BURO HAPPOLD

Co-op Live, Manchester

Verification Report for Drilling and Grouting Treatment of Mine Workings

BRA-BHE-XX-XX-RP-CG-0007

0042841

4 March 2021

Revision P03

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Revision	Description	Issued by	Date	Checked
P01	Draft for Comment	JH / FG	11/02/21	NP / HM
P02	For Information	JH / FG	12/02/21	NP / HM
P03	Updated, for information	JH / FG	04/03/21	NP / HM

https://burohappold.sharepoint.com/sites/0042841projectbradford/05_Discipline Specific/09_Ground Engineering/F9 Ground Eng- Site Inv/03 Reports/Grouting Verification Report/BRA-BHE-XX-XX-RP-CG-0007 rev P03.docx

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1 Introduction

1.1 General

BAM Limited (BAM) are in the process of preparing the land beneath the proposed Co-op Live Arena development at the OVG Manchester site on behalf of OVG (Europe) Limited (OVG) the 'Client'.

The site is underlain by Coal Measures including mine workings (2 no. shafts are already recorded on the site) and has been the subject of previous remediation works. A Coal Mining Risk Assessment has been prepared by Buro Happold [1] which summarises the condition of the site and risk avoidance measures to be adopted.

BAM proposed to undertake additional grouting works to further reduce the risks and uncertainty associated with the ground conditions with particular reference to proposed piling works for the main structural foundations. Cementation Skanska Limited (CSL) was appointed by BAM as the specialist contractor to design and undertake the work.

Permission to undertake the pressure grouting of the shallow mine workings within the treatment area was agreed and obtained by BAM from the Coal Authority (CA).

The main grouting works were undertaken on site between November 2020 and January 2021 and an interim verification report about those works prepared. This current and final edition of the report has been updated to include verification of the grout works within three apparent 'anomaly' locations (i.e. anomalous rock head levels encountered) which was carried out through February 2021. Full details of the works carried out to date are included in the contractor's Completion Report [2], dated February 2021.

This final Verification Report for drilling and grouting treatment of mine workings was prepared by Buro Happold on behalf of OVG Manchester and includes the following information:

- A summary of the main grout works undertaken between November 2020 and January 2021 and of the results;
- A summary of the grout works undertaken across three 'anomaly' locations (February 2021); and
- Confirmation that the works have been carried out in accordance with the CSL proposals and current industry guidelines.

This report summarises the drilling and grouting works carried out by CSL between November 2020 and February 2021 and describes the groundwater and surface water monitoring programme implemented prior to and during the works in line with the approved Groundwater Risk Assessment [3]. That programme was agreed with the Environment Agency to provide evidence that the grout works (which included injection below the water table) did not have a detrimental impact on controlled waters (the groundwater regime in the Coal Measures) and the nearby surface water (River Medlock).

1.2 Proposed Development

The proposed redevelopment is a large-scale arena structure with associated service yards. As proposed the footprint of the arena will take up most of the site. The current scheme requires significant earthworks operations to level the site and retaining solutions will be required around the perimeter. The main structure will have piled foundations comprising bored piles founded in the underlying Coal Measures strata. Selected development plans are included in Appendix A.

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1.3 Planning

1.3.1 Planning Conditions 5b and 9b

This report has been prepared to address the requirements of the Local Planning Authority with respect to the grouting work completed on site, set out in particular Conditions of the planning permission. The recent grouting activity has been undertaken under Planning Permission Ref. 127534/FO/2020, which was granted in October 2020. This formed an enabling planning permission to allow the grouting activity to take place in advance of the redevelopment of the site in accordance with Planning Permission Ref. 126431/FO/2020 relating to the new indoor arena.

This Verification Report forms the basis for discharge of conditions attached to aforementioned planning permissions, which require submission and approval of a Verification Report on completion of the grouting works. For ease of reference the wording of the Conditions (Condition 5b and Condition 9b) is presented below:

> *Upon completion of the approved intrusive site investigations and remedial works to mitigate the risk of coal mining legacy at this site, a verification report, or equivalent statement prepared by a competent person, shall be submitted for approval in writing by the City Council, as Local Planning Authority. This document shall confirm the methods and findings of the additional intrusive site investigations (including sampling and monitoring carried out) and the completed remedial works and/or mitigation necessary to demonstrate that the site has been made, safe and stable for any future development at this site.*

1.3.2 Planning Condition 7a

This current report forms part of the verification process across the site for works completed under the approved Remediation Strategy, on Planning permission Ref. 126431 submitted under CDN/20/0767. A later report will be submitted on completion of all enabling works and earthworks which will include the information compiled within this report.

The Environment Agency sought confirmation in the form of a Verification Report (this report) demonstrating the provisions of the local authority Planning Condition 7a with respect to the drilling and grouting treatment of mine workings (as a part of the approved Remediation Strategy), have been met. . Concerns initially raised by the Environment Agency regarding potential risks to controlled waters have been addressed through a programme of groundwater monitoring and visual controlled water inspections, as outlined within the Groundwater Risk Assessment [3]. Accordingly, this report should be submitted to the Local Planning Authority for their consideration with respect to Planning Condition 7a. This report provides the evidence that no significant alterations to groundwater on site has taken place as a result of the grouting work and no changes need to be made to the current approved Remediation Strategy.

For ease of reference, the wording of Planning Condition 7a is presented below:

> *Notwithstanding the Geo Environmental and Geo Technical Desk Study and gas calibration certificates stamped as received by the City Council, as Local Planning Authority, on the 30 March 2020 and 11 September 2020 respectively, prior to the commencement of development hereby approved, the following details shall be submitted for approval in writing by the City Council, as Local Planning Authority:*
>
> - *Submission of a remediation strategy.*
>
> *The development shall then be carried out in accordance with the approved remediation strategy.*

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1.3.3 Planning Condition 4

A Work Execution Plan for the CFA and Rotary Piling [4] has been submitted to the LPA under CDN/20/0767 and the LPA has confirmed the information is sufficient to discharge the condition. For ease of reference, Planning Condition 4 is included below. This Condition is attached to Planning Permission Ref. 126431/FO/2020:

> *Prior to the commencement of development, details of the method for piling, or any other foundation design using penetrative methods, shall be submitted for approval in writing by the City Council, as Local Planning Authority. The approved details shall then be implemented during the construction of the development.*

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2 The Site

2.1 Site Location and Description

The Site is centred at National Grid Reference SJ 86841, 98878, located off Sportcity Way, Manchester M11 3DU. It is located to the north east of Manchester City Centre, approximately 2.1km north east of Manchester Piccadilly Rail Station (Figure 2-1). The ground levels at the south of the site lie at approximately +60.6mOD and they fall towards the north with the lowest level at approximately +56.8mOD. The Site is approximately 4.46ha and located within the Etihad Campus in the ward of Ancoats and Beswick, Manchester. It is bound by Sportcity Way to the north, Alan Turing Way to the east, Ashton Canal to the south, and Joe Mercer Way to the west.

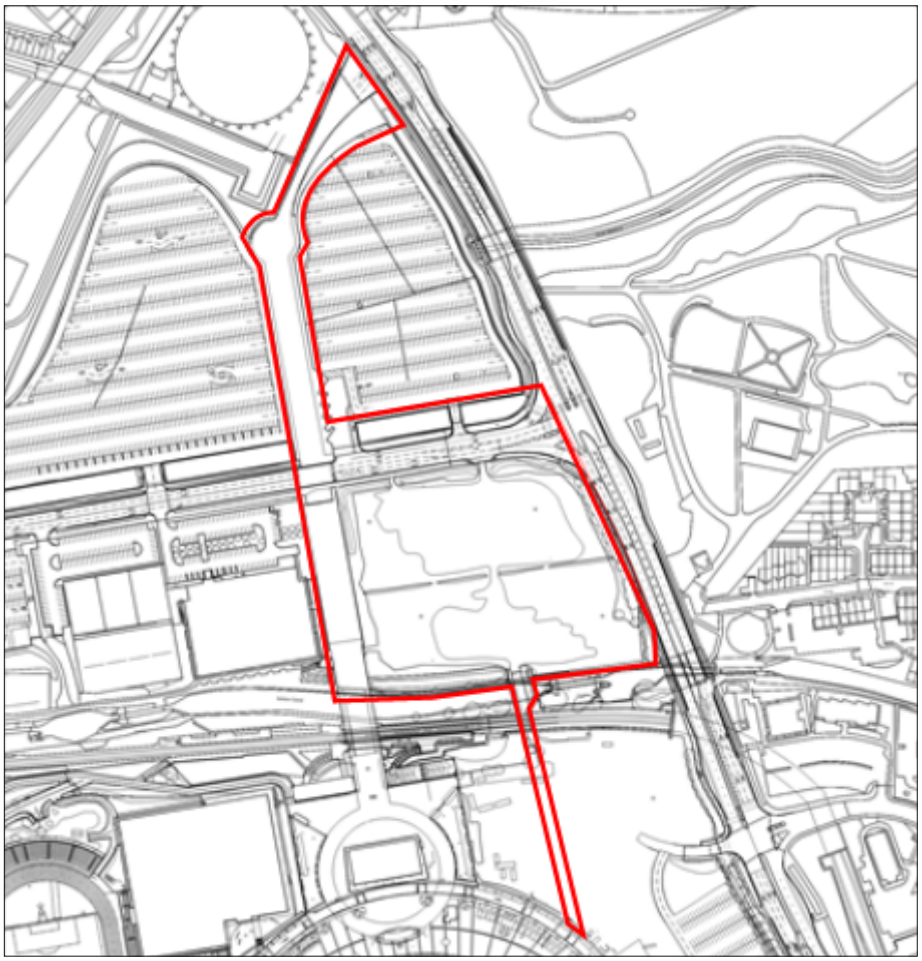


Figure 2-1 Red line boundary

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2.2 Encountered Geology

The geology below the site has been defined by data from recent and historical ground investigations, namely:

- BuroHappold Engineering, "BRA-BHE-XX-XX-RP-CG-0004 Interpretative Report," 2020 [4]
- May Gurney Geotechnical, "Site Investigation Final Factual Report," 2010 [5]
- Norwest Holst Soil Engineering Ltd, "Factual Site Investigation Report at Bradford Road Gas Works, Manchester," 1986 [6]
- Structural Soils "OVG Manchester Factual Report on Ground Investigation, Report No. 765000-1 (04) March 2020 [7]

A ground investigation location plan is shown in Appendix A.

A summary of the geology encountered across the site is as follows:

- Made Ground (Soft to firm brown black sandy gravelly CLAY. Locally sandy clayey GRAVEL and occasionally fine to coarse SAND. Constituents include ash, coal, clinker, brick, sandstone, limestone, pottery, concrete, rootlets, wood, plastic, rebar.) – varying in thickness between 1.3-7.2m.
- Alluvium (Soft to firm orangish brown slightly gravelly sand CLAY) - varying in thickness between 0.30 – 2.0m.
- River Terrace Gravels (Medium dense to very dense orangish brown slightly gravelly to gravelly clayey fine to coarse SAND) - varying in thickness between 0.60 – 3.0m.
- Glacial Till (Soft to very stiff brown gravelly CLAY) - varying in thickness between 0.90 – 12.0m
- Coal Measures (Very weak to weak grey MUDSTONE with laminations of light grey siltstone and/or fine-grained sandstone. Discontinuities are closely spaced, planar smooth or undulating rough, clean, locally polished or clay smeared. Locally, bands of very weak black COAL. – encountered at depths varying between 11.50 – >18.0m

The Made Ground and superficial deposits are reasonably thick across the site, with typically between 13-14m of superficial deposits above the top of the rockhead, except in the far north-west corner where there is between 16-17m. Further details of the ground conditions encountered on site are presented in the above mentioned reports.

2.3 Hydrogeology

The superficial deposits have been classified as Secondary (undifferentiated) Aquifer. Secondary (undifferentiated) Aquifer is assigned where it is not possible to attribute either category (Secondary A or Secondary B) to the rock type.

The Coal Measures are classified as Secondary (A) Aquifer, defined as permeable layers capable of supporting water supplies at a local rather than strategic scale and in some cases forming an important source of base flow to rivers.

2.4 Hydrology

The River Medlock is located 24m to the north-west of the site and flows south and west toward the River Irwell in Manchester city centre. The downstream water level of the River Medlock (recorded on 1st July 2008, at the New Viaduct street culvert) is +41.7mOD and the upstream water level recorded on the same day at the Sportcity culvert is +42.9mOD.

The Ashton Canal is located along the southern boundary of the site (8m south). A topographical survey records the east side of Lock No. 9 (SE of the site) is at approximately +60.4mOD and west of the lock (SW of the site) the ground drops to +56.7mOD. A steep embankment up to the site is present on the south-west side with the site at approximately +59.0mOD.

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3 Drilling and Grouting Works

3.1 Historical Drilling and Grouting Treatment Works

Historical drilling and grouting treatment works have taken place on site due to the identification of a number of shaft locations encountered on site and as such, the previous treatment works validation and verification reports have been referred to below.

- Buckingham Group Contracting Ltd, "Verification Report," Manchester, 2011 [8]
- BWB Consulting Ltd, "Master Mine Stabilisation Works Validation Report," 2011 [9]
- BWB Consulting Ltd, "Area C Mine Stabilisation Works Validation Report," 2011 [10]

The below plan illustrates the previous treatment area beneath the proposed development site.

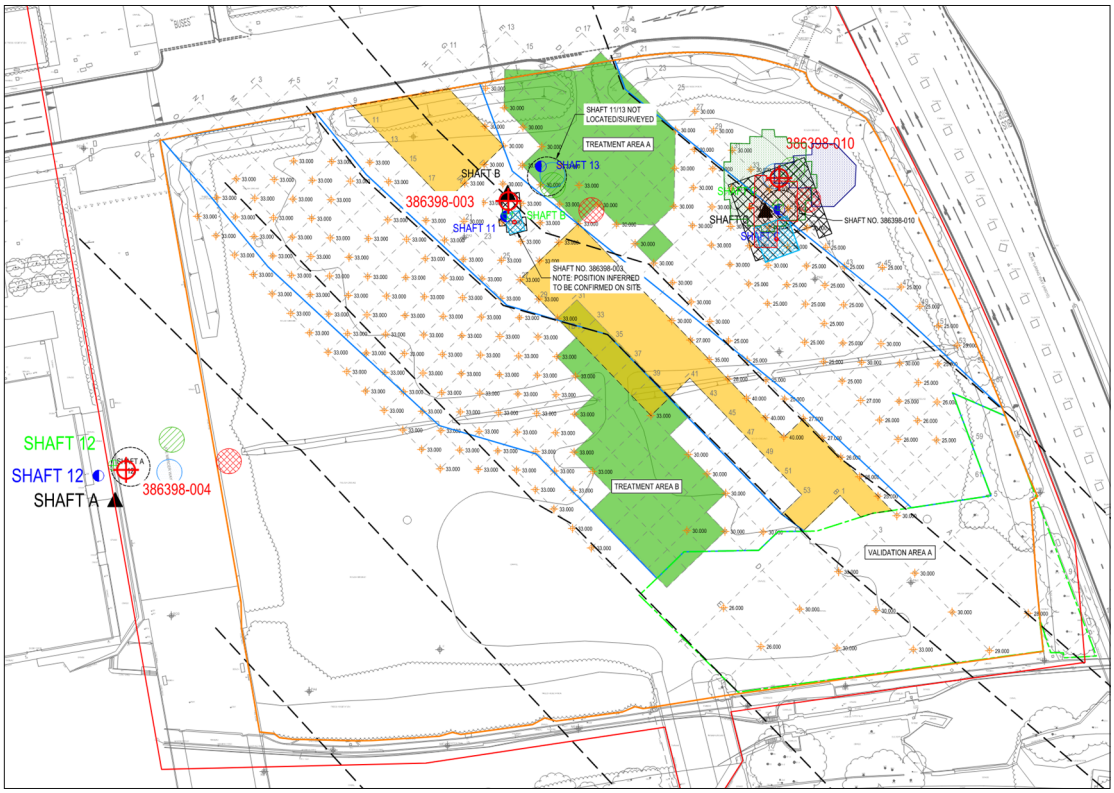


Figure 3-1 Plan showing BWB grout works and historical mine search areas, presented in full within Appendix A

3.2 Summary of the CSL Drilling and Grouting Philosophy

The previous site investigation, treatment works and the proposed substructure design of the Arena development, have formed the basis for further grouting works to be carried out across the site. A summary of the CSL Drilling and Grouting Philosophy is outlined below, presented in full within Appendix B:

- Records indicate that the Bradford Four Foot and Bradford Three Quarters seams have previously been grouted across part of the site (see Figure 3-1). The previous grouting and validation work ([10], [9]) will include treatment up to 30mbgl identifying two seams of coal.

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- A shallow seam was identified between +45.0mAOD and to +25.8mAOD at thicknesses of between 0.08m – 1.15m. It is assumed that this seam is the Bradford Three Quarter.
- A deeper seam was identified at a depth of between +43.4mAOD to +10.1mAOD with an approximate thickness between 0.01 – 1.62m. It is assumed that this seam is the Bradford Four Foot.
- Due to the depth of the piles in some areas of the site, consideration has been given to the potential treatment of the deeper 18-inch seam. The initial probing was used to assess the required depth of treatment.

Initial probe drilling shall be undertaken on a radial 21m grid to determine the effectiveness of the previous grouting and provide initial confirmation of the seam levels and thickness. A 14m and 7m grid (effectively a staged 7m grid) will then be implemented to depths determined by the initial 21m probing grid. This grid will then be closed down, effectively a 14m primary with 7m secondary grid, to provide a 7m grid. A 3.5m grid will be carried out upon review of the drilling and grout takes.

For strength testing, a set of six test cubes will be taken from the grouting pipe at surface positions every 24 hours. The cubes will be marked, handled, stored and tested by an approved independent testing laboratory in accordance with BS: 1881. The Contractor will provide projected 3, 7, 14 and 28 day strengths of the grout. Crushing strengths shall not be less than 1.0 MN/m2 at 28 days. The injection pressure will be held for an appropriate period of time (approximately 5 minutes). Appropriate casing, capable of sustaining the test pressures, will be used. Unacceptable "voidage" will be determined as present within the ground should grout takes exceed 1 tonne. If this is encountered additional validation holes will be drilled and grouted in the immediate vicinity.

The full details of the Drilling and Grouting Philosophy is presented within Appendix B and the works carried out are presented within the contractors Completion Report [2].

3.3 The Programme

The main phase of works was undertaken between 16th November 2020 and 29th January 2021 and comprised the treatment of the proposed development site. Some supplementary works beyond this main programme were completed in February 2021 (see below, Section 3.5).

3.4 Obstructions

During the drilling and grouting works, a number of obstructions were recorded in the northwest of the site. These obstructions are in connection with the previous land use and comprise a number of reinforced concrete structures. CSL have carried out inclined drilling to grout beneath these obstructions. Access restrictions for drilling on the site also included an exclusion zone for the UU sewer crossing the site and existing cables which have not yet been decommissioned. In these areas inclined drilling and grouting was undertaken.

3.5 Anomalous Features

3.5.1 Probing Investigation

During the drilling and grouting works, 3 No. treatment holes recorded anomalies in bedrock level" at locations BS13, BK09 and BY11. These anomalous features, are recorded to extend to depths of the order 42m (BK09), 28m (BS13) and approximately 20m (BY11) and are noted to be significantly deeper than rockhead levels in adjacent probe locations. These locations were further investigated by a programme of inclined probe drilling followed by vertical probe drilling. The approach to dealing with these locations was consistent with the approved methodologies under Planning

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Permission Ref 127534/FO/2020.. During this treatment work, groundwater monitoring and visual inspections to the River Medlock were continued.

All 3 No. locations were considered to be anomalous features within the ground conditions where locally deeper rockhead levels had been encountered and which vary in plan size and depth. The 3 No. features have subsequently been treated in accordance with the CSL specification and Coal Authority guidance. The 3 No. locations have been summarised in Table 3-1 below.

Table 3-1 Anomalous Location Investigation Summary

Area	Feature/Gridline Reference	Possible Feature Plan Dimension (m)	Depth to Base (m)	Total Grout Acceptance (m^3 [T])	Centre Point (X)	Centre Point (Y)
A	BS13	2.0 x 1.0	28	8.85 [3.125]	386827.943	398897.282
A	BK09	1.0 x 0.50	42	32.60 [11.512]	386798.716	398904.998
B	BY11	2.25 x 1.25	19.50	1.0 [0.353]	386844.667	398907.991

A programme of targeted probe drilling undertaken at the identified positions (BS13, BK09 & BY11) confirmed these to be anomalous features by virtue of the observed variation in bedrock level compared with adjacent probe locations. The probing report notes that drilling suggests "soft ground or back filled" conditions but does not note the presence of open voids during the probing. The origins of these features have not been established with certainty however pressure grouting was undertaken as part of the remediation works.

3.5.2 Treatment Procedure

A shaft frame and platform (bailey bridge), generally 20 m across, was constructed centrally over the feature. All stabilisation works were carried out from this platform.

A series of treatment boreholes were drilled to the base of the feature at various increments between 0.25m to 1.0m and orientated north – south and east - west. The boreholes were cased off to just above the base of the feature and was then reverse stage pressure grouted (1.5psi) at each position, in 2.00 m lifts, to the surface.

Additional validation holes were subsequently drilled and grouted for locations BS13 and BK09 utilising the same process as above to ensure the effectiveness of the treatment. The validation holes were proven to be successfully validated in accordance with the CSL philosophy and validation methodologies. Location BY11 was considered by the contractor to not require additional validation testing due to the nominal grout take and the dimension of the anomaly.

Full details of the treatment works of each anomalous feature are provided in the CSL completion report (Appendix M, Report Ref. BRA-CSL-ZZ-ZZ-RP-X-00900)

3.6 Ghost Shaft

A conjectured shaft or "Ghost Shaft" was previously noted in the Coal Mining Risk Assessment, this was not recorded by the Coal Authority, and was probably a duplicate of an existing known shaft. Probing in the conjectured area during the drilling and grouting treatment works did not provide any further evidence of this shaft.

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4 Verification

4.1 Summary of risks

A groundwater risk assessment [3] was completed prior to the grouting works commencing, to be read in conjunction with the approved Remediation Strategy [11]. The sensitive receptors, pathways and the assessed risk with regard to the site-wide grouting works are summarised below:

- River Medlock – Infill grout driving contaminated water to the surface or via permeable horizons - **Low**
- Ashton Canal – Surface water run-off – **Low**
- Existing Utilities – Grout travelling with water flow – **Very Low**

Hazard realisation and mitigation measures were provided to ensure these potential risks were appropriately managed throughout the grouting programme. For the River Medlock, this included groundwater monitoring across the site together with visual inspections at either end of the culvert northeast and southwest of the site. For Ashton Canal, this included control of surface operations to ensure no potentially hazardous materials were able to migrate toward the sensitive receptor. All existing utilities were removed prior to the grout treatment work, with the exception of the UU sewer, which formed part of the grout works, to be sealed and infilled.

4.2 Regulatory Position Statement

A response to the EA Regulatory Position Statement (RPS 108) was completed prior to any grout work taking place and formed part of the groundwater risk assessment report [3]. The position of this response remains mostly unchanged, but has been updated below to reflect the drilling and grouting works completed:

The location does not fall within a groundwater Source Protection Zone 1: *No.*

The injection is solely below the ground surface: *Yes, injection of grout was below rock head level (>11.5mbgl), down to 62mbgl (SW corner).*

The activity complies with the requirements of any necessary planning approvals: *Yes.*

You have carried out an assessment of the ground conditions and potential receptors and are able to confirm the pollution will not occur from your operation: *Yes, full assessment provided within the Buro Happold Interpretative Report* [4] *which confirms there are limited pollution pathways to sensitive receptors (i.e. River Medlock). This has been further clarified by the risk assessment presented within the Groundwater Risk Assessment* [3].

The operation does not involve the discharge of hazardous substances or non-hazardous pollutants other than those inherently part of the solid content of the grout or other media essential additives: *No, see Appendix B (CSL Drilling & Grouting Philosophy) and CSL Completion Report* [2] *for details of the solid content of the grout media used.*

The materials forming the grout or other media comply with all relevant waste protocols, such as the quality on use of PFA, and any other relevant code of practice: *Confirmed. See Appendix B (CSL Drilling & Grouting Philosophy).*

There will be no liquid discharge other than slurry formed by grout or other media in admixture with water: *Confirmed. See Appendix B (CSL Drilling & Grouting Philosophy).*

The activity does not constitute or form part of another regulated facility such as an installation, waste or mining waste operation as listed in EPR 2010 Regulation 8: *No.*

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4.3 Groundwater monitoring

4.3.1 Baseline readings

Baseline groundwater monitoring took place daily between 19th October and 17th November 2020. There are a total of nine monitoring locations across the site, as shown on the site location plan within Appendix A. Each location was monitored once a day, for approximately 4 weeks (there are a total of 170 baseline monitoring readings). The data is presented in Figure 4-1 below.

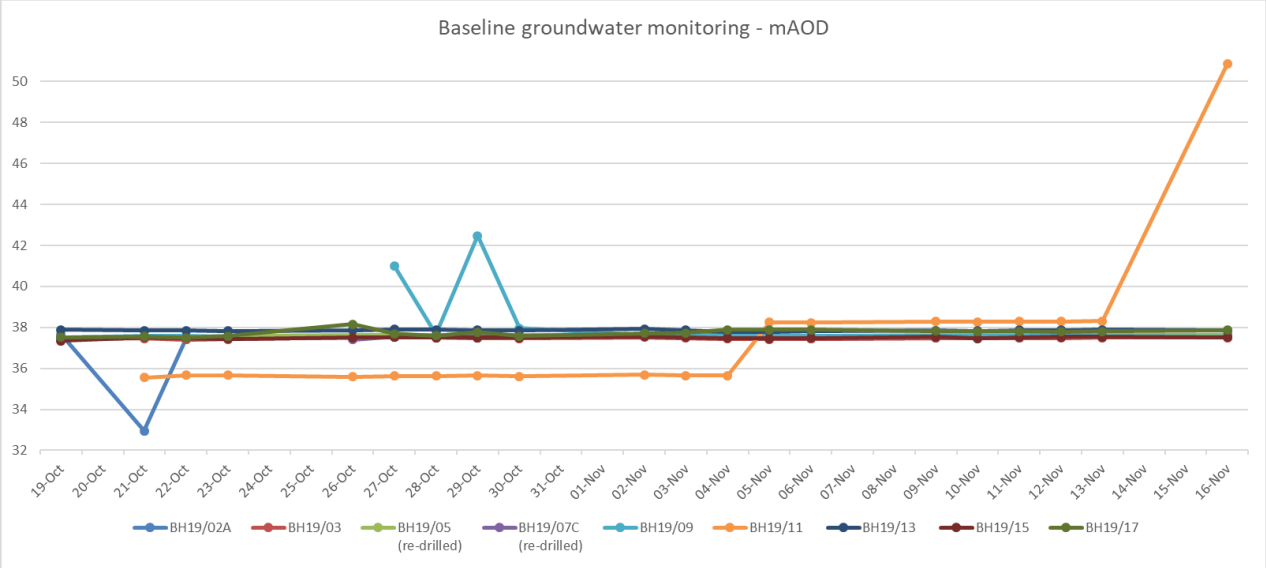


Figure 4-1 Baseline groundwater monitoring

Two locations had to be re-drilled prior to the groundwater monitoring commencing, to replace the damaged monitoring wells already on site, these were BH19/05 and BH19/07C. BH19/07c did not detect any water during the initial reading taken on 23rd October and the base was recorded as 18mbgl. The Contractors confirmed this borehole was drilled and installed to 25mbgl so returned to site and cleared the base of the well. Thereafter the base of the well was generally recorded at 24.2mbgl and groundwater levels were typically consistent with those recorded elsewhere on site.



Photograph 4-1 BH19/09 flooded installation

There were some issues regarding the installation at BH19/09. Following heavy rainfall, water was flooding the area around that well and causing surface water to flow into the installation. This resulted in anomalous readings between the 26th October and the 29th October (see adjacent, Photograph 4-1). Remedial action included excavating a sump around the well to prevent water flowing in, followed by installation of raised caps 9th / 10th December 2020.

BH19/11 included some variable readings during the baseline monitoring, with a recorded 'false' water level of 21.4mbgl throughout the first week of monitoring. It is believed this may have been triggered by dampness on the side of the monitoring pipe or confusion in the readings when they were being taken. The actual recorded reading during this initial week was recorded as approximately 24mbgl. Later in the baseline period this changed to 21.4mbgl and remained consistently at this level, with one exception on 16th November. No obvious signs of surface water ingress or

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previous heavy rainfall were noted on this occasion however grout works had also not commenced. That reading from 16th November is considered to have been erroneous as later readings (once grouting had commenced) recorded a steady level at around 21.8mbgl (+38.1mAOD).

Generally, baseline readings were recorded across all locations around +37.6mAOD throughout the four-week period.

4.3.2 Monitoring during the main CSL grout programme

Once CSL commenced with the main programme of grout work, BAM took groundwater readings twice a day, daily throughout this programme (17th November 2020 through to 28th January 2021). Thereafter, groundwater readings were reduced to once daily to continue monitoring the groundwater whilst the grouting in areas of 'soft spots' took place. The results of the groundwater monitoring up to and including the 19th February 2021 are illustrated below.

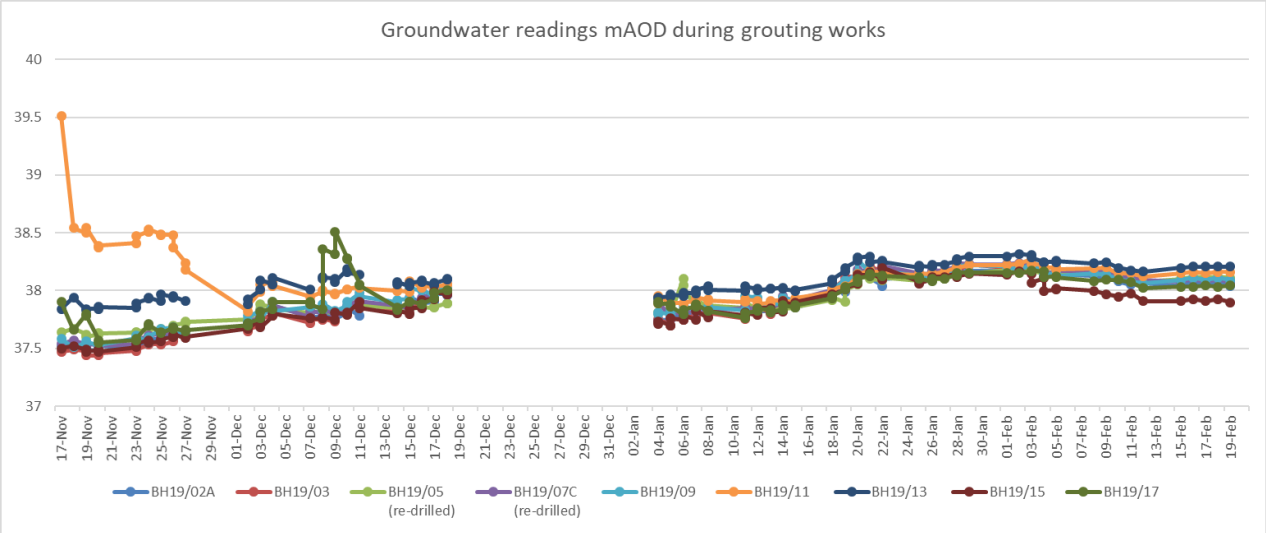


Figure 4-2 Groundwater monitoring during grouting works

Initially there were some variable groundwater readings associated with BH19/11, and again across multiple wells following installation of the raised cap covers. Overall, groundwater readings did not change significantly with a slight upward trend of <1.0m. The period of monitoring took place during heavy rainfall which was reflected in the monitoring data. There was no indication of local groundwater rise associated with grouting activity. The groundwater levels in the Coal Measures remained below the culvert level (downstream +41.7mAOD and upstream +42.9mAOD [data recorded in 2008]) throughout the grouting programme.

In addition to the groundwater monitoring, samples were occasionally collected using a bailer to inspect the clarity of the water. Examples of some of the samples are shown below in Photograph 4-2 to Photograph 4-4, taken on 14th December 2020. The majority of samples were retrieved as either clear or with slight cloudiness to them. On a couple of occasions, oily globules were observed within sample tube for BH19/07C. BAM proceeded with monitoring this location more carefully, the globules did not increase in density and on days following the encounter samples returned as clear. These globules can be seen in Photograph 4-5. On all sampling occasions following the contamination encounter, samples were recorded as clear. Oily sheens were also recorded in some locations within the Secondary A Aquifer during the previous groundwater monitoring (as part of the Structural Soils Ground Investigation). These sheens and globules are considered to represent residual contamination associated with the former industrial site.

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Photograph 4-2 BH19/02A water sample



Photograph 4-3 BH19/03 water sample



Photograph 4-4 BH19/05 water sample



Photograph 4-5 BH19/07c contamination: oily globules present

4.4 River Medlock visual inspections

Two locations were visually inspected twice daily (morning and afternoon) throughout the main programme of works. One location was inspected at the eastern entrance of the culvert, SW1 and a second location, downstream of the grouting works at the western exit of the River Medlock, SW2.

Throughout the main programme of grouting, no visual changes to the water were recorded at either location. BAM continued visual inspections of the river during grouting of the anomalies once daily . Below are some of the photographs taken at the beginning, middle and end of the main grout works.

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Photograph 4-6 SW1 27th November 2020 in the afternoon



Photograph 4-7 SW2 27th November in the afternoon



Photograph 4-8 SW1 15th December 2020 in the morning



Photograph 4-9 SW2 15th December 2020 in the morning



Photograph 4-10 SW1 4th February 2021 in the afternoon



Photograph 4-11 SW2 4th February 2021 in the afternoon

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4.5 Grouting Validation Works

CSL undertook grouting validation tests at 21 no. locations across the site including 4 no. locations below the Arena floor outside the main area of recent grout treatment. CSL also undertook additional validation tests during the course of the grouting works to further validate specific locations. Full details of the validation testing undertaken are included in the contractor's Completion Report [2].

4.6 Independent site inspections

Buro Happold carried out three inspections over the three-month grouting period (17th December 2020, 18th January 2021 and 28th January 2021). These inspections were primarily to witness some of the validation hole locations but also included inspections of the River Medlock. During these visits a brief induction was provided and personnel escorted around the site. In general, the inspections found the site to be in good order with the appropriate environmental management in place, including appropriate PPE worn by all personnel.

Buro Happold witnessed a total of 11 of the 21 No. validation hole locations with a BAM representative witnessing the remaining (10 No.). The effectiveness of the treatment works was assessed using grout injection tests in each of the test holes under a constant pressure of up to a maximum of 30 PSI (200kN/m^2). Full details of the validation testing is provided in the contractor's Completion Report [2]. The Buro Happold site visit reports are presented in Appendix C.

Soil bunds were created around the northwest corner along the north of the site to control surface water and prevent any off site migration of surface water run off onto Sportcity Way (see Photograph 4-12). Soil bunds were also constructed at the southern end of the site to prevent surface water migration off site into Ashton Canal (see Photograph 4-13). Accordingly, there was no off-site run off during the works.



Photograph 4-12 Bunds in the northern part of the site



Photograph 4-13 Bunds in the southern part of the site

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4.7 Unexploded Ordnance (UXO)

UXO risk on site was assessed as Moderate by BAE Systems Environmental [12]. A Safety and Awareness Briefing for unexploded ordnance was provided to all CSL workforce upon their commencement on site by EOD Contracts Ltd. The induction presentation has been provided by BAM for verification purposes. No suspect UXO was encountered during the works.

4.8 Ad hoc responses – ground gas

Ground gas monitors were connected to the rigs during the grout works. On 27th November 2020, elevated readings of hydrogen sulphide occurred within BF-03 (northwest corner of the site). CSL personnel working with the rig also detected an odour so stopped works immediately and moved away from the rig. The location was left to 'vent' over the weekend before commencing with grout works again on the Monday morning (30th November). No odour / gas was recorded on Monday 30th (or subsequently) so works continued.

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5 Conclusion

5.1 Grout works

On the basis of site observations, drilling and grouting records, validation boreholes Buro Happold can confirm that the drilling and grouting works generally accord with the contractor's proposals including the Drilling and Grouting Philosophy (Appendix A).

Depending on the location of the identified anomalous feature and the requirements of the Coal Authority, further engineering works, in addition to the drilling and grouting stabilisation undertaken, may be required.

CSL has confirmed that the records have been reviewed and they are satisfied with the works carried out across the site and consider the site to have been successfully treated for the intended purpose in support of the proposed foundation piling design. CSL has also confirmed they are satisfied with the drilling and grouting treatment works within the areas of encountered obstructions and areas affected by access restrictions.

A conjectured shaft or "Ghost Shaft" was previously highlighted within the CMRA. Probing in the conjectured area during the drilling and grouting treatment works did not provide any further evidence of this shaft.

5.2 Groundwater monitoring and visual inspections

Using the information provided by BAM and CSL, together with independent inspections completed by Buro Happold, achievement of the remedial objectives set out in the Groundwater Risk Assessment [3] and Remediation Strategy [11] has been successfully delivered throughout the grouting works programme, up to and including the 19th February 2021.

The specific aim of the Groundwater Risk Assessment [3] was:

i. To ensure that the proposed grout works (which include some injection below the water table), will not have a detrimental impact on controlled waters (the groundwater regime in the Coal Measures) and the nearby surface water (River Medlock).

The specific aims of the Remediation Strategy [11] were:

i. To ensure that potential risks from land contamination at the site to people and the environment are appropriately mitigated in both the short and the long term;
ii. To ensure that the development itself can be constructed safely without ground contamination giving rise to unacceptable risks to workers and neighbours.
iii. To meet specific planning conditions put in place by the Local Planning Authority.
iv. To ensure Client expectations are satisfied.
v. To minimise long term liabilities.

These aims informed the contamination related objectives, engineering related objectives and management related objectives which are set out in detail within Section 4 of the Strategy.

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5.3 Compliance with Remediation Strategy

5.3.1 Grouting works

All grout works were completed in line with the CSL Drilling and Grouting Philosophy, the Remediation Strategy and the Groundwater Risk Assessment. No significant grossly contaminated material was encountered during the works. On one occasion hazardous ground gas (suspected hydrogen sulphide) was encountered, Buro Happold were immediately informed and the recommended actions carried out by CSL (venting over the weekend before continuing with grout works). Contamination was observed within some of the water samples taken during the groundwater monitoring. This contamination was in the form of oily globules and / or sheen. Previous groundwater monitoring also recorded oily sheen on groundwater. These sheens and globules are considered to represent residual contamination associated with the former industrial site.

5.4 Long-term monitoring

With all grout treatment works now complete, no further monitoring of the groundwater wells or visual inspections of the River Medlock are required. This corresponds with the Work Execution Plan piling risk assessment [4] submitted to the LPA under CDN/20/0767.

5.5 Status of site at completion of works

This report forms part of the verification process across the site for works completed under the approved Remediation Strategy. A later report will be submitted on completion of all enabling works and earthworks which will include the information compiled within this report.

Based on the above, it is concluded that the provisions of the local authority Planning Condition 7a have been met with respect to the drilling and grouting treatment works which form part of the approved Remediation Strategy. Initial concerns raised by the Environment Agency have been addressed through a programme of groundwater monitoring and visual controlled water inspections, as outlined within the Groundwater Risk Assessment. Accordingly, this report should be submitted to the Local Planning Authority for their consideration with respect to Planning Condition 7a. This report provides the evidence that no significant alterations to groundwater on site has taken place as a result of the drilling and grouting treatment work and no changes need to be made to the current approved Remediation Strategy.

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APPENDIX A Proposed Development Plan & Site Plans

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REVISIONS		
REV	DATE	DESCRIPTION
P01	21.10.2019	STAGE 3 DESIGN FREEZE
P02	29.11.2019	DRAFT RIBA STAGE 3

KEY PLAN



- Auditorium
- Back of House Circulation
- Concessions & Catering
- Concourse
- Corridors/Circulation
- Hospitality
- Kitchens
- Medical
- Merchandise
- Offices
- Plant
- Riser
- Storage
- Ticketing
- Vertical Circulation
- WCs

OWNERSHIP BOUNDARY
LINE FLOOR ABOVE
LINE FLOOR BELOW

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0 5 10 20 m

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PROJECT NAME
OVG MANCHESTER

DRAWING TITLE
LEVEL 01 - ALL ZONES

RL 61.62

STATUS	PROJECT No.
DRAFT RIBA STAGE 3	4933
DATE	SCALE	SIZE
19.07.2019	1 : 250	A0
DRAWN	CHECKED	APPROVED
MC	PG	DS

PROJECT	ORIGIN	ZONE	LEVEL	TYPE	ROLE	DRAWING	REV
BRA-POP-	ZZ-	01-	DR-	A-		0103	P02

DRAFT

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CONSTRUCTION.

MAINTENANCE/CLEANING/OPERATION.

DECOMMISSIONING/DEMOLITION.

Notes

1848 RIVER MEDLOCK POSITION, SUBSTATION & TANKS LOCATIONS - GROUNDSURE.

SHAFT A - ARUP, MINESHAFT AND MINE WORKINGS, FIGURE 14, 15.10.08.

SHAFTS B & C - BWB CONSULTING, AS BUILT MINESHAFT POSITIONS, DRAWING NO. NTH/185/201, REVISION P1, 14.03.11.

SHAFT 13 - ARUP, MINESHAFTS AND MINE WORKINGS, FIGURE 14, 15.10.08.

COAL SEAMS AND FAULTS - ARUP, COAL SEAMS AND MINESHAFT DETAILS, DRAWING NO., ARP-LAY-CG-132, REVISION C, 01.03.10.

COAL PROBE BOREHOLE LOCATIONS - NORWEST HOLST ENGINEERING, MINE SHAFTS LOCATION SITE PLAN, DRAWING NO. 14/6873/AO, AUGUST 1986.

BASE OF MADE GROUND/TOP OF NATURAL GROUND - ARUP, BASE OF MADE GROUND CONTOURS, DRAWING NO. ARP-LAY-CE-242, REVISION C, 01.03.10

CONTAMINATION HOTSPOTS, HISTORICAL TANK & SUMP - ARUP, EARTHWORKS VALIDATION PLAN, DRAWING NO. CLC060405, 23.01.04.

2004 SITE TREATMENT WORKS - ARUP, DRILLING AND GROUTING TREATMENT LOCATION PLAN, DRAWING NO. CLC060403, 23.01.04.

2011 SHAFT A - C TREATMENT - BWB CONSULTING, FIGURE 2 AREA C MINESHAFT INVESTIGATION, VALIDATION AND TREATMENT WORKS, DRAWING NO. NTN185/03/AREAC/F2, FEBRUARY 2011.

TREATMENT AREA A - BWB CONSULTING, FIGURE 5 TREATMENT AREA A MINE STABILISATION WORKS, DRAWING NO. NTH185/03/AREAC/F5, JANUARY 2011.

TREATMENT AREA B - BWB CONSULTING, FIGURE 6 TREATMENT AREA B MINE STABILISATION WORKS, DRAWING NO. NTH185/03/AREAC/F6, JANUARY 2011.

VALIDATION AREA - BWB CONSULTING, FIGURE 4 VALIDATION AREA A MINE STABILISATION WORKS, DRAWING NO. NTH185/03/AREAC/F4, FEBRUARY 2011.

BURIED OBSTRUCTIONS - BUCKINGHAM GROUP CONTRACTING, SURVEYED OBSTRUCTIONS, DRAWING NO. 005, REVISION A, 11.02.11.

HISTORICAL REMEDIATION - ARUP, PREVIOUS ENABLING AND REMEDIAL WORKS, FIGURE 15, 25.09.08.

RESIDUAL CONTAMINATION - ARUP, POTENTIAL RESIDUAL CONTAMINATION, FIGURE 16, 15.10.08.

SITE BOUNDARY

SITE CONSTRAINTS

HISTORICAL FEATURES

EXISTING Ø375 SEWER

EASEMENT - 3M FROM SEWER EXTENTS

BURIED OBSTRUCTIONS (SURVEYED 2011)

C — APPROX. SHAFT LOCATION

COAL SEAM

FAULT

COAL PROBE - NORWEST HOLST 1986

BOREHOLE - BURO HAPPOLD 2019

BOREHOLE - MAY GURNEY 2009

TRIAL PIT - BURO HAPPOLD 2019

BASE OF MADE GROUND/TOP OF NATURAL GROUND - 1M INTERVALS (mOD)

CONTAMINATION HOTSPOT

SITE TREATMENT

GROUT TREATMENT WORKS - 2004

SHAFTS A - C EXTENTS OF PROBING - 2011

ENCOUNTERED SHAFT AND EXTENT OF PLUG/CAP - 2011

GROUT TREATMENT WORKS - 2011

VALIDATED AREA - 2011

SITE REMEDIATION

BRADFORD ROAD GASWORKS - AREA 1 1998

BRADFORD ROAD GASWORKS - AREA 5 1998

SPORTCITY WEST 2002

EASEMENT - 8M FROM EXTENT OF CULVERT

CULVERT (RIVER MEDLOCK)

MINING ADIT

CP4

CP3

CONCRETE BLOCKS. REMEDIATED DOWN TO 8mBGL. SIMILAR FEATURES MAY BE PRESENT AT SHALLOWER DEPTHS FURTHER SOUTH.

PIT TERMINATED ON HARD STRATA AT 2.0 mBGL

CONCRETE SLAB AT 1.6 mBGL (0.6m IN LENGTH). CONCRETE SLAB AT 2.1 mBGL (0.7m LENGTH). PIT TERMINATED ON HARD STRATA AT 2.3 mBGL.

TERMINATED ON HARD STRATA - 2.2mBGL

TERMINATED ON HARD STRATA - 2.2mBGL

OBSTRUCTION 50.95 - 50.35 mOD

CONCRETE & REINFORCED CONCRETE 50.78 - 49.98 mOD

OBSTRUCTION 50.87 - 49.87 mOD

PIT TERMINATED ON HARD STRATA AT 1.1 mBGL

PIT TERMINATED ON HARD STRATA AT 1.9 mBGL

COBBLES OF REINFORCED CONCRETE AT 3.3 mBGL. DIFFICULT TO EXCAVATE AFTER 3.5 mBGL.

PIT TERMINATED ON HARD STRATA AT 0.8 mBGL

OP19/01(CONCRETE)

JMW CRIB WALL FOUNDING SLAB AT 1.0 mBGL

SHAFT A (12)

REMOVAL OF SPENT OXIDE COVERED DEMOLITION RUBBLE IN FOUR BAYS OF THE PURIFIERS.

RIVER MEDLOCK - 1848 LOCATION

JMW CRIB WALL FOUNDING SLAB AT 1.7 mBGL

PIT TERMINATED ON HARD STRATA AT 2.2 mBGL

CONCRETE OBSTRUCTION AT 2.2 mBGL. CONCRETE OBSTRUCTION AT 2.7 mBGL. MEDIUM TO HIGH BOULDER CONTENT FROM 3.0 mBGL.

METAL SHEET (0.6M LONG) AT 1.5 mBGL, PIT TERMINATED ON HARD STRATA AT 2.2 mBGL

JMW CRIB WALL FOUNDING SLAB AT 3.2 mBGL

REMOVAL OF SPECIAL WASTE AND CONTAMINATED WATER. WORKS INCLUDE MINESHAFT TREATMENT.

IDENTIFIED INFRASTRUCTURE ASSOCIATED WITH THE FORMER GASWORKS WHICH REMAINS IN SITU AT DEPTH BENEATH THE SITE.

PIT TERMINATED ON HARD STRATA AT 2.5 mBGL

PIT TERMINATED ON HARD STRATA AT 2.4 mBGL

PIT TERMINATED ON HARD STRATA AT 3.5 m BGL.

BRICK LAYER INTACT WITH CONCRETE SLAB 0.6 -1.0 mBGL.

TANKS - 1979

HARD STRATA FROM 1.5 mBGL, CONCRETE BLOCK AT 1.8 mBGL PIT TERMINATED ON HARD STRATA AT 2.3 mBGL.

SUMP (REMEDIATED 2003)

SUBSTATION - 1948

SUBSTATION - 1979

TREATMENT AREA A

TREATMENT AREA B

VALIDATION AREA A

SHAFT 11/13 NOT LOCATED/SURVEYED

SHAFT 11/13

SHAFT NO. 386398-003 NOTE: POSITION INFERRED TO BE CONFIRMED ON SITE

SHAFT NO. 386398-010

BRADFORD 4 FOOT (SUB-OUTCROP)

BRADFORD 3/4 SEAM (SUB-OUTCROP)

THIN COAL 'C'

THIN COAL 'B'

THIN COAL 'A'

COMPACTED BRICK AND CONCRETE OBSTRUCTION AT 0.7 mBGL, PIT TERMINATED.

OBSTRUCTION 58.34 mOD

CONCRETE 44.31 - 42.51 mOD

OBSTRUCTION 56.51 mOD

OBSTRUCTION 57.52 mOD

CONCRETE OBSTRUCTION AT 2.2 mBGL, CONCRETE OBSTRUCTION AT 2.7M. MEDIUM TO HIGH BOULDER CONTENT FROM 3.0 mBGL.

TPO19/05 (BRICKS)

TP19/06 (BRICKS)

REMOVAL OF ALL SOIL IN EXCESS OF:

TPH 5000 mg/kg
DRO 1000 mg/kg
PAH 100 mg/kg

SUBSURFACE TANK DECOMMISSIONED AND MATERIAL REMOVED. BRICK BUILT SUMP CONTENTS AND STRUCTURE EXCAVATED AND DISPOSED OFF SITE. MATERIAL ABOVE METROLINK TUNNEL REMOVED.

SOLID AND MADE GROUND MAY EXIST WITH CONCENTRATIONS OF TPH UP TO 5000mg/kg, DRO & PAH UP TO 1000mg/kg.

SOIL & MADE GROUND REUSED ON SITE IS KNOWN TO CONTAIN ELEVATED TPH (AVOVE 5000mg/kg) BELIEVED TO BE DUE TO THE PRESENCE OF BLACK TOP AND ELEVATED PHYTOTOXIC DETERMINANDS.

TANK (DECOMISSIONED 2003)

KEYPLAN
SCALE 1:5000

PLANNING BOUNDARY

SITE

Rev	Description	Date	Drn	Ch'd
P03	PLANNING	31.01.20	NG	FG
P02	DRAFT PLANNING	20.12.19	NG	FG
P01	DRAFT STAGE 3	27.11.19	NG	FG

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Project **OVG MANCHESTER**

Drg Title CONSTRAINTS PLAN

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Checked by FG

Job No. 0042841
Date NOV 2019
Rev P03

Drawing No. BRA-BHE-XX-XX-DR-GE-0101

Richard.Lanham:\\Bh-bathfs\projects\0042841 Project Bradford\05 Ground Eng\Site Investigation\Model\BRA-BHE-XX-XX-DR-GE-0101.dwg



DEVELOPMENT BOUNDARY

GROUND INVESTIGATION

BOREHOLE - MAY GURNEY 2009

BOREHOLE - BUROHAPPOLD 2019

DRILL & GROUT POINT - 2011

43.50 CONTOUR - TOP OF COAL MEASURES (mOD) 0.5M INTERVALS

48.31 ELEVATION OF TOP OF COAL MEASURES (mOD) RECORDED IN EXPLORATORY HOLES AND FROM DRILL & GROUT RECORDS

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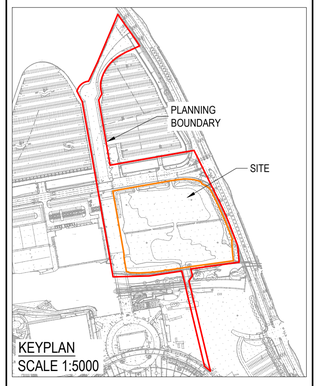
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Notes



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Drg Title CONTOUR PLOT
TOP OF COAL MEASURES

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Job No. 0042841
Date NOVEMBER 2019
Rev P03

Drawing No. BRA-BHE-XX-XX-DR-GE-0301

Richard Latcham 10n.latham@gmail.net 00420841 Project Stratford 00 General Engr Site Investigation BRA-BHE-XX-XX-DR-GE-0301.dwg



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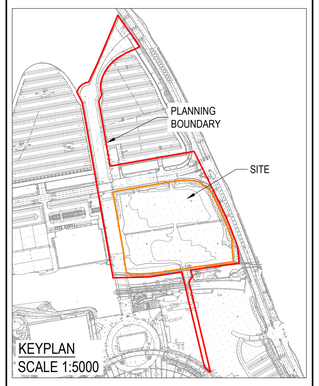
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CONSTRUCTION.

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Notes
SEE DRAWING NO. 0042841-BHE-XX-XX-DR-GE-0101 FOR CROSS SECTIONS.



Rev	Description	Date	Drn	Ch'd
P03	PLANNING	31.01.20	NG	FG
P02	DRAFT FOR PLANNING	20.12.19	NG	FG
P01	DRAFT STAGE 3	27.11.19	NG	FG

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Project **OVG MANCHESTER**
Drg Title CROSS SECTION LOCATION PLAN

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Drawn by NG
Checked by FG

Job No. 0042841
Date NOV 2019
Rev P03

Drawing No. BRA-BHE-XX-XX-DR-GE-0200

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- SITE BOUNDARY
- INFERRED COAL SEAM
- TREATMENT AREAS
- VALIDATION AREA
- 30.000 BASE OF DRILL & GROUT PROBE (mBGL)
- MINE SHAFT LOCATION - COAL AUTHORITY
- AREA NOT COVERED BY DRILL & GROUT WORKS
- INCLINED GROUT ZONES
- SHAFTS A - C EXTENT OF PROBING - 2011
- ENCOUNTERED SHAFT EXTENT OF PLUG/CAP

HISTORICAL MINE SHAFT LOCATIONS - REFER TO DRAWING NO. BRA-BHE-XX-XX-DR-GE-0104

- MINE ABANDONMENT PLAN 1
- MINE ABANDONMENT PLAN 7
- MINE ABANDONMENT PLAN 7
- 386398-??? MINE SHAFT - COAL AUTHORITY
- SHAFT REFERENCE TAKEN FROM ARUP (2008). 'SPORTCITY CONSTRAINTS ESTABLISHMENT: CONTEXT REPORT ISSUE 1.
- SHAFT REFERENCE TAKEN FROM ARUP (2019). 'EXTENT OF PREVIOUS REMEDIATION AND RESIDUAL CONSTRAINTS'. ECS-ARP-SW-DR-CG-0002, REV F1.
- SHAFT REFERENCE TAKEN FROM OVE ARUP & PARTNERS (1998). 'MANCHESTER STADIUM, EASTLANDS; INTERIM GEOTECHNICAL DESK STUDY'. DRAFT 1.
- Norwest Holst investigation (1998)
- Soil Mechanics mine shaft search extents (2000)
- Approximate extent of Van Elle search (2003) - 173 probes

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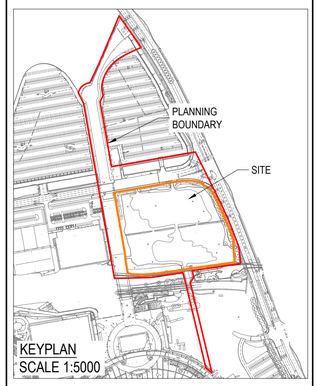
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Notes

1. WHERE SHAFT COORDINATES ARE NOT AVAILABLE, PLANS HAVE BEEN OVERLAID AS ACCURATELY AS POSSIBLE, REFERENCE SHOULD BE MADE TO ORIGINAL PLANS AND EXACT LOCATIONS PN THIS PLAN CAN NOT BE RELIED UPON



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Drg Title BASE OF DRILL & GROUT HOLES (mBGL) AND HISTORICAL SHAFT LOCATIONS

Scales@A1 1:500	Job No. 0042841
Drawn by NG	Date JAN 2020
Checked by AKS	Rev P01
Drawing No. BRA-BHE-XX-XX-DR-GE-0105	

Jonathan Howe i:\0s-cad\02project cad\0042841 Project Brasfield\05 Ground Eng-Site inv\Sheet\BRA-BHE-XX-XX-DR-GE-0105.dwg

APPENDIX B Cementation Skanska Drilling and Grouting Philosophy

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Cementation SKANSKA

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Grouting Philosophy

Location: Manchester

Project: Project Bradford

Document Status:			**Issued for Comments**	
Issue / Revision Description: P06			Date: 25 November 2020	
Cementation Section	Title	Name [Print]	Signature	Date
Author	**Business Stream Director**	**Caroline Rookes**		**04/12/20**
Reviewer				
PC Review Section	Title	Name [Print]	Signature	Date
Approver:				
Acceptor:				

Format	Document Number	Revision	Date of issue
A4	**22D990 / XXX / 001**	**P06**	**04/12/2020**

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1.0 INTRODUCTION

2.0 SCHEDULE OF DRAWINGS

3.0 GROUTING PHILOSOPHY

4.0 SEQUENCE OF DRILLING AND GROUTING

5.0 CONSTITUENT MATERIALS FOR GROUTING

6.0 STORAGE AND USE OF MATERIALS

7.0 GROUT MIX

8.0 PREPARATION WORKS

9.0 DRILLING PROCEDURES

10.0 GROUTING PROCEDURES

11.0 GROUT TESTING

12.0 IN SITU TESTING

13.0 RECORDS

14.0 METHOD STATEMENTS

15.0 COMPLETION REPORT

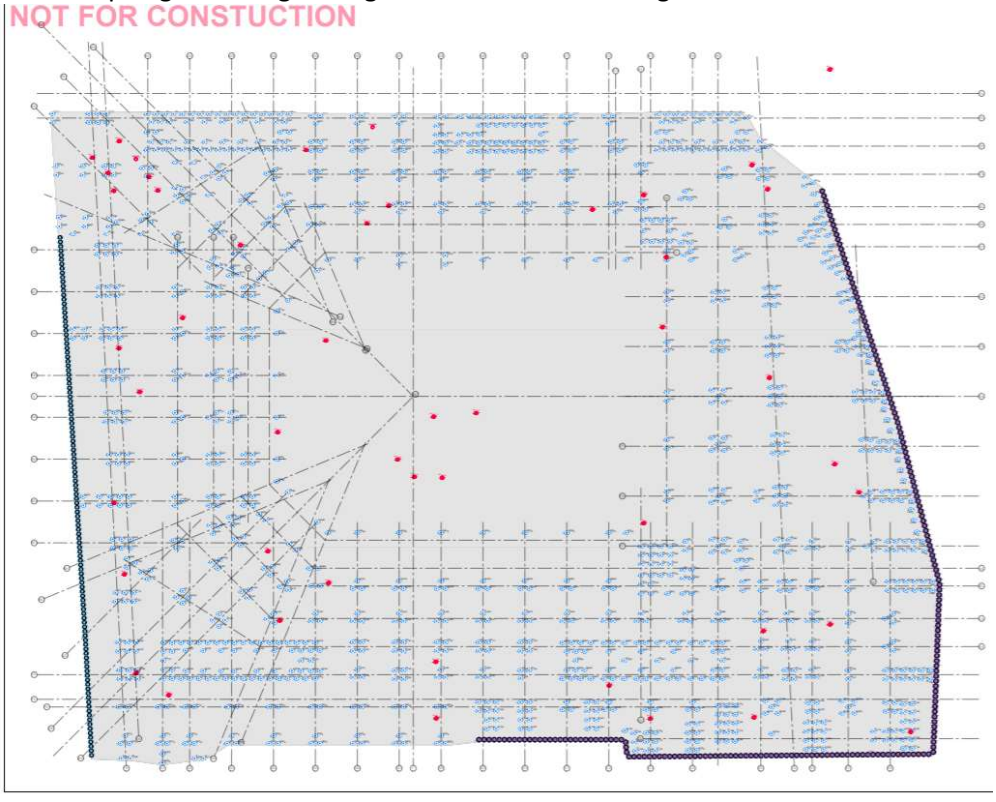
1.0 INTRODUCTION

The Project Bradford site is approx. 21,000m2. The site is roughly rectangular in shape and bounded to the south by the Ashton Canal, to the east by Alan Turing Way (A6010), to the west by Joe Mercer Way, which is a pedestrian walk way leading to the City of Manchester Stadium.

The site is located above two main coal seams, the Bradford Four Foot and the Bradford Three-quarter seams. Consideration / confirmation of the 18 inch seam will needed for the deeper pile toes. Historically 2No shafts have been located on the site and treated, Ref 386398-003 (grouted and capped) and Ref 386398-010 (grouted). there is potentially a third shaft (the ghost shaft), however previous investigations have been unable to locate it.

There have been several previous grouting contracts on areas of site to treat the coal seams, however the validation of these work cannot be adequately assessed and there could be a risk that should any remaining voids be encountered during the proposed piling works this will impact on the installation of the piling. The proposed drilling and grouting works are to validate the previous grout works and treat any open voids encountered.

Currently the longest proposed piles, are in the north west corner of the site and have a toe level of 26.6m AOD, with a seam indicated around 16.98m AOD, we are therefore anticipating 42m deep probes in this area working, based on approx. 59m AOD working platform. From the meeting with the EA and the ground water levels given in BH Appendix B Ground Water Risk Assessment in association with proposed grouting work, both the piling and the grouting will be installed below ground water level.



2.0 SCHEDULE OF DRAWINGS

Buro Hapold Drawings

- BRA-BHE-ZZ-PL-DR-S-0700_P02 Piling GA
- BRA-BHE-ZA-PL-DR-S-0701_P02 Piling Zone A
- BRA-BHE-ZB-PL-DR-S-0702_P02 Piling Zone B
- BRA-BHE-ZC-PL-DR-S-0703_P02 Piling Zone C
- BRA-BHE-ZD-PL-DR-S-0704_P02 Piling Zone D

Cementation Skanska Drawing

- 22D990-CSL-00-F1-SK-X-0008 P01 Bearing Pile arrangement with local boreholes
- 22D990-CSL-00-F1-SK-X-019 C03 Grout Layout

BAM Drawing

- Exclusion zones / UU/ Canal/Vegetation etc

3.0 GROUTING PHILOSOPHY

The purpose of the drilling and grouting works is to mitigate the risk of voids during the installation of the piling and protect the foundations from the future effects of ground instability caused by void migration from the potential collapse of mining-related voids at depth beneath the site by the consolidation of voided and broken ground by the injection of cementitious grout.

Records indicate that the Bradford Four Foot Bradford Three Quarters Seam have previously been grouted on part of the site. Previous grouting and validation work on the site footprint have treated up to 30m depth identifying two seams of coal.

A shallow seam was identified between +45.0mAOD and to +25.8mAOD at thicknesses of between 0.08m – 1.15m. It is assumed that this seam is the Bradford Three Quarter. Information taken from the Coal Mining Risk Assessment BRA-BHE-XX-XX-RP-CG-0005

A deeper seam was identified at a depth of between +43.4m AOD to +10.1m AOD with an approximately thicknesses of 0.01 – 1.62m. It is assumed that this seam is the Bradford Four Foot. Information taken from Coal Mining Risk Assessment BRA-BHE-XX-XX-RP-CG-0005

Due to the depth of the piles in some areas of the site, consideration has been given to the potential treatment of the deeper 18inch seam. The initial probing will be used to assess the required depth of treatment

The grouting proposals are based on the requirement for treatment to install the pile design based on the loads provided in BRA-BHE-XX-XX-SC-S-0010_P02 Stage 4a Pile Schedule.

Based on the Stage 4a pile design the site has been zoned into pile lengths as detailed on Cementation Skanska Drawing 22D990-CSL-00-F1-SK-X-0008 P01. A summary of the initial probe depths are detailed in Appendix A. Actual depth will be amended dependent on the depth and thickness of the seams encountered on site. Initial probing will be taken to one depth for each area, based on the deepest pile toe and closest boreholes.

Whilst any voids will be grouted during the initial probing, the 21m grid will be used to confirm seam levels and thickness across the site and assist in treatment depths.

The grouting philosophy will adapt to the ground conditions encountered. The drilling approach will initially follow the corresponding boreholes and the below guidance.

Initial probe bore drill depth determination parameters

- 10 x pile diameter (750mm assumed) below the designed pile toe (minimum) And
- Until the most significant seem and 1.0m below (which ever the greater)

Note: If seam is encountered and potentially worked 10 x theoretical seam thickness will be proven to ensure that once grouted sufficient rock cover will be provided below the pile toe.

Following the initial probing the results will be reviewed and drill depth adjusted for the remainder of the bores.

- Once 10 x seam is proven the adjacent bores will be drilled to seam plus one meter.
- A select number of the 7.0m grid bores will be taken to full depth where additional information is deemed required.

An observational approach to achieving satisfactory treatment is an integral requirement of the works. Records will be provided to BAM as detailed in this document. In addition, regular progress/review meeting will be held to review the works undertaken and advise on changes to the grouting strategy.

4.0 SEQUENCE OF DRILLING AND GROUTING

4.1.1 The anticipated sequence of drilling and grouting is as follows;

4.1.2 Initial probe drilling shall be undertaken an a 21m radial grid, to determine the effectiveness of the previous grouting on the site. The depth of the probe holes will be based on the Stage 4 pile lengths, the requirement for rock cover of ten time the seam thickness beneath the toe of the piles and the depth and thickness of the seams indicated in the Site Investigation. The assumptions made in the design of the grouting works will be reviewed and any necessary amendments made to the grouting layout as works progress.

4.1.3 Drilling and grouting of holes will be carried out within the Bradford Four Foot and the Bradford Three-quarter seams and potentially the 18 inch seam. The holes will be installed to the predetermined infill pattern, progressing to a 14m, 7m and 3.5m radial grid where open workings are encountered. Hole layouts and depth will be amended following the initial probing and reviewed as works progress.

The 21m grid will provide initial confirmation of the seams, workings etc. The 14 and 7 m grid (effectively a staged 7m grid) will then be installed to the depths determined by the initial 21m probing grid. The grid will then be closed down, effectively a 14m primary with 7m secondary gird, to provide a 7m grid. 3.5m grid will then be carried out upon review of the drilling and grout takes. The 10:1 grout will allow the grout to flow to ensure the smaller voids are targeted.

Cementation Skanska Drawing 22D990-CSL-00-F1-SK-X-019 P03 Preliminary Grout Layout details the initial treatment layout.

It is envisaged that drilling will be undertaken from north to south, however completion requirements for follow on activities will be reviewed as works progress.

4.1.4 It should be noted that perimeter grouting is not envisaged at this stage, however should open voids in excess of 0.5m height be encountered in close proximity to the site boundary this will be subject to reviews as the works progress.

4.1.5 The location of the ghost shaft has been investigated a number of time, without success. There is uncertainty over the existence of the shaft and whether it is a duplicate of another shaft on site. We would propose to complete the treatment of the site, to identify any evidence of an additional shaft. Should there be no indication of the shaft's location after the works, additional probing will be considered to a shallow depth 10-15m primarily focused on pile positions in the suspected location.

4.1.6 Upon completion of the grouting the hole will be backfilled to surface.

5.0 CONSTITUENT MATERIALS FOR GROUTING

5.1.1 Water to be used in grout shall be from the public supply of potable water and shall be at least to the quality specified in BS EN 1008:2002.

5.1.2 Ordinary Portland Cement (OPC) will comply with BS EN 197-1:2000.

5.1.3 PFA will be conditioned hopper ash, or dry powder ash, to BS3892: Part 3 of a type suitable as a constituent for grout and obtained from an approved supplier.

5.1.4 Whilst the use of sand is not currently proposed should a localised perimeter cut off be considered the following will apply. Sand shall generally comply with BS EN 12620:2002 and be of a grading suitable for use in the Contractor's plant.

6.0 STORAGE AND USE OF MATERIALS

6.1.1 Cement will be delivered in bulk and stored in a silo to prevent contamination and deterioration.

6.1.2 Bulk delivered of PFA will be stored and handled such that a dust hazard is not created. The PFA will be contained within storage area set consisting of storage containers. Water spray to douse stockpiles will be employed where necessary.

6.1.3 Materials with a limited shelf life will be disposed of off the site immediately, following expiry of the manufacturer's time limit for their use

6.1.4 A central storage area is proposed for the mixing of the grout, no materials will be stored within 30m of the Ashton Canal

7.0 GROUT MIX

7.1 Grouting Plant

7.1.1 Grout materials shall be introduced into the mixer via approved weight batching equipment. The grout mixer shall comprise a two component mechanically agitated colloidal grout mixer capable of producing a homogenous mix, all particles being thoroughly wetted without segregation occurring. Mixing time shall not be less than 5 minutes. A positive displacement grout pump shall be used for all grouting operations.

7.1.2 Provision shall be made for monitoring the quantity of grout being delivered from the grouting plant using calibrated flow meters or similar approved. The Contractor shall supply details of the method of monitoring and calibration of equipment.

7.2 Grout Mix Design

7.2.1 The grout mixes to be employed in the execution of the works are as detailed below, subject to satisfactory performance in the grouting trial. All proportions are presented by weight and are based on neat OPC cement: water mixes. Should PFA or other pozzolans be substituted for OPC the contractor should submit detailed grout mix design information to the Designer for review and comment.

7.3 Infill Grout

7.3.1 Infill grouting will commence with 10 :1 PFA Cement grout mix. Subject to grout takes this may be reviewed and thickened progressively to prevent excessive grout flow

7.3.2 Grouting in any hole shall be terminated at a maximum take of 5m 3 . Thereafter grouting may recommence after a period of 6 hours.

7.4 Perimeter curtain wall grout (if required)

7.4.1 Cement : PFA : 1 : 9 (Cement: PFA: Sand = 1 : 6 : 1, where cavities exceeding 500 mm in height are found).

7.4.2 Sand may be added in place of PFA where grout consumption or spread is required to be limited.

7.4.5 Cubes will be taken for testing at 3, 7, 14 and 28 day to confirm the strengths of the grout. Crushing strengths shall be not less than 1.0 MN/m2 at 28 days.

7.5 Grout Flow Properties

7.5.1 The water : cement ratio shall range between 0.5 : 1 - 2.0 : 1. Grout flow properties will vary significantly with water : cement ratio but will be ascertained during initial grout trials and monitored routinely during production / injection operations.

8.0 PREPARATION WORKS

8.1.1 Prior to the grouting works the ground will be stripped (as may be necessary) and a stable working platform established, taking cognisance of the potential for subsidence due to collapse of mine workings. This will be undertaken by BAM prior to Cementation Skanska mobilising to the work area.

9.0 DRILLING PROCEDURES

9.1.1 All drill holes used for the injection of grout into rock will be drilled by rotary percussive techniques down to 1.0m below the pavement of the target workings. Holes will be installed with 76mm casing and 48mm button bit rods.

9.1.2 Grout injection holes will be cased through the superficial deposits to 1.0m depth below rockhead. Grout holes will be kept open by means of a series of temporary steel casings placed to rock head until grout injection into the workings is complete.

9.1.3 Where a hole proves abortive because it becomes obstructed, or because of the failure to progress the hole, a new hole drilled and cased in close proximity. The amended position of the hole will be recorded

9.1.4 Where vegetation, existing services and structures are present on site, drill holes will be raked to ensure exclusion zones are maintained whilst the target treatment area is drilled.

9.1.5 A noise and vibration assessment will be carried out by others to determine services and structures that may require monitoring during the works. An additional requirement will be agreed prior to works commencing on site

10.0 GROUTING PROCEDURES

10.1 General

10.1.1 Immediately prior to grouting each hole, the grouter will check that the tremie and/or temporary casing is unobstructed to the required depth to receive the tubing or pipe for grout. Obstructions shall be dealt with as described in section 9.1.3 above.

10.1.2 Grout will be tremmied into position down each hole via a series of steel/alkathene tubes placed to the bottom of the hole. The grout line at the surface is attached to an approved T-connection with an attached pressure gauge fixed to the top of the drill hole. The quantity of grout being delivered in the line will be recorded so that both the flow rate and total injected volume are known. Grouting pressures will be monitored at ground level close to the point of injection.

10.1.3 The grout shall be injected into rock until either

(a) A limiting pressure in the range of 50 -200kN/m2 is reached dependent on hole depth(or a lower pressure if the base of the drill hole casing is within 5m of ground level), the pressure will be reflected the depth of the seam treated with a pressure of 10kN/m2 per metre up to a maximum of 200kN/m2 ie 20m depth of treatment
(b) A maximum grout take of 5m 3 is attained, or
(c) Grouting is terminated in the event of grout being expelled from the ground.

10.1.4 If the selected refusal pressure (typically in the range of 50-200kN/m2) is not attained after the injection of 5m 3 of grout, the grout tube or pipe will be removed from the hole and injection suspended.

After a period of at least 6 hours, up to a further 5m 3 of grout shall be injected. Injection shall again be suspended for at least 6 hours and the process shall be repeated with further quantities of 5m 3 .

If the hole is still accepting grout after a total of 20m 3 of material has been injected without any sign of the hole being completed, a review will be undertaken to determine whether the injection is to be continued or other measures such as secondary or test holes are required.

10.1.5 Care shall be taken to ensure that uplift pressures are not allowed to develop under the railway track, any adjacent services, during grout injection. Dependent on the sensitivity of the structure is required monitoring will be undertaken by others

10.2 Infilling

10.2.1 The grouting of infill holes will proceed systematically from the deepest point of the workings. Once the down dip perimeter has been confirmed, sequencing of the drilling maybe amended to meet operational requirements (test piles, preparations works) This will be agreed with BAM in advance of works commencing.

Whilst a perimeter curtain in not currently envisaged this will be determined by initial probing. If required a localised perimeter will be installed to ensure that grout does not migrate off the site footprint.

10.2.2 Grout injection will be carried out as described under the general procedure, but immediately the grout tubes, or pipes are withdrawn, the T-connection shall be attached to the top of the casing lining the hole down to rockhead, and further grout shall be injected up to the specified pressures.

10.2.3 Upon completion of the grout hole it will be backfilled to surface

11.0 GROUT TESTING

11.1.1 The viscosity of the grout on site will be monitored during injection operations. A minimum of two tests will be undertaken every 24 hours for each grout mix used.

11.1.2 Grout bleed will be recorded at hourly intervals from 2 hours after monitoring starts for not less than 6 hours, until settled conditions occur.

One test shall be carried out each day on each grout mix used. Bleed capacity will be measured in a clear plastic or glass graduated cylinder, which has an internal diameter not less than 50 mm, with a volume of approximately 1000ml. Bleed capacity will not exceed 5%.

11.1.3 For strength testing, a sets of six test cubes will be taken from the grouting pipe at surface positions every 24 hours.. The cubes shall be marked, handled, stored and tested by an approved independent testing laboratory in accordance with BS 1881. The Contractor shall provide projected 3, 7, 14 and 28 day strengths of the grout. Crushing strengths shall be not less than 1.0 MN/m2 at 28 days.

11.1.4 For each test there shall be a record of the results including:

1. Date.
2. Contract Title.
3. Area Identification.
4. Test position, co-ordinates and level.
5. Method of Test used.
6. All information required by the appropriate British Standard test procedure

12.0 IN SITU TESTING

12.1.1 Grout acceptance testing will be checked by drilling validation holes in positions to be agreed with the BAM / BH. An allowance of 1No validation hole per 1000m2 has been allowed for.

Grout will be injecting through casings set into rockhead, under typical pressures of 50kN/m2 as outlined in the requirements for infill grouting.

The injection pressure will be held for an appropriate period of time (approximately 5 minutes). Appropriate casing, capable of sustaining the test pressures, will be used. Unacceptable voidage will be determined as present within the ground should grout takes into the ground exceed 1 tonne. If this is encountered additional validation hole will be drilled and grouted in the immediate vicinity.

12.1.2 After satisfactory testing, validation holes will be back filed in accordance with the requirements for grouting infill holes.

13.0 RECORDS

13.1.1 The following records are to be provided by the Contractor:

1. Drilling Records (to be provided for each shift);
2. Grouting Records (to be provided for each shift);

13.1.2 As work proceeds, separate records will be maintained for 'Drilling', for 'Grouting' and for 'Materials and Plant Received'. The records will be submitted to BAM within 24hours of the completion of each shift.

13.2 Daily Drilling Records

13.2.1 The following daily drilling records will be provided for each hole and contain the following information:

1. Job title and location.
2. Hole reference number.
3. Date.
5. Plant in use, crew members and hours worked.
6. Method of boring or drilling, flushing medium and type of drill bit.
7. Type, diameter and depth of casing used.
8. Diameter and depth of hole at the beginning and end of each working day or shift.
9. Nature of flush returns to surface.
10. Loss of any flushing medium during drilling.
11. Standing time, with reason, or time lost overcoming obstructions.
12. Details of underground services located.
13. Details of any settlement or ground heave.
14. Daily and cumulative length drilled.

15. Description, with identification, of the stratum and whether it is intact or broken.
16. Depths at which groundwater is encountered (if apparent).
18. Details of any voids or suspended workings.
19. Details of any emissions of gas, water etc.
20. Depth of completed hole.

13.3 Daily Grouting Records

13.3.1 Daily grouting records shall be provided for each hole and contain the following information:

1. Job title and location.
2. Hole reference number.
3. Date.
4. Contractor's name.
5. Plant in use, crew member and hours worked.
6. Details of type of injection and grout-line dimensions (e.g. tremie injection through 25mm diameter line).
7. Type of grout mix and volumetric quantity injected.
8. Bleed Capacity Readings as outlined in Section 11.2.
9. Grout viscosity readings.
10. Grout pressures recorded, with the corresponding depths.
11. Details of casing abandoned.
12. Completion status of the grouting operation.

13.4 Material and Plant Records

13.4.1 The records of 'Materials and Plant Received' shall show in particular that shifts quantities by weight of each type of material and the cumulative quantities from the commencement of the Works.

13.4.2 Notwithstanding the information listed above, the Contractor shall provide any other information required by Designer.

14.0 METHOD STATEMENTS

14.1.1 Prior to commencing works on site a Works Execution Plan (including method statements and risk assessments will be submitted to BAM for approval.

The following aspects of the works will be covered by the method statements

1. Method and types of access arrangements.
2. Safe working procedures including fail safe methods for working in proximity to railway Overhead Line Equipment.
3. Drilling methods.
4. Grouting methods (materials, mixes, mixing and injection arrangements).

5. Record-keeping formats.
6. An outline sequence of working covering the formation of perimeter and primary grout holes and secondary check holes.

15.0 COMPLETION REPORT

Following completion of the works a completion report will be produced detailing the work undertaken including

1. As built drilling and grouting records
2. As built drawings of holes drilling and volume of grout injected
3. QA records and validation

APPENDIX C Buro Happold Site Visit Validation Reports

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BURO HAPPOLD

Geotechnical Group Site Visit Record Sheet

Job Title:	**Co-Op Live (Project Bradford)**		
Job No:	**0042841**	**Date of visit:**	**17/12/20**
Page:	**1 of 2 pages**		

Purpose of Visit:
Site visit to witness the grouting validation of 4 No. bore locations.

Weather Conditions:
Overcast with some sun. Cold ~5°C with occasional rain

Personnel:
CSL – Gavin Clifford, Oliver Partington and CSL groundworkers.
BAM – Phil London and Martin Horne
BH – Justin Hobkirk

Work in Progress :
Cementation Skanksa Limited (CSL) drilling and grouting works were being carried out across the site. 6 No. rigs were on site carrying out the works.

Buro Happold had selected 4 No. validation holes however only 3 No. were able to be carried out with the 4th validation location (BD32) to be carried out post-Christmas during the following site visit. An outline summary of the validation locations are as follows:

Area	Grid Ref	Pressure/Grout take	Validated
Area G	AZ36	30 PSI for 5mins/ injected 100l	Acceptable
Area G	AN36	30 PSI for 5mins/injected 200l	Acceptable
Area E	AU30	30 PSI for 5 mins/injected 900l	Acceptable
Area E	BD32	Not completed	N/A

A plan layout of the validation locations is presented in Enclosure 1 and site photos are provided below.

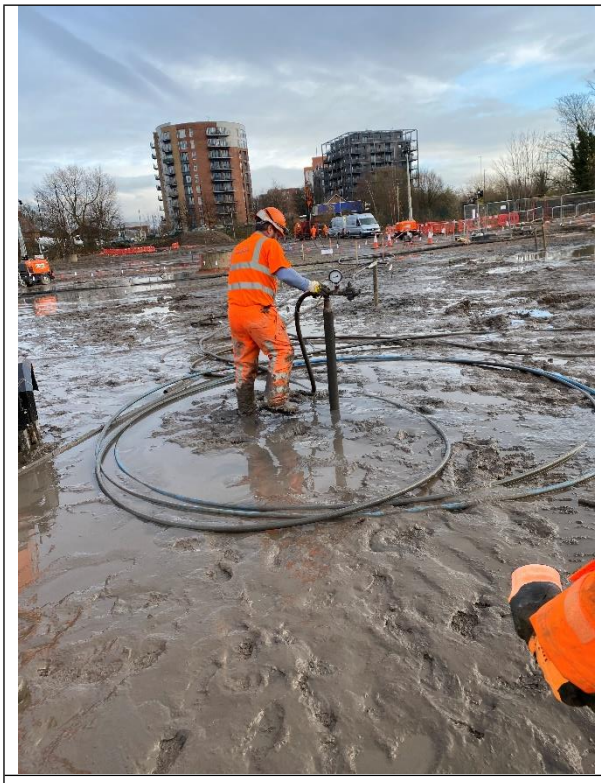
General Comments:
BAM carrying out ground water monitoring of the River Medlock to ensure water levels were "normal" and that no grout was present within the river.

Signed:		**Date:**	**08/01/21**
Distribution:	**BAM** **OVG** **Turner & Townsend**	**Project Leader: Nigel Pickering**	

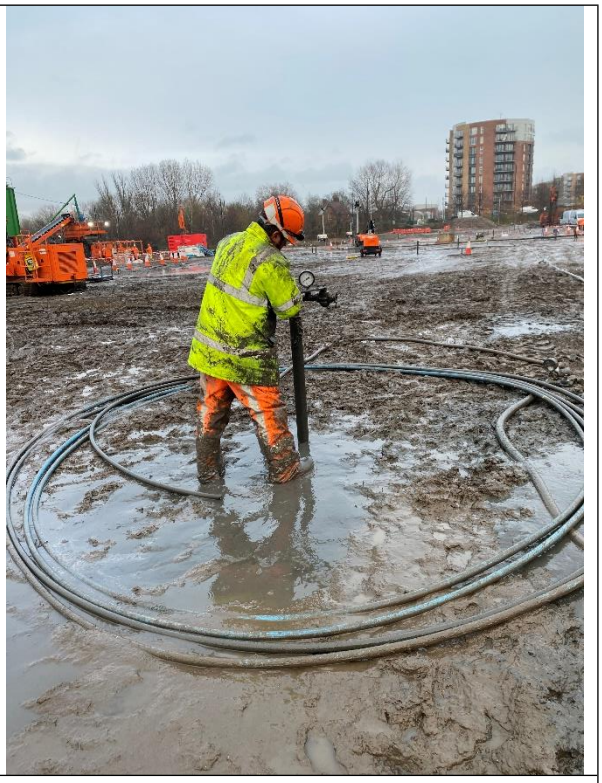
NB the PC is to receive a copy in all cases.

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Site Photos



Validation Location AZ36



Validation Location AN36



Validation Location AU30



River Medlock

Enclosure 1

BURO HAPPOLD

Geotechnical Group Site Visit Record Sheet

Job Title:	**Co-Op Live (Project Bradford)**		
Job No:	**0042841**	**Date of visit:**	**18/01/21**
Page:	**1 of 2 pages**		

Purpose of Visit:
Site visit to witness the grouting validation of 7 No. bore locations. However, 8 No. validation locations were completed as the missed location prior to Christmas was carried out.

Weather Conditions:
Overcast. Cold ~6°C with occasional rain.

Personnel:
CSL – Gavin Clifford, Oliver Partington and CSL groundworkers.
BAM – Phil London and Martin Horne
BH – Justin Hobkirk

Work in Progress:
Cementation Skanksa Limited (CSL) drilling and grouting works were being carried out across the site. 6 No. rigs were present on site. However, 2 No. rigs were being packed up in preparation for demobilisation from site, circa 4 No. rigs carrying on with drilling and grout works.

Buro Happold had selected 7 No. locations for validation holes to take place. However, the 4th validation location (BD32) which was preselected prior to Christmas has been grouted and therefore another validation location was selected (BC32) and was completed on site. An outline summary of the validation locations are as follows:

Area	Grid Ref	Pressure/Grout take	Validated
Area E	BC32	30 PSI/200l	Acceptable
Area F	BM40	30 PSI/200l	Acceptable
Area F	BW42	30 PSI/100l	Acceptable
Area F	CH32	30 PSI/500l	Acceptable
Area D	CA26	30 PSI/100l	Acceptable
Area D	CM14	30 PSI/100l	Acceptable
Area C	AS20	30 PSI/100l	Acceptable
Area C	BB14	30 PSI/200l	Acceptable

A plan layout of the validation locations is presented in Enclosure 1 and site photos are provided below.

General Comments:
BAM carrying out ground water monitoring of the River Medlock to ensure water levels were "normal" and that no grout was present within the river. Setting out of the remaining validation locations was being carried out.

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Signed:		**Date:**	**08/01/21**
Distribution:	**BAM** **OVG** **Turner & Townsend**	**Project Leader: Nigel Pickering**	

NB the PC is to receive a copy in all cases.

Site Photos

	
Validation Location BW42	Validation Location BM40

	
Validation Location CH32	Validation Location CA26
	
Validation Location CM14	Validation Location BB14

	
Validation Location AS20	Validation Location BC32

Enclosure 1

KEY

7 No. Historical Validation Holes (BWB)

Skanksa Grout Holes Grout >1.5T

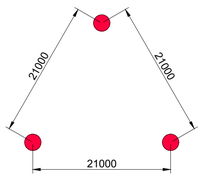
21No. Validation Holes — Proposed / Completed

Completed Area

NOTES

- TREE POSITIONS TAKEN FROM CAD FILE:- ***'Tree Line.dwg'*** RECEIVED VIA EMAIL ON 05.10.20.
- SITE BOUNDARY, EXCLUSION ZONE AND GROUT PLANT AREA TAKEN FORM CAD FILE:- ***'Grouting Logistics with contours.dwg'.***
- GROUTING LAYOUT TO BE READ IN CONJUNCTION WITH PILE LAYOUT DRAWINGS:-
  - ***BRA-BHE-ZA-PL-DR-S-0701 P02***
  - ***BRA-BHE-ZB-PL-DR-S-0702 P02***
  - ***BRA-BHE-ZC-PL-DR-S-0703 P02***
  - ***BRA-BHE-ZD-PL-DR-S-0704 P02***
- CSL ACCEPTS NO LIABILITY FOR THE ACCURATENESS OF THE CONSTRAINTS DATA PROVIDED BY BAM OR OTHERS.
- PLATFORM CERTIFICATE AND PERMIT TO BREAK GROUND TO BE ISSUED BY BAM.
- MANAGEMENT OF SERVICES BY BAM.
- 3.5m GRID IS MINIMUM SPACING AND GROUND CONDITION DEPENDANT.
- SHAFT LOCATIONS TAKEN FROM : ***BRA-BHE-XX-XX-DR-GE-0107 P01.dwg***
- ADDITIONAL SHAFT LOCATION UNKNOWN.
- BACKGROUND INFO SHOWN FROM: ***Grouting Constrains 4.11.20 - stripped.dwg***
- DRAWING CO-ORDINATED USING: ***Grouting Constrains 4.11.20 - stripped.dwg***

KEY.



SHAFT LOCATIONS (APPROXIMATE ONLY)

Area A - 2641m²
Area B - 2691m²
Area C - 1917m²
Area D - 2426m²
Area E - 2383m²
Area F - 3588m²
Area G - 2790m²
Arena - 3278m²

3.16T
3.95T
2.3T
2.3T
4.42T
4.9T
7.4T
4.1T
4.1T
3.95T
3.3T
2.3T
3.3T
4.1T
2.3T
2.8T
4.74T
3.318T
3.1T
2.3T
2.5T
AU30
BD32
AN36
AZ36
4.1T
2.8T
2.0T
4.1T

SHAFT 11/13 NOT LOCATED/SURVEYED
SHAFT 13
SHAFT 11
SHAFT NO. 386398-003
NOTE: POSITION INFERRED TO BE CONFIRMED ON SITE
LOCATION INDICATIVE
SHAFT NO. 386398-010
EXCLUSION ZONE
GROUT PLANT AREA
TREES IN PLACE DURING GROUTING WORKS
TREES TO BE REMOVED PRIOR TO GROUTING WORKS
TO BE REVIEWED DUE TO POTENTAIL SEVICES AND SITE BOUNDARY PROXIMITY
gas location
IN ABEYANCE
HOLES DELETED

REV	MODIFICATION	BY	DATE
C03	IN ABEYANCE AREA ADDED, SHAFT LOCATIONS REVISED, HOLES REMOVED, HOLES TO BE REVIEWED	S.A.W.	25/11/20
C02	BACKGROUND INFORMATION ADDED (SEE BACKGROUND NOTE)	S.A.W.	09/11/20
C01	ISSUED FOR CONSTRUCTION	J.H.	22/10/20

Status: FOR CONSTRUCTION

Cementation SKANSKA

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Job: PROJECT BRADFORD

Drawing Title: GENERAL GROUTING ARRANGEMENT

Scale:	Drawn By	Checked
A1 @ NTS	J.H	G.C
Project No.	**Date**	**Approved**
22D990	09/11/20	G.C

Drawing Number: 22D990-CSL-00-F1-SK-X-019 — Revision: C03

BURO HAPPOLD

Geotechnical Group Site Visit Record Sheet

Job Title:	**Co-Op Live (Project Bradford)**		
Job No:	**0042841**	**Date of visit:**	**28/01/21**
Page:	**1 of 2 pages**		

Purpose of Visit:
Site visit to witness the investigation of 1 No. of the 'soft spots' (BS13) on site.

Weather Conditions:
Overcast. Cold ~4°C. Dry.

Personnel:
CSL – Gavin Clifford, Oliver Partington and CSL groundworkers.
BAM – Phil London and Martin Werner
BH – Justin Hobkirk

Work in Progress:
BAM have set up a suitable working platform to allow the Bailey bridge to be placed level and orientated north to south. A working platform for the crane had been setup to allow manoeuvring of the bridge.

Cementation Skanksa Limited (CSL) were setting up the drilling rig on the bailey bridge to start drilling the first location away from BS13. The first location measured approximately 1m away north from BS13 in accordance with the CSL method of proposed investigation into the 'soft spot'.

Subsequent to this and prior to the drilling of the second location, a hydraulic hose on the rig had broken at approximately between 1-2pm which meant works was halted. This was then fixed at approximately 4pm and drilling works were able to continue.

A further 3 locations were drilled at 0.5m spacing which equated to a total of 2.5m spacing from BS13 location, these were in a northerly direction. All of these locations that were drilled encountered soft ground at approximately 4m bgl (from ground surface). From ~4m bgl the casing/rods were able to be pushed into the ground without the force of the drilling hammer. The casings were pushed into the ground to a depth of approximately 26m bgl which reduced to 14m bgl in a northern direction.

Works were stopped due to the end of the working day 5:30pm and were progressed the following day. Details of the remaining works can be found in the CSL progress report (Date TBC).

An annotated diagram of the drilling procedure is presented in Enclosure 1 and site photos are provided below.

General Comments:
2 No. drilling rigs are currently on site to allow the investigation of the 'soft spots' to continue and remaining casings to be pulled from the validation hole locations.

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Signed:		**Date:**	**28/01/21**
Distribution:	**BAM** **CSL** **OVG** **Turner & Townsend**	**Project Leader: Nigel Pickering**	

NB the PC is to receive a copy in all cases.

Site Photos



Bailey bridge with drilling rig drilling first location.



Crane working platform when manoeuvring the bailey bridge.



Ramp constructed to allow drilling rig to access the bridge.



Side view (looking west) of the bailey bridge to show location BS13 and rig setup 1m away.

Enclosure 1

KEY

- 7 No. Historical Validation Holes (BWB) ◆
- Skanksa Grout Holes Grout >1.5T ○
- 21 No. Validation Holes — Proposed ▲ / Completed ▲
- Completed Area ▭
- Order Completed 1

NOTE:
CONTRACTOR TO REVIEW SUGGESTED LOCATIONS AND CONFIRM AGREEMENT

Area A - 2641m²
Area B - 2691m²
Area C - 1917m²
Area D - 2426m²
Area E - 2383m²
Area F - 3588m²
Area G - 2790m²
Arena - 3278m²

BD04 2.9T
BU04 2.3T
CE04
AW08 7.6T
AY11 7.4T
CN08 3.3T
BB14 6
AS20 7
BK15
BX15
BU26
BF25
CA26 4
CM14 5
BC32 8 2.5T
AU30 5.3T
AM35 2.3T/3.0T
AZ36
CH32 3
BM40 2
BW42 1

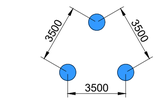
2.5T 2.0T 3.16T 3.95T 2.3T 2.5T 7.6T 4.42T 4.9T 4.1T 3.95T/7.6T 3.318T 5.3T 3.95T 3.1T/7.1T 4.1T 2.8T/6.0T 2.3T 2.5T/4.7T/6.3T 4.7T/2.8T 2.5T/3.0T 4.74T 4.75T

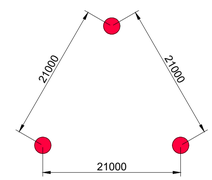
SHAFT 11/13 NOT LOCATED/SURVEYED
SHAFT 13
SHAFT 8 386398-003
SHAFT 11
SHAFT NO. 386398-003 NOTE: POSITION INFERRED TO BE CONFIRMED ON SITE
SHAFT NO. 386398-010
LOCATION INDICATIVE
possible shaft
EXCLUSION ZONE
GROUT PLANT AREA
TREES IN PLACE DURING GROUTING WORKS
TREES TO BE REMOVED PRIOR TO GROUTING WORKS
ADDITIONAL HOLES ADDED
IN ABEYANCE
TO BE REVIEWED DUE TO POTENTAIL SEVICES AND SITE BOUNDARY PROXIMITY
gas location

NOTES

- ADDITIONAL SHAFT LOCATION UNKNOWN.
- BACKGROUND INFO SHOWN FROM: ***Grouting Constrains 4.11.20 - stripped.dwg***
- DRAWING CO-ORDINATED USING: ***Grouting Constrains 4.11.20 - stripped.dwg***
- CEMENTATION MAY NEED TO ADD OR DELETE FUTHER HOLES BASED ON ACTUAL GROUND ENCOUNTERED AND GROUT TAKES.

KEY.





SHAFT LOCATIONS (APPROXIMATE ONLY)

Rev.	Date	Initials
000	15/01/2021...	JJH

C04	ADDITIONAL GROUTING HOLES ADDED	S.A.W.	21/12/20
C03	IN ABEYANCE AREA ADDED, SHAFT LOCATIONS REVISED, HOLES REMOVED, HOLES TO BE REVIEWED	S.A.W.	25/11/20
C02	BACKGROUND INFORMATION ADDED (SEE BACKGROUND NOTE)	S.A.W.	09/11/20
C01	ISSUED FOR CONSTRUCTION	J.H.	22/10/20
REV	MODIFICATION	BY	DATE

Status: FOR CONSTRUCTION

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BURO HAPPOLD

CONSTRUCTION

15/01/2021

BURO HAPPOLD

GROUND ENGINEERING

Job Title: CO-OP LIVE

Job Number: 0042841

Sketch Title/Number: SUGGESTED VALIDATION TEST LOCATIONS COOP-BHE-XX-XX-SKE-CG-0001

Document Number: 0001

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