Appendix 12: Hydrogeological Risk Assessment for s73 Development (June 2017)

FWS Geological & Geo-Environmental Consultants

SIRIUS MINERALS PLC – SECTION 73 PLANNING SUBMISSION FOR THE NORTH YORKSHIRE POLYHALITE PROJECT

REPORT	**HYDROGEOLOGICAL RISK ASSESSMENT**
SITE	**SECTION 73 WORKS AT WOODSMITH MINE, NORTH YORKSHIRE**
DOCUMENT NUMBER	**40-FWS-WS-83-PA-RA-0001**

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HYDROGEOLOGICAL RISK ASSESSMENT FOR THE SECTION 73 WORKS AT WOODSMITH MINE, NORTH YORKSHIRE

1 INTRODUCTION

1.1 General Background

Since approval of the scheme detailed in planning permission NYM/2014/0676/MEIA at Woodsmith Mine, modifications have been undertaken to the application documentation to address design amendments. These modifications have included amendment and revision to the foreshafts, substructures, drift portal, tunnel and to the earthworks aspects of the mine surface development.

This document summarises the modifications made to the substructures and earthworks elements and identifies the impact these design changes have had on the hydrogeological assessment and mitigation measures proposed.

1.2 Objectives

The purpose of this document is to:-

- Identify the design changes to the substructures, construction methodology and earthworks incorporated into the amended development.
- Identify which effects and impacts have been affected by the design changes.
- Assess the magnitude of risk to hydrogeological receptors from the design changes.
- Identify, where appropriate, any additional hydrogeological mitigation measures that may be warranted as part of the development.
- Provide recommendations on any further hydrogeological risk assessment considered necessary as part of the detailed design to confirm the effectiveness of the proposed groundwater controls put in place during the construction, post-construction or site decommissioning phases of the development.

2 DATA SOURCES

The data considered within this report are from the following sources:-

Hydrogeological Data

- FWS Consultants Ltd, 2016. Hydrogeological Baseline Report for the Doves Nest Farm Minesite, North Yorkshire 2012 to 2016 (Ref 1).
- FWS Consultants Ltd, September 2014. Hydrogeological Risk Assessment of the Minesite Development at Dove's Nest Site, North Yorkshire (Ref 2).
- FWS Consultants Ltd, 2014. Preliminary Waste Management Plan (Ref 3).

- FWS Consultants Ltd, 2015. Hydrogeological Assessment of Changes to the York Potash Planning Submission for the Mine Surface Development Site and the Minerals Transport System (Ref 4).
- FWS Consultants Ltd, 2014. Preliminary Quantitative Hydrogeological Risk Assessment of Pollution Impact from Permanent Waste Management Facilities (Ref 5).
- FWS Consultants Ltd, 2017 Hydrogeological Risk Assessment for the Phase 2 Works at Doves Nest Farm Minesite, North Yorkshire (Ref 6).
- FWS Consultants Ltd, 2017 Hydrogeological Risk Assessment for the Phase 3 Works at Woodsmith Mine, North Yorkshire (Ref 7).
- FWS Consultants Ltd, 2017 Hydrogeological Risk Assessment for the Phase 4 Works at Woodsmith Mine, North Yorkshire (Ref 8).

Ecological Data

- Royal Haskoning DHV, Hydrogeologically Supported Terrestrial Ecosystems and Ecological Monitoring for the Phase 2 Works at Woodsmith Mine No. RHDHV TN002 (Ref. 6).

Development Details Sought via the Section 73 Application

Construction development details provided by Sirius Minerals, Arup and Cartwright Pickard, including:-

Sirius Minerals

- Drawing 1000-ENV-DFS-DWG-005 Proposed Mine and MTS Structures.

Arup

- YP-P2-CX-036 Pyritic Mudstone facilities and temporary NHNI Waste Storage Facilities.
- YP-P2-CX-509 Issue 2 Minesite Working Plan Surface Water Drainage.
- YP-P2-CD-080 Surface Water Drainage General Arrangement.
- YP-P2-CD-200 Earthworks Strategy Groundwater Drainage Design.
- YP-P2-CX-508 Working Plan General Arrangement and earthworks.

Cartwright Pickard Architects

- Drawing 653-AP-0007 Rev 9 Proposed Mine Buildings Site Plan.
- Drawing 653-ASK-1000 Rev 0 Woodsmith Mine Comparative Sections.

3 DETAILS OF THE CHANGES TO THE APPROVED SCHEME SOUGHT VIA THE SECTION 73 APPLICATION

3.1 General Description

As part of the Section 73 application, the following changes to the approved scheme are sought.

- Minehead Layout – Variation to the buildings at the Minehead to include wider diameter foreshafts to the Men and Material and Minerals Shafts, incorporating access and ventilation. This replaces the need for the previously approved Drift Portal and Tunnel, its associated onsite structures, the -45m level roadway and has also removed the requirement for the ventilation shaft, thereby reducing the size of the Intake Ventilation Equipment Building, as shown on Cartwright Pickard Drawing 653-AP-0007;

- Construction Methods - Amendments to the construction methods to the above include raising and extending the Construction Platform, removal of the Construction Platform perimeter grout wall and relief drain, utilising diaphragm walling instead or grouting and adopting temporary dewatering within the Construction Platform area, as shown on Arup Drawing YP-P2-CX-508;

- Landscaped Bunding – Amendments to the landscaped bunding and Non Hazardous Non Inert (NHNI) Extractive Waste Management Facilities, to accommodate a revised road layout and to accommodate the revised quantities of extractive materials generated from the mine development works as shown on Arup Drawings YP-P2-CX-036 and YP-P2-CX-508;

- Water Attenuation – relocation of water attenuation ponds and silt trap ponds, as shown on Arup Drawing YP-P2-CX-509;

- Internal Access Road – the addition of an internal access road linking the approved Welfare Entrance and the Construction Platform, as shown on Arup Drawing YP-P2-CX-508; and

- Construction of temporary and permanent soil mounds, as shown on Arup Drawing YP-P2-CX-508;

The programme for completing construction of the elements that interact or impact on the groundwater system will be as follows:

  - Temporary de-watering – fully complete by Spring 2018.
  - Diaphragm walling – fully complete by Spring 2018.
  - Construction of substructures – fully complete by Spring 2018.
  - Construction of hardstanding – fully complete by Spring 2018.
  - Construction of buildings – fully complete by Spring 2019.
  - Construction of bunding and NHNI facilities – ongoing throughout minesite construction with the final completion by Spring 2022.

The following sections present details of the design levels and construction methodology for the above design amendments.

3.2 Site Construction

The design changes to the substructures associated with the Construction / Operation Platform and associated shafts, and the amendments to the earthworks are summarised below. No design changes are proposed in relation to the MTS Tunnel, Welfare Facilities or to the Groundwater Discharge Well.

Construction Platform

Approved Design		Record of Amendments to Design			
Dimensions	**Groundwater Mitigation Measures**	**Dimensions**	**Groundwater Mitigation Measures**	**Comments**	**Document/ Drawing Recording Design Change**
410m x 150m Formation Level @199.35m AOD. Groundwater drainage blanket.	Basal groundwater drainage blanket above a geosynthetic clay liner (GCL) pollution control membrane. Grout wall along western and southern perimeter to aquitard at base of Moor Grit @ 195m AOD. A groundwater relief drain around the grout wall.	Plan area 410m x 200m over two tiers with the western area at @203m AOD and the eastern area at 200m AOD.	Enhanced geological pollution control barrier at the base of the shaft platform construction.	Raising the Construction Platform level has negated the requirement for a groundwater drainage blanket, the grout wall and the relief drain.	Arup Drawing YP-P2-CX-508 and YP-P2-CD-200

Minerals Shaft

Approved Design		Record of Amendments to Design			
Dimensions	**Groundwater Mitigation Measures**	**Dimensions**	**Groundwater Mitigation Measures**	**Comments**	**Document/ Drawing Recording Design Change**
Building substructure chamber 200.7 to 195.2 m AOD. Dimensions 78.6 x 27.5m.	Pre-grout wall 5 to 10m wide to 192m AOD in the Scarborough Formation.	Building substructure two "L" shaped chambers from 203.5 to 199 m AOD. Dimensions ~25m x 30m.	Temporary dewatering from Construction Platform perimeter wells.	Raising the base of the substructure will enable construction in the dry utilising temporary dewatering and tanking of the substructure.	Sirius Drawing 40-SMP-WS-10-PA-DT-0001
Headframe Chamber 195.2 to 164.2 m AOD of external circular dimensions 9m radius.	Pre-grout wall 5 to 10m wide to 90 m AOD into the Whitby Mudstone.	Foreshaft chamber 34.4m diameter from 203.66 m AOD to 147 m AOD.	Diaphragm wall construction to be adopted, requiring temporary dewatering to 200.66m AOD, where	Grouting to headframe substructure has been replaced by diaphragm walling construction with localised temporary	

			necessary from Construction Platform perimeter wells.	dewatering.	
Upper Shaft 164.2 to >-599m OD with an external diameter of 11m.	Pre-grout wall 5 to 10m wide where necessary through the Cleveland Ironstone and Staithes Sandstone.	Upper Shaft 147 to >-599m OD with an external diameter of 9.9m.	Diaphragm wall construction to ~83m AOD, beneath which pre-grout as per the approved design. To enable diaphragm walling temporary dewatering to 200.66m AOD will be undertaken, where necessary from Construction Platform perimeter wells.	Grouting to the upper shaft structure through the Ravenscar Formation has been replaced by diaphragm walling with localised temporary dewatering.	
Horizontal connection drift to MTS.	189 m AOD and 7m external diameter.	No design change proposed.			
Lower Shaft -600 m to -1,400m OD with an external diameter of 11m.	Pre-grout in Sherwood Sandstone -600m to -840m OD, in Roxby and Eskdale -840m to -940m OD and in Carnallitic Marls at -1130 m OD and Brotherton -1200 to -1240m OD.	No design change proposed.			

Men and Materials Shaft and Drift Portal / Tunnel

Approved Design		Record of Amendments to Design			
Dimensions	**Groundwater Mitigation Measures**	**Dimensions**	**Groundwater Mitigation Measures**	**Comments**	**Document/ Drawing Recording Design Change**
Building substructure chamber 200.7 to 195.2 m AOD of rectangular dimensions 119 x 52.4 m.	Pre-grout wall 5 to 10m wide to 192m AOD in the Scarborough Formation.	Building substructure "L" shaped chamber from 203 to 198.5 m AOD. Dimensions ~25m x 30m.	Temporary dewatering from Construction Platform perimeter wells.	Raising the base of the substructure has enable construction in the dry utilising temporary dewatering and tanking of the substructure.	Cartwright Pickard Drawing 653-ASK-1000, Arup Drawing YP-P2-CX-508 and Sirius Drawing 40-SMP-WS-10-PA-DT-0001
Headframe chamber 195.2 to 155.7m AOD of circular external dimensions 9m radius.	Pre-grout wall 5 to 10m wide to 90 m AOD in Whitby Mudstone.	Foreshaft chamber 38.4m diameter from 203 m AOD to 133 m AOD.	Diaphragm wall construction to be adopted, requiring temporary dewatering to 200.66m AOD, where necessary from Construction Platform perimeter wells.	Grouting to headframe substructure has been replaced by diaphragm walling construction with localised temporary dewatering.	
Upper Shaft 155.7 to -600m OD with an external diameter of 11m.	Pre-grout wall 5 to 10m wide where necessary through the Cleveland Ironstone and Staithes Sandstone.	No design change			
The Drift Portal / Tunnel and interconnection to the Men and Materials Shaft Service Bank at 160.3 to 155.1 m AOD, perimeter chambers 7m wide 190m long with an interconnecting chamber 4m wide x 34m long and a central east – west	Pre-grout wall 5 to 10m wide to around the drift and bank level chambers in the Moor Grit, Scarborough and Cloughton Formation.	The Drift Portal / Tunnel and the -45m road network has been designed out by adopting a wider and deeper foreshaft arrangement.	None required	The total substructure chamber volume has been significantly reduced and its associated area of grouting within the Moor Grit, Scarborough and Cloughton removed from the scheme.	Sirius Drawing 40-SMP-WS-10-PA-DT-0001

chamber 15m wide x 78 m long.					
Lower Shaft -600m to -1,344 m OD with an external diameter of 11m.	Pre-grout in Sherwood -600m - -840m OD. In Roxby and Eskdale -840m to -940m OD and Carnallitic Marls at -1130 m OD and Brotherton -1200 to -1240 m OD.	No design change proposed.			

Intake Ventilation Equipment Building

Approved Design		**Record of Amendments to Design**			
Dimensions	**Groundwater Mitigation Measures**	**Dimensions**	**Groundwater Mitigation Measures**	**Comments**	**Document/ Drawing Recording Design Change**
Fan House substructure chamber 200.7 to 190.2 m AOD Dimensions 62m x 28m.	Pre-grout wall 5 to 10m wide to ~192m AOD Scarborough.	The requirement for a fan house substructure has been deleted from the design by incorporating this arrangement into the Men and Materials Shaft winding gear substructure construction.	None	No substructure or pre-grouting will now be required	Sirius Drawing 40-SMP-WS-10-PA-DT-0001
Intake Shaft 190.2 to 100.1m AOD with an external diameter of 11m.	Pre-grout wall 5 to 10m wide down to the Whitby Mudstone.	The requirement for an independent ventilation shaft has been designed out by adopting a wider and deeper foreshaft arrangement to the Men and Materials Shaft	None	No shaft, horizontal development or grouting through the Ravenscar Formation will now be required.	
Intake Ventilation Horizontal Development 100.2 to 92.3m AOD length 110m width 9.5m.	Pre-grout wall 5 to 10m wide.				

MTS/Exhaust Ventilation Shaft

Approved Design		Record of Amendments to Design			
Dimensions	**Groundwater Mitigation Measures**	**Dimensions**	**Groundwater Mitigation Measures**	**Comments**	**Document/ Drawing Recording Design Change**
Shaft 199.3 to -160m OD with an external diameter of 11m.	Pre-grout wall 5 to 10m wide to the Whitby Mudstone.	Shaft 200.8 to -160m OD with an external diameter of 10.4m.	Diaphragm wall construction to be adopted to 120m below ground (~80m AOD), requiring temporary dewatering to 200.66m AOD, where necessary from Shaft Platform perimeter wells.	Grouting to the shaft substructure has been replaced by diaphragm walling construction with localised temporary dewatering.	Sirius Drawing 40-SMP-WS-10-PA-DT-0001
Horizontal Drift at -175m OD 10.7m wide x 7.5m high x 119m long.	Pre-grout only where necessary.	No design change proposed.			YP Drawing 1000-ENV-DFS-DWG-001
Minerals Store and Loading Facility at -159.6m OD 273m long x 16 m high x 15 m wide.	Pre-grout only where necessary.	No design change proposed.			
Minerals Transport Tunnel at -158.8m OD External Diameter 6m.	Pre-grout only where necessary.	No change.			

Landscaped Screening Bunds and Surface Water Attenuation Ponds

Approved Design		Record of Amendments to Design			
Summary Details	**Groundwater Mitigation Measures**	**Summary Details**	**Groundwater Mitigation Measures**	**Comments**	**Document/ Drawing Recording Design Change**
Landscaped bunds A, B, D and G for the containment of inert materials	None	No change for the containment of inert materials within the footprint of Bunds A, B and D			Arup Drawing YP-P2-CX-036
Landscaped bunds C, E, F for the containment of Non Hazardous Non Inert (NHNI) materials	A 1m basal engineered clay liner and a cover layer comprising GCL and Geofin drainage layer within the 1-2m thick engineered cap over the NHNI Bund C facility and incorporation a Geofin drainage layer and a 1-2m soil cover layer over E and F. Groundwater drainage layers below Bund F. Around the western limit of Bund C is a groundwater re-infiltration trench fed by surface water collected in the geofin drainage layer within the cover system.	The plan area of NHNI material stored within the south western facility (formerly Bund C) has been reduced by approximately 50% from the approved scheme. The plan area of NHNI material stored within the eastern facilities (formerly Bunds E, F and G) has been increased by approximately 50% from the approved scheme.	A 1m basal engineered clay liner and a cover layer comprising GCL and Geofin drainage layer within the 1-2m thick engineered cap over the south western NHNI facility and incorporation a Geofin drainage layer and a 1-2m soil cover layer over the eastern NHNI facility. Groundwater drainage layers below the eastern NHNI facility. Around the western limit of Bund C is a groundwater re-infiltration trench fed by surface water collected in the geofin drainage layer within the cover system.	The volume of NHNI material to be stored onsite has increased to accommodate additional arisings from the MTS tunnel. The surface area of the geofin drainage system has been increased within the cover to Bund C to maximise the recharge quantity re-infiltrated through the trench.	

Temporary Inert Bund I facility	None	Bund I has been deleted	None		
Temporary NHNI Facility Bund H	To include a basal engineered clay liner overlain by a Geosynthetic Clay Liner (GCL) and a 0.5m thick leachate drainage layer placed on a profiled base with a fall towards a leachate extraction sump in the east. The NHNI waste is to be covered with a GCL liner with a 0.3m thick layer of inert subsoil. This NHNI waste will be removed at the end of the construction programme and the area reinstated as landscaping on completion.	No change			
Surface water attenuation pond and wetland areas	None	Reconfiguration of siltation trap, attenuation ponds and wetland areas in the northeast of the site	None	No impact on groundwater conditions	Arup Drawing YP-P2-CD-080

3.2.1 Minesite Operation

As a consequence of the construction design amendments, the following changes to operation of the minesite's groundwater management measures will be undertaken to those presented in the approved scheme.

Approved Details		**Record of Amendment to Operational Details**		
Summary Details	**Groundwater Operational Measures**	**Summary Details**	**Groundwater Operational Measures**	**Comments**
Groundwater piped drainage blanket to the Operation Platform	To be operated in accordance with the Groundwater Management Plan and Remedial Action Plan	No groundwater drainage blanket is required in the amended design.		The groundwater drainage blanket will not be part of the Operational System
Groundwater drainage blanket and piped system to collect Dove's Nest spring discharge and other surface spring issues encountered beneath the proposed Landscaped Mound.	To be operated in accordance with the Groundwater Management Plan and Remedial Action Plan	No change proposed, as shown on Arup Drawing Arup Drawing YP-P2-CD-200.		The groundwater drainage blanket to collect spring discharges is be part of the Operational System as per the Approved Design.
Groundwater dewatered during the Operational Phase of the minesite from the Men and Materials Incline, the shafts and from the MTS.	During the Operational Phase, all non-domestic waste water generated by the mining works will be piped, through the MTS Tunnel, to a treatment and discharge facility at the Wilton Site.	The amended scheme has a reduced volume of substructures, (i.e. foreshafts, shafts and the MTS) from which a lower volume of non-domestic waste water will be generated during operational conditions.	No change.	The proposed amendments to the scheme from the Approved design will reduce the volume for waste groundwater to be piped for offsite treatment.
The recharge trench around the south western perimeter of Bund C providing re-infiltration to the Moor Grit aquifer.	To be operated in accordance with the Groundwater Management Plan and Remedial Action Plan	No change proposed, as shown on Arup Drawing Arup Drawing YP-P2-CD-200.		The recharge trench is be part of the Operational System as per the Approved Design.

3.2.2 Decommissioning

As part of the design amendments to the decommissioning scheme, except for deletion of the groundwater drainage blanket beneath the Construction Platform area from the final landform, no other changes to the groundwater management measures are proposed.

4 SUMMARY HYDROGEOLOGICAL RISK ASSESSMENT

4.1 General

From the previous hydrogeological risk assessments (Ref 2, 5, 6, 7 and 8), the principal sensitive hydrogeological receptors identified in close proximity to the mine include; the very high sensitivity Spring Flush hydrogeologically supported terrestrial ecosystem and springs used for domestic water supplies at Moorside and Soulsgrave farms to the southwest and southeast of the site. In addition, down hydraulic gradient of the NHNI facilities to the east of the development are the Moor Grit, Scarborough and Cloughton Secondary A aquifers, which are characterised as of moderate sensitivity.

Presented below is a summary of the groundwater mitigation measures incorporated into the amended design, the key changes to the hydrogeological conceptual model for the mine surface development created by the Section 73 design amendments and the potential changes to the physical and chemical effects on the sensitive hydrogeological receptors caused by these design amendments. By adopting the methodology for the hydrogeological risk assessment detailed in Section 4 of the Hydrogeological Risk Assessment Report (Ref 2), construction, operational and decommissioning phase impacts are then evaluated in respect of the principal sensitive hydrogeological receptors identified in close proximity to the mine.

Through this supplementary risk assessment, it is demonstrated that by inclusion of appropriate mitigation measures the proposed design modifications to the development present no long term adverse impacts to any of the hydrogeologically sensitive receptors, including the hydrogeologically supported Spring Flush terrestrial ecosystem, nearby spring discharges or to the Secondary A aquifers underlying the site.

4.2 Design and Mitigation Changes

The design changes to the mine surface development include amendments to the earthworks and mine substructures that interact with the groundwater system in the superficial deposits and the bedrock strata. The mitigation measures included within the design, the principal changes to the hydrogeological conceptual model to the approved scheme (Ref 2 and 5) and the resultant changes to the physical and chemical effects are summarised below:-

4.2.1 Earthworks

Construction / Operation Platform

Construction Phase Groundwater Mitigation Measures	The raised two tiered Construction Platform will include a basal natural geological or enhanced geological clay liner of 0.5m minimum thickness to separate construction surface waters from groundwater within the Moor Grit aquifer.
Operational & Decommissioning Phase Groundwater Mitigation Measures	None
Changes to the Conceptual Model Arising from the Design Amendments	The design amendment to the platform will result in a localised 50m extension to the east and raising of the platform level by around 3m to an elevation above the mean groundwater level within the Moor Grit aquifer. As a consequence of raising the platform above the groundwater table, there is no longer a requirement for a groundwater drainage blanket, grout wall or relief drain to control shallow groundwater within the Moor Grit aquifer.
Effects	This design change to the platform reduces the physical effects of these construction works on groundwaters in the Moor Grit aquifer local to this area and to the west in the Central Wet Heath/Mire area of the Ugglebarnby Moor SAC. In particular, it reduces the magnitude of effects that the construction works have on both lowering groundwater levels and on changing flow paths in this shallow aquifer. The principal physical groundwater effect, arising from the minor platform extension of the lower tier to the east, is that it will locally reduce recharge to the Moor Grit aquifer in this area.

Permanent Waste Storage Facilities

Construction Phase Groundwater Mitigation Measures	The NHNI facilities are designed to incorporate a 1m thick basal engineered clay liner and a cover layer comprising GCL and Geofin drainage layer within the 1-2m thick engineered cap over the south western NHNI facility and incorporating a Geofin drainage layer and a 1-2m soil cover layer over the eastern NHNI facility. A recharge trench will be constructed around the western perimeter of the south western NHNI facility to discharge surface waters, collected within the geofin drainage layer installed in the soil cover, into the Moor Grit aquifer. The re-infiltration quantity into this trench has been increased by expanding the area from which surface waters are to be collected from and redirected into this infiltration drain. Groundwater drains will be installed in the superficial deposits at the location of Dove's Nest spring and in an area to the north of this spring to collect and control groundwater discharge beneath the eastern toe slope area to the landscape mounds.
Operational & Decommissioning Phase Groundwater Mitigation Measures	The groundwater drainage blanket, collecting spring issues beneath the northeastern NHNI facility and groundwater drains in the cut slopes to the Welfare Facility, will be operated in accordance with a Groundwater Management Plan and a Remedial Action Plan for implementing urgent and corrective actions. The recharge trench around the western perimeter of the southwestern NHNI facility and the engineered capping system above all the NHNI extractive materials management facilities will be managed and operated in accordance with a Groundwater Management Plan and a Remedial Action Plan for implementing urgent and corrective actions.
Changes to the Conceptual Model Arising from the Design Amendments	The design amendment increasing the volume and surface area of the capped and lined NHNI facilities will locally reduce the area for rain infiltration into the Moor Grit, Scarborough and Cloughton aquifers and will increase the footprint over which leachate egress can occur.
Effects	Although these NHNI facilities are located outside of the recharge catchment areas to the Spring Flush and Moorside Farm Spring, the reduced recharge over the footprint of these facilities will cause a local reduction in groundwater levels in the Moor Grit presenting an additional physical effect on to these sensitive receptors. To mitigate this reduction in recharge to the Moor Grit aquifer, the discharge into the re-infiltration trench along the south western boundary has been increased by expanding the surface water catchment area feeding this recharge system. The overall increase in the plan area of NHNI facilities will increase the

volume of leachate egressing into the underlying aquifers. From the preliminary quantitative modelling (Ref 5), due to the very low concentrations of contaminants and high dilution factors previously determined, it is considered that this increase in the basal area to the NHNI facilities is unlikely to present a significant adverse chemical effect on groundwater quality. As such, leachate egress from these waste facilities is determined to present a very low magnitude of chemical effect on groundwater quality down hydraulic gradient in the shallow aquifers.

4.2.2 Substructures

Construction Phase Groundwater Mitigation Measures	Diaphragm walling will be used for all foreshaft and shaft construction works, within the Ravenscar Formation, instead of grouting and temporary dewatering. Localised temporary dewatering will be carried out to maintain trench stability during diaphragm walling and to enable dry construction of shallow substructures within the Moor Grit aquifer. These temporary works will be adopted instead of grouting and temporary dewatering, as included for in the approved scheme. Grout curtains, with a maximum permeability of 1 x 10^{-9} m/s, will be adopted for all shaft excavations in permeable strata below the Whitby Mudstone. Dewatering from these excavations will be minimised to a maximum of 36 m^3/day. Construction phase fresh, sulphatic and saline groundwaters will be treated within an onsite facility prior to either discharge to an onsite Deep Groundwater Discharge Well into the Sherwood Sandstone, or tankered to an offsite waste water disposal facility.
Operational Phase Groundwater Mitigation Measures	Groundwater dewatered from the shafts and from the Minerals Transport System will be managed as non-domestic waste water that will be piped through the Minerals Transport System Tunnel to a treatment and discharge facility at the Wilton Site. It is intended that the Deep Groundwater Discharge Well will not be used for regular discharge of non-domestic waste water generated by the works during the operational period, although it will be maintained to accommodate for temporary discharges, should this prove necessary.
Decommissioning Phase Groundwater Mitigation Measures	All shafts and associated chambers will be capped, plugged and backfilled in a manner to maintain the long term structural and the geotechnical stability of the site and the wider environment. The design of these works will ensure the hydrogeological conditions in the surface Secondary A Aquifers in the Ravenscar Group are maintained in their current condition and are isolated from the sulphatic and saline groundwater below the Whitby

Mudstone. In addition, groundwater ingress and migration into the shafts from the Non Secondary B and Principal Aquifers below the Whitby Mudstone, in particular those present in the Sherwood Sandstone and Brotherton Limestone, will be isolated by means of plugging the shafts and backfilling. This will be designed to prevent any continued water ingress or flow in the shafts and groundwater ingress or flow into or through the mine workings at depth.

The Deep Groundwater Discharge Well will be grouted up and sealed, with all head works removed.

Changes to the Conceptual Model Arising from the Design Amendments

The proposed design amendment to the Mineral, Men and Materials, and MTS shafts will reduce the depth and volume of their substructures. It will also remove the requirement for providing a grouted annulus and undertaking dewatering during construction through the Moor Grit, Scarborough and Cloughton Formations associated with construction of the headframe chambers, and in the Saltwick Formation associated with the upper shaft construction. During the diaphragm trenching process to the foreshaft and shaft walls, temporary dewatering will now also be undertaken in the Moor Grit aquifer.

Removal of the drift portal, the tunnel, the ventilation shaft and their associated grouted and lined structures, will reduce the physical impedance to groundwater flows within the Moor Grit, Scarborough and Cloughton aquifers. This design amendment will also reduce the volume of groundwater ingress from structures during operation that has to be accommodated for as waste water within the piped offsite treatment system.

Effects

Temporary dewatering, for the diaphragm wall trenching process and for construction of the shallow basement structures, will cause an alteration to groundwater flow paths and levels local to these areas. From the results of previous modelling (Ref 7 and 8), this localised, short duration dewatering, to depths of between 3m to 6m, is simulated to cause a high magnitude of effect at source but only a low magnitude of effect adjacent to the site boundary.

Diaphragm walling to the foreshaft and shaft structures together with construction of the lined impermeable substructures, penetrating into the shallow Secondary A Aquifers, will cause a local alteration to groundwater flow paths in these areas. The design amendments to the substructures, including; removal of the Southern Intake Ventilation Shaft, the Drift Portal and Tunnel and the -45m bank level and associated roadways, will reduce the extent of low permeable grout zones within the Moor Grit, Scarborough and Cloughton Formations. Reducing the overall volume of the basement and headframe chambers and replacing the 5m to 10m grouted annulus to the foreshaft and shafts with diaphragm walling, will reduce the extent of low permeable zones within the Moor Grit, Scarborough and Cloughton

Formations. This design amendment will also reduce the volume of groundwater ingress from structures during operation to be accommodated for as waste water within the piped offsite treatment system. Overall, these proposed changes will cause a reduction in the physical effect on groundwater levels within the Moor Grit and Scarborough Formation and on changes to groundwater flow paths.

The proposed design amendment to the shafts and to the depth and volume of the substructures within the near surface mine development will reduce the long term physical effects on groundwaters in the near surface aquifers in this area of the site. This design amendment will also reduce the volume of groundwater ingress from structures during operational to be accommodated for as waste water within the piped offsite treatment system.

4.3 Construction Impacts

Ecosystems

The Spring Flush area is identified to be the only hydrogeologically supported terrestrial ecosystem within Ugglebarnby SAC. This Spring Flush ecosystem is of very high sensitivity to any reduction in groundwater levels and changes in groundwater quality.

Preliminary modelling of the localised temporary dewatering within the Moor Grit aquifer, to facilitate both diaphragm walling and dry excavation for the construction of the shaft winder unit substructures, indicates that this design modification presents a negligible long term hydrogeological impact on the Spring Flush ecosystem (Ref 7 and 8).

The modification to the Construction Platform design, to remove the groundwater drainage blanket by raising the formation level above the water table in the Moor Grit in conjunction with maintaining the south western re-infiltration trench, is expected to cause no significant change to the groundwater levels previously modelled in the shallow aquifers up hydraulic gradient of these works underlying the Spring Flush area of Ugglebarnby Moor SAC (Ref 2). As such, the predicted small post construction groundwater level changes in the Moor Grit aquifer induced by the modified design along the eastern boundary of the SAC are considered to present a negligible long term hydrogeological impact on the Spring Flush ecosystem.

The design modification reducing the amount and volume of low permeable substructures (i.e. removal of the Southern Intake Ventilation Shaft, the Drift Portal and Tunnel, and the -45m bank level roadways, and reducing the volume of the headframe chambers by replacement with diaphragm walled foreshafts), will cause a corresponding reduction in the change to groundwater levels modelled in the shallow aquifers underlying the Spring Flush within the Ugglebarnby Moor SAC (Ref 2) and are therefore expected to present a negligible long term hydrogeological impact on the Spring Flush ecosystem.

The amendments to the plan areas of NHNI facility are expected to cause no measurable change to groundwater levels or quality modelled in the shallow aquifers underlying the Spring Flush

area (Ref 2 and 5) and present a negligible long term physical and chemical hydrogeological impact on the Spring Flush ecosystem.

Spring Discharge

The Moorside Farm and Soulsgrave Farm spring discharges are of very high sensitivity to any reduction in groundwater level and quality in the Moor Grit and Scarborough aquifers, respectively.

The modelling to date (Ref 7 and 8) of temporary dewatering to facilitate the diaphragm walling and substructure construction indicates that this short duration dewatering will have a negligible long term hydrogeological impact to these spring discharges. None of the other proposed design amendments will present an adverse physical or chemical hydrogeological impact on these spring discharges.

By incorporating the proposed surface water re-infiltration trench to the west of Bund C and by increasing the catchment area discharging into this trench, the proposed design amendments to the Construction Platform and NHNI facilities, will cause no measurable change to the groundwater levels modelled (Ref 2) in the shallow aquifers up hydraulic gradient of Moorside Farm Spring. As such, ground water flows from Moorside Farm or Soulsgrave Farm springs will be maintained at their current flow rate condition and the amended design will present a negligible long term hydrogeological impact on these spring discharges.

Aquifers down Hydraulic Gradient of the NHNI Extractive Materials Management Facilities

The Moor Grit, Scarborough and Cloughton aquifers down hydraulic gradient of the NHNI facilities are of moderate sensitivity to changes in groundwater levels and quality.

The proposed design amendments to the Construction Platform and substructures are determined to present negligible adverse hydrogeological impact on aquifers down hydraulic gradient of the NHNI extractive material management areas.

The modification to the plan areas of NHNI facilities east of the Construction Platform will locally reduce the plan area for water recharge into the Moor Grit and Scarborough aquifers. This is expected to cause a minor change to groundwater levels in these aquifers down hydraulic gradient at the eastern site boundary and a negligible adverse hydrogeological impact. Based on the results of the preliminary quantitative modelling (Ref 5), it is expected that the leachate egress likely from the increased basal plan areas will continue to present only a minor adverse hydrogeological impact on groundwater quality down hydraulic gradient in these aquifers at the site boundary.

Requirement for Additional Mitigation Measures

This supplementary hydrogeological risk assessment has demonstrated that the amended scheme design presents no significant adverse long terms adverse hydrogeological impacts. As such, no additional mitigation measures will be warranted to accommodate the amended design for the construction or long term operational phase of this development. As part of the detailed construction design, steady state and transient modelling of the long term operational conditions will be undertaken to finalise the extent of the geofin catchment area and the geometry of the

recharge trench around the western boundary of the southwestern NHNI facility. In addition, pollution modelling of the final footprint of the NHNI facilities will be undertaken as part of the Environmental Permit application, to confirm the detailed design of the encapsulation and groundwater control measures.

4.4 Operational and Decommissioned Impacts

The operational and decommissioned phases of the amended scheme have a similar landform to that of the approved scheme and will also include implementation of the Bund C recharge trench. From the modelling undertaken to date (Ref 2 and 5) of this landform, it is considered that the magnitude of physical and chemical effects of the modified mine surface development on the ecological, spring and Secondary A aquifers receptors will remain unchanged from that identified for the approved scheme. As such, the amended scheme design is considered to present a negligible to minor adverse hydrogeological impact on these receptors as previously determined for the approved scheme design.

This supplementary hydrogeological risk assessment has demonstrated that the amended design presents no significant long term adverse hydrogeological impacts on the Spring Flush ecosystem, the sensitive springs adjacent to the mine or to the Secondary A aquifers and, as such, no additional mitigation measures will be warranted for the long term operational phase of this development. As part of the construction detailed design stage, steady state and transient modelling of the long term operational conditions will be undertaken to finalise the extent of the geofin catchment area and geometry of the recharge trench around the western boundary of the southwestern NHNI facility. In addition, pollution modelling of the final footprint of the NHNI facilities will be undertaken as part of the Environmental Permit application, to confirm the long term design and operation of the encapsulation and groundwater control measures.

5 CONCLUSIONS

Since approval of the minesite Planning Application, design amendments have been made to the Construction Platform, substructures, shafts and to the volume and surface arrangement of the Non-Hazardous Non-Inert Waste Facilities.

The proposed design change to the Construction Platform is the most significant improvement to reducing the development's impacts on the groundwater system. By raising the formation level above the water table in the Moor Grit, it has been possible to design out the groundwater drainage blanket, the perimeter grout wall and relief drain. The consequence of this design change is that the amended design has a significantly reduced impact on locally changing groundwater flows and levels both on and adjacent to the site.

The proposed design changes to the arrangement of shallow substructures, including the deletion of the previously proposed South Ventilation Shaft, Drift portal and Tunnel, the -45m bank seat and roadway system in the Ravenscar Formation, will locally reduce the overall volume of these structures and their consequential impedance to groundwater flows and the requirement for dewatering. The proposed design changes to the construction methodology, including replacing grouting and dewatering in the Ravenscar Formation to utilising diaphragm walling and temporary dewatering to facilitate dry construction techniques, will reduce the overall volume of low permeable zones around substructures and their consequent impedance

to groundwater flows. These changes will also locally reduce the requirement for temporary dewatering. These minor design changes to the shallow mine substructures will have a very low magnitude of effect on the overall groundwater system, by marginally reducing the lowering of groundwater levels in the near surface aquifers on and adjacent to the site.

The proposed design changes to the earthworks include the local north eastern extension of the Construction Platform and an extension to the plan areas of NHNI facilities. The local small extension of the Construction Platform has no additional effect on lowering groundwater levels in the Moor Grit aquifer to the west of the site in the vicinity of Ugglebarnby Moor SAC. Although increasing the plan areas of the NHNI facilities by around 40% will marginally increase the volume of leachate egressing into the underlying aquifer, due to the low concentrations of contaminants in this leachate and the high degree of dilution occurring in the rock aquifer, this design modification is considered to present no significant adverse chemical effect on groundwater quality within the shallow aquifers at the site boundary. As such, the proposed modifications to the earthworks designs are considered to present a very low magnitude of physical and chemical effect on groundwater levels and quality in the shallow aquifers in close proximity to these works.

Based on the findings of this supplementary qualitative risk assessment, the amended mine development is determined to present a negligible adverse physical and chemical impact on all of the key sensitive hydrogeological receptors, including the Ugglebarnby Moor SAC ecological systems, the Moorside and Soulsgrave farm springs and the Secondary A Aquifers underlying and adjacent to the site.

Detailed quantitative modelling of groundwater levels and spring flow rates will be undertaken to finalise the design of the perimeter recharge trench to the southwestern NHNI facility and quantitative contamination transport modelling will be carried to finalise design of the basal liner and capping system to these facilities. The results of this modelling will be presented in supporting construction phase documents for the discharge to hydrogeological planning conditions and to the Environmental Permit application.

By adopting the mitigation measures included for in the approved scheme, it is concluded that the modified development design will present no significant additional adverse hydrogeological risks to the environment during its construction, operation or long term post decommissioned phases. As such, no additional mitigation measures are warranted.

C BELL
ASSOCIATE DIRECTOR

R IZATT-LOWRY
DIRECTOR

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