

APPENDIX D

GROUND MOVEMENT

ASSESSMENT



**139 Cranley Gardens
London
N10 3AG**

Ground Movement Analysis
& Building Damage Assessment

Lee Doherty

August 2023

J23175
Rev 1



Ground investigation | Geotechnical consultancy | Contaminated land assessment



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Contents

1.0	Introduction	1
2.0	The Site	2
3.0	Summary of Ground Conditions	2
4.0	Construction Sequence	3
5.0	Ground Movements	4
6.0	Building Damage Assessment	7
7.0	GMA Conclusions	10

Appendix



1.0 Introduction

Geotechnical and Environmental Associates Limited (GEA) has been commissioned by Symmetrys, on behalf of Lee Doherty, to carry out a ground movement analysis and building damage assessment relating to the proposed construction of a basement extension at 139 Cranley Gardens, London N10 3AG, in the London Borough of Haringey.

A desk study (report ref 21/33613, dated May 2021) and subsequent ground investigation (report ref 21/33613, dated May 2021) have previously been completed for the client by Site Analytical Services (SAS) Ltd, the findings of which have been used in the derivation of parameters for use in this assessment.

1.1 Proposed Development

The proposals include the formation of a new basement area and swimming pool beneath the existing rear extension, part of the rear garden and an existing garden building, as shown on the drawing extract below.

It is understood from the information provided that the proposed basement will extend to a depth of about 3.5 m to 6.5 m below existing ground floor level, corresponding to temporary benchmark (TBM) levels of about 8.0 m TBM, 7.0 TBM and 5.5 m TBM for the mezzanine, poolside and swimming pool levels, respectively.

This report is specific to the proposed development and the advice herein should be reviewed if the development proposals are amended.

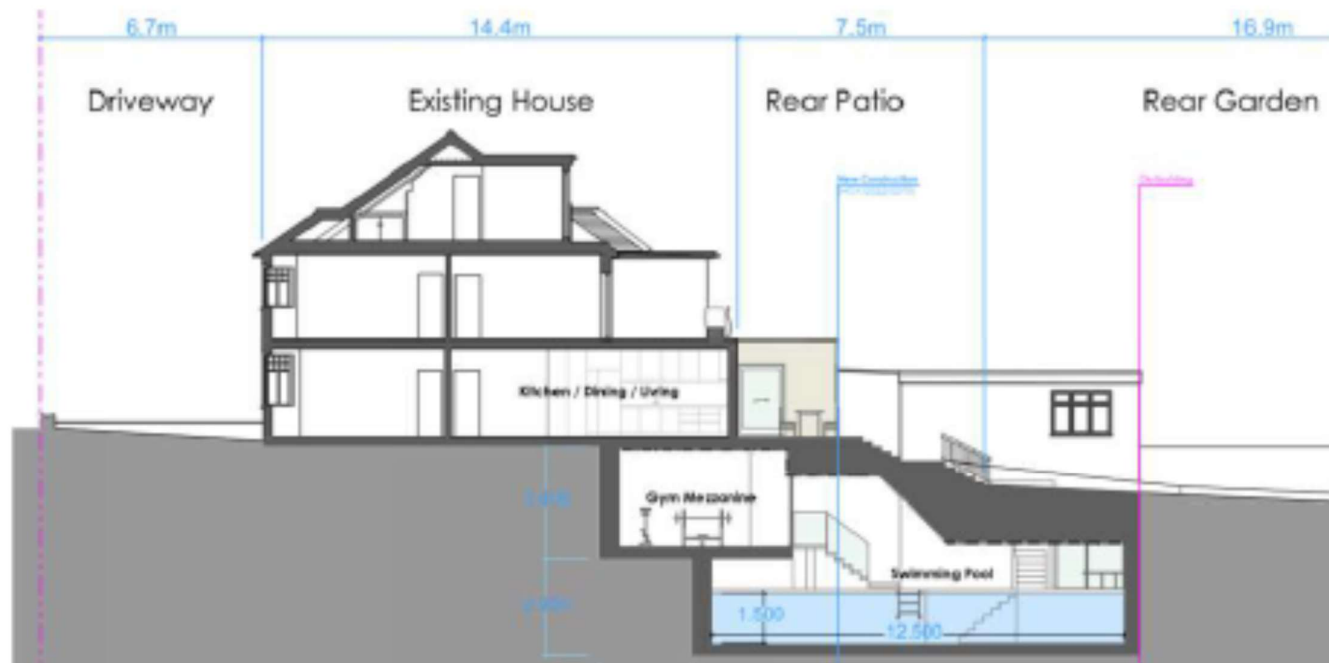


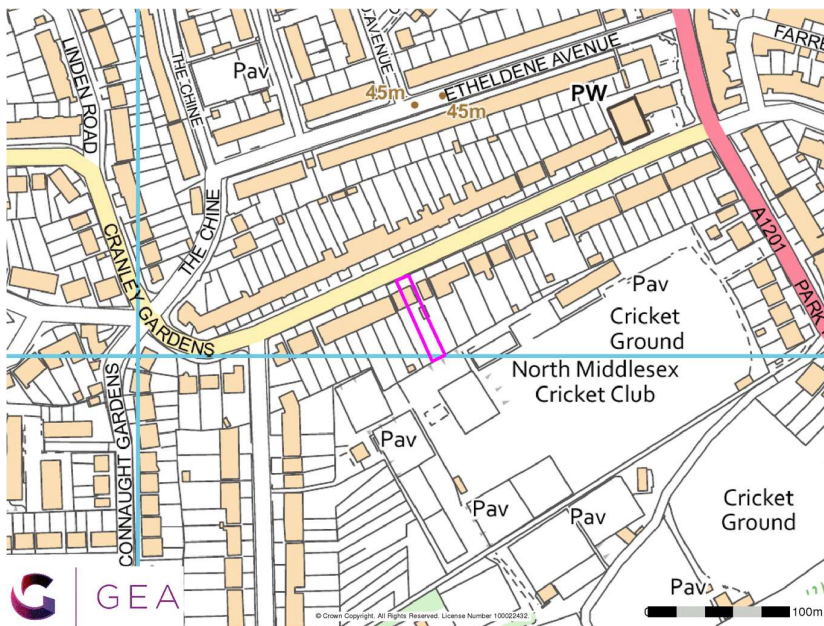
Figure 1. Proposed Section A-A.



2.0 The Site

The site is located in the London Borough of Haringey, immediately to the north of Crouch End Playing Fields. It fronts onto Cranley Gardens to the north and is bounded by the adjoining properties of Nos 137 and 141 Cranley Gardens to the west and east, respectively, with the northmost part of Crouch End Playing Fields to the south.

The site may additionally be located by National Grid Reference 529192, 189043 and is shown on the map extract below.



The northern part of the site is occupied by a two-storey semi-detached house, with an extensive rear garden, which includes a single-storey building with existing basement. The site level reduces to the rear of the house, with a drop of about 0.5 m to a terrace, with a further 0.5 m to 1.0 m drop to the adjoining garden area.

3.0 Summary of Ground Conditions

The SAS investigation generally confirmed the expected ground conditions in that, beneath a limited thickness of made ground, London Clay was encountered to the full depth of the investigation, of 12.0 m (approx -1.5 m TBM).

Beneath a surface covering of grass, made ground, comprising dark brown silty slightly clayey topsoil, with occasional brick and concrete, was encountered to a depth of 0.6 m. Below this, the London Clay comprised an upper layer of firm becoming stiff mottled light brown silty clay, which extended to a depth of 2.0 m and was underlain by stiff brown silty sandy clay to the full depth of the investigation, of 12.0 m.

Groundwater was not encountered during drilling, but was subsequently monitored at a depth of 0.85 m. However, as the London Clay comprises an aquiclude that cannot support a water table, this water presumably represented perched or surface water that had become trapped in the standpipe and was unable to drain away due to the low permeability of the surrounding soils.

GEA has previously carried out an investigation at No 112 Cranley Gardens, approximately 15 m to the northwest of the site. The investigation generally confirmed the expected ground conditions in that, below a limited thickness of made ground, the London Clay was encountered to the maximum depth investigated. The made ground extended to depths of between 0.3 m and 1.1 m and the London Clay comprised firm brown fissured silty slightly sandy clay to a maximum depth of 11.30 m, whereupon stiff dark grey fissured silty slightly sandy clay was proved to the maximum depth investigated of 15.00 m. Monitoring of the standpipes encountered perched water at depths of between 1.82 m and 5.69 m, whilst a series of trial pits indicated that the existing buildings were supported by spread foundations extending to depths of between 1.07 m and 1.30 m.

The base of the London Clay was not proved in the above investigations, but a review of deep borehole information held by the BGS shows that it is likely to extend to a depth of approximately 42 m (approx. -30 m TBM) in this area.



4.0 Construction Sequence

It is understood that the proposed basement excavation will be supported by reinforced concrete underpinning, to be completed in a series of stages, or lifts, in order to reach proposed formation level for the mezzanine, poolside and pool levels.

The proposed RC floor slabs, which will act as permanent props, will be constructed at the highest level first and when each floor has achieved adequate strength, the temporary props will be removed; the next level of underpinning and excavation will take place and the process repeated until the structure is complete.

Essentially the sequence may be considered as two groups of activities, the first comprising the short-term temporary works, whilst the second represents the construction of the permanent works.

The following sequence of operations has been derived to enable analysis of the ground movements around the basement, both during and after construction, and is based on the drawings in Appendix A of Symmetrys' Basement Impact Assessment (report ref 21066-SYM-XX-XX-RP-S-0001-Rev D, dated May 2023). Temporary benchmark (TBM) levels have been taken from the site survey drawings included in the (unreferenced) Design and Access Statement completed by Crawford Partnership Architects in February 2023.

In general, the sequence of works for basement construction will comprise the following stages:

- G 1: Temporary prop boundary wall of existing outbuilding;
- G 2: Demolish existing outbuilding except propped boundary wall;
- G 3: Install internal CFA piles;
- G 4: Install transitional underpinning below 139 Cranley Gardens gable wall and 137/139 Cranley Gardens party wall to prevent the occurrence of differential settlements;
- G 5: Underpin in hit/miss sequence existing building walls where located above the proposed basement footprint, and install retaining walls in underpinning (hit/miss) sequence down to proposed mezzanine / existing outbuilding basement level* (excavation level of approx. 8.0 m TBM);

- G 6; Install temporary struts and walers to allow soil level to be reduced*;
- G 7: Excavate proposed basement area down to proposed mezzanine / existing outbuilding basement level (excavation level of approx. 8.0 m TBM);
- G 8: Cut piles to proposed mezzanine / existing building basement slab cut-off level;
- G 9: Demolish existing outbuilding walls at basement level;
- G 10: Cast second stage underpinning to reach poolside formation level and swimming pool structure formation levels* (approx. 7.0 m TBM to 5.5 m TBM);
- G 11: Excavate to proposed poolside and swimming pool levels (excavation level of approx. 7.0 m TBM to 5.5 m TBM);
- G 12: Cut piles to proposed pool side slab and swimming pool slab cut-off levels;
- G 13: Cast RC slab above heave protection at basement mezzanine, poolside and swimming pool level;
- G 14: Cast RC slab at ground floor level;
- G 15: Dismantle temporary works and proceed with installation of superstructure.

(*) Sequence of works to be read in conjunction with typical multi-stage underpinning sequence highlighted in drawing 21066-SYM-XX-XX-SK-S-0201/0202/0203-REV P1.

The detail of the support provided to adjacent walls is beyond the scope of this report and the structural engineer will be best placed to agree the methodology with the chosen contractor(s) once appointed.



5.0 Ground Movements

The sides of an excavation will move to some extent regardless of how they are supported. The movement will typically be both horizontal and vertical and will be influenced by the engineering properties of the ground, groundwater level and flow, the type of retaining wall construction and the efficiency or stiffness of any support structures used.

An analysis has been carried out of the likely movements arising from the proposed basement excavation, with the results used to predict the effect of these movements on identified sensitive surrounding structures.

5.1 Basis of Ground Movement Assessment

An assessment of ground movements within and surrounding the excavation has been undertaken using the P-Disp and X-Disp computer programs licensed from the OASYS suite of geotechnical modelling software from Arup. These programs are commonly used within the ground engineering industry and are considered to be appropriate tools for this analysis.

The X-Disp and P-Disp programs have been used to predict ground movements likely to arise from the excavation and construction of the proposed basement. This includes the heave / settlement of the ground (vertical movement) and the lateral movement of soil behind the proposed retaining walls (horizontal movement).

For the purpose of these analyses, the corners have been defined by x and y coordinates, with the x-direction orientated with the existing party walls (approximately north-south), whilst the y-direction is orientated with Victoria Road (approximately east-west). Vertical movement is in the z-direction. The basement has been modelled as an irregular polygon, with maximum dimensions of approximately 9.0 m by 16.0 m, with excavation levels of between 8.0 m TBM and 5.5 m TBM (approx. 4.0 m to 6.5 m below the level of the rear extension, or 1.0 m to 2.5 m below the basement of the existing outbuilding).

The analysis has been undertaken in a series of four stages, the first three of which represent the short-term (undrained) movements and broadly correspond with the principal elements of the proposed construction sequence, namely first stage underpinning & excavation (Analysis Stage 1), second stage underpinning & excavation (Analysis Stage 2)

and formation of the proposed swimming pool (Analysis Stage 3). The final stage, Analysis Stage 4, does not correspond to any specific 'stage of construction', but reflects the total (drained) movements that are likely to occur as a result of the proposed development.

It is assumed that suitable propping will be provided during the construction of the basement and in the permanent condition, such that the walls can be considered to be very stiff for the purpose of the ground movement modelling.

The full outputs of all the analyses can be provided on request but samples of the output movement contour plots and the tables of movements are included within the appendix.

5.2 P-Disp Model

Unloading of the London Clay will take place as a result of the excavation of the proposed basements and the reduction in vertical stress will cause heave to take place. Undrained soil parameters have been used to estimate the potential short-term movements, which include the "immediate" or elastic movements as a result of the basement excavation. Drained parameters have been used to provide an estimate of the total long-term movement.

The elastic analysis requires values of soil stiffness at various levels to calculate displacements. Values of stiffness for the soils at this site are readily available from published data¹ and a well-established method has been used to provide estimated values. For the purpose of this analysis, conservative relationships of $E_u = 600 C_u$ and $E' = 450 C_u$ have been used to obtain values of Young's modulus for the cohesive soils.

The soil parameters used in this analysis are summarised in the table below.

Stratum	Base of Stratum (m TBM)	E_u (KN/m ²)	E' (KN/m ²)
Made Ground	10.0 (varies)	10,000	10,000
London Clay	-1.5*	36,000 to 105,000	27,000 to 78,750
London Clay	-30.0	105,000 to 231,000	78,750 to 173,250

*Maximum depth of investigation.

1 Burland JB, Standing, JR, and Jardine, FM (2001) *Building response to tunnelling, case studies from construction of the Jubilee Line Extension*. CIRIA Special Publication 200



The excavation of up to 3.5 m to 6.5 m of soil to form the proposed basement structure will result in an unloading of about 65 kN/m² to 125 kN/m².

A rigid boundary for the analysis has been set at the base of the London Clay at a level of about -30 m TBM), with an increase in cohesion of 7.5 kN/m² per m increase in depth adopted to provide a conservative estimate of the likely strength profile below the depth of the investigation.

Information provided by the consulting engineer indicates that loads on the proposed underpinning will result in a bearing pressure of about 60 kN/m². An assessment of the potential behaviour of these foundations has been included within the analysis, with a staged approach to the modelling adopted to reflect the change in the way the loads are applied during the course of construction.

5.3 Ground Movements – Surrounding the Basement

The magnitude of the settlement resulting from the proposed basement construction will be controlled to a large extent by the quality of workmanship, particularly with respect to walls constructed by underpinning techniques.

For the purpose of this assessment a high quality of construction has therefore been assumed, with continued loading from the existing building, such that potential movements are expected to be kept to a minimum.

5.3.1 Model Used

For the X-Disp analysis, the soil movement relationships used for the embedded retaining walls are the default values within CIRIA report C760², which were derived from a number of historic case studies.

Installation of Proposed Underpinning:

It is assumed that the RC concrete underpinning will be supported or propped in the temporary condition to maintain stability during the excavation and that reinforced concrete liner walls will be cast at a later stage in the appropriate areas.

The installation curves for the panel-like planar diaphragm wall have therefore been adopted as most appropriate for the soil movement relationship for walls installed by underpinning techniques.

Excavation Phase:

Published data for ground movements associated with underpinning is limited compared to other types of retaining wall, although it is possible to use the well-documented predictions and movement curves for embedded retaining walls contained within CIRIA C760.

It is generally accepted that overall horizontal movements from underpinning would be expected to be in the order of 5 mm for a single stage underpin with a retained height of about 3.0 m, equivalent to a normalised relationship of 0.15%, with movement that diminishes with distance from the wall according to the trend line set by a wall within clay (see Fig 6.15a of CIRIA C760). As movements are intrinsically linked to retained height, it therefore follows that there would be a corresponding increase or decrease in movements proportionate to the depth of the underpinning.

A horizontal ground movement curve, which when combined with the installation movements, gives a normalised relationship of 0.15%, has therefore been adopted for the excavation phases for the proposed basement, with any associated vertical movements predicted using the associated vertical movement curve for 'excavation in front of a stiff wall in stiff clay'.

Additional movements:

The vertical movements obtained from the corresponding P-Disp analysis (Analysis Stages 1 to 4), have also been imported into the corresponding X-Disp models to account for any additional vertical settlement on these structures, to enable a damage assessment to be undertaken of all the potential movements for each stage of the analysis.

5.3.2 Results

The movements predicted by the combined X-Disp and P-Disp analysis are summarised in the table below; the results are presented below and in subsequent tables to the degree of accuracy required to allow predicted variations in ground movements around the structure(s) to be illustrated but may not reflect the anticipated accuracy of the predictions.

2 Gaba, A, Hardy, S, Powrie, W, Doughty, L and Selemetas, D (2017) *Embedded retaining walls – guidance for economic design* CIRIA Report C760



Analysis Stage 1 - Short-term movements following first stage underpinning & excavation

.Phase of Works	Wall Movement (mm)*	
	Vertical Settlement	Horizontal Movement
Immediately behind wall	<1.0 to 6.0	<1.0 to 6.0
At 5 m from wall	<2.0	<2.0
At 10 m from wall	<1.0	<1.0

*A positive number denotes settlement, whilst a negative number denotes heave.

Analysis Stage 2 – Short-term movements following second stage underpinning & excavation

.Phase of Works	Wall Movement (mm)*	
	Vertical Settlement	Horizontal Movement
Immediately behind wall	2.0 to 8.0	2.0 to 8.0
At 5 m from wall	<2.0	<4.0
At 10 m from wall	<1.0	<2.0

*A positive number denotes settlement, whilst a negative number denotes heave.

Analysis Stage 3 - Short-term movements following swimming pool construction

.Phase of Works	Wall Movement (mm)*	
	Vertical Settlement	Horizontal Movement
Immediately behind wall	2.0 to 8.0	2.0 to 9.0
At 5 m from wall	<3.0	<4.0
At 10 m from wall	<1.0	<2.0

*A positive number denotes settlement, whilst a negative number denotes heave.

Analysis Stage 4 Total movements from proposed basement construction process

.Phase of Works	Wall Movement (mm)*	
	Vertical Settlement	Horizontal Movement
Immediately behind wall	3.0 to 8.0	2.0 to 9.0
At 5 m from wall	<3.0	<4.0
At 10 m from wall	<1.0	<2.0

*A positive number denotes settlement, whilst a negative number denotes heave.

It is important to note that the movements in each table reflect those that will have occurred by the end of that stage and represent the cumulative progression of ground movements throughout the construction process, i.e., Analysis Stage 2 includes the movements that will result from this and the previous stage, and so on through each of the remaining stages.

The estimated movements in the tables above are considered to represent a worst-case scenario, particularly as the movements resulting from basement excavation will be minimised due to control of the propping in the temporary works and a regime of monitoring.

5.4 Ground Movements – Within the Excavation

5.4.1 Results

The P-Disp analysis indicates that short-term heave at the center of the proposed basement excavation is likely to be in the order of 5 mm to 6 mm, with up to 2 mm of settlement anticipated on the proposed underpinning.

In the long term, following completion of the basement construction. A further 4 mm of heave is estimated as a result of long-term swelling of the underling London Clay, with a further 1 mm to 2 mm of settlement expected on the proposed underpinning.

The potential movements are summarised in the table opposite.



Location	Short-term Movement (mm)*			Total Movement (mm)*
	Stage 1	Stage 2	Stage 3	Stage 4
Centre of basement excavation	-4.0 to -5.0	-4.0 to -5.0	-5.0 to -6.0	-9.0 to -10.0
Edge of excavation / underpinning	0.0 to 1.0	1.0 to 2.0	1.0 to 2.0	2.0 to 4.0

Stage 1 = First stage underpinning & excavation to Mezzanine Level; Stage 2 = Second stage underpinning & excavation to Poolside Level; Stage 3 = Localised underpinning & excavation to swimming pool level; Stage 4 = Total (short term + long term) movements from development. *Negative values indicate heave and positive indicates settlement

If a compressible material is used beneath the slab, such as for the mezzanine and poolside level excavations, it will need to be designed to be able to resist the potential uplift forces generated by the ground movements. In this respect, potential heave pressures are typically taken to equate to around 50 % of the total unloading pressure, assuming a linear relationship between heave movement and the pressure applied to the underside of the slab, which in this case is taken to be inflexible. However, if there is some flexibility in the slab, this value would reduce as the slab deflects and it would be reasonable to assume that the heave pressure would reduce to around 40 % to 35 % of the unloading pressure.

6.0 Building Damage Assessment

In addition to the above assessment of the likely movements that will result from the excavation, any neighbouring buildings within the zone of influence of the excavations are considered to be sensitive structures, requiring Building Damage Assessments, on the basis of the classification given in Table 6.4 of CIRIA report C760³.

The nearby buildings or structures included in this assessment are as follows, with all other structure at sufficient distance as not to be affected by the proposed development:

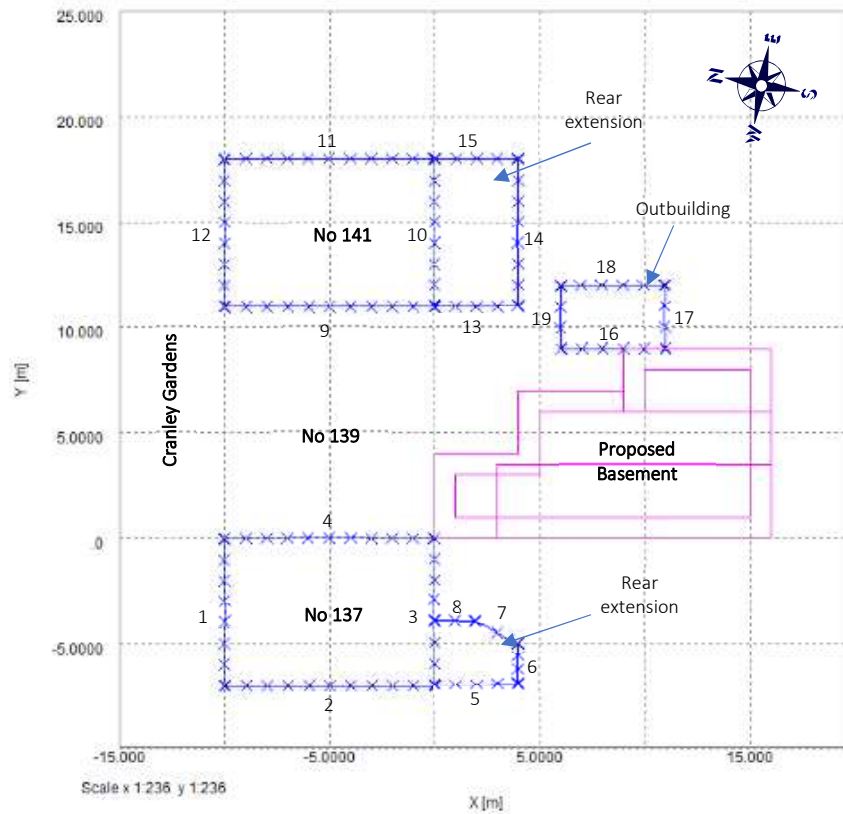
- the adjoining property of No 137 Cranley Gardens, with associated rear extension, to the west; and
- the adjoining No 141 Cranley Gardens, with associated rear extension and outbuilding, to the east.

The sensitive structures outlined have been modelled as lines in the analysis and are the lines along which the damage assessment has been undertaken. For clarity, these critical lines and the specific reference numbers used in the assessment are shown on the plan opposite.

These lines are expected to be sensitive at their foundation level, which, from previous experience of the area are expected to be in the order of 1.0 m deep, with the level reducing with ground level from the front to the rear of each site. However, for the purpose of this analysis, they have all been set at an elevation of 11.0 m TBM, such that they are therefore subject to the full range of movement predicted at the top of the proposed excavations and provide a conservatively assessment of the likely impact of the proposed development.

Building heights have been derived from the number of storeys, as observed during the previous investigation and from information provided by the structural engineers.

3 Gaba, A, Hardy, S, Powrie, W, Doughty, L and Selemetas, D (2017) *Embedded retaining walls – guidance for economic design*. CIRIA Report C760



6.1 Damage to Neighbouring Structures

The combined movements resulting from underpinning and excavation of the proposed basement, have been used to carry out an assessment of the likely damage to adjacent properties and the results are summarised in the table overleaf.

Structure	Elevation Ref	Critical Stage(s)	Max Tensile Strain (%)	Maximum Damage Category*
No 137 Cranley Gardens	1	4	<0.01	Negligible (0)
	2	2	<0.01	Negligible (0)
	3	3	0.04	Negligible (0)
	4	4	0.04	Negligible (0)
	5	4	<0.01-	Negligible (0)
	6	3 & 4	0.08	Slight (2)
	7	4	0.01	Negligible (0)
	8	3	<0.01	Negligible (0)
No 141 Cranley Gardens	9	2	0.01	Negligible (0)
	10	2	0.02	Negligible (0)
	11	4	<0.01	Negligible (0)
	12	2	<0.01	Negligible (0)
	13	2	<0.01	Negligible (0)
	14	2, 3 & 4	0.06	Very Slight (1)
	15	2	<0.01	Negligible (0)
	16	2	0.06	Very Slight (1)
	17	4	0.06	Very Slight (1)
	18	1	0.03	Negligible (0)
	19	2 & 3	0.06	Very Slight (1)

*From Table 6.4 of C760: Classification of visible damage to walls.



The damage to the adjoining and nearby structures has been predicted to generally be Category 0 (negligible), with some limited sections of Category 1 (Very Slight) damage to the rear extension and outbuilding to the rear of No 141 Cranley Gardens, and a single segment of Category 2 (slight) damage to the rear elevation of the extension to the rear of No 137 Cranley Gardens.

The results are based on individual building lines, or walls, that in some instances have been further divided into a series of segments that are assumed to be able to move independently of one another, with the most critical segment determining the result for the entire wall. In reality, this is unlikely to be the case as the walls will behave as single stiff elements that are also joined continuously with the rest of the structure. The results therefore provide a conservative estimate of the behaviour of each of the sensitive structures and overestimate the degree of damage, although they provide a useful indication of the most critical structures within the adjoining properties that may require further assessment, as detailed below.

6.1.1 No 137 Cranley Gardens Rear Extension (Elevation ref 6)

The specific building line highlighted above has been sub-divided by the X-Disp software into a series of two segments, only one of which is predicted to sustain 'Slight (2)' damage. As this wall is more likely to behave as single structure, the individual segment results have been combined to provide an overall damage assessment along the full length of the structure, as detailed in the table below.

Elevation ref	Segment No	Segment length (m)	Individual Segments		Combined Results	
			Max Tensile Strain (%)	Category of Damage*	Max Tensile Strain (%)	Category of Damage*
6	1	1.60	0.049	Category 0 – Negligible	0.055	Category 1 Very Slight
	2	0.35	0.083	Category 2 - Slight		

As demonstrated above, when the individual segment results are combined for this structure, the predicted damage reduces to 'Very Slight (1)'.

6.2 Monitoring of Ground Movements

The predictions of ground movement should be checked by monitoring of the adjacent properties and structures. The structures to be monitored during the construction stages should include the existing property and the neighbouring structure assessed above. Condition surveys should be carried out before and after the proposed works.

The precise monitoring strategy will be developed at a later stage and will be subject to discussions and agreements with the owners of the adjacent properties and structures. Contingency measures will be implemented if movements exceed predefined trigger levels. Both contingency measures and trigger levels will need to be developed within a future monitoring specification for the works.



7.0 GMA Conclusions

The analysis has concluded that the predicted damage to the neighbouring properties from the construction of the proposed basements would be 'Negligible' to 'Very Slight'

On this basis, the damage that has been predicted to occur as a result of the construction the proposed basement falls within acceptable limits. However, it is assumed that careful control and monitoring will be required to ensure that no excessive movements occur that would lead to damage in excess of these limits.

The separate phases of work, including underpinning and subsequent excavation of the proposed basement, will in practice be separated by a number of weeks. This will provide an opportunity for the ground movements during and immediately after installation of the retaining walls to be measured and the data acquired can be fed back into the design and compared with the predicted values. Such a comparison will allow the ground model to be reviewed and the predicted wall movements to be reassessed prior to the main excavation taking place so that propping arrangements can be adjusted if required.



Appendix

Ground Movement Analysis

P-Disp Analysis

Contour plots of Vertical Displacement for:

Stage 1 – Short-term Movement – First Stage Underpinning & Excavation
Stage 2 – Short-term Movement – Second Stage Underpinning & Excavation
Stage 3 – Short-term Movement – Swimming Pool Excavation
Stage 4 – Total Movements

X-Disp Analysis

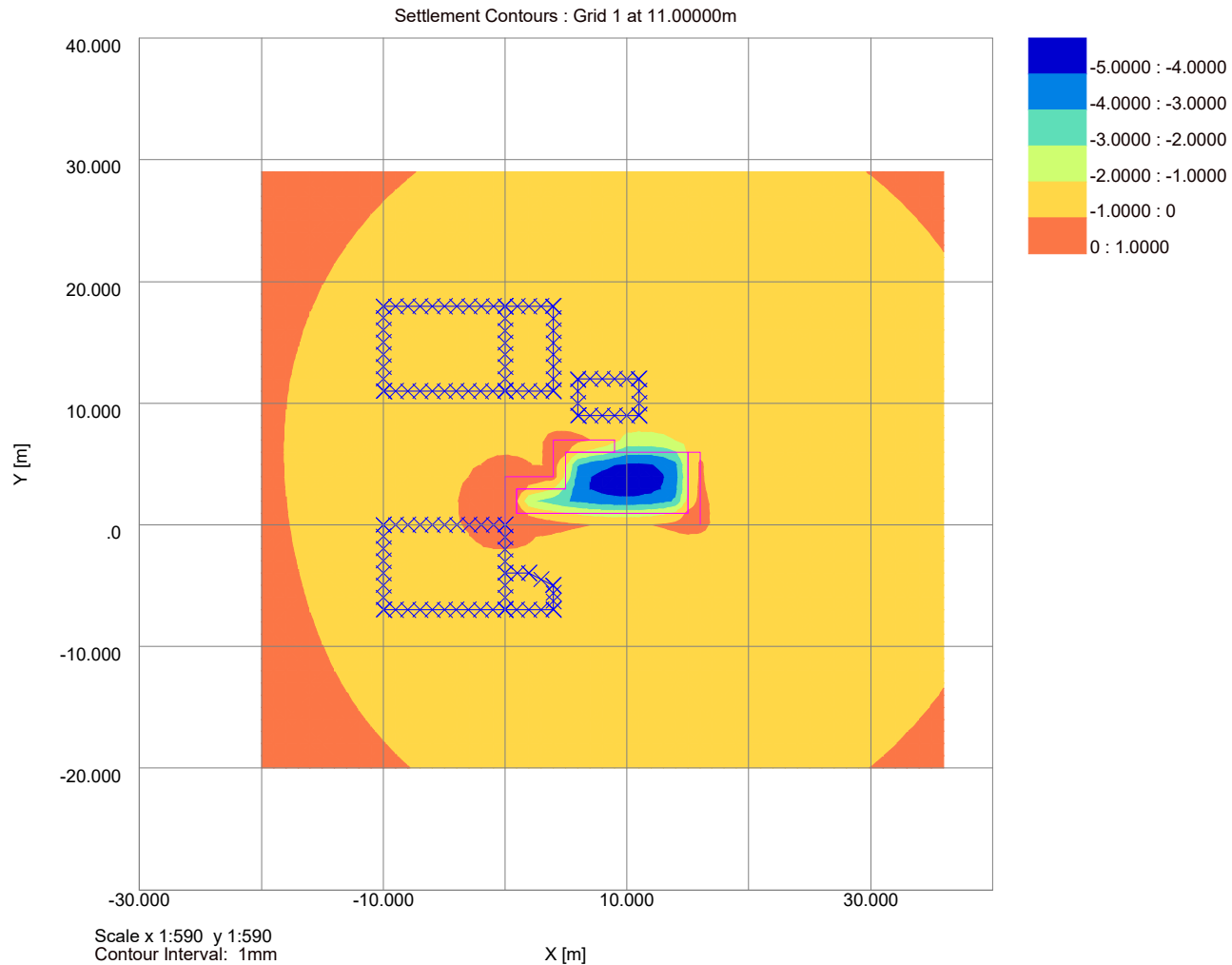
Contour Plots of Vertical & Horizontal Displacement for:

Stage 1 – Short-term Movement – First Stage Underpinning & Excavation
Stage 2 – Short-term Movement – Second Stage Underpinning & Excavation
Stage 3 – Short-term Movement – Swimming Pool Excavation
Stage 4 – Total Movements

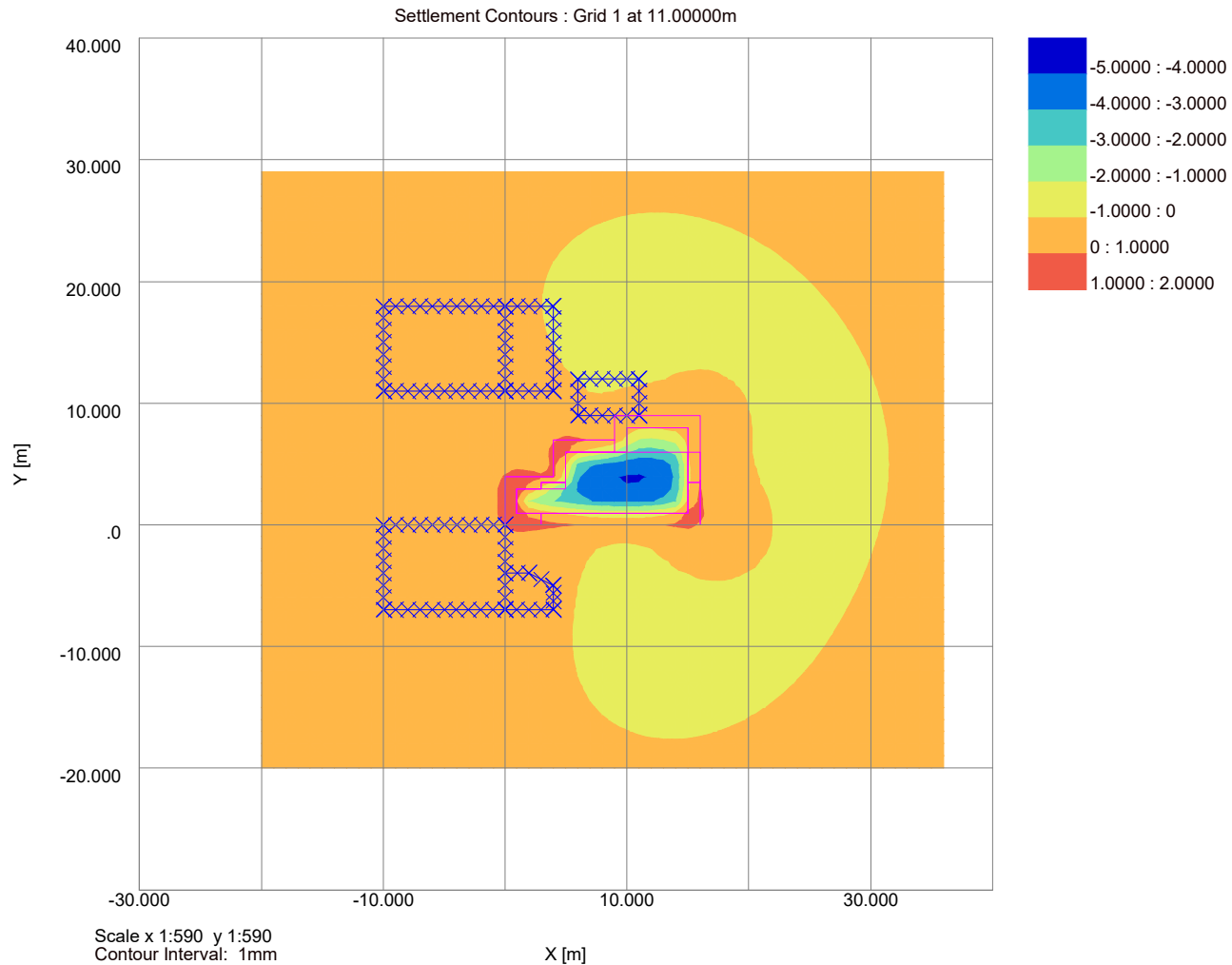
Building Damage Assessment

Tabular Outputs of Building Damage Results (Stage 1 to 4)

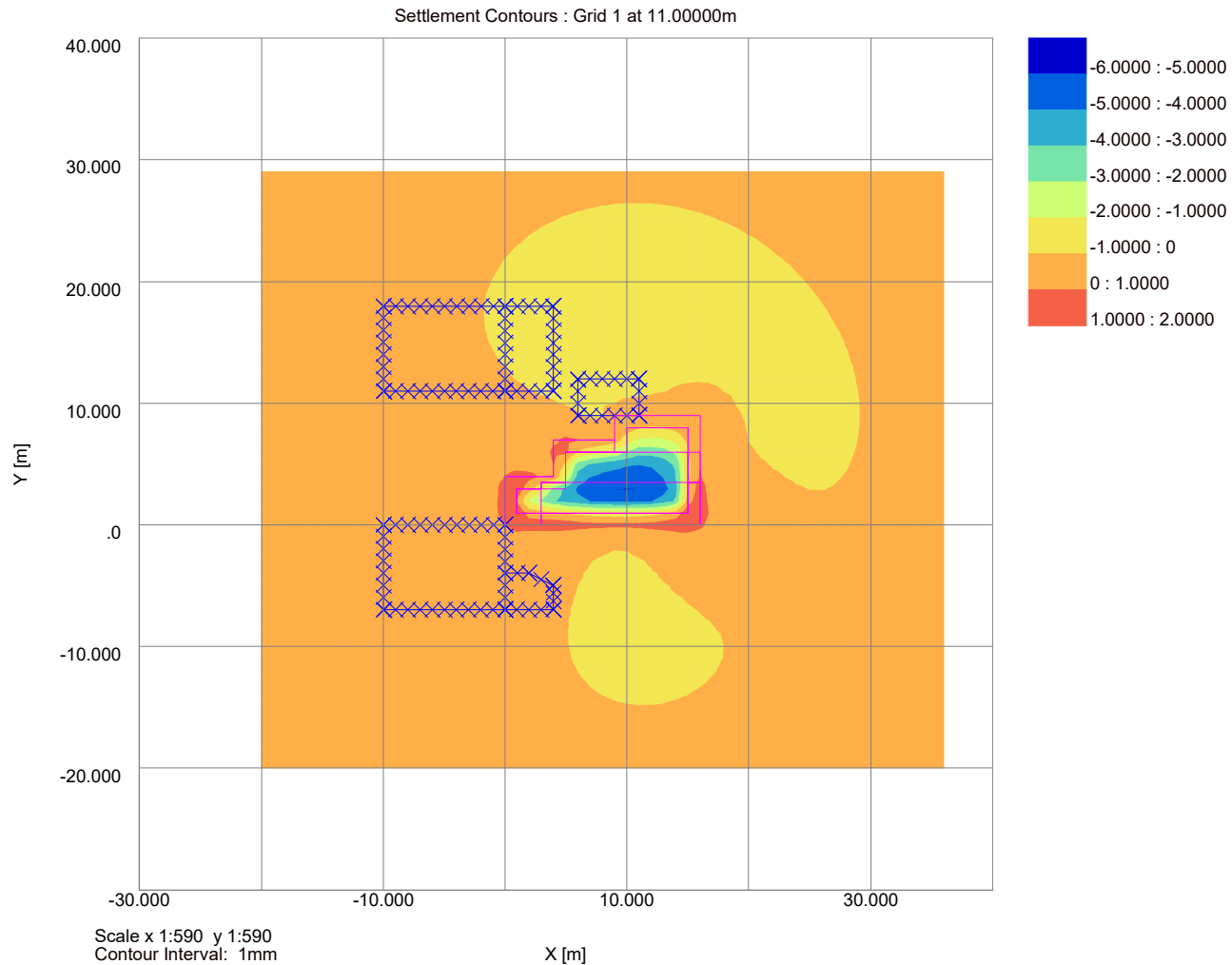
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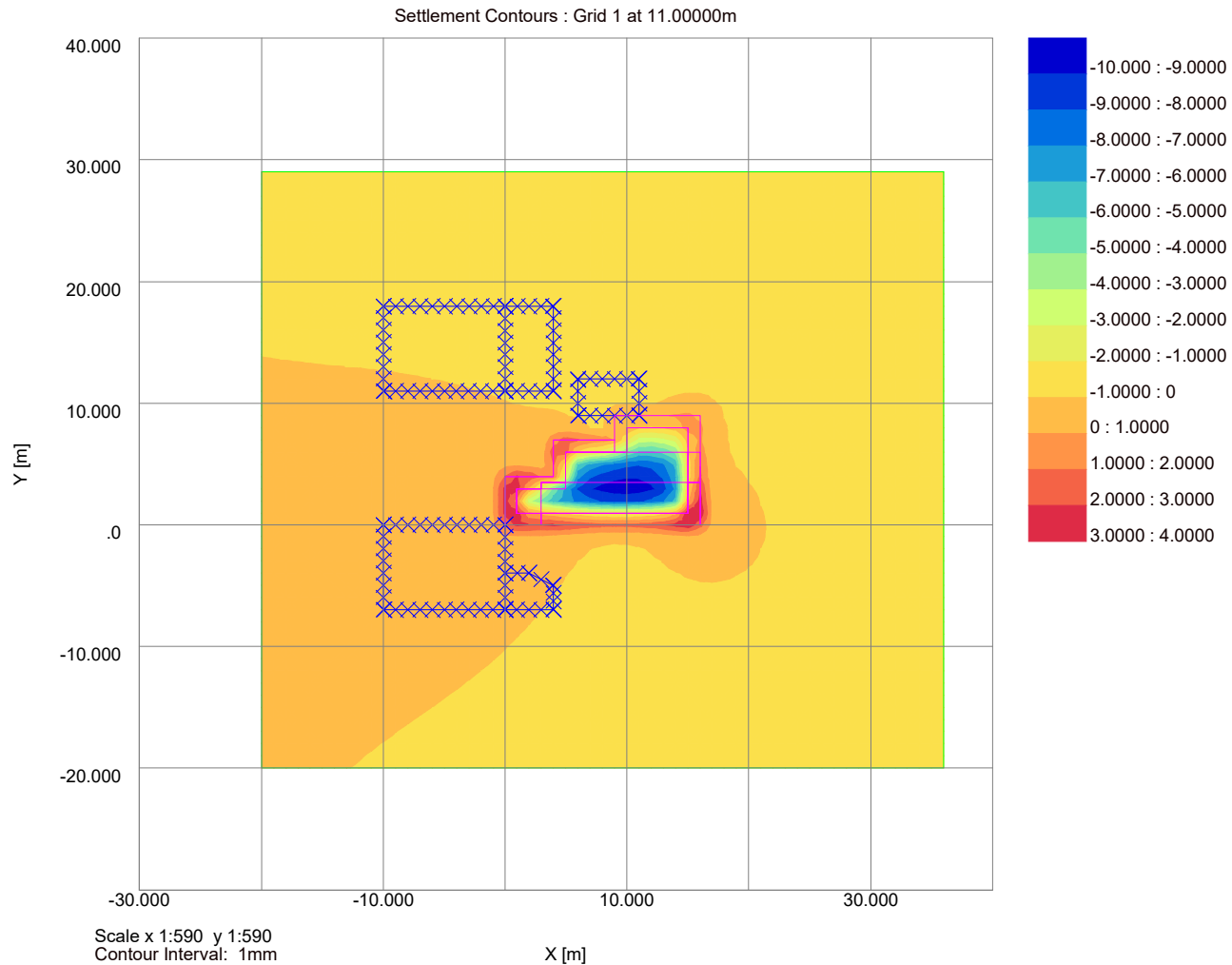
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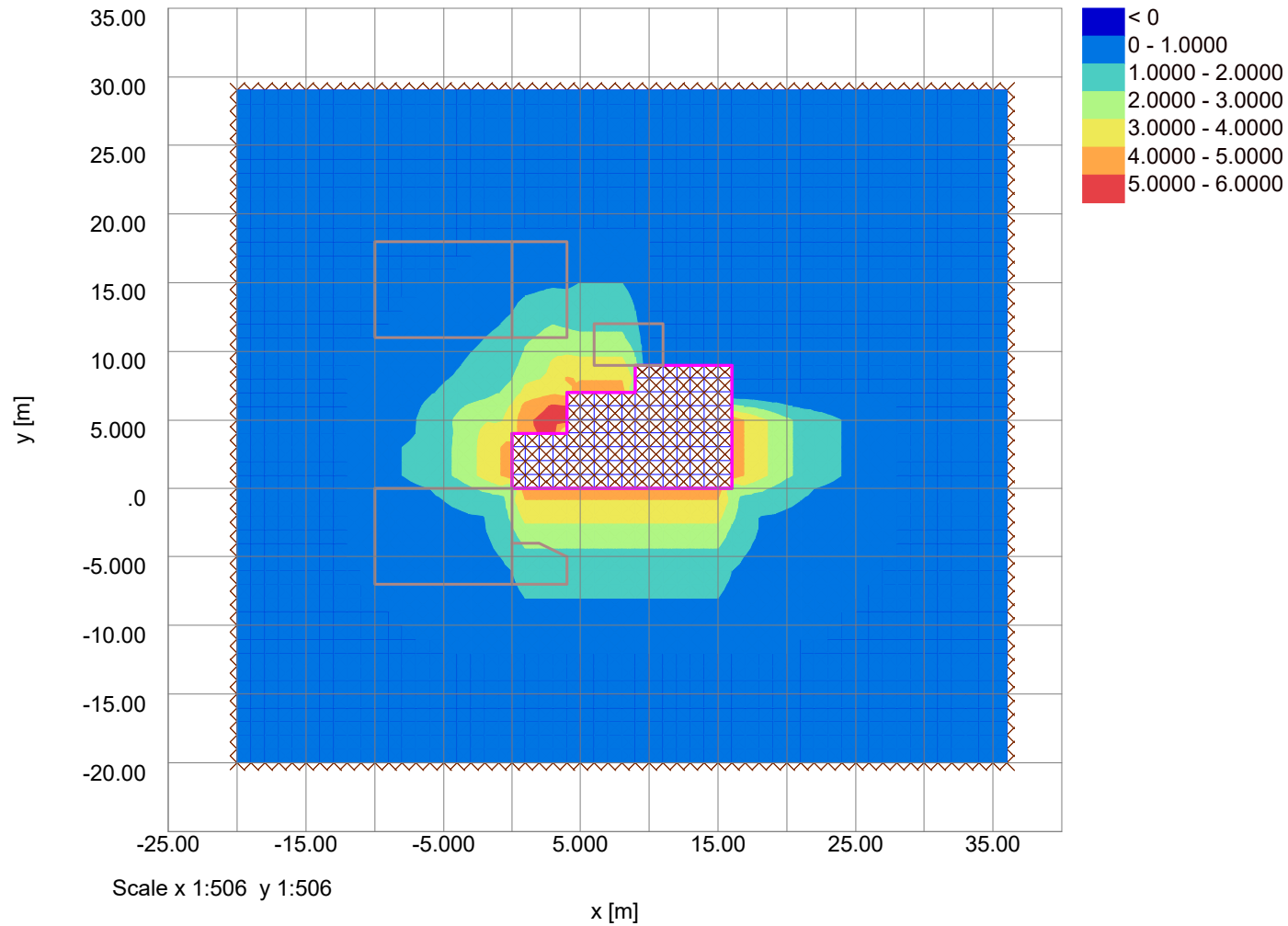


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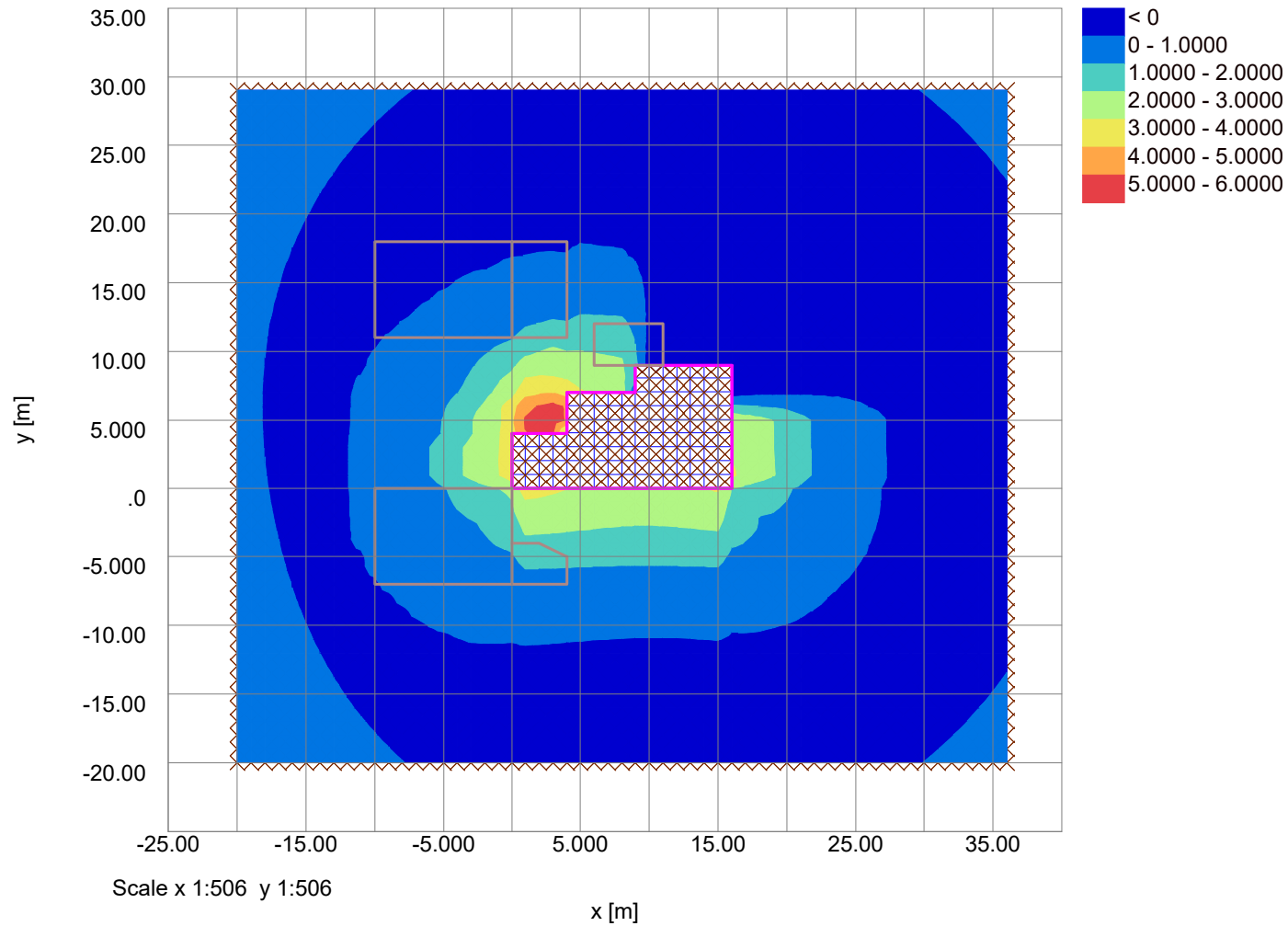
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Horizontal Displacement Contours: Grid 1 (level 11.000m) Interval 1mm



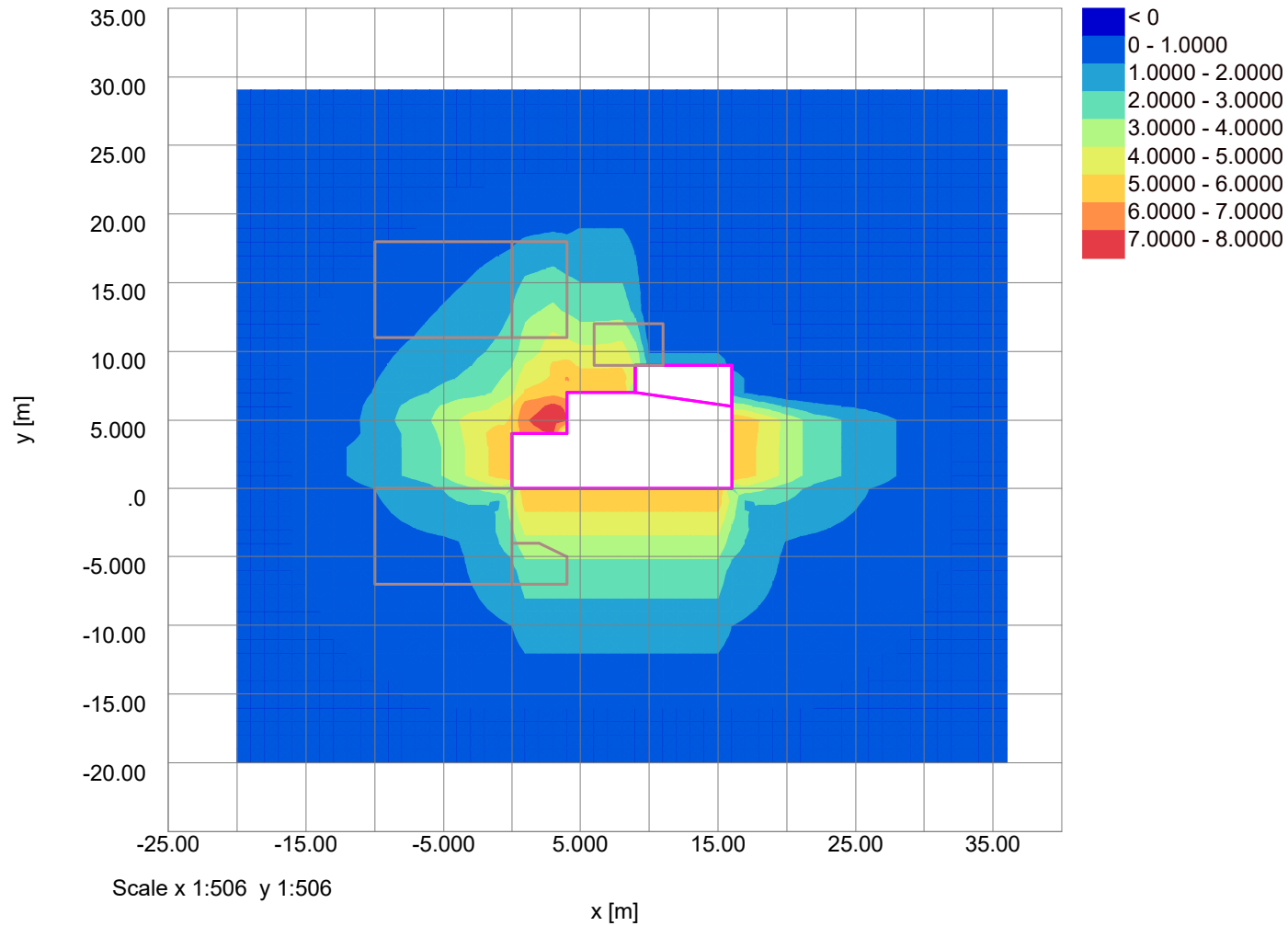
Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Vertical Settlement Contours: Grid 1 (level 11.000m) (Interval 1mm)



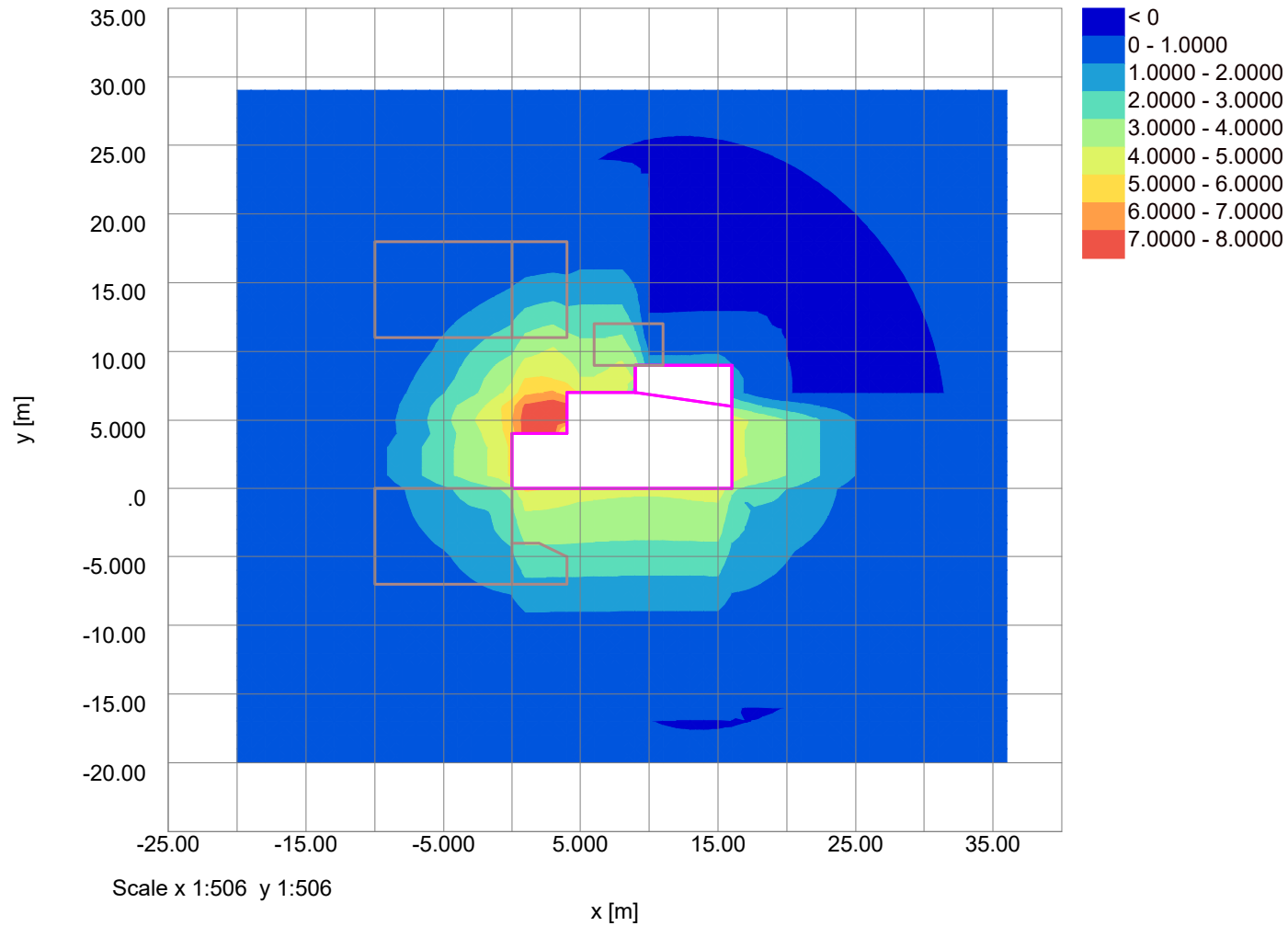
Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Horizontal Displacement Contours: Grid 1 (level 11.000m) Interval 1mm



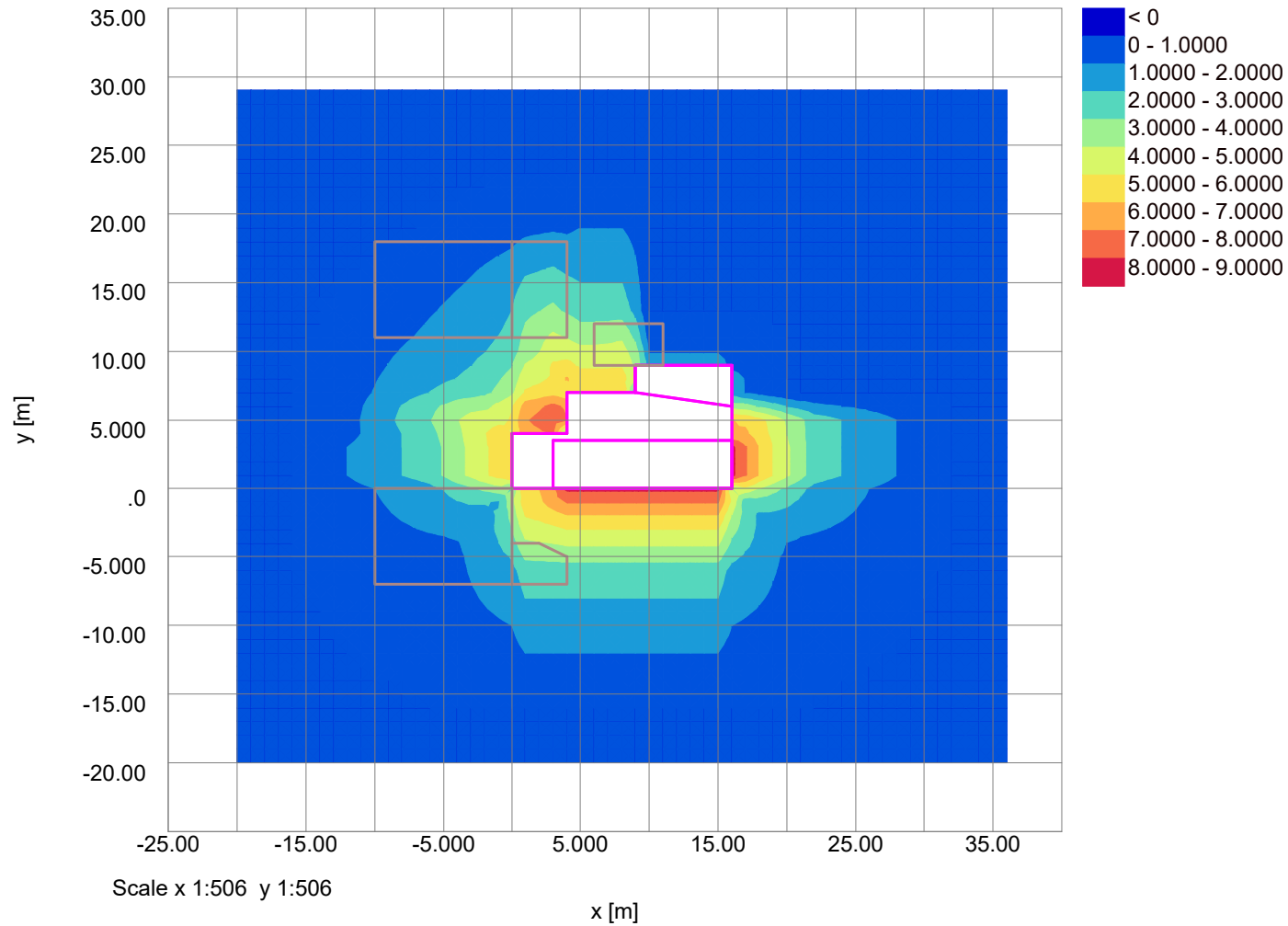
Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Vertical Settlement Contours: Grid 1 (level 11.000m) (Interval 1mm)



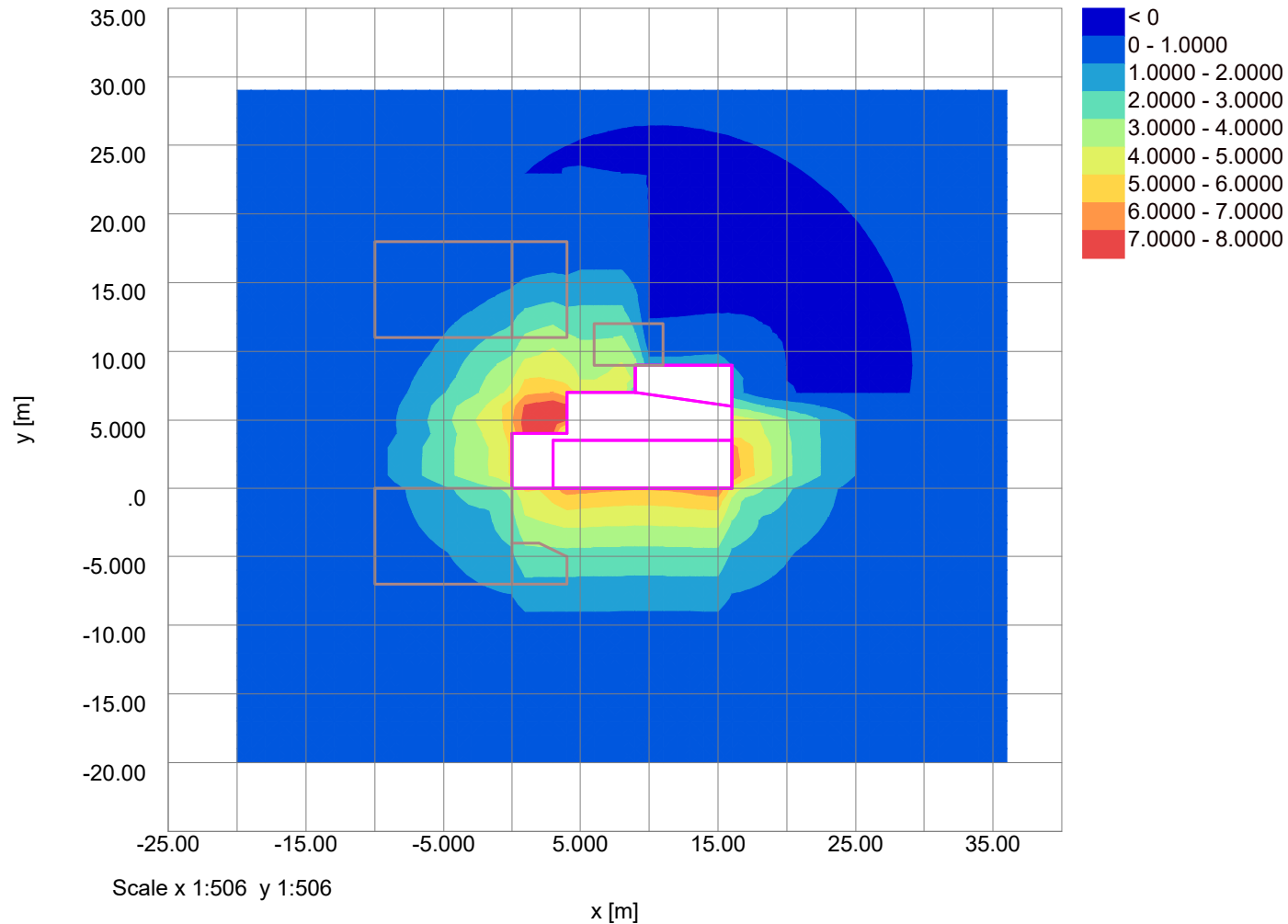
Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Horizontal Displacement Contours: Grid 1 (level 11.000m) Interval 1mm



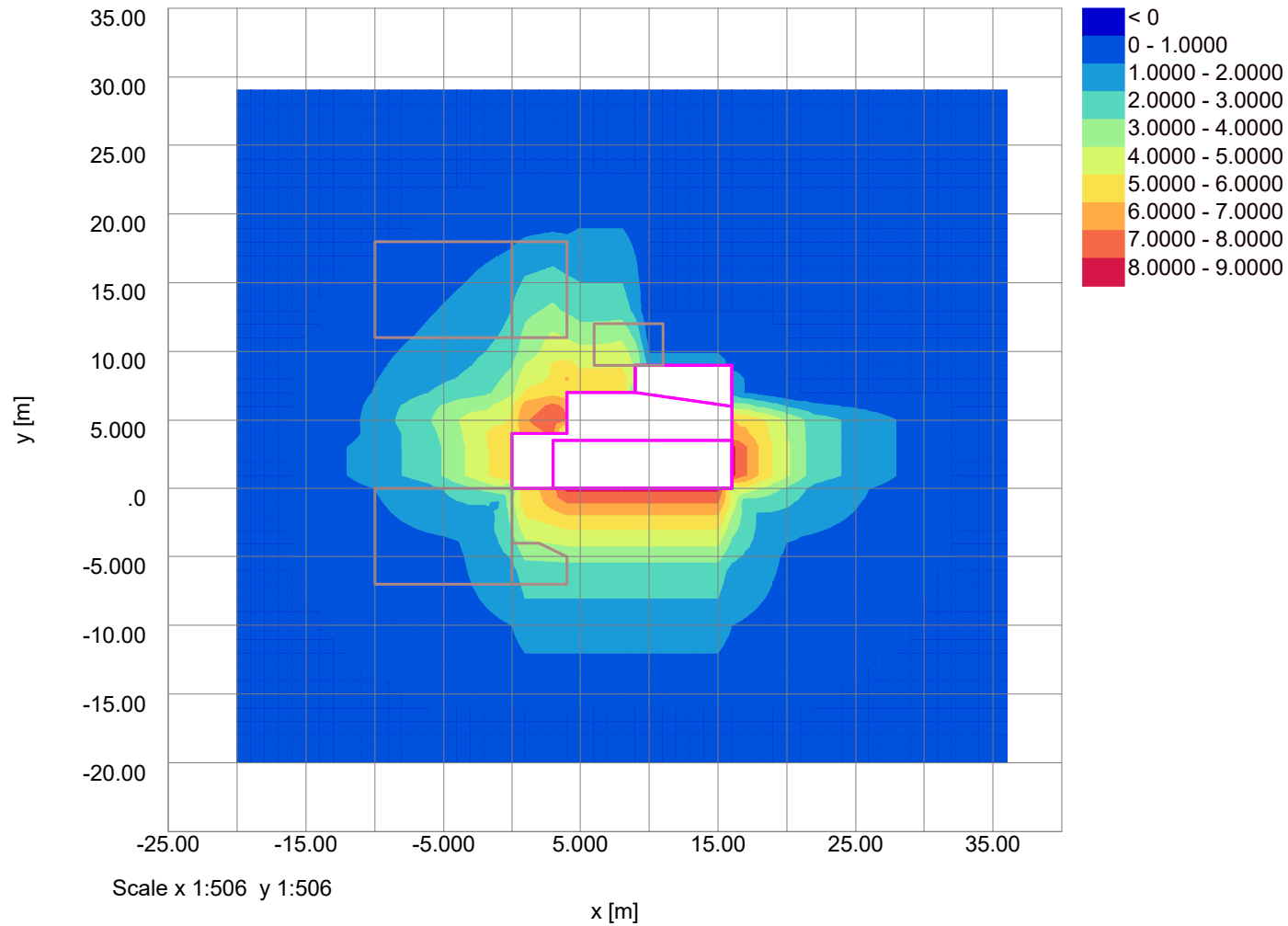
Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Vertical Settlement Contours: Grid 1 (level 11.000m) (Interval 1mm)



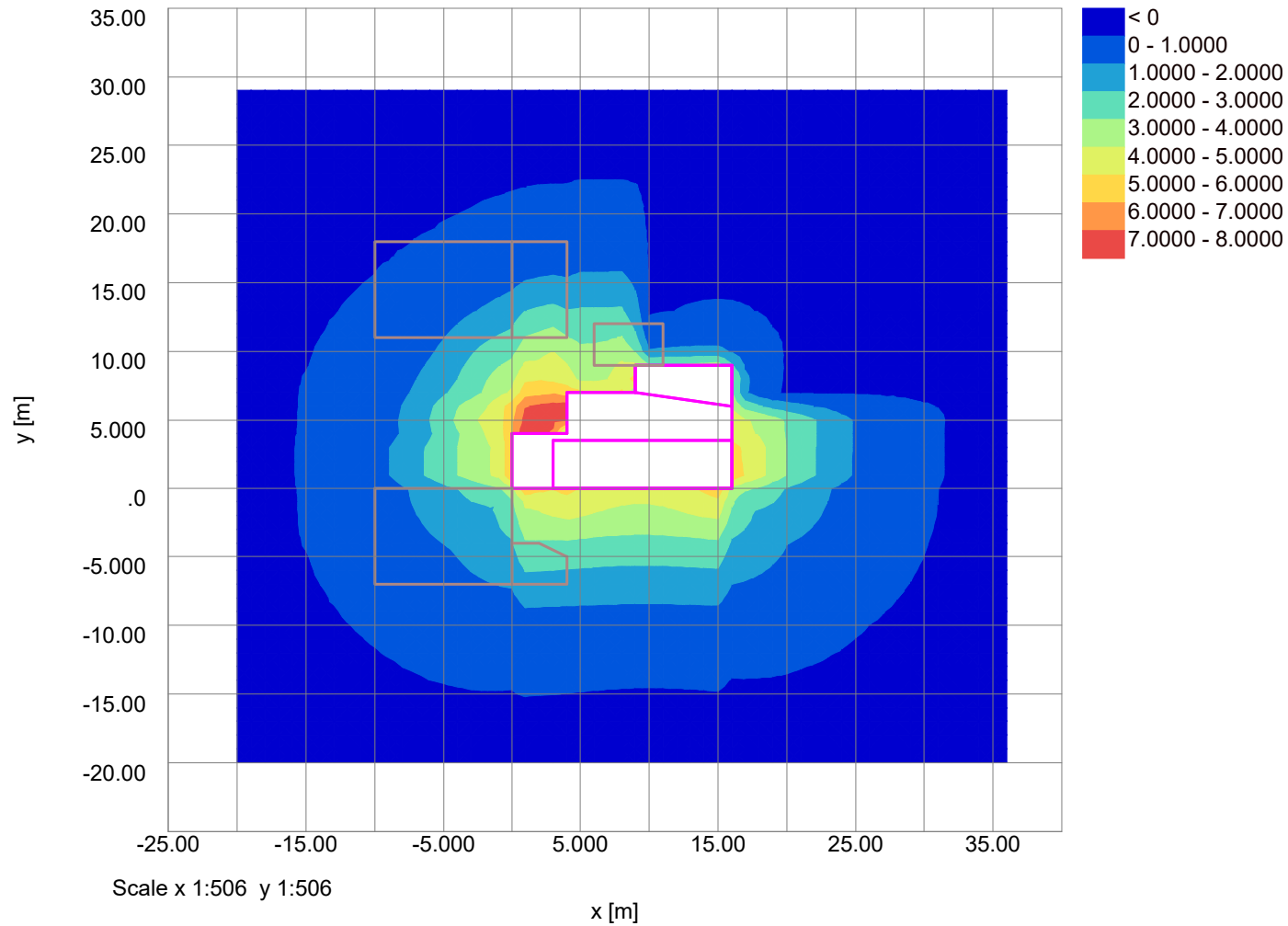
Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Horizontal Displacement Contours: Grid 1 (level 11.000m) Interval 1mm



Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Vertical Settlement Contours: Grid 1 (level 11.000m) (Interval 1mm)





GEOTECHNICAL AND ENVIRONMENTAL ASSOCIATES LTD

139 Cranley Gardens

GMA

Stage 1 - Installation & Excavation to Mezzanine Level

Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Specific Building Damage Results - Detail

Stage:	Stage: Name	Specific Building: Name	Sub-building	Vertical Offset	Segment	Start	Length	Curvature	Deflection	Average
Max	Max Gradient	Min	Damage Category							
Ref.	Building:	Name		from Line for					Ratio	Horizontal
Tensile	of	of Vertical	Radius of	Vertical						Strain
Strain	Horizontal	Displacement	Curvature	Movement						
Displacement	Curve			Calculations						
Curve										
[%]		[m]		[m]		[m]	[m]		[%]	[%]
0	Base Model 1	No 137 Cranley Gardens Frontage		0.0	All vertical displacements are less than the limit sensitivity.					
	2	No 137 Cranley Gardens Far Elevation		0.0	1	4.9750	1.6306	None	158.83E-6	-0.0011749
252.31E-6	21.700E-6	-68.916E-6	79168. 0 (Negligible)		2	6.6056	3.3444	None	689.49E-6	-0.0044438
969.21E-6	55.671E-6	-68.916E-6	36885. 0 (Negligible)		1	0.0	2.6945	None	799.43E-6	0.019878
0.020280	-286.31E-6	-280.38E-6	27981. 0 (Negligible)		2	2.6945	1.6065	None	180.17E-6	0.037237
0.037292	-390.68E-6	-280.38E-6	108130. 0 (Negligible)		3	4.3010	2.6490	None	0.0026248	-0.017826
0.0038656	0.0011288	-365.71E-6	6290.9 0 (Negligible)		1	0.0	1.2975	None	288.47E-6	0.039083
0.039155	-390.68E-6	252.69E-6	36312. 0 (Negligible)	0.0	2	1.2975	3.0210	None	583.28E-6	0.037763
0.038090	-390.68E-6	282.59E-6	79036. 0 (Negligible)		3	4.3185	4.6365	None	0.0026855	0.018244
0.020448	-272.92E-6	282.59E-6	16569. 0 (Negligible)		1	0.0	3.9500	None	35.672E-6	0.0
43.380E-6	0.0	10.819E-6	859580. 0 (Negligible)	0.0	1	0.0	1.9500	None	0.0010084	0.025000
0.025713	-249.94E-6	-391.17E-6	15335. 0 (Negligible)	0.0	1	0.0	2.1910	None	379.87E-6	0.0086753
0.0089726	-121.45E-6	-211.54E-6	71387. 0 (Negligible)	0.0	1	0.0	1.9000	None	128.75E-6	0.0
121.70E-6	0.0	-20.525E-6	182610. 0 (Negligible)	0.0	1	3.9800	3.8970	None	0.0018005	0.0057997
0.0070717	-132.45E-6	-179.82E-6	27298. 0 (Negligible)		2	7.8770	2.0730	None	828.08E-6	-0.0064349
0.0013719	91.951E-6	-179.82E-6	23842. 0 (Negligible)		1	0.0	2.9786	None	0.0022330	0.017244
0.018479	-231.83E-6	303.26E-6	15017. 0 (Negligible)							
	11	No 141 Cranley Gardens Far Elevation		0.0	All vertical displacements are less than the limit sensitivity.					
	12	No 141 Cranley Gardens Frontage		0.0	All vertical displacements are less than the limit sensitivity.					



GEOTECHNICAL AND ENVIRONMENTAL ASSOCIATES LTD

139 Cranley Gardens

GMA

Stage 1 - Installation & Excavation to Mezzanine Level

Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Stage:	Stage: Name	Specific	Specific	Building: Name	Sub-building	Vertical Offset	Segment	Start	Length	Curvature	Deflection	Average
Max	Max	Gradient	Max	Gradient	Min	Damage	Category					
Ref.	Building:				Name	from	Line for				Ratio	Horizontal
Tensile	of	of	Vertical	Radius of								
0.0035660	13	No 141	Cranley Gardens	Extension		0.0	1	0.0	3.9500	None	0.0051197	-0.010012
	163.60E-6	-162.87E-6	3003.0	0 (Negligible)								
0.040991	14	No 141	Cranley Gardens	Extension		0.0	1	0.0	3.9714	None	0.0040682	0.036031
	-436.03E-6	442.31E-6	12158.0	0 (Negligible)								
	15	No 141	Cranley Gardens	Extension		0.0	All vertical displacements are less than the limit sensitivity.					
35.763E-9	16	No 141	Cranley Gardens	Outbuilding		0.0	1	0.0	0.49278	None	0.0	0.0
	0.0	79.333E-6	1539.6	0 (Negligible)								
0.044781	0.0	0.0026688	1525.9	0 (Negligible)			2	0.49278	1.9723	None	0.047573	0.0
0.046132	0.0	0.0026688	1462.4	0 (Negligible)			3	2.4651	2.0146	None	0.049133	0.0
35.763E-9	0.0	24.983E-6	1615.9	0 (Negligible)			4	4.4797	0.47029	None	0.0	0.0
0.0015385	17	No 141	Cranley Gardens	Outbuilding		0.0	1	0.0	2.9490	None	0.0015455	0.0
	0.0	-160.41E-6	16659.0	0 (Negligible)								
0.033172	18	No 141	Cranley Gardens	Outbuilding		0.0	1	0.0	1.6554	None	0.034628	0.0
	0.0	-0.0014505	457.26	0 (Negligible)			2	1.6554	2.2983	None	0.017348	0.0
0.015994	0.0	-0.0014505	2782.1	0 (Negligible)			3	3.9538	0.99521	None	1.0734E-6	0.0
1.0371E-6	19	No 141	Cranley Gardens	Outbuilding		0.0	1	0.0	2.9490	None	0.0011140	0.053247
0.054356	-582.99E-6	-378.61E-6	25961.1	(Very Slight)								
Tensile horizontal strains are +ve, compressive horizontal strains are -ve.												



GEOTECHNICAL AND ENVIRONMENTAL ASSOCIATES LTD

139 Cranley Gardens

GMA

Stage 2 - Installation & Excavation to Poolside Level

Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Specific Building Damage Results - Detail

Stage:	Stage: Name	Specific Building: Name	Sub-building	Vertical Offset	Segment	Start	Length	Curvature	Deflection	Average
Max	Max Gradient	Min	Damage Category							
Ref.	Building:	Name		from Line for					Ratio	Horizontal
Tensile	of	of Vertical	Radius of	Vertical						Strain
Strain	Horizontal	Displacement	Curvature	Movement						
Displacement	Curve			Calculations						
Curve										
[%]		[m]		[m]		[m]	[m]		[%]	[%]
0	Base Model 1	No 137 Cranley Gardens Frontage	0.0	1	0.0	4.1800	None	558.09E-6	-0.0038401	
826.30E-6	47.116E-6	59.164E-6 59360. 0 (Negligible)		2	4.1800	2.7700	None	211.61E-6	-774.76E-6	
198.30E-6	19.287E-6	59.164E-6 117530. 0 (Negligible)		1	0.0	5.5890	None	0.0013372	238.75E-6	
0.0015162	37.670E-6	-140.73E-6 45383. 0 (Negligible)		2	5.5890	4.3610	None	0.0011229	-0.0078267	
0.0016799	100.85E-6	-140.73E-6 29121. 0 (Negligible)		1	0.0	1.6225	None	237.84E-6	0.026007	
0.026080	-390.68E-6	-294.58E-6 62611. 0 (Negligible)		2	1.6225	1.6886	None	191.25E-6	0.039083	
0.039145	-390.68E-6	-294.58E-6 398750. 0 (Negligible)		3	3.3111	3.6389	None	0.0059463	-0.016153	
0.0047556	0.0016363	-586.85E-6 2640.0 0 (Negligible)		1	0.0	2.9260	None	0.0021546	0.039083	
0.040255	-390.68E-6	380.24E-6 7840.3 0 (Negligible)		2	2.9260	2.4306	None	158.58E-6	0.039013	
0.039085	-390.68E-6	298.61E-6 364760. 0 (Negligible)		3	5.3566	4.5934	None	0.0012725	0.019672	
0.020709	-386.20E-6	298.61E-6 23088. 0 (Negligible)		1	0.0	3.9500	None	70.734E-6	0.0	
85.938E-6	0.0	6.4963E-6 588590. 0 (Negligible)		1	0.0	1.0065	None	317.49E-6	0.031357	
0.031478	-429.30E-6	-427.08E-6 31659. 0 (Negligible)		2	1.0065	0.94355	None	269.77E-6	0.053547	
0.053644	-582.99E-6	-427.08E-6 33766. 1 (Very Slight)		1	0.0	2.1910	None	4.8772E-6	0.012146	
0.012150	-121.45E-6	-195.92E-6 5.5605E+6 0 (Negligible)		1	0.0	1.9000	None	182.16E-6	0.0	
172.20E-6	0.0	-7.2920E-6 129060. 0 (Negligible)		1	0.0	6.2766	None	0.0035962	0.0086552	
0.012404	-155.45E-6	-307.42E-6 18847. 0 (Negligible)		2	6.2766	3.6734	None	0.0020884	-0.010613	



GEOTECHNICAL AND ENVIRONMENTAL ASSOCIATES LTD

139 Cranley Gardens

GMA

Stage 2 - Installation & Excavation to Poolside Level

Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Stage:	Stage:	Name	Specific	Specific	Building:	Name	Sub-building	Vertical	Segment	Start	Length	Curvature	Deflection	Average
Max	Max	Gradient	Max	Gradient	Min	Damage	Category							
Ref.	Building:		Name		from		Line	for					Ratio	Horizontal
Tensile	of	of	Vertical	Radius	of									
0.0024237	167.61E-6	-307.42E-6	14222. 0	(Negligible)										
	10	No 141	Cranley Gardens	Rear Eleavtion	0.0	1	0.0	1.0482	None	35.933E-6	0.010280			
0.010287	-129.92E-6	395.23E-6	73903. 0	(Negligible)										
	11	No 141	Cranley Gardens	Far Elevation	0.0	1	0.0	3.9800	None	178.28E-6	-772.11E-6			
183.86E-6	24.476E-6	38.381E-6	216610. 0	(Negligible)										
	12	No 141	Cranley Gardens	Frontage	0.0	1	4.9643	1.9847	None	207.24E-6	0.0021392			
0.0022170	-44.047E-6	-45.915E-6	107660. 0	(Negligible)										
	13	No 141	Cranley Gardens	Extension	0.0	1	0.0	0.99205	None	1.1850E-6	-0.0047416			
948.32E-6	133.97E-6	-214.43E-6	219390. 0	(Negligible)										
	14	No 141	Cranley Gardens	Extension	0.0	1	0.0	0.29154	None	0.0	0.055833			
0.055833	-558.02E-6	534.86E-6	155490. 1	(Very Slight)										
	15	No 141	Cranley Gardens	Extension	0.0	1	0.0	3.9000	None	364.61E-6	-0.0029871			
621.24E-6	35.702E-6	35.457E-6	88376. 0	(Negligible)										
	16	No 141	Cranley Gardens	Outbuilding	0.0	1	0.0	0.56572	None	0.0	0.016750			
0.016750	-167.47E-6	-162.32E-6	1033.7 0	(Negligible)										
	17	No 141	Cranley Gardens	Outbuilding	0.0	1	0.0	1.1638	None	0.0012097	0.055618			
0.056148	-582.99E-6	470.43E-6	6104.4 1	(Very Slight)										
	18	No 141	Cranley Gardens	Outbuilding	0.0	1	1.9800	1.9696	None	50.421E-6	-888.96E-6			
0.040819	-408.03E-6	470.43E-6	8846.9 0	(Negligible)										
	19	No 141	Cranley Gardens	Outbuilding	0.0	1	0.0	0.22022	None	0.0	0.060272			
179.92E-6	21.098E-6	-0.0025849	1516.1 0	(Negligible)										
	20	No 141	Cranley Gardens	Outbuilding	0.0	1	0.0	0.22022	None	0.0	0.060272			
0.0018329	-18.452E-6	13.376E-6	97735. 0	(Negligible)										
	21	No 141	Cranley Gardens	Outbuilding	0.0	1	0.0	0.22022	None	0.0	0.060272			
0.060272	-602.36E-6	-396.36E-6	307720. 1	(Very Slight)										
	22	No 141	Cranley Gardens	Outbuilding	0.0	1	0.0	0.22022	None	0.0	0.060272			
0.058913	-602.36E-6	-396.36E-6	24828. 1	(Very Slight)										

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.



GEOTECHNICAL AND ENVIRONMENTAL ASSOCIATES LTD

139 Cranley Gardens

GMA

Stage 3 - Installation & Excavation to Pool Level

Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Specific Building Damage Results - Detail

Stage:	Stage: Name	Specific Building: Name	Sub-building	Vertical Offset	Segment	Start	Length	Curvature	Deflection	Average
Max	Max Gradient	Max Gradient	Min	Damage Category						
Ref.	Building:	Building:	Name	from Line for					Ratio	Horizontal
Tensile	of	of Vertical	Radius of	Vertical						Strain
Strain	Horizontal	Displacement	Curvature	Movement						
Displacement	Curve			Calculations						
Curve										
[%]		[m]		[m]		[m]	[m]		[%]	[%]
0	Base Model 1	No 137 Cranley Gardens Frontage	0.0	1	0.0	4.1824	None	557.54E-6	-0.0038389	
826.01E-6	47.116E-6	58.770E-6 59479. 0 (Negligible)		2	4.1824	2.7676	None	210.93E-6	-773.74E-6	
197.88E-6	19.287E-6	58.770E-6 117890. 0 (Negligible)		1	0.0	5.5926	None	0.0013354	236.15E-6	
0.0015124	37.670E-6	-140.25E-6 45458. 0 (Negligible)		2	5.5926	4.3574	None	0.0011163	-0.0078301	
0.0016792	100.85E-6	-140.25E-6 29268. 0 (Negligible)		1	0.0	3.4140	None	267.05E-6	0.035648	
0.035815	-455.01E-6	-303.27E-6 47793. 0 (Negligible)		2	3.4140	0.65771	None	7.3517E-6	0.041447	
0.041448	-418.27E-6	-303.27E-6 183030. 0 (Negligible)		3	4.0717	2.8783	None	0.0055255	-0.034586	
0.0075953	0.0017093	-530.64E-6 2964.6 0 (Negligible)		1	0.0	2.8895	None	0.0021575	0.039083	
0.040243	-390.68E-6	374.41E-6 7856.6 0 (Negligible)		2	2.8895	2.5397	None	191.02E-6	0.039003	
0.039094	-390.68E-6	296.20E-6 300770. 0 (Negligible)		3	5.4292	4.5208	None	0.0012473	0.019368	
0.020370	-386.20E-6	296.20E-6 23205. 0 (Negligible)		1	0.0	3.9500	None	60.941E-6	0.0	
74.065E-6	0.0	5.7948E-6 672930. 0 (Negligible)		1	0.0	1.6144	None	0.0011092	0.049006	
0.049668	-832.64E-6	-458.90E-6 11202. 0 (Negligible)		2	1.6144	0.33562	None	0.0	0.083333	
0.083333	-832.64E-6	-458.52E-6 53876. 2 (Slight)		1	0.0	2.1910	None	131.54E-6	0.012207	
0.012310	-122.61E-6	-214.07E-6 206170. 0 (Negligible)		1	0.0	1.9000	None	260.25E-6	0.0	
246.01E-6	0.0	38.832E-6 90338. 0 (Negligible)		1	0.0	6.2641	None	0.0035715	0.0086774	
0.012395	-155.45E-6	-305.08E-6 18946. 0 (Negligible)		2	6.2641	3.6859	None	0.0021074	-0.010585	



GEOTECHNICAL AND ENVIRONMENTAL ASSOCIATES LTD

139 Cranley Gardens

GMA

Stage 3 - Installation & Excavation to Pool Level

Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Stage: Max Ref.	Stage: Max Gradient	Name Specific Building: Max Gradient	Specific Building: Min	Building: Name Damage Category	Sub-building Name	Vertical Offset from Line for	Segment	Start	Length	Curvature	Deflection	Average Ratio Horizontal
0.0024241	167.61E-6	of 10	-305.08E-6	14165. 0 (Negligible)	Cranley Gardens Rear Eleavtion	0.0	1	0.0	1.0778	None	56.801E-6	0.010355
0.010367	-129.92E-6	of 12	392.01E-6	70657. 0 (Negligible)	Cranley Gardens Frontage	0.0	1	0.0	3.9800	None	177.77E-6	-772.11E-6
0.024610	-258.23E-6	of 11	392.01E-6	15409. 0 (Negligible)	Cranley Gardens Far Elevation	0.0	1	0.0	3.9800	None	177.77E-6	-772.11E-6
183.64E-6	24.476E-6	of 12	37.775E-6	217600. 0 (Negligible)	Cranley Gardens Frontage	0.0	1	4.9643	1.9847	None	207.37E-6	0.0021392
0.0022170	-44.047E-6	of 13	-45.552E-6	107580. 0 (Negligible)	Cranley Gardens Extension	0.0	1	0.0	0.99187	None	1.1062E-6	-0.0047401
948.04E-6	133.97E-6	of 13	-210.86E-6	225200. 0 (Negligible)	Cranley Gardens Extension	0.0	2	0.99187	2.9581	None	0.013782	-0.021220
0.0096893	280.68E-6	of 14	412.20E-6	1279.6 0 (Negligible)	Cranley Gardens Extension	0.0	1	0.0	0.36604	None	0.0	0.055833
0.055833	-558.02E-6	of 14	527.54E-6	122670. 1 (Very Slight)	Cranley Gardens Extension	0.0	2	0.36604	6.5830	None	0.0051287	0.038874
0.046537	-558.02E-6	of 15	527.54E-6	12701. 0 (Negligible)	Cranley Gardens Extension	0.0	1	0.0	3.9000	None	361.89E-6	-0.0029871
620.88E-6	35.702E-6	of 16	34.873E-6	88997. 0 (Negligible)	Cranley Gardens Outbuilding	0.0	1	0.0	0.56679	None	0.0	0.016750
0.016750	-167.47E-6	of 16	-159.96E-6	1031.7 0 (Negligible)	Cranley Gardens Outbuilding	0.0	2	0.56679	1.9433	None	0.063321	0.0010253
0.060121	632.61E-6	of 17	0.0029486	1227.1 1 (Very Slight)	Cranley Gardens Outbuilding	0.0	3	2.5101	1.8300	None	0.057392	-0.015887
0.048941	632.61E-6	of 17	0.0029486	1414.9 0 (Negligible)	Cranley Gardens Outbuilding	0.0	4	4.3402	0.60985	None	0.0	0.0
35.763E-9	0.0	of 17	29.827E-6	973.14 0 (Negligible)	Cranley Gardens Outbuilding	0.0	1	0.0	1.1886	None	0.0013776	0.055308
0.055924	-582.99E-6	of 17	459.92E-6	5949.0 1 (Very Slight)	Cranley Gardens Outbuilding	0.0	2	1.1886	0.77802	None	0.0	0.040819
0.040819	-408.03E-6	of 18	459.92E-6	9087.6 0 (Negligible)	Cranley Gardens Outbuilding	0.0	1	1.9800	1.9685	None	67.868E-6	-889.60E-6
181.71E-6	21.098E-6	of 18	-0.0025836	1517.7 0 (Negligible)	Cranley Gardens Outbuilding	0.0	2	3.9485	1.0005	None	10.304E-6	0.0018281
0.0018320	-18.452E-6	of 19	13.288E-6	91690. 0 (Negligible)	Cranley Gardens Outbuilding	0.0	1	0.0	0.040757	None	0.0	0.060272
0.060272	-602.36E-6	of 19	-387.51E-6	1.5873E+6 1 (Very Slight)	Cranley Gardens Outbuilding	0.0	2	0.040757	2.9082	None	891.30E-6	0.058307
0.059185	-602.36E-6	of 19	-387.51E-6	22239. 1 (Very Slight)	Cranley Gardens Outbuilding	0.0	2	0.040757	2.9082	None	891.30E-6	0.058307

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.



GEOTECHNICAL AND ENVIRONMENTAL ASSOCIATES LTD

139 Cranley Gardens

GMA

Stage 3 - Installation & Excavation to Pool Level

Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Specific Building Damage Results - All Combined Segments

Stage: Name	Specific Building: Name	Sub-building	Vertical	Combined	Start	Length	Curvature	Deflection	Average	Max		
Damage Category	Building: Ref.	Name	Offset from Line for Vertical Movement Calculations [m]	Segment	[m]	[m]		Ratio [%]	Horizontal Strain [%]	Tensile Strain [%]		
0 (Negligible)	Base Model 1	No 137 Cranley Gardens	Frontage	0.0	1	0.0	6.9500	None	431.83E-6	-0.0026183	564.80E-6	0
(Negligible)	2	No 137 Cranley Gardens	Far Elevation	0.0	1	0.0	9.9500	None	872.25E-6	-0.0032963	755.49E-6	0
(Negligible)	3	No 137 Cranley Gardens	Rear Elevation	0.0	1	0.0	6.9500	None	0.0029028	0.0071097	0.010360	0
(Negligible)	4	No 137 Cranley Gardens	Party Wall	0.0	1	0.0	9.9500	None	0.0010209	0.030105	0.031504	0
(Very Slight)	5	No 137 Cranley Gardens	Extension	0.0	No combined segments for this stage, specific building and offset.							
	6	No 137 Cranley Gardens	Extension	0.0	1	0.0	1.9500	None	0.0010257	0.054915	0.055640	1
	7	No 137 Cranley Gardens	Extension	0.0	No combined segments for this stage, specific building and offset.							
	8	No 137 Cranley Gardens	Extension	0.0	No combined segments for this stage, specific building and offset.							
(Negligible)	9	No 141 Cranley Gardens	Near Elevation	0.0	1	0.0	9.9500	None	0.0028190	0.0015416	0.0054037	0
(Negligible)	10	No 141 Cranley Gardens	Rear Eleavtion	0.0	1	0.0	6.9490	None	0.0040396	0.019045	0.023568	0
	11	No 141 Cranley Gardens	Far Elevation	0.0	No combined segments for this stage, specific building and offset.							
	12	No 141 Cranley Gardens	Frontage	0.0	No combined segments for this stage, specific building and offset.							
(Negligible)	13	No 141 Cranley Gardens	Extension	0.0	1	0.0	3.9500	None	0.011596	-0.017082	0.0077948	0
(Negligible)	14	No 141 Cranley Gardens	Extension	0.0	1	0.0	6.9490	None	0.0051546	0.039767	0.047534	0
	15	No 141 Cranley Gardens	Extension	0.0	No combined segments for this stage, specific building and offset.							
	16	No 141 Cranley Gardens	Outbuilding	0.0	1	0.0	4.9500	None	0.027358	-0.0035530	0.033846	0
(Very Slight)	17	No 141 Cranley Gardens	Outbuilding	0.0	1	0.0	1.9667	None	0.0024000	0.049576	0.051286	1
(Negligible)	18	No 141 Cranley Gardens	Outbuilding	0.0	1	1.9800	2.9690	None	234.15E-6	26.176E-6	260.46E-6	0
(Very Slight)	19	No 141 Cranley Gardens	Outbuilding	0.0	1	0.0	2.9490	None	892.29E-6	0.058334	0.059222	1

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.



GEOTECHNICAL AND ENVIRONMENTAL ASSOCIATES LTD

139 Cranley Gardens
GMA
Total

Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Specific Building Damage Results - Detail

Stage:	Stage: Name	Specific	Specific Building: Name	Sub-building	Vertical Offset	Segment	Start	Length	Curvature	Deflection	Average
Max	Max Gradient	Max Gradient	Min	Damage Category							
Ref.	Building:	Building:	Ref.	Name	from Line for					Ratio	Horizontal
Tensile	of	of Vertical	Radius of		Vertical						Strain
Strain	Horizontal	Displacement	Curvature		Movement						
Displacement	Curve				Calculations						
Curve											
[%]		[m]			[m]		[m]	[m]		[%]	[%]
0	Base Model 1	No 137	Cranley Gardens	Frontage	0.0	1	0.0	4.1409	None	543.83E-6	-0.0038581
826.87E-6	47.116E-6	57.715E-6	60190.0	(Negligible)		2	4.1409	2.8091	None	216.75E-6	-790.82E-6
202.60E-6	19.287E-6	57.715E-6	115880.0	(Negligible)		1	0.0	5.4474	None	0.0012625	342.88E-6
0.0015250	37.670E-6	-131.98E-6	47166.0	(Negligible)	0.0	2	5.4474	4.5026	None	0.0012090	-0.0076990
0.0016732	100.85E-6	-131.98E-6	27869.0	(Negligible)		1	0.0	6.9500	None	0.0078762	0.0071097
0.015930	0.0017093	-941.71E-6	1266.10	(Negligible)	0.0	1	0.0	4.0072	None	0.0060018	0.039083
0.043429	-390.68E-6	609.51E-6	2561.70	(Negligible)		2	4.0072	1.4087	None	322.14E-6	0.038943
0.039029	-390.68E-6	288.98E-6	342570.0	(Negligible)		3	5.4159	4.5341	None	0.0012155	0.019424
0.020404	-386.20E-6	288.98E-6	23535.0	(Negligible)		1	0.0	3.9500	None	85.028E-6	0.0
103.32E-6	0.0	23.192E-6	354580.0	(Negligible)	0.0	1	0.0	1.4342	None	983.98E-6	0.044694
0.045219	-832.64E-6	-420.63E-6	12258.0	(Negligible)		2	1.4342	0.51581	None	0.0	0.083333
0.083333	-832.64E-6	-413.57E-6	34078.2	(Slight)	0.0	1	0.0	2.1910	None	356.63E-6	0.012207
0.012486	-122.61E-6	-233.52E-6	76044.0	(Negligible)	0.0	1	0.0	1.9000	None	95.430E-6	0.0
90.230E-6	0.0	-5.1929E-6	246360.0	(Negligible)	0.0	1	0.0	6.2367	None	0.0035148	0.0087261
0.012373	-155.45E-6	-298.18E-6	19180.0	(Negligible)		2	6.2367	3.7133	None	0.0021419	-0.010525
0.0024233	167.61E-6	-298.18E-6	14122.0	(Negligible)	0.0	1	0.0	1.1416	None	102.77E-6	0.010502
0.010525	-129.92E-6	382.55E-6	64872.0	(Negligible)		2	1.1416	5.8074	None	0.0039089	0.020724



GEOTECHNICAL AND ENVIRONMENTAL ASSOCIATES LTD

139 Cranley Gardens

GMA

Total

Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
Made by MP	Date 11-Jul-2023	Checked Date

Stage:	Stage:	Name	Specific	Specific	Building:	Name	Sub-building	Vertical	Offset	Segment	Start	Length	Curvature	Deflection	Average
Max	Max	Gradient	Max	Gradient	Min	Damage	Category								
Ref.	Building:		Name		Name		from Line for		Ratio		Horizontal				
Tensile	of	of	Vertical	Radius	of										
0.024570	-258.23E-6	382.55E-6	15611. 0	(Negligible)											
	11	No 141	Cranley Gardens	Far Elevation			0.0	1	0.0	2.9850	None	107.35E-6	-0.0013745		
281.42E-6	24.476E-6	36.199E-6	213360. 0	(Negligible)											
	12	No 141	Cranley Gardens	Frontage			0.0	1	5.9571	0.99186	None	0.0	0.0013754		
0.0013754	-29.021E-6	-43.936E-6	107010. 0	(Negligible)											
	13	No 141	Cranley Gardens	Extension			0.0	1	0.0	1.0010	None	4.8900E-6	-0.0048192		
963.84E-6	133.97E-6	-203.84E-6	187930. 0	(Negligible)											
								2	1.0010	2.9490	None	0.013650	-0.021244		
0.0096044	280.68E-6	413.06E-6	1286.6 0	(Negligible)											
	14	No 141	Cranley Gardens	Extension			0.0	1	0.0	0.54207	None	0.0	0.055833		
0.055833	-558.02E-6	509.58E-6	81111. 1	(Very Slight)											
								2	0.54207	6.4069	None	0.0049543	0.038408		
0.045772	-558.02E-6	510.61E-6	12870. 0	(Negligible)											
	15	No 141	Cranley Gardens	Extension			0.0	1	0.0	3.9000	None	337.91E-6	-0.0029871		
617.87E-6	35.702E-6	33.635E-6	93944. 0	(Negligible)											
	16	No 141	Cranley Gardens	Outbuilding			0.0	1	0.0	0.67091	None	0.0	0.016750		
0.016750	-167.47E-6	-220.86E-6	1082.8 0	(Negligible)											
								2	0.67091	1.7368	None	0.044111	0.0038696		
0.043689	632.61E-6	0.0019976	2163.1 0	(Negligible)											
								3	2.4077	1.6032	None	0.063526	-0.022173		
0.053578	632.61E-6	0.0019976	1651.4 1	(Very Slight)											
								4	4.0109	0.93908	None	0.0	0.0		
35.763E-9	0.0	-23.687E-6	569.19 0	(Negligible)											
	17	No 141	Cranley Gardens	Outbuilding			0.0	1	0.0	1.9667	None	0.015768	0.049576		
0.060807	-582.99E-6	0.0013253	1366.8 1	(Very Slight)											
	18	No 141	Cranley Gardens	Outbuilding			0.0	1	1.9800	1.9561	None	215.36E-6	-897.48E-6		
216.47E-6	21.098E-6	-0.0025485	1516.5 0	(Negligible)											
								2	3.9361	1.0129	None	41.939E-6	0.0018098		
0.0018259	-18.452E-6	43.224E-6	47767. 0	(Negligible)											
	19	No 141	Cranley Gardens	Outbuilding			0.0	1	0.0	2.9490	None	0.0012535	0.058334		
0.059582	-602.36E-6	-373.43E-6	17011. 1	(Very Slight)											
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GEOTECHNICAL AND ENVIRONMENTAL ASSOCIATES LTD

139 Cranley Gardens
GMA
Total

Job No.	Sheet No.	Rev.
J23175		
Drg. Ref.		
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Specific Building Damage Results - All Combined Segments

Stage: Name	Specific Building: Name	Sub-building	Vertical	Combined	Start	Length	Curvature	Deflection	Average	Max
Damage Category	Building: Ref.	Name	Offset from Line for Vertical Movement Calculations [m]	Segment		[m]		Ratio [%]	Horizontal Strain [%]	Tensile Strain [%]
0 (Negligible)	Base Model 1	No 137 Cranley Gardens Frontage	0.0	1	0.0	6.9500	None	417.89E-6	-0.0026183	562.23E-6 0
(Negligible)	2	No 137 Cranley Gardens Far Elevation	0.0	1	0.0	9.9500	None	764.86E-6	-0.0032963	733.67E-6 0
(Negligible)	3	No 137 Cranley Gardens Rear Elevation	0.0	No combined segments for this stage, specific building and offset.						
(Negligible)	4	No 137 Cranley Gardens Party Wall	0.0	1	0.0	9.9500	None	0.0030585	0.030105	0.034295 0
(Very Slight)	5	No 137 Cranley Gardens Extension	0.0	No combined segments for this stage, specific building and offset.						
	6	No 137 Cranley Gardens Extension	0.0	1	0.0	1.9500	None	832.96E-6	0.054915	0.055503 1
	7	No 137 Cranley Gardens Extension	0.0	No combined segments for this stage, specific building and offset.						
	8	No 137 Cranley Gardens Extension	0.0	No combined segments for this stage, specific building and offset.						
(Negligible)	9	No 141 Cranley Gardens Near Elevation	0.0	1	0.0	9.9500	None	0.0027586	0.0015416	0.0053211 0
(Negligible)	10	No 141 Cranley Gardens Rear Eleavtion	0.0	1	0.0	6.9490	None	0.0039554	0.019045	0.023474 0
	11	No 141 Cranley Gardens Far Elevation	0.0	No combined segments for this stage, specific building and offset.						
	12	No 141 Cranley Gardens Frontage	0.0	No combined segments for this stage, specific building and offset.						
(Negligible)	13	No 141 Cranley Gardens Extension	0.0	1	0.0	3.9500	None	0.011488	-0.017082	0.0077254 0
(Negligible)	14	No 141 Cranley Gardens Extension	0.0	1	0.0	6.9490	None	0.0049881	0.039767	0.047283 0
	15	No 141 Cranley Gardens Extension	0.0	No combined segments for this stage, specific building and offset.						
(Negligible)	16	No 141 Cranley Gardens Outbuilding	0.0	1	0.0	4.9500	None	0.020389	-0.0035530	0.024320 0
	17	No 141 Cranley Gardens Outbuilding	0.0	No combined segments for this stage, specific building and offset.						
(Negligible)	18	No 141 Cranley Gardens Outbuilding	0.0	1	1.9800	2.9690	None	502.34E-6	26.176E-6	528.82E-6 0
	19	No 141 Cranley Gardens Outbuilding	0.0	No combined segments for this stage, specific building and offset.						

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.



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