



Firethorn Developments Limited

Gateway 36 Development Site – Phase 3

External Yard Settlement Monitoring Validation

323064-R02 (00)

RSK GENERAL NOTES

Project No.: 323064-R02 (00)

Title: External Yard Settlement Monitoring Validation: Gateway 36 Development Site – Phase 3

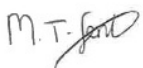
Client: Firethorn Developments Limited

Date: April 2023

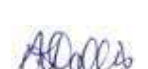
Office: RSK Environment Limited, Spring Lodge, 172 Chester Road, Helsby, Cheshire, WA6 0AR. Contact: Siôn Roberts, Tel: 01928 726006.

Status: Rev 00

Author Matthew Fenton **Technical reviewer** Gary McGuicken

Signature  Signature 

Project manager Siôn Roberts **Quality reviewer** Ang Wallis

Signature  Signature 

Revision control sheet				
Revision ref.	Date	Reason for revision	Amended by:	Approved by:
Rev 00	14/04/2023	First issue	n/a	see above

RSK Environment Limited (RSK) has prepared this report for the sole use of the client, showing reasonable skill and care, for the intended purposes as stated in the agreement under which this work was completed. The report may not be relied upon by any other party without the express agreement of the client and RSK. No other warranty, expressed or implied, is made as to the professional advice included in this report.

Where any data supplied by the client or from other sources have been used, it has been assumed that the information is correct. No responsibility can be accepted by RSK for inaccuracies in the data supplied by any other party. The conclusions and recommendations in this report are based on the assumption that all relevant information has been supplied by those bodies from whom it was requested.

No part of this report may be copied or duplicated without the express permission of RSK and the party for whom it was prepared.

Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

This work has been undertaken in accordance with the quality management system of RSK Environment Ltd.

CONTENTS

1	INTRODUCTION.....	1
1.1	Commissioning	1
1.2	Definition of roles	1
1.3	Proposed development.....	1
1.4	Background	1
1.5	Scope of works	2
1.6	Previous reports	2
2	SITE DETAILS	3
2.1	Site description	3
3	WORKS UNDERTAKEN	4
3.1	Chronology.....	4
3.2	Installation of monitoring infrastructure.....	4
3.2.1	Site supervision.....	4
3.2.2	Monitoring rods	4
3.3	Settlement monitoring	5
3.3.1	Monitoring methodology.....	5
3.4	Engineering fill placement.....	6
4	MONITORING RESULTS	7
4.1	External yard settlement data	7
5	CONCLUSIONS.....	9

FIGURES

Figure 1	Site location plan
Figure 2	Proposed development layout
Figure 3	Settlement monitoring infrastructure location

APPENDICES

Appendix A	Service constraints
Appendix B	RSK external yard monitoring specification
Appendix C	Photographic log
Appendix D	Monitoring rod settlement results

1 INTRODUCTION

1.1 Commissioning

RSK Environment Limited (RSK) was commissioned by Firethorn Developments Limited (Firethorn, the Client, who are the site owners) to prepare this settlement monitoring validation of external yard areas for the Gateway 36 Phase 3 development site, near Barnsley. The project was carried out to an agreed brief as set out in RSK's proposal 323064TL01(00) dated 1 August 2022.

This report is subject to the RSK service constraints in Appendix A.

1.2 Definition of roles

Firethorn Developments Limited – is the Client for the works and site owner.

Quartz Project Services – is the project manager for the development appointed by the Client.

Core Special Projects Limited – The Contractor was required to supply, install, and protect the settlement monitoring infrastructure as outlined in the specification (323064-R01 (00), External Yard Monitoring Specification Report, dated 16 August 2022) for the works undertaken in the External Yard Area.

RSK Environment Limited – is the geotechnical and environmental consultant and are responsible for preparing the External Yard Monitoring specification for monitoring and validating settlement of the original ground level beneath the external yard area and for producing validation of the works (this report).

1.3 Proposed development

It is understood that the site is being redeveloped for commercial end-use, including a large single warehouse building with supporting offices and external yard areas.

1.4 Background

Historically, the site was subject to deep underground mining (Rockingham Colliery from pre-1893 to 1980) and was used for opencast coal mining (RJB Mining 1991 to 1997). The materials used to backfill the opencast voids include re-worked superficial soils and re-worked Pennine Middle Coal Measures moved locally to minimise haulage. This backfill material is recorded as being placed in an uncontrolled manner and restoration of the wider site was completed by 2002.

The Phase 3 area is proposed for commercial development with associated infrastructure. In order to provide the required development platform significant earthworks were required to regrade site levels, generally cutting levels by several metres to the south and raising levels to the north in external yard areas. RSK prepared a ground treatment specification for surcharging the building footprint (which was generally in an area of cut) and a 5.00m perimeter buffer, which has been completed and reported separately (RSK report 325389-R06 (00), dated November 2022). Within the external yard area to the north of the

building footprint, ground levels had to be raised to achieve final levels, which would induce settlement of the original ground level surface.

This validation report provides settlement monitoring data of the original ground level following placement of engineered fill to final levels.

1.5 Scope of works

RSK carried out a geotechnical settlement assessment based at the time of levels being raised in external yard areas by up to 5.50m (RSK letter report 325389-PL03 (00), dated October 2021). This confirmed that raising levels to this extent would be expected to induce significant settlement (of the order of 123mm). Based on previous settlement monitoring data from a plot-specific load test (5.00m height), and from 5.00m surcharge ground treatment over similar ground conditions on the adjacent Phase 2 development, the majority of load-induced settlement from raising levels would be expected to occur during or shortly after final levels had been achieved. It was recommended that once final levels had been achieved in the external yard area, the final landform should be left for a minimum of 3 months (and monitoring continued to demonstrate settlement is substantially complete) prior to construction of roads and infrastructure.

RSK prepared a settlement monitoring specification for the external yard areas (RSK report 323064-R01(00), dated August 2022. See Appendix B) which detailed the installation and monitoring requirements of settlement monitoring rods at original ground level prior to placement and compaction of engineered fill. The specification allowed for the installation of permanent ground markers (PGMs) at the finished level surface to monitor any potential self-weight settlement of the engineered fill. At the time, RSK were asked to prepare a tender for an earthworks specification for the placement and compaction of engineered fill, but were not instructed to complete. The placement and compaction of engineered fill was undertaken by the Contractor to a earthworks specification prepared by others, and as such RSK did not install PGMs on the final level surface.

1.6 Previous reports

The following reports should be read in conjunction with this validation report:

- 1) 322638-R02 (00), J36 Rockingham – Phase 2 Geo-environmental and Geotechnical site investigation, dated 21 May 2020
- 2) 325389PL03, Phase 3 Advice Note on ground Settlement of External Yard Areas, dated 27 October 2021
- 3) 323064-R01 (00), External Yard Monitoring Specification Report, dated 16 August 2022.

2 SITE DETAILS

2.1 Site description

The centre of the site is located at National Grid reference 435403 401141 and is shown in Figure 1. The site is being developed for commercial use with associated infrastructure, including a large single warehouse building with supporting offices and external yard areas. The proposed layout of the site is presented in Figure 2.

The site covers an area of approximately 10.5 hectares. Prior to the earthworks and ground treatment of the building footprint which started in July 2021, the site was generally occupied by grass land and woodland, with a public footpath crossing the site from the south-west to the north-east. At that time ground levels fell across the site by 10.00m to 15.00m from south to north.

Access onto the site is from the recently constructed estate road leading off the Dearne Valley Parkway roundabout.

Historical mapping indicates a legacy of mining operations at the site with extensive opencast (surface) mining in the 1990s. The backfilling of this was largely completed by 1997 with final restoration completed by 2002. Along the corridor of the Dearne Valley Parkway the opencast backfill was placed as engineered fill, but in the surrounding areas, including Phase 3, the backfill materials are understood to have been placed as a non-engineered fill.

Previous ground investigations by RSK in 2015 and 2019 have confirmed the presence of a variable thickness of opencast backfill across the Phase 3 area, ranging from approximately 20.00m in the west and 50.00m in the east.

3 WORKS UNDERTAKEN

3.1 Chronology

Placement and compaction of the engineered fill was undertaken by the Contractor to an earthworks specification prepared by others. Levels in the external yard area were then raised to achieve final platform levels by the placement and compaction of engineered fill. Prior to raising levels, RSK prepared the specification (323064-R01 (00)) to monitor the settlement of the original ground level.

In the external yard area, the works required for the settlement monitoring included the installation of the monitoring rods and obtaining baseline levels; the placement of the engineered fill by the contractor during which time periodic surveying of the monitoring infrastructure took place; and settlement monitoring upon completion of filling. These are summarised in chronological order in Table 1 below.

Table 1: Chronology of works

Site activity undertaken	Commencement date	Completed date
Installation of monitoring rods	18/08/2022	22/08/2022
Baseline control station installation and baseline readings	19/08/2022	22/08/2022
Engineered fill placement	22/08/2022	23/09/2022
Settlement measurement during upfill	22/08/2022	20/09/2022
Settlement measuring post-upfill	26/09/2022	17/01/2023

A photographic log is presented in Appendix C.

3.2 Installation of monitoring infrastructure

3.2.1 Site supervision

An RSK engineer supervised installation of the settlement monitoring rods and preparation of the surface by removing vegetation and any underlying soft or organic materials, and levelling of the surface prior to placement of the settlement monitoring rods.

3.2.2 Monitoring rods

The monitoring infrastructure included a total of eight settlement monitoring plates/rods (the Rod Settlement System GEO-XR produced by Geosense was agreed with the Contractor in advance and details were included in the RSK Specification Report 323064-R01 (00) which is included in Appendix B of the report), referenced MP1 to MP8. The installation of these rods was completed by Core Special Projects Limited under RSK supervision and was completed by 22 August 2022. These were placed in the proposed External Yard area and the locations are presented in Figure 3.

The monitoring rod baseplates were seated within a shallow excavation after removal of any surface vegetation or unsuitable (soft or loose) materials and were concreted into place while ensuring the rod was vertical (based on spirit level measurements). Extensions rods were also supplied and were added as required to ensure the top of the rod protruded above formation level during and after upfilling. The rods were encased in the provided sleeves as they were installed. For each baseplate and as each extension was added, RSK engineers precisely levelled the elevation of each monitoring rod.

RSK established a stable off-site survey control station to establish a baseline elevation of each installed rod, with ground-level changes monitored alongside settlement monitoring.

Monitoring pins (MPs) MP2 and MP3 were installed so the baseplate was in contact with the pre-existing ground level of the area before placement of the surcharge (this required the two baseplates to be installed within excavated pits). MP8 was found to be broken on 1 September 2022 and was replaced on 12 September 2022 and re-surveyed. MP4 was unable to be monitored from 14 November 2022 as initially it was covered by standing water and then was damaged from 30 November 2022. As a result, no further readings were able to be taken at MP4 from this date.

The results of the monitoring are discussed in Section 4.1.

3.3 Settlement monitoring

The monitoring rods were measured relative to a baseline taken from an established stable control location prior to upfilling. Settlement monitoring for the MP infrastructure was conducted at regular intervals during and post placement of the required engineered fill. Measurements were taken weekly from all the monitoring rod locations, both during upfilling and post-completion except for MP4, which was damaged on 14 November 2022 and removed.

Due to ground conditions and localised standing water, it wasn't always possible to monitor each monitoring rod every week. Three of the monitoring locations had frequent surface water flooding which denied access to the monitoring rods. MP8 was damaged on 01 September 2022 and repaired on 12 September 2022 when monitoring resumed and continued for the full monitoring period thereafter.

MP5 was damaged on 12 September 2022 and replaced as MP5A on 20 September 2022, allowing continued monitoring of relative settlement. MP7 was disturbed in early November due to site activities, and was subsequently replaced as MP7A. As a result of this disturbance, the data for MP7 and MP7A will be presented but not included in the reporting.

Precise levelling of the monitoring rods was undertaken using a Leica Sprinter 250M Digital Level with an accuracy of 1mm (standard deviation height measurement per 1km distance levelled) using an established off-site stable control, and was levelled by a surveyor and assistant from Central Alliance (an RSK company).

3.3.1 Monitoring methodology

Baseline readings were taken for each monitoring pin at the time of installation and readings are taken relative to the null baseline elevation. For each pin, elevation readings

were then taken and amended for the difference due to any extensions added to the top of the rod. Ground level readings were also measured adjacent to each pin relative to the baseline ground level at the survey control station.

Monitoring pins were precise levelled generally weekly throughout the works, with both the pin reading and pin ground level reading recorded at each location for each monitoring round.

3.4 Engineering fill placement

The formation construction began 22 August 2022 and was completed on 23 September 2022.

Placement and compaction of engineered fill was undertaken by CORE SP to an earthworks specification prepared by others, and RSK had no involvement with the supervision or validation of these works.

As per the geotechnical report produced by RSK (reference 325389PL03, dated October 2021), the building footprint was generally within an area of cut and levels in the external yard area would need to be raised by approximately 5.00m based on modelling to induce sufficient settlement. However, the thickness of engineered fill was up to 8.00m at the northern end of the external yard area where there were areas of locally deeper cut, with fill thickness reducing southwards and towards the east in areas to be built upon.

At the onset of the works, it was agreed that the fill was to remain in place for a minimum of 12 weeks post-completion of final levels to allow monitoring to be completed to demonstrate that settlement is substantially complete.

4 MONITORING RESULTS

4.1 External yard settlement data

Settlement was recorded during and post placement of the engineered fill. Settlement monitoring results were collected from the start of the works on 22 August 2022 until 17 January 2023. The total monitoring period represents a 148-day period, with 116 days post completion of the engineered fill (completed 23 September 2022).

As MP2 and MP3 were installed in excavated pits to reach the pre-existing ground level, these are discussed separately from the main data set as the ground will have been pre-loaded.

The recorded settlement monitoring results (excluding MP2, MP3, and MP7) for the total monitoring period ranged from -137mm to -172mm, with an average final settlement of -156mm.

Measured settlement indicates that 36 percent of the average total recorded settlement (-156mm) had occurred by 23 September 2022, when the placement of the engineered fill was completed. The average settlement recorded from 19 December 2022 to the final monitoring round on 17 January 2023, representing 29 days, increased from -146 to -156mm, indicating negligible ongoing settlement.

The final recorded settlement was generally as expected, showing greater settlement in areas where a greater thickness of fill was placed. In areas where fill was greater (up to 8m), we recorded final settlement values up to -172mm at MP1.

A summary of settlement data is presented in Table 2 below, excluding MP2, MP3, and MP7.

Table 2: Settlement data summary

Monitoring Rod	Final fill thickness (m)	Total observed settlement (mm)	Monitoring Period (days)
1	6.1	-172	148
4*	5.6	-144	56
5	3.8	-61	25
5A**	7.2	-153	119
6	8.0	-137	148
7	6.5	-207	84
7A**	6.5	-258	64
8	5.7	-161	148
Notes: * MP4 was broken on 17 October 2022 so the above data represents settlement until that date. ** MP5 was Damaged on 12 September 2022 and replaced by 20 September 2022. Data measured after this date was recorded as relative settlement monitoring rod 5A. *** MP7 had suspected possible movement of the sensor which led to a sudden change in data values on 14 November 2022 and so the data recorded following this was recorded as relative settlement monitoring rod MP7A.			

The recorded settlement results for MP2 and MP3 for the total monitoring period were -89mm and -71mm respectively, with an average final settlement of 80mm. These are lower than expected due to the original ground level being preloaded prior to placement of the monitoring pins at the reduced level.

A summary of MP2 and MP3 settlement data is shown in Table 3.

Table 3: MP2 and MP3 settlement data summary

Monitoring Rod	Final fill thickness (m)	Total observed settlement (mm)	Monitoring Period (days)
2	3.1	-89	148
3	2.8	-71	148

The results of the monitoring are presented in both tabular and graphical form within Appendix D, which includes ground level change data monitored alongside settlement.

5 CONCLUSIONS

RSK have previously completed site investigation and assessment work at the Gateway 36 Phase 3 development site, including borehole and trial pit investigations. A large-scale settlement load test was also historically completed by RSK, which demonstrated that significant settlement could be induced by construction loads and that ground improvement works were required to improve the engineering properties of the opencast backfill.

Following a detailed geotechnical analysis undertaken by RSK (reference 325389PL03, dated 27 October 2021), ground treatment works were designed, and the modelling indicated that 123mm of settlement could be expected over 12 weeks where levels are to be raised by 5m.

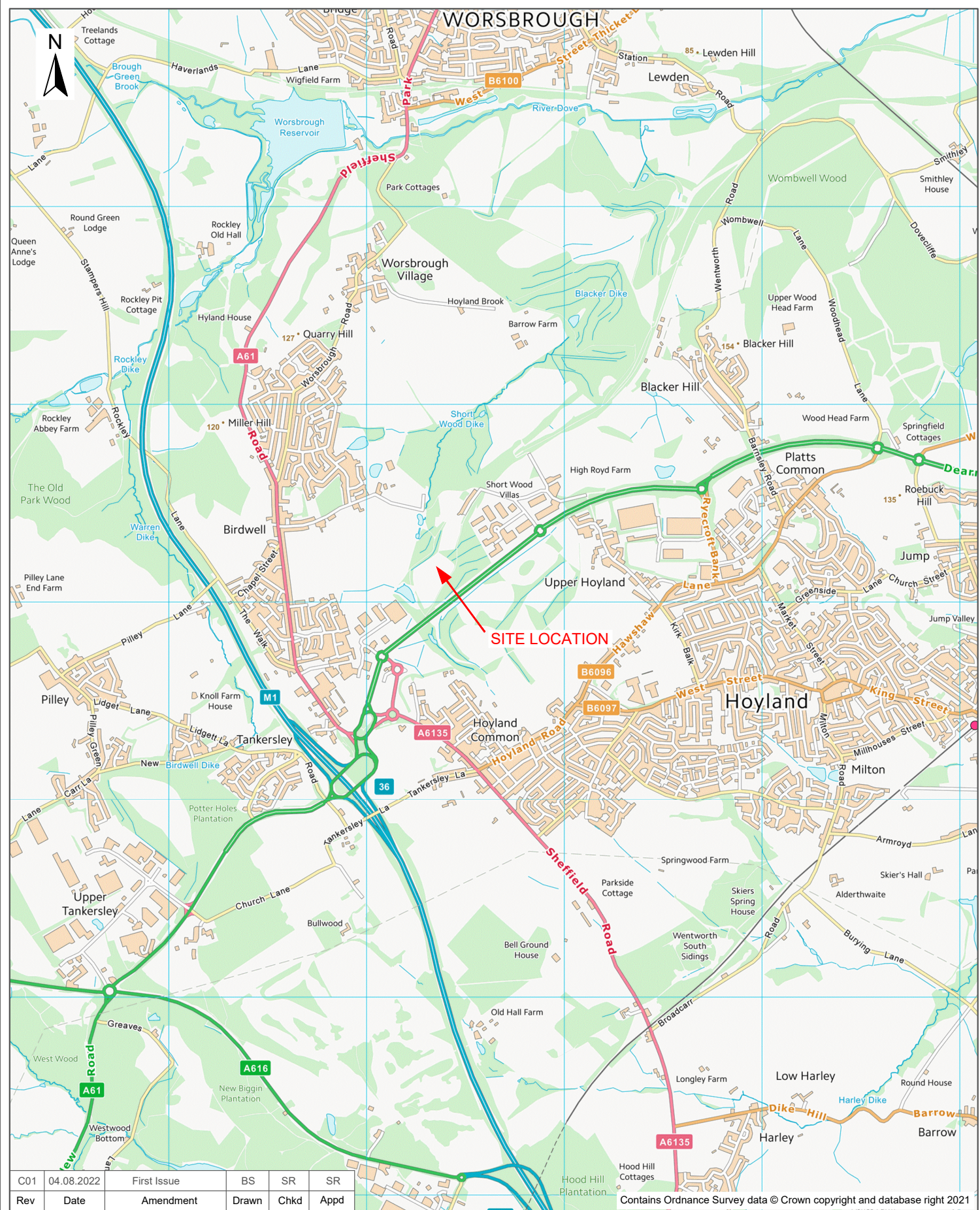
Engineering fill was placed to produce the final landform and final levels in the external yard area between 22 August 2022 and 23 September 2022. Settlement of the original ground surface was monitored during placement of the engineered fill and for sixteen weeks post-completion of the earthworks using Geo-Sense Monitoring Rods that were installed prior to placement of the engineered fill, and then precisely levelled relative to a stable off-site control.

Settlement monitoring data confirmed that recorded settlement was as expected where levels were raised up to 5.00m, greater settlement was recorded where levels were raised above 5.00m, and that the required settlement has been induced and construction can commence. The potential for limited post construction settlement should be allowed for – a higher residual settlement tolerance for the external areas and an increased maximum differential settlement would typically be adopted for such external and road areas.

FIGURES



FIGURE 1 SITE LOCATION PLAN



C01	04.08.2022	First Issue	BS	SR	SR
Rev	Date	Amendment	Drawn	Chkd	Appd

Contains Ordnance Survey data © Crown copyright and database right 2021

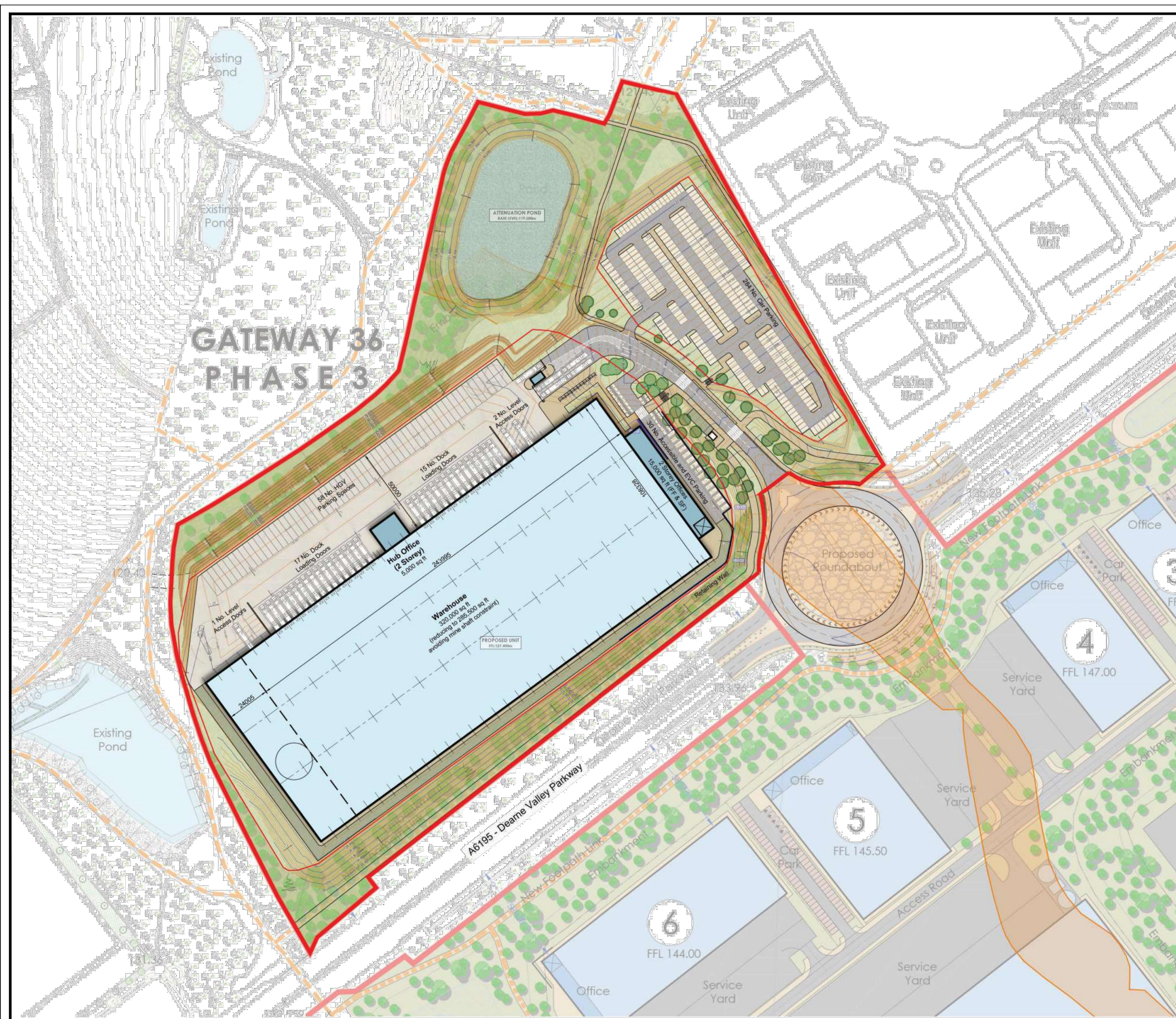


Spring Lodge
172 Chester Road
Helsby
WA6 0AR

Tel: +44(0)1794 329276
Email: info@rsk.co.uk
Web: www.rsk.co.uk

Client		Firethorn Developments Limited			
Project Name		Gateway 36 Phase 3 - External Yard Settlement Monitoring			
Description		Site Location Plan			
Dimension	Size	Scale	Geolocation	Project ID	Drawing no.
m	A4	1:25,000	435344,401181	323064	11101
Rev	File name				
C01	323064-HE-111-SS-D-C-11101-C01				

FIGURE 2 PROPOSED DEVELOPMENT LAYOUT



GATEWAY 36
PHASE 3

LEGEND:

Site boundary

NOTE:
Proposed layout '21049_F0004[C]_Site Layout - Option 3 Revision E, dated 27.01.2021

01	24.08.21	FIRST ISSUE	HD	SR	SR
REV	DATE	DESCRIPTION	BY	CHD	APR.
Dimensions		Projection	Scale	Orig Size	
m			1:2,000	A3	

Spring Lodge
172 Chester Road
Helsby
Cheshire
WA6 0AR

Tel: +44 1928 726006
Fax: +44 1928 725633
Web: www.rsk.co.uk

CLIENT
EOS INC LIMITED

PROJECT
GATEWAY 36 DEVELOPMENT SITE - PHASE 3

TITLE
PROPOSED DEVELOPMENT LAYOUT

JOB No.:		DRAWING FILE:			
325389		FIGURE 02			
BY:	DATE:	CONTRACT NO.	FIGURE 2	REV:	
HD	24.08.21			01	

Scale 1 : 2,000

0

20

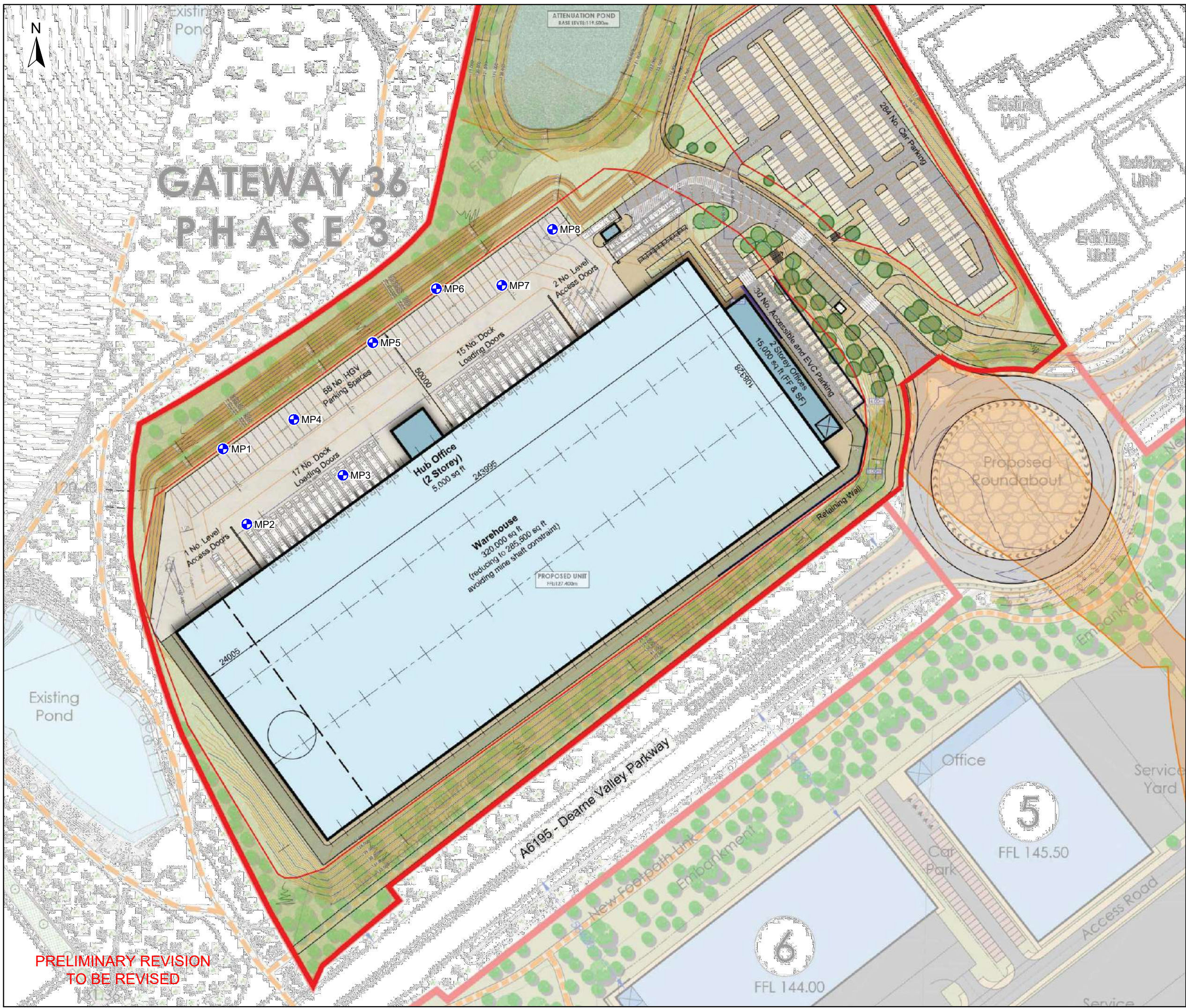
40

60

80

100m

FIGURE 3 PHASE 3 SETTLEMENT MONITORING INFRASTRUCTURE



LEGEND

- Site boundary
- External Yard Monitoring Rod Location

Notes:

Development Layout drawing from UMC Architects, Proposed layout 21049_F0004[E]_Site Layout -Option 3 Revision E, dated 27.07.2021

P02	17.02.23	First Issue	LS	##	##
Rev	Date	Amendment	Drawn	Chkd	Appd

**RSK
GEOSCIENCES**

Spring Lodge
172 Chester Road
Helsby
WA6 0AR

Tel: +44(0)1794 329276
Email: info@rsk.co.uk
Web: www.rsk.co.uk

Client
Firethorn Developments

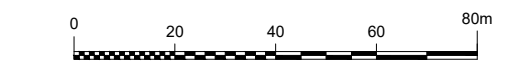
Project Name
Gateway 36 - Phase 3 Construction
Settlement monitoring and validation

Description
Monitoring Rod Locations

Project ID	Drawing no.	Revision
323064	22201	P02

File name
323069-HE-222-SS-D-C-22201-P02

Dimensions	Scale	Size
m	1:1500	A3



APPENDICES

APPENDIX A

SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for Harworth Estate Limited (the "Client") in accordance with the terms of a contract between RSK and the Client. The Services were performed by RSK with the reasonable skill and care ordinarily exercised by an environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the Client.
2. Other than that, expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed in writing, the Services were performed by RSK exclusively for the purposes of the Client. RSK is not aware of any interest of or reliance by any party other than the Client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. **Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.**
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the Client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the Client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off site of asbestos, invasive plants, electromagnetic fields, lead paint, heavy metals, radon gas, persistent, bioaccumulative or toxic chemicals (including PFAS/ PFOS) or other radioactive or hazardous materials, unless specifically identified in the Services.
7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a visual inspection of the site together with RSK's interpretation of information, including documentation, obtained from third parties and from the Client on the history and usage of the site, unless specifically identified in the Services or accreditation system (such as UKAS ISO 17020:2012 clause 7.1.6):
 - a. The Services were based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely.

b. The Services were limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the visual inspection.

c. The Services did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services.

RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the Client and RSK.

8. The intrusive environmental site investigation aspects of the Services are a limited sampling of the site at pre-determined locations based on the known historic / operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the properties of the materials adjacent and local conditions, together with the position of any current structures and underground utilities and facilities, and natural and other activities on site. In addition, chemical analysis was carried out for a limited number of parameters (as stipulated in the scope between the client and RSK, based on an understanding of the available operational and historical information) and it should not be inferred that other chemical species are not present.
9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (intrusive and sample locations etc) annotated on site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.
10. The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and ground gas concentrations and flows, may vary from those reported due to seasonal, or other, effects and the limitations stated in the data should be recognised.
11. Asbestos is often observed to be present in soils in discrete areas. Whilst asbestos-containing materials may have been locally encountered during the fieldworks or supporting laboratory analysis, the history of brownfield and demolition sites indicates that asbestos fibres may be present more widely in soils and aggregates, which could be encountered during more extensive ground works.
12. Unless stated otherwise, only preliminary geotechnical recommendations are presented in this report and these should be verified in a Geotechnical Design Report, once proposed construction and structural design proposals are confirmed.

APPENDIX B

RSK EXTERNAL YARD MONITORING SPECIFICATION



Firethorn Developments Limited

Gateway 36 Development Site – Phase 3

External Yard Settlement Monitoring Specification

323064-R01 (00)

RSK GENERAL NOTES

Project No.: 323064-R01 (00)

Title: External Yard Settlement Monitoring Specification: Gateway 36 Development Site – Phase 3

Client: Firethorn Developments Limited

Date: 16 August 2022

Office: RSK Environment Limited, Spring Lodge, 172 Chester Road, Helsby, Cheshire, WA6 0AR. Contact: Siôn Roberts, Tel: 01928 726006.

Status: Rev 00

Author Siôn Roberts **Technical reviewer** Gary McGuicken

Signature  Signature 

Project manager Siôn Roberts **Quality reviewer** Ang Wallis

Signature  Signature 

Revision control sheet		
Revision reference	Date	Reason for revision
Rev 00	August 2022	First issue

RSK Environment Limited (RSK) has prepared this report for the sole use of the client, showing reasonable skill and care, for the intended purposes as stated in the agreement under which this work was completed. The report may not be relied upon by any other party without the express agreement of the client and RSK. No other warranty, expressed or implied, is made as to the professional advice included in this report.

Where any data supplied by the client or from other sources have been used, it has been assumed that the information is correct. No responsibility can be accepted by RSK for inaccuracies in the data supplied by any other party. The conclusions and recommendations in this report are based on the assumption that all relevant information has been supplied by those bodies from whom it was requested.

No part of this report may be copied or duplicated without the express permission of RSK and the party for whom it was prepared.

Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

This work has been undertaken in accordance with the quality management system of RSK Environment Ltd.

CONTENTS

1	INTRODUCTION.....	1
1.1	Commissioning	1
1.2	Background	1
1.3	Objectives	1
1.4	Definition of roles	1
1.5	Proposed development.....	2
2	SITE INFORMATION	3
2.1	RSK reports.....	3
2.2	RSK drawings	3
3	SETTLEMENT MONITORING.....	4
3.1	Settlement monitoring infrastructure.....	4
3.1.1	Monitoring rods	4
3.1.2	Permanent ground markers	4
3.2	Surface preparation	4
3.3	Installation of monitoring rods.....	4
3.4	Baseline readings	5
3.5	Settlement monitoring during upfilling.....	5
3.6	Settlement monitoring post-upfilling.....	5
3.6.1	Monitoring rods	5
3.6.2	Permanent ground markers	6
3.6.3	Completion works	6
4	REPORTING REQUIREMENTS.....	7

FIGURES

- Figure 1 Site location plan
- Figure 2 Proposed location of settlement monitoring rods prior to upfilling
- Figure 3 Proposed locations of permanent ground markers post-upfilling

APPENDICES

- Appendix A Service constraints
- Appendix B Rod settlement system datasheet

1 INTRODUCTION

1.1 Commissioning

RSK Environment Limited (RSK) was commissioned by Firethorn Developments Limited (Firethorn, the Client, who are the site owners) to prepare this settlement monitoring specification of external yard areas for the Gateway 36 Phase 3 development site, near Barnsley. The project was carried out to an agreed brief as set out in RSK's proposal 323064TL01(00) dated 1 August 2022.

This report is subject to the RSK service constraints in Appendix A.

1.2 Background

The Client wishes to develop the Phase 3 area of the Gateway 36 site in order to facilitate a commercial development with associated infrastructure. In order to achieve final development levels in the external yard areas, ground levels will need to be raised by up to approximately 5m, which will induce significant settlement, most of which would occur during or shortly after construction (based on the findings of the large-scale loading test previously undertaken by RSK). This was outlined in the RSK plot specific geo-environmental report (reference 325389-R01(00), dated April 2021) and RSK report 322638-R02(00), dated May 2020. More recently, RSK prepared a detailed geotechnical analysis of anticipated settlement of the external yard areas (reference 325389PL03, dated 27 October 2021, which recommended that settlement monitoring infrastructure should be installed and monitored during the Phase 3 earthworks to record settlement, and that once the final development levels are reached the platform should be left for at least three months (and monitoring carried out to demonstrate settlement is substantially complete) prior to construction of roads and infrastructure.

1.3 Objectives

The objective of this specification is to detail the requirements so that settlement of the original ground level within the external yard area can be monitored during and post-up filling; and, to validate that the anticipated settlement has been induced and that any going settlement is of a tolerably low order.

1.4 Definition of roles

Firethorn Developments Limited – is the Client for the works.

Quartz Project Services – is the project manager for the development appointed by the Client.

Core Special Projects Limited – is the Contractor responsible for the placement and compaction of engineered fill, including in the external yard area, to meet the requirements of their Contract documents. The Contractor will be required to supply,

install and protect the settlement monitoring infrastructure specified within this document.

RSK Environment Limited – is the geotechnical and environmental consultant and are responsible for preparing this specification and for monitoring and validating settlement of the original ground level beneath the external yard area.

1.5 Proposed development

The approximate centre of the site is located at National Grid reference 435403 401141 and is shown in Figure 1.

2 SITE INFORMATION

This section lists all Site Information that is currently available.

2.1 RSK reports

RSK have completed site investigation and assessment work including borehole and trial pit investigation and a large-scale settlement load test. Details of work completed to date can be found in the latest versions of the reports referenced below:

- 325389-R01 (00) Gateway 36 – Phase 3 Development Summary Geo-environmental Report, April 2021
- 325389-R02 (00) Gateway 36 – Phase 3 Development Non-technical Ground Conditions Summary Report, April 2021
- 325389-R03 (00) Gateway 36 – Phase 3 Development Mineshaft Investigation Factual Report, July 2021
- 325389-R04 (01) Gateway 36 – Phase 3 Ground Treatment Specification, July 2021
- 325389-R05 (00) Gateway 36 – Phase 3 Mineshaft Geotechnical Design report, September 2021
- 325389PL03 – Advice Note on Ground Settlement of External Yard Areas, October 2021.

2.2 RSK drawings

The RSK drawings that accompany this specification are:

- 323064-HE-111-SS-D-C-11101-C01 Site location plan
- 323064-HE-322-SS-D-C-32201-C01 Proposed location of settlement monitoring rods prior to upfilling
- 323064-HE-322-SS-D-C-32202-C01 Proposed locations of permanent ground markers post-upfilling.

3 SETTLEMENT MONITORING

Settlement of the original ground surface shall be monitored during and following placement of engineered fill. Settlement monitoring will be recorded using settlement monitoring rods supplied and installed by the Contractor in advance of placing fill materials. Upon completion of upfilling, permanent ground markers will be installed by RSK to monitor settlement of the external yard surface.

The installation of settlement monitoring infrastructure will be supervised by RSK, and all monitoring will be undertaken by RSK.

The required works are described in further detail below.

3.1 Settlement monitoring infrastructure

3.1.1 Monitoring rods

The Contractor shall supply and install eight Geosense Rod Settlement GEO-XR plates/rods, the manufacturers datasheet is provided in Appendix B. The Contractor shall also supply the required number of extension rods and sleeves to extend the top of the rod to protrude above the final formation level. The monitoring rods comprise a baseplate with a 1.0m inner steel rod, and an outer plastic sleeve. Extension rods are then screwed into the existing rod as upfilling advances and need to be monitored/surveyed as each section is added. RSK shall extend the monitoring rods during upfilling (Section 3.5) and will require adequate notice (minimum three working days) before ground levels in the vicinity of the Geosense equipment are raised.

3.1.2 Permanent ground markers

Settlement of the finished formation surface shall be monitored upon completion of earthworks in the external yard areas using permanent ground markers (PGMs). These shall be supplied and installed by RSK as soon as practicably possible following completion of final levels.

3.2 Surface preparation

The surface shall be trimmed to remove any degraded areas/soft spots and vegetation and shall be free of water. The formation shall be horizontal to receive the baseplate.

The RSK Supervisor will inspect the area and undertake testing of the formation with a hand shear vane to confirm that soils achieve a minimum in situ shear strength of 65 kPa.

3.3 Installation of monitoring rods

The Contractor shall place the monitoring rod base plates and rod at the locations indicated on Figure 2, these locations may be moved locally at the discretion of the RSK supervising engineer.

The Contractor shall seat the monitoring rod baseplate on to the formation, and ensure that the rod is vertical, this is to be confirmed with a spirit level.

The base plate shall be concreted into place, with concrete mounded over the baseplate. The rod shall be checked for vertical alignment with a spirit level.

The concrete shall be left to cure for a minimum of 24 hours before baseline readings (Section 3.4 below) are taken.

3.4 Baseline readings

RSK shall establish a stable off-site survey control station and use a precise level to establish a baseline elevation of each installed monitoring rod.

3.5 Settlement monitoring during upfilling

RSK shall confirm to the Contractor that the baseline reading is acceptable and that upfilling can commence.

RSK will undertake regular settlement monitoring of the installed monitoring rods during upfilling. RSK shall precisely level each monitoring rod immediately before adding the extension rod(s), and shall then immediately precise level the top of the monitoring rod.

The Contractor shall give RSK a minimum of three working days' notice before extensions are needed.

The Contractor shall ensure that the monitoring rods are not damaged during the placement and compaction of fill, and that the rods remain vertical throughout.

The Contractor will allow safe access for RSK to undertake monitoring and extension of the monitoring rods, which may require the Contractor to cease working in particular areas during monitoring visits.

3.6 Settlement monitoring post-upfilling

The Contractor will allow safe access to RSK to undertake monitoring. At the time of post-upfilling monitoring (which will continue for 3 months) it is expected that only limited Contractor operations will be taking place in the vicinity of the monitoring infrastructure, however this may require the Contractor to cease working in particular areas during monitoring visits.

3.6.1 Monitoring rods

Once the final formation levels have been reached in the external yard area, the Contractor shall protect the monitoring rods from damage by plant movements.

The Contractor shall also cover the monitoring rods to prevent surface water ingress entering the engineered and formation.

RSK shall undertake weekly settlement monitoring for a minimum of 12 weeks. Monitoring may continue until approval is given by RSK that the anticipated settlement has been induced and any on-going settlement is of a tolerably low order.

3.6.2 Permanent ground markers

Once the final formation levels have been reached in the external yard area, RSK shall install up to 20 PGMs at the formation surface at the indicated positions shown on Figure 3. These locations may be moved locally at the discretion of the RSK supervising engineer.

The Contractor shall ensure that they protect the PGMs from damage by plant movements. If any are damaged this must immediately be reported to RSK in order that replacements are installed and monitored (all associated costs would be met by the Contractor). Any delays in reporting damage could result in uncertainties in monitoring results and the requirement to extend the monitoring period.

RSK will undertake precise levelling of the installed PGMs at the same time as levelling of the monitoring rods (Section 3.6.1).

3.6.3 Completion works

When all monitoring is completed to the written approval of RSK, then the infrastructure should be decommissioned by the Contractor.

The eight Geosense Monitoring Rod positions should have the top sleeve and rod sections removed and the annulus around the rod grouted with a weak grout mix to fill the voids to the full depth of the base plate and in the immediate vicinity.

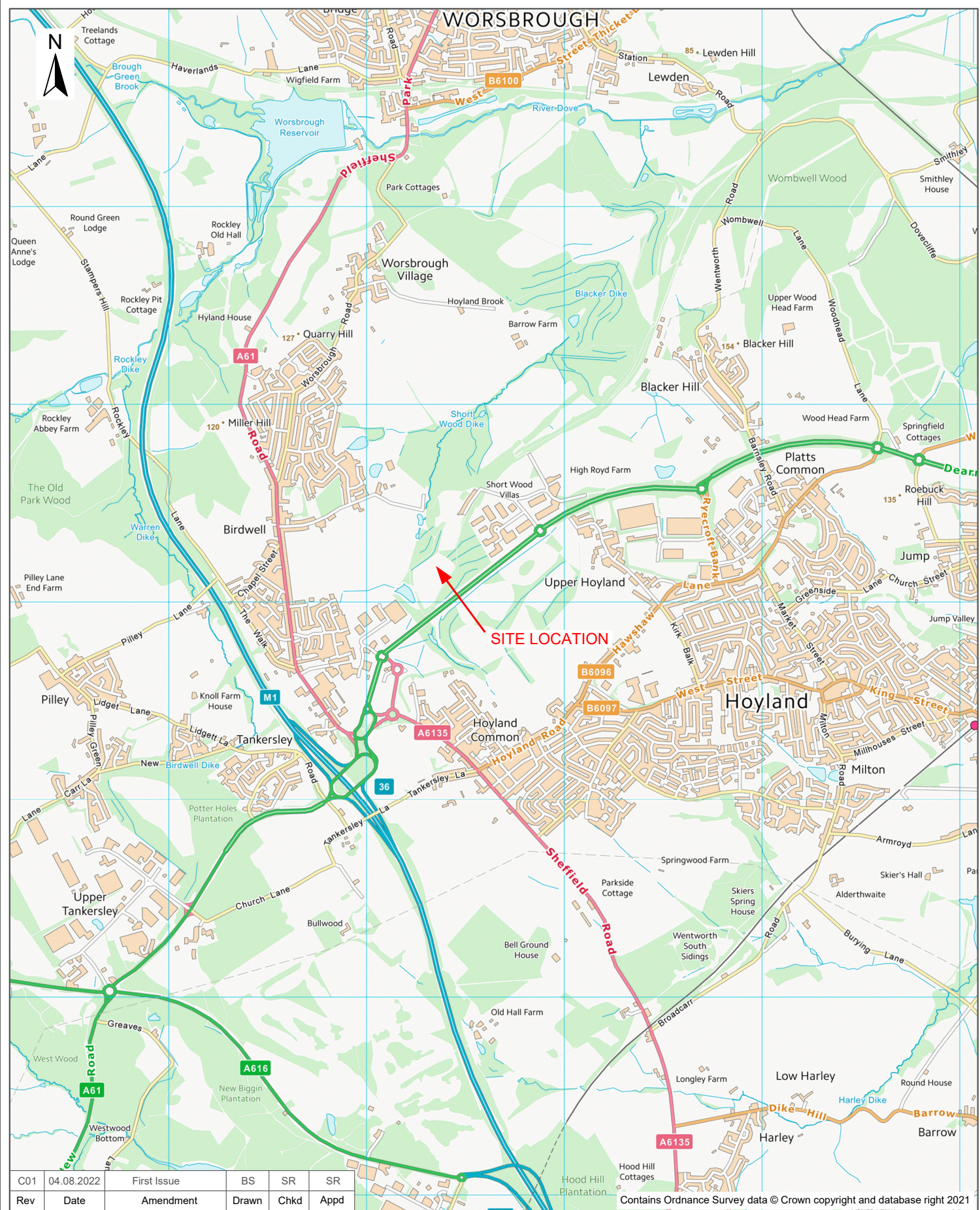
The PGMs can also be removed.

4 REPORTING REQUIREMENTS

RSK will provide a settlement validation report for the external yard area following completion of all necessary monitoring (and any additional monitoring if required).

The Contractor is to provide in CAD format (to national grid co-ordinates) a topographical survey of the external yard area at the time of installation (Section 3.3), and upon completion of the final levels.

FIGURES



C01	04.08.2022	First Issue	BS	SR	SR
Rev	Date	Amendment	Drawn	Chkd	Appd

Contains Ordnance Survey data © Crown copyright and database right 2021



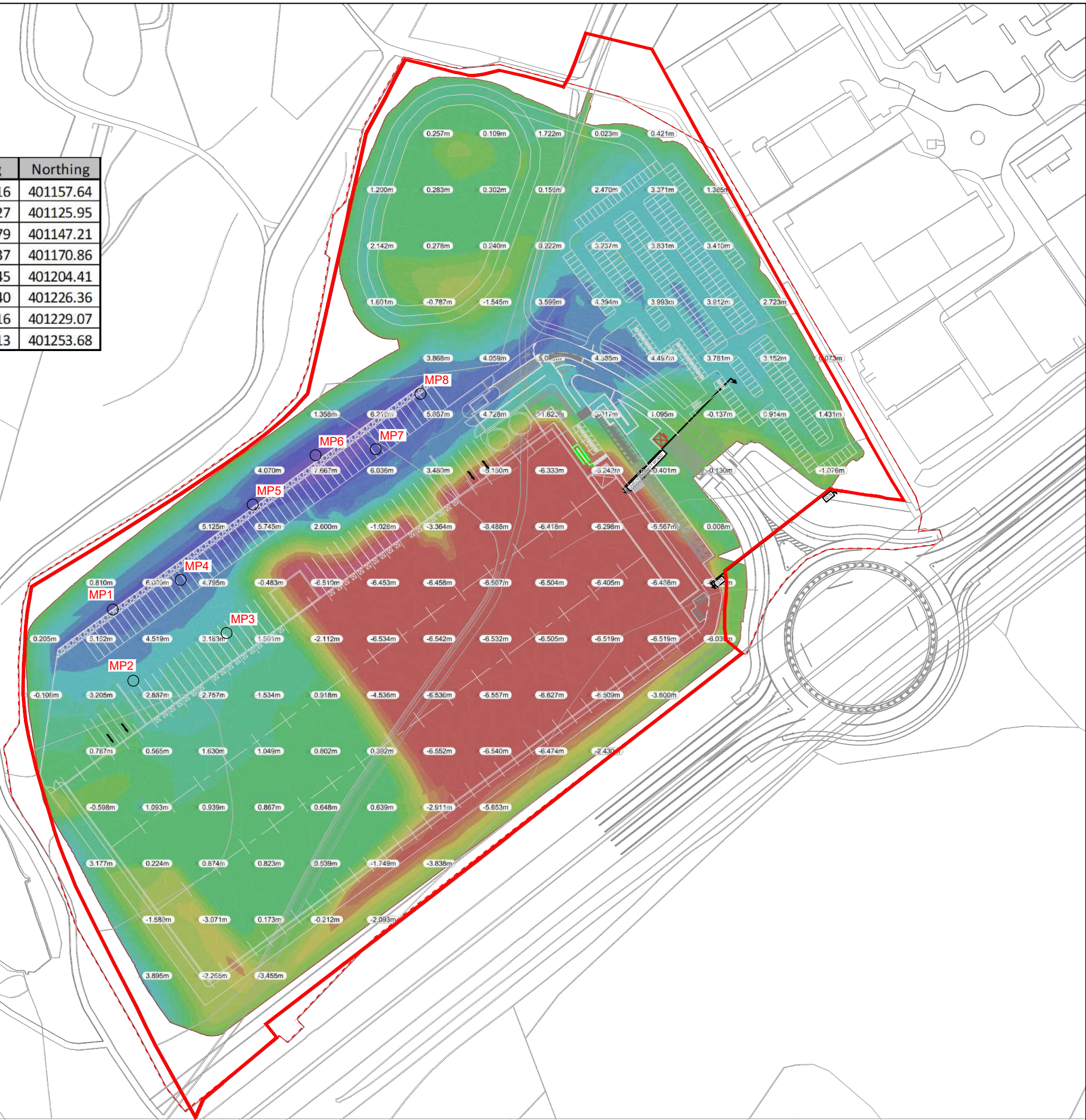
Spring Lodge
172 Chester Road
Helsby
WA6 0AR

Tel: +44(0)1794 329276
Email: info@rsk.co.uk
Web: www.rsk.co.uk

Client		Firethorn Developments Limited			
Project Name		Gateway 36 Phase 3 - External Yard Settlement Monitoring			
Description		Site Location Plan			
Dimension	Size	Scale	Geolocation	Project ID	Drawing no.
m	A4	1:25,000	435344,401181	323064	11101
Rev		File name			
C01		323064-HE-111-SS-D-C-11101-C01			



Monitoring Rod ID	Easting	Northing
MP1	435274.16	401157.64
MP2	435283.27	401125.95
MP3	435324.79	401147.21
MP4	435304.37	401170.86
MP5	435336.45	401204.41
MP6	435364.40	401226.36
MP7	435391.16	401229.07
MP8	435411.13	401253.68



LEGEND

- Site boundary
- Proposed proprietary settlement monitoring rods installed prior to placement of Engineered fill

SURFACE LEVEL DATA					
NUMBER	MINIMUM LEVEL	MAXIMUM LEVEL	COLOUR	AREA	VOLUME
1	-8.000	-7.000		355.371m²	92.192m³
2	-7.000	-6.000		17279.681m²	8449.728m³
3	-6.000	-5.000		1698.261m²	18550.313m³
4	-5.000	-4.000		1396.659m²	19991.900m³
5	-4.000	-3.000		2050.968m²	21875.640m³
6	-3.000	-2.000		3449.433m²	24397.169m³
7	-2.000	-1.000		3119.002m²	27766.643m³
8	-1.000	0.000		4954.141m²	31451.634m³
9	0.000	1.000		17648.327m²	41703.099m³
10	1.000	2.000		7869.095m²	27832.463m³
11	2.000	3.000		5873.131m²	20714.362m³
12	3.000	4.000		8129.990m²	14601.853m³
13	4.000	5.000		4270.003m²	7729.029m³
14	5.000	6.000		3424.497m²	3778.294m³
15	6.000	7.000		1647.408m²	1254.104m³
16	7.000	8.000		569.714m²	256.669m³
17	8.000	9.000		16.224m²	1.359m³

Notes:

Settlement monitoring rods to be:
Positions to be determined locally on site
Located on original ground level
Formation to be free of water, soft deposits, organic debris
Formation to be of firm stiffness or greater and horizontal
Contractor to ensure that monitoring rods are protected from damage and remain vertical and unaffected by plant movements

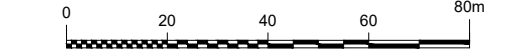
Base plan provided by Core Special Projects Limited
No.Ref:21056-G36-EW CUT & FILL PLAN

C01	04.08.2022	First Issue	BS	SR	SR
Rev	Date	Amendment	Drawn	Chkd	Appd



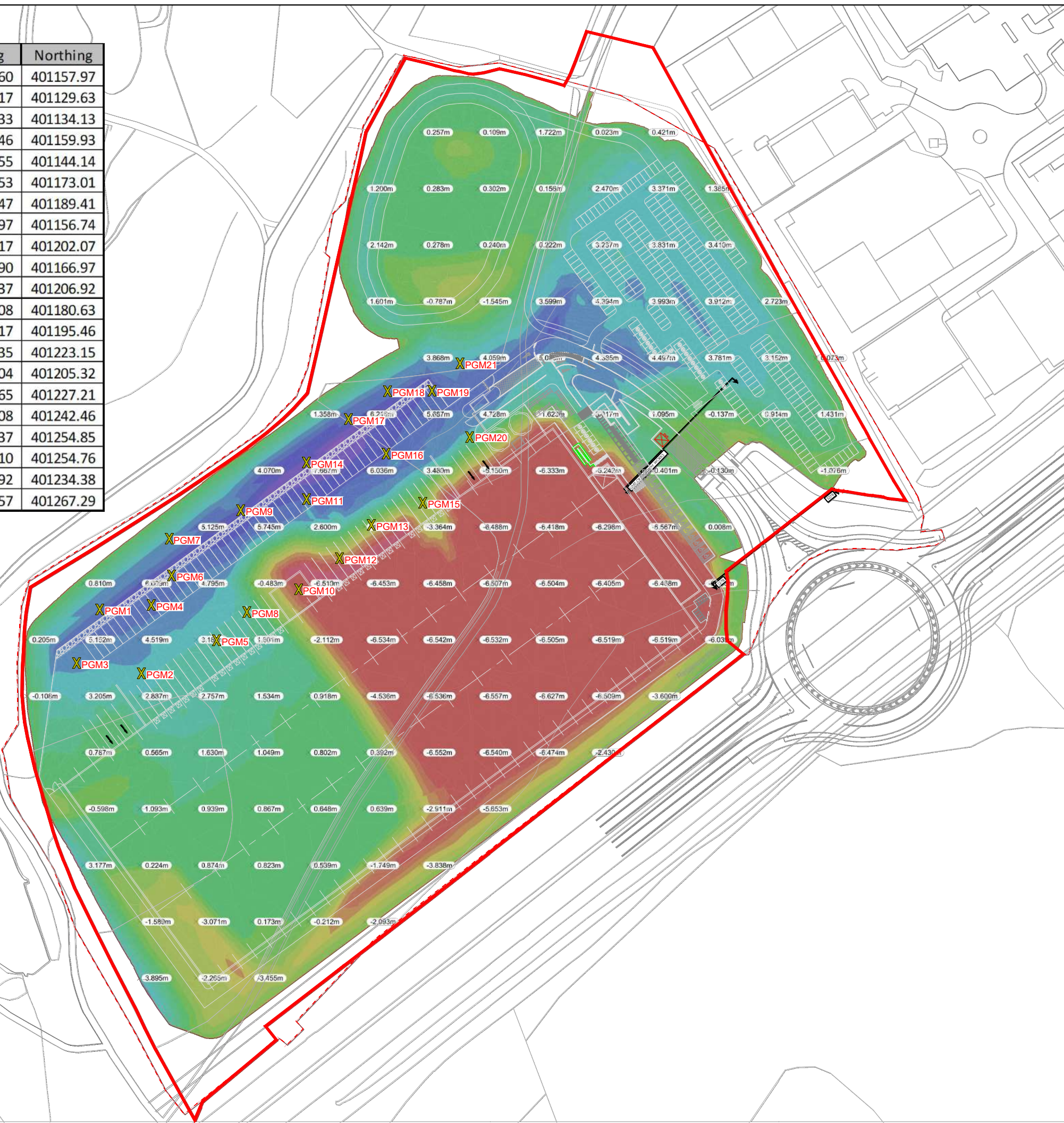
Spring Lodge
172 Chester Road
Helsby
WA6 0AR

Tel: +44(0)1794 329276
Email: info@rsk.co.uk
Web: www.rsk.co.uk

Client		
Firethorn Developments Limited		
Project Name		
Gateway 36 Phase 3 - External Yard Settlement Monitoring		
Description		
Proposed locations of Settlement Monitoring Rods Prior to Upfilling		
Project ID	Drawing no.	Revision
323064	32201	C01
File name		
323064-HE-322-SS-D-C-32201-C01		
Dimensions	Scale	Size
m	1:1500	A3
		



Ground Marker ID	Easting	Northing
PGM1	435268.60	401157.97
PGM2	435287.17	401129.63
PGM3	435258.33	401134.13
PGM4	435291.46	401159.93
PGM5	435320.55	401144.14
PGM6	435300.53	401173.01
PGM7	435299.47	401189.41
PGM8	435333.97	401156.74
PGM9	435331.17	401202.07
PGM10	435356.90	401166.97
PGM11	435360.37	401206.92
PGM12	435375.08	401180.63
PGM13	435389.17	401195.46
PGM14	435360.35	401223.15
PGM15	435412.04	401205.32
PGM16	435395.65	401227.21
PGM17	435379.08	401242.46
PGM18	435396.37	401254.85
PGM19	435416.10	401254.76
PGM20	435432.92	401234.38
PGM21	435428.57	401267.29



LEGEND

— Site boundary

X Proposed location of permanent ground marker to be installed by RSK following completion of final levels in external yard area

SURFACE LEVEL DATA					
NUMBER	MINIMUM LEVEL	MAXIMUM LEVEL	COLOUR	AREA	VOLUME
1	-8.000	-7.000		355.371m²	92.192m³
2	-7.000	-6.000		17279.681m²	8449.728m³
3	-6.000	-5.000		1698.261m²	18550.313m³
4	-5.000	-4.000		1396.659m²	19991.900m³
5	-4.000	-3.000		2050.968m²	21875.640m³
6	-3.000	-2.000		3449.433m²	24397.169m³
7	-2.000	-1.000		3119.002m²	27766.643m³
8	-1.000	0.000		4954.141m²	31451.634m³
9	0.000	1.000		17648.327m²	41703.099m³
10	1.000	2.000		7869.095m²	27832.463m³
11	2.000	3.000		5873.131m²	20714.362m³
12	3.000	4.000		8129.990m²	14601.853m³
13	4.000	5.000		4270.003m²	7729.029m³
14	5.000	6.000		3424.497m²	3778.294m³
15	6.000	7.000		1647.408m²	1254.104m³
16	7.000	8.000		569.714m²	256.669m³
17	8.000	9.000		16.224m²	1.359m³

Notes:

- Positions to be determined locally on site
- located on final formation level
- Contractor to ensure that PGM locations are protected from damage until completion of monitoring.

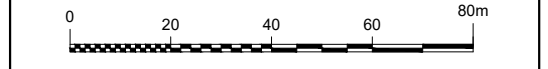
Base plan provided by Core Special Projects Limited
No.Ref:21056-G36-EW CUT & FILL PLAN

C01	04.08.2022	First Issue	BS	SR	SR
Rev	Date	Amendment	Drawn	Chkd	Appd



Spring Lodge
172 Chester Road
Helsby
WA6 0AR

Tel: +44(0)1794 329276
Email: info@rsk.co.uk
Web: www.rsk.co.uk

Client Firethorn Developments Limited		
Project Name Gateway 36 Phase 3 - External Yard Settlement Monitoring		
Description Proposed locations of Permanent Ground Markers post-Upfilling		
Project ID 323064	Drawing no. 32202	Revision C01
File name 323064-HE-322-SS-D-C-32202-C01		
Dimensions m	Scale 1:1500	Size A3
		

APPENDIX A

SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for Firethorn Developments Ltd (the "Client") in accordance with the terms of a contract between RSK and the Client, dated 1st August 2022. The Services were performed by RSK with the reasonable skill and care ordinarily exercised by an environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the Client.
2. Other than that, expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed in writing, the Services were performed by RSK exclusively for the purposes of the Client. RSK is not aware of any interest of or reliance by any party other than the Client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. **Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.**
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the Client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the Client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, invasive plants, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials, unless specifically identified in the Services.
7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a visual inspection of the site together with RSK's interpretation of information, including documentation, obtained from third parties and from the Client on the history and usage of the site, unless specifically identified in the Services or accreditation system (such as UKAS ISO 17020:2012 clause 7.1.6):

- a. The Services were based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely.
- b. The Services were limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the visual inspection.
- c. The Services did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services.

RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the Client and RSK.

8. The intrusive environmental site investigation aspects of the Services are a limited sampling of the site at pre-determined locations based on the known historic / operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the properties of the materials adjacent and local conditions, together with the position of any current structures and underground utilities and facilities, and natural and other activities on site. In addition, chemical analysis was carried out for a limited number of parameters (as stipulated in the scope between the client and RSK, based on an understanding of the available operational and historical information) and it should not be inferred that other chemical species are not present.
9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (intrusive and sample locations etc) annotated on site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.
10. The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and ground gas concentrations and flows, may vary from those reported due to seasonal, or other, effects and the limitations stated in the data should be recognised.
11. Asbestos is often observed to be present in soils in discrete areas. Whilst asbestos-containing materials may have been locally encountered during the fieldworks or supporting laboratory analysis, the history of brownfield and demolition sites indicates that asbestos fibres may be present more widely in soils and aggregates, which could be encountered during more extensive ground works.
12. Unless stated otherwise, only preliminary geotechnical recommendations are presented in this report and these should be verified in a Geotechnical Design Report, once proposed construction and structural design proposals are confirmed.

APPENDIX B

ROD SETTLEMENT SYSTEM DATASHEET

Rod Settlement System GEO-XR

Geosense® GEO-XR single point rod settlement system is used to monitor sub-surface settlement or heave of ground



Rod Settlement System GEO-XR

Overview



APPLICATIONS

Embankments

Pre-loads

Deep excavations

FEATURES

Simple to install & use

Low cost

Geosense® GEO-XR single point rod settlement system is used to monitor sub-surface settlement or heave of ground.

The system comprises a series of inner steel rods and plastic outer sleeves together with plates when positioned on ground before fill or Borros type anchors when used in boreholes.

The inner steel rod is made from heavy duty 1 metre lengths of 25mm outside diameter with a 3/4" BSPM thread with external socket.

The outer plastic sleeves in 1 metre lengths can be 60mm (2") or 165 mm (6") diameter with flush threads so that the inner and outer rod can be extended together.

A circular or square thick steel plate with a 3/4" BSPF socket welded onto it allows the datum plate to be placed and the first inner rod connected. Outer sleeves are placed over the steel rods as filling occurs.

Rod Settlement System GEO-XR

Specifications

RODS/SLEEVES

Steel rod OD	25, 33mm
Steel rod ID	19, 25mm
Steel rod connection	3/4", 1" BSPF/M
Steel rod length	1 metre
PVC sleeve OD	60, 165mm
PVC sleeve ID	52, 150mm
PVC sleeve connection	Flush thread
PVC sleeve length	1 metre

BASE PLATES

Material*	Mild steel
Standard Dimensions**	300 x 300mm square
Standard Plate thickness**	10mm
Weight	7.1kg

* Other materials available on request

** Other sizes, shapes and thicknesses available on request



Geosense Ltd, Nova House, Rougham Industrial Estate, Rougham, Bury St Edmunds, Suffolk IP30 9ND, England

www.geosense.co.uk e sales@geosense.co.uk t +44(0)1359 270457

APPENDIX C

PHOTOGRAPHIC LOG

Photograph No 1: Taken on 18 August 2022 – Example of confirmation that the base plates the monitoring rods were installed on were levelled before installation was completed.



Photograph No 2: Taken on 23 August 2022 – Monitoring rod (blue tubing) locations in background on proposed External Yard Area.



Photograph No 3: taken on 26 August 2022 – Levelling of the External Yard Area with Monitoring Rod in place.



Photograph No 4: taken on 26 August 2022 – Shows a bulldozer working on increasing the levels of the surcharge and the monitoring rods with their extension tubing.



Photograph No 5: taken on 26 August 2022 – This shows how the surcharge had been brought to level and then rolled, with the yellow flags on the right of the photograph marking the required level.



Photograph No 6: taken on 01 September 2022 – Continued work on increasing the levels in the External Yard Area, with monitoring rod in the centre of the rolled area.



Photograph No 7: taken on 05 September 2022 – Removal of surcharge for engineered fill.



Photograph No 8: taken on 9 September 2022 – Continued work on increasing the levels with an orange barrier indicating the position of the monitoring rod.



Photograph No 9: taken on 28 November 2022 – Monitoring visit showing monitoring rods in-situ after raising of ground levels.



APPENDIX D
MONITORING ROD SETTLEMENT RESULTS

Table 3: Settlement Data (mm)

Lapsed Time (days)	0	8	14	21	25	29	35	42	49	56	63
Monitoring Point	22/08/2022	30/08/2022	05/09/2022	12/09/2022	16/09/2022	20/09/2022	26/09/2022	03/10/2022	10/10/2022	17/10/2022	24/10/2022
MP1	0	0	-2	-39	-56	-73	-86	-103	-112	-115	-119
MP2	0	-6	-8	-47	-47	-52	-63	-70	-72	-72	-70
MP3	0	-12	-10	-48	-48	-51	-54	-60	-61	-61	
MP4	0	-2	2	-33	-58	-75	-120	-140	-142	-144	
MP5	0	6	-15	-61		0	-34	-28	-35	-59	-57
MP6	0	28		-1	-19	-42	-71	-88	-96	-103	-103
MP7	0	7	6	-49	-54	-98	-124	-114	-118	-126	-131
MP7A											
MP8	0	16			-18	-30	-61	-77	-86	-88	

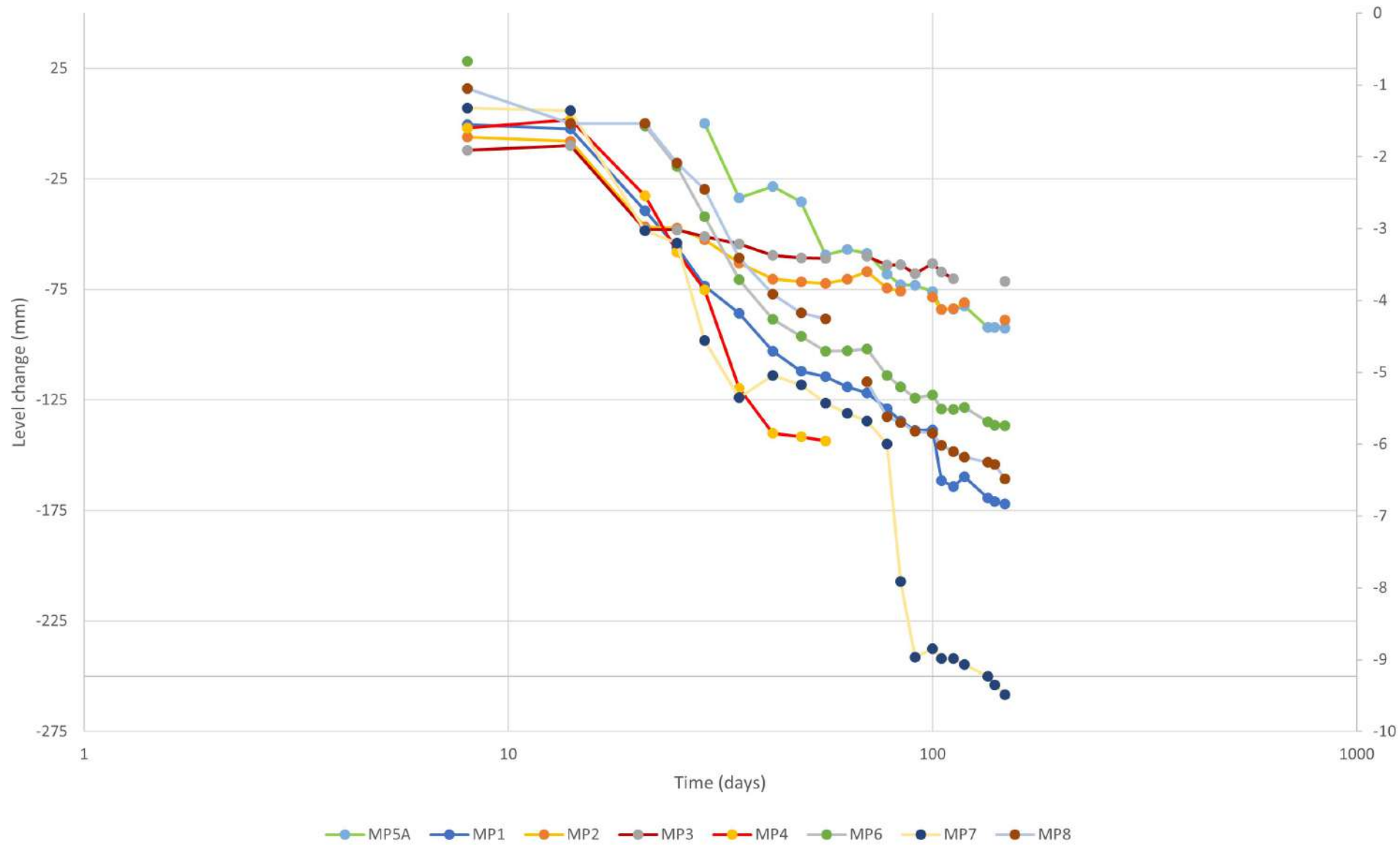
Table 3: Settlement Data (mm)

Lapsed Time (days)	70	78	84	91	100	105	112	119	135	140	148
Monitoring Point	31/10/2022	08/11/2022	14/11/2022	21/11/2022	30/11/2022	05/12/2022	12/12/2022	19/12/2022	04/01/2023	09/01/2023	17/01/2023
MP1	-122	-129	-135	-139	-139	-161	-164	-160	-169	-171	-172
MP2	-67	-74	-76		-78	-84	-84	-81			-89
MP3	-60	-64	-64	-68	-63	-67	-70				-71
MP4											
MP5	-59	-68	-73	-73	-76	-84	-84	-82	-92	-92	-92
MP6	-102	-114	-119	-124	-123	-129	-129	-128	-135	-136	-137
MP7	-135	-145	-207	-241	-238	-242	-242	-245	-250	-254	-258
MP7A			0	-34	-31	-35	-35	-38	-43	-47	-51
MP8	-117	-133	-135	-139	-140	-145	-148	-151	-153	-154	-161

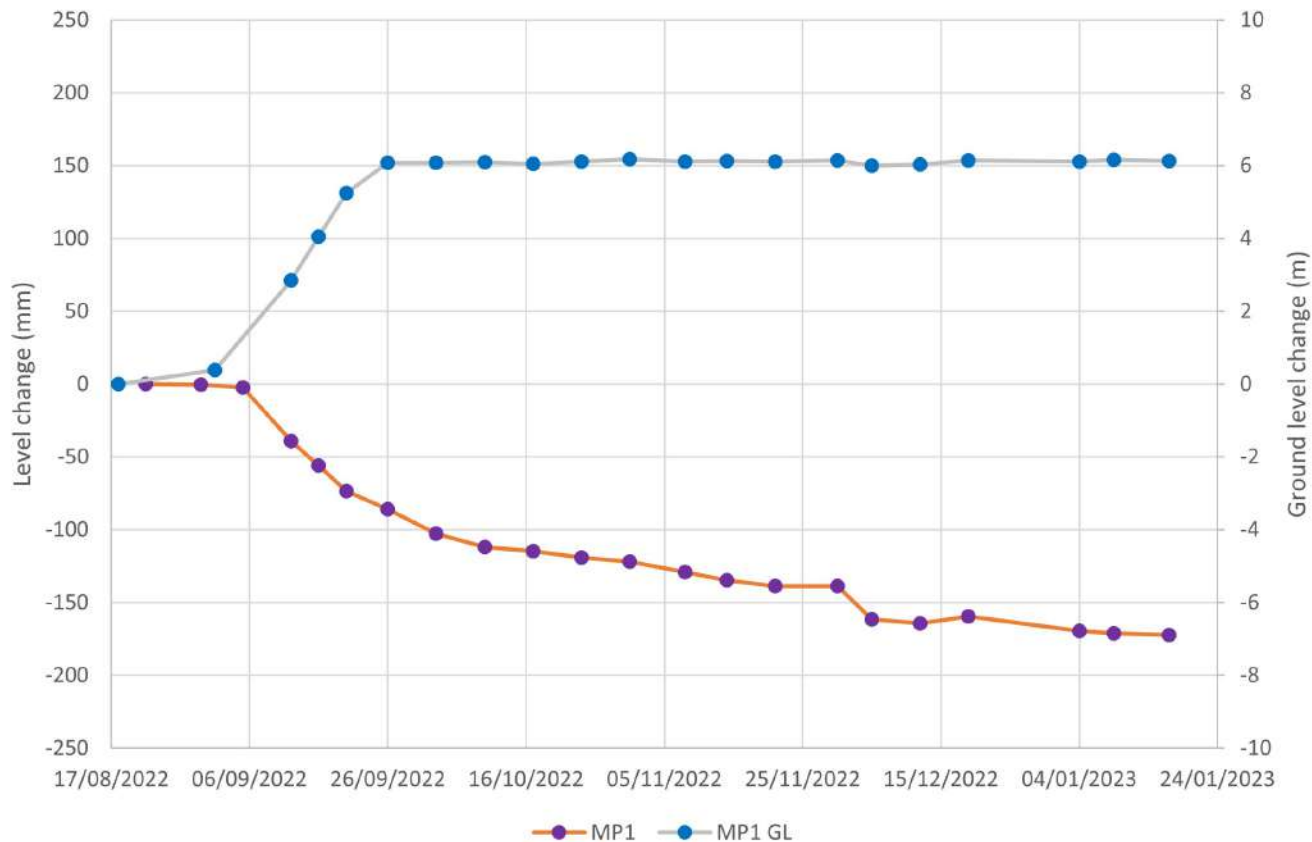
Table Key

	Relative Data set MP7A due to slip on monitoring rod
	Relative Data set MP5A following damage to monitoring rod
	No data collected

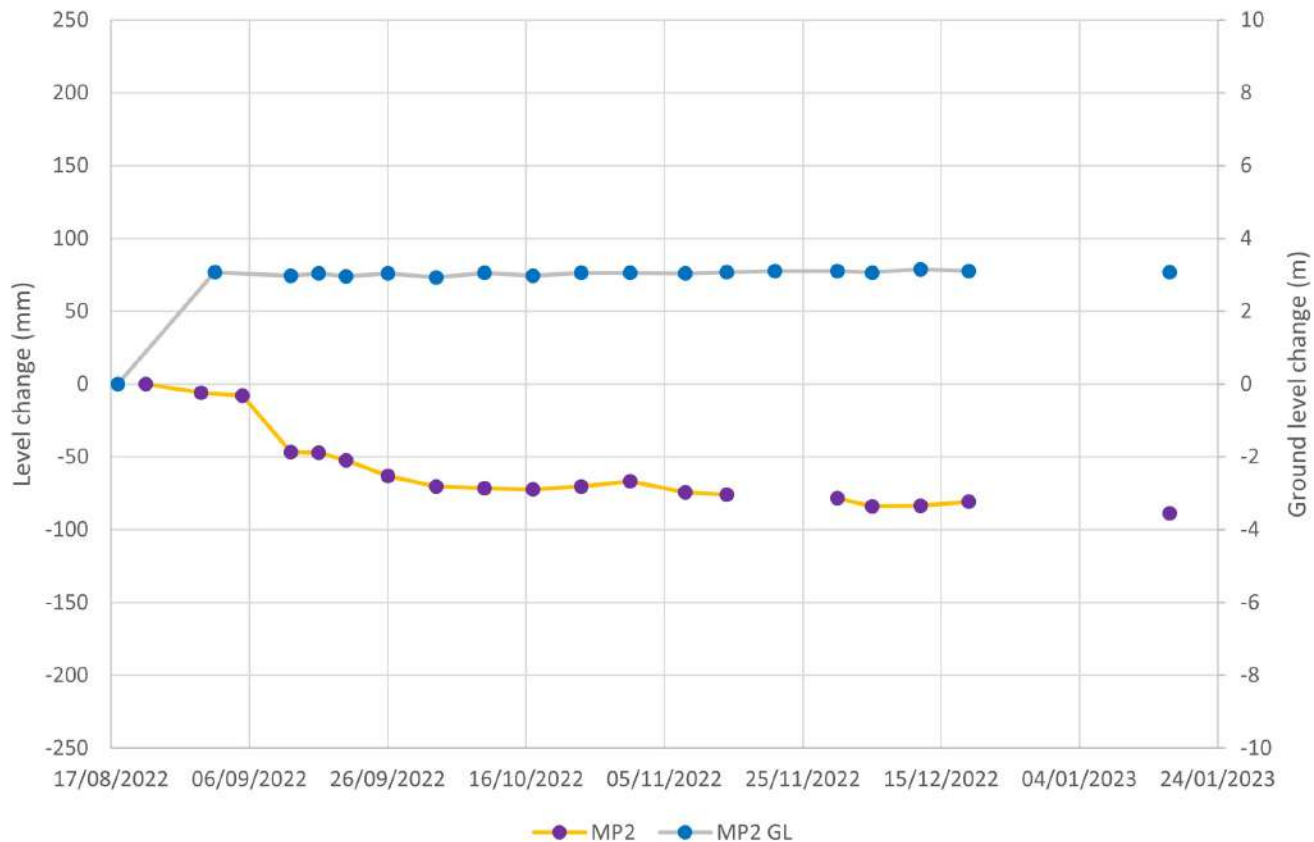
Settlement Measured - plotted Logarithmically



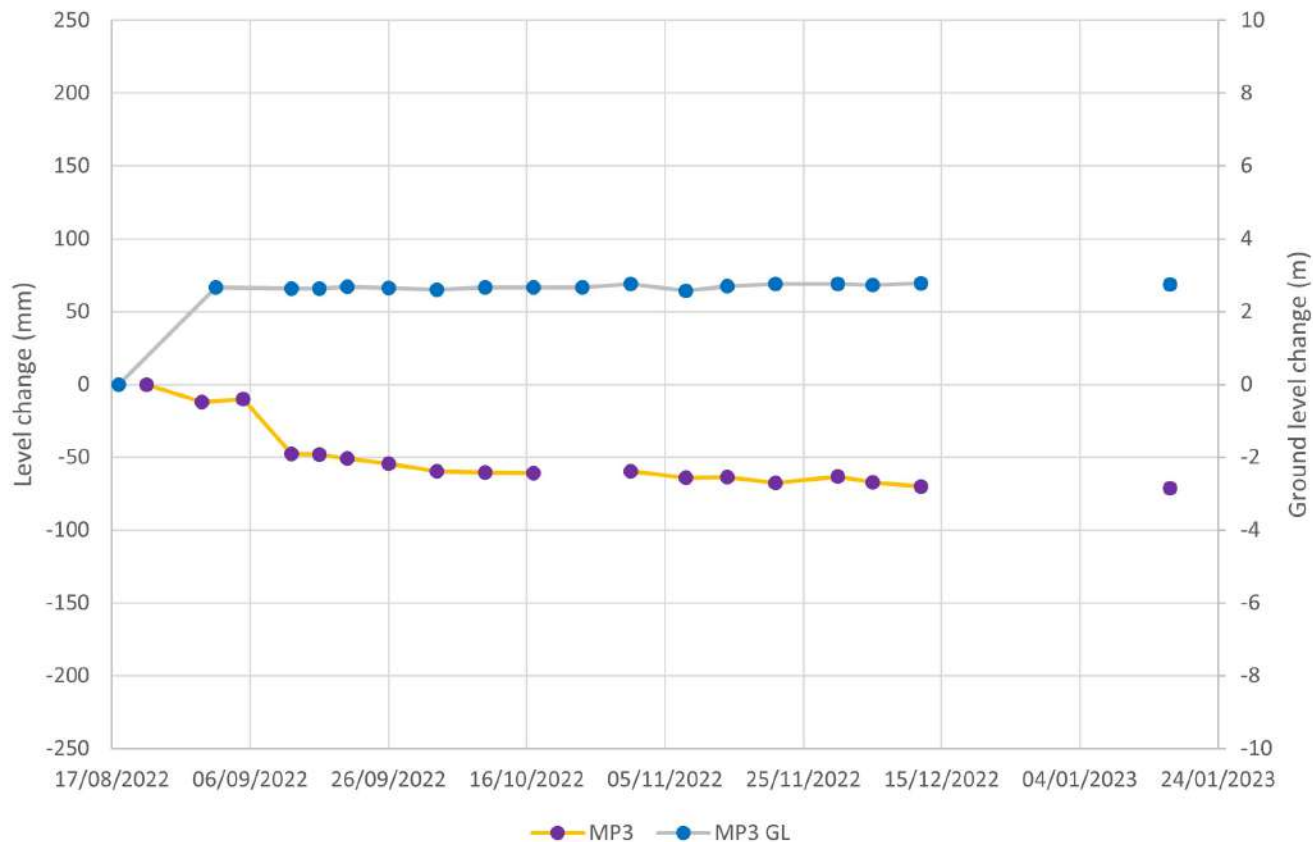
Settlement Measured - MP1



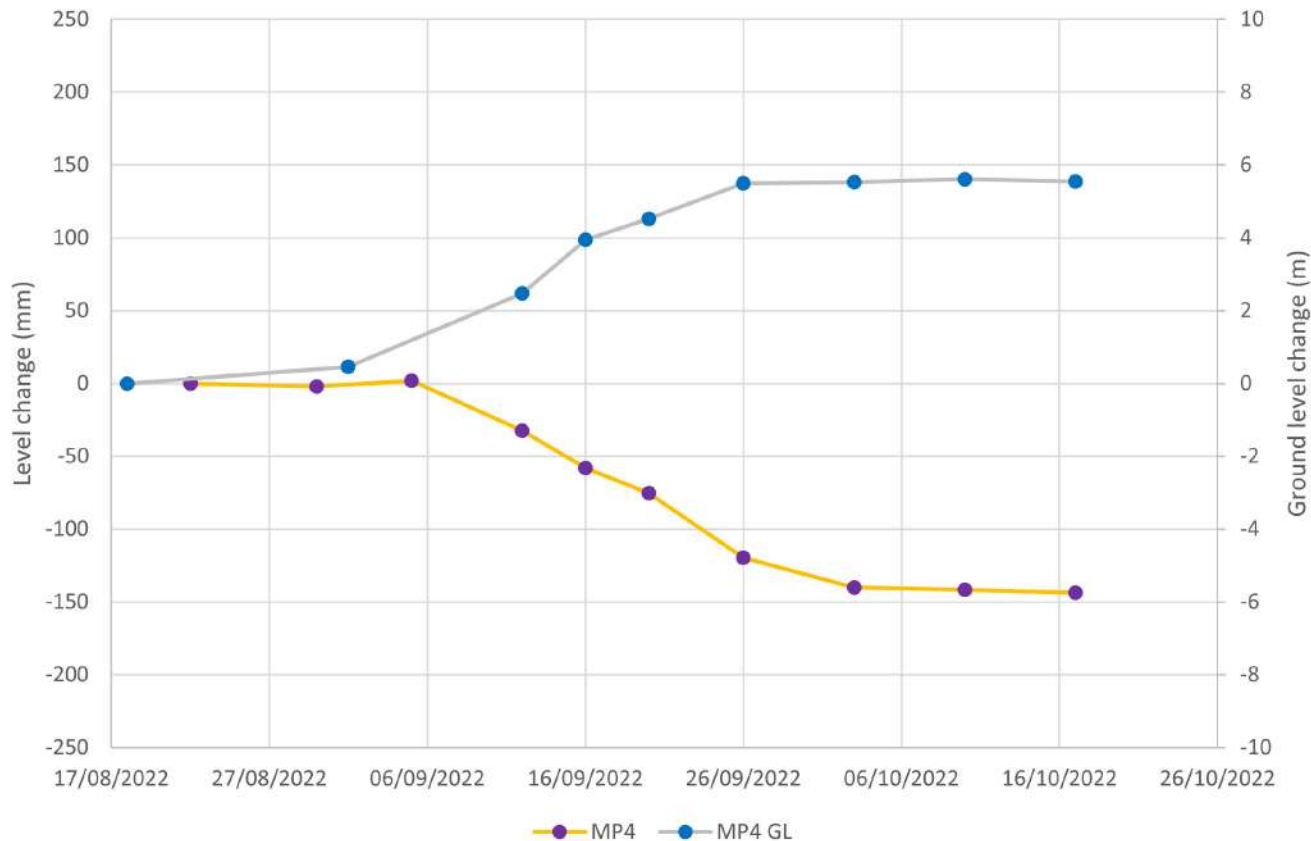
Settlement Measured - MP2



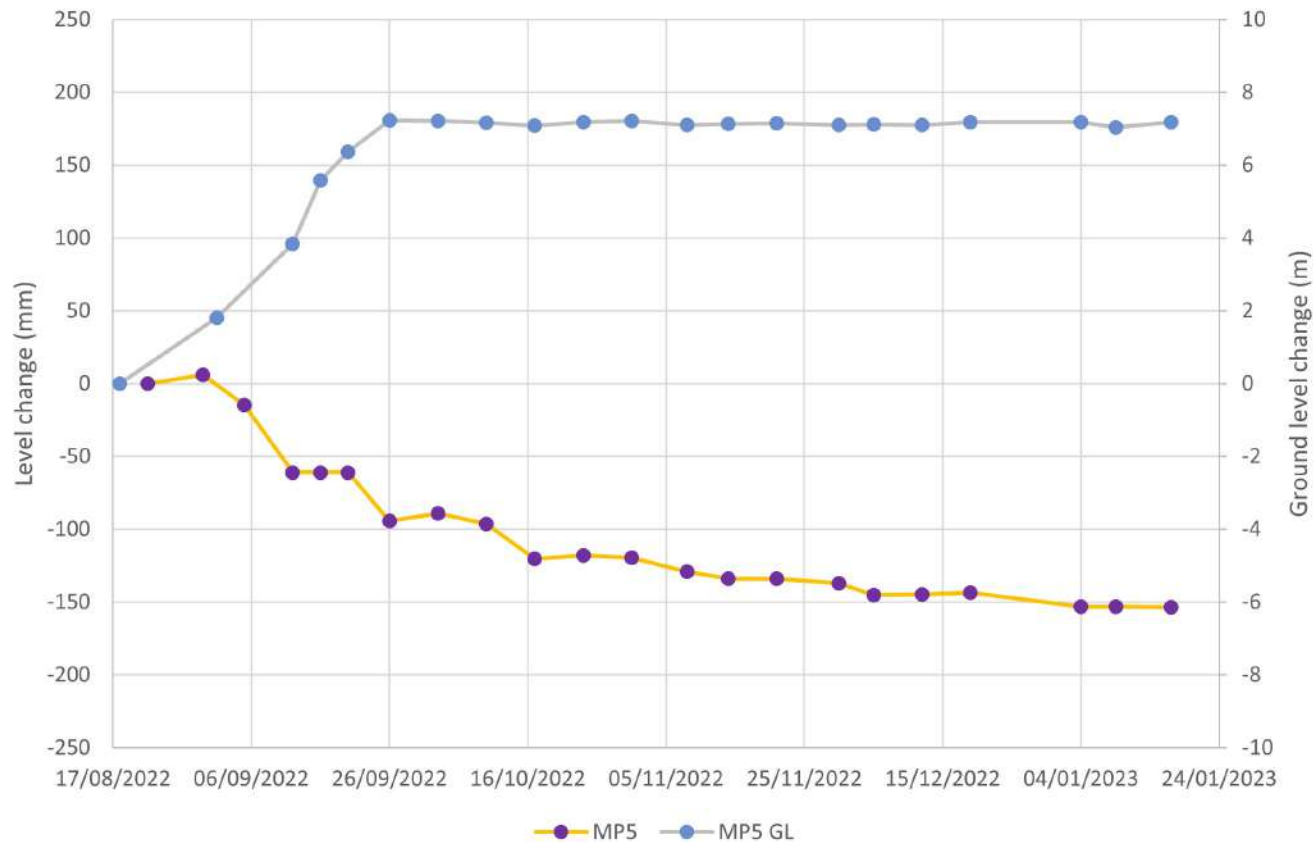
Settlement Measured - MP3



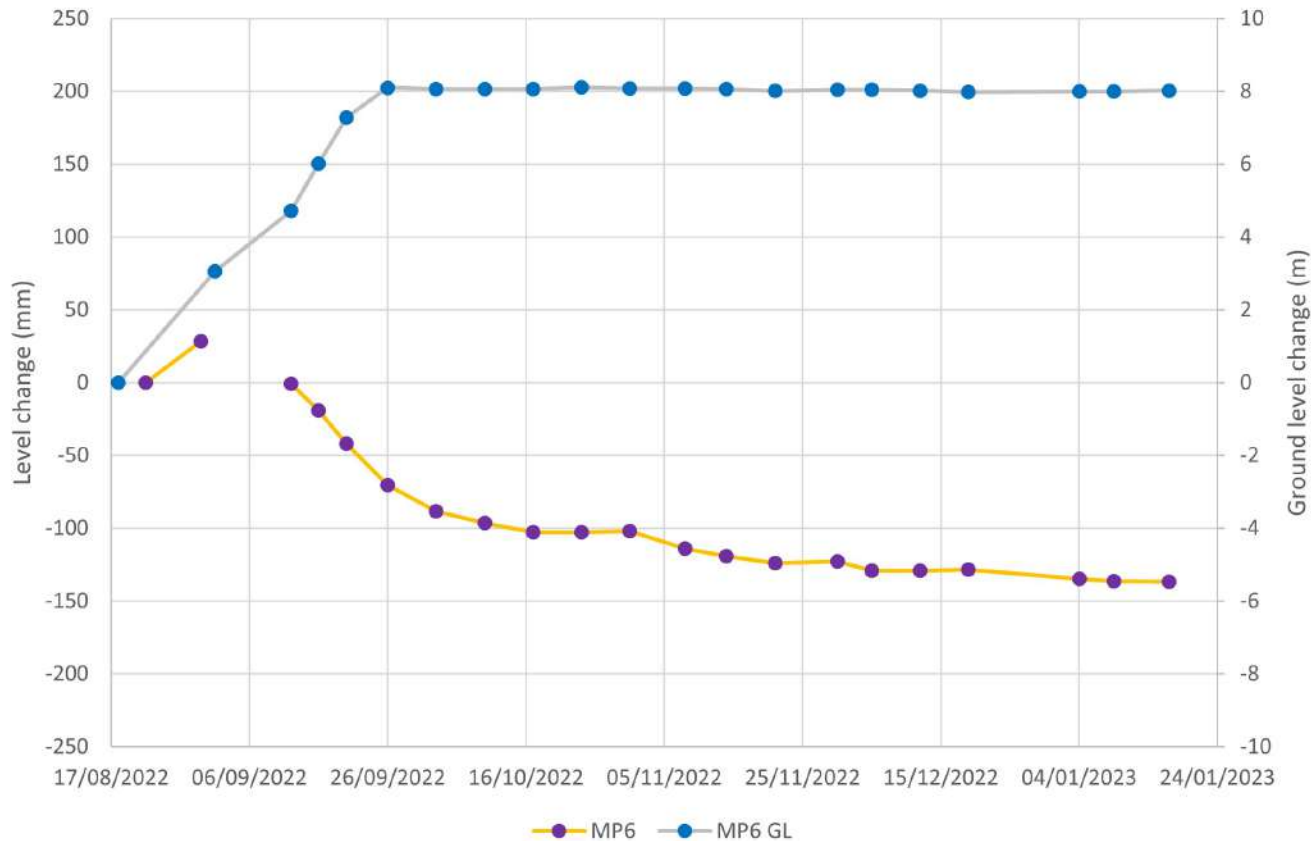
Settlement Measured- MP4



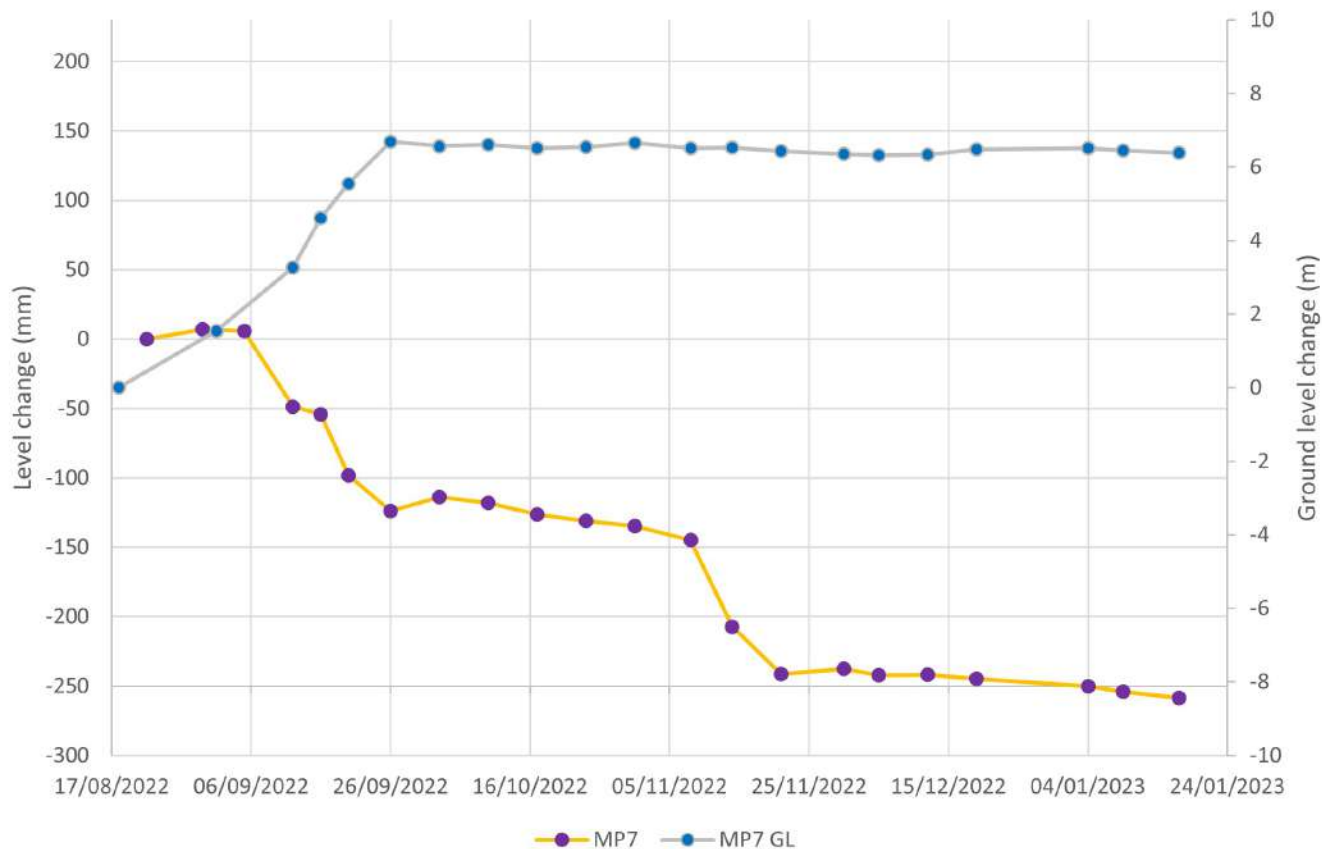
Settlement Measured - MP5



Settlement Measured - MP6



Settlement Measured - MP7



Settlement Measured - MP8

