPIED. HENCE, DO NOT RELY ON ANY SCALES QUOTED. WORK ONLY TO FIGURED DIMENSIONS (DO NOT SCALE). ALL DIMENSIONS TO BE CHECKED ON SITE. ANY ERRORS OR OMISSIONS TO BE REPORTED TO THE ENGINEER IMMEDIATELY.

C.D.M.

SIGNIFICANT RISKS AND HAZARDS:

KEY DESIGN DECISIONS TO REDUCE OR ELIMINATE HAZARDS:

Rev.	Date	By	Details Of Revision
P1	21.07.15	TH	FIRST ISSUE

Client
STANLEY SIDINGS LTD.

Project
CAMDEN LOCK VILLAGE

Title
BUILDING D FOUNDATION AND THAMES WATER INTERFACE

WALSH
Structural and Civil Engineers
London
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walsh.co.uk

Status
PRELIMINARY

Drawn	TH	A1 Scales	1:50, 1:250		
Date	21.07.15	Eng.	NM	Chk.	App'd.

File Ref.

ACTUAL DIMENSION = 80mm

Drawing No.	Rev.
2765/DE/602	SK

APPENDIX B

Thames Water assessment criteria

4 Assessment Criteria Guidance

The criteria given below are suggested to facilitate the preparation of impact assessment documents in respect of our existing apparatuses. They are for guidance only and represent levels of change in strain and joint rotation below which the risk of significant damage may be considered negligible. It should be noted that it is the Designer's responsibility to select appropriate values for specific assessments.

Values lower than those detailed in the tables below are likely to be acceptable to us. However, higher values would require justification that the risk of damage remains negligible. We do not guarantee that even lower values will not result in damage. If alternative criteria values are considered to be appropriate by Designers, it is suggested that we are consulted as early as possible in the assessment process.

Table 1 - Assessment Criteria for Existing Thames Water Pipeline and Sewer Assets

PIPE TYPE	Diameter (mm)	Allowable Increase in Strain (με)		Rotation (deg.)
		Tension	Compression	
Brick Sewer (red / yellow / blue brick)	N/A	500	25% of the allowable stress	N/A
Cast Iron Lead-yarn joints	N/A	100	1200	0.1
Ductile Iron (Lead-yarn gasket joints)	N/A	500	700	0.5
Ductile Iron (Rubber gasket joints)	N/A	500	700	2.0
Steel	N/A	450	450	1.5
Vitrified Clay	<125	80	400	0.5
	>125	80	400	See Table 2
Concrete (unreinforced)	<225	20	400	0.5
	225 – 750	40	400	See Table 2
	>750	60	400	

Table 2 - Maximum Rotation for Vitrified Clay and Concrete Pipes

Diameter (mm)	Rotation (deg.)
< 375	2.0
375 – 750	1.0
750 – 1400	0.5
> 1400	0.3

APPENDIX C

WALLAP output

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	26.10	1 Made Ground	1 Made Ground
2	24.60	2 London Clay	2 London Clay

SOIL PROPERTIES

No.	Soil type / Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made Ground	18.00	18000	0.561	NC (0.490)	1.000 (2.389)	1.000 (2.390)	30.00u
2	London Clay (24.60)	20.00	50000 (6000)	1.000	OC (0.490)	1.000 (2.475)	1.000 (2.476)	50.00u (6.000)
3	London Cl.. (24.60)	20.00	37500 (4500)	0.593	OC (0.200)	0.367 (1.423)	3.241 (5.034)	5.000d
4	Made Ground DR	18.00	10800	0.561	NC (0.200)	0.346 (1.340)	3.442 (5.007)	30.00d

Additional soil parameters associated with Ka and Kp

No.	Soil type	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	0.00	0.500	0.00	0.00	0.500	0.00
2	London Clay	0.00	0.667	0.00	0.00	0.667	0.00
3	London Clay DR	24.00	0.667	0.00	24.00	0.667	0.00
4	Made Ground DR	26.00	0.500	0.00	26.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	25.00	25.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	25.10	25.10	0.0	1	21.50	21.50	0.0	MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 19.00
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 3.0000E+07 kN/m2
Moment of inertia of wall I = 8.4823E-03 m4/m run
E.I = 254469 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	25.80	1.00	0.300000	3.000E+07	30.00	0.00	0	Yes
2	22.00	1.00	0.300000	3.000E+07	30.00	0.00	0	Yes
3	25.50	5.00	0.010000	2.000E+08	20.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	26.10	0.00(A)	30.00	10.00	20.00	=	N/A	1.00 -

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 26.10
2	Change EI of wall to 254469 kN.m2/m run From elevation 26.00 to 19.00 Yield moment not defined Reset wall displacements to zero at this stage
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 25.30 on PASSIVE side
5	Install strut or anchor no.3 at elevation 25.50
6	Excavate to elevation 21.50 on PASSIVE side
7	Install strut or anchor no.2 at elevation 22.00
8	Install strut or anchor no.1 at elevation 25.80
9	Remove strut or anchor no.3 at elevation 25.50
10	Change properties of soil type 2 to soil type 3 Ko pressures will not be reset
11	Change properties of soil type 1 to soil type 4 Ko pressures will not be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: Serviceability Limit State
All loads and soil strengths are unfactored

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.25

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 0 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

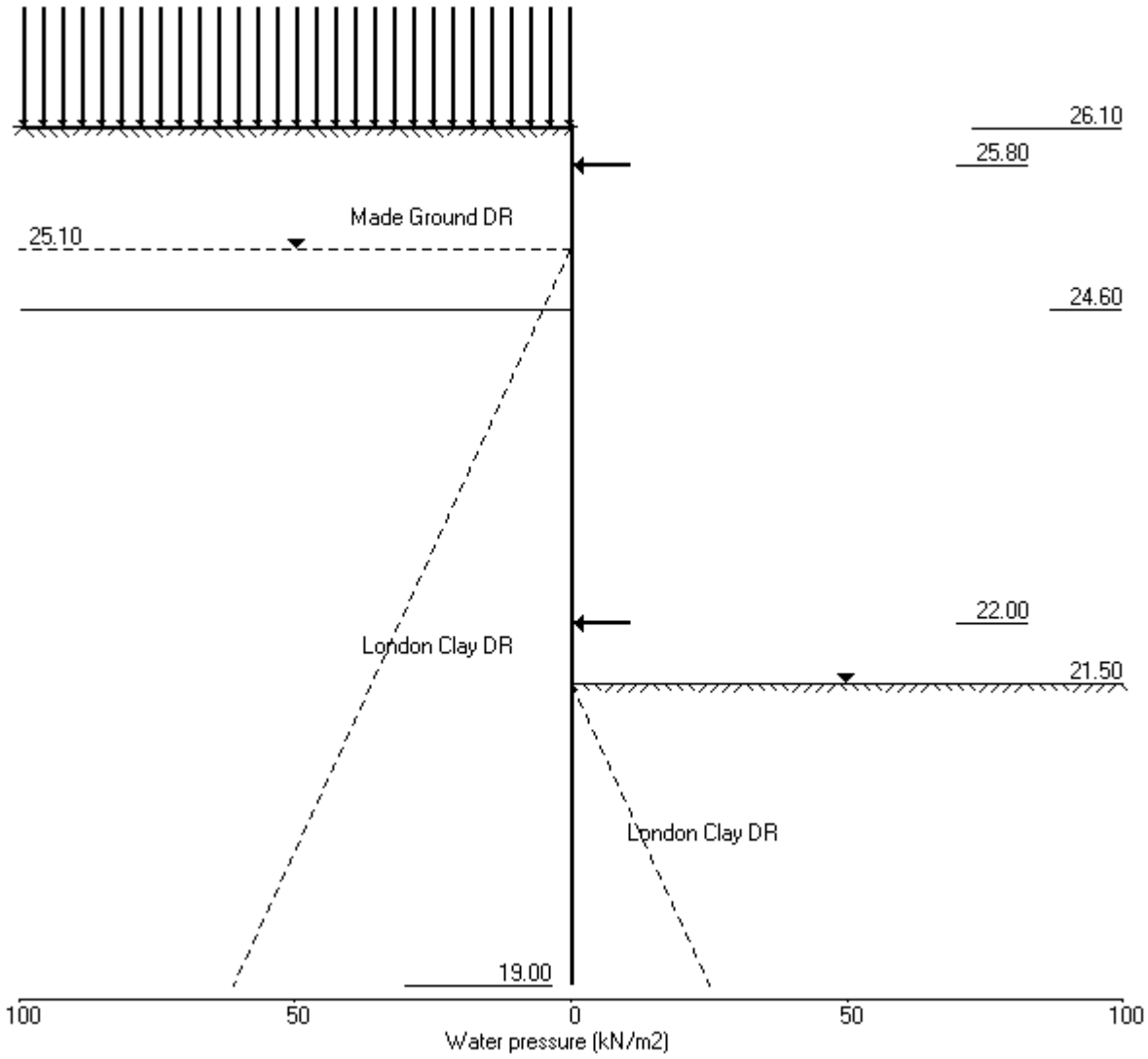
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 26.10	Yes	Yes	Yes
2	Change EI of wall to 254469kN.m2/m run	No	No	No
3	Apply water pressure profile no.1	No	No	No
4	Excav. to elev. 25.30 on PASSIVE side	No	No	No
5	Install strut no.3 at elev. 25.50	No	No	No
6	Excav. to elev. 21.50 on PASSIVE side	No	No	No
7	Install strut no.2 at elev. 22.00	No	No	No
8	Install strut no.1 at elev. 25.80	No	No	No
9	Remove strut no.3 at elev. 25.50	No	No	No
10	Change soil type 2 to soil type 3	No	No	No
11	Change soil type 1 to soil type 4	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.11 Change soil type 1 to soil type 4



Units: kN,m

Stage No. 4 Excavate to elevation 25.30 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 19.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.250 Toe elev.	Wall Penetr -ation
4	26.10	25.30	Cant.	6.742	19.54	25.14	0.16

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	26.10	7.28	0.001	2.02E-04	0.0	0.0	
2	26.00	8.52	0.001	2.02E-04	0.8	0.0	
3	25.80	11.00	0.001	2.02E-04	2.7	0.4	
4	25.50	14.72	0.001	2.02E-04	6.6	1.7	
5	25.30	17.19	0.001	2.01E-04	9.8	3.4	
		12.44	0.001	2.01E-04	9.8	3.4	
6	25.10	13.39	0.001	1.99E-04	12.4	5.6	
7	25.00	13.84	0.001	1.98E-04	13.7	6.9	
8	24.60	15.61	0.001	1.91E-04	19.6	13.5	
		-18.87	0.001	1.91E-04	19.6	13.5	
9	24.30	-16.94	0.001	1.83E-04	14.3	18.5	
10	24.00	-14.93	0.001	1.72E-04	9.5	22.0	
11	23.60	-12.25	0.001	1.56E-04	4.0	24.6	
12	23.20	-9.65	0.001	1.39E-04	-0.3	25.3	
13	22.80	-7.21	0.001	1.22E-04	-3.7	24.4	
14	22.40	-4.98	0.001	1.06E-04	-6.1	22.3	
15	22.00	-2.96	0.000	9.24E-05	-7.7	19.4	
16	21.75	-1.80	0.000	8.46E-05	-8.3	17.4	
17	21.50	-0.72	0.000	7.78E-05	-8.6	15.3	
18	21.15	0.54	0.000	6.98E-05	-8.7	12.2	
19	20.80	1.71	0.000	6.36E-05	-8.3	9.2	
20	20.40	2.98	0.000	5.85E-05	-7.3	6.0	
21	20.00	4.23	0.000	5.54E-05	-5.9	3.3	
22	19.60	5.53	0.000	5.39E-05	-3.9	1.3	
23	19.30	6.56	0.000	5.35E-05	-2.1	0.3	
24	19.00	7.65	0.000	5.35E-05	0.0	-0.0	

(continued)

Stage No.4 Excavate to elevation 25.30 on PASSIVE side

Node no.	Y coord	ACTIVE side						
			Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
1	26.10	Total>	20.00	0.00	91.70	7.28	7.28	4737
2	26.00	Total>	21.80	0.50m	93.50	8.52	8.52	4737
3	25.80	Total>	25.40	1.50m	97.10	11.00	11.00	4737
4	25.50	Total>	30.80	3.00m	102.50	14.72	14.72	4737
5	25.30	Total>	34.39	4.00m	106.09	17.19	17.19	4737
6	25.10	Total>	37.99	5.00m	109.69	19.66	19.66	4737
7	25.00	Total>	39.79	5.50m	111.48	20.90	20.90	4737
8	24.60	Total>	46.97	7.50m	118.67	27.56	27.56	4737
		Total>	46.97	7.50m	170.77	20.36	20.36	13159
9	24.30	Total>	52.94	9.00m	181.20	27.25	27.25	13633
10	24.00	Total>	58.91	10.50m	191.62	34.18	34.18	14106
11	23.60	Total>	66.85	12.50m	205.51	43.40	43.40	14738
12	23.20	Total>	74.78	14.50m	219.37	52.58	52.58	15370
13	22.80	Total>	82.68	16.50m	233.22	61.67	61.67	16001
14	22.40	Total>	90.56	18.50m	247.04	70.64	70.64	16633
15	22.00	Total>	98.42	20.50m	260.85	79.50	79.50	17264
16	21.75	Total>	103.32	21.75m	269.46	84.98	84.98	17659
17	21.50	Total>	108.21	23.00m	278.07	90.42	90.42	18054
18	21.15	Total>	115.05	24.75m	290.10	97.98	97.98	18607
19	20.80	Total>	121.87	26.50m	302.12	105.48	105.48	19159
20	20.40	Total>	129.65	28.50m	315.84	114.01	114.01	19791
21	20.00	Total>	137.41	30.50m	329.55	122.53	122.53	20423
22	19.60	Total>	145.15	32.50m	343.23	131.06	131.06	21054
23	19.30	Total>	150.95	34.00m	353.49	137.48	137.48	21528
24	19.00	Total>	156.74	35.50m	363.74	143.93	143.93	22002

Node no.	Y coord	PASSIVE side						
			Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
1	26.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	25.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	25.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	25.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	71.70	4.75	4.75	4897
6	25.10	Total>	3.60	1.00m	75.30	6.27	6.27	4897
7	25.00	Total>	5.40	1.50m	77.10	7.05	7.05	4897
8	24.60	Total>	12.60	3.50m	84.30	11.95	11.95	4897
		Total>	12.60	3.50m	136.40	39.24	39.24	13603
9	24.30	Total>	18.60	5.00m	146.86	44.19	44.19	14093
10	24.00	Total>	24.60	6.50m	157.32	49.11	49.11	14582
11	23.60	Total>	32.60	8.50m	171.26	55.65	55.65	15235
12	23.20	Total>	40.61	10.50m	185.21	62.23	62.23	15888
13	22.80	Total>	48.61	12.50m	199.15	68.88	68.88	16541
14	22.40	Total>	56.62	14.50m	213.10	75.62	75.62	17194
15	22.00	Total>	64.63	16.50m	227.05	82.46	82.46	17847
16	21.75	Total>	69.63	17.75m	235.77	86.78	86.78	18255
17	21.50	Total>	74.64	19.00m	244.49	91.14	91.14	18663
18	21.15	Total>	81.65	20.75m	256.71	97.43	97.43	19235
19	20.80	Total>	88.67	22.50m	268.92	103.76	103.76	19806
20	20.40	Total>	96.68	24.50m	282.88	111.03	111.03	20459
21	20.00	Total>	104.70	26.50m	296.84	118.29	118.29	21112

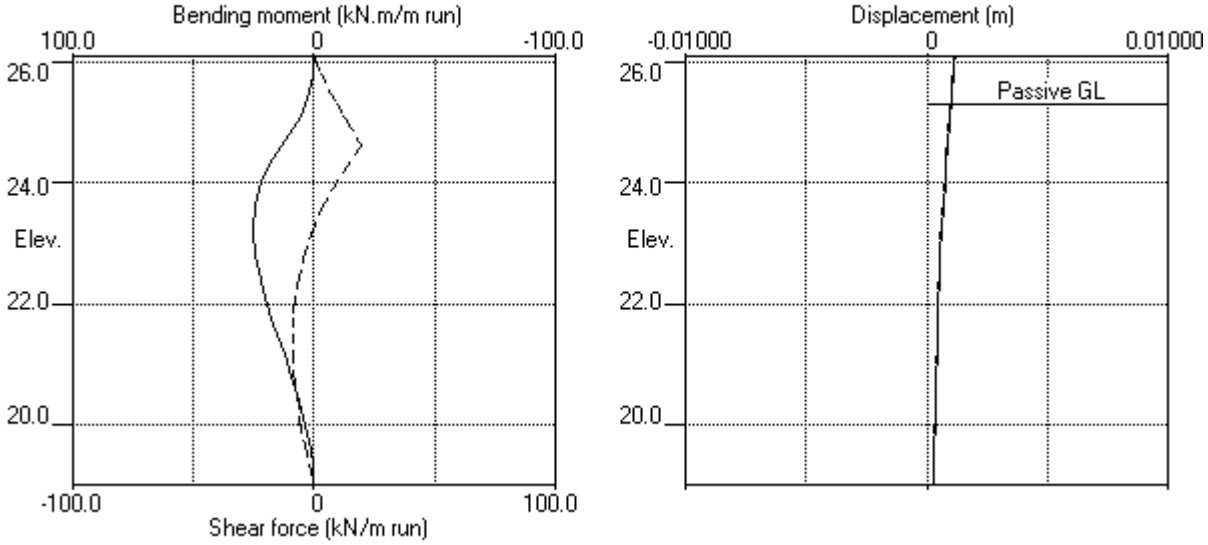
(continued)

Stage No.4 Excavate to elevation 25.30 on PASSIVE side

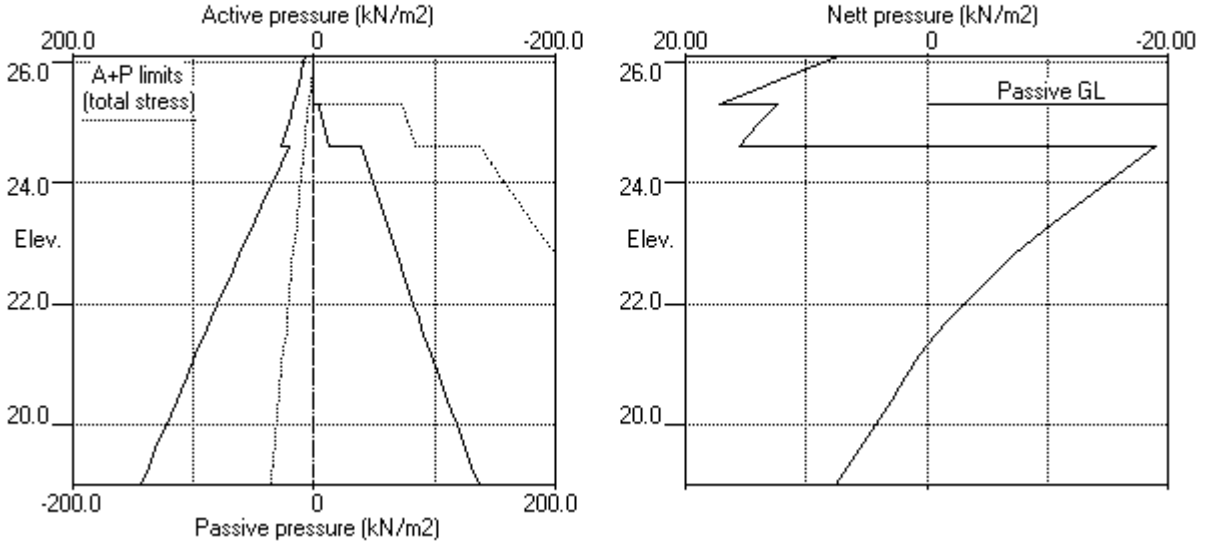
Node no.	Y coord	PASSIVE side						
			Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
22	19.60	Total>	112.73	28.50m	310.81	125.53	125.53	21765
23	19.30	Total>	118.75	30.00m	321.29	130.92	130.92	22254
24	19.00	Total>	124.77	31.50m	331.76	136.28	136.28	22744

Units: kN,m

Stage No.4 Excav. to elev. 25.30 on PASSIVE side



Stage No.4 Excav. to elev. 25.30 on PASSIVE side



Units: kN,m

Stage No. 6 Excavate to elevation 21.50 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 19.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.250 Toe elev.	Wall Penetr -ation
6	26.10	21.50	25.50	2.983	n/a	21.23	0.27

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	26.10	1.87	0.003	-4.80E-04	0.0	-0.0	
2	26.00	2.90	0.003	-4.80E-04	0.2	0.0	
3	25.80	4.98	0.003	-4.80E-04	1.0	0.1	
4	25.50	8.09	0.003	-4.80E-04	3.0	0.7	44.6
		8.09	0.003	-4.80E-04	-41.7	0.7	
5	25.30	10.16	0.003	-4.76E-04	-39.8	-7.5	
6	25.10	12.23	0.003	-4.65E-04	-37.6	-15.2	
7	25.00	13.26	0.003	-4.57E-04	-36.3	-18.9	
8	24.60	19.18	0.004	-4.08E-04	-29.8	-32.2	
		7.50	0.004	-4.08E-04	-29.8	-32.2	
9	24.30	9.00	0.004	-3.54E-04	-27.4	-40.9	
10	24.00	10.50	0.004	-2.88E-04	-24.4	-48.7	
11	23.60	12.87	0.004	-1.85E-04	-19.8	-56.8	
12	23.20	19.67	0.004	-6.84E-05	-13.2	-63.5	
13	22.80	26.86	0.004	5.61E-05	-3.9	-67.0	
14	22.40	34.48	0.004	1.81E-04	8.3	-66.3	
15	22.00	42.59	0.004	2.99E-04	23.7	-60.0	
16	21.75	47.90	0.004	3.65E-04	35.1	-52.7	
17	21.50	53.40	0.004	4.21E-04	47.7	-42.4	
		-32.42	0.004	4.21E-04	47.7	-42.4	
18	21.15	-29.98	0.004	4.80E-04	36.8	-27.7	
19	20.80	-26.73	0.003	5.19E-04	26.9	-16.6	
20	20.40	-22.19	0.003	5.45E-04	17.1	-8.0	
21	20.00	-16.93	0.003	5.58E-04	9.3	-3.0	
22	19.60	-11.02	0.003	5.63E-04	3.7	-0.6	
23	19.30	-6.20	0.003	5.64E-04	1.1	-0.0	
24	19.00	-1.06	0.002	5.64E-04	0.0	-0.0	

At elev. 25.50 Strut force = 223.2 kN/strut = 44.6 kN/m run

(continued)

Stage No.6 Excavate to elevation 21.50 on PASSIVE side

Node no.	Y coord	ACTIVE side						
			Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	26.10	Total>	20.00	0.00	91.70	1.87	1.87	2971
2	26.00	Total>	21.80	0.50m	93.50	2.90	2.90	2971
3	25.80	Total>	25.40	1.50m	97.10	4.98	4.98	2971
4	25.50	Total>	30.80	3.00m	102.50	8.09	8.09	2971
5	25.30	Total>	34.39	4.00m	106.09	10.16	10.16	2971
6	25.10	Total>	37.99	5.00m	109.69	12.23	12.23	2971
7	25.00	Total>	39.79	5.50m	111.48	13.26	13.26	2971
8	24.60	Total>	46.97	7.50m	118.67	19.18	19.18	2971
		Total>	46.97	7.50m	170.77	7.50	7.50a	8252
9	24.30	Total>	52.94	9.00m	181.20	9.00	9.00a	8549
10	24.00	Total>	58.91	10.50m	191.62	10.50	10.50a	8846
11	23.60	Total>	66.85	12.50m	205.51	12.87	12.87	9242
12	23.20	Total>	74.78	14.50m	219.37	19.67	19.67	9638
13	22.80	Total>	82.68	16.50m	233.22	26.86	26.86	10034
14	22.40	Total>	90.56	18.50m	247.04	34.48	34.48	10430
15	22.00	Total>	98.42	20.50m	260.85	42.59	42.59	10827
16	21.75	Total>	103.32	21.75m	269.46	47.90	47.90	11074
17	21.50	Total>	108.21	23.00m	278.07	53.40	53.40	11322
18	21.15	Total>	115.05	24.75m	290.10	61.37	61.37	11668
19	20.80	Total>	121.87	26.50m	302.12	69.61	69.61	12015
20	20.40	Total>	129.65	28.50m	315.84	79.30	79.30	12411
21	20.00	Total>	137.41	30.50m	329.55	89.25	89.25	12807
22	19.60	Total>	145.15	32.50m	343.23	99.43	99.43	13203
23	19.30	Total>	150.95	34.00m	353.49	107.21	107.21	13500
24	19.00	Total>	156.74	35.50m	363.74	115.12	115.12	13797

Node no.	Y coord	PASSIVE side						
			Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	26.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	25.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	25.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	25.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	25.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	24.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	24.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	23.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	23.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	22.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	22.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	21.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	169.85	85.81	85.81	20298
18	21.15	Total>	7.00	1.75m	182.05	91.35	91.35	20919
19	20.80	Total>	14.00	3.50m	194.25	96.34	96.34	21540
20	20.40	Total>	22.01	5.50m	208.20	101.50	101.50	22250
21	20.00	Total>	30.02	7.50m	222.15	106.18	106.18	22960
22	19.60	Total>	38.03	9.50m	236.11	110.45	110.45	23671

(continued)

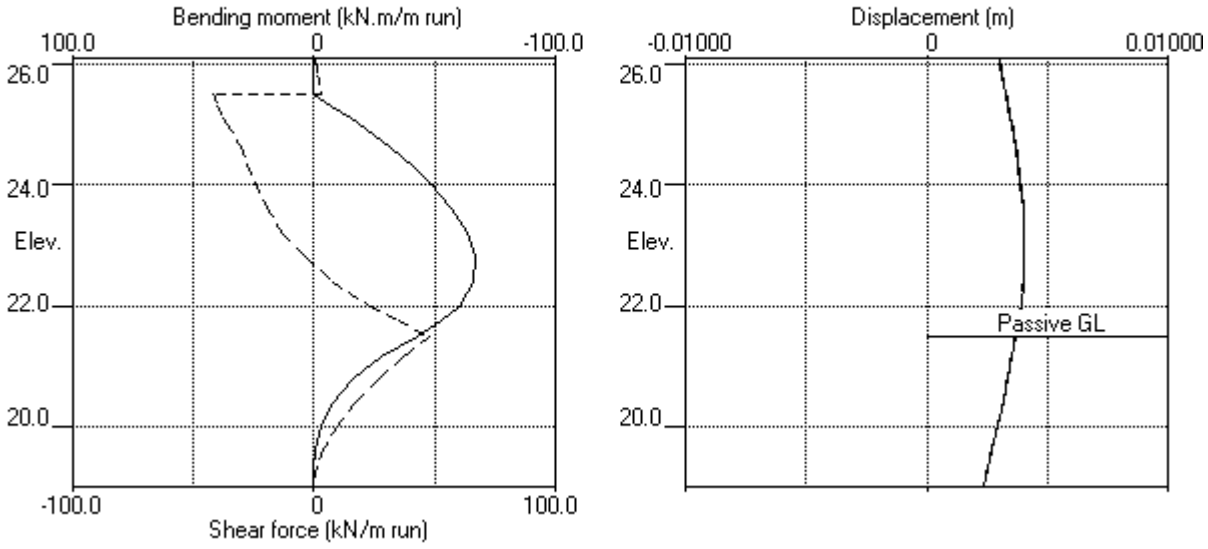
Stage No.6 Excavate to elevation 21.50 on PASSIVE side

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
23	19.30	Total>	44.05	11.00m	246.59	113.41	113.41	24203
24	19.00	Total>	50.07	12.50m	257.07	116.17	116.17	24736

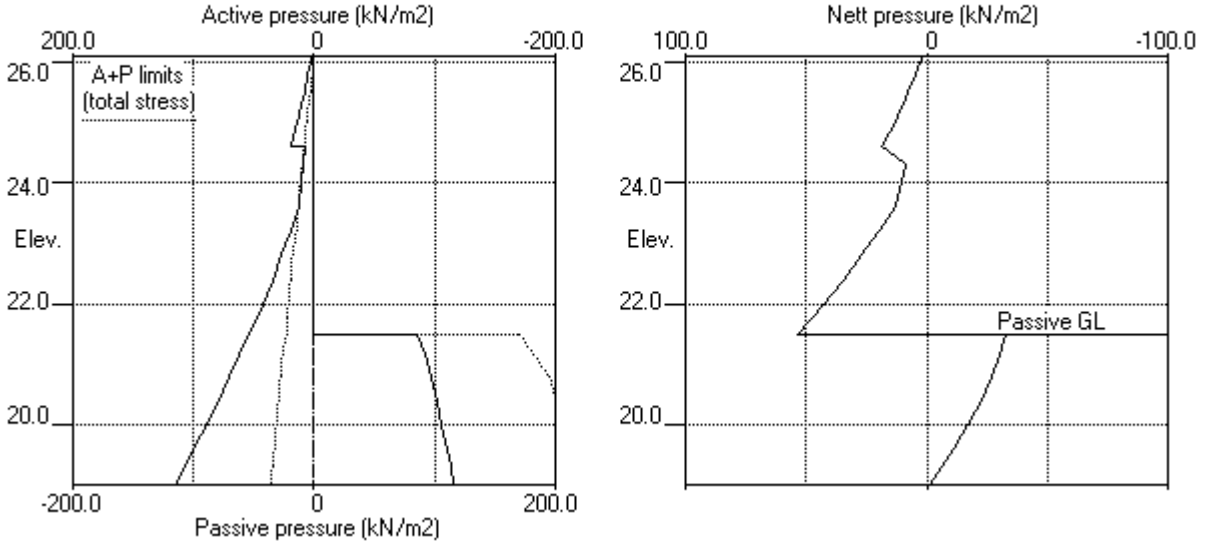
Note: 10.50a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.6 Excav. to elev. 21.50 on PASSIVE side



Stage No.6 Excav. to elev. 21.50 on PASSIVE side



Units: kN,m

Stage No. 10 Change properties of soil type 2 to soil type 3
Ko pressures will not be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 19.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.250 Toe elev.	Wall Penetr -ation
10	26.10	21.50		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	26.10	1.56	0.003	-5.47E-04	0.0	-0.0	
2	26.00	2.47	0.003	-5.47E-04	0.2	0.0	
3	25.80	4.34	0.003	-5.47E-04	0.9	0.1	39.5
		4.34	0.003	-5.47E-04	-38.6	0.1	
4	25.50	7.34	0.003	-5.39E-04	-36.9	-11.2	
5	25.30	9.35	0.004	-5.27E-04	-35.2	-18.4	
6	25.10	11.37	0.004	-5.07E-04	-33.1	-25.3	
7	25.00	12.38	0.004	-4.95E-04	-31.9	-28.5	
8	24.60	18.22	0.004	-4.33E-04	-25.8	-40.2	
		13.27	0.004	-4.33E-04	-25.8	-40.2	
9	24.30	17.36	0.004	-3.70E-04	-21.2	-47.3	
10	24.00	21.45	0.004	-2.98E-04	-15.4	-52.8	
11	23.60	26.90	0.004	-1.92E-04	-5.7	-56.4	
12	23.20	32.33	0.004	-8.14E-05	6.1	-56.4	
13	22.80	37.77	0.004	2.51E-05	20.2	-51.2	
14	22.40	43.19	0.004	1.17E-04	36.3	-40.0	
15	22.00	48.60	0.004	1.84E-04	54.7	-21.9	80.0
		48.60	0.004	1.84E-04	-25.3	-21.9	
16	21.75	51.98	0.004	2.19E-04	-12.7	-26.7	
17	21.50	55.36	0.004	2.55E-04	0.7	-28.2	
		30.19	0.004	2.55E-04	0.7	-28.2	
18	21.15	20.07	0.004	3.03E-04	9.5	-26.4	
19	20.80	9.94	0.004	3.45E-04	14.8	-22.1	
20	20.40	1.03	0.004	3.82E-04	17.0	-15.6	
21	20.00	-6.96	0.004	4.05E-04	15.8	-9.0	
22	19.60	-14.74	0.003	4.17E-04	11.4	-3.6	
23	19.30	-20.47	0.003	4.21E-04	6.2	-1.0	

(continued)

Stage No.10 Change properties of soil type 2 to soil type 3
Ko pressures will not be reset

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
24	19.00	-20.63	0.003	4.21E-04	0.0	-0.0	
At elev. 25.80 Strut force =			39.5 kN/strut =		39.5 kN/m run		
At elev. 22.00 Strut force =			80.0 kN/strut =		80.0 kN/m run		

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	26.10	Total>	20.00	0.00	91.70	1.56	1.56	22264
2	26.00	Total>	21.80	0.50m	93.50	2.47	2.47	22264
3	25.80	Total>	25.40	1.50m	97.10	4.34	4.34	5727
4	25.50	Total>	30.80	3.00m	102.50	7.34	7.34	5727
5	25.30	Total>	34.39	4.00m	106.09	9.35	9.35	5727
6	25.10	Total>	37.99	5.00m	109.69	11.37	11.37	5727
7	25.00	Total>	39.79	5.50m	111.48	12.38	12.38	5727
8	24.60	Total>	46.97	7.50m	118.67	18.22	18.22	5727
		5.00	41.97	8.27	161.20	8.27	13.27a	8416
9	24.30	8.00	44.94	9.36	170.85	9.36	17.36a	8719
10	24.00	11.00	47.91	10.45	180.47	10.45	21.45a	9022
11	23.60	15.00	51.85	11.90	193.25	11.90	26.90a	9426
12	23.20	19.00	55.78	13.33	205.96	13.33	32.33a	9830
13	22.80	23.00	59.68	14.77	218.61	14.77	37.77a	10234
14	22.40	27.00	63.56	16.19	231.19	16.19	43.19a	10638
15	22.00	31.00	67.42	17.60	243.70	17.60	48.60a	11042
16	21.75	33.50	69.82	18.48	251.49	18.48	51.98a	11294
17	21.50	36.00	72.21	19.36	259.24	19.36	55.36a	11547
18	21.15	39.50	75.55	20.58	270.06	20.58	60.08a	11900
19	20.80	43.00	78.87	21.80	280.82	21.80	64.80a	12254
20	20.40	47.00	82.65	23.19	293.07	25.88	72.88	12658
21	20.00	51.00	86.41	24.57	305.26	30.89	81.89	13062
22	19.60	55.00	90.15	25.94	317.39	36.12	91.12	13466
23	19.30	58.00	92.95	26.96	326.47	40.17	98.17	13769
24	19.00	61.00	95.74	27.99	335.52	44.33	105.33	14072

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	26.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	25.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	25.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	25.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	25.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	24.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	24.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	23.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	23.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	22.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	22.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

(continued)

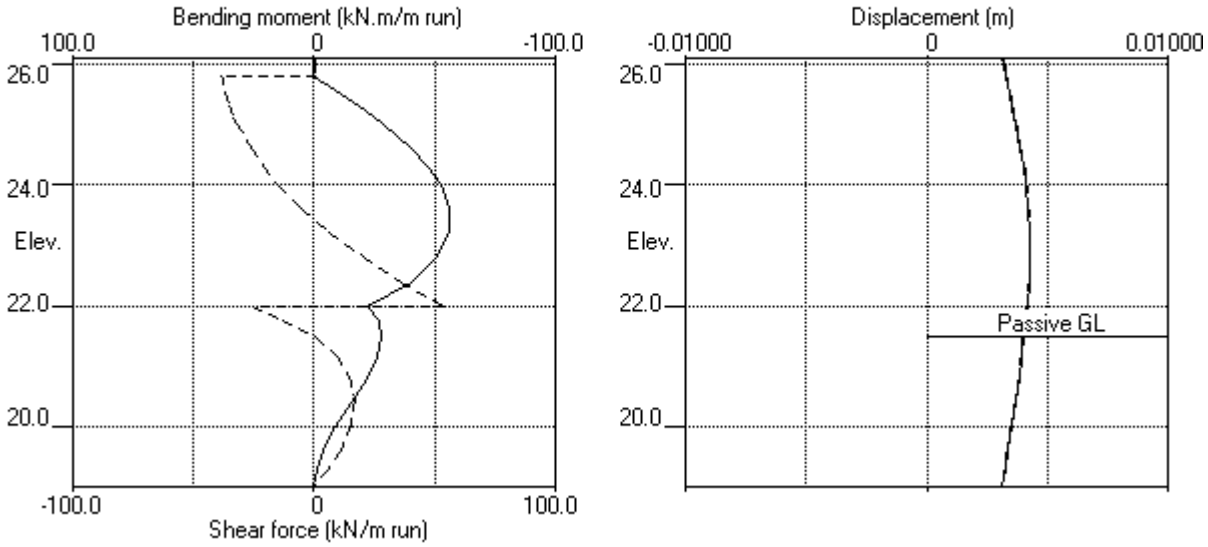
Stage No.10 Change properties of soil type 2 to soil type 3
Ko pressures will not be reset

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
16	21.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	25.17	25.17	25.17p	11547
18	21.15	3.50	3.50	0.00	36.52	36.52	40.02p	11900
19	20.80	7.00	7.00	0.00	47.87	47.87	54.87p	12254
20	20.40	11.00	11.01	0.00	60.85	60.85	71.85p	12658
21	20.00	15.00	15.02	0.00	73.84	73.84	88.84p	13062
22	19.60	19.00	19.03	0.00	86.86	86.86	105.86p	13466
23	19.30	22.00	22.05	0.97	96.64	96.64	118.64p	13769
24	19.00	25.00	25.07	2.08	106.44	100.96	125.96	14072

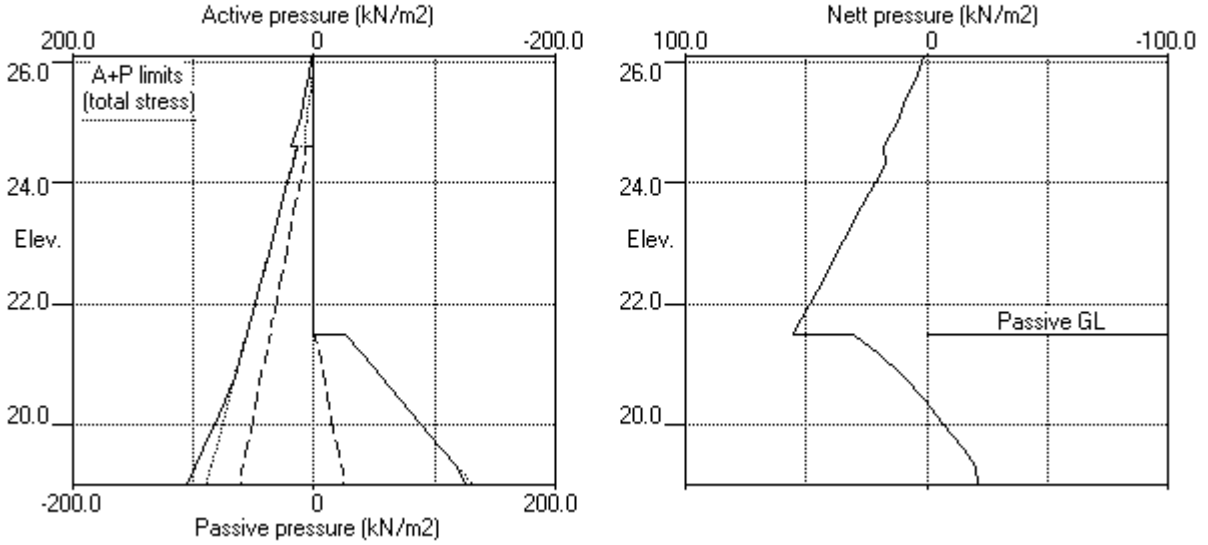
Note: 64.80a Soil pressure at active limit
118.64p Soil pressure at passive limit

Units: kN,m

Stage No.10 Change soil type 2 to soil type 3



Stage No.10 Change soil type 2 to soil type 3



Units: kN,m

Stage No. 11 Change properties of soil type 1 to soil type 4
Ko pressures will not be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 19.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.250 Toe elev.	Wall Penetr -ation
11	26.10	21.50		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	26.10	1.56	0.003	-5.47E-04	0.0	-0.0	
2	26.00	2.47	0.003	-5.47E-04	0.2	0.0	
3	25.80	4.34	0.003	-5.47E-04	0.9	0.1	39.5
		4.34	0.003	-5.47E-04	-38.6	0.1	
4	25.50	7.34	0.003	-5.39E-04	-36.9	-11.2	
5	25.30	9.35	0.004	-5.27E-04	-35.2	-18.4	
6	25.10	11.37	0.004	-5.07E-04	-33.1	-25.3	
7	25.00	12.38	0.004	-4.95E-04	-31.9	-28.5	
8	24.60	18.22	0.004	-4.33E-04	-25.8	-40.2	
		13.27	0.004	-4.33E-04	-25.8	-40.2	
9	24.30	17.36	0.004	-3.70E-04	-21.2	-47.3	
10	24.00	21.45	0.004	-2.98E-04	-15.4	-52.8	
11	23.60	26.90	0.004	-1.92E-04	-5.7	-56.4	
12	23.20	32.33	0.004	-8.14E-05	6.1	-56.4	
13	22.80	37.77	0.004	2.51E-05	20.2	-51.2	
14	22.40	43.19	0.004	1.17E-04	36.3	-40.0	
15	22.00	48.60	0.004	1.84E-04	54.7	-21.9	80.0
		48.60	0.004	1.84E-04	-25.3	-21.9	
16	21.75	51.98	0.004	2.19E-04	-12.7	-26.7	
17	21.50	55.36	0.004	2.55E-04	0.7	-28.2	
		30.19	0.004	2.55E-04	0.7	-28.2	
18	21.15	20.07	0.004	3.03E-04	9.5	-26.4	
19	20.80	9.94	0.004	3.45E-04	14.8	-22.1	
20	20.40	1.03	0.004	3.82E-04	17.0	-15.6	
21	20.00	-6.96	0.004	4.05E-04	15.8	-9.0	
22	19.60	-14.74	0.003	4.17E-04	11.4	-3.6	
23	19.30	-20.47	0.003	4.21E-04	6.2	-1.0	

(continued)

Stage No.11 Change properties of soil type 1 to soil type 4
Ko pressures will not be reset

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
24	19.00	-20.63	0.003	4.21E-04	0.0	-0.0	
At elev. 25.80 Strut force =			39.5 kN/strut =		39.5 kN/m run		
At elev. 22.00 Strut force =			80.0 kN/strut =		80.0 kN/m run		

Node no.	Y coord	ACTIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	26.10	0.00	20.00	0.00	219.06	1.56	1.56	2223
2	26.00	0.00	21.80	0.00	225.25	2.47	2.47	2223
3	25.80	0.00	25.40	0.00	237.65	4.34	4.34	2223
4	25.50	0.00	30.80	0.00	256.23	7.34	7.34	2223
5	25.30	0.00	34.39	0.00	268.61	9.35	9.35	2223
6	25.10	0.00	37.99	0.00	280.99	11.37	11.37	2223
7	25.00	1.00	38.79	0.00	283.73	11.38	12.38	2223
8	24.60	5.00	41.97	0.00	294.68	13.22	18.22	2223
		5.00	41.97	8.27	161.20	8.27	13.27a	7719
9	24.30	8.00	44.94	9.36	170.85	9.36	17.36a	7997
10	24.00	11.00	47.91	10.45	180.47	10.45	21.45a	8275
11	23.60	15.00	51.85	11.90	193.25	11.90	26.90a	8645
12	23.20	19.00	55.78	13.33	205.96	13.33	32.33a	9016
13	22.80	23.00	59.68	14.77	218.61	14.77	37.77a	9386
14	22.40	27.00	63.56	16.19	231.19	16.19	43.19a	14444
15	22.00	31.00	67.42	17.60	243.70	17.60	48.60a	14993
16	21.75	33.50	69.82	18.48	251.49	18.48	51.98a	15336
17	21.50	36.00	72.21	19.36	259.24	19.36	55.36a	15678
18	21.15	39.50	75.55	20.58	270.06	20.58	60.08a	16158
19	20.80	43.00	78.87	21.80	280.82	21.80	64.80a	16638
20	20.40	47.00	82.65	23.19	293.07	25.88	72.88	17187
21	20.00	51.00	86.41	24.57	305.26	30.89	81.89	17735
22	19.60	55.00	90.15	25.94	317.39	36.12	91.12	18284
23	19.30	58.00	92.95	26.96	326.47	40.17	98.17	18695
24	19.00	61.00	95.74	27.99	335.52	44.33	105.33	19107

Node no.	Y coord	PASSIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	26.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	25.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	25.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	25.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	25.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	24.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	24.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	23.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	23.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	22.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	22.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

(continued)

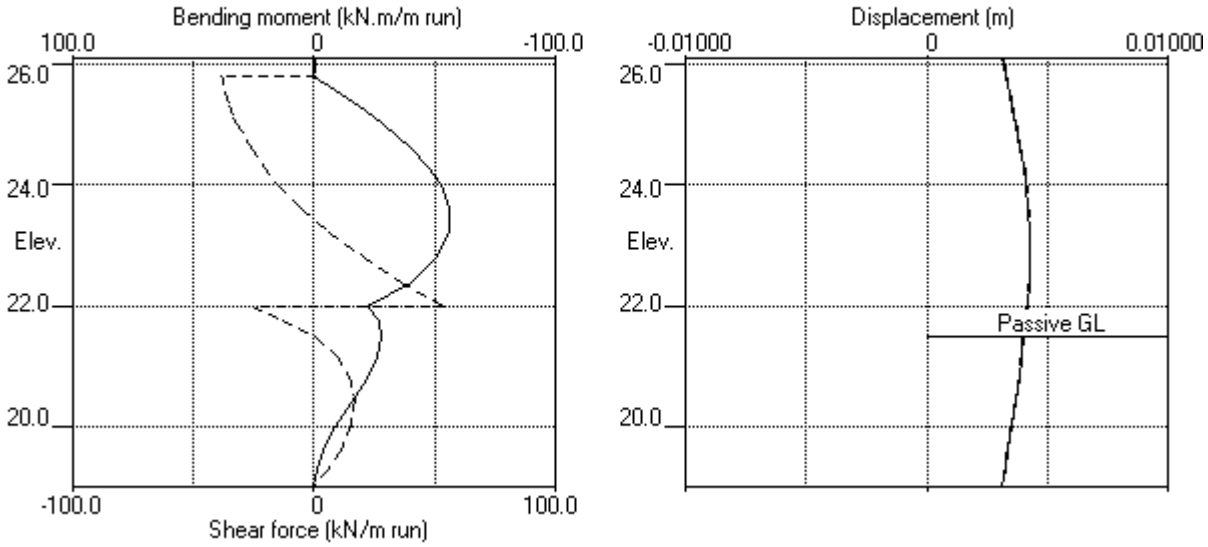
Stage No.11 Change properties of soil type 1 to soil type 4
Ko pressures will not be reset

Node no.	Y coord	PASSIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
16	21.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	25.17	25.17	25.17p	15678
18	21.15	3.50	3.50	0.00	36.52	36.52	40.02p	16158
19	20.80	7.00	7.00	0.00	47.87	47.87	54.87p	16638
20	20.40	11.00	11.01	0.00	60.85	60.85	71.85p	17187
21	20.00	15.00	15.02	0.00	73.84	73.84	88.84p	17735
22	19.60	19.00	19.03	0.00	86.86	86.86	105.86p	18284
23	19.30	22.00	22.05	0.97	96.64	96.64	118.64p	18695
24	19.00	25.00	25.07	2.08	106.44	100.96	125.96	19107

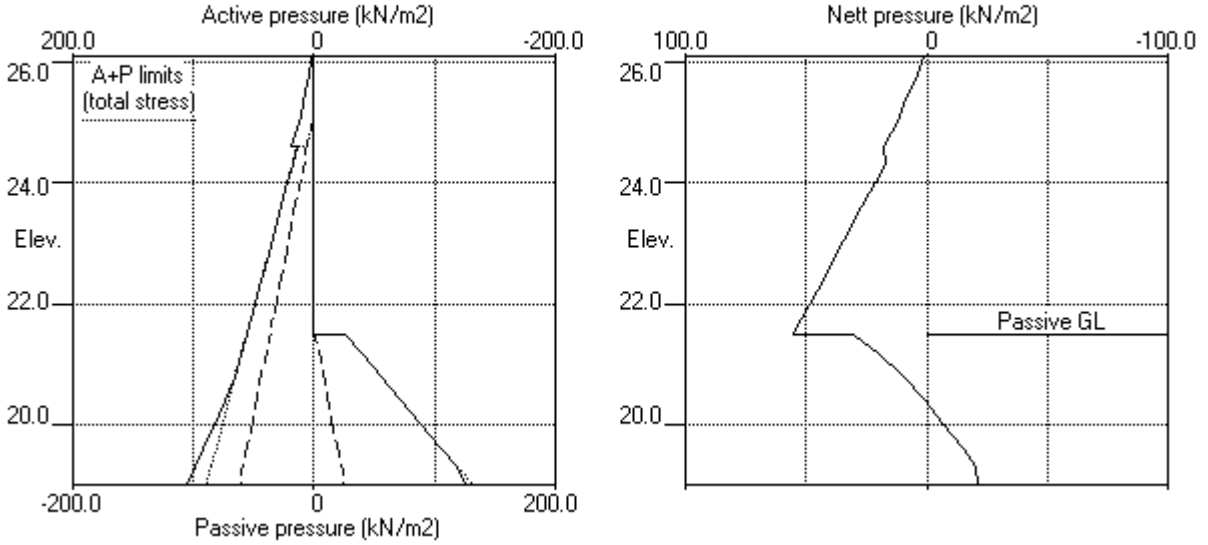
Note: 64.80a Soil pressure at active limit
118.64p Soil pressure at passive limit

Units: kN,m

Stage No.11 Change soil type 1 to soil type 4



Stage No.11 Change soil type 1 to soil type 4



Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: Serviceability Limit State

All loads and soil strengths are unfactored

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 19.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.250 Toe elev.	Wall Penetr -ation
1	26.10	26.10	Cant.	Conditions not suitable for FoS calc.			
2	26.10	26.10		No analysis at this stage			
3	26.10	26.10	Cant.	Conditions not suitable for FoS calc.			
4	26.10	25.30	Cant.	6.742	19.54	25.14	0.16
5	26.10	25.30		No analysis at this stage			
6	26.10	21.50	25.50	2.983	n/a	21.23	0.27
7	26.10	21.50		No analysis at this stage			

All remaining stages have more than one strut - FoS calculation n/a

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Limit State: Serviceability Limit State

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment Calculated		Bending moment Factored		Shear force Calculated		Shear force Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	26.10	0.003	0.000	0	-0	0	-0	0	0	0	0
2	26.00	0.003	0.000	0	0	0	0	1	0	1	0
3	25.80	0.003	0.000	0	0	1	0	3	-39	4	-52
4	25.50	0.003	0.000	2	-11	2	-15	7	-42	9	-56
5	25.30	0.004	0.000	3	-18	5	-25	10	-40	13	-54
6	25.10	0.004	0.000	6	-25	8	-34	12	-38	17	-51
7	25.00	0.004	0.000	7	-29	9	-39	14	-36	19	-49
8	24.60	0.004	0.000	13	-40	18	-54	20	-30	26	-40
9	24.30	0.004	0.000	19	-47	25	-64	14	-27	19	-37
10	24.00	0.004	0.000	22	-53	30	-71	9	-24	13	-33
11	23.60	0.004	0.000	25	-59	33	-79	4	-20	5	-27
12	23.20	0.004	0.000	25	-63	34	-86	6	-13	8	-18
13	22.80	0.004	0.000	24	-67	33	-90	20	-4	27	-5
14	22.40	0.004	0.000	22	-66	30	-89	36	-6	49	-8
15	22.00	0.004	0.000	19	-60	26	-81	55	-25	74	-34
16	21.75	0.004	0.000	17	-53	24	-71	35	-13	47	-17
17	21.50	0.004	0.000	15	-42	21	-57	48	-9	64	-12
18	21.15	0.004	0.000	12	-28	16	-37	37	-9	50	-12
19	20.80	0.004	0.000	9	-22	12	-30	27	-8	36	-11
20	20.40	0.004	0.000	6	-16	8	-21	17	-7	23	-10
21	20.00	0.004	0.000	3	-9	4	-12	16	-6	21	-8
22	19.60	0.003	0.000	1	-4	2	-5	11	-4	15	-5
23	19.30	0.003	0.000	0	-1	0	-1	6	-2	8	-3
24	19.00	0.003	0.000	0	-0	0	-0	0	0	0	0

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment						Shear force					
	Calculated				Factored		Calculated				Factored	
no.	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	kN/m
1	14	23.20	-0	26.10	19	-0	11	24.60	-5	21.15	15	-7
2	No calculation at this stage											
3	14	23.20	-0	26.10	19	-0	11	24.60	-5	21.50	15	-6
4	25	23.20	-0	19.00	34	-0	20	24.60	-9	21.15	26	-12
5	No calculation at this stage											
6	1	25.50	-67	22.80	1	-90	48	21.50	-42	25.50	64	-56
7	No calculation at this stage											
8	No calculation at this stage											
9	0	25.80	-65	22.80	0	-88	46	21.50	-38	25.80	62	-51
10	0	25.80	-56	23.60	0	-76	55	22.00	-39	25.80	74	-52
11	0	25.80	-56	23.60	0	-76	55	22.00	-39	25.80	74	-52

Maximum and minimum displacement at each stage

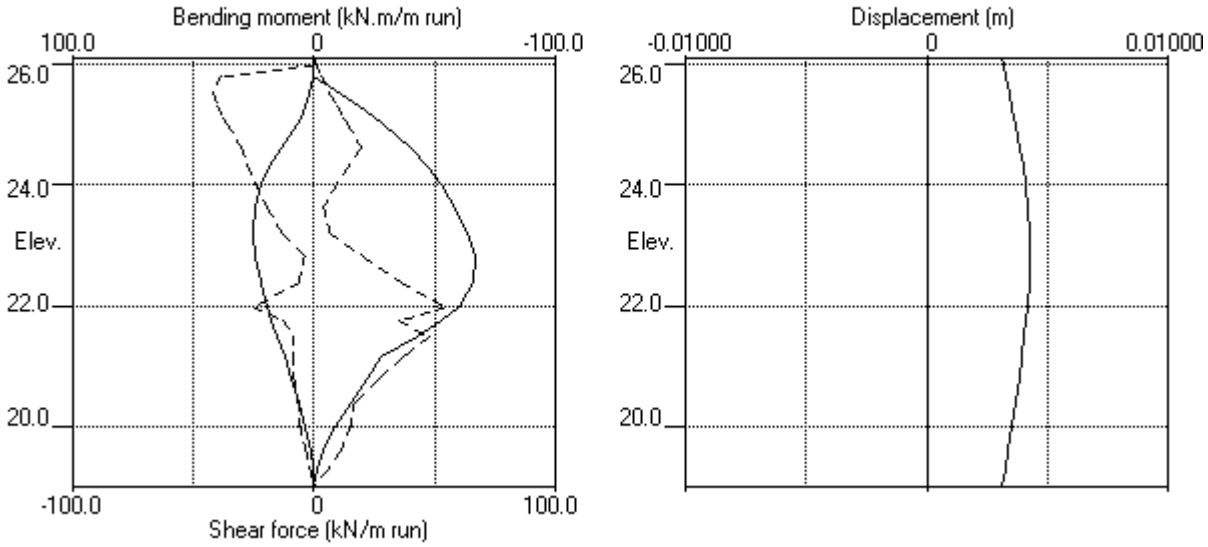
Stage	Displacement				Stage description
no.	maximum	elev.	minimum	elev.	
	m		m		
1	0.002	26.10	0.000	26.10	Apply surcharge no.1 at elev. 26.10
2	Wall displacements reset to zero				Change EI of wall to 254469kN.m2/m run
3	0.000	19.00	0.000	26.10	Apply water pressure profile no.1
4	0.001	26.10	0.000	26.10	Excav. to elev. 25.30 on PASSIVE side
5	No calculation at this stage				Install strut no.3 at elev. 25.50
6	0.004	22.80	0.000	26.10	Excav. to elev. 21.50 on PASSIVE side
7	No calculation at this stage				Install strut no.2 at elev. 22.00
8	No calculation at this stage				Install strut no.1 at elev. 25.80
9	0.004	23.20	0.000	26.10	Remove strut no.3 at elev. 25.50
10	0.004	22.80	0.000	26.10	Change soil type 2 to soil type 3
11	0.004	22.80	0.000	26.10	Change soil type 1 to soil type 4

Strut forces at each stage (horizontal components)

Stage	Strut no. 1 at elev. 25.80			Strut no. 2 at elev. 22.00			Strut no. 3 at elev. 25.50		
no.	Calculated		Factored	Calculated		Factored	Calculated		Factored
	kN per m run	kN per strut	kN per strut	kN per m run	kN per strut	kN per strut	kN per m run	kN per strut	kN per strut
6	---	---	---	---	---	---	45	223	301
9	39	39	52	6	6	8	---	---	---
10	39	39	53	80	80	108	---	---	---
11	39	39	53	80	80	108	---	---	---

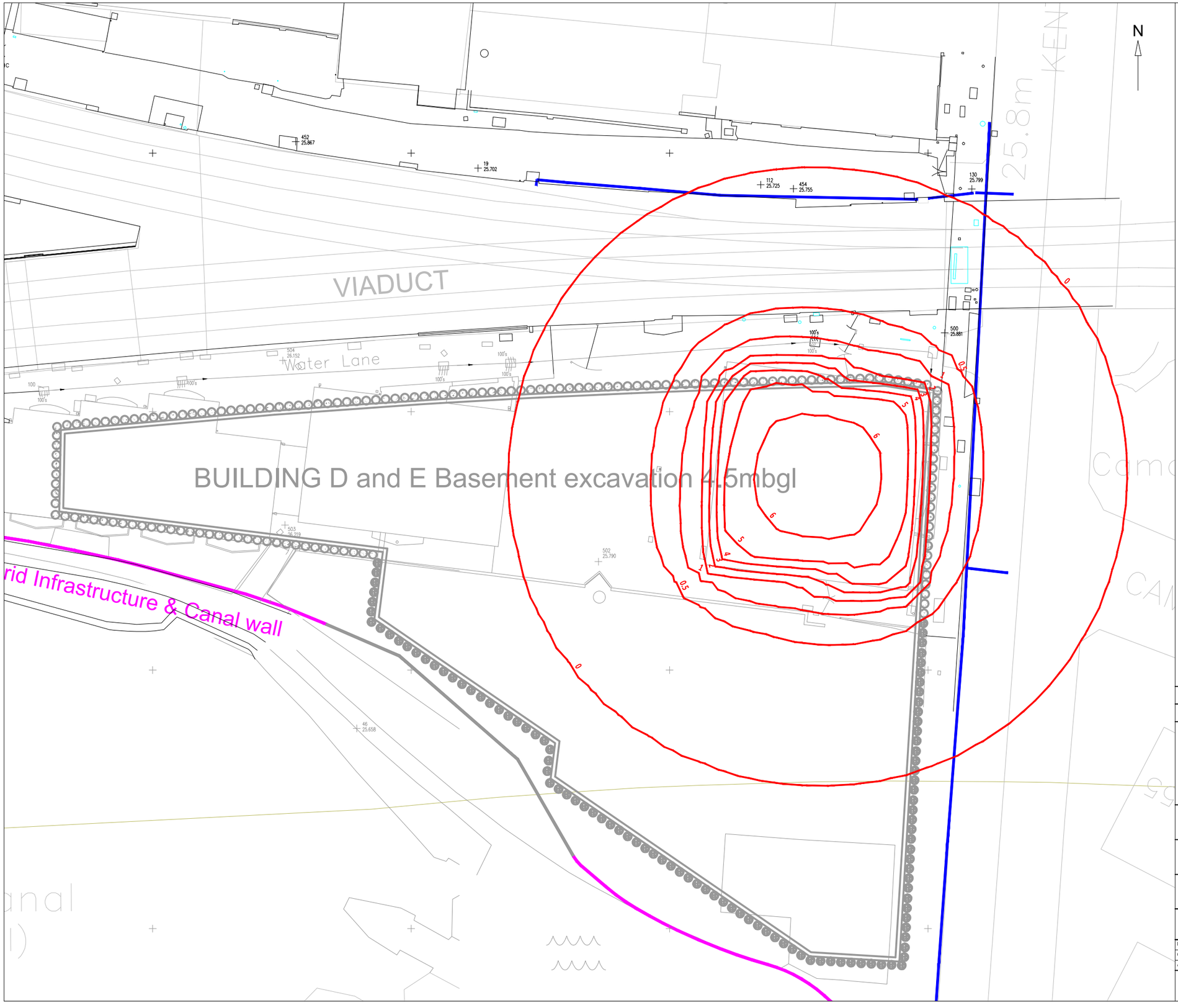
Units: kN,m

Bending moment, shear force, displacement envelopes



APPENDIX D

Pdisp contour plots



Negative values indicate heave and positive values indicate settlement

Rev	Date	Comments
*	*	*

Card Geotechnics Ltd
4 Godalming Business Centre
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Surrey
GU7 1XW
T: 01483 310600

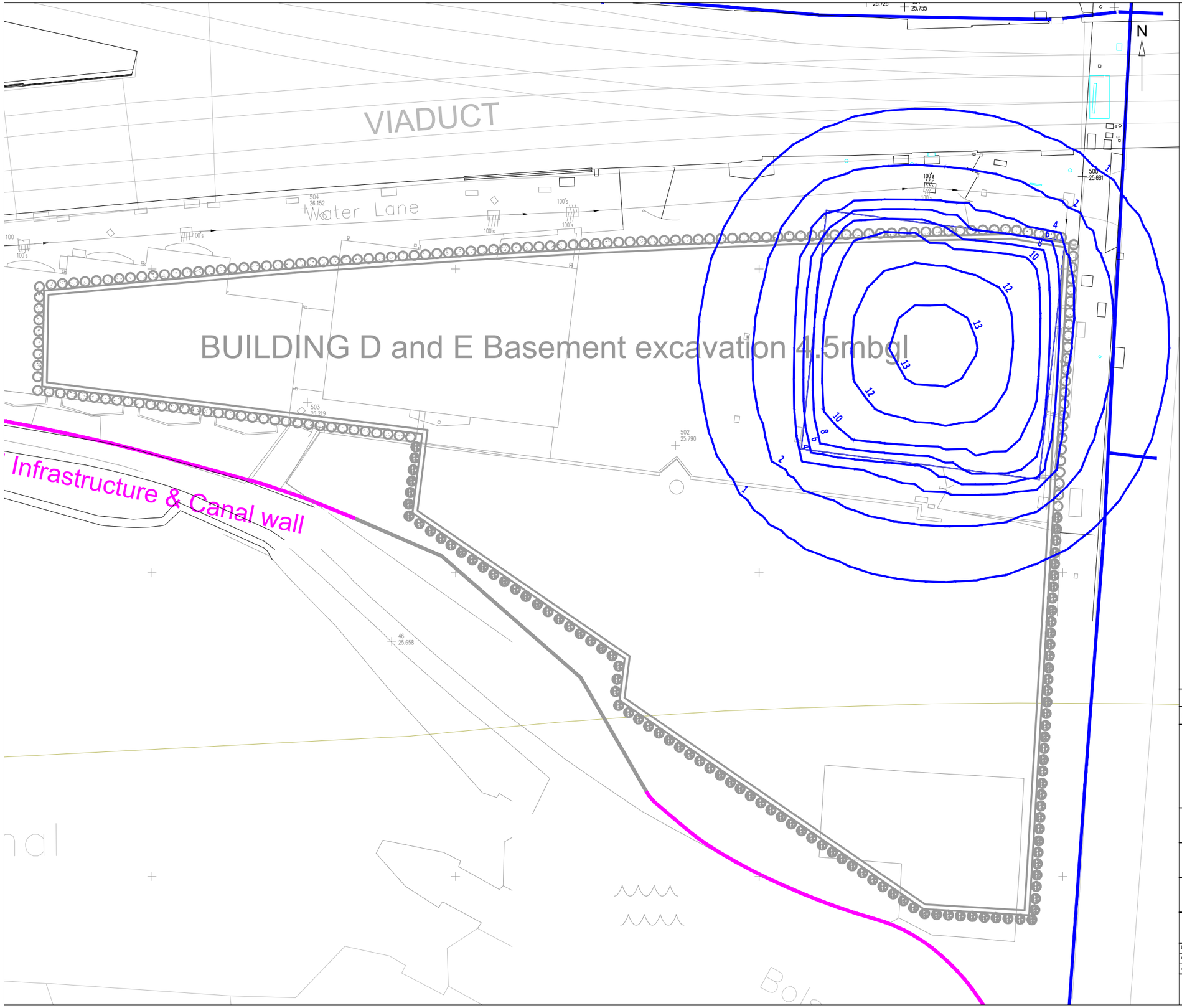
Project: **Camden Lock Village Phase 2, London**

Client: **Walsh Associates**

Drawing title: **Ground movement contours: Stage 1 Existing (undrained)**

Scale(s)	Job No.
NTS	**CG/18067a**

Drawn	TSB	15/09/15	Dwg No. **Appendix D 001**	Rev. **0**
Checked	ADC	15/09/15		
Approved				



Negative values indicate heave and positive values indicate settlement

Rev	Date	Comments
*	*	*

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Project
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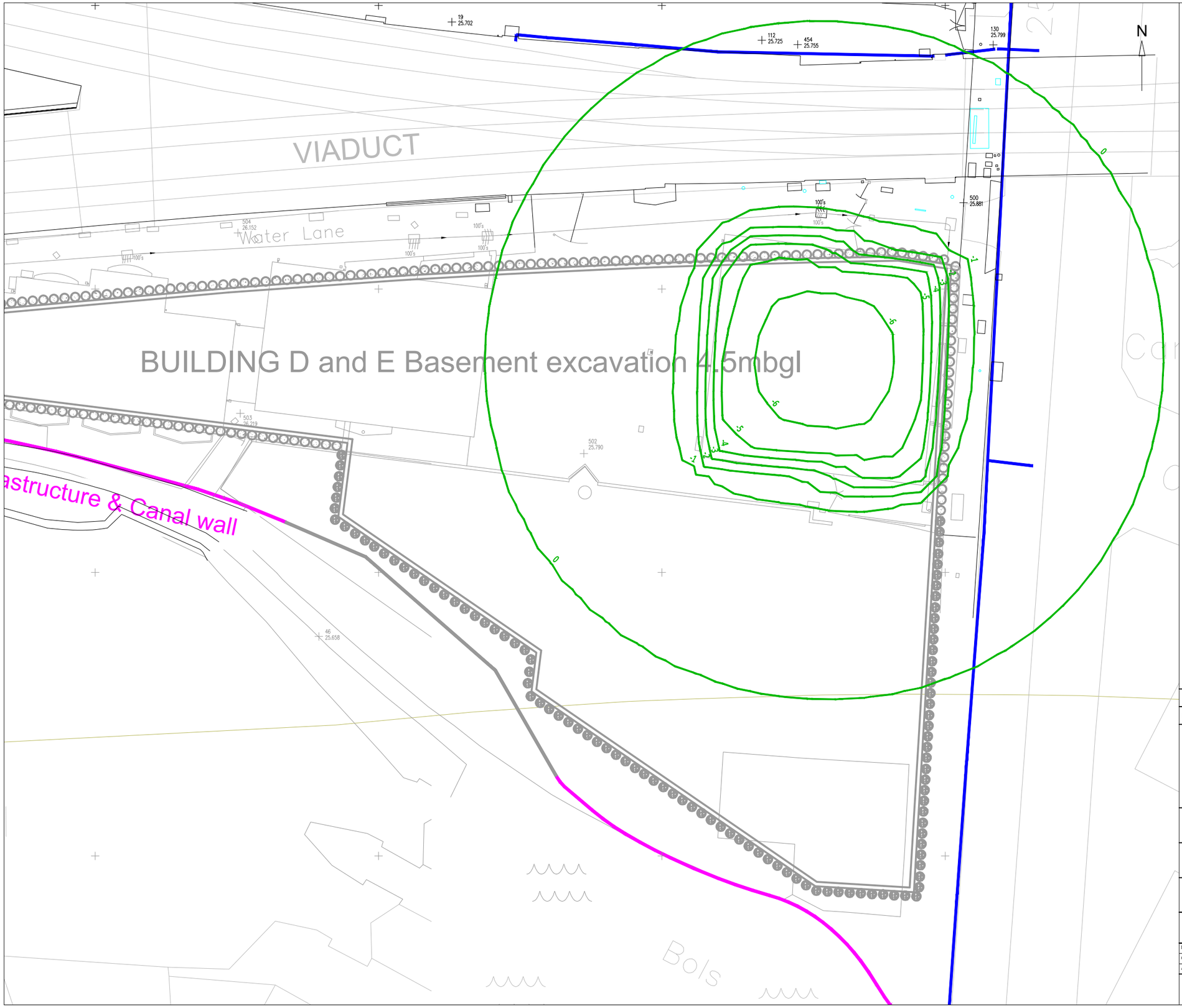
Client
Walsh Associates

Drawing title
Ground movement contours: Stage 1 Existing (drained)

Scale(s)	Job No.
NTS	**CG/18067a**

Drawn	TSB	15/09/15	Dwg No. **Appendix D 002**	Rev. **0**
Checked	ADC	15/09/15		
Approved				



Negative values indicate heave and positive values indicate settlement

*	*	*
Rev	Date	Comments

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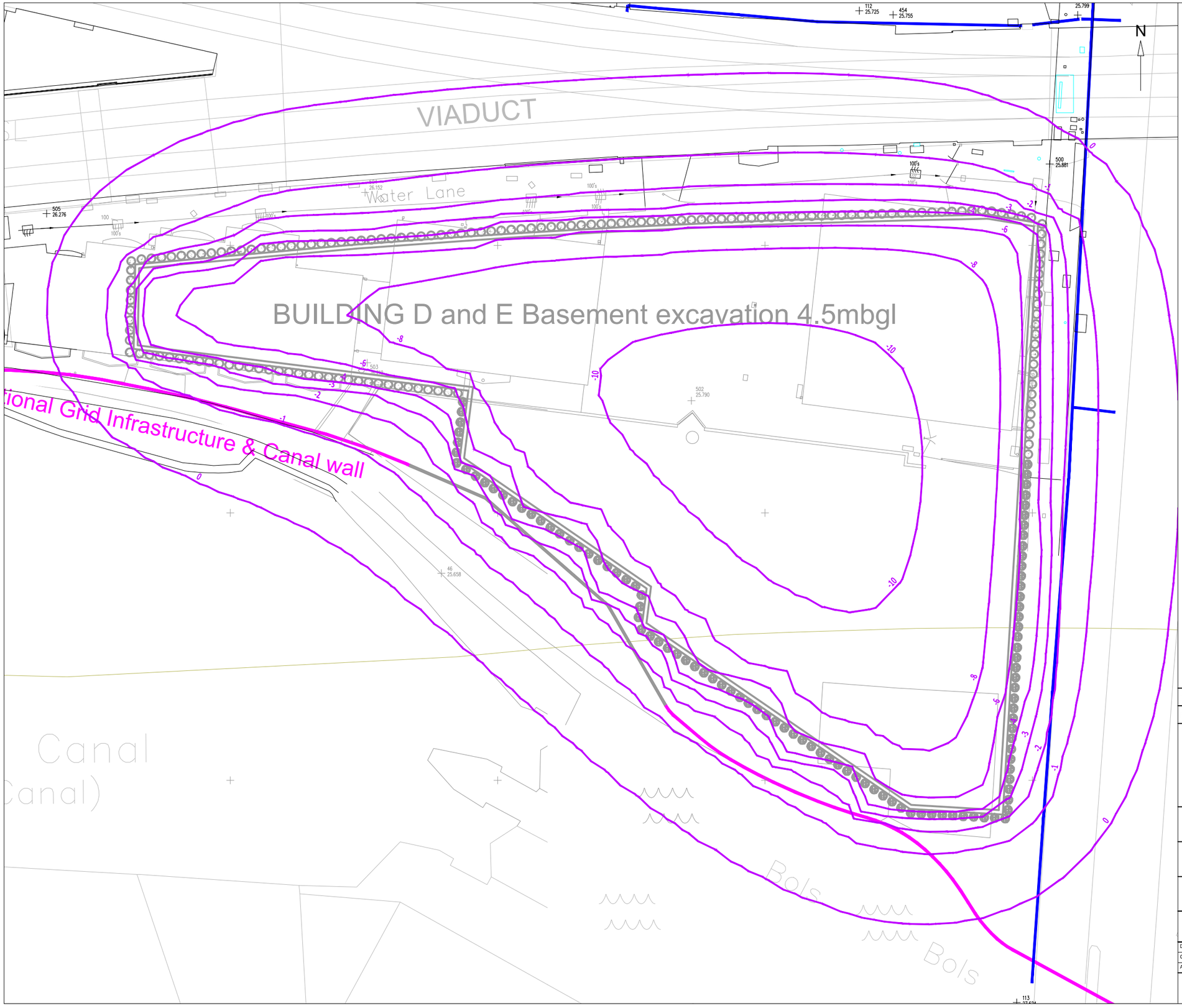
Drawing title
Ground movement contours: Stage 2 Demolition (undrained)

Scale(s)	Job No.
NTS	**CG/18067a**

Drawn	TSB	15/09/15	Dwg No. **Appendix D 003**	Rev. **0**
Checked	ADC	15/09/15		
Approved				



Negative values indicate heave and positive values indicate settlement

*	*	*
Rev	Date	Comments

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Project
Camden Lock Village Phase 2, London

Client
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Drawing title
Ground movement contours: Stage 3 Excavation (undrained)

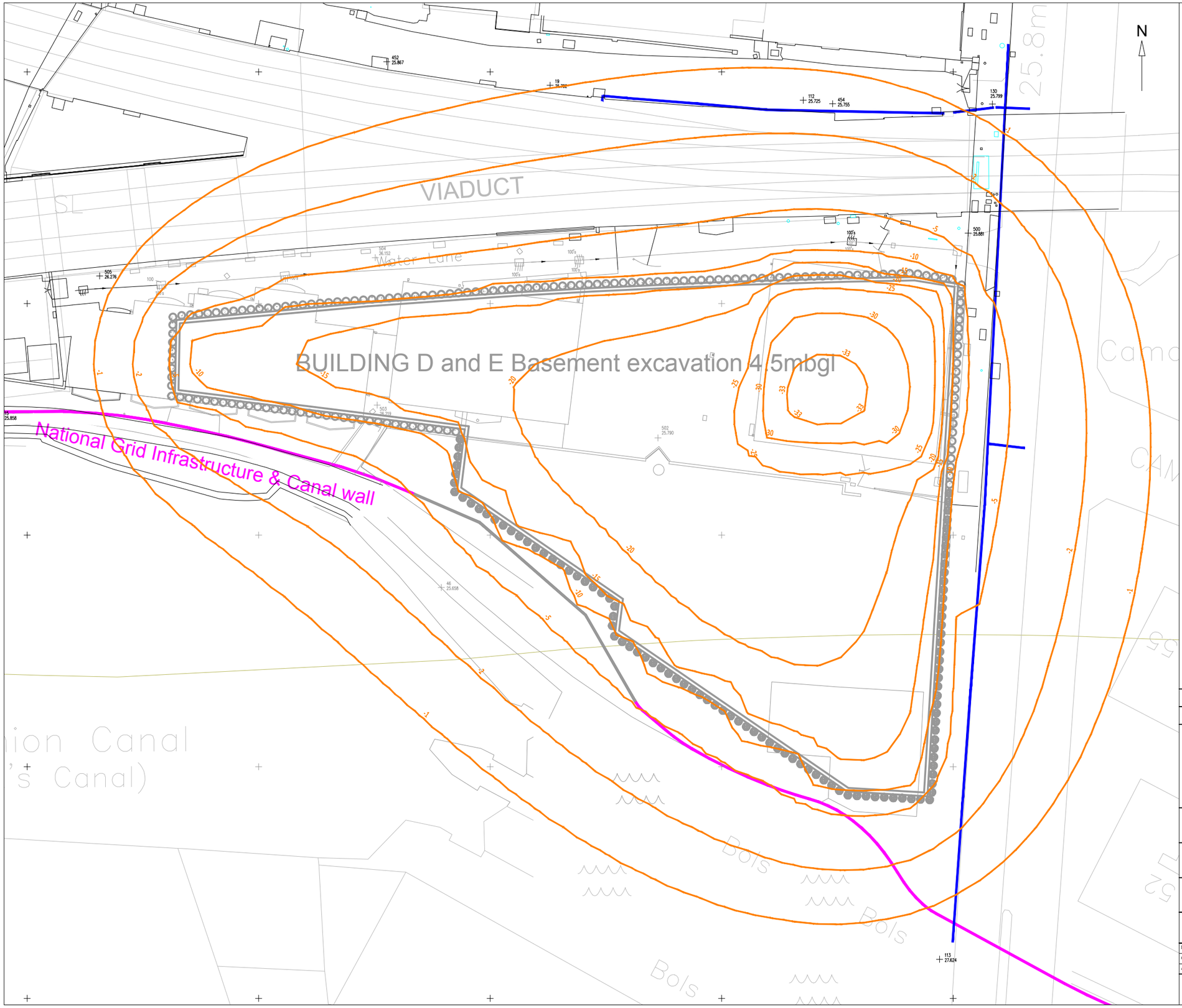
Scale(s)
NTS

Job No.
CG/18067a

Drawn	TSB	15/09/15
Checked	ADC	15/09/15
Approved		

Dwg No.
Appendix D 004

Rev.
0



Negative values indicate heave and positive values indicate settlement

*	*	*
Rev	Date	Comments

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Project
Camden Lock Village Phase 2, London

Client
Walsh Associates

Drawing title
Ground movement contours: Stage 4 Final (drained)

Scale(s)	Job No.
NTS	**CG/18067a**

Drawn	TSB	15/09/15	Dwg No. **Appendix D 005**	Rev. **0**
Checked	ADC	15/09/15		
Approved				

APPENDIX E

Joint rotation calculations

W O R K S H E E T				
Client	Walsh Group			
Job Title	Camden Lock Village, London: Area D and E			
Design status		Job No.	CG/18067A	
Date	Sep-15	Qual. Plan	CGL	
Made by	A.Cadman	Checked by	R.Ball	SHEET No. 1 of 2

Card Geotechnics Limited

Title	Utilities Damage Assessment - rotation check (Stage 3)

Legend
Input data
Output data

Pipeline detials		
Typical pipe section length	3.66	m
Young's Modulus of pipe (metal)	2.00E+08	MPa
Pipe diameter, D	0.4064	m

Calculating vertical curvature coeficant		
Differential movement points k and j (ε_{kj})	0.00038	m
Differential movement points j and i (ε_{ji})	0.00087	m
Pipe span L_{ji}	1.83	m
Pipe span L_{kj}	1.83	m

vertical curvature, Z"(Yj)	-0.000016

Calculating lateral curvature coeficant		
Differential movement points k and j (P_{kj})	0.000	m
Differential movement points j and i (P_{ji})	0.00043	m
Pipe span L_{ji}	1.83	m
Pipe span L_{kj}	1.83	m

Lateral curvature, X"(Yj)	-0.000067

Joint Rotation Calculation		
Formula - top line	3.3489003	
Formula - bottom line	3.3489005	
Joint rotation	0.021	Degree
Allowable joint rotation	0.1	Degree

Allowable rotation > Calculated rotation, Pipe Okay in rotation

W O R K S H E E T				
Client	Walsh Group			
Job Title	Camden Lock Village, London: Area D and E			
Design status		Job No.	CG/18067A	
Date	Sep-15	Qual. Plan	CGL	
Made by	A.Cadman	Checked by	R.Ball	SHEET No. 2 of 2

Card Geotechnics Limited

Title	Utilities Damage Assessment - rotation check (Stage 4)

Legend
Input data
Output data

Pipeline detials		
Typical pipe section length	3.66	m
Young's Modulus of pipe (metal)	2.00E+08	MPa
Pipe diameter, D	0.4064	m

Calculating vertical curvature coeficant		
Differential movement points k and j (ε_{kj})	0.00029	m
Differential movement points j and i (ε_{ji})	0.00031	m
Pipe span L_{ji}	1.83	m
Pipe span L_{kj}	1.83	m

vertical curvature, Z"(Yj)	0.000040

Calculating lateral curvature coeficant		
Differential movement points k and j (P_{kj})	0.001	m
Differential movement points j and i (P_{ji})	0	m
Pipe span L_{ji}	1.83	m
Pipe span L_{kj}	1.83	m

Lateral curvature, X"(Yj)	0.000212

Joint Rotation Calculation		
Formula - top line	3.3489001	
Formula - bottom line	3.3489003	
Joint rotation	0.022	Degree
Allowable joint rotation	0.1	Degree

Allowable rotation > Calculated rotation, Pipe Okay in rotation