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SIRIUS MINERALS PLC - DISCHARGE OF PLANNING CONDITIONS FOR PLANNING APPLICATION NYM/2014/0676/MEIA, NORTH YORKSHIRE POLYHALITE PROJECT

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REPORT	GROUNDWATER MANAGEMENT SCHEME
SITE	PHASE 4 DEVELOPMENT WORKS AT WOODSMITH MINE, NORTH YORKSHIRE
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APPENDICES

GROUNDWATER MANAGEMENT SCHEME FOR PHASE 4 WORKS AT WOODSMITH MINE, NORTH YORKSHIRE

1 INTRODUCTION

1.1 General Background

This document has been prepared on behalf of Sirius Minerals Plc (Sirius Minerals) and provides the Groundwater Management Scheme for the Phase 4 Works at Woodsmith Mine (Phase 4 Works), as outlined in the Environmental Statement (Ref. 1) and confirmed by the Hydrogeological Risk Assessment (Ref. 2). This is required to satisfy Condition 47 of the North York Moors National Park Authority (NYMNPA) planning permission NYM/2014/0676/MEIA.

This Groundwater Management Scheme is for the Phase 4 Works only, as detailed in Section 1.3, and will be revised to accommodate the scope of subsequent development phases and submitted to NYMNPA for approval.

1.2 Objectives

The objective of this Groundwater Management Scheme is to present details of the approved Phase 4 Works and the hydrogeological mitigation measures to be undertaken as part of these works.

1.3 Phase 4 Works

A summary description of the principal construction elements of the Phase 4 Works is presented below:-

- Operation of the concrete batch plant;
- Installation, commissioning and operation of the bentonite plant;
- Installation of concrete guide walls (excavate to -3.5m and concrete wall down to -1.5 to -1.75 m);
- Mobilisation to site of diaphragm walling equipment (cutters, cranes, workshops etc.);
- Diaphragm wall construction to -60m below ground level at the Production, Service and Mineral Transport System shafts;
- Limited continuation of earthworks to create an area for future storage of spoil.

1.4 Compliance with Conditions

The table overleaf sets out the wording of Planning Condition 47 to Planning Consent Ref. No. NYM/2014/0676/MEIA and details where the relevant material, to comply with this condition, has been provided within this report:-

NYMPA	Compliance with Condition 47
Following the approval of the Revised Hydro-Geological Risk Assessment but prior to the commencement of development, a Groundwater Management Scheme (covering construction, operation and post-operation phases), shall be submitted to and approved in writing by the Local Planning Authority in consultation with the Environment Agency.	Consultation was been undertaken with the Environment Agency in January and April 2017 to develop this Groundwater Management Scheme that is provided for the Phase 4 Works at Woodsmith Mine only.
The Scheme shall include technical drawings detailing the conceptualised hydrogeology with the final detailed designs of the proposed mitigation measures outlined in the Environmental Statement and in accordance with the details in the York Potash Project: Habitats Regulations Assessment prepared by Amec Foster Wheeler dated June 2015 with document reference 35190CGos064R, and the final design details of the lining systems for the proposed shaft.	Final designs, technical details, a conceptualised hydrogeological cross section and plans of the mitigation measures for the Phase 4 Groundwater Management Scheme are provided in Section 2 and details of the compliance monitoring and reporting to validate their implementation is presented in Section 3.
Development shall thereafter proceed only in strict accordance with the approved Scheme and a timetable to be included within it.	The timetable for implementing the Phase 4 Works Groundwater Management Scheme is presented in Section 4.

2 GROUNDWATER MANAGEMENT MEASURES – PHASE 4 WORKS

2.1 General

Groundwater management measures, listed below, are required within the Phase 4 works for construction requirements and to manage environmental risk.

- Dewatering well operations within the shaft platform area to maintain groundwater levels 3 m below the shaft platform level (bspl) during diaphragm walling (Drawing 1433DevOD268). As part of this process, a monitoring regime will be implemented to both establish groundwater levels in diaphragm walling areas, to confirm the necessity for dewatering, and to monitor water quality from the well discharge ports, to confirm whether the water can be discharged directly to surface waters (Drawing 1433DevOD286).

- Construction of a bunded slab area to contain the tanks for preparation of stabilizing slurry for use in the diaphragm walling, as illustrated in Arup Drawings 40-ARI-WS-71-CI-DR-1081 and 40-ARI-WS-71-CI-DR-1084.

- During diaphragm wall construction, guide walls are to be constructed through the shaft platform locally penetrating the natural geological clay barrier and / or the Phase 3 installed recompacted clay liner overlying the Moor Grit aquifer. As part of this process, to maintain the integrity of the geological clay barrier, the clay liner will locally be reinstated around the diaphragm wall guide walls, as illustrated in Arup Drawings 40-ARI-WS-71-CI-DR-1060, 40-ARI-WS-71-CI-DR-1061 and 40-ARI-WS-71-CI-DR-1082.

- During trench cutting to form the diaphragm walling, monitoring will be undertaken of slurry losses, by observation of slurry levels within the trench and by real time groundwater quality

monitoring from an array of wells, to direct the use and form of measures to mitigate uncontrolled slurry loss beyond the trench walls from impacting on groundwater quality within the Moor Grit, Scarborough and Cloughton aquifers.

- Verification testing on the diaphragm walling arisings to confirm their chemical and geotechnical suitability for re-use as inert fill within the landscaped screening bunds.

- Construction of concrete diaphragm walls to prevent groundwater ingress into the shaft and head frame structures for the Production, Service and Materials Transport System (MTS) shafts (AMC Drawings 40-AMC-WS-11-CI-DR-1901, 40-AMC-WS-12-CI-DR-1901, 40-AMC-WS-13-CI-DR-1901, 40-AMC-WS-71-CI-DR-0079, 40-AMC-WS-71-CI-DR-0080 and Y17015002, (Ref. 10). As part of this process, panel surveys will be maintained to record the geometry of panel joints.

To verify that implementation of these groundwater management measures has been undertaken in accordance with their design specifications, compliance monitoring, testing and recording of the construction phase monitoring and "as built works" will be documented in Construction Validation Reports, as detailed in Section 3.

Due to the chemically sensitive nature of the groundwaters underlying the area of the Phase 4 construction activities, pollution control procedures are incorporated into the Construction Environmental Management Plan (CEMP) to address the specific risks to groundwater, as detailed In Section 2.4.

To demonstrate the effectiveness of the groundwater management measures adopted during the Phase 4 Works, the ground and surface water monitoring scheme (Ref. 3) and associated remedial action plan (Ref. 4) will be implemented.

2.2 Temporary Well Dewatering

2.2.1 General

To facilitate diaphragm walling, it is a requirement of the slurry trench cutting process that groundwater levels are maintained at a minimum of 3m below the Shaft Platform level throughout wall construction. Subject to the elevation of natural groundwater levels within the shaft platform area at the time of diaphragm walling, temporary dewatering will be undertaken from the array of wells illustrated in Arup Drawing 40-ARI-WS-71-CI-DR-1058. Throughout the diaphragm walling process, groundwater levels are to be maintained below the design levels detailed in Table 1.

Table 1 - Target Groundwater Levels For Temporary Dewatering

Structure	Platform Level (m AOD)	Seasonal High Water Table (m AOD)	Target Groundwater level
Service Shaft	203.17	199.8	200.1m AOD
Production Shaft	203.66	202.0	200.6 m AOD
MTS Shaft	200.66	198.9	197.6 m AOD

2.2.2 Installations

Groundwater Level Installations

The groundwater level monitoring wells installed as part of the Phase 3 works, as illustrated in Drawing Nos 1433DevOR286 and 1433DevOD280, and detailed in Table 2, will be monitored as part of the Phase 4 works, in accordance with the Ground and Surface Water Monitoring Plan (Ref. 3).

Table 2 - Diaphragm Walling Groundwater Level Monitoring Wells

Shaft Location	Existing Monitoring Well		New Monitoring Well	
	No.	Response zones (m bgl) [m AOD]	No.	Response zones (m bgl) [m AOD]
Production	505	2.50 to 10.05m bgl 201.00 to 193.45m AOD		
	507	2.90 to 10.90m bgl 200.67 to 192.67m AOD		
			520	3.5 to 11m bgl 200.0 to 192.5m AOD
Service	SS2	4.0 to 7.0m bgl 198.96 to 195.96m AOD		
	HG135	3.0 to 8.5m bgl 200.20 to 194.70m AOD		
			521	3.5 to 8.0m bgl 200.0 to 195.5m AOD
Materials Transport Shaft	HG116	2.0 to 6.0m bgl 198.38 to 197.38m AOD		
	BH515	2.5 to 9.9m bgl 198.51 to 191.11m AOD		
			522	2.5 to 8.0m bgl 198.5 to 193.0m AOD

Discharge Ports from the Dewatering System To Monitor For Slurry Losses

Each dewatering wellhead will include a sampling tap to allow monitoring, and a control valve, to allow each well to be isolated from the dewatering system, as illustrated in Arup Drawing 40-ARI-WS-71-CI-DR-1058. Water generated from the dewatering system will be discharged via a holding tank with a minimum capacity of $10m^3$, where it can be monitored visually for evidence of turbidity (Drawing 40-ARI-WS-71-CI-DR-1058).

Clean water, generated from the dewatering system, will be discharged via the piped drainage system into the drainage ditch outflowing into a tributary to Sneaton Thorpe Beck, Arup Drawings 40-ARI-WS-71-CI-DR-1058 and 40-ARI-WS-71-CI-DR-1084. Turbid water, held in the holding tank, will be pumped to the site-wide surface water drainage system to discharge to on-site attenuation facilities for removal of silt, as shown on Arup Drawing 40-ARI-WS-71-CI-DR-1084.

2.2.3 Operational Management

Management of Groundwater levels

Groundwater level monitoring will be carried out of the wells listed above, supplemented with monitoring the dewatering well array, where possible, prior to commencement and throughout the dewatering operations. This monitoring will be undertaken on a daily frequency to demonstrate when temporary dewatering is required to maintain groundwater levels at the shaft locations below the maximum permitted water levels, as detailed in Table 3. Control Trigger Values are proposed to indicate when dewatering should be implemented to maintain water levels below the maximum permissible Compliance Trigger Values.

Table 3 - Groundwater Level Control and Compliance Trigger Values for the Diaphragm Walling

Shaft Location	Temporary Monitoring Well	Control Trigger Value (m bspl) [m AOD]	Compliance Trigger Value (m bspl) [m AOD]
Production	505,507,520	4 m bspl [199.66m AOD]	3 m bgl [200.6m AOD]
Service	SS2, HG 135, 521	4 m bspl [199.17m AOD]	3 m bgl [200.1m AOD]
MTS	HG116, 515, 522	4 m bspl [196.66m AOD]	3 m bgl [197.6m AOD]

During dewatering operations, the discharge flow rate to the surface water system will be maintained below a daily Control Trigger Value of 20l/s. During temporary dewatering, the Dewatering Contractor will be responsible for maintaining daily records of the dewatering operations undertaken and the flow rate of groundwater discharged from the system into the surface water drainage, as shown in Arup Drawing 40-ARI-WS-71-CI-DR-1058.

Monitoring of Discharge Ports for Evidence of Slurry Losses

Water from the dewatering system, discharged to the holding tank (Drawing 40-ARI-WS-71-CI-DR-1058) will be monitored visually on a 2 hourly basis for evidence of turbidity. Should evidence of bentonite be observed, the following action will be implemented:

1 A sample will be taken from the sampling tap of each active well to identify the source of the bentonite.
2 The affected well or wells will be temporarily isolated and the discharge from the dewatering system monitored to confirm that the flow is now free from bentonite.
3 In the event that flow remains contaminated with bentonite step 1 will be repeated.
4 Turbid water held in the holding tank will be pumped to the site-wide surface water drainage system to discharge via to on-site facilities for removal of silt.
5 The affected well or wells will be restarted once corrective action has been taken to prevent bentonite losses from the D-wall trench, as detailed in Section 2.3.3 below.

2.2.4 Documentation and Reporting

The Dewatering Contractor will be responsible for all pre-commencement and construction phase water level monitoring of the dewatering well monitoring boreholes and for providing a weekly summary report to the Environmental Engineer.

The Dewatering Contractor will be responsible for identifying to the Environmental Engineer and to Sirius Minerals any exceedance in the groundwater level Control or Compliance Trigger Values and providing details of remedial actions to rectify the breach on the day of the occurrence.

During temporary dewatering, the Dewatering Contractor will be responsible for maintaining daily records of the dewatering operations undertaken and the flow rate of groundwater discharged from the system to surface water drainage. This information will be provided to the Environmental Engineer in a weekly summary report, including records of any exceedances in the groundwater level and quality Control or Compliance Trigger Values or surface water discharge Control and Compliance Trigger Values and remedial actions taken.

The Dewatering Contractor will be responsible for identifying (within 1 hour of occurrence) to the Environmental Engineer, Sirius Minerals and AMC any evidence of the presence of bentonite slurry within the abstracted waters and the pumping of any waters containing high suspended solids into the siltation ponds to enable implementation of corrective action has been taken to prevent bentonite losses from the D-wall trench, as detailed in Section 2.3.3 below. The Dewatering Contractor will provide a record of such events and the mitigation actions taken to the Environmental Engineer in a weekly summary report.

2.3 Diaphragm Walling

2.3.1 General

A schematic hydrogeological cross section through the depth of diaphragm walling is shown in Drawing No. 1433DevOR268 and 1433DevOD280 and a geological section for each diaphragm wall is shown in AMC Drawings 40-AMC-WS-11-CI-DR-1901, 40-AMC-WS-12-CI-DR-1901 and 40-AMC-WS-13-CI-DR-1901.

Diaphragm walling will entail the following principal elements as detailed in AMC's Diaphragm Walling Construction Plans (Ref. 7 to 15):-

- **Guide walls**: lightly reinforced 1.75 m high concrete guide walls constructed at the surface to maintain the horizontal alignment, wall continuity and provide support for the upper soils during panel excavation, as shown in Arup Drawing 40-ARI-WS-71-CI-DR-1060.

- **Trench Cutting**: the 1.2 m wide diaphragm wall sections are excavated by trench cutters in a sequence of primary and secondary panels, as shown in AMC Drawings 40-AMC-WS-11-CI-DR-0079 and 40-AMC-WS-11-CI-DR-0080. Trench cutters operate with two opposite-running cutter wheels, which cut and crush the strata and transport the rock waste to the surface within bentonite slurry by a suction pump.

- **Trench Stability**: during the cutting operation, trench stability is maintained using a water based bentonite stabilizing fluid.

  The bentonite slurry will be prepared in tanks within the Slurry Plant Area, as shown in Arup Drawing 40-ARI-WS-71-CI-DR-1081 and detailed in AMC Operation of Slurry Plant plan (Ref. 11). The Slurry Plant Area will be located on a bunded concrete slab with an independent surface water drainage system including isolator valves.

  In the event of substantial slurry losses from the trench excavation, observed by a sudden or continued drop in bentonite slurry levels within the guidewalls as monitored by the Cutter Operator, the following contingency measures will be adopted by the Contractor, as detailed in AMC's slurry loss management plan (presented in Appendix C of Ref. 10).

  1. Increase the rate of slurry feed to the trench.

  2. Recover the cutter, and dependent on the rate of slurry losses adopt one of the following mitigation measures.

     a. Increase the slurry density and viscosity by the application of Slurry Additive LTA 3 at a rate of 0.5kg/m^3 of slurry within the trench.

     b. Fill the trench with sand.

     c. Fill the trench with extractive rock arisings.

     d. Fill the trench with concrete.

  In the event of a major slurry loss, the Contractor will maintain regular review of the real time groundwater quality monitoring system detailed in Section 2.3.3 below.

  During trench cutting, the density and viscosity of the bentonite stabilising slurry will vary in relation to the proportion of rock fines suspended within the slurry. Where high fines causes an unacceptable increase in the density of the slurry, additive LTA 16 will be applied at a rate of up to 1.0 litres per cubic metre of slurry to reduce the density of the slurry, as detailed in AMC's slurry loss management plan (Ref. 10). Where high levels of rock fines in the slurry causes a reduction in the fluid's pH and a consequential increase in slurry viscosity, Sodium Bicarbonate will be applied at a rate of up to 5 kg per cubic metre of slurry to increase the pH of the stabilising slurry to between its optimal range of pH 7 to 10, as detailed in AMC's slurry loss management plan (Ref. 10).

- **Management of Trench Cutting Arisings**: During trench cutting, the rock arisings will be pumped within the bentonite slurry suspension from the rotating cutting heads, to a dedicated de-sanding unit at the surface, as detailed in Refs. 10 and 11. The rock waste generated from this process will be screened into separate silt to gravel sized fragments with the following gradings (4 mm – 80 mm, 0.02 mm – 4 mm and <0.06 mm). These three rock material size fractions will be separated onto a concrete apron in front of the de-sanding unit that will drain to a blind sump. The arisings will be tested to confirm their chemical and geotechnical suitability for reuse in the permanent works, as an "inert" Class 4 Landscape quality fill, as detailed in Section 2.3.2 below.

- **Reinforced Concrete Wall Construction**: Once the trench has been cut to its full depth, reinforcement will be lowered into the trench and then tremie-method concreting will be carried out. The concrete materials utilised in this process comprise inert aggregate, cement and plasticizers. These plasticizers will comprise compounds that are characterised non-hazardous and non-ecotoxic. The wall will be constructed utilising a concrete material of a minimum permeability of 1×10^{-10} m/s and with panel joints cut to maintain a minimum permeability for the wall of 1×10^{-10} m/s.

2.3.2 Specification

Specification of Bentonite Slurry

The specification for the stabilising slurry mix will be as detailed in AMC Slurry Management Plan (Ref. 8) and will comprise the following mix per cubic metre of trench stabilising slurry:

- 1000 litre of water.
- 35-40 kg bentonite powder (Berkbent CGB or similar).

Specification of Bentonite Slurry Admixtures

The specification for the slurry additives that will be applied to the bentonite slurry to manage its viscosity, pH balance and density are detailed in the Slurry Management Plan (Ref. 8) and summarised in Table 4.

Table 4 - Bentonite Slurry Additives

Product	Purpose	Chemical Composition	Hazardous Substances (Groundwater Daughter Directive (2006/118/EC) (GDD)
Sodium Bicarbonate	Reduce viscosity by pH level adjustment	Sodium Bicarbonate	Contains no hazardous substances.
BAUER Slurry LTA 3	Is an additive to increase the viscosity of the slurry to block voids to mitigate slurry losses in zones of highly permeable strata.	Poly-acrylic acid, sodium salt	Contains no hazardous substances.
BAUER Slurry LTA 16/17	Plasticizer	Poly-acrylic acid, sodium salt	Contains no hazardous substances.

Specification for Diaphragm Wall Arisings for Reuse as Inert Class 4 Material in the Permanent and Temporary Landscaped Screening Bunds

Rock waste materials generated from the diaphragm walling process that are to be deposited in the temporary and permanent storage mounds as “inert” fill (as shown in Arup Drawing 40-ARI-WS-71-CI-DR-1082) are to be placed in accordance with the principals of the Specification for Highway Works, Series 600 Earthworks (Ref. 16).

Compliance testing will be undertaken to confirm the acceptable moisture content ranges, appropriate to cohesive and granular materials generated by the Diaphragm Walling process, to enable placement as a geotechnically acceptable Class 4 landscape fill. In addition, compliance testing will be undertaken to demonstrate that the chemical constituents of these arisings classify as non-hazardous "inert". Presented below is a summary of the geotechnical and chemical compliance testing to be undertaken and the acceptability criteria to be achieved.

Compliance Testing

- Geotechnical acceptability testing will be undertaken on all arisings to be reused as Class 4 materials, as follows:
  - Grading 1 per 1,000m^3.
  - Natural Moisture Content 1 per 250 m^3.
  - Optimum Moisture Content (OMC) 1 per 1,000 m^3.
  - Five Point MCV Calibration 1 per 1,000 m^3.
  - Single Point MCV 1 per 250 m^3.

- Geotechnical end product testing will be undertaken on cohesive Class 4 materials only, as follows:
  - Shear strength by hand vane 1 per 250 m^3.

- Chemical acceptability testing will be undertaken, in accordance with the waste classification guidance (Ref. 15), on all arisings generated from the diaphragm wall excavation that are to be retained as "inert" fill. This testing will be undertaken at a minimum frequency of at a frequency of 1 test per 2,000 m^3 and will include analysis of the soil's total element concentrations as detailed in Table 5 together with a Full Inert Waste Acceptance Criteria Test Suite, as detailed in Table 6.

Table 5 – Analysis of Total Element Concentrations

Determinand	Analytical Detection Limit (mg/kg unless otherwise stated)
Aluminium	1
Arsenic	0.2
Antimony	1
Boron (water soluble)	0.2
Cadmium	0.1
Calcium	1
Chromium	0.15
Hexavalent Chromium	1
Cobalt	0.7
Copper	0.2
Iron	1200
Lead	0.3
Magnesium	1
Manganese	20
Mercury	0.05
Molybdenum	0.4
Nickel	1
Phosphorus	1
Potassium	1
Selenium	0.5
Sodium	0.1
Strontium	1

Tungsten	1
Vanadium	0.8
Zinc	1
Conductivity	1 uS/cm
pH	-
Carbonate (as CaCO3)	1%
Chloride	1
Total Sulphate as SO4	0.01%
Sulphide	10
EPH (C10-C40)	10
Speciated PAHs	1.6

Acceptance Criteria

- Geotechnical Criteria
  - Natural Moisture Content BS 1377:Part 2 OMC -5% +5%
  - OMC BS 1377:Part 4 (2.5 kg Rammer).
  - MCV Clause 632 (SHW) minimum value 6.
  - Shear Strength >50kN/m^2.

- Chemical Acceptance Criteria
  - Analysis of the total concentration results will be undertaken using HazWaste online assessment to determine whether the concentration of any element within the waste, or the combination of elements within the waste is deemed hazardous in accordance with current guidance (Ref. 15).
  - Analysis of the Inert WAC test results will be undertaken by comparison with the inert waste acceptance criteria detailed in Table 6.

Table 6 – Full WAC Test Suite and Acceptance Criteria

Parameter	**Criteria**
Parameters determined as total concentrations	
Total organic carbon (%w/w)	3%
Loss on ignition (%w/w)	6
BTEX (mg/kg)	
PCB's (7 congeners) (mg/kg)	1
Mineral Oils C10 – C40 (mg/kg)	500
PAH's (mg/kg)	100
Limit values (mg/kg) for compliance leaching test using BS EN 12457 at L/S 10 l/kg	
Arsenic	0.5
Antimony	0.06
Barium	20
Cadmium	0.5
Chloride	800
Total Chromium	0.5
Copper	2
Iron	1200
Fluoride	
Lead	0.5
Mercury	0.01
Molybdenum	0.5
Nickel	0.4
Phenol Index	1
Selenium	0.1

Zinc	4
Dissolved organic Carbon at own pH or pH 7.5-8	500
Total Sulphate as SO4	1000
Total Dissolved Solids	4,000

Service Shaft Diaphragm Walls

At the Service Shaft, a diaphragm wall will be constructed 1.2 m wide, 37.4m diameter and 60 m deep, below the Shaft Platform at an elevation of 203.17 m AOD, as illustrated in AMC Drawing No. 40-AMC-WS-12-CI-DR-1901, 40-AMC-WS-71-CI-DR-0079 and 40-AMC-WS-71-CI-DR-0080.

This wall will be constructed to minimise groundwater ingress into the shaft and achieve a maximum design permeability of 1 x 10^{-10} m/s for joints and concrete down the full wall height.

Production Shaft Works

At the Service Shaft, a diaphragm wall will be constructed 1.2 m wide, 34.4m diameter and 60 m deep, below the Shaft Platform at an elevation of 200.66 m AOD, as illustrated in AMC Drawing No. 40-AMC-WS-11-CI-DR-1901, 40-AMC-WS-71-CI-DR-0079 and 40-AMC-WS-71-CI-DR-0080.

This wall will be constructed to minimise groundwater ingress into the shaft and achieve a maximum design permeability of 1 x 10^{-10} m/s for joints and concrete down the full wall height.

Mineral Transport System Shaft (MTS)

At the MTS Shaft, a diaphragm wall of 1.2m wide, 10.4m diameter and 60m deep is to be constructed from the Shaft Platform at an elevation of 200.8m AOD, as illustrated in AMC Drawing No. 40-AMC-WS-13-CI-DR-1901, 40-AMC-WS-71-CI-DR-0079 and 40-AMC-WS-71-CI-DR-0080.

This diaphragm wall is to be constructed to achieve a maximum design permeability down the full wall height of 1 x 10^{-10} m/s.

2.3.3 Operational Management

Visual Observations of Slurry Losses by the Cutter Operator

During trench cutting operations, the Contractor will monitor the bentonite slurry levels within the trench guide wall to identify drop in slurry levels, indicative of slurry losses in zones of high permeability (Refs. 8 and 10). In the event of substantial losses, observed by a sudden or continued drop in bentonite slurry levels within the guidewalls, the contingency measures detailed in Appendix C of Ref. 10 will be adopted.

Groundwater Quality Installations To Monitor For Slurry Losses

Arrays of nested monitoring wells, set at a radius of approximately 50m and a spacing of approximately 50m, will be constructed around the diaphragm wall perimeters as detailed in

AMC's monitoring programme for D-Walling Slurry losses and illustrated in AMC Drawings 40-AMC-WS-CI-DR-001 and AMC-WS-CI-DR-001 (Ref. 14).

Each well array will comprise two nests of three, 2-inch diameter PVC standpipe piezometers installed with three <10m length screened intervals per nest within each proposed 8 inch borehole. The individual monitoring response zones will be separated from one another by a bentonite plug. The length and vertical alignment of the six screened response zones, will be design specifically for that location and targeted on the Moor Grit, Scarborough and Cloughton aquifer units to provide designed response zones across the full 60m depth of diaphragm walling.

Four far-field borehole will also be installed to the same specifications, one each located to the northeast, southeast, northwest and southwest of the shaft platform, just within the site boundary.

From AMC's review of the chemical characteristics of the slurry mix (Ref. 14), it has been determined that the following "indicator" parameters can be monitored within the background groundwater quality to indentify when slurry migration beyond the trench walls causes a chemical impact on local groundwater quality:-

- pH
- Conductivity
- Temperature
- Salinity
- Density
- Total Dissolved Solids
- Dissolved oxygen
- Oxidative redox potential

Identification of changes in concentrations of these indicator parameters, within groundwaters around the diaphragm walling construction works, will be carried out by real time monitoring using AquaTROLL400 or AquaTROLL600 Multi-parameter Probe installed in the wells, as detailed in the Construction and Operation Phase Groundwater and Surface Water Monitoring Scheme for the Phase 4 Works at Woodsmith Mine (Ref. 3). Evaluation of these results will be undertaken in relation to Control Trigger Values set in the Monitoring Scheme (Ref. 3) and mitigation measures will be implemented, where necessary, in accordance with the Remedial Action Plan (Ref. 4) and AMC's slurry loss contingency measures detailed in Appendix C (Ref. 10)

Concrete and Joint Quality of Diaphragm Walling

During construction of the concrete diaphragm wall, concrete cube testing will be undertaken in accordance with BS EN 12350-1:2000 of representative samples.

Secondary panels will be cut into the primary panels to expose fresh concrete surfaces on the adjacent elements as illustrated in AMC Drawings 40-AMC-WS-71-CI-DR-0079 and 40-AMC-WS-71-CI-DR-0079. The joints between primary and secondary panels will be cleaned, as detailed in the diaphragm wall installation plan (Ref. 10). Monitoring of the panel joints will be undertaken

by interrogation of the cutter steering system reports to verify that the completed wall will provide a compliant low permeable structure, as per the design.

2.3.4 Documentation and Reporting

The Contractor is responsible for providing "as built" records of the diaphragm walls to the Environmental Engineer, including concrete permeability testing and joint records.

During construction, the Contractor will be responsible for maintaining daily records of the diaphragm walling operations including identification and management of slurry fluid losses. This information will be provided together with the results of the groundwater quality real time monitoring to the Environmental Engineer in a weekly summary report and will identify any significant or sustained losses in bentonite slurry into the Ravenscar aquifers and mitigation measures taken.

Inspection and monitoring of the performance of the diaphragm walling, to prevent groundwater ingress into the permanent chambers, will be undertaken in subsequent construction phases, following excavation of the rock inside the walls.

2.4 Construction Environmental Management Plan

The site compounds for the plant and maintenance areas for the Phase 4 Works will be operated in accordance with a Construction Environmental Management Plan (CEMP), produced to satisfy the requirement of NYMNPA Planning Condition 93. To ensure that appropriate pollution control measures are adopted for construction operations, to mitigate potential impacts on groundwaters, the CEMP will include specific procedures to provide the following groundwater management controls:-

- Storage of potentially polluting materials including fuels, lubricants, salts, concrete and waste materials.

- An Incident Response Plan to deal with any pollution that may occur during the course of construction.

3 COMPLIANCE MONITORING

An Environmental Engineer will be appointed by Sirius Minerals to oversee implementation of the Groundwater Management Measures during the Phase 4 Works and undertake the following inspections, reviews and reporting during construction of the works, as detailed in Section 2.

3.1 Temporary Well Dewatering

- Review of the Contractor's pre-commencement and construction phase water level monitoring and of the weekly summary reports on the flow rate of groundwater discharged from the system to surface water drainage.

- Review of the Contractor's monitoring of the dewatering well ports for any evidence of bentonite slurry loss within the abstracted waters and of their records on the pumping of any waters, containing high suspended solids, into the siltation ponds.

3.2 Diaphragm Walling

- Review of the Contractor's records of the diaphragm walling operations and of the real time groundwater quality from the perimeter monitoring wells, including the identification and management of slurry fluid losses.

- Review of the Contractor's "as built" records of the diaphragm walls, including concrete permeability testing and joint records.

4 TIMETABLE FOR IMPLEMENTING THE PHASE 4 WORKS GROUNDWATER MANAGEMENT SCHEME

The timetable for undertaking the Phase 4 Works, including the associated groundwater management scheme, is July 2017 to March 2018.

C BELL
ASSOCIATE DIRECTOR

R IZATT-LOWRY
DIRECTOR

5 REFERENCES

1 Royal HaskoningDHV, 2014. York Potash Project Mine, MTS and MHF Environmental Statement.

2 FWS Consultants Ltd, May 2017. Hydrogeological Risk Assessment For The Phase 4 Works At Woodsmith Mine, North Yorkshire (1433DevOR205).

3 FWS Consultants Ltd, May 2017. Construction and Operation Phase Groundwater and Surface Water Monitoring Scheme for the Phase 4 Works at Woodsmith Mine, North Yorkshire. Doc. Ref. No. 1433DevOR206.

4 FWS Consultants Ltd, May 2017. Remedial Action Plan for the Phase 4 Works at Woodsmith Mine, North Yorkshire. Doc. Ref. No. 1433DevOR207.

5 FWS Consultants Ltd, May 2017. Addendum to Groundwater Management Scheme. Phase 2 Development Works at Woodsmith Mine, North Yorkshire Ref. No. 1433DevOR214.

6 FWS Consultants Ltd, August 2015.Geotechnical data report For the Doves's Nest Shaft Boreholes SM11 and SM14 Ref. 1433OR64/August 2015.

7 AMC May 2017, Document Ref. 40-AMC-WS-10-SW-RA-0001 MOBILISATION DEMOBILISATION.

8 AMC May 2017, Document Ref. 40-AMC-WS-10-SW-RA-0002 SLURRY MANAGEMENT PLAN (BENTONITE).

9 AMC May 2017, Document Ref. 40-AMC-WS-10-SW-PL-0003 PROJECT MANAGEMENT PLAN (CONSTRUCTION PHASE PLAN)

10 AMC May 2017, Document Ref. 40-AMC-WS-10-SW-RA-0004 INSTALLATION OF DIAPHRAGM WALL SHAFTS.

11 AMC May 2017, Document Ref.40-AMC-WS-10-SW-RA-0005 OPERATION OF SLURRY PLANT.

12 AMC May 2017, Document Ref. 40-AMC-WS-10-SW-RA-0006 INSTALLATION OF GUIDEWALLS.

13 AMC May 2017, Document Ref. 40-AMC-WS-71-EN-PL-0004 ENVIRONMENTAL MANAGEMENT PLAN.

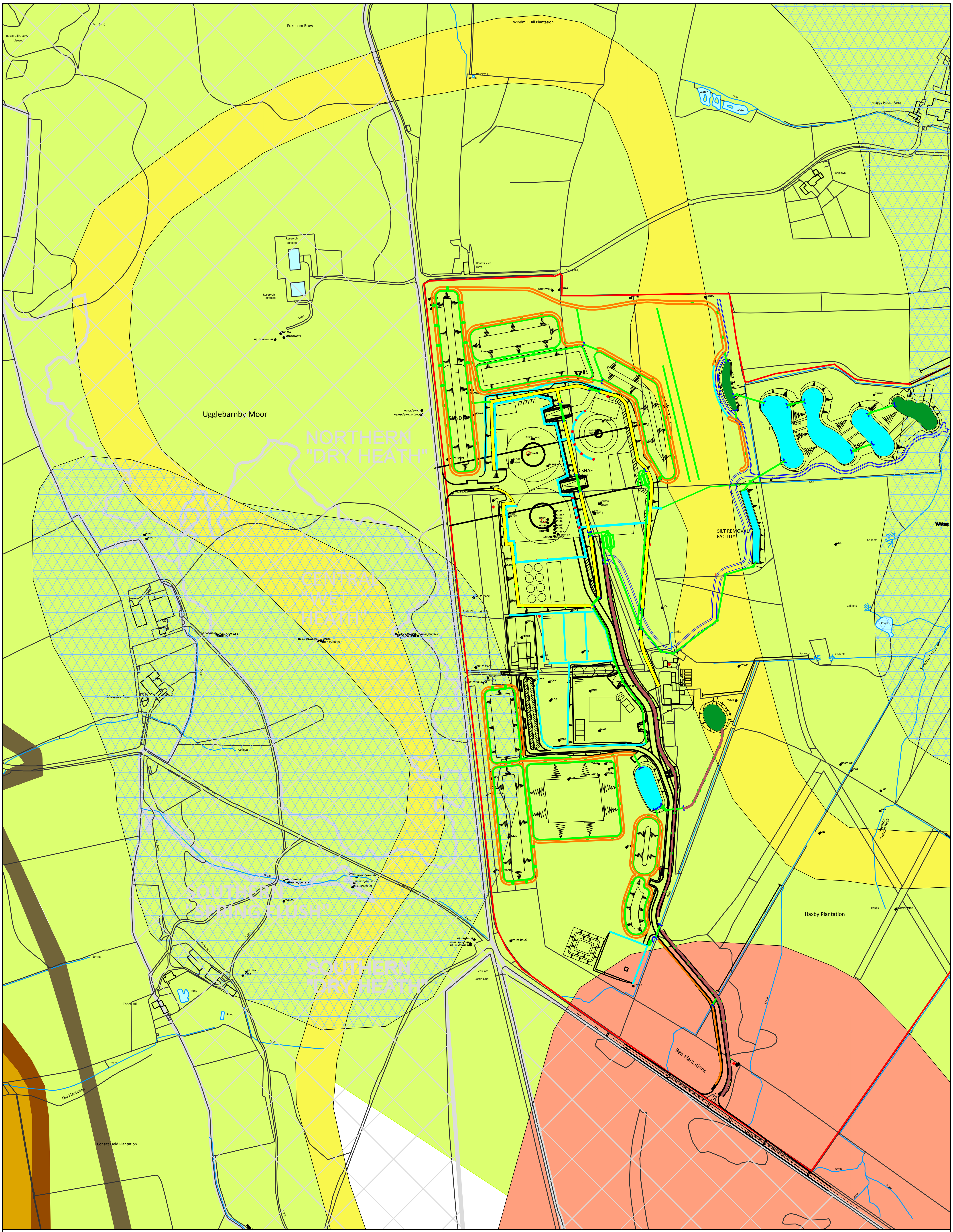
14 AMC May 2017, Document Ref. 40-AMC-WS-72-SW-MS-0001 MONITORING PROGRAMME FOR D-WALL SLURRY LOSSES.

15 Environment Agency Technical Guidance WM3 (1st Ed 2015) Guidance on the classification and assessment of waste.

16 Volume 1, Specification for Highway Works, Series 600Earthworks. November 2009.

APPENDIX 1

DRAWINGS



NOTES / KEY

SITE OWNERSHIP BOUNDARY

NYM SAC

SURFACE WATER

BOREHOLES GCBH01

HYDROGEOLOGICAL RECPTORS MF2

LINE OF CROSS SECTION

CROSS SECTION A-A' and B-B' DRAWING 1433DevOD244

CROSS SECTION A-A' DIAPHRAGM WALL DRAWING1433DevOD268

CROSS SECTION C-C' DRAWING 1433DevOD266

CROSS SECTION D-D' DRAWING 1433DevOD267

GEOLOGY

GLACIAL TILL

LONG NAB

MOOR GRIT

SCARBOROUGH FORMATION

CLOUGHTON & SALTWICK FORMATION

ELLER BECK FORMATION

DOGGER FORMATION

WHITBY MUDSTONE

DRAWING TITLE

GEOLOGICAL MAP AND LINE OF CROSS SECTIONS

PROJECT TITLE

NORTH YORKSHIRE POLYHALITE PROJECT

CLIENT SIRIUS MINERALS PLC	
STATUS FINAL	PROJECT NUMBER 1433Dev
DRAWN BY CB	DATE May 2017
SCALE 1:5,000@A3/1:2,500@A1	DRG. No. 1433DevOD280

FWS Geological & Geo-Environmental Consultants

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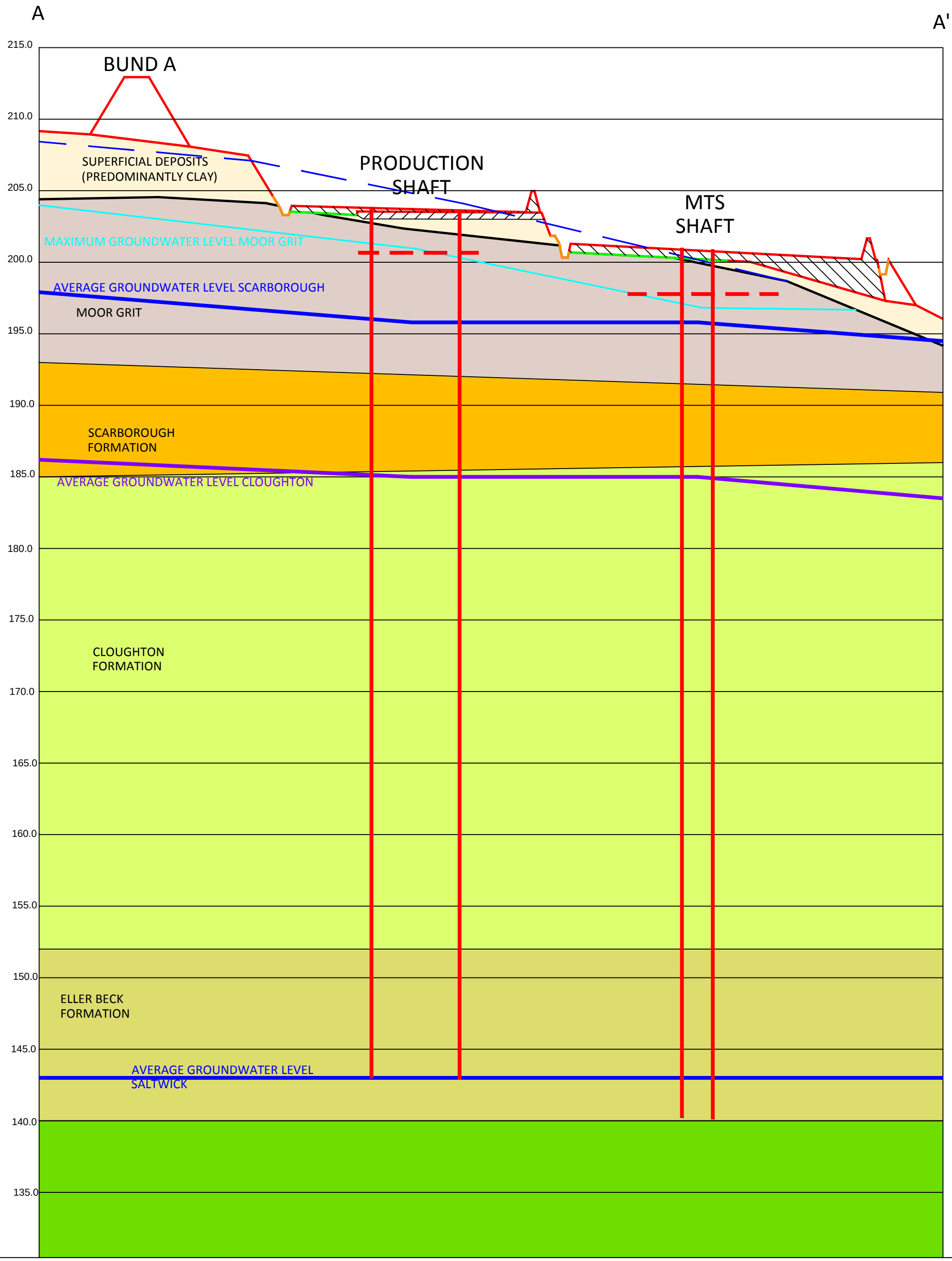
Merrington Lane Industrial Estate
Spennymoor
County Durham
DL16 7UT



NOTES / KEY

PHASE 2&3 WORKS
GEOMEMBRANE
LINED DRAINAGE DITCH

GEOLOGY

- EXISTING GRANULAR PLATFORM CONSTRUCTION
- NEW GRANULAR PLATFORM CONSTRUCTION
- COHESIVE SUPERFICIAL DEPOSITS
- MOOR GRIT
- SCARBOROUGH FORMATION
- CLOUGHTON FORMATION
- ELLER BECK
- SALTWICK FORMATION
- DOGGER FORMATION
- WHITBY MUDSTONE FORMATION

DRAWING TITLE
SCHEMATIC DRAWING OF DIAPHRAGM WALL GROUNDWATER MANAGEMENT MEASURES

PROJECT TITLE
NORTH YORKSHIRE POLYHALITE PROJECT

CLIENT
SIRIUS MINERALS PLC

STATUS
FINAL

PROJECT NUMBER
1433Dev

DRAWN BY
CB

DATE
May 2017

SCALE
AS SHOWN

DRG. No.
1433DevOD268Rev4

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County Durham
DL16 7UT

A1

B 1416

N

Existing drainage pipe.

Existing drainage ditch.

Discharge from dewatering system to existing ditch.

Standby discharge to slit removal facility for turbid groundwater.

Dewatering system discharge to existing drainage pipe via holding tank.

Notes:

1. Dewatering during phase 3 to a maximum of 3m below platform level.

Key:

- Approximate location of dewatering wells. Actual number and location to be determined by specialist dewatering contractor.
- Temporary dewatering pipeline
- Existing culvert

Issue	Date	By	Chkd	Appd
3	26/05/17	JB	CW	AH
	Issue for Planning			
2	25/05/17	JB	CW	AH
	Issue for Planning			
1	25/05/17	JB	CW	AH
	Issued for Planning			
0	31/03/17	JB	CW	AH
	Issued for Planning			

ARUP

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Client
Sirius Minerals Plc

Job Title
Woodsmith Mine
Proposed Minehead

Woodsmith Mine
Construction Phase 3 and 4
Platform Dewatering
Infrastructure

Scale at A1 1:1250

Discipline Civil

Job No **253285**

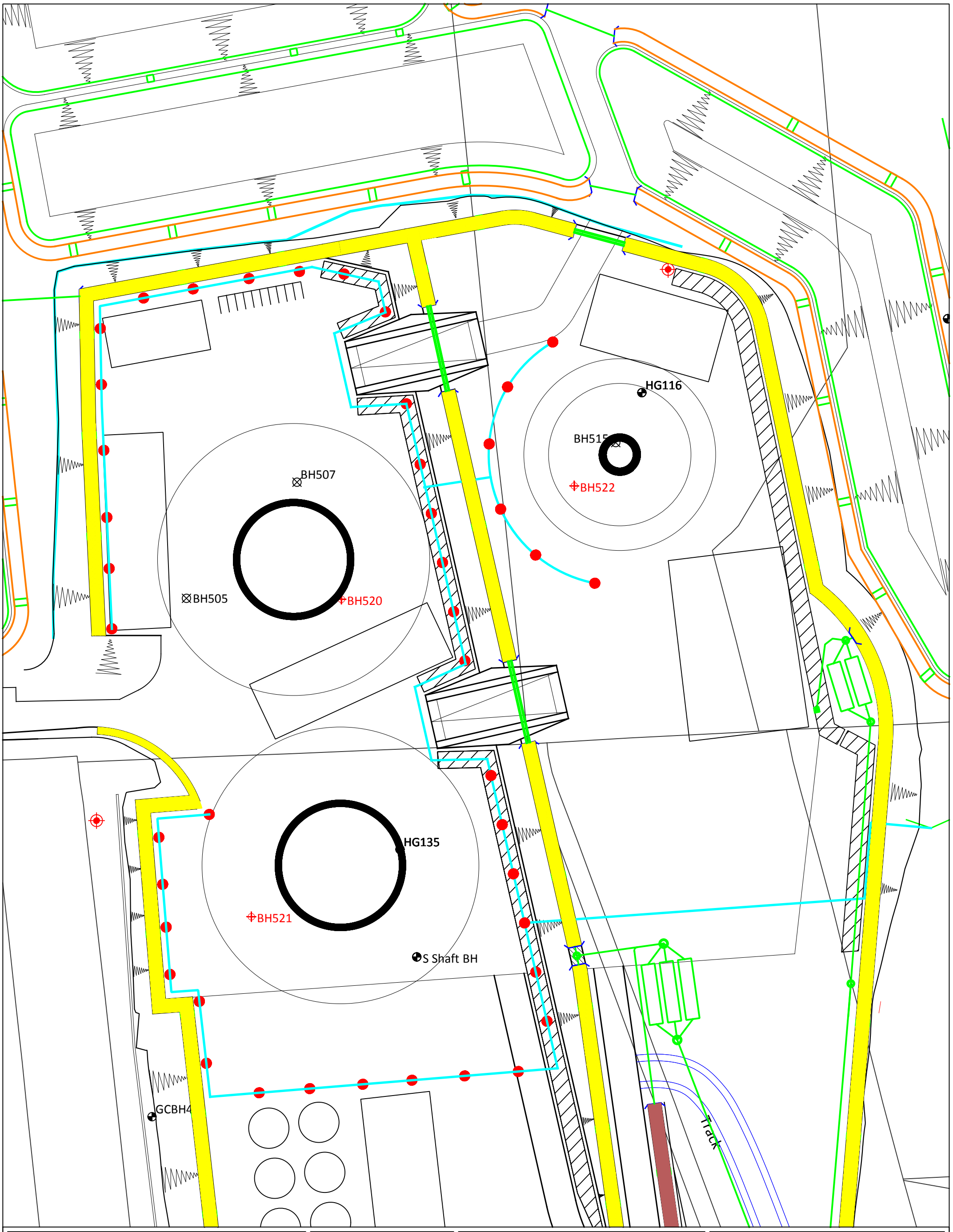
Drawing Status **Planning**

Drawing No **40-ARI-WS-71-CI-DR-1058**

Issue **3**

Do not scale

\\Global\europe\Leeds\Jobs\250000\253285-001\2 Arup - P10 Platform Redesign\0-20 CAD P10 - Platform Redesign\0_Drawings\40-ARI-WS-71-CI-DR-1058.dgn



NOTES / KEY

EXISTING MONITORING WELLS ⊕ GCBH01

NEW MONITORING WELLS ⊕ BH520

DEWATERING LOCATIONS ●

DRAWING TITLE
MONITORING WELL ARRANGEMENT FOR TEMPORARY PHASE 4 DEWATERING

PROJECT TITLE
NORTH YORKSHIRE POLYHALITE PROJECT

CLIENT
SIRIUS MINERALS PLC

STATUS	PROJECT NUMBER
FINAL	1433Dev
DRAWN BY	DATE
CB	May 2017
SCALE	DRG. No.
1:1,000@A3	1433DevOD286

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