GOLDER
MEMBER OF WSP

REPORT

Technical Review Report of the Waste Management Plan for the Curraghinalt Project

WMP Review - Curraghinalt Project

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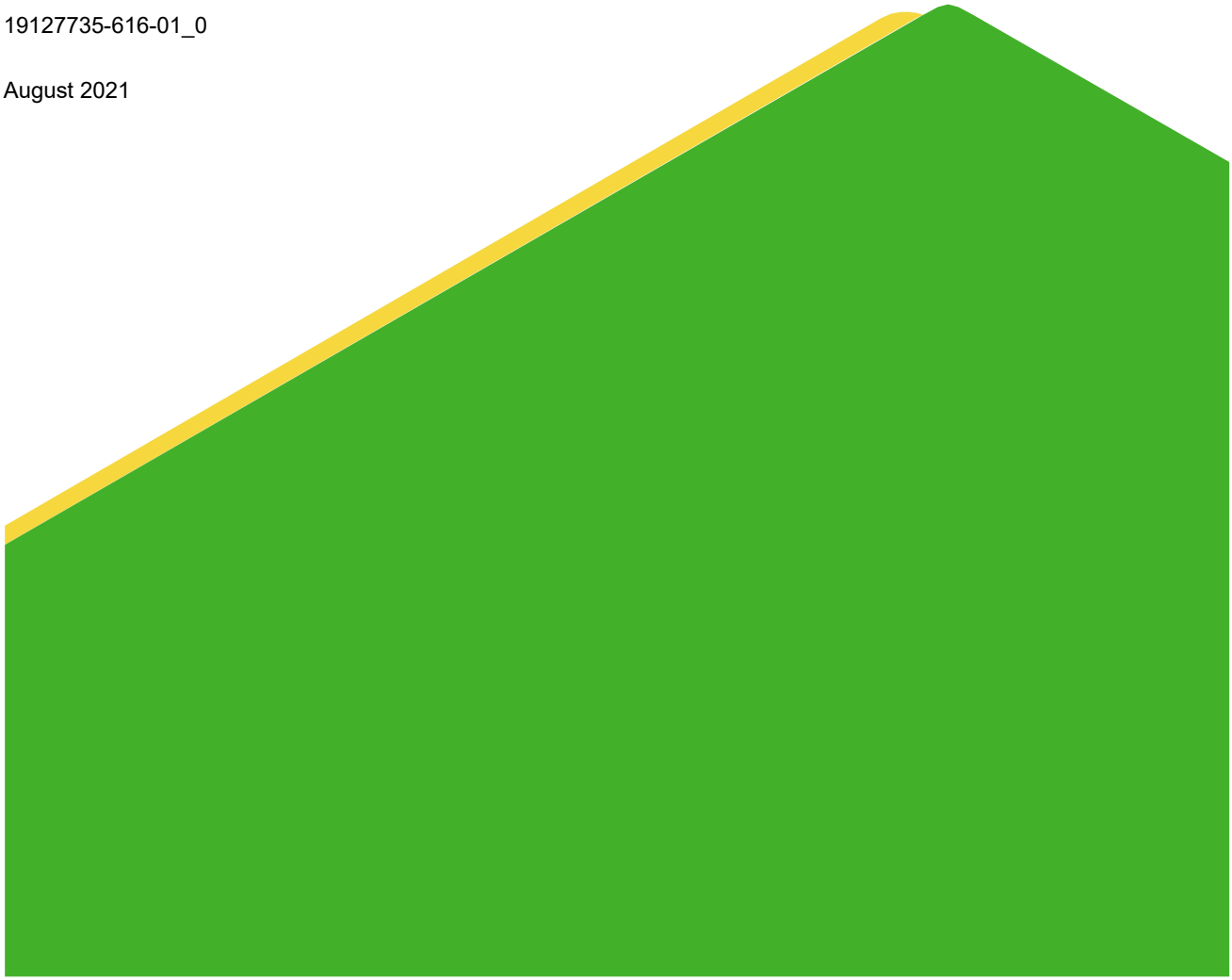

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Executive Summary

Introduction

This document outlines the comments, queries and findings from the review by Golder Associates (UK) Ltd (Golder) of the Waste Management Plan for a proposed gold mine situated around Curraghinalt, County Tyrone, Northern Ireland (the WMP). The WMP was prepared by SRK Consulting (UK) Ltd (SRK) on behalf of Dalradian Gold Ltd (DGL) as part of a planning application (Planning Reference *LA10/2017/1249/F WMP*). The version of this report, which has been reviewed by Golder and which forms the basis of this report, was issued under a Further Environmental Information request (FEI2) numbered *U7511 2020* and dated June 2020 which forms Appendix B3 of the all-encompassing package of FEI documents issued in support of the planning application.

Department for Infrastructure (DfI), which commissioned this review, requested that Golder carry out a specifically detailed examination in several areas, alongside the more general review. The areas to be considered in detail are:

- Surface Water Quantity and Quality;
- Groundwater quality including seepage model;
- Geochemistry Models; and
- Compliance with Parts 9 & 10 of *The Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland)* 2015 (2015 No.85) (the *2015/85 Regulations).*

The WMP is presented in 17 Sections with supporting information contained in 11 appendices. For ease of reference this document will follow the same top level chapter structure as that outlined within the WMP. The chapters outline the areas of review undertaken for each element of the documentation. The review includes commentary and questions which Golder has put to the designers. Each appendix also has its own dedicated chapter which includes further Golder comment.

Each chapter will conclude with an overall assessment of the efficacy of the content using a traffic light system, as shown in the table below.

Table: Example of assessment of chapter efficacy

Description of Assessment	Acceptable	Further Clarification	Unacceptable

The traffic light system definitions are as follows:

Acceptable: Golder considers that the material presented is acceptable for examination at Public Inquiry;

Further Clarification: Golder requires some further clarification on a point of technical query. This further clarification is not considered to represent a hinderance to Public Inquiry proceeding; and

Unacceptable: Golder considers that the quality of the material presented is unacceptable for consideration at Public Inquiry.

The documents which were provided to Golder for review are presented in the table below:

Table: Documents reviewed under FEI Rev 2 Appendix B

Document	Section or Appendix Number	Date	Review documented
FEI Appendix B3 - Mine Waste Management Plan	1) Introduction 2) Site Description and Setting 3) Waste Characterisation 4) Waste Storage Facility Classification 5) Operation and Waste Treatment Methods 6) Design Risk Assessment 7) Design of the Mine Waste Facilities 8) Design of the Paste Backfill Plant 9) Peat Management 10) Construction Materials 11) Control and Operational Monitoring Procedures 12) Closure, Post-closure and Monitoring 13) Prevention of Environmental Pollution 14) Review of Waste Management Plan 15) Accident Prevention 16) Best Available Technique Assessment 17) References	June 2020 (Addendum 2)	This document (as per sections identified)
Geology Report	Appendix A	2019	This document - Section 18.0.
Paste Backfill Testing Report	Appendix B	2019	This document – Section 19.0.
Geochemical Report	Appendix C	2020 (Addendum)	This document – Section 20.0. Also previously: *19127735-612-01 Geochemistry (PHREEQC) Review* (now incorporated into this document).
NI DOE Questionnaires	Appendix D	2019	This document – Section 21.0.
Peat Management Plan	Appendix E	2019	This document – Section 22.0.

Document	Section or Appendix Number	Date	Review documented
Peat Landslide Assessment	Appendix F	2019	This document – Section 23.0
Mine Waste Facility Technical Design Report	Appendix G	2019 and 2020 Addendum 2	This document – Section 24.0.
Conceptual Closure Plan	Appendix H	2019	This document – Section 25.0.
Groundwater Impact Assessment	Appendix I	2020 (Revision)	This document – Sections 26.0 and 27.0. Also previously: *19127735-610-01 Seepage Modelling Review* and *19127735-611-01 Groundwater Modelling Review* (now both incorporated into this document).
Surface Water Impact assessment	Appendix J	2020 (Revision)	This document – Sections 28.0 and 29.0. Also previously: *19127735-613-01 Water Balance Review* and *19127735-614-01 Surface Water Quality Review* (now both incorporated into this document).
Surface and Groundwater (Environmental) Monitoring Plan	Appendix K	2019	This document – Section 30.0.

Assessment

Golder has carried out a detailed review of the content, aims and objectives of the WMP and has, where necessary, raised queries and sought clarification on multiple technical and interpretative issues (as set out in the report below). It considers that to date it has received adequate responses to these questions and that currently no significant areas of concern remain to be explored. It can therefore with confidence make the following statements:

- The groundwater (including seepage) and surface water models used to support the assessment of potential impacts to the environment and human health are robust;

- The geochemical modelling presented is sufficiently robust to support the assessment of potential impacts to the environment and human health;
- The proposals for the excavation, storage and reuse of peat are comprehensive, as is the overall assessment of risk associated with peat instability;
- The proposed design of the MWF and water storage ponds are considered to be comprehensively described and assessed as adequate fit for purpose;
- The stability and sensitivity analyses completed for the MWF are appropriate and show that the overall design of the MWF and the water storage ponds are robust;
- The characterisation of mine waste arising and the waste storage facility classification as non 'Category A' are accurate;
- The WMP complies with the *2018 EU BAT/BREF Guidance* document on the management of waste from the extractive waste industry;
- The proposed environmental monitoring programme is reasonable for the site and follows a risk-based approach; and
- Accident Prevention measures proposed are in line with the *2015/85 Regulations*.

In conclusion, the review has not identified any issues within the WMP that render the material unacceptable for consideration at Public Inquiry.

Abbreviations and Acronyms

Stakeholders

Table: List of project stakeholders

Short Name	Company / Government Department Name
DAERA	Department of Agriculture, Environment and Rural Affairs
DfI	Department for Infrastructure
DGL	Dalradian Gold Ltd
HSENI	Health & Safety Executive Northern Ireland
Kaya	Kaya Consulting Ltd
Minefill	Minefill Services Inc
NI DOE	Northern Ireland Department of the Environment
NIEA	Northern Ireland Environment Agency
P&C	Paterson & Cooke
SEPA	Scottish Environmental Protection Agency
SLR	SLR Consulting Ltd

SRK	SRK Consulting (UK) Ltd
URSTM	Unité de Recherche et de Service en Technologie Minérale

Technical, other

Table: List of technical abbreviations

Abbrev	Definition	Abbrev	Definition
BGS	British Geological Survey	OPC	Ordinary Portland Cement
BREF	Best Available Technique Reference	PAF	Potentially Acid Forming
CDA	Canadian Dam Association	PAG	Potentially Acid Generating
CEM	Calcium Enriched Mixture	PBF	Paste Backfill Facility
CEMP	Construction Environmental Management Plan	PBP	Paste Backfill Plant
COC	Constituent of Concern	PGA	Peak Ground Acceleration
COS	Crushed Ore Stockpile	PLHRA	Peat Landslide Hazard and Risk Assessment
CQA	Construction Quality Assurance	PMP	Peat Management Plan
CRCP	Conceptual Rehabilitation and Closure Plan	PPG	Pollution Prevention Guidelines
CSL	Critical State Line	PSD	Particle Size Distribution
CSM	Conceptual Site Model	RA	Risk Assessment
CTP	Concentrate Treatment Plant	RCP	Representative Concentration Pathway
DoE	Department of Environment	RO	Reverse Osmosis
DSF	Dry Stack Facility	ROM	Run of Mine
DSG	Dalradian Supergroup	RQP	River Quality Planning
DWS	Drinking Water Standard	SAC	Special Areas of Conservation
EIA	Environmental Impact Assessment	SGEMAP	Surface Water and Groundwater Environmental Monitoring and Action Plan
EQS	Environmental Quality Standards	SHG	Southern Highland Group
ES	Environmental Statement	SPT	Standard Penetration Test

Abbrev	Definition	Abbrev	Definition
EWC	European Waste Code	SWAc	Surface Water Accounting model
EWF	Extractive Waste Facility	SWCC	Soil Water Characteristic Curve
EWIW	Extractive Waste Influenced Water	SWIA	Surface Water Impact Assessment
FOS	Factor of Safety	TIC	Tyrone Igneous Complex
GCL	Geosynthetic Clay Liner	TPG	Tyrone Plutonic Group
GGBS	Ground Granulated Blast Furnace Slag	TVG	Tyrone Volcanic Group
GHB	General Head Boundaries	UCS	Uniaxial Compressive Strength
GIA	Groundwater Impact Assessment	UF	Ultra Filtration
GPP	Guidance for Pollution Prevention	UG	Underground
HCT	Humidity Cell Testing	USGS	United States Geological Survey
HDPE	High Density Poly Ethylene	WMP	Waste Management Plan
HSMS	Health & Safety Management System	WTP	Water Treatment Plant
ICOLD	International Commission on Large Dams	WWTP	Waste Water Treatment Plant
LOM	Life of Mine		

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1.0 INTRODUCTION

1.1 Chapter Summary

The introduction to the WMP *U7511 2020* confirms that SRK Consulting (UK) Ltd (SRK) was retained by Dalradian Gold Ltd (DGL) to prepare a Waste Management Plan (WMP) in support of an application for Planning Permission for a proposed gold mine in Curraghinalt, Co Tyrone, Northern Ireland (the Project) (Planning Reference *LA10/2017/1249/F WMP*). It notes that the WMP will include details of all mining wastes (but not non-mining wastes) generated as a direct result of the development.

The introduction confirms that the 2020 WMP replaces the 2019 WMP and reflects modifications to the shape of the Mine Waste Facility (MWF) that arose in early 2020 following comments received by Department of Agriculture, Environment and Rural Affairs (DAERA) Countryside and Coast Landscape Architects. It is further noted that the 2020 WMP also includes outputs from the revised geochemistry, groundwater and surface water assessment reports, updated in June 2020.

For the purposes of background, the mine waste storage areas at the Curraghinalt Mine are noted by SRK to consist of the following:

1) Mine Waste Facility (MWF) - A fully lined facility, within which dewatered tailings (referred to herein as “rougher” tailings) will be placed and compacted as a solid waste material. Waste rock from mining operations will also be stored in this facility, together with ore sorter rejects, small amounts of drilling muds from regional exploration programmes (including surface and underground) and sediment collected in the water storage ponds. Excess peat and soil generated from ground preparation / construction will be temporarily stockpiled adjacent to the MWF and used to progressively rehabilitate the final landform. This facility is referred to as a Dry Stack Facility (DSF) in other documentation submitted in the planning application;

2) Paste Backfill Plant (PBP) – A combination of scavenger and rougher tailings will be dewatered at the underground PBP. Cement and ground granulated blast furnace slag (GGBS) will be imported and added as binders to produce paste thickened tailings in the PBP;

3) Backfilling of excavation voids – Mined out voids will be progressively filled with cemented fill (paste tailings / cement blend) throughout the operational phase. The paste backfill blend will be pumped further underground and co-disposed with a proportion of the waste rock and ore sorted rejects generated from mining operations;

4) Water Storage Ponds and associated infrastructure – Three water storage ponds are proposed, consisting of the Upper East, Lower East, and West Ponds. The Lower East and Upper East Ponds will be used to store process affected contact water from the MWF and site runoff before treatment. The West Pond will also receive water pumped from the underground workings. Runoff from the MWF and the mine site will need to be treated before discharge. Settled solids will collect in the ponds, which will require periodic removal and safe disposal in the MWF; and

5) Water Treatment Plant (WTP) – The water treatment plant has been designed to treat contact water flows collected in the various ponds. Water recycling will occur within the overall process where possible, and final output from the treatment plant may be pumped back to the Clean Water Pond that will provide make-up water for the Process Plant. Any excess treated water will be discharged to the Pollanroe Burn at a designated discharge point south of the treatment plant. All water released to the Pollanroe will be of sufficient quality to meet the site discharge consent. Dry residue (crystallised salt) generated from the water treatment plant process will be periodically collected and transported to a licenced waste disposal facility for off-site controlled disposal.

1.1.1 Objectives of the WMP

In Section 1.3, the objectives of the WMP are set out. In summary, the WMP states that DGL intends to minimise, treat, recover and dispose of extractive waste by employing best available techniques (BAT) while simultaneously taking into account the principles of sustainable development. It references the specific objectives of the plan, as required by Schedule 1 of *The Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland)* 2015 (2015 No.85) (hereafter *the 2015/85 Regulations*) and confirms that a summary of how these objectives have been met by the WMP is provided in Appendix D to the WMP as a completed questionnaire.

Golder comment:

Golder carries out a thorough analysis and consideration of whether these objectives have been met throughout this review document, however during this introduction Golder is satisfied that the objectives as outlined within the WMP are satisfactory.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the objectives of the WMP clearly outlined and adequate in nature?	✓		

1.1.2 Relevant Legislation and Standards

Section 1.4 of the WMP details the relevant legislation that has been considered in the preparation of the WMP. SRK notes that both a Mining Licence and Planning Permission must be obtained and that completion of an Environmental Impact Assessment (EIA) process and submission of an Environmental Statement (ES) are prerequisites to the submission of the application for Planning Permission. Further, a grant of Planning Permission is prohibited by Regulation 4 of the *2015/85 Regulations* without prior approval of a WMP.

The legislation considered in the preparation of the WMP is stated to include the following:

- *2015/85* Regulations which transpose the Mining Waste Directive (*Directive 2006/21/EC* of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries);
- Commission Decision *2000/532/EC* which deals with characterisation of waste and which is subsequently amended by *2014/955/EU* (Commission Decision of 18 December 2014 amending Decision *2000/532/EC* on the list of waste pursuant to Directive *2008/98/EC* of the European Parliament and of the Council);
- Annexe III of Directive *2008/98/EC* which defines properties of waste which render it hazardous. This annexe has been replaced by Commission Regulation *1357/2014* of 18 December 2014 and Council Regulation *2017/997* of 8 June 2017;
- Directive *2008/98/EC* (replaced by Commission Regulation *1357/2014* and Council Regulation *2017/997*) and waste containing substances classified as dangerous according to Regulation (EC) No *1272/2008* of 16 December 2008 on classification, labelling and packaging of substances and mixtures;

- *2009/337/EC* (Commission Decision of 20 April 2009 on the definition of the criteria for the classification of waste facilities in accordance with *Annexe III of Directive 2006/21/EC* of the European Parliament and of the Council concerning the management of waste from extractive industries;
- Water Framework Directive (Directive *2000/60/EC* of the European Parliament and of the Council establishing a framework for community action in the field of water policy) as amended by Decision No. *2455/2001/EC* establishing the list of priority substances and Directive *2008/105/EC* on environmental quality standards in the field of water policy (subsequently amended by Directive *2013/39/EU)* and daughter directives;
- Groundwater Directive (Directive *2006/118/EC* of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration);
- Directive *2006/11/EC* (Directive *2006/11/EC* of the European Parliament and of the Council of 15 February 2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community) noted to be no longer in force;
- *The Quarries Regulations (Northern Ireland) 2006* (SR 205), Part V;
- *The Mines Regulations (Northern Ireland) 2016* (SR 2015 No. 427);
- *Water Environment (Floods Directive) Regulations (Northern Ireland) 2009* (SR 376);
- *Reservoirs Act (Northern Ireland) 2015*; and
- Northern Ireland Health and Safety Legislation (https://www.hseni.gov.uk/topic/legislation).

The following guidance documents have been used in relation to mine waste management:

- *EU Best Available Technique Reference Document: European Commission Reference Document on Best Available Techniques for Management of Waste from the Extractive Industries, in accordance with Directive 2006/21/EC 2018;*
- *CEN/TR 16363:2012 Characterisation of Waste – Kinetic testing for assessing acid generation potential of sulphidic waste from extractive industries;*
- *CEN/TR 16376:2012 Characterisation of Waste – Overall guidance document for characterisation of waste from extractive industries;*
- *CEN/TS 14429:2005 Characterisation of waste – leaching behaviour tests – Influence of pH on leaching with initial acid/base addition;*
- *CEN/TS 14997:2006 Characterisation of waste – leaching behaviour tests – Influence of pH on leaching with continuous pH-control;*
- *EN 12457 – 1/2/3/4 Characterisation of waste – leaching compliance tests of granular waste materials and sludges;*
- *Guidance on the Classification and Assessment of Waste (1st Edition v1.1, May 2018);*
- *Technical Guidance WM3. Northern Ireland Environment Agency (NIEA);*
- *BRE Report "An engineering guide to seismic risk to dams in the UK";*
- *BRE "An engineering guide to the safety of embankment dams in the UK";*

- *BS5930/EN - BS 5930:2015 "Code of practice for ground investigations" came into effect on 31 July 2015 (supersedes BS 5930:1999+A2:2010, which is withdrawn);*
- *ICOLD (*International Commission on Large Dams*) Bulletins; and*
- *Eurocode 7: Geotechnical Design HSE Guidance.*

Golder comment:

Golder considers that all relevant European, UK and Northern Ireland legislation has been consulted and / or used in the preparation of the WMP. Further, the list of guidance documents listed is considered to be sufficient for the preparation of a WMP in Northern Ireland. It is noted that technical appendices to the WMP provide a detailed list of legislation and in some cases guidance documents relevant to the topic being assessed.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the list of legislation adequate for the preparation of a WMP for a mine development in Northern Ireland?	✓		
Is the list of guidance documents adequate for the preparation of a WMP for a mine development in Northern Ireland?	✓		

2.0 SITE DESCRIPTION & SETTING

2.1 Chapter Summary

2.1.1 Site location, layout and land survey

This section of the WMP confirms Site Location, Site Layout and Survey of Land. The assessment of alternative locations for the MWF is addressed under Site Layout.

Under Site Layout (section 2.2), it is noted that the Project is comprised of five project sites (areas), these include the proposed infrastructure site (Area A), the proposed mineral extraction area (Area B), the existing surface infrastructure site (Area C), the passing bays on the Camcosy Road (Area D) and the proposed mineral exploration area (Area E).

Wastes will be generated within the proposed infrastructure site (from pre-construction, ore processing and water treatment activities), from development of the mine workings and underground mining (waste rock), and from exploration drilling (drilling muds) within the proposed mineral extraction / exploration areas and DGL regional surface programmes respectively. Key surface infrastructure components of the project which relate to the WMP include the underground mine where mine waste will be produced, a mineral process plant which will produce tailings, the MWF, including drainage and water storage ponds, and a Paste Backfill Facility (PBF) which will be located underground within Area B.

Section 2.2.1 indicates that 19 alternative sites were considered for the location of the MWF. Seven sites were proposed during 2011 as part of the preliminary economic assessment completed for the Curraghinalt Project

(*Micon International, 2012*). The other sites were included during 2015 (*SRK, 2015*). It is noted by SRK that although the site selection process initially included topography constraints only, all of the candidate sites were subsequently reviewed from an ecology, visual, water and traffic management perspective by specialists on the EIA team. It is stated that environmental considerations were given high priority in the evaluation of the sites. An updated site selection study was undertaken from January to June 2015 and is documented in the ES for the Curraghinalt Project.

Golder comment:

Golder has reviewed the relevant section of the ES for the Curraghinalt Project and is satisfied that the site selection process for the WMF completed was acceptable.

Chapter 4 of the ES (*Project Description*), prepared by SRK, confirms that as part of the project development studies, a number of alternatives (sites) were considered for mining, infrastructure, location, processing and waste management. Golder recognises that these are constrained somewhat with respect to the location of the gold deposit. Chapter 5 of the ES (*Project Alternatives*) describes in detail SRK's assessment of alternatives. A 'do nothing' alternative approach was not considered. SRK states that a number of changes and modifications were incorporated into the project design as a result of stakeholder consultation and that there was close collaboration between the EIA and engineering study teams.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the site selection process for the WMP acceptable and have sufficient alternatives been considered?	✓		
Has the selection and weighting process been clearly defined?	✓		

2.1.2 Habitats

This section of the WMP also addresses habitats on and around the application site. It is noted that these have been identified and mapped by means of a series of Phase 1 Habitat Surveys using standard methodology (*Nature Conservancy Council, 1990*). In addition, a Phase 2 Habitat Survey has been undertaken at the proposed infrastructure site and involved classification of vegetation communities in accordance with NVC system (*Rodwell, 1991a, 1991 b, 1992 and 2006*). The results of this survey are presented in detail in the Environmental Statement and a summary is also provided within the WMP.

Golder comment:

Golder notes that the habitat surveys have been carried out and documented within the ES and summarised within the WMP. However, the scope of Golder's review does not extend to ecological aspects including habitats and hence no comment on the above is provided here. Golder notes that potential impacts to surface water and groundwater are considered in reviews in Sections 26.0, 27.0, 28.0 and 29.0.

Golder conclusion:

No comment provided.

3.0 WASTE CHARACTERISATION

3.1 Chapter Summary

This section of the WMP deals primarily with the characterisation of the different wastes generated on the site and the geochemical assessments carried out on these materials to support the classification. In the WMP, it is noted that this section has been structured to meet the technical requirements for waste characterisation provided in Schedule 2 of the *2015/85 Regulations* and Section 4 of the Mine Waste Directive guidance document issued by the Minerals Unit of the former Department of Environment (DoE).

Also referenced in this section of the WMP is Appendix C of the WMP which provides a Geochemical Report for the project. Golder has also reviewed this document and includes review comments under Section 20.0 of this report.

3.2 Geological Background to the Deposit

In this section, it is noted that although DGL has interests within six contiguous mineral prospecting licence areas (DG-01 to DG-06), the Curraghinalt Project mineral resource falls within the DG-01 prospecting licence area. It is further noted that the Crown Estate Agreements are in place for DG-01 along with the other five prospecting licence areas.

SRK describes the geological characterisation of the mine which has been provided in significant detail in the ES.

Golder comment:

The geological summary provides a background or understanding of the source of the material that will be generated. It is also noted that Appendix B to the WMP contains an in-depth geological description of the site. Golder has reviewed this document and has provided commentary in Section 18.0 of this report.

3.3 Nature of Waste and Intended Handling

This section of the WMP is significant for planning / permitting purposes because it describes the waste generating processes (Section 3.3.1 in the WMP) and the types and quantities of wastes, classification of wastes according to the European List of Waste and intended location of disposal (Section 3.3.2 in the WMP).

3.3.1 Waste generation processes

The WMP notes in this section that solid and liquid wastes will be generated during the construction and operational phases of the project. It provides a figure which indicates where the different waste streams are created, processed (if applicable) and ultimately stored or disposed of (Figure 3-2).

In relation to waste generation, the WMP notes that *"During the construction phase, earthworks activities will generate a number of solid wastes including uncontaminated soil, sub-soil and peat due to stripping activities and waste rock from surface and underground excavations. The operational phase of the project will generate a number of solid and liquid wastes from activities such as underground mining, mineral processing and refining activities, water treatment and exploration drilling."*

In relation to solid waste disposal, the WMP notes that "*Waste rock generated during underground mining activities will either be transported to the surface for disposal in the MWF or will be stockpiled underground for use as backfill material in mined out stopes. During ore processing and the production of a concentrate, a number of solid wastes will be generated, including rougher and scavenger tailings. Ore sorter rejects will be produced underground at the primary crushing plant. This material will be used as backfill in the underground mine or stored in the MWF.*"

In relation to liquid waste disposal, the WMP notes that "*Liquid wastes include excess underground mine water, over-drain water from the MWF, drilling fluids and cuttings from exploration drilling and solids which have settled within the water storage ponds. Exploration drilling activities require water and different types of drilling muds which aid in the drilling process, these fluids are re-circulated through the drill hole to aid drilling progress and are captured in sumps at the drill site. Drill cuttings and fluids will require pumping out of the sumps for disposal prior to drill site rehabilitation being undertaken. Excess mine water and drilling fluids from underground and water from over-drain discharge from the MWF will be pumped to the water treatment plant. The water treatment plant will generate a dry residue which will be periodically collected and disposed of at an off-site facility. Any solids which settle within the water storage ponds will be periodically removed by excavator and placed in the lined MWF area.*"

Golder comment:

The description of the waste summary (Figure 3-2) and the descriptions of the waste generation processes appear to be adequately described to allow an assessment of waste characteristics.

3.3.2 Waste types

This section of the WMP provides information on the main types of mining waste that will be generated by the project (Table 3-1). The information provided includes estimated quantities of waste and the corresponding European List of Waste codes according to Commission Decision *2014/955/EU* of 18 December 2014, and ultimate storage locations for the wastes. An important distinction is made by SRK that "*that the 2015/85 Regulations only require waste codes to be assigned to wastes stored within waste storage areas (ie the MWF and Water Storage Ponds)".* Table 3.1 however deals with all mine wastes generated without consideration of the final storage location. SRK notes that was done for the purposes of completeness.

Golder comment:

The following points are noted from Table 3-1 in the WMP:

- The only waste classified as Hazardous is the scavenger tailings (European Waste Code (EWC) Code 01 03 04*);
- The wastes deposited in the MWF and PBF will be a combination (and / or a mixture) of waste streams; and
- The dry residue from the water treatment plant (reverse osmosis) will be directly transported off site to an appropriate waste disposal facility.

Section 3.3.2 of the WMP presents the classification of the waste types before a detailed discussion of the waste in Section 3.3.4 and Section 3.3.5. Overall, the assessment of waste types to be stored on site is acceptable and discussion on these sections is given below.

Golder conclusion:

The classification of the waste types by EWC code for the mine waste material that will be stored on site is considered to be acceptable.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Has sufficient information been provided with the WMP regarding type, quantity and EWC code for all mine wastes that will be stored on site during the full life cycle of the project?	✓		

3.3.3 Geotechnical Behaviour of the Waste

Schedule 2 of the *2015/85 Regulations* requires a description of the physical characteristics of the waste to be deposited in the MWF and the Water Storage Ponds (with specific reference to stability). To address this, SRK has provided the following reports:

- Details of geotechnical test work completed on representative paste backfill samples is included in *Curraghinalt Gold Project. Paste Characterisation Testing. Minefill Services Inc. July 2019* (Appendix B, see Section 19.0);
- Details of the geotechnical behaviour of the tailings and waste rock material that will be stored in the MWF is discussed in *Mine Waste Facility Technical Design Report for the Curraghinalt Project*. SRK Consulting (Canada) Inc. November 2017 (Appendix G, see Section 24.0);
- Further details of the geotechnical behaviour of the tailings and waste rock material that will be stored in the MWF Addendum: *Mine Waste Facility Design for the Curraghinalt Project*. SRK Consulting (Canada) (Appendix G, see Section 24.0); and
- Further details of the geotechnical behaviour of the tailings and waste rock material that will be stored in the MWF Addendum 2: *Mine Waste Facility Design for the Curraghinalt Project*. SRK Consulting (Canada) (Appendix G, see Section 24.0).

Golder comment:

Golder has reviewed these reports in detail and refers the reader to the sections given above.

3.3.4 Geochemical Characteristics and Behaviour of the Waste

Schedule 2 of the *2015/85 Regulations* requires description of the waste chemical characteristics to be stored in the mine waste facilities. To address this, SRK has prepared a Geochemical Characterisation Report for the Curraghinalt Gold Deposit (June 2020), which was included in Appendix C. A comprehensive review of this report by Golder can be seen in Section 20.0.

The objective of this report is to provide a robust estimation of the short-term and long-term behaviour of the different types of mining waste to be generated throughout the life of the project.

The report replaced the following two previous submissions prepared in support of the planning application:

- *A Geochemical Characterisation Report for the Curraghinalt Gold Project, Northern Ireland*. SRK Consulting (UK Ltd, 2017); and
- Addendum to the *Curraghinalt Geochemistry Characterisation Report*, SRK Consulting (UK) Ltd, 2019.

Further studies

SRK has also undertaken geochemical characterisation studies to assess the Acid Rock Drainage and Metal Leaching (ARDML) potential of the waste rock and tailings material that will be generated during operations.

Golder's technical review of SRK's findings follow below.

Assessment of 'inert' characteristics

The *2015/85 regulations* provide the definition of "inert waste". This definition is referenced and reproduced within this section of the WMP. On the basis of this definition, SRK concludes the following:

"The multi-element assay data for the various waste streams has identified arsenic concentrations (plus some other parameters) which are elevated relative to average crustal abundance in the majority of samples analysed. For this reason, none of the waste streams have been characterised as "inert".

Assessment of 'hazardous' characteristics

According to the definitions from the *2015/85 Regulations*, hazardous waste has the meaning given in Article 3(2) of *Council Directive 2008/98/EC*. Furthermore, Schedule 2 of the *2015/85 Regulations* also states that the hazardous characteristics of waste should be determined according to the relevant entry in Decision *2000/532/EC* which has been amended by Commission Decision *2014/955/EU* of 18 December 2014.

SRK has used HazWasteOnline™ software along with the following guidance document during the assessment of the geochemical characteristics of each waste type:

> *Guidance on the classification and assessment of waste (1st Edition, v1.1, May 2018). Technical Guidance WM3*. Northern Ireland Environmental Agency, May 2018.

SRK summarises the outcomes of this assessment (full details of the geochemical characterisation of each waste stream are included in the WMP Appendix C). Further details of the review by Golder of Appendix C are provided in Section 20.0 of this report.

This Section of the WMP presents the findings of the testing programme completed by SRK to assess the potential that the following waste streams may present adversely on human health or the environment. The detailed test work and results are presented in this section for the following:

- Waste Rock;
- Ore Sorter rejects;
- Tailings; and
- Cemented paste backfill.

Golder comment:

The detailed geochemical review is presented in Section 20.0 of this report.

Golder conclusion:

The detailed geochemical review is presented in Section 20.0 of this report.

3.3.5 Waste Characterisation Summary

Schedule 2 of the *2015/85 Regulations* requires the characterisation of wastes to be stored in an extractive waste site or facility. Under the Regulations, extractive waste has the following possible classifications:

- Unpolluted soil and peat;
- Non-waste;

- Inert waste;
- Hazardous waste; or
- Non-hazardous non-inert waste.

Golder comment:

A summary of the waste streams that are to be stored in the MWF and water storage ponds, and therefore require characterisation as per Schedule 2 of the *2015/85 Regulations*, are listed in Table 3-2 (within the WMP). As the cemented paste backfill is to be stored in an extractive void (Section 4.1.1 in the WMP) SRK states that it is not subject to requirements of Schedule 2 of the *2015/85 Regulations*, and it has been included in the table for completeness only. SRK further states that as it demonstrates in Section 3, Section 13 and Appendices C, I and J (WMP), none of the stored waste streams present a risk to groundwater or surface water resources during operations or post-closure. Golder has provided a review of these sections in this document. Overall, in consideration of the comments presented in these sections, Golder agrees with the waste classification given in the WMP.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the waste classifications given to waste types (as per Schedule 3 of the *2015/85 Regulations*) acceptable?	✓		

4.0 WASTE STORAGE FACILITY CLASSIFICATION

4.1 Chapter Summary

This section of the WMP deals with the classification of the waste storage facility. In order to achieve this objective, the WMP looks at the relevant regulations and guidance available, the definitions of the components as well as the classification itself.

4.1.1 Definition of Waste / Regulation Context

Following categorisation of each mine waste stream generated at the mine, it is necessary to classify each waste storage area considered in this plan. SRK lists the legislation it has used as the basis for classification of each waste storage area (or waste returned to the void for rehabilitation purposes). SRK also includes for the purposes of reference, the definitions of extractive waste sites and waste facilities which are reproduced from the *2015/85 Regulations*.

SRK states that the definitions for both extractive waste sites and waste facilities exclude excavation voids in which waste is placed for rehabilitation and construction purposes, and that this is aligned with the Mine Waste Directive.

Within the WMP, it says that on that basis, there is a clear distinction between waste placed within excavation voids for restoration or construction purposes and waste stored above ground in ‘waste storage facilities’ (including Category A facilities) or ‘extractive waste sites’. SRK has therefore assigned the location where extractive waste including a portion of the waste rock and ore sorter reject materials plus cemented paste tailings

will be placed as an 'excavation void'. The waste placed in the excavation void contributes to restoration by providing geotechnical support to the underground mine and support to the overlying rock mass.

Golder comment:

Based on the paste backfill blends tested, the backfill will meet the requirements set out in Article 10 (to ensure stability of waste, prevention of pollution of soil, surface water and groundwater and monitoring of waste in the excavation void).

It will also meet the requirements in the *2015/85 Regulations* that relate to backfilling extraction voids with extractive waste. The chapter adds that specifically the requirements of both Regulation 6 (Clause 2; Part 'h') and Regulation 10 (Clause 3; Part 'a' and Part 'b') are met.

SRK notes that in Regulation 10, there is necessity to comply with the *Water Framework Directive* (*Directive 2000/60/EC* of the European Parliament and of the Council establishing a framework for community action in the field of water policy). Additionally, the MWF and Water Storage Ponds have been classified as per the *2015/85 Regulations* using the following categories:

- Extractive waste site; or
- Waste facility; or
- Category A waste facility.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is SRK's assumption on the classification of the excavation void correct?	✓		

4.1.2 Definition of Category A

Classification of Category A is significant because it defines how waste is to be treated. SRK's consideration of this is therefore outlined below.

As outlined in Schedule 3 of the *2015/85 Regulations*, a waste facility shall be classified as Category A if:

1) A failure or incorrect operation, e.g. the collapse of a heap or the bursting of a dam, could give rise to a major accident, on the basis of a risk assessment taking into account factors such as the present or future size, the location and the environmental impact of the waste facility; or

2) It contains waste classified as hazardous under Directive *2008/98/EC* above a certain threshold amended by Commission Regulation *1357/2014* and Council Regulation *2017/997*); or

3) It contains substances or preparations classified as dangerous within the scope of Regulation (EC) *1272/2008*.

In Commission Decision *2009/337/EC,* it is stated that if the predicted consequences in the short or the long term of a failure due to loss of structural integrity, or due to incorrect operation of a mining waste facility could lead to serious danger to the environment, a mining waste facility shall be classified as Category A.

At Article 4(3) (a-c) of the Commission Decision *2009/337/EC,* the definition of serious danger to the environment is expanded and it is stated that:

- The potential for loss of life or danger to human health shall be considered to be negligible or not serious if:
  - People other than workers operating the facility that might be affected are not expected to be present permanently or for prolonged periods in the potentially affected area;
- The potential danger for the environment shall be considered to be not serious if:
  - The intensity of the potential contaminant source strength is decreasing significantly within a short time;
  - The failure does not lead to any permanent or long-lasting environmental damage; and
  - The affected environment can be restored through minor clean up and restoration efforts.

Golder comment:

Golder considers that the legislation and criteria outlined above are suitable for a determination of whether the MWF or the water storage ponds are Category A facilities.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Has SRK referenced the correct legislation and hence assessment criteria regarding waste facility classification?	✓		

4.1.3 Category A Assessment

Assessments have been carried out to determine whether the MWF or the Water Storage Ponds are Category A Facilities (as defined in Schedule 3 of the Regulations). As SRK discusses above, the PBF has been defined as an 'Extraction Void' as opposed to a mine waste facility and has therefore been excluded from this assessment.

SRK states that none of the facilities meet the criteria for Category A classification provided in Schedule 3 of *2015/85 Regulations* as:

- They do not contain hazardous waste or dangerous substances, according to the thresholds in Decision *337/2009/EC*, and
- The risk of a major accident from structural failure or incorrect operation does not result in serious danger to the environment or human health.

The design risk assessment (Section 6) presents the risks that have been assessed and the mitigation measures that are built into the design of the waste facilities to control the risks. Further detail on how these conclusions are reached is included in Appendix D of the WMP and commentary on the review by Golder is provided in Section 6) of this report.

Golder comment:

Golder considers that the MWF does not meet the criteria to be classified as a Category A facility and further, that the predicted consequences of a failure due to loss of structural integrity, or due to incorrect operation of a mining waste facility, would not lead to serious danger to the environment or to greater than not serious potential for loss of life or danger to human health.

Golder conclusion:

Golder concurs that the WMF is not a Category A facility and considers the assessment in the WMP to be satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the Category A assessment for the MWF correct?	✓		
Is the Category A assessment for the Water Storage Ponds correct?	✓		

4.1.4 Classification of Areas

For each waste storage facility, the relevant classification has been assigned based on the provisions in the *2015/85 Regulations*. As both the MWF and the Water Storage ponds are not considered to be Category A Facilities or extractive waste sites, both areas are classed as 'Waste Facilities'.

Golder comment:

Golder considers that the designation of these infrastructure items as Waste Facilities is appropriate.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the designation of the WMF as a Waste Facility correct?	✓		
Is the designation of the Water Storage Ponds as Waste Facilities correct?	✓		

5.0 OPERATION AND WASTE TREATMENT METHODS

5.1 Chapter Summary

This chapter of the WMP presents the volumes of waste that will be generated during the operation of the mine, the processing that generates the waste streams and the principles of waste prevention and minimisation applied to the operation of the mine. The waste storage arrangements are also summarised.

5.1.1 Mining and Processing

The WMP states that the estimated ore reserve for Curraghinalt is approximately 8.7 million tonnes (Mt). Ore will be mined by conventional underground longhole and cut and fill mining methods. Ore will be crushed underground, passed through an ore-sorter and then conveyed from underground to a surface stockpile, before conveying to the mill and separation of the gold-rich material into a concentrate for off-site processing.

The WMP then describes the process plant and its component unit operations:

- Surface Ore Handling;
- Crushed Ore Stockpile (COS);
- Primary Grinding;
- Secondary Grinding;
- Gravity Separation;
- Flotation;
- Concentrate Thickening; and
- Filtration.

SRK states that:

"During mine decline and access portal development, extracted waste rock will be used as construction material on the surface.

"Any settled solids which accumulate in the water storage ponds (which are fed by the perimeter interception ditches) will also be disposed in the MWF.

"During operations excess mine water and overdrain runoff from the MWF will be sent to the water treatment plant for ultra-filtration (UF) and reverse osmosis (RO) treatment prior to being discharged to the water course under consent. On-site and within the process, opportunities will also be available for recycling and re-use of water. The water treatment process proposed generates a dry residue material which will be transported and disposed of off-site."

A drawing, Mineral processing flow chart, figure 5-1 in the WMP, shows the process pictorially.

Golder comment:

The above section is a concise summary of the mining and processing activities that will generate waste on site.

5.1.2 Waste Volumes (Surface Storage)

The estimated quantities of tailings and waste that will be stored in the MWF are summarised in Table 5-1 of the WMP (and reference *JDS, 2019*). A waste rock placed density of 2.04 t/m^3 has been assumed based on an in-situ specific gravity of 2.73 and a 1.34 bulking factor. A density of 1.95 t/ m^3 has been assumed for ore sorter rejects based on the same specific gravity and a 1.4 bulking factor. A density of 1.5 t/m^3 has been assumed based on the results of Standard Proctor Tests completed on representative tailings samples.

Golder comment:

It is noted that over the 20-year period allowed for in Table 5-1 of the WMP, a total 4.8 million m^3 of material will be placed to the MWF. This is comprised of 2.42 million m^3 of rougher tailings, 0.57 million m^3 of waste rock and 1.72 million m^3 of ore sorter rejects. The bulking factors used in the assessment are more likely to be higher than will be achieved than lower; this represents a conservatism in the assessment in terms of the overall risk of storage capacity being exceeded.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the waste volume calculations including bulking factors used reasonable?	✓		

5.1.3 Waste Prevention and Reduction

In this section of the WMP, SRK states that in order to minimise waste generation where possible, DGL has considered the potential for re-use, recycling and recovery of mining waste where practical. Measures in the project design will minimise the quantity of waste that will be placed on surface. This includes backfilling of the excavation voids with mine waste which will both reduce the quantity placed at surface and the requirement to source structural fill for the voids from elsewhere. The results from a waste characterisation programme have been used to support waste management decisions.

SRK says that DGL has aimed to limit the environmental impact of operations by encapsulating all potentially acid generating waste rock as underground backfill and disposing of the balance of non-acid generating waste rock in the MWF. DGL's approach is to reduce the potential for acid rock drainage (ARD) or metals leaching from the surface waste storage facilities. This is to address long-term environmental concerns and to promote mitigation strategies for the site with the intent of encapsulating all Potentially Acid Forming (PAF) material within cemented backfill.

This section continues with the following statements which are relevant to waste reduction:

"To minimise the footprint area and increase the options for siting of the MWF, tailings will be dewatered and the material will be placed and compacted in thin lifts. Pressure filtration of tailings significantly reduces the moisture content of the material and hence the volume of excess water available. In turn, there is less potential for material seepage from the tailings following placement in the MWF.

"To improve the slope stability of the external slopes of the MWF landform, inert waste rock will be used to buttress the perimeter slopes, construct drainage systems and provide access roads. Waste rock not required for these uses will be incorporated into the main part of the facility.

"Soil and peat excavated from the area during the construction phase will be set aside for re-use during progressive rehabilitation of the MWF (ie used for cover material). Where suitable, excavated peat will also be used in habitat enhancement and redressing within the site. Proposed peat management measures are explained in detail in Section 9, and the Peat Management Plan (2019) and Peat Landslide Hazard and Risk Assessment are included in Appendices E and F of this report.

"Throughout the life of the mine, measures to further reduce the quantities of waste generated will be considered."

Golder comment:

The use of the waste management hierarchy of waste prevention and reduction are standard practice.

Golder conclusion:

The methods to prevent and reduce waste during operation of the mine are reasonable.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the planned measures for waste rock, tailings, and peat (to manage it and reduce the volume) realistic and achievable?	✓		

5.1.4 Waste Storage

This section of the WMP summarises the capacity of the planned waste storage areas on the site. It is a brief summary of the waste storage areas whose design and construction (DSF and water storage ponds) are presented in detail in following sections of the WMP.

The MWF will provide capacity for up to 4.8 Mm^3 for storage of tailings, waste rock and ore sorter rejects and will be situated immediately adjacent to the processing plant.

Solid mining and processing waste generated by the project will either be used in the construction of and / or stored within the MWF or used as backfill material to be placed in mined out stopes underground for geotechnical support purposes.

Underground mine water will be pumped to the West Pond for temporary storage before treatment in the water treatment plant. Dry residue from the water treatment plant will be transported off-site for disposal. The settled solids from the water storage ponds will be periodically excavated and placed on the MWF.

Golder comment:

This section of the WMP is a summary presentation of waste storage plans. Further review of the MWF is presented in the following sections.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the waste storage provisions considered adequate (subject to individual technical assessments)?	✓		

6.0 DESIGN RISK ASSESSMENT

6.1 Chapter Summary

The WMP states that in order to demonstrate that the design of management of extractive waste at Curraghinalt will not give rise to an unacceptable risk to the environment and human health, surface water, hydrology and geotechnical risk assessments have been carried out, which cover each of the waste facilities and the extractive void. The aim of the risk assessments is to ensure that the objectives included in Paragraph 3, Schedule 1 of the *2015/85 Regulations* are met. These objectives are confirmed in the WMP in Section 6.

The risk assessments consider potential source, pathway and receptor linkages which could occur at each of the MWFs, as well as the management measures that will be implemented to minimise risks to human health and the environment. This chapter also considers the potentially sensitive receptors which have been identified and assessed.

The risk assessments have considered the risks presented by the following potential hazards:

- Stability of the final MWF external slopes;
- Hydrogeology (groundwater);
- Hydrology (surface water);
- Particulate matter (dust);
- Mud (on roads);
- Noise and Vibration; and
- Accidents and their consequences (fire, spillage and leakage, security and vandalism).

The Risk Assessment (RA) is presented by SRK in Table 6-1 in the WMP.

Golder comment:

It is noted that no definition of the consequences and probability of exposure has been provided within Section 6 of the WMP. For this reason, it is difficult to understand the overall ratings allocated for Consequence and Probability of Exposure. Further, no information has been provided on the calculation of the overall risk and the matrix used to determine the risk level.

With respect to the “Waste rock geochemistry” risk identifier, Golder notes the comments and agrees that the procedures for managing waste streams to ensure PAF rock is stored underground and not at surface are to be defined as part of the final mine design. However, this does not impact on the risk assessment identifier being considered at Public Inquiry as the risk linkage is sufficiently developed for the planning stage.

The “Cover system failure” risk identifier does not include an assessment of the potential impacts to human health from wind-blown dust. It is recognised that this has been assessed in Chapter 13 of the WMP and so the potential impacts to human health are well understood however it is considered that this linkage should be included here also.

Golder conclusion:

Despite the above, Golder has been able to understand the risk matrix used and has been able to complete its review of the risk assessment data. The comments noted above re wind-blown dust will not impact on the risk assessment findings and are included for completeness.

The RA is considered fit for purpose but would benefit from the addition of the clarifications above.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the Risk Assessment fit for purpose? Have risks been identified that have not been addressed?	✓		
Are the definitions of Consequences and Probability of Exposure given in the risk assessment adequate?		✓	

7.0 DESIGN OF THE MINE WASTE FACILITIES

7.1 Chapter Summary

7.1.1 Mine Waste Facility Construction and Operation

Mine Waste Facility Components

This section of the WMP provides a summary of the different components that make up the MWF, and are listed as follows:

- Mine Waste Facility storage area, which is High Density Polyethylene (HDPE) lined and includes a waste rock toe buttress, and an outer waste rock shell;
- An underdrainage non-contact culvert system to divert groundwater below the facility. Underdrains are positioned in natural depressions (stream courses), beneath the installed liner, to intercept groundwater flows;
- Overdrains (finger drains) to direct the excess water above the liner;
- Contact water diversion ditch;
- Access and haul roads;
- West and East Diversion Ditch to divert clean water around the MWF; and
- Lower East Pond, Upper East Pond and West Pond – composite lined (HDPE & GCL) facilities which will contain contact water from the MWF. This water will be recycled within the process or be treated in a dedicated water treatment plant before being returned to the plant for re-use or discharged.

Golder comment:

The Mine Waste Plan indicates a list of factors which it states have been taken into account in the design of the MWF. Further it lists a number of design principles or design criteria that have been satisfied through the design work undertaken. These factors and principles are presented in Table 1 below.

All of these factors listed above form either an integral part of the review carried out by Golder or a check that sufficient consideration has been invested at this stage of the design development and that any relevant aspects have been flagged for further consideration at later stages of design where appropriate.

Table 1: Design Aspects and Design Principles for the Mine Waste Facility

Factors stated to be taken into account in design of MWF	Stated Design Principles / Criteria*
Topographic suitability (volume/storage ratio)	DP1: To prevent pollution of soil, air, groundwater, or surface water (in accordance with the requirements of the Groundwater, Dangerous Substances and Water Framework Directive) and to take account of protected areas (Special areas of Conservation (SAC) and Areas of Special Scientific Interest (ASSI)), and geological, hydrological, hydrogeological, seismic and geotechnical factors
Geological and geotechnical site suitability	DP1: see above DP2: To ensure physical stability in the short and long term
Seismic considerations	DP1: see above
Hydrology under both extreme drought and flood conditions	DP1: see above DP3: To provide for the efficient collection and control of water
Environmental Risk	DP1: see above DP4: To control erosion caused by water or wind DP5: To minimise impacts in relation to landscape and visual amenity
Construction specification QA/QC	DP1: see above
Inspection and auditing	DP1: see above
Engineered closure	DP1: see above DP6: To make provision for the rehabilitation of the land and the closure of the mining waste facility; DP7: To make arrangements for aftercare of the mining waste facility

* DP numbers assigned by Golder during review for ease of reference.

Golder conclusion:

Golder considers that the design factors considered for the MWF and the stated design principles and criteria are sufficiently developed for consideration at Public Inquiry.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Have sufficient factors been taken into account in the design of the MWF and are the Design Principles adequate?	✓		

Construction Sequence

Section 7.1.2 of the WMP provides details of the construction sequencing for the WMF. As this is useful background information to understanding the design of the MWF itself, this information is summarised here. The MWF will be constructed as a starter embankment and three staged cells to facilitate progressive closure. The first two cells have been sized to store a combined volume of 2.9 Mm^3, while Cell 3 provides additional storage to accommodate a total of 4.8 Mm^3. The stages and construction sequencing is summarised as follows (refer to Figure 7-1 and Table 7-1 within the WMP for further details):

- Pre-production Stage – During Year -1 and Year -2, waste rock generated from the underground mine will be placed around the southern extents of the MWF to form a starter embankment;
- Stage 1: Rougher tailings, waste rock and ore rejects are stored in Cell 1 from Year -2 to Year 4. Cell 1 is constructed in stages during the year preceding full mine development (Year -2) to ensure the full cell footprint is available by Year -1 to store ore sorter rejects and waste rock only. Cell 2 is constructed in the last two years of this stage (Year 3 and 4) so that it is available to receive waste in Year 5. Cover construction for Cell 1 is planned to start in Year 3 and finish in Year 5 (Stage 2);
- Stage 2: All tailings and waste are stored in Cell 2 from Year 5 to Year 8. Cell 2 is previously constructed in Stage 1, and Cell 1 is completely covered in Year 5 after deposition transfers to Cell 2. Cell 2 cover construction is planned to start in Year 6 and finish in Year 8; and
- Stage 3: All tailings, waste rock and ore sorter rejects are stored in Cell 3 from Year 9 onwards. Waste rock and ore sorter rejects will be transported to the MWF via conveyors and will be deposited at a drop point located to the north of the facility. The modelled MWF landform includes storage capacity for the estimated 293,400 m^3 of fill materials required to construct the final cover at closure.

Golder comment:

Golder has considered the construction sequencing for the MWF and does not have any comments.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the construction sequence assumptions reasonable and achievable?	✓		

Configuration

Some of the design criteria for the MWF are presented within Table 7-2 of the WMP. To summarise, the MWF will be a 28 hectare HDPE lined facility extending to a maximum elevation of 286 masl at a maximum height of 21 m, slopes will be at 3H:1H at the south side and 2.5H:1V slopes on all other sides with 5 m benches every 10 m of vertical raise. Details for the overdrains and underdrains are also provided.

Golder comment:

Golder has considered the basis of design and basic facility configuration for the MWF and does not have any comments. This section of the WMP is considered adequate.

Foundation preparation

This section provides details on the preparation of the foundation of the MWF. Golder has noted that the following aspects have been accounted for:

- Footprint of the MWF shall be progressively stripped to the depth necessary to remove all organics and topsoil to expose organic-free soil material with material saved for restoration purposes;
- Where benches are required, additional soil excavation and surface grading to meet the required shape of each bench will be completed. Golder understands that this is effectively creating a key-in for the bench into the natural ground to improve stability;
- The surface of the sub-grade, including exposed benches, will be rolled with a smooth drum vibratory compactor to improve its density and prepare for lining (a bedding layer of sandy material will be used where required);
- A geotextile protector shall be placed above the sub-grade and beneath the HDPE liner to minimise the risk of puncture during installation and initial loading; and
- The HDPE liner will be placed by a qualified installer according to the Construction Quality Assurance (CQA) procedures (Section 7.5 of the WMP).

Golder comment:

Golder notes that to reduce the likelihood of translational failure along the liner interface with the dry stack tailings, benching was introduced along the surface of the superficial material (SRK, 2020) *(SRK 2020 Addendum – Design drawings U7511-DSF-003)*.

Golder further notes that the design of the proposed benching is not outlined in detail in Addendum 2. It is referred to as “where necessary”. However, Section 7.1.4 of the WMP does confirm that the benches will be every 10 m vertical height. As the benching is modelled in the stability analysis, it should be noted that the frequency used in the stability analysis should be set as a minimum or the analysis rerun. This is a consideration for the later design stages.

Golder conclusion:

Golder considers that the proposed procedure for foundation preparation is adequate for ensuring that the facility is safely lined with a high-quality lining system. It is noted that provisions have been made for benching to increase the liner interface with the tailings.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the foundation preparation for the MWF adequately described, particularly in relation to the HDPE liner?	✓		

Underdrainage construction

This section provides details on the construction of the underdrainage beneath the MWF. Further design details for underdrains are provided in Second Addendum to the Mine Waste Facility Design (Appendix G). Golder has reviewed both and notes that the following aspects have been accounted for:

- A system of contour underdrains and main underdrains shall be constructed in natural channels prior to installation of the HDPE liner to direct non-contact water from surface water flow paths beneath the facility;
- Underdrains will consist of a perforated drainage pipe installed on a bedding layer and surrounded by drainage gravel;
- Suitable fill will then be placed above the drainage gravel to form a bedding layer for the HDPE liner; and
- The main underdrains will report to a series of concrete seepage collection chambers located immediately south of the facility which will in turn transport non-contact water to the discharge location at the head of the Pollanroe Burn.

Golder comment:

Golder notes that SRK has designed the use of underdrains to manage water flow below the HDPE liner. The underdrains manage groundwater flow and convey it towards the drainage outlets at the toe. The drains convey the water away and prevent formation of upward pressure underneath the HDPE liner.

The underdrain frequency was increased in the 2020 addendum (SRK, 2020) *(SRK 2020 Addendum – Section 4.2 – Increased drains)*.

Golder conclusion:

The initial design put forward by SRK provided a limited network of drains below the liner. The increased frequency presented in Addendum 2 provides a more robust drainage solution.

The additional drains are a good use of available rock fill which will help mitigate against phreatic surface development below the liner.

Overall, the underdrainage system is considered adequate.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the proposed underdrain construction fit for purpose?	✓		

Overdrainage construction

This section provides details on the construction of the overdrainage within the MWF. Further design details for overdrains are provided in Second Addendum to the Mine Waste Facility Design (Appendix G). Golder has reviewed both and notes that the following aspects have been accounted for:

- Overdrains will be constructed in a herringbone network of main overdrains and contour overdrains will be installed to generally follow the natural contours and flow channels; they are required to reduce the internal phreatic surface within the MWF;
- Contour overdrains will be constructed on the liner-covered benches and will consist of perforated drainage pipes embedded in waste rock windrows, each of which will overlie a bedding layer and follow the contours of the HDPE liner surface;
- The contour overdrains will connect to the main overdrains which will be constructed above the liner in the same natural channels in which the main underdrains are installed;

- Main overdrains will consist of perforated drainage pipe, surrounded by waste rock which overlies a bedding layer; and
- The main overdrains will report to a series of seepage collection chambers, which in turn will be connected to the West and Lower East Pond by a solid HDPE pipe.

Golder comment:

Golder notes that on internal drainage, SRK has designed the use of overdrains to manage water flow above the HDPE liner. The overdrains are implemented to manage water draining through the stack. The drains convey the water to prevent unacceptably high heads from forming on the HDPE liner.

Following additional test work, the distribution of the overdrains was amended *(SRK 2020 Addendum – Section 4.3 – Increased above liner drainage)*. The test work indicated a reduced permeability of the dry stack tailings (one order of magnitude) and so additional drainage will reduce the impact of head developing on the liner.

Golder conclusion:

The initial design put forward by SRK provided a limited network of drains above the liner. The increased frequency presented in Addendum 2 provides a more robust drainage solution. The drainage was designed using seepage modelling to define the required frequency and size to efficiently drain the stack.

Additional drainage was implemented at every other bench. The horizontal drain is formed of rock fill and provides a drainage pathway from the centre of the stack to the perimeter rock fill berms.

Although further detail could be presented on the size and the frequency of the horizontal drainage in Addendum 2 (SRK, 2020), the information provided is sufficient to determine the potential efficacy of the proposed system. The additional drains are a good use of available rock fill which will help mitigate against phreatic surface development and an undrained response to the stack.

Overall, the overdrainage system is considered adequate.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the proposed overdrain construction fit for purpose?	✓		

Toe drain (starter embankment)

This section provides details on the construction of the toe drain at the base of the starter embankment of the MWF. Further design details for toe drains are provided in Second Addendum to the Mine Waste Facility Design (Appendix G). Golder has reviewed both and notes that the following aspects have been accounted for:

Waste rock material (up to 285,000 m^3 in Year -1) will be placed in Cells 1, 2 and 3 as a starter embankment as using this material for the starter embankment in all three cells provides the opportunity to improve global slope stability along the southern sections of the MWF where external slopes are highest. Further, it enables the commencement of early reclamation of the external slope of the landform, thereby reducing infiltration of runoff through the stored waste materials.

Golder comment:

The purpose of the section is unclear given that it is primarily titled Toe Drain however provides information on the construction methodology for the starter embankment. Although this results in a dearth of information on the toe drain itself, it is noted that details for the toe drain are presented on the drawings.

Golder conclusion:

Overall, it is considered that the inclusion of a toe drain at this location to convey drainage waters away from the WMF itself is the most critical aspect and it is noted that it has been included within the stability analyses.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the proposed toe drain construction fit for purpose?	✓		

Transport and placement of waste material

This section provides details on the transport and placement of waste material into the MWF. Further design details are provided in Second Addendum to the Mine Waste Facility Design (Appendix G, reviewed in Section 24.0). Golder has reviewed both and notes that the following aspects have been accounted for:

- Spreading and compaction of the dewatered tailings material will commence using a bottom-up placement sequence;
- The placement will begin on the east part of the MWF and will advance towards the west;
- The dewatered tailings material will be hauled to the MWF using haul trucks, spread with a CAT D4 dozer or similar, and compacted with a vibratory roller in maximum 0.3 m lifts;
- Tailings will be placed close to optimum moisture content to improve workability during compaction and to control dust generation. Sufficient compaction of each lift is required;
- A waste rock outer shell shall be constructed progressively on the surface (final configuration) of the MWF to limit erosion from heavy rainfall; and
- The surface of the facility will be covered with waste rock directly following the completion of tailings placement to limit exposure of the tailings material to rainfall.

Golder comment:

Golder has reviewed the description of the transportation and placement of the mine waste material. Further, Golder has reviewed Appendix G including the two addenda and based on an overall understanding of the waste materials and the waste facility, it is considered that the procedure as described for the transportation and placement of mine waste materials is satisfactory and achievable.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the proposals for transport and placement of waste material satisfactory and achievable?	✓		

7.1.2 Mine Water Balance and Surface Water Management

Section 7.2 of the WMP addresses both the water balance for the mine and the management of surface water in general. Section 7.2 is broken down into four sub parts, 7.2.1 to 7.2.4 and further references Appendix I. Golder has reviewed all this information and provides comment below and in Sections 26.0 and 27.0 (Appendix I, Groundwater) and Sections 28.0 and 29.0 (Appendix J Surface Water).

Section 7.2 of the WMP notes that water management is fundamental to the effective operation of the mine and lists the aims of mine water management for the project as:

- Capture, storage and treatment of all water that contacts mining activities/infrastructure and which could have poor water quality. This includes provision of suitable freeboards and contingency plans to prevent uncontrolled spills from water management infrastructure;
- Limit natural runoff from outside of the proposed infrastructure site from contacting mine infrastructure to reduce water volumes which need to be treated; and
- Capture of clean (non-contact) surface water runoff from upslope of the proposed infrastructure site and within the proposed infrastructure site to be available for use as fresh water in mining operations.

Water balance

This section of the WMP provides a brief summary of the water balance calculations carried out for the Curraghinalt project. It references Appendix I as the document which provides details for the water balance assessment carried out.

Section 7.2.1 of the WMP states that appropriate management of storm water and process affected water flows generated during operation is essential to ensure that the MWFs are safely managed during the operations and post-closure phases of the project. To achieve this, a site wide water balance has been produced to quantify flows of water generated from underground mining operations, the process plant and the natural environment. In turn, this data has been used to design appropriate water management features around the surface infrastructure and MWFs.

Currently, predictions based on model best estimate inputs indicate that there is a low risk of water shortage at the mine, primary due to storage within the clean water pond. The water balance has also been used to confirm that the surface water ponds have been designed to accommodate design flood conditions.

Golder comment:

Refer to Section 28.0 of this report for review comments on the water balance assessment.

Golder conclusion:

Refer to Section 28.0 of this report for review comments on the water balance assessment.

Surface water management arrangement

The surface water management system designed for the MWFs is shown in Figure 7-3 in the WMP. The following comments about catchments have been noted by Golder during its review:

- Surface water from hillslopes located on the eastern side of the catchment will be routed around the periphery of the mine to ultimately discharge into the Pollanroe Burn on the slopes upstream of the mine outfall;
- Surface water from the proposed infrastructure site and MWF will be routed through a series of ditches to three water storage ponds; these are the Upper East Pond (capacity: 52,870 m^3), Lower East Pond

(capacity: 9,973 m^3) and West Pond (capacity: 38,855 m^3) which will receive surface water runoff and seepage from the proposed infrastructure site including the MWF; and

- The West Pond will also receive water pumped from the underground workings. The West Pond will receive runoff from the part of the MWF that will not be utilised for waste storage during the early years of operation. It will also receive runoff from the west diversion ditch that will collect run off from the Pollanroe catchment to the west of the site. Water within the West Pond can be used as make-up water in the process plant.

The WMP notes that the ponds are connected by culverts and emergency spillways to control flows between each water storage area.

A full review of the WMP surface water management system and water balance is included in Sections 28.0 and 29.0.

Golder comment:

Refer to Section 29.0 of this report for review comments on the surface water assessment.

Golder conclusion:

Refer to Section 29.0 of this report for review comments on the surface water assessment.

Water treatment plant design

This section of the WMP provides a brief summary of the design of the water treatment plant. It notes that a water treatment plant will be located to the south of the east and west water ponds. Water will be recycled within the process, and ultimately following full treatment can either be discharge to Pollanroe Burn under consent or be returned to the Clean Water Pond for re-use. Overflow from the Clean Water Pond will be discharged to the Pollanroe Burn south of the water treatment plant.

The treatment plant proposed at the surface infrastructure site will use RO technology, with a two stage RO system to meet water quality requirements. The proposed system will include a crystalliser to limit the volume of the plant effluent. The solid residue will be transported off-site for disposal by a registered waste management company.

Golder comment:

Golder has noted the inclusion of two stage RO technology with crystalliser. This type of water treatment technology has been used on numerous other mine sites for similar applications and subject to adequate process design, should be sufficient for the intended purpose at Curraghinalt. Use of RO to treat wastewater conforms with the 2018 BAT for management of waste from the extractive industry (refer Section 16.0). A full review of the WMP surface water management system and water balance is included in Sections 28.0 and 29.0 and this will provide further commentary on the efficacy of the proposed treatment.

Golder conclusion:

Golder considers that the proposed water treatment technology is capable of providing a suitable solution for the Curraghinalt Project and is listed as a best available technology (BAT) for treatment of wastewater in the 2018 MWEI BREF document.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the proposed water treatment technology (RO) capable of providing an adequate water treatment solution for the Project (subject to technical assessment)? (Sections 28.0 and 29.0.)	✓		

Water discharges to environment

This section of the WMP addresses water discharges to the environment however it is noted that this is also addressed in detail in Appendix I and Appendix J, both of which Golder has reviewed and provided review comments in Sections 28.0 and 29.0 of this report. The WMP notes that water discharges from the project will occur from two distinct points:

i) overflow from the Clean Water Pond which will be combined with discharge from the water treatment plant at the proposed infrastructure site, and

ii) discharge from the existing exploration surface infrastructure site.

Water collected from under the MWF liner will be directed to the head of the Pollanroe Burn. It is noted that the principal site discharge will increase the flow in the middle and lower section of the burn and that the change in flows has been assessed in the EIA process.

The following is noted within the WMP and is considered relevant to water treatment and water discharges: *"DGL already operates a dedicated Water Treatment Plant under Discharge Consent at the existing surface infrastructure site. This treatment plant will be upgraded during mine construction and the consent will be updated. DGL intends to obtain a second Discharge Consent covering discharges from the proposed infrastructure site. All future discharges from the mine, both in terms of quantity and quality will be managed to meet agreed specific regulatory requirements at the point of discharge*."

Golder comment:

It is noted that at mine closure water will discharge long term from the mine adit. The information provided in this section is useful background, however the technical detail which requires assessments is provided in Appendix I and Appendix J to the WMP. A full review of the WMP surface water management system and water balance is included in Sections 28.0 and 29.0.

Golder conclusion:

Refer to Section 28.0 of this report for review comments on the water balance assessment and to Section 29.0 for review comments on the surface water assessment as both relate to water discharges to the environment.

7.1.3 Construction and Design Principles

This section deals with the relevant construction and design principles as well as the relevant legislation. It notes that the MWFs will be designed and constructed in strict compliance with all relevant legislation including the following:

- Quarries Regulations (Northern Ireland) 2006 (SR 205);
- The Mines Regulations (Northern Ireland) 2016 (S.R. 2016 No. 427);
- The Health and Safety at Work (Northern Ireland) Order 1978; and

- Water Environment (Floods Directive) Regulations (Northern Ireland) 2009 (SR 376).

Further to the above the following Pollution Prevention Guidelines (PPGs) and Guidance for Pollution Prevention (GPP) are listed as being relevant to the construction works:

- PPG01 – General guide to prevention of pollution;
- GPP02 – Above ground oil storage tanks;
- GPP05 – Works and maintenance in or near water;
- PPG06 – Working at construction and demolition sites;
- GPP13 – Vehicle washing and cleaning; and
- GPP21 – Pollution incident response planning.

The WMP notes that a definitive list of all applicable guidelines will be agreed with the Department of Agriculture, Environment and Rural Affairs (DAERA) when the final Construction Environmental Management Plan (CEMP) is being produced. Discharge consents and noise criteria will also be agreed and put in place in advance of construction.

Golder comment:

The list of legislation outlined within the WMP as being relevant to the **design and construction** of the WMFs appears to encompass the full range of legislation required. A list of guidance relevant to **pollution prevention** is also provided, though it is noted that a list of all applicable guidelines will be agreed with DAERA prior to the creation of the CEMP. This is considered to be adequate from a pollution prevention point of view (further detail is also given in the ES for the site).

It is noted however that there is a significant amount of **tailings industry** guidance that relates to the operation, construction and design of mine waste management facilities that are not referenced here. Much of the guidance has been referenced elsewhere within this document and appears to have been used extensively within the design process.

Golder conclusion:

Sufficient legislation and guidance are referenced in order to meet the demands of the *2015/85 Regulations.*

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the correct legislation and guidance referenced for construction & design of the MWFs?	✓		

7.1.4 Operations and Management

This section of the WMP provides details for the monitoring and inspection of the MWF and ponds. The WMP notes that these facilities will undergo strict inspections in accordance with the guidelines set out in *Establishment of Guidelines for the inspection of mining waste facilities, inventory and rehabilitation of abandoned facilities and review of the BREF document No. 070307/2010/576108/ETU/C2. Annexe 2, Guidelines for the Inspection of Mining Waste Facilities, April 2012*.

In the WMP, SRK notes some of the obligations which must be met during operation of the mine waste facilities as outlined within the above guidance document. These obligations include the following:

- Operator – the operator is obliged to report on the results of the monitoring and inspection programme on request and, on a regular basis, to use Independent Experts to perform inspections and to supervise, improve and audit the management of the facility according to BAT, best practice and company policy. A monitoring and inspection plan has to be prepared according to the legislation, the permit and BAT, and in close cooperation with the competent authority. The operator must also ensure that:
  - The management of a waste facility shall be in the hands of a Competent Person and that adequate technical development and training of staff has to be provided;
  - There must be suitable plans and arrangements for regular monitoring and inspection of the waste facility by competent persons and that the results of the monitoring and inspections need to be implemented in order to avoid instability or contamination of water or soils;
  - That records from the monitoring and inspections are to be kept in a structured manner and reported in a suitable format to the Competent Authority at a frequency defined by the Competent Authority or at least annually;
  - An Engineer must be appointed to conduct at least annual inspections of the facilities and monitoring records to ensure continued compliance; and
  - An Independent Engineer must be appointed to complete at least two annual inspections of the facilities.
- Competent Authorities are obliged to carry out regular inspections to assure the compliance of the facility in comparison with the control referential (ie the permit and applicable legislation). They may also appoint independent experts to perform inspections or to validate monitoring and inspection reports from the operator in accordance with Article 17 of *The Mining Waste Directive (2006/21/EC*).

Golder comment:

Golder considers that the use of the document *Establishment of Guidelines for the inspection of mining waste facilities, inventory and rehabilitation of abandoned facilities and review of the BREF document No. 070307/2010/576108/ETU/C2. Annexe 2, Guidelines for the Inspection of Mining Waste Facilities* for determining the monitoring, inspection and auditing requirements is acceptable. Golder is aware of other suitable guidance documents that could be consulted such as the relevant guidance from Mining Association of Canada (MAC) however BREF is considered acceptable and conforms with the requirements of the *2015/85 Regulations Part 4 Section 9(c)(d)*.

Golder conclusion:

The proposed schedule for monitoring is considered to satisfy the requirements of the *2015/85 Regulations*.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the proposed schedule for monitoring and inspection (as *per Establishment of Guidelines for the inspection of mining waste facilities, inventory and rehabilitation of abandoned facilities and review of the BREF document No. 070307/2010/576108/ETU/C2. Annexe 2, Guidelines for the Inspection of Mining Waste Facilities*) compliant with the requirements of *2015/85 Part 4 Section 9 (c)(d)?*	✓		

7.1.5 Construction Quality Assurance (CQA)

This section of the WMP deals with Construction Quality Assurance (CQA). It is noted however that Section 5.1 of Appendix G Second Addendum contains specific details for all construction activities and Golder provides review comments on this in Section 24. However, some points of note from this section include the following:

- All construction work will be carried out in accordance with a detailed CQA plan prepared by the Design Engineer;
- Records will be maintained of all construction activities related to foundation preparation, underdrainage construction, HDPE liner installation, buttress construction and pond construction and
- A Geotechnical Engineer will be appointed to oversee the CQA plan during all construction works.

Golder comment:

Please refer to Section 24.0 for review comments on CQA.

Golder conclusion:

Please refer to Section 24.0 for review comments on CQA.

8.0 DESIGN OF THE PASTE BACKFILL PLANT

8.1 Chapter Summary

This section of the WMP deals with the design of the paste backfill plant. SRK commences this section by reconfirming the point made previously that the area denoted as the paste backfill facility is not designated as a mine waste facility, rather it is classed as an Extractive Void.

The main points noted by Golder during the review of this section of the WMP are as follows:

- The paste backfill plant will be located centrally underground near the top of the deposit. This location was selected to reduce the area of disturbance on surface and to reduce the need to extend the tailings pipeline and power cables further than necessary;
- The paste backfill plant consists of the following components: Filter feed tank, pumps, and agitator; Drill hole wash tank and pumps; Underground cement silos, slag storage and metering system; Process water tank and pumps; Disc filter with vacuum pump and ancillary equipment; Filter cake conveyor and

weigh belt; Continuous high-intensity paste mixer complete with washing system; Paste pump complete with hydraulic power pack; and a High pressure paste pipeline flush pump;

- The paste backfill plant will accept a mix of rougher and scavenger tailings which, when combined with binders, will form a cement paste that will be pumped as backfill into the underground cavities or excavation void;
- The cement and imported slag (GGBS) that form the binders will be transferred to the plant using HGV vehicles which will connect to cement / slag distribution pipes leading to the plant;
- As underground development will occur during the construction phase before the process plant is operating, mined out voids will be available for accepting backfill material as soon as the plant is commissioned; and
- Filtrate from the paste backfill plant will be pumped back to the process plant or direct to the water treatment plant.

8.1.1 Waste types sent to excavation voids

The WMP lists the following as the only waste types that will be sent to the excavation voids: rougher and scavenger tailings resulting from processing of ore within the processing plant, waste rock from underground mining and ore sorter rejects from the plant.

Golder comment:

Golder considers that the above description of the waste material to be used for backfilling to be appropriate.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the description of the waste types to be sent to the excavation voids accurate?	✓		

8.1.2 Production of paste backfill material

This section of the WMP describes the quantities of backfill material that will be produced and the process of producing the paste backfill. The WMP states that an average of 18 t/h of rougher tailings and 12 t/h of scavenger tailings will be mixed in the paste mixer before being pumped to the paste backfill plant and ultimately sent to the excavation voids.

Some points noted by Golder during its review include the following:

- The overflow will flow by gravity to the process water tank and the underflow, which will have achieved a density of approximately 63% solids, will be pumped to the paste holding tank. The thickened tailings will be pumped from the paste holding tank, using two pumps and two on standby, to the paste backfill plant;
- The high stock tank provides more than eight hours of surge capacity to the tailings filters;
- Two filters, one on standby, will process up to 46 tph of paste;

- The tailings will be filtered to reduce the moisture to 15% prior to loading the solids into trucks for deposition at the dry stack facility;
- The filtrate will be pumped to the process water tank to be reused in the process;
- Calcium Enriched Mixture (CEM) and ground granulated blast furnace slag (GGBS) will be stored in two silos with a live capacity of 75 t. The silos will be equipped with aeration pads, an aeration cone, a manual slide gate and a rotary airlock feeder;
- The inclusion of a belt scale conveyor to control the binder addition will provide flexibility in the event of variability in the ore being processed or to meet an increased requirement of the strength characteristics of the paste backfill blend as it allows for the recipe to be amended over the course of the LoM; and
- The belt scale conveyors will be provided with a total dust confine enclosure with access doors.

Golder comment:

The above information has been noted as part of the review.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the quantities of backfill materials which will be produced realistic & the description of the process of producing the paste backfill adequate?	✓		

8.1.3 Transport and placement of paste backfill material

This section of the WMP addresses the proposed methodology for the transport and placement of the paste backfill material.

Golder has noted the following points during its review:

- The underground paste distribution network is limited by the piston pump pressure which is 50 bar;
- A distribution station will be installed on the third level interval on each cross-cut (West, Centre and East) which are covered by the distribution cone;
- Drill holes complete with casing and / or permanent pipeline will distribute the paste from the plant to each main drift distribution station. From the distribution stations, a permanent pipeline will be installed all along the main drift; and
- The outgoing paste from the plant goes directly into distribution stations. Each distribution station forwards the paste to the permanent piping, installed along the nearest main drift. From there, temporary piping will be used to reach the targeted stope, located on the same level or on two lower levels via a drill hole.

Golder comment:

The paste back filling test work is summarised in Section 19.0 (Appendix B of the WMP) where further commentary is also provided. It is noted test work was conducted on blends of tailings at 3:1 (rougher to cleaner tailings) and 1:1 with various binder contents.

Golder conclusion:

The recommended mix was a 2:1 ratio and Golder notes that no test work was presented for this blend. The report does however indicate that this ratio has little impact on the strength gain of the back fill and was selected as it aligned to the production ratios of the rougher and cleaner tailings.

Golder therefore recommends that this blend is checked through laboratory test work at detailed design stage to inform the design of the paste back fill plant, pumps and pipelines. However, it is considered satisfactory at this stage of the design development.

Golder also considers the proposed methodology and proposed equipment to be adequate although this too will need to be confirmed at design stage.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the methodology for transport & placement of the backfill material as described and fit for purpose?	✓		
Is the test work on the different blends of tailings at 1:1 and 3:1 sufficient to provide confidence that the proposed mix at 2:1 can achieve the objectives?	✓		

8.2 Assessment of Efficacy of Design of Paste Backfill Plant

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Overall, is the proposed design of the paste backfill plant capable of achieving the mine's backfilling objectives?	✓		

9.0 PEAT MANAGEMENT

9.1 Chapter Summary

A summary of SRK's proposals for Peat Management is explored in more detail in the WMP in Appendix E (Section 22.0) and Appendix F (Section 23.0). A summary of strategy, storage methods, peat and soil mixing, and stockpiles, is examined below.

9.1.1 Peat Management Strategy

This section of the WMP address the management of peat at the site. SRK notes that a Peat Management Plan (PMP) and a Peat Landslide Hazard and Risk Assessment (PLHRA) are included in Appendices E and F. Golder has reviewed these documents and has provided comments in Sections 22.0 and 23.0 of this report respectively.

The following extract from the WMP provides a brief description of how peat will be dealt with, this is included for background only: *"Suitable excavated peat will be re-used at the site for habitat enhancement and for landscaping on berms and landscape dressing of construction areas immediately following construction. This material will be primarily the acrotelmic peat where suitable. The remaining peat and topsoil cleared from the site will be transferred to clearly demarcated stockpiles within the footprint of the MWF. Site rehabilitation will be carried out in periodic campaigns throughout the construction process. In the longer term, the remaining peat will be used for progressive rehabilitation following capping of each segment of the final MWF landform."*

Golder comment:

Golder review comments on peat management are provided in Sections 22.0 and 23.0 of this document.

Golder conclusion:

Golder review comments on peat management are provided in Sections 22.0 and 23.0 of this document.

10.0 CONSTRUCTION MATERIALS

10.1 Chapter Summary

Section 10 of the WMP is a brief section (less than one page) discussing construction materials. Specifically it refers to the use of waste rock as a construction material. The outline procedures for the identification of waste rock are presented (visual inspection of blast face followed by collection of grab samples).

As per the WMP, samples of waste rock collected will be analysed:

"..to check sulphide levels and element concentrations in relation to crustal abundance. Regular sampling will be undertaken during the construction phase, to ensure the suitability of materials.

"During operations there will be a team of geologists responsible for grade control of the ore. This team will also be responsible for identification of inert waste material which is suitable for construction activities".

Golder comment:

Maximising the re-use of suitable materials on site is best practice. The regular testing of this material to ensure its suitability is appropriate and recognises the potential for leaching of materials and is added as a method to protect the water environment.

Golder conclusion:

The re-use of materials in Chapter 10 is a brief statement on the intention to re-use waste rock material for construction activities. This is best practice and reduces the carbon footprint of the proposed project. The monitoring of the waste rock is important to ensure leaching of metals from the rock is not occurring is important.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the proposed re-use of waste rock an acceptable approach for construction materials?	✓		

11.0 CONTROL AND OPERATIONAL MONITORING PROCEDURES

11.1 Chapter Summary

The WMP confirms that an Operating and Maintenance Manual (O & M Manual) will be prepared prior to the construction phase of the project. This is an industry-standard significant document which will set out the procedures required to operate, monitor the performance of and maintain the MWFs. It will also help ensure that operations are run in accordance with the design and that regulatory and corporate policy obligations are met.

The WMP confirms that the O & M Manual will be prepared in accordance with the principals set out in the guidance document:

"Establishment of Guidelines for the inspection of mining waste facilities, inventory and rehabilitation of abandoned facilities and review of the BREF document No. 070307/2010/576108/ETU/C2. Annexe 2, Guidelines for the Inspection of Mining Waste Facilities, April 2012. DHI"

11.1.1 O & M Manual content

The O & M Manual will define and describe:

- Project description, background and history;
- Tailings transport and stacking methodology;
- Paste backfill transport and placement methodology;
- Hydrology / Seismology;
- Environmental Controls;
- Instrumentation;
- Inspection and Monitoring Routines;
- Contact details for Statutory Appointees;
- Proforma Inspection and Monitoring Sheets;
- Instrumentation Maintenance; and
- Emergency Response Protocol.

This section also confirms that it is intended that the O & M Manual be incorporated and integrated with the maintenance procedures for the processing plant and other on-site facilities.

11.1.2 Control Mechanisms & Water Management

The specific requirements for control of the MWFs are listed as Control Mechanisms and can be seen in Section 11.2.

A further section (11.3) confirms how Underdrains and Overdrains are to be employed to manage water in the MWF, while section 11.4 explains how the PBF requires fresh water for the paste recipe and for cleaning / purging purposes.

11.1.3 Operational Monitoring and Inspections

The key information regarding Operational Monitoring and Inspections (more typically found in this section) is set out in 11.5. Table 11-1 is reproduced from the BREF 2018 document for management of waste from

extractive industries. Table 11-1 confirms schedules for inspections, reviews, audits and safety evaluations of existing dams. Further arrangements for continuous and automatic monitoring are explained (via alarmed remote access capability) as well as additional daily inspections by an operator or shift supervisor. Their specific daily duties are also listed. Other schedules for monthly and annual visits and the recording of data can also be found in this section.

11.2 Golder Summary

Golder comment:

An O & M Manual is an industry standard document which is typically considered live or dynamic, ie subject to daily use and regular updates as and when the situation demands it. It is also often expected to be subject to a wide-ranging annual review.

Employees and their nominees would expect to refer to an O& M Manual at least daily and as such it is considered a key document which is expected to cover all aspects of operations and maintenance.

No mention is made if it should be considered a “live” document and it doesn’t set out if it is to be subject to regular review. This is something which may wish to be considered when the document is being prepared.

Table 11-1 of the WMP is taken from the 2018 MWEI BREF and is considered best practice.

Golder conclusion:

The range and scope of the document as set out in the WMP is adequate, and it is considered that an O&M Manual prepared for the mine on this basis should be fit for purpose.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the range and scope of the O&M Manual outline sufficient to allow the preparation of an appropriate document?	✓		

12.0 CLOSURE, POST-CLOSURE AND MONITORING

12.1 Chapter Summary

Section 12 of the WMP presents the closure, post closure and monitoring conceptual arrangements for the closure of the project, which includes the underground mine, process plant and surface infrastructure. Section 12 summarises the content of the Conceptual Rehabilitation and Closure Plan (CRCP) which is presented in Appendix H of the WMP. Both social and environmental costs are considered.

The after-closure period is estimated at ten years. A proposed monitoring frequency for groundwater and surface water is presented over this ten-year timeframe.

12.1.1 Financial Guarantee

Financial Provisioning for closure of the mine is discussed and acknowledged, and as per legislative requirements, the provision must be agreed with the planning authority prior to commencement. Both the CRCP and the financial provision will also require regular review and update during the operational period of the mine.

These reviews will also require agreement from the planning authority at that time. The calculation of the closure costs is not presented in Section 12 but is given in Appendix H of the WMP.

Golder comment:

The after-closure monitoring period is estimated at ten years. Appendix H estimates post closure monitoring at five years. It is unclear from review of Section 12 of the WMP and Appendix H (Golder review of Appendix H can be found in Section 25.0 of this report) if there are two different time periods ie a five year active closure period followed by a ten year post closure period. This should be clarified by the Northern Ireland Environment Agency (NIEA) and the planning authority.

Golder conclusion:

Golder agrees that at this stage of the lifecycle of the proposed project, the CRCP is conceptual in nature. Section 12 is a summary of the more detailed Appendix H. The closure and post closure objectives are clearly defined. Social as well as environmental closure costs are considered. DGL recognises that the calculation of financial provision must be agreed with the planning authorities prior to commencement. Details such as the length of post closure monitoring must be agreed with the NIEA.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the Rehabilitation & Closure Plan sufficiently developed for consideration at Public Inquiry?	✓		

13.0 PREVENTION OF ENVIRONMENTAL POLLUTION

13.1 Chapter Summary

Section 13 of the WMP considers the prevention of pollution described for three media: water, air and soil. It presents the findings from the ES which assess the impacts to water, air and soil and describes the measures proposed for the WMF to prevent environmental pollution. Golder has reviewed the findings of the chapter by media as per the WMP.

13.2 Review Comments

13.2.1 Water

As noted at the beginning of the chapter, the Water section of Chapter 13 represents a summary of the hydrogeological and hydrological impact assessments (Appendix I and Appendix J of the WMP). Golder has completed an in depth review of Appendix I and Appendix J of the WMP in this document (Sections 26.0, 27.0, 28.0 and 29.0). The prevention of water pollution is discussed under each heading of the WMP in turn below.

Management of leachate and seepage from the Mine Waste Facility during operation and post-closure

The management of leachate is achieved by capture of leachate generated by a basal HDPE liner with over drains. Horizontal drains will also be constructed through the tailings. Construction Quality Assurance (CQA) will be used during the construction process with liner seam weld testing. Drainage is connected to the surface water pond system with treatment at the WWTP prior to discharge. The MWF will be reclaimed in lifts with soil cover added throughout the operational phase of the mine. This will in turn, minimise the potential for leachate generation at the DSF.

Underdrain systems will be installed to direct clean groundwater from beneath the DSF to a surface water pond with direct discharge to surface water (without treatment). In the event of impact being detected in the underdrain stream (manholes and sampling point available) it can be diverted to the Waste Water Treatment Plant (WWTP). In the event of seepage through the DSF liner, this will be collected in the underdrains. The underdrains discharge to the Pollanroe burn (unless diverted to the WWTP).

Predictive modelling of the concentrations of contaminants in seepage to private abstractions indicates a low potential risk to groundwater (applying drinking water standards). This is the case during operation and closure scenarios. For a detailed review of these topics please refer to Appendix C (Geochemical Characterisation, Section 20.0), Appendix I (Groundwater impact assessment report, Sections 26.0 and 27.0),) and Appendix J (Surface Water Impact Assessment report, Sections 28.0 and 29.0).

Surface water is the main receptor from the DSF during operation and closure as the collected water will ultimately discharge to surface waters. Surface water quality modelling demonstrated that water quality in the Owenreagh River will not be impacted. The surface water quality modelling applied Environmental Quality Standards (EQS) where available as the appropriate acceptance criteria for the Owenreagh. The Pollanroe is classed as a low ecological value river and applies Drinking Water Standard (DWS) to this receptor.

Section 13 of the WMP (as referenced by the appendices) states that no significant impacts are predicted to surface water bodies throughout the operational and closure period.

The report states that upon final capping of the MWF, flow will be reduced as capping is completed and infiltration reduces. Therefore, the residual risk to controlled waters receptors is considered lower in the closure phase. Confirmation that leachate drainage, groundwater and surface water monitoring programmes will be established is given (refer below).

Golder comment:

Based on the detailed reviews of Appendix C, Appendix I and Appendix J, Golder considers that the potential groundwater and surface water interactions with leachate / seepage are well understood. The management of leachate during the operational and closure phase of the mine considers this impact through a risk assessment. Mitigation measures have been identified and control / management procedures identified.

Golder conclusion:

Satisfactory.

Management of leachate and mobilisation of substances from Paste Backfill Facility (PBF) during operation and closure

During the operational phase of the mine there is potential for paste backfill / waste rock placed in voids to contact water. Dewatering with a developed cone of depression will draw contact towards the mine. Water will be pumped to the infrastructure site for treatment and discharge to the Pollanroe burn.

Modelling predictions state that after approximately 15 years of mine closure, groundwater gradients will return to pre mining directions with groundwater flow moving into the ‘wider’ groundwater system. The existing adit and mine closure is designed so that water can continue to discharge from the adit and to the Pollanroe Burn. Modelling estimates that approximate 80% of the water will discharge through the adit at closure when groundwater levels rebound to pre-mining activity. Section 13 (with reference to the groundwater impact assessment, Appendix I and geochemical modelling report Appendix C) states:

“No pollution of groundwater or negative impacts to receptors are therefore predicted……Furthermore, except for substances that are already naturally elevated in groundwater, predicted concentrations at (and inside) the

mine boundary are compliant with values in the Northern Ireland drinking water standard. This shows the underground mine presents a low risk of impact to groundwater quality during the rebound period."

As a means of monitoring and control, confirmatory samples of the paste backfill material will be completed. Groundwater monitoring will also be completed during operation and closure and assessed against modelled predictions and to ensure appropriateness of management measures.

Golder comment:

The assumptions and conclusions of this section of the WMP have been reviewed in detail in Appendix C and Appendix I (Sections 20.0, 26.0 and 27.0). Please refer to these appendices for detailed comments on the appendices which form the basis for the information presented in this section.

Golder conclusion:

The review of Appendix C and Appendix I found overall agreement with the modelling and conclusions presented in these Appendices. Golder considers therefore the information presented in Section 13 is representative of the modelled predictions. The management and mitigation measures proposed appear to be appropriate for this site.

Collection ponds

The Collection pond construction (including lining system) is briefly outlined in this section. The collection ponds will collect contact and mine water. Water will be recycled or sent to treatment prior to discharge. The treatment plant will use RO technology to treat water. The collection ponds are designed for a 1 in 1,000-year storm event. Emergency spillways are in place in the event of the capacity of collection ponds exceeding to divert water to the Pollanroe Burn.

Silt will be managed by mechanical removal to the MWF for placement with rougher tailings, ore sorter rejects and waste rock.

Drainage will be constructed beneath the collection ponds to manage groundwater beneath the ponds. This groundwater is diverted to the Pollanroe burn through drainage channels. Groundwater will be monitored as per the groundwater monitoring programme to check groundwater quality discharging to the Pollanroe Burn, which will also be monitored. Refer to Appendix K (Section 30.0).

Golder comment:

Summary information on the collection ponds is provided here with details in the relative appendices mentioned above. Adequate design, control, management and monitoring considerations for the collection ponds have been presented.

Golder conclusion:

The information provided for the prevention of environmental pollution to water is a summary for the detailed analysis and mitigation measures presented elsewhere in the WMP. Golder has assessed these detailed surface water and groundwater impact assessments and the detailed geochemical characterisation report for the site in the corresponding appendices. These Appendices underpin the summary information presented in Section 13. Golder considers that these are acceptable and that the design management and monitoring measures given for the protection of surface water and groundwater at the MWF are acceptable for discussion.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the proposed management and controls on leachate / seepage adequate to prevent potential risks to groundwater and surface water?	✓		
Have the potential risks from paste backfill to groundwater and surface water been adequately described with appropriate mitigation measures in place?	✓		

13.2.2 Air

The findings of this section are summarised from an air quality and dust impact assessment carried out as part of the Curraghinalt EIA process and presented in the *Environmental Statement* (ES) (Section 8.6 and Appendix C19) and the *ES Addendum* (Section 4.2.6 and Appendix C19). Commitments to ongoing monitoring of air quality are given in the ES (Chapter 10, Section 10.3.3). The AMS / EPA Regulatory Model AERMOD was used to predict ground level pollutant concentrations at receptor points within the vicinity of modelled sources during operation. The air dispersion modelling and the impact assessment were carried out in accordance with Northern Ireland, Ireland and UK requirements and good practice.

Golder comment:

The assessment of dust was completed as follows:

1) 2017 ES - modelling of potential impacts (health and nuisance to identified receptors);

2) An updated modelling assessment in 2019 to account for changes to the MWF design; and

3) An updated modelling assessment in 2020 to account for changes to MWF design and processes.

AERMOD is an industry standard tool used in this type of assessment. Golder has not completed a detailed review of the models produced as part of the EIA as this it is understood that this review is being completed by others.

Golder conclusion:

The cited legislation, standards and guidelines used in the technical assessments are reasonable and the Air Quality Standards as well as derived Environmental Assessment Limits (for quartz / respirable crystalline Silica) are also considered reasonable.

The air quality and dust results are only presented at the sensitive receptors and the presented contour plots do not show the installation boundary. The maximum predicted pollutant concentrations at the site boundary compared with the Air Quality Standards should also be presented.

Management of dust blow from construction and operation of the MWF and collection ponds

The management of dust blown wind will be controlled by good construction practice during construction. Construction of berms and lifts to the DSF will consider the potential to generate wind-blown dust e.g. finer material placed behind coarser material, and minimise same. Handling material and covering correctly to minimise surface areas that can generate dust will be completed. Water will be used to damp down surfaces

during drier periods. As the DSF is constructed, soil cover with promotion of vegetative growth will be completed to minimise dust generation.

Dust emissions from earth movement, materials handling (crushers, sorters, etc) construction and haulage on unpaved roads was modelled using AERMOD. Two time steps are used (0-5 years and 15-20 years to take into account the changes in the MWF over the lifetime of the mine. Both health and nuisance dust are considered.

Inhalable and respirable dust were modelled. The models show that modelled results were significantly below thresholds requiring action. Regardless, the WMP gives the following commitments in managing dust emissions in addition to design commitments as follows:

- The MWF will be sequenced, reclamation will be an ongoing process as the side slopes are developed and each phase is completed;
- Haul truck loading and offloading operations to the MWF working area will be co-ordinated in such a way as to minimise double handling of material;
- Unloading of materials at the MWF working area will be carefully undertaken to ensure minimum exposure to winds and in such a way that releases of dust to atmosphere are minimised;
- The MWF working area will be managed to ensure that the profile of material will minimise wind whipping, as well as using wind-break fencing to prevent wind-blown dusts;
- The MWF working area will be managed and clearly and physically delineated to deter vehicles from accessing areas of the MWF that have already been stabilised and re-vegetated;
- The unpaved haul roads across the MWF area will be frequently monitored for wind-blown dust potential and wetted as appropriate using a water bowser; and
- The dust suppression equipment used in the MWF working area will be regularly checked to ensure that it is working properly.

During the construction phase of the MWF the following commitments are made to control dust emissions:

- Covering vehicles used to carry waste rock to reduce dust emissions during transportation;
- Daily and weekly inspections of the construction site for dust deposition;
- Sweeping of hardstanding areas for vehicles; and
- Storage of fine, dry construction materials within buildings or in areas shielded from the wind.

An addendum to the air quality chapter of the ES was completed in 2019. This included updated modelling runs using AERMOD to account for changes to the design of the MWF and proposed processing. The conclusions from this work were that the risk to receptors has not changed (compared to the 2017 ES). The 2019 addendum however made the following commitments to control dust based on the change to operations on site. These are focused on the ore sorter reject stockpiling as follows:

- The ore sorter reject re-handling zone will be immediately under the proposed waste ore conveyor on the northern boundary of the MWF. The waste ore stockpile area will be surrounded by the proposed 5 m berm which will reduce exposure and the potential for wind-blown dusts;
- A dust suppression system (consisting of water sprayers) will be installed on the conveyor system to ensure that the ore sorter rejects can be dampened whenever suitable meteorological conditions allow for wind-blown dust potential;

- Loading of ore sorter reject material to haul trucks for transport to the MWF at the stockpile area will be carefully undertaken to ensure minimum exposure to winds and in such a way that releases of dust to atmosphere are minimised;
- The ore sorter reject re-handling zone will be managed and clearly and physically delineated to deter vehicles from running over the waste ore stockpile edge;
- The ore sorter reject stockpile will be managed to ensure that the profile of material will minimise wind whipping; and
- The dust suppression equipment used in the ore sorter reject re-handling zone will be regularly checked to ensure that it is working properly.

Golder comment:

The measures presented for the prevention of dust generation, the management controls and the monitoring of same are considered acceptable based on the model predictions. Golder considers that a speed limit for all traffic movement on haul roads should be implemented to control dust emissions from this source.

Golder conclusion:

Satisfactory.

Management of emissions from placement of waste rock and paste backfill in the PBF via ventilation raises during operation

This Section of the WMP deals with the potential for emission to be generated underground during the operational period of the mine and escape via the main ventilation shafts that supply fresh air to the mine.

AERMOD was used to model measured concentrations at the top and bottom of the existing ventilation raise (benzene, nitrogen dioxide and sulphur dioxide). Particulate and carbon monoxide concentrations were not available, so the model applied occupational exposure limits.

The model predicts negligible impacts to air quality at identified receptors. The management and control of fugitive dust emissions through the ventilation shafts will be mitigated with the following measures:

- All scavenger and flotation tailings will be pumped underground as a slurry to the underground (UG) paste backfill plant, thus minimising potential for dust generation during transit;
- Cement and binders will be delivered to the paste backfill mixer unit by downpipes from the surface (which pass through existing ventilation raises). These will be covered at the surface with pre-fabricated shelters;
- Underground (UG) conveyor belts (which supply the binder to the paste silos) will be fully enclosed to contain all dust; and
- Mechanical dust collectors will be installed on the paste mixer units and cement silos in the UG areas.

Golder comment:

The AERMOD models were completed with some conceptual measurements as particulate and CO data were not available. The ventilation shafts will need to be monitored during operational phase so that particulate matter generated during operations can be measured and compared against predictive models.

It is not clear if the results of the model predictions from the ventilation shafts were combined with the results from the other sources of air emissions / dust on site to demonstrate that the cumulative impact on identified

receptors is not predicted to occur. This is a minor clarification as the language in the report refers to point emissions that include the ventilation raises but also appears to separate these sources elsewhere in the report. It is recognised that the ventilation raises are remote to the other potential dust sources on site over a valley and as such this may be discounted. However, for clarity it would be useful to understand which is the case.

The maximum predicted pollutant concentrations at the site boundary compared with the Air Quality Standards should also be presented.

Golder conclusion:

It should be clarified if the model predictions presented for point sources include the ventilation raises ie a cumulative assessment of all sources identified is given or if not the reasons for this. Predicted concentrations at the site boundary should be presented.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the management and control of dust emissions from the surface operations of the MWF during construction and operational phase acceptable?	✓		
Are the modelling of air quality / dust emissions at the site considered acceptable for presentation at Public Inquiry?		✓	
Are the modelling of dust emissions from the ventilation shafts during the operational period of the mine acceptable?		✓	

13.2.3 Soil

This section of the WMP states that:

"Topsoil and peat (where unavoidable) will be stripped and stockpiled for use in restoration of the proposed infrastructure site. Peat will also be transferred to a habitat enhancement area to the north of the proposed infrastructure site. Erosion control measures and measures to reduce mobilisation of suspended solids in run off will be implemented during construction and operation to reduce off-site sediment transport at the proposed infrastructure site and at the peat habitat enhancement areas. These are described further in the Environmental Statement (plus addendum to this report) and Construction Environmental Management Plan. The pollution prevention measures discussed in this section for water and air quality will also prevent contamination of soil resources."

Golder comment:

Review of the ES and CEMP are outside the Golder scope of work. Golder notes that the minimisation of topsoil and peat removal are a priority, and preservation of topsoil and peat will be managed during construction.

Golder conclusion:

The implementation of the CEMP will be important in ensuring that management measures for the protection of peat and soils are completed.

13.2.4 Environmental Monitoring

A draft Surface Water and Groundwater Environmental Monitoring and Action Plan (SGEMAP) has been prepared for the site, revised October 2020. This is referenced in Appendix I of the WMP. The updated SGEMAP is presented as Appendix D2 of the FEI II information pack submitted by DGL. In order to consider the environmental monitoring programme for liquid streams, the SGEMAP should be referred. A summary of the SGEMAP is given for leachate, groundwater and surface water as follows:

Leachate

Leachate monitoring is described in Section 13.4.1 of the WMP. Monthly monitoring is proposed for the leachate generated from the toe drains of each MWF cell. Similarly monthly monitoring of leachate quality is also proposed for the PBF, ingress water into the sumps outside paste and waste rock filled stopes will be monitored to provide characterisation of drainage water (leachate) from paste and waste rock backfill areas. Leachate will be monitored on at least a monthly basis during operation. The monitoring requirement post closure is proposed to be assessed based on operational results.

Golder comment:

The frequency of the monitoring proposed and locations (although clearly not defined yet for the PBF) presented in Section 13 of the WMP are considered to be in line with good management practice for a site such as this. Golder notes that that the planning authority / NIEA will agree a monitoring regime for the site. Golder cannot find specific reference to leachate in Appendix J (as referenced in the WMP and this is considered to be a typographical error).

Golder conclusion:

Locations for leachate monitoring are made available via access manholes in design drawings therefore Golder considers that sufficient information is available at this stage for presentation at Public Inquiry.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the leachate monitoring programme sufficiently developed for consideration by planning authority / NIEA?	✓		

Groundwater monitoring

The groundwater monitoring programme is based on the findings of the Groundwater Impact Assessment (GIA) (Appendix I). Golder has reviewed Appendix I (Sections 26.0 and 27.0) and considers that the GIA is sufficiently robust for consideration at Public Inquiry. The underpinning conceptualisation of groundwater and groundwater risk is considered to be well understood for the proposed project. This conceptual model underpins the risk assessment and the SGEMAP for the site.

The groundwater monitoring programme applies a risk based approach to identify potential receptors and builds a monitoring programme around this. The monitoring programme refers to the groundwater framework directive as being applied for compliance requirements. The SGEMAP sets clearly defined objectives.

Groundwater monitoring programmes for all phases of the project lifecycle are given (baseline, construction, operation and closure). The rationale for the monitoring programme is presented. Trigger levels and compliance limits are defined. Action plans are presented in the event of exceedances of these triggers.

Golder comment:

The SGEMAP is well presented and clearly states the legislative criteria, purpose, risk based approach and groundwater monitoring programme for the site during all phases of the project lifecycle. Action plans are presented with clearly defined follow ups in the event of trigger level exceedances or changes in groundwater quality and quantity. Golder has not completed a review of the proposed groundwater compliance limits. It is important to state that the final limits will be agreed with the regulator.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the groundwater monitoring programme sufficiently developed for agreement with planning authority / NIEA?	✓		

Surface water quality

As above, the surface water monitoring programme is given in the SGEMAP. The conceptualisation of the surface water balance and quality have been reviewed by Golder in detail in the Surface Water Impact Assessment (SWIA) (Sections 28.0 and 29.0). Therefore, the assumptions presented in the surface water monitoring programme that refer to the SWIA are considered accurate.

The SGEMAP Sections referring to surface water quality and quantity mirror the presentation in the groundwater section.

Golder comment:

The SGEMAP is well presented and clearly states the legislative criteria, purpose, risk based approach and surface monitoring programme for the site during all phases of the project lifecycle. Action plans are presented with clearly defined follow ups in the event of trigger level exceedances or changes in surface water quality and quantity. Golder has not completed a review of the proposed surface water compliance limits. It is important to state that the final limits will be agreed with the regulator.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the surface water monitoring programme sufficiently developed for agreement with planning authority / NIEA?	✓		

Air quality

The air quality environmental programme is described in the WMP as follows:

"Continuous air quality and dust monitoring locations will be installed along the proposed Curraghinalt Project boundary. This continuous air quality and dust monitoring will be used to establish if the recommended mitigation measures allow for the relevant limits to be achieved at the nearest sensitive receptors.

"During operation, the unpaved haul roads across the MWF area will be frequently inspected for wind-blow dust potential and wetted as appropriate using a water bowser. As the PBF is underground, no specific dust monitoring is considered necessary for this facility beyond that required for occupational health and safety associated with underground workers.

"Ventilation for the PBF is provided by ventilation in the mine as a whole, and as such any emission to air will be via the exhaust air raise."

Golder comment:

The air quality monitoring programme for the MWF will be by way of a continuous monitoring programme along the proposed Curraghinalt project boundary. Golder recommends that the CEMP presents the continuous monitoring requirements for the construction phase. Golder notes that the air quality and dust scheme presented in the ES (choice of methods, pollutants included and monitoring periods) are considered to be standard practice.

Golder conclusion:

The air quality monitoring programme is in outline only at present. It is important that the final agreed CEMP (not reviewed by Golder) includes air quality monitoring at the construction phase.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the air quality monitoring programme sufficiently developed for agreement with planning authority / NIEA?		✓	

14.0 REVIEW OF WASTE MANAGEMENT PLAN

14.1 Chapter Summary

This is a brief section within the WMP which confirms the planned review structure of the document which is required by Regulation 6 of the *2015/85 Regulations.* It states that the WMP will be reviewed:

- At least every five years after the date on which planning permission is granted or the plan approved;
- In the event of a substantial change to the operation of the facility or the extractive waste types deposited.

The chapter further confirms that following the review, the WMP will be amended as necessary.

Golder comment:

These review criteria are minimum legislative requirements. For operational reasons, more regular reviews may be considered.

Golder conclusion:

The statement confirms compliance with Regulation 6 (part 5 and part 6) of the *2015/85 Regulations*.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the arrangements for the review structure of the WMP in accordance with the requirements of Regulation 6 of the *2015/85 Regulations*?	✓		

15.0 ACCIDENT PREVENTION

15.1 Chapter Summary

This section of the WMP gives a summary of the actions proposed by Dalradian to develop accident prevention policies and safety management systems for the site including accident response. It confirms that although not required by the *2015/85 Regulations* because the mine waste facilities at Curraghinalt are not Category A, DGL is committed to meeting industry good practice.

15.1.1 Additional Requirements

The WMP states that DGL will prepare the following prior to construction beginning:

- An accident prevention policy;
- A safety management system to implement the policy; and
- An internal emergency plan, specifying the measures to be taken onsite.

The relevant planning authority is identified as the DfI and the WMP states that *Copies can be provided to DfI on request.*

Golder comment:

The commitment to developing these above policies and plans is in line with industry good practice and will be issued prior to commencing construction. Golder agrees that as the facility is not a Category A facility that Part 2 regulation 2(d) of the 2015/85 Regulations do not apply. However, the delivery of a robust accident prevention and safety management programme for the site are good practice. Golder has considered the accident prevention chapter as relates to the 2015/85 regulations.

15.1.2 Development of an Accident Prevention Policy

The WMP states that this Policy will also be in place prior to construction, and that it will include the following:

- Commitments to achieve a high standard of protection.
- A statement of DGL's aims and principles of action and its commitment towards continuously improving its control of accident hazards at the mine.
- Commitments to provide and maintain a management system including the following elements: a) organisation and personnel; b) identification and evaluation of hazards; c) operational control; d)

management of change; e) planning for emergencies; f) monitoring performance; and g) audit and review. Appropriate objectives will be included under each of the listed elements.

- Commitment to continuously improving the control of accident hazards.

As per widespread practice, the policy will be signed and dated by senior management.

Golder comment:

The accident prevention policy outline contains the elements needed to deliver a robust policy. The commitment by senior management to the policy is an important inclusion.

Framework

This section confirms the framework for the system which will form part of the Health & Safety Management System (HSMS). It will be put into effect in the construction phase and reviewed and updated for operations. It also highlights the features which are important for emergency management and accident prevention.

The framework is set out in Section 15.3.1 of the WMP, along with its Quality alignment, and the individual elements are presented in Table 15-1.

Golder comment:

The framework elements presented to form the HSMS are consistent with industry good practice.

Features of the HSMS Important for Accident Prevention

This section sets out the essential information that roles and responsibilities will be clearly defined using a table and / or organogram. The system will also cover the roles and responsibilities of contractors.

There are further sections on resource allocation, personal performance, worker involvement, intelligence gathering, internal communication, priorities for improvement, procedures, management of change, active and reactive monitoring, investigation and response, audit and review.

Golder comment:

This section logically presents the elements important for accident prevention. A short section could be considered here, setting out proposed methods of how these systems will be implemented (e.g. via policies, shared workspaces, daily briefings) and frequency. However, there is sufficient information presented here to form a robust accident prevention programme.

The Emergency Preparedness and Response Element of the HSMS

This section sets out the preparedness for emergency situations, including the process of identifying a situation, the organisation of personnel and steps to manage it, training and resources needed and the response measures to it.

These response measures are set out as follows:

- Contain, where practicable, any emergencies and their effects within project site boundaries;
- Provide information to and consult with the surrounding community regarding environmental risks and response measures;
- Safely return to normal operations following an emergency; and
- Identify the cause(s) of emergency event and that corrective and preventative measure to avoid a reoccurrence.

Golder comment:

This section is high level. Further information could be included, for example on communications with external emergency providers, communication with stakeholders and media presentation / liaison, in order to demonstrate the widest range of measures considered.

15.1.3 Internal Emergency Plan for the Mine Waste Facility

This is another comprehensive section which includes the following sub sections:

- Application of the Emergency Plan;
- Scope of the Plan;
- Objectives of the Plan;
- Information to be included in the Plan;
- Emergency Response Training and Drills;
- Specific Emergency Response Procedures; and
- Review of the Internal Emergency Plan.

The WMP confirms this Plan will be prepared in accordance with the requirements of *Planning (Management of Wastes from Extractives Industries) Regulations (Northern Ireland) 2015* (SR 85).

It further confirms that the plan will be reviewed annually and tested periodically during the life of the mine. It will remain a dynamic (live) document and will be amended as required to ensure its effectiveness.

Golder comment:

The elements presented in the internal emergency plan are comprehensive for this stage of the proposed project. Golder agree that the final plan will be simple and easy to communicate for presentation purposes with appendices used to support the plan.

Golder conclusion:

The Proposed Safety management systems and accident prevention measures presented in Section 15 of the WMP are considered sufficiently robust for presentation at Public Inquiry. The proposed emergency plan elements are aligned to the *2015/85 regulations*.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the proposed accident prevention and proposed safety management systems sufficiently developed for presentation at Public Inquiry?	✓		

16.0 BEST AVAILABLE TECHNIQUE ASSESSMENT

16.1 Chapter Summary

Section 16 of the WMP presents the Best Available Technique Assessment (BAT) assessment for the proposed project.

The WMP states the following:

"An assessment has been carried out which compares the latest Curraghinalt MWFs designs against the Best Available Technique Reference (BREF) guidelines outlined in the EU document, European Commission Reference Document on Best Available Techniques for Management of Waste from the Extractive Industries, in accordance with Directive 2006/21/EC 2018. The outcomes of this assessment are included in Table 16-1."

Table 16-1 presents the tabulated assessment which is the common methodology of presenting BAT assessments. Each BAT is presented and how it is applied to the proposed project. The BAT table also shows which phase of the proposed project lifecycle the BAT applies to ie planning, design, construction, operation closure and aftercare.

16.2 Review and Assessment

Golder comment:

The BAT table is well presented and clearly states the BAT conclusions from Chapter 5 of the above BREF document. In relation to the specific BAT conclusions, Golder notes the following:

BAT 11 – Design for Closure

BAT 11 includes a requirement for consideration of:

"A design of the EWF (Extractive Waste Facility) that takes into consideration possible premature closure."

The CRCP (Appendix H of the WMP) does not include a scenario of premature closure. The site will be progressively rehabilitated as operations progress. Section 12.1 of the WMP states:

"A financial guarantee will be provided by DGL to ensure that all conditions on the planning permission pertaining to the management of extractive waste, including after-closure conditions, are met and there are funds readily available at any given time for the rehabilitation of the land affected by waste facilities."

It is noted that DGL has committed to making all necessary financial provision however it is suggested that the provision of the financial guarantee should take into account a premature closure scenario.

BAT 44 – Surface Water Status Deterioration

"Collection and off-site treatment of Extractive Waste Influenced Water (*EWIW). Relevant for the liquid phase of spent drilling muds and other extractive wastes from oil and gas exploration and production, including flowback and produced water."*

Golder does not consider this BAT is applicable to the proposed project.

Golder conclusion:

The BAT Assessment follows the guidance provided in the MWEI BREF document and considers the BAT applicable to the proposed project.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the Best Available Techniques given in the 2018 MWEI BREF applied to the site?	✓		
Are all closure scenarios suggested by BAT 11 considered within the financial provision?		✓	

17.0 REFERENCES

Not reviewed.

18.0 REVIEW OF APPENDIX A – GEOLOGY REPORT

18.1 Chapter Summary

The geological setting and mineralisation are detailed in Appendix A to the WMP report and are summarised below.

The Curraghinalt project area lies within Dalradian Supergroup (DSG) rocks, comprising Neoproterozoic meta-sediments and mafic meta-igneous rocks aged ca.800-500 Ma. Dalradian sedimentation ended at the Caledonian Orogeny with associated deformation and regional metamorphism ca.475-465 Ma. The ca.30° NW-dipping, NE-SW trending Omagh Thrust separates the Dalradian meta-sedimentary rocks to the north and the underlying Ordovician Tyrone Igneous Complex (TIC) rocks to the south. The TIC comprises ophiolitic Tyrone Plutonic Group (TPG) rocks and island-arc Tyrone Volcanic Group (TVG) rocks. The Dalradian rocks have undergone folding (weakly preserved); nappes (SE-facing recumbent folds); peak meta-morphism; and late stage deformation (localized kink bands and brittle fractures). Peak meta-morphism coincided with emplacement of the DSG in a SE direction over the TIC along the Omagh Thrust.

Property licence DG1 (Curraghinalt deposit), also DG3, DG4, DG5 and DG6, lies within the DSG, while property licence DG2 is largely within the TIC. The DSG is divided into the older Argyll Group (AG) and the younger Southern Highland Group (SHG). The AG and SHG comprise predominantly clastic marine sedimentary rocks. AG rocks in the property comprise quartzose psammite and thin pelite interbeds of the Newtonstewart Formation in the core of the recumbent Sperrin Fold to the NW of the deposit. These rocks are flanked by Dungiven Limestone Formation rocks in DG3 and DG4.

Moving SE into the Curraghinalt DG1 license area, the SHG is divided into the Dart, Glenelly, Glengawna and Mullaghcarn Formations. These four formations comprise a thick sequence of turbiditic arenite and pelitic meta-sedimentary rocks with rare volcaniclastic (green bed) and calcareous schist units. Metamorphic grade increases N to S across the DSG from lower greenschist facies to lower amphibolite facies.

Gold-mineralized quart-carbonate veins of the Curraghinalt deposit are hosted by the Mullaghcarn Formation rocks, comprising psammites and semi-pelites with subordinate pelitic and chloritic semi-pelites. High grade gold mineralisation occurs as a series of west-northwest trending, average 55°-75° North-dipping, subparallel stacked veins and arrays of narrow extension veinlets. Gold mineralisation is associated with variable abundances of carbonate, chalcopyrite and tennantite-tetrahedrite. Veins range from cm-scale to over 3 m wide, are traceable to at least 1950 m along strike and to around 1200 m depth. The vein system is cut by two E-W,

steeply north-dipping, 4-7 m wide ductile shear zones: the Crowsfoot and Kiln Shear zones. Gouge zones (from brittle reactivation) are also evident along the Kiln Shear zone.

The regional geology is presented in Figure 7.2 of Appendix A and re-presented in Figure 1 below for ease of reference.

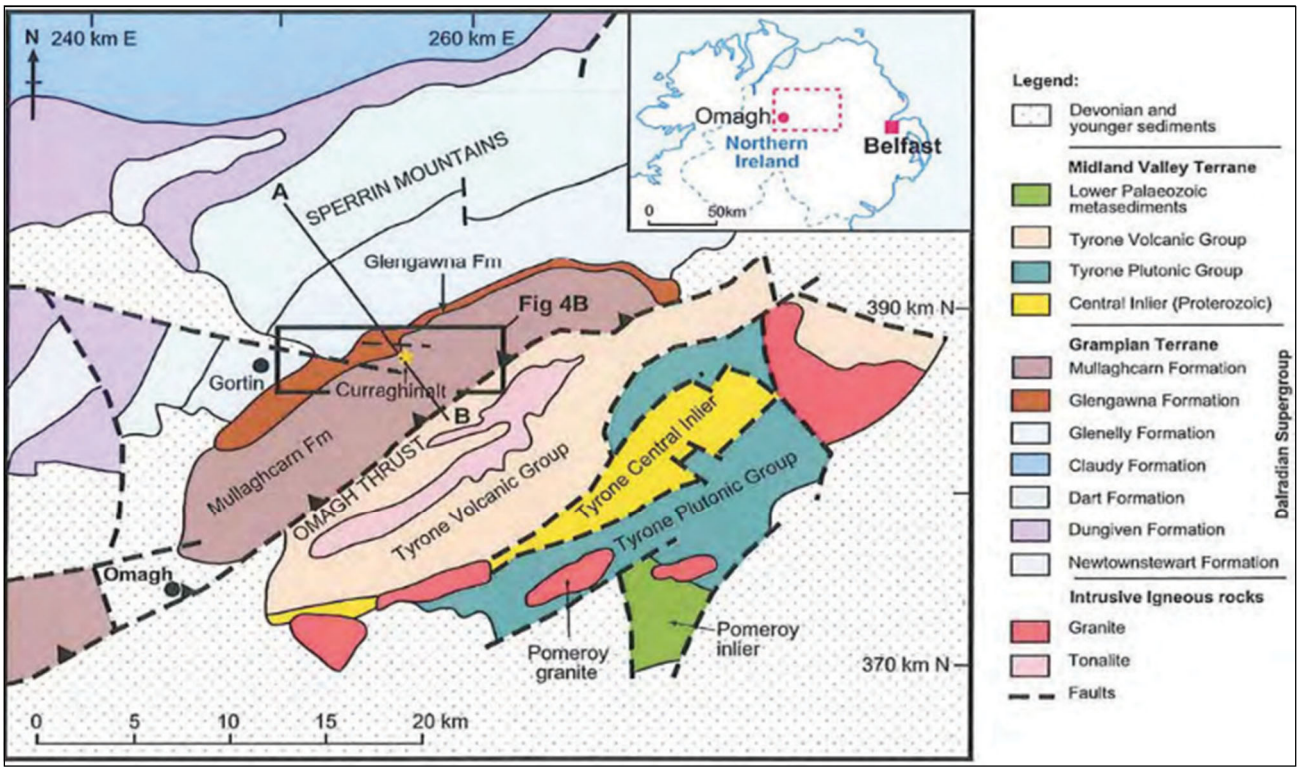

Figure 1: Regional Geology of the Southern Sperrin Mountains[1]

18.1.1 Mullaghcarn Formation and any Presence of Karst and Palaeokarst

Specifically, regarding the Mullaghcarn Formation, psammites and pelites would not normally be associated with karst, and palaeokarst would be unlikely although they could be possible if the rock had a history of carbonate content or origin. The British Geological Survey (BGS) lists the Mullaghcarn Formation as quartz and albite psammite and semi-pelites, consistent with the information provided in the Appendix A report, with no obvious reference to carbonates or evaporites within the Mullaghcarn Formation.

The All-Ireland Karst Landform database indicates that most karst in Ireland is found in Carboniferous Limestones but it is possible for karst to develop elsewhere if soluble rock is present and ground conditions allow. There are no indicators of karst recorded in the database to date within the vicinity of the project area – the nearest indicators are located approximately 2.5 km to the west of Omagh with the possibility of the underground mine being slightly closer, given the NW dip of the fault.

Although the presence of karst or palaeokarst closer to the project site cannot therefore be definitively ruled out, it is considered that the likelihood of there being the potential for karstic or paleokarstic conditions at the site is low. Immediately to the west of the Curraghinalt Deposit and within DG1 is the Glengawna Formation, which underlies the Mullaghcarn Formation, followed by the Glenelly Formation (Figure 7.4 within Appendix A and re-presented below in Figure 2 for ease of reference).

[1] Rice et al. (2016)

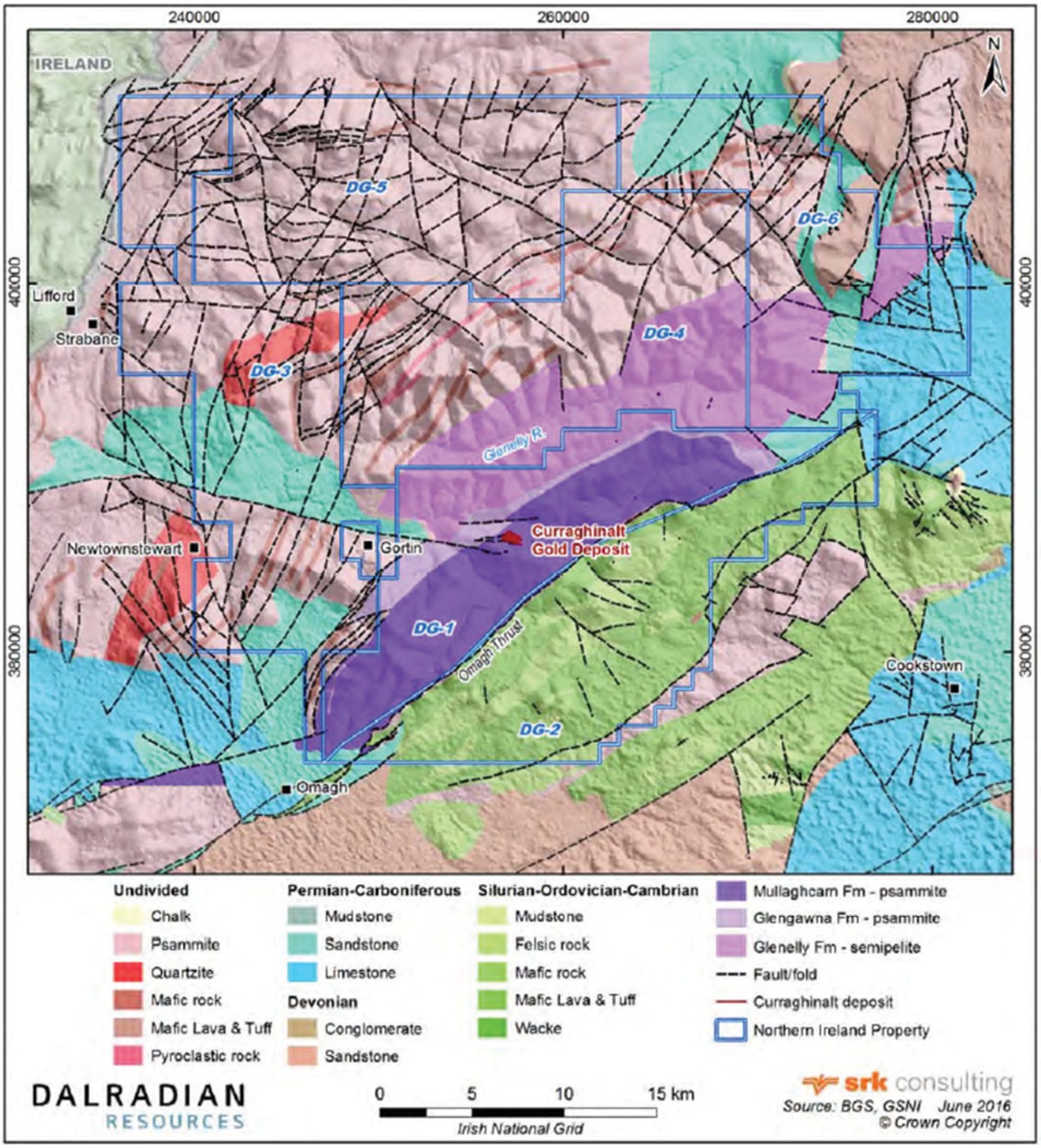

Figure 2: Property Geology[2]

Golder comment:

- The Glengawna (pale mauve, above) comprises black graphitic pelites (which could be a risk to mining stability, depending on conditions), psammite and semi-pelite, with no indication of potential for karst;

[2] Modified from BGS DiGMapGB (1:625K) and Geological Survey of Northern Ireland (1:10K)

- The Glenelly Formation (pink) is indicated to be relatively thin and comprise schistose, pelite and semi-pelite with minor psammite, limestone, calcareous semi-pelite and volcaniclastic. The limestone would be a potential karst host-rock and calcareous semi-pelite is an indicator of karst potential;
- Beyond the Glenelly Formation, and which may or may not lie within DG1, the Dart Formation (not shown on the map) is also indicated to contain calcareous semi-pelite; and
- The Dart Formation overlies limestone of the Dungiven Formation further west, which is indicated in the Appendix A report to be within DG3 and DG4, although the map (blue) does not indicate this but does show limestone in DG6 and a small amount of DG2 with limestone.

The BGS indicates the Dungiven Formation Limestone to comprise meta-limestone with no obvious reference in immediately available publications that notes karst potential in this unit. Also a further check on the BGS's Lyell collection does not appear to reveal any reference to karst or palaeokarst in the Glenelly, Dart or Dungiven formations.

18.1.2 Karst deposits in the wider Northern Ireland

Further searches on karst and caves indicates various locations in Northern Ireland, mostly in Fermanagh, with a scattering of others appearing in Antrim, Armagh and in Tyrone. The two locations in Co. Tyrone are in the Slieve Beagh (Ballyshannon Limestone Formation) and Lough Lee-Binnawooda (Darty Limestone Formation) areas. None of the locations are related to geological periods before the Carboniferous period (Dalradian predates the Carboniferous period).

18.1.3 Omagh Fault

The Omagh Fault which is exposed in the Mountfield Old Quarry, divides the overlying Mullaghcarn Formation to the underlying Tyrone Volcanics. The fault is indicated to dip NW at approx. 40° in the Mountfield Old Quarry location.

The presence of the Omagh Fault has been considered within the review by Golder of Appendix A – Geology Report. Although faults can present significant risks to mining, it is considered that the Omagh Fault is too far removed from the Curraghinalt Site to present any particular risks.

18.2 Geological Summary Conclusions

Golder comment:

It is considered that a sufficient understanding of the geological conditions underlying the site has been developed through both desk studies of the available data and the boreholes completed to date. Despite this adequate level of understanding, further confirmation of the geological conditions through intrusive investigations would be warranted during further stages of design. One objective of the intrusive investigations should be to further confirm the current understanding that karst does not pose a risk to the development. However, at this stage of the design development, it is considered that the risk is sufficiently low to not be of concern.

Golder conclusion:

Golder considers that a sufficient understanding of the geological conditions underlying the site has been developed through both desk studies of the available data and the boreholes completed to date. The risk of there being karstic or paleokarstic conditions at the site to an extent that could cause instability of the surface infrastructure is considered to be low.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the description of Geological Setting & Mineralisation sufficient?	✓		

19.0 REVIEW OF APPENDIX B – PASTE BACKFILL TESTING REPORT

19.1 Chapter Summary

19.1.1 Report / Studies Background

Appendix B presents the Paste Characterisation Testing Report for the Curraghinalt Gold Project. This report was prepared by Minefill Services Inc of Washington, USA, for DGL and was issued in July 2019. The report summarises the test work and paste characterisation for cemented paste backfill proposed for the project.

The report notes that paste backfill will be generated from a mixture of two types of tailings, rougher tailings, and finer concentrate regrind cleaner tailings (scavenger). The tailings characterisation testing completed as part of the scope undertaken by Minefill was carried out partially at Pocock Industrial in Salt Lake City (rheology testing), and SGS Lakefield in Lakefield, Ontario (strength testing).

It is noted that two previous studies have been carried out on the tailings stream at Curraghinalt. These are a Paterson and Cooke (P&C) study completed in 2015 and a Unité de Recherche et de Service en Technologie Minérale (URSTM) study completed in 2016. P&C performed an initial laboratory investigation comprising particle sizing, a mineralogical investigation, dewatering and thickening testwork, rheology testwork and strength testing of paste cylinders. This testwork was conducted on a 7:1 rougher / cleaner tailings blend.

The work carried out by URSTM was rheological and mineralogical testing in support of a paste mix design in 2016. The focus of this investigation was to determine the optimum recipe to achieve the desired target strengths for various binder contents and binder types. Much of this work was focused on the acid generating potential of the paste, and the chemical stability of the paste.

19.2 Testing Findings and Conclusion

The work completed by Minefill uses the previous data as part of the data set for analyses and complements it with further test work. The mineralogy of the Curraghinalt tailings is discussed (based on URSTM 2016) and it is noted that the cleaner tailings have a very high pyrite content (over 40%) which can be problematic due to the very high specific gravity of the pyrite solids which can cause segregation and settling in the pipe system, as well as adverse reactions with the cement proposed - Ordinary Portland Cement (OPC). Further to this, it is noted that the tailings contain elevated sulphate levels (1,300 ppm), elevated sulphur (200,000 ppm) and elevated dissolved sulphates in the process water (5,500 ppm).

The rougher tailings was found to have a P80 of 160 microns and the scavenger tailings (referred to as cleaner tailings within the Appendix B report) was found to have a P80 of 48 microns. The specific gravity for the rougher tailings was determined to be 3.08 while for the scavenger tails, it was determined to be 3.02.

The report notes that the proportions of rougher tailings and concentrate cleaner tailings is expected to remain at a fairly constant 2:1 ratio, but that over short durations it may vary from 1:1 to 3:1. As such the final paste mix designs need to accommodate potential variations in the blend. Initial rheological characterisation test work was carried out with a 3:1 ratio of rougher tailings to cleaner tailings. A subsequent test programme was carried out

to determine the rheological properties of a 1:1 blend of rougher tailings to cleaner tailings. Results indicate, for the most part, consistent trends for the 1:1 and 3:1 blends, despite the difference in Particle Size Distribution (PSDs). This indicates that the rheology is largely independent of the blend at these ratios.

Uniaxial compression testing was carried out on 50 mm x 100 mm cylindrical samples of paste mixes prepared at binder contents of 3%, 5 % and 7% (binder being a 70 / 30 blend of slag / OPC) cured for 7 and 28 days. The use of a slag / OPC binder was required to buffer the impact of the very high sulphate values in the process water, and the high pyrite content of the cleaner tailings.

The results from the testing indicate strengths that are sufficiently high for backfill purpose for all of the samples tested, it is noted that the 1:1 blend samples return similar results to the 3:1 blend (within 10%).

In order to achieve the required Uniaxial Compressive Strength (UCS) of 220 kPa at 7 days, Minefill recommends that 3% binder is used for longhole retreat backfilling and cut and fill backfilling whereas a 4% binder should be used for undercut sills. It is further recommended that the target backfill recipe should comprise a 2:1 blend of mill rougher tailings and cleaner tailings, mixed with a premixed 70 / 30 slag / OPC binder. It is not anticipated that any admixtures will be required although a recommendation is made to make provision for the addition of a hydration retardant product for when the paste travel time from the paste plant to the stope exceeds 45 minutes.

The tests results indicate sufficient strengths will be achieved in the backfill with the proposed recipe. The ratio of rougher and cleaner tailings in the paste mix have no material impact on paste strength.

Golder comment:

It is noted test work was conducted on blends of tailings at 3:1 (rougher to cleaner tailings) and 1:1 with various binder contents. It does not appear that the difference in the blends has any difference on the backfill strengths which is surprising given the difference in grading and pyrite content. The test results indicate that there can be a reasonable level of confidence that the backfilling process will be capable of producing a suitable paste backfill for safely backfilling the mine cavities.

Golder conclusion:

It is noted however that while the recommended mix is a 2:1 blend, no test work has been presented to date for this blend. It is recommended that that this blend is checked through laboratory test work at detailed design stage to inform the design of the paste back fill plant, pumps and pipelines. However, it is considered satisfactory at this stage of the design development.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the test work for paste backfill adequate for presentation at Public Inquiry?	✓		

20.0 REVIEW OF APPENDIX C - CURRAGHINALT GEOCHEMISTRY CHARACTERISATION REPORT

20.1 Chapter Summary

Golder has reviewed reports and associated models regarding the modelling of contact water qualities from the proposed Curraghinalt project underground mine and associated infrastructure. This work was undertaken by SRK and presented in the report entitled *A Geochemical Characterisation Report for the Curraghinalt Gold Deposit, Northern Ireland*[3], October 2020.

20.2 Data Provided

Contact water quality modelling is reported in the document *A Geochemical Characterisation Report for the Curraghinalt Gold Deposit, Northern Ireland* (Appendix C to the 2020 WMP)[4].

Four main geochemical models have been provided, comprising:

- "3_U7582_DSF_BaseCase_v1.9" (Base Case model for the Dry Stack Facility);
- "3_U7582_UG_LOM_BaseCase_v1.11 (Base Case model for the underground mine during Life of Mine);
- "3_U7582_UG_Closure_BaseCase_v1.6 (Base Case model for the underground mine after closure); and
- "3_U7582_UG-Adit_BaseCase_v1.11" (Base Case model for the adit after closure).

The geochemical models were implemented using PHREEQC software of the US Geological Survey, while the model input files were generated using Microsoft Excel. Model input files were provided in Excel file format for each model, along with an Adobe Acrobat (.pdf) printout of the PHREEQC model input (.pqi) file. Further to this, a number of sensitivity scenarios (12 for the DSF and 60 for the underground mine) were provided in Excel and .pdf file format.

The associated PHREEQC model input (.pqi), PHREEQC model output (.pqo), run log (phreeqc.log) and thermodynamic database (.dat) files were not provided.

20.3 Summary of review comments

20.3.1 Modelling software and objectives

The objectives of the geochemical characterisation and modelling programme are described as follows:

- To determine characteristics, implications and potential for Acid Rock Drainage and Metal Leaching (ARDML) from the waste materials from the development proposed under the FEI2 response; and
- To provide a prediction of future water quality that would result from water contacting these materials.

The predictive geochemical modelling was undertaken using the United States Geological Survey (USGS) thermodynamic code PHREEQC (v3.6.2.15100; Parkhurst and Appelo, 2013)[5].

[3] SRK Consulting. 2020. A Geochemical Characterisation Report for the Curraghinalt Gold Deposit, Northern Ireland. Prepared for Dalradian Gold Limited. October 2020

[4] SRK Consulting. 2020. Waste Management Plan for the Curraghinalt Project, County Tyrone, Northern Ireland. Prepared for Dalradian Gold Limited. Appendix B3 to the FEI2 Volume 2 Second Addendum to the Environmental Statement. October 2020

[5] Parkhurst, D. L., & Appelo, C. A. J. (2013). Description of input and examples for PHREEQC version 3: a computer programme for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations (No. 6-A43). US Geological Survey. https://pubs.er.usgs.gov/publication/tm6A43

Golder comment:

The contact water quality modelling objectives sufficiently address the requirements of the Environmental Statement[6].

PHREEQC is a standard tool used for source term water quality modelling. PHREEQC version 3 is capable of simulating the equilibrium chemistry of aqueous solutions interacting with minerals, gases, solid solutions, exchangers, and sorption surfaces, and can also model kinetic reactions and one-dimensional transport. This tool is considered suitable to achieve the outlined modelling objectives.

Golder conclusion:

The modelling software and objectives are considered appropriate.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the objectives of the geochemical modelling appropriate for the proposed development?	✓		

20.3.2 Assessment of the Methodology Underpinning the Assessment of Acid Generating Rock and Changes in Water Chemistry

This section presents the methodology underpinning the assessment of acid generating rock and changes in water chemistry both above and below groundwater levels and at different phases of the project fit for purpose and representing best practice?

Overall Geochemical Modelling Approach

The approach which was adopted for the numerical calculations undertaken in order to predict contact water quality generated from the DSF and underground mine both during mining and post-mining are outlined in Section 10.1 of the report *Geochemical Characterisation Report for the Curraghinalt Gold Deposit, Northern Ireland*"[3]. The approach combines the following inputs:

- Geology (defined mass of each rock type);
- Mine design (physical parameters of the mine facilities, eg surface area, volume, footprint);
- Groundwater flow estimates (annualized volume of water entering and leaving the underground mine, providing chemical load in and out of the model and used in the definition of reactive mass);
- Groundwater rebound estimates (annualized level of the water table allowing for the definition of the portion of the mine above and below the water table, as well as an annualized interaction thickness of rising groundwater);
- Surface water estimates (precipitation, runoff, infiltration and drain-down outputs from the mine water balance, used to calculate the reactive mass of material in the DSF);
- Baseline water chemistry (used to calculate groundwater chemical load);

[6] SRK Consulting. 2017. Environmental Statement for the Curraghinalt Project, County Tyrone, Northern Ireland. Volumes 1, 2 and 3.

- Rock weathering rates (based on the kinetic test programme, used to calculate material release rates); and
- Attenuation (simulated using PHREEQC model with Dzombak and Morrel adsorption coefficients; solubility products for solids held within Minteq database).

Golder comment:

The outlined approach takes into account the different factors typically considered relevant to the generation of acid rock drainage and changes in water chemistry in a mine setting such as the proposed Curraghinalt Project.

Golder conclusion:

The approach is considered appropriate to sufficiently address the requirements of the Environmental Statement[4] and WMP[7].

Assessment of Geochemical Mass Release Rates and Background Water Qualities used in the Models

Section 10.3 of the *2020 Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[1] presents the mass release rates for Waste Rock, Underground Wall Rock, Ore Sorter Rejects and Tailings. It also presents the chemical composition of baseline groundwater and rainwater used in the models.

This section describes the methodology and rationale used to select the portions of kinetic test data which were used to describe chemical mass release from the different mine materials at different locations and stages of the project.

Golder comment:

The described methodology is considered appropriate to develop conservative source terms for the different materials.

The differentiated treatment of mercury analytical results due to changing limits of detection achieved in the three separate geochemical characterisation studies (2013, 2016 and 2018/19) is considered adequate.

The presented baseline groundwater and rainwater chemistries are considered appropriate.

Golder conclusion:

The geochemical mass release rates and background water qualities used in the models are considered appropriate.

Assessment of the Thermodynamic Database used in the Models

Section 10.4 of the 2020 *Geochemical Characterisation Report for the Curraghinalt Gold Deposit*"[3] states that "a modified version of the Minteq.v4 thermodynamic database (*Declercq et al 2016*)" was used in the PHREEQC models.

Golder comment:

The modified thermodynamic database used in the simulations was not supplied with the model files.

The standard Minteq.v4 thermodynamic database is commonly used in mining geochemistry studies.

[7] SRK Consulting. 2020. Waste Management Plan for the Curraghinalt Project, County Tyrone, Northern Ireland. Prepared for Dalradian Gold Limited. Appendix B3 to the FEI2 Volume 2 Second Addendum to the Environmental Statement. October 2020

Very little detail about the modifications of the Minteq.v4 thermodynamic database is presented in the *2020 Geochemical Characterisation Report*. The report only states that "the database was modified to expand the number of mineralogical phases, include sorption data for manganese species together with corrections for weak and strong site adsorption of anions to hydrous ferric oxide".

The Geochemical Characterisation Report submitted in 2017[8] describes the addition of three arsenic phases commonly occurring in mine sites reporting elevated arsenic content and the modification of the thermodynamic constant of another arsenic phase.

No further details about the modifications relating to the modification of adsorption of anions to hydrous ferric oxide have been found in any of the submitted geochemistry reports.

The impact of using a modified instead of a standard Minteq.v4 thermodynamic database in the geochemical models has been assessed in the Verification Runs within sections 20.3.4 and 20.3.5; differences in the modelling results have generally been found to be small.

Golder conclusion:

The thermodynamic database used in the models is considered appropriate based on the results of the verification runs (see sections 20.3.4 and 20.3.5 below).

Assessment of Mineral and Gas Phase Equilibration used in the Models

Section 10.5 of the 2020 *Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3] describes the mineral equilibrium phases that were allowed to precipitate if they become oversaturated, and the gas phases that interact with the liquid phase. Regarding the suite of minerals chosen, the report first states that it "was based on the geology and mineralisation of the deposit and an understanding of the types of minerals commonly observed in waste rock leachates", and subsequently that "*these minerals were selected after preliminary geochemical calculations and/or from mineralogical analysis*".

The geochemical model requires the definition of the saturation index above which the mineral phase will precipitate from solution, or below which the phase will dissolve if it is present as a solid in the system. SRK used the theoretical limit (SI = 0) or saturation indices of the secondary phases within the surrounding groundwater when they were above 0 to represent the site-specific conditions.

Equilibrium phases and saturation indices included in the DSF geochemical models are given in Table 10-10, those for the underground mine models are given in Table 10-11.

The report states that pCO_2 and pO_2 were maintained at 60% of the atmospheric values within the DSF and underground models to account for reduced gas flow through the facilities.

Golder comment:

- The reasons for selection of the suite of minerals chosen are not presented in a unified manner in the report, but the suite of minerals which have been used is reasonable for the expected geochemical conditions in the simulated facilities.
- The saturation indices of the secondary phases for the DSF model in Table 10-10 and the underground mine in Table 10-11 display significant over-saturation of Manganese (Mn) and Iron (Fe) phases, which may indicate that the redox potential of groundwater assumed in the model calculations is more oxidising

[8] SRK Consulting. 2017. A Geochemical Characterisation Report for the Curraghinalt Gold Deposit, Northern Ireland. Prepared for Dalradian Gold Limited. November 2017.

than field conditions. This could lead to under-estimation of mineral precipitation of these phases (more conservative results) if redox conditions in the modelled environment are oxidising.

- The postulated reduction of pO_2 and pCO_2 to 60% of atmospheric values was not implemented correctly in the PHREEQC model files (neither for the DSF nor the underground mine). The partial pressures in the DSF model file for O_2 (SI=-0.65, equivalent to a concentration of 22.4% vs. an atmospheric value of 21%) and CO_2 (SI=-2, equivalent to a concentration of 7940 ppm vs. an atmospheric value of 410 ppm) are higher than stated in the report and higher than atmospheric levels.
- Higher oxygen levels may lead to a higher proportion of the less mobile oxidised species for iron, manganese, arsenic and other redox-sensitive elements (less conservative results). However, even if oxygen levels would be reduced to 13% (0.6 times 21% as postulated in the report) in the simulation, conditions would still be oxic and differences in redox speciation are expected to be minor.
- On the other hand, higher CO_2 levels may cause more acidic conditions which may enhance mobility of metals (more conservative results).
- In the PHREEQC model file of the **DSF Base Case model** (tab “10_ToPhreeqc” in file “3_U7582_DSF_BaseCase_v1.9.xlsx”), the mineral equilibrium phases and saturation indices match the values given in Table 10-10, except for $Sn(OH)_4$ which is included in the PHREEQC model file with an SI of 0.6, but not shown in Table 10-10. It is unclear why this solid phase has been included.
- The equilibrium phases and saturation indices for the underground models given in Table 10-11 do not match the list in the **underground mine Base Case operational model** (tab “8_LOM_ToPhreeqc” in file “3_U7582_UG-Adit_BaseCase_v1.11.xlsx”). The list in the model file contains most mineral phases from Table 10-10, and some from Table 10-11, but all SI values are set to zero. No explanation is given for this discrepancy.
- For the **underground mine Base Case closure model** (tab “8_Closure_ToPhreeqc” in file “3_U7582_UG-Adit_BaseCase_v1.11.xlsx”) and the **underground mine Base Case Adit model** (tab “8_Adit_ToPhreeqc” in file “3_U7582_UG-Adit_BaseCase_v1.11.xlsx”), the list of equilibrium phases matches those given in Table 10-11, except for Anglesite ($PbSO_4$) which is listed in Table 10-11 but not used in the PHREEQC model (this omission leads to more conservative predictions). However, the saturation indices of several minerals with SI>0 do not match. No explanation is given for this discrepancy.

Golder conclusion:

Despite the noted discrepancies between the mineral lists in the report tables and the actual PHREEQC model files, the minerals and saturation indices which have been used in the PHREEQC model files are considered reasonable for the simulated facilities.

Assessment of Adsorption Reactions Implemented in the Models

Section 10.6 of the 2020 *Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3] describes the adsorption reactions implemented in the PHREEQC models. The models assume that trace metals may be removed from solution via sorption onto freshly precipitated ferrihydrite.

Golder comment:

Adsorption of trace metals onto ferrihydrite is commonly observed in mining-impacted settings and inclusion into the geochemical models is considered appropriate.

Golder conclusion:

The adsorption reactions implemented in the models are considered appropriate.

Assessment of Model Assumptions and Limitations

Section 10.6.1 of the 2020 *Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3] describes the model assumptions and limitations.

Golder comment:

The model assumptions and limitations described in this section are considered appropriate for the conceptual settings of the Curraghinalt DSF and underground mine.

Golder conclusion:

The model assumptions and limitations described in this section are considered appropriate for the conceptual settings of the Curraghinalt DSF and underground mine.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the methodology underpinning the assessment of acid generating rock and changes in water chemistry appropriate?	✓		

20.3.3 Assessment of Guidelines Considered

Section 10.7 of the *2020 Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3] summarises the set of water quality screening and target values developed by SRK against which the predicted source terms have been assessed. These are presented in Table 10-12 of the report for the following categories:

1) Screening level for protection of groundwater: Proposed Infrastructure Area during operations and following closure;
2) Screening level for protection of groundwater: Proposed Infrastructure Area including long-term liner degradation via stress crack development;
3) Groundwater Target: Proposed Mine Area;
4) Screening level for protection of groundwater: Proposed Mine Area during closure;
5) Drinking Water Standards;
6) Average Baseline Data Curraghinalt Burn (outliers removed); and
7) Screening Level for the Protection of Surface Water.

Golder comment:

The guidelines and methodologies applied to derive target values and screening levels are considered appropriate.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the guidelines and methodologies applied to derive target values / screening levels appropriate?	✓		

20.3.4 Validity of Key Assumptions and Conclusions – Dry Stack Facility

The validity of key assumptions and conclusions for each conceptual model and computer model associated with the DSF is discussed in each of the following sections.

Conceptual Model

The conceptual model for the DSF during life of mine (LOM) and post-closure are presented in Section 10.2.1 of the *2020 Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3].

The conceptual model takes into account that the DSF will contain dry stacked tailings, non-acid generating waste rock and ore sorter rejects, and will be built in three consecutive cells which will be progressively rehabilitated throughout the mine life. The conceptual model presented provides a description of waste material masses, volumes and footprints; water flows which interact with the wastes and mobilise chemical mass; gas exchange and the effects of progressive rehabilitation.

Golder comment:

The descriptions provided for the conceptualisation are in line with what would be expected for the DSF setting and are considered adequate.

Golder conclusion:

Satisfactory.

Numerical Model Development

Section 10.4.1 of the 2020 *Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3] presents the overall approach applied to predicting the DSF seepage quality, particularly the scaling factors which were used to predict solute release rates at field scale (R_{field}) from laboratory kinetic test release rates (R_{lab}). The following scaling factors (from Kempton, 2012) were used:

$$R_{field} = R_{lab} \times SF_{size} \times SF_{moist} \times SF_{contact} \times SF_{Temp} \times SF_{O2}$$

where

- SFf_{size} represents grain size effects;
- SF_{moist} represents a reduction in oxidation in the case of a severe lack of water; this factor is not relevant in this setting and is set to 1;
- $SF_{contact}$ represents the amount of material in contact with water that can also be mobilised/flushed;
- SF_{Temp} is the temperature scaling factor; and
- SF_{O2} represents the reduction in the field oxidation rate caused by the limited O_2 availability in the pore gas.

Different scaling factors have been determined for tailings material, waste rock and ore sorter rejects, as well as depending on the absence (open conditions) or presence of a cover (closed conditions).

A summary of the individual scaling factors and resulting overall scaling factors for the different materials with and without a cover is presented in Table 10-9 of the Geochemical Characterisation Report.

Golder comment:

The approach described by *Kempton (2012)* is widely used in mine waste geochemistry for the prediction of mine contact water quality based on scaling of laboratory data to field conditions.

The individual scaling factors for the different effects and materials are considered reasonable for the simulated settings.

The combined scaling factors for open and closed waste rock, open and closed ore sorter rejects and open and closed tailings are considered appropriate.

Golder conclusion:

The approach applied to predicting the DSF seepage quality is considered appropriate.

Assessment of associated levels of uncertainty and sensitivity analysis of the inputs and outputs

The *2020 Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3] presents DSF modelling results of source term concentrations predicted for a "Base-Case" scenario (Section 11.1.1) and for ten sensitivity scenarios (Section 11.2). These are summarised in Table 2 below.

Table 2: Summary of base case scenario and sensitivity scenarios presented for the DSF

Results Table	Table Title
Table 11-5	Summary of the Base Case Results for the DSF Model
Table 11-8	Summary of the Case Results without Thermodynamic Calculations for the DSF Model
Table 11-11	Summary of the Results without Surface Complexation Calculations Case Results for the DSF Model
Table 11-18	Summary of the x 0.5 Scaling Factor Case Results for the DSF
Table 11-19	Summary of the x 2 Scaling Factor Case Results for the DSF
Table 11-30	Predicted Mine Water Composition for the DSF Obtained using the Variation in Humidity Cell Testing (HCT) Inputs (Average All Results)
Table 11-31	Predicted Mine Water Composition for the DSF Obtained using the Variation in HCT Inputs (Max Average Results)
Table 11-32	Predicted Mine Water Composition for the DSF Obtained using the Variation in HCT Inputs (Max All Results)
Table 11-33	Predicted Mine Water Composition for the DSF Obtained using the Variation in HCT Inputs (Ore Sorter Global Composite)
Table 11-34	Predicted Mine Water Composition for the DSF Obtained using the Variation in HCT Inputs (Ore Sorter ROM Composite)
Table 11-35	Predicted Mine Water Composition for the DSF Obtained using the Variation in HCT Inputs (T17 Vein Tailings Sample)

The Summary section 11.2.6 of the sensitivity analysis highlights the following aspects:

- "*The predictions are resilient to change in scaling factors for both the underground mine and DSF".*
- *"In terms of hydrogeological modelling, … light of the timescale considered … it appears that climate change impacts are minor against the predicted base case scenario."*
- *"A more significant effect is the geochemical release rate inputs (HCT and Monolithic Leach Test (MLT)), especially in terms of mercury and chromium VI. This highlights the need for an ongoing waste characterisation programme…"*
- *"The particular focus is to ascertain if hazardous substances (As, Cr(VI), Hg and Pb) would be caused to exceed the proposed guideline values. As observed above, this is possible if there is significant deviation from the current base case scenario in terms of material reactivity and parameters contributing to the scaling factors definition (eg particle size distribution). Should variation of an order of magnitude or more be observed then the predictive modelling should be repeated to confirm compliance*."

Golder comment:

A screening of the tabulated results suggests that generally, the lowest source term concentrations were obtained in the sensitivity scenario "x 0.5 Scaling Factor Case" (Table 11-18), and the highest source term concentrations in the sensitivity scenario "Variation in HCT Inputs (Max All Results)" (Table 11-32).

Golder conclusion:

The scenarios and parameter variations which have been simulated are considered appropriate to assess the sensitivity of DSF model outcomes to variations in the input parameters.

Verification Runs

This section presents confirmation of which model runs were analysed / re-run and opinion on how relevant / adequate each model is or what their shortcomings / limitations are.

The following Excel and PHREEQC model files of the DSF were opened and run for verification purposes:

- DSF Base Case (file 3_U7582_DSF_BaseCase_v1.9.xslx, tab "10_ToPhreeqc"), SRK results presented in Table 11-1 of the report.
- DSF Sensitivity Case without Surface Complexation Calculations (files 11_U7582_DSF_BaseCase_v1.9_NoSC.xslx and .pdf), SRK results presented in Table 11-11 of the report.
- DSF Sensitivity Case using x2 Scaling Factor (files 8_U7582_DSF_BaseCase_v1.9 - x2.xslx and .pdf), SRK results presented in Table 11-15 of the report.

Golder comment:

As the modified Minteq thermodynamic database was not provided, the models were run using the standard Minteq.v4 database which is included in the PHREEQC version 3 release. No significant discrepancies between the tabulated results and the verification runs were detected, despite the presumed differences between the thermodynamic databases.

It is noted that for the Base Case DSF model, no ferrihydrite precipitation is predicted for any stage of mine development. Therefore, no surface complexation reactions can occur, because they would require the presence of ferrihydrite. Accordingly, the results of the Sensitivity Case without Surface Complexation Calculations (Table 11-11) should be the same as the Base Case (Table 11-5). Results for seepage are

identical, but results for runoff are not. The reason for this discrepancy may relate to the application of different SI values for O_2 and CO_2 in the Sensitivity Case without Surface Complexation Calculations compared to the Base Case.

For the Sensitivity Case using x2 Scaling Factor (file "8_U7582_DSF_BaseCase_v1.9 - x2.xlsx"), no significant discrepancies between the tabulated results and the verification runs were detected.

Golder conclusion:

The verification runs are considered satisfactory.

Assessment of Key Model Reported Conclusions

The main conclusions regarding the DSF Base Case model are presented in Section 11.1.1 of the 2020 *Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3]. The Base Case source term chemistry results are shown in Table 11-1 of the report and are compared to the proposed screening values for the surface and groundwater:

- This comparison indicates that the runoff source term predictions are below the proposed screening values for surface water.
- For the infiltration source term, exceedances during LOM are predicted with respect to nitrate, arsenic, antimony and molybdenum. However, it is noted that water infiltrating the DSF will be captured by the liner and treated during LOM. For post closure, an exceedance of the Screening Level for the Protection of Surface Water is predicted for molybdenum.

Golder comment:

These key conclusions are valid for the values presented in the table.

Golder conclusion:

These key conclusions are considered appropriate.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the key model (computer and conceptual) assumptions and conclusions for the dry stack facility valid?	✓		

20.3.5 Validity of Key Assumptions and Conclusions – Underground Mine

This section describes each conceptual model and computer model summarising key assumptions and opinion on whether they are correct, incorrect, or insufficient.

Conceptual Model

The conceptual model for the underground mine during Life of Mine (LoM) and post-closure are presented in Section 10.2.2 of the *2020 Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3].

The conceptual model takes into account that the mine will be progressively backfilled as it develops. The backfilled material is composed of waste rock (including all Potentially Acid Generating (PAG) material), ore sorter rejects and cemented paste tailings (including all high sulphur material).

During LoM, the area will be dewatered and water infiltrating the underground mine will be pumped and treated. Post closure, the mine will be fully backfilled, and the dewatering will stop. Groundwater rebound to pre-mining level is estimated to take 15 years, but it is anticipated that some elements of the underground mine will lose hydrogeological containment between year 3 and year 7. At this stage, mine water will start discharging into the surrounding strata. As the groundwater rebounds, it will mobilise any unflushed available solutes generated in the interim between the end of mine life and the rebound.

The conceptual and numerical models differentiate between the portion above and below the level 168 m, because the adit at this level will remain open after closure. The portion of the mine above the level 168 will drain to the adit in perpetuity. This upper portion is considered to remain oxygenated and free draining. In the portion of the mine located below the level 168, mine water rebound will occur; this portion is considered not to be in equilibrium with atmospheric gases.

The conceptual and numerical models consider a first flush effect where soluble weathering salts are formed by the inflow of groundwater on the wall, paste backfill and backfilled waste rock, which are mobilised during the rebound phase post-closure.

Golder comment:

The descriptions provided for the conceptualisation take into account the key effects that are typically considered for underground mine settings such as the Curraghinalt project.

Golder conclusion:

The conceptual model is considered appropriate.

Numerical Model Development

The numerical model simulates geochemical interactions between water entering the mine workings with the following reactive masses:

- The mine workings surface;
- The backfilled waste rock;
- The backfilled ore sorter rejects; and
- The cemented paste backfill.

The degree of reaction is dependent on the extent of water and oxygen penetration within the material. During operations, the mine workings surfaces have been exposed to oxygenated conditions and have weathered to form secondary minerals, including soluble salts. These soluble salts and other weathering products will dissolve into waters entering the mine workings, both during the remaining life of mine and post-closure.

To calculate mass release from the mine workings surfaces, the laboratory Humidity Cell Testing (HCT) data is scaled to reflect the mass release of solutes under field leaching conditions, based on estimates of the total mass of material available for leaching in the mine workings surfaces (exposed surface areas and proportion of each material type in the mine workings). This information is coupled with an estimate of the density and thickness of fracturing in the mine walls and a reactive rim or ‘oxidized rind’ of 0.012 m thickness, to calculate a mass of reactive rock.

The reactive mass of the paste backfill is defined as a reactive interface between the paste and the wall rock. The report states that for the Base Case, this reactive interface is estimated based on a reactive thickness of one centimetre over the surface area of the paste backfilled portions of the underground mine, a fracture density of 5%, and a paste density of 2,010 kg/m^3.

The scaling factor considered for the backfilled waste rock is the same as that considered for the waste rock within the surface facilities.

No information is given about the methodology applied to estimate solute mass release from ore sorter rejects.

Golder comment:

- The implementation of the conceptual and numerical approach was reviewed based on the Base Case model (3_U7582_UG-Adit_BaseCase_v1.11.xlsx).
- In the calculation of mass release from the mine workings surfaces, the Excel spreadsheet (tab “01_Mine Design”) appears to include only mass release from waste lithologies, not from veins that are exposed on the mine walls. The geochemical characteristics of vein material are not discussed in the report, but the average proportion of veins in the total waste tonnage is only about 4%. Therefore, the impact of this omission is expected to be small compared to the overall uncertainties in the upscaling process.
- The justification of the thickness of the reactive rim or ‘oxidized rind’ 0.012 m on the surfaces of rock fragments cites SRK (2008). This reference is missing in the final list, and has therefore not been verified. However, based on professional experience, this value is within the expected range of reaction depth, and the lack of a citation is not a major concern.
- The description provided for calculation of mass release from paste backfill suggests that this is based on the reactive mass of paste. However, tab “00_ReadMe” of the Excel file mentions that in Version 0.4 the calculations were updated to use surface area for paste instead of reactive mass. This approach is implemented on tab “01_Mine Design”. The surface area of paste in the mine workings is calculated based on geometric CAD data, and then the reactive surface area of the paste is determined by applying a single scaling factor of 5% to account for fracture density, presumably fractures on the mine wall in contact with the paste. This approach is reasonable.
- In the underground mine Excel model, the temperature scaling factor has not been applied. The report does not explain why this effect has been excluded. This omission leads to more conservative modelling results (higher predicted concentrations).
- The other three scaling factors for backfilled waste rock and ore sorter rejects are similar to those applied to the DSF model.

Golder conclusion:

Despite the minor observations highlighted above, the approach applied to predicting the underground mine water quality is considered appropriate.

Assessment of associated levels of uncertainty and sensitivity analysis of the inputs and outputs

For the underground mine below level 168, the *2020 Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3] presents modelling results of source term concentrations predicted for the “Base-Case” scenario (Section 11.1.2) and for 17 sensitivity scenarios (Section 11.2). These are summarised in Table 3 below.

Table 3: Summary of base case scenario and sensitivity scenarios presented for the underground mine below level 168

Results Table	Table Title
Table 11-6	Summary of the Base Case Results for the Underground Mine Water Model
Table 11-9	Summary of the Results without Thermodynamic Calculations for the Underground Mine Water Model
Table 11-12	Summary of the Results without Surface Complexation Calculations Case Results for the Underground Mine Water Model
Table 11-14	Summary of the Results using the Low-end (P10) Hydrogeological Model Results for the Underground Mine Water Model
Table 11-16	Summary of the Results using the high end (P90) Hydrogeological Model Results for the Underground Mine Water Model
Table 11-20	Summary of the Different Scaling Factors for the Underground Mine Water Model (All)
Table 11-21	Summary of the Different Scaling Factors for the Underground Mine Water Model (Waste Rock and Ore Sorter Rejects)
Table 11-22	Summary of the Different Scaling Factors for the Underground Mine Water Model (Paste Backfill and Wall Rock)
Table 11-26	Summary of the Base Case Results with a Fracture Density of 1%
Table 11-28	Summary of the Results with a Fracture Density of 10%
Table 11-36	Predicted Mine Water Composition for the Underground Mine Water Model Obtained using the Variation in HCT Inputs (Average All Samples)
Table 11-37	Predicted Mine Water Composition for the Underground Mine Water Model Obtained using the Variation in HCT Inputs (Max All Samples)
Table 11-38	Predicted Mine Water Composition for the Underground Mine Water Model Obtained using the Variation in HCT Inputs (Max Average)
Table 11-39	Predicted Mine Water Composition for the Underground Mine Water Model Obtained using the Variation in MLT Inputs (Global Composite 1:1)
Table 11-40	Predicted Mine Water Composition for the Underground Mine Water Model Obtained using the Variation in MLT Inputs (Global Composite 2:1)
Table 11-41	Predicted Mine Water Composition for the Underground Mine Water Model Obtained using the Variation in MLT Inputs (Global Composite 3:1)
Table 11-42	Predicted Mine Water Composition for the Underground Mine Water Model Obtained using the Variation in MLT Inputs (Rougher yr 7+ : Scavenger yr 7+ at 2:1 ratio)
Table 11-43	Predicted Mine Water Composition for the Underground Mine Water Model Obtained using the Variation in MLT Inputs (Rougher yr 7+ : Scavenger yr 7+ at 3:1 Ratio)

For the underground mine adit, the *2020 Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3] presents modelling results of source term concentrations predicted for the "Base-Case" scenario (Section 11.1.2) and for 17 sensitivity scenarios (Section 11.2). These are summarised in Table 4 below.

Table 4: Summary of base case scenario and sensitivity scenarios presented for the underground mine adit

Results Table	Table Title
Table 11-7	Summary of the Base Case Results for the Underground Mine Adit Model
Table 11-10	Summary of the Results without Thermodynamic Calculations for the Underground Mine Adit Model
Table 11-13	Summary of the Results without Surface Complexation Calculations Case Results for the Underground Mine Adit Model
Table 11-15	Summary of the Results using the Low-end (P10) Hydrogeological Model Results for the Underground Mine Adit Model
Table 11-17	Summary of the Results using the High End (P90) Hydrogeological Model Results for the Underground Mine Adit Model
Table 11-23	Summary of the Different Scaling Factors for the Underground Mine Adit Model (All)
Table 11-24	Summary of the Different Scaling Factors for the Underground Mine Adit Model (Waste Rock and Ore Sorter Rejects)
Table 11-25	Summary of the Different Scaling Factors for the Underground Mine Adit Model (Paste Backfill and Wall Rock)
Table 11-27	Summary of the Mine Adit Model Results with a Fracture Density of 1%
Table 11-29	Summary of the Mine Adit Model Results with a Fracture Density of 10%
Table 11-44	Predicted Mine Water Composition for the Underground Mine Adit Model Obtained using the Variation in HCT Inputs (Average All Samples)
Table 11-45	Predicted Mine Water Composition for the Underground Mine Adit Model Obtained using the Variation in HCT Inputs (Max All Samples)
Table 11-46	Predicted Mine Water Composition for the Underground Mine Adit Model Obtained using the Variation in HCT Inputs (Max Average)
Table 11-47	Predicted Mine Water Composition for the Underground Mine Adit Model Obtained using the Variation in MLT Inputs (Global Composite 1:1)
Table 11-48	Predicted Mine Water Composition for the Underground Mine Adit Model Obtained using the Variation in MLT Inputs (Global Composite 2:1)
Table 11-49	Predicted Mine Water Composition for the Underground Mine Adit Model Obtained using the Variation in MLT Inputs (Global Composite 3:1)
Table 11-50	Predicted Mine Water Composition for the Underground Mine Adit Model Obtained using the Variation in MLT Inputs (Rougher yr 7+ : Scavenger yr 7+ at 2:1 ratio)

Results Table	Table Title
Table 11-51	Predicted Mine Water Composition for the Underground Mine Adit Model Obtained using the Variation in MLT Inputs (Rougher yr 7+ : Scavenger yr 7+ at 3:1 Ratio)

The Summary of the sensitivity analysis (Section 11.2.6 of the *2020 Geochemical Characterisation Report*) discussed above applies to both the underground mine and DSF and is not repeated here.

Golder comment:

A screening of the tabulated results suggests that generally, both for the mine below level 168 and the adit, the lowest source term concentrations were obtained in the sensitivity scenario “Fracture Density of 1%” (Table 11-27 and Table 11-28), and the highest source term concentrations in the sensitivity scenario “Variation in HCT Inputs (Max All Samples)” (Table 11-37 and Table 11-45).

Golder conclusion:

The scenarios and parameter variations which have been simulated are considered appropriate to assess the sensitivity of underground mine model outcomes to the input parameters.

Verification Runs

This section provides confirmation of which model runs were analysed / re-run and opinion on how relevant / adequate each model is or what their shortcomings / limitations are.

The following Excel and PHREEQC model files of the underground mine were opened and run for verification purposes:

- Underground mine below level 168 Base Case for Life of Mine (files 3_U7582_UG-Adit_BaseCase_v1.11.xslx [tab 08_LOM_ToPhreeqc] and 3_U7582_UG_LOM_BaseCase_v1.11.pdf), full SRK results presented in Table 11-2 of the report;
- Underground mine below level 168 Base Case for Closure (files 3_U7582_UG-Adit_BaseCase_v1.11.xslx [tab 08_Closure_ToPhreeqc] and U7582_Adit_Closure_BaseCase_v1.11.pdf), full SRK results presented in Table 11-3 of the report;
- Underground mine adit Base Case for Closure (files 3_U7582_UG-Adit_BaseCase_v1.11.xslx [tab 08_Adit_ToPhreeqc] and 3_U7582_UG_LOM_BaseCase_v1.11.pdf), full SRK results presented in Table 11-4 of the report; and
- Underground mine Adit Sensitivity Case with a Fracture Density of 1% (files 34_U7582_UG-Adit_BaseCase_v1.11-0.001FD.xslx and 34_U7582_Adit_Closure_BaseCase_v1.11-0.001FD.pdf), SRK results presented in Table 11-27 of the report.

Golder comment:

As the modified Minteq thermodynamic database was not provided, the models were run using the standard Minteq.v4 database which is included in the PHREEQC version 3 release. The following seven equilibrium phases had to be excluded from the model to be able to run the simulations: Cassiterite, Conichalcite, Dawsonite, Fluorapatite, Mg-Gypsum, Mn(OH)3, Pharmacolite;

The largest relative differences in predicted concentrations between the values reported by SRK and those calculated using the standard Minteq.v4 database are observed (in decreasing order) for P, As, V, F, Sn.

All other simulated parameters typically display differences of less than ±1% between the standard Minteq.v4 database and SRK's modified database.

These differences indicate that the modifications to the thermodynamic database have a minor or negligible impact for most simulated elements. The elements with higher differences in predicted concentrations are not considered contaminants of major concern for the Curraghinalt deposit.

For the Base Case underground mine model, ferrihydrite precipitation does occur. Therefore, surface complexation reactions can occur in the underground mine model, but as discussed in Section 11.2.2 of the report, the effect is very subtle compared to the effect of the precipitation of secondary mineral phases.

The Sensitivity Case which is stated to represent a decrease of the fracture density from 5% to 1% in fact represents calculations for a fracture density of 0.1%. Even this decrease by two orders of magnitude decreases predicted solute concentrations by only a factor of about 3.

Golder conclusion:

Despite the minor observations highlighted above, the verification runs are considered satisfactory.

Assessment of Key Conclusions

The main conclusions regarding the underground mine Base Case model are presented in Section 11.1.2 of the *2020 Geochemical Characterisation Report for the Curraghinalt Gold Deposit*[3]. The Base Case source term chemistry results of the underground mine below level 168 are shown in Table 11-2 of the report for LoM and in Table 11-3 of the report for closure. Adit closure water quality draining from above the level 168m is given in Table 11-4. The simulated concentrations are compared to the proposed screening values for the surface and groundwater:

- The predicted mine water chemistry during the life of mine (LoM) exceeds groundwater screening values for several parameters including ammonia, nitrate, arsenic, chromium (IV), mercury, molybdenum, lead, antimony, thallium and uranium. During LoM, it is understood that the water will be pumped and treated.
- For the post closure simulations of the underground mine below level 168m, no exceedances with respect to hazardous substances are predicted. The predicted chemistry indicates exceedances with respect to the groundwater screening values for ammonia (until year 9), nitrate (year 6), molybdenum (year 2), and antimony (year 10). Exceedances with respect to the surface water screening values are expected for ammonia (7 years), nitrate (3 years), antimony (3 years) post closure and for manganese after year 19. As no water is expected to discharge from the underground mine below level 168m to surface until year 15 post-closure, only manganese will show exceedances with respect to surface water screening levels for all of the modelled years post closure.
- For the predicted adit chemistry post closure of water draining from above the level 168m, nitrate, molybdenum and antimony are predicted to exceed the surface water screening values until year 1, 7 and 12 respectively. After year 19, the rebounding water emanating from the adit causes a manganese exceedance with respect to surface water screening values.

Golder comment:

These key conclusions are valid for the values presented in the tables.

Golder conclusion:

The key conclusions are considered appropriate.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the key model (computer and conceptual) assumptions and conclusions for the underground mine valid?	✓		

20.4 Assessment of compliance of the predicted outcomes with regulation 9 & 10 and the EC Directives referenced within

DfI questions

The following specific question/s were put by DfI and are included in full here for the purposes of completeness:

Do the predicted outcomes resulting from the assessment of acid generating rock and changes in water chemistry both above and below ground levels, at different phases of the project, demonstrate compliance with regulation 9 & 10 and the EC Directives referenced within?

What do the outcomes from the models mean in terms of compliance with regulation 9 & 10 and the EC Directives referenced within it?

Golder comment:

During mine operation, contamination risks for surface and groundwater will be managed by means of active water treatment. The Base Case simulations indicate that after closure, contact water from the underground mine may exceed surface water and / or groundwater screening values for ammonia, nitrate, molybdenum, antimony and manganese. Particularly manganese may require long-term management by active or passive treatment.

For DSF contact water, only molybdenum is predicted to exceed surface water screening values after closure in the Base Case simulations and may require long-term management by active or passive treatment.

Golder conclusion:

These considerations are addressed in more detail in the Surface and Groundwater Impact Assessment reports (sections 26.0, 27.0, 28.0 and 29.0).

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the predicated outcomes of assessments of acid generating rock and changes in water chemistry, both above and below ground, compliant with regulation 9 & 10 and the relevant EC Directives?	✓		

20.5 Assessment of Model Assumptions and Limitations

DfI questions

The following specific question/s were put by DfI:

What impact do the limitations of the model have on assessment of environmental impacts as per compliance with regulation 9 & 10 and the EC Directives referenced within?

Golder comment:

A number of uncertainties are associated with the PHREEQC models, as with any model. These relate, inter alia, to the conceptualisation and parameterisation of the models. The range of predictions has been estimated using a number of sensitivity scenarios which cover a wide range of parameter uncertainties. The sensitivity runs demonstrate that other parameters than those mentioned in the previous sections may exceed the screening values under certain circumstances and may require management during or after mine operation.

Golder conclusion:

As above.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the model limitations sufficiently well understood and tested to allow consideration of compliance with regulation 9 & 10 and the EC Directives referenced within?	✓		

20.6 Suitability of source term water quality Models (Fit for Purpose)

DfI questions

The following specific question/s were put by DfI:

Is the methodology underpinning the assessment of acid generating rock and changes in water chemistry both above and below ground levels at different phases of the project **fit for purpose and represent best practice**?

Are additional model scenarios/ other models recommended?

What additional information is required?

Is other modelling software recommended?

Which worse-case scenarios need to be assessed, if any?

Golder comment:

Despite minor issues and discrepancies highlighted in the preceding sections, the methodology underpinning the assessment of acid generating rock and changes in water chemistry both above and below ground levels at different phases of the project is considered fit for purpose and to represent best practice.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the source term water quality models fit for purpose?	✓		

20.7 Chapter conclusion and recommendations

The methodology and results of the modelling of contact water qualities from the proposed Curraghinalt project underground mine and associated infrastructure as described in the *2020 Geochemical Characterisation Report* are considered appropriate for use in the water quality models and impact assessments for the proposed Curraghinalt project.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the document: *A Geochemical Characterisation Report for the Curraghinalt Gold Deposit, Northern Ireland, October 2020* fit for purpose and suitable for presentation to Public Inquiry?	✓		

21.0 REVIEW OF APPENDIX D - NI DOE PLANNING UNIT QUESTIONNAIRES

21.1 Chapter Summary

Appendix D of the WMP presents the completed Northern Ireland Department of the Environment (NI DOE) planning unit questionnaire to assist in the determination of whether the facility is a Category A waste facility or not (as outlined in Schedule 3 of the *2015/85 Regulations*). The questionnaire is titled "*Operator Assessment of Potential for Category A facilities*" and is completed by the applicant.

There are eight sections in the questionnaire (completed by the applicant) which asks:

1) Is a waste facility present?

2) Will the waste facility contain hazardous or dangerous substances (with reference to EC Decision *337/2009/EC*)?

3) Does the existing facility (or would the planned facility) constitute a significant hazard under the terms of the *Quarries Regulations 2006*?

4) Can the operator confirm;

   a) That in your opinion, structural failure or incorrect operation of the waste facility would not result in potential for loss of life or serious danger to human health considering any human beings other than site workers, who are present outwit the site, permanently or for prolonged periods.

   b) (i) the operation complies with the *Quarries Regulations 2006;*

   (ii) that where the facility is or would qualify as a significant hazard the necessary geotechnical assessment work for the waste facility has been undertaken; and

   (iii) Any notifiable tips have been notified to HSENI.

5) (Whether or not classed as a significant hazard under the Quarries Regulations), is there a type of event where solid waste or slurry material could spill over the site boundary or onto an undisturbed area of the site. If so, it would be useful if you could estimate the maximum reach of any spill or state a distance beyond which it certainly would not reach, taking into account the surrounding landform?

6) Are there any designated habitats which might be affected by the spill?

7) Is it predicted that the impact of a spill would exceed the criteria for serious danger to the environment in Decision *337/2009/EC*?

8) Is there any other risk of serious danger to the environment above the thresholds in Decision *337/2009/EC* (ie, those in Question 7) above) which might result from incorrect operation such as unmitigated acid rock drainage?

The questionnaire was completed for both the water storage ponds and the DSF separately. The conclusion of the assessment for both the water storage ponds and the DSF is that none of the facilities are a Category A facility.

Golder comment:

The questionnaire is a summary of more detailed analysis presented in the waste management plan. For example, the classification of waste types, the water balance storm water event modelling and the failure analysis of the DSF. Golder has reviewed this information as part of the WMP. The completion of the questionnaire aligns with the information presented in the WMP in detail.

Golder conclusion:

The Category A classification result given in Appendix D is appropriate as per the information provided in the WMP.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is Appendix D completed as per the information provided in the WMP?	✓		
Is the Category A assessment conclusion in Appendix D appropriate?	✓		

22.0 REVIEW OF APPENDIX E - PEAT MANAGEMENT PLAN

22.1 Chapter Summary

Appendix E presents a Peat Management Plan (PMP) which has been prepared by SLR on behalf of DGL. The purpose of this document is stated as follows: *"to ensure that there has been systematic consideration of peat management and a quantitative assessment throughout the construction activities associated with the proposed mine infrastructure development for the Curraghinalt Gold Project*."

The PMP was created to account for all peat excavated across the proposed infrastructure site. It is noted that the PMP which is dated July 2019 was updated in response to the FEI request from the DfI in January 2019, however the original document was created as part of the Environmental Impact Assessment (EIA) stage of the mine development works.

Peat has been identified within the proposed infrastructure site and the ecology and depth of peat has been investigated and characterised. The depth, nature and extent of peat has been investigated through peat depth probing, peat cores and trial pits undertaken through a number of surveys at the site.

The Stage 1 of the PMP considers the excavation of peat and soil across the site as a result of construction of the proposed over-ground mine development. It considers the potential for minimising excavation and disturbance in order to reduce any unnecessary surplus of peat which will require management at the site. The PMP states that "*the best management option with regard to minimising the potential for surplus peat is to reduce its production; therefore, the design of the infrastructure layout is aimed to minimise peat excavation where possible".*

22.2 Relevant Guidance & Legislation

SLR notes that the most appropriate UK based guidance has been primarily developed in Scotland for wind farm projects and forestry by Scottish regulatory authorities and the Scottish Environmental Protection Agency (SEPA). Therefore, the PMP has been prepared based on the following relevant guidance:

- *SEPA Regulatory Position Statement - Developments on Peat (SEPA, February 2010);*
- *Guidance on the Assessment of Peat Volumes, Re-use of Excavated Peat and the Minimisation of Waste (Scottish Renewables and SEPA, January 2012);*
- *Floating Roads on Peat - Scottish Natural Heritage and The Forestry Commission Scotland (August 2010);*
- *SEPA Restoration Techniques using Peat Spoil from Construction Works (July 2011); and*
- *Northern Ireland Peatlands and Uplands Biodiversity Delivery Group (https://www.daerani.gov.uk/articles/peatlands) 2019.*

SLR describes how the relevant guidance documents outline the hierarchy of management approaches through which the effectiveness of the approach to peat management can be optimised at development sites, as well as the main stages in the development process, and what data should be gathered and assessed at each to inform a site specific PMP. It is confirmed that this PMP has been prepared in accordance with the principles in the guidance for a Stage 1 plan (EIA stage).

22.3 Peat Volumes, Re-Use

The PMP details the methodologies required to assess all potential surplus materials and presents preliminary estimates of the expected volume of excavated peat and required re-use volumes for habitat enhancement, landscape dressing following construction and re-use in a topsoil medium in the restoration of the DSF. In particular, this report considers the construction of the mine surface infrastructure, including the DSF, that will result in the excavation of peat. The principles behind peat management are noted as follows:

- Prevention and re-use are the most appropriate means of managing peat excavated during construction at the Curraghinalt site.
- Excess or surplus peat will be required to be stored on site before it can be used on a phased basis as a topsoil medium in restoration.
- The site of the proposed mine infrastructure was selected based on a number of criteria and an assessment, of active blanket bog Annex I Priority Habitat on the ridge.

The PMP includes estimates of the volume of peat generated during the construction phase for the site infrastructure and identifies potential areas where peat can be re-used at the site and also stored in the short-to-medium term. It notes that where peat cannot be re-used in landscaping during or following construction works at the development site, it will have to be stored over the short-to-medium term before it can be re-used on a phased basis in ongoing restoration works.

It is noted that the PMP is based on site specific environmental information for the proposed infrastructure site, including peat depths; the physical characteristics of the peat; and peat ecology and habitats. As part of its review, Golder has reviewed all of the geotechnical and environmental aspects however although ecological assessments have been considered on a holistic level, no commentary is provided on any ecological aspects as it is understood that review of these aspects are being completed by others.

22.3.1 Surveys & Assessments

In relation to the numerous surveys and assessments carried out on peat at the site, the PMP states that *"Peat depths across the proposed infrastructure site were determined from a number of surveys undertaken at Curraghinalt since 2012, including the ecological survey, the soil sampling survey and Peat Landslide Hazard Risk Assessment (PLHRA) survey. These included a Phase 1 and Phase 2 peat survey, undertaken in 2012 and 2015 respectively, which were for ecological purposes and included peat depth and characterisation surveys. A specific reconnaissance walkover survey and peat depth survey was undertaken in March 2017 for the PLHRA."*

With respect to the extent of peat probing carried out, the following is noted: *"Peat depths have been determined by probing peatland at predetermined locations. In 2012, the probing was undertaken at 100 m intervals across the ridge. In 2015, the probing was undertaken at 50 m intervals and focused on the proposed infrastructure site, but also extended to parts of the application site not previously surveyed. The proposed infrastructure site was included as part of a wide area across the mountain which was covered by the Phase 1 Peat Survey. The Phase 2 Peat survey focused on the proposed infrastructure area, as did the detailed probing undertaken for the PLHRA. The Phase 1 Peat Probing site survey included a total of 248 probes. A further 1,378 probes were undertaken as part of the Phase 2 Peat Probing site survey and a final 137 were completed as part of the PLHRA."*

In addition to peat probing, it is noted that soil samples were taken from peatland habitats within the proposed infrastructure site in January 2016, to provide a better understanding of the likely potential for peat instability within the infrastructure area. Subsoil samples (beneath the peat soils) were also taken at approximately 100 m intervals.

The peat depths across the site are shown in Figures 1, 2 and 3 which are presented within the PMP.

Golder comment:

The main area of concern for Golder as part of the review was in Infrastructure Site / Area A. The PMP notes that "*Peat depths in excess of 5 m were identified at the site in the Valley Mire, along the eastern edge of the proposed infrastructure area*". Other than this, it is noted that peat depths are typically less than 1 m depth with some isolated areas between 1.0 and 1.5 m in depth. In fact, Golder notes based on the peat depth drawing prepared by SLR, that approximately 50% of the overall area of Area A does not have any peat presence and that two thirds of the area with peat presence will have depths less than 1 m.

Further to the above, Golder notes that for the area where infrastructure will actually be located within Site A, it is estimated that only approximately a third of this area will have peat present.

Golder conclusion:

Golder consider the peat surveys and assessments were comprehensive in nature and provide sufficient coverage of the study area.

22.3.2 Ground Investigation Works

In relation to ground investigation works at the infrastructure site, the PMP notes that *"A geotechnical Ground Investigation (GI) was undertaken in the proposed infrastructure area in December 2015 and January 2016 by*

SRK. The purpose of the geotechnical investigation was to determine ground conditions in the infrastructure areas. The GI programme comprised a total of twelve boreholes to a maximum depth of 16 m below ground level and twenty three trial pits to a maximum depth of 4.5 m below ground level. In situ geotechnical testing was undertaken at the site, including Standard Penetration Tests (SPT's), Pocket Penetrometer tests, and Torvane Shear tests. Soil and weathered bedrock samples from the trial pits and boreholes were taken for geotechnical laboratory testing."

Golder notes that this investigation typically encountered a combination of topsoil and peat to a depth of 0.5 m, followed by gravelly and silty sands to 3.1 m depth. Below this, the bedrock (Schist) is encountered and this is noted to be initially weathered in nature. In fact, only three of the 35 exploratory locations encountered peat.

The peats in the main mire area on the slope of Crocknamoghil are typically uniform in their physical structure comprising a shallow fibrous acrotelmic layer up to 0.4 m in depth and a pseudo-fibrous catotelmic upper layer between the acrotelmic layer and the mineral subsoils, with humification ranging (based on Von Post classification of humification ranging from H1 (no decomposition) to H10 (highly decomposed) from H1 to H6 / H7, but with H9 recorded at one location. The water content of the peats is dependent upon the levels of rainfall but typically range from B2 to B1 (scale from B1 (dry) to B5 (very high moisture)) with pockets of deeper peat, water content may reach B3.

In the PMP, SLR notes that the total peat volume which will require excavation at the site is estimated to be c. 165,569m^3. Based on the peat characterisation, SLR has estimated the volumes of acrotelmic and catotelmic peat which require excavation. The total volume of acrotelmic peat and the upper catotelmic peat (fibrous and pseudo-fibrous) is estimated to be approximately 88,246 m^3 and the total remaining volume of catotelmic peat (amorphous) is estimated to be approximately 77,323 m^3. Of this, approximately 10,500 m^3 of excavated peat will be used for peat habitat enhancement and approximately 33,000m^3 of acrotelmic peat will be used for landscaping during or immediately following the construction works.

Golder comment:

Golder has noted the above information as part of its review.

Golder conclusion:

Satisfactory.

22.3.3 Location of DSF Facility Relative to Peat

The PMP discusses the location of the DSF Facility. It notes that one of the considerations in the site selection for the DSF was the distribution of peat across the site and an objective to avoid peat where possible, and where not possible to avoid, to reduce the volume of peat generated.

Golder comment:

In general, given the extent of peat present within the DSF, Golder considers that the objective of avoiding or reducing peat excavation has been largely met.

Golder conclusion:

Satisfactory.

22.3.4 Construction Environmental Management Plan Relative to Peat

Golder notes that an outline Construction Environmental Management Plan (CEMP) has been prepared which incorporates mitigation management measures. One of the purposes of the CEMP is to specify the peat which

will be excavated and how it will be managed and re-used. The outline CEMP provides details for what will be covered within the construction stage CEMP.

The PMP states that "*The timing of the infrastructure development means that approximately 59% of the peat which requires to be excavated at the site will be excavated at the start of the project (during the 2-year construction phase). All peat other than that present beneath Cells 2 and 3 of the Dry Stack Facility (DSF) will need to be excavated and re-used within the early years of the site development works*."

Golder notes that the CEMP contains measures for ensuring that the acrotelmic and catotelmic components of the peat are excavated separately so that they can, in turn be stockpiled separately as outlined above. Further, the CEMP contains details for the transportation of peat for the habitat enhancement area to ensure that the peat turves are disturbed as little as possible and that cross contamination with other materials does not occur. The CEMP also notes that areas throughout the construction project have been identified to accommodate this volume of material for landscaping and that the detailed re-use will be designed by the site contractor during the construction phase.

Golder comment:

Golder considers that the information set out in the PMP will allow for the management of peat to be adequately addressed within a construction stage CEMP.

Golder conclusion:

Satisfactory.

22.3.5 Peat Management Post Construction

It is anticipated that all the peat excavated will either be re-used in landscaping following construction, for peat habitat enhancement purposes or stored for subsequent mixing with mineral subsoil to create a topsoil medium for restoration of the DSF and other areas where required on a phased basis.

Two peat storage areas have been identified at the site from walkover and ecological surveys. These include an area for habitat enhancement, adjacent to existing peat at the site and areas within the footprint of the DSF for the short-to-medium term storage of the pre-mixed peat and soil pending re-use as a topsoil medium in progressive restoration works across the DSF.

It is noted that the PMP contains plans to store the acrotelmic and catotelmic peats separately so that they are readily available for use or further processing as necessary; this will result in optimised re-use of the available materials. Further to this, provision has been made to use the valley mire peat for landscaping use only as it has been deemed unsuitable for the habitat enhancement area. The peat used to create the peat habitat enhancement areas and the pre-mixed topsoil medium will be stored behind engineered retention berms. These berms will be constructed of mineral subsoils (site-won glacial till) and in accordance with a recognised earthworks engineering specification (e.g. Series 600 of the Specification for Highway Works or similar). It is also envisaged that the retention berms (and any excavated peat or pre-mixed topsoil medium stored behind them) will be constructed over in-situ mineral subsoils and/or bedrock and relatively gentle slopes.

Golder comment:

It is noted that no floating tracks or roads on peat are proposed within the infrastructure area (Area A). Roads and access tracks will require the complete excavation of peat to the competent substrate beneath. The proposed infrastructure site requires a number of cut off ditches to be constructed around the site. The purpose of the ditches is to intercept surface water runoff and direct it around the site and to provide for surface water

management at the site. The ditches will be engineered, and where they are in peat, measures will be taken, similar to those for roads and access tracks.

Following excavation of peat, there is a possibility of minor slippage from the cut face of the peat mass; therefore regular inspections are proposed checking for evidence of instability (cracking, bulging, excessive discharge of water or sudden cessation in discharge). It is also proposed within the PMP that stability analysis will be conducted to determine Factor of Safety (FOS) where significant depths of peat are to be stored adjacent to an excavation. Finally, monitoring will be undertaken post-construction to ensure that hydrological pathways from the peat are maintained.

Golder conclusion:

The proposed areas for peat habitat enhancement and the storage of peat before re-use in restoration has been addressed for engineering assessment and design to ensure their stability. The ground conditions based on initial assessment and as part of the DSF suggest the underlying glacial substrate would be a suitable surface for creation of peat storage areas. The long-term re-use of peat for habitat enhancement requires engineered retention berms and/or cells which are proposed to be keyed into the underlying (mineral subsoil) substrate to ensure stability.

22.3.6 Peat Landslide Hazard and Risk Assessment

A Peat Landslide Hazard and Risk Assessment (PLHRA) was undertaken in 2017 for the project site and identified areas of Negligible, Low and Medium risk at the proposed infrastructure site (Area A) without any infrastructure development. There were only two small areas identified as being of medium risk and they are located in the north east corner of the site and will be excavated as part of the development thereby removing risk. No areas of high risk were identified in the assessment. The PLHRA was undertaken in respect of in-situ peat at the existing site, without any infrastructure development.

Golder notes that slope stability assessments have been carried out for the peat enhancement area and that the factors of safety obtained for this assessment were all suitably high. It is noted that this assessment should be repeated at detailed design or even construction stage when more data is available for the underlying conditions and the topographical conditions at the peat enhancement area.

Golder comment:

It is considered that the guidance documents listed within the PMP provides suitable guidance to work with. Golder notes that it is confirmed by SLR that the PMP has been prepared in accordance with the principles in the guidance for a Stage 1 plan and Golder further notes that the PMP is a comprehensive document that provides significant detail. The objectives of trying to avoid where possible, and where not possible to avoid, to reduce the volume of peat generated has been largely met through the site selection of the location for the infrastructure.

Golder conclusion:

The outline CEMP details a significant number of mitigations and methodologies that will be used to ensure the proper management of peat at the site for optimal re-use. The construction stage CEMP should be adequate if it takes into account all of the details outlined at this stage.

Golder also notes that the proposals outlined within the PMP for inspections and monitoring are adequate and is noted that stability assessments are also proposed where necessary. Golder has also considered the peat risk ratings and note that these are considered to be negligible or low for almost the entirety of the infrastructure site.

Golder notes that slope stability assessments have been carried out for the peat enhancement area and that the factors of safety obtained for this assessment were all suitably high. It is noted that this assessment should be repeated at detailed design or even construction stage when more data is available for the underlying conditions and the topographical conditions at the peat enhancement area.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the Peat Management Plan fit for purpose and suitable to be presented to Public Inquiry?	✓		

23.0 REVIEW OF APPENDIX F - PEAT SLIDE RISK ASSESSMENT

23.1 Chapter Summary

Appendix F contains a Peat Landslide Hazard and Risk Assessment (PLHRA) report which has been prepared by SLR on behalf of DGL. It is noted that the PMP for the project was updated following an FEI request from the DfI in March 2019. The key changes involved the removal of two storage cells to the west of the proposed DSF, and the use of the area of the proposed DSF for peat storage. The PLHRA was also updated subsequent to the update of the PMP.

SLR states that the purpose of the PLHRA is to determine whether the presence of peat occurring at the proposed infrastructure site (Area A) poses a potential risk, such that suitable controls and appropriate methodologies can be employed during design, construction and commissioning of the proposed infrastructure to mitigate against potential risks from peat instability. The purpose of this PLHRA is also to ensure that there has been systematic consideration of peat landslide risk both in its present state and during the construction stage activities associated with the proposed mine infrastructure development. This report addresses all peat at the proposed infrastructure site that is present and is to be excavated and relocated during the construction phase.

In the PLHRA, it is stated that "*the principal objective of this assessment was to establish the extent of organic peat (>0.5 m) and peaty soils (at the proposed infrastructure site, with the purpose of identifying potential for instability at the site, areas of potential concern and any mitigation measures required to ensure the maintenance of peat stability before, during and after planned construction. All aspects of construction would be based on ensuring minimum disruption to peat areas, by avoidance of deeper peat in the first instance during an iterative layout design process, and secondly, if peat cannot be avoided, by minimising disturbance through good construction practice*."

23.2 Site Description relative to Peat

23.2.1 Site History

The site has been used extensively previously for peat / turf cutting for fuel, with large areas of peat being removed for fuel; the site has also been used for grazing. There are a limited variety of soil types in the area around Curraghinalt. Upland areas are characterised by peat, while the valley floor areas are characterised by soils derived from alluvium with localised peaty soils where drainage is poor. The area underlying the proposed infrastructure site is predominantly underlain by glacial till / weathered rock and peat on elevated ground, with glaciofluvial deposits, typically sands and gravels in valley floor areas.

The proposed infrastructure site is underlain by areas of peat deposits overlying sandy clays and minor sandy silts derived from underlying bedrock which has been weathered in situ or transported a short distance. Peat

thickness is generally between 0.1 to 1.0 m, with thicker peats at the eastern edge of the area which are up to 6.5 m in thickness at the valley mire.

It's believed that the peat has been extensively worked in the local area for more than 400 years and many of the existing fields used for grazing would have been covered in peat. The peat has therefore been extensively modified, either reduced in thickness or removed entirely. The areas where the processing plant and crusher stockpile area are to be located have all been subject to modification over the centuries.

23.2.2 Assessment of Current Site Conditions

The soils at the proposed infrastructure site comprise peat on the higher slopes and poorly drained Gleys on the lower slopes. The Gley soils have been improved through drainage for agricultural pastures. A ground investigation comprising boreholes and trial pits was undertaken across the infrastructure area and some comment has been provided on this in Section 22.0 (Appendix E, Peat Management Plan).

The PLHRA notes that the principal environmental receptors lying downgradient of the proposed infrastructure which could be susceptible to potential adverse effects from a peat landslide are most likely to be watercourses and water bodies; residential properties and farmland; and ecological habitats. The main influences on slope stability from a peat perspective are geological, geotechnical, geomorphic, hydrological, topographic, climatic, agricultural and human influences such as drainage and construction activity. It notes that peat stability is affected to a degree by changes to any of the above listed factors and, as such, it is vital to appreciate that changes to the existing equilibrium will affect the level of slope stability during construction and operation of the proposed infrastructure. It is further noted that potential instability outside the boundary of the site can also impact the stability of peat within the site or the infrastructure on the site itself.

The PLHRA also states that the principal surface indicator of peat slide potential is cracking of the peat land surface and it is the identification of crack patterns in the field and the attendant causes of the cracking that is fundamental to a peat stability assessment. Sites that have exhibited natural instability in the past are likely to be more susceptible to future instability during and following construction of the proposed mine, therefore it is important to identify such instability (if present) as part of the Peat Stability Assessment.

The PLHRA provides descriptions on the different types of instability in peat; namely bog bursts, peat slides and bog slides. Of note within these descriptions are that bog bursts are normally seen in peat depths greater than 1.5 m and in areas where the peat is typically annually waterlogged. Also, peat slides can occur in peat depths up to 2 m where there is a slope gradient between 5 degrees and 15 degrees with a greater humification of the lower catotelmic layer. A bog slide is typically a peat slide with slip zone internally within the different peat strata.

The report also notes the following "*The stability of a peat mass is maintained by a complex interrelationship of many factors, some of which may not be immediately obvious. Significant factors include sloping rock head and proximity to a water body. Rainfall often acts as the trigger after the slope has already been conditioned to fail by natural processes.*"

Golder comment:

A summary is provided of the peat surveys, assessments and investigations that have been completed at Curraghinalt and at the proposed infrastructure site in particular. This is similar to that provided within the PMP (Section 22.0) and no further commentary or summary is provided here.

Golder conclusion:

Satisfactory.

23.3 Planning of Site Infrastructure

A large extent of the site was found to have a thin peaty soil cover over glacial till, however peat is extensively developed along the eastern edge of the site. To the northeast, the peat is typically peatland bog and will have limited impact from the proposed infrastructure. The eastern edge of the site is identified as a valley mire, an area of deeper peat associated with the Pollanroe Burn.

The Phase 1 GI data was used to guide decisions on the siting of infrastructure in the early stages of project planning; the proposed infrastructure site was located off the peat capping the ridge between the Owenreagh River and Owenkillew River as far as is possible taking account of other constraints.

The report notes the following in relation to how peat depths were assessed:

- If the soil is less than 0.5 m thickness, then it is considered peaty soil;
- Thin peat was classed as being 0.5 m to 1.5 m thick; and
- Deposits of peat in excess of 1.5 m were classed as thick peat.

It is noted that almost half (49.6%) of the probes intersected peaty soils (less than 0.5 m), with a further ~28% encountering peat depths between 1 m and 1.5 m. Only ~14% of probes encountered peat depths in excess of 1.5 m. The majority of this 14% is noted to be within the 1.5 to 2.5 m depth range and it is noted that peat depths between 2.5 and 3.0 m and greater than 3.0 m are both less than 1 %. Further to this, the PLHRA states that "*Accumulations of peat up to 0.5m thick are considered to be too thin to be classified as true peat accumulations and are often classified as organic soils or peaty soils*." On this basis, it notes that more than 27% of the samples probed were deemed to be peaty soils.

Golder comment:

No further commentary or summary is provided here.

Golder conclusion:

N/A.

23.3.1 Locational Findings

Similar to the PMP, the PLHRA concludes that the peat depth probing has shown that the majority of the deep peat is located along the valley mire area along the east and south east of the site, with some deeper peat to the north east.

In the PLHRA, SLR has produced a drawing (Figure 6) which shows the extent and depth of the peat recorded. This is the same figure that was included within the PMP and Golder has provided some comments in relation to peat depths within the infrastructure area within this Section and in Section 23.3.2 of this report. However, the following section presented in the PLHRA was not included within the PMP and is included here as it provides some useful information on the areas where the more significant depths of peat are located:

"*The depth of peat within the proposed infrastructure area varies considerably ranging from shallow peaty soil of 0.2 m up to deep peat in excess of 5 m. The areas with the deepest peats are found within the mire area at the head of the Pollanroe Burn valley and in the mire area along the upper Pollanroe Burn valley where 6.4 m of peat was recorded and is the deepest known area of peat in the entire proposed infrastructure site. Further areas of deep peat up to 4 m in depth are found at the mire area at the head of the Pollanroe Burn on the edge of the peatland and on the valley floor but generally the valley ridges and slopes have shallow peat. The main peatland area on the slope of Crocknamoghil typically has peat ranging from 0.2 m up to a maximum depth of 1.6 m. It appears that this whole area has been historically cutover that has removed in the region of 1 m of*

peat, evident by the level of peat adjacent the northern boundary of the site and by small remnant areas of elevated peat with vertical banks. Further degradation of the peats have occurred through drainage and damage caused by grazing livestock."

The PLHRA provides some information on the peat characterisation of the peats encountered in the main mire area on Crocknamoghill Ridge as well as the infrastructure area including the valley mire. It also noted that the substrate encountered was noted to be either a sand and / or gravel, of glacial origin (glacial till) and occasionally interbedded with silty sands or rock.

Golder comment:

No further commentary or summary is provided here.

Golder conclusion:

N/A.

23.3.2 Ground Conditions

In Table 5.2 of the PLHRA, SLR presents an outline of the ground conditions found at each of the infrastructure locations characterising the general site conditions, slope and peat classification. This indicates that the access track, the DSF, the upper and lower East Ponds the Clean Water Pond, the Warehouse / Mine Rescue Pad and the Car Park will all encounter maximum peat depths in excess of 1.5 m, however averaged depths of peat are significantly lower (all less than 1.3 m and less than 0.8 m when the two East Ponds are excluded). No evidence of instability within the peat was noted in the inspections. It is noted from Table 5.2 that the Clean water Pond and the Car Park are the two areas with maximum peat depths greater than 1.5 m which have steep slopes noted within the gradient description.

Section 6 of the PLHRA presents the methodology and findings from the actual Peat Landslide Hazard and Risk Assessment itself. SLR notes that following its site reconnaissance visit and appraisal of the available data, the potential for a peat slide occurring at the site was assessed as 'negligible' to 'low'. This was based on the fact that there was no evidence of historical or current peat slide activity at the site and the conclusions of a detailed site walkover and results from site probing as well as significant proportion of the site is underlain by peaty soils. To further quantify this initial assessment, SLR carried out analysis of the terrain at site utilising GIS to analyse in situ ground slopes and gradients. Figure 5 confirms that the ground slopes at site in the vicinity of the proposed site infrastructure are generally less than 8° with some steeper gradients associated with incised water courses.

In relation to the methodology, the PLHRA notes the following: "*The site specific slope data has been combined with the site specific peat depth data and using SE Guidance for the assessment of the risk of instability in peat, an assessment of peat slide risk has been completed. The method of risk and hazard assessment has been developed with reference to the SE Guidance. Key factors which may have an effect on the stability of the peat deposits have been identified leading to an assessment of the risk of instability. Having been assessed, the hazard was then considered for identified potential receptors. Coefficients were attributed to the key factors that have the greatest influence on peat stability. Risk coefficients were determined, which, when combined with an assessment of vulnerability of potential targets, were developed into an assessment of the hazard*."

SLR describes the coefficients used for slope gradients for both risk and hazards in Table 6.1 of the PLHRA. It notes that the objective is to determine the peat areas that would have an effect on the proposed infrastructure and to set out the mitigation to be adopted and incorporated into the design of the proposed infrastructure.

Golder comment:

An inspection of Figure 6 from the PLHRA, shows that the car park has been largely located to avoid the peat and it is considered that the greater depth of peat is likely to be very localised. The Clean Water Pond, although it is partially located in an area without any peat, does require some significant excavation into a valley with steeply sloping peat deposits and this is considered to be the area that presents the most significant risk from a review of the available data.

The stability of peat is a complex subject and there are numerous inter-relationships that affect the stability. For this reason, the PLHRA states that "*a purely quantitative assessment should only be considered as a guide and a qualitative assessment of stability should be used to inform the final recommendations*". This statement is based on the premise as stated by SLR that a quantitative assessment requires a numerical input and such an analysis cannot account for the unquantifiable input required for a comprehensive peat stability assessment.

SLR notes that the main factors controlling the stability of the peat mass are the surface gradients, the depth and condition of the peat at each location and the type of substrate. Further, SLR states that although the natural moisture content and undrained shear strength of the peat are important, it is generally accepted that where present, the peat will be saturated and have a very low strength and that it would be unrealistic to rely on specific values of shear strength to maintain stability when previous analysis of failed slopes indicates that there is often a significant discrepancy between measured strength in peat and stability. For this reason, worst case assumptions for shear strength and groundwater level have been made.

Golder conclusion:

This approach is considered to be suitably conservative given the nature of the peat assessment.

The four key factors identified as being critical to stability and the development of a risk rating system and for which risk coefficients have been allocated are:

- A - Slope gradient – graduated gradient scale from 0° to >12° which largely covers the potential for both peat slides (gradients of 4-15°) and bog slides (gradients of 2-10°). Coefficients range from 1 for slopes less than 2° to 8 for slopes greater than 12°;
- B - Peat thickness and ground conditions – coefficients are based on the depth of peat from the peat probing, these range from 1 for peat less than 0.5 m depth, 2 for thin peat (0.5 to 1.5 m) and 3 for thick peat (greater than 1.5 m). A coefficient of 8 has been allowed where there is evidence of historical instability however it is also noted that this has not been used due to no evidence of same;
- C - Substrate type or condition – coefficients are based on the type of underlying stratum with sand/gravels allocated a 1; clay and rock allocated a 2 representing softening of the clays or a smooth rock head and unknown underlying stratum allocated a 3; and
- D - Historic instability - evidence of previous slips allocated a 5. As there was no evidence of historical instability, this aspect was ultimately removed from the assessment.

The risk rating coefficient or score was derived by multiplying the coefficients for factors A, B and C above enabling potential areas of concern to be highlighted. If the risk rating co-efficient is less than 5, this risk is considered negligible, if between 5 and 15, the risk is considered low, between 15 and 31 has been allocated a medium risk and a risk rating of greater than 31 is considered high risk based on the SE Guidance 2017. The guidance provides suggested actions for each risk rating, with negligible requiring monitoring, low requiring further investigation and hazard mitigation, medium requiring risk avoidance or mitigation measures to reduce risk to low and high suggesting avoidance of development at these locations. It is noted that the addition of

substrate into the assessment is over and above the latest SE Guidance and is considered by SLR to make the assessment more robust.

23.3.3 Locational Studies at Probe Locations

An assessment was carried out by SLR at each of the 1,763 probe locations. The stability risk rating identified the following:

- Negligible risk at 953 probe locations;
- Low risk at 793 probe locations;
- Medium risk at 17 probe locations;
- High risk at 0 probe locations; and
- No peat was recorded at 395 probe locations, hence no risk.

SLR presents a drawing, Figure 7, which presents the interpreted risk of peat instability based on the multiplication of the risk coefficients discussed above. A review of Figure 7 indicates that the vast majority of the infrastructure area is coloured green or yellow indicating negligible of low risk. This assessment is based on the stability of the peat in its current status ie without any construction having taken place.

Golder comment:

Golder notes from Table 6.6 of the PLHRA that all infrastructure locations with the exception of the Clean Water Pond return a negligible, low or negligible to low risk. The Clean Water Pond itself returned a low to medium risk reflecting the fact that it is only partially located within an area of peat but that the area of peat contains some steep side slopes.

When the above assessment is repeated with consideration given to the construction of the proposed infrastructure but with no mitigation measures considered, the risk ratings for some infrastructure locations change. The assessment indicates that during and post construction, the peat stability risk for most areas remains Low, however for the DSF, Clean Water Pond, Upper East Pond, Track to Access Mine and sections of the New Public Road, the risk is Medium to High without mitigation.

Golder conclusion:

Golder notes however that what is being tested here is a hypothetical scenario where the mine infrastructure is constructed as planned but without the removal of any underlying peat. This is a test which indicates that it is not a workable solution to not mitigate the presence of peat below these items of infrastructure. It is noted that the risk associated with these infrastructure areas is associated with the loading of peat in the valley mire ie in the area of the Clean Water Pond and to the east of the DSF and East Ponds.

23.3.4 Investigation into the Five Infrastructure Areas returning potentially greater risks

The next assessment carried out by SLR looks at these five infrastructures areas which returned either a Medium or a High risk. It is considered that all other areas that returned a low risk do not require any further mitigation. This assessment looks at a range of mitigation measures before applying the most appropriate and repeating the assessment. The conclusion is that the most appropriate mitigation measure is to remove the peat from beneath the items of infrastructure thus removing the risk completely. When the risk assessment is completed for this mitigation scenario, all five of the areas which identified as a Medium or High risk when no mitigation measures were considered now return a Negligible risk.

Golder comment:

The overall conclusion in the PLHRA regarding peat stability is that the existing risk is Negligible to Low risk of peat instability over the site at present, before any construction works. Some very limited areas of medium risk have been identified but do not occur on the proposed infrastructure.

Golder conclusion:

The infrastructure will pose no significant risk to peat stability with a risk rating of Low during and post construction. This is on the basis of all peat encountered below the relevant site infrastructure being excavated and removed as a mitigation measure.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the Peat Slide Risk Assessment fit for purpose and able to be presented to Public Inquiry?	✓		

24.0 REVIEW OF APPENDIX G - MINE WASTE FACILITY FEASIBILITY STUDY REPORT & ADDENDUMS

24.1 Chapter Summary

Appendix G presents a report which provides details of the design of the MWF. Further to this report *Mine Waste Facility Technical Design Report for the Curraghinalt Project, County Tyrone, Northern Ireland* are two additional addendums which issued after the original report issued in November 2017. These are as follows:

- *Addendum: Mine Waste Facility Design Curraghinalt Project, County Tyrone, Northern Ireland* which was issued July 2019. This addendum updates the design with a number of modifications which impact the MWF, primarily in relation to the makeup of the waste materials. Details of additional laboratory testing are provided; and
- *Addendum 2 - Second Addendum: Mine Waste Facility Design, Curraghinalt Project, County Tyrone, Northern Ireland* which was issued in June 2020. This addendum presents a modification to the shape of the MWF which in turn led to minor adjustments to the MWF design, including a slight shift northward and steepening of the slope on the north side of the MWF to maintain a storage capacity of 4.8M cubic meters. Also presented are updated seepage analyses for the WMF.

All of these documents were created by SRK for DGL. Although Golder has reviewed all documents in order to understand the development of the design, review comments have in general only been provided for the latest design variations where the design has developed. Comments on previous design variations are only provided where there is some relevance to the final design.

In its report *Mine Waste Facility Technical Design Report for the Curraghinalt Project, County Tyrone, Northern Ireland*, SRK notes that the scope of work associated with the MWF design includes the following tasks:

- Completion of an overburden geotechnical investigation, including field investigations and a subsequent laboratory testing programme, to characterise the sub-surface geotechnical conditions, tailings and waste rock, to support the MWF design;

- MWF design, including the facility layout and the design of the facility components, including the internal water management aspects;
- Determination of the material quantities to construct the MWF; and
- Provision of documentation relative to the project description and planning application.

24.2 Consideration of Relevant Legislation

In relation to legislation and European Union Directives, incorporating Best Available Technologies (BAT) from the European Commission, SRK notes that the following have been used:

- *Planning (Management of Wastes from Extractives Industries) Regulations (Northern Ireland) 2015 (SR 85);*
- *Extractive Waste Directive 2006 and Extractive Waste Directory Annex 2010-2012;*
- *European Commission Reference Document on Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities 2009;*
- *Quarries Regulations (Northern Ireland) 2006 (SR 205);*
- *Water Environment (Floods Directive) Regulations (Northern Ireland) 2009 (SR 376);*
- *Reservoirs Act (Northern Ireland) 2015;*
- *Mines and Quarries (Tips) Act 1969; and*
- *EPR6.14 Additional Guidance for Mining Waste Operations, Environment Agency 2011.*

Further to the above list of legislation, SRK notes that international guidelines which represent current best practice in relation to mine waste management have been used during the design of the MWF and that reference will be made to these within the individual sections.

Golder comment:

Golder has assessed the legislation and guidance referenced by SRK and considers that the list presented is suitable for a development such as Curraghinalt. Similarly, Golder considers that the use of international guidelines which represent best practice is a suitable approach.

Golder conclusion:

The legislation cited and approach regarding international industry guidance are acceptable.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the list of legislation cited for the design of the MWF considered adequate?	✓		
Is the approach of using BAT and international industry guidance for the design of the MWF considered suitable?	✓		

24.3 Review of Project Setting

The following points were considered noteworthy to the design of the MWF during Golder's review of Section 2 (Project Setting) of the report *Mine Waste Facility Technical Design Report for the Curraghinalt Project, County Tyrone, Northern Ireland*:

- The Mullaghcarn Formation is host to the Curraghinalt gold deposit and consists predominantly of semi-pelites and psammites with subordinate pelite horizons and chloritic semi-pelites;
- The 2007 seismic hazard map provided by British Geological Survey (*BGS 2016*) indicates the project site is located within the zone of lowest peak ground acceleration (PGA) as measured by units of gravitational force, g. This is due to the infrequent occurrence of any significant earthquakes in this area throughout the historical record (*BGS 2016*). The expected PGA within this area ranges from 0.005 g to 0.02 g for a 2,500 year return period;
- The Owenkillew and Owenreagh Rivers are within the River Foyle and Tributaries Special Area of Conservation (SAC), which supports a significant presence of Atlantic salmon and otter. The Owenkillew River also features a significant population of the freshwater pearl mussel, as well as extensive beds of Stream Water. The Owenreagh River is an ASSI for the feature of freshwater pearl mussel;
- The project area is characterised by annual rainfall in the order of 1,150 – 1,350 mm per annum, with high seasonality. The wettest period is between October and January and the driest period between April and July; and
- The hills forming the ridge between the Owenkillew and Owenreagh Rivers comprise a hydraulic divide with groundwater flowing away from the high ground towards the valleys. Piezometric groundwater levels in the fresh bedrock in valley areas are greater than shallow units indicating a natural upward gradient and discharge to the river valleys. Most groundwater flow is shallow, discharging locally and rapidly to surface waters.

24.3.1 Ground Conditions

In its report *Mine Waste Facility Technical Design Report for the Curraghinalt Project, County Tyrone, Northern Ireland*, SRK notes that the main objective for the ground investigation was to complete the geotechnical and hydrogeological characterisation of the foundation conditions for the MWF, the proposed Process Plant and the surrounding areas where associated infrastructure will be situated in accordance with Part V of the *2006 Northern Ireland Quarries Regulations (SR 205, 2006*).

The SRK ground investigation (2015-16) comprised 11 boreholes and 23 trial pits with a combination of in-situ and laboratory testing. Six boreholes and seven test pits were completed in the vicinity of the MWF. According to SRK, the sub-surface conditions encountered within the MWF area typically consists of:

- Top Soil (Peaty soil) – consists of dark grey to black, sandy silty peat with high organic content. The average thickness of this layer was observed to be approximately 0.6 m, with a soft to firm consistency;
- Gravelly Sand or Silty Sand – composed of gravelly sand with some silt extending from 0.6 m to 3 m below ground surface. The thickness of this layer is minimal on the east limit of the MWF boundary and increases moving towards the west. Also, the east part of MWF footprint has a higher silt content. The N value for this layer ranges from 28 to >50 blow counts indicating this material is dense to very dense;
- Weathered Schist – Consists of light greyish brown cobbly gravel with some sand and a trace of silt. This layer extends from 3 m to 6.5 m below the ground surface. The N values were >50 blow counts indicating this material is very dense; and

- Fractured Schist – The fractured bedrock extends from 6.5 m to 18 m below the ground surface.

SRK notes that based on the measured water levels in the piezometers and the recorded water level in the test pits, the average depth of groundwater is approximately 2 m below the ground surface within the footprint of the MWF.

Further the report notes that SPT tests were conducted in all the boreholes drilled. Most of the results reported refusal in the bedrock geology. The report *Mine Waste Facility Technical Design Report for the Curraghinalt Project, County Tyrone, Northern Ireland* presents a range of 28 - >50 N values for the gravelly sand and >50 for the weathered bedrock geology *(Section 3.3 – Sub-surface soil stratigraphy)*.

Golder comment:

The reported SPT N-value (range of 28 - >50) for the gravelly sand and silty sand omits two results of 17 (BH07) and 26 (BH10). Although these values were not used to calculate the strength values, it is noted that the range of strengths within the MWF footprint is wider than reported. However, it is considered that a suitably extensive ground investigation has been carried out and it appears that a reasonable understanding of the sub-surface conditions has been obtained suitable for the level of design development.

Golder conclusion:

Golder considers that the ground investigation into the sub-surface conditions at the Curraghinalt site has been adequate for the level of design development currently being considered.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the extent of the ground investigation considered adequate for the level of design development and has an adequate understanding of the sub-surface conditions been developed?	✓		

24.3.2 Basis of Design

In its report *Mine Waste Facility Technical Design Report for the Curraghinalt Project, County Tyrone, Northern Ireland,* SRK notes that the ore reserve is estimated to be approximately 8.6 million tonnes (Mt) over a mine life of 20-25 years.

MWF Storage Requirements and Sensitivity

The mine life waste storage requirements have been estimated assuming placed densities of 1.5 t/m^3 for the tailings, 2.04 t/m^3 for the waste rock and 1.95 t/m^3 for the ore sorter rejects. SRK notes that there is potential for both the water content and compacted dry density to vary with time, especially during periods of high precipitation. Proctor testing indicates that the tailings have a maximum dry density of 1.65 t/m^3 at an optimum moisture content of 16.5%. SRK further notes that if the moisture content was to increase by 5%, the maximum dry density reduces to 1.55 t/m^3.

In its report, *Mine Waste Facility Technical Design Report for the Curraghinalt Project, County Tyrone, Northern Ireland,* SRK provides a range of densities that might be achieved for the tailings and the mine rock, these ranges are considered by SRK to be conservative:

- Tailings densities could vary from 1.5 t/m^3 to 1.65 t/m$^{3;}$ and

- Waste rock densities could range from as low as 1.8 t/m^3 to as high as 2.1 t/m^3.

SRK references the Greens Creek dry stack facility in Alaska which it states achieved mean placed densities in the order of 98.8% of the Standard Proctor maximum dry density (with a range between 88% and 104%) in 2015. SRK notes that this was in a region with comparable rainfall to the Curraghinalt Project, but with a much finer tailings product.

SRK notes in the second addendum that *"mine waste which cannot be stored underground must be stored in the MWF".* For this reason, it states that the mine waste strategy incorporates two technologies recognised by the EU as best available technologies for minimising the quantity of mine waste that must be stored on surface, these are: 1) the use of waste rock and tailings as underground backfill and 2) the use of ore sorting to reduce the quantity of processed ore and therefore, the quantity of tailings.

Golder comment:

Golder is satisfied that the densities used for estimating the required storage space in the MWF are reasonable. The range of densities provided by SRK are considered to be realistic as there will be variability in the mine rock for example. The level of conservatism in relation to the range of densities that will be achieved for the tailings is somewhat of an unknown and it is possible that the range will be wider than expected. However, Golder is satisfied that the averaged density selected for the purpose of this capacity assessment is appropriate given the available data.

Golder notes the report *Mine Waste Facility Technical Design Report for the Curraghinalt Project, County Tyrone, Northern Ireland* states that the total storage requirement could be as high as 5.3 Mm^3 (compared to the base case of 4.9 Mm^3). This is an additional 0.4 Mm^3 approximately or 8%. While it is recognised that these quantities have since been superseded by revised quantities in Addendum 2, the concept of a maximum increased requirement of approximately 8% is likely to be still valid as will be the prospect of risk mitigation by increasing the footprint of the facility in a westward direction (pending further permitting approvals).

Given that much of the mine rock will be placed for engineering purposes to a specified density, Golder considers that the mine rock aspect of the MWF capacity sensitivity assessment is likely to be conservative.

Golder conclusion:

Golder considers that the MWF storage assessment and sensitivity analyses to be appropriate and that a suitable mitigation is possible for an overrun scenario should it arise.

Seepage Analyses

It is noted that updated seepage analysis was provided in Addendum 2. This update was based on the additional laboratory testing results. Golder has carried out a review of Appendix I *DSF and Pond Seepage Review, Curraghinalt Gold Mine Project, Northern Ireland* of the WMP which presented an in-depth analysis of seepage from the WMF. Review comments from Golder review are contained in Section 26.0 of this report.

The modelling indicates the phreatic surface could vary between 2.5 to 5.0m under normal operating scenarios over the life of mine. SRK notes that the outputs from seepage modelling were used to optimise the geometry and frequency of overdrains and horizontal drains. Further to this, Golder has noted that the seepage modelling has fed into the slope stability sensitivity analyses.

MWF Layout

SRK notes that the MWF layout comprises an area of 28 ha and is designed as a mine waste facility for co-disposal of dewatered tailings and waste rock. The layout provides storage of 4.8 Mm^3 of mine waste (both

tailings and waste rock) in three cells which will extend the facility platform to a final elevation of 286 AOD. SRK also notes that the design remains consistent with the 2017 ES.

Northern Ireland Facility Classification

SRK provides a summary of what constitutes a Category A classification, as outlined in Schedule 3 of *The Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015.* Golder has provided comments on the classification of the facility in Section 4.0 of this document. SRK notes that although the MWF is not a Category A facility, it has been designed to meet the requirements for a Category A facility.

Design Parameters and Design Criteria

Table 5 of *Mine Waste Facility Technical Design Report for the Curraghinalt Project, County Tyrone, Northern Ireland* provides the design parameters and design criteria for the MWF. It is noted that stability requirements have been sourced from UK seismic hazard (BRE 1991) and European mine waste guidance that relates to Directive *2006/21/EC* and complemented by international best practice references CDA (2013, 2014) and ICOLD (1989, 1996, 2011).

SRK notes in Addendum 1 that although the MWF is not classed as a Category A facility and there is therefore no regulatory requirement to install a geomembrane beneath the MWF, DGL has committed to constructing the MWF over an HDPE liner in order to limit MWF seepage from entering the underlying foundation materials.

In Addendum 2, SRK notes that the design parameters and seismic design criteria, are based on a combination of Canadian Dam Association (CDA, 2019), ICOLD and Eurocode guidelines.

Golder comment:

Golder is satisfied that the design parameters and design criteria are suitable and adequate for the MWF.

Golder conclusion:

Golder considers the selection of design criteria and FOS with an inclusion of reliance on CDA and ICOLD guidelines to be appropriate as these are generally more stringent and are also one of the most readily accepted guidelines for mine waste design in the industry.

24.3.3 Laboratory Testing

Superficial Deposits

SRK undertook laboratory testing on the superficial deposits to characterise the material and determine geotechnical parameters for the stability analysis. Particle Size Distribution (PSD) testing of 24 samples determined a majority of the superficial material to be granular with only five samples considered fine grained. *(Mine Waste Technical Design Report 2017 – Appendix A – Ground Investigation summary – Section 3.2 – In-situ Testing and Results and Groundwater Depths - Appendix E – Overburden Laboratory Results Summary).*

Two disturbed samples were taken, one from within the MWF footprint (TP13) and the other to the west (TP20). Proctor testing was carried out to determine the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) for the samples *(Mine Waste Technical Design Report 2017 – Appendix A – Ground Investigation summary – Section 4.1.5 Proctor Compaction tests)*. These parameters were then used to prepare the shear box samples. The shear box results gave a lower bound peak strength of 19 kPa cohesion and 35° friction angle and residual strength of 3 kPa cohesion and 31° friction angle *(Mine Waste Technical Design Report 2017 – Appendix A – Ground Investigation summary – Section 4.1.6 Direct Shear Testing)*.

For the modelling of the material, a cohesion of 0 kPa and friction angle of 35° was adopted and referred to as a conservative estimate. No undrained values were required as the foundation was considered to be granular

and therefore would drain *(Mine Waste Technical Design Report 2017 - Appendix D – Stability Analysis – Section 2.3.3).*

Golder comment:

The geotechnical strength parameters appear to be representative from the data set collected by SRK. This can be confirmed at later stages of design development through additional direct shear testing which will better constrain the strength properties. The observed peak strength of the material when including cohesion is above the modelled value.

Golder conclusion:

The selection of parameters from laboratory testing is considered to be acceptable.

Bedrock Geology

There are no reported tests conducted on the underlying bedrock described as Weathered Schist from 3 m to 6.5 m below ground level becoming Fractured Schist proven to 18 m below ground level. *(Mine Waste Technical Design Report 2017 – Appendix A – Ground Investigation summary – Section 5.3 MWSF Area)*.

Golder comment:

It is unclear how geotechnical properties assigned to these layers have been assessed. It is noted that these values are critical to the stability analyses of the MWF since deep seated failure planes are modelled penetrating through these layers. Additional information and analyses should be sought at detailed design stage however it is considered that the assumptions made regarding the geotechnical properties of the bedrock are adequate for the current stage of design development.

Golder conclusion:

The selection of geotechnical properties for the bedrock is considered adequate for the current stage of design development.

HDPE Liner interface

The frictional strength between the liner and the dewatered tailings was highlighted by SRK as a key stability risk. This interface friction will be lower than the internal frictional properties of the dewatered tailings and the underlying bedding layer.

SRK undertook lab testing on smooth and textured HDPE liner and identified early in the design process that a textured liner would be required to comply with the FoS requirements. This was initially taken to be an interface friction angle of 34° which was later amended to 32° following further test work (SRK, 2019) *(SRK 2019 Addendum - Appendix B – Stability Analysis Update)*.

SRK has then selected an interface friction angle of 25° (with sensitivity analysis dropping the value to 20°) in the final round of stability analysis (SRK, 2020) *(SRK 2020 Addendum - Appendix B – Stability Analysis Update – Table 3-8)*.

Golder comment:

Golder does not understand the reason for the reduction in interface friction to 25° for the most recent set of analysis as the results of the test work (SRK, 2019) gives a strength of 30°+. This reduction is a conservative approach and as a result the modelling shows that even if the interface friction angle is worse than anticipated (from poor connection between the material or damage to the liner), then the MWF still complies with the required FOS.

Golder conclusion:

The approach of selecting parameters for determining the FoS for the HDPE liner interface is considered adequate even if conservative.

Ground model layout

The Mine Waste Facility report (SRK, 2017) provides a summary of the ground investigation undertaken 2015 – 2016. The report highlights that only 6 boreholes and 7 trial pits were included when determining the site wide ground model. *(Mine Waste Technical Design Report 2017 – Section 3.3 – Sub-Surface Soil Stratigraphy).*

Golder comment:

Additional borehole and trial pits are present within proximity to the stack and could be included in creating the ground model. Golder considers that a total of ten borehole and 13 trial pits should be included. The results from BH 02 found a deeper weathered profile than that of the ground model. Golder notes however that the stability assessment found the foundation soils to not be problematic from a stability perspective. Despite this, it would be considered prudent to expand the profile in future stages of design development.

The ground model selected for the stability analysis (3 m superficial deposits and 3.5 m weathered zone) is considered by SRK to be a conservative and representative ground model for the MWF *(Mine Waste Technical Design Report 2017 – Section 6.2.1 – Model Development and Appendix D – Stability Analysis)*. Golder has been unable to determine if this is conservative as outlined above, a greater selection of exploratory locations could increase the thickness of the superficial deposits.

Golder conclusion:

From the GI data available, Golder agrees with the ground model presented by SRK.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the ground model considered to be adequate for the current level of design development?	✓		

24.3.4 Tailings Parameters

Over the period of time that the design for the MWF has been developed, six rounds of tailings testing were completed to establish the physical properties of the tailings as a result of changes to the gradation of the crushed ore used to feed the processing plant and to the metallurgical process. A brief description of these different rounds of testing is provided below:

- First Round (2015): An initial round of tailings test work was completed on tailings samples composed of silty sand with an average of 44% (by weight) passing 0.075 mm. These tailings were found to be non-plastic with 9% clay sized particles and a specific gravity of the tailings particles of 2.75;
- Second Round (2016): sample composed of coarser material, mainly composed of silty sand with 33% (by weight) passing 0.075 mm. These tailings were found to be non-plastic with 5% clay sized particles and a specific gravity of the tailings particles of 2.72. At the time, it was anticipated that this sample was more representative of the tailings that will be generated during the life of mine;

- Third Round (2017): samples tested had the same gradation as those tested in 2016. This test work was completed as the first and second rounds of test work included only a single Proctor, triaxial, and consolidation test;
- Fourth Round (2018): sample BL335-01 from metallurgical tests obtained using conventional processing and the use of cyanide. However, in 2019, cyanide was removed from the metallurgical process. The tailings sample was composed of silty sand with 40-50% (by weight) passing 0.075 mm and had a very low clay content due to the removal of most of the clay-bearing material as a result of the addition of ore sorting into the process. The tailings were non-plastic and the measured specific gravity of the tailings particles was 2.74 to 2.75;
- Fifth Round (2019): The test work was completed using the same tailings samples tested in the fourth round: sample BL335-02 obtained from metallurgical tests based on 96.2% rougher tailings and 3.8% scavenger tailings from a flotation circuit that involved no cyanide. It is noted that no scavenger tailings will report to the MWF however the presence of a small percentage of scavenger tailings is immaterial to the test results. The tailings had a very low clay content due to ore sorting. The tailings were composed of silty sand with 40-50% (by weight) passing 0.075 mm and were non-plastic and the measured specific gravity of the tailings particles was 2.74 to 2.75; and
- Sixth Round (late 2019): sample BL460-01 which consisted of 100% rougher tailings from a flotation circuit that involved no cyanide. Again, the tailings had a very low clay content due to the removal of clay-bearing material as a result of ore sorting.

Based on the above, it is noted that the samples of tailings tested in the sixth rounds of tailings laboratory testing is the most representative of the tailings stream that is expected to be generated and stored within the MWF. However, SRK notes that the geology of the fourth round sample is very similar to the fifth round sample and that although cyanide was used in the processing of the samples, the particle size distribution indicates the silt fraction is similar to the samples from the fifth and sixth rounds and for this reason, the test results for the fourth round was used as part of the data base related to the physical properties of the tailings.

It is noted that Paterson & Cooke Canada (P&C) carried out a range of tests in 2016 on a sample of tailings that corresponded to the round 2 sample. Thickening results indicate that 64% solids can be readily achieved for the tailings material using conventional thickening. SRK states that *"based on a tailings gradation comparison from other operations and experience, it is expected that the tailings coming off the filter press will be close to the optimum moisture content, ie approximately 13 to 15% ww/wt (15 to 17% ww/ws)."*

The test results indicate the main waste rock types have a low slaking potential and, therefore, a high slaking durability.

SRK provides a summary of the geochemical characteristics of the tailings and the waste rock within the report. Golder has however carried out a comprehensive review of Appendix C of the WMP and has provided commentary on the geochemical properties and ARD potential of both the tailings and the waste rock within Section 20.0 of this report.

Golder comment:

A wide range of testing has been completed on the tailings samples to date given the level of design development. It is acknowledged that some of this additional test work has been due to changes on the processing methodology however even the earlier test work lends itself to understanding the overall characteristics of the material even if it is no longer directly representative of the tailings stream expected to be generated. For this reason, Golder considers that an adequate level of tailings testing has been completed. In relation to the test work carried out by P&C on the thickening characteristics, it is noted that the expected tailings

stream (rougher tailings) is coarser than the sample tested and hence is expected to display similar or better thickening capacity.

Golder conclusion:

Golder considers that an adequate amount of tailings testing has been carried out and that a sufficient amount of information has been gathered on the geotechnical parameters and characteristics of the tailings.

Strength

Tailings test work has been carried out in six phases. The test work was varied as the understanding of the process and tailings output advanced. The samples from the final three rounds of testing (fourth, fifth and sixth) correspond to the rougher tailings stream which will transferred to the MWF.

Initial test work resulted in the dewatered tailing being assigned a strength of 35° (SRK, 2017) *(Mine Waste Technical Design Report 2017 –Appendix D – Stability Analysis).*

Follow up test work on the rougher tailings stream found lower friction strengths, this resulted in the attribution of a friction strength of 30° (SRK, 2019). *(SRK 2019 Addendum – Section 5.2.2 – Results and Discussion).*

Golder comment:

Golder concurs with the reduced strength value to 30° following the additional test work.

In the most recent SRK addendum (SRK, 2020) testing is presented to interpret an undrained strength ratio for the dewatered tailings. The rationale for requiring this parameter is consideration of a case where there is rapid loading of the tailings mass, and there is no time for dissipation of pore pressures. The test work showed that all samples responded in a dilatative manner (some initial contraction) and so the risk of liquefaction is not deemed to be a problem. An undrained strength ratio of 0.4 $Su/\sigma v'0$ was assigned (using the results of the initial contraction). A minimum value of 0.26 was not included as it represents poorly compacted material (82% of MDD) *(SRK 2020 Addendum – Section 4.6 – Stability results)* however this figure was later used as a sensitivity scenario.

Golder conclusion:

The undrained strength analysis for the dewatered tailings provides an additional level of analysis which provides an improved level of certainty in the design. The likelihood of an undrained response in the tailings mass is low, but it could occur if the construction is not properly managed.

Critical State

Undrained triaxial test work conducted by SRK at both 82% and 95% maximum dry density (MDD) *(SRK 2020 Addendum 2 - Appendix B Section 2.3 – Material properti*es) indicate that the tailings do not appear to be susceptible to static liquefaction with work hardening behaviour exhibited for all stress paths.

Golder comment:

It is difficult to be certain that the materials, if poorly compacted in the deepest parts of the stack, where saturation has been shown to occur in the transient seepage analyses, are not susceptible to liquefaction. To address this issue thoroughly, the development of the critical state line (CSL) is required.

Depending on the Maximum Credible Earthquake (MCE), the potential for cyclic liquefaction also requires consideration depending on the outcomes of the CSL assessment. Seepage analyses indicates that some areas within the body of the stack may remain saturated however, they remain a significant distance from the outer faces and as such are unlikely to control the stability of the stack. It is considered prudent to assess this at

detailed design stage however it is considered that sufficient assessment has been completed for the current stage of design development.

Golder conclusion:

Golder considers that sufficient assessment of the liquefaction potential has been completed for the current stage of design development.

Filter Tests

Filter test work described in the MWF design report (SRK, 2017) indicates that the moisture contents for the tailings filter cake was between 20 – 22 %. The tailings grind was subsequently modified and assumed achievable moisture contents of 15 – 17 % were reported however, no test work to support these assumptions *(SRK 2017 – Section 4.1.1 – Physical properties)*.

Golder comment:

It may be prudent to conduct filter test work on samples of the new tailings materials to check these are achievable moisture contents. However, the mixing ratio of tailings to waste rock in Cells 1 and 2 of the MWF suggest that excess moisture within the filter cake is unlikely to be of operational concern.

Golder conclusion:

Golder considers that sufficient assessment has been completed to determine the efficacy of the proposed filter operation for the proposed tailings stream for the current stage of design development.

24.3.5 Stability Models

SRK states that the three sections A-A', B-B' and C-C' were selected for the stability analyses as they were considered to be the more critical sections in terms of slope stability and to reasonably illustrate the changes in the shape and internal design of the MWF across its breadth. Some additional considerations relative to the stability assessment are outlined below:

- The analysed cross-sections were at the south and north limits of all three cross sections, including the upstream side of the ponds immediately south of the MWF (cross sections A-A and C-C);
- An initial screening analysis was undertaken to confirm the liner selection, ie whether it be smoothed or textured. The results showed that a double-sided textured HDPE liner is required to meet the minimum factor of safety requirements;
- The stability of the facility was assessed for both long-term static and pseudo-static (earthquake loading) conditions;
- The models were analysed using three modes of searches for the failure surface in order to assess both circular and non-circular failures: Grid and radius (circular failure surface), Specified entry and exit locations (circular failure surface), and Multiple fully specified failure surface (for translational sliding failures along the liner);
- An undrained strength analysis has been undertaken to address construction pore pressures; and
- Sensitivity analyses were completed to evaluate the impact of potential changes in select input parameters to the factor of safety.

In addition to the base case conditions identified above, sensitivity analyses were completed on the following key parameters:

- The sensitivity of the phreatic surface above the liner - the phreatic level of 5 m (based on seepage analysis) was considered along with two extreme cases, 10 m and 20 m;
- The sensitivity of undrained strength ratio S_u/σ'_{v0} - the base case S_u/σ'_{v0} for the tailings (0.4 based on CU testing) was reduced to 0.26;
- The sensitivity of the angle of internal friction for the tailings – the angle used was increased to assess the presence of waste rock and ore rejects in the MWF. A value of 32.5 degrees was used, which was calculated based on the expected makeup of waste within Cell 3 (which is the critical cell from a stability point of view as it contains a greater proportion of tailings);
- The sensitivity of tailings / liner interface friction angle – a reduced peak strength tailings/liner interface friction angle of 20 degrees was used instead of the 25 degrees selected from laboratory test results and published literature; and
- The sensitivity using the residual shear strength – an analysis was completed using an angle of friction of 20 degrees for tailings rather than the 30 degrees used for the base case.

Golder comment:

The additional sensitivity analysis carried out in Addendum 2 provides greater certainty on the stability of the structure. Lower bound strengths were initially selected for the tailings and the HDPE liner interface friction angle, so values lower than this are not in keeping with the test work conducted to date. Additional test work on the strength of the dewatered tailings and confirmation of the HDPE interface friction angle with the new tailings stream could be conducted to improve confidence in the model.

The results of the base case stability assessment show that minimum factor of safety (FoS) requirements are exceeded for all scenarios. It is noted that all sensitivity analyses outlined above returned FoS values above the requirement indicating that the design is robust.

Other design stability checks that have been noted by SRK within the overall Appendix G documents looks at alternatives that include either sand bedding or a geofabric layer under the HDPE liner in the case that proof-rolling alone does not provide a suitable substrate for liner placement. The key findings that a sand bedding layer provides a satisfactory FoS however the use of a geotextile over the entire footprint does not provide a satisfactory FoS. However, an acceptable FoS will be achieved if geotextile use is limited to the area upslope of the toe drain and no more than 20% of the upper extent of the toe drain. Sand bedding would be placed beneath the remainder of the toe drain (approximately the lower 80% of the toe drain).

Golder conclusion:

Golder is satisfied that the stability analyses as well as the sensitivity analyses carried out indicate that the design of the facility is robust.

Design Criteria

Design criteria governing the stability assessment of the MWF are set out in the MWF design report (SRK, 2017) and subsequently in the MWF design report addendum 2 no. (SRK, 2020) (*Mine Waste Technical Design Report 2020 – Section 3.4 – Design Parameters and Design Criteria)*.

Golder comment:

Neither document refers to the use of the MCE in design for closure. Due to the low seismicity of the region, assessment of the MCE will require a deterministic assessment in accordance with the requirements of the governing guidelines, indicated as the CDA guidelines. The pseudo-static stability analyses for closure should

consider the calculated MCE. The design geometry is unlikely to change due to this load case however, it should be checked at detailed design stage.

The MWF design report addendum 2 no. (SRK, 2020) (*Mine Waste Technical Design Report 2020 – Section 3.4 – Design Parameters and Design Criteria)* provides a comparison between the use of CDA and EU BAT for the use of design factors of safety for stability analyses.

Golder conclusion:

Golder considers the design criteria to be satisfactory for the current stage of design development.

Geometry selection

In the addendum (SRK, 2020), SRK have selected three section lines to provide a more complete assessment of the stack. Section A-A' and C-C' account for the presence of collection ponds near the toe and Section B-B' assesses a larger toe drain *(SRK 2020 Addendum – Section 4.6 – Stability results)*.

Golder comment:

There is a possibility that a higher section line could have been taken through the small channel between section line A and B, and this may have influenced the results of the stability analysis. It is noted however that no FoS were particularly close to the required value and as such, it is not expected that a slightly modified section line would change the overall outcome.

The layout and depth of the benching completed in the foundation is not defined or discussed in detail in the SRK report. The frequency and depth of the benching will influence the stability of the slope and so if the benching is determined to be less frequent or shallower than that presented in the slope models then addition analysis will be required.

Golder conclusion:

Golder is satisfied that the sections selected provide a reasonable representation for the current level of design development. Further detailing of the benches and their impact of the overall stability should be completed at later design stages ie detailed design.

Undrained case

Following test work undertaken by SRK, an undrained strength was determined for the tailings stack. Undrained analysis was considered appropriate as it is deemed feasible that the tailings may have an undrained response to rapid loading from construction. Two tests were carried out at appropriate sample densities, a slightly lower undrained strength ratio of 0.4 was considered the average. Analysis was undertaken with the full dewatered tailings stack assigned undrained and effective strength parameters. The results showed a reduced FoS for the undrained analysis, but it still complied with the design requirements *(SRK 2020 Addendum – Section 4.6 – Stability results)*.

Golder comment:

The undrained analysis is a good additional assessment. By applying the undrained strength across the full WMF, it represents a worst-case scenario as well as an unlikely one. Only the areas beneath a rapidly loaded area would be anticipated to react in an undrained manner, so this assessment is a conservative one. The analysis by SRK found a lowest FoS of 1.33 when considering a high rise in phreatic level (20 m +) within the stack and use of a reduced shear strength ratio (0.26) (indicating a poor compaction regime during placement), both of these scenarios are not considered likely. It is also noted that these FoS are all greater than the required FOS of 1.1.

Golder conclusion:

Golder considers that the completion of undrained stability analysis is appropriate even though it represents a conservative and unlikely scenario. Further, the outcome from this modelling indicates that the MWF remains stable in this scenario.

Failure planes selected

Primarily SRK completed one stability run where they assessed circular slip surfaces through the foundation material and translational failures along the liner and tailings interface (SRK, 2017) *(Mine Waste Technical Design Report 2017 –Appendix D – Stability Analysis, Section 2.6.1 Initial Screening Results).*

SRK completed base case assessments of the failure planes and determined that failure along the liner would provide the lowest Factor of Safety. They therefore used the "weak layer function" in the Slide software model which would select a failure plane along the HDPE liner and dry stack tailings interface (SRK, 2020) *(SRK 2020 Addendum – Section 4.6.3 – Results Table 4-6).*

Golder comment:

By utilising the reduced interface friction angle of 25°, Golder agrees that the failure will most likely occur along the interface between the dry stack tailings and the HDPE liner. Deeper circular failures through the foundation have been assessed in the different phases of stability analysis (SRK, 2017) (SRK, 2020) and higher Factors of Safety were recorded.

Golder conclusion:

Golder considers the failure plane selection to be appropriate.

Review of Stability Models

SRK provided six sets of stability models for Golder to review. The stability files were created using Slide software and the folder names are listed below:

- Base Case – Pond;
- Base Case – With Weak layer and Water Level +5 m;
- Base Case – Without Weak layer;
- Sensitives 1 – Global;
- Sensitives 2 – Global; and
- Sensitives 3 – Pond.

Golder comment:

Of the files listed above, the model with the main base case analysis is the "without weak layer" file. This analysis covered the drained and undrained cases with and without the weak basal layer. Nearly all the analysis matched the results recorded in the addendum (SRK, 2020). The section A-A undrained (no weak layer) and drained (no weak layer) results do not match those reported, 1.95 and 2.23 reported and 2.22 and 1.68 recorded in the models respectively. It is not known why this discrepancy exists however it is noted that all FoS are sufficiently high to have confidence that the design is robust.

Golder conclusion:

Golder was satisfied with the review of the stability models in that the overall stability of the MWF was confirmed.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Does the review of the stability models support the overall finding regarding stability of the WMF as reported within the WMP?	✓		

24.3.6 Design

Water flow management

The designed drainage system for the facility consists of the following components:

- Underdrains: Within the footprint of the facility, there are two streams and an area where the contours appear to show the potential for surface water to flow. A system of Contour and Main Underdrains is proposed along these flow paths prior to installation of the HDPE liner and will pass beneath the starter embankment to seepage collection chambers. The underdrains will direct groundwater flows beneath the MWF to the southern toe of the MWF. The Contour Underdrains will be installed at the back of benches which will be excavated and graded to convey water to the nearest natural drainage channel. The spacing of the Contour Underdrains will be 20 m and each Contour Underdrain will consist of 150 mm diameter perforated HDPE drainage pipe embedded in gravel. A bedding layer will overlie the surface of the gravel. The Contour Underdrains will connect to the Main Underdrains which will be constructed in natural channels where flow is focussed by the natural topography. These underdrains will consist of a 300mm perforated HDPE drainage pipe, surrounded by drainage gravel and overlain by a bedding layer;
- Overdrains: The drainage system above the liner will comprise a system of overdrains installed immediately above the liner and multiple horizontal drains installed at different elevations within the MWF. The geometry and frequency of the overdrains and horizontal drains described below have been optimized based on the seepage modelling. The overdrain system will consist of Contour and Main Overdrains. The layout of the overdrains will coincide with the system of benches and natural drainage channels utilised by the underdrain system. The Contour Overdrains will be constructed on the liner-covered benches and consist of 150mm diameter perforated HDPE drainage pipes embedded in waste rock windrows, each of which will overlie a bedding layer and follow the contours of the HDPE liner surface. The Contour Overdrains at minimum 20 m spacing will connect to the Main Overdrains which will be constructed above the liner in the same natural channels in which the Main Underdrains are installed. Each Main Overdrain will consist of 300 mm perforated HDPE drainage pipe, surrounded by waste rock which overlies a bedding layer. The Main Overdrains will report to a series of seepage collection chambers, which in turn will be connected to the West and Lower East Pond with a solid 300 mm diameter HDPE pipe. Further to this, horizontal drainage layers consisting of ore rejects with an overlying filter layer comprised of waste rock will be placed within the tailings to expedite the dissipation of excess pore pressures during construction. This will have the benefit of reducing the phreatic surface within the MWF while also providing a trafficable surface;
- Starter Embankment / Toe Drain: Up to 285,000 m^3 of inert waste rock will be brought to surface and used for the construction of a starter embankment within Cells 1, 2 and 3. This starter embankment will serve as / contain a waste rock toe drain along the southern toe of the facility. The overdrains will be connected to this toe drain to allow contact water to drain through to the MWF toe; and

- Diversion Ditches: Diversion ditches will be constructed outside the limits of the MWF to prevent this water from contacting the MWF.

SRK's initial design consisted of a dry stack tailings benched landform. In the initial phases of design surface water drainage was noted but designs not yet implemented to contain it. The updated design solution utilises rockfill outer berms for the filter stack *(SRK 2020 Addendum – Section 4.5)* The rock fill berms aid in draining the surface water down the outer slopes and reduce the likelihood of infiltration of water into the stack.

Golder comment:

The rockfill berms and low permeability of the filter stack tailings will promote flow of surface water off the MWF and into the surface water drainage.

Golder conclusion:

This solution is considered an improvement on the initial design and provides a suitable solution to drain surface water from the stack.

Erosion protection

Addendum 2 provided additional details related to improved erosion protection. It is noted that the proposed perimeter berms will extend around the external slopes of the MWF and provide increased erosion protection as waste rock will be placed. Perimeter berms will be 5 m in height and placed ahead of the filter tailings as the upper deck of the facility is raised. Seepage analyses indicate that the berms will also facilitate drawdown of the phreatic surface within the MWF during operations. The starter embankment will be constructed of waste rock. Above the starter embankment, the perimeter berms will consist of either waste rock or ore rejects and waste rock.

Golder comment:

The use of waste rock to construct external berms provides additional stability whilst also providing a method of reducing the impact of erosion and gullying and promoting free drainage of water from the MWF.

Golder conclusion:

Golder considers this to be satisfactory

Internal erosion protection

It is understood that SRK has produced a Technical Memorandum on the filter compatibility of the dry stack tailings and the toe drain rock fill. This document has not currently been reviewed by Golder. It is considered that filter compatibility is an issue that can be resolved in any case during the detailed design stage through the use of selected filter materials and hence this is not considered to be an issue for this assessment.

Capping and seepage protection

SRK has noted through all stages of design that a prominent issue is the lack of locally sourced fine fill to be used for the capping of the facility *(SRK 2020 Addendum – Section 4.7 – Engineered Cover Design)*.

The initial design only accounted for a 300 mm impermeable layer (SRK, 2017) *(Mine Waste Technical Design Report 2017 – Section 9 – Conceptual Closure Strategy)*. This has been increased to 1 m in the most recent design (SRK, 2020) *(SRK 2020 Addendum – Section 4.7 – Engineered Cover Design)*. A mix of ore rejects / waste rock and low permeability soil (bentonite amended soil) is proposed for the capping layer. The capping layer will be used to create a smooth final landform to reduce the visual impact of the structure.

Golder comment:

The increase in capping layer thickness is a more appropriate solution, given the limitation on available fine fill, the use of soil mixing and additions of bentonite with help to provide a sufficient barrier to infiltration. Additional test work is required to confirm the quantities of bentonite to achieve the required permeability. Suitable methodologies will need to be outlined to ensure adequate mixing of the materials so that no high permeability pockets are created in the cover. The use of soil cover from the footprint for final coverage of the landform will require suitable management of the topsoil so that it is safely stored and the quality doesn't degrade.

Golder conclusion:

The proposed capping solution is considered appropriate for the control of seepage into the MWF.

Foundation preparation

As part of the sub-grade preparation for each cell, sections of the cell footprint will undergo stripping to the depth necessary to remove all peat, organics and topsoil to expose inert, organic-free soil material. The material stripped from each cell will be stockpiled for subsequent use as cover material as part of the MWF engineered cover. Where benches are required, additional soil excavation and surface grading to meet the required shape of each bench will be completed. The surface of the sub-grade, including exposed benches, will be proof rolled with a smooth drum vibratory compactor to improve its density and flatten any angular rocks. Where proof rolling will not provide a suitable surface for liner installation, a compacted, sandy bedding layer, obtained from stripping and / or foundation preparation at other parts of the MWF footprint, will be placed.

Golder comment:

With regards to the installation of the textured HDPE liner, peat and topsoil will be removed and the surface of the competent mineral soil (glacial till primarily) will be proof rolled with a smooth drum vibratory compactor to improve its density and flatten any angular rocks which could potentially pose a risk to the integrity of the liner. This surface will then be inspected to assess its suitability for liner placement. If liner bedding is required beneath small portions of the MWF, a geotextile (such as filter fabric) can be used without impacting the stability of the MWF. In the event that liner bedding is required over significantly large areas of the MWF, an alternative of a sand layer will be used.

Golder conclusion:

The foundation preparation protocol is considered adequate.

24.3.7 Construction Schedule

The MWF will be constructed in three staged cells as outlined below:

- Cell 1 construction will be staged between the two years preceding full mine development (Year -1 and -2) to ensure the full cell footprint is available by Year 1. All tailings and waste rock not needed as underground backfill from Year -2 to Year 5 will be stored in Cell 1. The closure cover at Cell 1 will be placed as and when climatic and ground conditions allow, starting as late as Year 4 and finishing in Year 6 (first year of mine waste deposition during Stage 2);
- Cell 2: Drains and the placement of the HDPE liner at Cell 2 will occur in the last two years of Stage 1 (Years 4 and 5) so that it is available to receive waste in Year 6. Tailings and waste rock will be stored in Cell 2 from Year 6 to Year 11. Cell 2 cover construction is planned to start as late as Year 9 and finish in Year 11; and

- Cell 3 construction would likely occur in the last two years of Stage 2 (Years 10 and 11), so that it is available for use in Year 12. Tailings and waste rock will be stored in Cell 3 from Year 12 to the end of the LOM. Cell 3 cover construction would start as late as two years prior to the end of the LOM, finishing at the end of the LOM.

SRK notes that the mine waste schedule indicates there will be additional quantities of NAG waste rock reporting to the MWF over and above that which is required for the construction of the starter embankments and drainage systems. Portions of this additional waste rock will be used to construct internal access roads and ramps within the MWF, and these, as vertical extensions of the overdrains and toe drain to facilitate the drawdown of phreatic levels within the MWF. This waste rock will be placed, to provide temporary running surfaces which are better suited for use by haul trucks. Excess waste rock which is not used for temporary running surfaces and / or vertical drains can simply be encapsulated as horizontal lifts within the filtered tailings. And where these are connected with the vertical drains, they have the potential advantage to draw down phreatic levels where there are no vertical drains.

Golder comment:

SRK provides a series of guidelines which focus primarily on the construction sequencing and the placement and compaction details. These guidelines have been reviewed by Golder and are considered to be reasonably comprehensive and can form the basis of construction stage documents.

Golder conclusion:

Golder is satisfied that the guidelines provided for construction sequencing can form the basis of construction stage documents.

Construction Quality Assurance

The second Addendum provides details on the proposed Construction Quality Assurance (CQA) procedures that will be used for the construction of the MWF. The procedures include details for ensuring the CQA of the following components of the works:

- Foundation preparation;
- Installation and testing of the HDPE liner;
- Construction of the underdrains;
- Construction of the overdrains;
- Construction of the Starter Embankment; and
- Placement of filtered tailings into the MWF.

Rate of construction

SRK completed analysis in Addendum 2 to determine the influence of an undrained soil response to the stability of the stack. The results found that even when responding in an undrained condition (where excess pore pressures have accumulated in the soils), the MWF will still comply with the required FOS's *(SRK 2020 Addendum – Section 4.6.3 – Results Table 4-7).*

Golder comment:

Rates of construction are not discussed in the SRK reports. Using vibrating wire piezometers in the tailings stack, the influence of different construction rates can be assessed early on in the project. These rates can then be used to define allowable construction rates to allow excess pore pressures to dissipate. Installation of

vibrating wire piezometers is noted within the sections on Monitoring with Addendum 2 hence this has been considered.

Golder conclusion:

The use of vibrating wire piezometers to monitor excess pore pressure within the MWF is considered appropriate.

Weather influence

SRK outlines in all three documents that weather conditions may produce problems for the placement and compaction of the dry stack tailings. Further clarity is provided in Addendum 2 (SRK, 2020); during light to moderate precipitation the placement process will be expedited to reduce the risk of excessive water absorption. In heavy rainfall, work will be halted. If the rainfall is for a prolonged period of time, then placement should be limited to at least 50 m from the northern toe drain and 100 m from the toe drain on the south side *(SRK 2020 Addendum – Section 5.3.1 Tailings)*.

Golder comment:

The clarification on only placing in selected areas during prolonged rainfall is a good addition, these works should not be carried out in excess rainfall where the project timeline allows. The test work on material with a reduced density (82%) showed the undrained strength reduction was approximately half, this highlights the need for proper placement.

Golder conclusion:

The modelling confirmed that the 50 m and 100 m distances are sufficient enough for the weaker fill to not reduce the FoS below the requirements.

24.3.8 Monitoring

SRK notes that Monitoring and Surveillance Monitoring through the operating and post-closure life of the MWF is necessary for evaluating performance of the MWF; therefore, a manual detailing the operation, management and surveillance (OMS) requirements for the MWF will be prepared for use by mine staff. An emergency action plan will also be developed as part of the operations manual to address events such as groundwater and embankment seepage; erosion, sloughing, and settlement; large-scale MWF failure; fugitive dust; and other reportable incidents.

Tailings Properties Production records, depositional procedures and placed densities will be monitored on at least a monthly basis to track the volume of tailings, waste rock and ore sorter rejects within the MWF. The densities and cumulative tonnages are to be compared to the projected design values. In the event that there are significant differences, the storage capacity calculations for the MWF are to be revisited to ascertain the impact on the remaining life of the facility.

In Addendum 1, SRK provides some details for what the monitoring program will entail:

- Details for routine inspections, engineering audits, and emergency response plans;
- Installation of piezometers to monitor the porewater pressure profile of the foundation materials as well as the DSF; and
- Installation of survey monuments, prisms and/or extensometers to monitor the movement of the facility.

SRK references the need for a monitoring programme as part of a risk mitigation plan. Monitoring is required as part of best practise for the construction, operation and closure of all tailings facilities *(Mine Waste Technical*

Design Report 2017 – Section 8 – Monitoring and Surveillance). The three methods of monitoring outlined by SRK are:

- Detailed inspections and engineering audits;
- Installation of piezometers to monitor pore water pressures; and
- Installation of survey monuments, prisms and/or extensometers to monitor the movement of the facility.

Golder comment:

Further details on the monitoring plans will be set out in the next phase of design. The use of vibrating wire piezometers to measure pore pressures in the foundation of the stack and within the tailings are essential to maintain safe levels.

Golder conclusion:

VWPs should be used to monitor the rate of dissipation within the tailings following each construction phase; this can be used to manage construction rates safely. The survey monuments can be regularly monitored by a surveyor to monitor the settlement or movement of the crest line. In addition, In-place Inclinometers or Shape array should be considered as methods of live tracking of any slope movements.

Risk Assessment

An Environmental Risk Assessment has been undertaken in order to identify risks and impacts associated with the MWF. Further to this a design assessment has identified a number of potential risks associated with the design that should be considered in greater depth during the detailed design and / or operations phases.

Golder comment:

Golder has carried out a review of the risk assessments and has found them to be suitably comprehensive for the current phase of design development.

Golder conclusion:

The risk assessment is considered appropriate.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the design of the WMF considered to be well described and robust?	✓		

25.0 REVIEW OF APPENDIX H - CONCEPTUAL CLOSURE PLAN

25.1 Chapter Summary

Appendix H of the WMP is the Conceptual Rehabilitation and Closure Plan (CRCP) for the proposed Gold Mine. The CRCP provides conceptual plans for closure of the underground mine and the related surface infrastructure. The CRCP will be used to develop the detailed closure and aftercare arrangements for the project during operation.

Section 2.2.4 of the document references formal commitments given to local stakeholders at a public meeting in November 2016.

The CRCP sets clear conceptual closure objectives (Section 3.1 of document) that are related to the EIA. The closure plan considers both the environmental and social implications for closure of the project. The conceptual decommissioning / closure activities and the post closure activities for the entire project site are given in Appendix H. The level of detail presented currently is considered sufficient.

The document makes it clear that the CRCP is a live (dynamic) document that will need to be updated regularly during the operational period of the mine and sets a three year review cycle, with a final cycle no less than three years prior to closure to ensure sufficient planning time is in place for agreement of the plan (and to allow for financial provision).

The CRCP provides the legislative context including the legal and regulatory requirements (section 2 of Appendix H). This includes commitment to ensuring that financial provision is in place for the project prior to commencement (Section 3.6). The CRCP includes a reference to the International Cyanide Management Code. As is noted in the 2020 WMP for the site, cyanide will no longer be used on site so this is no longer considered relevant.

The CRCP is presented in Section. 4. The CRCP is orderly and identifies the activities that need to be completed for successful closure.

Section 5 of the document provides a closure cost estimate. Golder did not review the calculations or assumptions presented with in the closure cost estimate. All costs presented are August 2016.

Golder comment:

Development of the detailed closure plan should review and include formal commitments given to local stakeholders in November 2016 and the intervening period (if any).

The post closure monitoring programme is estimated at five years for purposes of presenting an outline of monitoring costs. The CRCP acknowledges the post closure monitoring programme is to be agreed with NIEA.

The closure plan has presented sufficient information to demonstrate that DGL is aware of the commitments required for the closure and post closure monitoring of the project which includes the MWF. DGL commits to making the appropriate financial provision to complete the detailed closure and aftercare management of the project to be agreed with the planning authority. The financial provision must be in place prior to commencement of management of extractive waste as stated therein.

The costings provided are as of August 2016 and as acknowledged in the report will need to be updated as part of the next revision of the CRCP.

Golder conclusion:

The CRCP presents the steps to orderly closure and aftercare management of the project at this stage in the project lifecycle.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Does the CRCP demonstrate sufficient consideration of the closure and post closure requirements of the project?	✓		

26.0 REVIEW OF APPENDIX I – HYDROGEOLOGICAL IMPACT ASSESSMENT REPORT: DSF & POND SEEPAGE REVIEW

26.1 Chapter Summary

This chapter includes Golder's review of the DSF & Pond Seepage arrangements. This is one of the principal areas that DfI requested that Golder conduct a detailed and thorough examination of. For the purposes of clarity and for ease of reference, this chapter will therefore be confined to the DSF & Pond Seepage Review and Section 27.0 will cover further elements of Golder's assessment of the WMP's Hydrogeological Impact Report.

26.1.1 Background

Golder has reviewed the report and associated models of an analysis of internal drainage and the potential for seepage to groundwater from the proposed dry stack facility (DSF) and associated ponds for the Curraghinalt Gold Project presented in the draft report by SRK *Annexe E: DSF and pond seepage review: Curraghinalt Gold Mine Project, Northern Ireland* (October 2020, reference U7511).

It is stated in SRK (2020) that the DSF and pond seepage review was primarily undertaken to inform:

- A groundwater impact assessment through a review of calculated seepage rates from the DSF and ponds; and,
- Geotechnical studies through modelling of the performance of drainage design measures.

It is not stated in SRK (2020) what the secondary purpose of the study was.

The scope of the work as stated by SRK (2020) was as follows:

- Analysis of the estimation of water levels inside the DSF; and
- Analysis of liner seepage rates from the DSF and associated ponds.

SRK (2020) notes that the interpretation of the significance of these values is outside the scope of its report, hence this review does not comment on the significance of the results. The 2020 SRK report is stated to supersede a 2017 report that is not the subject of this review.

The following sections summarise the key points based on Golder's review of the DSF and pond seepage report prepared by SRK (2020).

Summary of Contents

The following notes are made with regard to the DSF and pond seepage assessment:

26.1.2 Model code selection

- The model code selected for the seepage modelling of the DSF was RS2, developed by Rocscience[9]. The code is one of a number of finite element codes used for 2D seepage modelling in and from such facilities. Unlike some other codes it is unable to directly simulate rainfall recharge processes and the ground-atmosphere interface however it is considered that SRK have adequately addressed this limitation by undertaking recharge calculations external to the model and applying a recharge term.
- The seepage from the ponds is reported to have been undertaken in Microsoft Excel incorporating Palisade's @Risk[10] Monte Carlo added in to facilitate probabilistic modelling. The relevant Excel

[9] https://www.rocscience.com/software/rs2

[10] https://www.palisade.com/risk/default.asp

spreadsheets have not been provided for review so Golder has not had the opportunity to determine if their functionality is as described in SRK, 2020.

26.1.3 Assumptions

- The DSF design is described as incorporating a series of contour overdrains on the base of the facility spaced every 20 m combined with horizontal drains every 10 m. The model is constructed such that these drains are intercepted in the modelled cross section. This has the effect of, in the model, maximising the impact of the drains. Away from the drains, less drainage may be achieved. As part of the model sensitivity analysis, the impact of this was modelled by reducing the number of drains, resulting in a rise of heads and increase in seepage. The results of the sensitivity analysis emphasise the importance of having a maximum drain spacing of 10 m.
- SRK states that it has used precipitation and evapotranspiration for 2016 as representative of an average year for the purpose of its recharge calculation. It appears this is based on calculation of mean precipitation, with 2016 being representative of a mean year, and does not account for any long term trends resulting from climate change. No further justification has been given for this.
- The modelling work has not considered the impact of climate change on recharge to the facility. Given the models are run for a 1,000 year time period, consideration to the impact of climate change (eg Representative Concentration Pathway (RCP) 4.5 and 8.5) should be made. SRK states in the report that the model is not sensitive to variations in climate inputs and on this basis has not simulated the impact of climate change. It is considered that this approach is acceptable on the basis that the model is used as a risk assessment tool rather than a design or performance model, where the impacts of climate change, albeit potentially limited, may be of importance.
- The recharge calculations have been undertaken using Surface Water Accounting (SWAc) developed by Groundwater Sciences Ltd. SWAc implements the methods for soil moisture deficit and recharge accounting set out in guidance developed by the Food and Agriculture Organisation[11] and is considered fit for purpose.
- While the recharge calculation method is considered fit for purpose, it is noted that shallow interflow processes in the DSF cover will not be simulated. It is considered that this will not have any material impact on the results of the modelling.
- The recharge calculation is time invariant in that it is assumed that infiltration through the cover in year 10 will be the same as that in year 100 or 1000. SRK states that the infiltration change due to climate change will not be significant and that the model is relatively insensitive to variations in recharge. On this basis it has not simulated the change in infiltration due to climate change. It is considered that this approach is acceptable on the basis that the model is used as a risk assessment tool rather than a design or performance model. It is noted however that some changes in soil cover condition that may occur over time, for example the potential for by-pass flow, may increase as vegetation cover becomes established, with associated root penetration, and or borrowing activity occurs.
- SRK makes a number of assumptions with regard to the percentage of runoff that will occur from the facility during rainfall events. It is stated in Section 3.2.2 that "*The run-off factors were calibrated to achieve a run-off in the range of 55% based on the HOST 19 classification for impermeable soft substrates with high water storage*." Golder notes that based on the description used, the HOST

[11] ttp://www.fao.org/3/x0490e/x0490e00.htm

classification should be 20 based on IOH, 1995[12]. The stated use of HOST 19 may be a typographical error, however SRK should be requested to confirm the classification stated and to address the consequent impact of any changes in the assumptions. It is not considered that the impacts of any changes will materially alter the outcomes of the study.

- SRK has provided justification with regard to the use of Giroud, 1997 for the calculation of flow through the membrane liner that supports its opinion that this approach is suitable given the presence of the liner underdrains rather than the solution of Giroud and Bonaparte, 1989[13].
- The defect frequency assumed for the operational period is considered suitable and in line with published guidance. Golder notes however that the while the Environment Agency of England and Wales reports[14] the onset of degradation after 1,500 – 2,100 years at 15ºC, the US National Research Council (2007)[15] reports a service life of approximately 1,000 years at 10ºC and 565 – 900 years at 20ºC. The modelling undertaken by SRK ceases after 1,000 years which SRK states is justified as the stresses on the system are greater in earlier stages of the facility development. Hence, while its model may not simulate the entire life of the facility in terms of the assessment of risk to the environment, the period of highest risk has been evaluated.
- The approach to the calculation of an equivalent hydraulic conductivity for the membrane liner so as to be able to simulate it within an EPM model code is considered appropriate. While in theory a mechanistic approach representing defects specifically is possible, this is not considered practicable due to likely model instability combined with unrealistic run times. Additionally, it would not impact on the outcome in terms of informing an assessment of overall flows and or risk.
- SRK used calculated unsaturated flow parameters based on calculating a soil water characteristic curve (SWCC) using an empirical method that draws on a database of statistical correlations between particle size distributions and measured SWCCs. This method is encoded in RETC, which is derived originally from the US Soil Salinity Laboratory's Rosetta code[16], which is embedded within Hydrus-1D developed by PC-Progress[17]. While this approach is standard practice and may give appropriate values, future consideration should be given to undertaking laboratory measurements to derive a SWCC.

26.2 Conclusions

Golder comment:

It is considered unlikely that any of the issues raised above will significantly impact on the model results with regard to the magnitude of calculated pore pressures or seepage from the facility.

Golder conclusion:

On this basis it is considered that the modelling work undertaken by SRK can form the basis of an assessment of risk to groundwater which can be used to inform an Environmental Impact Assessment. It should be noted

[12] Institute of Hydrology, 1995. Hydrology of soil types: a hydrologically-based classification of the soils of the United Kingdom. Report No. 126, dated November 1995. http://nora.nerc.ac.uk/id/eprint/7369/1/IH_126.pdf

[13] Giroud JP and Bonaparte R (1989a). Leakage through liners constructed with geomembranes – part I. Geomembrane liners. Geotextiles and Geomembranes 8: 27-67
Giroud JP and Bonaparte R (1989b). Leakage through liners constructed with geomembranes. Part II: Composite liners. Geotextiles and Geomembranes 8, No. 2, 71–11

[14] England and Wales Environment Agency (2004) The Likely Medium to Long Term Generation of Defects in Membrane Liners. R&D Technical Report P1-500/1/TR

[15] National Research Council (2007). Assessment of the performance of engineered waste containment barriers. The National Academies Press, Washington D.C.

[16] https://www.ars.usda.gov/pacific-west-area/riverside-ca/agricultural-water-efficiency-and-salinity-research-unit/docs/model/rosetta-model/

[17] https://www.pc-progress.com/en/Default.aspx?hydrus-1d

that while suitable as a risk assessment tool, the model as developed could not be considered as a model of the performance of the DSF over its life.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is this modelling valid? Are the assumptions on the potential for seepage to groundwater from the proposed DSF adequate and satisfactory in order to be presented to Public Inquiry?	✓		

27.0 REVIEW OF APPENDIX I – HYDROGEOLOGICAL IMPACT ASSESSMENT REPORT: GROUNDWATER MODELLING REVIEW

27.1 Chapter Summary

This chapter covers the remaining aspects of Golder's review of Appendix I of the WMP, Hydrogeological Impact Assessment Report. As previously, this is a specific area that DfI requested Golder to undertake a detailed and thorough examination of the findings, interpretation and analysis.

Golder has undertaken its review of the report and associated models of an analysis of the impact to groundwater from the proposed Curraghinalt project underground mine and associated infrastructure undertaken by SRK and presented in the draft report *Groundwater model report for the Curraghinalt project*[18].

27.2 Data provided

Groundwater modelling is reported in *Groundwater model report for the Curraghinalt project*[18] and provided in Annexe D of *Groundwater impact assessment for the Curraghinalt project, County Tyrone, Northern Ireland*[19].

Four groundwater flow models have been provided, comprising:

- Baseline calibration model (Model number: CUR414);
- Predictive operational period model with mine development (CUR416);
- Predictive operation period without mine development (CUR416 NoMine); and
- Predictive closure model (CUR432).

Model input (text) and output files (text or MODFLOW binary files) were provided for each model run along with the model run log[20] (description of model runs and associated input and output files). The MODFLOW models were developed using the Groundwater Vistas user interface. The associated model package files (.gwv) were not provided. Additionally, FlowSource model files were provided in ctl, excel or text format.

As part of the review, the operational model (CUR416) was opened in Groundwater Vistas and key aspects checked against those reported in the accompanying report[19].

[18] SRK Consulting. 2020. Numerical Groundwater Model Report for the Curraghinalt Project. Prepared for Dalradian Gold Limited. October 2020

[19] SRK Consulting. 2020. Groundwater Impact Assessment For The Curraghinalt Project, County Tyrone, Northern Ireland. Prepared for Dalradian Gold Limited. October 2020.

[20] SRK_GWModelRunLog_2020.1.xlsm

27.3 Review Comments

27.3.1 Modelling objectives and confidence

The groundwater modelling objectives are described as[21]:

- To conceptualise and quantify current conditions at the Project site based on existing information (through acceptable calibration); and
- To predict a future change or impact in response to the Project.

The main aspects of the Project development addressed are:

- Groundwater drawdown due to mining; and
- Migration of groundwater emanating from beneath the dry stack facility (DSF).

Specific issues, as identified in the groundwater impact assessment, to be addressed by the numerical modelling are outlined in Table 1-1 of *Groundwater model report for the Curraghinalt project* and include:

- What are the forecast changes in water level at private abstraction boreholes as a result of Project development?
- What are the forecast changes in baseflow contribution to surface watercourses as a result of Project development?
- What are the forecast changes in groundwater levels in the peatland areas as a result of Project development?
- Post mine closure, how long will it take for groundwater levels to rebound and stabilise?
- Once mine dewatering ceases on closure, where will mine water migrate to once it has come into contact with the mine walls?

The confidence level in the model has been assessed.

Golder comment:

The groundwater modelling objectives are clearly defined and the model confidence has been assessed using recognised guidelines[22]. SRK reports the model as a Class 3, highest confidence, model and documents the classification review in Table 3-3.

Golder conclusion:

Overall the classification seems reasonable against the descriptions provided.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the modelling objectives met and is the resulting Class 3 categorisation, indicating highest confidence, reasonable?	✓		

[21] SRK Consulting. 2020. Numerical Groundwater Model Report for the Curraghinalt Project. Prepared for Dalradian Gold Limited. October 2020.

[22] Barnett, B,. Townley, L. R., Post V Evans, R. R., Peeters, L., Richardson, S., Werner, A. D., Knapton, A., Boronkay. A. 2012. Australian groundwater modelling guidelines. Waterlines Report Series No 82, June 2012.

27.3.2 Hydrogeological conceptualisation

Conceptual hydrogeological models for current site (baseline), operating, and closure conditions are presented in diagrammatic and written format in Sections 4 and 5 of *Groundwater impact assessment for the Curraghinalt project, County Tyrone, Northern Ireland*[23].

Golder comment:

The baseline conceptual site model (CSM) presented provides description of climate and recharge, geological units, faults, hydrogeological units, hydraulic properties, groundwater levels, groundwater flow direction, water chemistry, and groundwater vulnerability and use.

Golder conclusion:

The descriptions provided are in line with what would be expected for a CSM, although it should be noted that the underlying data from which the baseline CSM was developed has not been reviewed.

CSMs for the operating mine and during closure are also presented and provide clear description of the anticipated changes to hydrogeological conditions and potential impacts to groundwater during these stages.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the hydrogeological conceptualisation fit for purpose?	✓		

27.3.3 Modelling software and scenarios

Groundwater flow modelling has been undertaken by SRK using MODFLOW 96 code used in the Groundwater Vistas pre and post processing interface.

The following modelling scenarios were developed:

- Calibration model (CUR414);
- Operations model (CUR416) and no mine operational model (CUR416 NoMine) for comparative analysis; and,
- Closure model (CUR416).

The operational model runs for a 25 year period from January 2020 to December 2044. The closure model is run for a period of 75 years (75 annual stress periods with 10 timesteps per stress period) from January 2045 to January 2120. The modelling duration seems reasonable to enable quasi-steady state conditions to be achieved.

Golder comment:

MODFLOW is a standard code for numerical groundwater flow modelling and Groundwater Vistas is a common commercial Graphical User Interface (GUI). It is noted that the MODFLOW-96 code has been superseded by MODFLOW-2000, MODFLOW-2005, and, most recently, MODFLOW 6, however, there are no known faults in the Modflow-96 code which would significantly affect the results in relation to the stated objectives.

[23] SRK Consulting. 2020. Groundwater Impact Assessment For The Curraghinalt Project, County Tyrone, Northern Ireland. Prepared for Dalradian Gold Limited. October 2020.

Golder conclusion:

Overall the model code is considered suitable for the outlined modelling objectives, although more recent code developments (ie MODFLOW-USG) may have allowed for better spatial discretization of irregular shaped features, such as structures (faults) and mine workings and increased vertical resolution of the underground mine (the model uses 6 Layers). Additionally, alternative model codes are available that are better at handling near surface processes (saturated / unsaturated interfaces) (ie MODFLOW-SURFACT).

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the modelling software, and resulting scenarios, suitable and fit for purpose?	✓		

27.3.4 Model domain and boundaries

The model domain covers an area of 89.8 km^2 with the extent set to be outside of the maximum zone of influence (groundwater drawdown) associated with mining activities. Hydrological divides (such as rivers) were not used to define the model boundaries as they are reported to not necessarily be acting as hydrogeological divides, particularly in the deep bedrock.

The model grid is 100 metres by 100 metres, refined to 20 metres by 20 metres in the mine area (portal, decline, DSF areas) and further refined to 5 metres by 5 metres in the existing and planned future underground mine area.

General Head Boundaries (GHB) are applied on all sides of the model[24].

Golder comment:

The model extent seems sufficient to capture the effects on groundwater from the mining area. Appropriate cell refinement has been undertaken around the underground mine and DSF.

Golder conclusion:

The GHB conditions applied are reasonable given the distance from the area effected by mining operations. The model water balance indicates that the GHB is likely to have minimal influence, overall contributing 0.3% of inflows and 4.1% of outflows (Model CUR416 Stress Period (SP) 300).

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the model domain and boundaries and the GHB conditions applied reasonable?	✓		

27.3.5 Hydrogeological zones

Hydrogeological zones have been included in the numerical model aligned with the identified hydrogeological units in the CSM. A total of 6 layers are included comprising:

[24] A GHB allows groundwater to move into and out of the model domain depending on the groundwater head (elevation) along the boundary.

- Layer 1 – Superficial deposits (peatland, alluvium and glaciofluvial deposits) (1-10 m thick);
- Layer 2 – Heavily weathered basement rock (9-19 m thick);
- Layer 3 – Moderately fractured basement rock (30 m thick);
- Layer 4 – Fresh bedrock (upper) (130 m thick);
- Layer 5 – Fresh bedrock (lower) (510-860 m thick); and
- Layer 6 – Fresh bedrock (layer below active base of mining in layer 5) (50 m thick).

Layers 2 to 6 occur across the model extent. Layer 1 is limited to where superficial deposits are mapped.

Faults have been characterised into six groups based on their identified or assumed hydrogeological characteristics. Faults have been incorporated into the model as vertical domains of increased permeability. The width of the faults is the same as the model cells and can vary from 5 metres up to 100 metres depending on the location.

Golder comment:

The grouping of superficial deposits into one layer assumes that there is only one type of each lithology (peat, alluvium, glaciofluvial deposit) at any location. It is likely that alluvium and glaciofluvial deposits overlap in the river valley areas, although it may not be significant from a modelling standpoint given the similarity in reported hydraulic conductivity values for these units (see Section 27.3.6).

The glacial till is not represented in the groundwater model. SRK reports that this is due to the understanding that the "*formation is generally less than a few metres in thickness and possibly absent in places*"[25] and, were to be included, may "*lead to numerical instability*"[26]. Model cells are set as inactive where glacial till is the only superficial deposit. Where model cells are inactive, recharge is applied to the uppermost active model layer (Layer 2, weathered bedrock).

It is anticipated that the glacial till, where present, would have the effect of reducing recharge to groundwater. A reference is cited in the *Groundwater Impact Assessment report*[25] that "*as a general rule, till reduces the recharge potential to an underlying aquifer by about 30%*". Although the net effect of the till on reducing recharge may be accounted for in the model as the recharge rate has been calibrated with measured river baseflow (Section 27.3.8) the local distribution of recharge will differ where till is present or absent.

Additionally, the upland blanket bog peat typically forms on the clayey till areas[26], with the low permeability till potentially providing a hydraulic barrier between the peatland and groundwater in the underlying weathered bedrock. This is a further indication that till may reduce recharge to the underlaying strata.

Golder conclusion:

Golder considers the above to be satisfactory.

[25] SRK Consulting. 2020. Numerical Groundwater Model Report for the Curraghinalt Project. Prepared for Dalradian Gold Limited. October 2020.

[26] SRK Consulting. 2020. Groundwater Impact Assessment For The Curraghinalt Project, County Tyrone, Northern Ireland. Prepared for Dalradian Gold Limited. October 2020.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the hydrogeological zones represented accurately in the model conceptualisation?	✓		

27.3.6 Hydraulic parameters

Initial horizontal hydraulic conductivity (K_x/K_y) properties were assigned to each model layer in the calibration model (CUR414) based on the geometric mean value derived from hydraulic testing.

Vertical hydraulic conductivity (K_z) values were estimated. The vertical hydraulic conductivity for all units were assigned lower values than the measured horizontal conductivity due to "vertical variations in hydraulic conductivity"[25] except for delineated faults where they were assigned the same value. Storage parameters were taken from a combination of field tests and literature values. Faults are represented by zones of increased permeability.

Golder comment:

SRK reports that the level of confidence in the model hydraulic parameters is high. With regard to horizontal hydraulic conductivity of the bedrock units, this is considered reasonable as numerous tests were conducted (weathered bedrock – 24, moderately fractured bedrock – 16, upper fresh bedrock – 9, lower fresh bedrock – 16, Upper fresh bedrock faults – 5, and Lower fresh bedrock faults - 6).

Fewer tests were reported as undertaken in the peatland (6) alluvium (4), and glaciofluvial (1) units.

Golder conclusion:

It is considered a reasonable approach that the vertical hydraulic conductivity for the weathered bedrock and overlying units are reduced relative to the measured horizontal conductivity. However, the rationale provided for reducing the vertical hydraulic conductivity relative to the measured horizontal hydraulic conductivity for the bedrock units, where groundwater movement is considered to be controlled by fractures/discontinuities, is unclear. It is reported that joints are typically inclined to sub-vertical implying greater vertical connectivity[25] (it is also reported that there is preferential orientation of joints to the NW-SE, indicating horizontal anisotropy not captured in the model). The effect of approximate isotropic ($K_h \cong K_z$) bedrock conditions is assessed as part of sensitivity analysis (Scenario 23 Upper K_z for bedrock) but it is not possible, given how results are presented, to see the effect on groundwater model results.

A limited number of storage values are available for the bedrock units (5 in total) and for the alluvium (1). Storage and specific yield parameters used are mostly literature values, although this is not considered unusual.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the assumptions on the hydraulic parameters reasonable?	✓		

27.3.7 Boundary conditions

All rivers and streams in the active model domain are modelled as river boundary conditions[27] with the river stage assumed to equal the topographic elevation at that location. The riverbed thickness is set to one metre. Local drainage lines were added based on the topography and identification of drainage ditches from satellite imagery.

The peat is also assigned as a river boundary condition in the model with the stage set to equal the top elevation of peat (Layer 1) (note: it is reported as the 'bottom' of the peat, but this was confirmed by SRK as a typographic error). These river nodes will essentially act as drain nodes and will remove excess recharge from the peat.

Golder comment:

The river cells are assigned a fixed head for the duration of the model, which conceptually assumes that the level of water in the river does not change over time. The SRK models use ground level as the river stage as is commonly adopted.

Golder conclusion:

Representation of the peatland as drain cells (albeit using river boundary conditions) in the model is a commonly used approach.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the assumptions on the boundary conditions reasonable?	✓		

27.3.8 Recharge

The amount of recharge to be applied to the MODFLOW model has been estimating using a separate surface water accounting model (SWAc). The model is 1D and assesses flow from ground surface, through the soil zone and unsaturated zones. The flow components modelled for grassland and peat are:

- Runoff (dependent on daily rainfall flux and antecedent soil moisture conditions);
- Soil moisture accounting (incoming water to replenish soil moisture) and actual evapotranspiration; and
- Interflow and combined near surface lateral flow processes (infiltrating water that does not reach the saturated zone and migrates laterally).

Daily time series of precipitation, temperature and potential evapotranspiration were applied to the SWAc model. Daily rainfall and temperature were obtained from the Lough Fea weather station, approximately 20 km east of the project site, for the period January 1966 to January 2020. Evapotranspiration is calculated for the period January 1981 to January 2020.

Monthly recharge estimate is output from the SWAc model. A calibrated recharge rate of 20% of mean annual precipitation is estimated (period 2012-2020) and is within the range estimated based on calculated river

[27] River boundaries are a type of head dependent boundary, allowing flow into or out of the river cell depending on the head difference between the river and groundwater, the vertical hydraulic conductivity, and the thickness and conductance of river sediments. All flow is vertical. The rate of flow depends on the head difference between the river stage and groundwater level. Where groundwater heads are higher than the river stage then groundwater discharges to the river; where groundwater heads are lower than the river stage then the river provides water to groundwater. Where the groundwater heads are lower than the river bottom elevation then a constant flow rate is determined.

baseflow and catchment area (14% and 22% for the catchments upstream of FL05 and Owenkillew monitoring stations respectively).

Forecast datasets for use in operational and closure models were based on data from 2016, which was identified as the rainfall year closest to the mean for years 1981 to 2019. A representative dry year (1995) was included every ten years.

The potential impact of climate change on recharge was included as part of model sensitivity analysis by incorporating upper and lower bounds for assumed climate change using data from the UK Climate Projections (UKCP18). Median (RCP[28]4.5) and upper limit (RCP 8.5) emission scenarios, both with a 50% chance of exceedance, were selected.

A 'surplus water mechanism' was additionally applied to the operational and closure MODFLOW models to allow the rejected recharge to be made available for groundwater recharge under operating mining conditions. To allow for this the MODLFOW EVT package was used with water 'injected' to the peat in the MODFLOW model where groundwater levels dropped below ground surface, up to the limit of available surplus surface water.

Golder comment:

- The SWAc tool, developed by Groundwater Sciences Ltd., implements the methods for soil moisture deficit and recharge accounting set out in guidance developed by the Food and Agriculture Organisation[29] and is considered fit for purpose. The approach makes allowance for near surface processes and antecedent conditions for two main land uses (grassland and peat).
- Derived recharge is applied uniformly across the model surface and does not account for the local effects of land use, topography, or geology on precipitation and recharge. This is considered acceptable in the absence of additional data to enable distributed recharge to be applied.
- The SWAc model has been calibrated against measured river peak flows and estimated baseflow for the Owenkillew Crosh and FL05 monitoring stations. The calibration is reported to provide a reasonable fit for the timing of peak and recession of peak and baseflows. It is also reported that the modelled baseflow reduces to lower levels (zero) than the measured river baseflow due to averaging out of seasonal rainfalls as recharge migrates from the point of recharge to discharge to the river. This explanation is considered reasonable, however, it would also be expected that the total annual baseflow would be equitable and that therefore the modelled baseflow peak would correspondingly be higher than the measured baseflow peak (to allow the annual totals to be equivalent). This is not shown in the figures provided which show peak modelled baseflow equivalent or lower than measured baseflow for the date ranges displayed.
- It is noted in model calibration that there is a measured increase in Owenkillew river flows and subsequent baseflow estimates from 2009, which may reflect an increase in groundwater recharge. SRK examined the rainfall / evaporation post-2009 and didn't identify any correlating increase suggesting that the change was unlikely to be due to climatic influences. In the absence of an explanation for the increase in river flow, modelling analysis was undertaken to assess potential increased recharge (27%) on model calibration (model run CUR401). The results indicated that model calibration was relatively insensitive to the increase in recharge (NRMSE increase from 3.6% to 3.7%).

[28] Representative Concentration Pathway (RCP) is a greenhouse gas concentration trajectory used by the IPCC used to describe different climate futures.

[29] http://www.fao.org/3/x0490e/x0490e00.htm

- The annual recharge for the base case predictive models uses the representative average year (2016) and representative dry year (1995). The year 2016 was selected as most representative based on the lowest deviation from the annual mean for years 1981 to 2019. The representative average year is looped for predictive modelling with inclusion of a dry year every 10 years. This approach is considered reasonable given that the effects of climate change are considered as part of model sensitivity analysis. However, an alternative approach may have been to apply the same randomised annual rainfall sampling procedure as applied to the water balance model.

Golder conclusion:

Conceptually it seems acceptable to allow rejected recharge (ponding and runoff) from the peat to be made available for recharge ('surplus water mechanism') under operating mining conditions. Adequate monitoring will be required during operations to confirm the conceptualisation or identify deviations and implement mitigation measures.

The net seepage (balance of flow into and flow from) from the peatland at peak drawdown is modelled to increase by approximately 385 m^3/d[30] (175 m^3/d of which is in the Curraghinalt Burn Catchment), which is supplied by the 'surplus water mechanism'. The proportion of increased seepage flow to the available surplus water is not reported (in total or for each delineated peatland catchment) and is considered of value to be described, as the outcome is a reduction in available runoff in the peatland.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the recharge mechanisms and estimates used in the model acceptable?	✓		

27.3.9 Model Calibration and Verification

Transient model calibration was undertaken using a trial and error approach where changes to the model input parameters were changed to improve correlation between measured data and model results. Parameters (hydraulic conductivity, storage, specific yield, and recharge) were adjusted within the range of measured data or reasonable literature values.

Model verification was performed by comparing the calibration model output with a dataset not used for calibration. Datasets from three river gauging stations were used in the calibration and verification process.

Golder comment:

- The approach to model calibration follows standard practice and appropriate acceptance criteria were established.
- Calibration was undertaken by varying hydraulic conductivity (K_{xy} and K_z), storage, specific yield, and recharge within reasonable ranges.
- It is observed that the calibrated model K_x/K_y values are lower than the geometric mean for the upper and lower fresh bedrock units (Layer 4 and Layer 5 respectively).

[30] SRK Consulting. 2020. Numerical Groundwater Model Report for the Curraghinalt Project. Prepared for Dalradian Gold Limited. October2020.

- Calibration indicated a marginally poorer fit of modelled to observed groundwater heads and modelled to observed adit outflows when recharge and vertical hydraulic conductivity were increased (model runs CUR402 to CUR405). The changes in recharge and vertical hydraulic conductivity modelled are not stated.
- It is uncertain why the horizontal hydraulic conductivity was not also adjusted when assessing the potential effect of recharge on model calibration. The model verification outputs appear to indicate that the total modelled river baseflow (the groundwater component) for the Owenkillew River at Crosh are less than measured (Figure 3-21), indicating an underestimate of groundwater discharge to the surface water systems.
- At a model scale the calibration meets the defined acceptance criteria. It is reported that poorest calibration (NMRSE >5%) is identified at locations near to where the current exploration adit is located, suggesting that the model does not fully represent these local stresses. Effort was made by SRK to provide explanation for the poorer fit, namely structural (fault) or drill hole connections not originally included were suspected to cause these differences. As a result, higher permeability zones were included around VWP01. A hypothetical fault at VWP03 was also included in sensitivity scenarios to aid the calibration efforts at the adit location.

Golder conclusion:

In general, modelled groundwater levels near to the adit are lower than observed in shallower units and higher than observed in deeper units. A reasonable fit is reported for modelled and observed outflows from the adit for data from October 2018 to December 2019, suggesting that the model is appropriately representing the total flow to the adits, although the source of the groundwater may not be fully representative (ie the model may overestimate flows from above and underestimate flows from below).

It is reported that open drill holes could be having an influence on the adit flow rates. It is important to ensure that all drill holes are adequately sealed following drilling to remove such pathways.

Footnote 10 on Page 48 of 184 appears to include a typographic error referencing model run CUR400 rather than CUR406.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Does the model calibration exercise demonstrate reasonable fit with observed parameters?	✓		

27.3.10 Mine workings representation

The mine development is based on the 2019 Mine Design with an arbitrary start date of January 2020. The mine is represented in the groundwater model as a series of drain cells using a linear interpolation algorithm to enable smooth transition of mine shapes between time steps. The stopes are assumed to be backfilled with a low permeability paste (represented by a reduced drain conductance from 0.5 m/d to 0.0014 m/d) whilst development areas are backfilled with a higher permeability coarse rockfill. Groundwater inflow from fault structures, where intersected by workings, are assumed to be grout sealed and associated drain cells are assigned a low conductance of 0.0014 m/d.

In the closure model, drain cells are used to represent mine workings above the level of the exploration adit portal (168 m level) that will continue to free drain to the adit to provide a single point of discharge. Workings below the 168 m level are assigned hydraulic properties to reflect backfilling of stopes and tunnels. Stopes are

assigned a hydraulic conductivity of 8.7 x 10^{-3} m/d to reflect a mix of paste backfill and waste rock between paste lifts. The mine development areas (tunnels) are assigned a hydraulic conductivity of 5 m/d increasing to 15 m/d for a small volume of the mine in close proximity to drains represented in layers 4 and 5.

Golder comment:

- The representation of the mine development using drain cells is a common modelling approach. Although the model lateral discretisation is appropriate for the dimensions of the underground development (5 m cell size), the vertical discretisation is not (Layer 3, 30 m thick; Layer 4, 130 m thick; and Layer 5 >510 m thick). To account for this discrepancy, SRK 'implement a new drain for every new working within a cell during each (month) time increment' with 'multiple drains in a cell representing workings at different levels'. It is accepted that different drain stage elevations can be applied to a cell over time to represent the vertical progression of a mine, but it is uncertain how multiple concurrent drains are applied to represent workings at different levels.
- It is uncertain how the drain cell approach used captures the mining out and subsequent paste backfill of horizons as the mine progresses vertically. It is possible that the reduced drain conductance, used to represent the effects of paste backfill, is applied once the maximum mining level (lowest drain stage) has been reached, which is considered a conservative approach (ie the modelled underground workings remaining open for longer than planned). Conversely, groundwater inflows could be underestimated where the reduced conductance is applied 3 months after the initial mining level is complete.

Golder conclusion:

Allowance is not made for increased bedrock permeability around the mining area associated with micro-fracturing developed during mine development. This is considered appropriate when considering the scale and objectives of the numerical model. It has been confirmed by SRK that geotechnical consultants assessed that surface subsidence would be minimal (0-0.2m) and that they considered it not sufficient to develop or enhance shallow groundwater flow. This approach is considered acceptable.

During closure, the hydraulic properties of the mine area are adjusted to reflect the backfill used and is considered an appropriate approach.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the mine workings represented in the model representative for use in the model?	✓		

27.3.11 Dry stack facility

The Dry Stack Facility (DSF) is represented in the groundwater model as a zone of zero recharge and evapotranspiration based on negligible estimated seepage rates through the facility liner. Underdrains, located beneath the DSF liner, are represented using steady state river boundary conditions with the stage and bottom elevation equal to 1m below topography. DSF ponds are represented in the model as steady-state drain boundaries with stage equal to the pond bottom.

Golder comment:

Seepage analysis for the DSF near to the end of operations indicates a 'most likely' seepage rate of 0.14% (approximately 1.19 m^3/d) of annual precipitation up to 0.27% (approximately 2.25 m^3/d) for the conservative

case[31]. Assuming liner degradation during closure, the conservative seepage case increases to 8.8 m^3/d. For comparison, the operational groundwater flow model indicates a flow of 277 m^3/d beneath the facility. Given this, it is considered reasonable to assign zero recharge and evapotranspiration to the DSF area in the groundwater model considering that the stated objectives do not include modelling of solute transport in groundwater from the DSF seepage and that a quantitative risk assessment approach is used to assess the associated seepage risk.

Golder conclusion:

Underdrains are represented in the model using river boundary conditions set to operate essentially as drain cells and remove groundwater where heads are greater than 1m below the original ground surface and is considered an appropriate approach.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the DSF and underdrains conceptualisation applied in the model reasonable?	✓		

27.3.12 Sensitivity

The significance of uncertainty in model input parameters was tested through sensitivity analysis. A total of 117 sensitivity runs were performed for the calibration, operations, and closure models. For the calibration model, parameters varied were horizontal and vertical hydraulic conductivity, storage, and specific yield. Sensitivity to climate change (RCP4.5 and RCP8.5) was additionally modelled for the operational and closure models.

The operational and closure model sensitivity scenarios were used to examine the relative effect of input parameter changes on the identified impacted receptors.

Golder comment:

- The sensitivity of the models to input parameters has been tested following appropriate guidelines[32].
- The calibration model is reported to be relatively insensitive to the range of hydraulic properties changes tested apart from a global change in S_y. As reported, the relative insensitivity could be due to either well constrained input parameters or the model is affected by non-uniqueness (ie a number of parameter combinations could yield similar calibration results but may impact model forecast outcomes).
- The range of input parameters (20th and 80th percentiles) used for sensitivity analysis (see Table 7-2[33]) do not align with the reported 20th and 80th percentiles based on site test data (see Figure 3-18 and Figure 3-19[33]). SRK has advised that the percentile ranges applied in sensitivity analysis are based on the variation from mean as identified from the field testing[34]. This results in hydraulic property ranges used during the sensitivity analysis being lower than those observed from field testing. Although it could reasonably be expected that the range of field testing results be covered by the sensitivity analysis, the ranges used

[31] SRK Consulting. 2020. Annexe E: DSF and pond seepage review: Curraghinalt Gold Mine Project, Northern Ireland. October 2020. U7511.

[32] Barnett, B,. Townley, L. R., Post V Evans, R. R., Peeters, L., Richardson, S., Werner, A. D., Knapton, A., Boronkay. A. 2012. Australian groundwater modelling guidelines. Waterlines Report Series No 82, June 2012.

[33] SRK Consulting. 2020. Numerical Groundwater Model Report for the Curraghinalt Project. Prepared for Dalradian Gold Limited. October 2020.

[34] Email communication, Michael Palmer, SRK Consulting. 13 August 2020. Dalradian groundwater model review.

during sensitivity analysis are considered broadly acceptable as the average hydraulic conductivity for each bedrock unit, as derived from field testing, is included in the ranges used.

- The operational model sensitivity analysis indicates that the potential effects of climate change on groundwater receptors are not simulated to have a significant effect and are within the range for other sensitivity model runs.

Golder conclusion:

The operational model base case is within the P10-P90 range for model sensitivity runs and generally close to the median value or above.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Has a sufficiently robust sensitivity analysis been completed on the model input parameters?	✓		

27.3.13 Operational model forecasts

Mine inflow and drawdown

Estimate of groundwater inflow rates and drawdown during the operational phase of the mine are output from the base case operational model. The impact on groundwater levels are presented as groundwater drawdown contours. Potential groundwater drawdown in 33 abstraction wells and one spring have been assessed using the operational groundwater model and a range of impacts assessed through sensitivity analysis.

Golder comment:

- Estimate of inflows to the operational mine workings are presented in total and for each layer and shows a gradual increase in inflow rate as the mine expands and deepens, reaching a plateau around 2028. Greatest inflow is modelled to be from Layers 3 and 4 as shown in Figure 3. Significantly lower inflows to the underground are modelled in Layer 5 due to the hydraulic conductivity assigned to this layer being 2 to 3 orders of magnitude lower than Layer 4.
- Sporadic increases in inflows from Layer 5 are seen in Figure 3 and are advised to be due to workings intersecting higher permeability faults that are then grout sealed (hydraulic conductivity reduced to 0.0014 m/d in the model) after 3 months[35]. This is considered conceptually reasonable.

[35] Telephone communication, Michael Palmer, SRK Consulting. 20 August 2020.

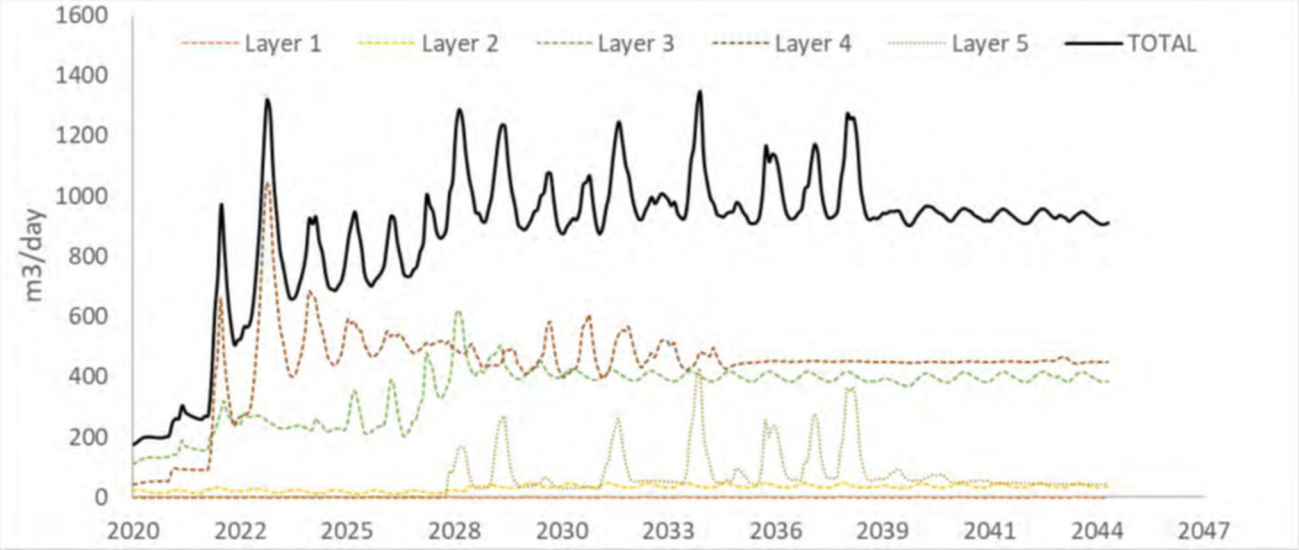

Figure 3: Predicted dewatering rates from the underground mine workings (Figure 5-1)[36]

- The largest reductions in hydraulic head (drawdown) are modelled in close proximity to the: Predicted dewatering rates from the underground mine workings (Figure 5-1) mine footprint, principally in layer 4 and 5. The lateral extent of drawdown is modelled to increase with depth. This is reported as being due to a combination of the "low permeability impeding the hydraulic head reduction upwards into shallow layers" and "the shallower units are relatively much more permeable and are supported by river flow and high recharge".
- The impact on shallow wells is presented for the base case operational model and as part of sensitivity analysis. It is clearly reported where wells / springs may be impacted (drawdown >5% of well depth) and a range of potential impacts are presented for wells of unknown depth. The impact to private abstractions is adequately described in the Groundwater Impact Assessment report and appropriate mitigation measures outlined.

Golder conclusion:

Golder considers the above to be satisfactory.

Peatland water levels

The operational and sensitivity modelling results are used to assess the likely impact of mining on groundwater levels in the peatland. The operational model indicates a net increase of seepage from the peatland (Layer 1) to the weathered bedrock (Layer 2) of 385 m^3/d, with 147 m^3/d from the Curraghinalt Burn (up to 171 m^3/d from sensitivity scenarios). Available additional recharge is provided through the 'surplus water mechanism'.

Golder comment:

Modelling results indicate a decrease in groundwater discharge from weathered bedrock to the peat in the valley areas and an increase in seepage from the peat to the weathered bedrock outside of the valleys. A reduction in groundwater levels in the peatland is not seen in the model results as the increased seepage is balanced, at least on a monthly basis, by the 'surplus water mechanism'. In the valley areas, the modelled reduction in

[36] SRK Consulting. 2020. Numerical Groundwater Model Report for the Curraghinalt Project. Prepared for Dalradian Gold Limited. October 2020.

groundwater discharge from the weathered bedrock to peat will reduce river flows in the Curraghinalt Burn and Attagh Burn (see Surface Water Baseflow, below).

The amount of water available from the 'surplus water mechanism' relative to the mining induced seepage is not reported.

Golder conclusion:

As above.

Surface water baseflow

The physical impact of mine development to the surface water courses has been assessed by comparing modelled changes in the groundwater contribution (baseflow) to rivers and streams in the model area.

The model results indicate minimal effect on overall summer flow rates for larger watercourses (Owenkilew River and Owenreagh River) and more distant burns (Glenealy Burn, Alwories Burn and Atacomcosy Burn). A greater, but still relatively small reduction in river flow (approximately 2-3%) is identified for watercourses overlying the mining area (Curraghinalt Burn and Attagh Burn) or near to the TMF ponds (Pollanroe Burn). Sensitivity analysis indicates that the maximum estimated baseflow change for the parameters tested increases the change in baseflow as a percentage to average summer flows by 4.65% Attagh Burn and from zero to 4.31% reduction for other streams.

The Curraghinalt Burn is modelled to change from being a system that receives groundwater (gaining stream) to one that will discharge to groundwater (losing stream).

Golder comment:

It is considered appropriate that the reduction in river flow is discussed based on the average summer flows, which can reasonably be considered flow minima.

The reduction in river flow associated with reduced runoff from the peat due to mining induced seepage outweighs baseflow impacts, most significantly for the Curraghinalt Burn, with the cumulative effects discussed in the Surface Water Impact Assessment Study[37].

Golder conclusion:

As above.

Inflow rates to the DSF underdrains and DSG ponds

The effect of underdrains beneath the DSF on local groundwater flows has been assessed in the operational model by assigning river boundary conditions to the planned underdrain locations with the river stage and bottom set to equal topography. Zero seepage is allowed from the DSF as estimated seepage rates are low relatively to the underlying groundwater flow.

Water storage ponds at the DSF are also designed to have underdrains, which are also represented in the model as river boundary conditions.

[37] SRK Consulting (UK) Ltd. 2020. Surface water impact assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. UK7511. October 2020.

Golder comment:

There is a modelled reduction in groundwater levels local to the DSF due to the underdrainage systems. There is a corresponding reduction in groundwater flow to the proximal discharge location (Pollanroe Burn). Conceptually this is considered consistent and appropriate.

Golder conclusion:

Groundwater collected in the underdrains will be discharged to Pollanroe Burn and therefore there will be no net reduction in flow.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are operational model forecasts reasonable?	✓		

27.3.14 Closure model forecasts

Mine flooding and rebound

When dewatering activities cease then the underground mine will begin to fill with water. The closure model was used to simulate groundwater rebound, migration, and discharge at the end of mining operations and through the closure period.

Groundwater head recovery to a steady-state level is modelled to take 15 years, with near complete recovery after approximately 10 years.

Outflows from the adit, as estimated from flows extracted by the model drain cells in the mine area (Layers 2 to 4 of the model), for the first 6 years following closure are relatively stable at approximately 20 m^3/day before increasing to approximately 800 m^3/day once groundwater levels recover in layers 3 and 4 of the model.

Golder comment:

The continued operation of the drainage adit is represented by retaining drain cells in the mined areas above the 168 m level (Layers 2 to 4), which is considered conceptually consistent.

Golder conclusion:

Satisfactory.

Groundwater migration during closure

FlowSource has been used in combination with MODFLOW outputs to estimate fractional and volumetric flows from the backfilled areas of the mine and from the DSF area and ponds. The purpose was to simulate possible pathways for contact water from the mine to migrate to downstream receptors and to inform quality aspects of the groundwater impact assessment. Groundwater quality issues are assessed using the following quality parameters:

- Groundwater compliance limits: not to exceed limits at a point between the source and identified receptor;
- Groundwater design target limits / assessment limits: maximum acceptable design concentration at specific location. Design targets are lower than relevant compliance limits providing a precautionary approach;
- Source term concentrations: predicted source term concentrations for the DSF and underground mine; and,

- Groundwater screening values: back calculated concentrations applied at the source zone to ensure the groundwater target limit is not exceeded. Output from the flow source modelling are used in this calculation.

Golder comment:

FlowSource allows calculation of the volume and proportion of water in MODFLOW model cells that reach a predefined destination and is used to illustrate advective flow pathways and source distribution. The approach is considered appropriate to estimate where contact water from the underground mine and DSF area may migrate and how much may be discharged during closure to inform calculation of groundwater screening values. It does not provide estimate of likely concentrations of solutes that may reach these receptors.

The risk-based screening approach to assess groundwater quality impacts is considered appropriate in the context of an Environmental Statement.

Comment on the approach used to quantify source term concentrations are provided in Golder, 2020.

Golder conclusion:

As above.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are closure model forecasts estimated by the model reasonable?	✓		

27.4 Groundwater Modelling - Conclusions

Overall, it is considered that the groundwater modelling work undertaken by SRK is appropriate to address the questions as defined in the modelling objectives and to inform the Groundwater Impact Assessment.

In general, it is considered unlikely that the issues raised by Golder in this review will significantly impact on the model results regarding groundwater levels and flows when consideration is given to the numerous sensitivity scenarios undertaken.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the groundwater modelling undertaken by SRK sufficient & appropriate to address the modelling objectives and to inform the GIA?	✓		

28.0 REVIEW OF APPENDIX J - HYDROLOGICAL IMPACT ASSESSMENT REPORT: WATER BALANCE REVIEW

28.1 Chapter Summary

Golder has undertaken a full review of the water balance models used to support assessment of the possible impacts to surface water quantity from the proposed Curraghinalt underground gold mining project. An assessment of surface water quality models is presented in Section 29.0.

These detailed and thorough reviews, and those relating to seepage and groundwater (Sections 26.0 and 27.0) were undertaken at the specific request of DfI in order to better understand any impact relating to water management at the mine site.

This review of water balance was undertaken with consideration given to the stated purpose of the models, applicable requirements of the *Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015*, Regulations 9 and 10 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015*, EC Directives *2000/60/EC, 2006/11/EC* and *2006/118/EC*, and good international industry practice.

A review of the modelling undertaken to support the assessment of the potential impacts to surface water quality is presented in Section 29.0 of this report.

28.2 Data Provided

Surface water quantity modelling for the proposed Curraghinalt Gold Mine project was carried out for both operations and closure conditions. Surface water quantity modelling for mine operations consisted of a mine water balance which is reported in *Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update*[38]. This report is also included as Annexe A of the *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland* report[39].

Water inputs, outputs, and internal transfers for the mine site during operations were assessed by Kaya Consultants Ltd (Kaya) using GoldSim™ Monte Carlo Simulation Software. Table 5 outlines the GoldSim™ models which have been provided to Golder.

Table 5: Water Quantity (Flow) Models

Model Name	Model Description
Curraghinalt_WB_Oct_2020_Monthly FINAL_Base.gsm	Base Case
Curraghinalt_WB_Oct_2020_Monthly FINAL_S1-1.gsm	Sensitivity S1-1
Curraghinalt_WB_Oct_2020_Monthly FINAL_S1-2.gsm	Sensitivity S1-2
Curraghinalt_WB_Oct_2020_Monthly FINAL_S1-3.gsm	Sensitivity S1-3
Curraghinalt_WB_Oct_2020_Monthly FINAL_S1-4.gsm	Sensitivity S1-4
Curraghinalt_WB_Oct_2020_Monthly FINAL_S1-5.gsm	Sensitivity S1-5
Curraghinalt_WB_Oct_2020_Daily_S1-6.gsm	Sensitivity S1-6
Curraghinalt_WB_Oct_2020_Daily_S1-7.gsm	Sensitivity S1-7
Curraghinalt_WB_Oct_2020_Monthly FINAL_S2-1.gsm	Sensitivity S2-1
Curraghinalt_WB_Oct_2020_Monthly FINAL_S3-1.gsm	Sensitivity S3-1
Curraghinalt_WB_Oct_2020_Monthly FINAL_S3-2.gsm	Sensitivity S3-2
Curraghinalt_WB_Oct_2020_Monthly FINAL_S3-3.gsm	Sensitivity S3-3

[38] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020.

[39] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020.

Curraghinalt_WB_Oct_2020_Monthly FINAL_S3-4.gsm	Sensitivity S3-4
Curraghinalt_WB_Oct_2020_Monthly FINAL_S4-1.gsm	Sensitivity S4-1
Curraghinalt_WB_Oct_2020_Monthly FINAL_S4-2.gsm	Sensitivity S4-2
Curraghinalt_WB_Oct_2020_Monthly FINAL_S5-1.gsm	Sensitivity S5-1
Curraghinalt_WB_Oct_2020_Monthly FINAL_S5-2.gsm	Sensitivity S5-2
Catchment For Model - Monthly Evap - Present Day	Australian Water Balance Model (AWBM) (for estimating mine site runoff)

The following spreadsheet calculations supporting the water balance modelling was also provided to Golder:

Pollanroe and Owenreagh Flows Sent to Golders.xlsx[40]

Surface water quantity modelling during mine closure consists of calculations which were undertaken for average and low flow conditions in the receiving watercourses. These calculations are reported in the *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland* report[41]. The review of these calculations is discussed in *Dalradian Proposed Curraghinalt Project Surface Water Quality Review* Section *29.0*, alongside the review of the modelling undertaken to support the assessment of potential impacts to surface water quality.

28.3 Modelling objectives

Water balance modelling was undertaken to support mine planning and design, and to assess the possible impacts on downstream watercourses during operations. The specific objectives of the modelling were to:

- Calculate operational water levels/volumes in the water management ponds;
- Calculate the water treatment rates required to maintain water levels in the ponds at appropriate operational water levels, as required for flood water management;
- Assess whether there is sufficient water within the treated water volume and intercepted clean water volume to provide make-up for the process;
- Provide flow estimates for discharges from the mine; and
- Provide inputs to geochemical models.

28.4 Review comments

28.4.1 Modelling Software

Modelling of the mine water balance during operations was undertaken in GoldSim™, a Monte Carlo simulation software designed to support decision-making and risk analysis by simulating future performance while representing the uncertainty and risks inherent in engineering, science, and business systems.

[40] Kaya Consultants Ltd. n.d. Pollanroe and Owenreagh Flows sent to Golders.xlsx.

[41] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

Golder comment:

GoldSim™ is a standard tool used within the mining industry for water balance modelling. The software allows for the creation of flexible, graphically transparent models capable of the probabilistic simulation of hydrological and mine operating inputs. It is used at mine sites worldwide by the largest mining companies and leading consulting firms for strategic planning, optimisation of operations, risk analyses, and environmental impact assessments.

Golder conclusion:

GoldSim™ is considered suitable for the outlined model purpose and objectives (Section 28.3)

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the use of GoldSim™ software to model the water balance appropriate in order to meet purpose & objectives?	✓		

28.4.2 Model Scenarios

GoldSim™ modelling was undertaken for the operational phase of the mine and included a Base Case scenario and 16 sensitivity runs to assess responses to changes in selected model inputs, mine operating parameters, and flow routing. In addition to the 16 sensitivity runs presented to Golder (listed in Table 5, Table 10, Table 11, Table 12 and Table 13), an additional sensitivity run (model not provided to Golder) was carried out, the details of which are provided in Section 28.4.8.

Golder comment:

Golder has reviewed the submitted model files as well as the supporting reports and, based on this review, the model scenarios (base case and sensitivity runs) which have been undertaken are considered to be appropriate.

GoldSim™ modelling was not undertaken for mine closure. However, spreadsheet calculations to assess the possible impacts to downstream watercourses during mine closure were undertaken which included estimates of various flows, eg site runoff, basal drain and seepage flows from the dry stack facility (DSF), and flows in the Pollanroe and Owenreagh Rivers. Review of these calculations are discussed in Section 29.0

Golder conclusion:

The model scenarios (base case and sensitivity runs) which have been undertaken are considered to be appropriate.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the resulting model scenarios (base case and sensitivity runs) appropriate?	✓		

28.4.3 Conceptual Models

Conceptual models (block flow diagrams) for operating conditions in Years 6, 12 and 20 of the Life of Mine (LoM) are presented in *Curraghinalt Gold Mine Project- Site Water Balance - 2020 Update*[42]. The conceptual models consider the following:

- Mine facilities (Underground Mine, Processing Plant, and DSF);
- Proposed water storage ponds (Clean Water Pond, West Water Pond, East Water Ponds);
- Water Treatment Plant; and
- Receiving watercourses (Pollanroe Burn).

Water balance inputs, transfers, and outputs are provided in Table 6 and include water in the ore, mine dewatering flows, precipitation on the DSF and water storage ponds, and runoff from natural and disturbed (developed) catchments.

Table 6: Flows in the Conceptual Models

Water Balance Inputs	Water Balance Outputs	Flow Transfers between Facilities
Water in the ore	Water in the concentrate	Water in the tailings
Mine dewatering flows	Water in the paste to underground	DSF seepage
Precipitation on the DSF	Evaporation from the water ponds	Pumped water from the West and East Water Ponds to the Treatment Plant
Runoff from natural and disturbed catchments	Spray water	Recycled water from the Clean Water Pond to the Process Plant Site
Direct rainfall on the water ponds	Evaporator losses	
Sewage	Water treatment plant releases	
	Overflow from the Clean Water Pond	

Golder comment:

Based on the available information, the conceptual models represent all key infrastructure and flows on site and the physical environment to an adequate resolution.

Golder notes that it would be helpful if a legend item was included which clearly identified the net rainfall on the ponds in Figures 14, 15 and 16 in *Curraghinalt Gold Mine Project - Site Water Balance - 2020 Update*[42] However, the omission of this legend item does not affect the outcomes of the water balance review.

[42] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

Golder conclusion:

The conceptual models represent all key infrastructure and flows on site and the physical environment to an adequate resolution. Whereas some additional clarity could be added to in terms of reporting the conceptual models, this does not affect the outcomes of the water balance review.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the conceptual models (which represent all key infrastructure and flows on site) reasonable and fit for purpose?	✓		

28.4.4 Model Simulation Settings

For impact assessments during operations, the GoldSim water balance model was run with boundary conditions and timesteps as outlined in Table 7.

Table 7: GoldSim model Boundary Conditions and Timesteps

Model Parameters	Model Input
Start Date	January 1, 2022
End Date	January 1, 2042
Simulation Timestep	2-day
Number of Realizations	100

Golder comment:

The water balance is run over the planned duration of the mining operations, and the model start and end dates are acceptable. The use of a 2-day simulation timestep is convenient for the purposes of extracting and viewing results. However, it should be noted that all timeseries were inputted on a monthly basis, and the resolution of the outputs is driven by the monthly resolution of the inputs. The monthly resolution of inputs is deemed appropriate for assessing most flow impacts within the Pollanroe Burn and Owenreagh River, with the exception of reductions in daily flows per *Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015* (Sections 4.5 and 4.11.1). Further details on the appropriateness of using daily flows is presented in Section 28.4.5.

Golder notes that the model is run on the calendar, as opposed to the hydrologic year (starting at the end of the summer). However, it was noted in the *Curraghinalt Gold Mine Project - Site Water Balance - 2020 Update*[43] that an assessment of the implications of running the model on the calendar (as opposed to the hydrologic) year was carried out, and the differences in model predictions between the two approaches ranged from 0 to 2%. On this basis, Golder deems that the approach of running the model on the calendar year basis is adequate.

The model set-up of 100 realisations is deemed appropriate as it allows the model to cycle through all possible combinations of the annual historical datasets (further details on the representation of hydrology within the water balance presented within Hydrology in Section 28.4.6). Golder notes that 54 years of hydrologic data are cycled

[43] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

within the model for each model simulation. As mentioned further in the Section, the 54 years of historical rainfall data include a 1-in-80 wet year. Given the 20-year mine life, Golder considers the cycling of the 54 years of rainfall / runoff data adequate for assessing risk regarding water operations at the mine and has calculated a 22% risk of occurrence of the 1-in-80 wet year occurring at least once during the life of the mine.

Golder conclusion:

The water balance is run over the planned duration of the mining operations; the model start and end dates are acceptable. The use of a 2-day simulation timestep is convenient for the purposes of extracting and viewing results. The model set-up of 100 realisations is deemed appropriate as it allows the model to cycle through all possible combinations of the annual historical datasets. Given the 20-year mine life, Golder considers the cycling of the 54 years of rainfall / runoff data adequate for assessing risk regarding water operations at the mine.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the model simulation settings appropriate to estimate water balance during the mine operation period?	✓		

28.4.5 Key Model Inputs and Assumptions

Key model inputs consisted of the following:

- Monthly timeseries of historical precipitation and evaporation for Lough Fea climate station;

Monthly timeseries of future climate precipitation and evaporation for Representative Concentration Pathway (RCP) 4.5 (further described in

- Table 9);
- Monthly timeseries of historical and future runoff (natural and disturbed catchments);
- Monthly timeseries of runoff and seepage from active and reclaimed areas on the DSF;
- Clean Water, East and West Pond surface areas and capacities; and
- East and West Pond buffer volumes.

The key assumptions underpinning the model inputs are:

- Representation of the climate with data from the Lough Fea station is appropriate;
- Future climate at the mine will follow RCP 4.5 predictions;
- Runoff from natural catchments calculated using the AWBM adequately represent runoff from the mine site areas;
- Runoff from disturbed mine areas is 20% greater than runoff from natural catchments;
- Runoff and seepage rates from active and reclaimed areas of the DSF calculated using the Surface Water Accounting Model (SWAc) adequately represent flows from the DSF; and
- Pond freeboards are adequate.

Golder comment:

Golder's comments on the inputs and assumptions listed above are presented in Table 8 and

Table 9 respectively.

Table 8: Golder Comments on Key Model Inputs

Key Input	Golder Comment
Monthly timeseries of historical and future climate precipitation and evaporation, monthly timeseries of runoff from natural and disturbed catchments, and monthly timeseries of runoff and seepage from active and reclaimed areas on the DSF.	Golder has assessed the suitability of the monthly timeseries against the modelling objectives (Section 28.3) and excepting the objective to assess discharges from the mine, considers that a monthly input time series is appropriate for these objectives. The modelling objective to assess discharges from the mine is relevant to the assessment of compensation flow requirements in Pollanroe Burn and Owenreagh River. The relevant river flow standards and objectives against which these requirements can be assessed are defined under the *Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015*[44]. These river flow standards consider permitted daily abstraction rates as a percentage of natural mean daily flows. The results of the water balance show that the flow in the Pollanroe Burn will, on a monthly and annual basis, be augmented during low and average flow conditions, notably through (i) the dewatering of the underground mine (after treatment) and (ii) through natural groundwater inflows to the Under Drain which discharges to the Pollanroe Burn. However, the water balance does not account for daily variations. In the event that compensation flows are required to meet the requirements of the *Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015,* groundwater can continue to be pumped from the underground workings at rates that will allow these river flow standards to be met[45]. Golder notes that while a further assessment of the mine discharges which takes daily inputs into account would be helpful, it is not expected to change the overall results from the water balance.
East and West Pond buffer volumes, surface areas, and capacities.	The buffer volumes were based on the required flood storage for the 1-in-1,000 year, 24-hour event; the input of a buffer volume to store runoff from an extreme storm is considered appropriate. However, the calculations were carried out externally to GoldSim™ and Golder has not reviewed these calculations. Note that the Clean Water Pond is not

[44] Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015

[45] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

	intended for flood storage and so no buffer volumes were considered within the water balance. The surface areas and capacities of the ponds were provided to the authors of the water balance; Golder cannot independently assess the suitability or correctness of these inputs.

Table 9: Golder Comments on Key Assumptions

Key Assumption	Golder Comment
Representation of the local climate with data from the Lough Fea station is appropriate.	This assumption is reasonable based on the limitations of available climate data. *Curraghinalt Gold Mine Project- Site Water Balance - 2020 Update*[46] indicates that Lough Fea is the closest station and has a comparable elevation to the mine site. Golder estimates the station is located approximately 18.5 km east of the mine site and has an elevation of 225 m AMSL.
Future climate at the mine will follow RCP 4.5 predictions.	IPCC's *Climate Change 2014: Synthesis Report*[47] adopts four possible future climate change scenarios called Representative Concentration Pathways or RCPs. These are RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5. Each scenario describes a different climate future depending on greenhouses gas emissions and land use. The likelihood of RCP 2.6 and RCP 8.5 is considered low. The RCP 4.5 climate predictions are considered to be a medium stabilization pathway[48.] Golder deems this to be a reasonable approach for the Base Case and all the sensitivity runs bar one. A sensitivity run was undertaken considering RCP 8.5 which is discussed further in Section 28.4.8.
Runoff from natural catchments calculated using the AWBM adequately represent runoff from the mine site areas.	Runoff from natural catchments was calculated using the AWBM[49]. Calculations were undertaken separately from the site-wide water balance, and outputs from this model were used as inputs to the site-wide water balance. The results from the AWBM were calibrated, through visual comparison, to flow duration curves from four local monitoring locations. No validation of the AWBM runoff values was carried out. The modelled normalised flow-duration curves show a good visual match to the observed flow-duration curves for the small catchments on the site. However, Golder notes that the modelled flow duration curve under-predicts low flows and over-predicts high flows. Further

[46] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

[47] IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, 151 pp.

[48] Department for Environmental, Food and Rural Affairs (DEFRA). 2018. UKCP18 Guidance: Representative Concentration Pathways. Obtained from https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---representative-concentration-pathways.pdf

[49] Broughton, W. 2004. The Australian Water Balance Model. Environmental Modelling and Software. Volume 19, Issue 10, Pages 943 – 956.

Key Assumption	Golder Comment
	discussion on the implications (if any) of this would be useful. However, Golder notes that sensitivity analyses (S1-1 and S1-2) were carried out to address uncertainties in runoff. As such, while a discussion on implications would be useful, Golder considers that uncertainty in runoff inputs has been sufficiently addressed. Given the limited site-specific data available (between two and six years of daily data), Golder considers the lack of a validation exercise reasonable. Due to the lack of validation, the fit of the modelled catchment results to the observed local site catchment runoff should be quantified using an appropriate goodness-of-fit approach. Overall, however, Golder deems the calibration of the flow duration curves through visual comparison to be adequate.
Runoff from disturbed catchments is 20% greater than runoff from natural catchments.	Disturbed catchments will include unpaved roads, hard standing areas and roofs[50]. A runoff rate (percentage of rainfall occurring as runoff) for disturbed catchments would lie between the rate of 65% for natural catchments and 90% from hardstanding areas during storm events. The report goes on to state that the representation of runoff from disturbed areas through a 20% increase of natural runoff provides a balanced rate within the above-mentioned range of 80%. Golder considers this approach reasonable given the above logic and due to the monthly resolution of the model. Golder also notes that results from Sensitivity Run S1-1 (runoff increased by 20%, monthly rainfall data resolution) and Sensitivity Run S1-7 (runoff increased by 20%, daily rainfall data resolution) do not indicate any infringement on the freeboard requirements in the storage ponds.
Runoff and seepage rates from active and reclaimed areas of the DSF calculated using the SWAc adequately represent flows from the DSF.	Runoff and infiltration rates for the DSF were input to the water balance model based on calculations by SRK. Golder considers this approach reasonable, based on a general understanding of SWAc modelling. Golder has not reviewed the SWAc model used specifically for the assessment of the DSF flows. As stated in the *Curraghinalt Gold Mine Project - Site Water Balance - 2020 Update****Error! Bookmark not defined.***, the hydrological inputs to this model are the same as that for the water balance.
Pond freeboards are adequate.	The East and West ponds will be operated so that there is sufficient freeboard in the ponds to accommodate a 24-hour, 1 in 1,000 year storm event[50]. These calculations were carried out externally to GoldSim and Golder has not reviewed these calculations. However, selection of the 24-hour, 1 in 1,000-year storm is reasonable; the

[50] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

Key Assumption	Golder Comment
	probability of this storm event occurring at least once during the 20 years of mining operations is 2%.

Golder conclusion:

Golder identified that monthly timeseries inputs are not appropriate for assessing compliance with daily river flow standards in *Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015*. However, further assessment of the mine discharges which takes daily inputs into account, while being helpful, is not expected to change the overall results from the water balance, which indicates monthly and annual flows in the Pollanroe Burn are augmented during low and average flow conditions.

The modelled normalised flow-duration curves show a good visual match to the observed flow-duration curves for the small catchments on site. Golder notes that modelled flow duration curves for Pollanroe Burn tended to under-predict observed high flows and to reasonably match observed low flows. Further discussion on the implications of the under-prediction of high flows (if any) would be useful. However, Golder notes that the inputs and assumptions of the water balance are appropriate and does not consider that any further assessment is required at this planning stage.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the model inputs and assumptions used in the water balance appropriate?	✓		

28.4.6 Model Logic and Calculations

Hydrology

A stochastic approach to rainfall, runoff and evaporation modelling was presented in *Curraghinalt Gold Mine Project - Site Water Balance - 2020 Update*[51]. This approach consisted of the shifting of historical annual timeseries, in randomised order, based on Monte Carlo seeding. The annual historical datasets were shifted starting in January of each year.

Golder comment:

The time-shifting approach to hydrologic inputs applied to the model allowed for a range of climate conditions to be considered. The historical climate time series input to the model(s) represents a range of climate conditions ranging from the 1-in-80 wet year to 1-in-200 dry year[51]. As discussed further in this section in Climate Change (below), adjustments were made to the historical datasets to incorporate climate change effects. The impact of these climate change adjustments to the return periods represented within the model is not reported. However, Golder deems the time-shifting approach to hydrologic model inputs adequate based on the 20-year life of the mine and estimates a 22% risk of occurrence of the 1-in-80 wet year occurring at least once during the life of the mine, and a 10% risk of occurrence of the 1-in-200 dry year occurring at least once during the life of the mine.

[51] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

The shift is based on a calendar year (starting at the beginning of January), rather than a hydrologic year (starting at the end of the dry season). However, an additional assessment was carried out to assess the implications of aligning the shift with the hydrologic year and, based on the results, there was no significant difference in the model results between the two approaches.

Golder conclusion:

Golder considers that the approach to modelling hydrologic inputs (ie time-shifting at the start of a calendar year) is appropriate and does not consider that any further assessment is required.

Climate Change

Golder noted that climate change was incorporated based on linear interpolation between historical climate data for 2020 and climate predictions for benchmark years 2040 and 2060. Golder also notes that the monthly rainfall for 2040 and 2060 benchmark years were calculated based on an average of the monthly anomalies of the previous and subsequent five years of data. The averaging of these years was undertaken to extract key climate trends and remove interannual variations deemed to reflect variabilities in the modelling.

Golder comment:

There is currently no standard industry practice or regulatory guidance on incorporating climate change predictions into mine water balance models. However, the linear interpolation of monthly rainfall and evaporation between historical data for 2020 and climate change benchmark years 2040 and 2060 is considered reasonable for the purposes of mine planning.

Golder has not reviewed the raw climate prediction data, and so cannot speak to the validity of calculating 2040 and 2060 benchmark rainfall by averaging the previous and subsequent years.

Golder conclusion:

Golder notes that there is no standard industry practice or regulatory guidance on incorporating climate change predictions into mine water balance models. However, the linear interpolation of monthly rainfall and evaporation is considered appropriate. Golder has not reviewed the raw climate prediction data and cannot speak to the validity of averaging rainfall for years previous and subsequent to 2040 and 2060.

Flow Rates

As mentioned in Section 28.4.5, runoff rates from natural catchments were estimated using the AWBM, whereas runoff and seepage flow rates from the DSF were calculated using the SWAc. These timeseries, which were derived separately from the site-wide water balance, were input directly into the model. The runoff rates from disturbed areas were based on the application of a 20% increase to the runoff rates from natural catchments.

The model logic also considered transfers between the site facilities as well as discharges to the environment (as outlined in Table 6).

Golder comment:

The logic and calculations with regard to flow rates in the water balance model have been reviewed and are deemed correct. Given that the model inputs and assumptions are considered reasonable (Section 28.4.5), the flow rates calculated in the model are acceptable.

Golder conclusion:

Golder considers that the approach taken to determine flow rates is appropriate and does not consider that any further assessment is required.

Water Storage and Spill Assessment

The East and West Ponds will be operated so that there is sufficient freeboard in the ponds to accommodate a 24-hour, 1 in 1,000 year storm event. The flood storage requirements were assessed outside of Goldsim™ and Golder has not reviewed these calculations. To determine whether freeboard is maintained within the ponds, the available flood storage capacities in the ponds in the water balance must be manually compared to the flood storage requirements. There is no inherent logic within the model which alerts the user as to whether or not the storage requirements are compromised during model runs; this needs to be assessed through the inspection of the model outputs.

Golder comment:

Golder has reviewed the approach for assessing the likelihood of spills from the East and West Ponds and can confirm it is acceptable and sufficient for the purposes of mine planning.

Golder conclusion:

The approach taken to assess the likelihood of spills is sound and sufficient for the purposes of mine planning. Golder does not consider that further assessment is required at this planning stage.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the water balance model logic and calculations sufficient for the purposes of mine planning?	✓		

28.4.7 Uncertainty in Model Inputs and Outputs

The following sources of uncertainty are associated with key model inputs[52]:

- Rainfall and approach to modelling climate variability; and
- Flood storage assumptions.

The following sources of uncertainty are associated with key model outputs[52]

- Water Treatment Capacity;
- Clean Water Pond Design and Risk of Water Shortages;
- Compensation Flow; and
- Engineering Designs.

Golder comment:

Golder considers that all sources of uncertainty have been captured in the list above. The sources of uncertainty listed for the model inputs have been addressed through sensitivity analysis assessments (Section 28.4.8), as well as the application of a stochastic approach to modelling climate (Section 28.4.6 Hydrology).

[52] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

Two sources of uncertainty listed for the model outputs, (i) Water Treatment Capacity and (ii) Clean Water Pond Design and Risk of Water Shortages, have also been addressed through sensitivity analysis assessments (Section 28.4.8).

The possibility exists that a higher compensation flow may be required by regulators through the permitting process; however, as increased monthly and annual flows are provided to the Pollanroe Burn, there is confidence that increased demands for compensation flows could be met[53]. Golder notes that no sensitivity analysis assessment has been carried out to assess to what extent increased compensation flow demands could be provided from the Clean Water Pond. However, the exclusion of this assessment does not affect the validity of the results from the Base Case.

Regarding uncertainty relating to engineering designs, the designs of engineered structures were provided to the authors of the water balance by others, and so the authors were reliant on information provided to them regarding sizing and operation of these structures[53] Golder has not reviewed these engineering designs as part of the water balance review however a review of these designs has been conducted by others within the Golder Review Team.

Golder conclusion:

All identified sources of uncertainty in model inputs and outputs have been addressed adequately through sensitivity analysis assessments. Golder notes that no sensitivity analysis assessment has been carried out to assess to what extent, increased compensation flow demands (if required) could be provided from the Clean Water Pond. However, the exclusion of this assessment does not affect the validity of the results from the Base Case. Golder does not consider that further assessment is required at this planning stage.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Have all identified sources of uncertainty in model inputs and outputs been addressed adequately through sensitivity analysis assessments?	✓		

28.4.8 Sensitivity Analysis of Model Inputs

The *Curraghinalt Gold Mine Project - Site Water Balance - 2020 Update* reports the results and conclusions of a series of sensitivity analyses carried out on certain hydrologic inputs and other key inputs, process water demands and changes in mine infrastructure, water management options, and conservative model runs using GoldSim™. The models used to carry out these sensitivity analyses are presented in Table 5. An additional sensitivity run (model not provided to Golder) was carried out to assess the implications of aligning the shift of the annual historical climate datasets with the hydrologic year, as opposed to the calendar year. Based on reporting in the *Curraghinalt Gold Mine Project- Site Water Balance - 2020 Update,* the differences in model predictions between the two approaches ranged from 0 to 2%.

Golder comment:

Golder has reviewed the inputs and outputs to these models, as well as the results and conclusions presented in Section 7 of the *Curraghinalt Gold Mine Project - Site Water Balance - 2020 Update*[53]. The sensitivity analyses carried out adequately represent credible “worst-case” scenarios.

[53] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

Golder's comments regarding each of the sensitivity analysis assessments are presented in Table 10, Table 11, Table 12 and Table 13.

Table 10: Sensitivity Analysis Parameters – Hydrologic Inputs and Other Key Inputs

Model Description	Sensitivity Parameter	Golder Comment
Base Case	None	Base Case considered climate change under RCP 4.5 conditions. Golder consider this appropriate.
Sensitivity S1-1	Runoff + 20%	As the Base Case model already simulates a wet year (1-in-80 year wet), Golder considers this increase to the runoff flow rates (natural and disturbed catchments) to be appropriate for assessing uncertainty due to rainfall and runoff characteristics.
Sensitivity S1-2	Runoff – 20%	As the Base Case model already simulates a dry year (1-in-200 year dry), Golder considers this decrease to the runoff flow rates (natural and disturbed catchments) to be appropriate for assessing uncertainty due to rainfall and runoff characteristics.
Sensitivity S1-3	Underground inflow + 20%	Golder considers this increase to the underground inflow to be appropriate for assessing uncertainty in groundwater inflows. The assessment of the underground inflow rates was carried out separately as part of the "Dalradian Proposed Curraghinalt Project Groundwater Modelling Review"[54].
Sensitivity S1-4	Underground inflow – 40%	Golder considers this decrease to the underground inflow rates to be appropriate for assessing uncertainty in groundwater inflows. The assessment of the underground inflow rates was carried out separately as part of the *Dalradian Proposed Curraghinalt Project Groundwater Modelling Review*.
Sensitivity S1-5	Climate Change at RCP 8.5	As demonstrated in Table 8 of the *Curraghinalt Gold Mine Project - Site Water Balance - 2020 Update*[55], summer months are projected to experience less rainfall while winter months are projected to experience more rainfall. The report presents, qualitatively, that the model does not predict any shortages in the drier summer months, and that increased treatment rates are needed in the winter months. However, the modelling shows that the available storage capacity in the East and West Ponds never falls below the flood storage requirements[54].

[54] Golder Associates Ltd. 2020. Dalradian Proposed Curraghinalt Project Groundwater Modelling Review. Document No. 19127735.611.01.E

[55] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

Model Description	Sensitivity Parameter	Golder Comment
		Upon review of the RCP 8.5 climate inputs, Golder has noted the following: ■ Rainfall: no climate change adjustments were made to the rainfall inputs to present the RCP 8.5 scenario ■ Evaporation: No climate change adjustments were made to evaporation inputs to represent the RCP 8.5 scenario. These rainfall and evaporation inputs only affect the ponds in the model and do not impact runoff and seepage rates. The pond areas are small and so the exclusion of climate updates to these inputs will not substantially affect the model results. Golder considers the RCP 8.5 climate scenario to be appropriate for assessing uncertainty in climate change predictions.
Sensitivity S1-6	Daily hydrological timestep	Upon review of the sensitivity analysis model, Golder has noted that runoff values were input on a daily basis; however, rainfall and evaporation values were input on a monthly basis. The rainfall and evaporation inputs only affect small pond surface areas and so the monthly resolutions of these inputs will not substantially affect the model results. Golder considers a daily hydrological timestep to be adequate for assessing uncertainties in the climate inputs.
Sensitivity S1-7	Daily hydrological timestep in addition to increase in runoff by 20%	Upon review of the sensitivity analysis model, Golder has noted that runoff values were input on a daily basis. However, rainfall and evaporation values were input on a monthly basis. The rainfall and evaporation inputs only affect small pond surface areas and so the monthly resolutions of these inputs will not substantially affect the model results. Golder considers the combination of a daily hydrological timestep and increased runoff to be adequate for assessing the robustness of the model regarding the required flood storage in the East and West Ponds, as well as the maximum required treatment rate. Golder notes that the Clean Water Pond receives diverted water from north of the proposed infrastructure site. Water will be stored for additional make-up to the processing plant, and to provide compensation flow to the Pollanroe Burn. The

Model Description	Sensitivity Parameter	Golder Comment
		pond will have a spillway to allow free overflow to the Pollanroe Burn during extreme storm events.

Sensitivity analysis assessments were carried out on process water demands and changes in mine infrastructure. The parameters adjusted, as well as Golder's comments, are shown in Table 11.

Table 11: Sensitivity Analysis Parameters - Process Water Demands and Changes in Mine Infrastructure

Model Description	Sensitivity Parameter	Golder Comment
Sensitivity S2-1	Fresh Water Requirement increased by 100%	Golder considers this increase to the fresh-water requirements to be an appropriate upper range for assessing uncertainty in this process water demand.
Sensitivity S3-1	Maximum Treatment Rate decreased by 50%	Golder considers this reduction in the maximum treatment rate to be an appropriate upper range for assessing uncertainty in freshwater requirements. Under this sensitivity analysis scenario, there is some encroachment on the flood storage requirements in the pond (freeboard)[56]. However, Golder has reviewed the model and no spill is reported from the pond.
Sensitivity S3-2	Maximum Treatment Rate increased by 50%	Golder considers this increase in the maximum treatment rate to be an appropriate lower range for assessing uncertainty in freshwater requirements.
Sensitivity S3-3	Increased Loss to Evaporator in the RO Treatment Plant (increased from 0.5% to 2.5%)	No justification has been provided as to the range of values considered and Golder cannot provide comment. However, Golder notes that these flows constitute a minor component of the overall flows in the water balance and impacts of changes to these flows are anticipated to be negligible.
Sensitivity S3-4	Additional storage requirements in the East and West Ponds (storage requirement increased by 50%)	Golder considers this increase to the flood storage requirements in the East and West Ponds to be an appropriate upper range for assessing uncertainty in hydrology inputs and freeboard requirements.

Sensitivity analysis assessments were carried out on water management options. The adjusted model logic, as well as Golder's comments, are shown in Table 12.

[56] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

Table 12: Sensitivity Analysis Parameters - Water Management Options

Model Description	Sensitivity Parameter	Golder Comment
Sensitivity S4-1	Divert Natural Runoff in Western Diversion Channel to Pollanroe	In the Base Case, the West Diversion Channel reports directly to the West Pond. The purpose of this sensitivity assessment was to assess the impact on (i) required treatment rates and (ii) available flood storage in the West Pond, in the event that the operational (or planning) decision is made to re-route the West Diversion channel directly to the Pollanroe Burn. Note that this diversion of the West Diversion Channel to the Pollanroe Burn is considered only as part of the sensitivity analysis. The assessment demonstrates that the proposed water treatment capacity and pond volumes are conservative23, as the possibility would exist for this water to discharge directly to the Pollanroe Burn, pending approval by the regulator. Golder considers this assessment adequate for assessing the impact on treatment rates and water flood storage requirements in the event that this approach is considered. However, Golder notes that the increase in Pollanroe Burn flows is not specifically modelled (the diverted flows do not report to any receiving water body within the model), and is not discussed in the provided report. If consideration (as part of future planning processes or operational decision-making) is to be given to diverting this water directly to the Pollanroe Burn, additional effort would be needed to assess the downstream impacts on the Pollanroe Burn.
Sensitivity S4-2	Runoff from undeveloped areas of DSF released to Pollanroe	In the Base Case, the runoff from undeveloped areas on the DSF reports directly to the West Pond. The purpose of this sensitivity assessment is similar to S4-1. Like S41, the assessment demonstrates that the proposed water treatment capacity and pond volumes are conservative24, as the possibility would exist for this water to discharge directly to the Pollanroe Burn. This possibility is only considered as part of the sensitivity analysis. Golder considers this assessment adequate for assessing the impact on treatment rates and water flood storage requirements in the event that this approach is considered. However, Golder notes that the increase in Pollanroe Burn flows is not specifically modelled (the diverted flows do not report to any receiving water body within the model) and is not discussed in the provided report. If consideration (as part of future planning processes or operational decision-making) is to be given to diverting this water directly to the Pollanroe

Model Description	Sensitivity Parameter	Golder Comment
		Burn, additional effort would be needed to assess the downstream impacts on the Pollanroe Burn.

Conservative sensitivity analysis runs were carried out, combining changes to multiple model parameters. The parameters adjusted, as well as Golder's comments, are shown in Table 13.

Table 13: Sensitivity Analysis Parameters - Conservative Sensitivity Model Runs

Model Description	Sensitivity Parameter	Golder Comment
Sensitivity S5-1	Conservative Wet Weather Run, with increased runoff rates (+20%) from all surfaces, and increased underground inflows (+20%)	Golder considers these increases in runoff and underground inflows reasonable for assessing a conservative wet weather scenario. The percentage increases are consistent with sensitivity analysis runs S1-1 and S1-3 in Table 10.
Sensitivity S5-2	Conservative Dry Weather Run with increased flood storage requirement (+50%), reduced runoff rates (-20%) and increased freshwater demand (+100%)	Golder considers these changes in the flood storage requirement of the East and West Ponds, runoff rates and fresh water demand appropriate for assessing a conservative dry weather scenario. The percentage changes are consistent with sensitivity analysis runs S3-4 (Table 11)), S1-2 (Table 10), S2-1 (Table 11) .

Golder conclusion:

Some gaps in the sensitivity analysis assessments were noted in Table 10, Table 11, Table 12 and Table 13 and are summarised as follows:

- Sensitivity Analysis S1-6 (Daily Hydrological Timestep) considers daily runoff and seepage inputs, but monthly rainfall and evaporation inputs.
- Sensitivity Analysis S1-7 (Daily Hydrological Timestep in Addition to Increase in Runoff by 20%) considers daily runoff and seepage inputs, but monthly rainfall and evaporation inputs.
- Justification of the range of values considered in Sensitivity Analysis S3-3 (Increased Loss to Evaporator in the RO Treatment Plant).
- Assessment of the impacts of diverting runoff from undeveloped areas to Pollanroe Burn modelled in Sensitivity Analyses S4-1 (Divert Natural Runoff in Western Diversion Channel to Pollanroe) and S4-2 (Runoff from Undeveloped Areas of DSF Released to Pollanroe), in the event of planning or operational changes.

Although these gaps are noted, Golder does not consider any further assessment is required at this planning stage.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the sensitivity analyses of model inputs satisfactory at this planning stage?	✓		

28.4.9 Key Modelling Conclusions

The key conclusions regarding surface water quantity modelling, as outlined in the *Curraghinalt Gold Mine Project - Site Water Balance - 2020 Update* report[57] are as follows:

- There is a low risk of water shortage at the mine site and a low risk of spillage of untreated mine water;
- The model predicts that the pond water levels can be operated with more than sufficient freeboard above the operational water levels in the East and West Ponds;
- The sensitivity analysis assessments show that the water management plan, proposed water treatment capacity and pond volumes are robust with respect to uncertainties in model inputs; and
- There may be options to reduce flow rates to the water management ponds in the future, but the approach taken is conservative and considers the management of runoff from the full site area.

Golder comment:

It is Golder's opinion that the overall conclusions are sound based on the results presented.

Golder conclusion:

The key conclusions of the water balance are sound based on the results presented and Golder does not consider that further assessment is required.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the key modelling conclusions of the water balance satisfactory based on the results presented?	✓		

28.4.10 Key Model Limitations

Golder notes the following key model limitations:

- Absence of site-specific, long-term climate data;
- Lack of site-specific flow data; and

[57] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

- Extraction of climate change data (precipitation and temperature) from a 25 km^2 grid encompassing the project site.

Golder comment:

These model limitations have been sufficiently addressed in the modelling approach and through the consideration of sensitivity assessments.

Golder conclusion:

The model limitations have been sufficiently considered; Golder does not consider that any further assessment is required.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Have the key model limitations been sufficiently considered?	✓		

28.5 Compliance with Regulatory Requirements

Golder has assessed the outcomes of the water balance against the following key guidelines and directives:

- *Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015;*
- *Regulation 9 of the "Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015";*
- *Regulation 10 of the "Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015";*
- *EC directive 2000/60/EC;*
- *EC directive 2006/11/EC;* and
- *EC directive 2006/118/EC.*

Upon review of the above-mentioned documents, Golder has considered the compliance of the outcomes of the water balance based on the following key issues: (i) Maintenance of low flows (ii) Reduction of erosion and (iii) Prevention of contamination of receiving water bodies. The following sections discuss the compliance of the outcomes of the water balance in relation to these issues.

28.5.1 Maintenance of Low Flows

The EC Directive *2000/60/EC* speaks to the need for achieving Good water status in each river basin, whether this be from an ecological, hydrological, or hydrogeological perspective. The *Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015*[58] presents standards for water flow and water level in rivers of High, Good, Moderate and Poor status.

[58] Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015

As noted in the report *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland*[59], the Owenkillew and Owenreagh Rivers are considered as salmonoid watercourses of Good Status.

The Owenreagh River is classed as a Type C2 river under the *Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015*. As the Pollanroe Burn is a tributary to the Owenreagh River, Golder has applied the river flow standards and objectives of the Owenreagh River to the Pollanroe Burn for the purpose of this review.

Therefore, for both the Pollanroe Burn and Owenreagh River (classified as C2 and of Good status), the permitted reduction in flow (abstraction) per day, as a percentage of the natural mean daily flow, should not exceed[58]:

- 25% at natural mean daily flow exceeding the 60th percentile low flow condition;
- 20% at natural mean daily flow exceeding the 70th percentile low flow condition;
- 15% at natural mean daily flow exceeding the 95th percentile low flow condition; and
- 10% at natural mean daily flow not exceeding the 95th percentile low flow condition.

According to the *Curraghinalt Gold Mine Project - Site Water Balance - 2020 Update* report[60], increases in monthly average and low flows are predicted for both the Owenreagh River and Pollanroe Burn.

Golder comment:

The predicted increases in average and low flow conditions for both the Owenreagh River and Pollanroe Burn are based on assessment of monthly climate and hydrology inputs. Flows in these rivers will be augmented through (i) the dewatering of the underground mine (after treatment) and (ii) through natural groundwater inflows to the Under Drain which discharges to the Pollanroe Burn.

However, the water balance does not take account of daily variations. The *Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015* outlines permitted daily abstraction rates as a percentage of natural mean daily flows. In the event that compensation flows are required to meet these river flow standards, discharge from underground workings can continue to be pumped at rates that allow the standards to be met. Further assessment of the mine discharges (taking daily inputs into account), while being helpful, is not expected to change the overall results from the water balance.

Golder conclusion:

In the event that compensation flows are required to meet river flow standards, discharge from underground workings can continue to be pumped at rates that allow the standards to be met. Golder notes that a further assessment of the mine discharges which takes daily inputs into account, while being helpful, is not expected to change the overall results from the water balance. Golder does not consider that further assessment is required.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Does the assessment provide confidence that the regulations related to flow can be complied with?	✓		

[59] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020.

[60] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

28.5.2 Reduction of Erosion

Regulation 9 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015*[61] speaks to the reduction of erosion, caused by water or wind, as far as it is technically possible and economically viable.

The Pollanroe Burn will receive inflows from the proposed infrastructure site (which includes discharge from the Water Treatment Plant and overflow from the Clean Water Pond), the contributing catchment downstream of the proposed infrastructure site, as well as from the East Diversion Ditch. The East Diversion Ditch and the Clean Water Pond receive runoff from catchments which would report to the Pollanroe Burn under baseline (undeveloped site) conditions. Overall, the development of the proposed infrastructure site will increase flows within the Pollanroe catchment (due to increased runoff rates from disturbed ground etc) under average and low flow conditions. However, under flood flow conditions, the only releases allowed from the site for storm events up to and including the 1-in-2 year up to the 24-hour, 1-in-1,000 year event will be discharged from the Water Treatment Plant[62]. As such, flood flows in the Pollanroe Burn are predicted to be lower during operations than under baseline conditions, as flood waters will be stored and managed within the proposed infrastructure site and will be limited by the treatment rates[62]. The maximum treatment rate is 83.3 L/s, which is lower than the baseline 1-in-2 year flood flow of 900 L/s.

For closure, a qualitative assessment of impacts to flows was carried out based on an “areas assessment” of runoff rates from reclaimed areas[62]. There will be a risk of increased surface water runoff from the surface of the DSF. The need for mitigation of these flows as part of the closure planning process was highlighted; however, it was stressed that with mitigation in place, it was expected that flood flows would be maintained at baseline conditions. Overall, the flows reporting to the Pollanroe Burn are expected to be increased or very similar to baseline conditions.

Golder comment:

Given that the discharges to the Pollanroe Burn from the proposed infrastructure site would be controlled and limited to the water treatment rate during flood events (which is lower than the baseline 2-year flood flow of 900 L/s), it is Golder’s opinion that the increase in flows reporting to the Pollanroe Burn is unlikely to increase the risk of accelerated erosion in the channel. It is Golder’s recommendation, however, that during the detailed design stage, hydraulic analysis of the Pollanroe Burn be undertaken to assess the need for any required erosion protection controls within the channel itself. Golder also recommends proper engineering design be applied to the outfall locations at Pollanroe Burn (East Diversion and Water Treatment Plant outfall) during the detailed design stage, to reduce risk of erosion in the channel at these locations.

Golder conclusion:

Golder notes that the results conform with Regulation 9 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015*; Golder does not consider that further assessment is required.

[61] The Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015. 2015 No. 85

[62] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Does the plan for reduction of erosion conform with Regulation 9 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015?*	✓		

28.5.3 Prevention of Contamination of Receiving Water Bodies

Both Regulations 9 and 10 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015* require the prevention of contamination of surface water in the short and long-term perspectives. The EC directives *2006/11/EC* and *2006/118/EC* both refer specifically to pollution through the discharge of specific dangerous substances.

Under climate conditions up to the design event (24-hour, 1-in-1,000 year storm), any discharge from the mine will pass through the water treatment plant. However, any flows in excess of design conditions (greater than the 24-hour, 1-in-1000 year event) will be released via pond spillways to the Pollanroe Burn, and will bypass the water treatment plant. The release of flows during a storm event exceeding the design event would therefore potentially cause a risk to water quality in the receiving water body, as these flows will bypass the water treatment plant. The risk of contamination to receiving water bodies in an event in excess of the 24 hour, 1-in-1000 year event was assessed, and during such a large flood event, limited impacts are expected downstream of the ponds due to dilution in the receiving water bodies (Section 29.0). Overall, the predicted increases in contaminant concentrations are within the range of values seen in the river under natural conditions, and exceedances of guideline values are predicted only for those parameters that exceed guidelines under baseline conditions. This is discussed further in the *Dalradian Proposed Curraghinalt Project Surface Water Quality Review* (Section 29.0).

In accordance with Regulations 9 and 10 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015,* the water balance demonstrates that contaminated water and leachate is collected using surface collection drains and overdrains. This contaminated water and leachate are treated through the water treatment plant, with the exception of seepage through the liner of the DSF to the underdrain reporting directly to the Pollanroe Burn. However, dilution calculations were carried out to assess the impact of the basal seepage on water quality in the Pollanroe Burn at the mouth, and the results of the assessment indicates that predicted concentrations in the Pollanroe Burn are lower than national drinking water standards, apart from specific parameters where average baseline conditions exceed drinking water standards. Golder's review of water quality impacts (including for events in excess of design conditions) is presented in *Dalradian Proposed Curraghinalt Project Surface Water Quality Review* (Section 29.0).

Golder comment:

Golder notes that contaminated water and leachate will be treated at the water treatment plant, except for seepage through the liner of the DSF to the underdrain reporting directly to the Pollanroe Burn. However, predicted concentrations in the Pollanroe Burn (based on the dilution assessments which include seepage from the DSF) are lower than national drinking water standards, apart from specific parameters where average baseline conditions exceed drinking water standards.

Golder conclusion:

Golder notes that the results conform with Regulations 9 and 10 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015,* as well as EC directives *2006/11/EC* and *2006/118/EC*. Golder does not consider that further assessment is required.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Does the plan for the Prevention of Contamination of Receiving Water Bodies conform with Regulations 9 and 10 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015, and* EC directives *2006/11/EC* and *2006/118/EC?*	✓		

28.6 Suitability of Water Balance Model (Fit for Purpose)

Golder has completed a review of the water balance models used to support assessment of the possible impacts to surface water quantity from the proposed Curraghinalt underground gold mining project. This review has been undertaken with consideration given to the stated purpose of the models (Section 28.3), applicable requirements of the *Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015*, Regulations 9 and 10 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015*, EC Directives *2000/60/EC, 2006/11/EC* and *2006/118/EC*, and good international industry practice.

Golder comment:

It is Golder's opinion that the water balance models are fit for purpose based on the following key points:

- Climate and hydrological characteristics and processes have been appropriately represented within the model;
- The logic and calculations within the model are sound;
- The model considers a range of uncertainty in the inputs, through the application of a stochastic approach to modelling hydrological inputs as well as a series of sensitivity analysis assessments;
- The model considers adequate freeboard requirements within the water storage ponds, and demonstrates that the ponds can be operated with more storage than actually required to capture the runoff from the 1-in-1000 year event; and
- The model addresses the requirements outlined in Regulations 9 and 10 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015*, EC Directives *2000/60/EC, 2006/11/EC* and *2006/118/EC*. The outcomes of the model are in compliance with the requirements of these documents.

However, the following points have been noted:

- The modelled flow duration curve for Pollanroe Burn tended to under-predict observed high flows and to reasonably match observed low flows. Further discussion on the implications (if any) of this would be useful. The fit of the modelled catchment results to the observed local site catchment runoff should be

quantified using an appropriate goodness-of-fit approach. However, no further assessment is required at this planning stage.

- Climate change was incorporated based on linear interpolation between historical climate data for 2020 and the climate predictions for benchmark years 2040 and 2060. The monthly rainfall for the 2040 and 2060 benchmark years were calculated based on an average of the monthly anomalies of the previous and subsequent 5 years of data. Golder cannot comment on the validity of averaging rainfall years previous and subsequent to the benchmark years.
- Golder notes that no sensitivity analysis assessment has been carried out to assess the range of flows that could be provided from the Clean Water Pond to provide compensation flows (if required) in the Pollanroe Burn and Owenreagh Rivers. No further assessment is required at this planning stage.
- No justification has been provided as to the range of values considered in Sensitivity Analysis S3-3 (Increased Loss to Evaporator in the RO Treatment Plant). No further assessment is required at this planning stage.
- Sensitivity Analyses S1-6 and S1-7 consider daily inputs to the water balance model. However, Golder has noted that rainfall and evaporation values were input on a monthly basis. No further assessment is required at this planning stage.
- Sensitivity Analysis S4-1 considers that natural runoff in the Western Diversion Channel is diverted to the Pollanroe Burn. However, the impacts of this diversion on the Pollanroe Burn are not assessed or discussed. If consideration (as part of future planning processes or operational decision-making) is to be given to diverting this water directly to the Pollanroe Burn, additional assessment would be needed to assess the downstream impacts on the Pollanroe Burn. However, no further assessment is required at this planning stage.
- Sensitivity Analysis S4-2 considers that runoff from undeveloped areas of DSF is released directly to the Pollanroe Burn. However, the impacts of this diversion on the Pollanroe Burn are not assessed or discussed. If consideration (as part of future planning processes or operational decision-making) is to be given to diverting this water directly to the Pollanroe Burn, additional assessment would be needed to assess the downstream impacts on the Pollanroe Burn. However, no further assessment is required at this planning stage.
- Hydraulic analysis of the Pollanroe Burn should be undertaken during the detailed design stage to assess the need for any required erosion protection controls within the channel itself. Proper engineering design of the outfall locations at Pollanroe Burn (East Diversion and Water Treatment Plant outfall) will be required during the detailed design stage, to reduce risk of erosion in the channel at these locations.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the water balance model appropriate and fit for purpose?	✓		

29.0 REVIEW OF APPENDIX J - HYDROLOGICAL IMPACT ASSESSMENT REPORT: SURFACE WATER QUALITY REVIEW

29.1 Chapter Summary

Golder has reviewed the reports and associated models / calculations relating to the analysis of the impact on surface water quality from the proposed Curraghinalt project underground mine and associated infrastructure.

Surface water quality is a further area that DfI specifically requested Golder to examine in detail.

29.2 Data Provided

Surface water quality modelling is reported in the report *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland*"[63]. A review of the potential impacts on flow rates is presented in *Dalradian Proposed Curraghinalt Gold Mine Project - Water Balance Review* (Section 28.0). Table 14 outlines the key files which have been provided to Golder.

Table 14: Key Water Quality Files provided to Golder

File Name
Sample Data - Owenreagh at Mouth.csv
Sample Data - Owenreagh at Pollanroe.csv
Sample Data – Pollanroe.csv
Input Table for Forwards Runs - Owenreagh at Mouth.docx
Curraghinalt_WB_Oct_2020_Monthly FINAL_Base_WQ.gsm
Closure WQ Calculations for Proposed Infrastructure Site (sent Golders) Oct 2020.xlsx
Attagh Burn Closure Calculations Oct 2020.xlsx
Curraghinalt Burn Closure Calculations Oct 2020.xlsx
Owenkillew River (at Curraghinalt Burn) Closure Calculations Oct 2020.xlsx
Owenkillew River (at Owenreagh) Closure Calculations Oct 2020

In addition to these key files, 168 input text files to the Environment Agency River Quality Planning Tool (Monte Carlo)[64] were provided to Golder by Kaya Consultants.

29.3 Summary of review comments - Operations

29.3.1 Modelling Software and Objectives

As stated within the Surface Water Impact Assessment for the *Curraghinalt Gold Project, County Tyrone, Northern Ireland*[65], the impacts on downstream watercourses during operations were supported through

[63] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020.

[64] Environment Agency. 2012. Introduction to River Quality Planning Setting Permits and Assessing Compliance.

[65] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. Annexe B – Proposed Discharge Criteria for Owenreagh River and Pollanroe Burn, County Tyrone, BT79 7SF October 2020

modelling in the River Quality Planning (RQP) Monte Carlo tool (Version 2.5). The objectives of the water quality modelling were described as follows:

- To estimate maximum discharge concentrations for the parameters outlined in Table 1-1 and Table 1-2 of Annexe B of the *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland*[65] report. These parameters are outlined in Section 29.3.2 (Table 16).
- To calculate the effect of the discharge on receiving waters.

Golder comment:

The water quality modelling objectives are clearly defined and sufficiently address the requirements of the Environment Statement[66].

The use of the River Quality Planning (RQP) Tool was considered as per instructions from the Northern Ireland Environment Agency (NIEA), as stated in the report *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland*[65]. This tool was developed by the UK Environment Agency (EA) and is suitable for the water quality model objectives listed above, as outlined by the EA publication *Modelling: surface water pollution risk assessment*[67].

Golder conclusion:

The approach taken to modelling water quality in the receiving water bodies using the RQP Tool is adequate.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the modelling software an appropriate tool for the stated objectives?	✓		
Are the water quality modelling objectives clearly defined?	✓		

29.3.2 Validity of Key Assumptions and Conclusions

Conceptual Site Models

Conceptual site models for operating conditions for Years 6, 12 and 20 of the LoM are presented in Section 6 of the *Curraghinalt Gold Mine Project Site Water Balance 2020 Update*[68].

Golder comment:

The conceptual site models presented provide description of flow rates and direction both within the site and through environmental discharges. The descriptions provided are in line with what would be expected for a conceptual site model (CSM).

No CSMs were provided for closure or existing conditions. While it would be useful for a CSM to be provided to illustrate the anticipated changes during closure, enough information was presented within the *Surface Water*

[66] SRK Consulting. 2017. Environmental Statement for the Curraghinalt Project, County Tyrone, Northern Ireland. Volumes 1, 2 and 3.

[67] Environment Agency. 2014. LIT 10419 Modelling: surface water pollution risk assessment.

[68] Kaya Consulting Ltd. 2020.Curraghinalt Gold Mine Project – Site Water Balance – 2020 Update. October 2020

Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland[69] to facilitate Golder's understanding of the site water interactions during closure to allow the assessment to be undertaken.

Golder conclusion:

While it would be useful for a CSM to be provided to illustrate the anticipated changes during closure, enough information has been presented within the relevant reports to allow for the review of the models and model results.

Model Scenarios and Modelled Water Quality Parameters

As mentioned previously in Section 29.3.1 the RQP models were run in order to:

- Estimate maximum discharge concentrations for the water quality parameters outlined in Table 16. This is described as "**backwards**" modelling[70]. The "backwards" modelling was carried out for (i) Owenreagh upstream of Pollanroe Burn and (ii) Owenkillew River at Curraghinalt Burn.
- Calculate the effect of the discharge on receiving waters for the water parameters outlined in Table 16. This is described as "**forwards**" modelling[70]. The "forwards" modelling was carried out for the following locations: (i) Pollanroe Burn at Mouth, (ii) Owenreagh River at Pollanroe Burn and (iii) Owenreagh River at the Mouth, (iv) Owenkillew River at Curraghinalt Burn, (v) Owenkillew at the Mouth and (vi) Curraghinalt Burn.

These scenarios are summarised in Table 15 below.

Table 15: Model scenarios – Operations

Type of Modelling ("Forwards" or "Backwards")	Location
Backwards	Owenreagh River upstream of Pollanroe Burn
	Owenkillew River at Curraghinalt Burn
Forwards	Pollanroe Burn at Mouth
	Owenreagh River at Pollanroe Burn
	Owenreagh River at the Mouth
	Owenkillew River at Curraghinalt Burn
	Owenkillew River at the Mouth
	Curraghinalt Burn

Table 16 presents the water quality parameters included in the "backwards" and "forwards" modelling exercise.

[69] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020.

[70] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

Table 16: Parameters considered in water quality modelling (Operations)

Parameter	Unit
TSS	mg/L
BOD	mg/L
Total Ammonia	mg/L as N
Nitrate	mg/L as N
Nitrite	mg/L as N
Chloride	mg/L
Fluoride	mg/L
Sulphate	mg/L
Aluminium	mg/L
Antimony	mg/L
Arsenic	mg/L
Barium	mg/L
Boron	mg/L
Cadmium	mg/L
Chromium III	mg/L
Chromium VI	mg/L
Chromium III + VI	mg/L
Cobalt	mg/L
Copper	mg/L
Iron	mg/L
Lead	mg/L
Manganese	mg/L
Mercury	mg/L
Molybdenum	mg/L
Nickel	mg/L

Parameter	Unit
Selenium	mg/L
Silver	mg/L
Sodium	mg/L
Uranium	mg/L
Zinc	mg/L

The water quality parameters pH and Oil and Grease were excluded from this modelling exercise.

In addition to the scenarios listed above which used the RQP models, the impacts on the Owenreagh river of events in excess of design conditions (prediction in Owenreagh River) were considered, based on an assessment of water quality within the ponds and applying dilution calculations to determine the impact on the river. The same parameters outlined in Table 16 were considered. The following events were considered:

- 1-in-1,000 year, 48-hour event; and
- 2 consecutive 1-in-100 year, 24-hour events.

Golder comment:

Based on the stated model objectives, these modelled scenarios are appropriate.

Regarding the list of parameters considered in water quality modelling, the report states that there is no NI standard for Orthophosphate. While this statement is correct, there is a NI standard for reactive phosphorous in rivers defined in Schedule 1 - Part 2 - paragraph 3 of SR351, but reactive phosphorous has not been modelled. Therefore, it has not been possible to assess the potential impact of the proposed project on reactive phosphorus levels in the surface water receptors.

However, phosphorous is not typically a constituent of concern (COC) in orogenic gold deposits such as the Curraghinalt deposit. Geochemical laboratory tests on rocks from the deposits displayed phosphorous concentrations at or close to the analytical detection limit for most samples. It is therefore considered unlikely that reactive phosphorous could be a COC at Curraghinalt.

Apart from phosphorous, the remaining list of parameters is considered appropriate based on the type of mine, regulations, and downstream conditions.

Golder conclusion:

The exclusion of reactive phosphorus from the modelling exercise is not expected to have a meaningful impact on the overall outcome of the surface water impact assessment.

Model Simulation Inputs

"Backwards" modelling

For the "backwards" modelling, the RQP Monte Carlo tool required the following inputs:

- Water quality standards or EQS (Environmental Quality Standards) for relevant parameters;

- Flow data for discharge and receiving waters (ie, Curraghinalt Burn, Pollanroe Burn and Owenreagh River); and
- Background water quality in receiving waters.

As stated in Section 29.3.2, the "backwards" modelling was carried out for the (i) Owenkillew River at Curraghinalt Burn and (ii) Owenreagh River upstream of the Pollanroe Burn, to determine discharge criteria which are protective of EQS and ensure that the chemicals and elements are not a potential risk to the environment.

For parameters with no EQS values, drinking water standards were taken forward as the proposed discharge criteria.

The flow data for discharge and receiving waters was determined based on a detailed hydrological assessment which had been undertaken as part of the Curraghinalt Mine Environmental Impact Assessment. Annual average flows and 95%ile low flows within the Owenkillew River and Owenreagh River (upstream of the Pollanroe Burn) were used for these calculations.

Background water quality in receiving waters was obtained from the baseline assessment and were entered into the RQP tool as non-parametric values.

Golder comment:

The methodology for "backwards" modelling is considered to be consistent with NIEA and EA guidance.

The calculations and assumptions to determine the discharge criteria, as well as flows for discharge and receiving waters have been reviewed and are considered appropriate.

Golder carried out a screening assessment of the results of the backwards modelling for all parameters, based on simple dilution calculations. The simple screening tests showed an overall agreement with the reported results. In addition, detailed screening tests of the hazardous parameters Chromium (VI), Lead, Mercury and Arsenic were carried out through use of the RQP Monte Carlo tool. The results of these tests for Chromium (VI) and Lead showed a reasonable match with the reported values, and Golder can corroborate these results. Golder notes the following points for the Owenreagh Catchment:

- The inputs for Arsenic, based on the snapshot of the RQP model inputs/ results, show the mean quality and standard deviation for the upstream river data to be 0.15 ug/L and 0.2 ug/L, respectively[71]. However, the mean quality and standard deviation for the baseline data is 0.56 ug/L and 0.36 ug/L, respectively, resulting in a maximum allowable discharge concentration of 191 ug/L (as opposed to the 203 ug/L reported). However, as the drinking water standard of 10 ug/L is assigned for Arsenic in the "forwards" calculations, this discrepancy has no bearing on the results.
- The results of the "backwards" calculations for Mercury (presented in Table 3-2)[71] indicate a maximum allowable discharge concentration of 0.094 ug/L. Golder is unable to corroborate this result as based on the snapshot of the RQP model inputs/results[71], the mean quality (based on 95%ile values) for the discharge data is 0.0058 ug/L, which is different from the baseline (95%ile) values reported of 0.005 ug/L (Table 3-1).

[71] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland - Annexe B (Proposed Discharge Criteria for Owenreagh River and Pollanroe Burn, Gortin, County Tyrone, BT79 7SF)

Golder conclusion:

The approach taken towards the “backwards” modelling is adequate. While some issues with the “backwards” modelling have been identified, the impact of the issues raised above on the simulated river water qualities is expected to be negligible.

“Forwards” modelling

For the “Forwards” modelling, the RQP Monte Carlo tool required the following inputs:

- Average and 95%ile flows for the receiving waters. This is based on the baseline hydrological assessment;
- Average and standard deviation of flow from the site. This is based on outputs from the water balance model which predicts discharge rates from the water treatment plant;
- Average and standard deviation of the discharge water quality. The average is set to the maximum allowed concentration in the proposed discharge criteria with the standard deviation set to zero, forcing all the discharge to be set to the maximum allowed concentration for all calculations.
- Statistics for receiving water quality. This is based on the baseline water quality set.

The “forwards” modelling was carried out for the (i) Pollanroe Burn at Mouth, (ii) Owenreagh River at Pollanroe Burn and (iii) Owenreagh River at the Mouth (iv) Owenkillew River at Curraghinalt Burn and (v) Owenkillew River at the Mouth and (vi) Curraghinalt Burn.

Golder comment:

Golder carried out screening for the average and standard deviation values used as the inputs (statistics) for the receiving water quality, based on sample data. The values used in the modelling exercise are in line with the screening exercise.

Furthermore, a simple screening assessment of the results of the ‘forwards’ modelling was carried out for all parameters, based on arithmetic dilution calculations. The simple screening tests showed an overall agreement with the reported results. In addition, detailed screening tests of the hazardous parameters Chromium (VI) and Lead were carried out through use of the RQP Monte Carlo tool. The results of these showed a reasonable match with the reported values.

Golder conclusion:

The approach taken towards the “forwards” modelling is adequate and no issues have been identified by Golder.

Events in Excess of Design Conditions

For the modelling of impacts on the Owenreagh River during events in excess of design conditions, the water quality in the ponds was ascertained through transport modelling in GoldSim (*Curraghinalt_WB_Oct_2020_Monthly FINAL_Base_WQ.gsm*), using the same hydrologic inputs and simulation settings as in the base model.

Golder comment:

Golder has reviewed the water quality simulations in the GoldSim model file *Curraghinalt_WB_Oct_2020_Monthly FINAL_Base_WQ.gsm* with the following observations:

Source term water quality for surface runoff from active areas of the DSF: The solute concentrations shown in Table 9-25 of the *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern*

Ireland[72] do not match the values implemented in the GoldSim model for some of the parameters (eg Cl, F, SO4, Al), also some parameter values in Table 9-25 do not match the geochemical modelling results reported in the 2020 Geochemical Characterisation Report[73].The impact of these discrepancies on modelling results is expected to be minor, because the concentrations in DSF runoff predicted by geochemical modelling are much lower than those predicted for DSF seepage and underground mine water, and DSF runoff is only a minor component of the pond water balance.

Source term water quality for runoff from the mine site area: The report states "Given the low concentrations of runoff over the active DSF (which would be considered as representative of runoff over exposed mine waste material), runoff concentrations from these areas of the mine are set to Pollanroe baseline water quality." Golder notes that this is a conservative assumption for all parameters except total ammonia and nitrate, for which concentrations are significantly higher in active DSF runoff than in the Pollanroe baseline.

Golder conclusion:

The impact of the issues raised above on the simulated pond water qualities is expected to be minor. Overall, the modelling approach taken is adequate.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the key assumptions and conclusions of the modelling approach taken valid?	✓		

29.3.3 Assessment of associated levels of uncertainty

The results of a scoping assessment were presented within the *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland*[74] report. The purpose of this assessment was to consider the potential impacts of various components of the development on surface water quality and to assess the level of detail required in the impact assessment.

Golder comment:

The scoping assessment provides some insight into the potential sources of uncertainty to the impact assessment, however, there is no discussion regarding potential sources of uncertainty in the modelling exercise. Golder has identified several sources of uncertainty, based on the review of the "Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland"[74] report:

- Flows in the receiving water bodies;
- Discharge flows from the mine site;
- Baseline water quality (in receiving water bodies); and
- Water quality of source terms for mine water discharges.

[72] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

[73] SRK Consulting. 2020. A Geochemical Characterisation Report for the Curraghinalt Gold Deposit, Northern Ireland. Prepared for Dalradian Gold Limited. October 2020

[74] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

Golder conclusion:

Some discussion on the levels of uncertainty in inputs and outputs, and the implications of these uncertainties, would be helpful as it would increase the robustness of the model results. However, the exclusion of this discussion has no bearing on the validity of the modelled results. Further comment is provided in Section 29.3.4 (below) as well as Section 29.4.3.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the levels of uncertainty as assessed within inputs and outputs likely to impact on the validity of the modelled results?	✓		

29.3.4 Assessment of sensitivity analysis of the inputs and outputs

No sensitivity analyses were carried out for surface water quality calculations for operational conditions.

Golder comment:

The assessment of East and West Pond water quality in the GoldSim model is based on estimates of water flows and water quality of different source terms, all of which have associated uncertainties. It is considered good practice to carry out a sensitivity analysis regarding both flows and qualities to assess their effects on the calculated pond water qualities.

Golder conclusion:

The exclusion of this sensitivity analysis has no bearing on the validity of these calculated qualities. However, a sensitivity analysis should be carried out in the next phase of design (subject to planning approval) to better understand the potential range of surface water concentrations in the ponds during operations. It is recognised that the pond water will be treated prior to discharge from the waste water treatment plant will be monitored and ultimately this is the key control on protection of surface water quality receptor from pond water discharges.

29.3.5 Assessment of Key Conclusions

Golder comment:

The key conclusions regarding surface water quality during **Operations** are as follows[75]:

- Changes to baseline concentrations are consistent with the aims of the discharge criteria calculations; ie, increases in baseline concentrations of 3% or 10% of the EQS maximum depending on whether baseline concentrations already exceed EQS or not.
- During events exceeding design conditions:
  - The results show slightly elevated concentrations from baseline in the Owenreagh River, but these increases are small given the large volume of water in the Owenreagh River compared to overflow from the water management ponds.
  - The predicted concentrations in the Owenreagh River are below the 95%ile (high) observed concentrations in the Owenreagh River, for all parameters apart from nitrite, mercury, selenium and

[75] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

uranium (however all measurements in the baseline data set are recorded below detection concentrations, as such the average and 95%ile values are the same).

- Overall, the predicted increases are within the range of values seen in the river under baseline conditions.
- The events considered are particularly extreme; any impacts would be transient and last for up to a few hours only while the flood passes.

Golder conclusion:

It is Golder's opinion that based on the results presented, the overall conclusions regarding "backwards" and "forwards" modelling during normal operations are sound.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the predictions of groundwater quality estimated in the models for the operational period robust and in compliance with the regulations?	✓		

29.4 Summary of review comments - Closure

29.4.1 Modelling Software and Objectives

Impacts on downstream watercourses during closure were calculated using dilution calculations carried out in the following Microsoft Excel™ spreadsheets:

- "Attagh Burn Closure Calculations Oct 2020.xlsx"[76]
- "Closure WQ Calculations for Proposed Infrastructure Site (sent Golders) Oct 2020.xlsx"[77]
- "Curraghinalt Burn Closure Calculations Oct 2020.xlsx"[78]
- "Owenkillew River (at Curraghinalt Burn) Closure Calculations Oct 2020.xlsx"[79]
- "Owenkillew River (at Owenreagh) Closure Calculations Oct 2020.xlsx"[80]

No modelling software was used to determine downstream impacts after closure. The objectives of the dilution calculations were as follows[81]:

- To assess downstream effects of any runoff or seepage from reclaimed mine areas; and
- To assess downstream effects of discharges from the adit at closure.

[76] Kaya Consultants. 2020. Attagh Burn Closure Calculations.xlsx. October 2020

[77] Kaya Consultants. 2020. Closure WQ Calculations for Proposed Infrastructure Site (sent Golders).xlsx. October 2020

[78] Kaya Consultants. 2020. Curraghinalt Burn Closure Calculations Oct 2020.xlsx. October 2020

[79] Kaya Consultants. 2020. Owenkillew River (at Curraghinalt Burn) Closure Calculations Oct 2020.xlsx. October 2020

[80] Kaya Consultants. 2020. Owenkillew River (at Owenreagh) Closure Calculations Oct 2020.xlsx. October 2020

[81] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

Golder comment:

The objectives of the dilution calculations are clearly defined and sufficiently address the requirements of the Environment Statement[82].

Golder conclusion:

The dilution calculations are considered suitable for the outlined model objectives.

29.4.2 Validity of Key Assumptions and Conclusions

As mentioned in Section 29.3.1, dilution calculations were used to assess downstream impacts during closure.

Conceptual Site Model

No conceptual site models were provided for closure.

Golder comment:

While it would be useful for a CSM to be provided to illustrate the anticipated changes during closure, enough information was presented within the *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland*[83] to facilitate Golder's understanding of the site water interactions during closure to allow the assessment to be undertaken.

Golder conclusion:

Satisfactory.

Model Scenarios

The closure calculations considered (i) impacts to the Owenkillew Catchment and (ii) impacts to the Owenreagh Catchment.

Owenkillew Catchment

Post-closure water quality calculations for the Owenkillew Catchment were carried out to consider mine flows throughout various periods of closure.

Table 17 shows the water quality parameters assessed in the dilution calculations for the Owenkillew Catchment, as calculated in the following spreadsheets:

- "Attagh Burn Closure Calculations Oct 2020.xlsx"[84]
- "Curraghinalt Burn Closure Calculations Oct 2020.xlsx"[85]
- "Owenkillew River (at Curraghinalt Burn) Closure Calculations Oct 2020.xlsx"[86]
- "Owenkillew River (at Owenreagh) Closure Calculations Oct 2020.xlsx"[87]

[82] SRK Consulting. 2017. Environmental Statement for the Curraghinalt Project, County Tyrone, Northern Ireland. Volumes 1, 2 and 3.

[83] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020.

[84] Kaya Consultants. 2020. Attagh Burn Closure Calculations.xlsx. October 2020

[85] Kaya Consultants. 2020. Curraghinalt Burn Closure Calculations Oct 2020.xlsx. October 2020

[86] Kaya Consultants. 2020. Owenkillew River (at Curraghinalt Burn) Closure Calculations Oct 2020.xlsx. October 2020

[87] Kaya Consultants. 2020. Owenkillew River (at Owenreagh) Closure Calculations Oct 2020.xlsx. October 2020

Table 17: Water Quality Parameters Assessed for Existing Infrastructure Site

Parameter	Unit
TSS	mg/L
BOD	mg/L
Total Ammonia	mg/L as N
Nitrate	mg/L as N
Nitrite	mg/L as N
Chloride	mg/L
Fluoride	mg/L
Sulphate	mg/L
Aluminium	mg/L
Antimony	mg/L
Arsenic	mg/L
Barium	mg/L
Boron	mg/L
Cadmium	mg/L
Chromium III	mg/L
Chromium VI	mg/L
Chromium III + VI	mg/L
Cobalt	mg/L
Copper	mg/L
Iron	mg/L
Lead	mg/L
Manganese	mg/L
Mercury	mg/L
Molybdenum	mg/L
Nickel	mg/L
Selenium	mg/L
Silver	mg/L

Parameter	Unit
Sodium	mg/L
Uranium	mg/L
Zinc	mg/L

The calculations were carried out for average and low flow conditions in the watercourses, and were reported for (i) Curraghinalt Burn for Years 1, 7, 13 and 50+ after the end of mine operations, (ii) Attagh Burn for Years 13 and 50+ after the end of mine operations, (iii) Glenealy Burn for Years 13 and 50+ after the end of mine operations, (iv) Owenkillew River (downstream of Curraghinalt Burn) for Years 13 and 50+ after the end of mine operations and (v) Owenkillew River (upstream of Owenreagh River) for Years 13 and 50+ after the end of mine operations. The reasoning for the assessment in these years is as follows[88]:

- Year 1 considered for the Curraghinalt Burn as the highest adit water quality concentrations are predicted in this year during the early closure period.
- Year 7 is considered for the Curraghinalt Burn as it is the year when groundwater is able to flow from the main underground mine to the adit. Note that neither Year 1 nor Year 7 are considered for the other points of interest as there is no adit flow to the other locations.
- Year 13 is considered for the rivers as it is the year the underground mine is fully infilled and the groundwater system reconnected close to pre-development conditions. As such, groundwater originating from the underground mine might be able to impact the burns and subsequently the receiving rivers. Note that there are no loadings from the adit or groundwater to the Glenealy Burn.
- Year 50 is considered for all points of interest as adit and underground mine water concentrations approach a steady state; results at this time are considered indicative of long-term predictions of water quality.

As small to negligible changes in water quality in the Owenkillew near the Curraghinalt Burn and Attagh Burn were predicted, and negligible changes in the Owenreagh River at closure were also predicted, no quantitative predictions of water quality were made for the Owenkillew River downstream of the Owenreagh River[88].

Impacts of climate change (RCP 4.5) were considered in the dilution calculations; the average, annual low flow and summer low flow rates for Years 1, 7, 13 and 50+ were adjusted to consider variations in flow rates throughout various stages of closure.

Golder comment:

Golder has checked the water quality and flow calculations for closure and the assessment for the Owenkillew Catchment is considered appropriate.

The RCP 4.5 climate scenario was considered in all dilution calculations. Golder notes that no climate change assessment was carried out for the RCP 8.5 climate scenario. While Golder is not aware of any regulatory requirement to consider the RCP 8.5 scenario, it would be considered best practice to consider this scenario in the next phase of design (subject to planning approval) to (i) better understand the potential range of surface water concentrations during closure, and (ii) reflect the uncertainty inherent in climate change predictions.

[88] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

Golder conclusion:

Golder has checked the water quality and flow calculations for closure and the assessment for the Owenkillew Catchment is considered appropriate. However, it would be considered good practice for the calculations to take the RCP 8.5 scenario into account in the next phase of design (subject to planning approval).

Owenreagh Catchment

Post-closure water quality calculations for the Owenreagh Catchment were performed for various phases of closure. Calculations of the impact of seepage and runoff from the DSF on the Pollanroe Burn and Owenreagh River were undertaken for the parameters where predicted concentrations in DSF seepage and/or runoff are higher than Pollanroe Burn baseline water quality[89]. Table 18 shows the water quality parameters assessed in the dilution calculations for the Owenreagh Catchment, as calculated in the spreadsheet "Closure WQ Calculations for Proposed Infrastructure Site (sent Golders) Oct 2020.xlsx"[90]. The spreadsheet applies simple mixing and dilution calculations of the different water types and flows to predict monthly water qualities for Year 2 and Year 20 after closure in (i) Pollanroe Burn at the Water Treatment Plant (WTP) outfall, (ii) Pollanroe Burn at Mouth, (iii) Owenreagh downstream of Pollanroe Burn, and (iv) Owenreagh at the mouth.

Table 18: Water Quality Parameters Assessed for Proposed Infrastructure Site

Parameter	Unit
Total Ammonia	mg/L as N
Nitrate	mg/L as N
Sulphate	mg/L
Antimony	µg/L
Arsenic	µg/L
Barium	µg/L
Boron	µg/L
Cobalt	µg/L
Chromium VI	µg/L
Total Chromium	µg/L
Molybdenum	µg/L
Nickel	µg/L
Selenium	µg/L
Uranium	µg/L
Zinc	mg/L

[89] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

[90] Kaya Consultants. 2020. Closure WQ Calculations for Proposed Infrastructure Site (sent Golders) Oct 2020.xlsx. October 2020

Golder comment:

Golder has checked the water quality and flow calculations for closure and the assessment for the Owenreagh Catchment is considered appropriate.

The RCP 4.5 climate scenario was considered in all dilution calculations. Golder notes that no climate change assessment was carried out for the RCP 8.5 climate scenario. While Golder is not aware of any regulatory requirement to consider the RCP 8.5 scenario, it would be considered best practice to consider this scenario in the next phase of design (subject to planning approval) to (i) better understand the potential range of surface water concentrations during closure, and (ii) reflect the uncertainty inherent in climate change predictions.

Golder conclusion:

Golder has checked the water quality and flow calculations for closure and the assessment for the Owenreagh Catchment is considered appropriate. However, it would be considered good practice for the calculations to take the RCP 8.5 scenario into account in the next phase of design (subject to planning approval).

Calculation Inputs

Owenkillew Catchment

As mentioned previously, no probabilistic modelling was carried out for closure. Instead, dilution calculations were carried out.

The following inputs were used for the closure dilution calculations:

- Adit and underground mine water flows for baseline conditions, as well as for key years after closure;
- Average, annual and low flows for the Curraghinalt Burn, Attagh Burn and Owenkillew River, for key years after closure;
- Average baseline concentrations in the Curraghinalt Burn, Attagh Burn and Owenkillew River; and
- Source term concentrations for adit discharge and underground mine water from geochemical modelling, for key years after closure.

Golder comment:

These inputs are considered appropriate for achieving the model objectives.

Golder conclusion:

Satisfactory.

Owenreagh Catchment

The following hydrological and flow inputs were used for the closure dilution calculations:

- Seepage from the Reclaimed DSF;
- Runoff from the Reclaimed DSF;
- Runoff from the Natural Catchment;
- Drain Down (Year 2 after closure);
- Seepage through the DSF liner;
- Average monthly flows in Pollanroe Burn;
- Average monthly flows in Owenreagh River at Pollanroe Burn; and

- Average monthly flows in Owenreagh River at the Mouth.

Loadings from the following sources were considered:

- Seepage from the DSF at end of reclamation;
- Seepage from the DSF post-closure;
- Runoff from closed DSF; and
- Baseline conditions in Pollanroe Burn and Owenreagh River.

Golder comment:

Based on the description of the proposed mine facilities provided during closure in the SWIA[91], the above inputs are suitable for the closure model.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the key assumptions and conclusions for closure modelling appropriate and fit for purpose?	✓		

29.4.3 Assessment of associated levels of uncertainty

The results of a scoping assessment were presented within the report *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland*[91]. The purpose of this assessment was to consider the potential impacts of various components of the development on surface water quality and to assess the level of detail required in the impact assessment.

Golder comment:

Golder has identified several sources of uncertainty, based on the review of the *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland*[91] report:

- Flows in the receiving water bodies;
- Discharge flows from the mine site;
- Baseline water quality (in receiving water bodies);
- Water quality of source terms for mine water discharges
- Climate change predictions.

Golder notes that consideration has been given to the uncertainty in climate change predictions, through the consideration of the RCP 4.5 climate change scenario in the dilution calculations. However, Golder notes the

[91] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

lack of discussion pertaining to the uncertainties associated with water quality and flow inputs to the closure calculations.

Golder conclusion:

Some discussion on the levels of uncertainty in inputs and outputs, and the implications of these uncertainties, would be helpful. However, the exclusion of this discussion has no bearing on the validity of the modelled results.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the modelled results valid, given the uncertainties identified by Golder for inputs and outputs?	✓		

29.4.4 Assessment of sensitivity analysis of the inputs and outputs

Based on information reviewed by Golder, no sensitivity assessments were carried out for closure water quality calculations, for either the Owenreagh or Owenkillew catchments.

Golder comment:

As stated in Section 29.4.3, when carrying out water quality calculations, it is considered good practice to carry out a sensitivity analysis regarding both flows and qualities. The exclusion of this sensitivity analysis has no bearing on the validity of these calculated qualities.

Golder conclusion:

Sensitivity analyses should be carried out in the next phase of design or closure planning (subject to planning approval), to better understand the potential range of surface water concentrations during closure in the Owenreagh and Owenkillew Catchments.

29.4.5 Assessment of Key Conclusions

Owenkillew Catchment

The **key** conclusions regarding surface water quality during closure within the Curraghinalt Burn, as presented in the *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland report*[92] include the following:

- In the first 7 years after the end of operations, nitrate, antimony and molybdenum concentrations in adit water are predicted to exceed the operational discharge criteria without further treatment, with manganese concentrations exceeding the discharge criteria after year 13.
- Concentrations of total ammonia in groundwater entering the Curraghinalt Burn from the underground mine (after year 7) are predicted to exceed the discharge criteria for year 7 only, with manganese the only other parameter with concentrations in excess of the discharge criteria values (after year 25).
- The results show no exceedances of the discharge consent limits in the Curraghinalt Burn until year 13 when manganese concentrations are predicted to exceed baseline and discharge limits in the burn.

[92] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

Concentrations increase further 50+ years after the end of operations. Manganese concentrations in adit and underground water are predicted to reach 293 µg/L 50 years after the end of operations.

The **key** conclusions regarding surface water quality during closure within the Attagh Burn, as presented in the *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland* report[92] include the following:

- No parameters exceed drinking water standards apart from iron and manganese which exceeded the standards under baseline conditions.

The **key** conclusions regarding surface water quality during closure within the Owenkillew River, as outlined in the report *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland*[92] include the following:

- The results show no exceedances of EQS other than silver which exceeded EQS under baseline conditions, due to the EQS being lower than the detection limit for that parameter. No change in the concentration is predicted in the Owenkillew River for silver at closure.
- The predictions for average concentrations are less than during operations, apart from manganese.
- By 50 years after closure, the predicted changes in concentration in the Owenkillew are even lower, with very small changes from baseline conditions.

Golder comment:

The adit and underground water will discharge to the Curraghinalt Burn (within the Owenkillew catchment) after closure. The concentration of manganese in this water 50 years after closure is predicted to be 293 µg/L[92]. To add some additional context around this discharge concentration, Golder has carried out a high-level assessment and compared this concentration to baseline concentrations at sampling points along the Attagh Burn (SW31 and SW32) and Glenealy Burn (SW03), both of which are local tributaries to the Owenkillew. Similarly to the Curraghinalt Burn, both the Attagh Burn and Glenealy Burn drain catchments which lie south of the Owenkillew River. The Curraghinalt Burn was not used for this comparison as it is already impacted by discharges from the existing adit.

Golder has calculated the average of the mean baseline manganese concentrations at the three sampling points as being 211.7 µg/L. The concentration of manganese in the adit and underground water 50 years after closure is higher than this calculated average. However, it is lower than the maximum concentrations at SW31 and SW32 (Attagh Burn) and SW03 (Glenealy Burn).

As of year 13 of closure, the Curraghinalt Burn (downstream of the mine water discharge) is predicted to have average manganese concentrations of 124 µg/L, which exceeds the reported average baseline manganese concentration in the Curraghinalt Burn of 69.7 µg/L upstream of the mine water discharge (SW02). However, this predicted average manganese concentration is lower than Golder's calculated average baseline concentration (211.7 µg/L) at the three sampling locations (SW31, SW32 and SW03). It is also only slightly higher than the Environmental Quality Standard for manganese of 123 µg/L[93]. Golder also notes that the Curraghinalt Burn has been considered to be of Low Sensitivity[93].

It is therefore possible that long-term active or passive treatment of manganese in the adit flows may have to be considered in the closure planning. The next phase of design, operational monitoring and more detailed

[93] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

closure planning (subject to planning approval and permitting) should place particular focus on manganese to assess whether long-term adit discharge treatment after closure may be required.

Golder conclusion:

It is Golder's opinion that the overall conclusions noted above are sound based on the models and results presented. Golder notes however that long-term active or passive treatment of the adit and underground water may be required and should be considered in operational and closure planning.

Owenreagh Catchment

The **key** conclusions regarding surface water quality during closure within the Pollanroe Burn, as presented in the *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland* report[94], include the following:

- Only total ammonia, nitrate and sulphate concentrations are predicted to exceed average baseline concentrations.
- The results show no exceedances of drinking water standards for any of the parameters with concentrations above baseline, apart from background iron and manganese.
- Background iron and manganese concentrations in the Pollanroe Burn are already above drinking water standards, but as predicted DSF seepage and runoff concentrations for these parameters are below average baseline concentrations in the Pollanroe Burn, there is expected to be no adverse change at closure.

The **key** conclusions regarding surface water quality during closure within the Owenreagh River, as presented in the *Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland* report[94] include the following:

- Runoff and seepage from the DSF have no measurable impact on baseline concentrations in Owenreagh.
- Nitrate concentrations exceed baseline conditions two years after closure, however after 20 years from the end of mining operations the nitrate concentration is predicted to have fallen to baseline conditions in the Owenreagh River at the confluence with the Pollanroe Burn.
- Average molybdenum concentrations are predicted to exceed baseline conditions as of closure, but still fall within the increased EQS allowance.

Golder comment:

It is Golder's opinion that the overall conclusions noted above are sound based on the results presented. Although some points have been noted, it is not anticipated that these overall conclusions would change substantially.

Golder conclusion:

Satisfactory.

[94] SRK Consulting. 2020. Surface Water Impact Assessment for the Curraghinalt Gold Project, County Tyrone, Northern Ireland. October 2020

29.5 Suitability of Water Quality models and Calculations (Fit for Purpose)

It is Golder's opinion that the surface water quality models and calculations are fit for purpose and achieve the overall objectives stated in Section 29.1. Any points raised above are summarised below, however as previously mentioned it is not anticipated that they would affect the overall conclusions in a meaningful way. These points are summarised as follows (refer to previous sections for full context):

- There is no conceptual site model presented outlining flows and flow directions during closure. However, this has no impact of the validity of the model results.
- The assessment of East and West Pond water quality in the GoldSim model is based on estimates of water flows and water quality of different source terms, all of which have associated uncertainties. No sensitivity analyses were carried out to consider uncertainties in the calculation inputs. These assessments should be considered in the next phase of design (subject to planning approval).
- With the exception of climate change inputs during closure, there is no discussion regarding potential sources of uncertainty within the modelling exercises/ calculations.
- No sensitivity analyses were carried out to consider uncertainties in the calculation inputs (flows and water quality inputs) for the dilution calculations during closure. These assessments should be considered in the next phase of design (subject to planning approval).
- Upon review of the dilution calculations for closure, it was noted that the RCP 8.5 climate change scenario was not considered. This assessment should be considered in the next phase of design (subject to planning approval).
- The RQP model inputs for the "backwards" modelling for the parameters Arsenic and Mercury are not consistent with the reported baseline values (for the Owenreagh Catchment).
- As previously noted, the source term water quality data for surface runoff from active areas of the DSF in the GoldSim water quality modelling of events in excess of design conditions contains some erroneous values, which may affect the simulated pond water quality during extreme events. However, the impact of these discrepancies on the simulated pond water quality is expected to be minor.
- Golder notes that long-term active or passive treatment of the adit and underground water may be required after mine closure and should be considered in the long-term operational and closure planning.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the water quality models and calculations fit for purpose and appropriate to be presented to Public Inquiry?	✓		

30.0 REVIEW OF APPENDIX K - SURFACE AND GROUNDWATER ENVIRONMENTAL MONITORING AND ACTION PLAN

Golder has completed the review of Appendix K Surface Water and Groundwater Environmental Monitoring and action plan (SGEMAP) in Section 13.0 above (refer to environmental monitoring). The SGEMAP presents the principles underpinning the SGEMAP, ie the surface water and groundwater impact assessments (reviewed in depth by Golder in this document, Sections 26.0, 27.0, 28.0 and 29.0). A risk based approach is used to establish the monitoring and action plan for the site which is presented in detail. The document is considered a live document and will be revised based on monitoring results observed throughout the lifecycle of the proposed project.

Golder comment:

Golder has provided in depth review of surface water quantity and quality assessments which underpin the risk based approach presented in the SGEMAP. A risk based approach is standard practice. Golder notes that the programme presented in the SGEMAP will need to be approved by the planning department / NIEA and that the SGEMAP is correctly considered a live document.

Golder conclusion:

Satisfactory.

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the SGEMAP sufficiently developed to be presented to Public Inquiry?	✓		

31.0 ASSESSMENT OF WMP: SUMMARY & CONCLUSIONS

31.1 Summary

Golder has assessed and reviewed each chapter and appendix of the Waste Management Plan (WMP) for a proposed gold mine situated around Curraghinalt, County Tyrone, Northern Ireland (issued under a Further Environmental Information request (FEI2), numbered *U7511 2020* and dated June 2020 which forms Appendix B3 of the all-encompassing package of FEI documents).

Golder has carried out a detailed review of the content, aims and objectives of the WMP and has, where necessary, raised queries and sought clarification on multiple technical and interpretative issues. It considers that to date it has received adequate responses to these questions and that currently no significant areas of concern remain to be explored. As noted below, there are a number of more minor clarifications which can be investigated and discussed further at Public Inquiry stage.

A summary of Golder's findings is presented in Table 19 below:

Table 19: Summary of Assessments

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Chapter 1 - Introduction			
Are the objectives of the WMP clearly outlined and adequate in nature?	✓		
Is the list of legislation adequate for the preparation of a WMP for a mine development in Northern Ireland?	✓		
Is the list of guidance documents adequate for the preparation of a WMP for a mine development in Northern Ireland?	✓		
Chapter 2 – Site Description & Setting			
Is the site selection process for the WMP acceptable and have sufficient alternatives been considered?	✓		
Has the selection and weighting process been clearly defined?	✓		
Chapter 3 – Waste Characterisation			
Has sufficient information been provided with the WMP regarding type, quantity and EWC code for all mine wastes that will be stored on site during the full life cycle of the project?	✓		
Are the waste classifications given to waste types (as per Schedule 3 of the *2015/85 Regulations*) acceptable?	✓		
Chapter 4 – Waste Storage Facility Classification			
Is SRK's assumption on the classification of the excavation void correct?	✓		
Has SRK referenced the correct legislation and hence assessment criteria regarding waste facility classification?	✓		
Is the Category A assessment for the MWF correct?	✓		
Is the Category A assessment for the Water Storage Ponds correct?	✓		

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the designation of the WMF as a Waste Facility correct?	✓		
Is the designation of the Water Storage Ponds as Waste Facilities correct?	✓		
Chapter 5 – Operation & Waste Treatment Methods			
Are the waste volume calculations including bulking factors used reasonable?	✓		
Are the planned measures for waste rock, tailings and peat (to manage it and reduce the volume) realistic and achievable?	✓		
Are the waste storage provisions considered adequate (subject to individual technical assessments)?	✓		
Chapter 6 – Design Risk Assessment			
Is the Risk Assessment fit for purpose? Have risks been identified that have not been addressed?	✓		
Are the definitions of Consequences and Probability of Exposure given in the risk assessment adequate?		✓	
Chapter 7 – Design of the Mine Waste Facilities			
Have sufficient factors been taken into account in the design of the MWF and are the Design Principles adequate?	✓		
Are the construction sequence assumptions reasonable and achievable?	✓		
Is the foundation preparation for the MWF adequately described, particularly in relation to the HDPE liner?	✓		
Is the proposed underdrain construction fit for purpose?	✓		
Is the proposed overdrain construction fit for purpose?	✓		
Is the proposed toe drain construction fit for purpose?	✓		

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the proposals for transport and placement of waste material satisfactory and achievable?	✓		
Is the proposed water treatment technology (RO) capable of providing an adequate water treatment solution for the Project (subject to technical assessment)?	✓		
Is the correct legislation and guidance referenced for construction & design of the MWFs?	✓		
Is the proposed schedule for monitoring and inspection (as per *Establishment of Guidelines for the inspection of mining waste facilities, inventory and rehabilitation of abandoned facilities and review of the BREF document No. 070307/2010/576108/ETU/C2. Annexe 2, Guidelines for the Inspection of Mining Waste Facilities)* compliant with the requirements of *2015/85 Part 4 Section 9 (c)(d)?*	✓		
Chapter 8 – Design of the Paste Backfill Plant			
Is the description of the waste types to be sent to the excavation voids accurate?	✓		
Are the quantities of backfill materials which will be produced realistic & the description of the process of producing the paste backfill adequate?	✓		
Is the methodology for transport & placement of the backfill material as described and fit for purpose?	✓		
Is the test work on the different blends of tailings at 1:1 and 3:1 sufficient to provide confidence that the proposed mix at 2:1 can achieve the objectives?	✓		
Overall, is the proposed design of the paste backfill plant capable of achieving the mine's backfilling objectives?	✓		
Chapter 9 – Peat Management Strategy			
Comments in Sections 22.0 and 23.0			

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Chapter 10 – Construction Materials			
Is the proposed re-use of waste rock an acceptable approach for construction materials?	✓		
Chapter 11 – Control & Operational Monitoring Procedures			
Is the range and scope of the O&M Manual outline sufficient to allow the preparation of an appropriate document?	✓		
Chapter 12 – Closure, Post-Closure & Monitoring			
Is the Rehabilitation & Closure Plan sufficiently developed for consideration at Public Inquiry?	✓		
Chapter 13 – Prevention of Environmental Pollution			
Are the proposed management and controls on leachate / seepage adequate to prevent potential risks to groundwater and surface water?	✓		
Have the potential risks from paste backfill to groundwater and surface water been adequately described with appropriate mitigation measures in place?	✓		
Are the management and control of dust emissions from the surface operations of the MWF during construction and operational phase acceptable?	✓		
Are the modelling of air quality / dust emissions at the site considered acceptable for presentation at Public Inquiry?		✓	
Are the modelling of dust emissions from the ventilation shafts during the operational period of the mine acceptable?		✓	
Is the leachate monitoring programme sufficiently developed for consideration by planning authority / NIEA?	✓		
Is the groundwater monitoring programme sufficiently developed for agreement with planning authority / NIEA?	✓		

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the surface water monitoring programme sufficiently developed for agreement with planning authority / NIEA?	✓		
Is the air quality monitoring programme sufficiently developed for agreement with planning authority / NIEA?		✓	
Chapter 14 – Review of Waste Management Plan			
Are the arrangements for the review structure of the WMP in accordance with the requirements of Regulation 6 of the *2015/85 Regulations*?	✓		
Chapter 15 – Accident Prevention			
Are the proposed accident prevention and proposed safety management systems sufficiently developed for presentation at Public Inquiry?	✓		
Chapter 16 – Best Available Techniques			
Are the Best Available Techniques given in the 2018 MWEI BREF applied to the site?	✓		
Are all closure scenarios suggested by BAT 11 considered within the financial provision?		✓	
Chapter 17 - References			
Not reviewed.			
Chapter 18 - Review of Appendix A – Geology Report			
Is the description of Geological Setting & Mineralisation sufficient?	✓		
Chapter 19 – Review of Appendix B – Paste Backfill Testing Report			
Is the test work for paste backfill adequate for presentation at Public Inquiry?	✓		
Chapter 20 – Review of Appendix C – Curraghinalt Geochemistry Characterisation Report			
Are the objectives of the geochemical modelling appropriate for the proposed development?	✓		

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the methodology underpinning the assessment of acid generating rock and changes in water chemistry appropriate?	✓		
Are the guidelines and methodologies applied to derive target values / screening levels appropriate?	✓		
Are the key model (computer and conceptual) assumptions and conclusions for the dry stack facility valid?	✓		
Are the key model (computer and conceptual) assumptions and conclusions for the underground mine valid?	✓		
Are the predicated outcomes of assessments of acid generating rock and changes in water chemistry, both above and below ground, compliant with regulation 9 & 10 and the relevant EC Directives?	✓		
Are the model limitations sufficiently well understood and tested to allow consideration of compliance with regulation 9 & 10 and the EC Directives referenced within?	✓		
Are the source term water quality models fit for purpose?	✓		
Is the document: *A Geochemical Characterisation Report for the Curraghinalt Gold Deposit, Northern Ireland, October 2020* fit for purpose and suitable for presentation to Public Inquiry?	✓		
Chapter 21 – Review of Appendix D – NI DOE Planning Unit Questionnaires			
Is Appendix D completed as per the information provided in the WMP?	✓		
Is the Category A assessment conclusion in Appendix D appropriate?	✓		
Chapter 22 – Review of Appendix E – Peat Management Plan			
Is the Peat Management Plan fit for purpose and able to be presented to Public Inquiry?	✓		
Chapter 23 – Review of Appendix F – Peat Slide Risk Assessment			

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the Peat Slide Risk Assessment fit for purpose and able to be presented to Public Inquiry?	✓		
Chapter 24 – Review of Appendix G – Mine Waste Facility Feasibility Study Report & Addendums			
Is the list of legislation cited for the design of the MWF considered adequate?	✓		
Is the approach of using BAT and international industry guidance for the design of the MWF considered suitable?	✓		
Is the extent of the ground investigation considered adequate for the level of design development and has an adequate understanding of the sub-surface conditions been developed?	✓		
Is the ground model considered to be adequate for the current level of design development?	✓		
Does the review of the stability models support the overall finding regarding stability of the WMF as reported within the WMP?	✓		
Is the design of the WMF considered to be well described and robust?	✓		
Chapter 25 – Review of Appendix H – Conceptual Closure Plan			
Does the CRCP demonstrate sufficient consideration of the closure and post closure requirements of the project?	✓		
Chapter 26 – Review of Appendix I – Hydrogeological Impact Assessment Report: DSF & Pond Seepage Review			
Is this modelling valid? Are the assumptions on the potential for seepage to groundwater from the proposed DSF adequate and satisfactory in order to be presented to Public Inquiry?	✓		
Chapter 27 – Review of Appendix I – Hydrogeological Impact Assessment Report: Groundwater Modelling Review			
Are the modelling objectives met and is the resulting Class 3 categorisation, indicating highest confidence, reasonable?	✓		

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Is the hydrogeological conceptualisation fit for purpose?	✓		
Is the modelling software, and resulting scenarios, suitable and fit for purpose?	✓		
Are the model domain and boundaries and the GHB conditions applied reasonable?	✓		
Are the hydrogeological zones represented accurately in the model conceptualisation?	✓		
Are the assumptions on the hydraulic parameters reasonable?	✓		
Are the assumptions on the boundary conditions reasonable?	✓		
Are the recharge mechanisms and estimates used in the model acceptable?	✓		
Does the model calibration exercise demonstrate reasonable fit with observed parameters?	✓		
Are the mine workings represented in the model representative for use in the model?	✓		
Is the DSF and underdrains conceptualisation applied in the model reasonable?	✓		
Has a sufficiently robust sensitivity analysis been completed on the model input parameters?	✓		
Are operational model forecasts reasonable?	✓		
Are closure model forecasts estimated by the model reasonable?	✓		
Is the groundwater modelling undertaken by SRK sufficient & appropriate to address the modelling objectives and to inform the GIA?	✓		
Chapter 28 – Review of Appendix J – Hydrological Impact Assessment Report: Water Balance Review			
Is the use of GoldSim™ software to model the water balance appropriate in order to meet purpose & objectives?	✓		

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Are the resulting model scenarios (base case and sensitivity runs) appropriate?	✓		
Are the conceptual models (which represent all key infrastructure and flows on site) reasonable and fit for purpose?	✓		
Are the model simulation settings appropriate to estimate water balance during the mine operation period?	✓		
Are the model inputs and assumptions used in the water balance appropriate?	✓		
Are the water balance model logic and calculations sufficient for the purposes of mine planning?	✓		
Have all identified sources of uncertainty in model inputs and outputs been addressed adequately through sensitivity analysis assessments?	✓		
Are the sensitivity analyses of model inputs satisfactory at this planning stage?	✓		
Are the key modelling conclusions of the water balance satisfactory based on the results presented?	✓		
Have the key model limitations been sufficiently considered?	✓		
Does the assessment provide confidence that the regulations related to flow can be complied with?	✓		
Does the plan for reduction of erosion conform with Regulation 9 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern Ireland) 2015?*	✓		
Does the plan for the Prevention of Contamination of Receiving Water Bodies conform with Regulations 9 and 10 of the *Planning (Management of Waste from Extractive Industries) Regulations (Northern*	✓		

Description of Assessment	Acceptable	Further Clarification	Unacceptable
Ireland) 2015, and EC directives *2006/11/EC* and *2006/118/EC?*			
Is the water balance model appropriate and fit for purpose?	✓		
Chapter 29 – Review of Appendix J – Hydrological Impact Assessment Report: Surface Water Quality Review			
Is the modelling software an appropriate tool for the stated objectives?	✓		
Are the water quality modelling objectives clearly defined?	✓		
Are the key assumptions and conclusions of the modelling approach taken valid?	✓		
Are the levels of uncertainty as assessed within inputs and outputs likely to impact on the validity of the modelled results?	✓		
Are the predictions of groundwater quality estimated in the models for the operational period robust and in compliance with the regulations?	✓		
Are the key assumptions and conclusions for closure modelling appropriate and fit for purpose?	✓		
Are the modelled results valid, given the uncertainties identified by Golder for inputs and outputs?	✓		
Are the water quality models and calculations fit for purpose and appropriate to be presented to Public Inquiry?	✓		
Chapter 30 – Review of Appendix K – Surface and Groundwater Environmental Monitoring and Action Plan			
Is the SGEMAP sufficiently developed to be presented to Public Inquiry?	✓		

31.2 Conclusions

Golder considers that the WMP presented to it for review is technically acceptable, able to be presented for consideration to Public Inquiry and fit for purpose to be used as a basis for assessment of the issues to be addressed.

It concludes that most chapters and appendices are acceptable. Some areas require further clarification (Table 19 above), and are found in Chapters 6, 13 and 16, but none impact the overall efficacy of the WMP.

There are further areas where Golder states that assessments within the WMP are acceptable for the purposes of consideration at a Public Inquiry but will require further development for any detailed design / detailed planning application. There are no chapters or appendices which Golder considers unacceptable.

Signature Page

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